

Ball Reverser®

NORCO

INC.

FLENNOR™ Power Transmission Products



Ball Reverser® Actuator

Patented

NORCO'S **Ball Reverser® Actuator** 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.

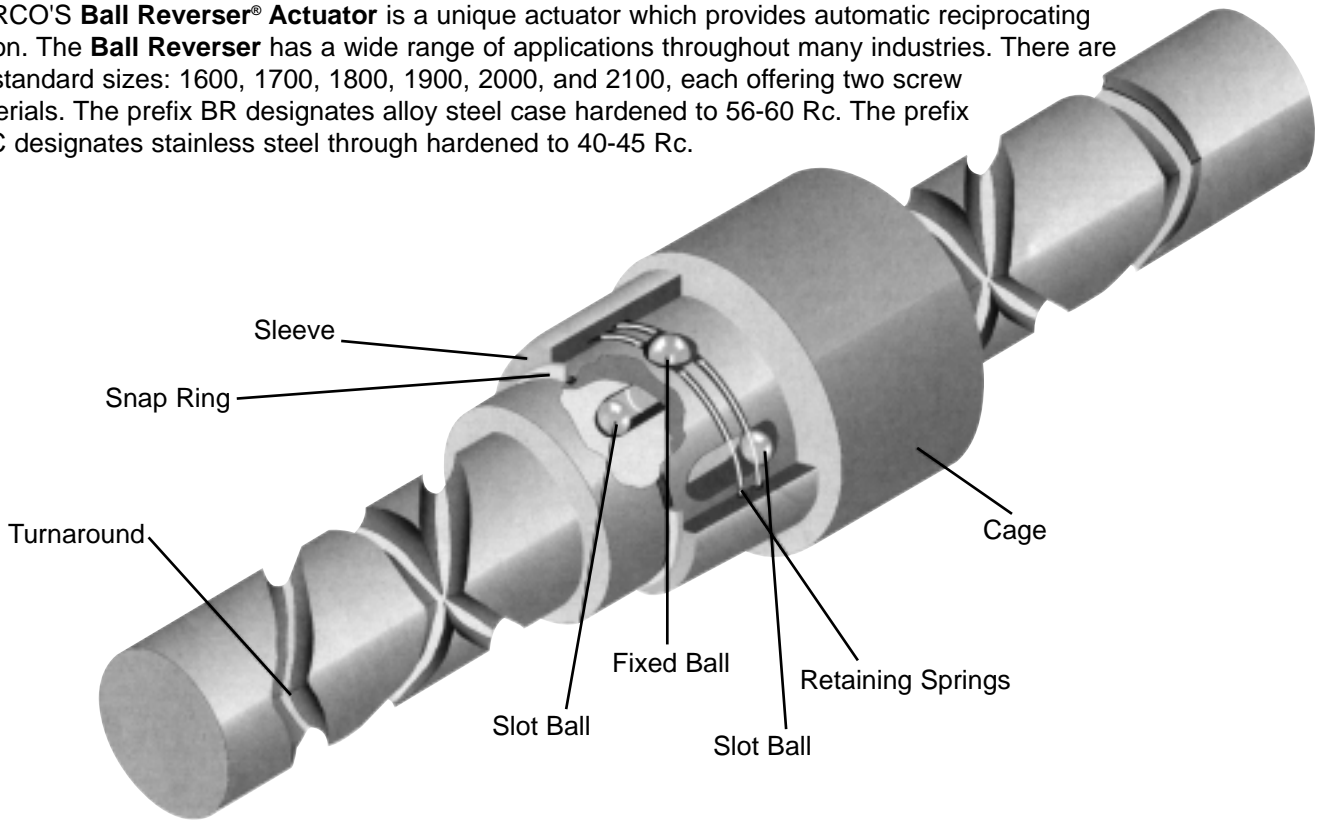


Figure 2

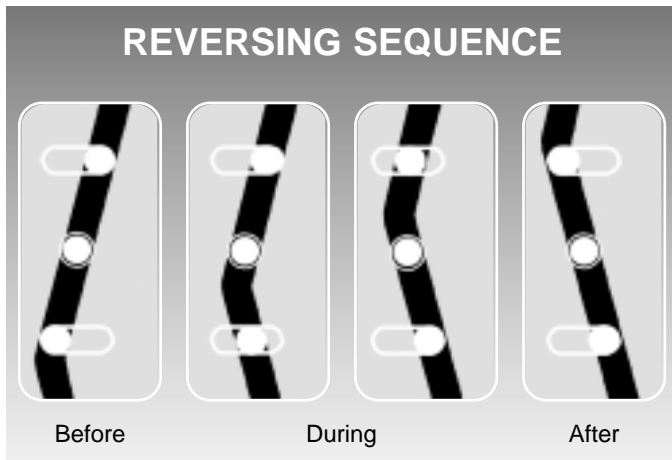
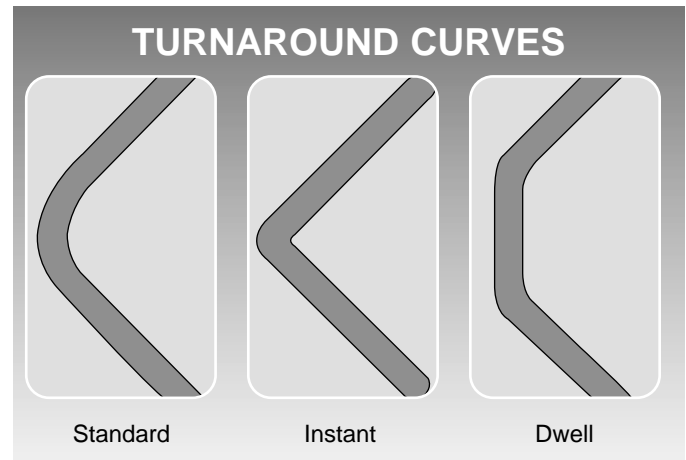


Figure 3



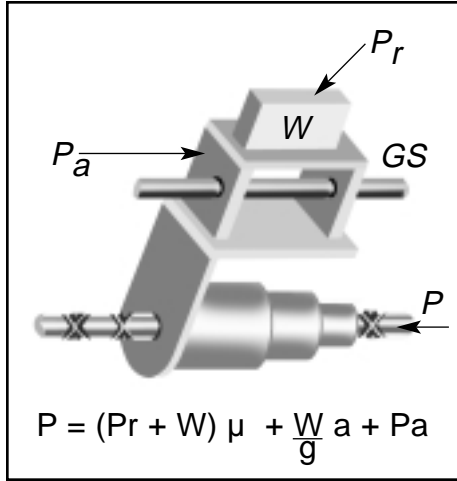
A key element in the **Ball Reverser's** function is the reversing sequence, as shown in Figure 2. The two slot balls move relative to the fixed ball as they follow the turn-around curve. The standard curve is designed for the optimum deceleration and acceleration of the mass for each size **Ball Reverser** 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.

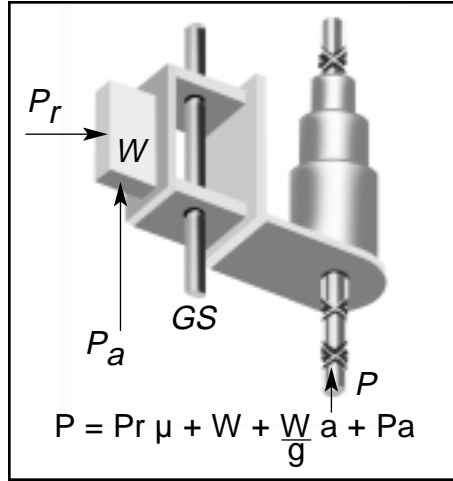
HORIZONTAL

Figure 4



VERTICAL

Figure 5



WINDING

Figure 6

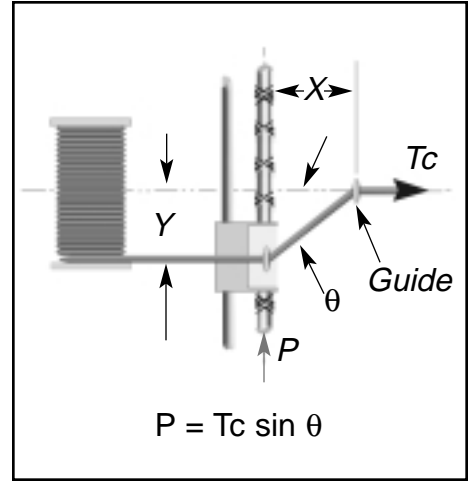


Figure 7

	Pm		Cn		Cs		LS	K
	LBS	(N)	LBS	(N)	LBS	(N)	RPM	
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 Pa = 30 lbs. Pr = 0 W = 20lbs.
 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

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

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

- (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:

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

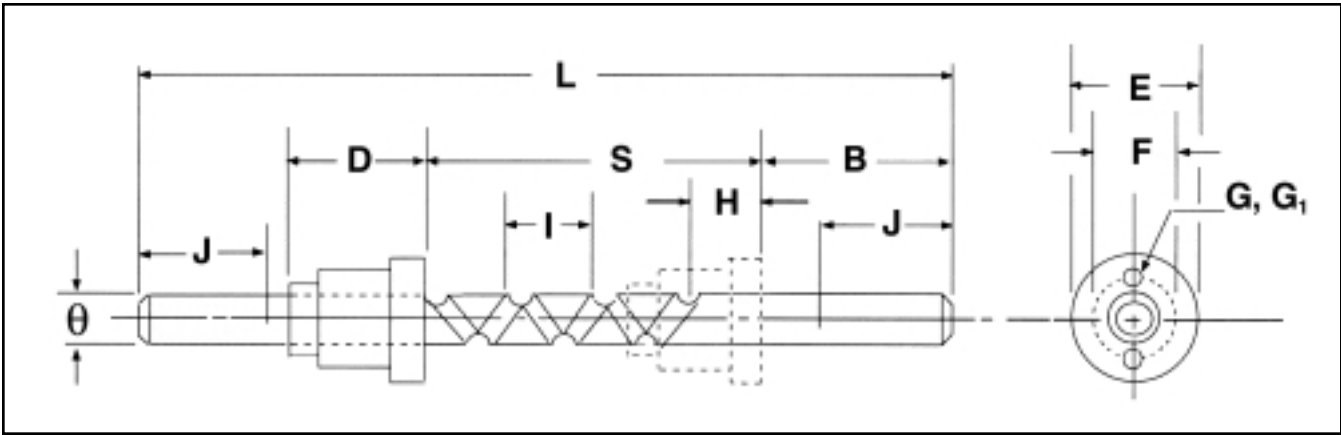
$$P = T_c (\text{SIN } \theta) P = 10,000 (0.0872) P = 872 \text{ lbs.}$$

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**.

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- ◆ Rollnut™ Oscillators
- ◆ Rollnuts™
- ◆ Timing Belt Drives

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		M 8		M 12		M 12	
G ₁		M 3		M 4		M 6						

DESCRIPTION	1600	1700	1800	1900	2000	2100
ASSEMBLY						
with alloy screw	BR 16XX-1	BR 17XX-1	BR 18XX-1	MBR 19XX-1	MBR 20XX-1	MBR 21XX-1
with stainless screw	BRC 16XX-1	BRC 17XX-1	BRC 18XX-1	MBRC 19XX-1	MBRC 20XX-1	MBRC 21XX-1
CAGE						
inch	CA16	CA17	CA18	MCA19	MCA20	MCA21
mm	MCA16	MCA17	MCA18			
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.

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.

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