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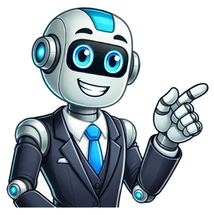

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This lets us provide the same savings to our customers in the form of constant higher prices for their scrap and recyclable materials. Some of the products we buy & sell:BrassCopperRadiatorsAluminumStainless steelInsulated wire & cableHigh temperature alloysPrecious metalsLeadZincCall us today at 215-288-6555 for additional information! Philadelphia, PA | Germantown, PA | Mount Airy, PA | Chestnut Hill, PA | West Oak Lane, PA | King of Prussia, PA | East Oak Lane, PA | East Falls, PA | Lawncrest, PA | Elkins Park, PA | Ashbourne, PA | Malvern, PA | Paoli, PA | Media, PA | Springfield, PA | Drexel Hill, PA | Aston , PA | Horsham, PA | Ardmore, PA | Broomall, PA | Upper Darby, PA | Blue Bell, PA | Lansdale, PA | Bala Cynwyd, PA | Chadds Ford, PA | Newtown Square, PA | Bryn Mawr, PA | Narberth, PA | Brass is a widely used metal alloy that has been a staple in human civilization for centuries. But what exactly is brass, and why is it so popular? Simply, brass is a versatile and valuable metal alloy made primarily of copper and zinc. Due to its excellent strength, ductility, corrosion resistance, and attractive yellow metallic appearance, brass has always been popular for everything from plumbing and musical instruments to decorative art pieces.Today, brass continues to play an important role in modern industry. In this article, we'll dive deep into the world of brass, exploring its composition, history, properties, types, uses, etc. Moreover, a comparison between copper, brass, and bronze will be described in this post. Read the article to learn more about brass. Let us start! What is Brass?Brass is an alloy of copper (Cu) and zinc (Zn) containing trace amounts of lead, iron, and other elements. The proportions of copper and zinc in brass can be altered to produce a variety of colors and mechanical, electrical, and chemical properties. However, the composition of brass is typically 66% copper and 34% zinc. Generally, brasses with a higher copper content are softer and more golden, while those with less copper and more zinc are harder and more silvery in color. Brass is known for its antibacterial and anti-biofouling characteristics. Brass has a brilliant gold-like appearance. Therefore, it is a popular material for drawer handles and doorknobs. Due to its low melting point, high workability, durability, and electrical and thermal conductivity, it has also been extensively utilized to create sculptures and utensils. Furthermore, the application of brass can be found in locks, hinges, gears, bearings, ammunition casings, zippers, plumbing, hose couplings, valves, and plugs and sockets. These are typical examples requiring corrosion resistance and low friction. Brass is an excellent option for musical instruments like horns and bells.A Brief History of BrassBrass has had a long and distinguished history, advancing many fields of human civilization for functional and aesthetic purposes. It is a material that has been fundamental in plumbing, architecture, art, music, weaponry, industry, and technology for centuries. Here is a brief history of brass:– Humans have used brass for over 2000 years. The earliest brass dates back to the 2nd millennium BC in ancient Mesopotamia, where it was used for decorations, coins, and copper-zinc alloys produced by cementation.– The Roman Empire expanded the use of brass between the 1st century BC and the 3rd century AD. They obtained higher purity copper and zinc, enabling stronger brass alloys. The Romans used brass for coins, utensils, art, helmets, musical instruments, and weaponry.-Brass production declined after the fall of the Roman Empire but was revived starting in the 11th century in Europe. New furnace technologies allowed higher-quality brass production. Brass was mainly used for decorative items and some limited industrial parts.-The Industrial Revolution led to advances in brass metallurgy and production. In 1837, James Joule discovered the Joule effect, which used brass rods in electromagnetic engines. Decorative uses of brass expanded along with plumbing, architecture, and transportation.-In the early 1900s, hot rolling mills and extrusion presses allowed the mass production of inexpensive brass rods, sheets, and tubes. Manganese brass and aluminum brass were introduced. Brass was used for radiators, electrical parts, valves, condensers, and ammunition.-World Wars I and II increased the demand for brass used in munitions, mechanical instruments, and chemical applications. Manganese brass, naval brass, and leaded machinable brass were widely used. Brass production accelerated to meet wartime demands.-In modern times, concerns over lead and other toxic elements have restricted their use in brass. However, brass remains important for building construction, electronics, transportation, industrial equipment, decorative items, musical instruments, and artwork.-The future of brass depends on continued copper and zinc mining and more sustainable production methods. Brass recycling now provides over half of all brass used today. Brass scrap is a highly valuable resource due to increasing costs and limited copper and zinc ores availability.Composition and Properties of BrassBrass plays an important functional and aesthetic role in the world. Brass compositions and properties are described below:Alloying ElementsThe primary components of brass are copper and zinc. The ratio of these two metals can vary, resulting in different types of brass with unique properties. The composition of brass is generally 66% copper and 34% zinc. However, by weight, brass contains between 55% to 95% copper and 5% to 45% zinc. Elements such as lead, tin, or aluminum can also be added to brass to enhance specific characteristics. Lead promotes corrosion resistance and machinability, whereas iron increases hardness and facilitates alloy forging easier. Material Properties The common types of brass grades include Alloy 260, Alloy 280, Alloy 360, Alloy 385, and Alloy 464. And we will explain them one by one later in the below part. The following table shows the material properties of these five types of brass grades. Alloy 260Alloy 280Alloy 360Alloy 385Alloy 464 Density (g/cm^3)8.538.398.498.478.41 Hardness,Rockwell (F,B)54 F85 F78 B65 B55 B Yield Strength (MPa)75145124-310138172-455 Ultimate Tensile Strength (MPa)300370338-469414379-607 Elongation @ Break (%)6845533050 Modulus of Elasticity (GPa)11010597–100 Machinability (%)30401009030 Brass Features:Brass is a soft metal that may be used when a low chance of sparking is necessary.Brass has a bright gold look most of the time, although it may also be reddish-gold or silvery-white. A larger ratio of copper results in a rosy tone, whereas a higher percentage of zinc makes the alloy look silver.Brass has greater malleability than bronze or zinc.Brass has acoustic qualities that make it suitable for use in musical instruments.The metal has a low coefficient of friction.The melting point of the alloy is relatively low.It's a good heat conductor.Brass is resistant to corrosion, including galvanic corrosion caused by seawater.Brass is a metal simple to cast.Brass is not a ferromagnetic metal. This renders it easier to separate from other metals for recycling.How is Brass Made?Brass is produced through the following basic steps:Step 1. Mining and processing copper ore into copper metal which is almost 100%, pure copper. Zinc ore is also processed into nearly pure zinc metal.Step 2. The purified copper and zinc metals are heated to melting points of 1083°C and 419°C in a furnace according to the desired brass composition.Step 3. The molten metals are mixed thoroughly to form brass according to predetermined percentages of copper and zinc. Impurities and bubbles are removed.Step 4. The molten brass is poured into molds to cast it into bars, ingots, or other shapes; or extruded through dies to form tubes, rods, or plates. Step 5. The cast or extruded brass is often treated using techniques like annealing, cold working, grinding, or polishing to improve properties, strength, hardness, surface finish, machinability, or corrosion resistance.Step 6. Additives like lead, tin, aluminum, or manganese are sometimes included in the composition to produce brass alloys with specific properties depending on the intended application.Step 7. Once cooled and treated, the brass product is finished and ready to be fabricated or used for its intended purpose. Final inspections verify that it meets the required standards.Types of BrassMaterial of brass can be divided into many types. Here we will introduce some commonly seen types: Alpha brasses, Alpha-beta brasses, Beta brasses, and Gamma brasses.Alpha BrassesAlpha brasses Contain 67-72% copper and 28-33% zinc. They are malleable and utilized in pressing, forging, and other related applications. In addition, they can be worked cold. Alpha brasses only have one phase and a face-centered cubic crystal structure. These brasses have a richer golden tone than others due to their high copper content. The alpha phase refers to a substitution solid solution of zinc in copper. It has properties similar to copper and is robust, strong, and relatively difficult to machine. The best formability is achieved at 32% zinc. Corrosion-resistant red brasses with a 15% or less zinc content belong here.Alpha-beta BrassesAlpha-beta brasses contain 55–65% copper and 35–45% zinc. These brasses, also known as duplex brasses, are suitable for hot working. They include both α and β' phases. The β'-phase is ordered body-centered cubic, with zinc atoms in the centers of cubes, and is tougher and stronger than α. Typically, alpha-beta brasses are worked hot. Because of the higher zinc content, these brasses are brighter than alpha brasses. At 45% zinc, the alloy possesses its highest strength.Beta BrassesBeta Brasses contain 50–55% copper and 45–50% zinc. These brasses can only be worked hot. They are harder, stronger, and appropriate for casting. Because of the high zinc-low copper content, they are among the brightest and least golden of the typical brasses. Beta brasses are often used for higher–strength applications, such as valves, gears, and bearings.Gamma BrassesGamma brasses contain 33–39% copper and 61–67% zinc. There are also Ag-Zn and Au-Zn gamma brasses, with Ag 30-50% and Au 41%, respectively. The gamma phase is an intermetallic compound with a cubic lattice structure, Cu_5Zn_8. Gamma brasses are typically used for specialized applications, including high-strength electrical contacts and fasteners.Typical Grade of BrassThere are several different brass alloys. They differ little according to the elemental composition, though. Some commonly employed brass alloys in rapid prototyping are listed below:Alloy 260 (Cartridge Brass) Alloy 260 is also referred to as cartridge brass. This brass alloy comprises around 70% copper and 30% zinc, with impurities. Alloy 260 has good hot formability and can be cold-worked easily. It is used in autos, ammunition, hardware, and fasteners, among other things.Alloy 280 (Muntz Metal)Alloy 280 contains around 60% copper, 40% zinc, and a trace amount of iron. Muntz metal was commonly used as an affordable alternative for the copper sheeting formerly placed on boat hulls to avoid the formation of marine organisms like barnacles on the hulls. Alloy 360 (Free Machining Brass)Alloy 360 comprises around 60% copper, 35.5% zinc, up to 3.7% lead, and trace amounts of iron. This type of alloy is one of the easiest materials to process out of all the brasses, with a 100% machinability grade. Alloy 360 is also an excellent choice for brazing and soldering applications. Designers and machinists use this alloy to create fittings, fasteners, valves, and hardware components.Alloy 385 (Architectural Bronze)Alloy 385 is an alloy of around 59% copper, 42% zinc, and up to 3.5% lead. This enhances its machinability and formability significantly. Because this alloy is easy to form, it is a good architectural material for aluminum extrusions. Alloy 464 (Naval Brass)Alloy 464 is also known as naval brass. This brass alloy comprises roughly 59% copper, 40% zinc, and 1% tin, with a trace of lead. The result is a metal with high corrosion resistance. It can also endure a broad range of temperature changes. Its adaptability for cold and hot forming operations, bending, soldering, and welding, among other things, makes it ideal for various applications. Applications include the different fittings used on a deck of a boat.What are the Advantages and Disadvantages of Brass?Brass boasts a range of benefits that make it a popular choice for various applications. Here is an overview of the advantages and disadvantages of brass:Advantages of BrassHigh Corrosion Resistance: Brass forms a protective oxide layer when exposed to air that prevents further corrosion. Some brasses resist saltwater and industrial pollutants. This property enables uses in plumbing, architecture, electronic parts, and marine equipment.Low Coefficient of Friction: Brass has a low coefficient of friction. As a result, it is perfect for sliding-wear applications. Good Castability and Machinability: Brass can be easily cast, stamped, machined, and polished. It has good wear properties in cutting tools, reducing fabrication costs and difficulties. This advantage allows the economical high-volume production of brass parts, components, and objects. Attractive Appearance: Brass has a bright gold metallic appearance for decorative architectural elements, artistic works, musical instruments, and consumer goods. When buffed and lacquered, brass provides an attractive, durable finish for furnishings and equipment. Antibacterial: Brass alloys contain copper with natural antimicrobial properties. Brass surfaces inhibit the growth of germs, algae, and bacteria. This advantage makes brass suitable and safe for plumbing systems, food processing equipment, hospitals, and other areas where hygiene is important.Recyclable: Brass scrap metal is highly recyclable and a valuable commodity. Most brass can be remelted and reformed indefinitely. This property contributes to the sustainability and economics of brass as an industrial material. Recycling helps reduce costs and the need for new mineral resources. Disadvantages of BrassRelatively Expensive: Although recyclable, copper and zinc components of brass alloys cost them more than base metals like iron or aluminum and some plastics. Material and production costs can be high depending on the price of copper and zinc. This disadvantage may limit very large-scale applications of brass. Heavy: The density of brass alloys is higher than most commercial metals. This results in heavy parts which require more labor and resources to machine, transport, and install. The weight factor must be considered, especially in large brass assemblies and constructions. Prone to Tarnishing: If not properly cared for, brass can develop a blackish tarnish due to oxidation. To avoid this, brass may need to be coated with a clear lacquer.Non-Hypoallergenic: Due to its copper or zinc content, brass can cause skin irritation in individuals with sensitive skin if not correctly treated with a lacquer coating. Hazardous Zinc Oxide Fumes: Melting and hot working brass at high temperatures can produce hazardous zinc oxide fumes, which require ventilation and respiratory protection for workers. Additional environmental controls may also be needed to trap and filter zinc emissions and prevent pollution. Non-sparking: Brass cannot be used where sparking could ignite flammable vapors or materials. The high thermal and electrical conductivity of brass poses risks of overheating and sparking/arcing in certain working environments. Intrinsically safe alloys must be used for these applications. Applications of BrassBrass is essential in society, industry, technology, infrastructure, art, and culture. Here are some of the typical applications of brass:Plumbing Fixtures and FittingsBrass is commonly used for plumbing parts like pipes, valves, pumps, water heaters, faucets, and joints. It resists corrosion, is durable, and inhibits bacterial growth.ArchitectureBrass has decorative and structural uses in buildings. Decorative uses include door knobs, handrails, statues, artwork, furniture trim, staircases, and kick plates. Structural uses include lanterns, door hardware, roofing, and flashing. The golden color highlights architectural features.Electronics and TelecommunicationsBrass is used for electronic parts that require conductivity and corrosion resistance, like plugs, jacks, switches, condensers, printed circuit boards, and shielding. The ability to alloy brass provides specific properties for electronic applications.Transportation EquipmentBrass is used throughout transportation for corrosion-resistant, attractive parts. Uses include door handles, trim, radiator parts, fasteners, instruments, and hardware in automobiles, trains, and aircraft. Naval brass withstands saltwater for marine propellers, pumps, and valves.Ammunition and Cartridges Cartridge brass, an alloy suited for deep drawing, makes cartridges and bullet casings. The brass must withstand high pressures, temperatures, and physical stresses from firing and loading ammunition.   Musical InstrumentsThe acoustic properties of brass alloys and their castability into precision bells and tubes have made them suitable for crafting musical instruments like trumpets, trombones, tubas, French horns, saxophones, bugles, etc. The brass parts help produce and amplify musical tones.Bearings and BushingsBrasses are suited for bearings and bushings that require corrosion resistance, durability, and moderate loads. The natural lubricity of brass also helps reduce friction and wear. Examples are phosphor bronze and tin bronze.Decorative ObjectsBrass is used for decorative items where appearance and shine are most important. Examples include statues, candlesticks, vases, lamps, chandeliers, door knockers, paperweights, and other metal art. Casting allows sharp detail and intricate shapes. The gold color is traditionally associated with prestige and style.Marine EquipmentNaval brass and other brasses resistant to saltwater corrosion are used for propellers, pumps, valves, condensers, fasteners, and hardware on seagoing vessels and equipment. They must withstand corrosion, impacts, erosion, and electrolytic reactions in ocean environments. Comparison between Copper, Brass, and BronzeAll three are known colloquially as "red metals." Copper is a nonferrous metal that exists in its pure state. Unlike bronze and brass, this metal occurs naturally and may be processed directly and immediately. Brass and bronze belong to the alloy. Copper is the primary element of both brass and bronze. The main secondary element of brass is zinc. It often contains lead and may include manganese, iron, aluminum, silicon, and other elements. However, bronze contains tin as its main secondary element. In addition, it also has nickel, aluminum, phosphorus, zinc, and others. Bronze is very resistant to corrosion caused by saltwater, but brass has great low-friction properties. In contrast, the high conductivity of copper makes it ideal for electrical applications.The following table further summarizes other brass, bronze, and copper differences. BrassCopperBronze Element CompositionPrimary: Copper and Zinc Others: Lead,Manganese,Iron,Aluminum,Silicon,etc.CopperPrimary: Copper and Tin Others: Nickel,Aluminum,Zinc,Phosphorus,etc. Corrosion ResistanceGood corrosion resistanceExcellent corrosion resistanceExcellent corrosion resistance Weight8720 kg/cu.m8930 kg/cu.m7400 – 8900 kg/cu.m DurabilityHighly durableDurableHighly durable MachinabilityA lower degree of machinabilityHigh machinabilityModerate machinability WeldabilityGood level of weldabilityHigh level of weldabilityHigh level of weldability Electrical Conductivity(Relative to Copper)28%100%15% Thermal Conductivity64 BTU/hr-ft^2-°F223 BTU/hr-ft^2-°F229 – 1440 BTU/hr-ft^2-°F Tensile Strength338 – 469 MPa210 MPa350 – 635 MPa Yield Strength95 – 124 MPa33.3 MPa125 – 800 MPa Melting Point927 °C1085 °C913 °C SummaryBrass is an alloy of copper and zinc that has a golden-yellow color. Brass is resistant to seawater corrosion and is simple to machine and shape. Its biocidal effect makes it a good material for antibacterial applications. In addition, brass can be found in applications that need low friction. Fittings, tools, appliance parts, and ammunition components are examples of such uses. When you're unsure whether brass or another material is right for your project, let LEADRP help. Our professional technicians and machinists will choose the best material for you. We also offer prototyping services such as sheet metal fabrication, CNC machining, injection molding, and 3D printing. Contact us and request a free quote today!ReferencesBrass – From WikipediaWhat Is Brass? Composition and Properties – From ThoughtCo Home » Inorganic Chemistry Brass is a metallic alloy that is formed through the combination of copper and zinc in different ratios. The hardness or softness of brass can be manipulated by altering the proportions of copper and zinc. The combination of various metallic elements such as aluminum, lead, and arsenic, can be employed as alloying elements in order to enhance robustness, pliability, and resistance to corrosion. Brass: Properties, Composition, Types, Advantages, Disadvantages, Application Brass finds widespread application in diverse industries owing to its distinctive properties. Throughout history, this alloy has been utilized for its distinctive characteristics, encompassing various purposes ranging from the production of coins and jewelry to its application in industrial sectors such as shipbuilding. Brass is a metallic compound composed of copper and zinc, with minor quantities of lead, iron, and various other elements. The color of the material is typically golden-yellow, although it may exhibit a reddish color when the alloy contains elevated copper content, commonly referred to as "red brass." Brass is recognized for its exceptional workability, machinability, as well as its antibacterial and anti-biofouling properties. Brass exhibits exceptional resistance to corrosion in seawater and possesses favorable machinability and formability characteristics. Additionally, it possesses biocidal properties that render it highly suitable for antibacterial purposes. Brass [Image source: veranda] Brass, being a copper alloy, exhibits numerous properties that are related to copper. Nevertheless, the alloy does demonstrate several distinct characteristics in comparison to both pure copper and other copper alloys. High malleability: The high malleability of brass is attributed to the presence of copper. While both bronze and brass contain copper, the malleability of bronze is comparatively lower than that of brass, primarily attributed to the disparity in their additional constituents. It has been observed that the influence of zinc on the properties of brass is comparatively lesser than that of tin. High melting point: The melting point of brass is approximately 900°C. The precise melting point varies depending on the relative concentrations of various metals within the alloy Conductivity: In addition to its malleability, copper is also responsible for the heat and electrical conductivity exhibited by brass. Copper is the second most conductive metal, surpassed only by silver. However, the utilization of silver for conduction purposes is not advisable due to its inadequate thermal resistance. Brass is commonly employed in numerous applications that necessitate efficient conduction in environments characterized by elevated temperatures. Corrosion resistance: Brass is classified as a non-ferrous metal, meaning it does not contain iron. This implies that it is resistant to corrosion caused by rust formation. Certain varieties of brass possess the capability to withstand the corrosive effects of saltwater, which is known to be tenfold more corrosive than freshwater. Due to this rationale, specialized brass alloys are employed in the external cladding of vessels and dock columns. Susceptibility to stress-cracking: Due to its superior strength and stiffness in comparison to pure copper, brass exhibits a heightened susceptibility to the formation of stress cracks. Non-ferromagnetic: Due to its non-ferromagnetic nature, brass exhibits enhanced recyclability, thereby facilitating its processing. Antibacterial property: Many non-ferrous metals possess the capacity to induce the well-known oligodynamic effect, a phenomenon characterized by the ability of metal ions to selectively target and eliminate specific proteins in unicellular organisms. Bacteria can be rapidly eradicated within a matter of minutes upon exposure to any of the aforementioned metals. Brass has been identified as one of the aforementioned materials. The aforementioned characteristic renders brass a suitable material for filtration and purification systems. The properties of brass can be altered by incorporating various metals into its composition. The chemical composition of the material can lead to variations in its color, hardness, texture, strength, and resistance to corrosion. Typically, brass exhibits a warm and golden hue. The incorporation of a 1 percent manganese content in brass results in a transformation of its color to a pleasant warm chocolate-brown hue, whereas the introduction of nickel imparts a silver appearance. The addition of lead to brass is a common practice aimed at enhancing its softness and, consequently, its malleability. The addition of arsenic to brass has been observed to enhance its stability in specific environmental conditions. The addition of tin to brass has been found to enhance its strength and hardness. The physical and mechanical properties of brass are influenced by its composition, thereby necessitating careful consideration of the appropriate type of brass for a given application. Various types of brass alloys can exhibit varying compositions of copper and zinc, resulting in a diverse array of characteristics such as strength, malleability, corrosion resistance, and thermal conductivity. This broad range of properties renders brass alloys suitable for numerous applications across various industries. Gaining a comprehensive understanding of the composition and properties of brass is crucial in order to make a well-informed decision regarding the most suitable type for one's specific requirements. Brass is commonly made up of two primary constituents, namely copper and zinc, although the inclusion of other metallic elements is possible for providing additional advantages. The relative proportions of these two constituent elements exhibit variation contingent upon the specific type of brass under production, with certain compositions containing higher quantities of copper, while others contain higher quantities of zinc. As an example, the composition of red brass consists of 85% copper and 15% zinc, whereas yellow brass is composed of 65% copper and 35% zinc. Various proportions result in the formation of brass alloys that possess unique characteristics tailored to specific uses. Brass alloys can be categorized into three primary classifications, namely alpha brasses, alpha-beta brasses, and beta brasses. Various types of brass possess distinct properties that render them appropriate for specific applications. Alpha brass gets its name from its uniform (alpha) crystal structure, which forms when less than 37% zinc is fused to copper. When zinc is dissolved in copper, an alpha-crystal structure forms, resulting in a solid solution with a uniform composition. These brass are more easily rolled, pulled, bent, and brazed than their counterparts, and they can be cold-worked or welded as well. Most brass is an alpha type, which consists of 70 percent copper and 30 percent zinc. This brass alloy, often known as 70/30 brass or "cartridge brass," is great for cold drawing because of its strength and flexibility. Because it contains more zinc than brass, it is also more resistant to corrosion. Fasteners such as the spring contacts in electrical sockets and wood screws are made from alpha alloys. Alpha-beta brass, often called "duplex brass" or "hot-working brass," has 37–45% zinc. They have alpha and beta-grain structures. In the beta phase, pure zinc resembles brass atomically. Zinc content determines the alpha-to-beta brass ratio. Tin, silicon, and aluminum can increase beta-phase brass in alloys. Alpha-beta brass is stronger, cold-resistant, and more common than alpha brass. Due to its increased zinc content, alpha-beta brass is cheaper but more susceptible to dezincification corrosion. Alpha-beta brass is better at high temperatures but less workable at room temperature than alpha brass. Lead improves machinability, but these brass don't shatter. Extrusion, stamping, and die casting are the most common hot-working alpha-beta brass methods. Beta Brass is a zinc-rich brass alloy. They are rarer than alpha or alpha-beta brass. Beta-crystal brass is stronger than alpha and alpha-beta brass. Thus, only hot wrought or cast. Anyone can investigate the effects of alloying metals with brass by identifying them by their features instead of their crystal structures. Beta brass includes free-machining, high-tensile, naval, dezincification-resistant, cold-working, and casting brass. R This brass is gunmetal, a high copper alloy containing tin, while yellow brass is a zinc-rich alloy. Brass's toughness and resistance to corrosion have made it a favored material for many years. Because of its versatility and malleability, it may be used for anything from elaborate jewelry to massive building projects. It's frequently used in things like exterior bollards and posts, as well as in musical instruments, door knobs, keys, locks, and hinges. All three elements are frequently denoted as "red metals" in common language. Both brass and bronze primarily consist of copper as their main constituent. The primary secondary element found in brass is zinc, whereas tin is commonly present as the second element in bronze. Bronze exhibits remarkable resistance to corrosion when exposed to seawater, while brass possesses notable low-friction properties. In contrast, copper exhibits a high level of suitability for electrical applications owing to its exceptional conductivity. Indeed, brass is considered suitable for various engineering applications of a general nature. However, caution is advised when employing brass in scenarios involving contact with acidic food substances, characterized by a pH level below 6. The toxicity of brass to certain microscopic organic life is attributed to the adverse impact of copper ions on diverse microorganisms. Individuals with skin sensitivity may experience an allergic reaction when exposed to brass. There are a lot of advantages associated with using brass. Because of its high copper content (more than 60%), it is very resistant to corrosion, making it a prime candidate for use in building projects where strength is of the utmost importance. Because of this, brass hardware will endure much longer than its counterparts produced from less durable metals like aluminum or steel. In addition, switches and sockets can be made from brass because of the metal's high electrical conductivity. Finally, brass's lack of magnetic properties makes metal ideal for use in very sensitive devices like medical scanners and satellite navigation systems. Versatility: There is a vast variety of uses for brass due to the metal's adaptability. It finds widespread application in the production of instruments, fittings, and fasteners for the building and plumbing industries. Jewelry and coins and medals are two more common applications for brass Durability: Brass exhibits exceptional durability and exhibits high resistance to corrosion. This characteristic renders it a highly suitable option for scenarios in which the metal will come into contact with moisture or other corrosive agents. In addition to its wear and tear resistance, brass possesses commendable durability, rendering it a favorable option for products subjected to frequent and intense usage. Conductivity: Brass, being a metal with high electrical conductivity, is considered to be an optimal material for various electrical applications. The exceptional electrical conductivity exhibited by brass renders it a highly favorable option for applications in electrical wiring and the production of electrical connectors. Affordability: Brass is considered to be a cost-effective metal option in the current market, rendering it a favorable selection for consumers who prioritize budgetary considerations. In contrast to precious metals like gold or silver, brass exhibits a significantly lower price point while retaining numerous comparable advantages. Attractiveness: The alloy known as brass possesses a visually appealing warm and golden color, which has the potential to enhance the appearance and sophistication of various applications. The utilization of brass is frequently observed in various decorative contexts, including but not limited to lighting fixtures, door hardware, and sculptures. Anti-bacterial activity: The antibacterial properties of brass can be attributed to its copper content, which has been found to effectively eliminate specific strains of bacteria. Due to its fundamental characteristics, this particular property renders it highly suitable for utilization in various applications, such as door knobs, with the primary purpose of impeding the transmission of bacteria. In marine applications, brass exhibits the ability to effectively inhibit biofouling. Vulnerable to Ruin: If not polished regularly, brass will oxidize and develop a black patina. A clear lacquer coating on the brass could help avoid this. Non-Hypoallergenic: Individuals with sensitive skin may experience skin irritation when exposed to brass, primarily due to the presence of copper or zinc. However, this can be mitigated by applying a lacquer coating to the brass surface. In comparison to other frequently encountered metals such as steel, brass exhibits a higher cost attributed to its elevated copper composition. Copper is a highly costly material. Brass finds extensive utilization in both decorative and mechanical applications. Brass is commonly employed in various applications that require reduced friction due to its distinctive attributes, such as corrosion resistance. The range of applications for these components encompasses fittings such as fasteners and connectors, tools, parts for appliances, and components for ammunition. Some of the major applications are: Decorative application: The aesthetic attraction of brass contributes to its widespread usage in decorative applications. The coloration of this entity exhibits a spectrum that spans from a pale golden hue to a silvery shade and can even approach a reddish tone. Brass is a popular material choice for residential dishwasher fittings and lamp fittings due to its aesthetic appeal and resistance to bacterial growth. Mechanical application: Brass, a versatile alloy composed primarily of copper and zinc, finds extensive utilization in various mechanical applications, ranging from the production of shell casings for M-16 assault rifles to the manufacturing of everyday use bearings and gears. Brass implements are renowned for their prolonged durability and diminished requirement for frequent honing. Historically, brass has been employed as a primary material in the production of diverse musical instruments. Brass is widely employed on a global scale for the fabrication of musical instruments such as trumpets, French horns, trombones, and tubas. The utilization of brass components is anticipated within the internal structure of electric musical instruments, specifically electric guitars, and electric violins. Brass possesses an outstanding degree of malleability, enabling it to be effectively manipulated through hammering processes in order to achieve desired shapes. Dezincification refers to the chemical process by which zinc is extracted from brass. DZR brass exhibits a notable degree of corrosion resistance, rendering it suitable for applications in environments that are susceptible to corrosion, such as boilers. The substance contains a small amount of arsenic. Brass is commonly utilized as a component material in two of the most prevalent plumbing and electrical systems found within residential dwellings. Brass alloys are utilized in the fabrication of diverse components found in electrical sockets and switches. Brass is frequently employed in plumbing systems for various applications, including the fabrication of valves and pipe fittings such as elbows, plugs, and couplings. Due to its reduced frictional properties, it is commonly employed in the fabrication of door knobs, locks, handles, and similar components. Two commonly utilized types of brass, namely cartridge brass and gliding metal brass, find extensive application in the production of ammunition, including bulletproof jackets. Aluminum brass, which typically consists of approximately 2% aluminum, finds application in condenser tubes and heat exchanger devices. The utilization of brass is observed in the manufacturing of fireplace equipment. Common Uses for Brass. (n.d.). Mead Metals, Inc.; www.meadmetals.com. Retrieved May 24, 2022, from About Author Alloy of copper and zinc "Arsenical brass" redirects here and is not to be confused with arsenical bronze or arsenical copper. For other uses, see Brass (disambiguation). Islamic Golden Age brass astrolabe Brass lectern with an eagle. Attributed to Aert van Tricht, Limburg (Netherlands), c. 1500. Brass is an alloy of copper and zinc, in proportions which can be varied to achieve different colours and mechanical, electrical, acoustic and chemical properties,[1] but copper typically has the larger proportion, generally 2⁄3 copper and 1⁄3 zinc. In use since prehistoric times, it is a substitutional alloy: atoms of the two constituents may replace each other within the same crystal structure. Brass is similar to bronze, a copper alloy that contains tin instead of zinc.[2] Both bronze and brass may include small proportions of a range of other elements including arsenic, lead, phosphorus, aluminium, manganese and silicon. Historically, the distinction between the two alloys has been less consistent and clear,[3] and increasingly museums use the more general term "copper alloy".[4] Brass has long been a popular material for its bright gold-like appearance and is still used for drawer pulls and doorknobs. It has also been widely used to make sculpture and utensils because of its low melting point, high workability (both with hand tools and with modern turning and milling machines), durability, and electrical and thermal conductivity. Brasses with higher copper content are softer and more golden in colour; conversely those with less copper and thus more zinc are harder and more silvery in colour. Brass is still commonly used in applications where corrosion resistance and low friction are required, such as locks, hinges, gears, bearings, ammunition casings, zippers, plumbing, hose couplings, valves, SCUBA regulators, and electrical plugs and sockets. It is used extensively for musical instruments such as horns and bells. The composition of brass makes it a favorable substitute for copper in costume jewelry and fashion jewelry, as it exhibits greater resistance to corrosion. Brass is not as hard as bronze and so is not suitable for most weapons and tools. Nor is it suitable for marine uses, because the zinc reacts with minerals in salt water, leaving porous copper behind; marine brass, with added tin, avoids this, as does bronze. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools used near flammable or explosive materials.[5] Microstructure of rolled and annealed brass (400× magnification) Brass is more malleable than bronze or zinc. The relatively low melting point of brass (900 to 940 °C; 1,650 to 1,720 °F, depending on composition) and its flow characteristics make it a relatively easy material to cast. By varying the proportions of copper and zinc, the properties of the brass can be changed, allowing hard and soft brasses. The density of brass is 8.4 to 8.73 g/cm^3 (0.303 to 0.315 lb/cu in).[6] Today, almost 90% of all brass alloys are recycled.[7] Because brass is not ferromagnetic, ferrous scrap can be separated from it by passing the scrap near a powerful magnet. Brass scrap is melted and recast into billets that are extruded into the desired form and size. The general softness of brass means that it can often be machined without the use of cutting fluid, though there are exceptions to this.[8] Aluminium makes brass stronger and more corrosion-resistant. Aluminium also causes a highly beneficial hard layer of aluminium oxide (Al_2O_3) to be formed on the surface that is thin, transparent, and self-healing. Tin has a similar effect and finds its use especially in seawater applications (naval brasses). Combinations of iron, aluminium, silicon, and manganese make brass wear- and tear-resistant.[9] The addition of as little as 1% iron to a brass alloy will result in an alloy with a noticeable magnetic attraction.[10] Binary phase diagram Brass will corrode in the presence of moisture, chlorides, acetates, ammonia, and certain acids. This often happens when the copper reacts with sulfur to form a brown and eventually black surface layer of copper sulfide which, if regularly exposed to slightly acidic water such as urban rainwater, can then oxidize in air to form a patina of green-blue copper carbonate. Depending on how the patina layer was formed, it may protect the underlying brass from further damage.[11] Although copper and zinc have a large difference in electrical potential, the resulting brass alloy does not experience internalized galvanic corrosion because of the absence of a corrosive environment within the mixture. However, if brass is placed in contact with a more noble metal such as silver or gold in such an environment, the brass will corrode galvanically; conversely, if brass is in contact with a less-noble metal such as zinc or iron, the less noble metal will corrode and the brass will be protected. To enhance the machinability of brass, lead is often added in concentrations of about 2%. Since lead has a lower melting point than the other constituents of the brass, it tends to migrate towards the grain boundaries in the form of globules as it cools from casting. The pattern the globules form on the surface of the brass increases the available lead surface area which, in turn, affects the degree of leaching. In addition, cutting operations can smear the lead globules over the surface. These effects can lead to significant lead leaching from brasses of comparatively low lead content.[12] In October 1999, the California State Attorney General sued 13 key manufacturers and distributors over lead content. In laboratory tests, state researchers found the average brass key, new or old, exceeded the California Proposition 65 limits by an average factor of 19, assuming handling twice a day.[13] In April 2001 manufacturers agreed to reduce lead content to 1.5%, or face a requirement to warn consumers about lead content. Keys plated with other metals are not affected by the settlement, and may continue to use brass alloys with a higher percentage of lead content.[14][15] Also in California, lead-free materials must be used for "each component that comes into contact with the wetted surface of pipes and pipe fittings, plumbing fittings and fixtures". On 1 January 2010, the maximum amount of lead in "lead-free brass" in California was reduced from 4% to 0.25% lead.[16][17] Brass sampling cock with stainless steel handle Dezincification-resistant (DZR or DR) brasses, sometimes referred to as CR (corrosion resistant) brasses, are used where there is a large corrosion risk and where normal brasses do not meet the requirements. Applications with high water temperatures, chlorides present or deviating water qualities (soft water) play a role. DZR-brass is used in water boiler systems. This brass alloy must be produced with great care, with special attention placed on a balanced composition and proper production temperatures and parameters to avoid long-term failures.[18][19] An example of DZR brass is the C352 brass, with about 30% zinc, 61–63% copper, 1.7–2.8% lead, and 0.02–0.15% arsenic. The lead and arsenic significantly suppress the zinc loss.[20] "Red brasses", a family of alloys with high copper proportion and generally less than 15% zinc, are more resistant to zinc loss. One of the metals called "red brass" is 85% copper, 5% tin, 5% lead, and 5% zinc. Copper alloy C23000, which is also known as "red brass", contains 84–86% copper, 0.05% each iron and lead, with the balance being zinc.[21] Another such material is gunmetal, from the family of red brasses. Gunmetal alloys contain roughly 88% copper, 8–10% tin, and 2–4% zinc. Lead can be added for ease of machining or for bearing alloys.[22] "Naval brass", for use in seawater, contains 40% zinc but also 1% tin. The tin addition suppresses zinc-leaching.[23] The NSF International requires brasses with more than 15% zinc, used in piping and plumbing fittings, to be dezincification-resistant.[24] This section relies largely or entirely on a single source. Relevant discussion may be found on the talk page. Please help improve this article by introducing citations to additional sources.Find sources: "Brass" – news · newspapers · books · scholar · JSTOR (January 2021) A collection of brass instruments The high malleability and workability, relatively good resistance to corrosion, and traditionally attributed acoustic properties of brass, have made it the usual metal of choice for construction of musical instruments whose acoustic resonators consist of long, relatively narrow tubing, often folded or coiled for compactness; silver and its alloys, and even gold, have been used for the same reasons, but brass is the most economical choice. Collectively known as brass instruments, or simply 'the brass', these include the trombone, tuba, trumpet, cornet, flugelhorn, baritone horn, euphonium, tenor horn, and French horn, and many other "horns", many in variously sized families, such as the saxhorns. Other wind instruments may be constructed of brass or other metals, and indeed most modern student-model flutes and piccolos are made of some variety of brass, usually a cupronickel alloy similar to nickel silver (also known as German silver). Clarinets, especially low clarinets such as the contrabass and subcontrabass, are sometimes made of metal because of limited supplies of the dense, fine-grained tropical hardwoods traditionally preferred for smaller woodwinds. For the same reason, some low clarinets, bassoons and contrabassoons feature a hybrid construction, with long, straight sections of wood, and curved joints, neck, and/or bell of metal. The use of metal also avoids the risks of exposing wooden instruments to changes in temperature or humidity, which can cause sudden cracking. Even though the saxophones and sarrusophones are classified as woodwind instruments, they are normally made of brass for similar reasons, and because their wide, conical bores and thin-walled bodies are more easily and efficiently made by forming sheet metal than by machining wood. The keywork of most modern woodwinds, including wooden-bodied instruments, is also usually made of an alloy such as nickel silver. Such alloys are stiffer and more durable than the brass used to construct the instrument bodies, but still workable with simple hand tools—a boon to quick repairs. The mouthpieces of both brass instruments and, less commonly, woodwind instruments are often made of brass among other metals as well. Next to the brass instruments, the most notable use of brass in music is in various percussion instruments, most notably cymbals, gongs, and orchestral (tubular) bells (large "church" bells are normally made of bronze). Small handbells and "jingle bells" are also commonly made of brass. The harmonica is a free reed aerophone, also often made from brass. In organ pipes of the reed family, brass strips (called tongues) are used as the reeds, which beat against the shallot (or beat "through" the shallot in the case of a "free" reed). Although not part of the brass section, snare drums are also sometimes made of brass. Some parts on electric guitars are also made from brass, especially inertia blocks on tremolo systems for its tonal properties, and for string nuts and saddles for both tonal properties and its low friction.[25] Main article: Antimicrobial copper-alloy touch surfaces See also: Antimicrobial properties of copper and Copper alloys in aquaculture The bactericidal properties of brass have been observed for centuries, particularly in marine environments where it prevents biofouling. Depending upon the type and concentration of pathogens and the medium they are in, brass kills these microorganisms within a few minutes to hours of contact.[26][27][28] A large number of independent studies[26][27][28][29][30][31][32] confirm this antimicrobial effect, even against antibiotic-resistant bacteria such as MRSA and VRSA. The mechanisms of antimicrobial action by copper and its alloys, including brass, are a subject of intense and ongoing investigation.[27][33][34] Cracking in brass caused by ammonia attack Brass is susceptible to stress corrosion cracking,[35] especially from ammonia or substances containing or releasing ammonia. The problem is sometimes known as season cracking after it was first discovered in brass cartridges used for rifle ammunition during the 1920s in the British Indian Army. The problem was caused by high residual stresses from cold forming of the cases during manufacture, together with chemical attack from traces of ammonia in the atmosphere. The cartridges were stored in stables and the ammonia concentration rose during the hot summer months, thus initiating brittle cracks. The problem was resolved by annealing the cases, and storing the cartridges elsewhere. Class Proportion by weight (%) Notes Copper Zinc Alpha brasses > 65 0 Also called CW617N or CZ122 or OT58. It is not recommended for sea water use, being susceptible to dezincification.[51][52] Yellow brass 67 33 An American term for 33% zinc brass. Further information: Art in bronze and brass Although forms of brass have been in use since prehistory,[53] its true nature as a copper-zinc alloy was not understood until the post-medieval period because the zinc vapor which reacted with copper to make brass was not recognized as a metal.[54] The King James Bible makes many references to "brass"[55] to translate "nechosheth" (bronze or copper) from Hebrew to English. The earliest brasses may have been natural alloys made by smelting zinc-rich copper ores.[56] By the Roman period brass was being deliberately produced from metallic copper and zinc minerals using the cementation process, the product of which was calamine brass, and variations on this method continued until the mid-19th century.[57] It was eventually replaced by speltering, the direct alloying of copper and zinc metal which was introduced to Europe in the 16th century.[56] Brass has sometimes historically been referred to as "yellow copper".[58][59] In West Asia and the Eastern Mediterranean early copper-zinc alloys are now known in small numbers from a number of 3rd millennium BC sites in the Aegean, Iraq, the United Arab Emirates, Kalmykia, Turkmenistan and Georgia and from 2nd millennium BC sites in western India, Uzbekistan, Iran, Syria, Iraq and Canaan.[60] Isolated examples of copper-zinc alloys are known in China from the 1st century AD, long after bronze was widely used.[61] The hilt of Sirohi swords (16-19th century CE) were made up of brass in India. The compositions of these early "brass" objects are highly variable and most have zinc contents of between 5% and 15% wt which is lower than in brass produced by cementation.[62] These may be "natural alloys" manufactured by smelting zinc rich copper ores in redox conditions. Many have similar tin contents to contemporary bronze artefacts and it is possible that some copper-zinc alloys were accidental and perhaps not even distinguished from copper.[62] However the large number of copper-zinc alloys now known suggests that at least some were deliberately manufactured and many have zinc contents of more than 12% wt which would have resulted in a distinctive golden colour.[62][63] By the 8th–7th century BC Assyrian cuneiform tablets mention the exploitation of the "copper of the mountains" and this may refer to "natural" brass.[64] "Oreikhalkon" (mountain copper),[65] the Ancient Greek translation of this term, was later adapted to the Latin aurichalcum meaning "golden copper" which became the standard term for brass.[66] In the 4th century BC Plato knew orichalkos as rare and nearly as valuable as gold[67] and Pliny describes how aurichalcum had come from Cypriot ore deposits which had been exhausted by the 1st century AD.[68] X-ray fluorescence analysis of 39 orichalcum ingots recovered from a 2,600-year-old shipwreck off Sicily found them to be an alloy made with 75–80% copper, 15–20% zinc and small percentages of nickel, lead and iron.[69][70] 7th-century Persian ewer in brass with copper inlay, Walters Art Museum, Baltimore, Maryland, US During the later part of first millennium BC the use of brass spread across a wide geographical area from Britain[71] and Spain[72] in the west to Iran, and India in the east.[73] This seems to have been encouraged by exports and influence from the Middle East and eastern Mediterranean where deliberate production of brass from metallic copper and zinc ores had been introduced.[74] The 4th century BC writer Theopompus, quoted by Strabo, describes how heating earth from Andeira in Turkey produced "droplets of false silver", probably metallic zinc, which could be used to turn copper into oreichalkos.[75] In the 1st century BC the Greek Dioscorides seems to have recognized a link between zinc minerals and brass describing how Cadmia (zinc oxide) was found on the walls of furnaces used to heat either zinc ore or copper and explaining that it can then be used to make brass.[76] By the first century BC brass was available in sufficient supply to use as coinage in Phrygia and Bithynia,[77] and after the Augustan currency reform of 23 BC it was also used to make Roman dupondii and sestertii.[78] The uniform use of brass for coinage and military equipment across the Roman world may indicate a degree of state involvement in the industry,[79][80] and brass even seems to have been deliberately boycotted by Jewish communities in Palestine because of its association with Roman authority.[81] Brass was produced by the cementation process where copper and zinc ore are heated together until zinc vapor is produced which reacts with the copper. There is good archaeological evidence for this process and crucibles used to produce brass by cementation have been found on Roman period sites including Xanten[82] and Nidda[83] in Germany, Lyon in France[84] and at a number of sites in Britain.[85] They vary in size from tiny acorn sized to large amphorae like vessels but all have elevated levels of zinc on the interior and are lidded.[84] They show no signs of slag or metal prills suggesting that zinc minerals were heated to produce zinc vapor which reacted with metallic copper in a solid state reaction. The fabric of these crucibles is porous, probably designed to prevent a buildup of pressure, and many have small holes in the lids which may be designed to release pressure[84] or to add additional zinc minerals near the end of the process. Dioscorides mentioned that zinc minerals were used for both the working and finishing of brass, perhaps suggesting secondary additions.[86] Brass made during the early Roman period seems to have varied between 20% and 28% wt zinc.[86] The high content of zinc in coinage and brass objects declined after the first century AD and it has been suggested that this reflects zinc loss during recycling and thus an interruption in the production of new brass.[78] However it is now thought this was probably a deliberate change in composition[87] and overall the use of brass increases over this period making up around 40% of all copper alloys used in the Roman world by the 4th century AD.[88] Baptism of Christ on the 12th-century baptismal font at St Bartholomew's Church, Liège Little is known about the production of brass during the centuries immediately after the collapse of the Roman Empire. Disruption in the trade of tin for bronze from Western Europe may have contributed to the increasing popularity of brass in the east and by the 6th–7th centuries AD over 90% of copper alloy artefacts from Egypt were made of brass.[89] However other alloys such as low tin bronze were also used and they vary depending on local cultural attitudes, the purpose of the metal and access to zinc, especially between the Islamic and Byzantine world.[90] Conversely the use of true brass seems to have declined in Western Europe during this period in favor of gunmetals and other mixed alloys[91] but by about 1000 brass artefacts are found in Scandinavian graves in Scotland,[92] brass was being used in the manufacture of coins in Northumbria[93] and there is archaeological and historical evidence for the production of calamine brass in Germany[82] and the Low Countries,[94] areas rich in calamine ore. These places would remain important centres of brass making throughout the Middle Ages period,[95] especially Dinant. Brass objects are still collectively known as dinanderie in French. The baptismal font at St Bartholomew's Church, Liège in modern Belgium (before 1117) is an outstanding masterpiece of Romanesque brass casting, though also often described as bronze. The metal of the early 12th-century Gloucester Candlestick is unusual even by medieval standards in being a mixture of copper, zinc, tin, lead, nickel, iron, antimony and arsenic with an unusually large amount of silver, ranging from 22.5% in the base to 5.76% in the pan below the candle. The proportions of this mixture may suggest that the candlestick was made from a hoard of old coins, probably Late Roman.[96] Latten is a term for medieval alloys of uncertain and often variable composition often covering decorative borders and similar objects cut from sheet metal, whether of brass or bronze. Especially in Tibetan art, analysis of some objects shows very different compositions from different ends of a large piece. Aquamaniles were typically made in brass in both the European and Islamic worlds. Brass aquamanile from Lower Saxony, Germany, c. 1250 The cementation process continued to be used but literary sources from both Europe and the Islamic world seem to describe variants of a higher temperature liquid process which took place in open-topped crucibles.[97] Islamic cementation seems to have used zinc oxide known as tutiya or tutty rather than zinc ores for brass-making, resulting in a metal with lower iron impurities.[98] A number of Islamic writers and the 13th century Italian Marco Polo describe how this was obtained by sublimation from zinc ores and condensed onto clay or iron bars, archaeological examples of which have been identified at Kush in Iran.[99] It could then be used for brass making or medicinal purposes. In 10th century Yemen al-Hamdani described how spreading al-iglimiya, probably zinc oxide, onto the surface of molten copper produced tutiya vapor which then reacted with the metal.[100] The 13th century Iranian writer al-Kashani describes a more complex process whereby tutiya was mixed with raisins and gently roasted before being added to the surface of the molten metal. A temporary lid was added at this point presumably to minimize the escape of zinc vapor.[101] In Europe a similar liquid process in open-topped crucibles took place which was probably less efficient than the Roman process and the use of the term tutty by Albertus Magnus in the 13th century suggests influence from Islamic technology.[102] The 12th century German monk Theophilus described how preheated crucibles were one sixth filled with powdered

calamine and charcoal then topped up with copper and charcoal before being melted, stirred then filled again. The final product was cast, then again melted with calamine. It has been suggested that this second melting may have taken place at a lower temperature to allow more zinc to be absorbed.[103] Albertus Magnus noted that the "power" of both calamine and tutty could evaporate and described how the addition of powdered glass could create a film to bind it to the metal.[104] German brass making crucibles are known from Dortmund dating to the 10th century AD and from Soest and Schwerte in Westphalia dating to around the 13th century confirm Theophilus' account, as they are open-topped, although ceramic discs from Soest may have served as loose lids which may have been used to reduce zinc evaporation, and have slag on the interior resulting from a liquid process.[105] 12th century "Bronze Head from Ife", actually of "heavily leaded zinc-brass" Some of the most famous objects in African art are the lost wax castings of West Africa, mostly from what is now Nigeria, produced first by the Kingdom of Ife and then the Benin Empire. Though normally described as "bronzes", the Benin Bronzes, now mostly in the British Museum and other Western collections, and the large portrait heads such as the Bronze Head from Ife of "heavily leaded zinc-brass" and the Bronze Head of Queen Idia, both also British Museum, are better described as brass, though of variable compositions.[106] Work in brass or bronze continued to be important in Benin art and other West African traditions such as Akan goldweights, where the metal was regarded as a more valuable material than in Europe. The Renaissance saw important changes to both the theory and practice of brassmaking in Europe. By the 15th century there is evidence for the renewed use of lidded cementation crucibles at Zwickau in Germany.[107] These large crucibles were capable of producing c.20 kg of brass.[108] There are traces of slag and pieces of metal on the interior. Their irregular composition suggests that this was a lower temperature, not entirely liquid, process.[109] The crucible lids had small holes which were blocked with clay plugs near the end of the process presumably to maximize zinc absorption in the final stages.[110] Triangular crucibles were then used to melt the brass for casting.[111] 16th-century technical writers such as Biringuccio, Ercker and Agricola described a variety of cementation brass making techniques and came closer to understanding the true nature of the process noting that copper became heavier as it changed to brass and that it became more golden as additional calamine was added.[112] Zinc metal was also becoming more commonplace. By 1513 metallic zinc ingots from India and China were arriving in London and pellets of zinc condensed in furnace flues at the Rammelsberg in Germany were exploited for cementation brass making from around 1550.[113] Eventually it was discovered that metallic zinc could be alloyed with copper to make brass, a process known as speltering,[114] and by 1657 the German chemist Johann Glauber had recognized that calamine was "nothing else but unmeltable zinc" and that zinc was a "half ripe metal".[115] However some earlier high zinc, low iron brasses such as the 1530 Wightman brass memorial plaque from England may have been made by alloying copper with zinc and include traces of cadmium similar to those found in some zinc ingots from China.[114] However, the cementation process was not abandoned, and as late as the early 19th century there are descriptions of solid-state cementation in a domed furnace at around 900–950 °C and lasting up to 10 hours.[116] The European brass industry continued to flourish into the post medieval period buoyed by innovations such as the 16th century introduction of water powered hammers for the production of wares such as pots.[117] By 1559 the Germany city of Aachen alone was capable of producing 300,000 cwt of brass per year.[117] After several false starts during the 16th and 17th centuries the brass industry was also established in England taking advantage of abundant supplies of cheap copper smelted in the new coal fired reverberatory furnace.[118] In 1723 Bristol brass maker Nehemiah Champion patented the use of granulated copper, produced by pouring molten metal into cold water.[119] This increased the surface area of the copper helping it react and zinc contents of up to 33% wt were reported using this new technique.[120] In 1738 Nehemiah's son William Champion patented a technique for the first industrial scale distillation of metallic zinc known as distillation per descencum or "the English process".[121][122] This local zinc was used in speltering and allowed greater control over the zinc content of brass and the production of high-zinc copper alloys which would have been difficult or impossible to produce using cementation, for use in expensive objects such as scientific instruments, clocks, brass buttons and costume jewelry.[123] However Champion continued to use the cheaper calamine cementation method to produce lower-zinc brass[123] and the archaeological remains of bee-hive shaped cementation furnaces have been identified at his works at Warmley.[124] By the mid-to-late 18th century developments in cheaper zinc distillation such as John-Jaques Dony's horizontal furnaces in Belgium and the reduction of tariffs on zinc[125] as well as demand for corrosion-resistant high zinc alloys increased the popularity of speltering and as a result cementation was largely abandoned by the mid-19th century.[126] Brass bed Brass rubbing List of copper alloys ^ Engineering Designer 30(3): 6–9, May–July 2004 ^ Machinery Handbook, New York, Industrial Press, Edition 24, p. 501 ^ Bearings and bearing metals. The Industrial Press. 1921. p. 29. ^ "copper alloy (Scope note)". British Museum. The term copper alloy should be searched for full retrievals on objects made of bronze or brass. This is because bronze and brass have at times been used interchangeably in the old documentation, and copper alloy is the Broad Term of both. In addition, the public may refer to certain collections by their popular name, such as 'The Benin Bronzes' most of which are actually made of brass. ^ "Hand Tools – Non-sparking tools". Canadian Center for Occupational Health and Safety. 1 December 2017. Retrieved 30 April 2022. ^ Walker, Roger. "Mass, Weight, Density or Specific Gravity of Different Metals". Density of Materials. United Kingdom: SImetric.co.uk. Retrieved 9 January 2009. brass – casting, 8400–8700... brass – rolled and drawn, 8430–8730 ^ M. F. Ashby; Kara Johnson (2002). Materials and design: the art and science of material selection in product design. Butterworth-Heinemann. p. 223. ISBN 978-0-7506-5554-5. Retrieved 12 May 2011. ^ Frederick James Camm (1949). Newnes Engineer's Reference Book. George Newnes. p. 594. ^ Copper Development Association. "Pub 117 The Brasses – Properties & Applications" (PDF). Archived from the original (PDF) on 30 October 2012. Retrieved 9 May 2012. ^ "Is Brass Magnetic? What Is Magnetic Brass?". Scrap Metal Junkie. 1 January 2020. Archived from the original on 16 March 2020. Retrieved 19 January 2020. ^ Metals in America's Historic Buildings: Uses and Preservation Treatments. U.S. Department of the Interior, Heritage Conservation and Recreation Service, Technical Preservation Services. 1980. p. 119. ^ Stagnation Time, Composition, pH, and Orthophosphate Effects on Metal Leaching from Brass. Washington DC: United States Environmental Protection Agency. September 1996. p. 7. EPA/600/R-96/103. ^ News & Alerts – California Dept. of Justice – Office of the Attorney General. 12 October 1999. Archived 26 October 2008 at the Wayback Machine, ^ News & Alerts – California Dept. of Justice – Office of the Attorney General. 27 April 2001. Archived 2008-10-26 at the Wayback Machine ^ San Francisco Superior Court, People v. Ilco Unican Corp., et al. (No. 307102) and Mateel Environmental Justice Foundation v. Ilco Unican Corp., et al. (No. 305765) ^ a b AB 1953 Assembly Bill – Bill Analysis Archived 25 September 2009 at the Wayback Machine. Info.sen.ca.gov. Retrieved on 9 December 2011. ^ Requirements for Low Lead Plumbing Products in California Archived 2 October 2009 at the Wayback Machine, Fact Sheet, Department of Toxic Substances Control, State of California, February 2009 ^ "Corrosion-Resistant (DZR or CR) Brass For Harsh Environments". RuB Inc. 24 May 2016. Retrieved 26 May 2020. ^ "Brass". Ocean Footprint. Retrieved 26 May 2020. ^ "Specifications" (PDF). Metal Alloys Corporation. Archived (PDF) from the original on 9 October 2022. Retrieved 6 January 2021. ^ "Red Brass/Gunmetals". Copper.org. Retrieved 26 May 2020. ^ "Gunmetal | metallurgy". Encyclopædia Britannica. Retrieved 26 May 2020. ^ "What is Naval Brass?". National Bronze Manufacturing. 17 May 2013. Retrieved 26 May 2020. ^ Bell, Terence. "Here's Why Alloys Can Change the Properties of Brass". ThoughtCo. Retrieved 28 January 2021. ^ "Copper in the Arts Magazine – August 2007: The Art of Brass Instruments". Copper.org. Retrieved 26 May 2020. ^ a b "EPA registers copper-containing alloy products" Archived 29 April 2015 at the Wayback Machine, May 2008 ^ a b c Michel, James H.; Moran, Wilton; Michels, Harold; Estelle, Adam A. (20 June 2011). "Antimicrobial copper displaces stainless steel, germs for medical applications: Alloys have natural germ-killing properties". Tube and Pipe Journal. ^ a b Noyce, J. O.; Michels, H.; Keevil, C. W. (2006). "Potential use of copper surfaces to reduce survival of epidemic methicillin-resistant Staphylococcus aureus in the healthcare environment" (PDF). Journal of Hospital Infection. 63 (3): 289–297. doi:10.1016/j.jhin.2005.12.008. PMID 16650507. Archived from the original (PDF) on 17 January 2012. ^ Schmidt, MG (2011). "Copper surfaces in the ICU reduced the relative risk of acquiring an infection while hospitalized". BMC Proceedings. 5 (Suppl 6): O53. doi:10.1186/1753-6561-5-S6-O53. PMC 3239467. ^ "TouchSurfaces Clinical Trials: Home". coppertouchsurfaces.org. ^ "355 Copper Alloys Now Approved by EPA as Antimicrobial". Appliance Magazine. 28 June 2011. Archived from the original on 18 July 2011. Retrieved 23 August 2011. ^ Kuhn, Phyllis J. (1983). "Doorknobs: A Source of Nosocomial Infection?" Archived 16 February 2012 at the Wayback Machine Diagnostic Medicine ^ Espírito Santo, Christopher; Taudte, Nadine; Nies, Dietrich H.; and Grass, Gregor (2007). "Contribution of copper ion resistance to survival of Escherichia coli on metallic copper surfaces". Applied and Environmental Microbiology. 74 (4): 977–86. doi:10.1128/AEM.01938-07. PMC 2258564. PMID 18156321. ^ Santo, C. E.; Lam, E. W.; Elowsky, C. G.; Quaranta, D.; Domaille, D. W.; Chang, C. J.; Grass, G. (2010). "Bacterial Killing by Dry Metallic Copper Surfaces". Applied and Environmental Microbiology. 77 (3): 794–802. doi:10.1128/AEM.01599-10. PMC 3028699. PMID 21148701. ^ Scott, David A. (2002). Copper and Bronze in Art: Corrosion, Colorants, Conservation. Getty Publications. ISBN 9780892366385. ^ Bradley, A. J.; Thewlis, J. (1 October 1926). "The Structure of γ-Brass". Proceedings of the Royal Society. 112 (762): 678–692. Bibcode:1926RSPSA.112..678B. doi:10.1098/rspa.1926.0134. ^ Simons, E. N. (1970). A Dictionary of Alloys, Cornell University ^ Joseph R. Davis (1 January 2001). Copper and Copper Alloys. ASM International. p. 7. ISBN 978-0-87170-726-0. ^ "Aluminum Brass Arsenical, UNS C68700". MatWeb. Retrieved 18 October 2023. ^ a b "70/30 Arsinical Brass Alloy 259, UNS-C26130". Austral Wright Metals. 2021. Archived from the original on 8 June 2023. Retrieved 18 October 2023. ^ "Doehler-Jarvis Company Collection, MSS-202". ^ Woldman's Engineering Alloys, 9th Edition 1936, American Society for Metals, ISBN 978-0-87170-691-1 ^ a b c d "Brass Product Guide". ^ "The Presidential Dollars". Copper Development Association. April 2007. ^ "464 Naval Brass (Tobin Bronze)". Kormax Engineering Supplies. Archived from the original on 17 August 2020. Retrieved 4 December 2017. ^ "C48500 Naval Brass "High Leaded"". Aviva Metals. 2023. Archived from the original on 28 November 2022. Retrieved 18 October 2023. ^ National Pollutant Inventory – Copper and compounds fact sheet Archived 2 March 2008 at the Wayback Machine. Npi.gov.au. Retrieved on 9 December 2011. ^ a b "C23000 Copper Alloys (Red Brass, C230) Material Property Data Sheet". Archived from the original on 30 March 2010. Retrieved 26 August 2010. ^ Ammen, C. W. (2000). Metalcasting. McGraw–Hill Professional. p. 133. ISBN 978-0-07-134246-9. ^ Jeff Pope (23 February 2009). "Plumbing problems may continue to grow". Las Vegas Sun. Retrieved 9 July 2011. ... Red brass typically has 5 percent to 10 percent zinc ... ^ Surveying Yachts and Small Craft. Adlard Coles. 2011. p. 125. ISBN 9781408114032. Beware of through hull fittings and tailpipes, or any other component in the assembly, made of TONVAL. This is basically brass and totally unsuitable for use below the waterline due to its tendency to dezincify and disintegrate ^ Print Layout 1 Archived 8 August 2007 at the Wayback Machine. (PDF) . Retrieved on 9 December 2011. ^ Thornton, C. P. (2007) "Of brass and bronze in prehistoric southwest Asia" Archived 24 September 2015 at the Wayback Machine in La Niece, S. Hook, D. and Craddock, P.T. (eds.) Metals and mines: Studies in archaeometallurgy London: Archetype Publications. ISBN 1-904982-19-0 ^ de Ruette, M. (1995) "From Contrefei and Speauter to Zinc: The development of the understanding of the nature of zinc and brass in Post Medieval Europe" in Hook, D. R. and Gaimster, D. R. M (eds). Trade and Discovery: The Scientific Study of Artefacts from Post Medieval Europe and Beyond. London: British Museum Occasional Papers 109 ^ Cruden's Complete Concordance p. 55 ^ a b Craddock, P. T. and Eckstein, K (2003) "Production of Brass in Antiquity by Direct Reduction" in Craddock, P. T. and Lang, J. (eds.) Mining and Metal Production Through the Ages. London: British Museum, pp. 226–27 ^ Rehren and Martinon Torres 2008, pp. 170–175 ^ Chen, Hailian (3 December 2018). Zinc for Coin and Brass: Bureaucrats, Merchants, Artisans, and Mining Laborers in Qing China, ca. 1680s–1830s. BRILL. ISBN 978-90-04-38304-3. ^ Humphreys, Henry Noel (1897). The Coin Collector's Manual: Comprising an Historical and Critical Account of the Origin and Progress of Coinage, from the Earliest Period to the Fall of the Roman Empire; with Some Account of the Coinages of Modern Europe, More Especially of Great Brit. Bell. ^ Thornton 2007, pp. 189–201 ^ Zhou Weirong (2001). "The Emergence and Development of Brass Smelting Techniques in China". Bulletin of the Metals Museum of the Japan Institute of Metals. 34: 87–98. Archived from the original on 25 January 2012. ^ a b c Craddock and Eckstein 2003 p. 217 ^ Thornton, C. P. and Ehlers, C. B. (2003) "Early Brass in the ancient Near East", in IAMS Newsletter 23 pp. 27–36 ^ Bayley 1990, p. 8 ^ "orichalc – definition of orichalc in English from the Oxford dictionary". oxforddictionaries.com. Archived from the original on 9 January 2015. ^ Rehren and Martinon Torres 2008, p. 169 ^ Craddock, P. T. (1978). "The Composition of Copper Alloys used by the Greek, Etruscan and Roman Civilisations: 3 The Origins and Early Use of Brass". Journal of Archaeological Science. 5: 1–16 (8). doi:10.1016/0305-4403(78)90015-8. ^ Pliny the Elder Historia Naturalis XXXIV 2 ^ "Atlantis' Legendary Metal Found in Shipwreck". DNews. 10 May 2017. Archived from the original on 17 May 2016. Retrieved 9 January 2015. ^ Jessica E. Saraceni (7 January 2015). "Unusual Metal Recovered from Ancient Greek Shipwreck – Archaeology Magazine". archaeology.org. ^ Craddock, P. T.; Cowell, M.; Stead, I. (2004). "Britain's first brass". Antiquaries Journal. 84: 339–46. doi:10.1017/S000358150004587X. S2CID 163717910. ^ Montero-Ruis, I. and Perea, A. (2007). "Brasses in the early metallurgy of the Iberian Peninsula". In La Niece, S., Hook, D., and Craddock, P. T. (eds.). Metals and mines: Studies in archaeometallurgy. London: Archetype, pp. 136–40 ^ Craddock and Eckstein 2003, pp. 216–7 ^ Craddock and Eckstein 2003, p. 217 ^ Bayley 1990, p. 9 ^ Craddock and Eckstein 2003, pp. 222–224. Bayley 1990, p. 10. ^ Craddock, P. T., Burnett, A., and Preston, K. (1980). "Hellenistic copper-based coinage and the origins of brass". In Oddy, W. A. (ed.). Scientific Studies in Numismatics. British Museum Occasional Papers 18 pp. 53–64 ^ a b Caley, E. R. (1964). Orichalcum and Related Ancient Alloys. New York; American Numismatic Society ^ Bayley 1990, p. 21 ^ Ponting, M. (2002). "Roman Military Copper Alloy Artefacts from Israel: Questions of Organisation and Ethnicity" (PDF). Archaeometry. 44 (4): 555–571. Bibcode:2002Archa..44..555P. doi:10.1111/1475-4754.t01-1-00086. ^ Ponting, M. (2002). "Keeping up with the Roman Romanisation and Copper Alloys in First Revolt Palestine" (PDF). IAMS. 22: 3–6. Archived (PDF) from the original on 9 October 2022. ^ a b Rehren, T (1999). "Small Size, Large Scale Roman Brass Production in Germania Inferior" (PDF). Journal of Archaeological Science. 26 (8): 1083–1087. Bibcode:1999JArSc..26.1083R. doi:10.1006/jasc.1999.0402. Archived from the original (PDF) on 10 December 2004. Retrieved 12 May 2011. ^ Bachmann, H. (1976). "Crucibles from a Roman Settlement in Germany". Journal of the Historical Metallurgy Society. 10 (1): 34–5. ^ a b c Rehren and Martinon Torres 2008, pp. 170–71 ^ Bayley 1990 ^ a b Craddock and Eckstein 2003, p. 224 ^ Dungworth, D (1996). "Caley's 'Zinc Decline' reconsidered". Numismatic Chronicle. 156: 228–234. ^ Craddock 1978, p. 14 ^ Craddock, P. T., La Niece, S. C., and Hook, D. (1990). "Brass in the Medieval Islamic World". In Craddock, P. T. (ed.), 2000 Years of Zinc and Brass. London: British Museum, p. 73 ^ Ponting, M. (1999). "East Meets West in Post-Classical Bet'shan'". Journal of Archaeological Science. 26 (10): 1311–1321. doi:10.1006/jasc.1998.0373. ^ Bayley 1990, p. 22 ^ Eremin, Katherine; Graham-Campbell, James; Wilthew, Paul (2002). Biro, K.T; Eremin, K. (eds.). Analysis of Copper alloy artefacts from Pagan Norse Graves in Scotland. Proceedings of the 31st International Symposium on Archaeometry. BAR International Series. Oxford: Archaeopress. pp. 342–349. ^ Gilmore, G. R. and Metcalf, D. M. (1980). "The alloy of the Northumbrian coinage in the mid-ninth century". In Metcalf, D. and Oddy, W. Metallurgy in Numismatics 1 pp. 83–98 ^ Day 1990, pp. 123–150 ^ Day 1990, pp. 124–133 ^ Noel Stratford, pp. 232, 245, in Zarnecki, George and others; English Romanesque Art, 1066–1200, 1984, Arts Council of Great Britain, ISBN 0728703866 ^ Craddock and Eckstein 2003, pp. 224–25 ^ Craddock et al. 1990, 78 ^ Craddock et al. 1990, pp. 73–76 ^ Craddock et al. 1990, p. 75 ^ Craddock et al. 1990, p. 76 ^ Rehren, T (1999) "The same... but different: A juxtaposition of Roman and Medieval brass making in Europe" in Young, S. M. M. (ed.) Metals in antiquity Oxford: Archaeopress pp. 252–257 ^ Craddock and Eckstein 2003, 226 ^ Rehren and Martinon Torres 2008, pp. 176–178 ^ Rehren and Martinon Torres 2008, pp. 173–175 ^ "The Ife Head" Archived 20 September 2016 at the Wayback Machine on the British Museum collection database. Accessed 26 May 2014 ^ Martinon Torres and Rehren 2002, pp. 95–111 ^ Martinon Torres and Rehren 2002, pp. 105–06 ^ Martinon Torres and Rehren 2002, p. 103 ^ Martinon Torres and Rehren 2002, p. 104 ^ Martinon Torres and Rehren 2002, p. 100 ^ Martinon Torres and Rehren 2008, 181–82, de Ruette 1995 ^ de Ruette 1995, 198 ^ a b Craddock and Eckstein 2003, 228 ^ de Ruette 1995, 198–9 ^ Craddock and Eckstein 2003, 226–27. ^ a b Day 1990, p. 131 ^ Day 1991, pp. 135–144 ^ Day 1990, p. 138 ^ Craddock and Eckstein 2003, p. 227 ^ Day 1991, pp. 179–181 ^ Dungworth, D. & White, H. (2007). "Scientific examination of zinc-distillation remains from Warmley, Bristol". Historical Metallurgy. 41: 77–83. ^ a b Day 1991, p. 183 ^ Day, J. (1988). "The Bristol Brass Industry: Furnaces and their associated remains". Journal of Historical Metallurgy. 22 (1): 24. ^ Day 1991, pp. 186–189 ^ Day 1991, pp. 192–93, Craddock and Eckstein 2003, p. 228 Bayley, J. (1990). "The Production of Brass in Antiquity with Particular Reference to Roman Britain". In Craddock, P. T. (ed.). 2000 Years of Zinc and Brass. London: British Museum. Craddock, P. T. and Eckstein, K (2003). "Production of Brass in Antiquity by Direct Reduction". In Craddock, P. T. and Lang, J. (eds.). Mining and Metal Production Through the Ages. London: British Museum. Day, J. (1990). "Brass and Zinc in Europe from the Middle Ages until the 19th century". In Craddock, P. T. (ed.). 2000 Years of Zinc and Brass. London: British Museum. Day, J. (1991). "Copper, Zinc and Brass Production". In Day, J. and Tylecote, R. F. (eds.). The Industrial Revolution in Metals. London: The Institute of Metals. Martinon Torres, M.; Rehren, T. (2002). "Agricola and Zwickau: theory and practice of Renaissance brass production in SE Germany". Historical Metallurgy. 36 (2): 95–111. Rehren, T. and Martinon Torres, M. (2008) "Naturam ars imitate: European brassmaking between craft and science". In Martinon-Torres, M. and Rehren, T. (eds.). Archaeology, History and Science: Integrating Approaches to Ancient Material. Left Coast Press. Look up brass in Wiktionary, the free dictionary. Wikimedia Commons has media related to Brass. Retrieved from "