TIRUPATI CARBON PRODUCTS PVT LTD

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Mechanical Carbon

carbon

it's nature and structure

Elemental carbon exists naturally in many parts of the world in the forms of graphite and diamond. It also exists industrially in the forms of a variety of cokes.

When mined, graphite is not particularly useful as an engineering material because of its softness, high impurity level and limited size. Cokes derived from coal sources, residues from oil distillation (petroleum cokes) and carbon blacks (obtained from burning oil and gases in limited supplies of air)are hard and vary in purity and structure depending on the source.

The manufacture of industrial carbon and graphite materials has developed over the years – the properties of the resultant products being considerably greater than those of the source materials. By judicious selection of raw materials, and by using a variety of manufacturing processes, carbon and graphite may be modified to provide products suitable for application in a wide variety of engineering and chemical environments.

The raw materials are powdered and bonded together with a pitch or tar and then molded or extruded under pressure to form a convenient size and shape. The resulting product is fired in a protective atmosphere to approximately 1000°C. During this process, the tar and pitch are converted to a coke, thereby cementing the particles of the other raw materials together, to form a cohesive mass. Such a product is known as amorphous carbon or carbon-graphite, depending on the raw material selected.

Some grades of carbon are further heat treated to temperatures of up to 2500°C at which level the amorphous carbon is transformed into a crystalline electro- graphite. This material has greater purity, improved electrical and thermal conductivities and better oxidation resistance.

Carbon and graphite materials that are produced by this means are porous and can be impregnated with synthetic resins or metals. The impregnates confer increased strength, lower permeability and improved wear-resistance characteristics to the basic carbons.

Carbon and graphite may readily be machined to close tolerances using normal workshop techniques of turning and grinding.

Most carbon components are individually designed to meet customers' requirements and are machined from blanks of the appropriate grade.

Components required in exceptionally large quantities may be mass produced by 'pressing to shape' - a manufacturing method which reduces or eliminates machining. It is essential that the Company's specialists are involved at the design stage, so as to derive maximum benefit from the process.

it's properties

Carbon possesses a unique combination of properties. Of particular interest to the engineer is that:

it is

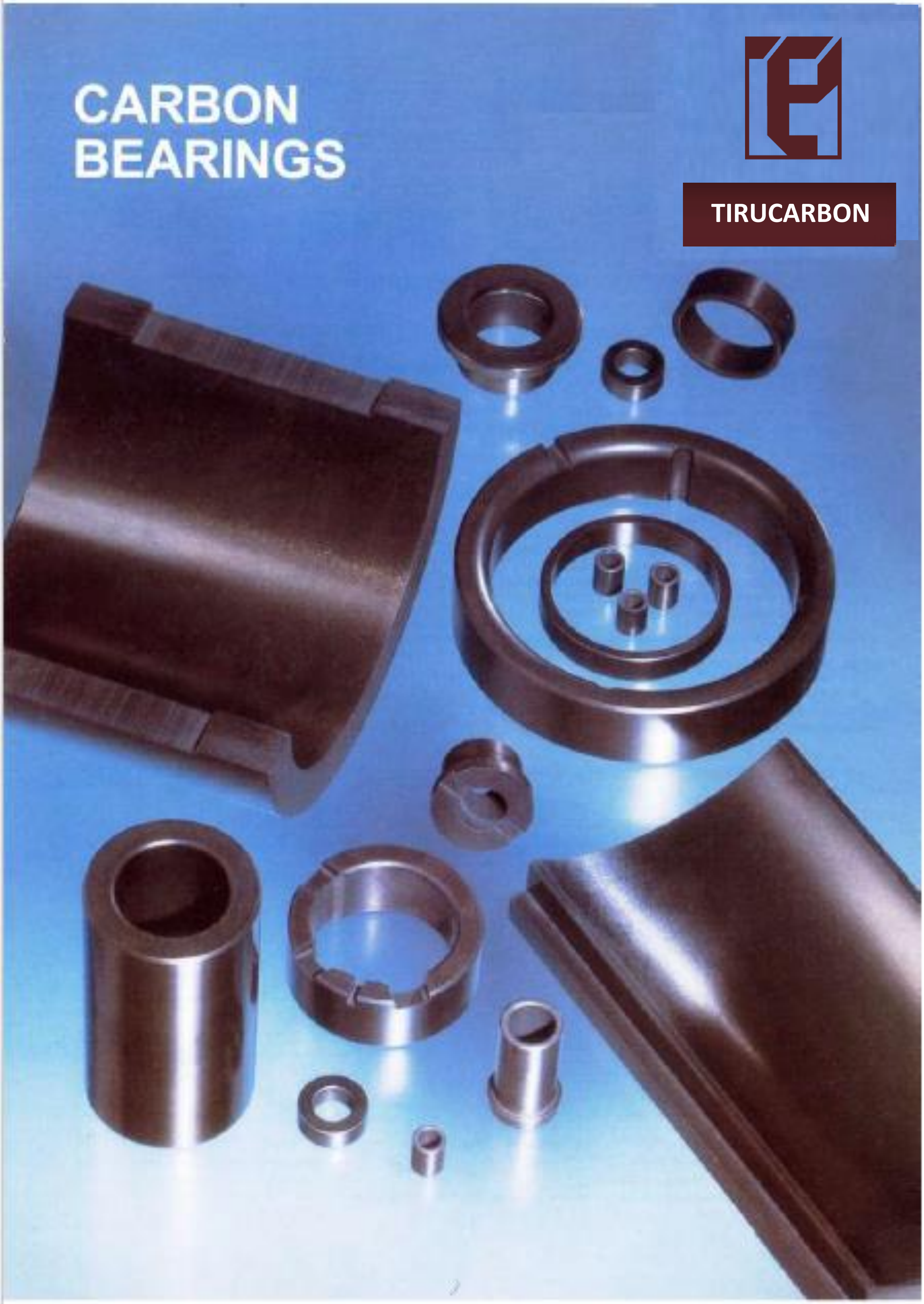
- **self-lubricating**
- **non-galling**
- **dimensionally stable**
- **chemically inert**
- **easily machined**
- **non-contaminating**
- **resistant to oxidation**

and has

- **low thermal expansion**
- **high thermal conductivity**
- **good thermal shock resistance**

These features enable carbon to be used in a vast range of industrial applications where conventional lubricants cannot be used because:

- of their nuisance or the risk of contamination
- of high temperatures
- the environment is contaminated with corrosive fluids
- the components are immersed in incompatible liquids


CARBON
BEARINGS
TIRUCARBON

bearings

1. INTRODUCTION

TCP has progressively developed carbon bearings over the years and currently these are used in a wide variety of applications where the operating conditions preclude the use of more conventional materials.

Some typical applications are:

- **aircraft engine fuel pumps**
- **submersible pumps**
- **canned motor pumps**
- **seal-less pumps**
- **chain grate stokers**
- **veneer drying ovens**
- **conveyors**

TCP Carbon bearings are usually press, shrink fitted or bonded direct into their housings. They are additionally available as sub-assemblies fitted into metal shrouds or as conveyor hanger bearings in self-aligning assemblies.

TCP Carbon is self-lubricating, chemically inert, dimensionally stable, non-hygroscopic and highly resistant to wear-characteristics which make it ideal for those hostile environments where conventional bearings cannot be used. Typical of these are where:

1. oil contamination cannot be tolerated 2. temperatures exceed the limits of normal lubricants 3. operation is in a non-lubricating fluid	TCP carbon bearings are capable of sustaining PV's (kg/cm^2 x m/s) of 1.5 at temperatures of 500° C in an oxidising atmosphere and well above 350 PV in non-lubricating liquids.

2. MATERIALS

Carbon grades

The selection of the appropriate TCP grade of carbon is dependent upon the bearing operating conditions and is usually from one of the following four categories:

1	TCY2 TCY10	amorphous carbon/graphite maximum temperature 300° C
2	TCY2C TCY10C	amorphous carbon/graphite, resin impregnated maximum temperature 270°C
3	TMY3A TMY10A	amorphous carbon/graphite copper impregnated maximum temperature 300° C
4	TEY9106	electrographite maximum temperature 500° C oxidising atmosphere 3000° C non-oxidising atmosphere

(NB: TCP Grade Data Sheets giving complete physical properties are available on these and other materials).

Shaft materials

The shaft to run against a TCP carbon bearing should be hard and corrosion-resistant such as austenitic iron, hardened stainless steel, thick chrome plate or stellite. Non-ferrous metals and mild steel should be avoided.

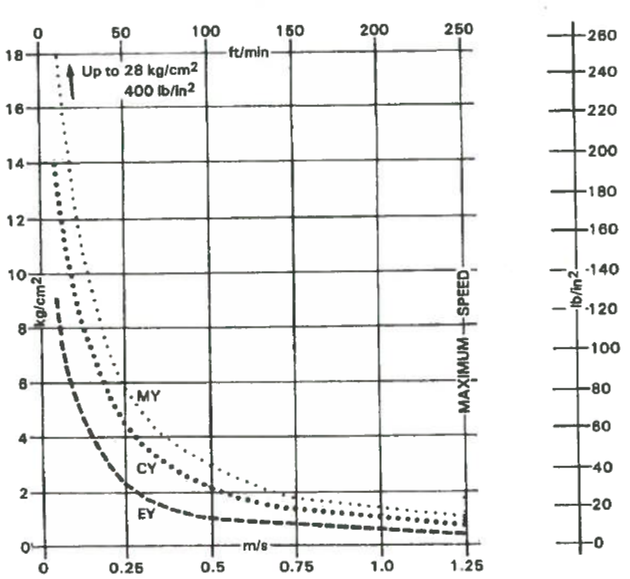
A shaft surface finish of between 0.25-0.50 microns Ra is recommended although for lightly loaded applications, 2 microns Ra may be accepted.

3. OPERATING LIMITS

Dry-running

The PV curves shown below provide a guide for the continuous operation of TCP carbon bearings. For short periods or interrupted operations, these recommendations may be exceeded by a generous margin.

PV CURVES – for continuous dry operations and steady loads



METRIC

Max. PV		(kg / cm² X m / s)
TCY GRADES	....	1.1
TEY GRADES	....	0.55
TMY GRADES	....	1.45

IMPERIAL

Max. PV		(lb / in² X ft / min)
TCY GRADES	....	3000
TEY GRADES	....	1500
TMY GRADES	....	4000

Wet running

TCP carbon bearings running in liquids of high lubricity are capable of achieving performances approximating to those of conventional metal bearings. In more mobile liquids such as water, petrol and kerosene the special characteristics of TCP carbon, allied to careful design, permit operations at PV's of 350 kg/cm^2 m/s and above.

Friction

The coefficient of friction is not a physical property of a material and depends on the nature and operating conditions of a rubbing pair. It will vary with the environment, load, speed, surface finish etc.

In dry operations, a TCP carbon bearing running against a hard well-finished shaft may be expected to show a coefficient of friction varying between 0.10 under light and 0.25 under heavy loads.

The characteristics of the liquid will determine the coefficient of friction in a fully lubricated application whilst under boundary layer conditions it will probably be within the range of 0.01 to 0.10.

4. DESIGN

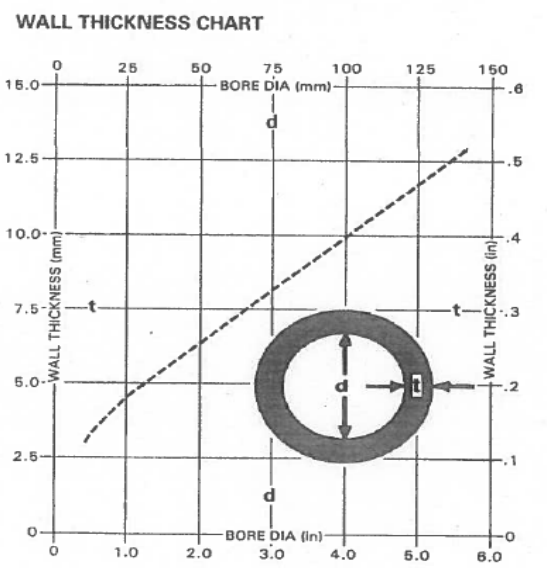
General

Well proven practices should be followed when designing a TCP carbon bearing. It should be as simple as possible and unnecessarily close tolerances avoided. The bearing must be fully supported in its housing and must not be retained by grub screws, pins or similar devices. In addition:

1. Flanged bearings are not recommended, axial loads should be carried on the end of a plain bearing or a separate thrust washer provided.
2. No oil, grease or abrasive dust should contaminate the rubbing surfaces of a dry bearing.
3. An adequate flow of liquid must be maintained at the rubbing surfaces of a lubricated bearing and any grooves provided to facilitate this must not interrupt the develop-ment of a hydrodynamic liquid film.

Dimensions

TCP carbon bearings are available with a maximum length of 100mm and 250mm outside diameter. The curve indicates recommended wall thickness.



Fitting

TCP carbon bearings should always be fully supported. It is desirable, therefore, that they be either press or shrink-fitted into metal housings.

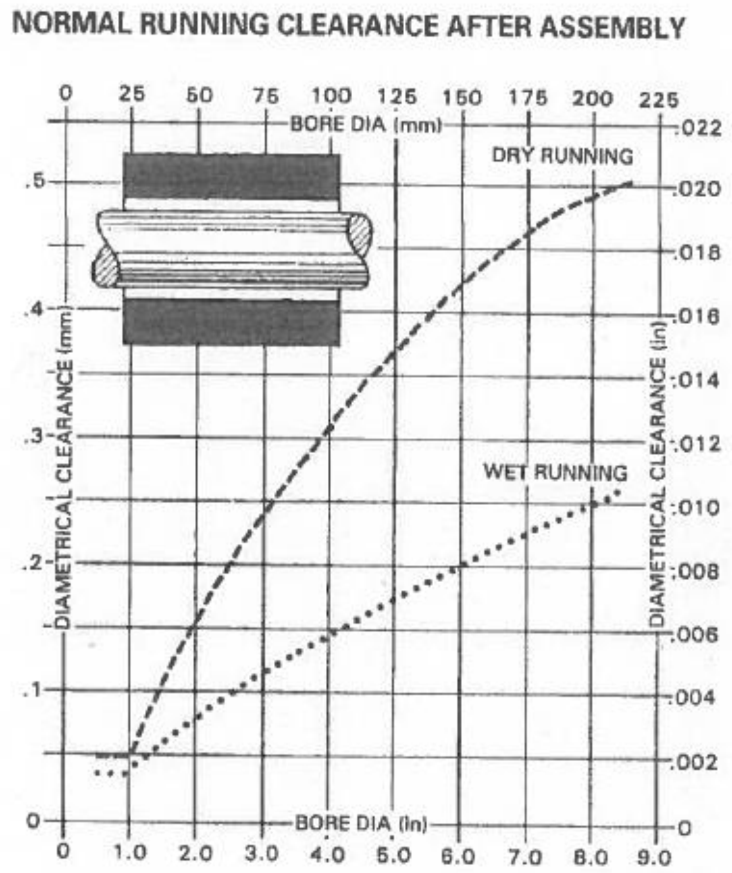
Press-fitting may only be employed for small bearings where the interference will not exceed 0.15mm.

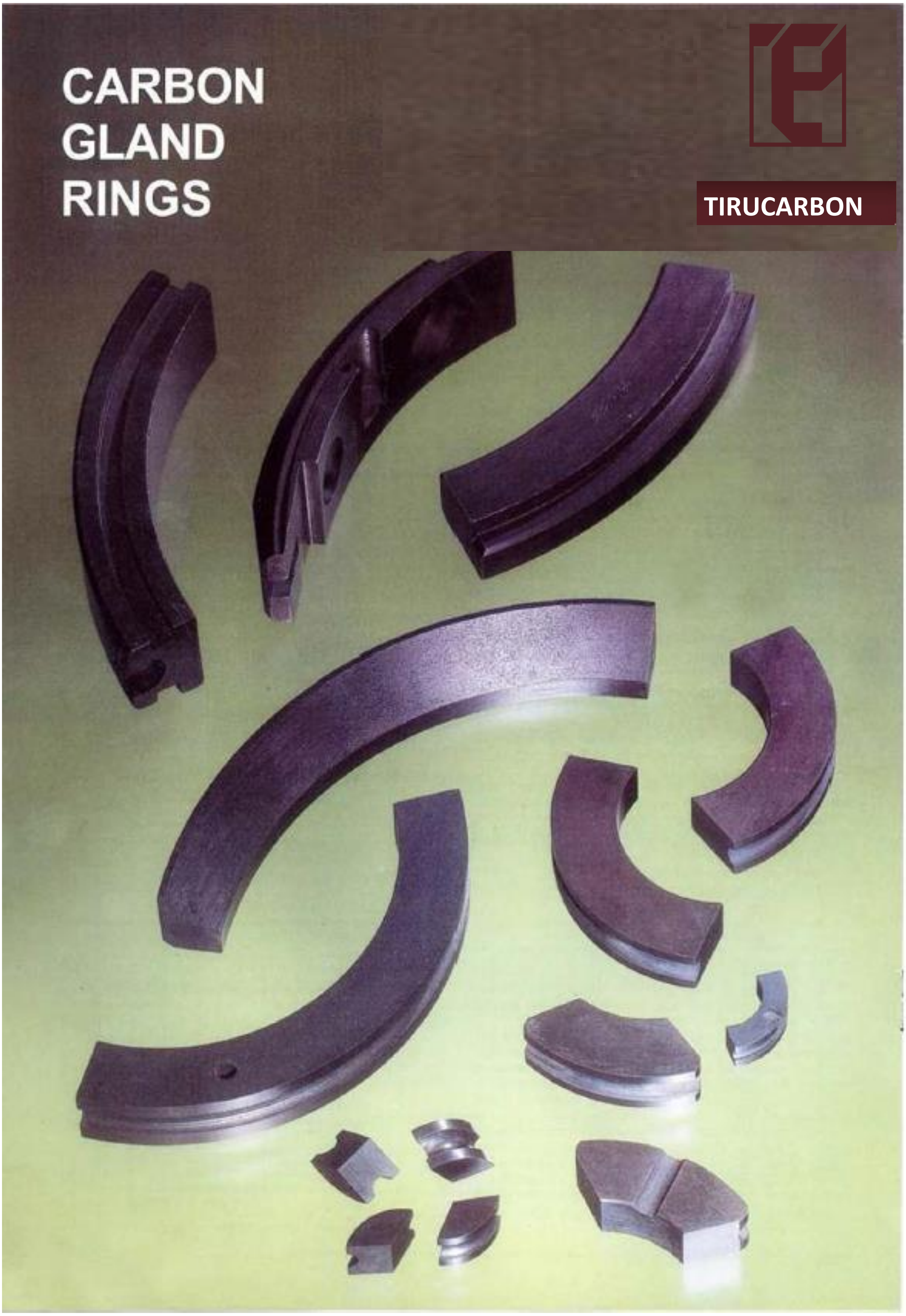
The coefficient of thermal expansion of carbon is about a quarter that of steel. In consequence shrink-fitting is essential for high temperature operations which, by pre-stressing the carbon, provides the added benefit of ensuring approximately constant running clearance.

In those applications where shrink-fitting into a housing is impracticable, TCP carbon bearings should be shrunk into a separate sleeve which in turn may be located in the main housing by conventional means.

Running clearances

The recommended running clearances for TCP carbon bearings are indicated in the curve below.




CARBON
GLAND
RINGS
TIRUCARBON

1. INTRODUCTION

The self-lubricating properties of carbon make it an ideal material for both contact and non-contact types of gland rings. Carbon gland rings are used for sealing liquids and gases, restricting leakage to a minimum. They provide a simple and effective seal on impulse turbines, low pressure fans and blowers, water turbines and the like.

Carbon gland rings are widely used as shaft seals in fans, and water and steam turbines. They are fabricated in segments which form a complete ring when encircled by a garter spring.

Extremely fine tolerances are observed in their manufacture and a feature of segments manufactured by TCP Carbon is their interchangeability with rings of like design.

The segments of a traditional fan or steam turbine gland are butt-jointed and, if conditions warrant, several rings are used in tandem. This design provides an efficient seal under stable running conditions.

Labyrinth designs incorporating graphite improve sealing efficiency in both steam and gas turbines. Rubbing contact between the shaft fins and graphite rings causes no damage. Very small radial clearances may, therefore, be tolerated resulting in a significantly reduced leakage rate. A special grade of graphite has been developed which is able to withstand both the high temperatures and pressures which obtain in this application and is sufficiently soft to permit the rotating shaft fins to cut into the stationary gland ring.

Carbon glands manufactured by TCP Carbon are also supplied for water turbines in hydro-electrical installations. The wedge type ring is a typical TCP design which, because of its improved efficiency, has been adopted as standard by many manufacturers in preference to the tenon-jointed ring. The ends of the segments of wedge ring are bevelled and the wedge pieces, which are interposed between the segments, move outwards to accommodate wear.

2. APPLICATIONS

2.1 Steam and Gas

For steam and gas applications, non-contact gland rings, which seal by throttling, are used. With these rings, the bore of the carbon ring is designed to match the shaft diameter at the operating temperature.

For assembly reasons the carbon rings are made in segments, and are held in position in L-housings, and a stop pin is fitted to each ring to prevent it rotating with the shaft. Either rectangular section rings or bevel-section rings may be used; the segments are usually butt-jointed.

BEVEL SECTION CARBON GLAND

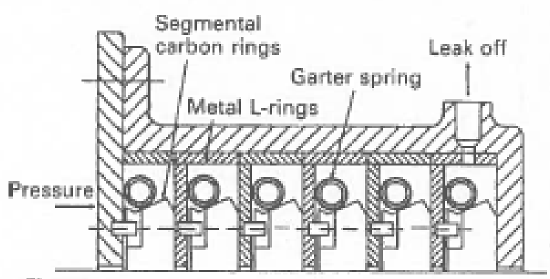


Figure 1

A bevel-section gland ring is shown in *Figure 1.*

2.2 Water Turbines

Segmental carbon rings with special joints, enabling the rings to maintain contact with the shaft as wear of the carbon occurs, are widely used for water turbines. The majority of rings supplied conform broadly to either one of two patterns the tenon type or the wedge type. Rings of the same type may differ in detail although they will generally comply with the following descriptions.

2.2.1 *Tenon Jointed Rings*

A gland arrangement using a tenon jointed ring is shown in *Figure 2.* Each segment is mated to its neighbour by an integral tongue fitting into a recess. The tenon joint itself can be either single or double and segments of both types are shown in *Figure 2.* A garter spring holds the segments together, and also loads them against the housing, so that a static seal across the radial face of the carbon is obtained.

A small gap is left in each joint permitting self adjustment of the ring. As wear of the carbon takes place, the segments move radially inwards under the action of the water pressure and the garter spring. Carbon rings of this kind are thus contact seals.

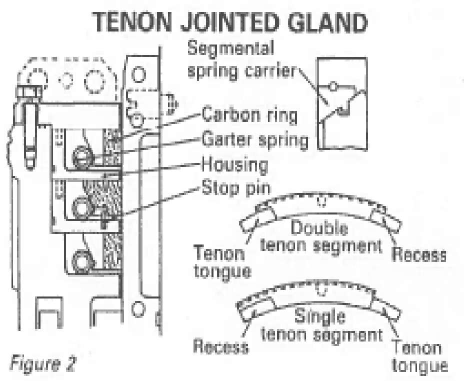


Figure 2

2.2.2 *Wedge Rings*

Carbon wedge rings are sometimes favoured alternatives to tenon rings on water turbines. A typical wedge ring arrangement is shown in *Figure 3.*

A wedge ring consists of a series of long segments and short wedge pieces. The ends of the segments are angled to present sliding surfaces to the tapered wedge pieces. A garter spring holds the segments and wedge pieces in position and stop pins locate the long segments in the housing.

The rings are fitted in pairs and displaced from each other, so that the long segments of one ring cover the wedge pieces of the adjacent ring. In this manner, no direct leakage path through a pair of rings exists. Axial compression springs are fitted in recesses in the gland housing to act on each pair of rings, so as to effect a seal across the radial face.

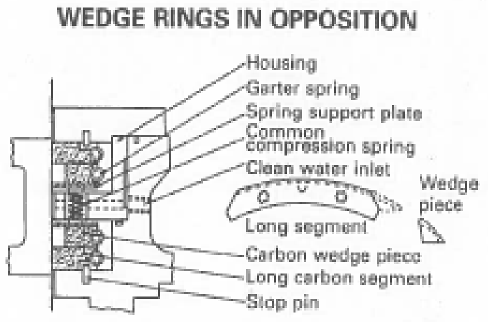


Figure 3

2.2.3 *Radial Face Seals*

Radial face seals are also employed in Francis turbines, and often take the form of two concentric carbon rings running against a counterface fixed to the turbine shaft. The rings are located in a suitable stationary housing and are initially loaded against the counterface by compression springs. A typical radial face seal is shown in *Figure 4*. The diameters of the rings involved usually necessitate segmental construction with the joints of the inner and outer rings staggered relative to each other. The segments are located with stop keys to prevent rotation of the carbon ring in the housing.

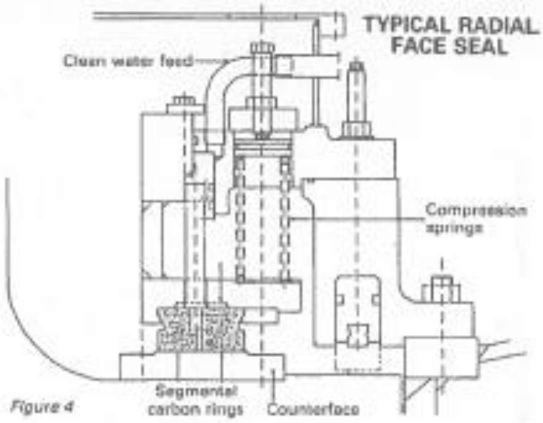


Figure 4

A circumferential annulus is formed between the two rings which is fed with clean water. The clean water, pressure is restricted to the minimum required to prevent dry running of the rings and generally does not exceed an over pressure of 2 kgf/cm2. It is essential that an adequate supply of clean water is available.

2.3 Carbon Labyrinth Glands

Carbon labyrinth glands are similar in function to metal labyrinths, but because much smaller radial clearances can be used, higher pressures, through a shorter axial length can be sealed effectively. They are used as main shaft seals in gas turbines, auxiliary steam turbines, rotary compressors and blowers. A typical carbon labyr-inth is shown in *Figure 5*.

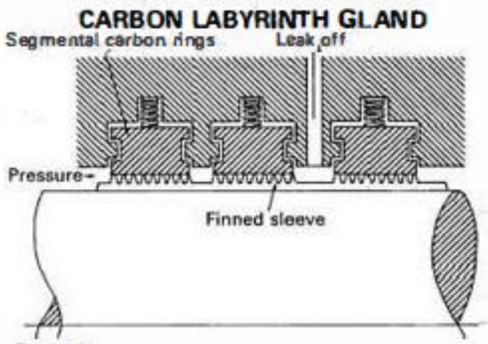
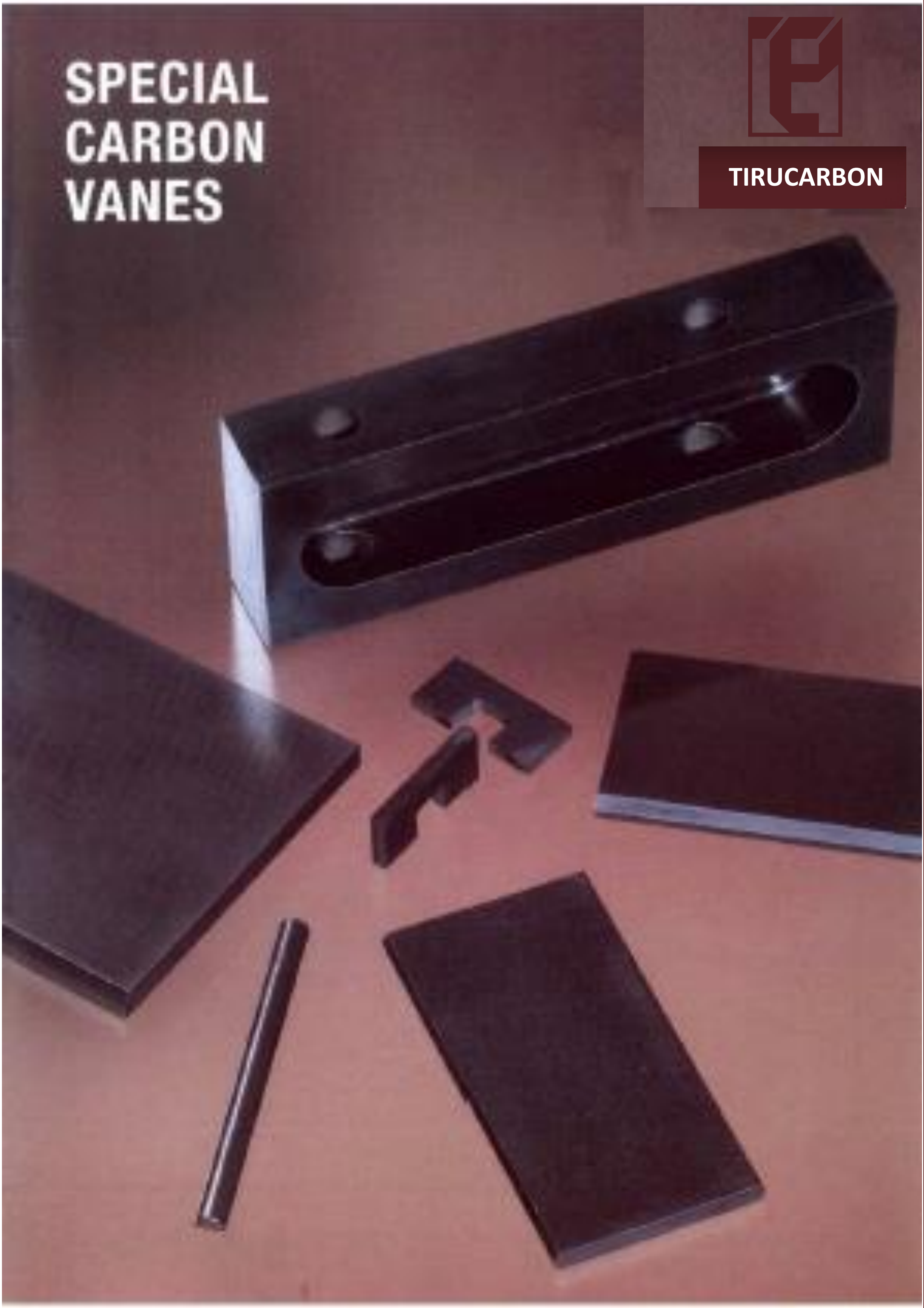


Figure 5

3. CARBON GRADES

Grade	Description	Hardness scleroscope	Bulk density	Transverse bend strength		Compressive strength		Porosity (apparent)
			kg/m^{3}x 10^3	kgf/cm^2	lbf/in^2	kgf/cm^2	lbf/in^2	%
TCY1 TCY2	Amorphous carbon / graphite, maximum temperature 300°C	60 60	1.70 1.70	280 315	4000 4500	840 1020	12000 14500	12 12
TCY2T	Amorphous carbon/graphite, wax impregnated, maximum temperature 300"C	60	1.70	315	4500	1020	14500	4
TCY2C	Amorphous carbon/graphite, resin impregnated, maximum temperature 270°C	80	1.84	560	8000	1830	26000	1
TCY2W	Amorphous carbon/graphite, resin impregnated, maximum temperature 300°C	74	1.84	350	5000	1270	18000	1
T EY9106	Electrographite, maximum temperature 500°C in an oxidising atmosphere	50	1.72	300	4200	600	8500	15


SPECIAL
CARBON
VANES

1. INTRODUCTION

TCP Carbon vanes are made in a range of carbon materials (carbon-graphite, metal impregnated carbon-graphite and resin bonded graphite) to meet many different application requirements. All TCP grades retain the basic properties which make carbon unique as an engineering material, and particularly suited for vanes which may operate in conditions beyond the limits of other materials.

Carbon is ideally suited for vanes used in rotary pumps and compressors for handling non-lubricating liquids and gases and where an oil-freed delivery is essential. In these applications the self-lubricating properties of TCP Carbon are critical and, as no odour or taste is imparted to the fluids with which it is in contact, is ideal for food processing plants.

TCP Carbon is dimensionally stable both through a wide temperature range and in a variety of fluids. Very fine vane-to-rotor slot clearances may, therefore, be set and maintained, thus ensuring maximum efficiency.

TCP resin bonded grades have found wide acceptance in the high duty market and is having a high impact strength and low friction. It is capable of operating under extreme conditions with the minimum of wear.

TCP Carbon vanes are used in many applications including:

- **Air pumps for the printing industry**
- **automotive fuel pumps**
- **bulk liquid metering**
- **garage forecourt pumps**
- **aircraft fuel tank metering**
- **drinks vending machines**

2. SELF-LUBRICATING

Carbon vanes are self-lubricating, and therefore ideal for pumps handling liquids whose lubricating properties are poor, such as petrol. Theycan also operate unlubricated in compressors to deliver air or gas uncontaminated by lubricating oil or grease, in which case the carbon gives a fine polish to the cylinder wall which reduces the wear rate of the vane after bedding in to almost negligible proportions.

3. CHEMICALLY INERT AND NON-TOXIC

Carbon vanes are chemically inert and non-toxic and cannot contaminate the liquid or gas being handled. They can safely be used in food processing equipment and in other fields where purity is essential.

4. UNAFFECTED BY MOST ACIDS, ALKALIES, PETROLS OR AQUEOUS SOLUTION

Carbon vanes are totally unaffected by water, most acids, alkalies or oil solvents such as petrol or paraffin. In these conditions. the liquid can reduce friction and wear by providing lubrication between vane and rotor slots and vane top and cylinder wall.

5. HIGH MECHANICAL STRENGTH

One of the most important requirements for vane materials is high mechanical strength. Carbon vanes meet this requirement. Their strength is indicated by the pressures regularly handled which range from 3.2 kgf/cm^2 (45 lbf/ in^2) down to high vacuum conditions, with peripheral speeds up to 12.7 m/sec (2500 ft-min).

6 . CYLINDER

It is important to use the correct cylinder material for operation with carbon vanes. Where possible a corrosion resistant metal should be used, and for optimum results this should be as hard as possible. Suitable materials are:

Ni-resist' cast iron
Cast iron, minimum of 220 Brinell
'Meehanite' cast iron
Hard stainless steel, minimum of 420 Brinell
'Nitralloy steel', fully hardened
Hard chrome plating 0.13 to 0.25.mm (0.005 to 0.010 in)
Hard alloy. e.g. cast aluminum, aluminum oxide coated.

The cylinder wall should be fine ground and honed, if possible, to a surface finish of 15/25 microinch CLA.

7. ROTOR

This should also be of corrosion-resistant material. Each slot should be well finished and free from any surface roughness.

8. APPLICATIONS

The applications where carbon vanes are being used are extensive. Typical of these are:

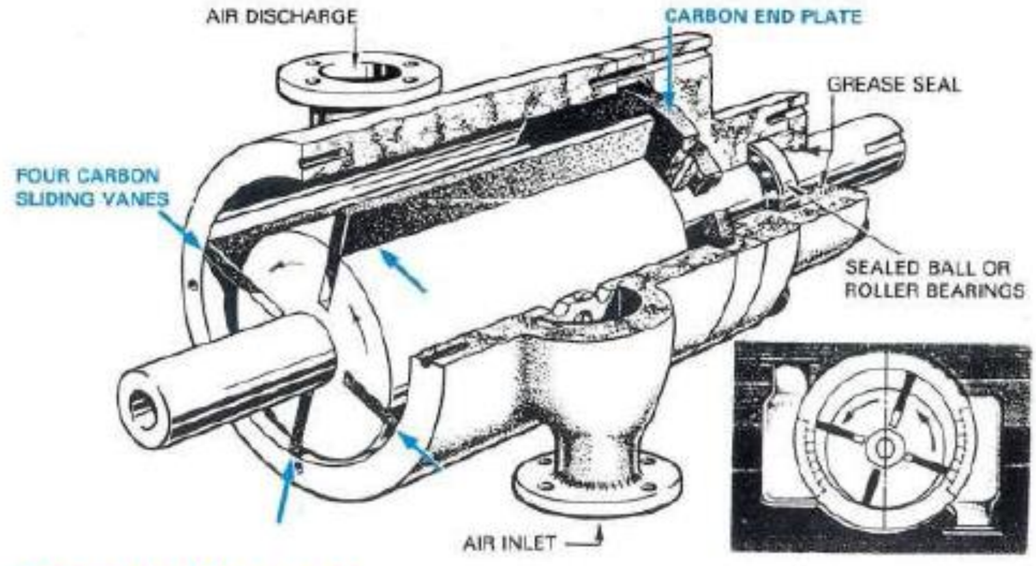
Dry running rotary compressors and vacuum pumps
mobile compressors fitted to bulk delivery tankers
printing machinery
spray paint equipment
packing machinery
food processing equipment
Wet running vane pumps and meters
automotive diesel fuel pumps
kerbside petrol pumps
drink vending machines
fuel tanker meters

9. PHYSICAL PROPERTIES

The figures quoted are for the grades most commonly used in the manufacture of vanes. These are typical values and allowance must be made for the variability attainable between individual batches and measurements.

The choice of the correct TCP grade depends on tfle operating conditions involved: whether liquid or gas is handled, the peripheral speed, the differential pressure, the type of rotor employed and the disposition of the slots (whether radial or inclined}, maximum permissible vane thickness and general design of the vanes. Our highly skilled engineers are available to give advice on the correct choice of material.

Grade	Description	Bulk density	Transverse bend strength	Compressive strength	Impact strength	Porosity (apparent)
		(kg/m^{3}x10^3)	(MPa)	(MPa)	(KJ m^{-2})	(x10^{-6} °C^{-1})
TCY10C	Carbon-graphite, resin impregnated	1.80	64	207	1.3	4.0
TCY10F	Carbon-graphite, carbonised impregnant	1.65	53	138	0.8	3.8
TMY10D	Carbon-graphite, copper/ lead impregnated	2.90	96	255	2.6	5.0
THYX67	Resin bonded graphite	1.68	75	114	2.0	15.0



TYPICAL ROTARY PUMP

Carbon Sealing Rings

The 'rubbing pair' is the heart of any mechanical seal and in the majority of designs one member of this will be carbon, where its unique properties are fully exploited.

TCP Carbon is the first choice of many manufacturers for applications ranging from the mechanical seal in a washing machine or car coolant pump to that in a pump operating in the hostile environment of a North Sea oil rig, in the stern shaft of a nuclear submarine or in the main shaft seal of an aircraft gas turbine.

TCP seal rings are machined to close tolerances from blank material or pressed to-shape when the demand is for large quantities. All are impregnated with either resin or metal to ensure impermeability and are lapped, when necessary, to within three helium light bands of flatness.

TCP Carbon seal rings are compatible with a wide range of metallic and ceramic counterfaces including silicon carbide.

A variety of counterface materials, pressures fluids, speeds and temperatures are accommodated by the versatility of the TCP range of Carbo Seals. The applications range from dish-washer seals to stern shaft seals for nuclear submarines.

Pumping equipment fitted with TCP Carbon Seal Faces is capable of handling a wide variety of materials including:

- PETROCHEMICALS
- ACIDS
- ALKALIES
- SOLVENTS
- FOODSTUFFS
- WATER
- REFRIGERANTS

Everybody involved with seals, from designers to users, can benefit from the excellent friction properties and high chemical resistance afforded by TCP materials.

For generations designers and engineers have used TCP expertise and materials to solve their tribological problems. Many of the materials have been tested and approved by major companies in the Aerospace, Nuclear, Sealing and Pumping Industries.

The experience, backed by on-going research and development programmes together with first class technical facilities, make TCP materials the ***Problem Solvers for Industry.***

For various mechanical carbon grades please visit our website **www.tirucarbon.com**

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