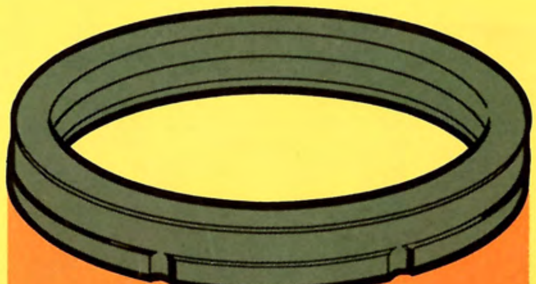
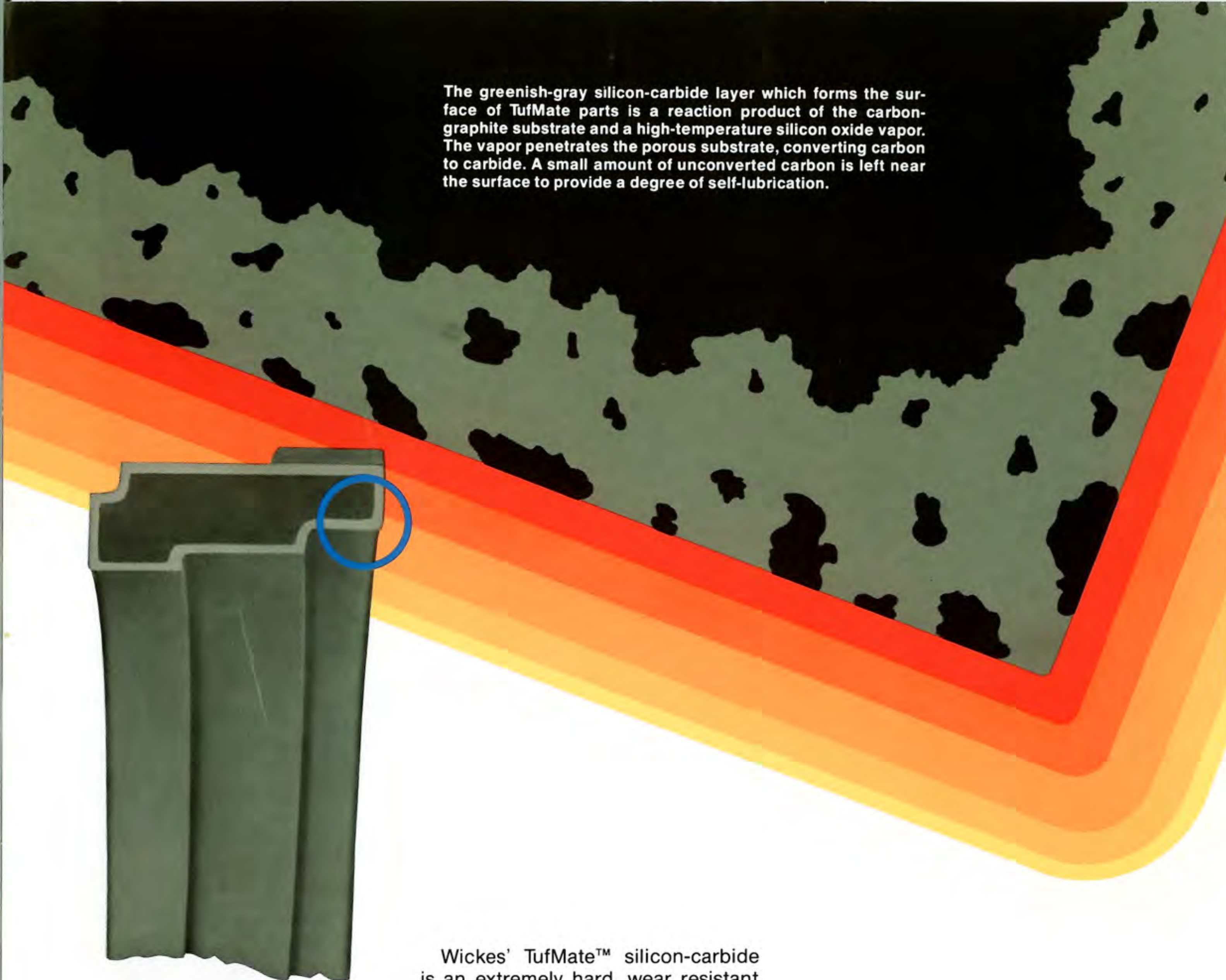
$$SiO_2 + 2C \rightarrow SiC + CO_2$$

TufMate™
SILICON - CARBIDE



the ultimate seal material

- dimensionally-stable
- super-hard
- non-corrosive
- self-lubricating
- low-cost



The greenish-gray silicon-carbide layer which forms the surface of TufMate parts is a reaction product of the carbon-graphite substrate and a high-temperature silicon oxide vapor. The vapor penetrates the porous substrate, converting carbon to carbide. A small amount of unconverted carbon is left near the surface to provide a degree of self-lubrication.

The broken cross-section of a typical TufMate seal ring shows the uniformity of surface conversion. This uniformity may be lacking in parts containing small holes, deep recesses or other configurations which restrict the circulation of silicon oxide vapor during the conversion process.

TufMate™

Wickes' TufMate™ silicon-carbide is an extremely hard, wear resistant material, developed for use in mechanical seals used in corrosive or abrasive environments. TufMate is not a natural product, but is produced by the high temperature conversion of a compatible carbon-graphite material. Parts are molded and machined to their final shape and dimensions in a special formulation of GRAPHITAR® carbon-graphite. Subsequent treatment converts the outer layer of carbon-graphite to silicon-carbide by means of a chemical reaction with silicon oxide vapor. Normal conversion depth is approximately .025 inches (.6 mm).

Microscopic examination of a sectioned TufMate part shows a surface matrix of silicon-carbide, containing some unconverted graphite. On a microscopic scale, conversion depth varies dramatically as a function of substrate porosity. By contrast, a macrophoto of a broken seal cross section shows a uniform conversion depth. Unlike bonded or plated wearing surfaces, the silicon-carbide layer is integral with the carbon-graphite substrate. Retention of some graphite at the surface of the part provides a significant degree of self-lubricity.

TufMate silicon-carbide is recommended for a wide range of demanding applications such as face seals, bearings, port plates, valve seats and similar components. It is less expensive and more resistant to a variety of corrosive media than solid tungsten carbide. It is more resistant to thermal shock than ceramics used in the same applications. Its self-lubricating characteristic enables TufMate silicon-carbide to perform with almost any ambient liquid as its lubricant.

TufMate silicon-carbide can be run against a variety of mating materials. It performs well when mated with tungsten carbide, ceramic, hardened tool steel, GRAPHITAR® carbon-graphite, or another silicon-carbide component. A TufMate vs. TufMate seal combines the bearing properties of GRAPHITAR with the abrasion resistance of silicon-carbide. Wickes engineers can recommend the proper grade of TufMate silicon-carbide for any combination of mating material, environment and service conditions.

Wickes Engineered Materials has run hundreds of hours of wear and friction tests to quantify the observed performance of TufMate seals.

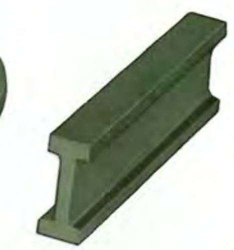
All tests were run on a standard friction test machine. Both seal and seat rings were lapped to a flatness of three light bands before testing. At least five runs were made with each material combination...values reported here are averages of those runs. All test runs exceeded 100 hours in length and wear measurements were prorated to provide comparable results.

TufMate silicon-carbide can be successfully operated in air at temperatures ranging from cryogenic to several hundred degrees. It is resistant to corrosion from most acids, alkaline chemicals, salt solutions, food products, gases, solvents and organic materials. Because of its extreme hardness, silicon-carbide is resistant to the abrasion of suspended solids of all types.

TufMate™ TEST RESULTS...

	WET*	DRY
TEST CONDITIONS		
Speed—feet per minute	570	1,408
Load—pounds per square inch	11.4	10.0
PV Factor	6,498	14,080
COEFFICIENT OF FRICTION		
TufMate vs. Tungsten Carbide	—	0.22
TufMate vs. TufMate	⟨0.1 est.	0.22
TufMate vs. Graphitar 39SC	⟨0.1 est.	0.15
TufMate vs. AD-85 Ceramic	⟨0.1 est.	—
SEAL WEAR (inches per hundred hours)		**SEAL/SEAT**
TufMate vs. Tungsten Carbide	—	.00027/(none)
TufMate vs. TufMate	.00031	.00024/.00043
TufMate vs. Graphitar 39SC	⟨.0001	(none)/.00036
TufMate vs. AD-85 Ceramic	.00205	—

*Wet tests run with 500 ppm solution of sodium chromate



TufMate silicon-carbide parts can be manufactured in any shape that can be machined from a carbon-graphite blank. Dead sharp edges and thin sections should be avoided where possible and fillets should be provided on inside corners. General tolerances are 0.15% on diameters, with a minimum of .004 inches, and .006 inches on lengths. Seal faces can be lapped to flatness tolerances of six or three light bands if necessary.

Silicon-carbide conversion is generally uniform on all part surfaces except small holes and deep recesses. Such hidden surfaces would rarely function as wear surfaces, so their incomplete conversion would not affect part performance.

TufMate silicon-carbide is produced in three grades. Grade 3014 offers a higher temperature capability than the other grades, but is quite porous (25% by volume). Grade 3018 is resin filled to minimize porosity. It is recommended for general sealing applications. Grade 3020 is similar to 3018, but receives a special treatment for corrosion resistance. 3020 would be recommended for service in extremely corrosive environments such as concentrated sulphuric acid, caustic soda and elemental bromine.

Physical properties of TufMate silicon-carbide parts vary with the ratio of part size to conversion depth. The following property values are based on testing with standard specimens:

TufMate™ SILICON-CARBIDE PROPERTIES:

Grade	3014	3018	3020
Compressive Strength—psi	9,000	10,000	10,000
Transverse Breaking Strength—psi	4,500	5,000	5,000
Tensile Strength—psi	1,800	2,000	2,000
Hardness—R_{15T}	90	90	90
Modulus of Elasticity—psi ($x10^6$)	1.8	1.8	1.8
Coefficient of Thermal Expansion ($x10^{-6}$)	2.1	2.1	2.1
Thermal Conductivity	30	30	30
Max. Operating Temp. in Air—°F	700	500	500
Apparent Density	1.9	1.9	1.9
Porosity—% by Volume	25	1	1

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