

## An A to Z of steel terminology

Air-Hardening steel	Steel that because of its high alloy content will form martensite when cooled in air from the austenitic state.
Alloy steel	A steel in which a deliberate addition of one or more alloying elements, e.g. Mn, Ni, Cr, Mo etc has been made during steel making to enhance the properties of the steel. The amounts of each element that must be present in steel before it is classified as an alloy steel are given in Table 1 in BS EN 10020: 1998. At low levels of addition the steels may be classified as micro or low alloy. The same standard classifies steels that do not meet the minimum requirements as 'non-alloy' steels.
Alpha-Iron	The form of iron (also referred to as ferrite) that exists naturally below 910°C in which the iron atoms are arranged in a body centred cubic (bcc) crystalline pattern, i.e. an iron atom at each corner of a cube and a single one right in the middle of the cube.
Anisotropy	Anisotropy is the word used to describe the fact materials in general, and steels in particular, are characterised by mechanical properties that differ depending upon the direction in which they are assessed. Particular use is made of this in cold reduced formable steels intended for deep drawing applications; the production process route is such as to enhance this particular property, which is given a numerical value by a parameter known as the 'r' value.
Annealing	A heat treatment that involves heating the steel to a pre-determined temperature, soaking the steel at that temperature for a pre-determined time and then cooling the steel down under controlled conditions. After being annealed steel will be closer to its equilibrium state. The temperature used can depend upon the chemical composition and the initial state of the steel and on the outcome desired of the treatment. This requirement of the treatment gives rise to the terms: stress-relief annealing, recrystallisation annealing, spheroidisation annealing and full annealing.
Arc furnace	A melting unit in which the heat is generated by striking an arc between graphite electrodes and the metal charge, which is usually in the form of solid scrap.
Arriss	Removal of sharp edges / corners in preparation for painting.
Austempering	A heat treatment process in which the steel is quenched from high temperature, when it is austenitic, to a temperature just above the austenite to martensite transformation temperature of the steel. The steel is then held at this temperature until it has transformed completely to bainite. It is then quenched to room temperature.
Austenite	A solid solution of one or more elements in gamma iron. (q.v.)
Austenitic steels	These are steels that contain sufficient austenite stabilising elements, such as Mn, Ni and N, so that the microstructure of the steel is austenitic at room temperature. Such steels cannot be quench or air hardened but will work harden rapidly; they are non-magnetic. Important examples of austenitic steels are 18/8 (18% Cr, 8% Ni) stainless steel and Hadfield's Manganese (14% Mn) rail steel.
Bainite	An acicular aggregate of ferrite and carbide particles formed when austenite is transformed on cooling at temperatures in the intermediate (200-450°C) range, i.e. above the martensite and below the pearlite range.
Bake hardenable steel	Bake hardenable steels are so constituted that after press forming and stoving (baking) through the paint curing process they age, i.e. they increase in strength. In this way, good formability is combined with added stiffness in the finished component, which frequently is an automotive body panel in which enhanced dent resistance is a desirable attitude.

Balanced steel	This is made by controlling the oxygen content of the liquid steel prior to ingot casting so that the amount of gas evolved during solidification balances the contraction, so minimising the formation of pipe. (NB. The majority of steels are now produced via the ConCast route.)
Basic oxygen steel making	Basic oxygen steel making is the process by which molten iron from a blast furnace is refined by the near total removal of carbon, silicon, manganese, phosphorus and sulphur to a point from which, by the addition of appropriate ferro-alloys and aluminium, the required grade of steel can be made. The process involves the injection of high volumes of oxygen at very high pressure into a vessel which originally will have contained a charge comprising approximately 20% selected ferrous scrap and 80% molten iron. The refractory lining of the vessel is basic, as opposed to acidic in nature, and basic fluxes are also added with the aim of creating a slag into which the impurities are driven. The capacity of vessels is very variable, but typically can range from around 200 tonnes to in excess of 350 tonnes. A cast of steel can be produced in less than 20 minutes. With modern refractories, a vessel is expected to be capable of producing in excess of 1000 heats before it needs to be relined.
Batching	The grouping together of parts to achieve an economic use of the process.
Bend test	A form of mechanical testing used to assess the ductility of a piece of steel. In carrying out such a test it will often be necessary to follow a detailed procedure which may cover the form, selection and preparation of the test specimen and exactly how the specimen is to be bent and the result assessed and reported, e.g. see BS1639: 1964. The results are normally expressed as a minimum bend diameter in the form $nT$ , where $n$ is a number (sometimes a decimal fraction), and $T$ is the thickness of the steel.
Billet	A semi-finished long product, sometimes of rectangular but more usually of square cross-section, with radiused corners. It can be produced from the hot rolling of a bloom, which has in turn been hot-rolled from ingot stock, or it can be produced directly by continuous casting. Square billet has sides between 50-120mm, whereas rectangular billet has a cross-sectional area between 2500 and 14400mm <sup>2</sup> and has a width to thickness ratio greater than 1:1 and less than 2:1. In practice, sizes up to 160mm square are often referred to as billet.
Bismuth	Added at a level of 0.1-0.2% as a direct replacement for lead, (it is more expensive, but there are not the toxicity problems associated with making lead additions), or at a lower level of 0.05-0.1% in combinations with sulphur, lead and tellurium, to improve the machinability of steel.
Blast furnace	A tall, 60-70m high, refractory lined furnace of circular cross-section (diameter at the base – 12m) from the bottom of which liquid cast pig iron is tapped periodically. This is produced by feeding in a solid mixture of iron ore, limestone and coke at the top and by blowing in pre-heated air, and usually fuel, at the bottom.
Bloom	A semi-finished long product, sometimes of rectangular but more generally of square cross-section, with radiused corners. It can be produced from the hot rolling of ingot stock or by continuous casting. Its size is larger than that of billet; a square bloom has sides generally greater than 120mm, whereas a rectangular bloom has a cross-sectional area greater than 14400mm <sup>2</sup> and has a ratio of width to thickness greater than 1:1 and less than 2:1.
Boron steels	Steels that contain additions of boron, generally between 0.002-0.003%, which is added to increase the hardenability of the steel.
Brazing	A method for joining steel parts together by melting a layer of a lower melting point alloy, usually brass, between the adjoining steel surfaces. The heat used is not sufficient to melt the steel and a flux is used to ensure flow of the brazing alloy between the steel surfaces.
Bright annealing	An annealing heat treatment carried out using either a specially controlled atmosphere or a vacuum, thus preventing oxidation and so keeping the surface of the steel being heat-treated bright and shiny.

Bright drawing	The process of drawing steel, which is initially at room temperature, in bar or coil form through a die in order to produce a product close dimensional tolerances, with changed mechanical properties and a bright surface finish. Prior to the drawing operation the steel surface may need to be prepared by pickling or shot blasting in order to produce a satisfactory initial surface condition.
Brinell hardness test	A test in which a hardened steel ball, usually 10mm in diameter, is pressed into the surface of the steel for a set time using a load of 3000kgf. The steel ball indenter is then removed and the diameter of the indentation is measured and used to determine the Brinell Hardness Number, HB, of the steel by reference to standard tables.
Calcium (Ca)	Aluminium – killed steel, while in the ladle prior to being cast, often has calcium, in the form of calcium silicide, injected into the liquid bath. The addition of calcium lowers the level of the remaining oxygen and sulphur contents of the steel and modifies the residual inclusion composition and shape. This has the effect of improving the cleanliness and castability and of reducing the anisotropy of toughness and ductility of the steel produced.
Carbides	Carbides are chemical compounds comprising carbon and either single metallic elements, or more complex combinations of more than one metallic element. The simplest example is iron carbide that is always present in steels. Provided carbides are present in the correct form, i.e. with regard to size and dispersion, they are beneficial. Particular use is made of carbides, (or the more complex carbonitrides, which include nitrogen) in high strength low alloy (HSLA) steels. A proportion of the increased strength of these materials is due to the effects which e.g. niobium carbide precipitates have on the structure of the product.
Carbon (C)	An essential alloying addition in steel. As the carbon content of steel increases so does the strength and hardness. To optimise the ductility and toughness for a given strength level the steel would be quenched and tempered. The majority of carbon would then be in the form of fine carbides. Carbon besides increasing the strength and hardness also increases hardenability (q.v.). In general, the higher the carbon content, the greater the care required in welding. (See Carbon Equivalent.)
Carbon equivalent (CEV)	A key parameter in assessing the weldability of a steel grade. The higher the value, the greater the care needed, especially with regard to pre- and post- heat treatment. $CEV = C + \frac{Mn}{6} + \frac{Cr}{5} + \frac{Mo}{5} + \frac{V}{15} + \frac{Ni}{10} + \frac{Cu}{10}$
Carbon-Manganese steels	Carbon-manganese steels refers to a family of medium to high strength steels which through a combination of correct selection of chemical composition and hot mill processing parameters produces products with enhanced formability and toughness.
Carbon steel	A non-alloy steel generally with a carbon content greater than 0.25%, in which the amount of carbon present is the major factor in determining its mechanical properties.
Carbonitriding	A thermochemical method of surface hardening a steel in which the steel is heated into the austenitic region and carbon and nitrogen diffused into the steel surface, following which, the steel is quenched.
Carburising	A thermochemical process in which steel is heated into the austenitic region in a carbon-rich atmosphere, so causing carbon to diffuse into the steel surface. The carburised steel product is then quenched.
Case-Hardening	A process in which the surface (case) of the steel is hardened and the interior (core) of the steel is left unchanged. A number of different techniques are available for achieving this objective.
Cast iron	Cast Iron differs from steel in that it has a much higher carbon content, 2.0-4.5%, in combination with amounts of silicon, manganese, phosphorus and sulphur as determined by the type of cast iron, and the end use.

Cementite	This is the name given to the compound of iron and carbon, Fe <sub>3</sub> C (iron carbide – colloquially ‘carbides’), which is a microstructural constituent found in many steels. It is very hard and brittle.
Charpy test	A test used to determine the degree of toughness of a steel. A standard Charpy test specimen is 10mm square in cross-section, 55mm long and has a V-notch machined in it at mid-length. The specimen is supported in a machine in which it is fractured by a swinging pendulum. The energy absorbed in fracturing the specimen in Joules (J) is read from a scale on the instrument, and is a measure of the toughness of the steel being tested. (See BS EN 10045-1: 1990).
Chromium (Cr)	Added to increase the hardenability of steel. A strong carbide former, so is present in quenched and tempered engineering steels, up to 3.5%, ball bearing steel, 1-1.5%, tool steels, (up to 12% in cold-working die steel) and in creep and heat resisting steels. When steels contain 11% or more of chromium they are termed stainless because of their corrosion resistance, which is due to the thin passive chromium-rich oxide film, which forms on the steel surface.
CNC	Computer Numerically Controlled.
Cobalt (Co)	An alloying element used in super high-speed steels, maraging steels, alloys for permanent magnets and in high temperature resistant alloys for use in jet engines.
Coefficient of expansion	The value of the ratio of the dimensional change (length, area, volume) of a material to the change in temperature that has caused it.
Cold drawing	A process in which steel, in the form for example of bar, rod, tube, section or wire, is reduced in cross-sectional area and so increased in length by being pulled through a die. Initially, the steel is at room temperature but the reduction process may cause a noticeable increase in the temperature of the drawn steel. Cold drawing increases strength but reduces ductility and toughness.
Cold reduced	See ‘Cold Rolled’.
Cold rolled	The term cold rolled is used to describe materials that have been rolled at a temperature below the so-called recrystallisation temperature. As a result of cold rolling the product is extremely hard, and in the great majority of cases it is necessary to anneal it before it has any commercial value. The product so produced is characterised by a good surface and enhanced thickness tolerances. Such a product is referred to as ‘cold reduced’.
Cold working	Changing the shape of a piece of steel, at a temperature which is below the recrystallisation temperature, i.e. by plastic deformation, e.g. by rolling, forging, extrusion, drawing, spinning, machining etc.
Continuous casting	A method of producing long lengths of solid steel of simple cross-sectional shape, such as slab, bloom or billet by pouring liquid steel from a ladle, via a tundish, into the top of a water-cooled metal mould of short length which is faced with a copper alloy. The solidifying product is continuously withdrawn from the bottom of the mould, and cut to length prior to further processing.
Controlled atmosphere	A type of atmosphere, e.g. a mixture of nitrogen and hydrogen, which is used in a heat treatment furnace to prevent unwanted reactions such as oxidation or decarburisation occurring to the work piece.
Core	The centre, as opposed to the surface layers, of a piece of steel, e.g. a coil.
Corrosion fatigue	Fatigue accelerated by simultaneous attack from a corrosive environment.
Creep	Time dependent plastic deformation. It is a serious design consideration when metals are operating under stress at high temperatures; creep rate is markedly temperature dependent. Creep tests involve the determination of the strain-time curve for the steel under constant stress and constant temperature conditions.

Critical cooling rate	The minimum rate of cooling that will produce a fully martensitic microstructure in a steel when it is cooled from austenitic condition to room temperature. As the alloy content and carbon content of steel is increased the critical cooling rate of the steel decreases.
Critical temperature	The temperature at which a phase change occurs in steel. The exact value of this temperature depends on the particular phase change occurring e.g. austenite to ferrite or cementite or the reverse, on the chemical composition of the steel, on whether the steel is being heated or cooled and on the rate of heating or cooling.
Crystalline fracture	When this type of fracture occurs in a steel it will have a shiny appearance as the fracture path in each grain has followed a cleavage plane so producing in each grain a flat reflective surface.
CTCD	Inspection technique on formed material.
Cyanide hardening	A surface hardening treatment in which low-carbon steel is immersed in a bath of molten cyanide-based salt causing carbon and nitrogen to diffuse into the steel surface so enabling a hardened case to be produced on the steel when it is quenched from the salt bath.
Decarburisation	A loss of carbon from the surface layers of steel caused by the steel having been held at high temperatures in an oxidising atmosphere.
Decoiling and cutting to length	The uncoiling, flattening if necessary and cutting to required length of strip originally in coil form.
Deep drawing steel	A steel, produced usually in the form of sheet, in which the composition and microstructure have been carefully controlled such that it has excellent cold forming properties when shaped by drawing or by pressing. In the case of carbon steel sheet a deep drawing quality grade would contain <0.06%C, <0.25%Mn and would have limitation on the sulphur and phosphorous contents. It will be aluminium killed.
Delta iron	The form of pure iron that exists between 1392°C and its melting point in which the iron atoms are arranged in a body centred cubic (bcc) crystalline pattern.
Deoxidation	The practice of adding elements to liquid steel before it is cast to control the level of dissolved oxygen in the liquid and therefore to control the amount of carbon monoxide evolved during solidification. Elements added for this purpose are Si and Al. Modern casting practice requires the complete removal of gaseous oxygen before casting commences; this steel is 'fully killed'.
Descaling	A process in which oxide (scale), formed on steel when it is at high temperature in an oxidising environment, is removed from the steel surface. Primary scale is usually removed in the first stage of a hot working operation using high-pressure water jets whereas secondary scale is usually removed by hot acid pickling or by shot blasting.
Deseaming	The removal of surface imperfections on steel by the controlled use of an oxy-acetylene gas burner. When used on-line in a rolling mill the process is often called 'scarfing'.
Die	A tool, usually containing a cavity, which is used to impart shape, or to change the shape of metal in liquid, solid or powder form. Examples are die-casting dies, forging dies, draw dies.
Dislocation	A discontinuity in the regular arrangement (crystallinity) of atoms in a metal grain (crystal).
Drawing	A process in which steel in the form for example of bar, rod, tube, section or wire is drawn (pulled) through a die in order to reduce its cross-sectional area, or in which a steel sheet blank is formed into a cup-shape by being deep drawn into a die.
Dress	To clean or prepare an edge for the next process or despatch.

Drop forging	A process in which hot steel blanks are shaped by forging into an impression formed within two dies. One die is attached to a stationary anvil and the other to a drop hammer. When the latter is dropped, either freely or under a power drive, the forging is formed by the closing together of the two dies.
Dry film	Thickness of paint film (dry).
Ductility	The ability of a metal to deform plastically without fracturing. From a tensile test, two simple measures of ductility obtained are elongation % and reduction in cross-sectional area %.
Dye penetrant inspection	A method of Non-Destructive Testing for determining whether or not surface porosity or cracks are present in a metal. The metal is coated with a penetrating liquid dye. The surface liquid is then removed and the metal coated with a white absorbent powder. The powder absorbs the dye held in the defects, so indicating their location.
Elastic limit	The maximum stress a metal can withstand without any permanent strain (deformation) remaining when the load is removed.
Elasticity	The property of a material that enables it to return to its original shape and dimensions when the stress on it causing these changes is removed.
Electrical steels	Steels in which the composition and processing conditions are controlled carefully in order to give the steel specific magnetic properties, so that they can be used as core materials in electrical machines. They are supplied in the cold rolled sheet or strip form, annealed and with an insulating coating on one, or both, faces of the sheet. They can be of a non-oriented grain type, in which case their magnetic properties are similar both in the direction of rolling and in the transverse direction, or a grain oriented type, in which case the steel has preferred magnetic properties in the rolling direction. Typically, a steel of the latter type contains >3% Si, and Mn in the range 0.05-0.07%.
Electroslag refining	A process for refining metallic alloys in which the alloy, in the wrought or as-cast state, in the form of an electrode is remelted through flux (slag) and solidified within a water-cooled copper mould.
Elongation	A measure of the ductility of a metal assessed in a tensile test. It is determined by dividing the elongation of the gauge-length of the fractured test piece by the original gauge-length.
End quench test	This is more commonly referred to as the JOMINY test. This test used to determine the relative hardenability of a steel. The test piece is heated into the austenitic range, and then subjected to quenching from just one end, after which the hardness is determined incrementally away from the quenched end.
Equiaxed crystals	Grains (crystals) that have approximately equal dimensions in each of three orthogonal directions. (i.e. at right angles to one another).
Equilibrium diagram	A plot of temperature against alloy composition showing the limits of composition and temperature ranges within which the various constituent phases of the alloy exist under equilibrium conditions.
Etching	The treating of a prepared polished metal surface with a chemical solution, or by other means, so that structural details of the metal surface are revealed. This may be a macro structure, or more commonly requires examination under an optical microscope.
Extrusion	The production of a length of uniform cross-section of metal from billet or ingot stock by forcing the metal to flow through a die, in direct extrusion, or to flow through or around the ram (die) in backward extrusion. In both cases, the finished section will have a smaller cross-sectional area than the starting material and therefore will be longer.
Fatigue	The effect on a metal of repeated cycles of stress. If these changes in stress are of sufficient magnitude and number the metal can fracture at a stress level considerably below that of its tensile strength.
Fatigue limit	The maximum value of the applied alternating stress that the material can withstand without failure ever occurring.

Fatigue testing	A mechanical test method for determining the range of alternating (fluctuating) stresses and the number of cycles a material can withstand before failure. The stresses can be tensional, compression or torsional, or a combination.
Ferrite	A solid solution of one or more elements in alpha or delta iron.
Ferro alloys	An alloy of iron containing sufficient of one or more other elements such as Si, Mn, Cr, Ti, V etc, making them of use as additions to molten steel, or cast iron, to meet an ordered specification.
Flame hardening	A process in which a high temperature flame is applied to the surface of a hardenable steel to convert it to austenite. The surface is then quenched to harden it.
Forming	The process of changing the shape of sheet metal by the application of load, i.e. in presswork or metal spinning.
Fracture face	The irregular surface produced when a piece of metal is broken.
Freecutting steels	Steels in which specific additions, the most common being S and Pb, have been made in order to improve their machinability.
Galvanic action	Corrosion induced by the action of an electric current caused to flow when two metals of dissimilar composition are connected electrically by an electrolyte. The metal higher in the galvanic series will act as cathode, while the other will act as anode and will therefore corrode.
Galvanising	Galvanising is the process in which corrosion protection is provided to a steel product by coating it in zinc. This can be achieved either through a hot dip process, or electrolytically. In the former, a cold reduced product passes through a series of heat treatments in which it is annealed and the surface is cleaned prior to the strip being passed continuously into a bath of molten zinc at c.440°C. The coating mass is controlled as a result of the strip then passed through a set of air (or nitrogen) knives which force surplus zinc back into the bath. The action of these knives is controlled by a meter that is set according to the coating mass actually required. The alternative method of coating is to do it electrolytically; in this case the feedstock is an annealed and temper rolled cold reduced product. Generally speaking, the coating masses so applied are much lighter than by hot dipping. It should be remembered that in addition to the continuous processes described above, for some applications post galvanising, i.e. hot dip galvanising after forming or fabrication, is appropriate. If steels are to be post-galvanised as part of the manufacturing process this should be stated at the time of ordering.
Galvanneal	A variation of the continuous hot dip galvanising process. Following the solidification of the strip on exit from the galvanising bath it is passed through another furnace in which the iron and zinc are caused to alloy (8-12% iron) more strongly than can be achieved purely by dipping. This product is used in the automotive industry where good corrosion resistance is combined with much improved weldability compared with a pure zinc coating.
Gamma iron	The form of iron that exists between 910°C and 1392°C, in which the iron atoms are arranged in a face centred cubic (fcc) crystalline pattern, i.e. an atom at each corner of a cube, and a further atom in the centre of each face.
Gas carburising	A method of case-hardening a steel in which carbon, from a gaseous atmosphere, is diffused into the surface of the steel while it is at high temperature in the austenitic condition.
Gauge length	A length on the parallel-sided central portion of a tensile test specimen that is used as the basis for determining the strain and total elongation of the specimen.
Gauge plate	In the trade this is also known as 'ground flat stock'. It is a tool steel usually containing 0.9% C, 1.2% Mn, 0.5% Cr. It is supplied, in the annealed condition, in short lengths, of rectangular cross-section strip with faces ground flat to close tolerances. It is used in the manufacture of gauges, dies, templates etc.

Grain size control	A term used to describe methods for controlling the grain size of steel during its manufacture.
Grain size measurement	The measurement of the grain size of a metal by observation of a metallographically prepared sample under a microscope. There are several methods available for quantifying the observations.
Graphitising	The partial, or complete conversion of the combined carbon that is in the form of iron carbide, Fe <sub>3</sub> C (cementite) uncombined carbon (graphite) and ferrite. This reaction can take place in steel or in cast iron. In the latter it often occurs at solidification rather than when the cast iron is in solid form.
Grey iron	A common form of cast iron so-called because the fracture surface of the iron has a grey appearance due to the graphite flakes present in the microstructure.
Grinding	The removal of material from a work-piece surface using a grinding wheel or abrasive belt.
Grinding cracks	The formation of shallow surface cracks on a ground work-piece. Normally caused by the generation of excessive heat when an incorrect grinding procedure has been used. Most commonly seen on hardened steel.
Grit	An angular steel abrasive used in the blast cleaning process.
Hard metal facing	The coating of a metal surface with hard metal alloy powders in order to increase the wear resistance of the surface.
Hardenability	A term applied to steels to describe the relative ease with which martensite can be formed in the steel. The lower the cooling rate at which a fully martensitic microstructure can be formed in the steel when it is cooled from austenitic condition the higher is the hardenability. Hardenability is commonly assessed by the Jominy end quench test.
Hardening	Increasing the hardness of metals by mechanical, thermo-mechanical, thermal or thermo-chemical treatments.
Hardness	A measure of the resistance of a metal to indentation by a loaded indenter. The common tests used to determine hardness are the Vickers, Brinell or Rockwell tests.
Heat	In steel making this is often used to describe the steel produced from a single melting operation.
Heat resisting steel	These are steels required to operate at very high temperatures and therefore they may require one or more of the following characteristics: creep resistance, resistance to oxidation, or other forms of gaseous attack, and freedom from microstructural changes that would lead to their embrittlement. Because service conditions can vary greatly a wide range of steel compositions came under the category of heat resisting with C-Mn, or low alloy steels of the CR Mo-V type being used to 500-525°C and austenitic stainless grades, containing for example 25% Cr, 20% Ni, being used at higher temperatures.
Heat treatment	Heating and cooling a solid metal or alloy in such a way as to obtain desired properties. Heating for the purpose of hot working is excluded from this definition.
High speed tool steel	Steel which is alloyed in such a way that it can be used as a cutting tool material to machine other metals at high speeds, and still retain its cutting ability, even though the tool tip is at a low red heat. The various grades of this steel all contain 0.6% or more of carbon, a combined content of 7%, or more, of the elements tungsten, molybdenum and vanadium, 3-6% of chromium and in those required to operate at the highest temperatures additions of 4-13% of cobalt.
High yield strength steel	Other terms used to describe this type of steel are High Strength Low Alloy (HSLA) steel or Microalloyed steel. It is a steel that with a combination of small amounts of niobium (Nb), vanadium (V) or titanium (Ti), or a controlled combination, and a controlled hot rolling practice has yield strength greater than that obtainable in a mild steel, (i.e. greater than ~275 Mpa).

Hooke's law	A law that states that when a material is behaving elastically, the strain in the material is directly proportional to the stress producing it.
Hot quenching	An imprecise term for describing the cooling of a material by quenching it into a medium, the temperature of which is above that of ambient.
Hot work	The plastic deformation of a metal by processes such as rolling, forging, or extrusion, carried out at a temperature and strain rate such that substantial strain hardening does not occur but instead the metal continues to yield relatively easily because the metal is recrystallising continuously.
Hydrogen (H)	A gas which, when present in steel, can cause embrittlement, hair-line cracking, or even complete fracture, especially of high strength steels. Is an option as a controlled atmosphere medium for annealing, e.g. Ebher annealing, and also in high temperature annealing of grain oriented electrical steels.
Impact test	A test using, for example, an Izod or a Charpy notched specimen to determine the relative toughness of the metal by measuring the energy absorbed when the test specimen is fractured by a weighted pendulum.
Inclusions	Particles, usually compounds, such as oxides, sulphides or silicates, but that could also be of any substance that is foreign to and essentially insoluble in the steel matrix, e.g. particles of lead.
Inclusion count	A quantitative assessment of the inclusion population of a metallic alloy. It is carried out microscopically on a prepared sample of the alloy and may include one or more of the following assessments: the number of inclusion particles present, their size, their shape, their type and their distribution.
Induction hardening	A process for surface hardening steel in which the surface of the steel is heated to an austenitic condition, by eddy currents from an inductor coil carrying a high-frequency alternating current, and then quenched immediately to form martensite. Changing the frequency of the inductor coil current can modify the depth of hardening achieved. To obtain sufficient hardness the steels hardened in this manner usually contain at least 0.3%C.
Ingot	A term used to describe a block of solid steel resulting from the batch casting of liquid steel into a stationary mould made usually of cast iron.
Ingot mould	The container into which molten steel is poured to produce an ingot. Usually it would be made of cast iron but for the production of very large forging ingots it would be made of sand.
Intercrystalline corrosion	Corrosive attack occurring preferentially in the grain boundary regions of an alloy. It is also known as intergranular corrosion.
Interrupted quenching	A term used to describe a quenching procedure in which steel, instead of being quenched into a liquid at ambient temperature, is quenched into a liquid, usually molten salt, at some elevated temperature. When the steel has been held for sufficient time at this temperature to achieve temperature uniformity, and/or has achieved the required microstructural transformation, it is further quenched to room temperature.
Iron	When used in the scientific or chemical sense this word refers to the chemical element Fe or to pure iron. It is the principal element present in steels and cast irons.
Izod impact test	An Izod impact test is similar to a Charpy test in that the notched specimen is of the same dimensions as a Charpy test piece and the energy absorbed when the specimen is fractured by a falling pendulum is used to assess the toughness of the steel sample. In the Izod test the specimen is struck by the pendulum when it is held vertically in a vice, whereas in the Charpy test the specimen is struck when in a horizontal position.
Jominy test	A test used to assess the hardenability of a steel. A standard Jominy specimen is 25mm in diameter and 100mm long with a flanged end. The specimen is heated to an austenitic condition and then end-quenched using a standardised water jet. When cool, a flat, 0.4mm deep, is ground along the length of the bar and hardness measurements made along the flat. The hardness results are then plotted against distance from the quenched end to give a Jominy hardenability curve for the steel.

Joule	A joule (J) is a unit of energy, including work and quantity of heat. It is the work done when the point of application of a force of 1 Newton (N) is displaced through a distance of 1 metre (m) in the direction of the force.
J Prep (Single/Double)	Preparation for welding.
Kerf	Width of material lost by oxy propane cutting flame.
Killed steel	Made by complete deoxidation of the molten steel before it is cast so that no gas evolution occurs during solidification. Normally this is achieved through additions of aluminium and/or silicon.
Lap	The presence of an area of 'double skin' on the surface of a wrought steel product, e.g. on a section of rolled bar. The most common cause of this type of defect is from excess material being squeezed out into the roll collar during a roll pass so forming a fin on either side of the product. On turning the steel for the next pass the fins are then rolled back into the steel surface so producing laps.
Laser cutting and welding	Laser cutting is a process in which a laser beam is used to cut e.g. blanks from a sheet of metal. Because of the intense and highly localised nature of a laser beam, a high degree of precision can be achieved. Provided the material being cut is of adequate quality, the risk of distortion is greatly reduced. The cut is much cleaner than one produced by any other means. Laser welding is the reverse of cutting; in this case the intense heat of a laser beam is being used to execute a precision weld of high quality.
L-D Process	A process of making steel in which oxygen is blown from a water-cooled lance onto a bath, consisting mainly of blast furnace iron, in a large refractory lined tillable vessel. The process is named after the two towns in Austria, Linz and Donawitz, from where it originates but is now more commonly known as Basic Oxygen Steel making (BOS) or the Basic Oxygen Process (BOP).
Leaded steels	Steels to which lead, in amounts between 0.15-0.35%, has been added, usually in conjunction with sulphur, to improve the machinability of the product.
Limit of proportionality	The maximum level of stress which a metal can withstand and still obey Hooke's Law, i.e. it is the point on the stress-strain which any increase in stress will cause a deviation from linearity. In practice, this means a permanent set.
Limiting ruling section	The maximum diameter bar size for which a stated set of mechanical properties can be obtained for a particular steel composition after a given quench and temper heat treatment.
Liquid carburising	A treatment in which carbon is diffused into the surface of steel, in order to harden it, through immersion of the state in a bath of molten sodium cyanide-based salt.
Machinability	A term used to describe the ease with which a metal can be machined
McQuaid-Ehn grain size test	A method for determining the re-formed parent austenite grain size of steels primarily intended for case-hardening, so is mainly used on carbon and alloy steels containing up to approximately 0.25% carbon. In the test, samples of the steel are carburised under standard conditions and the austenite grain size is revealed by the network of cementite that forms on their boundaries during slow cooling.
Macrostructure	The structure of metals as seen when viewed with the naked eye or at low magnification.
Magnetic crack detection	Also known as magnetic particle inspection. This is a non-destructive method of detecting surface and sub-surface discontinuities, (cracks, porosity etc.), in ferromagnetic materials. Finely divided magnetic particles, applied to the magnetised material, are attracted to, and outline the pattern of any magnetic leakage fields and so reveal the presence of the discontinuity that created the leakage.
Malleability	The characteristic of metals which permits them to be deformed plastically by compressive forces without fracture

Manganese (Mn)	A most useful additive to steels. Mild deoxidiser. Combines with sulphur and so decreases the chance of the steel suffering from hot shortness. Improves the toughness of ferrite-pearlite steels. Improves hardenability. Hadfield's manganese steel, which is characterised by its great resistance to wear, contains around 13% Mn. It is used in some grades of austenitic stainless steel to replace the more expensive nickel, as it is an austenite stabiliser.
Maraging steels	Maraging steels are a family of high nickel steels i.e. typically not less than 18% that are characterised by extreme high strength and toughness. Nickel is one of a group of possible additions to steel that encourages the formation of austenite, as opposed to carbides. Because of this, under the correct conditions high strength can be conferred by the transformation of austenite into martensitic type structures. The merit of maraging steels is that this change brought about as a result of a simple heat treatment, a consequence of which is that the problems of distortion normally associated with high temperature heat treatments are avoided. A typical heat treatment might involve heating to 820°C followed by air cooling (which avoids the distortion which would be associated with a faster rate cooling). The process is completed by ageing at a temperature in the range 450-510°C
Martempering	A heat transformation procedure in which an austenitised steel is quenched to a temperature just above MS, the martensite start temperature, at a rate fast enough to avoid the formation of ferrite, pearlite or bainite. The steel is then held at this temperature for long enough to achieve temperature uniformity without transformation and then cooled to room temperature. The process is employed to minimise the chance of quench cracking or distortion occurring.
Martensite	A microstructural form found in steel when it has been cooled from its austenitic state to room temperature at a greater than the critical cooling rate of the steel. It is a metastable solid solution with a body-centred tetragonal structure and its hardness depends primarily upon the carbon content of the steel.
Mass effect	A term used to emphasise the effect of section size on the rate at which a steel can be cooled through its austenitic transformation, and hence the effect of section size on the microstructure and mechanical properties that can be produced in a steel of a particular chemistry when cooled in this manner.
Maximum stress	When used in relation to the tensile testing of a metal the value of the maximum stress is obtained by dividing the maximum load to which the test piece is subject to by the original cross-sectional area of the specimens gauge length.
Melting point	The temperature at which a solid begins to melt.
Micron	A unit of length. It is $1 \times 10^{-6}$ (0.001mm).
Microstructure	The internal structure of a material revealed when a sample is polished, etched and viewed under a microscope.
Mild steels	A description generally taken to mean non-alloy steel with a maximum carbon content of about 0.25%.
Mill margin	Material allowed between mill supplied size & final cut size to allow cutting operations.
Modulus of elasticity	The ratio of the applied stress to the resultant strain, produced by the stress, occurring when the metal is behaving in an elastic manner. If the stress occurs from tensile loading conditions the ratio, the modulus elasticity, is known as Young's modulus (E) and it is a measure of the stiffness of the metal.

Molybdenum (Mo)	A strong carbide forming element in steel. Produces a pronounced secondary hardening effect and so is present in hot working tool steels and is used as a partial replacement for tungsten in certain grades of high-speed steel. Greatly improves hardenability (of the elements commonly added for this purpose only vanadium has a stronger effect), and reduces temper embrittlement, so is often used in quenched and tempered engineering steels. Used in conjunction with Cr and V in creep resistant steels. Up to 5% can be present in maraging steels. Added to stainless steels to promote resistance to pitting and crevice corrosion attack.
Nesting	Where parts are grouped together on a plate to achieve best fit and hence minimise yield loss.
Nickel (Ni)	Widely used as an alloying element in steels. Up to 5.0% can be present in general engineering and in case hardening steels. Improves strength and toughness and increases hardenability. Larger amounts are present in austenitic stainless and in heat resisting steels. Also used in Invar, a controlled thermal expansion alloy, and in permanent magnet alloys.
Niobium (Nb)	Known as columbium in the USA. A strong carbide forming element in steel. Present in amounts up to 0.1% in high strength low alloy (microalloyed) structural steel and used in stabilised grades of austenitic stainless steel. Can also be used as a stabilising element in ultra low carbon (ULC) steels.
Nitriding	A thermochemical treatment in which nitrogen is diffused into the steel. The treatment is usually carried out at a temperature around 500°C, in either a gas or salt bath atmosphere, or with the use of a plasma.
Non-Destructive Testing (NDT)	Also known as non-destructive inspection. Any technique that uses radiography, ultra-sonics, dye-penetrant, magnetic particles, eddy currents etc. to determine the quality of a material without permanently altering the completeness or properties of the material being tested.
Non-Magnetic steels	Steels that have a stable, fully austenitic microstructure.
Normalising	Heating up a steel to just above its upper critical temperature in order to transform it to austenite, followed by cooling to room temperature at such a rate that a refined equilibrium microstructure is produced. Often this means cooling in still air.
Notched bar test	A test in which the test specimen has a notch of a standard geometry machined in it in order to produce a local stress concentration at the notch root when the specimen is tested. (See Charpy and Izod Impact tests)
Notching	The cutting out of any of a variety of possible shapes from the edge of a section, plate, blank or part.
Oil hardening steel	A steel for which the liquid used for quenching is oil rather than any other medium.
Oiling	The coating of steel with oil as a temporary rust preventative.
Open hearth furnace	A melting furnace with a shallow hearth, on which the charge is placed beneath a low roof. Heating of the charge is both by direct flame and by radiation from the furnace roof and sidewalls. This type of furnace is no longer used in Western Europe as a steel making unit as the Basic Oxygen and the Electric Arc Furnace Steel making processes have now replaced it, for economic and quality reasons.
Orange peel effect	The name given to the appearance of the surface roughening that can occur when a metal with an unusually coarse grain size is plastically deformed.
Ore	A naturally occurring mineral that can be mined and treated for the extraction of any of its components, metallic or otherwise, on a commercial basis.
Over heating	Heating a metal to such a high temperature, or for such a long time that its properties are degraded. When the original properties of the metal cannot be restored by thermal, mechanical or thermo-mechanical treatment the overheating is often termed 'burning'

Oxidation	A chemical reaction in which oxygen combines with the metal to convert it to its oxide form.
Oxy-Acetylene welding	A process of fusion welding two pieces of metal together, with or without the addition of a filler metal, in which the heat source is a flame produced from the controlled combustion of oxygen and acetylene gases.
Oxygen (O)	Used in the Basic Oxygen Steel making process. When present in the form of oxide, inclusions in steel will reduce all mechanical properties, including ductility, and decrease machinability.
Pearlite	A microstructural constituent of steel. It is a mixture of ferrite and cementite that normally exists in lamellar form and results from the eutectoidal breakdown of cooling of austenite.
Phosphorous (P)	Its presence in steel is nominally limited to below 0.05% because of its embrittling effect. It is a powerful solid solution hardening agent. It is important to be aware phosphorous, especially in combination with silicon, can influence the control of post-galvanising.
PH value	A measure of the relative acidity or alkalinity of a solution. It is the reciprocal of the logarithm of the hydrogen-ion activity in the solution. The pH values range from 0 to 14. A value of 7 is taken as neutral with values of decreasing magnitude below this indicating acidity and with values of increasing magnitude above this indicating increasing alkalinity.
Pickling	The removal of surface oxides from metals by chemical or electrochemical reaction.
Pig iron	The high carbon iron produced from the blast furnace and cast into 'pig'.
Pinch pass	The pass of sheet metal, at room temperature, through rolls to effect a very small reduction in thickness. (Typically 0.7 - 1.2%.) On low-carbon annealed steel sheet this is carried out in order to prevent the occurrence of stretcher strain markings on subsequent shaping of the sheet.
Pipe	When used to describe a defect in a metal this term is used either to indicate: <ul style="list-style-type: none"> <li>i) The central cavity formed by contraction, during solidification, in the top of ingot stock</li> <li>ii) An imperfection seen in wrought material resulting from this cavity.</li> </ul>
Plate and cylinder rolling	The cold shaping of plate and sheet using rollers to produce cylinders or other rounded shapes, e.g. dished ends
Poisson's ratio	The absolute value of the ratio of the transverse (lateral) strain to the longitudinal strain when a material is being stressed elastically.
Powder metallurgy	The technology of producing metals in powder form and of using this powder in the production of useful objects, compaction and sintering.
Pre-Heating	The heating of metal stock prior to some further thermal or thermomechanical treatment.
Press blanking	Press blanking is process in which (shaped) blanks are pressed out of strip feeding continuously into the press blanking machine.
Profiles	With respect to steels this term covers two types of products: <ul style="list-style-type: none"> <li>i) Shapes cut by flame, plasma or laser from steel sheet, plate or slab.</li> <li>ii) Steel sheet could roll formed or pressed to different profiles for use, for example, as cladding for buildings.</li> <li>iii) It could also refer to the variation in gauge across the width of a flat rolled product.</li> </ul>
Profiling	The flame, plasma or laser cutting of shapes from sheet, plate or slab.
Projection welding	A resistance welding procedure in which the welds made between the parts to be joined are localised at performed projections (embossments) on the parts.
Proof stress	The stress that will cause a specified small and permanent extension of a given material. It is normally quoted as the stress to obtain a 0.1%, or a 0.2%, extension in the material, the values being obtained from a tensile test.

Quenching	The rapid cooling from high temperature, generally by immersion in water, oil or polymer solutions. E.g. Quenched & Tempered plates (RQT).
Quench cracking	Cracking, or even complete fracture, resulting from stress produced in the material by it being cooled rapidly from high temperature.
Radiography	A method of non-destructive inspection in which the object being inspected is exposed to a beam of X-rays or gamma rays and the resulting shadow image of the object is recorded on film or is displayed on a viewing screen or television monitor. Internal defects are then detected due to differences in absorption.
Recrystallisation	The formation of new strain-free grains in a metal brought about either by heating a cold-worked metal, or by hot working a metal, or by heating a metal through an allotropic change.
Red hardness	The hardness of a steel when it is at a temperature high enough to cause it to have a dull red appearance. The term usually associated with high speed tool steels as their chemical composition is such that they are generally capable of retaining sufficient hardness and hence their cutting ability even when the tool is at a dull red heat.
Reduction of area	The difference between the original cross-sectional area of the gauge length of a tensile specimen and the cross-sectional area at the point of fracture. This difference is usually then expressed as a percentage of the original cross-sectional area and the result used as a measure of the ductility of the metal being tested.
Residual stress	The stress in a body resulting from some previous forming and/or heat treatment operation. Found for example in castings, weldments and cold formed parts.
Rimming steel	Rimming steel ingots are produced by adjusting the oxygen content of the liquid prior to casting so that vigorous carbon monoxide evolution occurs during solidification. This produces an ingot with an outer layer of very pure iron which gives rise to a sheet product with excellent surface and good formability. The widespread adoption of the continuous casting process has resulted in rimming steels generally being replaced by killed steels.
Rockwell hardness testing	A hardness test in which an indenter, either a cone-shaped diamond or a hard steel ball, is left for a set time under constant load on the test specimen. On release of the load the Rockwell hardness of the material, which is related the depth of the indentation produced, is displayed on a dial.
Roller quenching	Roller quenching is a process associated with heat treatment. Components that have been taken up to the required temperature are then transported through the quenching medium on a roller table, thus rendering the process semi-continuous, and the properties of the product more consistent.
Rolling	The reduction of the cross-sectional area of metal stock by its passage between rotating rolls
Rolling lap	See 'Lap'.
Ruling section	The term ruling, or limited ruling section, is the maximum diameter or cross-section of a steel, of a particular chemical composition, up to which a specific set of mechanical properties apply after a given heat treatment. It is a term used particularly with respect to the mechanical properties of quenched and tempered steels.
Salt bath	A bath of molten salt, the composition of which is varied according to the temperature and treatment required, in which steels are thermally or thermo-chemically treated.
Scale	The thick oxide skin that forms on a steel when it is exposed to an oxidising environment for any length of time at high temperature.
Scarfing	The cutting out of surface defects on steel with the use.
Scrap	Discarded metallic material, arising from processing or from use, usually it is reclaimed by remelting and refining to produce new material.

Seams	Numerous shallow grooves, cracks or striations, continuous or intermittent on the surface of wrought steel, the surfaces on which when viewed microscopically are generally heavily oxidised and decarburised. They result from the elongation during working of trapped gas pockets, blowholes or cracks that formed during the casting of the steel.
Selenium (Se)	Can be added to improve the machinability of certain grades of stainless steel.
Shearing	Cutting of sheet or strip to size using shear blades, as in a guillotine.
Shearing test	Direct shear tests can be used to determine the shear strength of bar, plate or rivet stock. For a bar a portion of the test piece is clamped while the remaining portion extends over an open die. A load is applied, to this latter portion, at right angles to the specimen axis and increased until it shears through the specimen. The maximum load applied, divided by the area subjected to the shearing force gives the average shear strength of the material tested.
Sheets	Flat rolled steel product with a width of 600mm and a thickness of up to 3mm.
Shot	A round steel abrasive used in the blast cleaning process.
Silicon (Si)	Used as a deoxidiser in steel making, and also as a strengthening agent. An alloy addition in spring steels (~1.5%), in heat resisting steel (1.5 - 3.5%) and in steel sheet for transformer cores (>3%). It is important to be aware silicon can influence the control of post-galvanising, especially in combination with phosphorous.
Sitting	The cutting of wide strip into narrower strip usually carried out using rotary cutters. The strip is normally decoiled before it is slit.
Slotting	In sheet this involves the punching of elongated holes, (slots), through the steel using a punch and die. It is also applied to the cutting of a narrow aperture or groove in thicker material with a reciprocating tool cutter, broach or grinding wheel.
SG Iron	An abbreviation for Spheroidal Graphite Cast Iron. This type of cast iron is produced by adding small amounts of ST cerium or magnesium to a molten iron, which normally solidifies to give a flake graphite iron. The spheroidal rather than the flake morphology of the graphite gives a measurable degree of ductility to the cast iron.
Spinning	The forming of a seamless hollow metal part by forcing a rotating sheet metal blank to conform to the shape of a mandrel that is rotating concentrically with the blank.
Spot welding	A method of joining two pieces of overlapping sheet metal together in which the welded region is limited to a 'spot' of approximately circular cross section. This localised weld is nominally made by a resistance welding technique but can also be made using an arc.
Spring steel	Steel used for the manufacturer of springs. Depending on the type and application of the spring the steel composition can vary from a plain carbon type, to C-Si, to any of a range of alloy steels and if necessary to the use of a martensitic or austenitic stainless steel grade
Stabilisation	A term used in a number of different contexts: <ul style="list-style-type: none"> <li>(i) A thermal treatment to stabilise the microstructure, mechanical properties or dimensions of a metal.</li> <li>(ii) The addition of the elements Ti or Nb in certain grades of austenitic stainless steel.</li> <li>(iii) The effect of the addition of AI to deep drawing sheet steel to prevent it from ageing.</li> <li>(iv) The addition of Ti and/or Nb to interstitial free steels to prevent ageing.</li> </ul>
Stainless steel	An iron-based alloy containing 10.5%, or more, of chromium. By the addition of other alloying elements to this basic ferritic alloy, such as Ni, C, N and Mo, a variety of different grades of stainless steel, namely austenitic, martensitic duplex and precipitation-hardened can be produced.

Steel	An iron-based alloy in which the carbon content is less than its solubility limit in austenite. This limit is approximately 2.0% in non-alloy steel but may be higher in certain alloy steels.
Strain ageing	The changes in ductility, yield strength and tensile strength that can occur with time in certain steels when they are stored after they have undergone plastic deformation by cold working.
Strain hardening	The increase in strength and hardness that occurs when a metal is plastically deformed under such conditions that softening does not take place i.e. below the recrystallisation temperature. Also known as work hardening.
Stress relieving	Although a degree of stress relaxation (stress relief) may occur at room temperature, this term normally implies a heat treatment in which the material is heated up and soaked at a suitable temperature before being control cooled back to room temperature. Stress relief occurs by creep, so the degree of relief achieved is both time and temperature dependent.
Stress-Strain curve	A graphical plot of data obtained, usually from a tensile test, in which the stress on the metal being tested (the force causing the specimen to deform divided by the original cross-sectional area of the gauge length) is plotted against the resulting strain (the extension of the gauge length divided by its original length).
Subcritical annealing	An annealing heat treatment carried out as a temperature below the critical temperature of the steel.
Sulphur (S)	Normally kept as low as possible in steels as it has a detrimental effect on hot and cold formability, on ductility, or fatigue properties and on weldability. It is beneficial, in the form of manganese sulphide particles, on the machinability of steel and up to ~0.35% can be present in free-cutting materials.
Surface hardening	A generic term covering several processes, such as carburising, nitriding, flame and induction hardening, that can be used to produce a surface layer, on a specific type of steel, that is harder than the core of the steel.
Surface profile	Roughness of surface profile blast cleaning.
Surface quality	Cleanliness of material surface following blast cleaning
Swaging	A process in which by hot or cold working the cross-sectional area of metal stock in the form of bar, rod, wire or tube is progressively reduced along its length by forging, hammering or squeezing. In a rotary swage the reduction is achieved by rapid impact blows from revolving dies.
Swarf	The chips and other particles of metal that are removed from the work-piece during a machining operation.
Tellurium (Te)	Like selenium it is used, usually in conjunction with lead, to improve the machinability of steel.
Temper	A term which is used in a number of different contexts: <ul style="list-style-type: none"> <li>(i) A heat treatment carried out below the lower critical temperature to reduce the hardness and increase the toughness of steels that have been hardened by their transformation to martensite.</li> <li>(ii) In tool steels, the term is sometimes used, inadvisably so, to denote the carbon content of the steel.</li> <li>(iii) To grade the degree of hardness achieved by cold working of both non-ferrous metals and of low-carbon e.g. hard, half-hard, quarter-hard etc.</li> </ul>
Temper brittleness	A term used to describe a loss in toughness that can sometimes occur when a steel with a martensitic microstructure is tempered. It occurs only in alloy steels, which contain certain impurity elements, and which have either been tempered and then slowly cooled through, or used in, an embrittling temperature range.

Temper colours	The colour of the thin oxide film that develops on a steel surface when the steel is tempered. The colour, which can range from a light straw to a deep purple, depends on the film thickness and so is dependent on both the time and temperature of the tempering. It is used to judge tempering temperatures when more accurate methods are not available.
Temper rolling	In the steel industry this is a finishing light cold rolling reduction applied to cold-reduced and annealed low-carbon sheet to achieve one or more of the following: suppression of the yield point, increase in strength and hardness, improvement in flatness, attainment of a specific finish. In the case of metallic-coated steel sheet it may also be for the elimination and correction of flaws in the coating.
Tempering	A heat treatment, in which steel hardened by transformation to martensite, is heated to a temperature below the lower critical temperature in order to decrease hardness and improve toughness.
Tensile strength	This value is nominally obtained from a tensile test and is then the maximum load applied to the tensile test specimen before it fractures, divided by the original cross-sectional area of the gauge length. It is also known as the maximum stress or ultimate tensile strength.
Tensile test	A test in which a specimen of a standardised geometry is gripped at both ends and stretched at a slow controlled rate by axial loading until rupture occurs. The test provides information on the strength and ductility of the material tested. (See BS EN 10002-1: 1990)
Thermo-mechanically controlled rolling (TMCR)	<p>(i) <b>Thermo-mechanically rolling:</b> This is the conventional hot rolling process as a result of which, in combination with the chemical composition of the material, the prescribed mechanical properties are obtained in the as-rolled condition.</p> <p>(ii) <b>Normalised rolling:</b> By carefully selected chemical composition and finishing and coiling temperature a set of prescribed mechanical properties is obtained which will still be achievable after the product has itself been normalised, i.e. at &gt;900°C.</p>
Tin	A corrosion protective coating for steel as in tinsplate used in the packaging industry. An undesirable element in steel as it can give rise to hot shortness and to temper brittleness.
Tolerances	The permissible deviation in specified nominal dimensions, or in other characteristics, of a piece of material or a part.
Tool steel	A generic term covering a whole range of both carbon and alloy steels commonly used to make tools. This therefore includes steels used to make cutting tools, press tools, dies, moulds for both plastics and die-casting, hand-tools, in fact any tool used to shape metals or other materials.
Torsional strength	The resistance of steel, or any other material, to deformation when it is subjected to torque.
Toughness	A measure of the ability of a material to absorb energy and deform plastically before it fractures. It is proportional to the total area under the stress-strain curve, plotted from zero stress to fracture for the material. It is nominally determined for a metal from the energy absorbed in an impact test.
Transformation range	The range of temperature within which austenite forms when a steel is being heated up or within which austenite transforms when a steel is being cooled down.
Transformation temperature	The temperature at which a change in phase occurs in steel whilst still remaining a solid.
Transition temperature	An arbitrarily defined temperature, that lies within the temperature range where the fracture mode of a notched steel impact test changes from ductile to brittle.
Transverse test	A test made perpendicular to the principle direction in which the metal has been worked.
TTT Curve	An abbreviation for the Time-Temperature-Transformation curve.

Tufftriding	A process of low temperature (550-570°C), surface hardening of steel through immersion in a bath of molten cyanide-based salt. The resulting shallow nitrogen-enriched surface layer on the steel gives improvements in wear behaviour and in corrosion resistance.
Tungsten	Forms very hard stable carbides in steel, so is often found in tool steels, up to 1.5-2.5%. Much larger additions, 18% or more, can be found in some high speed steels.
Ultimate tensile strength	The maximum load that a material withstands in a tensile test before it fractures, divided by the original cross-sectional area of the gauge length of the specimen. A more correct term to apply to this parameter of a material is Tensile Strength.
Ultrasonic inspection	An inspection technique in which high frequency sound waves are introduced into material in order to detect any surface or subsurface flaws that may be present.
Upsetting	The working of a piece of metal so that its length is reduced and the cross-section of part or all of the metal is increased.
Vacuum Arc Remelting (VAR)	A process in which a metallic alloy in the form of an electrode, and which may be in either as-cast or wrought condition, is remained in vacuum, by means of a DC arc, and is then resolidified within a water-cooled copper mould. The primary benefits of the process are the removal of dissolved gases, the minimising of the content of undesired trace elements that have a high vapour pressure, improved cleanliness with respect to oxide inclusions and the avoidance of macro segregation and the minimising of micro segregation.
Vacuum degassing	A secondary refining process for liquid steel in which it is exposed to a low pressure environment with the aim of achieving one or more of the following: reduction of dissolved gases - improved cleanliness - greater uniformity control of chemical composition.
Vanadium (V)	Used in small amounts, up to 0.15% for grain refining and strengthening of microalloyed high strength structural steels and up to 0.2% in certain hot forging steels for improving hardenability. A strong carbide former, giving rise to secondary hardening, so is used in tool steels for use at elevated temperatures and in creep resistant steels.
Vee (Single/Double)	Preparation for welding.
Vickers hardness test	Also known as the diamond pyramid test, as the indenter used in the test is a pyramid shaped diamond. This is forced under a given load into the metal specimen for a fixed time. On removal of the load the diagonals of the diamond-shaped indentation are measured under a low-power optical microscope. The average value of the two readings together with the applied load is then used to determine from standard tables, a hardness number for the metal. The load used is varied according to the softness or hardness of the metal being tested, and also its thickness.
Welding	Joining two or more pieces of material together by the application of heat or pressure, or both, with or without the use of the filler material. The joint is formed either by inter-diffusion across the interface or by localised melting and re-solidification.
Wet film	Thickness of paint film (wet).
Whiskers	A term used to describe metallic filamentary growths, barely visible to the naked eye, that can form on metals and which are stronger than the metal from which they form because of their relative freedom from defects.
Widmanstätten structure	A description of a characteristic type of microstructure in which a second phase forms within a parent phase in a definite geometric pattern due to the crystallographic dependency between the two phases. The structure was originally observed in meteorites but can be produced readily in many metallic alloys e.g. the distribution and morphology of ferrite when it forms in coarse-grain austenite.
Wolfram	The earlier name given to the metal tungsten. Wolframite is the name of one of the minerals from which tungsten metal is extracted.

Woody fracture	A fracture that is fibrous or woody in appearance due to the elongated surfaces of separation on the fracture face. Seen particularly in fractures of wrought iron because of the presence in the material of elongated non-metallic particles.
Work harden	A reduction in malleability (particularly relevant stainless materials)
Wrought iron	A commercial iron that has been largely superseded today by mild steel. Because of its mode of manufacture it contained a large amount of elongated slag particles in a predominantly ferritic matrix.
X-Ray crystallography	The use of X-rays for determining the crystal structure of materials.
Yield	Resistance of material to bending.
Yield point	The point on the stress-strain curve of a metal at which it finishes deforming solely in an elastic manner and begins to deform plastically.
Yield strength	The stress at which a metal begins to deform plastically, i.e. the stress at which the stress-strain curve first begins to deviate from linearity. When this is difficult to distinguish, the yield strength is defined in terms of a 0.1% or a 0.2% strain has been obtained.
Young's modulus	When a material is behaving elastically, the ratio of the tensile or compressive stress to the resulting strain in the material is known as the modulus of elasticity, or Young's Modulus, of the material. It is the slope of the linear portion of the stress-strain curve of the material and is a measure of the stiffness of the material.
Zinc (Zn)	Applied to steels by hot dipping or by electroplating (galvanising) as a corrosion preventative coating.