

Aluminum Extrusion Glossary

Age Hardening. precipitation hardening. A process of aging that increases hardness and strength and ordinarily decreases ductility. Age hardening usually follows rapid cooling from solution heat treatment temperatures.

Aging. A change in properties of an aluminum alloy that generally occurs slowly at atmospheric temperatures and more rapidly at higher temperatures.

Alloy. Material that has metallic properties and which is composed of two or more chemical elements, one always being metal. The alloy's properties are usually different from those of the components.

Anneal. To subject to high heat with subsequent cooling so as to soften and render less brittle.

Annealing. Any treatment at elevated temperature which has for its principal purpose to soften and remove residual stresses. In wrought aluminum products, "annealing" generally connotes a treatment above the recrystallization temperature.

Aperture. The opening or openings in the die of the same cross-sectional area and contour as the product to be extruded.

Back Taper Relief. Cut-away portion of die beginning at breakaway point and angling toward the back of the die at approximately $1\ 1/2^\circ$ to 10° depending somewhat upon cutter angle of the end mill employed to cut the relief. If necessary, to back up a thin section of the die, such as a tongue, the angle can be zero. In such instances, the mill head is tipped parallel to the bearings; however, the cut should be stepped back at least 0.015" to provide clearance. This is termed "undercut."

Backer. A steel disk having an aperture somewhat larger than that of the die; it is similar to the latter but usually 2 to 3 times as thick. The backer is usually furnished with pins or lugs that interlock it with the extrusion die proper; it reinforces the die against billet pressure and provides a means of holding the die.

Bar. A solid section that is long in relation to its cross-sectional dimensions, having a symmetrical cross-section that is square or rectangular (excluding flattened wire) with sharp or rounded corners or edges.

Bearing. The depth of the extruding aperture, at right angles to the die face, which controls metal flow and to some extent speed of flow; the surface along which the aluminum flows and is shaped.

Bearing Length. Measurement of the bearing surface in depth at any given location; lengths may vary considerably in a complex extrusion, especially where section thickness differs.

Billet. A solid semi-finished round, square or rectangular cast bar produced in different diameters, sizes and lengths for use in the extrusion process. Billets may be cast to diameter and length or cast in logs and cut to length (direct chill). Billets may be solid or hollow (longitudinal hole through center) and are used in the as-cast or homogenized condition, depending upon end use and alloy.

Bolster. A hardened alloy steel disk with the same diameter as a die ring. It supports the die and backer and helps minimize deflection; sub-bolster is similar, with like functions.

Breakaway Point. Usually formed by the step where die relief starts and bearing surface ends; also where extrusion leaves bearing.

Breakout Pressure. Initial pressure required to start metal flow through the extrusion die.

Bridge Type Die. A die having a stationary core or mandrel which is held in place by core supports or webs (bridge) bolted to the back of the die. The die contains a weld chamber so that when the billet is pushed the metal divides to flow around the core supports and welds together in the welding chamber before passing through the die (also see porthole die and spider die).

Brinell Hardness. A measure of resistance to indentation; it is obtained by applying a load through a ball indenter and measuring the permanent impression in the material. The hardness value is obtained by dividing the applied load in kilograms by the spherical area of the impression in square millimeters. In testing aluminum alloys, a load of 500 kilograms is applied to a ball 10 millimeters in diameter for 30 seconds.

Butt. The unextruded portion of the billet remaining in the container after the extrusion press cycle is completed. The butt varies in thickness depending upon the billet condition. The butt is also called a heel.

Cable Sheathing. The process of extruding a tube around another product, such as an insulated cable; the cable acts as a moving mandrel.

Caving. (see deflection)

Choke. Angle filed on bearing surface at the point where bearing and die face meet (where aluminum enters aperture). Choke length varies with the choke angle (i.e. less angle lengthens and vice versa). Angle generally falls between 1 1/2 to 5°.

Co-extrusion. (see cable sheathing)

Cold Shut. Defective junction where two streams of metal have run together but failed to fuse together.

Cold Working. Mechanical deformation of metal or alloy at temperatures below those at which recrystallization occurs. Cold working aluminum gives increased hardness and improved strength. Cold worked metal may be brought back to the original state of workability by proper annealing.

Container. A steel cylinder usually fitted with a removable liner having an inside diameter slightly larger than the billet to be extruded. Lengths vary with the press tonnage rating and manufacturer. A unit of press tooling which holds or confines the billet during the extrusion cycle.

Contour Correction Rolling. An operation in which the extrusion is passed between rollers for the primary purpose of maintaining specified tolerances in angularity, cross-sectional space dimensions, flatness, and contour. Bow and twist may also be minimized or eliminated by contour rolling.

Core. A mandrel fixed in relation to the die which produces hollow or semi-hollow sections; e.g., in a bridge die, the mandrel is integral with the bridge. (See mandrel; also bridge, porthole and spider dies.)

Coring. A defect caused by the "folding in" of oxidized or liquated billet surface from the rear of the billet, also called "pipe", or "funnel".

Defect. Any condition that is not normal to product that may be cause for rejection.

Deflection. Distortion or bending of the die. Insufficient support of die will cause it to deflect, lessening the effectiveness of the bearing; also termed *dishing*, *caving*, and/or *sagging*.

De-twister. A mechanical device consisting of a rotation head stock and sliding tailstock both equipped with clamping jaws. The de-twister both twists and stretches the extrusion simultaneously.

Die. Unit of press tooling with one or more machined openings to produce the desired extruded section or sections.

Die Face. Surface of extrusion die facing the billet.

Dies, Hollow. Hollow or semi-hollow shapes are produced with "hollow" dies, either bridge, porthole or spider types. Extruded sections produced on such dies have one or more seams or longitudinal weld lines, due to the metal flow around the supports that hold the mandrel. The latter determines the inside contour of the section being extruded. After flowing around the supports, the metal is fused in a weld chamber before passing through the die proper.

Die, Solid. A steel disk, with one or more orifices or apertures, of the same cross-sectional area and contour as the desired product, through which metal is forced.

Die Holder. This is a component of the press, located between the container and press platen. The holder can be unlocked and the die withdrawn for the removal of butt and scrap.

Die Ring. A cylindrical sleeve that holds the die and backer in axial relationship to each other.

Die Tool Assembly. The various components making up the assembly within the tool carrier. A typical example would be (front to rear): die, backer enclosed in ring, bolster, sub-bolster.

Diffusion. A movement of atoms within a solution. The movement is usually from regions of high concentration toward regions of low concentration eventually resulting in uniformity of the solution which may be a gas, liquid, or solid.

Direct Chill Casting. The method used to produce logs of various diameters and lengths which will be cut to length for further processing into extrusion billet. This casting method is semi-continuous.

Discontinuities. Includes cracks, laps, folds, cold shuts, and flow throughs, along with internal defects such as inclusions, segregation, and porosity.

Dishing. (see deflection)

Distortion. Any deviation from the desired shape or contour.

Drawing. Reducing both wall thickness and outside diameter of tubing. It is a cold working process in which an extruded tube bloom is elongated by being pulled through a tapered die or series of tapered dies. A mandrel determines the inside diameter (see sinking).

Ductility. The extent to which metal will elongate under tension before rupture. Usually the elongation is measured over a length of four times the specimen diameter, e.g., over 2" on a 1/2" diameter specimen. The property of a material which permits it to be mechanically formed by rolling, drawing, forging, and similar operations, without fracturing the material.

Dummy Block. A steel disk, approximately 3" thick, with a diameter slightly smaller (approximately 0.025") than the inside of the container. It forms a protection against back feeding between the hot billet and the ram.

Electrical Conductivity. The capacity of a material to conduct or allow the flow of an electric current. Conductivity values for aluminum are expressed as percentages of the conductivity of the International Annealed Copper Standard, which, as indicated below, has a resistivity of 10.371 ohms per mil foot (a wire 0.001" in dia. and 1' long) at 20° C (68 F).

Electrical Resistivity. The electrical resistance of a body of unit length and unit cross-sectional area. The value of 10.371 ohms (mil, foot) at 20° C (68F) is the resistivity equivalent to the International Annealed Copper Standard (IACS) for 100 per cent conductivity, 1 foot in length and 1 circular mil in cross-sectional area, would have a resistance of 10.371 ohms.

Elongation. The linear stretch of material during tensile loading. The amount of permanent stretch in a test specimen before rupture, usually expressed as a percentage of the original length, such as 25% in 2"; the percentage of increase in length of a tension test specimen after rupture. The increase in distance between two gage marks that results from stressing the specimen in tension or fracture. Original gage length is usually 2" for sheet specimens and round specimens whose diameter is 1/2", or four times the diameter for specimens where that dimension is under 1/2". Elongation values depend to some extent upon size and form of the test specimen.

Endurance Limit. The limiting stress below which a material will withstand an indefinitely large number of cycles of stress. In the case of aluminum alloys, endurance limits are based on 500,000,000 cycles of completely reversed stress, using the rotating-beam type of machine and specimen.

Enter Point. Where aluminum enters the bearing; corner formed by die face and bearing. Angle should be sharp for most aluminum alloys.

Etchant. Chemical solutions used to change the metal surface for cleaning, examination or for finishing.

Etching. The application of an etchant to change the metal surface.

Eutectic Alloy. The composition in a binary alloy system which melts at the lowest temperature. More than one eutectic composition may occur in a given alloy system consisting of more than two metals.

Extrusion. Conversion of a billet into lengths of uniform cross-section by forcing plastic metal through or die orifice of the desired cross-sectional outline.

Extrusion (Direct). The method of extruding wherein the die and ram are at opposite ends of the billet and the product and ram travel in the same direction.

Extrusion (Indirect). The method of extruding where the die is at the ram end of the billet and the product travels through the hollow ram and in the opposite direction.

Extrusion Pressure. That force employed to cause cast billet to flow through a die.

Extrusion Rate. (see extrusion speed)

Extrusion Tools. The auxiliary equipment required to produce extrusions, which is not an integral or fixed part of the extrusion press. Tools consist principally of container, dies, die backers, dummy blocks, replaceable stems, etc.

Extrusion Speed. The rate at which an extrusion exists from the die; this is usually expressed as feet per minute.

Finishing. Usually secondary operations applied to extrusions to improve product dimensionally or change surface condition (etching) or color (anodizing, plating, painting, buffing, etc).

Flat Layout. Locating the apertures in a die so that the major axis of each shape is at right angles or parallel to a radius.

Frictional Heat. That heat imparted to the extrusion or billet as the result of metal movement within the container or through the die.

Funnel. A defect caused by the "folding in" of oxidized or liquated billet surface from the rear of the billet, also called "pipe."

Grain. Individual crystals which make up the crystalline structure of metal.

Grain Refiner. Any material, usually a metal from a special group, added to a liquid metal or alloy which produces a finer grain size in the subsequent solid.

Grain Size. The size of the grains or crystals in metal when measured with some accepted standard; as metal is crystalline in structure, crystals are generally referred to as grains; size is a measure of the individual crystal size and is usually reported in terms of grains per unit area (square millimeters) or unit volume (cubic millimeters).

Heaters, Gas (or Oil). A gas-fired furnace used to heat the extrusion billets to a predetermined temperature for extruding.

Heaters, Electrical Induction. A continuous type furnace that uses induction heat to bring billet to extruding temperature. Usually only two of three billets are heated in the cycle, differing from gas or oil-fired heaters in that the latter heats more billets in one cycle.

Heat Treat Tower. A large vertical tower equipped to handle long, extruded lengths in quantity. Also provided with a quench tank in which the extrusions can be instantly submerged.

Heat Treatment. Any sequence of steps involving heating and fast or slow cooling of aluminum to change its mechanical or physical properties or to stabilize its dimensions. (See aging, annealing, quenching, solution heat treatment, stabilization).

Heat-Treatable Alloys. Those aluminum alloys that obtain maximum strength by solution heat treatment and quenching.

Heel. (see butt)

Hollow Dies. Hollow or semi-hollow shapes are produced with "hollow" dies, either bridge, porthole or spider types. Extruded sections produced on such dies have one or more seams or longitudinal weld lines, due to the metal flow around the supports that hold the mandrel. The latter determines the inside contour of the section being extruded. After passing around the supports, the metal is fused in a weld chamber before passing through the die proper.

Homogenization. Thermal treatment of cast metal, producing uniform distribution of alloying elements; aids hot working and helps produce good as-extruded mechanical properties.

Inclusions. Impurities such as oxides, flux, refractories, etc., trapped in the metal during solidification.

Ingot. A casting, suitable for working or remelting, that has been poured from either a melting or blending furnace from which rolled or forged aluminum is to be produced. Ingots are melted to produce cast logs; these are cut into shorter pieces to produce extrusion billets.

Laying Out. (see orientation)

Log. A relatively long casting made by direct chill pouring which is later sawed to billet lengths for extruding.

Lubricant. Any of a number of liquids or semi-solids such as oil, kerosene, grease, lard, fat, soap, tallow and wax used on metal to reduce friction and binding during extruding or other forming operations.

Mandrel. The projection, fixed or floating, positioned in the die opening that forces metal to flow around it. The wall thickness of the extrusion is determined by the difference in the diameters of the die aperture and the mandrel.

Maximum Speed. The fastest practical rate for extruding.

Formula:

$\text{max ram speed (ipm)/12} \times \text{reduction ratio} = \text{maximum speed (ft/min)}$

Mechanical Working. Subjecting metal to pressure, exerted by rolls, hammers, presses, and other means, in order to change its shape or physical properties. (See also cold working).

Metal Flow. The manner in which metal moves both in the container and through the extrusion die.

Modulus of Elasticity. The ratio of stress to corresponding strain throughout the range where they are proportional. As there are three kinds of stresses, so are there three kinds of moduli of elasticity: modulus in tension, in compression, and in shear (latter same as modulus of rigidity).

Natural Aging. The spontaneous aging of a supersaturated solid solution at room temperature.

Orientation (laying out). Placement of die openings for best shape attitude and consequent flow distribution.

Permanent Set. Plastic (non-elastic) deformation or deformation above the elastic limit, remaining after the lead is removed.

Pipe. (defect; see funnel)

Pipe. A tube having certain standardized combinations of outside diameter and wall thickness, commonly designated by "Nominal Pipe Sizes" and "ASA (American Standards Association) Schedule Numbers."

Plastic. The property of a metal permitting it to deform non-elastically without rupture.

Porthole Die. A die having a stationary core or mandrel which is held in place by integral core supports or webs. The porthole die is a modification of the spider die except that the spider is replaced with a chambered disk that supports the stub mandrel; several "portholes" running through it annularly about the mandrel, distinguish the porthole types. The die contains a weld chamber so that when the billet is pushed the metal divides to flow around the core supports and welds together in the welding chamber before passing through the die. Porthole dies are used in producing extruded hollow shapes and tubing in soft alloys such as 6061 and 6063 (see bridge and spider dies).

Pull Over. A power-operated transfer type unit which conveys the extrusion from one place to another usually from the cooling table to the stretcher and detwister.

Quench. The rapid cooling of metal from above the critical range in some quenching medium, usually oil, water or air.

Quench, Air. Usually refers to quenching at the die, where large volumes of forced air are directed against aluminum sections as they emerge from the die.

Radial Layout. Locating the apertures in a die so that the major axis of each shape lies along a radius, giving each portion of bearing surface the same relationship to the center of the die as similar portions on other shapes.

Ram. Ram and stem are interchangeable terms describing any extension of the main cylinder in an extrusion press. The component which applies force against the dummy block.

Reducing (tube). Reducing the outside diameter of tubing by a pair of rolls of rockers that have been grooved about the circumference with a gradually increasing semi-circular groove. These rolls are made to rock forward and backward over a conical-shaped mandrel.

Reduction Ratio (extrusion ratio). Determined by the cross-sectional area of the container or billet divided by the cross-sectional area of the combined die openings. The comparison of cross-sectional billet area to cross-sectional area of extrusion.

Relief. (see speeds, back taper)

Residual Stresses. Those stresses set up within a metal as the result of non-uniform plastic deformation which may be caused by drastic temperature gradients in quenching.

Roll Straightening. Straightening and truing round tubing by rolling it between driven rolls and idler rolls of a roll straightener.

Sagging. (see deflection)

Scalping. A machining process for removing the outer "skin" of an as-cast billet.

Screw Index. A provision on some presses for moving the die in a horizontal plane with respect to the container.

Short Choke. Chamfer much shorter than regular choke, up to 45° compared to 0.5° or less; tends to slow metal flow as entering point is made farther from face of die.

Short Speed. Where bearing is given a short bevel up to about 45° at breakaway point to speed metal flow. A long bevel of 10° or under at the breakaway point may actually have a slowing effect on metal flow.

Shrinkage. The contraction of the extrusion due to such factors as cooling; the term is also sometimes used for actual thinning by die deflection or too fast an extruding speed.

Sinking. Sinking is similar to plug drawing except that no inside mandrel or plug is used. Wall thickness is not altered substantially in a sink pass (see also drawing).

Solid Dies. A steel disk with one or more orifices or apertures of the same cross-sectional area and contour as the desired product, through which metal is forced. Such dies are generally employed where shapes other than hollow are required. If solid dies are used for hollow shapes (as opposed to the use of "hollow" dies -bridge, porthole or spider dies -containing a fixed stub mandrel as an integral part of the die) then a mandrel actuated by

the action of the ram must be employed. These may be fixed or floating mandrels which require hollow (cast or bored) billets. An exception is the piercing type mandrel, which needs no cored billet.

Solidus. In a constitution or equilibrium diagram, the locus of points representing the temperatures at which various compositions finish freezing on cooling or begin to melt upon heating.

Solution Heat Treatment. A process in which an aluminum alloy is heated to a suitable temperature, is held at the temperature long enough to allow certain constituents to enter into solid solution and is then cooled rapidly to hold the constituents in solution. The metal is left in a super-saturated, unstable state and may subsequently exhibit age hardening.

Speeds. Opposite of chokes (see reliefs, back taper)

Spider Die. An extrusion die matched with a steel "spider" supporting a stub mandrel extending through the die opening. This combination is placed against the container and the metal billet is pushed between the legs of the spider and out through the annular opening between the die profile and the mandrel. The division of the metal around the legs welds together while passing through the annular opening. (See bridge die; also porthole die.)

Spreader. An auxiliary tool sometimes attached to the end of the container to produce an effective billet of greater size than the inside diameter of the container. Use of a spreader permits the extruding of sections considerably wider than container diameter, but only under definitely limited operating conditions.

Stabilization. Any treatment intended to stabilize the structure of an alloy or the dimensions of a part.

Stem. (see ram)

Stepped Extrusion. An extrusion having one or more abrupt changes in cross section at intervals in its length.

Stepped Extrusion Process. A process similar to the conventional extrusion process; however, the extrusion press is stopped when the billet is only partially extruded, and the split dies are removed and replaced with dies of larger opening or orifice. Extrusion is then resumed. The result is an extrusion which has an abrupt change in cross section. The first portion extruded having the smaller cross section is called the "minor" section; the second portion having the larger cross section is called the "major" section.

Stretch Straightening. Stretching extruded sections beyond the yield strength of the alloy to achieve longitudinal straightness.

Stretcher Flattening. A process of removing bow and twist where an extrusion is gripped between jaws and subjected to a stress higher than its yield strength and is elongated a definite amount to establish a permanent set.

Sub-Bolster. (see bolster)

Taper Heating. The staged or gradient application of heat through induction coils. Thermal differential between billet ends offsets the frictional and other heat generated during the extrusion cycle so that metal temperature at the die is constant. Under careful handling billet end may be quenched in water after heating to provide for a similar heat gradient.

Tensile Strength. The maximum tensile stress that a material is capable of withstanding without breaking under a gradually and uniformly applied load. Other terms that are commonly used to express the same thing are Ultimate Tensile Strength and less accurately, Breaking Strength.

Tongue. That portion of die base metal surrounded by the aperture except at one end, the latter termed base of the tongue.

Tongue Cave. Distortion of the die tongue.

Tube. A hollow section that is long in relation to its cross-sectional dimensions, whose cross-section is symmetrical and is round, square, rectangular, hexagonal, octagonal or elliptical, with sharp or rounded corners, and whose wall is of uniform thickness except as affected by corner radii.

Water Stain. A superficial etching of the surface from prolonged contact with moisture in restricted air space. Such stains are usually white or gray in appearance. This condition can find its water source from either condensation or wetting.