ARMSTRONG ENERGY

Vesconite Bushing Design Manual

How to design and specify bushes that work better last longer and cost less

Specialising in parts for power generation, oil and gas installations, and the mining industry.

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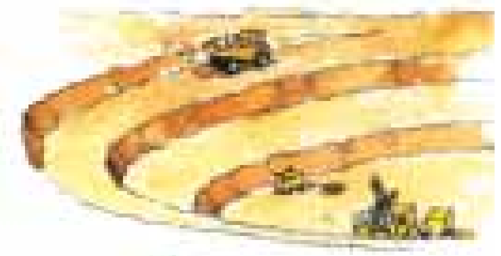
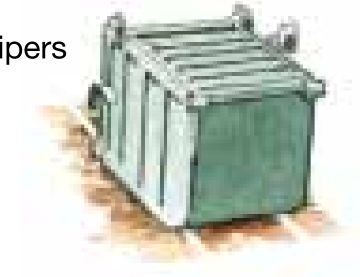


Mining

Mines are dirty and often wet or humid.
Bushes need to give long life even though poorly maintained and often abused:

- skip pivots
- winder brake callipers
- chair lifts
- feeder systems
- battery locomotive motor axles
- bin and hopper units



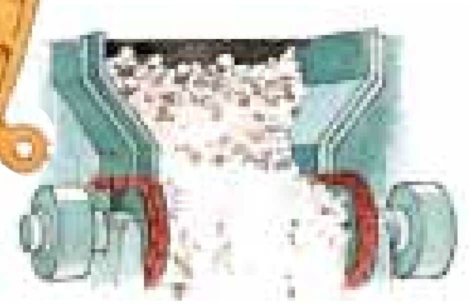
Earthmoving

Long life even in dirty conditions.
Loads are high and speeds low:

- suspension systems
- pivot points
- oscillating joints
- walking beams
- back hoe joints
- H-frames

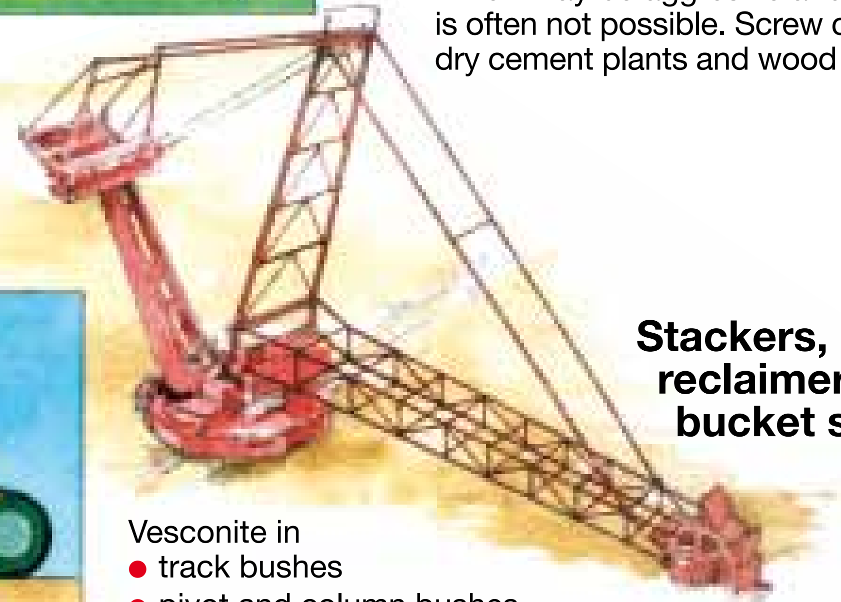
Crushers and feeders

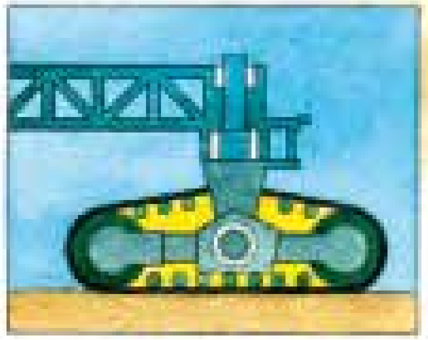
Vesconite bushes in large double toggle jaw crushers overcome greasing problems and give significantly longer life than bronze.



Screw conveyors

Hanger bearings experience wet or dry environments. They often come into contact with the transported medium which may be aggresive and lubrication is often not possible. Screw conveyors in dry cement plants and wood pulp plants.

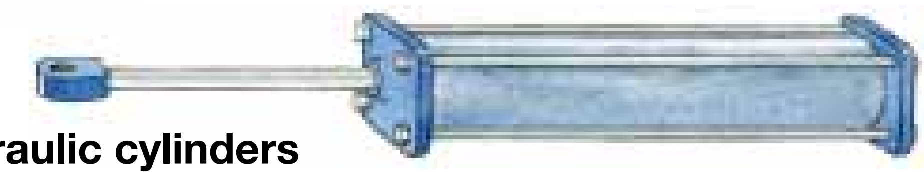




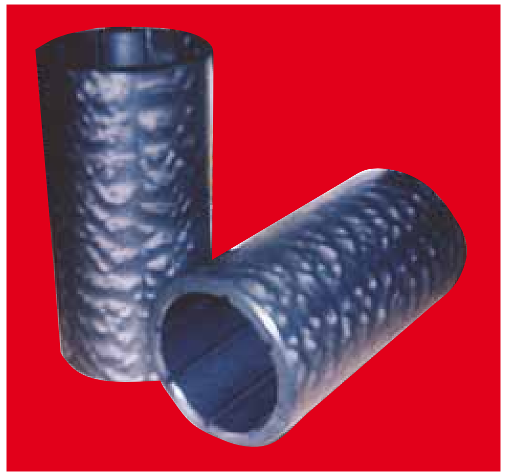
Stackers, reclaimers, bucket scoops

Vesconite in

- track bushes
- pivot and column bushes



Pneumatic and hydraulic cylinders



Example of Load / PV Limit Calculation

e.g. Load = 200kg   Shaft Ø = 25mm   Shaft Speed = 60 RPM   Bush Length = 50mm

(Refer to Page 8)

REFER STEP 1. Calculating the Load (P)

$$\text{Loading (P)} = \frac{\text{Mass supported by Bush (kg) X 9.8}}{\text{Shaft Ø (mm) X Bush Length}}$$

$$= \frac{200 \text{ X } 9.8}{25 \text{ X } 50}$$

= **<u>1.57 MPa</u>**

REFER STEP 2. Calculating the Surface Speed (V)

$$\text{Surface Speed (V)} = \frac{\text{RPM X } \pi \text{ X Shaft Ø}}{1000}$$

$$= \frac{60 \text{ X } 3.14 \text{ X } 25}{1000}$$

= **<u>4.71 metres/min</u>**

REFER STEP 3. Calculating the PV Rating

(Refer to Page 9)

PV = Load (P) X Speed (V)

= 1.57 X 4.71

= **<u>7.39 MPa.m/min</u>**

From the PV Limits chart on Page 10, it can be safely assumed that:

(i) Bush manufactured in Vesconite will require initital lubrication on installation only.

(ii) Bush manufactured in Vesconite Hilube will require no lubrication.

Typical Vesconite and Vesconite Hilube applications

Pumps

Vesconite bushes are suitable for operating with water or oil as a lubricant. The exceptionally low friction of Vesconite Hilube can survive a dry startup or temporary suspension of the process flow as a result of blockages.

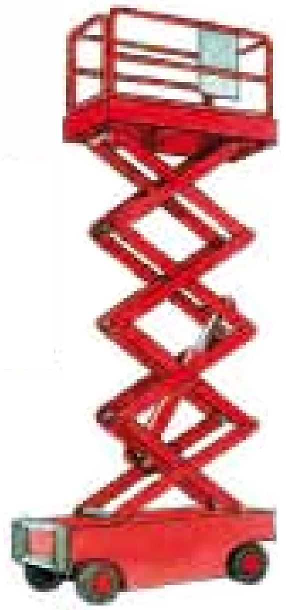
- lineshaft bearings
- casing wear rings
- impeller wear rings
- support bearings
- impeller support bearings

A Vesconite Pump Bearing Design Manual is available

Valves

Bush material is required to withstand the range of piped fluids:

- valve stem bushes
- pivot bushes



Tail and scissor lifts

Bushes are required to take high loads. Bushes often required to be thin walled in compact designs.

Brick and block making machines

Long life even in dirty conditions.

Conveyors and idlers

Applications requiring long life bushes under high loads.

- slow speed idlers
- feeder rollers
- castor wheels and
- pivot points

Forklift trucks

Vesconite gives low wear in demanding forklift applications:

- mast tilt cylinders
- mast pivots
- steer axles
- valve and pedal levers
- side shift slides
- mast slides
- suspensions

Vesconite replaces needle roller bearings on

- king pins
- thrust washers

Vesconite bushes could be your answer...

- Ensure longer bush life
- Reduce maintenance
- Reduce shaft wear
- Stop greasing
- Solve problems in wet conditions

Vesconite and Vesconite Hilube are premier bushing materials designed for longer life and lower shaft wear in poorly lubricated or dirty or wet applications.

Your journey starts here ...

The planet's most versatile bushes – dry, wet, dirty, greased or ungreased.

Different from bronze

- Vesconite is self lubricating
- Vesconite survives dirt

Different from nylon

- Vesconite does not soften in humid conditions or when immersed in water
- Vesconite does not swell in water

What is Vesconite?

Vesconite and Vesconite Hilube are specialised plain bearing materials made from internally lubricated low friction polymers.

Vesconite bushes give excellent wear in harsh, wet, dirty or unlubricated conditions.

Vesconite and Vesconite Hilube have proven advantages over traditional bushing materials such as bronze, acetal, nylons (whether plain or internally lubricated), nitriles, rubbers, elastomers, phenolics and laminates.

Vesconite

The internally lubricated polymer bush material, designed to operate

- under high loads
- with low speeds
- in dirty or wet conditions
- where a long life is required.

Vesconite Hilube

The advanced grade of Vesconite for

- lower friction
- longer life than standard Vesconite
- mechanical properties essentially the same as for Vesconite.

e.g. To machine a Vesconite bush to fit into a 120mm Ø housing and carry a 100mm Ø shaft. *(Refer to Page 10)*

1. Calculate Press Fit

= 0.05 + 0.2% Housing Diameter

= 0.05 + (0.002 X Housing Ø)

= 0.05 + (0.002 X 120)

= **0.29mm**

2. Calculate Bore Closure

$$= \text{Press Fit} \times \frac{\text{Housing Ø}}{\text{Shaft Ø}}$$

$$= 0.29 \times \frac{120}{100}$$

= **0.348mm**

3. Calculate Assembly Clearance

= 0.05mm + 2% NWT

= 0.05 + [0.02 ½ (120 -100)]

= **0.25mm**

From the above we can now calculate the following finished machined size.

Outside Ø

= Housing Ø + Press Fit

= 120 + 0.29

= **120.29mm**

Inside Ø

= Shaft Ø + Bore Closure + Assembly Clearance

= 100 + 0.348 + 0.25

= **100.60mm**

Press Fits

Polymers generally have a much lower rigidity than metals and show greater elasticity. This means that greater press (interference) fits and wider tolerances can be used.

The press fit recommended for normal conditions is:

Press fit = 0.05 mm + 0.2% housing diameter

Use greater press fits when operation below 5°C is expected because Vesconite contracts on cooling. Your Vesconite distributor can help specify a suitable press fit.

Bore Closure

This occurs when a bush is pressed into a housing, the inside diameter is reduced by an amount somewhat greater than the press fit.

$$\text{Bore Closure} = \text{Press Fit} \times \frac{\text{Housing Ø}}{\text{Shaft Ø}}$$

Assembly Clearances

Metal bushes generally require fairly fine clearances to avoid noisy operation and possible brinelling. Polymer bushes on the other hand require medium to large clearances to allow for thermal expansion, thermal conductivity and water absorption.

Generally speaking, increased clearances do not cause problems with polymer bushes owing to their greater elasticity and resilience. **Too fine clearances cause most of the failures associated with polymer bushes.**

Vesconite bushes enjoy a relatively low thermal expansion coefficient and negligible water absorption. They may be used with clearances finer than those advised for most polymers. **Nevertheless, clearances substantially larger than those specified for phosphor bronze bushes are generally required.**

The clearance recommended for normal conditions is:

Assembly clearance = 0.05 mm + 2% NWT

NWT = nominal wall thickness = ½ (housing Ø -shaft Ø)

Why Vesconite and Vesconite Hilube are ideal for long life, low maintenance bushes

Low wear

Vesconite gives a low wear rate on the bush and shaft.
In dirty conditions, Vesconite Hilube running against suitably hard shafts gives a low shaft and bush wear.

Low friction

Vesconite has a low friction even when running dry.

- Vesconite's low friction applies under actual operating conditions.
- Stick-slip is minimal with Vesconite and does not occur with Vesconite Hilube.

Internally lubricated

Vesconite is compounded with internal lubricants that form an integral part of the material. This gives Vesconite a low friction and a low wear rate even when running without lubrication.

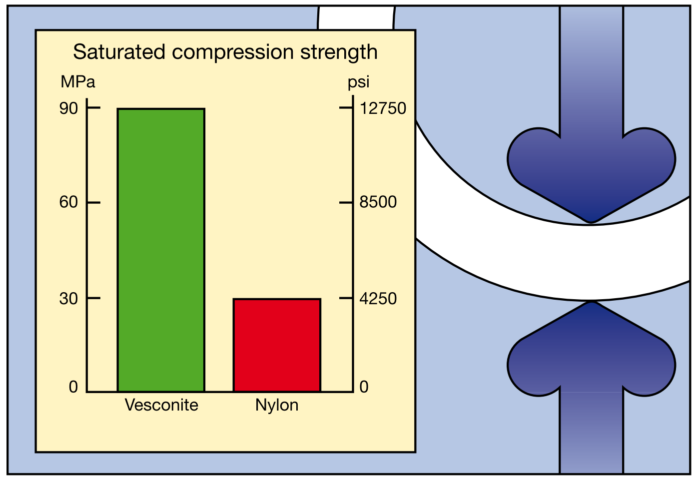
Common problems experienced

- *Bronze must be greased*
- *Lubrication is not always wanted or possible*
- *Grease on linear bearings can trap dirt*
- *Small oscillating movements do not spread grease.*

High compression strength

Vesconite has a compression strength of 90 MPa (12750 psi). The recommended design limit is 30 MPa (4250 psi) for static and slow speed applications.

- Vesconite keeps its strength even when wet
- Vesconite gives minimal compression, deformation or compression set
- Vesconite has excellent resistance to creep.



Common problems: *Nylons lose more than half of their strength and rigidity when wet, leading to creep under load.*

Low water swell

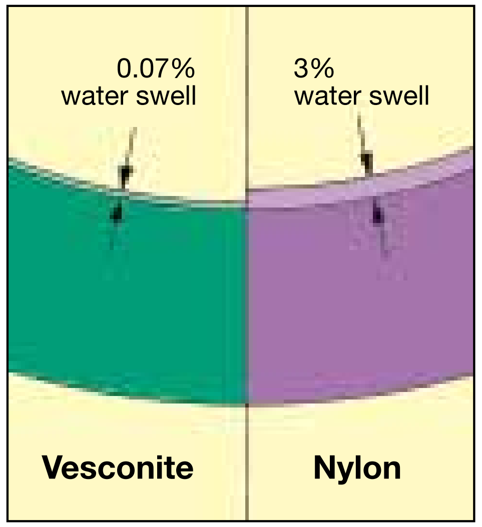
Vesconite absorbs less than 0.5% of water when immersed, giving a linear swell of less that 0.07%. In most applications this can be ignored.

This is especially important in applications that are immersed in water such as pumps, Archimedes screws, marine applications or in humid conditions.

Nylons absorb up to 9% of their mass, causing up to 3% swell and a critical loss of clearance that can lead to seizure.

To compensate for water swell, excessive clearances are used for nylons. Large clearances should be avoided because:

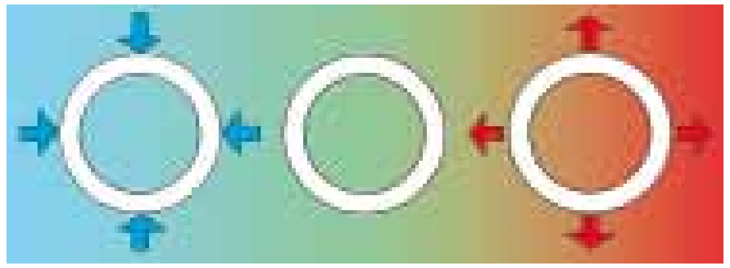
- *Bush wear rate increases*
- *Bush life is shortened*
- *Shafts are less stable.*



Low thermal expansion

Vesconite has a lower thermal expansion than most synthetic materials.

Vesconite can be precisely designed across a wide temperature range without the need for additional clearances.



Low shaft wear

Wear of expensive shafts can be a primary cost concern.

- Vesconite running against hard shafts gives low shaft wear.
- Vesconite Hilube gives even lower shaft wear.

In particular nylons are noted for wear to shafts.

Resistant to chemicals

Vesconite and Vesconite Hilube are resistant to a wide range of chemicals including acids, organic chemicals, solvents, hydrocarbons, oils and fuels.

Refer **Pump Bearing Design Manual** Pg 9-10

No delamination

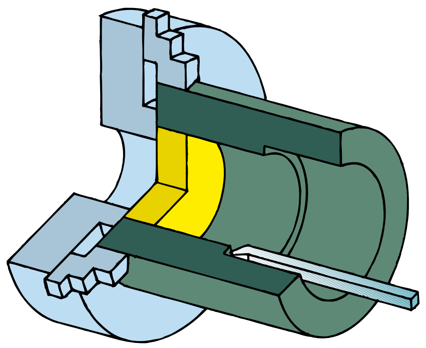
Vesconite is a homogeneous material and is not made up of bonded layers of material.

Vesconite does not delaminate when immersed in water or fluids.

Easy to machine

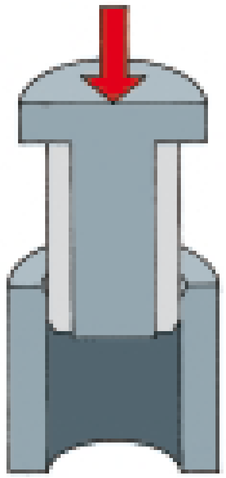
Vesconite can be easily machined on standard metalworking equipment.

Vesconite does not creep, deform or swell and machines easily to desired tolerances.



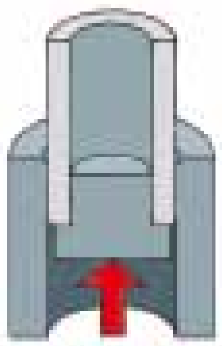
Easy to install

Vesconite bushes are easily installed on site.



Easy to remove

Vesconite does not corrode and seize in bush housings like bronze and metal backed bushes.



Safety and health

Vesconite does not contain any hazardous substances such as asbestos or fibres that make using, handling and machining unsafe.

Vesconite is approved for contact use with drinking water and food.

Environment friendly

Vesconite avoids many environmental problems because oil and grease lubrication can be dispensed with.

Vesconite contains no lead, asbestos or hazardous substances.

Designing press fits, clearances and tolerances

Correct bush design is essential for long life bush operation. Different bushing materials have different criteria for design. Vesconite and Vesconite Hilube are superior bushing materials, and must be correctly designed to avoid premature bush failure.

When Vesconite is considered for replacing bronze bushes, a new design should be generated with the correct fits and clearances appropriate to the unique properties of Vesconite.

The most common cause of failure is inadequate clearance. If too little clearance is provided, a bush may fail even if the application is suited to Vesconite. This may happen when Vesconite is machined to a bronze drawing specification.

Vesconite and Vesconite Hilube Size calculations

The standard design calculations for the use of Vesconite and Vesconite Hilube in applications are given below from first principles. These calculations are for free standing bushes before installation.

The same equations apply to both Vesconite and Vesconite Hilube.

1. Calculate the press fits / interference fits

The following equations are for press fitted bushes, the most common method for securing Vesconite.

Press fit = 0.05 mm + (0.002 x housing Ø) mm

Press fit = 0.002" + (0.002 x housing Ø) inches

2. Calculate the bore closure

The closure of the inside diameter when a bush is pressed into a housing is called the bore closure.

$$\text{Bore closure} = \text{press fit} \times \frac{\text{housing Ø}}{\text{shaft Ø}}$$

3. Calculate the assembly clearance

This is the difference in diameter between the fitted bush **inside diameter** and the shaft.

Assembly clearance = 0.05 mm + (0.02 x wall thickness) mm

Assembly clearance = 0.002" + (0.02 x wall thickness) inches

4. Calculate the bush dimensions

Outside diameter = housing diameter + press fit

Inside diameter = shaft diameter + bore closure + assembly clearance

3. Consider PV limits for load and speed combinations

The level of lubrication required is determined by the **PV – Combination of Load and Speed**. This lubrication is required to dissipate the heat buildup as well as to reduce the friction coefficient between the surfaces.

The following requirements are for Vesconite and Vesconite Hilube.

	Vesconite		Vesconite Hilube	
Lubrication requirements	**MPa.m/min**	**Psi.fpm**	**MPa.m/min**	**Psi.fpm**
No lubrication required. Initial greasing greatly increases wear life	< 5	< 2 500	< 8	< 4 000
Initial lubrication when installing the bush	< 10	< 5 000	< 15	< 8 000
Regular lubrication required	< 20	< 10 000	< 25	< 12 500
Circulating oil or water lubrication required	< 40	< 20 000	< 50	< 20 000
Circulating water lubrication required	< 200	< 100 000	< 200	< 100 000

Although an application may not require lubrication, initial greasing when fitting the bush is generally an advantage. Greasing on installation will significantly improve the life of a bush as well as reduce the risk of the shaft rusting.

The above data are based on numerous tests for Vesconite performance and represent guidelines. Applications have performed successfully with operating conditions beyond the limits noted.

The above guidelines also reflect continuous operation. Vesconite can operate successfully at higher PV levels in intermittent and short term operations.

Vesconite can be lubricated by using :

- grease – organic and synthetic greases are fine, synthetic greases tend to last longer
- oils
- water – clear water and sea water are good lubricants
- because it has a good resistance to chemicals, Vesconite can be lubricated by many liquids present in the application, such as gasoline, organic chemicals and water.

Temperature rating of Vesconite

Typically Vesconite and Vesconite Hilube are limited to 100° to 120°C (212° to 248°F) in dry conditions and 60° to 70°C (140° to 158°F) in immersed conditions.

For higher operating temperatures, please contact Armstrong Energy with details of your application.

Vesconite versus bronze

Better in dirt, no grease

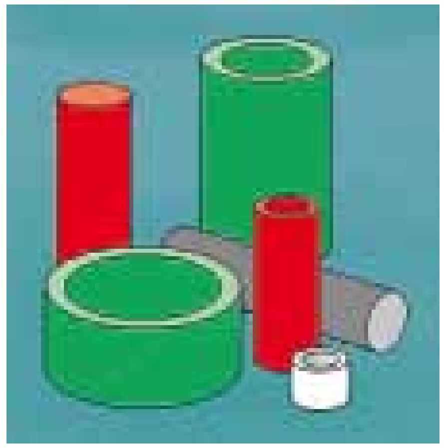
Internally lubricated Vesconite has a low friction even without lubrication and is able to offer a low wear rate even when intermittently lubricated.

Vesconite is a substantial improvement compared with bronze:

- bronze bushes must be greased
- greasing is most often not practical
- dirt and water causes high wear to bronze

Bronze is able to handle a higher static load, operating temperature and PV.

Vesconite versus nylons

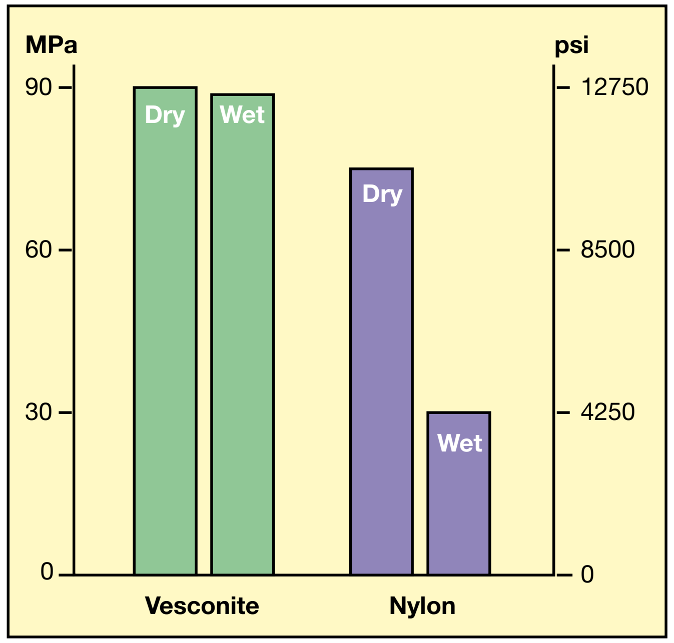


No swell, softening or seizing problems

Vesconite does not swell or soften in water, giving Vesconite bushes a more precise design and better wear.

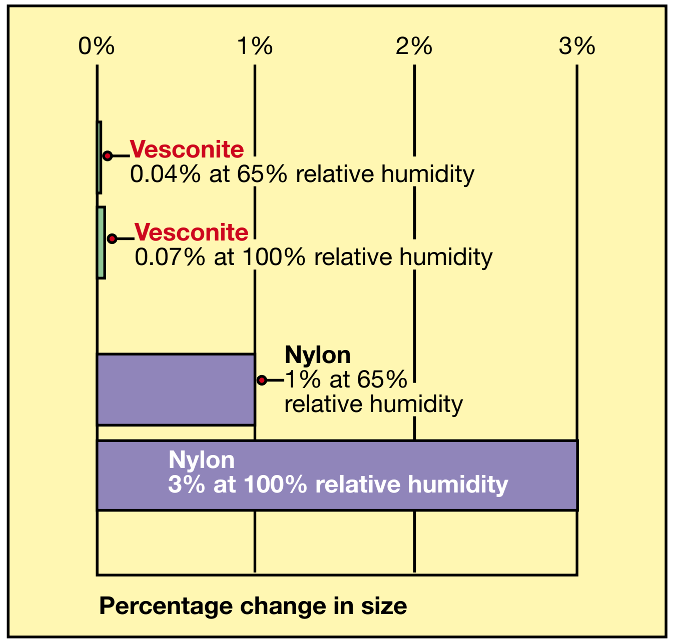
- Nylons swell, leading to loss of clearance and risk of seizure
- nylon softens significantly in water, leading to a loss of compression strength and creep
- nylon is not resistant to acids and solvents, whereas Vesconite is resistant
- Vesconite gives a better wear rate
- Vesconite results in much lower wear to expensive shafts.

Compression strength



Vesconite keeps its compression strength in humid environments.

Water swell



Vesconite does not swell in humid conditions.

Vesconite versus acetal (polyacetal or POM)

Longer wear life

- Vesconite has a lower friction and gives a longer wear life than acetal.
- Vesconite has a lower water absorption and thermal expansion than acetal, so Vesconite bushes can be designed with a higher degree of precision and smaller clearances without the fear of seizing on the shaft.
- Vesconite is available in a wider range of sizes.

Vesconite versus PEEK

Save money, longer wear life

PEEK is an expensive high temperature, high strength polymer.

- Vesconite offers moderate temperature resistance and will give longer wear life and better performance at a fraction of the cost of PEEK.
- Vesconite is available in a far larger range of sizes.

Vesconite versus UHMWPE

Higher compression strength and longer wear life

UHMWPE (Ultra High Molecular Weight Polyethylene) is a low friction material, but with its low compressive strength often results in material creep. While UHMWPE is ideal for wear strips and linings in abrasive conditions, it is only suited to the most lightly loaded bushings.

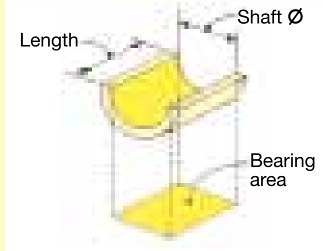
Vesconite versus PTFE

Longer wear life

PTFE is an ultra-low friction material that has a good chemical resistance. This makes PTFE a good material for sliding seals but the softness of the material limits the effectiveness as a bush.

- Vesconite can carry significantly higher loads without deforming.
- Vesconite gives a better bush wear life.

1. Calculate the load (P)



This is the pressure on the bush and is the load on the bush load area. The area is estimated to be the shaft diameter multiplied by the bush length.

The bush load is calculated as follows:

$$\text{Loading (P)} = \frac{\text{mass supported per bush (kg)} \times 9.8\ (\text{m.s}^{-2})}{\text{shaft diameter (mm)} \times \text{bush length (mm)}} \quad \text{(MPa) (Metric)}$$

$$\text{Loading (P)} = \frac{\text{mass supported per bush (lbs)}}{\text{shaft diameter (inches)} \times \text{bush length (inches)}} \quad \text{(psi) (Imperial)}$$

Maximum loads

Vesconite can safely be loaded to 30 MPa (4250 psi) in static and slow moving applications.

Vesconite has a compression failure limit of 90 MPa (12 750 psi) and so a safety factor of 3 is already included in the calculations.

2. Calculate the sliding speed (V)

This is the surface sliding speed between the bush and the shaft.
Maximum surface speed is **300 m/min** **(1, 000 ft/min)** in running dry and under a low load.

The surface speed is calculated as follows:

For rotation – rotational speed [RPM]

$$\text{Surface speed (V)} = \frac{\text{RPM} \times \pi \times \text{shaft diameter (mm)}}{1000\ \text{(mm/m)}} \quad \text{m/minute} \quad \text{(Metric)}$$

$$\text{Surface speed (V)} = \frac{\text{RPM} \times \pi \times \text{shaft diameter (inches)}}{12\ \text{(inches/ft)}} \quad \text{ft/minute} \quad \text{(Imperial)}$$

For oscillation – angle of oscillation [∝]

$$\text{Surface speed (V)} = \frac{\propto \times 2 \times \pi \times \text{diam (mm)} \times \text{frequency (cycles/minute)}}{360 \times 1000\ \text{(mm/m)}} \quad \text{(Metric)}$$

$$\text{Surface speed (V)} = \frac{\propto \times 2 \times \pi \times \text{diam (inches)} \times \text{frequency (cycles/minute)}}{360 \times 12\ \text{(inches/ft)}} \quad \text{(Imperial)}$$

For linear motion – travel distance [s]

$$\text{Surface speed (V)} = \frac{\text{s (mm)} \times 2 \times \text{frequency (cycles/minute)}}{1000\ \text{(mm/m)}} \quad \text{(Metric)}$$

$$\text{Surface speed (V)} = \frac{\text{s (inches)} \times 2 \times \text{frequency (cycles/minute)}}{12\ \text{(inches/ft)}} \quad \text{(Imperial)}$$