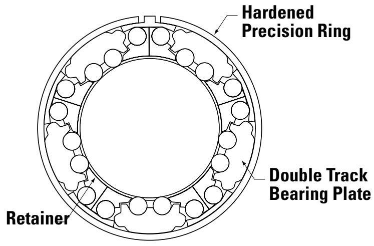
# Engineering


The Engineering Appendix contains valuable information on the application and use of Thomson Ball Bushing® Bearings, pillow blocks, 60 Case® LinearRace® shafts and supports, and accessories.

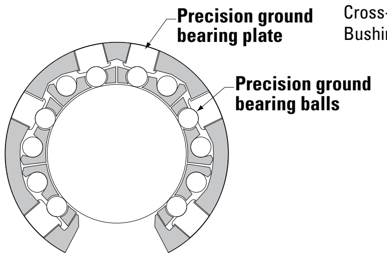
**Engineering....................................................................252**
- Performance Criteria ..............................................253
- Ball Bushing Life Expectancy and Load Capacity....257
- 60 Case LinearRace® Shafting Specifications .........259
- Load Consideration ..................................................260
- Coefficient of Friction...............................................261
- System Maintenance and Service ............................262
- Bearing Options .......................................................263
- Material Engineering Specifications.........................264
- 60 Case LinearRace Deflection ..................................265
- Ultra Light Aluminum LinearRace Deflection............266
- How to Cut 60 Case LinearRace Shafting..................267
- Application Tips .......................................................268
- Installation Guidelines .............................................269
- Tolerance Charts......................................................270
- Engineering Conversion Factors ..............................271
- Shafting Color Code Chart.......................................273

# Performance Criteria

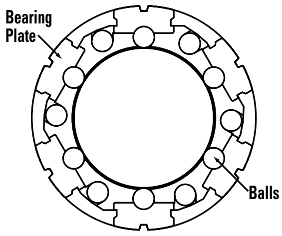
The following performance criteria relates to the use, installation and specification of Thomson Ball Bushing Bearings. Each performance criteria plays an important role in maximizing system effectiveness and life.



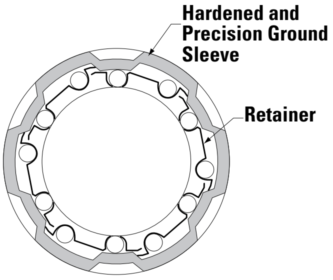

Cross-section of Super Smart Ball Bushing Bearing



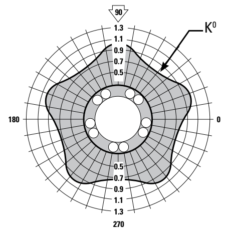

Cross-section of XR Ball Bushing Bearing




Cross-section of Super Ball Bushing Bearing




Cross-section of Precision Steel Ball Bushing Bearing




Polar Graph

## Dynamic Load Capacity

The dynamic load capacity of a Ball Bushing Bearing is determined by the reaction between the rolling elements and the inner and outer race. The rolling elements in a Ball Bushing Bearing are a series of hardened and precision ground bearing balls. The inner race is a hardened and precision ground 60 Case LinearRace.

The outer race can be a hardened and precision ground, ball conforming, steel bearing plate or a hardened and precision ground steel bearing sleeve. The dynamic load capacity is also affected by the orientation of the ball tracks, the size of the balls, the shape of the ball conforming groove, the number of balls that are in load contact and more.

Since the introduction of the Ball Bushing Bearing in 1945, Thomson has designed and developed Ball Bushing Bearing products that have continuously achieved dramatic increases in dynamic load capacity and life. Our most recent innovation is the Super Smart Ball Bushing Bearing which has six times the dynamic load capacity or 216 times greater life than the traditional Ball Bushing Bearing.

This increase in load capacity was achieved by maximizing the load reaction between the inner and outer races. This breakthrough in load capacity rivals that of linear guides while still retaining the added benefits of the RoundRail Advantage enabling the linear bearing to avoid many of the derating factors that can diminish the load/life performance of square rail products.

The dynamic load capacity of all Thomson Ball Bushing Bearings is based on a L10 life of two million inches (100 km for metric bearings) of travel. The dynamic load capacity can be affected by the orientation of the bearing with respect to the load or the direction of the applied load. A polar graph is included with each product specification to assist you in optimizing the load capacity as well as the performance of the Ball Bushing Bearing. To determine the resultant load capacity, find the angle at which the load is applied to the bearing and move in radially along that line until it intersects the curve. Move around circumferentially to the polar correction value located on the vertical axis. Next, multiply the proper correction factor by the dynamic load capacity listed in each product specification table.

## The RoundRail Advantage

The RoundRail Advantage is the inherent ability of a RoundRail bearing to accommodate torsional misalignment (caused by inaccuracies in carriage or base machining or by machine deflection) with little increase in stress to bearing components (Figure 1). This important feature to all Thomson Ball Bushing® Bearing systems reduces installation time and cost, while maximizing performance.

**Ball Bushing Bearing vs. Linear Guide**
The major difference between a Ball Bushing Bearing and linear guide system is primarily in the design of the inner race. The linear guide inner race has two, four or six ground grooves that guide the

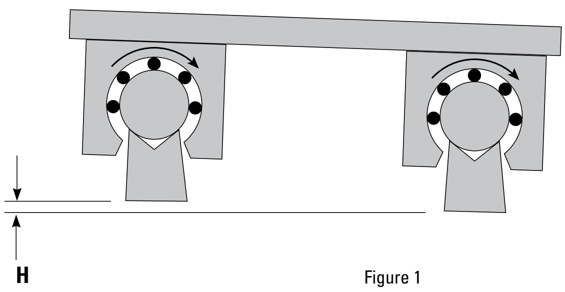



Figure 1

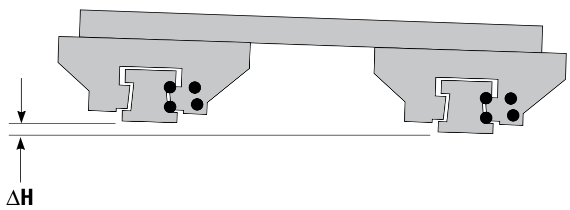



Figure 2

carriage and the precision balls. Due to the ball-conforming nature of the grooves, the carriage is prevented from accommodating torsional misalignment (Figure 2). If torsional misalignment is introduced to a linear guide system, the component stress increases, reducing life and performance. In a Ball Bushing Bearing system, the inner race is a hardened and ground 60 Case® LinearRace®. Since there are no grooves, the Ball Bushing Bearing system can accommodate torsional misalignment and operate without added stress to bearing components.

**60 Case LinearRace/Ball Bushing Bearing Fit-up**
There are three basic fit-up conditions of a Ball Bushing Bearing and 60 Case LinearRace: clearance, line-to-line and preload. In most product sections there are specification tables that detail the Ball Bushing Bearing working bore diameter and 60 Case LinearRace diameter tolerance as well as the fit-up between them. The clearance, line-to-line and preload conditions are shown by the abbreviation C for clearance, P for preload and .0000 for a line-to-line condition.

**Clearance**
The clearance between a Ball Bushing Bearing and a 60 Case LinearRace is a result of the Ball Bushing Bearing working bore diameter and the diameter tolerance of the 60 Case LinearRace. The working bore diameter of a Super Smart or Super Ball Bushing Bearing is a function of the housing bore diameter tolerance. In applications where high accuracy and repeatability is not required, clearance is acceptable. Clearance can be achieved by following the recommended housing bore guidelines found in the product specification sections. To check for a clearance condition, rotate the 60 Case LinearRace inside the Ball Bushing Bearing while installed in a housing bore. If you can freely rotate the 60 Case LinearRace then a clearance condition is present. For more details see the product specification sections.

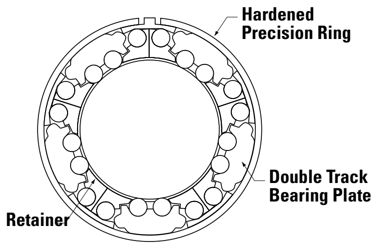
**Preload**
In applications where accuracy and repeatability are critical, the Super Smart, Super and Precision Steel Ball Bushing Bearings can be adjusted to a preload fit-up. The Super Smart and Super Ball Bushing Bearings are inherently adjustable and when installed in an adjustable housing bore a preload condition can be achieved. In a nonadjustable housing a preload condition can be obtained by making the size of the housing bore smaller or by increasing the diameter of the 60 Case LinearRace. To test for a preload condition in an adjustable or nonadjustable housing, simply rotate the 60 Case LinearRace inside the Ball Bushing Bearing while it is installed in the housing bore. If a slight drag is felt then a preload condition is present. When an adjustable housing is used the preload can be altered slightly. The Super Smart and Super Ball Bushing Bearing are more tolerant to preload than the Precision Steel Ball Bushing Bearing. Preload on a Super Smart and Super Ball Bushing Bearing should be a maximum of .001 inch per inch of 60 Case LinearRace diameter. Preload on a Precision Steel Ball Bushing Bearing should be a maximum of .0001 inch per inch of 60 Case LinearRace diameter. When all Ball Bushing Bearings are preloaded, extra care must be taken in mounting the 60 Case LinearRace parallel.

**Line-to-Line**
A line-to-line fit-up condition between a Ball Bushing Bearing and 60 Case LinearRace is when no clearance or preload is present. A line-to-line fit-up can be achieved in an adjustable or fixed diameter housing. For more details see the product specification sections.

Examples of Ball Bushing Bearing/60 Case LinearRace Fit-ups (in.)

| Ball Bushing Bearing Part Number | Working Bore Diameter | Recommended Housing Bore Diameter (fixed) | Actual Working Bore Diameter | 60 Case LinearRace Diameter | Ball Bushing Bearing/60 Case LinearRace Fit Up |
|---|---|---|---|---|---|
| SUPER 20 | 1.2500/1.2494 | 2.0008/2.0000 | 1.2508/1.2494 | 1.2495/1.2490 | .0018C/.0001P |
| A203242 | 1.2500/1.2494 | – | 1.2500/1.2494 | 1.2490/1.2485 | .0015C/.0004C |
| XA203242 | 1.2500/1.2496 | – | 1.2500/1.2496 | 1.2495/1.2490 | .0010C/.0001C |

The Super Smart Ball Bushing Bearing represents a major advancement in linear bearing technology worldwide. The Super Smart Ball Bushing Bearing offers twice the load capacity or eight times the travel life of the industry standard Super Ball Bushing Bearing. An enormous technological breakthrough, considering the Super Ball Bushing Bearing already offers three times the load capacity or 27 times the travel life of conventional Ball Bushing Bearings.




Cross-section of Super Smart Ball Bushing Bearing

Figure 1

Cross-section of Super Smart Ball Bushing Bearing

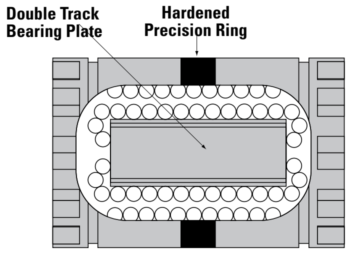



Figure 2

**Technologically Advanced Design**

The load carrying component of the Super Smart Ball Bushing Bearing is the combination of four hardened bearing quality steel components (Figures 1 & 2).

The first component is the hardened precision outer ring, which enables the bearing to maintain its diametral fit-up even after extended use, when standard self-aligning bearing plates would imbed into the housing. The unique ring design also allows for bearing adjustment and the removal of diametral clearance. The second component is the precision super finished double track bearing plate that provides twice the load capacity and in combination with the hardened precision steel band provides true universal self-alignment; which means optimum performance even with slight installation imperfections including housing bore out of roundness..

The third component is the rolling element. Each Super Smart Ball Bushing Bearing features precision ground balls manufactured to the highest quality standards for roundness and sphericity. The result is maximum load capacity, travel life and performance.

The last component is the 60 Case LinearRace shaft that functions as the inner race to the Super Smart Ball Bushing Bearing. Each 60 Case LinearRace is manufactured to the highest quality standards for roundness, straightness, surface finish and hardness. Roundness is held under .000080”; straightness to .001” per 12”; surface finish under 8 Ra microinch and hardness of at least 60 HRC. The combination of inner and outer race or 60 Case LinearRace and Super Smart Ball Bushing Bearing provides the fullest embodiment of the RoundRail Advantage.

## Self-Alignment

The Super Smart and Super Ball Bushing® Bearings are equipped with a built-in self-alignment feature that allows the bearing to absorb misalignment up to 0.5° per inch (Figure 3 and 4). This self-aligning feature allows the Super Smart and Super Ball Bushing Bearing to absorb misalignment caused by inaccuracies in housing bore alignment or 60 Case® LinearRace® deflection.

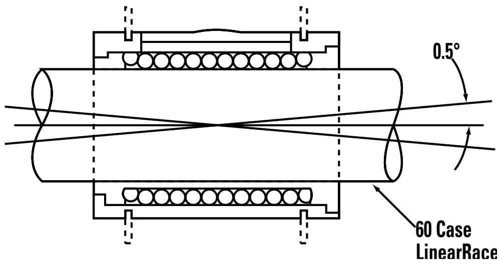



Figure 3

Super Ball Bushing Bearing Self-Alignment Feature

This rocking capability also provides smooth entry and exit of the precision balls into and out of the load zone assuring a constant low coefficient of friction. By compensating for misalignment, each bearing ball in the load carrying area is uniformly loaded providing maximum load capacity. Besides this rocking capability, only the Super Smart Ball Bushing Bearing provides two additional self-alignment features. They are Roll and Yaw.

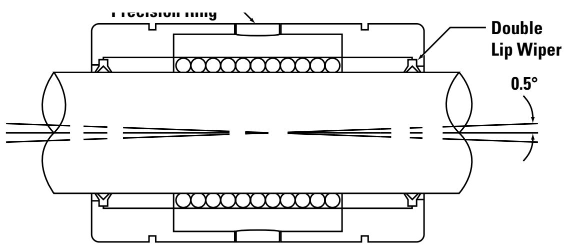



Figure 4

Super Smart Ball Bushing Bearing Self-Alignment Feature

**Roll**

The Super Smart Ball Bushing Bearing plate is designed with the radius of its outer surface smaller than the inside radius of the precision outer ring (Figure 5). This feature allows the bearing plate to compensate minor torsional misalignment still distribute the load on each of its two ball tracks. The roll component assures maximum load capacity and travel life.

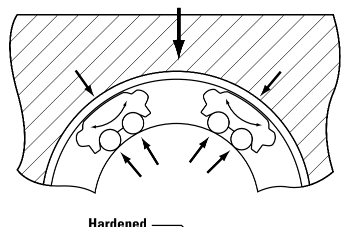


Figure 5

Super Smart Ball Bushing Bearing Self-Alignment Feature

**Yaw**

The shape formed by the Rock and Roll features enables the Super Smart Ball Bushing Bearing plate to even rotate about its center (Figure 6). This allows the Super Smart Ball Bushing Bearing to also absorb skew caused by misalignment. The result is a constant low coefficient of friction and maximum bearing performance.

Figure 7 below describes the conditions to which Super Smart and Super Ball Bushings automatically self-align. It is important to note that even though the Super Smart and Super Ball Bushing Bearings self-align, they still cannot absorb an out-of-parallel 60 Case LinearRace condition. Tolerance to 60 Case LinearRace out-of-parallelism is a function of clearance between the bearing and its 60 Case LinearRace.

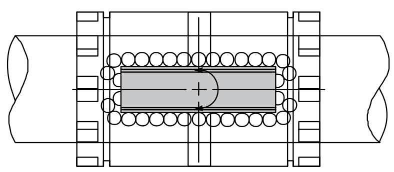


Figure 6

Bearing plates rotate about their center to prevent skewing relative to the 60 Case LinearRace.

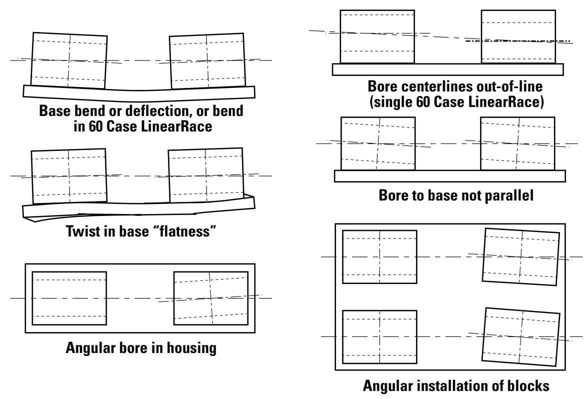



Figure 7

# Ball Bushing Bearing Life Expectancy and Load Capacity

There are many factors that affect Ball Bushing Bearing travel life such as 60 Case LinearRace hardness, the resultant load, the direction of the resultant load and Ball Bushing Bearing orientation. The dynamic load capacities and travel life graphs given in the specification tables found in each product section are based on a load applied at 90° relative to the horizontal plane with the Ball Bushing Bearing oriented as shown in each corresponding polar graph. Note: For Super Smart Ball Bushing Bearings and other extremely high load bearings, the bearing load capacity as indicated by the polar charts may be practically limited by the degree of shaft flexure acceptable, or the capacity of the shaft rail assembly fasteners. In such cases, the loads should be kept below these practical limits, however, the full corresponding life capacity benefits are still realized! The dynamic load capacity is also based on using only Thomson specified 60 Case LinearRace that is hardened to a minimum of 60 HRC.

For considerations other than those described above, the following formula is used:

$$W_R = \frac{P}{K_0 \cdot K_S \cdot K_L}$$

Where:

$W_R$ = required dynamic load capacity ($lb_f$ or N)
P = resultant of externally applied loads ($lb_f$ or N)
$K_0$ = factor for direction of resultant load
$K_S$ = shaft hardness factor (Equals 1.0 for 60 Case LinearRace)
$K_L$ = load correction factor

## Travel Life

The load correction factor, $K_L$, can be found from Figure 1 for inch product, and Figure 2 for Metric product. To determine $K_L$, for your required travel life, look for the value on the horizontal axis – Travel Life Factor – left side of the chart. (Interpolate as necessary – this is a Log-Log curve.) That is the value of your load correction factor.

Figure 1

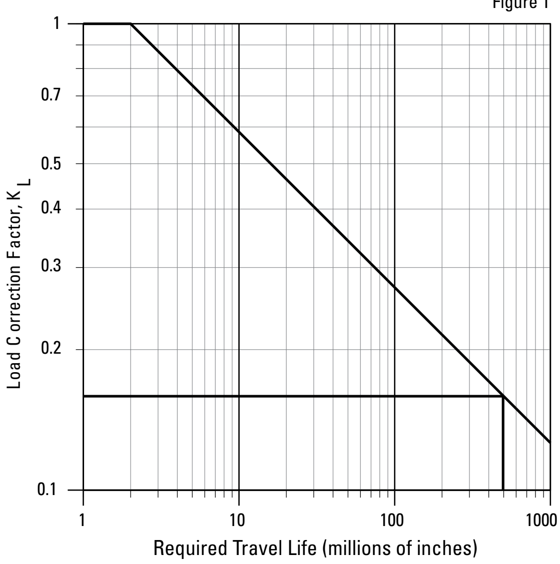
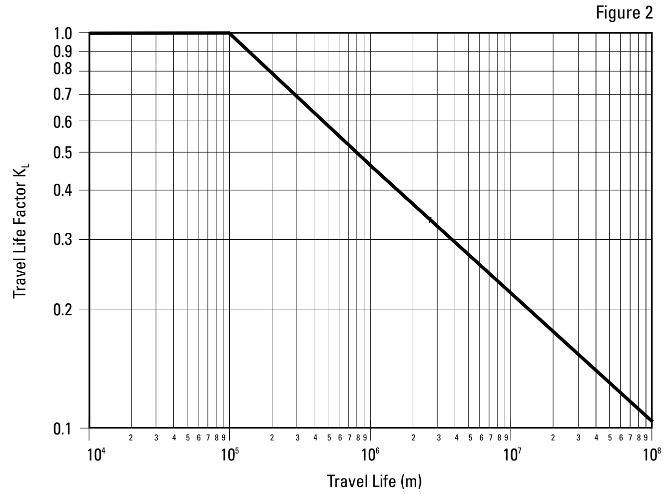



Figure 2




## 60 Case LinearRace Hardness

For shafts that do not meet 60 Case LinearRace hardness specifications of 60 HRC, shaft hardness factor $K_S$ must be applied. To determine $K_S$, simply enter Figure 3 with your shaft Rockwell hardness, find the value on the horizontal axis – Shaft Hardness – bottom of chart. Move vertically up until you intersect the curve. Then move horizontally until you reach the vertical axis – Shaft Correction Factor – left side of chart..

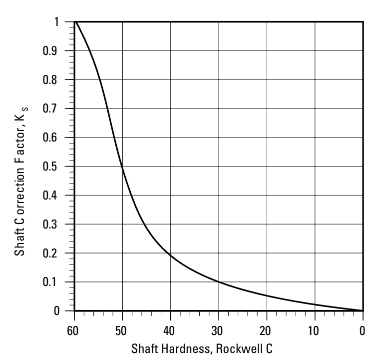



Figure 3

## Load Direction

In applications where the direction of the applied load is known, refer to the polar graphs on the product specification pages for the orientation factor (load correction factor is KL). A polar graph is referenced in Figure 4 for example.

Once you have determined your required dynamic load capacity refer to the product specification table for the proper Ball Bushing® Bearing size. Note: For Super Smart Ball Bushing Bearings and other extremely high-load bearings, the bearing load capacity as indicated by the polar charts may be practically limited by the degree of shaft flexure acceptable or the capacity of the shaft rail assembly fasteners. In such cases, the loads should be kept below these practical limits, however, the full corresponding life capacity benefits are still realized.

Note: Thomson Linear Ball Bushing Bearings are precision components.
To preserve bearing warranty, you must use the specified Thomson 60 Case® LinearRace®.

SSU-10-OPN
SSU-12-OPN
SSU-16-OPN
SSU-20-OPN
SSU-24-OPN

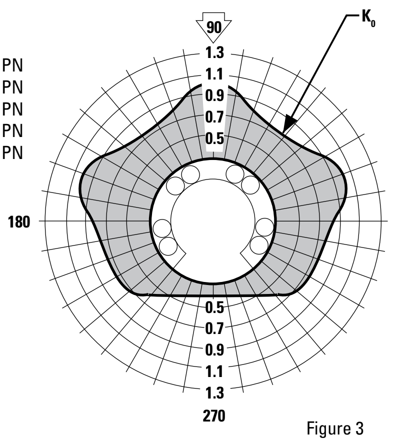



Figure 3

## Load Limit

The load limit is the maximum load which can be applied to the bearing. It is important to analyze your application so that peak and shock loading does not exceed the load limit.

## Dynamic Load Rating

The dynamic load rating is the maximum continuous load that can be applied to the bearing with a 90% reliability of achieving life of two million inches (100 km for metric bearings) under conventional operating conditions. However, it is important to remember that short strokes and the direction of the applied load can be significant factors.

The following formula may be used to determine travel life for metric bearings (SSEM, SPM, and MAM):

$$L_m = \left(\frac{W}{P} \bullet K_0 \bullet K_s\right)^3 \bullet 10^5 m$$

Where:
- $L_m$ = travel life (m)
- $W$ = dynamic load rating from tables (N)
- $P$ = resultant from externally applied loads (N)
- $K_o$ = factor for direction of resultant load
- $K_S$ = shaft hardness factor

**Sample Calculations:**

Determine the correct Ball Bushing Bearing size for your application. In this example, the bearing/shaft system is subjected to a load of 2300 N perpendicular to the direction of travel. The load is distributed equally among four closed type MultiTrac® Ball Bushing Bearings. The carriage reciprocates over a 0.3 m stroke at a frequency of 100 complete cycles per minute. The minimum service life required is 3500 hours. 60 Case LinearRace shafting is used.

The first step is to determine the average load on each Ball Bushing Bearing.

$$P = \frac{W}{P} = 575 \text{ N}$$

Next, determine the equivalent travel life in meters:

$$L_m = 2 \bullet s \bullet f \bullet L_h \bullet 60$$
$$L_m = 2 \bullet 0.3 \bullet 100 \bullet 3500 \bullet 60$$
$$L_m = 1.26 \bullet 10^7 m$$

Where:
- $s$ = stroke in meters
- $f$ = frequency in cycles per minute
- $L_h$ = required life in hours

From Figure 1 (Travel Life Chart), the travel life factor ($K_L$) is 0.2.

From Figure 2 (Shaft Hardness Chart), the shaft hardness factor ($K_S$) is 1.

For closed type MultiTrac Ball Bushing Bearings, the minimum value of Ko is 1, the assumed value for this calculation.

The required dynamic load capacity is obtained by using the following formula:

$$W_R = \frac{P}{K_L \bullet K_S \bullet K_q}$$

$$W_R = \frac{575}{0.2 \bullet 1 \bullet 1} = 2875 \text{ N}$$

By referring to the product specification and dimension sections of this catalog, the linear bearing with the next higher load capacity is the MultiTrac MA M40 with a dynamic load capacity of 3820 N.

## Determining the Travel Life

The expected travel life of the MultiTrac MA M40 bearing under the conditions described in the example is:
- $W$ = 3820 N is the rated dynamic load capacity
- $P$ = 575 N is resultant of external loads
- $K_o$ = 1 is the orientation factor
- $K_S$ = 1 is the shaft hardness factor

The values are substituted into the following formula:

$$L_m = \left(\frac{W}{P} \bullet K_0 \bullet K_s\right)^3 \bullet 10^5 m \qquad L_m = \left(\frac{3820}{575} \bullet 1 \bullet 1\right)^3 \bullet 10^5 m$$

$$L_m = 293 \bullet 10^5$$

This is converted into hours by the following:

$$L_h = \frac{L_m}{2 \bullet 60 \bullet s \bullet f} \qquad L_h = \frac{293 \bullet 10^5}{2 \bullet 60 \bullet 0.3 \bullet 100}$$

$$L_h = 8139 \text{ h}$$

# 60 Case LinearRace Shafting Specifications

Thomson 60 Case LinearRace provides the inner race for Thomson Ball Bushing Bearings. All 60 Case LinearRace is manufactured to extremely close tolerances for surface finish, roundness, hardness and straightness to provide long service life with reduced maintenance.

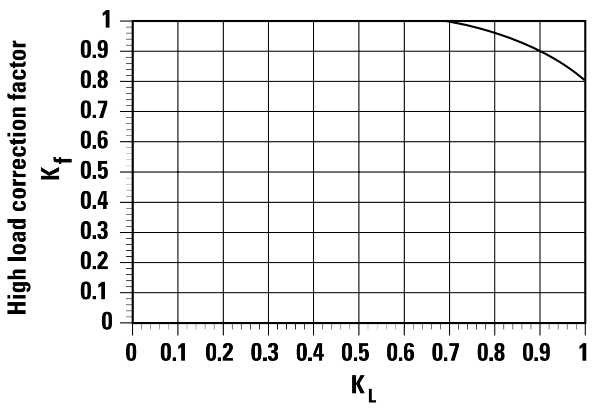
## Specifications

| | |
|---|---|
| Hardness: | HRC 60 minimum |
| Surface Finish: | 8 $R_a$ microinch |
| Roundness: | 80 millionths of an inch |
| Straightness: | Standard—.001 inch per foot cumulative (.002" TIR)<br>Special—.0005 inch per foot cumulative (.001" TIR) |
| Length Tolerance: | Standard +/–.030 inch for diameters up to 2 inches and +/–.060 inch for diameters 2 inch and over. Special length tolerances available. |
| Chamfer: | Standard chamfer on diameters up to 1 inch is .030" x 45° and .060" x 45° for diameters larger than 1 inch. |
| Tensile Strength: | Case: 335,000 psi, Core: 100,000 psi |
| Yield Strength: | Case: 250,000 psi, Core: 75,000 psi |

## Load Factor

In applications where the applied load exceeds 70% of the maximum dynamic load capacity of Super Smart Ball Bushing Bearings, a high load correction factor $K_f$ must be applied to $W_R$ when calculating travel life. (Figure 1)

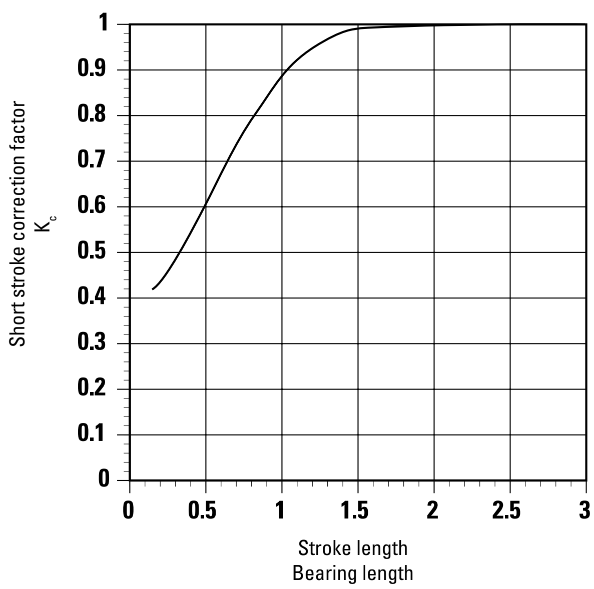
Figure 1




## Short Stroke Applications

In applications when the stroke length is short, the life of the shaft is shorter than that of the Ball Bushing Bearing. In short stroke applications, the required dynamic load capacity must be multiplied by the factor $K_c$ found on Figure 2.

Figure 2




Engineering

# Load Consideration

When designing a linear motion system, it is necessary to consider how the variables of operation will affect performance.

The following examples demonstrate how the position of the load and the center of gravity can influence the product selection. When evaluating your application, review each of the forces acting on your system and determine the best product for your needs.

## Terms:

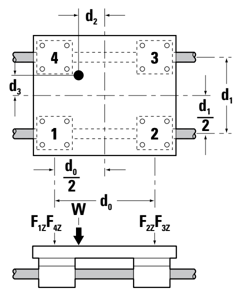
$d_0$ = distance between centerlines of pillow blocks
$d_1$ = distance between centerlines of 60 Case® LinearRace® ways (recommended spacing on $d_1$ is no more than 3x the $d_0$ distance)
$d_2$ = distance from centerline of carriage to load action point
d3 = distance from centerline of carriage to load action point
W = Load (lb)
$F_{NX}$ = Force in the X-axis direction ($lb_f$ or N)
$F_{NY}$ = Force in the Y-axis direction ($lb_f$ or N)
$F_{NZ}$ = Force in the Z-axis direction ($lb_f$ or N)

$$F_{1Z} = \frac{W}{4} + \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{2Z} = \frac{W}{4} - \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{3Z} = \frac{W}{4} - \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{4Z} = \frac{W}{4} + \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$



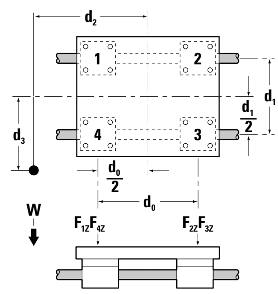

**Horizontal Application I**
At the time of movement with uniform velocity or at the time of stop.

$$F_{1Z} = \frac{W}{4} + \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{2Z} = \frac{W}{4} - \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{3Z} = \frac{W}{4} - \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{4Z} = \frac{W}{4} + \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

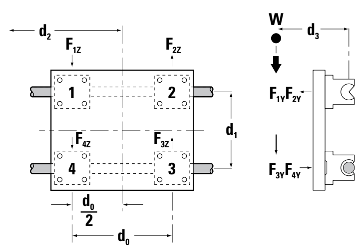



**Horizontal Application II**
At the time of movement with uniform velocity or at the time of stop.

$$F_{1Y} \cong F_{4Y} = \left(\frac{W}{2} \bullet \frac{d_3}{d_1}\right)$$

$$F_{1Z} = F_{4Z} = \frac{W}{4} + \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right)$$

$$F_{2Z} = F_{3Z} = \frac{W}{4} - \left(\frac{W}{2} \bullet \frac{d_2}{d_0}\right)$$



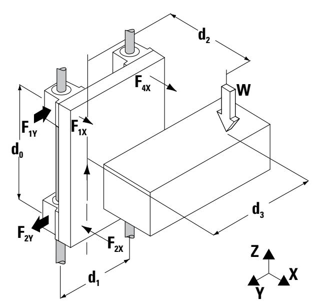

**Side Mounted Application**
At the time of movement with uniform velocity or at the time of stop.

$$F_{1X} \cong F_{4X} = \frac{W}{2} \bullet \frac{d_2}{d_0}$$

$$F_{1Y} \cong F_{4Y} = \frac{W}{2} \bullet \frac{d_3}{d_0}$$

$$F_{1X} + F_{4X} \cong F_{2X} + F_{3X}$$

$$F_{1Y} + F_{4Y} \cong F_{2Y} + F_{3Y}$$




**Vertical Application**
At the time of movement with uniform velocity or at the time of stop. At the time of start and stop, the load varies because of inertia.

# Coefficient of Friction

The coefficient of friction of Thomson Ball Bushing® Bearings ranges from 0.001 to 0.004. There are two components of the coefficient of friction: the rolling or operating friction and the static or breakaway friction.

**Coefficient of Rolling Friction**
The rolling coefficient of friction is measured by the force required to operate the Ball Bushing at a constant rate of travel. The formula for determining frictional resistance during operation is as follows:

$P_f = P \times f_r$

Where,
$P_f$ = Frictional resistance ($lb_f$)
P = Resultant of externally applied loads ($lb_f$)
$f_r$ = Coefficient of rolling friction

The following table describes the coefficient of rolling friction of Ball Bushing Bearings operating on Thomson 60 Case LinearRace. These values are grouped according to the number of ball circuits in each bearing. Friction coefficients are constant among bearings having three and four ball circuits, but slightly less for bearings with five or six ball circuits. A dry Ball Bushing Bearing has the lowest coefficient of friction due to the complete absence of lubricant surface tension effects. Values for grease lubrication ranges from 100% greater in the smaller sizes to 20% to 50% greater in the larger sizes. Oil lubrication (medium/heavy, viscosity 64 cs @ 100°F / 38°C) achieves frictional values slightly higher than those for grease lubrication.

Ball Bushing Bearing coefficients of rolling friction ($f_r$)

| Bearing I.D. | Number of Ball Circuits | Condition of Lubrication | Load in % of Rolling Load Rating (for 2,000,000 inches of travel) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 125% | 100% | 75% | 50% | 25% |
| 1/4, 3/8, 1/2, 5/8 | 3 & 4 | No Lube | .0011 | .0011 | .0012 | .0016 | .0025 |
| | | Grease Lube | .0019 | .0021 | .0024 | .0029 | .0044 |
| | | Oil Lube | .0022 | .0023 | .0027 | .0032 | .0045 |
| 3/4, 1 | 5 | No Lube | .0011 | .0011 | .0012 | .0015 | .0022 |
| | | Grease Lube | .0018 | .0019 | .0021 | .0024 | .0033 |
| | | Oil Lube | .0020 | .0021 | .0023 | .0027 | .0036 |
| 1 1/4 thru 1 | 6 | No Lube | .0011 | .0011 | .0012 | .0014 | .0019 |
| | | Grease Lube | .0016 | .0016 | .0017 | .0018 | .0022 |
| | | Oil Lube | .0018 | .0018 | .0019 | .0021 | .0027 |
| 5/8 thru 1 1/2 | 10 | No Lube | .0011 | .0011 | .0012 | .0013 | .0018 |
| | | Grease Lube | .0014 | .0014 | .0015 | .0016 | .0019 |
| | | Oil Lube | .0016 | .0016 | .0017 | .0019 | .0025 |

**Coefficient of Static Friction**
The coefficient of static or breakaway friction is measured by the force required to initiate Ball Bushing Bearing movement. The formula used to determine static frictional resistance is:

$P_f = P \times f_0$
where $f_0$ = Coefficient of static friction

The values for the coefficient of static friction or breakaway friction are not measurably affected by the number of ball circuits in the bearing or by the lubrication condition.

Ball Bushing Bearing coefficients of static friction ($f_0$)

| Load in % of Rolling Load Rating | | | | |
|---|---|---|---|---|
| 125% | 100% | 75% | 50% | 25% |
| .0028 | .0030 | .0033 | .0036 | .0040 |

**Seal Drag**
Another variable that affects the frictional resistance in a Ball Bushing Bearing system is seal drag. When seals are used to retain lubricant or to prevent entry of foreign particles, frictional resistance must be taken into account for determining total frictional drag. In applications where contamination is minimal, the seals can be removed to reduce frictional drag. In highly contaminated applications, seals, wipers and or scrapers are used to minimize the ingress of contamination into the bearing. This protective measure adds to the frictional drag of the bearing system. There is a fine line between minimizing frictional drag and maximizing contaminant protection which is controlled by the addition or removal of seals, wipers or scrapers. In applications that require low frictional drag in highly contaminated environments, contact Thomson application engineering.

Thomson can provide a specially formulated lubricant, specifically developed to meet a broad range of linear bearing applications. Thomson LinearLube lubricant is a synthetic lubricant that utilizes suspended Teflon® in a specially formulated compound. LinearLube lubricant provides excellent performance characteristics in a wide range of applications. It is FDA listed, non-polluting and non-corrosive. LinearLube lubricant will not stain and adheres tightly to parts forming a virtually water resistant barrier.

- Maintains properties in operating temperatures from -65°F to 450°F / -54°C to 232°C
- USDA Rated HL (Non-Toxic)
- Will not oxidize in use
- 100% water resistant

THOMSON
Linear Motion. Optimized.™

# System Maintenance and Service

All Thomson Ball Bushing® Bearings require a small amount of grease or oil to operate. For general applications, EP2 (extreme pressure NLGI grade2) lubricant is recommended to prevent wearing and rusting of the bearing surfaces. For food-grade applications, LinearLube (teflon-based synthetic grease) is recommended. When linear speeds are high, light oil should be used and the bearing should be prevented from running dry for a prolonged period of time. A medium to heavy oil or light grease has greater adhesion properties that afford longer bearing protection and minimize sealing problems.

All Thomson Ball Bushing Bearings are shipped with rust preventative oil. It is recommended that you lubricate the Ball Bushing prior to installation and periodically during operation to assure that the Ball Bushing does not run dry. Bearing lube cycle not to exceed 1 year or 100 km of travel (whichever comes first), but more frequent application may be required based on duty cycle, usage, environment and level of contamination. Thomson can provide a specially formulated lubricant, specifically developed to meet a broad range of linear bearing applications. Thomson LinearLube lubricant is a synthetic lubricant that utilizes suspended Teflon® in a specially formulated compound. LinearLube provides excellent performance characteristics in a wide range of applications. It is FDA listed, non-polluting and non-corrosive. LinearLube will not stain and adheres tightly to parts forming a virtually water resistant barrier.

- Maintains properties in operating temperatures from -65°F to 450°F / -54°C to 232°C
- USDA rated HL (Non-Toxic)
- Will not oxidize in use
- 100% water resistant

# Bearing Options

**Ball Options**

-CR Corrosion Resistant: This option is available on all Super and Super Smart Bushing Bearings and pillow blocks. The option provides stainless steel balls and plated bearing plates. For Super Smart, the outer band is also plated. Using stainless steel balls will reduce the dynamic load capacity by 30%.

-SS Stainless Steel: This option is available for metal A Bearings and MultiTrac® metric (MAM) bearings. The option provides stainless steel instead of carbon steel and stainless steel balls. For A Bearings, this is available up to and including 1" sizes. For MAM bearings, this option is available for all sizes except 40mm. Using stainless steel balls will reduce the dynamic load capacity by 30%.

-SP Stainless Steel Balls, Black Oxide Retainer and Sleeve: This option is available for all metal A Bearings and MultiTrac metric (MAM) bearings, and is a good alternative to –SS. Using stainless steel balls will reduce the dynamic load capacity by 30%.

-NB Nylon Balls: This option provides full nylon balls in place of carbon steel balls, resulting in a quiet bearing but reducing the load capacity by 90%. Available on all bearings.

-NBA Alternating Nylon Balls: This option is useful when a more quiet than standard bearing is desired but full nylon is not needed. This will reduce dynamic load capacity by 50%. Available on all bearings.

-OR Outrigger: Only two opposing bearing tracks.

**Lube Options**

-LL Bearing is lubricated at the factory with Thomson LinearLube.

-L4L Pillow block furnished with a Lube for Life cartridge on each end. This option is available on Super and Super Smart inch pillow blocks, sizes ½", ¾", 1", 1 ¼" & 1 ½".

-DP Bearing is shipped with no lubricant at all. (Typically all balled bearings are shipped with rust preventative only.)

**Other Options**

-RP The Roll Pack option eliminates the packing box. This may be desired on larger quantity orders.

-HP The bearing is treated with a black oxide finish. This option is available on metal A Bearings and MultiTrac metric (MAM) bearings.

Note: Up to 1 option per option category can be selected. (Example, A162536-SPLLRP)

Not all options are available in all sizes.
See catalog pages or contact Thomson Customer Support for combination availability.

# Material Engineering Specifications

## Ball Bushing® Bearing materials

The following is a tabulation of the materials used for the components of the various types of Ball Bushing Bearings

| Type | Outer Sleeve | Ball Retainers | Bearing Plates | Balls | End Rings/ Band |
|---|---|---|---|---|---|
| SSU, SSJM, SSEM, SPM, SUPER Ball Bushing Bearings | Delrin | Delrin | 52100 | Chrome Steel | None/ Steel |
| Series A, B, XA, ADJ, OPN and DS | 52100 | Steel | – | Chrome Steel | Steel |
| Stainless Steel (SS) to 1" I.D. Series A, XA, ADJ and OPN | 440A | Type 305SS | – | 440C | Type 303SS |
| Series MAM | – | Delrin | – | Chrome Steel | Steel |
| Series INST-SS | 440C | Brass | – | 440C | None |
| Series XR | Reinforced Nylon | Reinforced Polyester | 8620 | Chrome Steel | Steel |

Note: Materials called out are typical, certain series and sizes may vary.

## Corrosion Resistance

Super and Super Smart Ball Bushing Bearings can be supplied corrosion resistant with hard chrome-plated bearing plates and stainless steel balls. Load capacity will be 70% of regular Super Ball Bushing Bearings. To order, add suffix "CR" following the Super Ball Bushing Bearing part number.

Large sizes (over 1" diameter) of series A, XA, ADJ, OPN and B, Ball Bushing Bearings can be supplied with stainless steel balls and black oxide sleeves for limited protection against atmospheric corrosion. Load capacity will be 70% of regular steel bearings. To order, add suffix "SP" following the bearing part number.

## Stainless Steel Ball Bushing Bearings

Precision and MultiTrac® Ball Bushing Bearings can be supplied with stainless steel ball and end rings. To order, add suffix "SS" following the bearing part number. Precision bearings are made entirely of stainless steel components. MultiTrac bearings have stainless steel balls, end rings and outer sleeves. Load capacity will be 70% of regular steel bearings.

**Sizes available:**
Series A and XA: 1/4", 3/8", 1/2", 5/8", 3/4" and 1"
Series ADJ and OPN: 1/2", 5/8", 3/4" and 1"
Series MAM: 8mm (closed type only), 12mm, 16mm, 20mm, 25mm, 30mm

## Ball Bushing Bearings with nylon balls

For extremely quiet operation, Ball Bushing Bearings fitted with Nylon balls can be supplied in sizes 1/2" and larger. For estimating purposes, load ratings should be considered about 10% of those listed for Ball Bushing Bearings with steel balls. Prices and other information available on request.
NBA Bearings have a load rating of 50% listed dynamic.

## 60 Case® shafts – hardened and ground

| Material Type | AISI | Rockwell "C" |
|---|---|---|
| Solid 60 Case | Bearing-quality, high carbon alloy steel | 60 min |
| Tubular 60 Case | Bearing-quality, high carbon alloy steel | 58 min |
| Solid Stainless Steel | 440C Stainless(1) | 50 min |

(1) For applications using 440C stainless shafting with Thomson Ball Bushing Bearings, contact Thomson Customer Support with full application details for applicable load derating considerations.

## Maximum recommended operating temperatures for RoundRail bearings

The following are general recommendations. For additional information or more specific recommendations please contact Thomson Customer Support with full application details.

| Type of Ball Bushing Bearings | Maximum Operating Temperature | Load Rating at Maximum Operating Temperature as % of Catalog Load Rating |
|---|---|---|
| Series Super Smart, Super, MultiTrac & XR | 185°F / 85°C | 100% |
| Series A, B, XA, ADJ & OPN(2), Series DS, and Series RW S, V, A, B & C | 500°F / 260°C | 70% |
| Series A-SS, XA-SS, ADJ-SS, OPN-SS & INST-SS Stainless Steel (through 1" I.D.)(2) | 600°F / 316°C | 60% |

(2) Maximum operating temperature for these two series for full catalog load rating is 300°F/149°C.
Note: Type PB-A, PB-ADJ and PBO-OPN pillow blocks are assembled with plastic seal covers with a maximum operating temperature at 185°F. Remove seals and seal covers for use in higher temperatures.
Note: Seals max temperature is 250°F / 121°C.
Note: Shafting loses 5 points hardness for every 100°F / 38°C above 200°F / 93°C.
Note: For extreme minimum temperatures, contact Thomson Customer Support.

## Pillow blocks and shaft supports

| Part Type | Material |
|---|---|
| Type Super Smart and Super – Pillow Blocks, Flanged Blocks and Aluminum Shaft Blocks | Type 6061-T6511 Aluminum |
| Type PB pillow blocks | Ductile Iron |
| Type PBO & XPBO pillow blocks | Malleable/Ductile Iron |
| Type SR shaft support rails | Type 6061-T6511 Aluminum |
| Type LSR shaft support rails | 1010 Steel |
| Type XSR shaft support rails | Ductile Iron |
| Type SB shaft support blocks | Malleable Iron(3) |
| Waymount shaft supports | Malleable Iron Base with steel adjustment elements |

(3)Type 6061-T6511 Aluminum for 1/4" and 3/8" sizes only

## RoundRail linear guides

| Components | | Material |
|---|---|---|
| Supports | Type ASB End Support | Aluminum Alloy (4) |
| | Type SB End Support | Iron |
| | Type SRA End Support | Aluminum Alloy (4) |
| | Twin Shaft End Support | Aluminum Alloy (4) |
| | Twin Shaft Web End Support | Aluminum Alloy (4) |
| | Integrated End Support | Aluminum Alloy (4) |
| | Dual Shaft Support Rail | Aluminum Alloy (4) |
| | Inner Race (60 Case Shafting) | Case Hardened High Carbon Steel |
| Carriage | Universal Carriage | Aluminum Alloy (4) |
| | Twin Shaft Carriage | Aluminum Alloy (4) |
| | Twin Shaft Web Carriage | Aluminum Alloy (4) |
| | Modular Dual Shaft Carriage | Aluminum Alloy (4) |
| | Integrated Dual Shaft Carriage | Aluminum Alloy (4) |

(4) Custom Black Anodized for inch size systems. Custom Grey Anodized for metric size systems. Custom system lengths may require black paint to protect machine cut-off ends on Dual Shaft Rail Assemblies and Shaft support rails. If a specific surface finish is required contact Thomson Customer Support.
Note: Limited to a Max. Temperature of 185˚F / 85˚C

# 60 Case LinearRace® Deflection

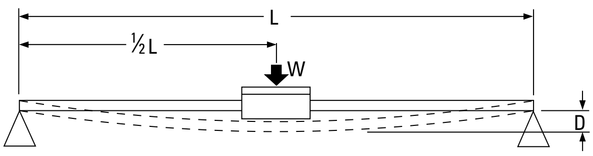
When Thomson 60 Case LinearRace is used in an end-supported configuration, it is important to ensure that 60 Case LinearRace deflections at the bearing locations are kept within performance limitations.

These equations give the deflection at the center of an end-supported 60 Case LinearRace. Systems with continuous 60 Case LinearRace support are not subject to the same types of deflection.

For more detailed information of the deflection characteristics of Thomson linear motion products, contact application engineering.

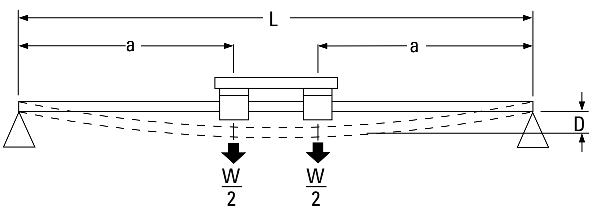
Simply Supported 60 Case LinearRace with One Block

DEFLECTION AT CENTER (D)




$$D = \frac{WL^3}{48\ EI} + \frac{5SL^4}{384\ EI}$$

Simply Supported 60 Case LinearRace with Two Blocks




$$D = \frac{Wa(3L^2 - 4a^2)}{48\ EI} + \frac{5SL^4}{384\ EI}$$

**LEGEND:**

| | | |
|---|---|---|
| **D** | = | **(in) (m)** |
| **W** | = | **($lb_f$) (N)** |
| **L** | = | **(in) (m)** |
| **a** | = | **(in) (m)** |
| **S** | = | **($lb_f$/in) (N/m)** |
| **E** | = | **($lb_f/in^2$) ($N/m^2$)** |
| **I** | = | **($in^4$)($m^4$)** |

**Values for Thomson 60 Case LinearRace**

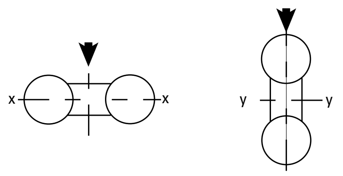
| LinearRace Diameter (In) | Solid | | Tubular | |
|---|---|---|---|---|
| | EI ($lb_f \cdot in^2$) | Weight (S) ($lb_f$ / in) | EI ($lb_f \cdot in^2$) | Weight (S) ($lb_f$ / in) |
| .187 | 1.8E+03 | .008 | – | – |
| .250 | 5.8E+03 | .014 | – | – |
| .375 | 2.9E+04 | .031 | – | – |
| .500 | 9.2E+04 | .055 | – | – |
| .625 | 2.3E+05 | .086 | – | – |
| .750 | 4.7E+05 | .125 | 4.6E+05 | .075 |
| 1.000 | 1.5E+06 | .222 | 1.3E+06 | .158 |
| 1.250 | 3.6E+06 | .348 | – | – |
| 1.500 | 7.5E+06 | .500 | 6.3E+06 | .328 |
| 2.000 | 2.4E+07 | .890 | 1.9E+07 | .542 |
| 2.500 | 5.8E+07 | 1.391 | 4.2E+07 | .749 |
| 3.000 | 1.2E+08 | 2.003 | 9.3E+07 | 1.112 |
| 4.000 | 3.8E+08 | 3.560 | 2.5E+08 | 1.558 |

| LinearRace Diameter (mm) | EI ($N \cdot m^2$) | Weight (S) (N /m) |
|---|---|---|
| 5mm | 5.838 | 0.0016 |
| 8mm | 38.26 | 0.0038 |
| 10mm | 93.41 | 0.0061 |
| 12mm | 193.7 | 0.0087 |
| 16mm | 612.2 | 0.0154 |
| 20mm | 1495 | 0.0240 |
| 25mm | 3649 | 0.0379 |
| 30mm | 7566 | 0.0542 |
| 40mm | 2.391E+04 | 0.0968 |
| 50mm | 5.838E+04 | 0.1513 |
| 60mm | 1.211E+05 | 0.2172 |
| 80mm | 3.826E+05 | 0.3870 |

**Deflection for Twin Shaft Web System**

Since the Twin Shaft Web rail has different stiffness depending on its orientation, an appropriate EI value must be used based upon the direction of loading. Select the orientation of your load from the figure below and then use the appropriate EI value in the deflection equation.

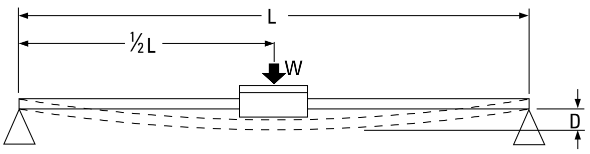
| Shaft Diameter (in) | EI Horizontal ($lb_f \cdot in^2$) | EI Vertical ($lb_f \cdot in^2$) |
|---|---|---|
| 1/2 | 1.9E+05 | 3.7E+06 |
| 3/4 | 9.4E+05 | 1.5E+07 |
| 1 | 3.0E+06 | 4.7E+07 |




Engineering

# Ultra Light Aluminum LinearRace® Deflection

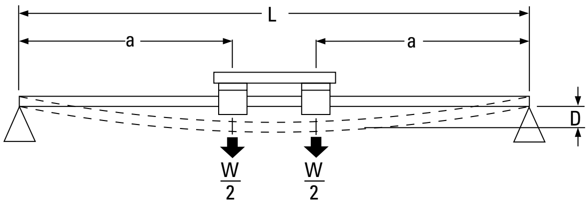
### Simply Supported 60 Case® LinearRace with One Block




$$D = \frac{WL^3}{48\,EI} + \frac{5SL^4}{384\,EI}$$

| Nominal Diameter (in) | EI (lbf • in²) |
|---|---|
| 1/4 | 1.92+03 |
| 3/8 | 9.79+03 |
| 1/2 | 3.13+04 |
| 5/8 | 7.50+04 |
| 3/4 | 1.56+05 |
| 1 | 5.00+05 |

### Simply Supported 60 Case LinearRace with Two Blocks




$$D = \frac{Wa(3L^2 - 4a^2)}{48\,EI} + \frac{5SL^4}{384\,EI}$$

**LEGEND:**

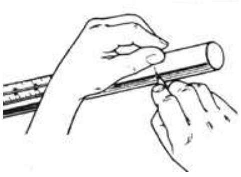
D = (in) (m)
W = ($lb_f$) (N)
L = (in) (m)
a = (in) (m)
S = ($lb_f$/in) (N/m)
E = ($lb_f$/in²) (N/m²)
I = (in⁴)(m⁴)

# How to Cut 60 Case LinearRace Shafting

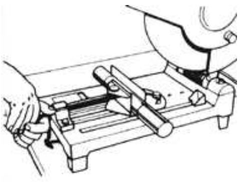
Genuine 60 Case LinearRace shafting has an extremely hard outer surface, HRC 60 and a soft core. The following steps will guide you in cutting 60 Case shafts. Remember: Always use goggles and normal shop safety precautions.

**With an abrasive cut-off saw. . .**
**(preferred method)**

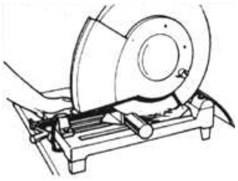
**Step 1:**
Mark the shaft at the desired length.



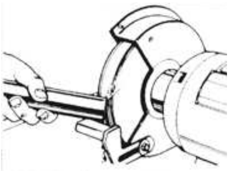
**Step 2:**
Secure shaft in vise with longer end clamped.



**Step 3:**
Cut the shaft at the mark.

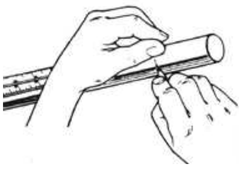


**Step 4:**
Chamfer the shaft by rotating it by hand while holding it against an abrasive wheel at approximately 45˚. Use an emery cloth to remove burrs and discoloration.

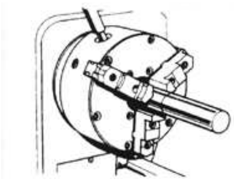


**With a lathe. . .**
**(using a collect type or standard 3-jaw chuck)**

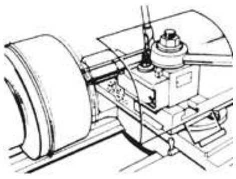
**Step 1:**
Mark the shaft at the desired length.



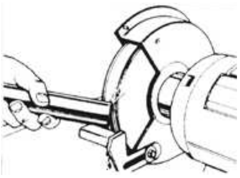
**Step 2:**
Secure shaft in lathe with longer end in spindle.



**Step 3:**
Use a sharp, carbide cut-off tool with shaft turning at approx. the following speeds: 400 rpm for dia. 1/4" - 1", and 300 rpm for dia. 1" or larger



**Step 4:**
Chamfer the shaft using a standard carbide turning tool or an abrasive wheel. Use an emery cloth to remove burrs and discoloration.



# Application Tips

**Two Ball Bushing® Bearings per 60 Case® LinearRace®**
When using the Super Smart, Super or Precision Steel Ball Bushing Bearing, it is recommended that two Ball Bushing Bearings be used on each 60 Case LinearRace. This will assure system stability as well optimum performance. If envelope constraints prohibit the use of two Ball Bushing Bearings per 60 Case LinearRace, contact application engineering.

**Ball Bushing Bearing Spacing vs. 60 Case LinearRace Spacing**
In parallel 60 Case LinearRace applications, the ratio of 60 Case LinearRace spacing to Ball Bushing Bearing spacing should always be less than three to one. This will assure a constant breakaway and operating friction.

**60 Case LinearRace Parallelism**
In most applications the maximum acceptable out of parallelism condition is .001” over the entire full system length. In applications where preload is present (such as when using Die Set Ball Bushing Bearings), a closer 60 Case LinearRace parallelism is recommended.

**Three or More Parallel 60 Case LinearRace Ways**
When aligning two 60 Case LinearRace ways parallel great care is required to assure a parallelism within .001” over the entire length of travel. When aligning multiple 60 Case LinearRace ways, parallelism between each 60 Case LinearRace should be held within the .001” specification.

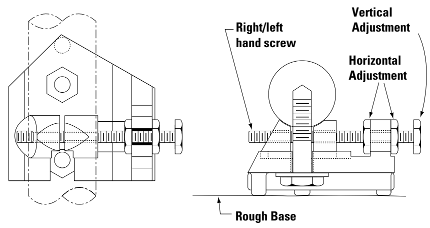
**Measuring 60 Case LinearRace Alignment**
Methods for establishing or checking 60 Case LinearRace straightness and parallelism depends on the accuracy required. Lasers, collimator or alignment telescopes can be used for very precise applications, while accurate levels, straight edges, micrometers and indicators will suffice for the majority of applications which have less stringent accuracy requirements.

**Installation of Super and Precision Steel Adjustable Type Ball Bushing Bearings**
When installing a Super Ball Bushing Bearing into a slotted adjustable housing, the bearing plate should not align with the adjustment slot. When installing a Precision Steel Adjustable Type Ball Bushing Bearing into a slotted adjustable housing, the bearing adjustment slot should be 90° to the pillow block adjustment slot. These important steps will assure accurate bearing adjustment.

**Access for Lubrication**
Thomson Super Smart and Super Ball Bushing Pillow Blocks are equipped with either an oil lubrication fitting or a 1⁄4-28 access for lubrication. To use the oil fitting simply insert a lubrication device into the oil nipple by depressing the spring loaded ball. The 1⁄4-28 tapped hole is a standard size for most grease and lubrication fittings. Simply install the lubrication fitting of your choice and it is ready for immediate use. Super Ball Bushing Pillow blocks in sizes .250 through .500 inch diameter are equipped with oil lubrication fittings. Super Ball Bushing pillow blocks in sizes .625 inch and above and all Super Smart Ball Bushing Pillow Blocks are equipped with a 1⁄4-28 access for lubrication. Metric Super Smart Pillow Blocks are equipped with a M6X1 access for lubrication.

**Waymount Support Block for RoundWay® Bearing Installation**
Standard Waymount LinearRace Support Blocks provide 60 Case LinearRace adjustment in both the horizontal and vertical direction. This product reduces installation time dramatically, while assuring precise 60 Case LinearRace alignment. This versatile design allows the Waymount support to be mounted vertically or horizontally and in many different RoundWay bearing applications. The number of Waymounts to be used is based on the maximum allowable 60 Case LinearRace deflection between supports and the accuracy required. Ordinarily indicators, sensitive levels and straight edges are adequate for most alignment conditions.

**Waymount Support Block**




**RoundWay Bearing/60 Case LinearRace Installation Using Grout**
Grouting is a very simple method of mounting a 60 Case LinearRace on almost any kind of surface, smooth or uneven. Grouting can also be used in conjunction with standard Waymount LinearRace support blocks or other 60 Case LinearRace supports to obtain maximum rigidity. Dams are fastened to the bed parallel to the 60 Case LinearRace which is then aligned with its mating 60 Case LinearRace (Figure 1). A compound is then poured under and around the lower circumference of the 60 Case LinearRace. This dries quickly forming a solid support of high compressive strength (over 12,000 psi) without affecting the initial straightness of the LinearRace.

If the bearing arrangement permits the grout to flow substantially around the circumference of the 60 Case LinearRace and side loads are light, Waymount LinearRace supports or other hold down bolts along the length made be unnecessary (Figure 2). Just one support at each end of the 60 Case LinearRace will usually provide final alignment and hold the 60 Case Linear-Race in position for grouting. If the length to diameter ratio is large, Waymount LinearRace supports should be equally spaced to minimize 60 Case LinearRace deflection. Grout should always be in direct contact with the surface of the bed or whatever base member provides primary rigidity and support.

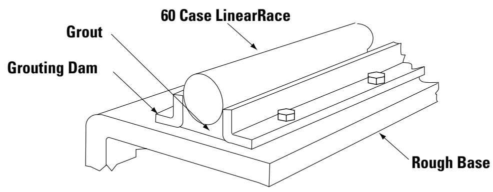



Figure 1

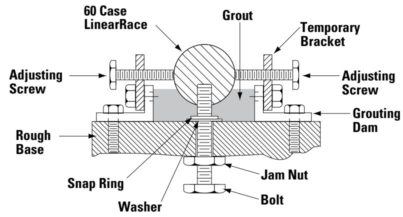



Figure 2

# Installation Guidelines

Thomson Ball Bushing Bearings are manufactured to exceptionally close tolerances and offer smooth, virtually friction-free motion. The performance features of the bearings will only be realized, however, if care is taken during their installation.

Two areas of primary importance are the bearings alignment and the shaft parallelism. Two bearings are normally used on each shaft to assure smooth operation. The housing should be carefully aligned using the method given below. If a single twin-type housing is used, these procedures are not necessary. It is also necessary to assure that the height from the housing mounting surface to the shaft is consistent within .001". Shimming may be necessary depending on the accuracy of the mounting surfaces to which the housings are bolted.

The housing can be mounted to the plate using the following procedure:

a. Prepare the carriage plate with one side having an abutting surface.
b. Mount two housings with the reference edges located against the abutting surface and tighten the hold down bolts. Figure #1
c. Mount the second pair of housings on the opposite side of the carriage and tighten the bolts finger tight.
d. Insert a location shaft of correct diameter and tolerance (h6) through these two housings and reference the distance from the abutting surface in [b] above, to this locating shaft. Figure #2
e. After appropriate alignment of this pair of housings, tighten bolts to secure housings to carriage.

After the carriage is properly prepared, the shafts must be mounted to the surface. To achieve smooth, accurate motion, the shafts must be mounted parallel within .001 inch over the length of the stroke. This can be done by using the following procedure:

a. Mount one shaft (either end-supported or fully supported) to the surface with mounting bolts finger tight.
b. Using an aligning device such as a laser, auto-collimator or other optics, sight the shaft straight and secure to mounting surface.
c. After this first shaft is fixed, the second shaft can be positioned and held down with bolts finger tight.
d. The carriage is then mounted and its movement will pull this second shaft parallel to the first. Figures #3 and #4
e. If the second shaft is then secured into position, the procedure is complete. Note that for fully supported systems, this securing should be done when the carriage is close to the bolts. For end supported systems, the securing should be done when the carriage is at the ends of the shafts. Figure #5
f. An additional check can be done at this time to assure that the carriage is tracking correctly (i.e., that the carriage edge is moving parallel to the shaft). An indicator touching the carriage edge should not vary, as the carriage is moved along the shafts. Figure #6

Figure 1

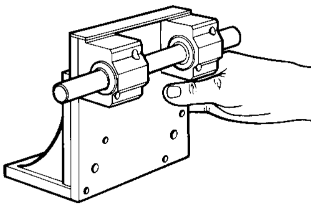


Figure 2

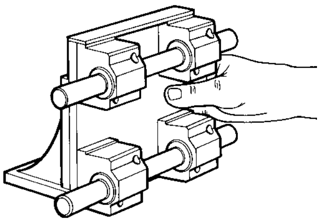


Figure 3

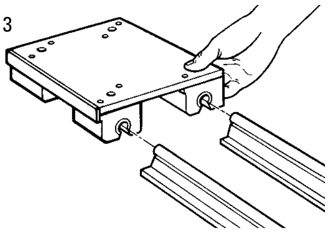


Figure 4

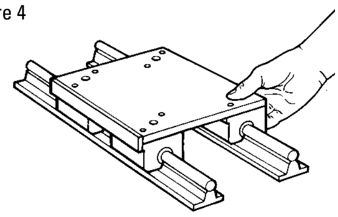


Figure 5

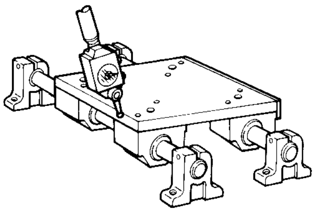
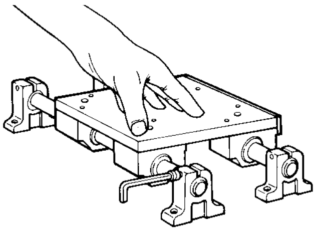


Figure 6



THOMSON
Linear Motion. Optimized.™

# ISO Tolerance Charts

**Tolerance zones for internal (hole) dimensions (H15 through H5)** (Dimensions in mm)

| Basic Size | H15 | H14 | H13 | H12 | H11 | H10 | H9 | H8 | H7 | H6 | H5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Over 6 | +0.580 | +0.360 | +0.220 | +0.150 | +0.090 | +0.058 | +0.036 | +0.022 | +0.015 | +0.009 | +0.006 |
| To 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 10 | +0.700 | +0.430 | +0.270 | +0.180 | +0.110 | +0.070 | +0.043 | +0.027 | +0.018 | +0.011 | +0.008 |
| To 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 14 | +0.700 | +0.430 | +0.270 | +0.180 | +0.110 | +0.070 | +0.043 | +0.027 | +0.018 | +0.011 | +0.008 |
| To 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 18 | +0.840 | +0.520 | +0.330 | +0.210 | +0.130 | +0.084 | +0.052 | +0.033 | +0.021 | +0.013 | +0.009 |
| To 24 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 24 | +0.840 | +0.520 | +0.330 | +0.210 | +0.130 | +0.084 | +0.052 | +0.033 | +0.021 | +0.013 | +0.009 |
| To 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 30 | +1.000 | +0.620 | +0.390 | +0.250 | +0.160 | +0.100 | +0.062 | +0.039 | +0.025 | +0.016 | +0.011 |
| To 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 40 | +1.000 | +0.620 | +0.390 | +0.250 | +0.160 | +0.100 | +0.062 | +0.039 | +0.025 | +0.016 | +0.011 |
| To 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 50 | +1.200 | +0.740 | +0.460 | +0.300 | +0.190 | +0.120 | +0.074 | +0.046 | +0.030 | +0.019 | +0.013 |
| To 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 65 | +1.200 | +0.740 | +0.460 | +0.300 | +0.190 | +0.120 | +0.074 | +0.046 | +0.030 | +0.019 | +0.013 |
| To 80 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 80 | +1.400 | +0.870 | +0.540 | +0.350 | +0.220 | +0.140 | +0.087 | +0.054 | +0.035 | +0.022 | +0.015 |
| To 100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 100 | +1.400 | +0.870 | +0.540 | +0.350 | +0.220 | +0.140 | +0.087 | +0.054 | +0.035 | +0.022 | +0.015 |
| To 120 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 120 | +1.600 | +1.000 | +0.630 | +0.400 | +0.250 | +0.160 | +0.100 | +0.063 | +0.040 | +0.025 | +0.018 |
| To 140 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 140 | +1.600 | +1.000 | +0.630 | +0.400 | +0.250 | +0.160 | +0.100 | +0.063 | +0.040 | +0.025 | +0.018 |
| To 160 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 160 | +1.600 | +1.000 | +0.630 | +0.400 | +0.250 | +0.160 | +0.100 | +0.063 | +0.040 | +0.025 | +0.018 |
| To 180 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Over 180 | +1.850 | +1.150 | +0.720 | +0.460 | +0.290 | +0.185 | +0.115 | +0.072 | +0.046 | +0.029 | +0.020 |
| To 200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Tolerance zones for external LinearRace® shaft dimensions (h15 through h5)** (Dimensions in mm)

| Basic Size | h15 | h14 | h13 | h12 | h11 | h10 | h9 | h8 | h7 | h6 | h5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Over 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 10 | -0.580 | -0.360 | -0.220 | -0.150 | -0.090 | -0.058 | -0.036 | -0.022 | -0.015 | -0.009 | -0.006 |
| Over 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 14 | -0.700 | -0.430 | -0.270 | -0.180 | -0.110 | -0.070 | -0.043 | -0.027 | -0.018 | -0.011 | -0.008 |
| Over 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 18 | -0.700 | -0.430 | -0.270 | -0.180 | -0.110 | -0.070 | -0.043 | -0.027 | -0.018 | -0.011 | -0.008 |
| Over 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 24 | -0.840 | -0.520 | -0.330 | -0.210 | -0.130 | -0.084 | -0.052 | -0.033 | -0.021 | -0.013 | -0.009 |
| Over 24 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 30 | -0.840 | -0.520 | -0.330 | -0.210 | -0.130 | -0.084 | -0.052 | -0.033 | -0.021 | -0.013 | -0.009 |
| Over 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 40 | -1.000 | -0.620 | -0.390 | -0.250 | -0.160 | -0.100 | -0.062 | -0.039 | -0.025 | -0.016 | -0.011 |
| Over 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 50 | -1.000 | -0.620 | -0.390 | -0.250 | -0.160 | -0.100 | -0.062 | -0.039 | -0.025 | -0.016 | -0.011 |
| Over 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 65 | -1.200 | -0.740 | -0.460 | -0.300 | -0.190 | -0.120 | -0.074 | -0.046 | -0.030 | -0.019 | -0.013 |
| Over 65 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 80 | -1.200 | -0.740 | -0.460 | -0.300 | -0.190 | -0.120 | -0.074 | -0.046 | -0.030 | -0.019 | -0.013 |
| Over 80 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 100 | -1.400 | -0.870 | -0.540 | -0.350 | -0.220 | -0.140 | -0.087 | -0.054 | -0.035 | -0.022 | -0.015 |
| Over 100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 120 | -1.400 | -0.870 | -0.540 | -0.350 | -0.220 | -0.140 | -0.087 | -0.054 | -0.035 | -0.022 | -0.015 |
| Over 120 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 140 | -1.600 | -1.000 | -0.630 | -0.400 | -0.250 | -0.160 | -0.100 | -0.063 | -0.040 | -0.025 | -0.018 |
| Over 140 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 160 | -1.600 | -1.000 | -0.630 | -0.400 | -0.250 | -0.160 | -0.100 | -0.063 | -0.040 | -0.025 | -0.018 |
| Over 160 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 180 | -1.600 | -1.000 | -0.630 | -0.400 | -0.250 | -0.160 | -0.100 | -0.063 | -0.040 | -0.025 | -0.018 |
| Over 180 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| To 200 | -1.850 | -1.150 | -0.720 | -0.460 | -0.290 | -0.185 | -0.115 | -0.072 | -0.046 | -0.029 | -0.020 |

| QUANTITY | CONVENTIONAL | | SI Unit | Conversion Factors | |
|---|---|---|---|---|---|
| | Inch Unit | Metric Unit (MKS) | | | |
| LENGTH | Inch<br>in. | Meter<br>m | Metre<br>m | 1 in. | = 25.4 mm |
| | | | | 1 mm | = 0.03937 in. |
| | | | | 1 m | = 3.2808 ft. |
| | | | | 1 ft. | = 0.3048 m |
| AREA | Square Inch<br>$in.^2$ | Square Meter<br>$m^2$ | Square Metre<br>$m^2$ | 1 $in.^2$ | = 6.4516 $cm^2$ |
| | | | | 1 $cm^2$ | = 0.155 $in.^2$ |
| | | | | 1 $m^2$ | = 10.764 $ft^2$ |
| | | | | 1 $ft.^2$ | = 0.092903 $m^2$ |
| MASS | Pound<br>$lb_m$ | Kilogram<br>kg | Kilogram<br>kg | 1 $lb_m$ | = 0.45359237 kg |
| | | | | 1 kg | = 2.2046 lb |
| FORCE | Pound Force<br>$lb_f$ | Kilogram Force<br>$kg_f$ | Newton<br>N | 1 $lb_f$ | = 0.45359237 $kg_f$ |
| | | | | 1 $lb_f$ | = 4.44822 N |
| | | | | 1 $kg_f$ | = 2.2046lbf |
| | | | | 1 $kg_f$ | = 9.80665 N |
| | | | | 1 N | = 0.1019716 $kg_f$ |
| | | | | 1 N | = 0.224809 $lb_f$ |
| STRESS<br>or<br>PRESSURE | Pounds per<br>square inch<br>$lb_f/in.^2$ | Kilograms per<br>square meter<br>$kg_f/m^2$ | Pascal<br>Pa | 1 MPa | = $10^6$ $N/m^2$ = $N/mm^2$ |
| | | | | 1 kPa | = $10^3$ $N/m^2$ |
| | | | | 1 $lb_f/inch^2$ | = 0.070307 $kg_f/cm^2$ |
| | | | | 1 $lb_f/inch^2$ | = 7.0307 x $10^{-4}$ $kg_f/mm^2$ |
| | | | | 1 $lb_f/inch^2$ | = 6.8947 x $10^{-3}$ $N/mm^2$ (MPa) |
| | | | | 1 $kg_f/cm^2$ | = 14.2233 $lb_f/in.^2$ |
| | | | | 1 $kg_f/cm^2$ | = 9.80665 x 10-2 $N/mm^2$(MPa) |
| TORQUE<br>or<br>WORK | Inch Pounds<br>$lb_f$-in. | Kilogram Meters<br>$kg_f$-m | Newton-<br>Metres<br>Nm | 1 lbf-in. | = 1.1521 $kg_f$-cm |
| | | | | 1 $kg_f$-cm | = 0.8679 $lb_f$-in. |
| | | | | 1 $lb_f$-in. | = 0.1129848 Nm |
| | | | | 1 $kg_f$-m | = 9.80665 Nm |
| | | | | 1 $kg_f$-cm | = 9.80665 x $10^{-2}$ Nm |
| | | | | 1 Nm | = 8.85 $lb_f$-in. |
| | | | | 1 Nm | = 10.19716 $kg_f$-cm |
| POWER | Foot pound per<br>minute<br>$lb_f$-ft./min. | Force per<br>second<br>$kg_f$-m/s | Newton Metre per<br>second<br>Nm/s | 1 kW | = 1000Nm/s |
| | | | | 1 kW | = 60,000 Nm/s |
| | | | | 1 kW | = 44,220 $lb_f$-ft./min. |
| | | | | 1 kW | = 1.341 hp |
| | | | | 1 hp | = 75 $kg_f$-m/s |
| | | | | 1 hp | = 44,741 Nm/min. |
| | | | | 1 hp | = 33,000 $lb_f$-ft.min. |
| | | | | 1 hp | = 0.7457 kW |
| VELOCITY | Feet per<br>second<br>ft./s | Meters per<br>second<br>m/s | Meters per<br>second<br>m/s | 1 ft./sec. | = 0.3048 m/s |
| | | | | 1 in./sec. | = 2.54 cm/s |
| | | | | 1 ft./sec. | = 0.00508 m/s |
| | | | | 1 mile/hr. | = 0.44704 m/s |
| | | | | 1 km/hr. | = 0.27777 m/s |
| | | | | 1 mile/hr | = 1.609344 km/hr. |
| ACCELERATION | Feet per second<br>squared<br>$ft./s^2$ | Meters per second<br>squared<br>$m/s^2$ | Metres per second<br>squared<br>$m/s^2$ | 1 $ft./s^2$ | = 0.3048 $m/s^2$ |

## Notes

## Notes

Notes

## Shafting Color Code Chart

| Material | Class | Random Length |
|---|---|---|
| Carbon Steel | S | Painted |
| Carbon Steel | L | 1/2 Black<br>1/2 Red |
| Carbon Steel | N | Gray |
| Carbon Steel | D | 1/2 Gray<br>1/2 Green |
| Carbon Steel | Metric H6 | Orange |
| Carbon Steel | Metric H4 | 1/2 Blue<br>1/2 Orange |
| Carbon Steel | Metric G6 | 1/2 Green<br>1/2 Orange |
| Carbon Steel Chrome | All | 1/2 Blue |
| 440C Stainless Steel | S | No Color |
| 440C Stainless Steel | L | 1/2 Orange |
| 316 Stainless Steel | L | 1/2 Cyan |
| 440C Stainless Steel | Metric | 1/2 Yellow |
| 52100 Tubular | S | No Color |
| 52100 Tubular | L | 1/2 Black<br>1/2 Red |
| Carbon Steel Deep Case | L | 1/2 Beige<br>1/2 Pink |
| Carbon Steel Deep Case | N | 1/2 Gray<br>1/2 Pink |
| Carbon Steel Deep Case | Metric H6 | Pink |

**USA, CANADA and MEXICO**
Thomson
203A West Rock Road
Radford, VA 24141, USA
Phone: 1-540-633-3549
Fax: 1-540-633-0294
E-mail: thomson@thomsonlinear.com
Literature: literature.thomsonlinear.com

**EUROPE**

**United Kingdom**
Thomson
Office 9, The Barns
Caddsdown Business Park
Bideford, Devon, EX39 3BT
Phone: +44 1271 334 500
E-mail: sales.uk@thomsonlinear.com

**Germany**
Thomson
Nürtinger Straße 70
72649 Wolfschlugen
Phone: +49 7022 504 403
Fax: +49 7022 504 405
E-mail: sales.germany@thomsonlinear.com

**France**
Thomson
Phone: +33 243 50 03 30
E-mail: sales.france@thomsonlinear.com

**Italy**
Thomson
Via per Cinisello 95/97
20834 Nova Milanese (MB)
Phone: +39 0362 366406
Fax: +39 0362 276790
E-mail: sales.italy@thomsonlinear.com

**Spain**
Thomson
E-mail: sales.esm@thomsonlinear.com

**Sweden**
Thomson
Estridsväg 10
29109 Kristianstad
Phone: +46 44 590 2400
Fax: +46 44 590 2585
E-mail: sales.scandinavia@thomsonlinear.com

**ASIA**

**Asia Pacific**
Thomson
E-mail: sales.apac@thomsonlinear.com

**China**
Thomson
Rm 805, Scitech Tower
22 Jianguomen Wai Street
Beijing 100004
Phone: +86 400 606 1805
Fax: +86 10 6515 0263
E-mail: sales.china@thomsonlinear.com

**India**
Thomson
c/o Portescap India Pvt. Ltd.
Office no. 103, 4TH floor,
Arena House, Road no.12,
Marol Industrial Area, Andheri East,
Mumbai Suburban, Maharashtra, 400093
E-mail: sales.india@thomsonlinear.com

**South Korea**
Thomson
3033 ASEM Tower (Samsung-dong)
517 Yeongdong-daero
Gangnam-gu, Seoul, South Korea (06164)
Phone: + 82 2 6001 3223 & 3244
E-mail: sales.korea@thomsonlinear.com

**SOUTH AMERICA**

**Brazil**
Thomson
Av. João Paulo Ablas, 2970
Jardim da Glória - Cotia SP - CEP: 06711-250
Phone: +55 11 4615 6300
E-mail: sales.brasil@thomsonlinear.com


www.thomsonlinear.com

RoundRail_LinearGuides_Components_CTEN-0002-06 | 20220215TJ



THOMSON®
Linear Motion. Optimized.™