Data Sheet

Linear bearings

Instrument ball bearings and shafts

The **RS** range of instrument quality ball bushing bearings are for 1⁄8in, 3⁄16in and 1⁄4in shafts. Each bearing contains three complete ball circuits.

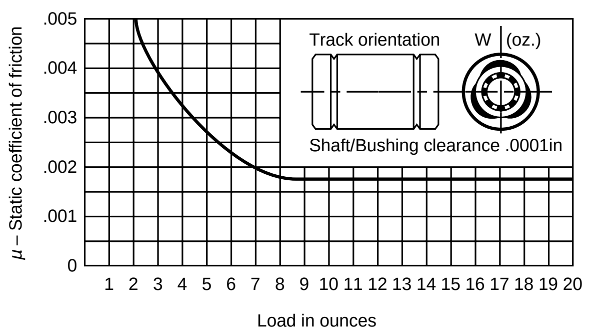
They are extremely rugged in construction and withstand high vibrational and shock loads. Precision manufacturing combined with the anti-friction rolling design assure minimum static and rolling friction, high reliability and repeatability.

Friction test

These bearings are 100% factory inspected for friction and dimensional accuracy.

The criterion for friction is the angle of a shaft down which they will continuously roll. The bearings are oriented with one ball track at the top of the shaft. Under clean conditions with one working track positioned directly under the load the instrument ball bushing bearing will roll down a shaft angle of 14 minutes (1⁄4 degree) with only a three-ounce load. The coefficient of friction under this very light load is 0.004. Under heavier loads the coefficient of friction is even less, as illustrated in Figure 1.

Figure 1



For optimum sensitivity the **RS** range of shafts are hardened to Rockwell 55 to 60c with a surface finish of 2-4rms.

Bore measurement

Rotate with light finger pressure on a series of plug gauges ranging in diameter from the nominal working bore diameter to the tolerance limit of minus 0.0003in. These plugs should take the tolerance range in 0.0001in steps; in other words, a total of four plug gauges for each bushing. When a slight drag or 'feel' is experienced a slight interference fit has developed and the bearing should be coded for use on a shaft having a diameter at least 0.0001in smaller than the plug gauge. An interference fit must be avoided or roughness and possible damage will result.

Cleaning

Absolute cleanliness is of utmost importance. These bearings have been assembled, cleaned, tested and packed in clean cabinets in filtered air. Installation should be conducted under similar clean conditions.

Note that there are through passages between the retainer and the outer sleeve. These permit cleaning solvent to be blown through and the escape of dust particles from the outside of the retainer as well as from the inside. Only cleaning solvent leaving no film or deposit should be used.

Special machining

These shafts can be specially machined to suit individual requirements for mounting or use. The shafts are most readily modified by simple secondary grinding. Reduced diameters, flats and special chamfers can be done this way. It is to the customer's advantage to limit special machining to these operations if possible.

Recommendations

For optimum performance the clearance between shaft and ball bushing bearing should be at least 0.0001in. An interference fit must be avoided or roughness and possible damage will result. In applications where interchangeability is desired, the selection of the proper shaft size will result in a clearance of 0.0001in to 0.0005in.

Metric ball bushings

The **RS** range of linear ball bushings is designed to offer a life expectancy of 100,000 metres of linear movement.

This is based on the dynamic load rating tables shown in the **RS** Catalogue assuming normal operating conditions.

The capacity figures listed assume the worst possible orientation of the bushing tracks; some increase can be achieved by optimum mounting. Life expectancy will also be affected by a variety of factors such as shaft hardness, operating temperatures and loading conditions.

Under normal operating conditions the following are assumed:

Shaft hardness 60HRC
Temperature <100°C

In most applications under normal conditions travel life expectancy can be calculated using the following equation:

$$L = \left(\frac{C}{P}\right)^3 \times 10^5$$

Where L = Life expectancy in metres of travel
C = Dynamic capacity in Newtons
P = Bearing load in Newtons

Co-efficient of friction

The co-efficient of friction of recirculating ball bushings, 0.001 to 0.004, is extremely low and can usually be disregarded in most applications. It is far less, but more constant, than the co-efficient of friction of plain bearings, which is of considerable advantage in applications where stick-slip action affects performance.

Dry ball bushings have the lowest co-efficient whereas oil gives friction values slightly higher than those for grease. The co-efficient of static, or breakaway friction is higher, and in some cases can be as much as twice the dynamic figure.

Where wiping contact seals, or flexible bellows covers, are used for protection, frictional resistance from those sources must be taken into account when assessing total friction losses, since it may be considerable.

Lubrication

A linear ball bushing requires far less lubrication than a plain sliding bearing. For most applications a lubricant serves mainly to protect the vital bearing parts against atmospheric corrosion. A bearing grease (of lithium base and number 2/3 consistency) has the advantage of good surface adhesion, and retention, and minimises sealing problems. A generous grease pack before mounting is recommended, working the grease well into each individual ball circuit.

Precision linear shafting

Shaft dia. mm	Diameter tolerance 0.001mm ISO tolerance band	Weight kg/m
	h6	
5	0 to -8	0.15
8	0 to -9	0.39
12	0 to -11	0.89
16	0 to -11	1.57
20	0 to -13	2.45
25	0 to -13	3.8

Ball bushing pillow blocks

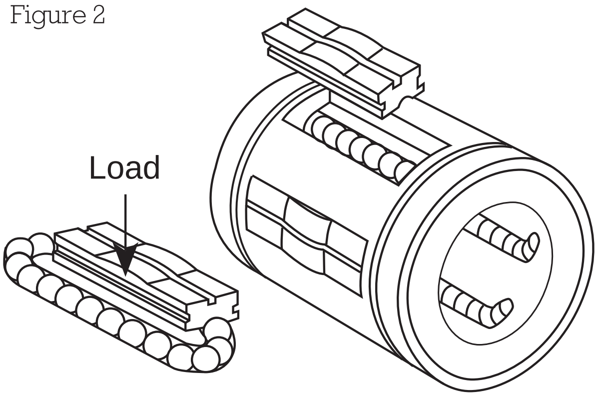
The ball bushing is secured in the housing by two external circlips (supplied) fitted to the grooves formed in the outside diameter of the bushing. The pillow blocks are formed from aluminium alloy (BS1474 HE30) extrusions and have a matt natural anodised finish.

Refer to page 4 of this data sheet for a typical application.

Super Plus open ball bushings

Super Plus ball bushing bearings are self-aligning, and provide smoother operation and a constant low coefficient of friction. They have three times more load capacity or 27 times more travel life than conventional linear bearings, (Figure 2).

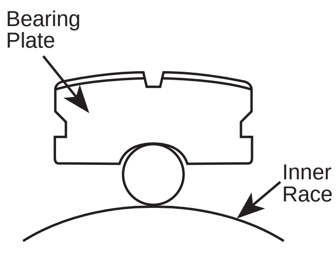
Figure 2



The bearing plates are hardened steel, precision ground with ball-conforming grooves (Figure 3).

The groove is slightly larger than the ball diameter, providing an optimal area for ball contact. The greater ball-to-bearing plate contact is what provides the increased load capacity or travel life of Super Plus ball bushing bearings.

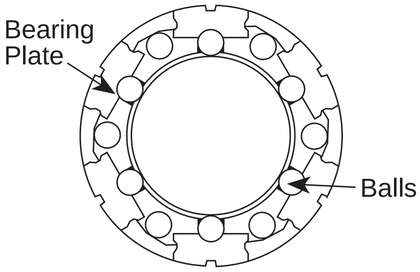
Figure 3



Zero clearance fit

The bearing plates are also designed to float radially. When the bearing is mounted in an adjustable housing, selected fit-ups can be achieved on the shaft. (Figure 4).

Figure 4 **Cross section of Super Plus ball bushing bearing**

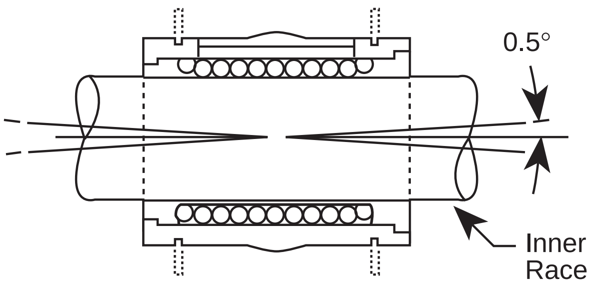


Self-Aligning

The precision ground bearing plates are designed to pivot 0.5° about their centres (Figure 5) to assure smooth entry and exit of the balls.

Each plate aligns automatically to compensate for inaccurate housing bore alignment, base flatness or carriage machining. This provides uniform ball loading, smooth ball recirculation and lower friction operation.

Figure 5



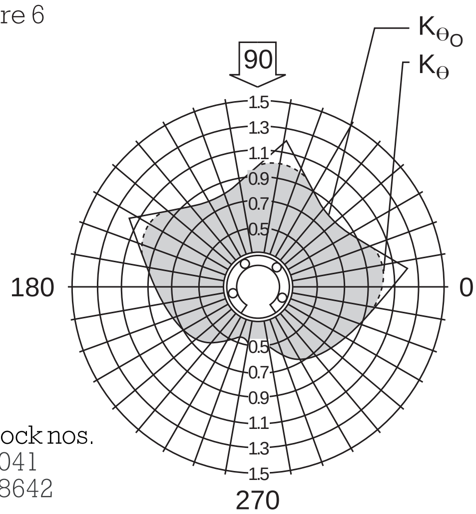
Smooth quiet operation

The bearing's outer sleeve and retainer are made of wear-resistant, low-friction engineering polymer. It reduces inertia and operating noise levels significantly.

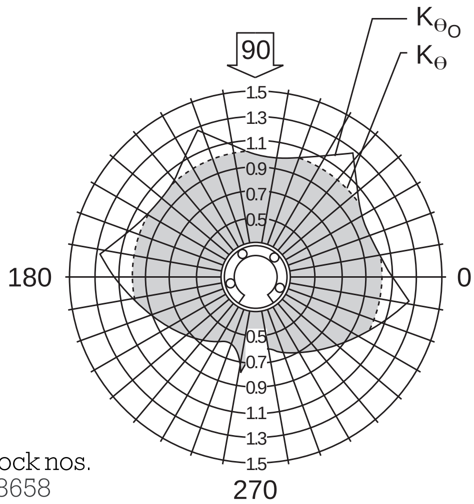
Load ratings

The dynamic load ratings listed in the **RS** Catalogue are for rated travel life of 100km. For longer travel lives, reduce load to $W.(100L)^{0.33}$ where L(km) is the required travel life. Do not exceed the Dynamic Load Rating for travel life of less than 100km. The Dynamic Load Ratings are valid for a resultant load applied at 90° with the ball tracks orientated as shown in the polar graphs (See figure 6). If the resultant acts along another direction, the appropriate multiplicative correction factor, $K\theta$ or $K\theta_0$,should be applied respectively. K_0 relating to Dynamic load rating and $K\theta_0$ relating to static load rating.

Figure 6



RS stock nos.
407-041
198-8642



RS stock nos.
198-8658
198-8664

Standard diametral clearances

The internal bearing diameter is affected by the housing bore, see Table 1 below.

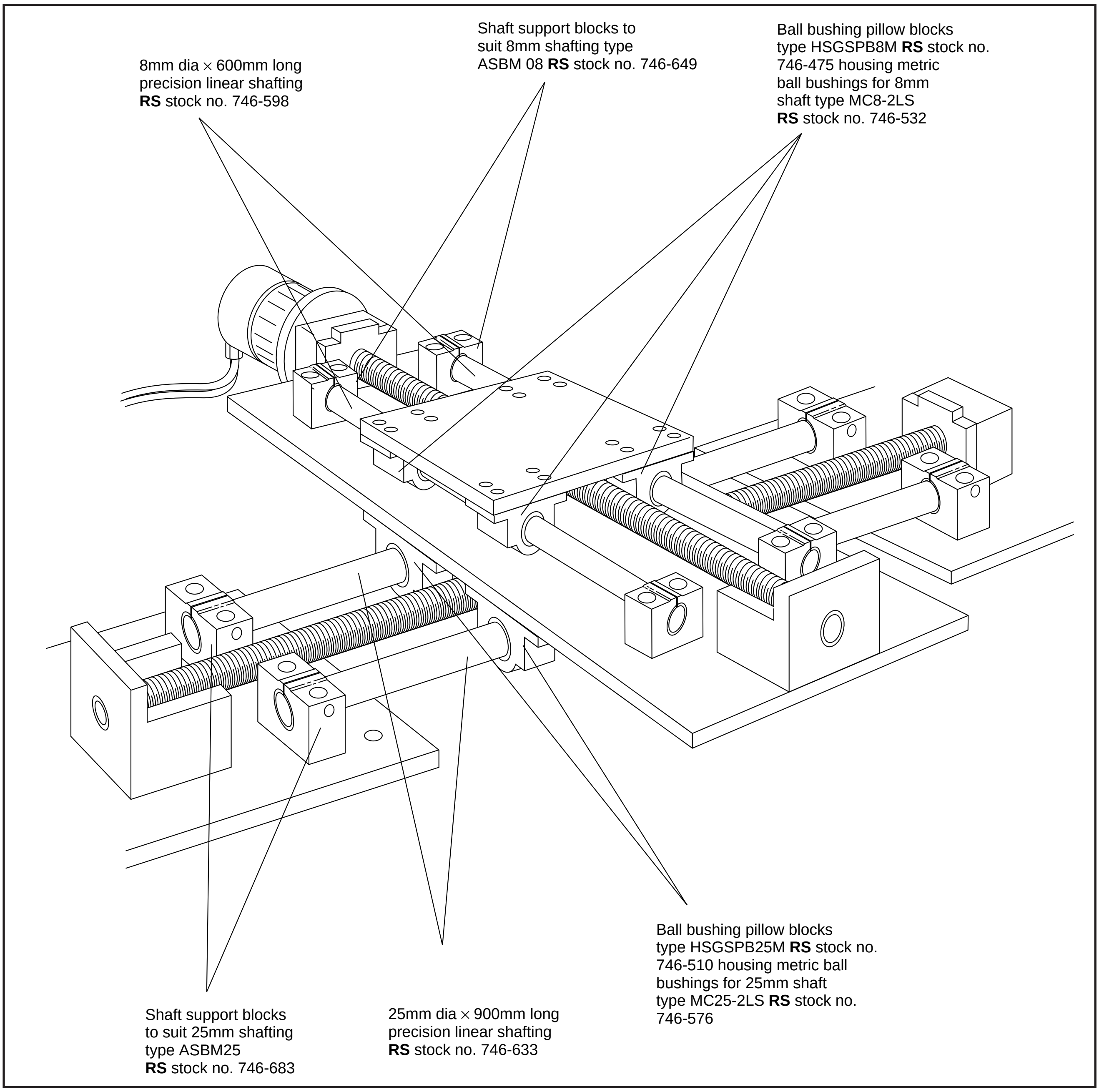
Nominal size d (mm)	Diametral clearance Housing bore H7 (μm)		Housing bore H6 (μm)	
12	+33	+4	+26	+3
16	+33	+4	+26	+3
20	+37	+6	+30	+4
25	+37	+6	+30	+4

Typical application – X-Y positioning system

Objective – to build a X-Y system that transfers the work piece between two separate machine stations.

Products specified:

Quantity	**RS** stock no.	Product
4	746-649	Shaft support blocks to suit 8mm shafting type ASBM08
2	746-598	8mm diameter × 600mm long precision linear shafting
4	746-475	Ball bushing pillow blocks type HSGSPB8M
4	746-532	Metric ball bushings for 8mm shaft type MC8-2LS
4	746-683	Shaft support blocks to suit 25mm shafting type ASBM25
2	746-633	25mm diameter × 900mm long precision linear shafting
4	746-510	Ball bushing pillow blocks type HSGSPB25M
4	746-576	Metric ball bushings for 25mm shaft type MC25-2LS



Linear guides

Metric hi-load series

The nominal life of a linear ball guide system is calculated as follows:

$$L = \left(\frac{C}{fw.f}\right)^3 \times 10^5 \text{ metres}$$

Where L = Nominal life (metres)
C = Basic dynamic load rating (N)
f = Applied load on bearing block (N)
fw = Load factor
1.0-1.2 for smooth operation
1.2-1.5 for normal operation
1.5-3.0 for shock and vibration.

Internal clearance

This refers to the amount by which the bearing will move vertically after fitting to the rail. The **RS** standard is +0.015mm maximum.

Accuracy standard

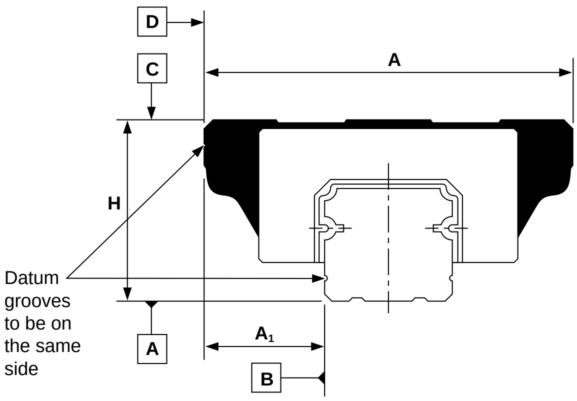
The high standard of manufacturing control of the **RS** guide rails and bearing blocks permits interchangeability of components without loss of performance. The accuracy standards shown overleaf will be maintained in all circumstances of basic component replacement.

Table 2

Unit 0.001mm

Tolerances	Size	
See Figure 2 for symbols	20	25
Overall height, H	±30	±35
Dimension A_1	±40	±40
Running parallelism of face C to face A Running parallelism of face D to face B	See Figure 3	

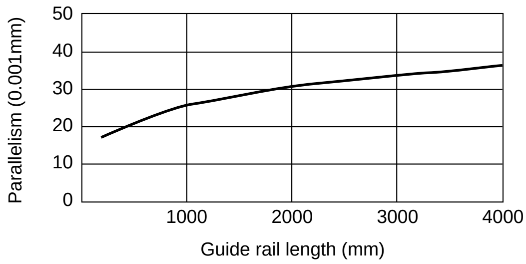
Figure 7



Dimensions

Type	A	A_1	H
HL20NTZ	44	20	30
HL25NTZ	48	25	40

Figure 8 **Parallelism**



Abutment shoulder heights and corner radii

In order to ensure the minimum clearance between the bearing block and a mounting shoulder, the shoulder height, H_r must not be exceeded – Figure 9.

The maximum corner radii for the rail and the block must be observed to ensure correct seating.

Table 3 Abutment dimensions

Unit mm

Size	Corner radius r (max.)	Guide rail shoulder height, H_r	Bearing block shoulder height, H_b
20	0.5	4.5	5
25	0.5	6	5

Figure 9

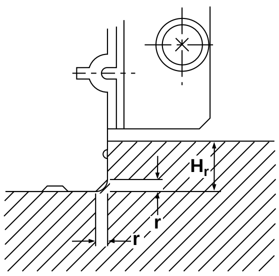
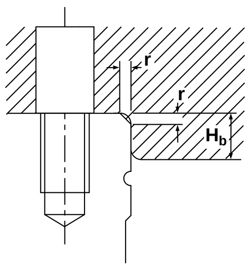


Figure 10



Lead screw assemblies

Specifications

Lead error	±.015in/ft (±0.12mm/100mm)
Repeatability	.003in (0.08mm)
Straightness	0.15in/ft (0.12mm/100mm)
Backlash	.003in(0.08mm) (zero when using anti-backlash nut)
Temperature range	-50°F to +200°F (–45°C to +93°C)

Design considerations

Critical speed

The critical speed of a lead screw shaft is the maximum speed (rpm) before the screw will become dynamically unstable. This results when the forced frequency of the rotating screw corresponds to its natural frequency. Its value is dependent on the length of the screw, the diameter of the thread, and the support configuration. The critical speed value is governed by the following equation:

Critical screw speed (N) = $K \times C \times 10^6 \times \frac{d}{D^2}$

Where:

K = End support factor
- 0.36 one end fixed, other free (Figure 11)
- 1.00 simple supports both ends (Figure 12)
- 1.47 one end fixed, one simple (Figure 13)
- 2.23 both ends fixed (Figure 14)

C = Material factor
- 4.5 for stainless steel screws

d = Root diameter of the screw

D = Length between bearing supports

Figure 11

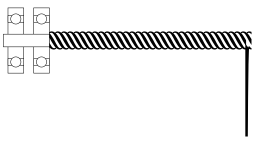


Figure 13

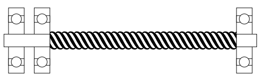


Figure 12

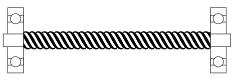
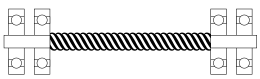


Figure 14



Load

In order to properly incorporate a lead screw into a design, load requirements must be taken into account. Maximum load values for the nuts are listed in the tables below. These numbers are based on the shear of the nuts and do not take shaft buckling into account (see Maximum column load formula below). Wherever possible, nuts should be positioned so as to be put in tension, pulling the load. This eliminates the need for buckling considerations. Listed below are some helpful formulas to assist in proper lead screw selection.

Maximum column load (F) = $K \times C \times 10^6 \times d^4/D^2$

Where:

K = End support factor
- 0.25 one end fixed, other free (Figure 11)
- 1.00 simple supports both ends (Figure 12)
- 2.00 one end fixed, one simple (Figure 13)
- 4.00 both ends fixed (Figure 14)

C = Material factor
- 13.4 for stainless steel screws

d = Root diameter of the screw

D = Length between the nut and the support bearing

Torque to move a load (T) = $F \times L/2 \times Pi \times E$

Where:

F = Load

L = Lead

E = Efficiency

Maximum load values for nuts

RS stock no.	Load rating (N)	Efficiency
756-056	222	46%
756-062	333	49%
756-078	1023	55%
756-084	1601	53%
756-179	222	46%
756-185	333	49%
756-191	1023	55%
756-208	1601	53%

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