DMR™

Fiber-Lube™

CJ Series

CJ composites are ideal for non-lubricated, high-load applications in a variety of climates and operating environments, exhibit a high load capacity similar to bronze, powdered metal and steel, and provide longer wear and extended operating life without the costs associated with lubrication. CJ composites are available with thick walls for drop in replacement of steel and bronze bearings. CJ composites also don't rust like metal components, so you can use them in environments where traditional metals corrode and fail. You'll find CJ bearing materials in heavy-duty agricultural, automotive, construction, industrial, marine, railway, and material handling equipment.

CJ composites possess a modulus of elasticity that falls between rigid metals and soft plastics. CJ components are rigid enough to support heavy loads, yet compliant enough to tolerate moderate amounts of shaft misalignment without highly stressing the ends. The composite wall acts like a spring and the thicker the wall section of the bearing the greater the deflection for a given load. Thick wall bearings tolerate greater shaft misalignment and provide better shock absorbency.

Features	**Benefits**
High-load capacity/ high-shock load capability	Accommodates tremendous compression loads that literally crush competing composite materials.
Self-lubricating design	Provides maintenance-free operation and eliminates the need for costly and messy greasing systems.
Low coefficient of friction	Reduces wear and extends operating life. Coefficients as low as 0.05 in dry applications and <0.009 in lubricated environments.
Temperature resistant	Operates flawlessly in temperatures ranging from cryogenic levels to a high of 300°F (149°C). Call for higher temperature availability.
Dimensionally stable in fluids (water, corrosive liquids, and chemical solutions)	Absorption rates are negligible, providing near zero swell.
Chemical resistant	Compatible with a wide range of lubricants and media.
Flexible material design	Suitable for press fit, freeze fit, epoxy bonding, as well as conventional mechanical retention.
Low weight/high strength	Accommodates high-load with a compact strength to weight ratio.
Thick-wall availability	Drop in replacement for metal or bronze bearings

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CJ Series

CJ Applications

- Back hoes
- Front end loaders
- Marine Davits/Sheaves
- Valve stem bushings
- Hitches
- Hydraulic cylinder pivots
- Graders
- Mining equipment
- Vending machines

FCJ Applications

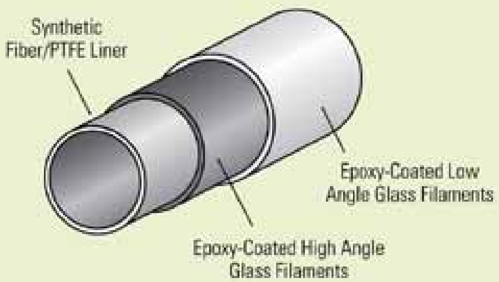
- Material handling equipment
- Packaging machinery
- Farm implements
- Spreaders
- Marine pivots
- Robotics
- Business machines
- Linear bearings
- Amusement park rides

Typical Specifications

Recommended Operating Limits and Engineering Information

Properties		CJ	FCJ
Maximum Pressure (P)	psi	60,000 [1]	20,000
(static)	MPa	241	138
Maximum Velocity (V)	ft/min	150	500
(no load)	m/sec	.76	2.54
Lubrication		No	No
Temperature	°F	-320/+350	-320/+350
—Typical Range	°C	-195/+176	-195/+176
Shaft Hardness		Rc 50	Rb 25
—Minimum, Rockwell Scale			
Shaft Finish		8-16	8-16
Recommended Ra (Microinches)			
Shaft Material Steel Steel			
Coefficient of Friction		.02 - .25	.01 - .20
(Static/Dynamic Range)			
Water Absorption		<.5%	<.5%
ASTM D570			
Corrosion Resistance		Excellent	Excellent
Linear Coefficient of Thermal Expansion	in/in/°F	7×10^{-6}	7×10^{-6}
	cm/cm/°C	13×10^{-6}	13×10^{-6}
(ASTM D696) 78°F to 300°F			
26°C to 149°C			

(1) 15,000 psi maximum dynamic



CJ Bearing Construction

Light-weight, high-strength, fatigue-resistant CJ composites are the ideal bearing choice for nonlubricated high-load/low-speed applications. CJ bearings provide excellent resistance to impact and shock loads and are capable of with standing a high degree of shaft misalignment.

FCJ bearings are the ideal choice for combination motion-oscillatory, linear, and/or rotary applications.Their ability to run successfully against mild steel shafting makes for a cost-competitive system. Their versatility makes them excellent general purpose self-lubricating bearings.

The self-lubricating wear surface of CJ and FCJ composites are capable of reducing both equipment costs and the need for maintenance. Use CJ bearings in applications where:

- Conventional lubricants will not function.
- Shock loads are present.
- Stick-slip operation is undesirable.
- Low cost is an issue, particularly when taking into consideration the bearing, lubrication system, or maintenance.

Use CJ when your application requires:

- High-load capacity.
- Resistance to chemical, galvanic, or fretting corrosion.
- Minimal galling and scoring.
- Reduced weight.
- Electrical insulation.

Use FCJ in applications where you would normally use low-speed porous and cast bronze. It is corrosion resistant, practically chemically inert and electrically insulative. FCJ bearings are more tolerant of small contaminants than standard CJ bearings. They are also easily machined using standard techniques. Standard FCJ sizes interc hange with standard bronze bearings. That means FCJ is not only an ideal alternative to metal, it's also a perfect fit.

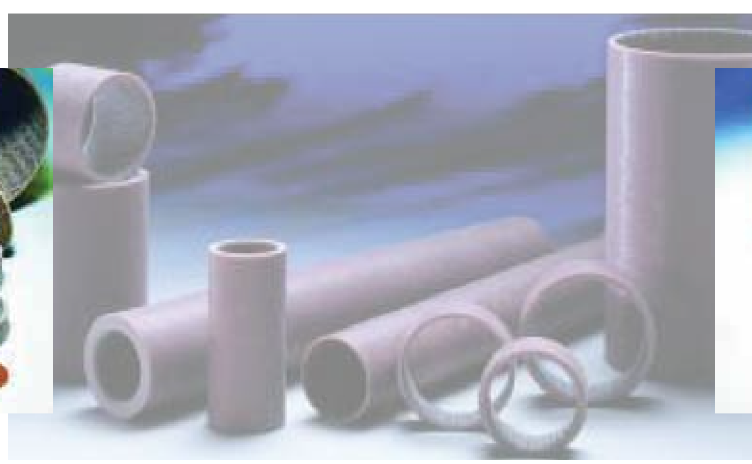


Figure A
Typical Wear Behavior For Composite Bearings

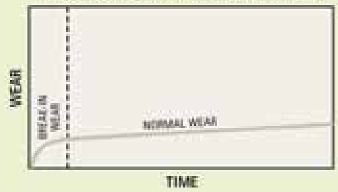


Figure B
Wear vs. Surface Finish

Figure C
Deflection
Chart shows the deflection and the permanent set of a typical CJ Composite Bearing at load.

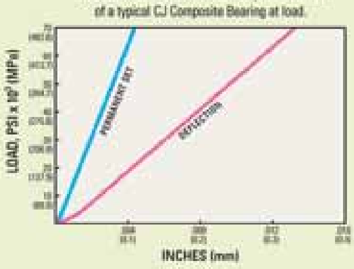
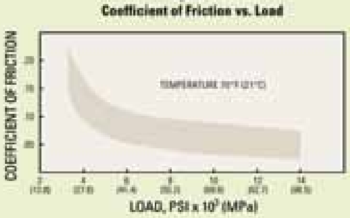


Figure D
Coefficient of Friction vs. Load



General Description

The CJ composite bearing is a multi-layer structure. The inner-most layer consists of a synthetic fiber/PTFE layer. The second layer consists of epoxy-coated high-angle glass filaments. The outer-most layer consists of epoxy-coated low-angle glass filiments.
The synthetic and PTFE fibers used in the liner have a long history of successful use as a bearing wear surface for rod end and aircraft spherical bearings. The high-load capacity and reliability of these bearings has made them the preferred design for many applications.
Fiberglass/epoxy filament wound composites were originally developed for use as pressure vessels and rocket motor cases. Their light weight, high strength, and fatigue resistance make them ideal materials for structural applications. When used to make a bearing, this material allows the selection of fiber angles to provide optimum strength and rigidity. The resulting structure has a modulus of elasticity of approximately 2 x 10^6 psi (13.79 GPa) placing it in an intermediate area between rigid metals and soft plastic. It is rigid enough to support heavy loads, and at the same time compliant enough to tolerate moderate amounts of shaft misalignment without highly stressing the bearing corners. The composite wall acts like a spring and the thicker the wall section of the bearing the greater the deflection for a given load (See **Figure C**). This allows thick wall bearings to tolerate greater shaft misalignment. The wear surface will support the shaft primarily as a function of the load rather than the shaft clearance. As load is applied, the wear surface will conform to the shaft assuring a large contact area. In contrast, the contact area of metal bearings decreases sharply as shaft clearances increase, and increase only slightly with load.

Bearing Wear

Figure A depicts the typical wear behavior of a CJ or FCJ bearing. There is an initial break-in period during which a transfer film is established on the mating surface. In some situations, up to .001" (.03mm) of wear may occur at break-in and in other situations the wear may be negligible. After the break-in period, the wear rate stabilizes and remains relatively constant for the life of the bearing. There is a transfer film of PTFE, epoxy, and some synthetic fiber that clings tenaciously to the metal surface, and acts as a lubricant between the shaft and the bearing.
The equilibrium wear rate depends on a number of factors including loads, speeds, shaft hardness, and shaft surface finish. Under laboratory conditions, radial wear is approximately proportional to both sliding distance and load. The wear rate is often reported as a factor K. This relationship can be expressed as follows:

W = KPVT

W = Radial wear in inches
K = Wear factor
P = Load in psi
V = Sliding velocity (ft/min)
T = Time in hours

The following table shows the actual measured wear factor for a number of conditions of oscillation and rotation. These values were obtained using Rc 50 shafts with a surface finish of 16 Ra(.4 μm). The wear factor would increase if the shaft material was softer or the surface finish rougher. The performance using the softer shafts was significantly lower, especially at the higher load condition. While performance is lower, it is adequate for many less demanding applications.

Measured Wear Factor for CJ Composite Bushings

Type of Operations	P lbs/in^2	V ft/min	K in^3 x min/lbs x ft x hr
Oscillation	229	43.6	$9.6x10^{-10}$
	4,900	2.0	$1.9x10^{-10}$
±25°	15,000	.73	$2.0x10^{-9}$
Rotation	64	78.5	$39.8x10^{-10}$
	64	157.0	$24.9x10^{-10}$
	256	39.3	$14.9x10^{-10}$
	512	39.3	$12.4x10^{-10}$

Measured Wear Factors for FCJ Composite Bearings

Type of Operations	P lbs/in^2	V ft/min	K in^3 x min/lbs x ft x hr
Oscillation	229	43.6	$7.4x10^{-10}$
	4,900	2.0	$1.6x10^{-10}$
±25°	14,000	.73	$5.52x10^{-10}$
Rotation	64	78.5	$33.1x10^{-10}$
	64	157.00	$19.9x10^{-10}$
	256	39.3	$14.6x10^{-10}$
	512	39.3	$12.41x10^{-10}$

Using wear factors, the radial wear of a CJ bearing can be estimated by calculating W and adding .001" (.025 mm) for break-in wear. The liner can sustain .015-.020" (.38mm-.51mm) wear and still operate normally. Bearings having an inside diameter of over 2-1/2" have a thicker liner capable of sustaining .025" to .030" (.64mm - .76mm) wear. Surface finish affects wear rate as shown in (See **Figure B**) Field experience has shown that hard chrome plating gives excellent wear performance and protects the shaft from corrosion. Softer coatings such as cadmium and zinc will not stand up in service and quickly wear off.

Load Capacity

Normal application of load will cause a simple elastic deflection of the CJ bearing along with some permanent set. The set is primarily due to compaction of the synthetic fiber/PTFE liner. We do not typically recommend subjecting the bearings to over 35,000 psi (241 MPa) load. In common with other materials, fiberglass/epoxy composites can undergo fatigue after repeated application of stress. Fatigue has not been a limiting factor in the use of the CJ bearing. Infact, laboratory tests have shown that in many cases the bearing is more fatigue-resistant than the shaft. Laboratory tests show that the bearings fail by a gradual crushing action rather than a rapid catastrophic failure. This is consistent with typical composite behavior in which stress is supported by many fibers. If one fiber breaks, the load is redistributed among the others. Breakage of the entire structure will not occur until a large number of the individual fibers are broken. CJ composite bearings can easily withstand over 35,000 psi (241 MPa) static load or 15,000 psi (103 MPa) dynamic load with a great deal of reliability. In many cases, higher loading can be tolerated if the design and conditions of service are discussed fully with a technical representative.

Length to diameter ratio is also an important design consideration. Test results from the laboratory and the field have shown that the optimum performance can be attained by specifying a length to inside diameter ratio (L/D) ranging from .5 to 2. When the L/D ratio of less than .5 is used, it is possible to create highly stressed areas at the corner of the bearing and cracking will occur at this location prematurely. If the L/D ratio is over 2, with any amount of shaft misalignment, cross corner jamming will occur and unit stresses can exceed the 15,000 psi (103 MPa) safe dynamic limit or the 35,000 psi (241 MPa) static limit of the bearings. Bearings built with the proper L/D ratio will accept misalignment and shock load without premature failure.

Coefficient of Friction

The coefficient of friction of a synthetic fiber/PTFE lined composite journal bearing running against a hardened Rc 50 steel shaft with a 16 Ra (.4 μm) surface, or less, varies from .02 to .25 depending on the load, the relative sliding velocity, and the bearing surface temperature. Generally, the coefficient of friction decreases with increasing load (See **Figure D**).

This information indicates that if the lowest coefficient of friction is desired, the smallest bearing capable of sustaining the load should be used, and that the bearings are capable of performing best under peak operating conditions when temperatures and loads may be higher.

Figure E
Deflection
Chart shows the deflection and the permanent set of a typical FCJ Composite Bearing at load.

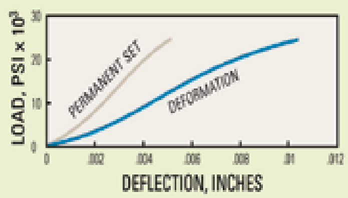
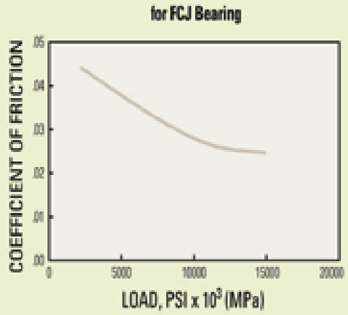


Figure F
Coefficient of Friction vs. Load for FCJ Bearing



Lubrication

The synthetic fiber/PTFE fabric wear surface of the CJ bearing is a self-contained boundary lubrication system; however, the addition of conventional lubricants often improves the overall performance of the CJ bearing.

"Lubricant" is a very general term, and it is often said that any liquid will act as a lubricant.

To some extent, this is true if hydrodynamic conditions are established, and the surfaces have minimal contact. The composite bearing, in earth moving equipment, operates generally in a state of boundary lubrication. Hydrocarbon oils are advantageous and can produce tenfold reductions in wear rates. Liquid lubricants can carry away heat and reduce the coefficient of friction. Greases can be used for lubrication, to prevent corrosion, and keep contamination out of the journal. In oscillating motion, the synthetic fiber/PTFE liner acts as a true boundary lubricant when the direction of motion changes and the lubrication film collapses. In rotation, with oil lubrication, the wear rate of the CJ composite has been found equal to sintered or cast bronze bearings. Fluorocarbon oils and greases should be avoided because they have been found to soften the synthetic fibers and greatly increase the rate of wear.

It is possible to add lubrication holes to the CJ bearing, but grooves are impractical. The abrasion resistance of the synthetic fibers makes groove fabrication difficult and costly.

Thermal Properties

The operating temperature range for CJ bearings is -320°F to +300°F (-195°C to +149°C).

The bearing has been heat stabilized at a temperature above 300°F (149°C) and very little dimensional change will occur in the bearing during operation. In the free state, the coefficient of expansion of the CJ bearing in the radial direction is approximately 7 x 10^{-6} in/in/°F.

When press fit into a housing, the CJ bearing assumes the coefficient of expansion of the housing material, as long as the press fit is maintained, and thus the elastic modulus of the bearing is maintained, because the elastic modulus of the bearing is lower than the elastic modulus of most metals.

The CJ composite is a thermal insulator and when heat is generated from running friction, the bearing wear surface may be hotter than the adjacent housing due to the thermal lag. Since the installed bearing cannot expand outward, it grows inward, reducing the shaft clearance. For this reason, the shaft clearance should be increased for dry running applications that have high running velocities.

Naturally, fluid cooling and lubricants will reduce the operating temperatures.

Heattransfer through the bearing wall is proportionalto the wall thickness, and the thinnerthe composite wall, the greater the transfer of heat.

Measuring Operating PV

PV is a means of measuring the performance capabilities of bearings. P is expressed as pressure or pounds per square inch on the projected bearing area. V is the velocity in feet per minute of the wear surface.
For sleeve bearings the surface speed V is .262 x RPM x diameter in inches. P is equal to the load on the bearing in pounds divided by the projected area in square inches. For sleeve bearings the projected area is the length times the diameter of the bearing.
PV is then obtained by multiplying the P x V as shown in the following example:

3⁄4" Shaft @ 341 RPM;
90 lb. total load, bearing length 1"

V = .262 x RPM x Diameter
or .262 x 341 x .750 = 67 ft/min

P = Total load ÷ projected area
area = .750 x 1.0 = .75 in^2

P = 90 lbs ÷ .75 = 120 psi

PV = 120 psi x 67 fpm = 8040 PV

Mechanical Properties

The CJ bearing has withstood static loads in excess of 50,000 psi (345 MPa) at room temperature. However, we do not generally recommend static loads in excess of 35,000 psi (241 MPa). At the recommended load limits, minimal crushing will occur. As the temperature increases, the load capacity of the bearing decreases. The composite backing tends to act as a shock absorber and reduces vibration. The maximum speed is 150 surface feet per minute for dry running applications.

Corrosion Resistance

The CJ bearing is not affected by corrosive environments. Some solutions of highly concentrated acids will attack the backing material.
Specific information can be obtained from our Technical Service Department. The shaft should be stainless steel or chrome-plated if an alloy steel is used. The CJ bearing cannot rust, but when using a lubricant, it should contain a rust inhibitor to protect the shaft.

SUPPLYING THE PACE OF INDUSTRY

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