KERONITE
ADVANCED SURFACE TECHNOLOGY

FREQUENTLY ASKED QUESTIONS

GENERAL

Q What is Keronite?
A Keronite is a unique surface treatment technology for light metal alloys, developed by Keronite Ltd of Cambridge UK. During the Keronite process, a sophisticated electric current is passed through a bath of non-toxic electrolyte solution. This technology, known as plasma electrolytic oxidation (PEO), transforms the surface of the substrate alloy into a dense, hard ceramic which is extremely resistant to corrosion and wear.

Q What substrates can be treated using Keronite technology?
A The Keronite process can be used on a wide range of light metal alloys. The Company has most experience with magnesium, aluminium and titanium alloys. The properties and appearance of the Keronite coating vary in accordance with the alloy used. The Keronite process cannot be used to coat steel, copper, zinc, stainless steel or other ferrous metals.

Q Is Keronite a cost-effective process?
A With high deposition rates, minimal pre- and post-treatment requirements, and no hazardous waste disposal, Keronite technology can prove an extremely cost-effective system solution. Moreover, Keronite improves the durability of components considerably, adding further value for the enduser. Users can often reduce the need for further post treatments which also reduces costs. Since Keronite ceramic contains no heavy metals, the treated components can also be easily recycled.

Q How does the cost of Keronite compare with that of other electrolytic oxidation technologies?
A This will vary from case to case but generally speaking, Keronite will be the most cost-effective of all MAO or PEO processes because its superior performance means that thinner layers can be used. The availability of large scale, automated Keronite facilities further reduces production costs, particularly for high volume applications.

Q Is Keronite available worldwide?
A Keronite equipment has been installed in a number of facilities across Europe, North America and Asia. Please contact info@keronite.com for details of the nearest operating site.

Q Is it possible to have samples coated for testing?
A Yes. There will be a small charge to cover the costs of processing samples. Please contact info@keronite.com for details.

Q What would be the cost of treating a surface area of 1 dm² with Keronite?
A There is no simple answer to this as there are many variables which determine the price: the geometry of the component; the alloy used; the thickness of the Keronite layer; the size of the machine being used; the number of parts being treated; the local labour rates; the jigging requirements; the condition of the parts to be treated; the need for masking; and the location of the Keronite plant. For a realistic quotation for a specific part, please contact info@keronite.com with all the details.

Q Is the technology patented?
A Yes. The basic Keronite technology is covered by patents owned by a subsidiary of Keronite Ltd. New international patents applications are filed every year as the process is developed further.

Q Is the Keronite process being used on an industrial scale?
A The Keronite process is being used across Europe, North America and Asia by a number of experienced surface treatment companies to process production volumes of components for a wide variety of industries. The largest volume applications to date include magnesium sunglasses, magnesium hand tools and aluminium architectural panels for building facades. The company has recently won the first volume production order for automotive pistons.

Q Can I see the Keronite process in operation?
A Yes - please contact info@keronite.com for details of the nearest facility.

Q Can anyone buy a Keronite machine?
A The company no longer sells equipment. It is the policy of Keronite Ltd to identify strategic partners and lease equipment only when there is a proven application. This ensures a low-investment start for our partner and because we retain ownership of the equipment, we work closely with our partners to ensure their Keronite facilities and businesses are successful. This also gives our partners easier access to technical support and process updates. Retaining ownership of the equipment enables Keronite to better control the know-how and prevent it from being copied and used by third parties.

Q What is the cost of a Keronite laboratory machine?
A The company no longer sells laboratory machines for the reasons outlined above.

PROCESS

Q Is any pre-treatment required in preparation for the Keronite process?
A The cleaning process simply involves the degreasing and rinsing of the substrate before the Keronite process in order to preserve the integrity of the electrolyte system. Sometimes, when processing cast magnesium components, it may be necessary to etch to remove any die dressing residues or other contamination.

Q Is the process environmentally-friendly?
A Yes - unlike those used in many conventional coating systems, Keronite proprietary electrolyte solutions contain no chrome or other heavy metals, no ammonia and no acids. The only waste is the spent electrolyte: a non-hazardous alkaline solution containing no heavy metals or other solids and requiring no special treatment prior to disposal.

Q Is the process safe to use?
A Yes - provided that the correct procedures are followed. As with any high power electrical process, the baths must be protected. No acids or corrosive solutions are used. The process generates no noise or odour.

Q Are complicated chemical checks required when operating the Keronite process?
A No - the process is simple to operate and the quality of the electrolyte is easily maintained by monitoring the electrical charge, measured in kilowatt hours.

Q How fast is the Keronite process?
A Keronite on aluminium grows at a rate of around 0.3 to 1 micron per minute, depending on the alloy. On magnesium, the process is even faster: up to as much as 5 microns per minute in certain cases. Because a number of pre- and post-treatment stages can often be eliminated when using Keronite, productivity can be further improved. This varies from application to application, but in most cases components require a simple de-greasing process before the Keronite treatment, and a water rinse before drying afterwards.

Q What factors determine the speed at which the Keronite layer is formed?
A There are a number of factors which determine the speed of deposition including the choice of alloy, the electrolyte used, the power supply, the size of the part, the temperature and control system programming.

Q How does Keronite perform in terms of throwing power?
A Traditionally, Keronite has demonstrated throwing power of 2-3 times the diameter of a hole, but much depends upon electrolyte management inside the hole. When handled correctly, throwing power greater than 15 times the width of a slot has been measured. Generally speaking, the Keronite process has much better throwing power than conventional electro-plating processes.

Q Are different electrolyte solutions available for different Keronite surfaces?
A Yes - Keronite produces and supplies different electrolyte solutions for aluminium and magnesium, and has recently developed a new electrolyte to produce a black surface on aluminium. Special electrolytes can also be developed or tuned to meet specific application requirements.

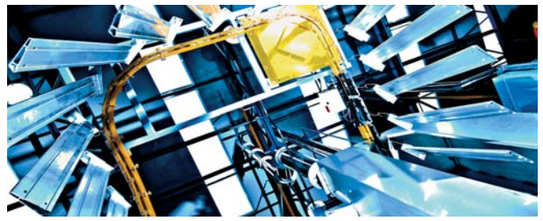
Q Within what parameters will the Keronite electrolyte function well?
A Keronite electrolyte solutions should be stored at room temperature between 4 and 40°C. The shelf life depends upon the particular formulation but is typically around 6 months. The in-service life of the electrolyte is measured in terms of the energy passed through it and ranges from 4.5 to 10 kWh per litre, depending upon the formulation used. After this, it should be replaced.

Q What is the electrical current density of the Keronite process?
A The current density of the Keronite process cannot be disclosed as this forms an important part of our intellectual property.

Q Is it necessary to control the temperature in the Keronite system?
A The optimum temperature range is between 15 and 25°C, although the process will work at anything from 5 to 50°C. In practice, production systems are operated within a narrower range of temperatures in order to control the consistency of the coating and to extend the life of the electrolyte.

Q What is the maximum surface area that can be treated using Keronite technology?
A As the processing equipment is manufactured by Keronite Systems, a subsidiary of Keronite Ltd, the plant can be designed to meet individual customer requirements. Components with a surface area of up to 4 m² are currently being processed, although this varies from alloy to alloy.

Q Is it possible to mask areas which should remain untreated?
A Yes - conventional masking techniques can be used to protect the areas which do not need to be treated.



Sur-Tech A/S
Bygmarken 1, 3520 Farum, Denmark
Tel. +45 44 95 65 66 Fax. +45 44 95 69 97
E-mail. st@sur-tech.dk Web. www.sur-tech.dk

Keronite International Ltd
Granta Park, Great Abington, Cambridge, CB1 6GP, UK
Tel. +44 (0)1223 893222 Fax. +44 (0)1223 894222
E-mail. info@keronite.com Web. www.keronite.com

PROPERTIES

Q How hard is Keronite?

A The hardness of Keronite on aluminium ranges from 400 - 2,000 HV, depending on the alloy used and the thickness of the Keronite layer. It is approx. 3 times harder than hard anodising and the surface is less prone to cracking.

The hardness of Keronite on magnesium ranges from 400 to 600 HV.

Q Can Keronite be used to provide wear resistance?

A Independent tests show that Keronite is 7 times more wear resistant than hard anodising, out-performing electroless nickel in ball-on-disk tests. Impregnation with PTFE can improve performance further.

Keronite can be used on magnesium to eliminate high friction and galling. Wear abrasion tests (Taber) suggest that Keronite performs 60 times better than bare magnesium and is twice as durable as anodising in a two-body abrasive wear scenario.

Q Is Keronite effective in protecting against corrosion?

A Keronite on aluminium will withstands over 2,000 hours in salt fog when sealed. Corrosion under the coating or around vulnerable edges, common problems in the case of anodising, is unlikely to occur with Keronite.

Keronite on magnesium prevents both atmospheric and galvanic corrosion and will withstand over 1000 hours in salt fog (ASTM B117).

Q What is the recommended thickness of the Keronite layer?

A On aluminium, the Keronite layer ranges from 1-150 microns, depending upon the surface properties required. Generally speaking, pre-treatment for adhesion or cession requires thinner layers and wear resistance requires thicker layers. Around 40 microns would be sufficient for most wear applications. In the case of magnesium, the thickness of the Keronite layer ranges from 5-50 microns. We would normally suggest 5-10 microns to protect against corrosion. In both cases, the thickness can be tightly controlled. Keronite grows in a uniform layer, partly inside and partly outside the surface of the substrate. Additional electrodes can be used to create thicker layers on the most critical surfaces if required.

Q Is Keronite available in different colours?

A The colour of Keronite will vary according to the alloying elements in the substrate metal. Black surfaces are available for aluminium, although the properties differ from those of standard Keronite on aluminium.

Q Can other coatings be applied on top of Keronite?

A Atomically bonded to the substrate, Keronite provides an ideal key for subsequent finishing with a variety of topcoats. It has a porous outer layer which can be impregnated not only with a variety of composites such as PTFE or other metals, but it also provides an excellent base for paints, lacquers, powdercoat and adhesives.

Q What are the benefits of Keronite over hard anodising?

A Not only can Keronite be applied to a wider range of alloys, but it can be up to three times harder than hard anodising, depending on the alloy used, and the Keronite surface is less prone to cracking. Independent tests have demonstrated that on some aluminium alloys, Keronite is seven times more wear resistant than anodising.

Q What are the benefits of Keronite over plasma sprayed ceramic?

A Keronite is an immersion process with excellent throwing power and, unlike spray processes, it can be used to protect the inner surfaces of even the most complex shapes. The porous outer layer and the atomic bond with the surface provide outstanding adhesion, ensuring that Keronite does not chip or delaminate as plasma sprayed ceramic tends to do.

Q To what extent does Keronite alter the dimensions of a component?

A As the Keronite layer grows partly above and partly below the substrate surface, there is little impact on the finished dimensions, making it suitable for use on precision components and threads. If necessary, the more porous outer layer of Keronite can be polished back to the original dimensions.

Q Does the quality of the substrate surface affect the finish?

A Yes - it is very important to use a good quality substrate. The quality of the Keronite layer relates directly to the quality of the substrate surface. Any imperfections in the substrate will be repeated in the outer profile of the Keronite layer.

Q What percentage of the Keronite layer is made up of alumina?

A When an aluminium substrate is used, the Keronite layer is approximately 95% alumina in three different forms: alpha, gamma and amorphous phases. The relative proportions of these three phases will vary according to the alloy used, the thickness of the coating and which part of the layer is measured. Thinner layers tend to have a greater proportion of gamma alumina (approximately 1600 HV hardness), and thicker layers have more alpha alumina (approximately 2400 HV). This explains why thicker layers are harder.

In the case of aluminium alloys containing silicon, the percentage of alumina can be as low as 70%, and the alumina is replaced by mullite. This creates a softer and rougher surface.

Q Does the Keronite process have an adverse effect on fatigue strength?

A Recent tests have demonstrated that Keronite on magnesium has no detectable effect on the fatigue strength. On aluminium, the Keronite layer has been shown to perform 60% better than anodising in this respect.

> > >

Q Is there any difference in the quality of the Keronite surface on rolled and casting alloys?

A In the case of magnesium, there is very little difference between the quality of Keronite produced on rolled or cast materials. However, as their surfaces contain different contaminants, they may require different cleaning processes. Casting flow marks created during the casting process as a result of slight variations in alloy composition may be visible in the Keronite surface since it is a conversion process rather than an applied coating. However, no differences in performance have been detected as a result of such flow marks.

In the case of aluminium, there is a bigger difference, mainly because of the presence of silicon in casting alloys, as this produces a softer and rougher surface.

Q Is Keronite dishwasher proof?

A Recent tests have demonstrated that bare Keronite on aluminium performs better than sealed anodising in dishwasher tests.

Q How flexible is the Keronite surface?

A There is a surprising amount of flexibility in the Keronite ceramic matrix. In recent tests carried out by the University of Cambridge, a detached layer of Keronite demonstrated up to 100% elongation before failure. Using the nano-indentation method, the Young's Modulus of a 100 micron Keronite film on aluminium alloy 6063 was found to average around 210 +/- 60 GPa with 20-25% elastic recovery.

Q How well does Keronite perform in terms of thermal cycling?

A As a ceramic, Keronite will remain stable well beyond the melting temperature of the aluminium or magnesium substrate used, so this will usually be the limiting factor in use. On aluminium, Keronite can withstand 500°C continuously, or temperatures up to 2000°C for short periods. Keronite on magnesium withstands short exposures to temperatures up to 1000°C with no adverse effects. The flexibility of the Keronite ceramic matrix enables thermal cycling without cracking as the substrate metal expands and contracts.

Q How effective is Keronite as an electrical insulator?

A The extent of the insulation is determined by the thickness of the Keronite layer. Generally speaking, Keronite will provide 100 V of electrical insulation per micron, provided it has been correctly sealed, and as Keronite is not prone to cracking, the insulation is extremely reliable.

Q What is the adhesion strength of the Keronite layer?

A The adhesion strength of Keronite is excellent. To our knowledge, no test equipment has ever succeeded in detaching the Keronite layer from the substrate. Any failure tends to occur in the testing adhesive itself, or in the case of thick layers of Keronite, the top, friable layer may become detached. For bonding applications, therefore, it is advisable to use a thin layer of Keronite in the range of 1-10 microns.

Q Can Keronite be used in a clean room, or does it generate dust?

A Sealed Keronite will not emit any dust at all.

Q What is the porosity of Keronite?

A Open porosity of 3-5% can be achieved. Closed porosity is under investigation.

Q Are there any limitations in terms of the counterparts used against Keronite surfaces?

A The hardness of the Keronite layer will usually need to be matched to that of the counterpart unless one is intended to be sacrificial. One of the advantages of Keronite is that the hardness can be varied as required over a wide range from 400 HV to 2000 HV in order to match or exceed the hardness of a wide range of counterparts including aluminium, steel, sand, silicon, textiles, paper and glass.

Q What is the relationship between the thickness of the Keronite and the corrosion resistance?

A It is usually the case that a thicker layer of Keronite will give better protection against corrosion, but this is not always so: very thin layers of bare Keronite may not form a complete film whereas very thick layers may be more porous and the protection will be slightly reduced. A medium thickness is best. If Keronite is being used as a pre-treatment for another top coat such as paint, adhesion will be better on thinner layers so this also needs to be taken into account.

Q What is the scratch resistance of topcoats applied to Keronite?

A Because of the structure of the Keronite surface, the adhesion of topcoats is excellent and Keronite performs three times better than anodising in terms of scratch resistance. Recent tests demonstrated that Keronite + powdercoat could not be removed, even using the scratch test equipment at maximum force.

Q Can Keronite be used to treat alloys containing silicon?

A Silicon is the main element that causes irregular features in the Keronite layer. These features are greater with an increased percentage of silicon, but it is still possible to treat alloys with up to 25% silicon using the Keronite process, provided that it is in fine dispersion. It is important to note that the greater the silicon content of the alloy used, the lower the hardness of the Keronite layer.

Q Can the treated surfaces be machined?

A Diamond-tipped or sometimes tungsten carbide-tipped tools can be used to machine Keronite surfaces.