*The Revolutionary Ball Bearing that Combines Unlimited Linear and Rotary Motion*

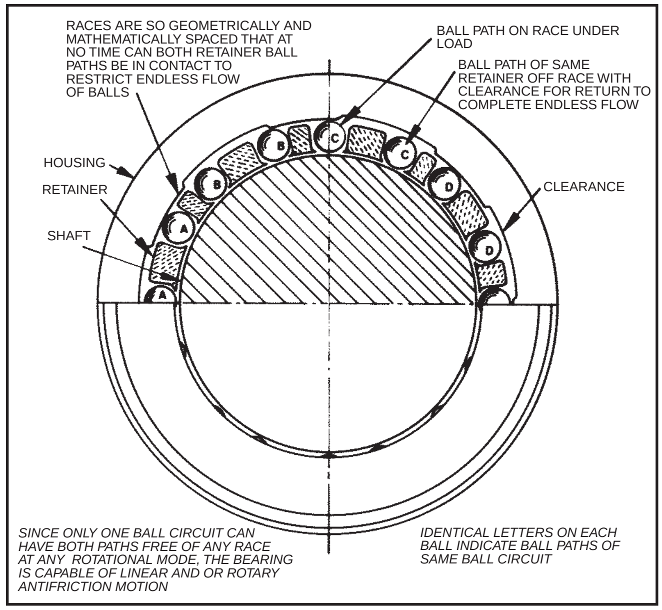
# THE LINEAR ROTARY BALL BEARING

# THE LINEAR ROTARY BEARING OPERATING PRINCIPLE

The Linear Rotary Bearing is the first to offer unlimited linear and rotary anti-friction motion and at greater load life ratings than competing linear bearings. It is also interchangeable with existing linears.

The success of the bearing is due to the effective use of mathematics and geometry in its design. The ball track path is oval in shape (for infinite ball flow) and both sides of the straight portion of the path are utilized. Two openings in the retainer on the same ball circuit (unlike other linear bearings having one opening) permit balls to contact the shaft and the inner race of the housing in either path, but not at the same time. For the balls to circulate, one path must be loaded and the other path must have clearance for the return of the balls. The races or inner surface of the housing are geometrically interrupted so that at no time can two paths of one track system be in contact. The clearance between the races permits the return flow of the balls. This ability of the retainers to rotate within the housing and the balls to rotate in any direction allows simultaneous linear and rotary motion. The longitudinal or reciprocal motion of the shaft causes the balls to circulate within their own track system. The rotational motion of the shaft causes the balls to flow much like a typical rotary bearing.

In an application where only linear motion exists, the movement of the balls on and off the races creates a torque on the retainer. The torque is unbalanced, meaning that the retainer is free to rotate. This causes the retainer to creep or rotate slightly due to the linear




motion of the shaft. This slight rotation offers the ball flow path, under load, exposure to new surfaces both on the race and on the shaft. This constant change of surfaces means *longer bearing and shaft life*. It is no longer necessary to orient the bearing during installation for optimum load carrying ability or, to break down an assembly periodically to rotate the bearing for increased life.

In applications where rotation exists, it is obvious that the rotation causes the ball flow to utilize the entire width of each race and bearing surface of the entire shaft.

In addition, this principle uses the maximum number of ball track systems and the largest ball diameters. Obviously, the more balls per circuit, the less unit load for each ball.

The Linear Rotary Bearing features longer life at greater loads, smoother operation and the unique advantage of linear rotary anti-friction motion.

# DESIGN CONSIDERATIONS

In both linear and/or rotary motion the purpose of a ball bearing is to reduce friction. Slides and bushings utilize various materials that tend to slightly reduce this friction problem. The ball bearing, however will outperform these devices and can reduce the coefficient of friction upwards of 100 times. The linear rotary bearing will offer this tremendous advantage in all directions of motion.

To take full advantage of this phenomenon, certain design considerations must be taken into account. Proper installation, lubrication and shaft characteristics will be discussed in the following paragraphs. Under “Design Considerations” shaft to bearing selection is emphasized. Because this is the world’s first bearing to offer unrestricted linear rotary anti-friction motion, certain parameters should be considered.

If the linear motion is prominent, greater clearance between bearing and shaft is recommended. For example, a shaft classified as “A” with a precision or super precision bearing is acceptable. If the rotary motion is prominent, a class “B” shaft is required with a precision or super precision bearing depending on the degree of precise rotary motion. If the rotary and/or linear motion requires a very high degree of precision, it is recommended that a “matched set” arrangement of shaft to bearing be considered. Here the bearing is matched to the shaft from line to line to within a few tenths depending on the diameters involved. Only in an extreme application would a press fit be suggested (as in the use of an “R” shaft). It should be noted again that the linear rotary bearing offers a considerable reduction in the coefficient of friction. It, therefore, has an extended life over such devices as bronze bushings, V-ways and non-recirculating ball strips. Another factor to be considered is that, as the latter devices wear, their relative positioning is no longer accurate as initially aligned. "Down Time" is extremely costly and the consequences are obvious.

# INSTALLATION

The linear rotary bearing, like competitive linear bearings, is highly critical of its environment and of installation procedures. In assembly, where more than one shaft is used, the second or succeeding shafts become redundant for guidance. Unless "perfect alignment" of the shafts (parallelism, not angularity) exists, a misaligned shaft will add a preload to the bearing and restrict the normally smooth and easy motion. The ideal shaft mounting arrangement is shown in figure 1. Here one

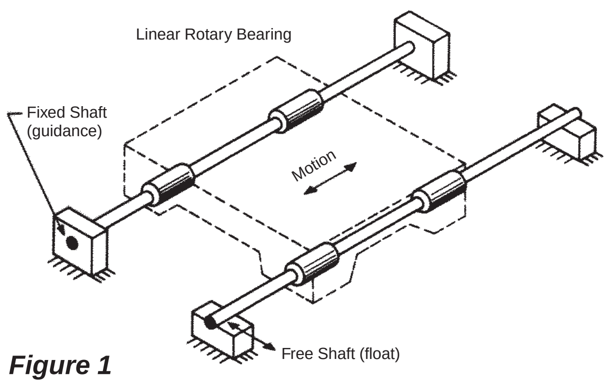



***Figure 1***

shaft is fixed and guides the system while the second or succeeding shafts "float" and are only load carrying members.

Another cause of restricted motion is "bore in accuracy." The bearing mounting hole should have a maximum diameter so that there is, at least, a line to line fit between the outside diameter of the bearing and the hole. A press fit (though not recommended for any linear bearing) transmits the press to the shaft and bearing clearance, creating a preload. Unknown in quantity of pounds, this could shorten the life cycle of the system greatly. If a press is mandatory, the solution is to choose a larger than normal clearance between the diameter of the shaft and bearing. This offers a safety margin.

The linear rotary bearing, by its inherent design of no inner race, is most susceptible to local contamination. The design features an optional integral seal. Here the contaminants are wiped free of the ball track system by cleansing the entering surfaces of the shaft.

The basic methods of mounting the linear rotary bearing are external and internal. For external mounting there are retaining ring grooves on the exterior surface of the bearing. These grooves accommodate standard retaining rings. A typical arrangement is shown in figure 2. Internal arrangements are shown in figures 3 and 4. Figure 3 illustrates the internal retaining rings at each

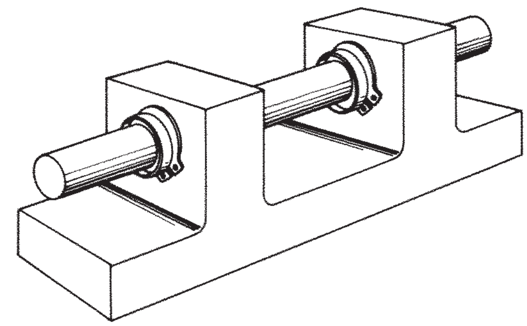


***Figure 2***

end of the bearing. Figure 4 shows the use of cover plates at each end of the assembly. If more than one bearing is used, a spacer may be inserted to secure the overall precise fit. Another means of installation is to coat the bearing with an adhesive (carefully covering the bearing innards) and to insert it into the mount.

To sum up, all means of cancelling error (tolerance and misalignment) should be incorporated into the design of systems utilizing the linear rotary bearing.

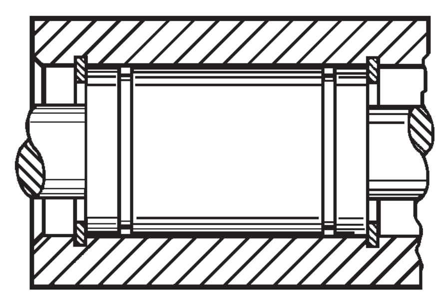


***Figure 3***

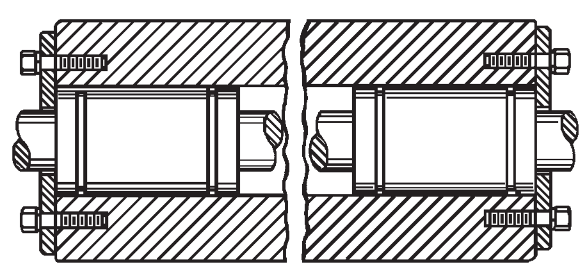
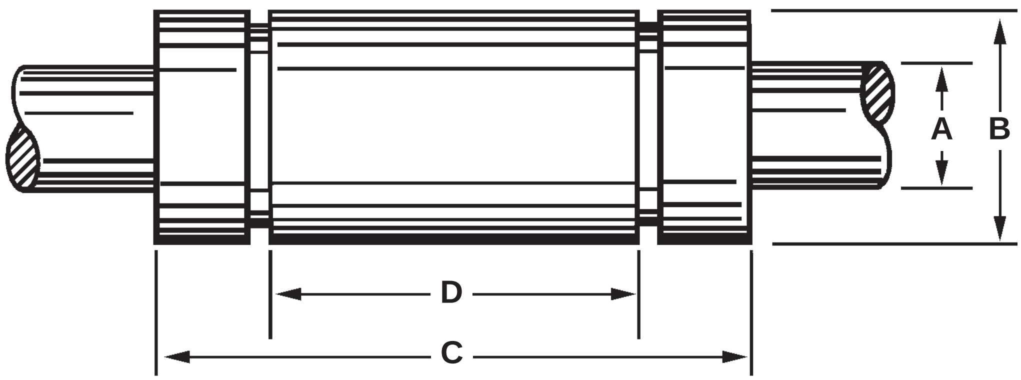


***Figure 4***

# SPECIFICATIONS–LINEAR ROTARY PRECISION




| Bearing No. | WORKING BORE | | | | OUTSIDE DIAMETER | | LENGTH | |
|---|---|---|---|---|---|---|---|---|
| | | LR | LRP | | | | | |
| | A | Tolerance + 0000 to | Tolerance + 0000 to | Concentricity (T.I.R.) | B | Tolerance + 0000 to | C | Tolerance + 0000 to |
| **6** | .3750 | -.0005 | -.0003 | .0005 | .6250 | -.0004 | .875 | -.015 |
| **8** | .5000 | -.0005 | -.0003 | .0005 | .8750 | -.0004 | 1.250 | -.015 |
| **10** | .6250 | -.0005 | -.0003 | .0005 | 1.1250 | -.0004 | 1.500 | -.015 |
| **12** | .7500 | -.0005 | -.0003 | .0005 | 1.2500 | -.0004 | 1.625 | -.015 |
| **16** | 1.0000 | -.0005 | -.0003 | .0005 | 1.5625 | -.0004 | 2.250 | -.015 |
| **20** | 1.2500 | -.0006 | -.0004 | .0010 | 2.0000 | -.0005 | 2.625 | -.020 |
| **24** | 1.5000 | -.0006 | -.0004 | .0010 | 2.3750 | -.0005 | 3.000 | -.020 |
| **32** | 2.0000 | -.0008 | -.0004 | .0010 | 3.0000 | -.0006 | 4.000 | -.020 |
| **40** | 2.5000 | -.0010 | -.0005 | .0015 | 3.7500 | -.0008 | 5.000 | -.025 |
| **48** | 3.0000 | -.0012 | -.0006 | .0015 | 4.5000 | -.0010 | 6.000 | -.030 |
| **64** | 4.0000 | -.0020 | -.0010 | .0020 | 6.0000 | -.0012 | 8.000 | -.040 |

# (LR) and LINEAR ROTARY SUPER PRECISION (LRP)

## NOTES

1) The groove widths match standard retaining ring thicknesses.
2) To order wipers — one end, add the suffix *W*, eg. *LR- W*
3) To order wipers — both ends, add the suffix *WW*, eg. *LR- WW*.
4) For shaft to bearing selection a clearance of .0005 is recommended.
5) **Shaft diameters greater than specified could cause ball loss during insertion.**

| DISTANCE BETWEEN RETAINING RINGS | | RETAINING RING GROOVE DIMENSIONS | | MAXIMUM SHAFT DIAMETER | | BALL DIA-METER | NO. OF BALL CIRCUITS | BEARING WGT. (Lbs.) | Bearing No. |
|---|---|---|---|---|---|---|---|---|---|
| D | TOLERANCE | GROOVE WIDTH | GROOVE DIAMETER | LR | LRP | | | | |
| .562 | ± .010 | .039 | .593 | .3745 | .3747 | 1/16 | 6 | .05 | **6** |
| .875 | ± .010 | .046 | .770 | .4995 | .4997 | 5/64 | 7 | .07 | **8** |
| 1.000 | ± .010 | .056 | 1.057 | .6245 | .6247 | 3/32 | 7 | .15 | **10** |
| 1.062 | ± .010 | .056 | 1.178 | .7495 | .7497 | 3/32 | 8 | .22 | **12** |
| 1.625 | ± .010 | .068 | 1.500 | .9995 | .9997 | 1/8 | 8 | .45 | **16** |
| 1.875 | ± .015 | .068 | 1.886 | 1.2494 | 1.2496 | 5/32 | 9 | .93 | **20** |
| 2.250 | ± .015 | .086 | 2.255 | 1.4994 | 1.4996 | 5/32 | 9 | 1.45 | **24** |
| 3.000 | ± .015 | .103 | 2.880 | 1.9992 | 1.9996 | 7/32 | 9 | 2.85 | **32** |
| 3.750 | ± .015 | .120 | 3.562 | 2.4990 | 2.4995 | 9/32 | 9 | 5.95 | **40** |
| 4.500 | ± .015 | .120 | 4.310 | 2.9988 | 2.9994 | 5/16 | 9 | 10.00 | **48** |
| 6.000 | ± .020 | .139 | 5.745 | 3.9980 | 3.9990 | 7/16 | 9 | 23.20 | **64** |

## CHART 1
# MAXIMUM ALLOWABLE LOADS

| Bearing Number | Shaft Diameter | REVOLUTIONS PER MINUTE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Linear Only | 50 | 100 | 200 | 300 | 500 | 900 | 1200 | 1500 | 1800 | 2400 | 3600 |
| **LR-6** | .3750 | 70 | 61 | 48 | 39 | 33 | 29 | 23 | 21 | 20 | 18 | 17 | 15 |
| **LR-8** | .5000 | 185 | 161 | 128 | 102 | 89 | 76 | 61 | 56 | 52 | 48 | 44 | 39 |
| **LR-10** | .6250 | 283 | 246 | 195 | 156 | 136 | 116 | 93 | 85 | 79 | 74 | 68 | 59 |
| **LR-12** | .7500 | 325 | 283 | 224 | 179 | 156 | 133 | 107 | 98 | 91 | 85 | 78 | 68 |
| **LR-16** | 1.0000 | 450 | 392 | 311 | 248 | 216 | 185 | 149 | 135 | 126 | 117 | 108 | 95 |
| **LR-20** | 1.2500 | 600 | 522 | 414 | 330 | 288 | 246 | 198 | 180 | 168 | 156 | 144 | 126 |
| **LR-24** | 1.5000 | 935 | 813 | 645 | 514 | 449 | 383 | 309 | 281 | 262 | 243 | 224 | 196 |
| **LR-32** | 2.0000 | 1340 | 1166 | 925 | 737 | 643 | 549 | 442 | 402 | 375 | 348 | 322 | 281 |
| **LR-40** | 2.5000 | 1830 | 1592 | 1263 | 1018 | 878 | 750 | 604 | 549 | 512 | 475 | 439 | —— |
| **LR-48** | 3.0000 | 2370 | 2062 | 1635 | 1304 | 1138 | 972 | 782 | 711 | 663 | 616 | —— | —— |
| **LR-64** | 4.0000 | 5285 | 4598 | 3647 | 2907 | 2537 | 2167 | 1744 | 1585 | 1480 | —— | —— | —— |

*NOTES: 1. Load ratings based on use with hardened shaft — Rockwell 60C*
*2. Based on travel life of 10 million inches*
*3. For speeds and loads not listed, consult Engineering Dept.*

## CHART 2
# SHAFT SELECTION CHART

Standard AISI C-1060 Steel hardened to Rockwell 58/63C or 440C Stainless steel shafts hardened to Rockwell 50/55C are charted below. Shafting can be supplied up to 12 feet long or can be cut to any length. Special tolerances, dimensions or end machining will be promptly quoted.

| Nominal Dia.* | Tolerance Code | TOLERANCES* | Weight per Inch (lb) | Min. Depth of Hardness |
|---|---|---|---|---|
| 3/8" | A<br>B | .3735/.3740"<br>.3740/.3745" | .031 | .040" |
| 1/2" | A<br>B<br>R | .4985/.4990"<br>.4990/.4995"<br>.4998/.5000" | .055 | .060" |
| 5/8" | A<br>B<br>R | .6235/.6240"<br>.6240/.6245"<br>.6248/.6250" | .086 | .060" |
| 3/4" | A<br>B<br>R | .7485/.7490"<br>.7490/.7495"<br>.7498/.7500" | .125 | .060" |
| 1" | A<br>B<br>R | .9985/.9990"<br>.9990/.9995"<br>.9998/1.0000" | .222 | .080" |
| 1-1/4" | A<br>B<br>R | 1.2485/1.2490"<br>1.2490/1.2495"<br>1.2498/1.2500" | .348 | .080" |
| 1-1/2" | A<br>B<br>R | 1.4984/1.4989"<br>1.4989/1.4994"<br>1.4997/1.5000" | .500 | .080" |
| 2” | A<br>B<br>R | 1.9980/1.9987"<br>1.9987/1.9994"<br>1.9997/2.0000" | .890 | .100" |
| 2-1/2" | A<br>B<br>R | 2.4977/2.4985"<br>2.4985/2.4993"<br>2.4995/2.5000" | 1.391 | .100" |
| 3" | A<br>B<br>R | 2.9974/2.9983"<br>2.9983/2.9992"<br>2.9994/3.0000" | 2.003 | .100" |
| 4" | A<br>B<br>R | 3.9964/3.9976"<br>3.9976/3.9988"<br>3.9991/4.0000" | 3.560 | .100" |

*For other sizes and tolerances, consult Linear Rotary Bearings.

# BEARING SELECTION

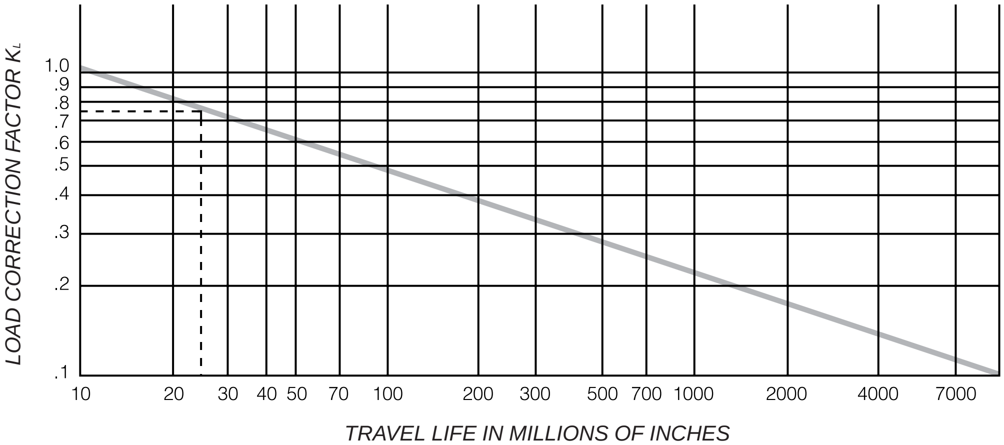



**CHART 3**

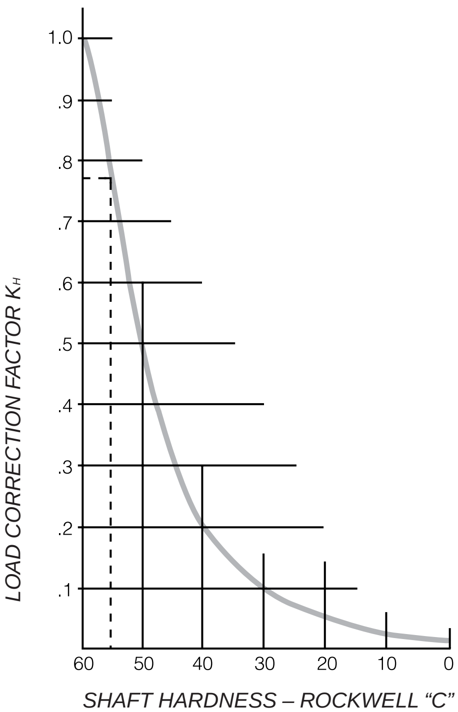



**CHART 4**

*Example:* A pick and place machine requires two linear rotary bearings. Total load is 800 lbs. Maximum rotation is 300 RPM. Shafts are to be hardened to Rc 55C. Travel life required is 25,000,000 inches.

*Calculations:*

Load per bearing = $\frac{800}{2}$ = 400 lbs. @ 300 RPM

Shaft hardness RC 55: from Chart 4 we obtain a load correction factor of $K_H = .76$

Load factor for 25,000,000 inches
Chart 3: $K_L = .75$

Factored load capacity = $\frac{400}{K_H\ K_L} = \frac{400}{.76 \times .75}$ = 702 lbs.

From Chart 1 we obtain for 702 lbs. @ 300 RPM a Linear Rotary bearing rated @ 878 lbs. (LR-40)

Margin of safety = $\frac{878}{702} - 1$ = 25%

*Note: Means of measuring inches of travel* = Shaft Dia. (inches) x 3.1416 x Revolutions + Linear Inches Travel

# SHAFT SELECTION

Because of its inherent geometric configuration, the linear rotary bearing has no inner race. Therefore, to take full advantage of its superior characteristics, **proper shaft selection is mandatory.** Under "Design Considerations" correct diameters were suggested. To achieve the full rated life cycle and smooth operation, the shaft should be AISI C-1060 steel case hardened to Rockwell 58-63C or from 440 Stainless Steel, case hardened to Rockwell 50-55C. If shaft hardness cannot be met, see Chart 4 for the reduction factor.

# LUBRICATION

The lubrication factor is a function of speed, linear plus rotary, where applicable. The faster the ball movement the less viscous the oil required. It is theoretically possible to use no lubricant at high speeds. The load factor must also be considered. It is suggested that a light machine oil be used, if only to prevent corrosion.

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Printed in U.S.A.