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Beryllium Critical Material Assessment

Beryllium has been designated as a critical material (European Commission Critical Raw Materials for the EU - Report of the Ad-hoc Working Group on defining critical raw materials, 2010). (Attachment 1) Raw materials are designated as being “critical” when the risks for supply shortage and their impacts on the economy are higher compared to other raw materials. According to the Commission paper, “*The most significant threats originate from perceived risks associated with the use of beryllium in electronic products. EU regulatory fears and NGO propagated “banning” of the use of materials containing beryllium lead to unwarranted attempts to find substitutes that do not offer the same qualities with respect to performance, sustainability and environmental protection. The data that authorities rely on is not current and does not reflect the most recent scientific studies. In general, authorities are reluctant to break from the past and are not open to new scientific studies even if they are conducted in accord with OECD guidelines or originate from proven workplace strategies. Because the cost of beryllium is high compared with that of other materials, it is used in applications in which its properties are crucial. In some applications, certain metal matrix or organic composites, high-strength grades of aluminium, pyrolytic graphite, silicon carbide, steel, or titanium may be substituted for beryllium metal or beryllium composites. Copper alloys containing nickel and silicon, tin, titanium, or other alloying elements or phosphor bronze alloys (copper-tin-phosphorus) may be substituted for beryllium-copper alloys, but these substitutions can result in substantially reduced performance.”* The inability to replace beryllium is also reflected in the United States Geological report on Beryllium (Attachment 2)

The concept of strategic importance is also reflected in the assessment document developed by the French Ministry of Defence “Chapter 4 - Resources Geostrategic Prospective for the Next Thirty Years." That document states, *“It is possible that imbalances between supply and demand could result in inter-state tensions which may potentially deteriorate into conflict. This tendency could be aggravated by a lack of substitutions for certain minerals like beryllium and platinum metals, and weak investment in mining for them. Given the time frame between prospecting and commercialization, it would be difficult to respond to a sharp rise in demand.”*

Beryllium has also been determined to be the only critical metal by the United States Department of Defense (Office of the Under Secretary of Defense Acquisition, Report of Meeting Department of Defense The Strategic Materials Protection Board, December 12, 2008) (Report of Meeting Department of Defense Strategic Materials}and is based on the fact that *“High purity beryllium is essential for important defense systems and unique in the function it performs, and that full involvement and support is necessary to sustain and shape the strategic direction of the market such that there must not be a significant and unacceptable risk of supply disruption.”* The report further states, “*High purity beryllium is both a strategic and a critical material. High purity beryllium is essential for important defense systems, and it is unique in the function it performs. High purity beryllium possesses unique properties that make it indispensable in many of today’s critical U.S. defense systems, including sensors, missiles and satellites, avionics, and nuclear weapons.”*

The above assessments reflect the strategic and critical nature on the use and supply of beryllium and beryllium alloys within France, and the EEA. Attachments 3 and 4 clearly validate the empirical studies described above.

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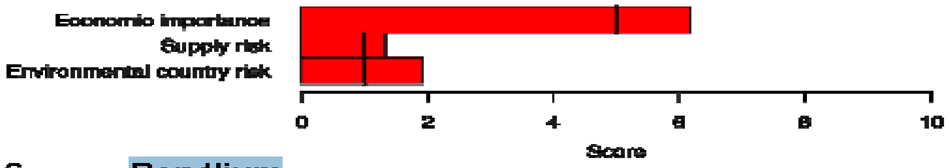
Attachment 1

Annex V to the Report of the Ad-hoc Working
Group on defining critical raw materials

The *ad-hoc* Working Group is a sub-group of the Raw Materials Supply Group and is chaired by the European Commission



6 Beryllium

6.1 Introduction

Beryllium (Be, atomic number 4) is a silvery-white shining, hard and brittle light metal, which is highly toxic[32]. Its mechanical and thermal properties relative to its low density is superior to those of all other materials. Formerly, the metal was also called glucinium.[33]

Beryllium is a relatively rare element of the earths crust, as it is inferior to 6 ppm, which means it is number 32 in the abundance order[34]. It is a sub-product from feldspar deposits, and Brazil has the largest beryl mineral reserves in the world. Beryllium is mostly extracted from beryl[34].

6.2 Basic Supply & Demand Statistics

As noted above, with an abundance of 6ppm in the earth's crust, beryllium is a rare element. Though, it occurs concentrated in some minerals, predominantly in the minerals beryl and bertrandite.[2] World resources are estimated at 80,000 tons, of which 65% are located in the United States[35]. Because of the military relevance of beryllium, information on reserves and applications is limited.

	Reserves (in tonnes; 2010)	Production (in tonnes; 2009)	
USA	NA	120	85.1%
China	NA	20	14.2%
Mozambique	NA	1	0.7%
Others	NA	small	>0.5%
Total	**0**	**141**	

32 Römpp Online: *Beryllium*. Georg Thieme Verlag, Stuttgart, 2002

33 Ullmann's Encyclopedia of Chemical Technology: *Beryllium and Beryllium Compounds*. Wiley-VCH Verlag, Weinheim, 2006

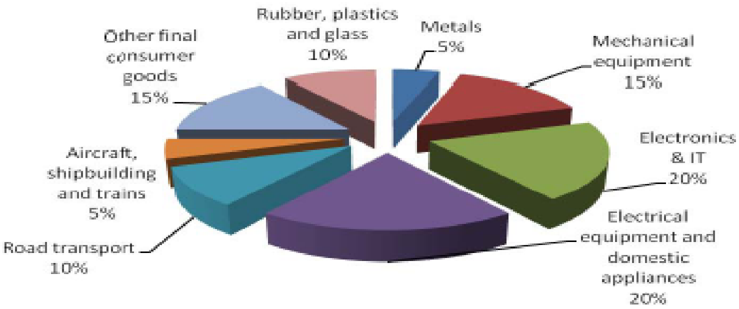
34 Pereira C. A., Renata (2004). Desenvolvimento de processo para obtenção de cloreto de berílio a partir do berilo mineral; Belo Horizonte

35 USGS Mineral Commodity Summaries 2010: *Beryllium*

Source: USGS 2010; ComExt (CN 8112 12 00)

Demand is limited by cost. Beryllium is not mined within the EEA. However, given estimated global reserve levels and annual usage, it appears that there is a abundant supply in the USA of the ores from which all Beryllium based materials are produced, reserves which could satisfy EU and world demand for over 100 years at current usage rates.

6.3 Economic Importance



Beryllium metal is used in discrete components within certain specialised, high technology equipment where low weight and high rigidity are important qualities (e.g. in aerospace equipment). As such, most beryllium is used for military purposes. Due to its high price and its toxicity, beryllium is only used in small quantities in the civilian sector.

- Approximately 40% of beryllium is used for Electronic equipment and domestic appliances and Electronics and IT - due to their favorable electric conductivity[36].
- Construction: Beryllium alloys are used for structural parts that have to be light and that are exposed to great forces (for example in the aircraft industry)[37], where lightweight structures, combined with rigid and good thermal properties are vital.

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[36] USGS Mineral Commodity Summaries 2010: *Beryllium*

[37] Römpp Online: *Beryllium* . Georg Thieme Verlag, Stuttgart, 2002

- Other applications where beryllium is used are[38,39]:
  - CT scanners and X-ray machines: Beryllium metal is used for x-ray transparent windows.
  - Ceramics: Beryllium oxide (BeO) is used for special ceramics.
  - Physical instruments: Beryllium has properties that make it interesting for a variety of physical instruments (e.g. neutron monochromators).
  - Joint European Torus Reactor and International Thermonuclear reactor: Important role in European efforts to develop controlled nuclear fusion energysystems, as a possible future alternative to the burning of fossil fuel.

6.4 Resource Efficiency: Recycling & Substitution

Substitution

Due to its high costs beryllium is only used in applications where its properties are crucial. Therefore it is hard to substitute. Nevertheless certain metal matrix or organic composites, high-strength grades of aluminum, pyrolytic graphite, silicon carbide, steel, or titanium may be substituted for beryllium metal or beryllium composites. There are some more possible substitutes in specific alloys, but often combined with a loss in performance.[42]

38 Römpp Online: *Beryllium.* Georg Thieme Verlag, Stuttgart, 2002
39 Ullmann’s Encyclopedia of Chemical Technology: *Beryllium and Beryllium Compounds*. Wiley-VCH Verlag, Weinheim, 2006
40 Civic, 2009
41 USGS Mineral Commodity Summaries 2010: *Beryllium*
42 USGS Mineral Commodity Summaries 2010: *Beryllium*

6.5 Specific issues

The most significant threats originate from perceived risks associated with the use of beryllium in electronic products. EU regulatory fears and NGO propagated “banning” of the use of materials containing beryllium lead to unwarranted attempts to find substitutes that do not offer the same qualities with respect to performance, sustainability and environmental protection. The data that authorities rely on is not current and does not reflect the most recent scientific studies. In general, authorities are reluctant to break from the past and are not open to new scientific studies even if they are conducted in accord with OECD guidelines or originate from proven workplace strategies. Algeria and South Africa resort to non-automatic export licensing to limit the quantities of waste and scrap exported. Russia applies a 6.5% export tax on waste and scrap.

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Attachment 2
2010 USGS Report on Beryllium
Click on Page to view entire report

BERYLLIUM

(Data in metric tons of beryllium content unless otherwise noted)

Domestic Production and Use: One company in Utah mined bertrandite ore, which it converted, along with imported beryl and beryl from the National Defense Stockpile, into beryllium hydroxide. Some of the beryllium hydroxide was shipped to the company's plant in Ohio, where it was converted into beryllium-copper master alloy, metal, and/or oxide—some of which was sold. Estimated beryllium consumption of 120 tons was valued at about $30 million, based on the estimated unit value for beryllium in imported beryllium-copper master alloy. Based on sales revenues, more than one-half of beryllium use was estimated to be in computer and telecommunications products, and the remainder was used in aerospace and defense applications, appliances, automotive electronics, industrial components, and other applications.

Salient Statistics—United States:	2005	2006	2007	2008	2009[e]
Production, mine shipments[e]	110	155	152	176	120
Imports for consumption[1]	93	62	72	70	20
Exports[2]	201	135	101	112	30
Government stockpile releases[3]	79	158	27	39	11
Consumption:					
Apparent[4]	84	226	100	212	120
Reported, ore	160	180	190	220	140
Unit value, average annual, beryllium-copper master alloy, dollars per pound contained beryllium[5]	99	128	144	159	120
Stocks, ore, consumer, yearend	35	50	100	61	60
Net import reliance[6] as a percentage of apparent consumption	E	[7]31	E	17	2

Recycling: Beryllium was recycled mostly from new scrap generated during the manufacture of beryllium products. Detailed data on the quantities of beryllium recycled are not available, but may represent as much as 10% of apparent consumption.

Import Sources (2005-08):[1] Kazakhstan, 58%; United Kingdom, 11%; Kenya, 8%; Ireland, 6%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations 12-31-09
Beryllium ores and concentrates	2617.90.0030	Free.
Beryllium oxide and hydroxide	2825.90.1000	3.7% ad val.
Beryllium-copper master alloy	7405.00.6030	Free.
Beryllium:		
Unwrought, including powders	8112.12.0000	8.5% ad val.
Waste and scrap	8112.13.0000	Free.
Other	8112.19.0000	5.5% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The Defense Logistics Agency, U.S. Department of Defense, had a goal of retaining 45 tons of hot-pressed beryllium powder in the National Defense Stockpile. Disposal limits for beryllium materials in the fiscal year 2010 Annual Materials Plan are as follows: beryl ore, 1 ton, and beryllium metal, 54 tons of contained beryllium.

Stockpile Status—9-30-09[8]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2009	Disposals FY 2009
Beryl ore (11% BeO)	—	—	[9]36	—
Beryllium-copper master alloy	—	—	[9]11	—
Beryllium metal:				
Hot-pressed powder	132	87	—	1
Vacuum-cast	16	16	36	14

Prepared by Brian W. Jaskula [(703) 648-4908, bjaskula@usgs.gov, fax: (703) 648-7757]

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Attachment 3

Impact of Beryllium on the French Economy

Beryllium is a critical element used in metallic form, or as a critical alloying element in components of such life-saving products such as airbag sensors, fire extinguishing system sprinkler heads, x-ray windows for mammography, medical lasers, landing gear bearings, and weather forecasting satellites. In applications where failure is not an option, there is often no other material that can deliver the performance and reliability demanded of beryllium.

Life would be made extremely difficult if beryllium-dependent applications such as the following examples were not available to Europe, or if the quality and reliability of the end-use products or systems were severely compromised by the unavailability of beryllium:

- CT Scanners that make breast cancer easier to detect at its early, most treatable stages
- Use to produce neutron beam to kill cancer cells
- Pressure sensors on fire fighter air packs
- Enemy-detecting radar and optical targeting systems on military aircraft
- Pacemakers
- Computers and the Internet infrastructure
- Automobile air bag sensors and anti-lock brake systems.
- Corrosion-free electronics housings that protect undersea fiber optic cables

France should not discard the benefits that beryllium brings to end-uses as noted below:

- In flammable gases or liquids environments, ranging from hospital operating theatres to oil and gas drilling rigs, beryllium's non-sparking properties protect people, equipment and resources from the danger of fire or explosion.
- By enabling high-frequency telecommunications, from cell phones to global positioning systems, to radar instruments, to tracking and monitoring systems, beryllium helps keep France secure and military personnel out of harm's way.
- Beryllium is the premier material used to control the intensely hot temperature gas plasma created in the ITER experimental fusion energy reactor, a technology with the promise to create unlimited amounts of clean, affordable energy.
- The high energy physics research work being carried out at the Organisation Europeenne pour la Recherche Nucleaire (Centre Europeenne pour la Recherche Nucleaire / CERN) will be placed in jeopardy.
- Copper beryllium materials are indispensable to the valve systems used to seal leaking oil wells. The recent oil spill disaster at the Macondo Well in the Gulf of Mexico was finally capped using clamps made of copper beryllium because of its incredible strength, resilience to stress and ability to slip over other materials without galling or creating sparks.
- Miniaturisation of electronic products requires the use of strong materials able to cope with higher stresses and operating temperatures. The growth in the use of electrical components in automobiles, computers, and miniature electronics will lead to higher demand for beryllium alloys because beryllium leads to improved energy efficiency, the potential to lower waste generation resulting from minimization and reduced raw material consumption.

France needs to be a part of this new age economy and not be an exporter of jobs, manufacturing and technology.

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Attachment 4

BERYLLIUM METAL IN THE EUROPEAN ECONOMIC AREA (EEA)

USES OF BERYLLIUM METAL

Beryllium metal is used to produce discrete components used within certain specialized, high technology equipment, where it remains environmentally inert throughout its useful life. Weight is a controlling factor when launching vehicles into space, and lightweight structures are vital. At the same time, however, it is imperative that such structures are rigid, and not subject to distortions or resonant vibrations which might reduce the accuracy of their instrumentation. Beryllium metal is the optimal material for these purposes, principally because of its high specific rigidity. It also has attractive thermal properties which reduce thermal distortions, both at the high temperatures experienced during launch and descent, and also at the sub-zero temperatures of space. It is an isotropic material, meaning it has uniform properties in all directions, which increases freedom of design. Its formability, machinability and joinability allow relative ease of manufacture of complex structures. No other material offers this useful combination of properties. These advantages are also of great value for the manufacture of telescope mirrors for use on spacecraft used for earth monitoring, weather satellites, or for deep space exploration. The segments of such mirrors can be well over 1 m in diameter, and need to incorporate thick section web designs in order to maintain a distortion free surface, which would often be too heavy if made in the traditional glass design. Furthermore, the isotropy and thermal properties of beryllium serve to minimise distortions which would otherwise reduce the resolution of the mirror. Additional advantages of beryllium for this application are its ability to be machined to form complex curved surfaces, its ability to be highly polished and its ability to accept coatings for enhanced reflectivity at various wavelengths. So too, the structural components made of beryllium offer comparable advantages in combination with the optical components. The use of beryllium made possible the Hubble Telescope and the building of the James Webb Space Telescope which is expected to launch in 2012. Beryllium was selected as the mirror technology for its demonstrated track record operating at cryogenic temperatures on space based telescopes. The value to society, the advances in science and the ability to obtain answers to fundamental questions about our universe is immeasurable.

Beryllium plays an important role in European efforts to develop controlled nuclear fusion energy systems, as a possible future alternative to the burning of fossil fuels, and is expected to continue to be of importance in the industrial development of such systems. Beryllium is crucial to the Joint European Torus (JET) Reactor and the International Thermonuclear Reactor (ITER), which is located at Cadarache, France, with many major systems manufactured in France and other EEA nations.

Europe plays a leading role in efforts to understand the fundamental nature of matter, using evidence generated by the ultra-high speed collision of sub-atomic particles, to release still smaller particles and attendant radiation. Such work is carried out at the Organisation Europeenne pour la Recherché Nucleaire (Centre Europeenne pour la Recherché Nucleaire/CERN) in Switzerland, a world leader in this research, and in several similar research facilities in Japan, UK, Korea and other nations. Because of its favourable nuclear properties, beryllium is often used to manufacture components for use in particle generation and detection equipment.

Both lives and money are being saved with isotopes produced by the High Flux Isotope Reactor at Oak Ridge National Laboratory. Beryllium is becoming the material of choice as the target material and its use is projected to save over five million dollars over the projected life of the reactor. The HFIR produces californium-252 used extensively in medical and industrial applications: cancer therapy, neutron radiography, elemental analysis, and as a start-up source for nuclear reactors. Californium-252 is effective in treating certain cervical and brain cancers that are otherwise incurable. Using it improves the 5 year survival rate from 12% to 54%. With this kind of progress in mind, researchers are investigating its applications to other cancers. Other medical isotopes produced at the HFIR include potassium-43 (for evaluation of coronary heart disease), palladium-103 (for treatment of prostate cancer), gadolinium-153 (for measuring bone loss in women), and tungsten-188 (associated with the treatment of cancer and arthritis). Thousands of patients undergo clinical evaluation or treatment using these and other isotopes each year

Beryllium is an integral material in much of the diagnostic equipment physicians rely on to accurately treat patients. The metal is used in virtually all CT scanners and X-ray machines. Specifically, beryllium is a key component of the next generation X-ray machines created for mammography, enabling lower dose CT Scans, with significantly finer tumor resolution, thus making breast cancer easier to detect at its early, most treatable stages. Specifically, beryllium is highly transparent to X-rays. For that reason it is used as a window material in X-ray emission and detection equipment. Such windows need to be made from extremely thin foil, to further enhance transparency, but also need to be strong enough to withstand external atmospheric pressure against the vacuum inside the equipment. The X-ray windows must also be bonded into their metallic housing rims by high temperature brazing, to provide a seal that can withstand the heat generated by the X-ray source, while maintaining a secure vacuum seal. The combination of properties offered by beryllium makes the metal uniquely suitable for this application.

Beryllium is also used in the experimental trials of Boron Neutron Capture Therapy (BNCT) for the treatment of cancer, because of its thermal properties and neutron yield. BNCT is an experimental form of radiotherapy using a neutron beam that interacts with boron injected into a patient. Beryllium targets can produce a neutron beam with properties and intensity such that the thermal neutrons undergo reaction with the boron-10 nuclei, forming a compound nuclide (excited boron-11) which quickly disintegrates to form lithium-7 plus an alpha particle. Both the alpha particle and the lithium ion produce closely spaced ionizations in the immediate vicinity of the reaction, with a range of approximately 5-9 micrometers, or roughly the thickness of one cell diameter. This technique is advantageous since the radiation damage occurs over a short range and thus normal tissues can be spared.

Modern defense systems rely heavily on sophisticated electronic equipment for navigation as well as for target acquisition and firing mechanisms. Beryllium metal is used in the targeting systems used on the European Tornado and Eurofighter aircraft. It is also used for the targeting mirrors on the French Leclerc, German Leopard and UK Challenger main battle tanks.

Beryllium is also used for detection systems that are used for national security applications at airports, ports and borders to screen against explosives and other materials. It is used in flow sensing technology for chemical processes and down-hole analytical equipment for the oil/gas industries. Beryllium has an extensive heritage in infrared and electro-optical applications. The scanning rates of optical components increase when high-stiffness, low mass materials are used. Optics maintain their integrity over extended periods of time when made of materials that exhibit superior dimensional and temporal stability. High performance laser scanners using small beryllium mirrors are incorporated into precision bar code readers such as those used at airports throughout the world.

USES OF BERYLLIUM CONTAINING ALLOYS

The largest use of beryllium is as an alloying element in copper beryllium alloys that are used to make components, which are inert, stable, and do not give off emissions during use. Beryllium-containing alloys are only used in critical locations in products where they provide a design solution based upon reliability, miniaturization, improved energy management and /or extending the service life. Almost all high reliability electronic connectors incorporate copper based terminals to carry the current or signal, because of the conductivity provided by this metal. Metals and alloys strengthened by cold working tend to suffer marked strength reduction and weakening after prolonged exposure to elevated temperatures because heat “relaxes” the strengthening stresses that were put into the metal by the cold working. This is obviously a matter of concern for the connectors that must operate in hot environments, such as in automobile engine and transmission control systems, aircraft applications and in many household appliances such as coffee makers, washing machines and dishwashers. Copper beryllium alloys are far less susceptible to these adverse effects and offer the connector designer the highest combinations of strength, conductivity, elevated temperature stress relaxation resistance and formability of any of the copper alloys.

For critical connections in circuitry where the highest performance and the greatest reliability are of paramount importance such as in medical device electrical connections, the superior properties of copper beryllium alloys are considered to be vital and unmatched. Safety devices made with beryllium-containing materials can make the difference between life or death, serious injury or walking away from a vehicle crash. The lifesaving technology incorporated in automotive air bags relies upon beryllium-containing alloys to allow them to function in a fraction of a second. Anti-lock brakes trust beryllium-containing alloys to transmit electrical signals through terminal connections when microseconds make a critical difference in preventing a collision. Beryllium containing alloy washers hold back the water in sprinkler systems in buildings for decades because of their corrosion resistance and long-term reliability in protecting people and property in the event of a fire.

Copper beryllium alloys offer designers the flexibility to employ smaller sized terminals and contacts to obtain the required reliability and performance. Electromechanical relays, switches, or connectors frequently require a design that has a single cantilevered beam section, anchored by insert moulding into a plastic housing. A wide selection of copper alloys is available to designers fo use in such applications, and by comparing the mechanical and physical properties of each alloy, the designer will determine the contact size and subsequent price for each candidate alloy. The combination of strength, conductivity and resistance to elevated temperatures provided by copper beryllium alloys allows a designer to use smaller section terminal beams than is possible with other candidate alloys. In addition to reducing the weight of metal required, the use of copper beryllium alloys allows the use of less plastic in the housing which results in using less total energy, and less cost for end-of-life disposal. A significant material weight savings can be achieved by using copper beryllium alloy compared to other common connector alloys. This weight reduction along with superior performance characteristics and reliability are the primary reasons why copper beryllium alloys are frequently selected.

The bushings and bearings in aircraft landing gear are subject to very great compressive and wear forces, and to a wide range of temperatures and corrosive atmospheres. Clearly, their reliable performance under these conditions is paramount to the safe landing of the aircraft, and the choice of material for their manufacture is critical. Copper beryllium alloys offers an attractive combination of properties, including reduced weight, wear resistance and anti-galling properties to prevent cold welding when rotating against dissimilar metal shafts and rotating components. Many aircraft, especially large airliners, use copper beryllium alloy bushings and bearings in their landing gear. On a typical commercial aircraft, the use of copper beryllium alloy bearings reduces the total weight of bearings on the plane by about 950 pounds (431 kg) and reduces the total weight of shafts or pins on the plane by about 3000 pounds (1361 kg). It has been estimated that the use of copper beryllium alloy bearings on commercial aircraft reduces fuel consumption by 24 billion litres per year and reduces associated carbon dioxide emissions by over 11 million metric ton per year. Copper beryllium alloys are selected by many designers for aircraft pitot tubes. The pitot-static system of instruments is a system used in aviation to determine an aircraft's airspeed, altitude, and altitude trend. Precision investment, or lost wax, casting is used to form the very specific aerodynamically shaped copper beryllium alloy shapes that pitot-static systems use to develop the pressure differential between the moving airflow past an aircraft and the static pressure as the prime reference source. The critical flight instruments this controls include air data computers, flight data recorders, altitude encoders, cabin pressurization controllers, and various airspeed switches. Errors in pitot-static system readings can be extremely dangerous and can lead to plane crashes, since the information obtained from the pitot static system, are critical to maintain flight control. Recent civil aviation disasters have been linked to inappropriate selection and design of pitot tubes, because a specific hazard to aviators arises from blocking of the pitot tubes by ice formation. Copper beryllium alloys offer distinct advantages over alternative high strength materials in that it provides superior high definition casting properties to allow the manufacture of pitot tubes with the benefit of a high thermal conductivity to allow effective melting of any ice formed in the pitot tubes. Copper beryllium alloys are also used at the instrument side of the pitot-static system, in the form of thin sheet that is stamped into the diaphragm of altimeters and other pressure reading devices.

Directional drilling for oil and gas requires electronic equipment units to be located behind the drilling tool for drill guidance and to sense drilling forces, pressures etc. The lengths of tube at the end of the drill string need to have sufficient flexibility to permit changes in the direction of the drilling tool. The materials chosen for these applications require various combinations of favourable properties and must be entirely reliable, operating thousands of meters from the drill head, under high stresses, at elevated temperatures and in corrosive geological environments. Down-hole failure is extremely expensive. Copper beryllium has found extensive use in such applications, with its unique combination of strength, flexibility, conductivity and resistance to wear and to corrosion and non-galling, while remaining essentially non magnetic in order not to interfere with the electronic equipment.

Copper beryllium alloy is used in medical instruments in the form of thin sheets that are stamped and shaped into the diaphragms used in the most sensitive stethoscopes, sphygmomanometers and other pressure reading devices used daily by many medical professionals. The transmission of sound and air pressure waves through the low mass, extremely thin diaphragms, provides sensitivity and responsivity to the instrumentation. High reliability medical electronic instruments, which involve either disposable components, or reusable components subject to frequent sterilization cycles, must have highly reliable electrical connector systems. Examples include endoscopic surgical cauterizing scalpels; connector terminals of EKG and other cardiac systems; nerve stimulation devices etc. Such systems invariably use copper beryllium alloy terminals. The ultra thin connecting wires used to connect heart stimulation devices such as pacemakers and defibrillators are subject to millions of stress reversals during the many years that they are expected to function unfailingly in a human body fulfilling it normal range of motions. Finely drawn, high conductivity copper beryllium alloy wire which is heavily plated with platinum or gold is frequently used to provide the combination of electrical conductivity, with high strength and fatigue resistance.