HDUR Gearing

HARMONIC DRIVE®

Total Motion Control

Harmonic Drive™ gear

Precision Gearing and Motion Control

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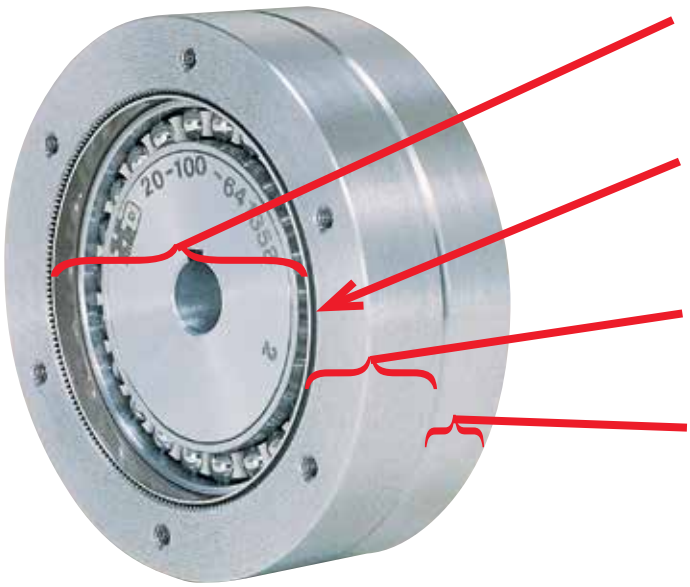
The Basic Assembly



1) The Wave generator (WG) is a thin raced bearings assembly fitted onto an elliptical plug, and normally is the rotating input member.

2) The Flexspline (FS) is a non-rigid ring with external teeth on a slightly smaller pitch diameter than the Circular Spline. It is fitted over and is elastically deflected by the Wave Generator.

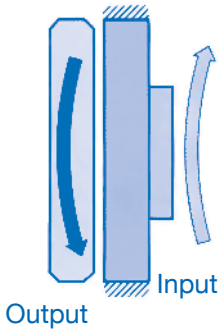
3) The Circular Spline (CS) is a rigid ring with internal teeth, engaging the teeth of the Flexspline across the major axis of the Wave Generator.

4) The Dynamic Spline (DS) is a rigid ring having internal teeth of same number as the Flexspline. It rotates together with the Flexspline and serves as the output member. It is identified by chamfered corners at its outside diameter.

The HDUR range has been developed to meet the trend towards flatter gear sets while retaining the many advantages of Harmonic Drive™ gears. It consists of four main parts: Wave Generator, Flexspline, Dynamic Spline, and Circular Spline. When assembled, rotation of the Wave Generator as a high speed input member imparts a rotating elliptical shape to the Flexspline. This causes progressive engagement of its external teeth with the internal teeth of the Circular Spline. The fixed Circular Spline, having a larger number of teeth than the Flexspline causes the latter to precess at a rate determined by the ratio of tooth difference to the total number of teeth.

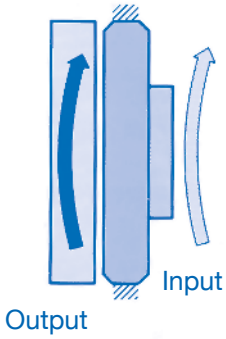
With the same number of teeth as the Flexspline, The Dynamic Spline rotates with, and at the same speed as, the Flexspline and is the output member of the drive.

Configurations



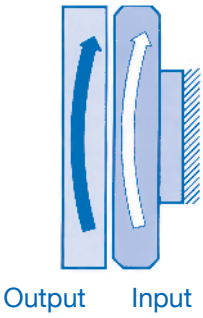
1) Reduction Gearing

WG Input
CS Fixed
DS Output
Ratio as listed
Input and output counter rotate.



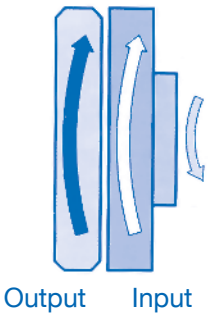
2) Reduction Gearing

WG Input
CS Output
DS Fixed
Ratio $\frac{1}{R+1}$
Input and output in same direction



3) Reduction Gearing

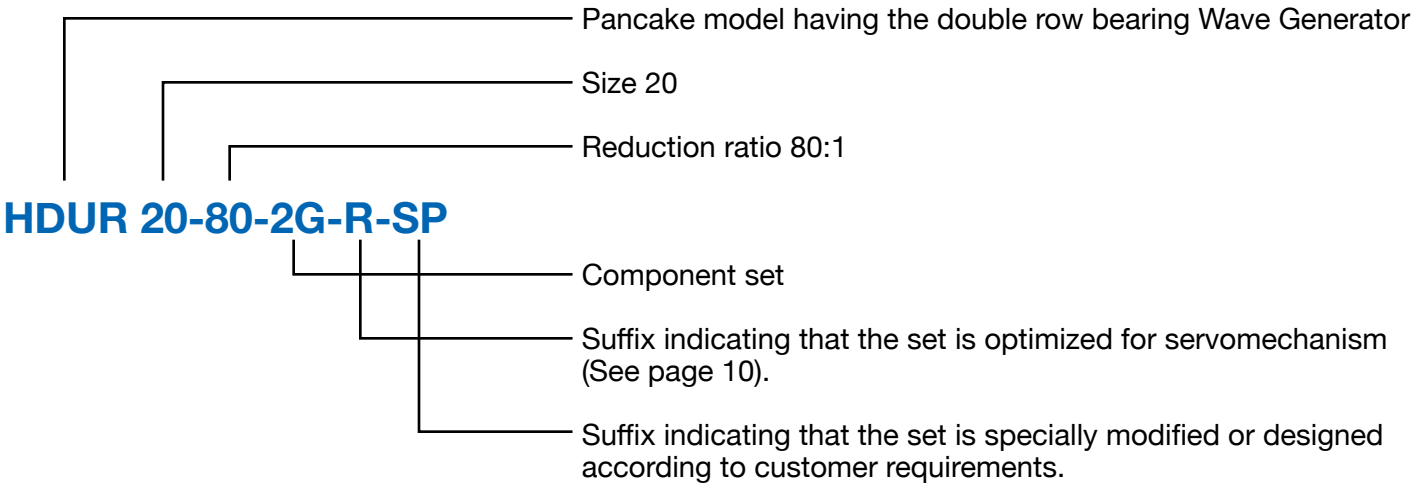
WG Fixed
CS Output
DS Input
Ratio $\frac{R}{R+1}$
Input and output in same direction.



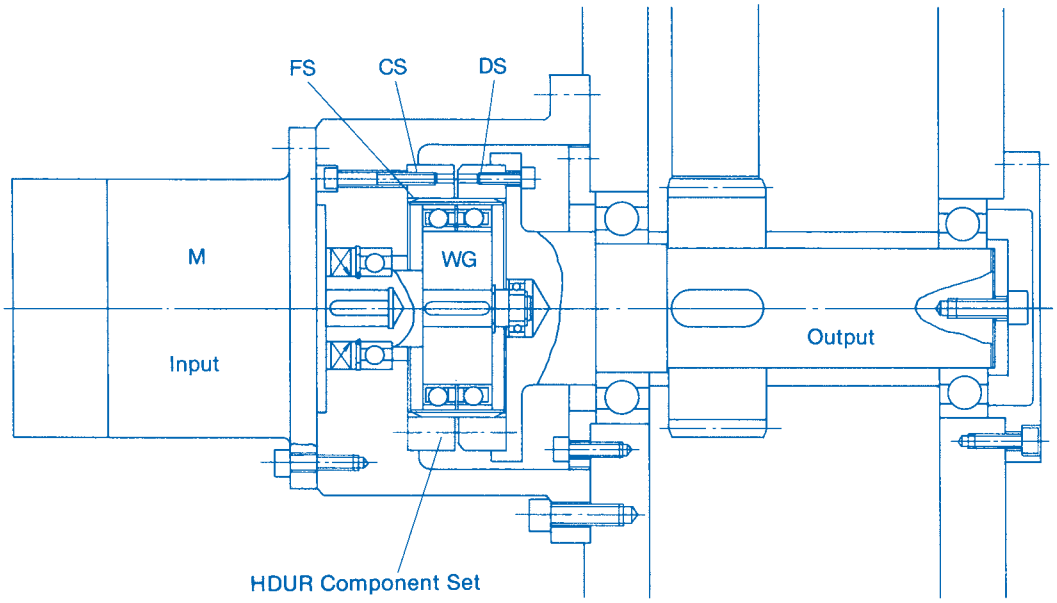
4) Differential

WG Control Input
CS Main-drive Input
DS Main-drive Output
Numerous differential functions can be obtained by combinations of speeds and rotations on the three shafts.

Ordering Information



Typical Applications



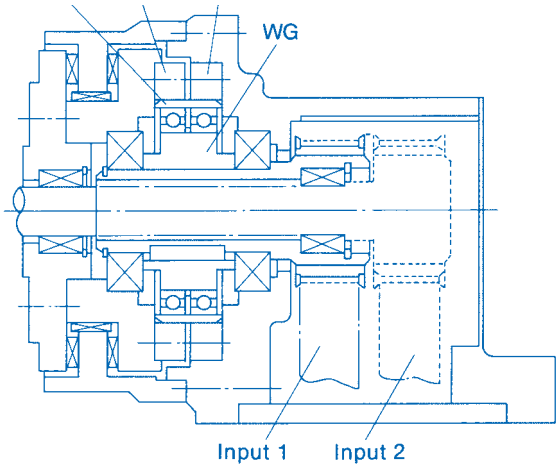
Shown above is an HDUR component set used as a milling machine

Advantages:
- Maximum reduction ratio in minimum space
- Low backlash
- Simple installation and maintenance

This application makes the most of the Harmonic Drive™ gear's unique features. The motor drives the Wave Generator (WG), and the Circular Spline (CS) is fixed to the casing. The output is taken from the Flexspline (FS) via the Dynamic Spline (DS). If the motor shaft is not oil sealed, an additional oil seal must be fitted.

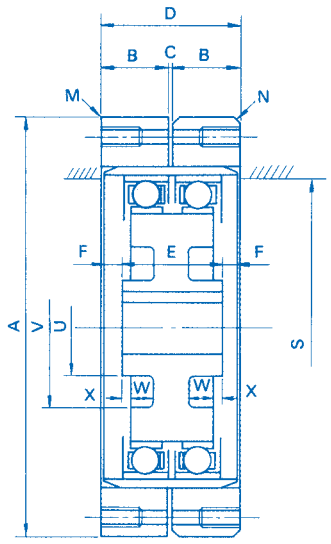
The installation tolerances may be found on page 12.

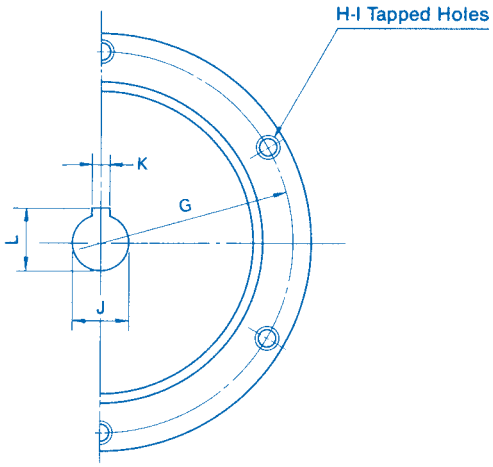
The HDUR component set shown is the drive of a robot joint. The input shaft is hollow, allowing another input shaft for the next stage to go through the Wave Generator. In another robotics application the hollow shaft is used to accommodate electric cables.

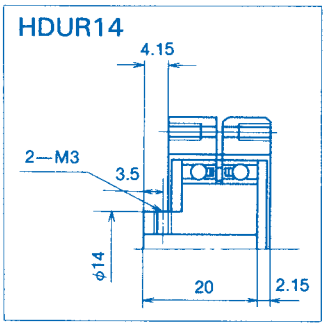


Dimensions

HDUR20-100 (See inset HDUR14 Wave Generator)







HDUR	14	20	25	32	40	50	65	80	100
A (h6)	$50^{\ 0}_{-0.016}$	$70^{\ 0}_{-0.019}$	$85^{\ 0}_{-0.022}$	$110^{\ 0}_{-0.022}$	$135^{\ 0}_{-0.025}$	$170^{\ 0}_{-0.025}$	$215^{\ 0}_{-0.029}$	$265^{\ 0}_{-0.032}$	$330^{\ 0}_{-0.036}$
B	8.5	12	14	18	21	26	35	41	50
C	1	1	1	1	1	1	1	1	1
D	18	25	29	37	43	53	71	83	101
E	—	17.3	20	25.9	31.5	39.1	50.5	62	77.2
F	—	3.85	4.5	5.55	5.75	6.95	10.25	10.5	11.9
G	44	60	75	100	120	150	195	240	290
H	6	6	6	6	6	6	6	8	8
I	M3 x 6	M3 x 6	M4 x 8	M5 x 10	M6 x 12	M8 x 16	M10 x 20	M10 x 20	M12 x 24
J (H7)	$6^{+0.012}_{0}$	$9^{+0.015}_{0}$	$11^{+0.018}_{0}$	$14^{+0.018}_{0}$	$14^{+0.018}_{0}$	$19^{+0.021}_{0}$	$24^{+0.021}_{0}$	$28^{+0.021}_{0}$	$28^{+0.021}_{0}$
J max.	8	11	11	17	20	26	26	32	32
K (JS9)	—	$3^{\pm 0.0125}$	$4^{\pm 0.0150}$	$5^{\pm 0.0150}$	$5^{\pm 0.0150}$	$6^{\pm 0.0150}$	$8^{\pm 0.0180}$	$8^{\pm 0.0180}$	$8^{\pm 0.0180}$
L	—	10.4	12.8	16.3	16.3	21.8	27.3	31.3	31.3
M (C)	0,2	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4
N (C)	1	1	1.5	1.5	1.5	1.5	1.5	2	2
U	—	—	22	28	32	38	44	52	58
V	—	—	32	42	52	62	86	100	128
W	—	—	4.8	6.1	7.6	9.8	12.6	16	19.7
X	—	42	1.6	1.9	2.5	3.2	4.4	5.1	6.3
S	29	42	53	69	84	105	138	169	211
Wt lb	0.4	1.1	1.8	3.7	6.8	13.2	27.3	48.9	93.5
Wt kgf	0.2	0.5	0.8	1.7	3.1	6.0	12.4	22.2	42.5

*The axial location surfaces at D width must extend radially inward to at least to S for Flexspline containment. The surface hardness in the region where the Flexspline abuts is recommended to be RC29-34.

Rating Table

HDUR	Ratio	Rated Speed	Rated Torque at Rated Speed		Limit for Average Torque		Limit for Repeated Peak Torque		Limit for Momentary Peak Torque		Max.Input Speed rpm		Limit for average Input Speed rpm	
		rpm	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Oil Lub.	Grease Lub.**	Oil Lub.	Grease Lub.**
14	88	2,000	6	53	10	88	10	88	20	176*	6,000	3,600	4,000	2,500
	100		8	70	10	88	14	125	20	176*				
	110		8	70	10	88	14	125	20	176*				
20	80	2,000	33	295	41	365	41	365	71	630	6,000	3,600	3,600	2,500
	100		40	355	49	435	53	470	94	830				
	128		40	355	49	435	67	590	100	900*				
	160		40	355	49	435	77	685	86	760*				
25	80	2,000	55	490	68	607	68	607	120	1,070	5,000	3,600	3,000	2,500
	100		66	580	91	807	91	807	160	1,410				
	120		66	580	108	905	102	905	190	1,680				
	160		66	580	108	1,200	135	1,200	170	1,520*				
	200		66	580	108	1,300	147	1,300	170	1,520*				
32	78	2,000	108	955	137	1,215	137	1,215	245	2,170	4,000	3,600	2.500	2,300
	100		137	1,215	176	1,560	176	1,560	323	2,860				
	131		137	1,215	216	1,910	254	2,250	450	3,990				
	157		137	1,215	216	1,910	294	2,600	500	4,420*				
	200		137	1,215	216	1,910	313	2,770	370	3,300*				
	260		137	1,215	216	1,910	313	2,770	370	3,300*				
40	80	2,000	196	1,735	245	2,170	245	2,170	430	3,820	4,000	3,300	2,000	2,000
	100		255	2,255	314	2,780	313	2,770	550	4,860				
	128		294	2,600	392	3,470	392	3,470	680	6,070				
	160		294	2,600	452	4,000	460	4,080	810	7,200				
	200		294	2,600	452	4,000	530	4,680	740	6,600*				
	258		294	2,600	452	4,000	630	5,555	740	6,600*				
50	80	1,700	363	3,210	440	3,900	440	3,900	780	6,940	3,500	3,000	1,700	1,700
	100		470	4,165	578	5,120	580	5,120	1,020	9,020				
	120		560	4,950	696	6,160	700	6,160	1,220	10,850				
	160		560	4,950	834	7,380	835	7,380	1,410	13,000				
	200		560	4,950	834	8,500	960	8,500	1,470	12,500*				
	242		560	4,950	834	10,400	1,180	10,400	1,410	12,500*				
65	78	1,450	745	6,590	917	8,160	920	8,160	1,610	14,300	3,000	2,200	1,400	1,400
	104		1,060	9,370	1,345	11,900	1,345	11,900	2,360	20,900				
	132		1,060	9,370	1,570	13,900	1,660	14,660	2,890	25,600				
	158		1,060	9,370	1,570	13,900	1,970	17,400	3,440	30,500*				
	208		1,060	9,370	1,570	13,900	2,180	19,300	2,580	22,900*				
	260		1,060	9,370	1,570	13,900	2,180	19,300	2,580	22,900*				
80	80	1,200	1,320	11,700	1,640	14,500	1,640	14,500	2,870	25,400	2,500	2,000	1,200	1,200
	96		1,660	14,700	2,050	18,100	2,050	18,100	3,580	31,700				
	128		2,360	20,900	2,310	20,400	2,830	25,000	4,960	43,900				
	160		2,360	20,800	2,310	20,800	3,390	30,000	5,940	52,600				
	194		2,360	20,800	2,310	20,800	4,310	38,100	6,900	61,100*				
	258		2,360	20,800	2,310	20,800	4,350	38,500	5,170	45,800				
	320		2,360	20,800	2,310	20,800	4,350	38,500	5,170	45,800*				
100	80	1,000	2,330	20,600	2,830	25,000	2,870	25,400	5,040	44,600	2,000	1,700	1,000	1,000
	100		3,210	28,400	3,940	34,900	3,940	34,900	6,920	61,300				
	120		3,210	34,400	4,780	42,300	4,780	42,300	8,400	74,400				
	160		3,210	39,600	5,730	50,700	6,240	50,700	11,000	97,000				
	200		3,210	39,600	5,730	50,700	7,180	50,700	12,440	110,100				
	242		3,210	39,600	5,730	50,700	7,970	50,700	9,410	83,300*				
	320		3,210	39,600	5,730	50,700	7,970	50,700	9,410	83,300*				

*Torque value limited by “Ratcheting”, see page 8. **For operating conditions see grease lubrication, page 11.

How To Use The Rating Table

Because of their simple, convenient construction and positional and rotational accuracy, Harmonic Drive™ component sets are used in large numbers in servo-controlled drives where the load and driving speed are seldom constant. With such applications in mind, the rating table presents four important torque capacity limits:

- Rated Torque at rated speed
- Allowable limit for Average Torque
- Allowable limit for repeated Peak Torque
- Allowable limit for Momentary Peak Torque

Rated Toque at Rated Input Speed

This is the maximum allowable output torque that can be developed continuously at the rated input speed shown in the first column. When a Harmonic Drive™ component set is to be operated at speeds other than the rated torque, the actual torque load at each speed needs to be converted to an Equivalent Torque (T_{eq}) using formulas 1, 2, and 3 on page 9.

Allowable Limit for Average torque

When a Harmonic Drive™ unit is used under a variable load, Average Torque may be calculated by formula 1 on page 9. Thus calculated Average Torque should not exceed this limit. Ignoring this limit will result in excessive heat generation, tooth wear, and deterioration of lubricant.

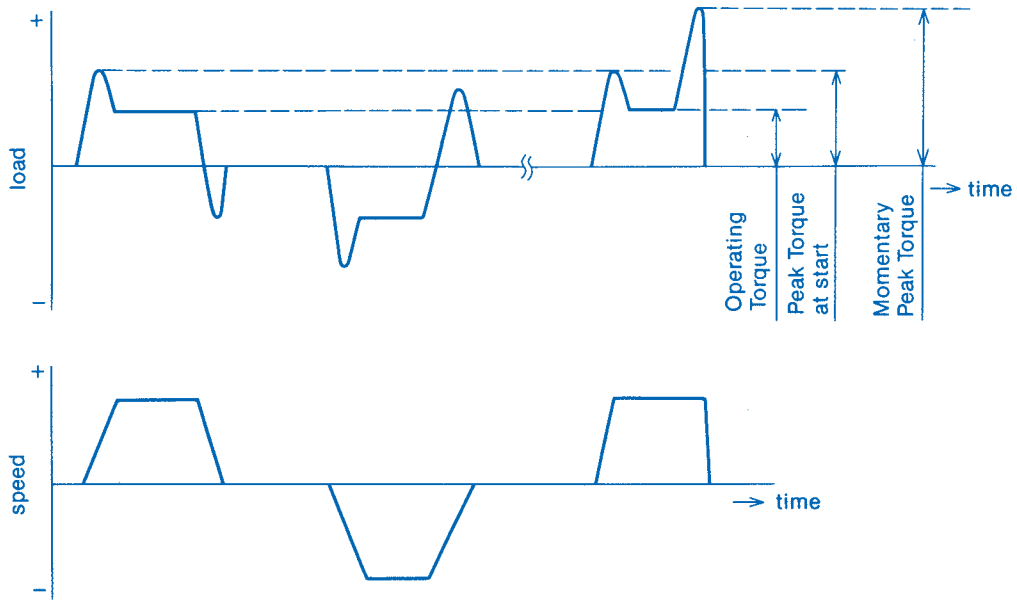
Allowable Limit for Repeated Peak Torque

This is the allowable output torque that can be developed when starting and stopping operation. Peak torque developed at starting and stopping can be estimated if the moment of inertia of motor and load, and accelerating (or decelerating) time are known.

Allowable Limit for Momentary Peak torque

Aside form the peak torque developed at starts and stops, Harmonic Drive™ transmission may be subjected to yet another type of peak torque, an example of which is the shock load generated by an emergency stop of the servo system. Another example is the shock load generated when the driven element, such as a robot hand, accidentally hits a hard object. The Rating Table gives the limit for such Momentary Peak Torque. ***Momentary Peak Torque must be restricted not only in its value but also in its frequency of occurrence.*** This is further explained in the next chapter titled “Factors Affecting Torque Capabilities.”

The variation of load and speed in typical operating cycles are schematically illustrated in the diagrams below.



Factors Affecting Torque Capabilities

The torque capabilities quoted in the Rating Table are determined by considering three factors: the strength of the Flexspline, the unit's ability to resist a phenomenon called ratcheting, and the operating life of the Wave Generator bearing.

Flexspline Strength

The Flexspline, the non-rigid member, is subjected to repeated deflections, and its strength limits the rating of the entire Harmonic Drive™ unit. The values given for Rated Torque at Rated Speed, Limits for Average Torque, and repeated Peak Torque are for the infinite fatigue life of the Flexspline. The Limit For Momentary Peak torque, however, exceeds the infinite fatigue limit of the Flexspline, and the load at this level must be restricted to 1×10^4 flex-cycles. ***Operating conditions exceeding the limit will lead to failure of the Flexspline.***

The allowable frequency of occurrence (N) of Momentary Peak Torque may be calculated by:

$$N \leq \frac{1 \times 10^4}{2 \times \frac{n}{60} \times t}$$

where n is the input speed in rpm and t is the duration of Momentary Peak Torque in seconds. Note that there are two flex-cycles for each input revolution. For example, if Momentary peak torque is expected to occur at a 2,00 rpm input speed and to last for 0.15 seconds, then:

$$N \leq \frac{1 \times 10^4}{2 \times \frac{2{,}000}{60} \times 0.15} \leq 1{,}000$$

Ratcheting

Another torque limit for Harmonic Drive™ transmissions under dynamic load is set by a momentary load releasing phenomenon called ratcheting. This is slippage of the meshing of the Circular Spline and Flexspline teeth as the result of deformation of drive members under excessive load.

In the Rating Table, values marked with asterisk(*) are the torque limits related to ratcheting. Ratcheting usually does not lead to immediate drive failure, but may result in "dedoidal", an improper tooth mesh that may cause undesirable vibration or eventual failure of the Flexspline. The ratchet point will decrease with each subsequent incident, and should not be intentionally utilized for machine overload protection purposes.

Operator Life of the Wave Generator Bearing

The life expectancies of Harmonic Drive™ component sets are based on the median life of the Wave Generator bearing. Rated Torque at Rated Speeds are based on a median bearing life (L_{50}) of approximately 15,000 hours. This means that operated at the constant rated speed and rated torque, 50 percent of a group of bearings would fail before these service hours.

Life expectancy of a unit operated at speed n and torque T conditions may be estimated by the relationship given below:

$$L_{50} = 15{,}000 \bullet \frac{\text{Rated Speed}}{n} \bullet \left(\frac{\text{Rated torque a rated Speed}}{T}\right)^3$$

Operating Speed

The Rating Table gives two limits, Maximum Input Speed and Limit for Average Input Speed, for both oil-lubricated and grease-lubricated units. Units may be operated continuously up to the maximum input speed limits, provided that the average speed during the operation, as calculated by formula 2, on pages 11 and 12, does not exceed the limit for the average input speed.

For continuous operation of grease-lubricated units at these speed limits, it is recommended that grease specially developed for Harmonic Drive™ transmissions be used. For a list of recommended available lubricants, see page 10 and 11.

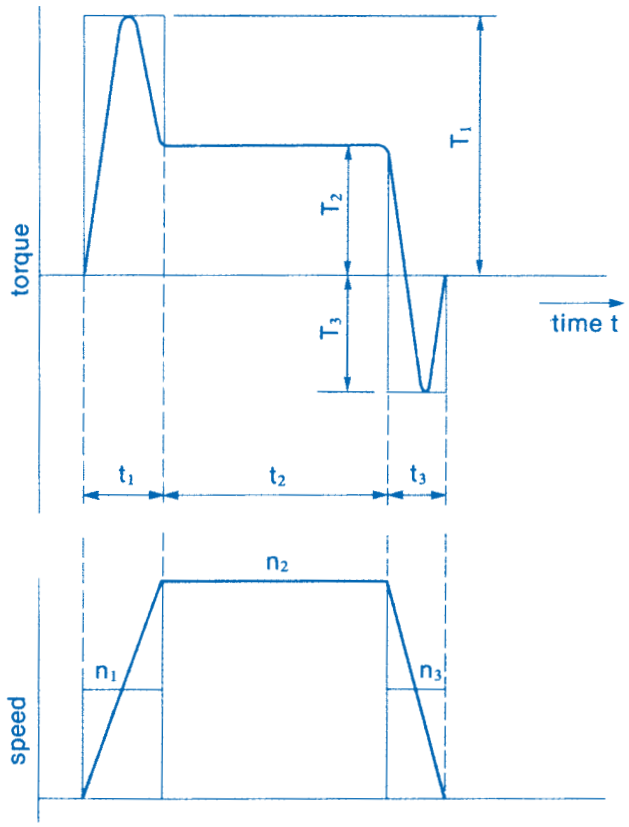
How To Select A Unit From The Rating Table

In actual applications, operating conditions are seldom constant. Torque and speed vary, and peak torque develops during acceleration and deceleration. The first step is to convert these variable torques and speeds to a constant average torque and speed.

Step 1: Average Torque and Speed

Consider a hypothetical operating cycle such as shown in the diagram on the following page

T_1 is the Peak torque developed during the acceleration t_1, T_2 is the Operational torque at constant speed n_2 that lasts for a period of t_2, and T_3 is the Peak Torque developed during acceleration t_3. n_1 and n_3 represent the Average Speed during acceleration and deceleration, which in this case are $\frac{n_2}{2}$



The Average Torque T_{av} for this cycle is calculated:

$$Tav = \sqrt[3]{\frac{n_1 t_1 T_1^3 + n_2 t_2 T_2^3 + n_3 t_3 T_3^3}{n_1 t_1 + n_2 t_2 + n_3 t_3}}$$

The Average Speed n_{av} for this cycle is

$$n_{av} = \frac{n_1 t_1 + n_2 t_2 + n_3 t_3}{t_1 + t_2 + t_3}$$

Step 2

The second step is to calculate as below an Equivalent Torque Teq that would give a median bearing life of 15,000 hours.

$$T_{eq} = T_{av} \bullet \sqrt[3]{\frac{n_{av}}{\text{Rated Speed}}}$$

Step 3

The third step is to estimate the level of Momentary Peak Torque and the frequency of its occurrence. Estimated Momentary Peak Torque must be less than the allowable limit given in the Rating Table, and the frequency of its occurrence must not exceed $1x10^4$ flex-cycles.

Step 4

The fourth step is to check these operating conditions against the values and limits given in the Rating Table for a unit under consideration. If any of the operating conditions exceed the limits, either the operating condition must be relaxed or another unit must be selected.

Example

A drive unit HDUR 40 ratio 100:1 is being considered for these operating torques and speeds:

Torque

- Peak torque during acceleration T_1.....2500 lb-in
- Operating torque T_2 .....1740 lb-in
- Peak torque during deceleration T_3 .....2200 lb-in

Time

- Accelerating time t_1.....0.2 seconds
- Operating time t_2.....2.0 seconds
- Decelerating time t_3.....0.3 seconds

Speed

- Operating speed n_2 ..... 2200 rpm
- Average speed during acceleration and deceleration n_1 and n_3 ..... 1100 rpm

Step 1

$$T_{av} = \sqrt[3]{\frac{1100x0.2x2500^3 + 2200x2x1740^3 + 1100x0.3x2200^3}{1100x0.2 + 2200x2 + 1100x0.3}}$$

$$= 1826 \text{ lb-in}$$

$$n_{av} = \frac{1100x0.2 + 2200x2 + 1100x0.3}{0.2 + 2 + 0.3} = 1980 \text{ rpm}$$

Step 2

$$Teq = 1826 \bullet \sqrt[3]{\frac{1,980}{2,000}} \quad 1,820 \text{ lb-in}$$

Step 3

It is estimated that approximately 4,500 lb-in of peak torque will develop momentarily at an emergency stop, which is estimated to take place at 2,200 rpm and last for 0.15 seconds. Allowable frequency of such Momentary Peak Torque is:

$$N = \frac{1x10^4}{2x \frac{2,200}{60} x0.15} = 900 \text{ times}$$

Step 4: Conclusion

Entering the Rating Table at the line corresponding to HDUR 40-100 we find that T_{eq}, T_{av}, Repeated Peak Torque and Momentary Peak Torque values, and speed conditions of this application are within the allowable limits:

	Estimated Operating Conditions	Rating and Limits
Equivalent Torque T_{eq}	1,820 lb-in	2,220 lb-in
Average Torque, T_{av}	1,826 lb-in	2,780 lb-in
Repeated Peak Torque	2,500 and 2,200 lb-in	2,770 lb-in
Momentary Peak Torque	4,500 lb-in	4,860 lb-in
Average Speed, n_{av}	1,980 rpm	2,000 rpm

Therefore, this unit is considered adequate for this application. It can be lubricated either with oil or Harmonic Grease SK-1. The occurrence of emergency stops must be less than 900 times during the expected service life of this unit.

Moment of Inertia

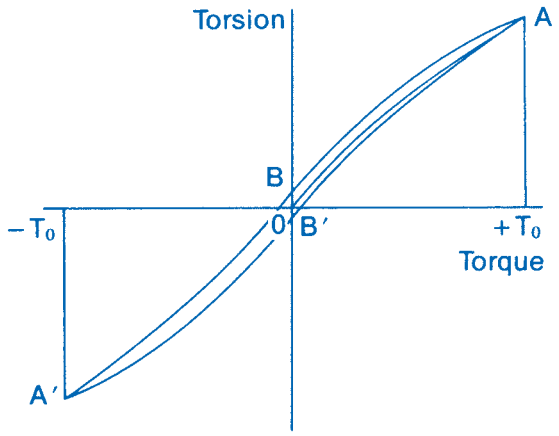
Inertia values at the high-speed shaft for HDUR component sets are given in table below.

Units with reduced input inertia may be supplied on a custom basis. Since the reduction of inertia is achieved by modifying the Wave generator and may affect the unit's torque capacity, each application requiring reduced inertia needs to be evaluated individually.

HDUR		14	20	25	32	40	50	65	80	100
Moment of Inertia J	kg-cm^2	0.06	0.32	0.70	2.6	6.8	21	76	213	635
	lb-in^2	0.02	0.11	0.24	0.89	2.3	7.1	26	73	217

Torsional Characteristics and Backlash

The torsional characteristics of the drive are an important consideration in a servo-drive system. When torque is applied to the output of the Harmonic Drive™ unit with the input rotationally locked, the torque-torsion relationship measured at the output typically follows the loop O-A-B-A'-B'-A illustrated.



Three major characteristics of interest in a servo driver are:

1) Harmonic Drive™ gears exhibits soft wind-up characteristics in the low torque region. The spring rates for three regions of the torque-torsion curve are given on pages 9 and 10.
2) The backlash in an assembled Harmonic Drive™ component set is defined as pure play existing between the input and output. Because of double row teeth mesh, HDUR component set exhibits backlash somewhat larger than HDUC component sets. Backlash of Series R (for robotics application) is optimized below 1.5 minutes of arc for all sizes. Backlash of non-optimized units are quoted below. Values are measured at output with input looked.

Backlash in assembled HDUR

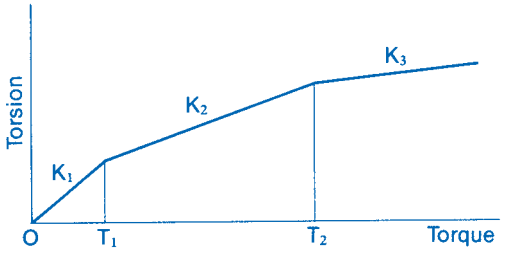
min. of arc

HDUR	14	20	25	32	40	50	65	80	100
Optimized, less than	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Non-optimized, less than	32	32	30	24	24	23	23	23	21

Spring Rate

For servo-drive applications, the torsional stiffness of the HDUR component set may be evaluated by dividing the torque-torsion curve in three major regions: a small torque region O-T_1, a middle torque region T_1-T_2, and a linear region T_2-T_3. Spring rates of these regions vs. size standard units are tabulated. The values quoted are the average of many tests of actual units. The spring rate of an individual unit may vary within approximately ±30% of the average.

Torque-Torsion Curve



K_1: Spring rate for torque region O-T_1
K_2: Spring rate for torque region T_1-T_2
K_3: Spring rate for torque region over T_2

Spring Rate HDUR Component Sets Series R

HDUR	T1		$K_1 x 10^5$/rad		T2		$K_2 x 10^4$/rad		$K_3 x 10^4$/rad	
	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in
14	1.0	8.9	0.26	2.3	5.0	44	0.64	5.7	1.0	8.9
20	2.0	17.4	0.81	7.2	23	200	2.8	25	3.0	27
25	5.0	43	1.6	14	37	330	3.7	33	5.4	48
32	9.0	78	2.8	25	78	690	8.4	74	12	106
40	18	156	6.1	54	156	1380	18	159	24	212
50	34	304	12	106	294	2600	34	300	48	425
65	78	694	26	230	549	4860	64	566	84	743
80	147	1300	51	451	1078	9550	130	1150	165	1460

Calculation Example

This formula is used to find the total wind-up (θ) at the output of an HDUR 25 ratio 100:1, when a torque load of 600 lb-in is applied.

$$\theta = \frac{T_1}{K_1} + \frac{T_2 — T_2}{K_2} + \frac{600 — T_2}{K_3} + \text{Backlash}$$

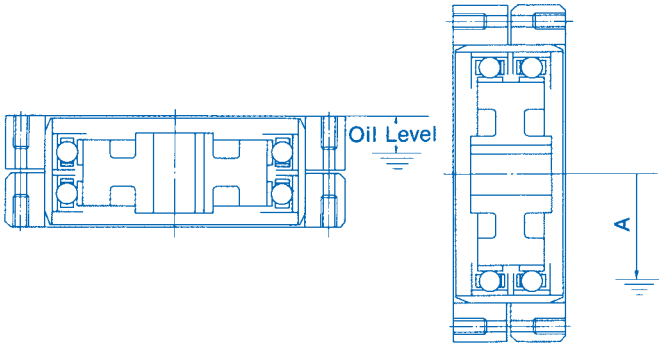
$$= \frac{43}{14x10^4} + \frac{330 — 43}{33x10^4} + \frac{600 — 330}{48x10^4} + \text{Backlash}$$

$$= 17.4x10^{-4} \text{ rad} + \text{Backlash}$$

Lubrication

As with HDUC component sets, oil lubrication is preferred. Although HDUR sets may be used in any attitude, it is essential that the wave generator bearing and gear teeth be properly lubricated. Minimum required oil amounts are tabulated below, but the actual amount will depend on the size of the housing.

In the case of horizontal shaft installation, the appropriate oil level below the gear set center line must be maintained as tabulated. For vertical mounting, the recommended level is the center line of the Upper Wave generator bearing balls.



Oil Level and Minimum Oil Quantity

HDUR		14	20	25	32	40	50	65	80	100
A	mm	7	12	15	31	38	44	62	75	94

Oil Temperature

In normal use, the oil temperature must not exceed 90°C, as oil loses its lubricating capability quickly above this limit.

Oil Change

The first change should be performed after 100 hours of operation. The need to perform subsequent oil changes will depend on operating conditions, but should take place at intervals of approximately 1,000 running hours.

Grease Lubrication

HDUR component sets may be operated with grease lubrication at rated torque but at reduced duty cycle. Imperial Molub Alloy No. 2 is recommended.

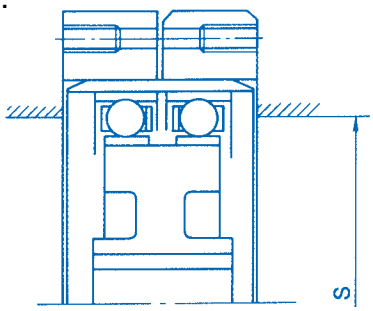
Grease lubrication may be used in applications where the duty cycle is less than 10 percent time-on and the length of time-on does not exceed 10 minutes of continuous operation. The maximum input speeds allowable for units lubricated by Molub Alloy No. 2 are given below:

HDUR	14	20	25	32	40	50	65	80	100
S	24.5	38	48	63	76	95	126	152	190

Harmonic Grease HC-1

As a result of an extensive search for a grease that will render improved performance in Harmonic Drive™ component sets, a new grease, named Harmonic Grease HC-1, has been developed. With Harmonic grease HC-1, ***units may be operated continuously.***

An important consideration in grease lubrication is ensuring that as much grease as possible is retained where lubrication is needed. To achieve this, it is recommended that the axial location surfaces at D width extend radially inward to the dimension shown. However, such an extension is not recommended for oil lubrication.



mm

HDUR	14	20	25	32	40	50	65	80	100
S	24.5	38	48	63	76	95	126	152	190

Grease Changes

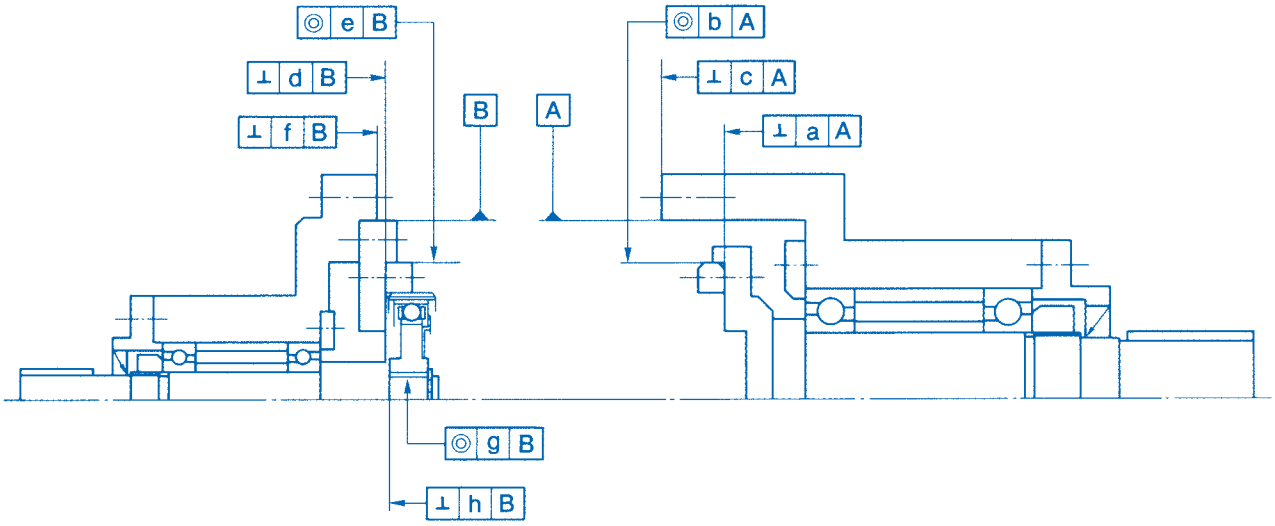
When operating the HDUR at rated torque, change grease after about 1,00 running hours. Light duty operation may permit longer service intervals. To change grease, Completely disassemble and clean units before re-greasing. Apply grease generously inside the Flexspline, the Wave generator bearing, and teeth of both the Circular and Dynamic Splines and the Flexspline.

The approximate amount of grease needed for each Harmonic Drive™ HDUR Component Set is tabulated below:

HDUR		14	20	25	32	40	50	65	80	100
Grease Weight	gr.	8	18	30	60	100	150	320	570	1150
	oz.	0,3	0.6	1	2	3.5	5.5	11	20	40

Installed Relationship and Recommended Tolerances for Housing

The Dynamic Spline is distinguished by its chamfered outer edge. HDUR component sets may be operated in any attitude with suitable bearing support of the input and output shaft, and a means of fixing the Circular Spline against rotation. Recommended installed relationships for the Series R units, (recommended for robotics application) are shown below:



HDUR	a	b	c	d	e	f	g	h
14	0.013	0.015	0.016	0.013	0.015	0.016	0.011	0.007
20	0.017	0.016	0.020	0.017	0.016	0.020	0.013	0.010
25	0.024	0.016	0.029	0.024	0.016	0.029	0.016	0.012
32	0.026	0.017	0.031	0.026	0.017	0.031	0.016	0.012
40	0.026	0.019	0.031	0.026	0.019	0.031	0.017	0.012
50	0.028	0.024	0.034	0.028	0.024	0.034	0.021	0.015
65	0.034	0.027	0.041	0.034	0.027	0.041	0.025	0.015
80	0.043	0.033	0.052	0.043	0.033	0.052	0.030	0.015
100	0.057	0.038	0.068	0.057	0.038	0.068	0.035	0.015

Efficiency

Efficiency varies depending on input speed, ratio, load level, temperature, and type of lubrication. The effect of these factors are illustrated in the curves shown.

Efficiency vs. Speed, Temperature, Reduction Ratio, and oil Lubrication

Chart 1

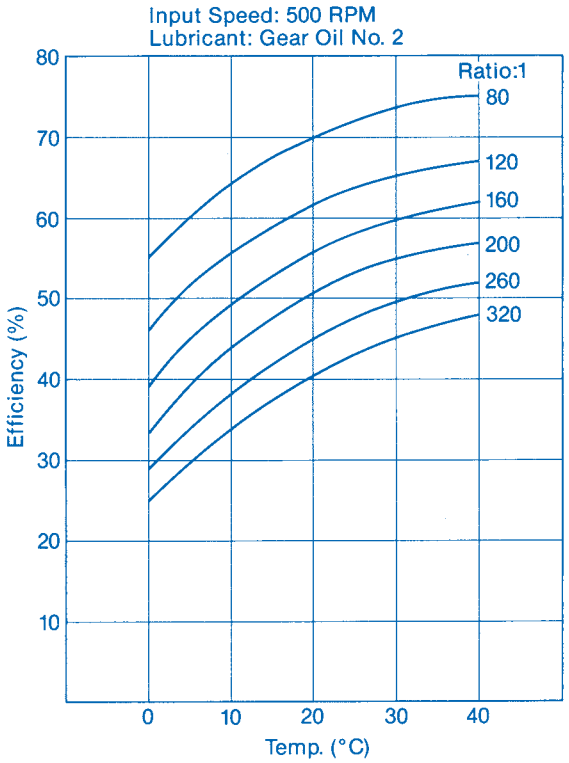


Chart 2

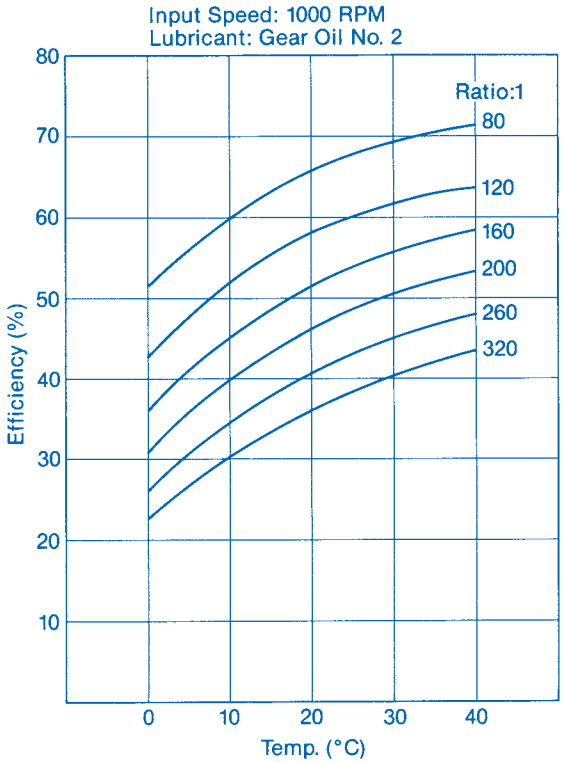


Chart 3

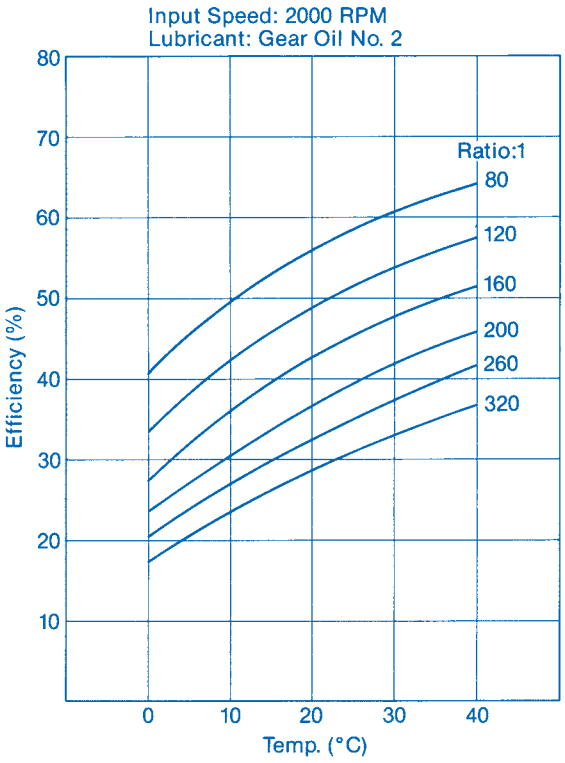
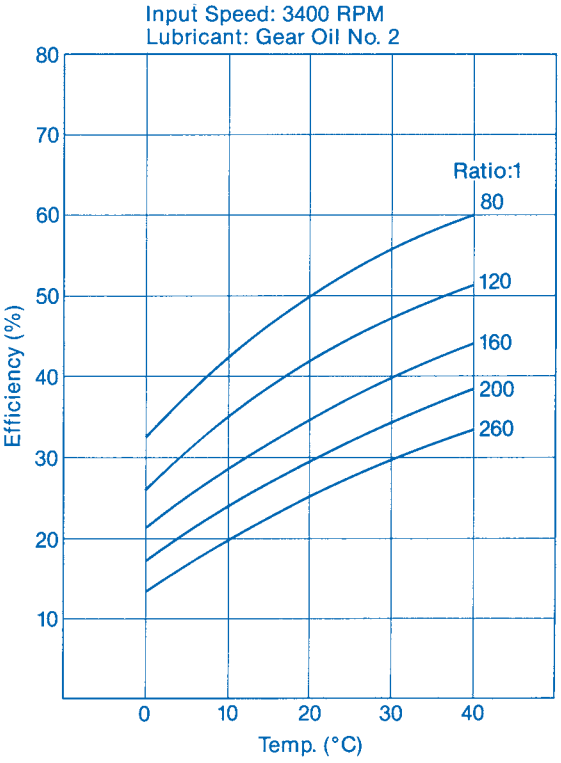


Chart 4



Efficiency (cont.)

Chart 5

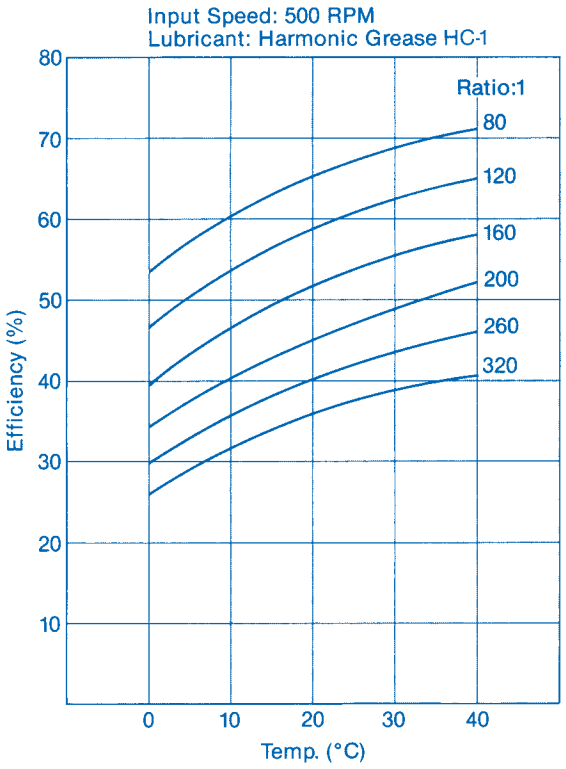


Chart 6

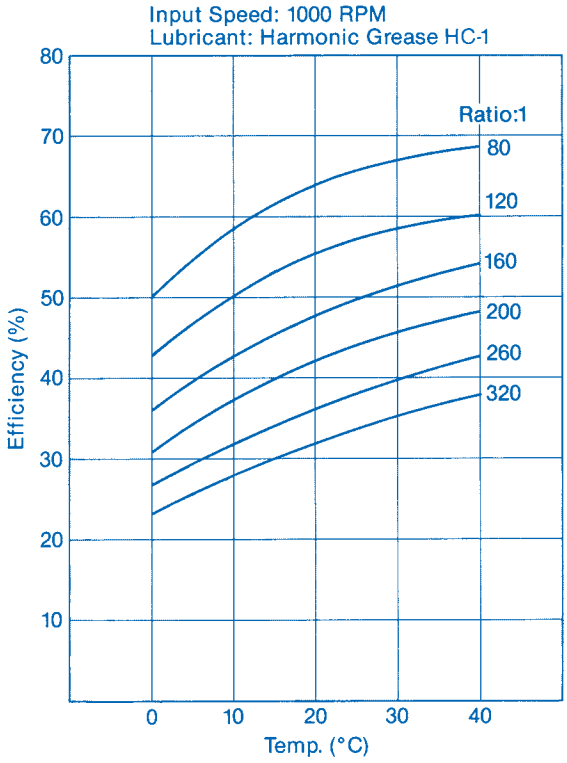


Chart 7

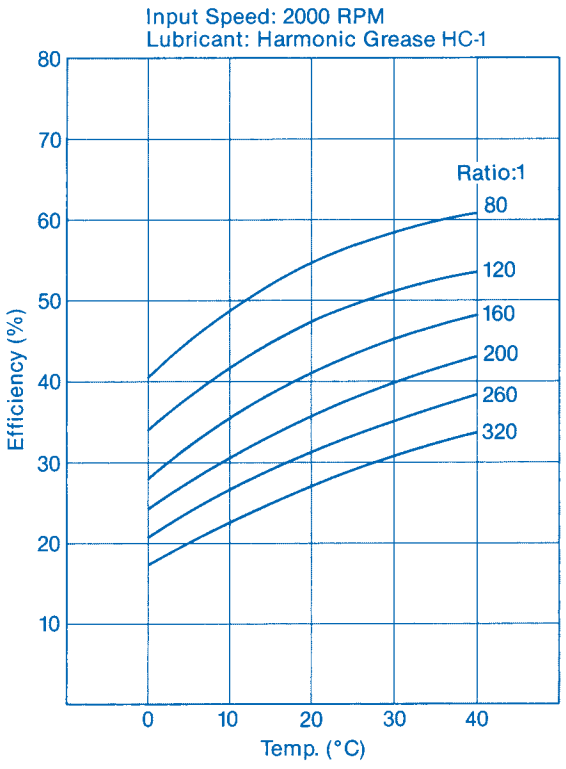
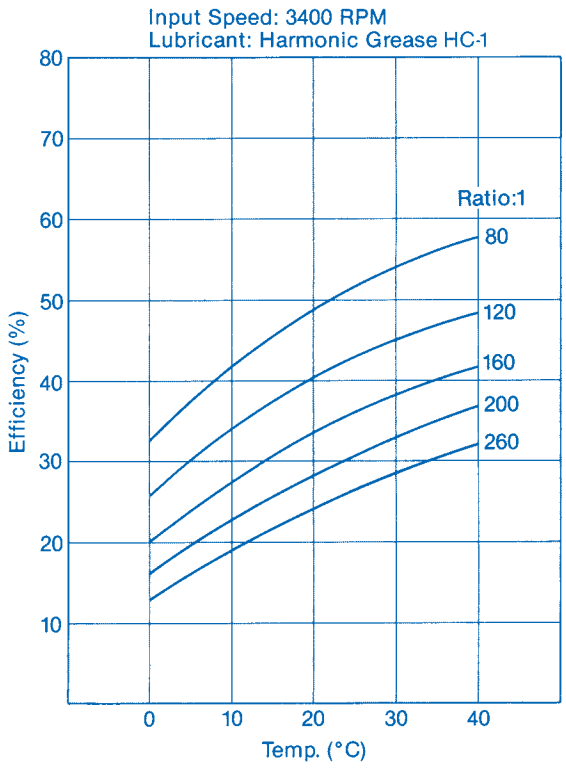
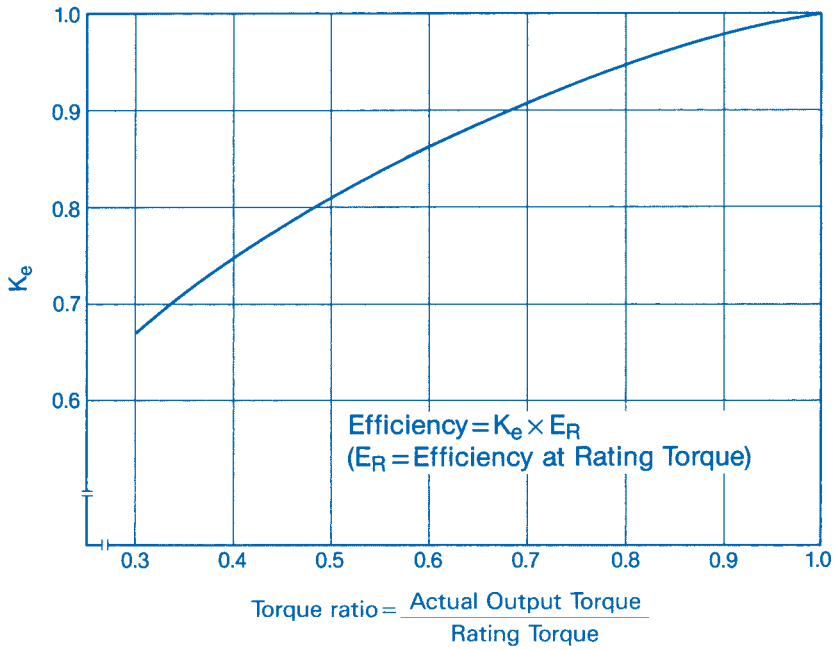


Chart 8



Efficiency vs. Load

Efficiency of the Harmonic Drive™ transmissions vary depending on output torque. The efficiency curves given on the preceding pages are for units operating at an output torque rated for 2,00 rpm. Efficiency of a unit operating at a load below the rated torque may be estimated using a compensation curve and formula shown below.



Ex. Efficiency of an HDUR 40-160-2GR operating at an input speed of 1,00 rpm, output torque of 1,560 lb-in, and at 40˚C may be estimated as follows:

Torque ratio= $\frac{1,560}{2,600}$ =0.6

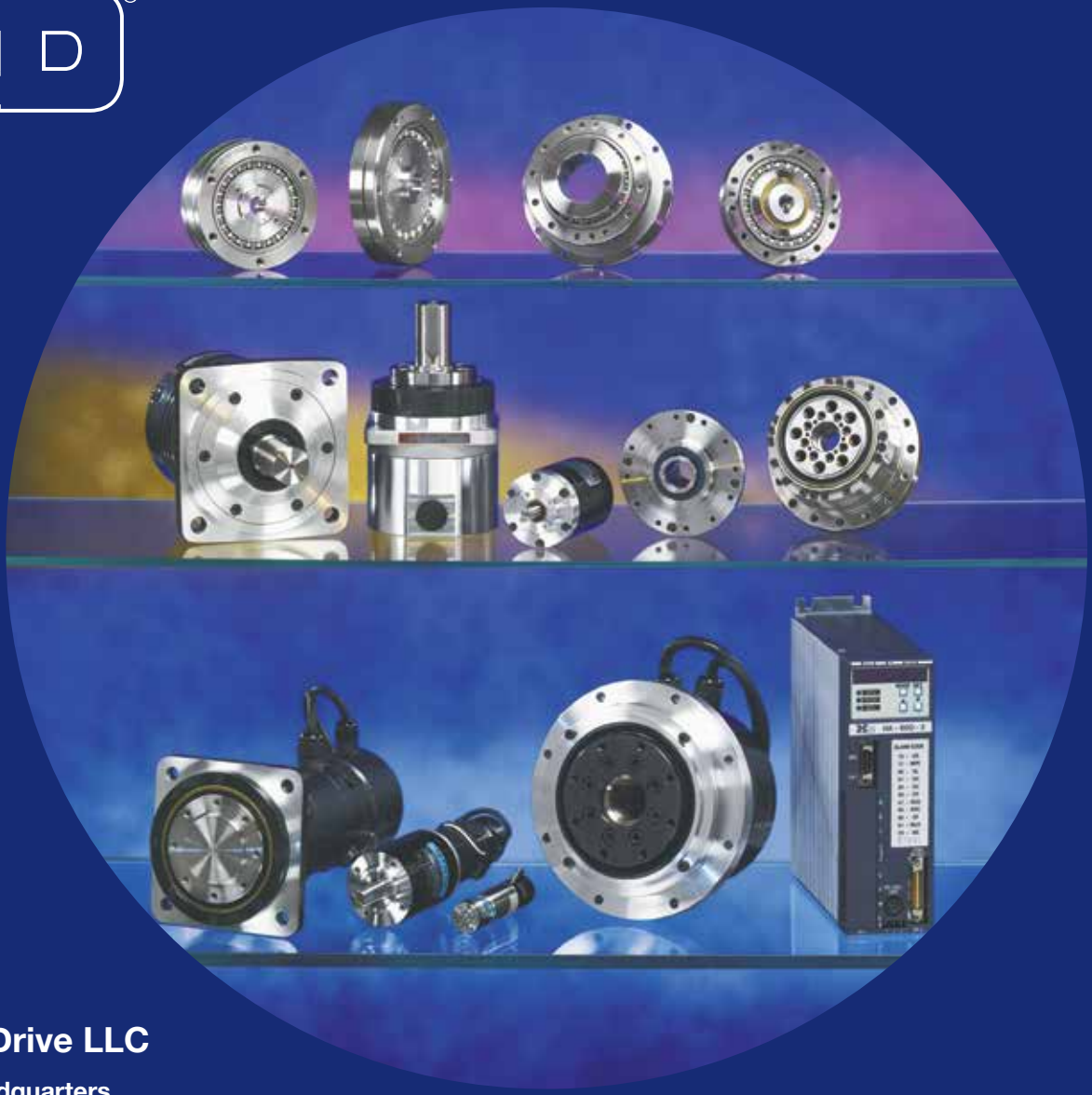
K_e=0.87

Efficiency (at 1,560 lb-in) = 58 x 0.87 = 50%

No-Load Starting Torque and Backdriving Torque

HDUR		14	20	25	32	40	50	65	80	100
Starting Torque	Ncm	0.7~4	0.7~6	0.7~20	1~30	3~50	4~100	7~200	28~280	98~680
	oz-in	1~5	1~8	1~28	1.4~42	4.2~70	5~140	10~280	40~400	140~970
Backdriving Torque	Nm	0.7~10	1~19	3~48	4~80	7~190	15~340	30~480	48~790	290~2500
	lb-in	6~90	9~170	26~430	35~700	60~1700	130~3000	260~4300	430~7000	2600~22000

Values quoted are based on actual tests with the component sets assembled in their housings, and inclusive of friction resistance of oils seals, and churning of oil.



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All specifications and dimensions in this manual subject to change without notice. This manual is correct as of July 2026.

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