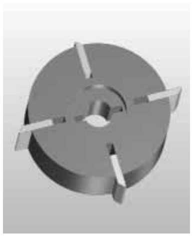
GRAPHITAR®

U.S. GRAPHITE, INC.

A Unique Engineering Material for a Wide Range of Demanding Applications



GRAPHITAR® is U.S. Graphite Inc.'s trade name for a family of carbon-graphite (mechanical carbon) products. U.S. Graphite traces its history back to 1891, when the company was formed to utilize a Mexican deposit of natural graphite. For over 100 years, USG has led in the development of mechanical carbons, from pencil "lead" to nuclear reactor components.

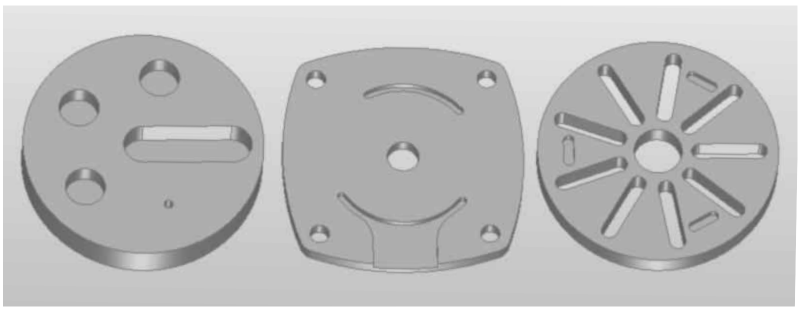
GRAPHITAR is made by blending powder allotropes of carbon, i.e. natural and artificial graphites, carbon blacks, petroleum cokes, etc. with a hydrocarbon binder, pressing this mix into shapes, then furnacing the shapes at over 2000°F. The resultant parts possess a unique combination of properties ... lubricity, corrosion resistance, thermal stability, and wear resistance.

The physical and mechanical properties of GRAPHITAR are controlled by adjusting the formulation and processing operations. This permits USG engineers to develop grades of GRAPHITAR well adapted to specific applications.

This catalog provides basic information about GRAPHITAR. Specific technical data and engineering assistance are available from USG's network of sales representatives or the technical staff at USG.

Since GRAPHITAR is a highly sophisticated product, each application should involve the cooperative efforts of the customer and USG's technical staff. USG maintains a staff of liaison personnel to turn customer requirements into GRAPHITAR products. Field sales representatives work directly with USG customers while GRAPHITAR product engineers at USG provide assistance in translating product requirements into GRAPHITAR components. USG engineering staff provide research and development in the areas of products, processing, applications and manufacturing.

USG is fully committed to improving the cost effective performance of your mechanical devices.



Lubricity and Lubrication

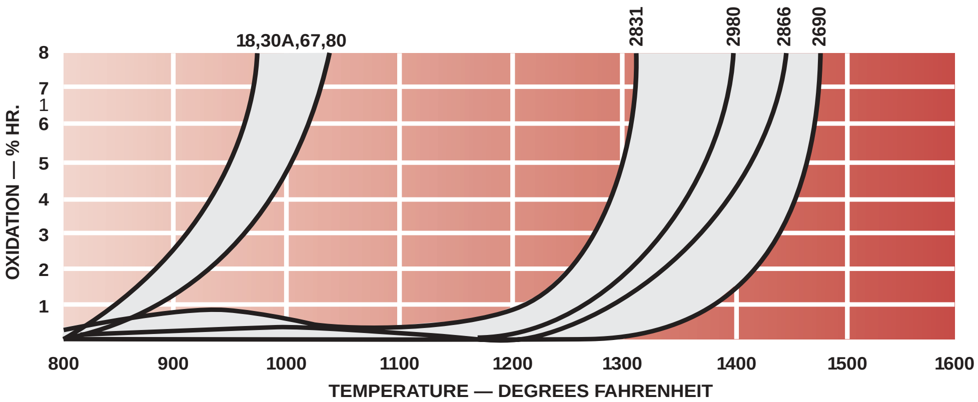
Graphite is one of the most efficient “dry lubricants” known, because of its laminar crystal structure and it’s ability to adsorb and retain polar gases such as water vapor. Other lubricants range from hot tar to chemicals, food products and live steam. Maximum performance is achieved if a liquid film is maintained between the GRAPHITAR and its mating member. Unless the GRAPHITAR part is completely immersed in a fluid, some provision should be made for maintaining a fluid film at the mating surface. This can be achieved by capillary action of the liquid through the material, by leakage along the part face or by providing grooves to conduct the fluid to the entire surface of the part.

Oxidation Resistance

GRAPHITAR will not support combustion, but will oxidize slowly if placed in a sufficiently hostile environment.

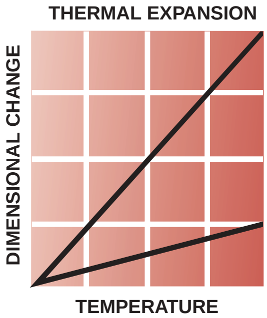
Oxidation resistance is usually measured as weight loss in air at a given temperature. The accompanying chart compares the oxidation resistance of several GRAPHITAR grades. The temperatures plotted refer to ambient conditions.

GRAPHITAR’s resistance to oxidation in media other than air is shown in the Chemical Compatibility chart, pages 8 and 9.



Thermal Stability

Because GRAPHITAR is furnaced at high temperatures, it has no internal stresses and is especially resistant to warping over a wide temperature range; GRAPHITAR will not melt or fuse at any temperature, but sublimes at approximately 6300°F. Its linear coefficient of thermal expansion is nominally one-forth to one-third that of steel. GRAPHITAR is therefore able to function under service conditions from cyrogenic to over 1000°F.



Wear Resistance

The natural lubricity of GRAPHITAR, its high hardness and low coefficient of friction, provide an exceptionally wear resistant material. GRAPHITAR parts show practically no measurable wear after an initial period of run-in. GRAPHITAR will not seize or gall. Its self-lapping characteristic allows GRAPHITAR to conform quickly to mating surfaces and provides an even dispersion of graphite on the wear surface.

Coefficient of Friction

The coefficient for dry GRAPHITAR ranges from .04 to .25, depending on many factors. The addition of a lubricating fluid will reduce the coefficient of friction by a factor of 10, in many cases. Other operating factors which affect GRAPHITAR's coefficient of friction include: temperature, surface pressure, rubbing speed, mating material, surface condition and GRAPHITAR Grade.

Flatness

GRAPHITAR is exceptionally stable over a wide range of temperatures and chemical environments. GRAPHITAR parts can be lapped by a USG's production department to flatness tolerances of 3 helium light bands (.000033 inches variation over the entire lapped surface).

Porosity

High pressure air can be metered through GRAPHITAR in air bearing applications; GRAPHITAR can be used as a reservoir for lubricants or inks. The open porosity of GRAPHITAR can range from about 20% down to a gas tight seal with a porosity of less than .01%. While some porous metals will react chemically with the medium with which they are filled, causing gumming and loss of porosity, GRAPHITAR is not subject to this problem.

Composition

GRAPHITAR is an engineered material. Its composition can range from all carbon to all graphite . . . and may also include impregnants such as metals, resins or lubricants. Control over both composition and processing variables permits GRAPHITAR engineers to produce a remarkably consistent and reproducible product.

Thermal Conductivity

GRAPHITAR is an excellent thermal conductor and is highly resistant to thermal shock. This characteristic is particularly important in jet engine seals, where temperatures can vary hundreds of degrees in a matter of seconds.The thermal conductivity of GRAPHITAR ranges from 3 to 30 BTU/°F/SQ.FT/FT/HR. GRAPHITAR closely approaches a true "black body" in its ability to radiate heat. This capacity, together with good thermal conductivity, makes a very useful combination for dissipating heat.

Electrical Properties

GRAPHITAR is an electrical conductor and is non-magnetic. Its resistance ranges from .0005 to .00018 ohms per inch cube. GRAPHITAR has a negative resistance coefficient.

General Design Considerations

Some GRAPHITAR parts may be used “‘as molded”, while others require additional machining or assembly operations.

For parts molded to their final shape, the limitations of the die molding process must be observed. Configurations which cannot be ejected from the die or stripped from the punch must be avoided. Radical changes in part cross-section and sharp internal angles create points of stress concentration in molded parts. It is usually preferable to create such configurations by machining from a GRAPHITAR blank.

GRAPHITAR is efficiently machined by grinding or diamond turning. Drilling is practical but tapped holes should be avoided in GRAPHITAR part design.

Whether a GRAPHITAR part should be molded or machined to its final configuration is an economic decision. If the volume is sufficient to warrant die costs, the savings of secondary machining operations are obvious. However, where very close tolerances are required, finish machining may be necessary.

Designers should avoid sharp edges unless they are essential to the function of the part. Sharp edges on GRAPHITAR parts are subject to chipping in machining and handling. Generally, small chips are not detrimental in service since they produce no burrs.

Assembly of GRAPHITAR Components

When combining GRAPHITAR with metal components the GRAPHITAR components should carry only compressive loads. It is usually possible to design a system in which GRAPHITAR provides the bearing capacity and metal components supply the required tensile and shear strengths.

Adhesive Bonding

All common adhesives are chemically compatible with GRAPHITAR. The selection of an adhesive involves the bond strength required, compatibility with the operating environment, and the physical characteristics of the material.

Best results have been achieved with thermo-setting adhesives which maintain sufficient viscosity during the curing cycle to minimize penetration into the porous GRAPHITAR structure. Adhesive bonding permits production of GRAPHITAR parts larger than those which can be molded as a single piece.

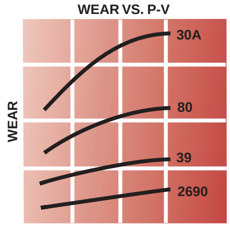
Mechanical Assembly

GRAPHITAR bearings are often pressed into a metal housing or the housing shrunk onto the GRAPHITAR bearing. This combination of GRAPHITAR and metal provides the bearing characteristics of one material and the structural strength of the other. For press fit bearings, interference should vary from about .002 inch at one half inch diameter to .0045 inches at two inch or greater diameters. Because GRAPHITAR has a low Young’s modulus and a low coefficient of thermal expansion, interference fits with steel housings have excellent holding power over a wide temperature range.

P-V Formula

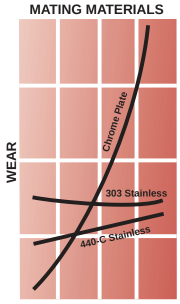
The product of pressure (in pounds per square inch) times velocity (in feet per minute) is a common rule-of-thumb factor for desribing the limits of bearing materials. The limiting P-V factor for any material varies considerably with operating conditions … lubrication, surface finish, mating material, etc. For dry conditions, a P-V factor of 15,000 should be used. When lubricated, P-V values of 150,000 are acceptable, and under ideal conditions, GRAPHITAR has performed well at P-V values of 1,000,000.

WEAR VS. P-V



Non-lubricated...mating material and rubbing speed constant.

MATING MATERIALS



Rubbing Speed
Non-lubricated...face load constant

Bearing Design

GRAPHITAR bearings should be designed as simply as possible. Grooves in bearing surfaces should be laid out in a moldable configuration. Unnecessarily close tolerances and sharp corners in grooves should be avoided. GRAPHITAR's porosity permits "self-lubricated" bearing applications. This factor also permits the use of GRAPHITAR as an air bearing material for high precision applications. Keeper plates and other mechanical accessories must be designed to provide evenly distributed support. Metal backed GRAPHITAR bearings are recommended for applications involving thermal or mechanical shock. GRAPHITAR is extremely resistant to rapid changes in temperature and, when combined with a metal backing, tends to maintain a constant clearance as operating temperature varies.

Wall Thickness

The wall thickness of a GRAPHITAR bearing is generally proportioned to its inside, or shaft diameter. As a rule of thumb, wall thickness can be calculated as .125 inch plus 1/8 of the bearing's I.D.

Bearing Assembly

O. D. GRAPHITAR			Interference at max. temp.	*Clearance
1/2"	to	1-1/2"	.0010	.003
1-1/2"	to	2-1/2"	.0015	.004
2-1/2"	to	3-1/2"	.0020	.005
3-1/2"	to	5"	.0025	.006
5"	to	7"	.0030	.008
7"	to	10"	.0040	.010

**Clearance required for easy insertion of GRAPHITAR into housing at shrink temperature.*

GRAPHITAR bearings must be installed with enough interference to remain secure at the maximum operating temperature. Because GRAPHITAR has relatively high compressive strength in relation to its modulus of elasticity, it will take large interference fits without rupturing. Its low coefficient of thermal expansion facilitates the use of shrink fits in achieving large interference fits. The values on the chart are used in calculating shrink fits, (refer to Bearing Assembly chart).

About .005" is the maximum interference obtainable by press fitting. Good alignment and a continuous full length press-in stroke should be used.

Flanged bushing designs should be avoided, especially where there is an interference fit. Shear stresses can cause cracking between flange and body. If both radial and thrust surfaces are required, use separate bushing and thrust washers. For the same reason, the extension of the bearing beyond an interference-fit housing should be less than 1/32 inch.

Bearing Clearance

A clearance of .001" per inch of shaft diameter is recommended for lubricated GRAPHITAR bearings and .003" per inch for non-lubricated service. Allowances must be made for elastic deformation of the bearing when retained by a press or shrink fit.

The I.D. will be reduced approximately 90% of the interference fit, assuming a steel retainer having a thickness equal to the GRAPHITAR wall thickness. For thinner retainers, the strain in the metal component must be calculated separately.

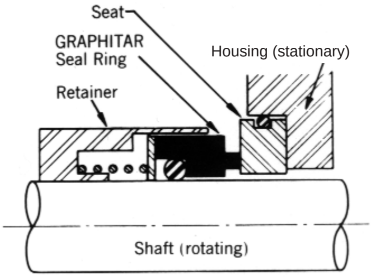
GRAPHITAR Bearing Grades

All grades of GRAPHITAR provide good bearing characteristics, but some grades are specifically associated with bearing applications. The following table presents a selection of general purpose bearing grades:

GRAPHITAR GRADE	TYPICAL APPLICATIONS
Grade 14	For heavily loaded, well lubricated applications. Water is an excellent lubricant for this grade.
Grade 18	For applications involving light loads and low speeds. An economical grade which is moldable into complex configurations.
Grade 39	For high speed, heavily loaded applications. Works well with light lubricants such as gasoline or kerosene and can be run without lubrication.
Grade 67	For light duty, non-lubricated applications. This grade is often used for guides and slides as well as conventional sleeve bearings.
Grade 80	For high temperature, low speed, marginally lubricated applications such as conveyors.
Grade 86	For a wide range of bearing applications which require good strength and hardness for high speed operations. Will handle heavy loads under either dry or lubricated conditions.

Seal Design

GRAPHITAR is self lapping and flexible enough to conform closely to its mating surface. GRAPHITAR is also a very hard material and extremely resistant to wear. It is lubricated by most fluids so that the medium being sealed can serve as the seal lubricant. GRAPHITAR's permeability can be controlled to allow the lubricating medium to be metered to the sealing surface or to completely contain even the most volatile fluids. GRAPHITAR is dimensionally stable under wide temperature variations and is strongly resistant to most chemical environments.



A typical face seal consists of a stationary seat, a rotating seal ring and the necessary hardware to hold both elements in place. The drawing above illustrates a typical mechanical face seal design. In general, the retaining mechanism for a GRAPHITAR seal ring should provide an evenly distributed pressure on the ring, sufficient to maintain the seal under any operating or static conditions. Additional pressure will only increase wear on the ring and mating seat.

The efficiency of a mechanical seal depends upon the degree of conformity of the two sealing surfaces. Ideally, the seal member and its seat should fit so perfectly that they are separated only by the thickness of a boundary layer of lubricant. The GRAPHITAR sealing member will very quickly assume the mating shape in service. Some GRAPHITAR seals are lapped to very close tolerances. Some are ground to commercial tolerances and allowed to assume the shape of the mating member in the initial run-in. Molded GRAPHITAR parts are most economical, but require a longer run-in period to form a seal. After its initial run-in, a GRAPHITAR seal will exhibit very little wear provided the shape and finish of the mating surface remain unchanged.

Mating Materials

As a rule, GRAPHITAR seals run best against a hard mating surface. Cast iron, hardened steel, chrome plated steel, ceramics and GRAPHITAR are all satisfactory seat materials. In addition to hardness, a prime factor in the selection of a mating material is its chemical compatibility with the environment. This is one reason why running GRAPHITAR against GRAPHITAR is often the solution to sealing problems where corrosive media are involved.

GRAPHITAR Seals Grades

Most GRAPHITAR grades will give satisfactory performance in seal applications. However, the following grades have been developed especially for use in seals:

GRAPHITAR GRADE	TYPICAL APPLICATIONS
Grade 30A	For low to medium pressure oil sealing applications. This grade has relatively high porosity, which aids seal face lubrication.
Grade 39	A universal grade for use in high pressure applications. Can be used to seal almost any medium except very strong oxidizing or alkaline agents. Grade 39 is the hardest of all GRAPHITAR grades, with a shore scleroscope reading of 100.
Grade 67	Similar to grade 30A in low to medium pressure applications.
Grade 70	This grade will perform well in non-lubricated service such as sealing air.
Grade 86	A universal grade for lubricated or non-lubricated service. Offers excellent compressive strength, an extremely low porosity and excellent wear resistance.
Grade 114	A very strong, hard grade, resistant to any chemical in which GRAPHITAR can function. Frequently used in sealing gasses.
Grade 2690	A high temperature material for seal applications.
Grade 3048	For aircraft engine main shaft seals. Combines excellent lubricity with good oxidation resistance for long service life.

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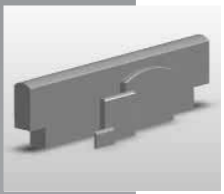
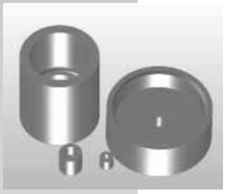


Vane Pumps

Vane pumps use GRAPHITAR vanes, end plates, liners and rotors. For best performance, GRAPHITAR vanes are machined for a close-tolerance fit between vane and rotor, a radiused contact edge and an exact length. Vanes should be specified up to the minimum length of the rotor. No allowance need be made for swelling of the vane in service. GRAPHITAR's high degree of stability in any pumped medium will maintain the close clearance originally built into the assembly. Centrifugal force is sufficient in most applications to maintain vane contact with the liner. Some low-speed pumps may require the use of a spring, hydraulic or pneumatic pressure behind the vane.

Inlet and outlet ports are usually molded into GRAPHITAR end plates to avoid radial machining on the pump liner. A commercial lap will give the bearing surface adequate flatness as it will seat itself against the rotating parts in operation. Liners are finished to the same length as the rotor by lapping both ends to a high degree of flatness and parallelism.



Piston Pumps

GRAPHITAR parts have also been successfully used in reciprocating pumps. Pistons, piston rings and valve plates of GRAPHITAR give longer life and positive sealing in applications where lubrication problems prohibit the use of other materials. Tensile loads on the piston can be met by running the rod through the piston and compressing the GRAPHITAR member between two metal washers. For applications where positive pressure is maintained on the piston, an open ball joint has given excellent performance. Piston rings can be gapped or segmented, with either buff or lap joints.

Service Life

Properly designed and assembled, GRAPHITAR pump components can be expected to show virtually no mechanical wear after a very short run-in period - provided their mating surfaces are hard and smooth.

Molding

All GRAPHITAR parts consist of graphite and carbon powders, molded to the desired shape under tremendous pressure and furnaced above 2000°F. Any contour on the outside and inside diameters, providing it is the full length of the part, can be formed. Shoulders, counterbores, blind holes and cavities can be molded into the part; depth should be limited to 1/3 of the length or thickness of part. Through holes are not a problem. Due to shrinkage during furnacing, molded tolerances between 1% and 2% of dimension, with a minimum of .005", are required. The exact tolerances will depend on size, grade and shape of part. Length is the most difficult dimension to control by molding. Generally, 030", per inch length will apply with a minimum of .020" for parts up to 1/2" long.

Size Limits

The maximum size of a single GRAPHITAR component is limited by USG's press capacity. Since the pressure required to mold each grade to its optimum physical properties varies, the maximum projected area of GRAPHITAR parts may change according to grade. See the GRAPHITAR grade list on page 10 for specific values. Parts larger than these limits can be bonded or mechanically assembled components; seal rings as large as 28" in diameter have been produced. Sections of less than .060" should not be molded.

Standard Tolerances

GRAPHITAR parts are generally machined to a standard tolerance of .004" on most dimensions. Parts can be made to tolerances as small as .0002" with special techniques. The following table details tolerances that are normally held on GRAPHITAR parts machined by USG:

STANDARD TOLERANCES		
DIMENSION	**TOLERANCE**	
Outside Diameter	0.004"	0.10mm
Inside Diameter	0.004"	0.10mm
Length (thickness)	0.010"	0.25mm
Parallelism	0.004"	0.10mm
Concentricity (T.I.R.)	0.004"	0.10mm

NOTE: Closer tolerances available as required

Graphitar Grades by Chemical compatibility category.

A		B		C		D	E	F
2	64	14	77	101	2831	2767	2690	111
3	67	35	86	102	2832	2840	2866	112
18	75	38	88	103	2833	2864	2936	113
30A	80	39	89	105	2835	2865	2980	114
34	84	40	92	107	2837		3048	
48	110	47	94	109	2859			
	2413	70	95		2887			
			108		2957			
					3030			

Chemical Compatibility of Graphitar®

Resistance to chemical attack varies among GRAPHITAR Grades. GRAPHITAR Grades can be grouped into six chemical compatibility categories ... see Chart at left. A GRAPHITAR component may be compatible with its chemical environment, yet suffer mechanical damage from corroded mating parts. This situation can be avoided by specifying GRAPHITAR for both mating surfaces.

CHEMICAL COMPATIBILITY CHART

CHEMICAL	GRAPHITAR CATEGORY SUGGESTED
ACIDS	
Abietic	A B C D - F
Acetic	A B - D - F
Acetic Anhydride	A B - D - F
Acetylsalicylic	A B C D - F
Adipic	A B C D - F
Aqua Regia	- - - - - -
Arsenic	A B C D - F
Ascorbic	A B C D - F
Battery	A B - D - F
Benzensulfonic	A B C D - F
Benzoic	A B C D - F
Boiler Acid Phosphates	A B C D - F
Boric	A B C D - F
Butyric	A B C D - F
Carbolic	A B - D - F
Carbonic	A B - D - F
Chlorine(Anhydrous Liquid)	A B - - - F
Chloric	- - - - - -
Chlorous	- - - - - -
Chloroacetic	A B - D - F
Chlorosulfonic	A B - D - F
Chromic	- - - - - F
Citric	A B C D - F
Cresylic	A B C D - F
Cyanic	A B - D - F
Fatty Acids	A B C D - F
Fluoboric	- - - - - F
Fluosilicic	A B - - - F
Formic	A B C D - F
Gallic	A B C D - F
Glutamic	A B C D - F
Hydrobromic	A B - D - F
Hydrochloric	A B - D - F
Hydrocyanic	A B - D - F
Hydrofluoric	- - - - - F
Hydrofluosilicic	A B - - - F
Hydrogen Peroxide	- - - - - -
Hypochlorous	- - - - - F
Isophthalic	A B - D - F
Lactic	A B C D - F
Lauric	A B C D - F
Maleic	A B - D - F
Malic	A B - D - F
Muriatic	A B - D - F
Nitrating (To 75%)	- - - - - F
Nitric 0 to 20%	A B - - - F
Nitric 20 to 100%	- - - - - F
Nitrous	A B - - - F
Oleic	A B - D - F
Oleum	- - - - - -
Orthophosphoric	A B - D - F
Organic Acids	A B - D - F
Oxalic	A B C D - F
Palmitic	A B C D - F
Perchloric	- B - - - -
Phenolsulfonic	A B - D - F
Phosphoric (Glacial)	A B - D - F
Phthalic	A B - D - F
Picric	A B - D - F
Propionic	A B - D - F
Pyrogallic	A B - D - F
Salicylic	A B - D - F
Sorbic	A B - D - F
Stearic	A B C D - F
Succinic	A B - D - F
Sulphuric (0-75%)	A B - D - F
Sulphuric (75-96%)	A - - - - F
Sulfurous	A B - - - F
Tannic	A B C D - F
Tartaric	A B C D - F
Terephthalic	A B - D - F
Toluenesulfonic	A B - D - F
Toluic	A B - D - F
Trichloroacetic	A B - D - F
Uric	A B - D - F
Valeric	A B - D - F
Vinyl Acetate	A B - D - F
ALKALINE CHEMICALS	
Ammonium Carbonate	A B - D - F
Ammonium Hydroxide	A B - D - F
Amyl Amines	A - - D - F
Anhydrous Ammonia Liquid	A B - D - F
Barium Hydroxide	A B - D - F
Bleaching Powder	- - - D - F
Butyl Amines	A B - D - F
Calcium Carbonate	A B - D - F
Calcium Hydroxide	A B - D - F
Calcium Hypochlorite	- - - D - F
Calcium Oxide	- - - D - F
Caustic Soda	- - - D - F
Cyclohexylamine	A B - D - F
Detergents	A B - D - F
Diethanol Amine	A B - D - F
Disodium Phosphate	A B - D - F
Hydrazine	- - - - - -
Hydroxylamine	A B - D - F
Lime Slurries	- - - D - F
Lithium Carbonate	A B - D - F
Lithium Hydroxide	A B - D - F
Lye	- - - D - F
Magnesium Hydroxide	A B - D - F
Monoethanolamine	A B - D - F
Morpholine	A B - D - F
Potassium Bicarbonate	A B - D - F
Potassium Carbonate	A B - D - F
Potassium Chlorate	- - - D - F
Potassium Cyanide	A B - D - F
Potassium Hydroxide	- - - D - F
Potassium Phosphate	A B - D - F
Pyridine	A B - D - F
Soap & Soap Solutions	A B C D - F
Sodium Bicarbonate	A B - D - F
Sodium Carbonate	A B - D - F
Sodium Hydroxide	- - - D - F
Sodium Hypochlorite	- - - D - F
Sodium Peroxide	- - - - - -
Sodium Phosphate	A B - D - F
Sodium Tetraborate	A B - D - F
"Tetramine" C	A B - D - F
Triethanolamine	A B - D - F
Triethylamine	A B - D - F
Trisodium Phosphate	A B - D - F
U rea	A B - D - F
Water Glass	A B - D - F
SALT SOLUTIONS	
Alkylaryl Sulfonates	A B C D - F
Allyl Chloride	A B - D - F
Alum (Ammonia)	A B - D - F
Alum (Chrome)	A B - D - F
Alum (Potash)	A B - D - F
Aluminum Chloride	A B - D- F
Aluminum Sulfate	A B - D - F
Ammonium Bicarbonate	A B - D - F
Ammonium Carbonate	A B - D - F
Ammonium Chloride	A B - D - F
Ammonium Nitrate	A B - D - F
Ammonium Phosphate	A B - D - F
Ammonium Sulfate	A B - D - F
Ammonium Thiocyanate	A B - D - F
Arsenic Trichloride	A B - D - F
Baking Soda	A B - D - F
Barium Carbonate	A B - D - F
Ba rium Ch oride	A B - D - F
Barium Suifate	A B - D - F
Barium Sulfide	A B - D - F
Borax	A B - D - F
Boiler Feed Water Compounds	A B C D- F
Calcium Bisulfite	A B - D - F
Calcium Chloride	A B - D - F
Calcium Sulfate	A B - D - F
Calgon	A B C D - F
Chromium Potassium Sulfate	A B - D - F
Copper Chloride	A B - D - F
Copper Nitrate	A B - D - F
Copper Sulfate	A B - D - F
Ferric Chloride	A B - D - F
Ferric Sulfate	A B - D - F
Ferrous Chloride	A B - D - F
Ferrous Sulfate	A B - D - F
Glauber's Salt	A B - D - F
Ink	A B - D - F
Lead Acetate	A B - D - F
Lead Carbonate	A B - D - F
Lead Nitrate	A B - D - F
Lithium Carbonate	A B - D - F
Magnesium Chloride	A B - D - F
Magnesium Oxide	A B - D - F
Magnesium Sulfate	A B - D - F
Manganous Sulfate	A B - D - F
Mercury Salts	A B - D - F
Nickel Acetate	A B - D - F
Nickel Chloride	A B - D - F
Nickel Nitrate	A B - D - F
Nickel Sulfate	A B - D - F
Nylon Salt	A B - D - F
Phosphorus Trichloride	A - - - - F
Potassium Bisulfide	A B - D - F
Potassium Carbonate	A B - D - F
Potassium Chloride	A B - D - F
Potassium Chromate	A B - D - F
Potassium Cyanide	A B - D - F
Potassium Iodide	A B - D - F
Potassium Permanganate	A - - - - F
Potassium Phosphates	A B - D - F
Potassium Sulfate	A B - D - F
Sal Ammoniac	A B - D - F
Sal Soda	A B - D - F
Sea Water	A B - D - F
Silver Nitrate	- B - - - F
Soda Ash	A B - D - F
Sodium Aluminate	A B - D - F
Sodium Acid Sulfate	A B - D - F
Sodium Bicarbonate	A B - D - F
Sodium Bisulfate	A B - D - F
Sodium Bisulfite	A B - D - F
Sodium Borate	A B - D - F
Sodium Carbonate	A B - D - F
Sodium Chloride	A B - D - F

GRAPHITAR®

CHEMICAL	GRAPHITAR CATEGORY SUGGESTED
Sodium Chromate	A B - D - F
Sodium Cyanide	A B - D - F
Sodium Dichromate	A B - D - F
Sodium Fluoride	A B - D - F
Sodium Nitrate	A B - D - F
Sodium Nitrite	A B - D - F
Sodium Phosphates	A B - D - F
Sodium Silicate	A B - D - F
Sodium Sulfate	A B - D - F
Sodium Sulfide	A B - D - F
Sodium Sulfite	A B - D - F
Sodium Thiosulfate	A B - D - F
Stannic Chloride	A B - D - F
Stannous Fluoride	A B - D - F
Sulfate Liquors	A B - D - F
Trisodium Phosphate	A B - D - F
Zinc Acetate	A B - D - F
Zinc Ammonium Chloride	A B - D - F
Zinc Chloride	A B - D - F
Zinc Hydrosulfite	A B - D - F
Zinc Sulfate	A B - D - F
FOOD & FOOD PRODUCTS	
Aspirin	A B C D - F
Alcohol	- B - D - F
Ale	- B - D - F
Beer	- B - D - F
Beet Sugar Liquors	- B - D - F
Butter	- B - D - F
Buttermilk	- B - D - F
Cane Sugar Liquors	- B - D - F
Castor Oil	- B - D - F
Cheeses	- B - D - F
Chocolate	- B - D - F
Cider	- B - D - F
Citrus Juices	- B - D - F
Coconut Oil	- B - D - F
Coffee	- B - D - F
Cola Drinks	- B - D - F
Corn Oil	- B - D - F
Cornstarch Slurry	- B - D - F
Cottonseed Oil	- B - D - F
Dextrin	- B - D - F
Dextrose	- B - D - F
Eggs	- B - D - F
Fish Oil	- B - D - F
Fruit Juices	- B - D - F
Gelatin	- B - D - F
Hydrogenated Fats	- B - D - F
Ice Cream	- B - D - F
Jelly	- B - D - F
Ketchup	- B - D - F
Lard	- B - D - F
Malt	- B - D - F
Monnitol	- B - D - F
Mayonnaise	- B - D - F
Maple Shrup	- B - D - F
Milk	- B - D - F
Mineral Oil	- B - D - F
Molasses	- B - D - F
Monosodiurn Glutamate	- B - D - F
Oleomargarine	- B - D - F
Olive Oil	- B - D - F
Palm Oil	- B - D - F
Pickle Solutions	- B - D - F
Salad Oil	- B - D - F
Sorbitol	- B - D - F
Saccharine	- B - D - F
Soybean Oil	- B - D - F
Sugar Solutions	- B - D - F
Soft Drinks	- B - D - F
Starches	- B - D - F
Vegetable Oil	- B - D - F
Vinegar	- B - D - F
Whiskey & Wine	- B - D - F
Wate\r	- B - D - F
Yeast	- B - D - F
Yogurt	- B - D - F
GASES	
Acetylene	A B C D E F
Air	A B C D E F
Ammonia Wet)	A B - D - F
Ammonia Anhydrous)	A - - D - F

CHEMICAL	GRAPHITAR CATEGORY SUGGESTED
Argon (inert)	A B C D E F
Boron Trifluoride	A B - D - F
Bromine	- - - - - F
Butadiene	A B C D E F
Butane	A B C D E F
Butylene	A B C D E F
Carbon Dioxide	A B C D E F
Carbon Monoxide	A B C D E F
Chlorine	- - - - - F
Cyanogen	A B C D E F
Cyclohexane	A B C D E F
Ethane	A B C D E F
Ether	A B C D E F
Ethylene	A B C D E F
Fluorine	- - - - - -
Freons	A B C D E F
Hydrogen	A B C D E F
Hydrogen Chloride	A B C D E F
Hydrogen Fluoride	- - - - - F
Hydrogen Sulfide	A B - D E F
Iodine	- - - - - F
Methane	A B C D E F
Natural Gas	A B C D E F
Neon	A B C D E F
Nitric Oxide	A B C D E F
Nitrogen	A B C D E F
Nitrous Oxide	A B C D E F
Oxygen	A B C D E F
Phosgene	- - - - E F
Propane	A B C D E F
Propylene	A B C D E F
Steam (to 500 F.)	A B C D - F
Sulfur Dioxide	A B - D - F
Sulfur Trioxide	- - - - - -
SOLVENTS & ORGANIC MATERIALS	
Acetaldehyde	A B C D - F
Acetone	A B C D - F
Acetophenone	A B C D - F
Acrolein	A B C D - F
Acetate Solvents	A B C D - F
Almond Oil	A B C D - F
Amyl Acetate	A B C D - F
Amyl Alcohol	A B C D - F
Amyl Chloride	A B C D - F
Aniline	A B C D - F
Anthracene	A B C D - F
Asphalt	A B C D - F
Benzaldehyde	A B C D - F
Benzene	A B C D - F
Butyl Alcohol	A B C D - F
Butyl "Cellosolve"	A B C D - F
Camphor	A B C D - F
Carbitols (Diethylene Glycol Ethers)	A B C D - F
Carbon Disulfide	A B C D - F
Carbon Tetrachloride	A B C D - F
Chloral	A B C D - F
Chlorobenzene	A B C D - F
Chlorothene	A B C D - F
Chloroform	A B C D - F
Coal Tar	A B C D - F
Creosote	A B C D - F
Cresol	A B C D - F
Crotonaldehyde	A B C D - F
Cumene	A B C D - F
Cyclohexane	A B C D - F
Diacetone	A B C D - F
Dibutyl Phosphite	A B C D - F
Dibutyl Phthalate	A B C D - F
Dichloroethane	A B C D - F
Dichloropentane	A B C D - F
Diesel Oil	A B C D - F
Diethylbenzene	A B C D - F
Diethyleneglycol	A B C D - F
Diethyl Sulfate	A B C D - F
Dimethyl Phthalate	A B C D - F
Dioxane	A B C D - F
Dipentene	A B C D - F
Diphenyl	A B C D - F
Dowtherms	A B C D - F
Ether-Diethyl	A B C D - F
Ether-Petroleum	A B C D - F
Ethyl Acetate	A B C D - F

CHEMICAL	GRAPHITAR CATEGORY SUGGESTED
Ethyl Alcohol	A B C D - F
Ethyl Benzene	A B C D - F
Ethyl Chloride	A B C D - F
Ethyl Mercaptan	A B C D - F
Ethyl Sulfate	A B C D - F
Ethylene	A B C D - F
Ethylene Dichloride	A B C D - F
Ethylene Glycol	A B C D - F
Ethylene Oxide	A B C D - F
Formaldehyde	A B C D - F
Freon (Liquefied)	A B C D - F
Fuel Oil	A B C D - F
Furfural	A B C D - F
Furfuryl Alcohol	A B C D - F
Gasoline	A B C D - F
Glycerine	A B C D - F
Glue	A B C D - F
Heptane	A B C D - F
Hydrazine Hydrate	A B C D - F
Isobutyl Acetate	A B C D - F
Isobutyl Alcohol	A B C D - F
Isopropyl Acetate	A B C D - F
Isopropyl Alcohol	A B C D - F
Isopropyl Ether	A B C D - F
Jet Fuel	A B C D - F
Kerosene	A B C D - F
Ketones	A B C D - F
Lubricating Oil	A B C D - F
Lacquers & Lacquer Solvents	A B C D - F
Linseed Oil	A B C D - F
Ligroin (Petroleum Ether)	A B C D - F
Methyl Acetate	A B C D - F
Methyl Acrylate	A B C D - F
Methyl Alcohol	A B C D - F
Methyl "Cellosolve"	A B C D - F
Methyl Chloride	A B C D - F
Methylethyl Ether	A B C D - F
Methyl Ethyl Ketone	A B C D - F
Methyl Formate	A B C D - F
Methyl Isobutyl Ketone	A B C D - F
Methyl Salicylate	A B C D - F
Mineral Oil	A B C D - F
Mineral Spirits	A B C D - F
Monoch loro benzene	A B C D - F
Naphtha	A B C D - F
Naphthalene	A B C D - F
Nitrobenzene	A B C D - F
Octyl Alcohol	A B C D - F
Oleyl Alcohol	A B C D - F
Ortho Dichlorobenzene	A B C D - F
Paint & Paint Vehicles	A B C D - F
Paraffin	A B C D - F
Paraffin Oils	A B C D - F
Para Dichlorobenzene	A B C D - F
Paraformaldehyde	A B C D - F
Paraldehyde	A B C D - F
Perchloroethylene	A B C D - F
Phenol	A B C D - F
Pine Oil	A B C D - F
Polyethylene	A B C D - F
Polystyrene	A B C D - F
Polyurethane	A B C D - F
Prestone	A B C D - F
Propyl Alcohol	A B C D - F
Propylene Dichloride	A B C D - F
Resorcinol	A B C D - F
Stoddard Solvent	A B C D - F
Styrene	A B C D - F
Tar	A B C D - F
Tetrachloroethane	A B C D - F
Terachloroethylene	A B C D - F
Toluene	A B C D - F
Trichlorobenzene	A B C D - F
Trichloroethylene	A B C D - F
Tricresyl Phosphate	A B C D - F
Turpentine	A B C D - F
Varnish	A B C D - F
Vinyl Acetate	A B C D - F
Vinyl Chloride	A B C D - F
Water	A B C D - F
Waxes	A B C D - F
Xylene	A B C D - F

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Graphitar® Grade List

Important Note: Data based on average values from standard specimens, tested in the molding direction on conventional laboratory equipment. Variations may occur due to part configuration, fabrication techniques or methods of measurement. Values are typical and should not be used for specifications.

Grade	Scleroscope Hardness	Compressive Strength PSI	Transverse Breaking Strength PSI	Tensile Strength PSI	Modulus of Elasticity x 10^6 PSI	Coefficient of Thermal Expansion x 10^6 In./In./°F*	Thermal Conductivity BTU/Sq. Ft./°F./Hr.	Maximum Recommended Operating Temperature °F. In Air	Apparent Density Gm/cc	Available Porosity % Volume	Maximum Size** Sq. In.	Composition***
1	70	12,500	3,500	2,500	1.6	1.9	3.6	700	1.68	14	60	CG
14	90	38,000	11,000	8,500	2.8	3.0	4.6	500	1.85	0.5	60	CGR
18	75	20,000	5,500	3,500	2.1	2.2	4.7	700	1.70	12	75	CG
30-A	85	25,000	7,000	5,500	18	2.5	3.7	700	1.68	13	45	CG
34	88	18,000	6,000	3,500	1.2	2.5	4.8	700	1.65	14	45	CGR
35	98	38,000	11,000	7,000	2.1	3.9	5.9	500	1.7	0.7	45	CGR
38	100	35,000	10,500	8,500	2.5	3.6	3.8	500	1.80	2	45	CGR
39	100	38,000	11,500	9,000	2.5	3.4	3.8	500	1.82	1	45	CGR
40	85	28,000	9,000	6,500	2.5	3.0	4.1	500	1.82	3.4	60	CGR
47	95	36,000	11,000	9,500	3.0	2.7	6.4	500	1.88	0.5	60	CGR
48	45	4,500	2,500	1,000	0.5	1.2	27.0	750	1.72	17	45	G
64	35	5,000	3,000	2,500	1.8	1.0	27.0	700	1.80	9	75	CG
67	75	13,000	6,500	4,000	1.6	2.1	5.3	700	1.72	11	45	CG
70	85	28,000	8,000	6,500	2.2	3.2	5.5	500	1.80	3	45	CGR
77	60	12,000	6,000	3,500	1.5	2.8	28.0	500	1.88	3	60	GR
80	75	25,000	10,000	5,500	2.4	2.3	7.0	700	1.80	7	45	CG
84	80	30,000	11,000	6,500	2.8	2.3	7.0	700	1.85	6	45	CG
86	90	36,000	12,500	9,500	3.0	2.3	7.6	500	1.90	0.5	45	CGR
88	95	28,000	8,000	6,000	1.8	2.9	3.9	350	1.80	0.5	45	CGR
92	90	32,000	8,800	7,000	2.8	3.2	5.1	500	1.82	3	75	CGR
94	90	30,000	8,500	6,000	2.2	3.5	5.5	500	1.82	1	45	CGR
95	40	6,000	3,500	3,000	2.0	1.5	27.5	350	1.85	1	45	GR
101	85	38,000	10,500	8,500	2.9	2.9	7.0	350	2.75	1	75	CGB
102	88	38,000	9,500	7,500	2.6	3.1	8.7	700	2.35	4	75	CGCu
103	89	35,000	10,500	7,500	2.8	3.1	9.3	700	2.70	3	75	CGAg
105	84	35,000	11,400	8,500	2.8	3.4	8.5	700	2.35	2	45	CGCuPb
107	92	38,000	10,000	7,500	3.5	2.4	7.0	700	2.20	1	75	CGSb
108	77	17,000	4,200	3,000	1.8	2.4	3.8	350	1.80	3	60	CGR
109	85	40,000	11,500	7,500	3.5	3.1	8.5	700	2.70	1	75	CGCuPb
110	92	32,000	10,000	8,500	3.3	2.3	8.0	700	1.9	1	45	CG
113	100	34,000	10,000	8,000	2.5	3.5	3.5	500	1.8	2	75	CGR
114	90	34,000	12,000	9,000	2.9	2.7	8.0	500	1.90	0.5	45	CGR
2413	60	7,000	2,500	1,000	1.0	2.3	4.1	700	1.55	20	50	CG
2690	97	23,000	6,400	5,000	1.4	2.4	20.6	1200	1.82	9	50	CGH
2767	90	25,000	8,000	6,000	2.0	3.4	5.5	500	1.83	0.5	45	CGR
2887	85	38,00	10,500	8,000	3.0	2.3	9.0	350	2.30	0.5	45	CGBR
2980	65	15,000	4,500	4,000	1.8	2.3	30.0	1000	1.85	4.0	50	CGH
3030	97	60,000	14,000	10,500	3.6	2.9	8.5	700	2.35	0.5		CGCrNi
3048	67	16,200	6,500	4,500	1.8	2.3	30.0	1000	1.85	5.0	50	CGH

*Average values at 70° to 500°F

**Maximum size for optimum properties. Larger parts can usually be produced with some reduction of physical properties.

***Composition: C=carbon, G=graphite, B=babbitt, Cu=copper, Sb=antimony, Ag=silver, Pb=lead, R=resin impregnated, H=High-temperature treated.

A World Leader in the Carbon Industry.

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