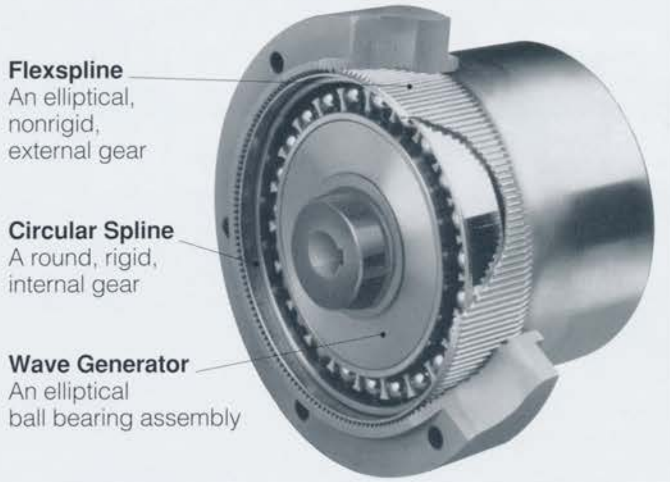
HDC CUP COMPONENT GEAR SET SELECTION GUIDE

Harmonic Drive® TECHNOLOGIES

PERFORMANCE DATA AND SELECTION GUIDE

This brochure provides technical specifications for Harmonic Drive Cup Component Gear Sets and offers a guide for correct size selection. More complex applications not covered in this brochure can be referred to our Engineering department.

HDC CUP COMPONENT GEAR SET



LOADING ANALYSIS

Normal operating conditions involve momentary peak torques substantially higher than constant speed running torques. These peak torques must be carefully considered when selecting a Harmonic Drive HDC Gear Set.

To select from the ratings table it is necessary to construct or estimate a torque speed profile diagram as in Figures 1 and 2.

Figure 1: Torque Profile

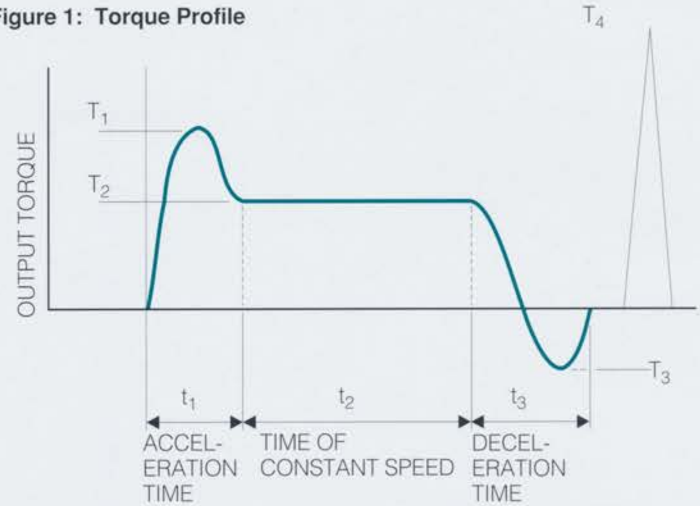
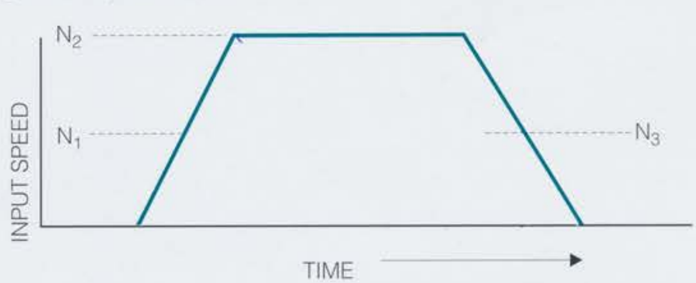


Figure 2: Speed Profile



Maximum Starting Torque, T_1

The torque required to accelerate the driven components from rest to normal continuous running speed.

Normal Constant Speed Torque, T_2

Normal Maximum Stopping Torque, T_3

Maximum Momentary Torque, T_4

The peak torque generated by sudden shock loads such as emergency stops or crashes. Particularly severe conditions exist with high output inertias and stringent rapid stop requirements.

Mean Torque, T

Calculate the mean torque.

$$T=\sqrt[3]{\frac{t_1N_1T_1^3+t_2N_2T_2^3+t_3N_3T_3^3}{t_1N_1+t_2N_2+t_3N_3}}$$

Mean Speed, N

Calculate the mean speed.

$$N=\frac{t_1N_1+t_2N_2+t_3N_3}{t_1+t_2+t_3}$$

RATINGS TABLE

HDC SIZE	RATIO	RATED OUTPUT TORQUE @ 1750 RPM		MAXIMUM OUTPUT TORQUE		STATIC TORQUE LIMIT		RATCHET TORQUE LIMIT		MAX INPUT SPEED (RPM)		STANDARD W/G INPUT INERTIA	NO-LOAD STARTING TORQUE
		lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	Oil	Grease	lb-in² (kg-cm²)	oz-in (N-cm)
10	60	30	3.4	30	3.4	50	5.7	50	5.7	15000	7500	0.0021 (0.0062)	0.6 (0.4)
	80	40	4.5	40	4.5	70	7.9	80	9.0				
14	60	102	11.5	119	13.4	202	22.8	140	15.8	12000	6000	0.0114 (0.0332)	1.0 (0.7)
	72	102	11.5	119	13.4	202	22.8	200	22.6				
	80	102	11.5	140	15.8	238	26.9	200	22.6				
	100	102	11.5	180	20.3	306	34.6	200	22.6				
20	50	350	40.0	470	53.1	1280	145	1120	127	11200	5600	0.068 (0.199)	2.5 (1.8)
	60	355	40.1	470	53.1	1280	145	1120	127				
	80	355	40.1	470	53.1	1240	140	1260	142				
	100	375	42.4	690	78	1620	183	1260	142				
	120	375	42.4	900	102	1970	223	1260	142				
	160	375	42.4	1120	127	2480	280	1120	127				
25	50	600	68	830	94	2570	290	1580	179	9000	4500	0.170 (0.494)	5.0 (3.5)
	60	620	70	830	94	2570	290	1580	179				
	80	620	70	830	94	2310	261	2050	232				
	100	620	70	1240	140	3050	345	2050	232				
	120	620	70	1690	191	3800	429	2050	232				
	160	620	70	1700	192	4650	525	1900	215				
	180	620	70	1580	178	5060	572	1580	178				
	200	620	70	1580	178	5320	601	1580	178				
32	50	1200	136	1830	207	4920	556	4000	452	7000	3500	0.55 (1.60)	11.0 (7.8)
	60	1245	140	1830	207	4920	556	4000	452				
	80	1245	140	1830	207	4520	511	5000	565				
	100	1245	140	2640	298	5800	655	5000	565				
	120	1245	140	3410	385	7220	816	5000	565				
	160	1245	140	4700	531	9190	1038	4700	531				
	180	1245	140	4000	452	9950	1124	4000	452				
	200	1245	140	4000	452	10610	1199	4000	452				
40	50	2000	226	2760	312	7330	828	6600	746	5600	2800	1.50 (4.36)	20 (14.1)
	60	2075	234	2760	312	7330	828	6600	746				
	80	2075	234	2760	312	6980	789	9000	1017				
	100	2610	295	4070	460	9450	1068	9000	1017				
	120	2610	295	5060	572	11120	1256	8300	938				
	160	2610	295	7200	813	14640	1654	7200	813				
	180	2610	295	6600	746	15790	1784	6600	746				
	200	2610	295	6600	746	17010	1922	6600	746				
50	50	3800	430	5110	577	13910	1571	15500	1751	4500	2250	4.3 (12.51)	40 (28.3)
	60	3890	440	5110	577	13910	1571	15500	1751				
	80	3890	440	5110	577	13060	1475	19000	2147				
	100	4860	549	6500	734	16860	1904	19000	2147				
	120	4860	549	9500	1073	20900	2361	17000	1921				
	160	4860	549	13100	1480	26830	3031	17000	1921				
	180	4860	549	15500	1751	28830	3257	15500	1751				
	200	4860	549	15500	1751	31190	3524	15500	1751				
65	50	7880	890	10200	1152	27750	3135	24000	2711	3500	1750	15.54 (45.21)	88 (92.1)
	60	7880	890	10200	1152	27750	3135	24000	2711				
	80	7880	890	10200	1152	26350	2977	30000	3389				
	100	9010	1018	15300	1728	36130	4082	30000	3389				
	120	9010	1018	19300	2180	42370	4787	27000	3050				
	160	9010	1018	26600	3005	54510	6158	24000	2711				
	180	9010	1018	24000	2711	59210	6690	24000	2711				
	200	9010	1018	24000	2711	64040	7235	24000	2711				
80	50	13700	1547	18200	2056	48000	5423	50000	5649	2800[1]	1400[1]	50.4 (146.7)	160 (113)
	60	13715	1550	18200	2056	48000	5423	50000	5649				
	80	13715	1550	18200	2056	45640	5156	65000	7343				
	100	17780	2009	26000	2937	61800	6982	65000	7343				
	120	17780	2009	33600	3796	74500	8416	60000	6778				
	160	17780	2009	47900	5411	98830	11165	55000	6213				
	180	17780	2009	50000	5648	107870	12186	50000	5648				
	200	17780	2009	50000	5648	115180	13012	50000	5648				
100	80	28000	3163	36200	4090	72400	8179	120000	13557	2250[1]	1125[1]	118 (343.3)	300 (212)
	100	28000	3163	48400	5468	96800	10936	120000	13557				
	120	28000	3163	59500	6722	119000	13444	110000	12427				
	160	28000	3163	77700	8778	155400	17556	110000	12427				
	200	28000	3163	89200	10077	178400	20155	83000	9377				
	320	28000	3163	83000	9377	178400	20155	83000	9377				

NOTES: 1) Thermal limitation: Consult factory for recommended duty cycle.

DEFINITIONS

Ratio

The optimum ratio for a particular application is usually dependent upon the requirements of the drive system. In general, however,

- Stiffness or spring rate is greater with ratios 80:1 and higher
- Efficiency decreases as ratio increases
- Positional accuracy is not a function of ratio
- Standard ratios are shown in bold type in the ratings table
- Many unlisted ratios above 50:1 are available. Consult our Engineering department for availability.

Maximum Output Torque Limit

This is the maximum allowable output torque that should be developed with dynamic torque at the input. Repetitive momentary or continuous running loads (T_1, T_2, and T_3) should not exceed this rating.

Static Torque Limit

This is the maximum allowable torque that should be applied to the output when the input is locked. A typical example is the torque applied to the output during a work or machining operation when the Harmonic Drive is stationary.

Ratchet Torque Limit

Under severe dynamic overload conditions, the pressure angles of the gear teeth produce separating forces which result in radial deflection at the tooth mesh. This deflection prevents correct movement of the teeth and causes the flexspline to move off center by one tooth. This phenomenon is called ratcheting and can be avoided by operating the gear set within the ratchet torque limit.

Such overloads typically occur during severe emergency stop conditions or by "crashing" the output drive during rotation. Ratcheting does not result in immediate failure of the gear set but causes poor performance and premature failure of the gear teeth and should, therefore, be avoided. If ratcheting is suspected, the assembly should be checked for the "dedoidal" condition described on Page 12.

Maximum Input Speed

The maximum input speed for an HDC Gear Set is limited by the DN value of the wave generator bearing and the type of lubricant used. Maximum input speeds for each size unit using recommended grease or oil lubricant are listed in the ratings table.

PROPER PERFORMANCE CAN ONLY BE ASSURED BY ADHERING TO STATED LIMITS.

RATINGS AND OPERATING LIFE

The operating life expectancy of HDC Gear Sets is based on the life of the ball bearings used for the input wave generator when run continuously at rated torque. If gear sets are properly mounted and lubricated, gear tooth life will be well in excess of bearing life, provided maximum torque and speed limits are not exceeded. Flexspline life is infinite provided concentricity requirements are maintained. Ratings listed are for a continuous input speed of 1,750 RPM and an L_{10} life of 3,000 hours. Average life, however, is 5 times this number.

Torque ratings for speeds other than 1,750 RPM can be calculated by the following equations:

$$\text{Rating @ N RPM} = \left[\frac{1750}{N}\right]^{1/3} \times \text{[listed rating @ 1750 RPM]}$$

and predicted life by

$$L_{10} = \left(\frac{1750}{N}\right)\left[\frac{\text{listed rating @ 1750 RPM}}{T}\right]^{3} \times 3000 \text{ hours}$$

Where T = mean torque
N = mean speed

Quick Selection

To make a quick selection from the ratings table for input speeds other than 1,750 RPM:

1) Calculate or estimate mean speed, N, and mean torque, T.

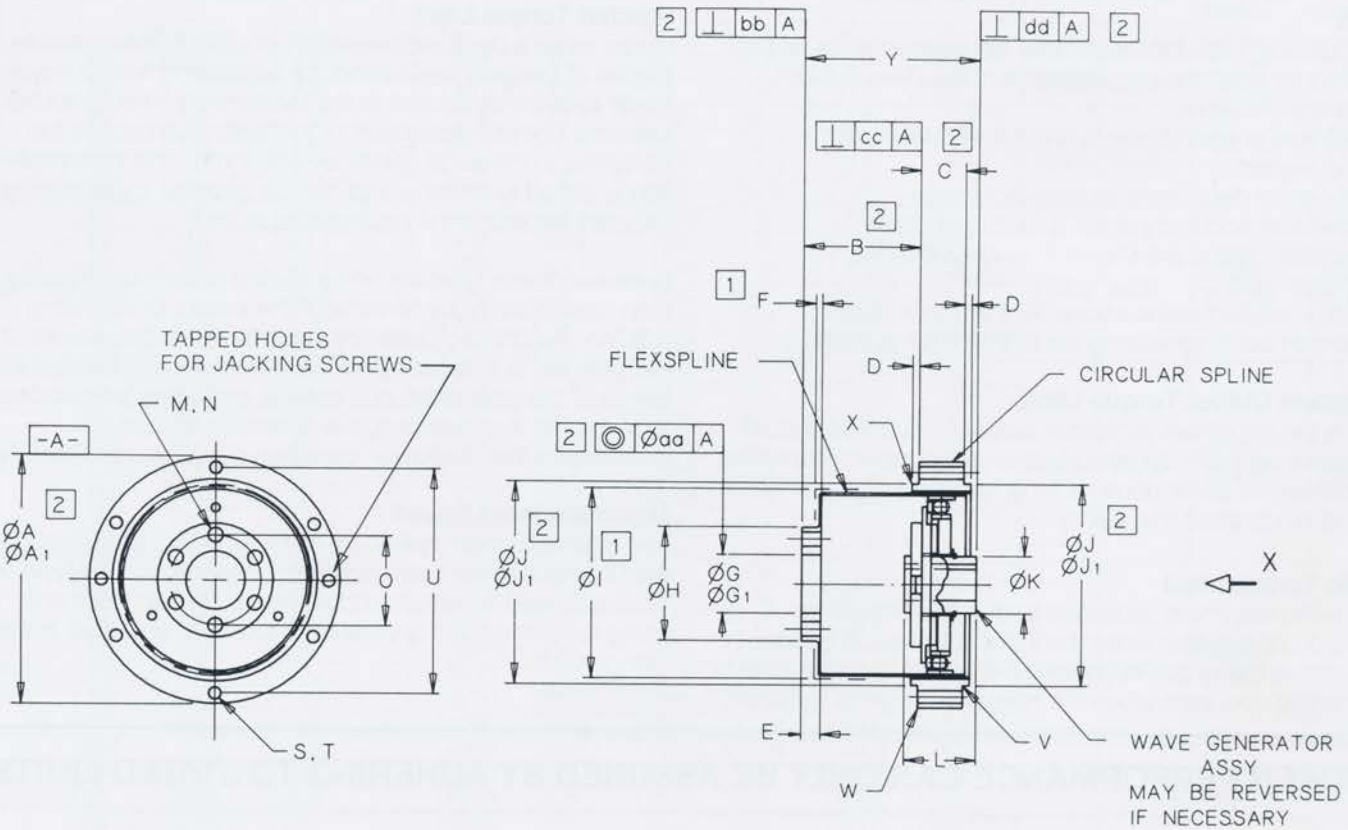
2) Calculate the equivalent 1,750 RPM rating, Tr.

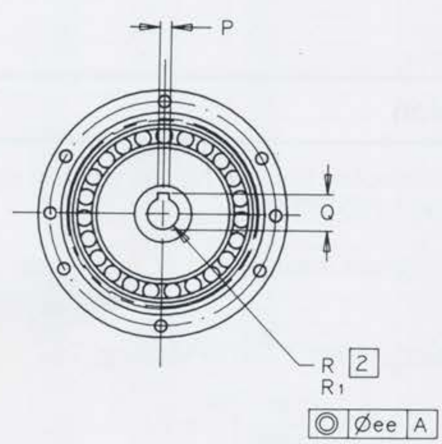
$$Tr = \left[\frac{N}{1750}\right]^{1/3} \times T$$

3) Select a suitable gear set from the 1,750 RPM rating table (T1750) — one which has a rating equal to or greater than Tr.

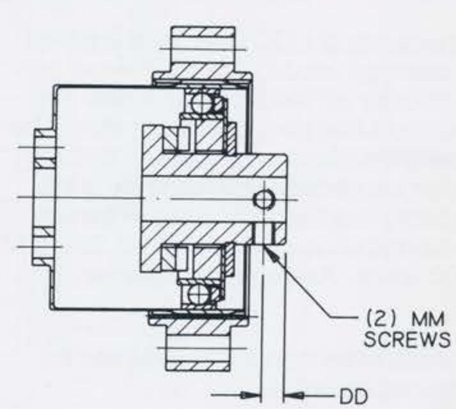
4) Calculate expected life.

$$L_{10} = \left[\frac{\text{listed rating @ 1750 RPM}}{Tr}\right]^{3} \times 3000 \text{ hours}$$





VIEW ON "X"
SIZES 20-100



INPUT FIXING FOR SIZES 10-14

NOTE: DOES NOT HAVE KEYWAY.

	UNIT SIZE	
DIM.	10	14
DD	2	3
MM	M2.5X0.45	M3X0.5

Note: Dimensions marked [1] denote maximum extent of encroachment of adjoining structure.

	UNIT SIZE									
	10	14	20	25	32	40	50	65	80	100
AØ	$38^{-0.016}$	$50^{-0.016}$	$70^{-0.019}$	$85^{-0.022}$	$110^{-0.022}$	$135^{-0.025}$	$170^{-0.025}$	$215^{-0.029}$	$265^{-0.029}$	$330^{-0.036}$
A1Ø	$38^{+0.034}_{+0.009}$	$50^{+0.034}_{+0.009}$	$70^{+0.040}_{+0.010}$	$85^{+0.047}_{+0.012}$	$110^{+0.047}_{+0.012}$	$135^{+0.054}_{+0.014}$	$170^{+0.054}_{+0.014}$	$215^{+0.061}_{+0.015}$	$265^{+0.069}_{+0.017}$	$330^{+0.075}_{+0.018}$
B	$15^{\pm0.25}$	$21.2^{\pm0.25}$	$31.3^{\pm0.3}$	$40.3^{\pm0.3}$	$52.3^{\pm0.3}$	$63.3^{\pm0.3}$	$80.3^{\pm0.3}$	$100.3^{\pm0.3}$	$119.3^{\pm0.3}$	$153.5^{\pm0.3}$
C	7	8	14	16	20	25	30	40	50	60
D	2	2	3	3	3	4	4	5	6	6
E	2.4	2.7	5.4	6.5	8.6	9.5	13.0	16.3	14.6	18
F	1.5	1.5	2	2	2	3	3	4	5	6
GØ	$6^{+0.010}$	$11^{+0.011}$	$16^{+0.011}$	$20^{+0.013}$	$26^{+0.013}$	$32^{+0.016}$	$40^{+0.016}$	$52^{+0.019}$	$65^{+0.019}$	$80^{+0.019}$
G_1Ø	$6^{-0.004}_{-0.016}$	$11^{-0.006}_{-0.024}$	$16^{-0.006}_{-0.024}$	$20^{-0.007}_{-0.028}$	$26^{-0.007}_{-0.028}$	$32^{-0.009}_{-0.034}$	$40^{-0.009}_{-0.034}$	$52^{-0.010}_{-0.040}$	$65^{-0.010}_{-0.040}$	$80^{-0.010}_{-0.040}$
HØ	15	23	31.6	39.5	52	64	79	103	126	158
IØ	26.2	37.4	52.3	65	84.6	104.6	131	169.4	209.3	261
JØ	$28^{-0.016}$	$38^{-0.016}$	$54^{-0.019}$	$67^{-0.019}$	$90^{-0.022}$	$110^{-0.022}$	$135^{-0.025}$	$177^{-0.025}$	$218^{-0.029}$	$272^{-0.032}$
J_1Ø	$28^{+0.028}_{+0.007}$	$38^{+0.034}_{+0.009}$	$54^{+0.040}_{+0.010}$	$67^{+0.040}_{+0.010}$	$90^{+0.047}_{+0.012}$	$110^{+0.047}_{+0.012}$	$135^{+0.054}_{+0.014}$	$177^{+0.054}_{+0.014}$	$218^{+0.061}_{+0.015}$	$272^{+0.069}_{+0.017}$
KØ	10	14	21	26	26	32	32	48	55	65
L	16	18	27	32	32	40	40	52	65	70
M	6	6	6	6	6	6	6	6	12	12
NØ	2.4	3.4	4.5	5.5	6.6	9	14	14	11	14
OØ	11	17	24	30	40	50	60	80	104	130
P	—	—	$3^{\pm0.013}$	$4^{\pm0.015}$	$5^{\pm0.015}$	$5^{\pm0.015}$	$6^{\pm0.015}$	$8^{\pm0.018}$	$8^{\pm0.018}$	$8^{\pm0.018}$
Q	—	—	10.4	12.8	16.3	16.3	21.8	27.3	31.3	31.3
RØ	$5^{+0.013}$	$6^{+0.013}$	$9^{+0.015}$	$11^{+0.018}$	$14^{+0.018}$	$14^{+0.018}$	$19^{+0.021}$	$24^{+0.021}$	$28^{+0.021}$	$28^{+0.021}$
R_1Ø	$5^{-0.004}_{-0.016}$	$6^{-0.004}_{-0.016}$	$9^{-0.005}_{-0.020}$	$11^{-0.006}_{-0.024}$	$14^{-0.006}_{-0.024}$	$14^{-0.006}_{-0.024}$	$19^{-0.007}_{-0.028}$	$24^{-0.007}_{-0.028}$	$28^{-0.007}_{-0.028}$	$28^{-0.007}_{-0.028}$
S	6	6	6	6	6	6	6	6	8	8
TØ	2.9	3.5	3.5	4.5	5.5	6.6	9	11	11	14
UØ	33	44	60	75	100	120	150	195	240	290
V	0.13	0.13	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
W	—	—	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
X	0.25	0.25	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Y	$27^{\pm0.3}$	$33.6^{\pm0.4}$	$51.5^{\pm0.5}$	$63.5^{\pm0.5}$	$77.5^{\pm0.6}$	$95.5^{\pm0.6}$	$116.4^{\pm0.7}$	$146.3^{\pm0.7}$	$177.3^{\pm0.7}$	$220.2^{\pm0.8}$
aa	0.040	0.040	0.044	0.047	0.050	0.063	0.066	0.070	0.090	0.110
bb	0.020	0.028	0.028	0.036	0.044	0.050	0.060	0.070	0.080	0.090
cc	0.010	0.011	0.031	0.033	0.035	0.045	0.047	0.049	0.064	0.080
dd	0.020	0.020	0.025	0.036	0.036	0.048	0.048	0.048	0.054	0.060
ee	0.040	0.040	0.044	0.047	0.050	0.063	0.066	0.070	0.090	0.110
WEIGHT lb/kgf	0.18/0.08	0.3/0.14	0.6/0.3	1.2/0.5	2.6/1.2	5.1/2.3	9.0/4.1	20.3/9.2	38.6/17.5	63.5/28.8

ALIGNMENT AND ASSEMBLY

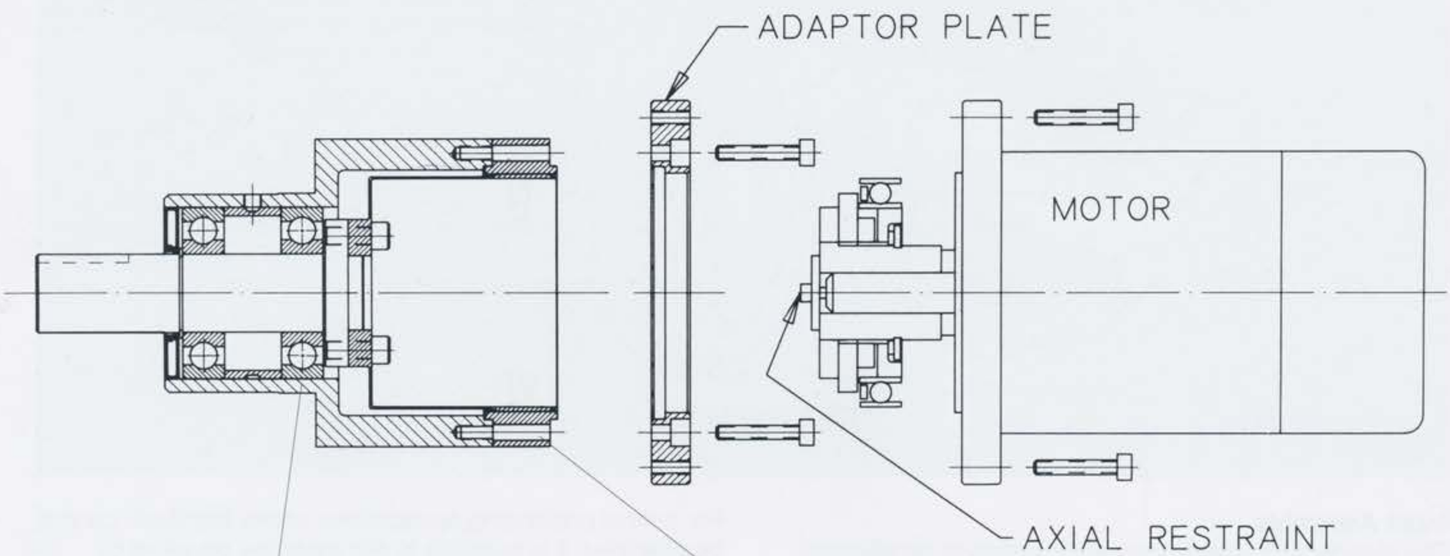
To achieve proper performance from Harmonic Drive Gear Sets, certain mounting and alignment requirements are necessary. Dimensions and tolerances marked [2] establish interface and installation requirements and must be adhered to under all load conditions.

Excessive deflection or improper alignment will affect the smoothness of motion or cause premature failure. All components must be restrained axially, including the wave generator which has a tendency to "walk" into the flexspline cup during operation.

Use high-strength alloy steel screws tightened to manufacturer's recommended torque specifications. Loctite or some other means to prevent loosening is also recommended. Typical tightening torques for high-tensile socket cap-head screws are as follows:

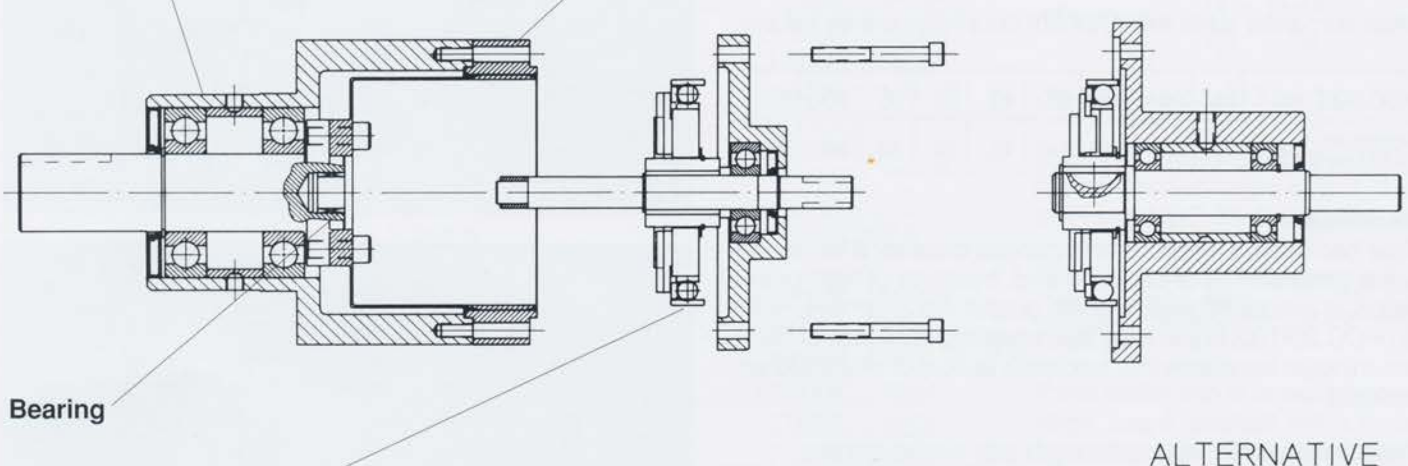
Screw Size		M2	M3	M4	M5	M6	M8	M10	M12
Tightening Torque	lb-in	5.3	19	41	85	140	350	680	1200
	Nm	0.6	2.1	4.6	9.5	16	39	77	135

TYPICAL INSTALLATION



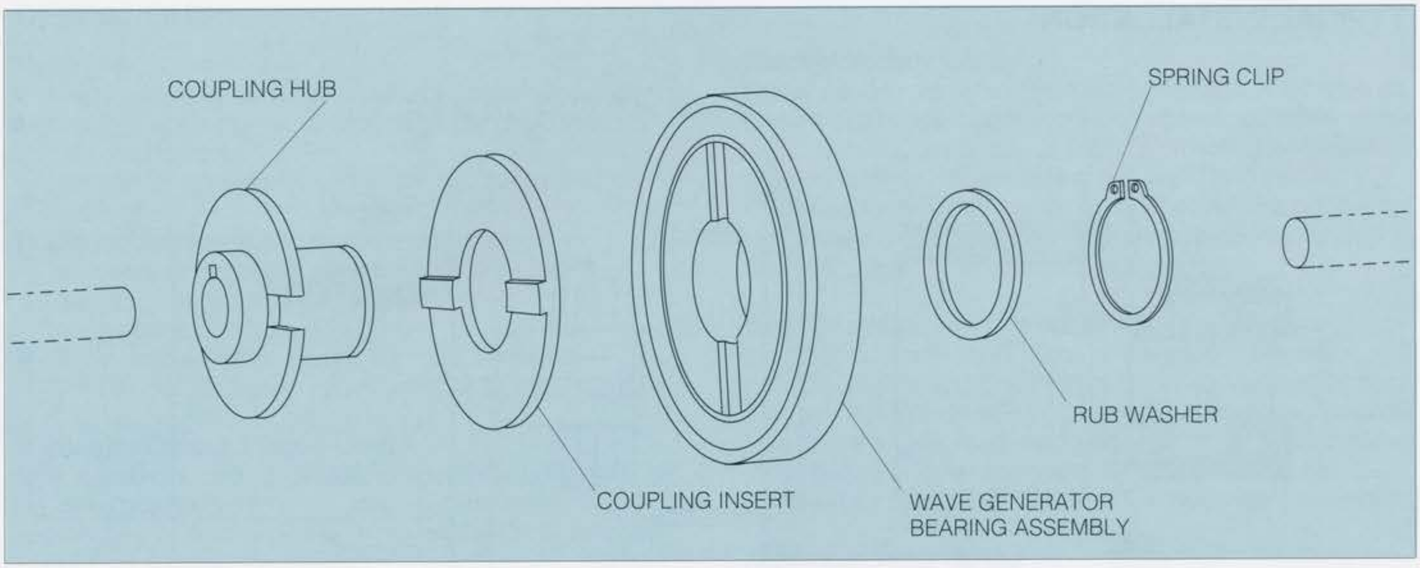
Flexspline Support
The flexspline must be connected to a bearing-supported shaft or fixed rotationally. Overhung loads from an external source require a suitable two-bearing support or a single four-point contact, "Gothic arch"-type bearing to maintain required tolerances [2].

Circular Spline
The circular spline may be located either on its outside diameter or on one of the two pilot diameters provided. Vibration may occur if the housing is allowed to distort the circular spline from roundness.



Bearing

Wave Generator
The standard wave generator is provided with an Oldham coupling to allow for misalignment of the input drive. The wave generator bearing is not designed to support a shaft. Additional bearing support should be provided.



Input Assembly
The standard input arrangement consists of an elliptical wave generator, a bearing assembly, and an Oldham coupling.

The wave generator assembly can easily be removed from the gear set and disassembled for attachment to the motor shaft. Attachment can be from either direction provided its position in relation to the circular spline datum face is maintained.

Coupling hubs can be removed and rebored, or supplied to suit various motor shaft configurations on a custom basis. Consult our Engineering department for details.

Maximum bore sizes with Oldham couplings are as follows:

HDC SIZE	10	14	20	25	32	40	50	65	80	100
Maximum Bore (mm)	6	8	10	14	14	19	19	30	35	35

Backlash
True backlash is limited to mechanical clearance in the wave generator input coupling and, because of high gear ratios, is almost negligible at the output. For example, with an HDC 20-100:1 ratio gear set, coupling backlash of 35 arc minutes translates into backlash at output of 35/100 arc minutes.

Typical measured values for each size are as follows:

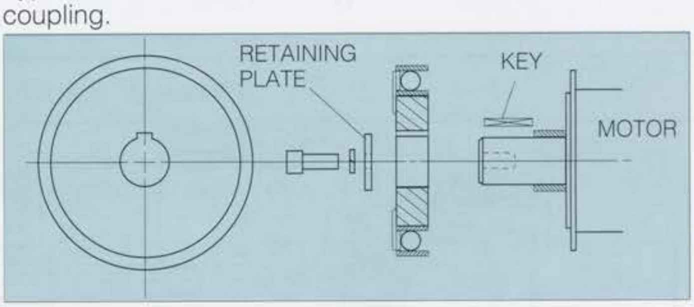
HDC SIZE	10	14	20	25	32	40	50	65	80	100
Max.Input Coupling Backlash (arc min.)	50	45	35	32	26	16	18	13	12	11

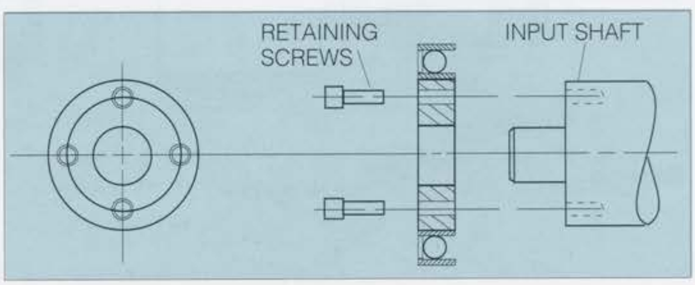
For critical positioning applications where backlash cannot be tolerated, it is possible to eliminate the coupling by mounting the input shaft directly to the wave generator. Consult our Engineering department for details.

Maximum bore sizes without Oldham couplings are as follows:

HDC SIZE	10	14	20	25	32	40	50	65	80	100
Maximum Bore (mm)	10	16	20	24	30	36	46	60	65	85

Typical attachment of wave generator without Oldham coupling.





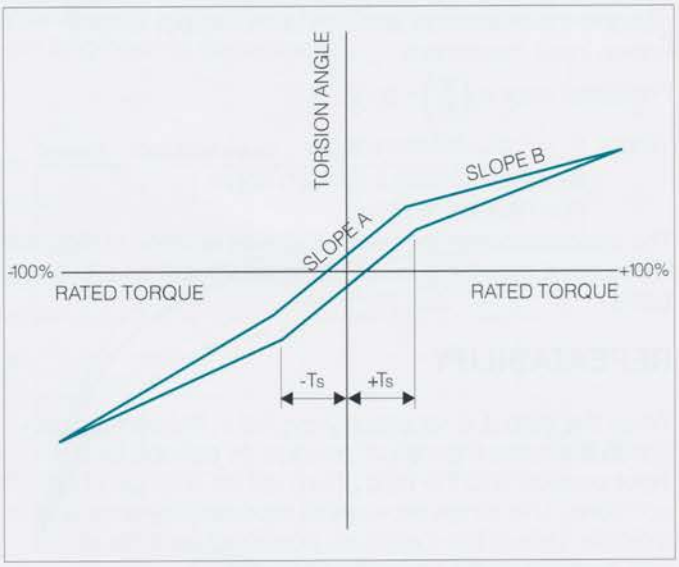
TORSIONAL SPRING RATE

For most practical purposes, the torsional spring rate of HDC components can be illustrated by a graph (Figure 3) with two distinct slopes, A and B.

A low torque applied to the output creates a nonlinear deflection shown in Slope A. This is sometimes referred to as "soft windup" and is dependent upon the clearance between the flexspline and the wave generator bearing race and the diametral clearance of the bearing. Stiffness for each size is shown in Figures 4 and 5. Gear set stiffness can be improved on a custom basis to increase the overall stiffness of the system. Designate K_2 when ordering.

See K_2 Slope A, Figures 4 and 5.

Figure 3: Torque - Torsion Graph



HDC SIZE	SLOPE A GUARANTEED MIN. R_1 lb-in/rad	SLOPE A GUARANTEED MIN. R_1 Nm/rad	K_2 R_1 lb-in/rad	K_2 R_1 Nm/rad	TORQUE RANGE Ts ± lb-in	TORQUE RANGE Ts ±Nm	SLOPE B R_2 lb-in/rad	SLOPE B R_2 Nm/rad
10	4500	508	7500	847	5	0.57	12000	1356
14	13500	1525	20500	2315	15	1.70	40000	4518
20	43000	4857	85000	9602	60	6.80	120000	13557
25	84000	9490	180000	20335	160	18.0	234000	26436
32	196000	22143	345000	38980	200	22.6	515000	58180
40	413000	46657	690000	77950	450	50.8	960000	108453
50	770000	86990	1.014×10^6	114553	800	90.4	1.88×10^6	212388
65	1.54×10^6	174000	2×10^6	226000	1400	158	4.12×10^6	465450
80	3.08×10^6	348000	4×10^6	451900	3000	339	7.68×10^6	867627
100	5.6×10^6	632645	7×10^6	790800	6000	678	15×10^6	1.7×10^6

Figure 4: 80:1 Ratio and Higher

HDC SIZE	SLOPE A GUARANTEED MIN. R_1 lb-in/rad	SLOPE A GUARANTEED MIN. R_1 Nm/rad	K_2 R_1 lb-in/rad	K_2 R_1 Nm/rad	TORQUE RANGE Ts ± lb-in	TORQUE RANGE Ts ±Nm	SLOPE B R_2 lb-in/rad	SLOPE B R_2 Nm/rad
10	3150	356	5250	593	5	0.57	12000	1356
14	9450	1067	14350	1621	15	1.7	40000	4518
20	30100	3400	59500	6722	60	6.8	120000	13557
25	58800	6643	126000	14235	160	18	234000	26436
32	137200	15500	241500	27283	200	22.6	515000	58180
40	289100	32660	483000	54566	450	50.8	960000	108453
50	539000	60892	709800	80188	800	90.4	1.88×10^6	212388
65	1.078×10^6	121784	1.4×10^6	158161	1400	158	4.12×10^6	465450
80	2.156×10^6	243568	2.8×10^6	316323	3000	339	7.68×10^6	867627
100	3.92×10^6	442852	4.9×10^6	553565	6000	678	15×10^6	1.7×10^6

Figure 5: 50:1 and 60:1 Ratios

The torsional spring rates shown in Figures 4 and 5 are measured by applying a torque to the output with the input fixed.

To calculate the maximum angular deflection of an HDC Cup Gear Set for an output torque, T, use the following equation:

$$\theta \text{Radians} = \frac{Ts}{R_1} + \frac{[T-Ts]}{R_2}$$

(See Figure 4 and 5 for Ts)

Example: When a torque of 600 lb-in is applied to the output of a standard HDC 25-100:1 ratio:

Total Angular Deflection =

$$\frac{160}{84000} + \frac{[600-160]}{234000} = 0.0038 \text{ radians}$$

If this deflection is unacceptably large, use a gear set with a custom K_2 spring rate (Slope A) or select a larger size.

Angular Deflection =

$$\frac{160}{180000} + \frac{[600-160]}{234000} = 0.0028 \text{ radians}$$

POSITIONAL ERROR

Positional error is the difference between the actual position and the theoretical position of the output for any known input movement.

Positional error = $\left(\frac{\theta_1}{R}\right) - \theta_2$

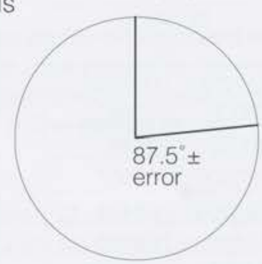
Where θ_1 = Input rotation angle
θ_2 = Actual output rotation angle
R = Reduction ratio

The maximum error for each HDC size is listed in Figure 6. However, it may be possible to improve this on a custom basis.

REPEATABILITY

When the output is repeatedly cycled in the same direction to the same theoretical position as defined by the input position and the ratio, there will be a range of actual positions. This range represents repeatability error and is typically 15% of the maximum positional error for each size gear set under no-load conditions.

For example, a positioning device is driven by an HDC-25 cup component set. The device rotates repeatedly between home position and a theoretical required position 87.5° away (Point A).

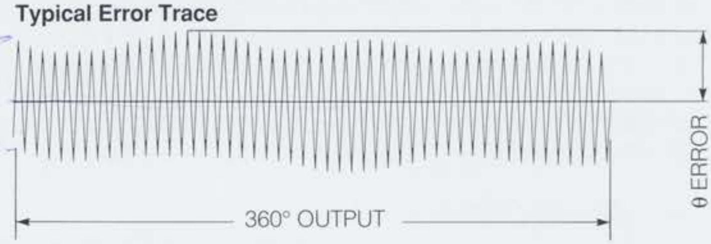


The maximum positional error of an HDC-25 is ± 60 arc seconds (see Figure 6). The maximum repeatability error is 15% of this, or ± 9 arc seconds. The actual position of the device, therefore, will always be within ± 9 arc seconds of Point A.

Figure 6

HDC SIZE	10	14	20	25	32	40	50	65	80	100
Maximum Positional Error ± arc seconds	150	110	75	60	47	38	30	25	19	15

Typical Error Trace



For applications with critical positioning requirements or those involving reversing loads, it may be necessary to consider hysteresis loss or lost motion, the value of which is a function of torsional windup and the torque profile for the particular application. Consult our Engineering department for assistance.

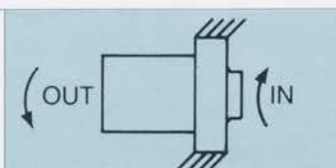
BACK DRIVING/REVERSIBILITY

HDC Gear Sets are not self-locking. They are reversible and cannot, therefore, be used to hold a load in position without the addition of a brake. This reversibility allows the HDC's use as a speed increaser, with the flexspline or circular spline as the drive member and the wave generator as the high-speed output element. Input/output versatility is demonstrated below.

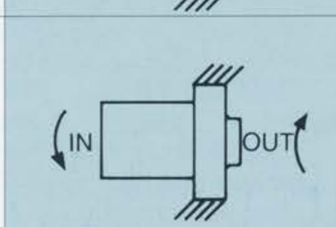
Note:
When using HDC Gear Sets as a speed increaser, be sure not to exceed the maximum speeds listed.

INPUT/OUTPUT VERSATILITY

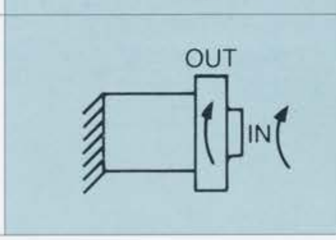
1.
Speed Reducer:
Circular Spline stationary. Wave Generator input. Flexspline output. Ratio as tabulated.

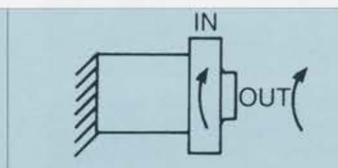


2.
Speed Increaser:
Circular Spline stationary. Flexspline input. Wave Generator output. Ratio as tabulated.

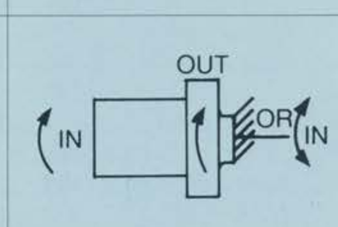


3.
Speed Reducer:
Flexspline stationary. Wave Generator input. Circular Spline output. Ratio as tabulated plus 1.

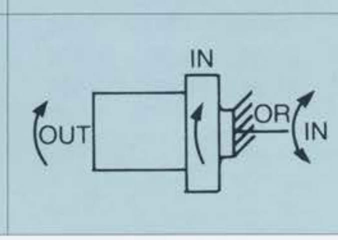




4.
Speed Increaser:
Flexspline stationary. Circular Spline input. Wave Generator output. Ratio as tabulated plus1.



5.
Speed Reducer/Differential:
Wave Generator stationary. Flexspline input. Circular Spline output.
Ratio = $\frac{\text{Tabulated Ratio}}{\text{Tabulated Ratio} + 1}$

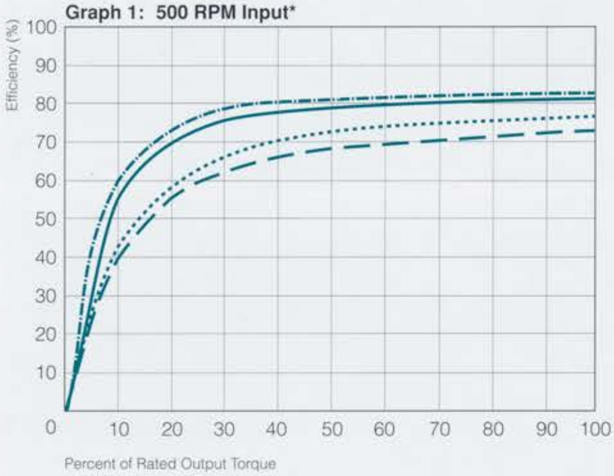


6.
Speed Increaser/Differential:
Wave Generator stationary. Circular Spline input Flexspline output.
Ratio = $\frac{\text{Tabulated Ratio} + 1}{\text{Tabulated Ratio}}$

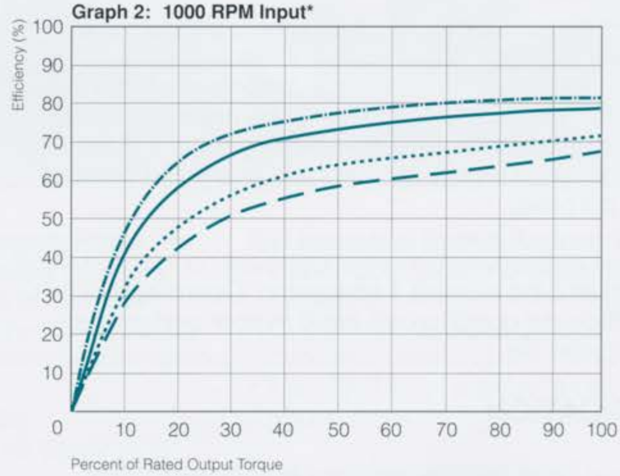
EFFICIENCY

The efficiency of HDC Gear Sets varies with speed, ratio, lubrication, and temperature. The following graphs show the approximate measured values of efficiency against percentage of rated torque. These values can be adjusted by a temperature factor (Graph 5); however, extremes of temperature or excessively low loading should be referred to our Engineering department.

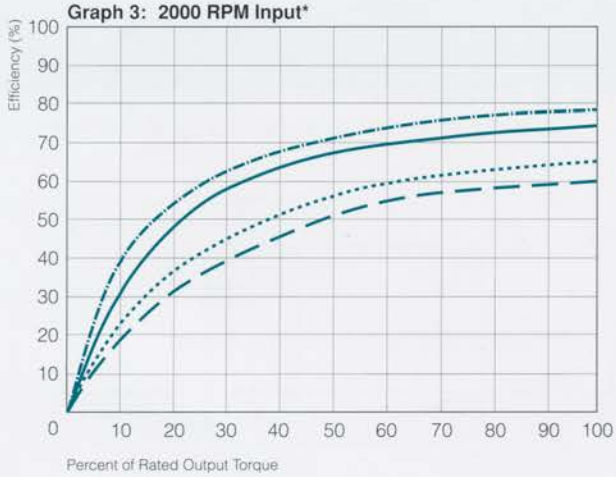
Graph 1: 500 RPM Input*



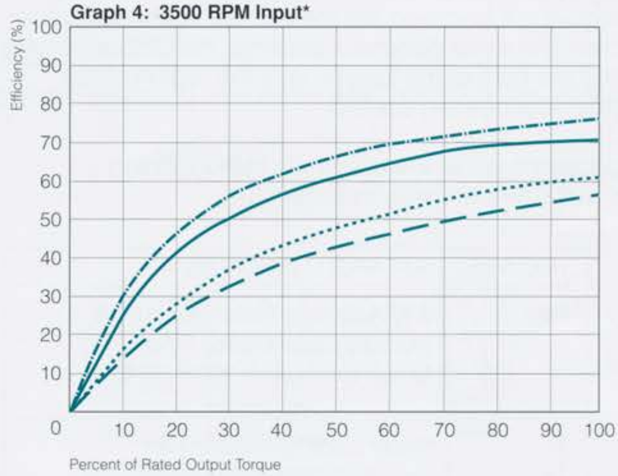
Graph 2: 1000 RPM Input*



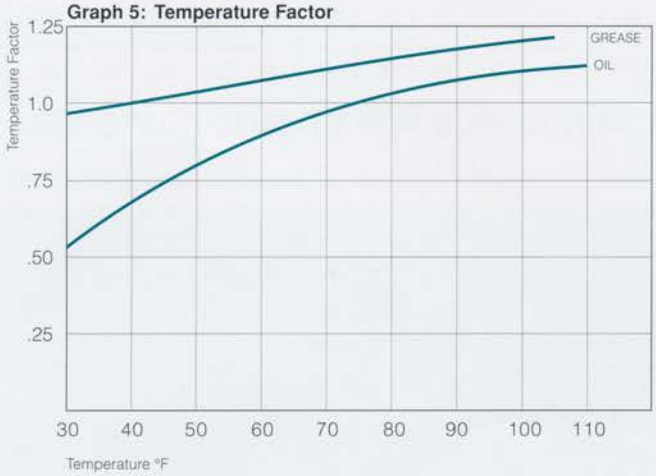
Graph 3: 2000 RPM Input*

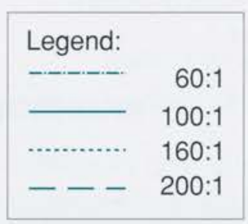


Graph 4: 3500 RPM Input*



Graph 5: Temperature Factor





* ATF

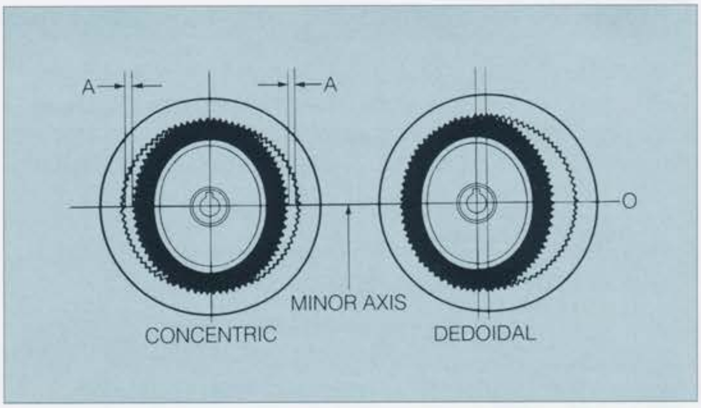
Multiply the efficiency value from Graphs 1-4 by the temperature factor from Graph 5.

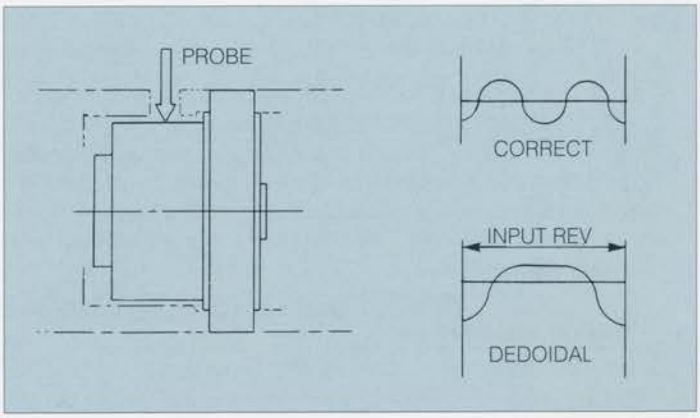
DEDOIDAL CONDITION

For proper operation of an HDC Gear Set, it is essential that the teeth of the flexspline be concentric with those of the circular spline. Incorrect assembly or loading in excess of the Ratchet Torque Limit will result in an off-center or "dedoidal" condition.

To check for such a condition, insert a feeler gauge at the two minor axis positions to insure an equal gap 'A'. Alternatively, position an indicator probe against the outer wall of the flexspline. For one complete revolution of the input there should be two equal deflections of the probe. We recommend including an access hole in the housing for this purpose.

If the unit is discovered to be in dedoidal condition, it must be reassembled to make it concentric. Operating the unit in the dedoidal condition will result in poor performance and reduced life.





LUBRICATION

Harmonic Drive gearing functions equally well in any mounting position, provided it is adequately lubricated. Areas requiring lubrication are the circular spline/flexspline tooth mesh, the wave generator bearing, the Oldham coupling, and the bore of the flexspline in the region of the wave generator bearing contact.

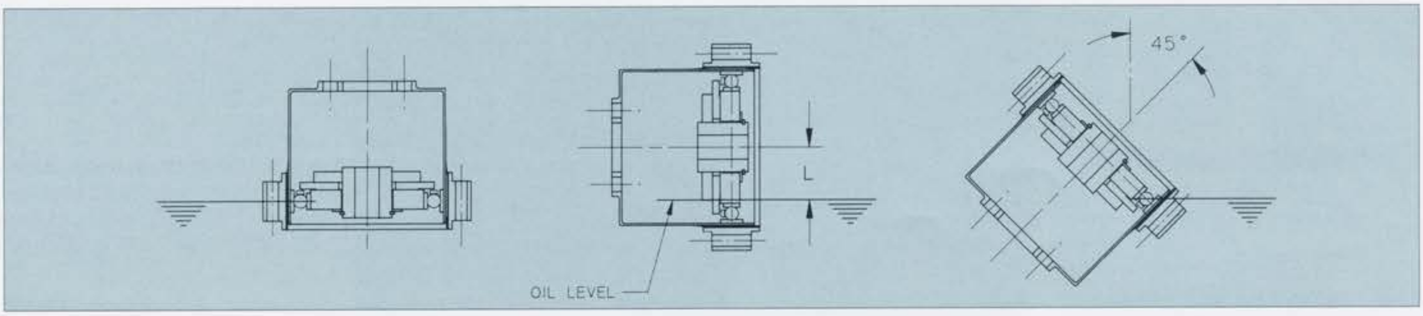
For applications within the maximum listed running speeds, suitable lubricants include:

	HDC SIZE	SUITABLE LUBRICANTS*
Oil	All	ATF Automatic Transmission Fluid (such as Exxon Dexron II) for temperatures up to 200°F (93°C)
Grease	10 14	Kluber L3200 (Available from Harmonic Drive Technologies)
	20 to 100	Exxon Beacon 325 or Andok B Shell Aeroshell 5 Amoco Super Mil A278323

**See ratings table on Page 3 for maximum running speeds*

HDC SIZE	10	14	20	25	32	40	50	65	80	100
Oil Level (L) (mm)	7	8	13	16	20	26	30	42	50	65

Oil Levels



HOUSED REDUCERS

All HDC Cup Component Gear Sets are available as fully housed reducers to satisfy a range of requirements from heavy-duty industrial applications to miniature precision servo applications.

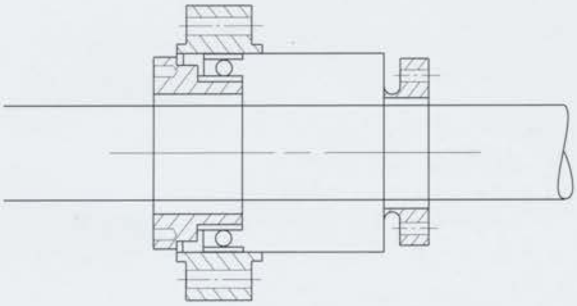
PSR Precision Servo Reducers
- Conventionally configured speed reducers
- For small servo applications
- High ratios
- Low to zero backlash
- Accuracies to arc minutes

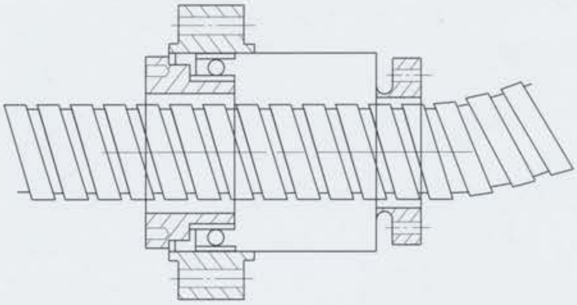
PCR Precision Compact Reducers
- Compact in-line speed reducers
- 50 to 200 times the torque from servomotors or steppers
- Provides a simple method for creating differentials
- Low to zero backlash
- Accuracies to arc minutes

ISR Industrial Speed Reducers
- Heavy-duty, industrial grade speed reducers
- Cup component design provides concentric shafting
- For high-ratio, continuous-use applications

THROUGH-HOLE DESIGN FOR PIPES OR CABLES

HDC T-Cup Component Gear Sets have a large center through-hole design to accommodate shafts, cables, pipes, etc. Consult our Engineering department for details.

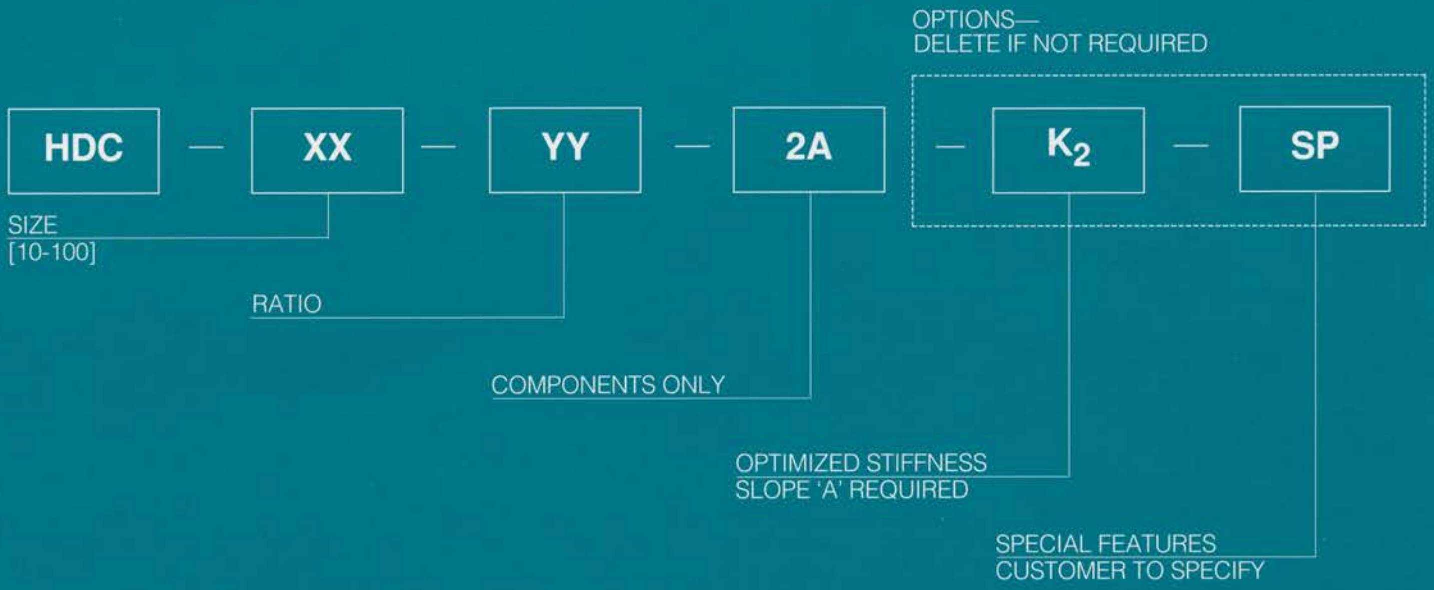




AEROSPACE QUALITY FOR SUPERCRITICAL APPLICATIONS

For many years Harmonic Drive Technologies has been supplying high-quality gear sets for commercial and military aerospace applications. In fact, Harmonic Drive Technologies has produced over 1500 space flight units with zero defects. Consult our Engineering department for details.

ORDERING DETAILS



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NSAI I.S. EN ISO 9001

HDCSG 7.5M 4/98N

Printed in USA