

# Engineering Information

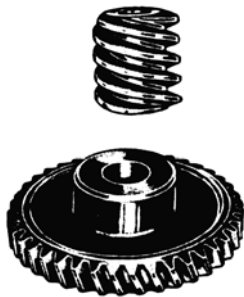
## Worms and Worm Gears

Boston standard stock Worms and Worm Gears are used for the transmission of motion and/or power between non-intersecting shafts at right angles (90°). Worm Gear drives are considered the smoothest and quietest form of gearing when properly applied and maintained. They should be considered for the following requirements:

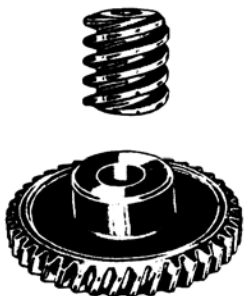
- HIGH RATIO SPEED REDUCTION
- LIMITED SPACE
- RIGHT ANGLE (NON-INTERSECTING) SHAFTS
- GOOD RESISTANCE TO BACK DRIVING

General nomenclature having been applied to Spur and Helical gear types, may also be applied to Worm Gearing with the addition of Worm Lead and Lead Angle, Number of Threads (starts) and Worm Gear Throat diameter.

### HOW TO TELL A LEFT-HAND OR RIGHT-HAND WORM OR WORM GEAR



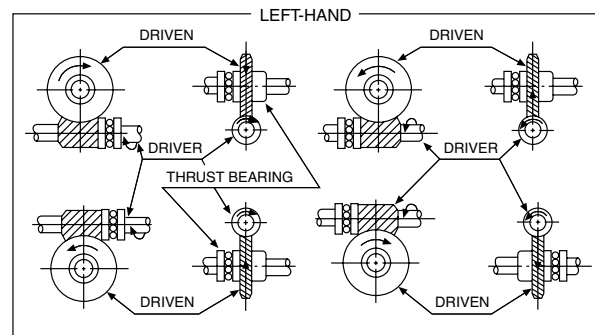
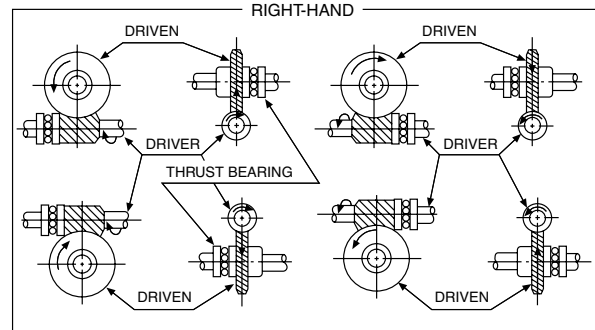
Threads of LEFT-HAND lean to the Left when standing on either end:



Threads of RIGHT-HAND lean to the Right when standing on either end:

### Thrust Loads

As is true with Helical and Bevel gearing, Worm gearing, when operating, produces Thrust loading. The Chart below indicates the direction of thrust of Worms and Worm Gears when they are rotated as shown. To absorb this thrust loading, bearings should be located as indicated.



### Efficiency

The efficiency of a worm gear drive depends on the lead angle of the worm. The angle decreases with increasing ratio and worm pitch diameter. For maximum efficiency the ratio should be kept low.

Due to the sliding action which occurs at the mesh of the Worm and Gear, the efficiency is dependent on the Lead Angle and the Coefficient of the contacting surface. A common formula for estimating efficiency of a given Worm Gear reduction is:

$$\text{EFFICIENCY} = E = \frac{\tan \gamma (1 - f \tan \gamma)}{f + \tan \gamma}$$

where  $\gamma$  = Worm Lead Angle  
 $f$  = Coefficient of Friction

For a Bronze Worm Gear and hardened Steel Worm, a Coefficient of Friction in the range of .03/.05 may be assumed for estimated value only.

### Worm and Worm Gear Formulas

To Obtain	Having	Formula
Circular Pitch (p)	Diametral Pitch (P)	$p = \frac{3.1416}{P}$
Diametral Pitch (P)	Circular Pitch (p)	$P = \frac{3.1416}{p}$
Lead (of Worm) (L)	Number of Threads in Worm & Circular Pitch (p)	$L = p(\text{No. of Threads})$
Addendum (a)	Diametral Pitch (P)	$a = \frac{1}{P}$
Pitch Diameter (D) of Worm ( $D_w$ )	Outside Diameter ( $d_o$ ) & Addendum (a)	$D_w = d_o - 2a$
Pitch Diameter of Worm Gear ( $D_g$ )	Circular Pitch (p) & Number of Teeth (N)	$D_g = \frac{N_g p}{3.1416}$
Center Distance Between Worm & Worm Gear (CD)	Pitch Diameter of Worm ( $d_w$ ) & Worm Gear ( $D_g$ )	$CD = \frac{d_w + D_g}{2}$
Whole Depth of Teeth ( $h_T$ )	Circular Pitch (p)	$h_T = .6866 p$
	Diametral Pitch (P)	$h_T = \frac{2.157}{P}$
Bottom Diameter of Worm ( $D_r$ )	Whole Depth ( $h_T$ ) & Outside Diameter ( $d_w$ )	$d_r = d_o - 2h_T$
Throat Diameter of Worm Gear ( $D_T$ )	Pitch Diameter of Worm Gear (D) & Addendum (a)	$D_T = D_g + 2a$
Lead Angle of Worm ( $\gamma$ )	Pitch Diameter of Worm (D) & The Lead (L)	$\gamma = \tan^{-1} \left( \frac{L}{3.1416d} \right)$
Ratio	No. of Teeth on Gear ( $N_g$ ) and Number of Threads on Worm	$\text{Ratio} = \frac{N_g}{\text{No. of Threads}}$
Gear O.D. ( $D_o$ )	Throat Dia. ( $D_T$ ) and Addendum (a)	$D_o = D_T + .6a$

### Self-Locking Ability

There is often some confusion as to the self-locking ability of a worm and gear set. Boston worm gear sets, under no condition should be considered to hold a load when at rest. The statement is made to cover the broad spectrum of variables effecting self-locking characteristics of a particular gear set in a specific application. Theoretically, a worm gear will not back drive if the friction angle is greater than the worm lead angle. However, the actual surface finish and lubrication may reduce this significantly. More important, vibration may cause motion at the point of mesh with further reduction in the friction angle.

Generally speaking, if the worm lead angle is less than 5°, there is reasonable expectation of self-locking. Again, no guarantee should be made and customer should be advised. If safety is involved, a positive brake should be used.

### Worm Gear Back-Driving

This is the converse of self-locking and refers to the ability of the worm gear to drive the worm. The same variables exist, making it difficult to predict. However, our experience indicates that for a hardened worm and bronze gear properly manufactured, mounted and lubricated, back-driving capability may be expected, if the lead angle is greater than 11°. Again, no guarantee is made and the customer should be so advised.

### Rating

The high rate of sliding friction that takes place at the mesh of the Worm and Gear results in a more complex method of rating these Gears as opposed to the other Gear types. Material factors, friction factors and velocity factors must all be considered and applied to reflect a realistic durability rating.