

*Metals*  
**Handbook<sup>®</sup>**  
**Ninth Edition**

**Volume 15**  
**Casting**

# **Metals Handbook® Ninth Edition**

## **Volume 15 Casting**

Prepared under the direction of the  
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Metals Handbook is a collective effort involving thousands of technical specialists. It brings together in one book a wealth of information from world-wide sources to help scientists, engineers, and technicians solve current and long-range problems.

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## Foreword

The subject of metal casting was covered—along with forging—in Volume 5 of the 8th Edition of *Metals Handbook*. Volume 15 of the 9th Edition, a stand-alone volume on the subject, is evidence of the strong commitment of ASM INTERNATIONAL to the advancement of casting technology.

The decision to devote an entire Handbook to the subject of casting was based on the veritable explosion of improved or entirely new molding, melting, metal treatment, and casting processes that has occurred in the 18 years since the publication of Volume 5. New casting materials, such as cast metal-matrix composites, also have been developed in that time, and computers are being used increasingly by the foundry industry. An entire section of this Handbook is devoted to the application of computers to metal casting, in particular to the study of phenomena associated with the solidification of molten metals.

Coverage of the depth and scope provided in Volume 15 is made possible only by the collective efforts of many individuals. In this case, the effort was an international one, with participants in 12 nations. The driving force behind the entire project was volume chairman Doru M. Stefanescu of the University of Alabama, who along with his section chairmen recruited more than 200 of the leading experts in the world to author articles for this Handbook. We are indebted to all of them, as well as to the members of the ASM Handbook Committee and the Handbook editorial staff. Their hard work and dedication has culminated in the publication of this, the most comprehensive single-volume reference on casting technology yet published.

William G. Wood  
President,  
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**The Ninth Edition of Metals Handbook  
is dedicated to the memory of  
TAYLOR LYMAN, A.B. (Eng.), S.M., Ph.D.  
(1917-1973)  
Editor, Metals Handbook, 1945-1973**

# Preface

The story of metal casting is as glamorous as it is ancient, beginning with the dawn of human civilization and interwoven with legends of fantastic weapons and exquisite artworks made of precious metals. It was and is involved in the two main activities of humans since they began walking the earth: producing and defending wealth. Civilization as we know it would not have been possible without metal casting. Metal casting must have emerged from the darkness of antiquity first as magic, later to evolve as an art, then as a technology, and finally as a complex, interdisciplinary science.

As with most other industries, the body of knowledge in metal casting has doubled over the last ten years. A modern text on the subject should discuss not only the new developments in the field but also the applications of some fundamental sciences such as physical chemistry, heat transfer, and fluid flow in metal casting. The task of reviewing such an extensive amount of information and of documenting the knowledge currently involved in the various branches of this manufacturing industry is almost impossible. Nevertheless, this is the goal of this Volume. For such an endeavor to succeed, only one avenue was possible—to involve in the preparation of the manuscripts as well as in the review process the top metal casting engineers and scientists in the international community. Indeed, nearly 350 dedicated experts from industry and academe worldwide contributed to this Handbook. This magnificent pool of talent was instrumental in putting together what I believe to be the most complete text on metal casting available in the English language today.

The Handbook is structured in ten Sections, along with a Glossary of Terms. The reader is first introduced to the historical development of metal casting, as well as to the advantages of castings over parts produced by other manufacturing processes, their applications, and the current market size of the industry. Then, the thermodynamic relationships and properties of liquid metals and the physical chemistry of gases and impurities in liquid metals are discussed. A rather extensive Section reviews the fundamentals of the science of solidification as applied to cast alloys, including nucleation kinetics, fundamentals of growth, and the more practical subject of interpretation of cooling curves. Traditional subjects such as patterns, molding and casting processes, foundry equipment, and processing and design considerations are extensively covered in the following Sections. Considerable attention has been paid to new and emerging processes, such as the Hitchiner process, directional solidification, squeeze casting, and semisolid metal forming. The metallurgy of ferrous and nonferrous alloys is extensively covered in two separate Sections. Finally, there is detailed information on the most modern approach to metal casting, namely, computer applications. The basic principles of modeling of heat transfer, fluid flow, and microstructural evolution are discussed, and typical examples are given.

It is hoped that the reader can find in this Handbook not only the technical information that he or she may seek, but also the prevailing message that the metal casting industry is mature but not aging. It is part of human civilization and will remain so for centuries to come. Make no mistake. A country cannot hold its own in the international marketplace without a modern, competitive metal casting industry.

It is a great pleasure to acknowledge the collective effort of the many contributors to this Handbook. The chairmen of the ten Sections and the authors of the articles are easily acknowledged, since their names are duly listed throughout the Volume. Less obvious but of tremendous importance in maintaining a uniform, high-quality text is the contribution of the reviewers. The Handbook staff of ASM INTERNATIONAL must also be commended for their dauntless and painstaking efforts in making this Volume not only accurate but also beautiful. Last but not least, I would like to acknowledge the precious assistance of my secretary, Mrs. Donna Snow, who had the patience to cope gracefully with the many tasks involved in such a complex project.

Prof. D.M. Stefanescu  
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By a resolution of its Board of Trustees, ASM INTERNATIONAL has adopted the practice of publishing data in both metric and customary U.S. units of measure. In preparing this Handbook, the editors have attempted to present data in metric units based primarily on *Système International d'Unités* (SI), with secondary mention of the corresponding values in customary U.S. units. The decision to use SI as the primary system of units was based on the aforementioned resolution of the Board of Trustees and the widespread use of metric units throughout the world.

For the most part, numerical engineering data in the text and in tables are presented in SI-based units with the customary U.S. equivalents in parentheses (text) or adjoining columns (tables). For example, pressure, stress, and strength are shown both in SI units, which are pascals (Pa) with a suitable prefix, and in customary U.S. units, which are pounds per square inch (psi). To save space, large values of psi have been converted to kips per square inch (ksi), where 1 ksi = 1000 psi. The metric ton ( $\text{kg} \times 10^3$ ) has been shown in megagrams (Mg). Some strictly scientific data are presented in SI units only. For example, the solubility of a gas in a metal is given only in milliliters per 100 grams of metal (mL/100 g).

To clarify some illustrations, only one set of units is presented on artwork. References in the accompanying text to data in the illustrations are presented in both SI-based and customary U.S. units. On graphs and charts, grids corresponding to SI-based units appear along the left and bottom edges. Where appropriate, corresponding customary U.S. units appear along the top and right edges.

Data pertaining to a specification published by a specification-writing group may be given in only the units used in that specification or in dual units, depending on the nature of the data. For

example, the typical yield strength of aluminum sheet made to a specification written in customary U.S. units would be presented in dual units, but the sheet thickness specified in that specification might be presented only in inches.

Data obtained according to standardized test methods for which the standard recommends a particular system of units are presented in the units of that system. Wherever feasible, equivalent units are also presented.

Conversions and rounding have been done in accordance with ASTM Standard E 380, with attention given to the number of significant digits in the original data. For example, an annealing temperature of 1570 °F contains three significant digits. In this case, the equivalent temperature would be given as 855 °C; the exact conversion to 854.44 °C would not be appropriate. For an invariant physical phenomenon that occurs at a precise temperature (such as the melting of pure silver), it would be appropriate to report the temperature as 961.93 °C or 1763.5 °F. In some instances (especially in tables and data compilations), temperature values in °C and °F are alternatives rather than conversions.

The policy on units of measure in this Handbook contains several exceptions to strict conformance to ASTM E 380; in each instance, the exception has been made in an effort to improve the clarity of the Handbook. The most notable exception is the use of  $\text{g/cm}^3$  rather than  $\text{kg/m}^3$  as the unit of measure for density (mass per unit volume).

SI practice requires that only one virgule (diagonal) appear in units formed by combination of several basic units. Therefore, all of the units preceding the virgule are in the numerator and all units following the virgule are in the denominator of the expression; no parentheses are required to prevent ambiguity.



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# Glossary of Terms

## A

- acid.** A term applied to slags, refractories, and minerals containing a high percentage of silica.
- acidity.** The degree to which a material is acid. Furnace refractories are ranked by their acidity.
- acid process.** A steelmaking method using an acid refractory-lined furnace. Neither sulfur nor phosphorus is removed.
- acid refractory.** Siliceous ceramic materials of a high melting temperature, such as silica brick, used for metallurgical furnace linings. Compare with *basic refractory*.
- addition agent.** (1) Any material added to a charge of molten metal in a bath or ladle to bring the alloy to specifications. (2) Reagent added to plating bath.
- additive.** Any material added to molding sand for reasons other than bonding, for example, seacoal, pitch, graphite, cereals.
- aerate.** To fluff up molding sand to reduce its density.
- airblasting.** See *blasting or blast cleaning*.
- air channel.** A groove or hole that carries the vent from a core to the outside of a mold.
- air dried.** Refers to the air drying of a core or mold without the application of heat.
- air-dried strength.** Strength (compressive, shear, or tensile) of a refractory (sand) mixture after being air dried at room temperature.
- air furnace.** Reverberatory-type furnace in which metal is melted by heat from fuel burning at one end of the hearth, passing over the bath toward the stack at the other end. Heat is also reflected from the roof and sidewalls. See also *reverberatory furnace*.
- air hole.** A hole in a casting caused by air or gas trapped in the metal during solidification.
- air setting.** The characteristic of some materials, such as refractory cements, core pastes, binders, and plastics, to take permanent set at normal air temperatures.
- allowance.** In a foundry, the specified clearance. The difference in limiting sizes, such as minimum clearance or maximum interference between mating parts, as computed arithmetically. See also *tolerance*.
- alpha process.** A *shell molding* and core-making method in which a thin resin-bonded shell is baked with a less expensive, highly permeable material
- alumina.** The mineral aluminum oxide ( $Al_2O_3$ ) with a high melting point (refractory) that is sometimes used as a molding sand.
- angularity.** The angular relationship of one surface to another. Specifically, the dimensional tolerance associated with such features on a casting.
- arbitration bar.** A test bar, cast with a heat of material, used to determine chemical composition, hardness, tensile strength, and deflection and strength under transverse loading in order to establish the state of acceptability of the casting.
- arbor.** A metal shape embedded in and used to support green or dry sand cores in the mold.
- arc furnace.** A furnace in which metal is melted either directly by an electric arc between an electrode and the work or indirectly by an arc between two electrodes adjacent to the metal.
- arc melting.** Melting metal in an electric arc furnace.
- as-cast condition.** Castings as removed from the mold without subsequent heat treatment.
- atmospheric riser.** A riser that uses atmospheric pressure to aid feeding. Essentially, a *blind riser* into which a small core or rod protrudes; the function of the core or rod is to provide an open passage so that the molten interior of the riser will not be under a partial vacuum when metal is withdrawn to feed the casting but will always be under atmospheric pressure.
- austenite.** A solid solution of one or more elements in face-centered cubic iron (gamma iron). Unless otherwise designated (such as nickel austenite), the solute is generally assumed to be carbon.
- ## B
- back draft.** A reverse taper that prevents removal of a pattern from a mold or a core from a core box.
- backing board (backing plate).** A second *bottom board* on which molds are opened.
- backup coat.** The ceramic slurry of dip coat that is applied in multiple layers to provide a ceramic shell of the desired thickness and strength for use as a mold.
- bake.** Heating in an oven to a low controlled temperature to remove gases or to harden a binder.
- baked core.** A core that has been heated through sufficient time and temperature to produce the desired physical properties attainable from its oxidizing or thermal-setting binders.
- bank sand.** Sedimentary deposits, usually containing less than 5% clay, occurring in banks or pits, used in coremaking and in synthetic molding sands. See *sand*.
- basic refractory.** A lime- or magnesia-base ceramic material of high melting temperature used for furnace linings. Compare with *acid refractory*.
- batch.** An amount of core or mold sand or other material prepared at one time.
- bath.** Molten metal on the hearth of a furnace, in a crucible, or in a ladle.
- bead.** (1) Half-round cavity in a mold, or half-round projection or molding on a casting. (2) A single deposit of weld metal produced by fusion.
- bedding.** Sinking a pattern down into the sand to the desired position and ramming the sand around it.
- bedding a core.** Placing an irregularly shaped core on a bed of sand for drying.
- bench molding.** Making sand molds by hand tamping loose or production patterns at a bench without the assistance of air or hydraulic action.
- bentonite.** A colloidal claylike substance derived from the decomposition of volcanic ash composed chiefly of the minerals of the montmorillonite family. It is used for bonding molding sand.
- bimetal.** A casting made of two different metals, usually produced by *centrifugal casting*.
- binder.** A material used to hold the grains of sand together in molds or cores. It may be cereal, oil, clay, or natural or organic resins.
- blackening.** Carbonaceous materials, such as graphite or powdered carbon, usually mixed with a binder and frequently carried in suspension in water or other liquid used as a thin facing applied to surfaces of molds or cores to improve casting finish.
- blasting or blast cleaning.** A process for cleaning or finishing metal objects with an air blast or centrifugal wheel that throws abrasive particles against the surface of the workpiece. Small, irregular particles of metal are used as the abrasive in *grit-blasting*; sand, in *sandblasting*; and steel balls, in *shotblasting*.
- bleed.** Refers to molten metal oozing out of a casting. It is stripped or removed from the mold before complete solidification.

## 2 / Glossary of Terms

- blended sand.** A mixture of sands of different grain size and clay content that provides suitable characteristics for foundry use.
- blind riser.** A riser that does not extend through the top of the mold.
- blister.** A defect in metal, on or near the surface, resulting from the expansion of gas in a subsurface zone. It is characterized by a smooth bump on the surface of the casting and a hole inside the casting directly below the bump.
- blow.** A term that describes the trapping of gas in castings, causing voids in the metal.
- blowhole.** A void or large pore that may occur because of entrapped air, gas, or shrinkage; usually evident in heavy sections.
- blow holes.** Holes in the head plate or blow plate of a core blowing machine through which sand is blown from the reservoir into the core box.
- bond clay.** Any clay suitable for use as a bonding agent in molding sand.
- bond strength.** The degree of cohesiveness that the bonding agent exhibits in holding sand grains together.
- bonding agent.** Any material other than water that, when added to foundry sands, imparts strength either in the green, dry, or fired state.
- boss.** A relatively short protrusion or projection from the surface of a forging or casting, often cylindrical in shape. Usually intended for drilling and tapping for attaching parts. See also *locating boss*.
- bottom board.** A flat base for holding the flask in making sand molds.
- bottom-pour ladle.** A ladle from which metal, usually steel, flows through a nozzle located at the bottom.
- bottom running or pouring.** Filling of the mold cavity from the bottom by means of gates from the runner.
- bridging.** (1) Premature solidification of metal across a mold section before the metal below or beyond solidifies. (2) Solidification of slag within a cupola at or just above the tuyeres.
- buckle.** (1) Bulging of a large, flat face of a casting; in investment casting, caused by dip coat peeling from the pattern. (2) An indentation in a casting, resulting from expansion of the sand, can be termed the start of an expansion defect.
- bumper.** A machine used for packing molding sand in a flask by repeated jarring or jolting. See also *jolt ramming*.
- burned-in sand.** A defect consisting of a mixture of sand and metal cohering to the surface of a casting.
- burned-on sand.** A misnomer usually indicating metal penetration into sand resulting in a mixture of sand and metal adhering to the surface of a casting. See also *metal penetration*.
- burnout.** Firing a mold at a high temperature to remove pattern material residue.
- burned sand.** Sand in which the binder or bond has been removed or impaired by contact with molten metal.
- C**
- calcium silicon.** An alloy of calcium, silicon, and iron containing 28 to 35% Ca, 60 to 65% Si, and 6% Fe (max), used as a deoxidizer and degasser for steel and cast iron; sometimes called calcium silicide.
- carbonaceous.** A material that contains carbon in any or all of its several allotropic forms.
- carbon dioxide process (sodium silicate/CO<sub>2</sub>).** A process for hardening molds or cores in which carbon dioxide gas is blown through dry clay-free silica sand to precipitate silica in the form of a gel from the sodium silicate binder.
- carbon refractory.** A manufactured refractory comprised substantially or entirely of carbon (including graphite).
- castability.** (1) A complex combination of liquid-metal properties and solidification characteristics that promotes accurate and sound final castings. (2) The relative ease with which a molten metal flows through a mold or casting die.
- castable.** A combination of refractory grain and suitable bonding agent that, after the addition of a proper liquid, is generally poured into place to form a refractory shape or structure that becomes rigid because of chemical action.
- casting.** (1) Metal object cast to the required shape by pouring or injecting liquid metal into a mold, as distinct from one shaped by a mechanical process. (2) Pouring molten metal into a mold to produce an object of desired shape.
- casting defect.** Any imperfection in a casting that does not satisfy one or more of the required design or quality specifications. This term is often used in a limited sense for those flaws formed by improper casting solidification.
- casting section thickness.** The wall thickness of the casting. Because the casting may not have a uniform thickness, the section thickness may be specified at a specific place on the casting. Also, it is sometimes useful to use the average, minimum, or typical wall thickness to describe a casting.
- casting shrinkage.** The amount of dimensional change per unit length of the casting as it solidifies in the mold or die and cools to room temperature after removal from the mold or die. There are three distinct types of casting shrinkage. Liquid shrinkage refers to the reduction in volume of liquid metal as it cools to the liquidus. Solidification shrinkage is the reduction in volume of metal from the beginning to the end of solidification. Solid shrinkage involves the reduction in volume of metal from the solidus to room temperature.
- casting stresses.** Stresses set up in a casting because of geometry and casting shrinkage.
- casting thickness.** See *casting section thickness*.
- casting volume.** The total cubic units (mm<sup>3</sup> or in.<sup>3</sup>) of cast metal in the casting.
- casting yield.** The weight of a casting(s) divided by the total weight of metal poured into the mold, expressed as a percentage.
- cast iron.** A generic term for a large family of cast ferrous alloys in which the carbon content exceeds the solubility of carbon in austenite at the eutectic temperature. Most cast irons contain at least 2% C, plus silicon and sulfur, and may or may not contain other alloying elements. For the various forms, the word cast is often left out, resulting in *compacted graphite iron*, *gray iron*, *white iron*, *malleable iron*, and *ductile iron*.
- cast structure.** The internal physical structure of a casting evidenced by the shape and orientation of crystals and the segregation of impurities.
- cavity.** The mold or die impression that gives a casting its external shape.
- cementite.** A very hard and brittle compound of iron and carbon corresponding to the empirical formula Fe<sub>3</sub>C, commonly known as iron carbide.
- centerline shrinkage.** Shrinkage or porosity occurring along the central plane or axis of a cast part.
- centrifugal casting.** The process of filling molds by (1) pouring metal into a sand or permanent mold that is revolving about either its horizontal or its vertical axis or (2) pouring metal into a mold that is subsequently revolved before solidification of the metal is complete. See also *centrifuge casting*.
- centrifuge casting.** A casting technique in which mold cavities are spaced symmetrically about a vertical axial common down-gate. The entire assembly is rotated about that axis during pouring and solidification.
- ceramic.** Material of a nonmetallic nature, usually refractory, made from fused, sintered, or cemented metallic oxides.
- ceramic molding.** A precision casting process that employs permanent patterns and fine-grain slurry for making molds. Unlike monolithic investment molds, which are similar in composition, ceramic molds consist of a cope and a drag or, if the casting shape permits, a drag only.
- CG iron.** Same as *compacted graphite iron*.
- chaplet.** Metal support that holds a core in place within a mold; molten metal solidifies around a chaplet and fuses it into the finished casting.
- charge.** (1) The materials placed in a melting furnace. (2) Castings placed in a heat-treating furnace.
- check.** A minute crack in the surface of a casting caused by unequal expansion or contraction during cooling.



- chill.** (1) A metal or graphite insert embedded in the surface of a sand mold or core or placed in a mold cavity to increase the cooling rate at that point. (2) White iron occurring on a gray or ductile iron casting, such as the chill in the wedge test. See also *chilled iron*. Compare with *inverse chill*.
- chill coating.** Applying a coating to a chill that forms part of the mold cavity so that the metal does not adhere to it, or applying a special coating to the sand surface of the mold that causes the iron to undercool.
- chilled iron.** Cast iron that is poured into a metal mold or against a mold insert so as to cause the rapid solidification that often tends to produce a white iron structure in the casting.
- clay.** A natural, earthy, fine-grain material that develops plasticity when mixed with a limited amount of water. Foundry clays, which consist essentially of hydrous silicates of alumina, are used in molds and cores.
- CO<sub>2</sub> process.** See *carbon dioxide process*.
- coining.** (1) The process of straightening and sizing castings by die pressing. (2) A press metalworking operation that establishes accurate dimensions of flat surfaces or depressions under predominantly compressive loading.
- coke.** A porous, gray, infusible product resulting from the dry distillation of bituminous coal, petroleum, or coal tar pitch that drives off most of the volatile matter. Used as a fuel in cupola melting.
- coke bed.** The first layer of coke placed in the cupola. Also the coke used as the foundation in constructing a large mold in a flask or pit.
- coke breeze.** Fines from coke screenings, used in blacking mixes after grinding; also briquetted for cupola use.
- coke furnace.** Type of pot or crucible furnace that uses coke as the fuel.
- cold box process.** A two-part organic resin binder system mixed in conventional mixers and blown into shell or solid core shapes at room temperature. A vapor mixed with air is blown into the core, permitting instant setting and immediate pouring of metal around it.
- cold chamber machine.** A die casting machine with an injection system that is charged with liquid metal from a separate furnace. Compare with *hot chamber machine*.
- cold cracking.** Cracks in cold or nearly cold metal due to excessive internal stress caused by contraction. Often brought about when the mold is too hard or the casting is of unsuitable design.
- cold lap.** Wrinkled markings on the surface of an ingot or casting from incipient freezing of the surface and too low a casting temperature.
- cold-setting process.** Any of several systems for bonding mold or core aggregates by means of organic binders, relying on the use of catalysts rather than heat for polymerization (setting).
- cold shot.** (1) A portion of the surface of an ingot or casting showing premature solidification; caused by splashing of molten metal onto a cold mold wall during pouring. (2) Small globule of metal embedded in, but not entirely fused with, the casting.
- cold shut.** (1) A discontinuity that appears on the surface of cast metal as a result of two streams of liquid meeting and failing to unite. (2) A lap on the surface of a forging or billet that was closed without fusion during deformation. (3) Freezing of the top surface of an ingot before the mold is full.
- collapsibility.** The tendency of a sand mixture to break down under the pressures and temperatures developed during casting.
- columnar structure.** A coarse structure of parallel columns of grains, that is caused by highly directional solidification resulting from sharp thermal gradients.
- combination die (multiple-cavity die).** In die casting, a die with two or more different cavities for different castings.
- combined carbon.** Carbon in iron that is combined chemically with other elements; not in the free state as graphite or temper carbon. The difference between the total carbon and the graphite carbon analyses. Contrast with *free carbon*.
- compacted graphite iron.** Cast iron having a graphite shape intermediate between the flake form typical of gray iron and the spherical form of fully spherulitic ductile iron. Also known as CG iron or vermicular iron, compacted graphite iron is produced in a manner similar to that for ductile iron but with a technique that inhibits the formation of fully spherulitic graphite nodules.
- constraint.** Any restriction that limits the transverse contraction normally associated with a longitudinal tension, and therefore causes a secondary tension in the transverse direction.
- consumable-electrode remelting.** A process for refining metals in which an electric current passes between an electrode made of the metal to be refined and an ingot of the refined metal, which is contained in a water-cooled mold. As a result of the passage of electric current, droplets of molten metal form on the electrode and fall to the ingot. The refining action occurs from contact with the atmosphere, vacuum, or slag through which the drop falls. See *electroslag remelting* and *vacuum arc remelting*.
- continuous casting.** A process for forming a bar of constant cross section directly from molten metal by gradually withdrawing the bar from a die as the metal flowing into the die solidifies.
- contraction.** The volume change that occurs in metals and alloys upon solidification and cooling to room temperature.
- convection.** The motion resulting in a fluid from the differences in density and the action of gravity. In heat transmission, this meaning has been extended to include both forced and natural motion or circulation.
- cooling stresses.** Stresses developed during cooling by the uneven contraction of metal, generally due to nonuniform cooling.
- cope.** The upper or topmost section of a flask, mold, or pattern.
- core.** (1) A specially formed material inserted in a mold to shape the interior or other part of a casting that cannot be shaped as easily by the pattern. (2) In a ferrous alloy prepared for case hardening, that portion of the alloy that is not part of the case. Typically considered to be the portion that (a) appears light on an etched cross section, (b) has an essentially unaltered chemical composition, or (c) has a hardness, after hardening, less than a specified value.
- core assembly.** A complex core consisting of a number of sections.
- core binder.** Any material used to hold the grains of core sand together.
- core blow.** A gas pocket in a casting adjacent to a cored cavity and caused by entrapped gases from the core.
- core blower.** A machine for making foundry cores using compressed air to blow and pack the sand into the core box.
- core box.** A wood, metal, or plastic structure containing a shaped cavity into which sand is packed to make a core.
- core dryers.** Supports used to hold cores in shape during baking; constructed from metal or sand for conventional baking or from plastic material for use with dielectric core-baking equipment.
- core filler.** Material, such as coke, cinder, and sawdust, used in place of sand in the interiors of large cores; usually added to aid collapsibility.
- coring.** A variable composition between the center and the surface of a unit of structure (such as a dendrite, grain, or carbide particle) resulting from the nonequilibrium growth that occurs over a range of temperature.
- core knockout machine.** A mechanical device for removing cores from castings.
- coreless induction furnace.** An electric induction furnace for melting or holding molten die casting metals that does not utilize a steel core to direct the magnetic field.
- core oil.** A binder for core sand that sets when baked and is destroyed by the heat from the cooling casting.
- core plates.** Heat-resistant plates used to support cores during baking; may be metallic or nonmetallic, the latter being a requisite for dielectric core baking.