



Ball Reverser



Ball Reverser

Patented

Ball Reverser Principle

General Information

NORCO'S **Ball Reverser** is a unique actuator which provides automatic reciprocating action. The **Ball Reverser** has a wide range of applications throughout many industries. There are six standard sizes: 1600, 1700, 1800, 1900, 2000, and 2100, each offering two screw materials. The prefix BR designates alloy steel case hardened to 56-60 Rc. The prefix BRC designates stainless steel through hardened to 40-45 Rc.

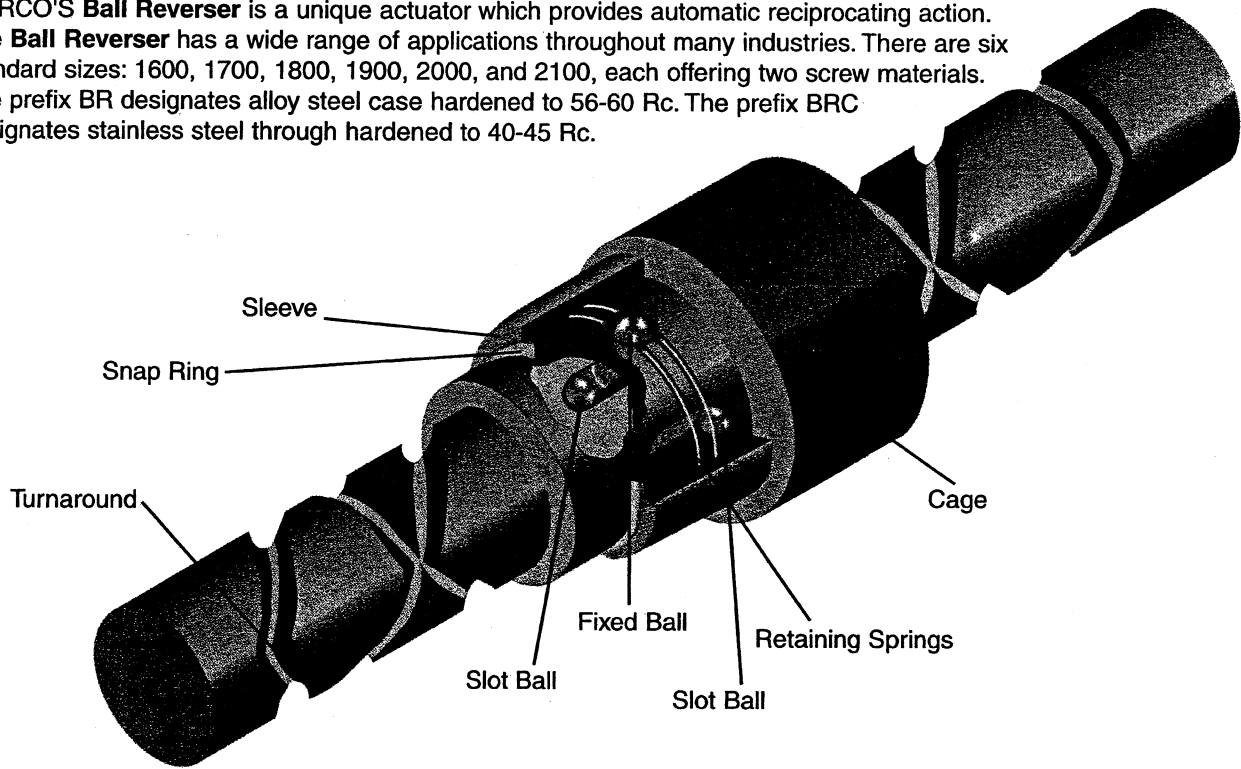
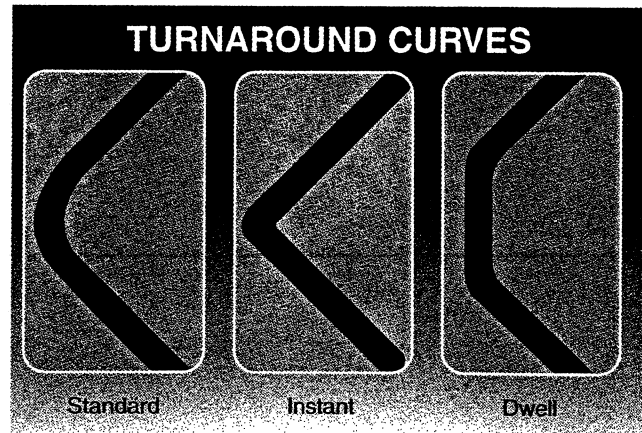
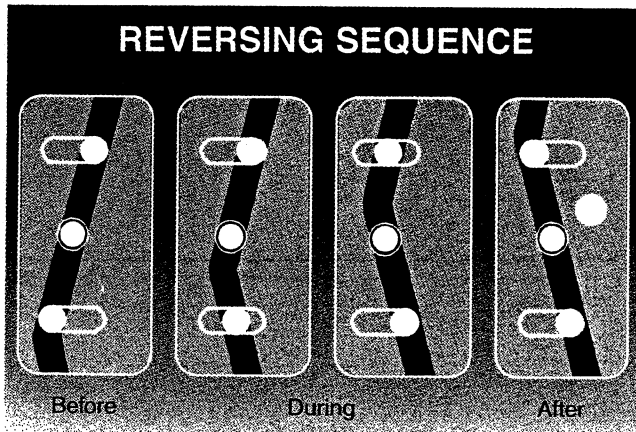


Figure 2

Figure 3



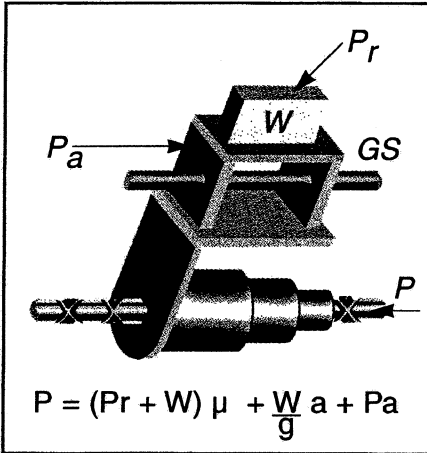
A key element in the **Ball Reverser's** function is the reversing sequence, as shown in Figure 2. The two slot balls move relative to the fixed ball as they follow the turnaround curve. The standard curve is designed for the optimum deceleration and acceleration of the mass for each size **Ball Reverser** according to the formulas shown. It is designated by the suffix "-1" in the part number; i.e., BR 1818 "-1". Figure 3 shows turnaround curves for special applications which require engineering review in order to maintain appropriate design limits.

The load and lie selection process which follows will determine which size BR or BRC is suitable for your application.

Ball Reverser life is rated in L_{10} hours of the nut assembly or screw, whichever is lower. The L_{10} life is defined as the number of hours that 90 percent of the units will exceed without failure. All life calculations are based on a "friendly environment," i.e., proper lubrication and alignment, no shock loading or other abnormal conditions.

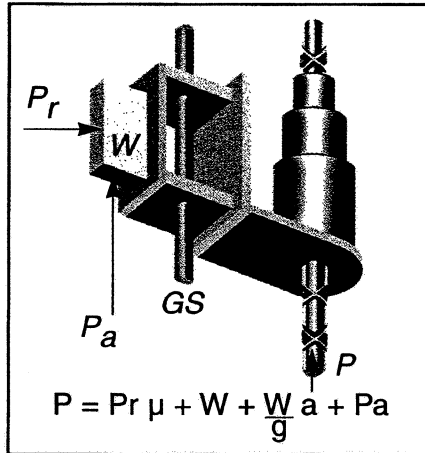
HORIZONTAL

Figure 4



VERTICAL

Figure 5



WINDING

Figure 6

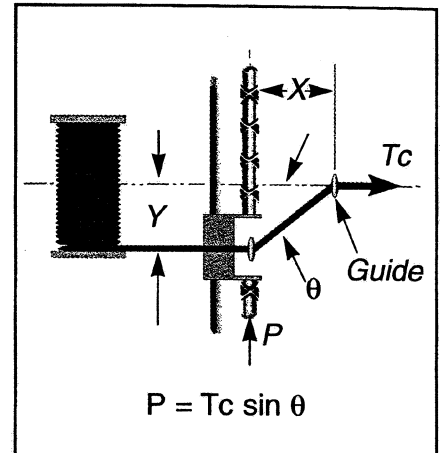


Figure 7

| | Pm | | Cn | | Cs | | LS | K |
|-------------|------|--------|------|--------|------|--------|-----|------|
| | LBS | (N) | LBS | (N) | LBS | (N) | | |
| 1600 | | | | | | | | |
| BRC | 12 | (53) | 47 | (209) | 33 | (147) | 675 | 3.9 |
| BR | 18 | (80) | 75 | (334) | 53 | (236) | 800 | 3.9 |
| 1700 | | | | | | | | |
| BRC | 22 | (98) | 81 | (360) | 56 | (249) | 675 | 5.8 |
| BR | 30 | (134) | 129 | (573) | 89 | (396) | 800 | 5.8 |
| 1800 | | | | | | | | |
| BRC | 39 | (173) | 106 | (473) | 72 | (320) | 540 | 7.6 |
| BR | 98 | (434) | 212 | (943) | 145 | (645) | 800 | 7.6 |
| 1900 | | | | | | | | |
| BRC | 120 | (534) | 283 | (1263) | 197 | (875) | 340 | 10.2 |
| BR | 282 | (1254) | 565 | (2513) | 392 | (1744) | 600 | 10.2 |
| 2000 | | | | | | | | |
| BRC | 240 | (1068) | 509 | (2242) | 356 | (1583) | 240 | 13.9 |
| BR | 593 | (2638) | 1014 | (4510) | 710 | (3158) | 500 | 13.9 |
| 2100 | | | | | | | | |
| BRC | 427 | (1899) | 886 | (3939) | 609 | (2708) | 160 | 18.0 |
| BR | 1100 | (4893) | 1765 | (7851) | 1214 | (5400) | 300 | 18.0 |

Figure 8

$$Pt \text{ (lbs)} = P + \frac{KWR^2}{1 \times 10^6}$$

$$Pt \text{ (N)} = P + \frac{KWR^2}{1 \times 10^5}$$

$$NL = \frac{16666}{R} \left[\frac{Cn}{P} \right]^3$$

$$SL = \frac{16666 S}{R} \left[\frac{Cs}{Pt} \right]^3$$

$$T \text{ (lb-in)} = \frac{Pt \times I}{2.83} \quad T \text{ (n-m)} = \frac{Pt \times I}{2837}$$

- a** = Carrier acceleration (in/sec² or m/sec²)
- CN** = Basic dynamic capacity (nut)
- Cs** = Basic dynamic capacity (screw)
- GS** = Guide System
- g** = Gravity acceleration (386 in/sec² or 9.801m/sec²)
- I** = Lead (inch or mm)
- K** = Inertia constant
- LS** = Limiting speed for standard selection
- NL** = Nut life hours
- θ** = Fleet angle = ARCTAN (y/x)
- P** = Applied Axial Load (lbs. or N)
- Pa** = Carrier axial load (lbs. or N)

- Pm** = Maximum Allowable Axial Load
- Pr** = Side loads (lbs or N)
- Pt** = Maximum inertial load at turnaround
- R** = Screw rpm
- S** = Stroke (page 6)
- SL** = Screw life hours
- T** = Input torque
- Tc** = Cable tension (lbs or N)
- μ** = Guide System (GS) Coefficient of friction
- W** = Carrier weight (lbs or Kg)
- X** = Distance between Ball Reverser center line and cable guide
- Y** = One-Half (1/2) the cable drum width

Selection Process

Ball Reverser selection has three steps, determination of (1) Load (2) Speed and (3) Life.

The axial load (P) on a **Ball Reverser** is the applied force parallel to the screw. All side loads (Pr) should be taken by the Guide System. Each has its own coefficient of friction (μ).

In all applications, the maximum inertia load (Pt) at the turnaround must not exceed the maximum allowable load (Pm), Figure 7.

Step 1 Determine Load

- (A) Calculate P using the formula in either Figure 4, 5, or 6.
- (B) Calculate Pt, Figure 8 and compare to Pm Figure 7.
- (C) Using the higher value of P or Pt, select the BR with a higher Pm from Figure 7.
- (D) Select Stroke, page 6.

Step 2 Determine Speed

- (A) Calculate RPM from linear speed and lead.
- (B) Compare the calculated RPM to the Limiting Speed (LS) and select the appropriate BR size in Figure 7.

Step 3 Determine Life

- (A) Calculate nut assembly and screw in L_{10} life.
- (B) Compare lower number vs. application requirements.

Example:

Given: Horizontal Application (Figure 4)
 Stroke = 8.9 inches $P_a = 30$ lbs. $P_r = 0$ $W = 20$ lbs.
 GS = Ball Bushings ($\mu = .004$)
 Travel Rate = 600 inches/min $a = .1g$.
 Life Required = 4 hours/day, 5 days/week, 100 weeks.

Step 1

- (A) $P = (0 + 20) 0.004 + \frac{(20 \times 0.1 \times 386)}{386} + 30 = 32.08$ lbs.
- (B) $P_t = 32.08 + \frac{7.6 \times 20 (600)^2}{1 \times 10^6} = 86.8$ lbs.
- (C) $P_t = 86.8$ lbs. < Pm 98 of the BR1800, therefore the BR 1800 is acceptable.
- (D) For stroke of 8.88 inches, select BR1818-1, i.e. index "18".

Step 2

- (A) 600 inches/min. \div x 1.00 inch Lead = 600 RPM
- (B) The BR 1800 Limiting Speed is 800 RPM, therefore the BR1800 is acceptable in this application.

Step 3

$$(A) NL = \frac{16666}{600} \left[\frac{212}{32.08} \right]^3 = 8016 \text{ hours}$$

$$SL = \frac{16666}{600} \times 18 \left[\frac{145}{86.8} \right]^3 = 2330 \text{ hours}$$

- (B) Therefore the life expectancy is 2,330 hours, which is the lower of the two values and is above the 2,000 hours required.

Summary:

BR1800 meets Load, Speed and Life minimum. Stroke index "18" is acceptable, 8.88 vs. 8.90 inches, therefore the most suitable part number is **BR1818-1** (MBR 1818-1 for metric mounting holes).

Other Considerations:

For certain applications, it is helpful to know the torque required to drive the Load. In the above example the torque required would be:

$$T = \frac{86.8 \times 1}{2.83} = 30.67 \text{ lb-in.}$$

Winding:

These applications have the maximum axial load for the **Ball Reverser** occurring at the ends of the cable drum. This is calculated as a function of the fleet angle (θ) and cable tension (Tc) shown in Figure 6.

Example:

Given:

- Drum Width: = 66 inches
- Cable Tension: = 10,000 pounds
- Cable Diameter: = .5 inch

$X = 377$ inches (Distance between **Ball Reverser** center line and cable guide)
 $Y = 33$ inches (1/2 the cable drum width)

Calculate:

$$\text{Fleet Angle } (\theta) = \text{ARCTAN } \frac{y}{x} = \frac{33}{377} = .0875 = 5^\circ$$

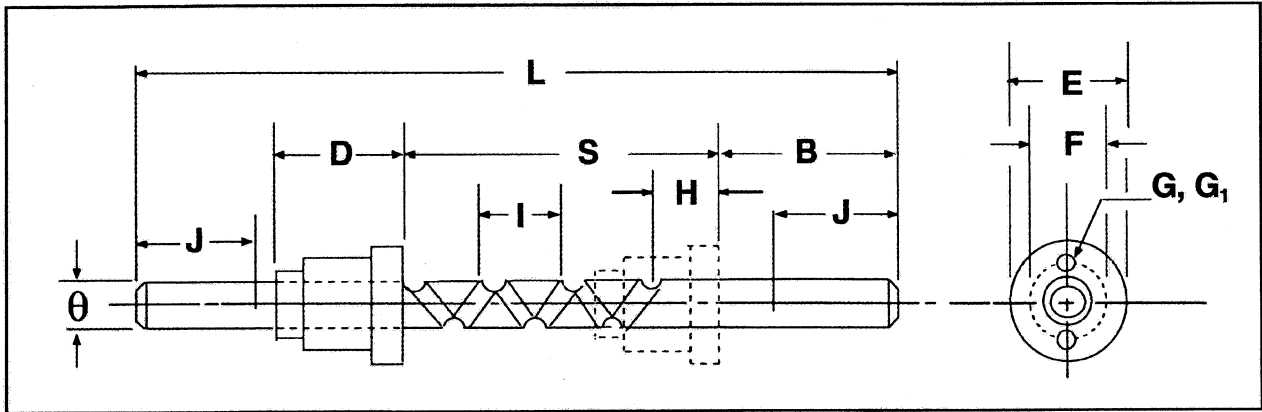
$$P = T_c (\text{SIN } \theta) P = 10,000 (0.0872) P = 872 \text{ lbs.}$$

When P has been calculated follow the normal steps for selecting the appropriate size of **Ball Reverser**. Figure 7 indicates that a BR2100 series is required because of its rated capacity of 1,100 lbs. To determine the proper stroke, subtract the cable diameter from the drum width. If this stroke cannot be found, consult our Engineering department. In this example, the appropriate "index" is "44" with a stroke of 65.5 inches, (66 inches minus .5 = 65.5 inches). The correct part number is **BR2144-1**.

ASK ABOUT OUR OTHER LINEAR MOTION PRODUCTS.

- ◆ Diamond Reverser
- ◆ Rollnuts
- ◆ Rollnut Oscillators

Basic Specifications



| SERIES | 1600 | | 1700 | | 1800 | | 1900 | | 2000 | | 2100 | |
|----------------|------|--------|-------|--------|--------|--------|-------|--------|-------|--------|-------|--------|
| | in. | mm | in. | mm | in. | mm | in. | mm | in. | mm | in. | mm |
| θ | .37 | 9.53 | .50 | 12.70 | .75 | 19.05 | 1.25 | 31.75 | 1.75 | 44.45 | 2.50 | 63.50 |
| I | .50 | 12.70 | .75 | 19.05 | 1.00 | 25.40 | 1.25 | 31.75 | 2.00 | 50.80 | 3.00 | 76.20 |
| B | 1.55 | 39.35 | 2.06 | 52.45 | 4.28 | 108.71 | 6.20 | 157.61 | 8.05 | 204.47 | 8.20 | 208.41 |
| J | 1.50 | 38.10 | 2.00 | 50.80 | 4.06 | 103.13 | 6.00 | 152.40 | 7.00 | 177.80 | 8.00 | 203.20 |
| D | 1.10 | 28.00 | 1.46 | 37.00 | 1.97 | 50.00 | 2.95 | 75.00 | 3.94 | 100.00 | 5.31 | 135.00 |
| E | .98 | 25.00 | 1.22 | 31.00 | 1.61 | 41.00 | 2.37 | 60.20 | 3.25 | 82.55 | 4.47 | 113.50 |
| H | .64 | 16.25 | .87 | 22.10 | 1.22 | 30.98 | 1.86 | 47.24 | 2.45 | 62.23 | 3.23 | 82.94 |
| F | .78 | 19.80 | .94 | 23.88 | 1.31 | 33.27 | 1.94 | 49.28 | 2.69 | 68.33 | 3.75 | 95.25 |
| Z | 4.38 | 111.30 | 5.87 | 149.10 | 10.56 | 268.20 | 16.13 | 409.70 | 21.00 | 533.40 | 22.87 | 580.90 |
| G | 6-32 | | 10-32 | | 1/4-20 | | | | | | | |
| G ₁ | | M 3 | | M 4 | | M 6 | | M 8 | | M 12 | | M 12 |

| DESCRIPTION | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 |
|---|-------------------------|-------------------------|-------------------------|---------------------------|---------------------------|---------------------------|
| ASSEMBLY with alloy screw with stainless screw | BR 16XX-1 BRC 16XX-1 | BR 17XX-1 BRC 17XX-1 | BR 18XX-1 BRC 18XX-1 | MBR 19XX-1 MBRC 19XX-1 | MBR 20XX-1 MBRC 20XX-1 | MBR 21XX-1 MBRC 21XX-1 |
| CAGE inch mm | CA16 MCA16 | CA17 MCA17 | CA18 MCA18 | CA19 MCA19 | CA20 MCA20 | CA21 MCA21 |
| SLEEVE | SL16 | SL17 | SL18 | SL19 | SL20 | SL21 |
| PARTS KIT | KT16 | KT17 | KT18 | KT19 | KT20 | KT21 |

Ball Reversers last longer with proper maintenance. Lubrication and appropriate use of component parts will increase its functional life. Norco recommends a light film of FNI-L4 lubricant (available from Norco) be applied to increase the life of the product. The replacement of the

Parts Kit (3 balls and 2 retaining springs) and Sleeve at appropriate intervals protect and extend the functional life of the Screw and Nut assembly. The Cage and Sleeve are a through hardened (Rc 55-60) bearing material. They are plated for a corrosion resistant finish.

S = Stroke (see page 6) **Z** = Total length factor **L** = Total length (S + Z)
H = Nut over travel **J** = Annealed length for alloy screw **XX** = Stroke "Index" (See page 6)

Note: The performance values do not constitute a warranty either in fact or implied. Specifications in this catalog are only a reference. NORCO reserves the right to change without prior notice.

Strokes in Inches

Sizes

| INDEXES | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | INDEXES | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 |
|---------|-------|-------|-------|-------|-------|-------|---------|-------|-------|-------|-------|-------|--------|
| 02 | 0.44 | 0.65 | 0.88 | 1.12 | 1.75 | 2.50 | 51 | 12.69 | 19.03 | 25.38 | 31.75 | 50.75 | 76.00 |
| 03 | 0.69 | 1.03 | 1.38 | 1.75 | 2.75 | 4.00 | 52 | 12.94 | 19.40 | 25.88 | 32.37 | 51.75 | 77.50 |
| 04 | 0.94 | 1.40 | 1.88 | 2.37 | 3.75 | 5.50 | 53 | 13.19 | 19.78 | 26.38 | 33.00 | 52.75 | 79.00 |
| 05 | 1.19 | 1.78 | 2.38 | 3.00 | 4.75 | 7.00 | 54 | 13.44 | 20.15 | 26.88 | 33.62 | 53.75 | 80.50 |
| 06 | 1.44 | 2.15 | 2.88 | 3.62 | 5.75 | 8.50 | 55 | 13.69 | 20.53 | 27.38 | 34.25 | 54.75 | 82.00 |
| 07 | 1.69 | 2.53 | 3.38 | 4.25 | 6.75 | 10.00 | 56 | 13.94 | 20.90 | 27.88 | 34.87 | 55.75 | 83.50 |
| 08 | 1.94 | 2.90 | 3.88 | 4.87 | 7.75 | 11.50 | 57 | 14.19 | 21.28 | 28.38 | 35.50 | 56.75 | 85.00 |
| 09 | 2.19 | 3.28 | 4.38 | 5.50 | 8.75 | 13.00 | 58 | 14.44 | 21.65 | 28.88 | 36.12 | 57.75 | 86.50 |
| 10 | 2.44 | 3.65 | 4.88 | 6.12 | 9.75 | 14.50 | 59 | 14.69 | 22.03 | 29.38 | 36.75 | 58.75 | 88.00 |
| 11 | 2.69 | 4.03 | 5.38 | 6.75 | 10.75 | 16.00 | 60 | 14.94 | 22.40 | 29.88 | 37.37 | 59.75 | 89.50 |
| 12 | 2.94 | 4.40 | 5.88 | 7.37 | 11.75 | 17.50 | 61 | 15.19 | 22.78 | 30.38 | 38.00 | 60.75 | 91.00 |
| 13 | 3.19 | 4.78 | 6.38 | 8.00 | 12.75 | 19.00 | 62 | 15.44 | 23.15 | 30.88 | 38.62 | 61.75 | 92.50 |
| 14 | 3.44 | 5.15 | 6.88 | 8.62 | 13.75 | 20.50 | 63 | 15.69 | 23.53 | 31.38 | 39.25 | 62.75 | 94.00 |
| 15 | 3.69 | 5.53 | 7.38 | 9.25 | 14.75 | 22.00 | 64 | 15.94 | 23.90 | 31.88 | 39.87 | 63.75 | 95.50 |
| 16 | 3.94 | 5.90 | 7.88 | 9.87 | 15.75 | 23.50 | 65 | 16.19 | 24.28 | 32.38 | 40.50 | 64.75 | 97.00 |
| 17 | 4.19 | 6.28 | 8.38 | 10.50 | 16.75 | 25.00 | 66 | 16.44 | 24.65 | 32.88 | 41.12 | 65.75 | 98.50 |
| 18 | 4.44 | 6.65 | 8.88 | 11.12 | 17.75 | 26.50 | 67 | 16.69 | 25.03 | 33.38 | 41.75 | 66.75 | 100.00 |
| 19 | 4.69 | 7.03 | 9.38 | 11.75 | 18.75 | 28.00 | 68 | 16.94 | 25.40 | 33.88 | 42.37 | 67.75 | 101.50 |
| 20 | 4.94 | 7.40 | 9.88 | 12.37 | 19.75 | 29.50 | 69 | 17.19 | 25.78 | 34.38 | 43.00 | 68.75 | 103.00 |
| 21 | 5.19 | 7.78 | 10.38 | 13.00 | 20.75 | 31.00 | 70 | 17.44 | 26.15 | 34.88 | 43.62 | 69.75 | 104.50 |
| 22 | 5.44 | 8.15 | 10.88 | 13.62 | 21.75 | 32.50 | 71 | 17.69 | 26.53 | 35.38 | 44.25 | 70.75 | 106.00 |
| 23 | 5.69 | 8.53 | 11.38 | 14.25 | 22.75 | 34.00 | 72 | 17.94 | 26.90 | 35.88 | 44.87 | 71.75 | 107.50 |
| 24 | 5.94 | 8.90 | 11.88 | 14.87 | 23.75 | 35.50 | 73 | 18.19 | 27.28 | 36.38 | 45.50 | 72.75 | 109.00 |
| 25 | 6.19 | 9.28 | 12.38 | 15.50 | 24.75 | 37.00 | 74 | 18.44 | 27.65 | 36.88 | 46.12 | 73.75 | 110.50 |
| 26 | 6.44 | 9.65 | 12.88 | 16.12 | 25.75 | 38.50 | 75 | 18.69 | 28.03 | 37.38 | 46.75 | 74.75 | 112.00 |
| 27 | 6.69 | 10.03 | 13.38 | 16.75 | 26.75 | 40.00 | 76 | 18.94 | 28.40 | 37.88 | 47.37 | 75.75 | 113.50 |
| 28 | 6.94 | 10.40 | 13.88 | 17.37 | 27.75 | 41.50 | 77 | 19.19 | 28.78 | 38.38 | 48.00 | 76.75 | 115.00 |
| 29 | 7.19 | 10.78 | 14.38 | 18.00 | 28.75 | 43.00 | 78 | 19.44 | 29.15 | 38.88 | 48.62 | 77.75 | 116.50 |
| 30 | 7.44 | 11.15 | 14.88 | 18.62 | 29.75 | 44.50 | 79 | 19.69 | 29.53 | 39.38 | 49.25 | 78.75 | 118.00 |
| 31 | 7.69 | 11.53 | 15.38 | 19.25 | 30.75 | 46.00 | 80 | 19.94 | 29.90 | 39.88 | 49.87 | 79.75 | 119.50 |
| 32 | 7.94 | 11.90 | 15.88 | 19.87 | 31.75 | 47.50 | 81 | 20.19 | 30.28 | 40.38 | 50.50 | 80.75 | 121.00 |
| 33 | 8.19 | 12.28 | 16.38 | 20.50 | 32.75 | 49.00 | 82 | 20.44 | 30.65 | 40.88 | 51.12 | 81.75 | 122.50 |
| 34 | 8.44 | 12.65 | 16.88 | 21.12 | 33.75 | 50.50 | 83 | 20.69 | 31.03 | 41.38 | 51.75 | 82.75 | 124.00 |
| 35 | 8.69 | 13.03 | 17.38 | 21.75 | 34.75 | 52.00 | 84 | 20.94 | 31.40 | 41.88 | 52.37 | 83.75 | 125.50 |
| 36 | 8.94 | 13.40 | 17.88 | 22.37 | 35.75 | 53.50 | 85 | 21.19 | 31.78 | 42.38 | 53.00 | 84.75 | 127.00 |
| 37 | 9.19 | 13.78 | 18.38 | 23.00 | 36.75 | 55.00 | 86 | 21.44 | 32.15 | 42.88 | 53.62 | 85.75 | 128.50 |
| 38 | 9.44 | 14.15 | 18.88 | 23.62 | 37.75 | 56.50 | 87 | 21.69 | 32.53 | 43.38 | 54.25 | 86.75 | 130.00 |
| 39 | 9.69 | 14.53 | 19.38 | 24.25 | 38.75 | 58.00 | 88 | 21.94 | 32.90 | 43.88 | 54.87 | 87.75 | 131.50 |
| 40 | 9.94 | 14.90 | 19.88 | 24.87 | 39.75 | 59.50 | 89 | 22.19 | 33.28 | 44.38 | 55.50 | 88.75 | 133.00 |
| 41 | 10.19 | 15.28 | 20.38 | 25.50 | 40.75 | 61.00 | 90 | 22.44 | 33.65 | 44.88 | 56.12 | 89.75 | 134.50 |
| 42 | 10.44 | 15.65 | 20.88 | 26.12 | 41.75 | 62.50 | 91 | 22.69 | 34.03 | 45.38 | 56.75 | 90.75 | 136.00 |
| 43 | 10.69 | 16.03 | 21.38 | 26.75 | 42.75 | 64.00 | 92 | 22.94 | 34.40 | 45.88 | 57.37 | 91.75 | 137.50 |
| 44 | 10.94 | 16.40 | 21.88 | 27.37 | 43.75 | 65.50 | 93 | 23.19 | 34.78 | 46.38 | 58.00 | 92.75 | 139.00 |
| 45 | 11.19 | 16.78 | 22.38 | 28.00 | 44.75 | 67.00 | 94 | 23.44 | 35.15 | 46.88 | 58.62 | 93.75 | 140.50 |
| 46 | 11.44 | 17.15 | 22.88 | 28.62 | 45.75 | 68.50 | 95 | 23.69 | 35.53 | 47.38 | 59.25 | 94.75 | 142.00 |
| 47 | 11.69 | 17.53 | 23.38 | 29.25 | 46.75 | 70.00 | 96 | 23.94 | 35.90 | 47.88 | 59.87 | 95.75 | 143.50 |
| 48 | 11.94 | 17.90 | 23.88 | 29.87 | 47.75 | 71.50 | 97 | 24.19 | 36.28 | 48.38 | 60.50 | 96.75 | 145.00 |
| 49 | 12.19 | 18.28 | 24.38 | 30.50 | 48.75 | 73.00 | 98 | 24.44 | 36.65 | 48.88 | 61.12 | 97.75 | 146.50 |
| 50 | 12.44 | 18.65 | 24.88 | 31.12 | 49.75 | 74.50 | 99 | 24.69 | 37.03 | 49.38 | 61.75 | 98.75 | 148.00 |

Length is designated by the index number as the last two digits in the part number description, i.e. BR 1818 is an alloy screw, size 1800, with a stroke of 8.88 inches.



Post Office Box 8233 • Waco, Texas 76714-8233
 8301 Imperial Drive • Waco, Texas 76712-6588
 Phone (254) 776-0650 • Fax (254) 776-6558