

Speed Reducer Backlash

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Backlash is the amount of clearance between the meshing teeth of two mating gears (Figure 1). An individual gear does not have backlash. In any gear set some amount of clearance is necessary for the gear set to perform properly.

Backlash provides clearance for lubricant to enter the gear mesh. It also compensates for tolerance variations including gear geometry (tooth thickness, run out, lead angle, tooth profile), assembled center distance, bearing run out, and thermal expansion. Insufficient backlash may cause noise, overloading, overheating of gears and bearings, possible seizing, and failure.

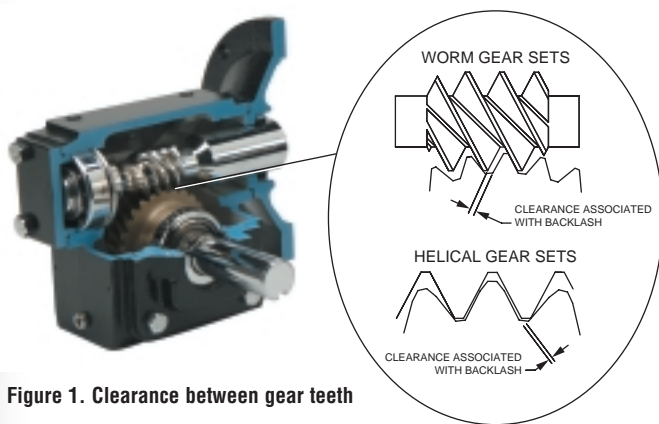


Figure 1. Clearance between gear teeth

Backlash in a worm gear set can change during the operating life of the gear reducer. Any wear that occurs will increase the space between the mating components, resulting in an increase in backlash. The majority of wear occurs during run-in when the gear develops an operating surface consistent with the driven load (Figure 2).

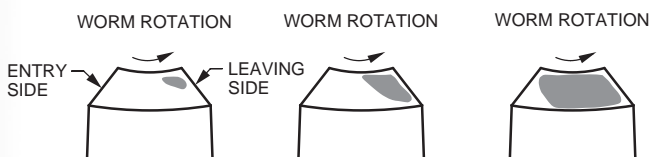


Figure 2. Bronze Gear Run-In

When is backlash an application consideration?

When worm gear reducers operate continuously in a single direction and in the absence of load reversals, backlash is generally not an application consideration. In this case, the standard reducer backlash is suitable.

For applications involving frequent starting and stopping, reverse rotation while positioning, or that have load reversals (when the torque changes direction causing separation and re-engagement of the tooth flanks), a worm reducer with reduced backlash is recommended (See Winsmith S-Minimizer products that are shipped with a maximum of 11 arc minutes). For precise positioning applications requiring near zero backlash, an adjustable precision-manufactured reducer is recommended (See Winsmith S-Eliminator products that are shipped with a maximum of 2 arc minutes).

Backlash Measurement

Backlash is typically measured by restricting the rotation of one of the gears in a set and measuring the rotational (arc) movement of the mating gear.

When measuring the backlash in worm gear reducers, the arc movement of the output shaft and attached gear is measured while restricting the rotation of the worm shaft. It is not correct to measure the worm arc movement while restricting the gear rotation because

Measuring Backlash

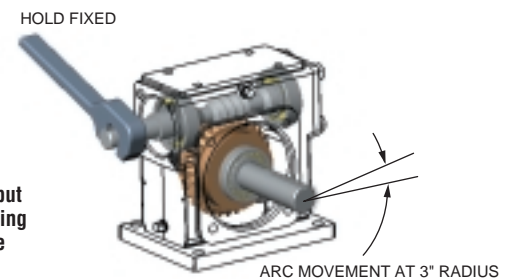


Figure 3. Fixed input shaft while observing the backlash at the output shaft

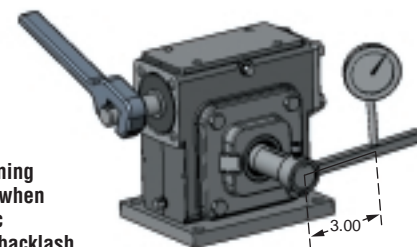


Figure 4. Positioning of the equipment when measuring the arc movement of the backlash

the measured result will be much greater and is not an indication of true tooth clearance. Axial clearance in the worm bearing(s) will add to the arc movement of the gear and appears as backlash. Typically, axial clearance is minimal and of little consequence for most applications. However, when low backlash is an application consideration, bearing endplay must be considered and reduced if necessary.

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Backlash specifications are generally provided in one of two terms: inches of movement at a defined radius or arc movement (degrees, minutes, seconds). The difference between these two terms is the unit of measure. While both of these terms accurately describe backlash measurement, the choice of term is usually associated with a specific purpose.

Backlash in inches of movement at a defined radius is generally associated with the actual backlash measurement. It refers to the arc movement about the center of the subject shaft at some reference radius. There is a quasi-industry standard of three inches for the reference radius. Because the arc movement will vary with the reference radius it is more convenient to convert this measurement to degrees because it is independent of the reference radius. When the level of precision is high, the backlash is often stated in arc minutes. Formulas for converting backlash measurements are:

1. Backlash in degrees as measured from some reference radius:

$$\text{Backlash in degrees} = \frac{\text{Backlash in inches} \times 57.296}{\text{Reference Radius (inches)}}$$

2. Backlash in inches at a defined reference radius:

$$\text{Backlash in inches} = \frac{\text{Backlash in degrees} \times \text{Radius (inches)}}{57.296}$$

3. Backlash in arc minutes:

$$\text{Backlash in arc minutes} = \text{Backlash in degrees} \times 60$$

The integer value is the measurement of arc minutes. Arc seconds are obtained by multiplying the decimal remainder by 60.

EXAMPLE:

$$\begin{aligned} .18 \text{ degrees} \times 60 &= 10.8 \text{ arc minutes} \\ .8 \text{ remainder} \times 60 &= 48 \text{ arc seconds} \end{aligned}$$

Therefore, 18 degrees = 10 arc minutes and 48 arc seconds

BACKLASH LEVEL FOR WINSMITH® PRODUCTS

IN ARC MINUTES	IN DEGREES*	IN INCHES@ REFERENCE RADIUS			BACKLASH LEVEL FOR WINSMITH PRODUCTS
		3"	12"	48"	
1	.017°	.0006"	.0035"	.0140"	S-ELIMINATOR™
2	.033°	.0017"	.0070"	.0279"	
3	.050°	.0026"	.0105"	.0419"	
4	.067°	.0035"	.0140"	.0558"	C-ELIMINATOR
5	.083°	.0044"	.0176"	.0704"	
6	.100°	.0052"	.0209"	.0837"	
7	.117°	.0061"	.0244"	.0977"	C-MINIMIZER
8	.133°	.0070"	.0279"	.1117"	
9	.150°	.0079"	.0314"	.1256"	
10	.167°	.0087"	.0349"	.1396"	S-MINIMIZER
11	.183°	.0096"	.0384"	.1535"	
12	.200°	.0105"	.0419"	.1675"	
13	.217°	.0113"	.0454"	.1814"	SE Encore
14	.233°	.0122"	.0488"	.1954"	
15	.250°	.0131"	.0523"	.2094"	
16	.267°	.0140"	.0558"	.2233"	
17	.283°	.0148"	.0593"	.2373"	
18	.300°	.0157"	.0628"	.2512"	
19	.317°	.0166"	.0663"	.2652"	
20	.333°	.0174"	.0698"	.2791"	
21	.350°	.0183"	.0733"	.2931"	
22	.367°	.0192"	.0768"	.3070"	
23	.383°	.0200"	.0803"	.3210"	
24	.400°	.0209"	.0837"	.3350"	
25	.417°	.0218"	.0872"	.3489"	
26	.433°	.0227"	.0907"	.3629"	
27	.450°	.0236"	.0942"	.3768"	
28	.467°	.0244"	.0977"	.3908"	
29	.483°	.0253"	.1012"	.4047"	
30	.500°	.0262"	.1047"	.4187"	

*To convert to radians, divide degrees by 57.3°.



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