WINSMITH

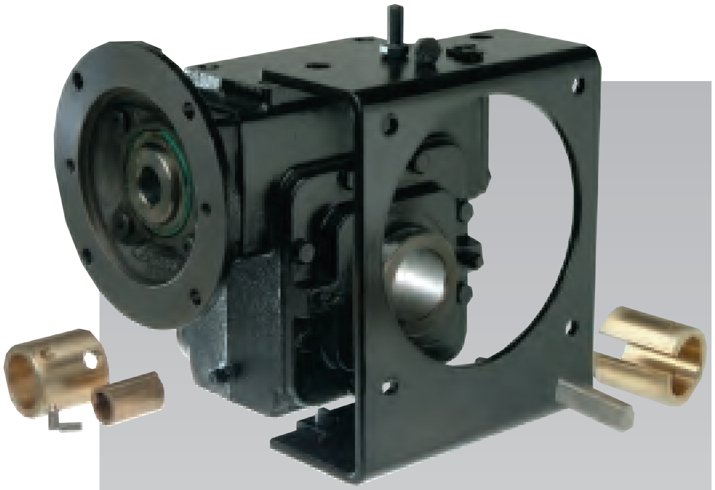
SE ENCORE™

Unique, Powerful Performance

WORM GEAR SPEED REDUCERS

SE Encore Appendix

SE Encore Appendix Table of Contents



SE Encore Worm Gear Speed Reducer Selection Criteria

When choosing an SE Encore speed reducer, a number of application issues require consideration. This section of the catalog assists with the selection of the optimal SE Encore worm gear speed reducer for an application. Proper reducer selection ensures desired operating results and long product life. The Selection Guide on page 219 employs a series of questions as a guide for this process. Each question includes referenced catalog pages that contain more detailed information.

Service Life and Catalog Ratings

Worm gear speed reducer ratings are based on a nominal service life when operated at the published levels. Nominal service life is defined by AGMA as 25,000 hours when the appropriate reducer service factor is selected, proper lubrication employed at installation, and appropriate maintenance practices are followed. If an application requires a nominal service life greater than 25,000 hours, a higher service factor should be used in the selection process. Contact Winsmith regarding the application and gearing configuration before employing service factors lower than 1.00 (a nominal service life of less than 25,000 hours). Intermittent duty applications with a high number of starts and stops can have a dramatic negative impact on the life of a worm gear speed reducer. Reference the Winsmith Motion Control Products catalog for additional information on the selection of intermittent duty reducers (available at www.WINSMITH.com).

Service Life

The nominal service life defined by AGMA is not a guarantee of the actual service life of any specific gear reducer, but is an average calculated life derived from industry formulas and other factors such as test results, proprietary calculations, and assumptions. These factors take into consideration the metal composition, the design of the gearing and bearings, as well as calculated loads. Service life calculations are not based on actual field conditions or applications, and do not represent a guarantee with respect to expected life, performance, or other characteristics of a gear reducer in any given application or use. The actual service life could vary substantially from the nominal service life.

Service life calculations apply only to the gearing and bearings. There are no service life calculations for other gear reducer components such as structural parts, seals, and lubricants.

Seals and lubricants are maintenance items; replacement cycles will vary with operating conditions. Regular inspections, followed by appropriate maintenance, are recommended.

Factors Affecting Service Life

In any given application, numerous factors can affect the service life of a speed reducer. Some of these include: overhung and thrust loads, environmental conditions, intermittent duty, and sealed vs. vented operation. These factors are discussed in further detail in this Appendix.

This appendix contains important information regarding Winsmith products, including selection, application, operation, and service factor information. Please review it and other available guidance carefully before selecting or recommending a gear reducer for any application.

SE Encore Worm Gear Speed Reducer Selection Criteria

Speed Reducer Selection Methods

There are two primary methods of choosing an SE Encore worm gear speed reducer when knowing the specific load requirements. When using either method, the first step is determining the application service factor using the tables on pages 233-235. Then, using the selection guides throughout this section, choose either of the following methods:

- **Selection Method #1:**
  When the required output torque and the speed reduction between the input and output shaft speeds are known, the proper speed reducer can be selected using the appropriate ratio, service factor, and output torque information found in the ratings section.
- **Selection Method #2:**
  When the available input horsepower and the speed reduction between the input and output shaft speeds are known, the proper speed reducer can be selected using the appropriate ratio, service factor, and output torque information found in the ratings section. Note that the speed reducer may be incorrectly sized (undersized or oversized) if the available input horsepower (motor) is used as the primary method for selection.

Selection Method #1: Speed Reducer Selection Procedure using Output Torque

When using the output torque for speed reducer selection, the applied output torque (output torque, lbf-in) and output speed (rpm) are requisites. The output torque is determined by the application requirements. The steps that follow help complete the selection of the optimal speed reducer:

1. Determine the service factor (S.F.) from the table on page 236 for the desired application and daily operating service duration.
2. Determine the design output torque (design output torque = applied output torque x S.F.).
3. Determine the speed reducer gear ratio or output speed (output rpm) required from the application (see page 218 for available standard ratios).

Selection Method #2: Speed Reducer Selection Procedure using Input Horsepower

When using the input horsepower for speed reducer selection, the applied input horsepower (input HP) and input speed (input rpm) are requisites. The input speed is typically constant and generated from an AC or DC motor. The steps that follow help complete the selection of the optimal speed reducer:

1. Determine the service factor (S.F.) from the table on page 236 for the desired application and daily operating service duration.
2. Determine the design input horsepower.
   The design input horsepower = applied input horsepower x S.F.
3. Determine the speed reducer gear ratio or output speed (output rpm) required for the application (see page 218 for available standard ratios).

Overhung and Thrust Load Requirements

These loads are in addition to the transmitted torque and are applied either to the input or to the output shaft of a speed reducer. Most often, the driven equipment handles these loads. However, in a relatively small number of applications, they are great enough that the strength of the reducer components becomes a factor in speed reducer selection. If excess overhung or thrust loads are transmitted to the reducer, the service life could experience a significant decrease from the published catalog levels. Please refer to “Overhung Load and Thrust” on page 227 of this section.

Output Speed and Gear Ratio Requirements

Selecting the correct SE Encore speed reducer ratio is an important initial application criterion because it determines the operating output speed of the speed reducer and sets the parameters for output torque and input horsepower. The gear reduction ratio also affects the selection of the reducer configuration because their performance characteristics vary dependant upon the center distance and configuration of the reducer.

The SE Encore series of worm gear speed reducers are available in three gear reduction combinations, each having a unique range of gear ratios:

1. Single reduction worm,
2. Double reduction worm, and
3. Double reduction helical/worm

SE Encore Worm Gear Speed Reducer Selection Criteria

Some of the same gear ratios found in one combination will overlap with those of one or more of the other two combinations and they will each exhibit different performance characteristics (output torque, input horsepower capabilities, efficiencies, etc.). Before finalizing the speed reducer selection, check each overlapping ratio combination for the optimal performance characteristics (see Table on page 218 for a summary of standard ratios).

Ratio Selection

1. Determine the RPM of the prime mover (i.e. motor) that attaches to the speed reducer.
    - Fixed input speed. The standard operating speed of an AC induction motor (e.g., 1750 RPM for a 4 pole motor).
    - Variable speed motor and control input. Choose the ratio that satisfies the application requirements and speed reducer limitations at the highest motor speed (e.g., for a motor with a variable speed between 583 and 1750 RPM range, use 1750 RPM for ratio selection).
    - Non-motorized input. A combination of belts and sheaves, or similar separate speed control devices can be used as an input to a gear reducer.
2. Determining the output RPM required for the application is independent of the speed reducer selection process. There are a number of useful formulas on page 238, that assist with this determination.
3. SPEED REDUCER RATIO = INPUT RPM / OUTPUT RPM. Based on the previous calculations, select the speed reducer ratio that corresponds to the center distance (size) and configuration (single, double, or helical/worm) from the Table 1. Input horsepower and output torque ratings at 1750 rpm and 1.0 service factor are included as a reference guide.

Product Configuration

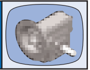
The SE Encore series of worm gear speed reducers offers a wide range of configurations to fit a variety of applications and design requirements. Achieving the most effective overall system performance requires consideration of the speed reducer configuration early in the design phase. Some important speed reducer configuration issues are:

1. Output shafts – solid or hollow
2. Speed reducer mounting – eleven standard types
3. Multiple reductions – worm or helical primary combined with a worm secondary

Environmental Requirements

Environmental conditions can decrease the service life of a speed reducer because they can cause deterioration of components such as shafts and seals. The WinGuard Epoxy Coating System encloses the entire SE Encore series of worm gear speed reducers offering significant protection from environmental elements.

However, there are some operating environments (i.e. outdoor, wash down, pharmaceutical, etc.) that require higher levels of contamination protection. Winsmith offers a number of worm gear speed reducer enhancements that address these conditions including stainless steel reducers and shafts, special seals, etc. Some of these special features are described in the Modified section of this catalog. For more detail, please visit **www.WINSMITH.com** and review our SE Maximizer Series product line.



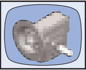
SE Encore Series Standard Ratios

TABLE 1. SE ENCORE STANDARD RATIOS[1] (Listed within reducer size by single, double, and helical/worm reduction)

Reducer Ratio[1]	Ratings @1.0 SF	REDUCER SIZE																			
		E13	E17		E20		E24			E26			E30			E35			E43		
		S	S	D	S	D	S	D	H	S	D	H	S	D	H	S	D	H	S	D	H
5	In HP	1.39	2.69		3.70		5.89			7.70			10.87			15.82			25.16		
	Out Tq	238	462		639		1017			1334			1886			2738			4382		
7.5	In HP	1.05	2.06		2.84		4.54			5.93			8.59			12.55			19.39		
	Out Tq	266	525		723		1168			1533			2232			3252			5011		
10	In HP	0.86	1.64		2.24		3.67			4.82			7.11			10.27			15.84		
	Out Tq	284	554		769		1249			1650			2448			3515			5400		
15	In HP	0.62	1.15		1.59		2.71			3.42			5.07			7.51			11.63		
	Out Tq	295	568		794		1359			1724			2578			3804			5819		
20	In HP	0.42	0.94		1.24		2.11			2.64			3.95			5.73			9.16		
	Out Tq	257	604		806		1383			1745			2645			3821			6007		
25	In HP	0.41	0.70		1.01		1.61		1.97	2.17		2.61	3.24		3.21	4.71		3.21	7.50		11.01
	Out Tq	304	547		803		1285		1718	1758		2266	2676		2751	3884		2728	5981		9309
30	In HP	0.35	0.66		0.86		1.45		1.69	1.80		2.26	2.67		2.66	4.07		2.66	6.40		9.18
	Out Tq	293	596		788		1360		1763	1712		2343	2586		2713	3943		2702	6013		9063
40	In HP	0.27	0.52		0.68		1.11		1.39	1.42		2.00	2.08		3.10	3.04		3.21	4.94		8.36
	Out Tq	276	603		795		1335		1812	1737		2596	2617		3993	3837		4100	6005		10417
50	In HP	0.17	0.41	0.487	0.56	0.727	0.92	1.148	0.821	1.18	1.491	1.146	1.72	1.873	1.792	2.44	3.109	3.215	3.96	7.019	6.798
	Out Tq	213	558	781	791	1166	1329	1859	1404	1748	2391	1954	2643	3017	3024	3753	4992	5419	5852	11058	11087
60	In HP	0.15	0.27		0.41		0.70		0.67	0.92		0.92	1.72		1.48	2.00		2.24	3.23		6.02
	Out Tq	202	417		656		1134		1358	1556		1860	2033		2962	3573		4494	5566		11444
75	In HP			0.258		0.364		0.618	0.586		0.831	0.789		1.301	1.244		2.883	2.756		5.176	5.013
	Out Tq			593		845		1476	1479		1985	1988		3111	3116		6891	6906		11804	11834
80	In HP		0.16		0.22		0.38			0.49			0.71			1.12			1.91		
	Out Tq		311		437		735			979			1478			2403			4114		
90	In HP								0.49			0.67			1.07			2.37			4.44
	Out Tq								1466			2006			3179			7088			12205
100	In HP			0.221		0.304		0.490	0.465		0.617	0.585		0.974	0.931		2.123	2.032		3.979	3.853
	Out Tq			671		930		1543	1547		1941	1944		3067	3071		6708	6728		11801	11828
120	In HP								0.365			0.499			0.799			1.514			3.404
	Out Tq								1445			1975			3128			5952			12152
150	In HP			0.135		0.199		0.334	0.307		0.464	0.418		0.750	0.663		1.647	1.461		2.990	2.783
	Out Tq			596		881		1513	1480		2076	2028		3307	3201		7461	7092		13130	12153
180	In HP								0.261			0.357			0.570			1.177			2.491
	Out Tq								1503			2063			3263			6787			12528
200	In HP			0.113		0.155		0.253	0.227		0.346	0.338		0.561	0.529		1.101	1.062		2.127	2.069
	Out Tq			652		900		1504	1414		2038	2142		3243	3347		6558	6770		12116	11774
250	In HP								0.194			0.263			0.418			0.670			1.318
	Out Tq								1485			2035			3241			5196			9071
300	In HP			0.078		0.116		0.190	0.151		0.266	0.203		0.418	0.323		0.949	0.563		1.149	1.669
	Out Tq			607		899		1551	1363		2132	1853		3409	2940		7763	5181		9075	13848
365	In HP								0.120			0.162			0.256			0.404			0.844
	Out Tq								1256			1715			2721			4339			7718
500	In HP			0.053		0.074		0.124			0.169			0.261			0.508			1.126	
	Out Tq			650		893		1527			2099			3354			6473			14299	
750	In HP			0.037		0.062		0.090			0.128			0.197			0.410			0.794	
	Out Tq			659		1088		1596			2200			3513			7442			14334	
1000	In HP			0.033		0.047		0.071			0.096			0.148			0.289			0.514	
	Out Tq			655		900		1541			2120			3392			6566			12353	
1500	In HP			0.022		0.037		0.052			0.074			0.113			0.244			0.459	
	Out Tq			664		1097		1611			2223			3555			7558			14638	
2000	In HP			0.020		0.028		0.038			0.054			0.083			0.184			0.320	
	Out Tq			727		1007		1530			2109			3369			7345			13427	
3000	In HP			0.015		0.021		0.028			0.040			0.059			0.118			0.185	
	Out Tq			749		1070		1445			1976			3164			6305			10773	
3600	In HP			0.010		0.016		0.025			0.036			0.049			0.080			0.126	
	Out Tq			581		893		1508			2054			3080			4954			8508	
4000	In HP			0.007		0.009		0.025			0.036			0.054			0.112			0.168	
	Out Tq			422		596		1447			1979			3171			6518			11206	
5000	In HP			0.006		0.008		0.023			0.034			0.050			0.103			0.154	
	Out Tq			423		597		1449			1982			3175			6563			11292	
6000	In HP			0.004		0.006		0.021			0.031			0.042			0.068			0.102	
	Out Tq			303		481		1524			2081			3123			5028			8695	
8000	In HP							0.011			0.017			0.022			0.041			0.061	
	Out Tq							988			1395			2050			3828			6560	
10000	In HP							0.008			0.011			0.015			0.027			0.043	
	Out Tq							818			1145			1696			2948			5534	

🟨	Single Reduction
🟦	Double Reduction
🟩	Helical/Worm Reduction

1. Special ratios and gearing are listed in the Modified section on page 133.
2. Exact ratios are listed in the Ratings section starting on page 157.
3. See page 229 for thermal limits of some ratings during continuous duty operation.
All ratings are for 1750 rpm



SE Encore Series Selection Guide

Elements of Selection Process	Reference Section
Output speed	Ratio selection – page 133 & 218
Output speed required ________________RPM	
Ratio required __________:1	
Reduction method -Single worm ___, Double/ worm ___, Helical/ worm ___	
Application service factor	Service factor – pages 233-236
Length of daily service __________ hours	
Planned starts and stops a day ___________	
Emergency stop requirements - describe _____________________________________	
Type of equipment being driven ____	
Load	Rating selection – pages 157-213
Using input HP requirements method	HP & torque selection – page 216
Input shaft configruation - separate style	
Input HP ____________	
Input speed to the gearbox ______________________RPM	
NEMA AC & DC motors	NEMA motors – page 239
Motor HP __________	
Motor speed or variable speed range __________ to ___________RPM	
Servo motors - constant and variable speed applications only	
(Intermittent duty cycles see Winsmith Motion Control Catalog 400)	
Motor torque rating _____________________ in lbs	lbf-in
Motor speed range _________ to ___________RPM	
Maximum operating speed for application ___________________RPM	
Using output torque requirements method	HP & torque selection – page 216
Output torque requirements	
Torque required to move the load _______________ in lbs	lbf-in
Torque required to start moving the load ________________ in lbs	lbf-in
Overhung and Thrust Load	Overhung & thrust load – page 216
Output shaft overhung load	
Amount of overhung load applied ____________ lbs	
Distance from the center of the housing where overhung load is applied ___________ in.	
Input shaft overhung load	
Input shaft overhung load _________________lbs	lbs
Output thrust load	
Amount of thrust load __________ lbs	
Configuration	
Output configuration requirements	Model quick selection – page: • 32-35
Output configuration - single reduction or last stage of a multiple reduction gearbox	• 68-71
Type of output shaft - solid _______ hollow _______	• 86-89
If hollow what is the bore size ___________	
Connection to the driven machine	
Footless (no base) ______ With feet (base) _________ Flange ____________	
Direction of the output shaft extension looking into the input	
Right _____ Left ______ Right & Left ______	
Position of the input shaft to output shaft	
Above _____ Below ______	
Special output shaft requirements ____	
Input configuration requirements	Model quick selection – page: • 32-35
Shaft input method – solid shaft	• 68-71
Connection method ______________________ (ie: belt and pully, coupling)	• 86-89
Connection equipment description ____	
Electric motor - AC/DC	Motor dimension – page 239
Quill or coupling ____	
Motor frame size or specification _____________________________________	
Servo motor	May require motor interface drawing
Quill or coupling	
Motor frame size or specification ___________________________________	
Other types of input contact the factory	
Mounting and Lubrication	
SE ENCORE product is lifetime lubricated	See product sections for further information
Environmental	
Environmental operating conditions	
For indoor dry applications ___________	Use standard SE Encore
Range of ambient operating temperature _____ to _____ degrees F	Lubrication section
For indoor wet applications ___________	Use SE Maximizer products
For outdoor applications _____________	Use SE Maximizer products

When this Selection Guide is done go to the Product Nomenclature section on page 4 and complete the unit selection process.

Speed Reducer Sealing and Venting

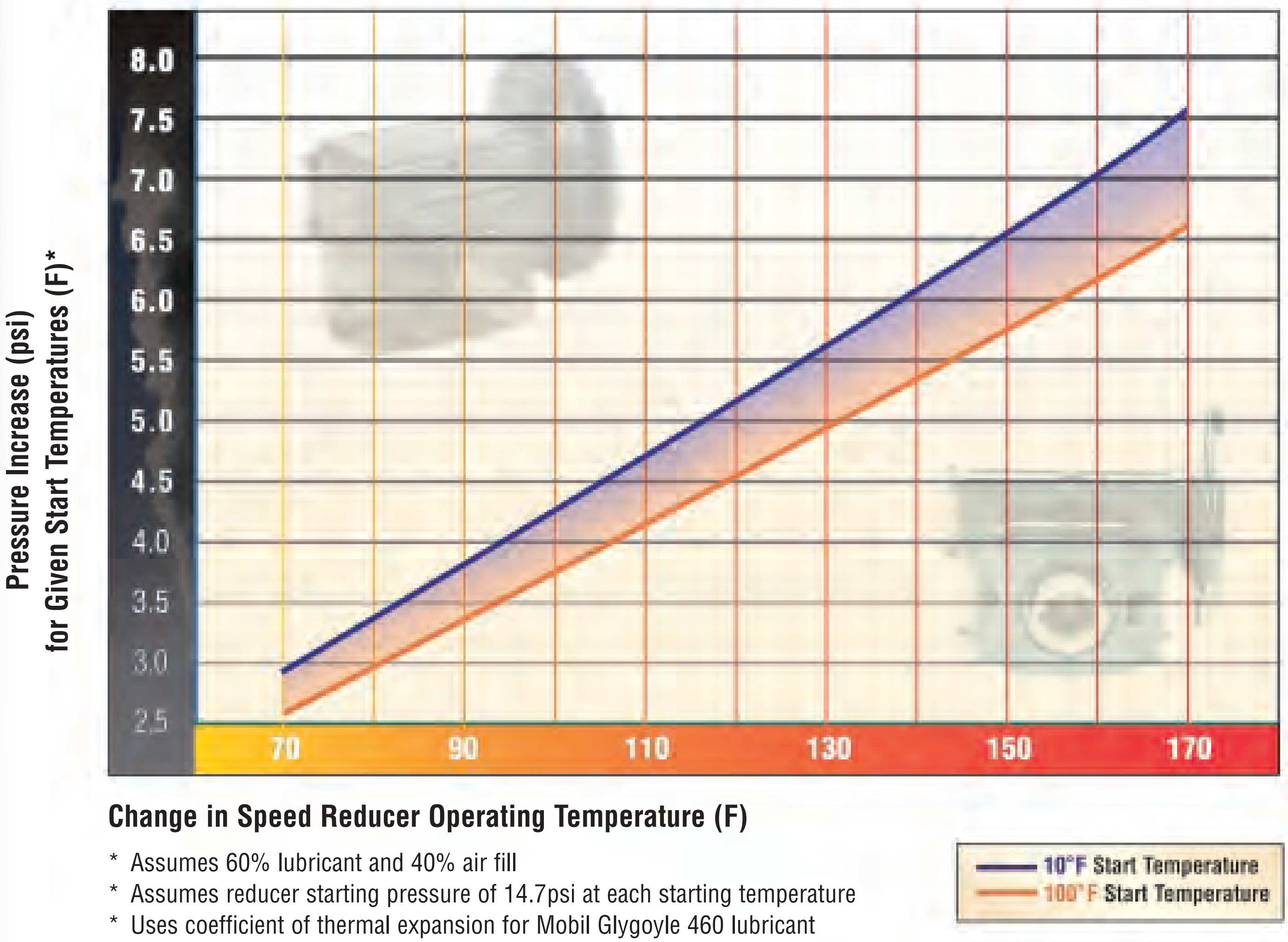
Sealed vs. Vented Speed Reducer Operation

All SE Encore series speed reducers are designed to operate sealed or vented. Deciding whether a speed reducer should operate sealed or vented requires an understanding of the application, the environment, the operation of radial shaft seals, and a review of the fundamentals of thermodynamics that govern the temperature and pressure relationship in the speed reducer.

Any significant increase in pressure in a sealed speed reducer decreases the operational service life of the radial lip seals. A pressure change of only 5 psi may reduce the seal life by as much as one third. There are two important phenomena that cause an increase in the internal pressure of a sealed speed reducer. First, the change of internal pressure during operation is proportional to the change of internal temperature that occurs during normal operation. The relationship follows the combined gas law expressed as $P_1V_1 / T_1 = P_2V_2 / T_2$. Secondly, radial lip seals can ingest or “pump” air into a speed reducer regardless of whether it is operating sealed or vented. While the rate of ingestion is highly variable and dependant on running time and speed, under continuous operating conditions the net effect of “pumped” air to the total pressure increase is significant. *Venting, or the use of a breather vent, is the only absolute method of eliminating the pressure increase in a speed reducer caused by the increased operating temperature.*

In some applications, the duty cycle of the speed reducer is intermittent, the run times short, and the temperature increase modest. While sealing the reducer during operation subsequently increases the pressure

Pressure Increase in a Sealed Speed Reducer (Combined Effect of Lubricant and Air Expansion)



* Assumes 60% lubricant and 40% air fill
* Assumes reducer starting pressure of 14.7psi at each starting temperature
* Uses coefficient of thermal expansion for Mobil Glygoyle 460 lubricant

Figure 1.

in these applications, the increase may be very small and therefore have minimal impact on the seal service life. Additionally, operating a sealed speed reducer may be the best choice in applications where external air-borne contamination causes a greater reduction in overall speed reducer service life than the negative impact of the internal pressure increase. The machine builder or the end equipment user should determine whether sealing or venting the speed reducer is the best choice for a specific application as this decision has a direct impact on the seal service life. The following section details the factors influencing seal life.

Internal Temperature and Pressure Increase in a Sealed Speed Reducer

A speed reducer experiences a significant internal temperature increase due to operating loads. The change in temperature of an operating speed reducer (from static ambient temperature to maximum operating temperature) often exceeds 130° Fahrenheit. In a sealed speed reducer, the increasing temperature results in a corresponding pressure increase as described by the combined gas law:

$P_1V_1 / T_1 = P_2V_2 / T_2$

In a closed system (e.g. sealed reducer), any change in temperature from one state of equilibrium to the next state of equilibrium results in a corresponding change in both oil volume and internal pressure. Moreover, the thermal expansion of the lubricant in the reducer can have a considerable effect on the pressure, temperature, and volume relationship. The influence of the lubricant's thermal expansion depends on the percent volume occupied by the lubricant compared to that of the air. Typically, the volume inside the reducer is about 60% lubricant and 40% air. The thermal expansion of the lubricant alone increases the internal pressure in the reducer by approximately 1.5 psi when the change in temperature is 130°F.

Figure 1 shows the total impact of the internal temperature and associated pressure increase at different ambient starting temperatures in a sealed speed reducer. Pressure increases greater than 5 psi can result from the combined effect of the lubricant's thermal expansion and the internal temperature change.

Seal "Pumping" Effects on Increased Pressure in an Operating Speed Reducer

Correctly operating radial shaft lip seals are dynamic and require the presence of a microscopically thin film of lubricant directly under the sealing lip. The seal lip imposes shear forces on the film as the shaft rotates beneath it. This creates a seal "pumping action" that circulates the lubricant residing closest to the seal back inside the speed reducer and away from the external environment. The pumping action of the seal prevents the lubricant from seeping out and is necessary for proper operation. Unfortunately, a correctly functioning radial shaft seal also causes an unintended and unavoidable side effect. Tests confirm that microscopic air bubbles and contaminants from the external environment are entrained in the lubricant. The actively pumping seal sweeps them inward with the induced lubricant flow and once inside, they escape into the speed reducer. With continuous operation, the air bubbles accumulate inside the reducer cavity. The seal is acting as an air pump, causing air ingestion that increases the internal pressure of a sealed speed reducer. Winsmith's extensive testing has verified that the increased internal pressure of the speed reducer and the rate of pressurization are dependent on many variables including operating time, linear velocity of the shaft under the seal, temperature, seal material, and seal and shaft manufacturing tolerances.

In summary, a significantly large percentage of sealed speed reducers develop an internal pressure of 5 psi or more when operated on a continuous duty cycle. This phenomenon can occur even when there is no change in temperature because the radial lip seals ingest air into the reducer (see Figure 2). Conversely, testing indicates that when a reducer operates in an intermittent manner (e.g. 5 minutes of run time every 30 minutes of dwell), the internal pressure build-up is very small.

The Effects of Temperature and Pressure on Seal Operating Life

The specific failure mechanisms of seals vary depending on the seal material. However, the normal "wear out" failure mode of an NBR rubber (Acrylonitrile-butadiene or "nitrile") dynamic radial shaft seal is related to time and temperature and often termed "embrittlement." Over time under some relative elevation of temperature, nitrile seals loose elasticity, develop micro cracks that cause an abraded sealing surface that can no longer properly contain the speed reducer lubricant. The embrittlement rate of NBR materials begins to accelerate at lip operating temperatures between 180°F and 200°F.

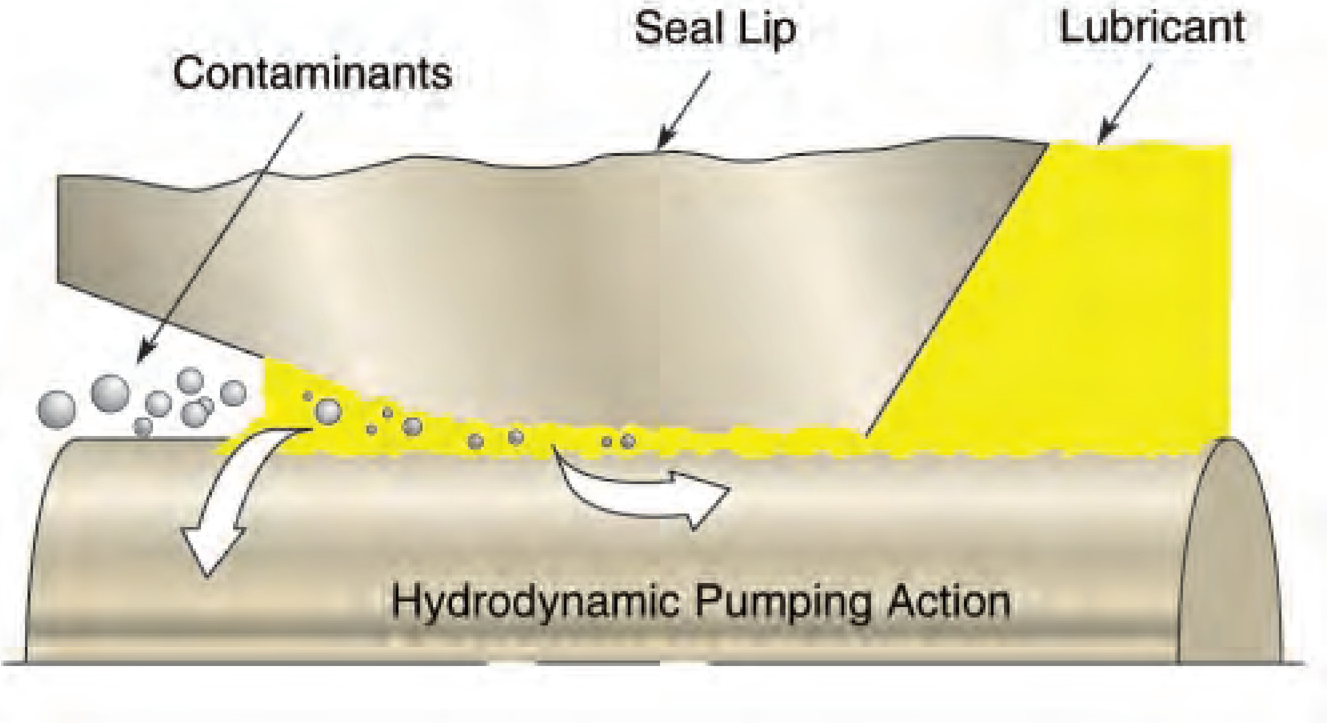


Figure 2. Ingestion of Air and Contaminant by a Radial Seal Courtesy of Parker Hannifin Corporation

The impact of increasing temperature and pressure in a sealed speed reducer on the service life of an NBR seal has been assessed by numerous seal manufacturers. While the results of these tests vary depending on variables such as the actual seal lip temperature, they indicate that a change in pressure as small as 5 psi can reduce the expected seal service life by one third. This is because a positive internal pressure differential in a speed reducer causes the shaft lip seals to exert a higher radial force on the shaft. Under dynamic conditions, this force increases the lip seal contact area on the shaft, increasing the friction, and thereby creating a correspondingly higher temperature between the shaft and the lip seal. This increase is directly proportional to the amount of radial force on the seal and to the speed of the shaft at the seal interface and causes a decrease in the seal life.

All SE Encore speed reducers with a quill input adaptor use special HNBR (hydrogenated nitrile butadiene rubber) or fluoroelastomer (aka Viton®) materials on all input shafts because these materials are tolerant of higher lip operating temperatures. The typical failure mode of HNBR material is blistering at the seal surface.

Performance Issues with Bladders and Expansion Chambers

Various speed reducer design approaches aimed at eliminating the internal pressure increase have incorporated internal collapsible diaphragms or bladders. Eliminating the pressure increase requires that the bladder or diaphragm collapse at very low pressures and have a volume that sufficiently accommodates the expansion of the air and the lubricant. In a reducer with a two inch center distance, the internal volume is between 30 in^3 and 40 in^3. Assuming the volume is 60% lubricant and 40% air and applying the previously discussed combined gas law over a temperature change of 130°F (70°F start, 200°F final), the size of an internal diaphragm or bladder required to prevent a pressure increase must be between 3.9 in^3 and 5.2 in^3. In most typical speed reducers, there is insufficient internal space for such a large bladder. Moreover, while some internal expansion chambers are effective in limiting or reducing internal pressure rise due to temperature changes, *none are completely effective in avoiding the pressure build up related to seal air pumping action associated with continuous duty cycle applications.*

Speed Reducer Sealing and Venting

Applications Determine When Sealing a Speed Reducer is Preferred to Venting

As covered in the preceding discussion, sealing a reducer can increase the internal pressure which results in decreased seal service life. This is especially prevalent when operating under continuous duty conditions. However, there are certain applications where the speed reducer duty cycle is highly intermittent, and run times are short with light average duty loads. Testing and field experience indicate that small internal pressure increases (1 – 2 psi) have a minimal effect on the seal service life.

Another application dependent situation where sealed reducer operation is preferred occurs when the external air environment is extremely contaminated with material that, if drawn into the reducer through a vent, can rapidly reduce seal, bearing, or worm gear life. In these applications, the increased pressure resulting from operating a sealed reducer can still have a significantly negative effect on seal life and, in these cases, require more frequent seal replacement. However, the reducer life may be lengthened by operating sealed rather than operating with an open vent in these types of harsh environments. Further, the machine builder or equipment operator might determine that the convenience of operating a sealed speed reducer outweighs the negative result of reduced seal service life. *The Winsmith two (2) year warranty on defect in parts and workmanship remains unaffected whether an SE Encore worm gear speed reducer operates with or without a vent since the vent/sealed decision only affects the service life of the speed reducer wear components.*

In conclusion, there are three fundamental factors that govern the speed reducer seal/vent decision. First, as the temperature increases in a sealed reducer, so will the pressure. Second, the radial shaft seals are designed to “pump” lubricant back into the speed reducer. This pumping action also causes an ingestion of air that increases the internal pressure. Any increase of pressure causes decreased dynamic radial seal life. Venting is the most cost effective method of eliminating the pressure. Finally, when extreme environmental conditions cause component or seal wear in excess of that caused by an increased internal pressure, sealing a speed reducer is the best likely alternative. However, under these conditions, seal wear is apt to take place at higher than predicted rates.

SE Encore Venting Solution is a Standard Feature

The SE Encore worm gear speed reducer series can satisfactorily operate sealed or vented. Each reducer is supplied with an optional “open-closed vent” that can be installed by the equipment builder or the equipment user. This exclusive Winsmith vent is made from black DuPont™ Zytel® Nylon with UV protection. The vent’s design incorporates a labyrinth with a dust/splash cap that minimizes contaminate and water incursion from the external environment created by general, harsh, and outdoor applications. The reducer housing offers multiple locations for vent installation depending on the final reducer mounting position on the equipment. Turning the top cap to the closed position ensures that no oil drains while the equipment is in transit to the operating location. Turning the top cap counter clockwise, by hand, opens the vent prior to running the speed reducer. A special screw driver slot molded into the cap allows easy actuation when access is limited. The vent should be installed in the highest pipe plug location available based on the actual mounting orientation of the speed reducer on the operating equipment. Additionally, a bright yellow plastic tag is provided with the vent that reads:

“IMPORTANT – VENT REQUIRES ACTIVATION
THIS UNIT HAS BEEN SHIPPED TO YOU WITH THE VENT IN THE CLOSED POSITION – IT IS IMPORTANT TO OPEN THE VENT BY MAKING A ONE QUARTER TURN COUNTER CLOCKWISE”

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Speed Reducer Self-Locking and Back-Driving

What is Self-Locking and Back-Driving?

The term self-locking, when applied to the operational performance characteristics of worm gear speed reducers, is defined as follows:

> When an external load applies a dynamic or static torque to the output worm gear shaft, and this torque does not result in any rotation of the input worm, the reducer is considered self-locking.

Conversely, back-driving is the opposite effect and is defined as follows:

> Back-driving occurs when an external load applies a dynamic or static torque to the output shaft and this torque does result in rotation of the input worm.

Depending on several design and load characteristics, worm gear speed reducers may be selected which either self-lock or back-drive and in some limited cases can do both depending on external loads and operational conditions. In most normal applications of a worm gear speed reducer, the input worm shaft is powered by an electric motor capable of applying a defined amount of speed and torque. This applied input torque is then amplified by the worm gear ratio while the speed is reduced proportionally. The amplified torque at the gear output shaft is then applied to the external load to perform the desired work.

It is important to note that there are some applications where the load characteristics cause a reversal of this normal flow of power from the input to the output of the speed reducer. This would apply where the reducer is being used as a worm gear speed increaser. Examples also include a worm gear speed reducer used on an overhead crane or vertical lift. Unless perfectly counter balanced a crane normally consumes input power during lifting operations, however when it is desired to lower the load, the load will apply a reverse torque to the output gear shaft as the load attempts to rapidly descend under the force of gravity. To prevent an undesired rapid decent of a vertical crane load it is required that the worm gear speed reducer absorbs power and provide a braking or reverse torque to the load. This kind of application is often referred to as an overhauling load.

Another overhauling application would be where a high inertia load is required to rapidly decelerate faster than friction forces alone would cause to occur. In this situation, as with many crane loads, it is desired that the speed reducer output smoothly apply a braking or reverse torque to the load in order to achieve desired operation.

Self-Locking:

Certain worm gear speed reducers have worm and gear geometries that prohibit dynamic reverse torque operation. Any torque reversal on the output shaft will cause the worm gear mesh to instantly lock up and the reducer will refuse to rotate. Great damage to perhaps both the worm gear speed reducer and the load may be the result when a gear mesh instantly locks up. Inherent characteristics in certain worm gear designs allow the reducer to immediately lock up the worm and gear mesh in reverse torque applications.

The causes of “lock up” behavior are complex. All worm gear designs exhibit components of both sliding and rolling friction in the worm thread and gear tooth mesh. When the friction component in the gear mesh reaches a critical amount, self locking can be the result. Many factors determine when this critical amount of mesh friction occurs, these include: the worm lead angle; the rotational speed; the reduction ratio; the type of gear tooth geometry used; gear and worm surface finish and hardness; temperature; the type and condition of the lubricant; the magnitude and frequency of any external vibration forces; any load pulsations; and the magnitude of the overhauling load.

Often, in a specific application, the point at which a particular self locking worm gear speed reducer actually locks up when static will be different than when it locks up dynamically. Specifically, selected self locking worm gear speed reducers may not dynamically self lock, but rather will freely back drive dynamically. However, this same reducer, once all rotation ceases, and it is stationary for some time, the reducer will self lock; even when a great deal of torque is applied to the output shaft. The result is that smooth acceptable operation with an overhauling load occurs when the reducer is running but once the reducer is stopped, it will not permit any rotation. In these situations the worm gear speed reducer is operating similar to the function provided by a static load brake.

Winsmith does not recommend or approve of the use of any worm gear speed reducer in any application where operational self-locking characteristics are use to replace a static or dynamic brake. Neither dynamic nor static self-locking performance of a worm gear speed reducer should ever be relied whenever any unintended load rotation might possibly result in damage or harm to either machinery or people. Self-locking Winsmith worm gear speed reducers should never be use to provide the function of a “fail safe” brake.

Speed Reducer Self-Locking and Back-Driving

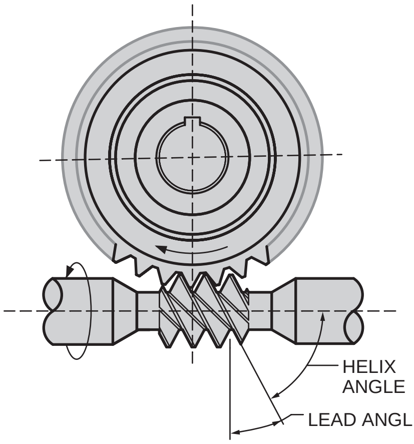


Figure 1.

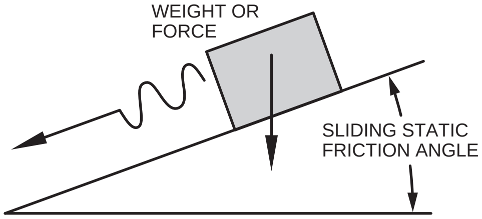


Figure 2.

When is a worm gear reducer considered to be Self-Locking?

Statically self-locking worm gear speed reducers can be obtained when the lead angle (Figure 1 above) of the worm threads is less than the sliding static friction angle (Figure 2 above) of the worm and gear. The sliding static friction angle of any two components is the angle at which, in Figure 2 above, the stationary block just starts to slide down the ramp shown. This angle is a primary function of the materials used to make the components and any lubricant applied at the sliding surfaces. For a bronze gear and a hardened steel worm operated in a typical worm gear speed reducer, the sliding static friction angle is generally assumed to be less than around eight (8) degrees. The sliding static friction angle may be lower than eight (8) degrees due to factors such as; surface finish, type of lubricant, condition of lubrication at the surfaces, and the presence of external vibration or load pulsations. After a reducer has run-in, the gear teeth become polished and thus the coefficient of friction angle is reduced. When static self locking is desired in an application, consideration must be given to the many factors including even the normal manufacturing tolerances that create variations in the lead angle of any specific worm or gear component part number.

The sliding dynamic friction angle is the angle, in Figure 2, where even when the block is in motion it will almost cease moving down the ramp. Under dynamic or rotating conditions of a worm and gear set, the sliding dynamic friction angle of the worm and gear is dependent on all the above discussed factors plus additionally it is a function of the rotational speed and the dynamic lubrication performance. For a bronze gear and a hardened steel worm operated in a typical worm gear speed reducer, the sliding dynamic friction angle is generally assumed to be less than around 2 degrees. If a worm gear reducer is selected with a worm thread lead angle of less than about 2 degrees it will normally dynamically self-lock. This means that whenever an external output load begins to overhaul or back drive the gear reducer, an abrupt immediate gear mesh lock-up or an intermittent or momentary lock-up is likely to occur. This almost always will result in serious, and perhaps permanent, damage to the worm gear speed reducer and perhaps also damage the driven load or machinery.

When a worm gear speed reducer is selected with a worm lead angle between a static sliding friction angle of about 8 degrees and a sliding dynamic friction angle of about 2 degrees, the reducer may exhibit both static self-locking, and at the same time, dynamic back-driving characteristics. The above operational characteristic of selected worm gear speed reducers may be extremely desirable in many applications where dynamic braking and static locking are desired. However, great care and prototype testing may be necessary in order to insure that the desired performance is achieved in a specific application. When the lead angle on worm threads is below 8 degrees, intermittent or momentary dynamic self-locking may also occur. When this occurs it is sometime times referred as “stick-slip” or “stair-stepping” operation and is generally undesirable and destructive.

NOTE:

The lead angles of the SE Encore Series were designed intentionally high for improved worm gear mesh power transfer efficiency. Depending on center distance, some sizes will have a tendency to be statically self-locking at 30:1 ratio and other sizes may not statically self lock at ratios as high as even 50:1. However, many special worm and gear ratio geometries are available to address various operational performance desires. Lead angles are not published, check with Winsmith for applications assistance.

SE Encore Series Lubrication

Mobil Glygoyle 460 Lubricant

Winsmith lubricates the entire SE Encore worm gear speed reducer series exclusively with Mobil Glygoyle® 460. In worm gear speed reducers, this advanced technology polyalkylene glycol (PAG) based synthetic oil provides exceptional performance properties and features including:

- improved efficiency
- lower operating temperatures
- high thermal and oxidative stability
- low deposit formation and sludge resistance
- excellent lubricity
- hydrolytic stability
- NSF H1 (formerly USDA) certified for incidental food contact

Lower Operating Temperatures

The improved SE Encore speed reducer efficiencies that result from Mobil Glygoyle 460 lubricant translate into lower operating temperatures. Testing has indicated that efficiency losses are decreased up to 20% when compared to polyalphaolefins (PAO) based synthetic lubricants and up to 35% when compared to standard 600W (mineral oil) worm gear lubrication (depending on the gear ratio). Additionally, this testing showed a 20°F lower operating temperature in a worm gear speed reducer using Mobil Glygoyle 460 when compared to that using a comparable PAO (Mobil SHC 634) lubricant at the same loaded condition. Further, the speed reducer with Mobil Glygoyle 460 operated several degrees cooler than that using another widely promoted competitive PAG based lubricant. A "rule of thumb" (valid within certain temperature ranges) is that oil and seal life double approximately every 18°F reduction in operating temperature. Therefore, the use of Mobil Glygoyle 460 lubricant in all SE Encore series worm gear speed reducers may double the lubricant and seal life in some applications.

Mixing of Lubricants

The PAG based stocks used in Mobil Glygoyle 460 do not chemically react with mineral or PAO lubricants and are not miscible. If they are mixed, an emulsion will form that will not provide proper lubrication. Therefore, care should be taken not to mix these incompatible lubricants. When switching from one lubricant type to another in a speed reducer, follow the instructions related to flushing procedures. This publication is available at www.WINSMITH.com.

Dependent on operating environment, a vented speed reducer may be subjected to lubricant contamination from external water or moisture. Hydrolytic stability is a measure of the lubricant's tendency to chemically react and breakdown in the presence of water. Unlike PAO based synthetic lubricants, PAG based lubricants do not break down and lose their lubricity in the presence of water. However, water concentrations above about 1% should be avoided due the potential of internal corrosion.

Lubricant Level and Mounting Position

Winsmith fills all SE Encore Multimount series worm gear speed reducers to an oil level that allows mounting in any position. This also applies to all MDNS (quill input adaptor, solid output shaft) and MDSS (quill input adaptor, hollow output shaft) models. All other SE Encore (Integral and Modified) series reducers are filled to the optimum oil level indicated by the intended operational mounting position specified on the order. Consult the ILE-08 bulletin for lubricant level adjustments if a change in the mounting position is required. Following these recommendations ensures that all of the internal speed reducer components receive proper lubrication.

Oil Change Frequency

Advanced PAG based lubricants are relatively new in the marketplace. Therefore, few "hard and fast," or "based-on-experience," rules can apply to the frequency of oil changes. Any claims that a worm gear speed reducer lubricant "never needs to be changed" are fictitious. In reality, the current limited industry experience with PAG based lubricants combined with the wide range of application demands, operating environments, and differing user life expectations govern the need and frequency of lubricant changes.

The best approach to determining oil change frequency is for each "user" or "equipment builder" to base oil change frequency on lubricant sampling performed in conjunction with an experienced testing laboratory. Depending on the application, operating conditions, and service life demands, the sample testing might be suggested every year or ever five years. The results should be a guide for defining oil change frequencies.

Winsmith has not defined a required oil change frequency for the SE Encore series of worm gear speed reducers. In many indoor environments that are relatively contaminate free and under normally loaded application conditions, changing the lubricant may never be necessary within the desired life of the speed reducer. However, when operating in heavily loaded applications, high temperature, or contaminated environments, all lubricants will experience performance degradation over time. In these conditions, it is recommended to periodically change the lubricant to maximize the service life of the speed reducer components. Contact Winsmith for addition information on special lubrication requirements.

Glygoyle is a registered trademark of Exxon Mobil Corporation or one of its subsidiaries.

OVERHUNG LOAD AND THRUST

Maximum Allowable Overhung Load

Overhung load (OHL) is a radial force imposed on the shaft of the reducer at a position beyond the outmost bearing. The values given in this catalog are the maximum allowable overhung load (or chain pull) capacity, in pounds, and are based upon the load being applied one shaft diameter from the oil seal face (max bore diameter for hollow shaft units). These values are independent of any other external forces (i.e. thrust) and are limited by the lesser of the bearing capacity or the shaft size. As speed increases above 2500 RPM, the bearing capacity decreases, reducing the overall OHL capacity. Additionally, the allowable overhung load will decrease as the center of the load gets farther from the speed reducer. This is discussed in detail under “Location of Overhung Loads.” Contact Winsmith for OHL values of speed reducers with a bolt-on base (e.g. XDTS).

The bending moment capacity of the speed reducer, in pound-force inches (lbf-in), is determined by multiplying the OHL capacity by the distance from the bearing to the catalog OHL location ℓ. See Table 2 for values of ℓ.

Maximum Allowable Overhung Loads Based Upon Chain Pull

When a chain, gear, or belt drive is mounted to a reducer shaft, the OHL is estimated using the following equation:

OHL = Transmitted Torque / Pitch Radius of the mounted member x OHL Factor x Service Factor

This calculated value, in addition to the weight of the mounted member, must not exceed the allowable OHL capacity of the reducer. Overhung loads are subject to the same service factors that control the capacity of the reducer as well as the overhung load factors.

Overhung Load Factors

With a chain drive, the overhung load is equal to the torque divided by the radius of the sprocket because there is practically no pull on the loose side of the chain.

If an external gear or pinion is used, the overhung load is along the line of action and is greater than the load computed from the torque and pitch radius. In this case, AGMA recommends that the net overhung load derived from the torque and pitch radius of the gear be multiplied by an OHL factor of 1 1/4.

When a “V” belt sheave is specified, there is a pull on the loose side of the belt. In this case the sum of the pull on the tight side and on the loose side is the overhung load. AGMA recommends that the net overhung load derived from the torque be multiplied by an OHL factor of 1 1/2 to allow for this loose side tension.

A flat belt pulley requires a tension on the loose side to keep it tight. Therefore, AGMA recommends that the net overhung load derived from the torque be multiplied by an OHL factor of 2 1/2.

Variable speed drives, with a flat faced pulley on the reducer, and used with a “V” belt, derive their variability by changing the tension in the belt. In this case use an OHL factor of 2 1/2 to 3 1/2.

These factors are expressed in Table 1.

TABLE 1. OVERHUNG LOAD FACTORS

Type Of Load	Multiply The Actual Calculated OHL By:
Chain Sprocket	1
Gear or Pinion	1-1/4
“V” Belt	1-1/2
Flat Belt	2-1/2
Variable Speed Drive Pulley	3-1/2

Overhung Position and Direction Limitations

The overhung load capacities listed in this catalog may be used when the force from the chain pull is directed toward the base or applied parallel to the base on the near side of the sprocket as shown in Figure 1. These illustrations demonstrate the ideal chain pull conditions and should be used whenever possible.

When the force from the chain pull is directed away from the base or applied parallel to the base on the far side of the sprocket (as shown in Figure 2), it may be necessary to reduce the allowable overhung load capacity. Avoid these chain pull directions or contact Winsmith for assistance.

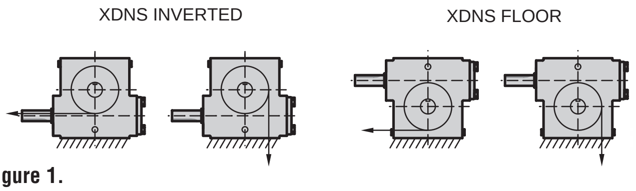


Figure 1.

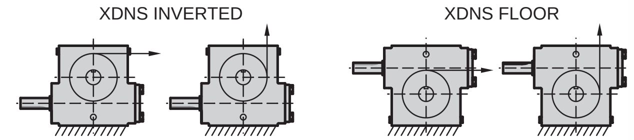


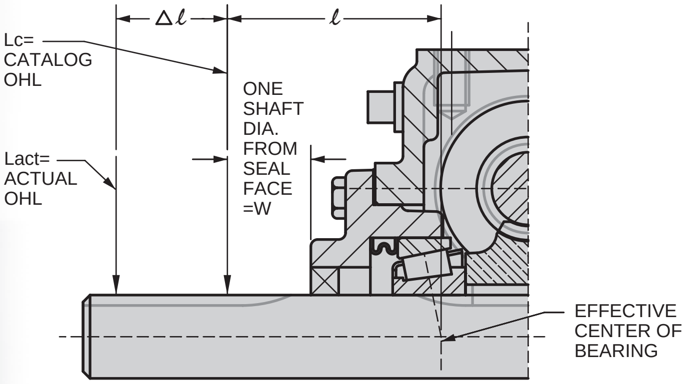
Figure 2.

SE Encore Series Overhung Load and Thrust

Location of Overhung Loads

In many cases, the center of the pulley, gear, or sprocket, which determines the location of the overhung load, does not coincide with the catalog position, “one shaft diameter from the seal face”. If the location of the overhung load is outside this position, then the allowable overhung load (La) can be determined from the equation:

$$La = Lc \times \left(\frac{\ell}{\ell+\triangle\ell}\right)$$



Where;

La = Allowable overhung load in pounds.

Lact = Actual overhung load.

Lc = Catalog rating of overhung load in pounds.

ℓ = A factor given in Table 2 (This is the actual distance from the effective center of the bearing to the reference location for the catalog OHL capacity).

$\triangle\ell$ = Distance from location of the actual overhung load to a point one shaft diameter from the seal face or housing.

Example:

An E30 XDNS reducer, with a gear ratio of 25:1, is subjected to a torque of 1500 lbf-in on the output shaft. The torque is transmitted through a chain sprocket of 3⁄4 pitch 23 teeth. The centerline of the sprocket is 5.00 inches from the center of the reducer. The service is 24 hours per day, uniform loading.

Data:

Service Factor = 1.25

Chain Overhung Load Factor = 1.0

Radius of 23 Tooth 3⁄4" Pitch Chain = 5.508"/2 = 2.754"

Catalog Overhung Load = 1350 lbs

Catalog OHL Location from Center of Housing = P - S + W = 5.88"- 2.88" + 1.375" = 4.375"

(Where P, S and W are taken from the E30 XDNS reducer layout shown in another section of this catalog)

Actual OHL Location from Center of Housing = 5.00"

ℓ (From Table 2) = 2.817"

$\triangle\ell$ = 5.00" - 4.375" = .625"

Design Overhung Load = Torque/Radius x Service Factor x OHL Factor = 1500/2.754 x 1.25 x 1.00 = 680 pounds

Allowable Overhung Load = La = Lc x ℓ /(ℓ + $\triangle\ell$) = 1350 x 2.817/(2.817 + .625)= 1105 pounds

Since the allowable OHL (1105 lbf) exceeds the design OHL (680 lbf), the unit can support the load.

TABLE 2. VALUE OF “ℓ” FOR SE ENCORE SPEED REDUCERS

Size	Solid Input Shaft			Output Shaft					
	SGL Reduction	DBL Reduction Worm-Worm	DBL Reduction Worm-Helical	Solid Output & Top Ext Vert.Output	Solid Output Bottom Ext Vert. Output	Hollow Output Except Drywell	Drop Bearing	Drywell Cover Side	Drywell Flange Side
E13	1.451			1.905	1.905				
E17	1.580	1.451		2.205	2.205	2.388			
E20	1.580	1.451		2.205	2.205	2.906			
E24	2.030	1.580	1.760	2.440	2.478	3.140			
E26	2.380	1.580	1.760	2.440	2.478	3.461	2.544		
E30	2.080	1.580	1.760	2.817	2.793	3.712	2.992	4.158	3.716
E35	2.980	1.580	1.760	3.303	3.303	4.103	3.312	4.715	3.914
E43	2.875	2.380	2.040	3.743	3.743	5.230	3.555	5.841	4.963

Maximum Allowable Thrust Load

The maximum allowable thrust load values (lbf) in this catalog assume that no simultaneous overhung load exists. Contact Winsmith if OHL and thrust loads exist simultaneously in the application.

SE Encore Series Thermal Limit Ratings

THERMAL LIMIT RATINGS[3]																								
Maximum input HP at 68°F (20°C) ambient temperature Single reduction with Mobil Glygoyle 460 lubricant																								
SIZE	RATIO[1]		5		7.5		10		15		20		25		30		40		50		60		80	
	INPUT RPM[2]	OUTPUT RPM	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)	INPUT HP	OUTPUT TORQUE (lbf•in.)
E13	Not Thermally Limited																							
E17																								
E20																								
E24																								
E26	2500	500	6.71	807	5.89	1055	5.08	1204	3.71	1286	2.94	1325	2.50	1382	2.13	1376	1.71	1416	1.43	1415	-	-	-	-
E30	2500	500	9.38	1134	8.34	1505	7.18	1715	5.33	1872	4.49	2070	3.70	2090	3.14	2084	2.52	2159	2.04	2097	-	-	-	-
	1750	350	10.49	1821	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
E35	2500	500	12.86	1562	10.90	1973	9.03	2157	6.58	2309	5.52	2545	4.75	2699	3.88	2575	3.20	2753	2.69	2804	2.32	2804	-	-
	1750	350	12.09	2093	11.62	3012	9.50	3254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E43	2500	500	19.27	2356	14.72	2673	11.89	3717	8.57	3021	7.06	3268	5.51	3106	4.81	3200	3.99	3438	3.43	3592	3.02	3686	2.42	3707
	1750	350	17.71	3086	13.50	3491	10.90	4873	7.87	3939	6.50	4267	5.09	4065	4.46	4197	3.73	4532	3.23	4764	2.86	4926	-	-
	1160	232	15.51	4056	11.80	4574	9.55	5848	6.93	5173	5.76	5631	4.59	5443	4.20	5900	3.74	6864	-	-	-	-	-	-
	870	174	13.96	4846	10.68	5486	8.65	7355	6.30	6218	5.26	6787	4.43	6980	4.08	7607	-	-	-	-	-	-	-	-
	600	120	12.13	6069	9.32	6886	7.58	11409	5.56	7847	4.68	8612	4.04	9077	3.74	9944	-	-	-	-	-	-	-	-
	300	60	9.49	9360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1. Exact ratio
2. If input speed is below 1160 RPM, please specify speed and mounting position to ensure proper lubrication.
3. If the input HP thermal capacity or limit exceeds the 1.00 service factor mechanical rating, then the reducer is not thermally limited and no thermal rating is shown in the above table.

Speed Reducer Backlash

Speed Reducer Backlash

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.

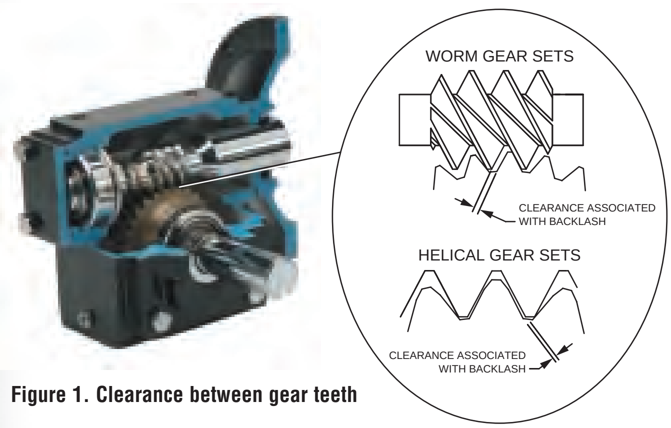


Figure 1. Clearance between gear teeth

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).

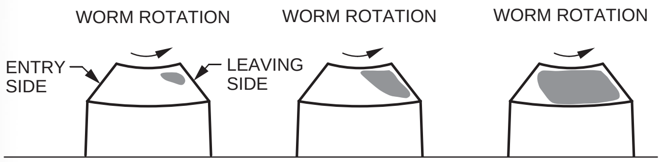


Figure 2. Bronze Gear Run-In

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 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 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.

Measuring Backlash

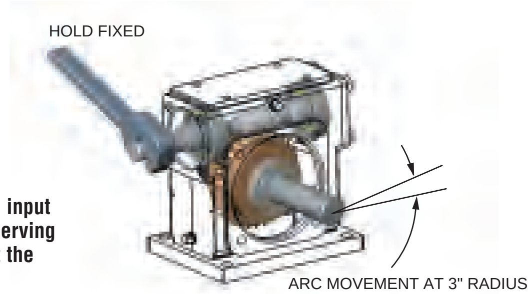


Figure 3. Fixed input shaft while observing the backlash at the output shaft

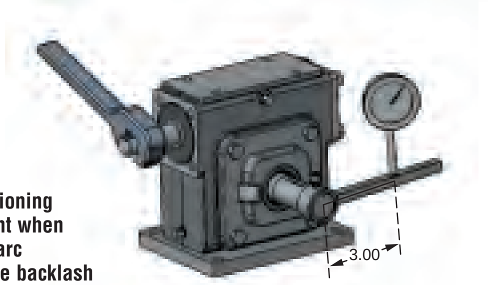


Figure 4. Positioning of the equipment when measuring the arc movement of the backlash

Speed Reducer Backlash

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:

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

2. Backlash in inches at a defined reference radius:

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

3. Backlash in arc minutes:

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

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

EXAMPLE:

.18 degrees x 60 = 10.8 arc minutes
.8 remainder x 60 = 48 arc seconds

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"	
2	.033°	.0017"	.0070"	.0279"	S-ELIMINATOR™
3	.050°	.0026"	.0105"	.0419"	
4	.067°	.0035"	.0140"	.0558"	
5	.083°	.0044"	.0176"	.0704"	
6	.100°	.0052"	.0209"	.0837"	C-ELIMINATOR
7	.117°	.0061"	.0244"	.0977"	
8	.133°	.0070"	.0279"	.1117"	
9	.150°	.0079"	.0314"	.1256"	
10	.167°	.0087"	.0349"	.1396"	
11	.183°	.0096"	.0384"	.1535"	C-MINIMIZER
12	.200°	.0105"	.0419"	.1675"	S-MINIMIZER
13	.217°	.0113"	.0454"	.1814"	
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"	SE Encore
28	.467°	.0244"	.0977"	.3908"	
29	.483°	.0253"	.1012"	.4047"	
30	.500°	.0262"	.1047"	.4187"	

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

Speed Reducer Efficiency and Run-in

Speed Reducer Efficiency

The efficiency of an SE Encore series worm gear speed reducer depends on many factors such as the lead angle of the worm threads, input speed to the reducer, operating load, and the temperature of the Mobil Glygoyle 460 lubricant.

The efficiencies published in this catalog are in accordance with ISO/DIS 14521.2 and are based on rated output torque, an operating temperature reflecting continuous operation, and Mobil Glygoyle 460 synthetic lubricant. If the operating temperature is not reached (such as with intermittent service), the operating efficiency will be less than rated efficiency. Speed reducer efficiency is optimized by performing a proper run-in during the initial use of a worm gear speed reducer.

When the rated efficiency is not listed in the catalog, it may be easily calculated in the following manner:

Efficiency = Output Horsepower / Input Horsepower

In order to establish the efficiencies of reducers where only the output torque and input horsepower are given, the output torque is converted to output horsepower by the following formula:

Output Horsepower = [Output Torque (lfb-in) x Output RPM] / 63,025

Speed Reducer Run-In

"Run-in," sometimes referred to as "break-in," is an important process required to optimize worm gear speed reducer service life. In many applications, concern or care relative to worm gear speed reducer run-in is not necessary. However, in some applications, properly addressing the interaction of the composite speed reducer materials may be critical to achieving desired service life expectations.

There are two significant elements of run-in. The first element is the run-in of the radial shaft lip seals and the respective mating shafts. Seal service life is dependent on many application and environmental factors; it can vary from 12 months to more than 10 years. However, the radial shaft lip seals in a speed reducer will reach their designed level of performance after an initial break-in period. It is normal and should be expected that the seal may permit some weepage of lubricant along the rotating shaft during the break-in period. After several hours of run-in, the seal and shaft will develop a conformal running surface with each other that will provide leak free operation throughout the components expected service life.

The second element is the run-in of the bronze gear and the case hardened worm input shaft. Worm gears operate using some degree of sliding action between the bronze gear and steel worm-on-shaft. Therefore, achieving the rated efficiency requires run-in time to obtain a work hardened surface on the bronze. Experience indicates that completing a run-in procedure lowers the initial friction in the gearset by 10 to 15 percent regardless of the bronze gear surface finish quality.

The gearing has a better chance of providing maximum performance and service life if part of the full working load is initially applied for a pre-set period of time. The first few hours of operation at gradually increasing loads will reduce the gearset friction. Gradually increasing to the full working load over 10 to 100 hours of operation will minimize the occurrence of any surface damage. Depending on the operating load and on the size and speed of the gearing, the efficiency will stabilize to a steady value during this period of run-in and the operating temperature will decrease (see Figure 1).

A reasonable run-in procedure consists of applying half the required load for a few hours and then increasing it to the full operating load in at least two stages. Applying the full load immediately concentrates high contact pressures on small areas. This may cause high local surface temperatures and some temporary damage to the surfaces. However, temporary damage to the bronze gear surfaces will often "heal" after continued running at full or less than full load.

In many applications, concern or care relative to worm gear speed reducer run-in is not necessary. However, in some applications, properly addressing the interaction of the composite speed reducer materials may be critical to achieving desired service life expectations.

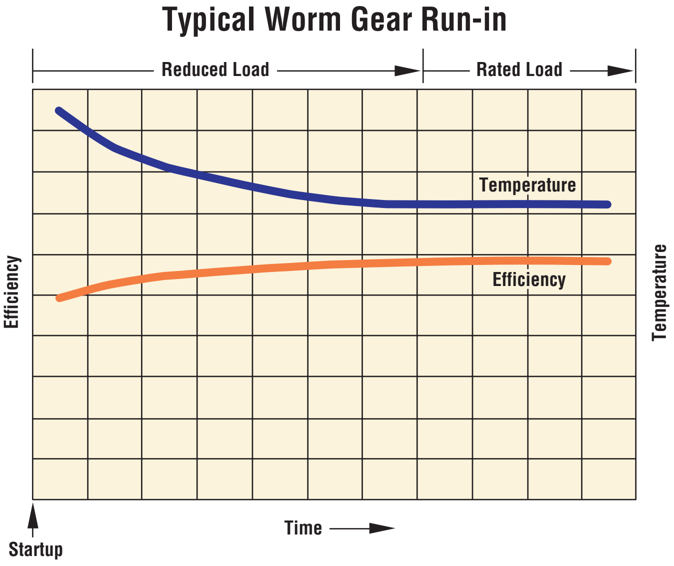

Typical Worm Gear Run-in

Figure 1. Operating temperature drop as a result of the increase in efficiency from a proper run-in procedure

Service Factor Section

Application service factors are used to adjust the SE Encore selection process to compensate for various loads that may be applied to the worm gear reducer during normal operation. Service factors are applied only to the mechanical rating and not the thermal rating of a worm gear reducer. The charts in this section have been expanded to include typical power transmission applications and their normal load rating. These charts are per AGMA standards. The ratings section of this catalog includes gear reducer rating tables for UNIFORM (1.00) load and service factored rating tables for MODERATE (1.25) and HEAVY (1.50) shock load applications.

Important Terms

APPLIED HP or TORQUE – This is the actual power applied to the input of the worm gear reducer by a drive or motor.

SERVICE FACTOR – Represents the adjustment needed in the APPLIED HP or TORQUE to insure the original design life of the SE Encore speed reducer is maintained in the application.

DESIGN HP or TORQUE – Include the appropriate service factor that accounts for the conditions under which the reducer will be used. Example: 1 HP APPLIED motor input times 1.25 SERVICE FACTOR results in a 1.25 DESIGN HP.

Load classifications are momentary changes in the applied load without changing direction or starting and stopping:

UNIFORM LOAD – Recurring shock loads that do not exceed the specified input or prime mover power.

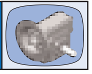
MODERATE SHOCK LOAD – Recurring shock loads that do not exceed 125% of the specified input or prime mover power.

HEAVY SHOCK LOAD – Recurring shock loads that do not exceed 150% of the specified input or prime mover power.

EXTREME SHOCK LOAD – Recurring shock loads that do not exceed 175% of the specified input or prime mover power.

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
AGITATORS (Mixers)			
Pure Liquids	–	1.00	1.25
Liquids and Solids	1.00	1.25	1.50
Liquids–Variable Density	1.00	1.25	1.50
BLOWERS			
Centrifugal	1.00	1.00	–
Lobe	1.00	1.25	1.50
Vane	–	1.00	1.25
BREWING AND DISTILLING			
Bottling Machinery	–	1.00	1.25
Brew Kettles, Continuous Duty	–	1.00	1.25
Cookers–Continuous Duty	–	1.00	1.25
Mash Tubs–Continuous Duty	–	1.00	1.25
Scale Hopper, Frequent Starts	1.00	1.25	1.50
CAN FILLING MACHINES	–	1.00	1.25
CAR DUMPERS	1.25	1.50	1.75
CAR PULLERS	1.00	1.25	1.50
CLARIFIERS	–	1.00	1.25
CLASSIFIERS	1.00	1.25	1.50
CLAY WORKING MACHINERY			
Brick Press	1.25	1.50	1.75
Briquette Machine	1.25	1.50	1.75
Pug Mill	1.00	1.25	1.50
COMPACTORS	1.50	1.75	2.00
COMPRESSORS			
Centrifugal	–	1.00	1.25
Lobe	1.00	1.25	1.50
Reciprocating, Multi-Cylinder	1.00	1.25	1.50
Reciprocating, Single-Cylinder	1.25	1.50	1.75

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
CONVEYORS–GENERAL PURPOSE			
Uniformly loaded or fed	–	1.00	1.25
Not uniformly fed	1.00	1.25	1.50
Reciprocating or shaker	1.25	1.50	1.75
CRANES			
Dry Dock			
Main Hoist	1.25	1.50	1.75
Auxiliary Hoist	1.25	1.50	1.75
Boom Hoist	1.25	1.50	1.75
Slewing Drive	1.25	1.50	1.75
Traction Drive	1.50	1.50	1.50
Container			
Main Hoist	Contact Winsmith		
Boom Hoist			
Trolley Drive			
(Gantry or Traction Drive)			
Mill Duty			
Main Hoist	Contact Winsmith		
Auxiliary			
Bridge and Trolley Travel			
Industrial Duty			
Main	1.00	1.25	1.50
Auxiliary	Contact Winsmith		
Bridge and Trolley Travel			
CRUSHER			
Stone or Ore	1.50	1.75	2.00
DREDGES			
Cable Reels	1.00	1.25	1.50
Conveyors	1.00	1.25	1.50



Service Factor Section

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
DREDGES (Continued)			
Cutter Head Drives	1.25	1.50	1.75
Pumps	1.00	1.25	1.50
Screen Drives	1.25	1.50	1.75
Stackers	1.00	1.25	1.50
Winches	1.00	1.25	1.50
ELEVATORS			
Bucket	1.00	1.25	1.50
Centrifugal Discharge	–	1.00	1.25
Escalators	Contact Winsmith		
Freight			
Gravity Discharge	–	1.00	1.25
EXTRUDERS			
General	1.25	1.25	1.25
Plastics			
Variable Speed Drive	1.50	1.50	1.50
Fixed Speed Drive	1.75	1.75	1.75
Rubber			
Continuous Screw Operations	1.50	1.50	1.50
Intermittent Screw Operations	1.75	1.75	1.75
FANS			
Centrifugal	–	1.00	1.25
Cooling Towers	Contact Winsmith		
Forced Draft	1.25	1.25	1.25
Induced Draft	1.00	1.25	1.50
Industrial & Mine	1.00	1.25	1.50
FEEDERS			
Apron	–	1.25	1.50
Belt	1.00	1.25	1.50
Disc	–	1.00	1.25
Reciprocating	1.25	1.50	1.75
Screw	1.00	1.25	1.50
FOOD INDUSTRY			
Cereal Cooker	–	1.00	1.25
Dough Mixer	1.00	1.25	1.50
Meat Grinders	1.00	1.25	1.50
Slicers	1.00	1.25	1.50
GENERATORS AND EXCITERS			
HAMMER MILLS			
HOISTS			
Heavy Duty	1.25	1.50	1.75
Medium Duty	1.00	1.25	1.50
Skip Hoist	1.00	1.25	1.50
LAUNDRY TUMBLERS			
LAUNDRY WASHERS			
LUMBER INDUSTRY			
Barkers			
Spindle Feet	1.25	1.25	1.50
Main Drive	1.50	1.50	1.50
Conveyors			
Burner	1.25	1.25	1.50
Main or Heavy Duty	1.50	1.50	1.50
Main Log	1.50	1.50	1.75
Re-Saw, Merry-Go-Round	1.25	1.25	1.50
Slab	1.50	1.50	1.75
Transfer	1.25	1.25	1.50
Chains			
Floor	1.50	1.50	1.50
Green	1.50	1.50	1.50

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
LUMBER INDUSTRY (Continued)			
Cut-off Saws			
Chain	1.50	1.50	1.50
Drag	1.50	1.50	1.75
Debarking Drums	1.50	1.50	1.75
Feeds			
Edger	1.25	1.25	1.50
Gang	1.50	1.50	1.50
Trimmer	1.25	1.25	1.50
Log Deck	1.50	1.50	1.50
Log Hauls–Incline–Well Type	1.50	1.50	1.50
Log Turning Devices	1.50	1.50	1.50
Planer Feed	1.25	1.25	1.25
Planer Tilting Hoists	1.50	1.50	1.50
Rolls–Live-off brg.–Roll Cases	1.50	1.50	1.50
Sorting Table	1.25	1.25	1.50
Tipple Hoist	1.25	1.25	1.50
Transfers			
Chain	1.50	1.50	1.50
Craneway	1.50	1.50	1.50
Tray Drives	1.25	1.25	1.50
Veneer Lathe Drives	Contact Winsmith		
METAL MILLS			
Draw Bench Carriage and Main Drive	1.00	1.25	1.50
Runout Tables, Non-reversing			
Group Drives	1.00	1.25	1.50
Individual Drives	1.50	1.50	1.75
Reversing	1.50	1.50	1.75
Slab Pushers	1.25	1.25	1.50
Shears	1.50	1.50	1.75
Wire Drawing	1.00	1.25	1.50
Wire Winding Machine	1.00	1.25	1.50
METAL STRIP PROCESSING MACHINERY			
Bridles	1.25	1.25	1.50
Coilers & Uncoilers	1.00	1.00	1.25
Edge Trimmers	1.00	1.25	1.50
Flatteners	1.00	1.25	1.50
Loopers (Accumulators)	1.00	1.00	1.00
Pinch Rolls	1.00	1.25	1.50
Scrap Choppers	1.00	1.25	1.50
Shears	1.50	1.50	1.75
Slitters	1.00	1.25	1.50
MILLS, ROTARY TYPE			
Ball & Rod			
Spur Ring Gear	1.50	1.50	1.75
Helical Ring Gear	1.50	1.50	1.50
Direct Connected	1.50	1.50	1.75
Cement Kilns	1.50	1.50	1.50
Dryers & Coolers	1.50	1.50	1.50
MIXERS, CONCRETE	1.00	1.25	1.50
PAPER MILLS			
Agitator (Mixer)	1.50	1.50	1.50
Agitator for Pure Liquors	1.25	1.25	1.25
Barking Drums	1.75	1.75	1.75
Barkers–Mechanical	1.75	1.75	1.75
Beater	1.50	1.50	1.50
Breaker Stack	1.25	1.25	1.25
Calender (anti-friction bearings only)	1.25	1.25	1.25
Chipper	1.75	1.75	1.75

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
PAPER MILLS (Continued)			
Chip Feeder	1.50	1.50	1.50
Coating Rolls	1.25	1.25	1.25
Conveyors			
Chip, Bark, Chemical	1.25	1.25	1.25
Log (including Slab)	1.75	1.75	1.75
Couch Rolls	1.25	1.25	1.25
Cutter	1.75	1.75	1.75
Cylinder Molds	1.25	1.25	1.25
Dryers (anti-friction bearings only)			
Paper Machine	1.25	1.25	1.25
Conveyor Type	1.25	1.25	1.25
Embosser	1.25	1.25	1.25
Extruder	1.50	1.50	1.50
Fourdriner Rolls (Includes Lumpbreaker, dandy roll, wire turning, and return rolls)	1.25	1.25	1.25
Jordan	1.25	1.25	1.25
Kiln Drive	1.50	1.50	1.50
Mt. Hope Rolls	1.25	1.25	1.25
Paper Rolls	1.25	1.25	1.25
Platter	1.50	1.50	1.50
Presses–Felt & Suction	1.25	1.25	1.25
Pulper	1.50	1.50	1.75
Pumps–Vacuum	1.50	1.50	1.50
Reel (Surface Type)	1.25	1.25	1.50
Screens			
Chip	1.50	1.50	1.50
Rotary	1.50	1.50	1.50
Vibrating	1.75	1.75	1.75
Size Press	1.25	1.25	1.25
Thickener (AC Motor)	1.50	1.50	1.50
(DC Motor)	1.25	1.25	1.25
Washer (AC Motor)	1.50	1.50	1.50
(DC Motor)	1.25	1.25	1.25
Wind & Unwind Stand	1.00	1.00	1.00
Winders (Surface Type)	1.25	1.25	1.25
Yankee Dryers (anti-friction bearings only)	1.25	1.25	1.25
PLASTICS INDUSTRY–PRIMARY PROCESSING			
Intensive Internal Mixers			
Batch Mixers	1.75	1.75	1.75
Continuous Mixers	1.50	1.50	1.50
Batch Drop Mill–2 smooth rolls	1.25	1.25	1.25
Continuous Feed, Holding & Blend Mill	1.25	1.25	1.25
Compounding Mills	1.25	1.25	1.25
Calenders	1.50	1.50	1.50
PLASTICS INDUSTRY–SECONDARY PROCESSING			
Blow Molders	1.50	1.50	1.50
Coating	1.25	1.25	1.25
Film1.25	1.25	1.25	-
Pipe	1.25	1.25	1.25
Pre-plasticizers	1.50	1.50	1.50
Rods	1.25	1.25	1.25
Sheet	1.25	1.25	1.25
Tubing	1.25	1.25	1.50
PULLERS–BARGE HAUL	1.00	1.50	1.75
PUMPS			
Centrifugal	–	1.00	1.25
Proportioning	1.00	1.25	1.50

APPLICATION	SERVICE FACTORS		
	UP TO 3 HRS. DAY	3-10 HRS. DAY	OVER 10 HRS. DAY
PUMPS (Continued)			
Reciprocating			
Single Acting, 3 or more cylinders	1.00	1.25	1.50
Double Acting, 2 or more cylinders	1.00	1.25	1.50
Rotary			
Gear Type	–	1.00	1.25
Lobe	–	1.00	1.25
Vane	–	1.00	1.25
RUBBER INDUSTRY			
Intensive Internal Mixers			
Batch Mixers	1.50	1.75	1.75
Continuous Mixers	1.25	1.50	1.50
Mixing Mill–2 smooth rolls–(If corrugated rolls are used, then use the same service factors that are used for a Cracker Warmer.)	1.50	1.50	1.50
Batch Drop Mill–2 smooth rolls	1.50	1.50	1.50
Cracker Warmer–2 roll; 1 corrugated roll	1.75	1.75	1.75
Cracker Warmer–2 corrugated rolls	1.75	1.75	1.75
Holding, Feed & Blend Mill–2 rolls	1.25	1.25	1.25
Refiner–2 rolls	1.50	1.50	1.50
Calenders	1.50	1.50	1.50
SAND MILLER			
SEWAGE DISPOSAL EQUIPMENT			
Bar Screens	–	1.00	1.25
Chemical Feeders	–	1.00	1.25
Dewatering Screens	1.00	1.25	1.50
Scum Breakers	1.00	1.25	1.50
Slow or Rapid Mixers	1.00	1.25	1.50
Sludge Collectors	1.00	1.00	1.25
Thickeners	1.00	1.25	1.50
Vacuum Filters	1.00	1.25	1.50
SCREENS			
Air Washing	–	1.00	1.25
Rotary-Stone or Gravel	1.00	1.25	1.50
Traveling Water Intake	–	1.00	1.25
SUGAR INDUSTRY			
Beet Slicer	1.50	1.50	1.75
Cane Knives	1.50	1.50	1.50
Crushers	1.50	1.50	1.50
Mills low speed end	1.50	1.50	1.50
TEXTILE INDUSTRY			
Batchers	1.00	1.25	1.50
Calenders	1.00	1.25	1.50
Cards	1.00	1.25	1.50
Dry Cans	1.00	1.25	1.50
Dryers	1.00	1.25	1.50
Dyeing Machinery	1.00	1.25	1.50
Looms	1.00	1.25	1.50
Mangles	1.00	1.25	1.50
Nappers	1.00	1.25	1.50
Pads	1.00	1.25	1.50
Slashers	1.00	1.25	1.50
Soapers	1.00	1.25	1.50
Spinners	1.00	1.25	1.50
Tenter Frames	1.00	1.25	1.50
Washers	1.00	1.25	1.50
Winders	1.00	1.25	1.50

Momentary Overloads And Frequent Starts And Stops

Normal starting , or occasional momentary peak loads up to 300% of catalog rating at 1750 RPM (maximum of 2 seconds each occurrence) and that occur two or three times per day are permissible when using a service factor of 1.0. If either of these values is exceeded, a service factor of 1.5 should be used. Heavy starting loads may be encountered when the output shaft of the reducer is directly coupled to larger gears or heavy masses. In these cases, a service factor of 2.0 should be used. Reversing drives and those subjected to quickly repeated shock loads of unusual or unpredictable intensity and stalling loads, drives that are overrunning, or that “wind up” due to quick power stoppage and storage of energy are not covered by the service factors above. In these cases, a service factor of at least 3.0 is recommended. Applications with frequent starts and stops should be evaluated using Winsmith’s Full Duty Cycle selection method that is detailed in the Motion Control Products catalog, available at www.WINSMITH.com.

CONVERSION TABLE

To Find Equivalent Service Factor When Using Single or Multi-Cylinder Engines.

For Hydraulic or Electric Motor Service Factor of:	Use this Service Factor for Single Cylinder Engines	Use this Service Factor for Multi-Cylinder Engines
1.00	1.50	1.25
1.25	1.75	1.50
1.50	2.00	1.75
1.75	2.25	2.00
2.00	2.50	2.25

AGMA SERVICE FACTOR CHART BASED ON LOAD CLASSIFICATION

Prime Mover	Duration of Service Per Day	Uniform	Driven Machine Load Classifications		
			Moderate Shock	Heavy Shock	Extreme Shock
Electric and	Occasional 1/2 hour	1.00	1.00	1.00	1.25
Hydraulic Motors	Less than 3 hours	1.00	1.00	1.25	1.50
(See above chart for	3-10 hours	1.00	1.25	1.50	1.75
internal combustion engines)	Over 10 hours	1.25	1.50	1.75	2.00

FOLLOWING SERVICE FACTORS APPLY FOR APPLICATIONS INVOLVING FREQUENT STARTS AND STOPS

Prime Mover	Duration of Service Per Day	Uniform	Driven Machine Load Classifications		
			Moderate Shock	Heavy Shock	Extreme Shock
Electric and	Occasional 1/2 hour	1.00	1.00	1.25	1.50
Hydraulic	Less than 3 hours	1.00	1.25	1.50	1.75
Motors	3-10 hours	1.25	1.50	1.75	2.00
	Over 10 hours	1.50	1.75	2.00	2.25

Resource Guide and Conversion Tables

LENGTH AND DISTANCE

From/To	in	ft	mm	cm	m
in	1	0.0833	25.4	2.54	0.0254
ft	12	1	304.8	30.48	0.3048
mm	0.03937	0.00328	1	0.1	0.001
cm	0.3937	0.03281	10	1	0.01
m	39.37	3.281	1000	100	1

MASS

From/To	gm	kg	slug	lb(m)	oz(m)
gm	1	.001	6.852 x 10^{-5}	2.205 x 10^{-3}	.03527
kg	1000	1	6.852 x 10^{-2}	2.205	35.274
slug	14590	14.59	1	32.2	514.72
lb(m)	453.6	.45359	.0311	1	16
oz(m)	28.35	.02835	1.94 x 10^{-3}	0.0625	1

FORCE

From/To	lb(f)	N	ozf	kgf	gmf
lbf	1	4.4482	16	.45359	453.6
N	.22481	1	3.5967	.10197	-
ozf	.0625	.27801	1	.02835	28.35
kgf	2.205	9.80665	35.274	1	1000
gmf	2.205x10^{-3}	-	.03527	.001	1

Note: lbf = 1 slug x 1 ft/s2 N = 1 kg x 1 m/s2

MATERIAL DENSITIES

From/To	oz/in³	in/lb³	gm/cm³
Aluminum	1.570	0.098	2.720
Brass	4.960	0.310	8.600
Bronze	4.720	0.295	8.170
Copper	5.150	0.322	8.910
Plastic	0.640	0.040	1.110
Steel	4.480	0.280	7.750
Hard Wood	0.460	0.029	0.800
Soft Wood	0.280	0.018	0.480

TEMPERATURE

F = (1.8 X C) + 32
C = .555 (F - 32)

GRAVITY

(Acceleration Constant)

$$G = \frac{386.1\ \text{in}}{s^2} = \frac{32.17\text{ft}}{s^2} = \frac{9.806\text{m}}{s^2}$$

ABBREVIATED TERMS

C = Celsius
cm = centimeter
F = Fahrenheit
ft = foot
gm = gram
gmf = gram force
in = inch
kg = kilogram

kgf = kilogram force
lbf = pound force
lbm = pound mass
mm = milimeter
m = meter
N = Newton
ozf = ounce force
ozm = ounce mass

TORQUE

From/To	gmf-cm	ozf-in	kgf-cm	lbf-in	N-m	ibf-ft	kgf-m
gmf-cm	1	1.388 x 10^{-2}	10_{-3}	8.679 x 10^{-4}	9.806 x 10^{-5}	7.233 x 10^{-5}	10^{-5}
ozf-in	72.007	1	7.200 x 10^{-2}	6.25 x 10^{-2}	7.061 x 10^{-3}	5.208 x 10^{-3}	7.200 x 10^{-4}
kgf-cm	1000	13.877	1	.8679	9.806 x 10^{-2}	7.233 x 10^{-2}	10^{-2}
lbf-in	1.152 x 10^{3}	16	1.152	1	.113	8.333 x 10^{-2}	1.152 x 10^{-2}
N-m	1.019 x 10^{4}	141.612	10.197	8.850	1	.737	.102
lbf-ft	1.382 x 10^{4}	182	13.825	12	1.356	1	.138
kgf-m	10^{5}	1.388 x 10^{3}	100	86.796	9.806	7.233	1

INERTIA (ROTARY)

From/To	gmf-cm²	oz-in²	gmf-cm-s²	kg-cm²	lb-in²	oz-in-s²	lb-ft²	kg-cm-s²	lb-in-s²	lb-ft-s² or slug-ft-s²
gm-cm²	1	5.46 x 10^{-3}	1.02 x 10^{-3}	10^{-3}	3.417 x 10^{-4}	1.41 x 10^{-5}	2.37 x 10^{-6}	1.02 x 10^{-6}	8.85 x 10^{-7}	7.38 x 10^{-8}
oz-in²	182.9	1	.187	.183	.0625	2.59 x 10^{-3}	4.34 x 10^{-4}	1.86 x 10^{-4}	1.61 x 10^{-4}	1.35 x 10^{-5}
gm-cm-s²	980.6	5.361	1	.981	.335	1.39 x 10^{-2}	2.33 x 10^{-3}	10^{-3}	8.68 x 10^{-4}	7.23 x 10^{-5}
kg-cm²	1000	5.467	1.019	1	.342	1.42 x 10^{-2}	2.37 x 10^{-3}	1.02 x 10^{-3}	8.85 x 10^{-4}	7.38 x 10^{-5}
lb-in²	2.92 x 10^{3}	16	2.984	2.925	1	4.14 x 10^{-2}	6.94 x 10^{-3}	2.98 x 10^{-3}	2.59 x 10^{-3}	2.15 x 10^{-4}
oz-in-s²	7.06 x 10^{4}	386.1	72.0	70.62	24.13	1	.168	7.20 x 10^{-2}	6.25 x 10^{-2}	5.21 x 10^{-3}
lb-ft²	4.21 x 10^{5}	2304	429.4	421.3	144	5.963	1	.430	.373	3.10 x 10^{-2}
kg-cm-s²	9.81 x 10^{5}	5.36 x 10^{3}	1000	980.6	335.1	13.887	2.327	1	.868	7.23 x 10^{-2}
lb-in-s²	1.129 x 10^{6}	6.18 x 10^{3}	1.152 x 10^{3}	1.13 x 10^{3}	386.1	16	2.681	1.152	1	8.33 x 10^{-2}
lb-ft-s² or slug-ft²	1.355 x 10^{7}	7.42 x 10^{4}	1.38 x 10^{4}	1.35 x 10^{4}	4.64 x 10^{3}	192	32.17	13.823	12	1

USEFUL FORMULAS

Required	Given	Formulas
Velocity or belt speed (V) in FPM	**Pitch Diameter of pulley in inches & RPM of shaft**	**$V = .262 \times P.D. \times RPM$**
RPM	Belt Speed or Velocity (FPM) P.D. of pulley in inches	$RPM = \frac{V}{.262 \times P.D.}$
P.D. of pulley in inches	Belt speed or Velocity (V) in FPM RPM of shaft	$P.D. = \frac{V}{.262 \times RPM}$
Horsepower (HP)	Force (F) in lbf. Belt speed or Velocity (V) in FPM	$HP = \frac{F \times V}{33{,}000}$
Horsepower (HP)	Torque (T) in lbf-in. RPM of shaft	$HP = \frac{T \times RPM}{63{,}025}$
Torque (t) in lbf-in.	Force (F) in lbf. Pulley radius (R) in. inches	$t = F \times R$
Torque (t) in lbf-in.	Horsepower (HP) RPM of shaft	$t = \frac{63{,}025 \times HP}{RPM}$
Torque (T) in lbf-ft	Horsepower (HP) RPM of shaft	$T = \frac{5{,}252 \times HP}{RPM}$
Force (F) in lbf	Horsepower (HP) Belt speed or Velocity (V) in FPM	$F = \frac{33{,}000 \times HP}{V}$
RPM of shaft	Horsepower (HP) Torque (T) in lbf-in.	$RPM = \frac{63{,}025 \times HP}{T}$
Effective Tension (Te) in lbf.	Torque (T) P.D. of pulley in inches	$Te = \frac{2 \times T}{P.D.}$
Torque (T) in lbf-ft due to inertia	Inertia (WR^2) in lbf-ft.^{2} Initial RPM_1 Final RPM_2 Time in seconds (t)	$T = \frac{(WR^2) \times (RPM_2 - RPM_1)}{307.6 \times t}$
Inertia (J_S) System including Motor and Gear Drive	Motor Inertia (J_M) Ratio of Gear Drive (M_G) Load Inertia (J_L) Gear Drive Inertia (J_G) Related to Input Coupling Inertia (J_C)	$J_S = J_C + J_M + J_G + \frac{1}{M_G^2} J_L$
Inertia Matching	Above	$JM : J_C + J_G + \frac{1}{M_G^2} J_L$

Horsepower And Torque

One (1) Horsepower (HP) = 33,000 foot pounds (lbf-ft) of work done in one (1) minute. Note that three (3) factors are involved:

Distance (ft)
Force (lbf)
Time (min)

Putting it another way, one (1) HP is equivalent to raising 33,000 pounds, one foot in one minute horsepower can be determined by the following formula:

$$HP = \frac{L \text{ (Load in lbf)} \times \text{Feet per minute}}{33{,}000}$$

To determine the relationship between horsepower and torque let:

HP = Horsepower
T = Torque in foot-pounds (lbf-ft)
t = Torque in inch-pounds (lbf-in)
N = R.P.M. (revolutions per minute)

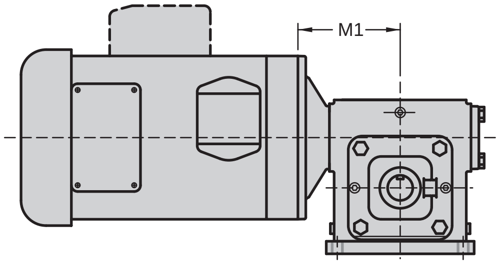
Then, one (1) HP = A Torque (Twisting force) of 63,025 inch pounds, turning 1 revolution in 1 minute.

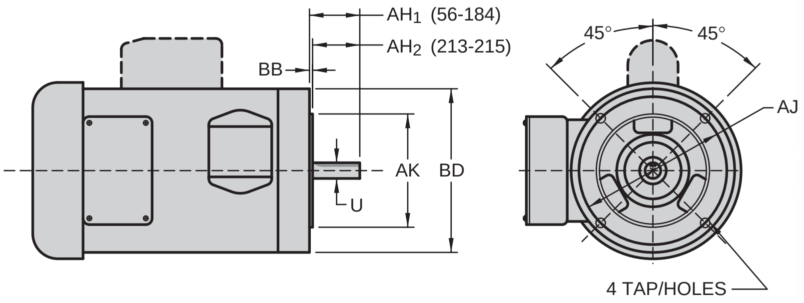
Therefore,

$$HP = \frac{t \times N}{63{,}025} \text{ or } \frac{T \times N}{5250} \text{ ; } t = \frac{63{,}025 \times HP}{N} \text{ or } T = \frac{5250 \times HP}{N}$$

NEMA/IEC Frame Reference Dimensions

NEMA/IEC FRAME SIZES





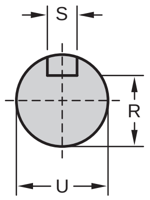
NEMA QUICK REFERENCE GUIDE

NEMA FRAME	U	AU$_1$	AU$_2$	AJ	AK	BB	BD	TAP
42	3/8	1-5/16	N/A	3-3/4	3	1/8	4-5/8	1/4-20
48	1/2	1-11/16	N/A	3-3/4	3	1/8	5-5/8	1/4-20
56	5/8	2-1/16	N/A	5-7/8	4-1/2	1/8	6-1/2	3/8-16
143T 145T	7/8	2-1/8	N/A	5-7/8	4-1/2	1/8	6-1/2	3/8-16
182	7/8	2-1/8	N/A	5-7/8	4-1/2	1/8	6-1/2	3/8-16
184	7/8	2-1/8	N/A	5-7/8	4-1/2	1/8	6-1/2	3/8-16
182T	1-1/8	2-5/8	N/A	7-1/4	8-1/2	1/4	9	1/2-13
184T	1-1/8	2-5/8	N/A	7-1/4	8-1/2	1/4	9	1/2-13
213	1-1/8	N/A	2-3/4	7-1/4	8-1/2	1/4	9	1/2-13
215	1-1/8	N/A	2-3/4					
213T	1-3/8	N/A	3-1/8					
215T	1-3/8	N/A	3-1/8					

SIZE	42C-48C	56C-140TC	180TC	210TC
	M$_1$	M$_1$	M$_1$	M$_1$
E13	▲3.56	3.63	N/A	N/A
E17	4.06	4.06	N/A	N/A
E20	4.06	4.06	N/A	N/A
E24	N/A	5.38	5.38	N/A
E26	N/A	5.38	5.38	N/A
E30	N/A	5.56	5.56	N/A
E35	N/A	5.81	5.81	N/A
E43	N/A	6.63	6.63	6.63

▲56C adaptor only

NEMA KEY & KEYWAY DIMENSIONS



NEMA SHAFT	KEYWAY DIMENSIONS	
(U)	(R)	(S)
3/8	21/64	FLAT
1/2	29/64	FLAT
5/8	33/64	3/16
7/8	49/64	3/16
1-1/8	63/64	1/4
1-3/8	1-13/64	5/16

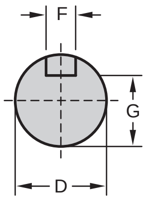
IEC B-5 FRAME QUICK REFERENCE GUIDE

IEC FRAME	U	AH$_1$	AJ	AK	BB	BD	HOLE
63	11	23	115	95	3	140	9
71	14	30	130	110	3.5	160	10
80	19	40	165	130	3.5	200	11
90	24	50	165	130	3.5	200	12
100	28	60	215	180	4	250	14
112	28	60	215	180	4	250	14
132	38	80	265	230	4	300	14

IEC B-14 FRAME QUICK REFERENCE GUIDE

IEC FRAME	U	AH$_1$	AJ	AK	BB	BD	TAP
63	11	23	75	60	2.5	90	M5
71	14	30	85	70	2.5	105	M6
80	19	40	100	80	3	120	M6
90	24	50	115	95	3	140	M8
100	28	60	130	110	3.5	160	M8
112	28	60	130	110	3.5	160	M8
132	38	80	165	130	3.5	200	M8

IEC KEY & KEYWAY DIMENSIONS



FRAME	D	G	F
63	11	8.5	4
71	14	11	5
80	19	15.5	6
90	24	20	8
100	28	24	8
112	28	24	8
132	38	33	10

Speed Reducer Specification Sheet

The worm gear reducer shall be made available with six input options and shall have the ability to be supplied with single and double reduction.

The input options shall consist of the following:

- Quill input adaptor to allow for connection to electric motors, utilizing a keyed hollow shaft suitable for direct attachment to a motor. The hollow motor input shaft shall be factory coated with a anti seize lubricant
- Coupled input adaptor to allow for the use of a flexible coupling to connect electric motors to the reducer.
- Hydraulic and servo motor input adaptors must be available.
- Non-Motorized and metric input adaptors must also be available.
- Solid input shafts shall be supplied with a key and can be used with a pulley and belt configuration.

The housings and covers shall be made of cast iron. All metal mating surfaces including, the input and output covers and motor adaptor flanges, shall be sealed with O-rings. The housings shall be designed with internal and external ribs and reinforced areas to handle the dynamic and static loads the reducers will experience during operation. Optional bolt on items such as bases, torque arms and brackets shall be made of steel.

The reducer and all add-on components shall be coated with an 8 mil (minimum) thick epoxy coating system. The epoxy coating shall have a minimum 60% solids loading when wet. Prior to coating, the reducer shall be prepared in a three stage hot iron phosphate dip process. The three stages shall consist of a hot iron phosphate dip, and rinse dip and a rust preventative dip. The coating system must be a 2 part, direct to metal, epoxy and must achieve an 8 mils dry thickness, minimum. The coating system shall exceed a 1,000 hour salt spray test per ASTM B-117 with no signs of degradation.

The input worm gear shall be made of alloy steel that is case hardened to a minimum Rockwell-C (RC) of 58.

The reducer shall be equipped with a vent that can be opened or closed by the operator. The vent shall have a labyrinth design to prevent high pressure wash down liquid from entering the reducer. The vent shall be made of black industrial duty, injection molded DuPont™ Zytel® Nylon with UV protection.

The reducers shall be filled and shipped with Mobil Glygoyle 460 polyalkylene glycol (PAG) synthetic lubrication (exception for Drywell reducers). The lubricant shall conform to NSF H1 (formerly USDA) certification. The bearings and reducer gears shall be splash lubricated.

Tapered roller bearings shall be utilized on the output shaft and either tapered roller or ball bearings shall be used on the input shafts. The bearings shall provide a minimum of 10,000 (or 6,250 L_{10}) hour average life. A crush ring shall be utilized to ensure the proper positioning of the output shaft taper roller bearings. The use of the crush ring allows for the automatic setting of the end play, 0" to 0.002", of the taper roller bearings.

The reducers with quill input adaptors shall include hydrogenated acrylonitrile butadiene rubber (HNBR) or fluroelastomer (aka Viton®) seals on the input shaft. The seals shall have a minimum temperature range of -40 to 300°F (-40 to 149°C). Shafts are to be center ground and then plunge ground to provide a seal surface of 16 to 20 micro inches Ra.

Reducers shall not include any silicon rubber of any type.

Fasteners shall be a minimum of Grade 5 except for the base mounting bolts shall be a minimum of Grade 8.

The reducer shall be supplied with multiple drain, fill and vent holes located in manner that facilitates maintenance and ventilation. The multiple holes allow for the reducer to be installed in all possible mounting positions including worm low. The drain and fill holes shall be shipped with threaded pipe plugs installed that are coated with a sealant and thread locking compound. The plugs shall be square head external type.

All reducers must be air pressure tested with a mass flow tester at 8 psi prior to shipment with no leak paths evident.

Motor adaptor flanges shall have threaded push off holes to facilitate the removal of motors. The holes shall have cast iron reinforcing boss pads that have minimum 1.5 times the number of threads than the hole diameter.

All hollow shaft models shall be supplied with symmetrical output shafts. The output shafts shall have puller slots machined into them to allow for removal of the reducer from the mounting shaft. The slots are designed for use with a hub puller. The hollow shafts shall have two (2) set screws set 65° apart to allow for maximum torque gripping transfer. Stainless steel output shafts shall be made available upon request.

Notes

Appendix

Notes

Warnings And Cautions

WARNING

Warnings

Winsmith products, and associated equipment and machinery, are intended for selection and use by trained and skilled persons capable of determining their suitability for the specific application or use. Proper selection, installation, operation and maintenance, including implementation of adequate safety precautions, are the responsibility of the purchaser or user. The following safety precautions, as well as additional safety precautions that may be required for the specific application or use, are the responsibility of the purchaser or user. FAILURE TO OBSERVE REQUIRED SAFETY PRECAUTIONS COULD RESULT IN SERIOUS INJURY TO PERSONS OR PROPERTY OR OTHER LOSS.

Lock-out/Tag-out

It is EXTREMELY IMPORTANT that equipment or machinery does not unexpectedly start. To prevent this possibility, all electrical or other input power sources must be turned off, and properly locked out. Tag out procedures must be followed before working on or near the reducer or any associated equipment. Loads on the input and output shafts should be disconnected prior to working on any reducer. Failure to observe these precautions may result in serious bodily injury and/or property damage.

Grounding

Be sure the unit and associated equipment are properly grounded and otherwise installed in accordance with all electrical code requirements.

Protective Guarding / Loose Clothing, etc.

Always insure there is proper protective guarding over all rotating or moving parts. Never allow loose clothing, hair, jewelry and the like to be worn in the vicinity of rotating or moving parts or machinery. The purchaser or user is responsible for complying with all applicable safety codes. Failure to do so may result in serious bodily injury and/or damage to property or other loss.

Selection & Installation

This reducer and associated equipment must be selected, installed, adjusted and maintained by qualified personnel who are knowledgeable regarding all equipment in the system and the potential hazards involved.

Consult Catalog Ratings.

Load, torque and other requirements must not exceed the published ratings in the current catalog and/or on the speed reducer nameplate, and the reducer selected must be consistent with all service factors for the application. See Winsmith catalogs and www.WINSMITH.com.

Brake Torque Loads.

Whenever a brake or any other stopping force is involved in an application, braking torque loads imposed on the gear reducer must not exceed the allowable load ratings.

Not a Brake

Speed reducers should never be used to provide the function of a fail safe brake or an assured self locking device. Speed reducers must never be used to replace a brake or a critical braking application function.

Excess Overhung Loads

Excessive overhung loads on the input or output shafts of a gear reducer may cause premature fatigue failures of the bearings and/or shafts. Mount gears, pulleys and sprockets as close to the housing as possible to minimize such loads. Do not exceed catalog ratings.

Excess Thrust Loads

Excessive thrust loads on the input or output shafts of a gear reducer may cause premature failure of bearings. Do not exceed catalog ratings.

Page 1 of 2

WARNING

Alignment

Properly align any input and output power transfer elements connected to the speed reducer. Even slight misalignments in a rigid mounting system may cause binding, large vibration forces or excessive overhung loads, leading to premature bearing, shaft, or speed reducer failure. Use of flexible couplings that allow the reducer and connected transfer elements to self-align during operation will compensate for minor misalignments.

Not a Support Structure

A speed reducer must never be used as an integral component of a machine superstructure or support frame that would subject it to additional loads other than properly rated loads transmitted through the shafts.

Mounting Position

Your Winsmith gear reducer should be mounted in one of the mounting positions shown in the catalog. Different mounting positions should not be used without contacting Winsmith as this may result in improper lubrication.

Overhead Mounting

Mounting of a speed reducer in overhead positions may be hazardous. Use of external support rails or structure is strongly recommended for any overhead mounting.

Lifting Eyebolts

Any lifting supports or eyebolts provided on the gear reducer are supplied with the purpose to vertically lift the gear reducer only, without any other attachments or motors. Inspect such supports and bolts before each use.

Properly Secure Mounting Bolts

Proper mounting bolts and proper torques must be applied and maintained to insure the gear reducer is securely mounted to the desired machinery. Inspect regularly as machine vibration may loosen fasteners.

Thread Locking Compound

Proper thread locking compound should be appropriately applied to the cleaned threads of all mounting bolts connecting or securing the speed reducer to equipment and any drive, accessories, or brake components attached to the speed reducer. If at any time after installation a factory supplied assembly or construction bolt is removed, care must be taken to thoroughly clean off the old thread locking compound and a new appropriate thread locking compound must be applied. Failure to properly apply new thread locking compound on all mounting or reducer construction bolts may result in serious injury or death from falling mechanical components.

Reducer Surface Is Hot

Operating gear reducers generate heat. Surface temperatures may become hot enough to cause severe burns. Proper personal protective equipment should be used.

Noise

Operating gear reducers may generate high noise levels. Use appropriate hearing protection and avoid extended exposure to high noise levels.

Lubricants Hot and Under Pressure

The temperature of lubricants inside a gear reducer may be very high. The reducer should be allowed to cool to ambient temperature before removal of any vent, drain, level, or fill plugs, and before removing seals or bearing covers. Gear reducers without a pressure vent may also be under great internal pressure. Slowly loosen the lubricant fill plug above the lubricant level to vent any internal pressure before further disassembly.

Lubricant Contact

Contact with lubricants can present safety concerns. Proper personal protective equipment should be used whenever handling speed reducer lubricants. Consult the lubricant MSDS sheet which is often available on the lubrication manufacturer’s website.

FDA, USDA, and NSF Applications

Factory supplied lubricants may not be suitable or safe for applications involving food, drugs and similar products. This includes applications subject to FDA, USDA, NSF or other regulatory jurisdiction. Consult the lubricant supplier or Winsmith for acceptable lubricants.

Inspection and Lubrication

Regularly inspect the gear reducer to ensure it is properly operating, and follow the all maintenance, operation and lubrication guidelines provided.

Terms And Conditions Of Sale

ENTIRE AGREEMENT

The parties agree that there are no understandings, agreements or representations, express or implied, not specified herein, respecting this offer or sale, and that this instrument contains the entire agreement between Seller and Buyer. No prior waiver, course of prior dealing or usage of the trade shall be relevant to supplement or to explain terms used in this agreement.

CONTROLLING TERMS

All sales are expressly limited to, and the rights and liabilities of the parties shall be governed exclusively by, the terms and conditions herein. In the event any purchase order or offer from Buyer states terms additional to or different from those set forth herein, this document shall be deemed a notice of objection to such additional or different terms and a rejection thereof. Any acknowledgment or shipment of product by Seller to Buyer subsequent to Seller's receipt of a purchase order or offer from Buyer shall not be deemed to be an acceptance by Seller of an offer to contract on the basis of any Buyer's terms and conditions. Receipt and acceptance by Buyer of products shall be conclusive evidence of Buyer's acceptance of the terms and conditions set forth herein as the sole controlling terms and conditions of the contract between Seller and Buyer. Stenographic and clerical errors by Seller are subject to correction.

ACCEPTANCE OF ORDERS

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All prices are subject to change without notice and shall be adjusted to the Seller's prices in effect on the date of shipment. Prices reflect standard packaging for domestic shipment only. All prices are in U.S. Dollars. All tooling and equipment Seller produces or acquires for purposes of filling this order shall remain property of Seller. All intellectual property associated with the products shall remain the sole property of Seller.

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Delivery dates are estimates and not a guaranty of a particular day of delivery and are based on the prompt receipt of all necessary information from the Buyer. Seller shall not be liable for failure or delay in shipping goods hereunder if such failure or delay is due to an act of God, fire, flood, war, labor difficulties, accident, strikes, lockouts, civil disorders, governmental priorities or embargoes, inability or difficulty in obtaining raw materials or supplies at customary terms and prices or any other causes or failure of presumed conditions of any kind whatsoever which are either beyond the reasonable control of the Seller or which would make impracticable the fulfillment of Seller's obligations hereunder. Buyer shall not refuse to accept deliveries so delayed. Seller shall be compensated for any and all extra costs and expenses occasioned by delays attributable to Buyer.

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All shipments are freight collect unless eligible for a freight allowance expressly set forth in current price sheets or on the face hereof. Seller reserves the right to select the method and type of transportation. If a method of transportation other than that selected by Seller is requested by Buyer, excess packing, shipping and transportation charges resulting from compliance with Buyer's request shall be for the Buyer's account. All shipments are F.O.B. point of shipment and risk of loss shall pass to Buyer after products are delivered to carrier. Claims for damage or loss in transit must be filed by Buyer against the carrier.

CANCELLATION OR MODIFICATION

Buyer may not cancel or modify any order, either in whole or in part, without Seller's prior written consent and then only upon payment to Seller for all applicable costs incurred by Seller, including, without limitation, costs of materials, labor, equipment and supplies, and for lost profits on cancelled or modified orders. Order changes or additions received after original order has been processed will be treated as a new order.

TAXES

Any taxes which Seller may be required to pay or collect with respect to the sale, delivery or storage of the products, including taxes upon or measured by the receipts from the sales thereof, shall be for the account of Buyer who shall promptly pay the amount thereof to Seller upon demand, or in lieu thereof, furnish Seller with a tax exemption certificate acceptable to the taxing authorities.

WARRANTY AND DISCLAIMER

Seller warrants that its products shall be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment. On equipment and materials furnished by Seller but manufactured by others, Buyer shall accept in lieu of any liability or guarantees on the part of Seller, the benefits of guarantees as are obtained by Seller from such manufacturers or vendors. SELLER MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN. Failure by Buyer to object to or reject products or materials delivered hereunder, in writing within 30 days from the date of shipment of the products or materials, shall constitute an acceptance and waiver by Buyer of all claims hereunder on account of alleged errors, shortages, defective workmanship or material, breach of warranty or otherwise, discoverable upon inspection by Buyer.

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Buyer's exclusive remedy on any claim of any kind for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from the design, manufacture, sale, delivery, resale, or repair or use of any products covered by or furnished under the contract, including but not limited to any claim for breach of warranty, negligence, strict liability or other tort, shall be the repair or replacement, F.O.B. Seller's factory, as Seller may elect, of the product or part thereof giving rise to such claim, except that Seller's liability for such repair or replacement shall in no event exceed the contract price allocable to the product or part thereof which give rise to the claim. SELLER SHALL IN NO EVENT BE LIABLE FOR DIRECT, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

RETURN OF MATERIAL

Seller's permission must be obtained in writing before any products are returned to it by Buyer. If products are returned without such permission, Buyer authorizes Seller, in addition to such other remedies as it may have, to hold the returned products at Buyer's sole risk and expense. All returns must be freight prepaid by Buyer. Seller will in no event accept the return of any product that upon return is in the opinion of Seller altered, damaged, used, or in other than first class salable condition.

INDEMNITY

Buyer agrees to indemnify, defend and hold harmless Seller from any claims, loss or damages arising out of or related to Seller's compliance with Buyer's designs, specifications or instructions in the furnishing of products to Buyer, whether based on infringement of patents, copyrights, trademarks or other rights of others, breach of warranty, negligence, strict liability or other tort.

PAYMENT

All invoices are due net 30 days from date of invoice unless otherwise specified by Seller. If at any time Seller deems itself insecure from any cause whatsoever, including but not limited to adverse changes in Buyer's financial condition or impairment of Buyer's credit, Seller may in its sole discretion stop delivery of goods, require advance payment for goods, and/or declare immediately due all indebtedness owed to Seller including amounts due hereunder. Payments not made when due shall bear interest at the prime rate plus 5% per annum or, if lower, the highest rate legally permissible, until paid. Credit balances will be applied against future purchases only and must be claimed within one year of creation or are waived.

GOVERNING LAW AND ARBITRATION

Any dealings or contract between the parties shall be governed by and construed in accordance with the law of the state of Ohio, excluding its choice of law provisions. Buyer and Seller agree that any action, suit or proceeding arising hereunder or related hereto may be brought in any state or federal court of competent jurisdiction sitting in the State of Ohio and each party submits to the jurisdiction of such courts. Either Buyer or Seller may elect to have any controversy arising under or in any way related to the subject matter hereof decided by arbitration by a single disinterested arbitrator in Columbus, Ohio, U.S.A., in accordance with the commercial rules of the American Arbitration Association then obtaining. The fee for the arbitrator shall be shared equally by the parties. Each party shall bear its own costs and expenses, including attorneys fees.

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Winsmith History

Winfield H. Smith founded Winsmith in 1901 and it has been a technology leader in geared speed reducer products for over 100 years. The company began operations in Buffalo, New York but moved to their current location South of Buffalo in the ’lake effect snow belt’ of Springville, New York. Winsmith’s history for product design innovation began with the new introduction of gear driven revolving display tables for the emerging concept department store window displays. Additionally, Winsmith developed worm gear drives for ice cream freezers.

During the 1920’s, Winsmith was one of the very first companies to introduce the concept of a totally enclosed standard worm gear reduction product line. These initial “A Line” products were soon superseded with a “B-Line” product offering in the early 1930’s and then again surpassed by “C-Line” product designed in the mid-1950’s. Today, C-line products are still in use throughout the world.

Winsmith consistently provides customers with high value products by combining product line innovation and value engineering as one continuous process. Over the past 28 years, this philosophy has driven the unprecedented introduction of seven new worm gear product lines, each providing increased value and power density.

During the 1970’s, Winsmith increasingly developed custom gearing designs with unique capabilities. Examples of various custom gear products have included the supply of all the ASR-9 (FAA Airport aircraft approach radar) tracking drive systems now in use at every major US airport; all tracking drives for the NOAA Nexrad Doppler weather radar systems throughout the world; the drives for ice cream machines found in every Dairy Queen® in the world.

Since that time, Winsmith has designed and produced a wide range of extremely modified and totally custom geared speed reducer products involving many different gearing technologies including worm, planetary, differential planetary, planocentric, epicyclical, and helical gearing. Today, these custom gear product development and production capabilities serve a wide range of applications including broadband satellite communications, solar energy array tracking, hydro flow generation, motion control, and aerial swing boom man lifts.

Winsmith production consist of three gearing manufacturing operations; each with unique capabilities. The Springville, NY, operation produces all the “legacy products,” high precision motion control drives, and low volume custom products. The Gainesville, GA, operation produces a wide range of higher volume industrial products. The Asheville, NC operation produces high volume products, marketed under the PERFECTION GEAR brand, that serve the aerial man-lift and crane swing boom drive markets. Since 1998, all of Winsmith’s plant operations are ISO 9001 certified and are also capable of complying with various MIL specifications including complete parts traceability. Winsmith has active lean six sigma programs in all plant operations.

Winsmith’s district sales offices are located throughout North America and staffed with over 100 people who provide a high level of local product application expertise, product support, and product service.

Winsmith’s history and continuing core focus provide customers with the very best value industrial worm gear reducer products. This focus is supported by an organizational commitment to quality, continuous improvement, and responsiveness to customer delivery and application requirements.

Peerless Winsmith, Inc. is a subsidiary of **HBD Industries, Inc.** HBD manufactures quality, application-engineered custom designed and standard industrial products serving many diverse industries and markets. Products manufactured by HBD and its subsidiaries include AC/DC/BLDC electric motors, aerospace precision components, budding strips, cemented tungsten carbide parts, closed die forgings, coated rubber fabrics, conveyor belting, drives, ducting, gear reducers, hose (automotive, aviation, hand-built, industrial, marine and petroleum), material handling equipment (metal separators/detectors and electro-magnetic lifting equipment), power transmission belts, rubber bands, rubber roll coverings and ventilation equipment (fans and blowers). For complete details on **HBD Industries, Inc.**, log onto **www.hbdindustries.com.**

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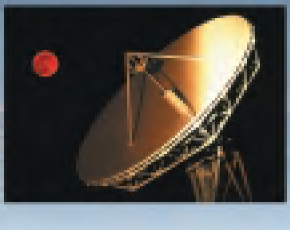

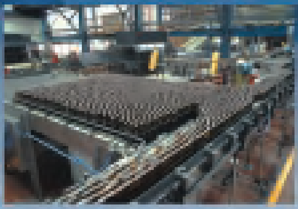

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172 EATON STREET, SPRINGVILLE, NY 14141-1197
PHONE: 716/592-9310 • FAX 716/592-9546
WEBSITES: www.WINSMITH.com
www.hbdindustries.com

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