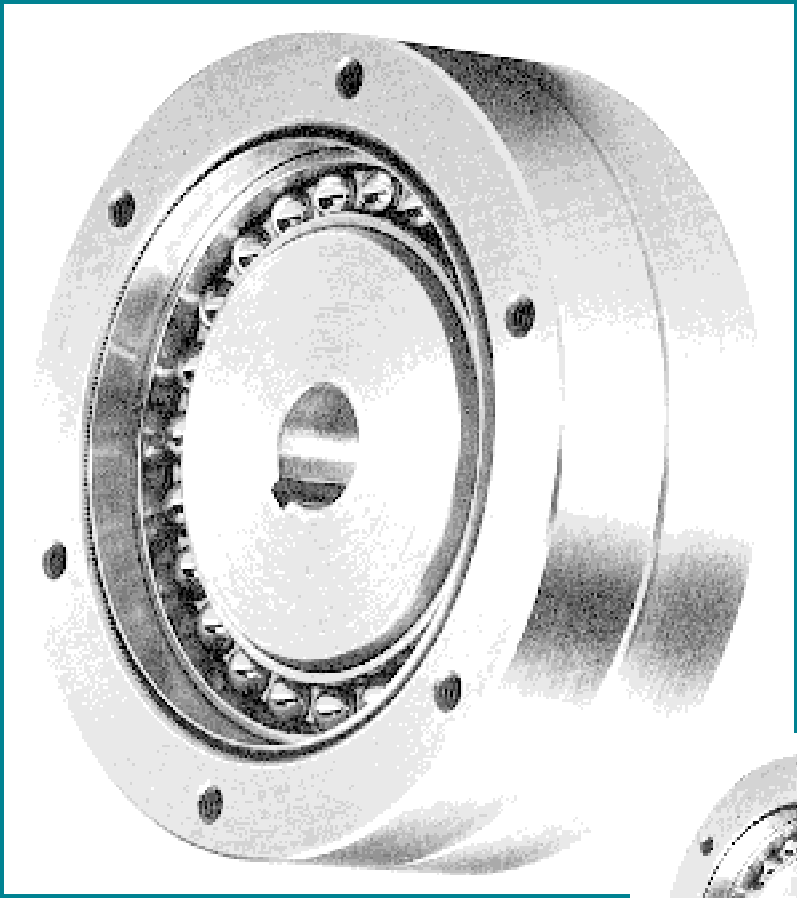
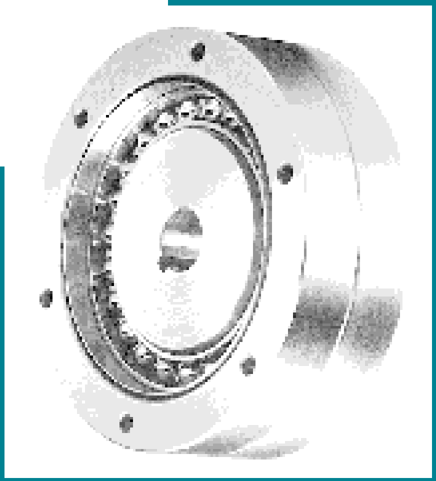
PANCAKE COMPONENT GEAR SETS



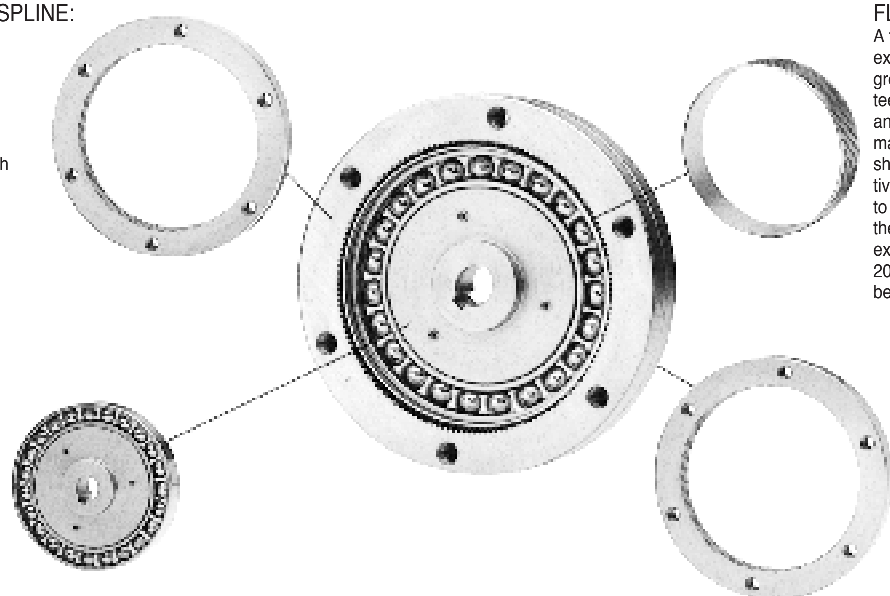


Harmonic Drive® TECHNOLOGIES

Pancake Component Gear Sets

The Most Axially Compact, Single-Stage, High-Ratio Gearing Available

DYNAMIC CIRCULAR SPLINE:
An internal gear which has the same number of teeth as the Flexspline and which rotates at the same speed and in the same direction as the Flexspline. It usually is the output element to which an output shaft is connected.



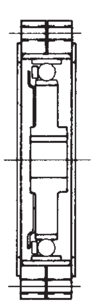
FLEXSPLINE:
A thin-walled steel ring with external spline teeth that progressively engage the internal teeth of the Static Circular Spline and Dynamic Circular Spline at the major axis of its rotating elliptical shape. Speed reduction relative to the Wave Generator is equal to one-half the number of teeth on the Flexspline's outside edge. For example, if the Flexspline has 200 teeth, the reduction ratio will be 100:1.

WAVE GENERATOR:
An Elliptical bearing and the rotating input element of the transmission. It is connected to a motor or other input shaft and imparts a rotating elliptical shape to the Flexspline.

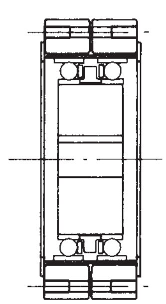
STATIC CIRCULAR SPLINE:
A fixed nonrotating internal gear which provides mechanical grounding for the transmission. It has two more teeth than the Flexspline to establish a positive transmission reduction ratio equal to one-half the number of Flexspline teeth.

Harmonic Drive pancake component gear sets provide high ratio precision speed reduction in an extremely compact package, yet offer many of the desirable performance characteristics of HDC cup components.

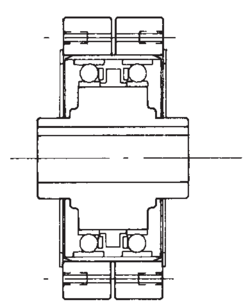
Four styles of pancake gearing are available and are described below. This brochure contains technical specifications for each type and offers a guide to correct size selection. More complex applications not covered in this brochure can be referred to our Engineering Department.



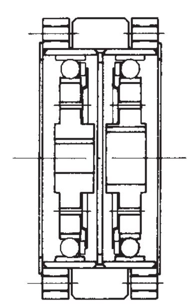
HDF



HDR



HDA



HDB

HDF pancake gearing uses a single wave generator bearing (see above) and is recommended for light duty speed reduction and phasing/differential applications. Ratios from 80:1 to 160:1 are available and output torques up to 5800 lb in (655 Nm).

The HDR utilizes a double wave generator bearing and is a heavy duty version of the HDF with only minimal increase in overall length. HDR should be used where generally heavier service is required or sudden shock loads may be expected. Ratios from 80:1 to 160:1 are available and output torques up to 26000 lb in (3000 Nm).

A variety of mounting options, and a large center through bore can be achieved by providing the HDR series with an extended and modified wave generator hub.
This style is designated HDA and standard ratios and performance ratings are as the equivalent HDR size.

The HDB was developed as a versatile simple differential drive transmission for direct phasing of rotating elements while they are in motion. Offsetting internal gear ratios deliver a through ratio of 1:1 and trim adjustments can be applied through one or both of two wave generators. Standard ratios and output torques are as the HDF.

RATING'S TABLE

HDF & HDB

SIZE	RATIO	MAXIMUM INPUT RPM		RATED TORQUE @ 1750 RPM		MAXIMUM OUTPUT TORQUE		APPROXIMATE WAVE GENERATOR INERTIA		NO LOAD STARTING TORQUE	
		Oil	Grease	lb-in	Nm	lb-in	Nm	lb-in²	Kg-cm²	oz-in	N-cm
14 HDF ONLY	80 100 110	6000	3500	56 56 56	6 6 6	90 90 90	10 10 10	0.011	0.033	3.0	2.1
20	80 100 120 160	6000	3500	246 246 246 246	28 28 28 28	250 300 350 390	28 34 40 44	0.049	0.144	4.5	3.2
25	80 100 120 160	5000	3500	406 406 406 406	46 46 46 46	425 600 700 780	48 68 79 88	0.124	0.362	6.0	4.3
32	80 100 120 160	4500	3500	810 810 810 810	92 92 92 92	950 1200 1400 1550	107 136 158 175	0.45	1.31	8.0	5.6
40	80 100 120 160	4000	3000	1705 1705 1705 1705	193 193 193 193	1700 2400 2700 3100	192 271 305 350	1.17	3.43	27.0	19.0
50	80 100 120 160	3500	2500	3180 3180 3180 3180	359 359 359 359	3100 4200 5200 5800	350 475 588 655	3.39	9.89	50.0	36.0

HDR & HDA

SIZE	RATIO	MAXIMUM INPUT RPM		RATED TORQUE @ 1750 RPM		MAXIMUM OUTPUT TORQUE		APPROXIMATE WAVE GENERATOR INERTIA		NO LOAD STARTING TORQUE	
		Oil	Grease	lb-in	Nm	lb-in	Nm	lb-in²	Kg-cm²	oz-in	N-cm
20	80 100 120 160	6000	3500	355 375 375 375	40 42 42 42	470 690 900 1120	53 78 102 127	0.095	0.28	12.8	9.0
25	80 100 120 160	5000	3500	620 620 620 620	70 70 70 70	830 1240 1690 1700	94 140 191 192	0.262	0.76	21.0	15.0
32	80 100 120 160	4500	3500	1245 1245 1245 1245	141 141 141 141	1830 2640 3410 4700	207 298 385 531	0.988	2.87	35.4	25.0
40	80 100 120 160	4500	3000	2075 2610 2610 2610	235 295 295 295	2760 4070 5060 7200	312 460 572 814	2.559	7.42	56.7	40.0
50	80 100 120 160	3500	2500	3890 4860 4860 4860	440 549 549 549	5110 6500 9500 13,100	577 735 1074 1480	7.730	22.42	87.8	62.0
65	80 100 120 160	3000	1800	7885 9010 9010 9010	891 1018 1018 1018	10,200 15,300 19,300 26,600	1153 1729 2181 3005	30.516	88.50	212.0	150.0

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. (See fig. 1 & 2)

Ratios

Standard ratios are listed in the above tables. Other ratios may be available on a custom basis including special double ratios up to 40,000: 1 in certain sizes.

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 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.

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.

For applications involving frequent fluctuations of speed or torque, calculate the mean speed N & mean torque T from the following equations.

For constant speed applications it is permissible to use the normal running torque T_2 from fig. 1 and normal input running speed from fig. 2.

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.

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

Figure 1: Torque Profile

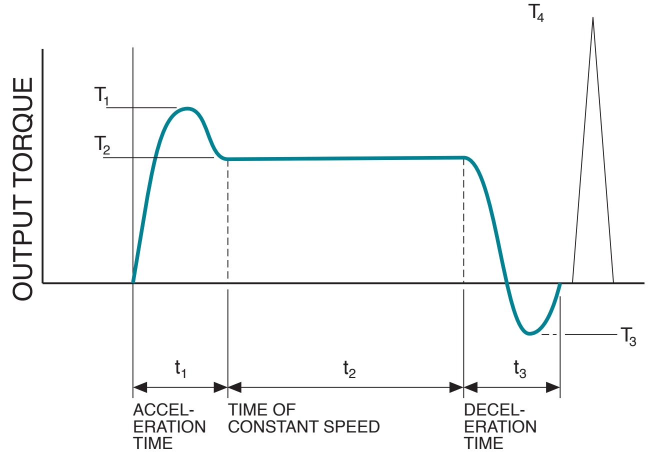
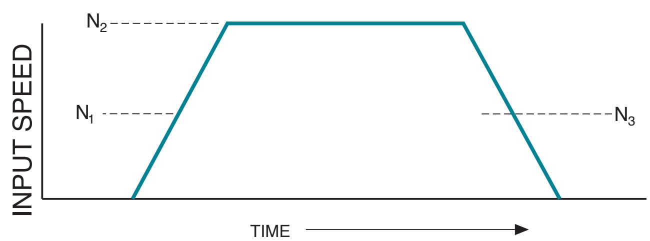


Figure 2: Speed Profile



RATINGS AND OPERATING LIFE

The operating life expectancy of Pancake 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 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 L_{10} life of 3,000 hours. Average life, however, is 5 times this number.

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.

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

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

4) Calculate expected life.

$$L_{10}=\left[\frac{\text{LISTED RATING @ 1750RPM}}{T_r}\right]^3\times 3000\text{ HOURS}$$

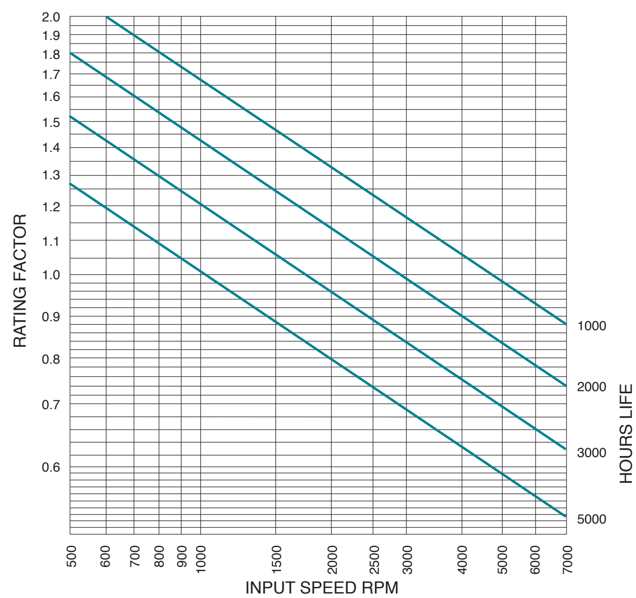
The torque rating of a gear set can be estimated for any input speed by multiplying the listed rated torque at 1750 RPM by the rating factor shown in graph figure 3.

EXAMPLE

The output torque rating of HDR 40, ratio 120:1 at 2500 RPM for a L_{10} life of 5000 hours.

Rating factor from graph 0.74
Rated torque HDR 40 @ 1750 RPM = 2610 lb. in.

Rating at 2500 RPM = 2610x0.74 = 1931 lb. in. for 5000 hours L_{10} life.



Backlash

Backlash is measured at the output (dynamic circular spline) with the static circular spline and the input wave generator locked. Typical measured values for each size are shown in the chart figure 3 low backlash options are available to order but must be designated K_2.

Figure 3

SIZE HDR, HDA & HDF		14	20	25	32	40	50	65
MAX BACKLASH	STANDARD	30	30	28	24	24	23	23
ARC MIN	OPTIMIZED K_2	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Torsional Spring Rate

A torque applied to the output of a gearset with the input locked, creates a deflection which can be represented by a torque torsion graph with two distinct slopes A and B (see figure 4)

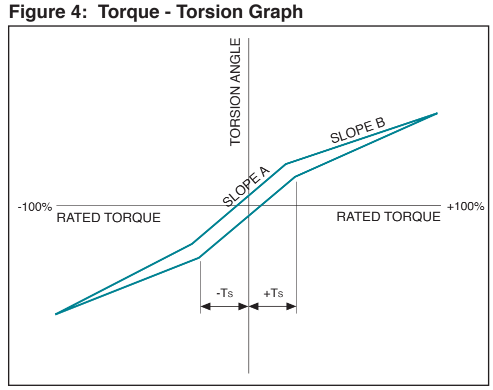
A low torque, T_S creates a non linear deflection, which is sometimes referred to as soft wind up. see slope A Optimized K_2 pancake gear sets have the slope A values listed in figure 5.

Torsional Spring Rate HDR & HDA

Figure 5

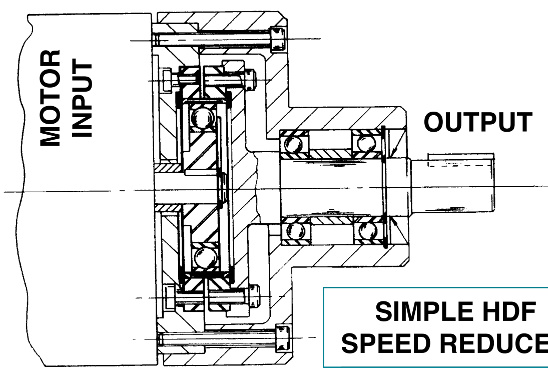
	SIZE	20	25	32	40	50	65
	Ts lb in	18.0	44.0	78.0	150.0	304.0	700.0
	Ts Nm	2.0	5.0	5.0	17.0	34.0	79.0
OPTIMIZED SLOPE A	lb in/RAD	7.2X10^{4}	14X10^{4}	25X10^{4}	54X10^{4}	106X10^{4}	230X10^{4}
(K_2)	Nm/RAD	0.81x10^{4}	1.6x10^{4}	2.8x10^{4}	6.1x10^{4}	12x10^{4}	26x10^{4}

Figure 4: Torque - Torsion Graph



ALIGNMENT & ASSEMBLY

Pancake gear sets are supplied as components only and are not self contained power transmissions. Suitable housings with bearing supports oil reservoirs and seals must be provided.



SIMPLE HDF SPEED REDUCER

Circular Splines

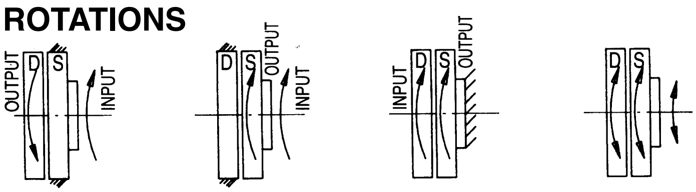
Must be mounted with suitable bearing arrangement or rotationally fixed to maintain the concentricity tolerances specified on the drawing under all load conditions.

Overhung loads from an external source require a suitable two bearing or four point contact bearing support.

Axial restraint in both directions must maintain the specified gap between the two circular splines.

Note: Static Spline marked S. Dynamic Spline marked D. will only give configuration below if mounted in correct position.

ROTATIONS



'S' Spline Fixed
Ratio = As Listed

'D' Spline Fixed
Ratio = As Listed + 1

Wave Generator Fixed
$$\text{Ratio} = \frac{\text{As Listed}}{\text{As Listed} + 1}$$

Differential
Arrangement

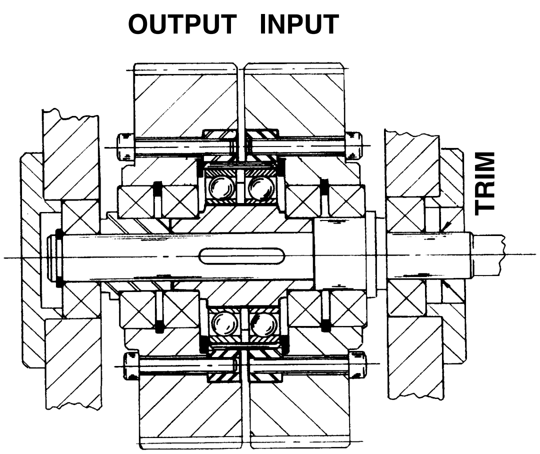
Flexspline

Two hardened washers are provided to prevent axial displacement of the flexspline.

These may be discarded if the customer supplied components in the vicinity of the flexspline are a minimum hardness of Rc45.

Wave Generator

Except in very special cases the wave generator bearing should not be used to support a shaft (consult factory). Axial restraint in both directions must be provided.

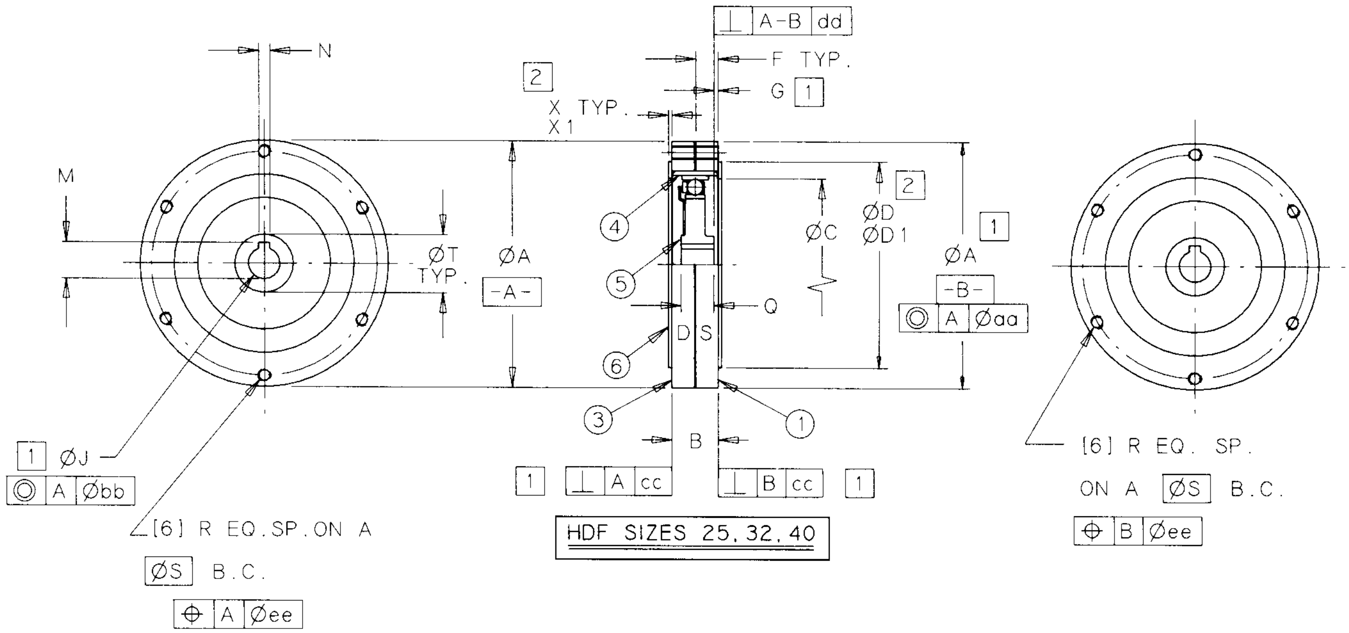


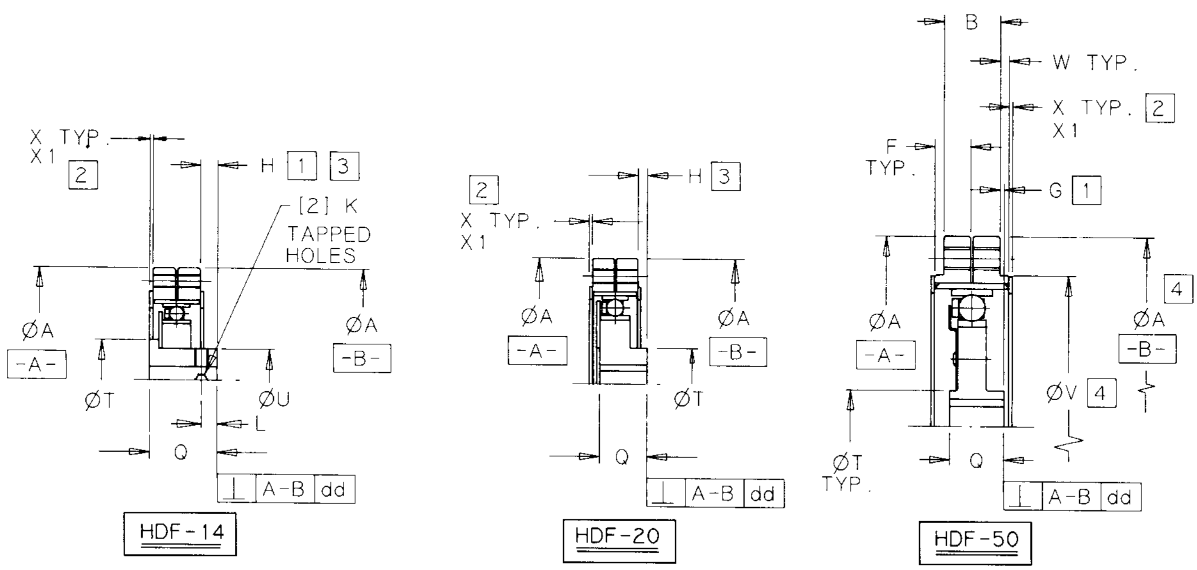
PHASE ADJUSTMENT WITH HDA

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	lb-in	5.3	19	41	85	140	350	680	1200
Torque	Nm	0.6	2.1	4.6	9.5	16	39	77	135

HDF DIMENSIONS





HDF

NOTE: ALL DIMENSIONS IN MM

	UNIT SIZE					
	14	20	25	32	40	50
ØA	$50^{-0.015}_{-0}$	$70^{-0.018}_{-0}$	$85^{-0.023}_{-0}$	$110^{-0.025}_{-0}$	$135^{-0.025}_{-0}$	$170^{-0.025}_{-0}$
B	$10.7^{\pm0.15}$	$12.7^{\pm0.15}$	$17.0^{\pm0.25}$	$21.0^{\pm0.25}$	$27.0^{\pm0.30}$	$25.0^{\pm0.30}$
ØC	$32^{\pm0.51}$	$47^{\pm0.51}$	$59^{\pm0.51}$	$77^{\pm0.51}$	$95^{\pm0.51}$	$119^{\pm0.51}$
ØD	$39.5^{\pm0.51}$	$54^{\pm0.51}$	$69.4^{\pm0.51}$	$92.1^{\pm0.51}$	$111.1^{\pm0.51}$	$134.4^{\pm0.51}$
ØD1	$40.2^{\pm0.51}$	$54.7^{\pm0.51}$	$70.2^{\pm0.51}$	$92.9^{\pm0.51}$	$111.9^{\pm0.51}$	$135.2^{\pm0.51}$
F	$5^{\pm0.1}$	$6^{\pm0.1}$	$8^{\pm0.2}$	$10^{\pm0.2}$	$13^{\pm0.2}$	$16^{\pm0.2}$
G	—	—	$.38^{\pm0.38}$	$.94^{\pm0.38}$	$1.8^{\pm0.38}$	$1.12^{\pm0.38}$
H	$3.76^{\pm0.38}$	$.94^{\pm0.38}$	—	—	—	—
ØJ	$6^{+0.012}_{-0}$	$9^{+0.015}_{-0}$	$11^{+0.018}_{-0}$	$14^{+0.020}_{-0}$	$14^{+0.020}_{-0}$	$19^{+0.020}_{-0}$
K	M3 x 0.5	—	—	—	—	—
L	$3.5^{\pm0.38}$	—	—	—	—	—
M	—	$10.4^{+0.10}_{-0}$	$12.8^{+0.010}_{-0}$	$16.3^{+0.010}_{-0}$	$16.3^{+0.010}_{-0}$	$21.8^{+0.010}_{-0}$
N	—	$3^{\pm0.0125}$	$4^{\pm0.013}$	$5^{\pm0.013}$	$5^{\pm0.013}$	$6^{\pm0.015}$
Q	15.0	11.4	12.8	15.6	19.4	23.2
R	M3 x 0.5	M4 x 0.7	M5 x 0.8	M6 x 1.0	M8 x 1.25	M10 x 1.5
S	44	60	75	100	120	150
ØT	18	20	28	36	32	50
ØU	14	—	—	—	—	—
ØV	—	—	—	—	—	$135^{-0.025}$
W	—	—	—	—	—	$4.52^{\pm0.1}$
X	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$1.57^{\pm0.13}$	$1.57^{\pm0.13}$
X1	$.94^{+0.13}_{-0}$	$.94^{+0.13}_{-0}$	$.94^{+0.13}_{-0}$	$.94^{+0.13}_{-0}$	$1.70^{+0.13}_{-0}$	$1.70^{+0.13}_{-0}$
aa	0.050	0.07	0.076	0.078	0.088	0.098
bb	0.013	0.013	0.015	0.015	0.018	0.020
cc	0.018	0.018	0.023	0.025	0.025	0.025
dd	0.010	0.010	0.013	0.013	0.013	0.015
ee	0.25	0.25	0.25	0.25	0.25	0.25
WEIGHT lb/kgf	0.2/0.09	0.7/0.32	1.3/0.59	2.3/1.04	4.4/2.00	7.3/3.31

A. Item ① Static circular spline [Marked ‘S’]

Item ② Only appears with HDR & HDA

Item ③ Dynamic circular spline [Marked ‘D’]

Item ④ Flexspline

Item ⑤ Wave Generator

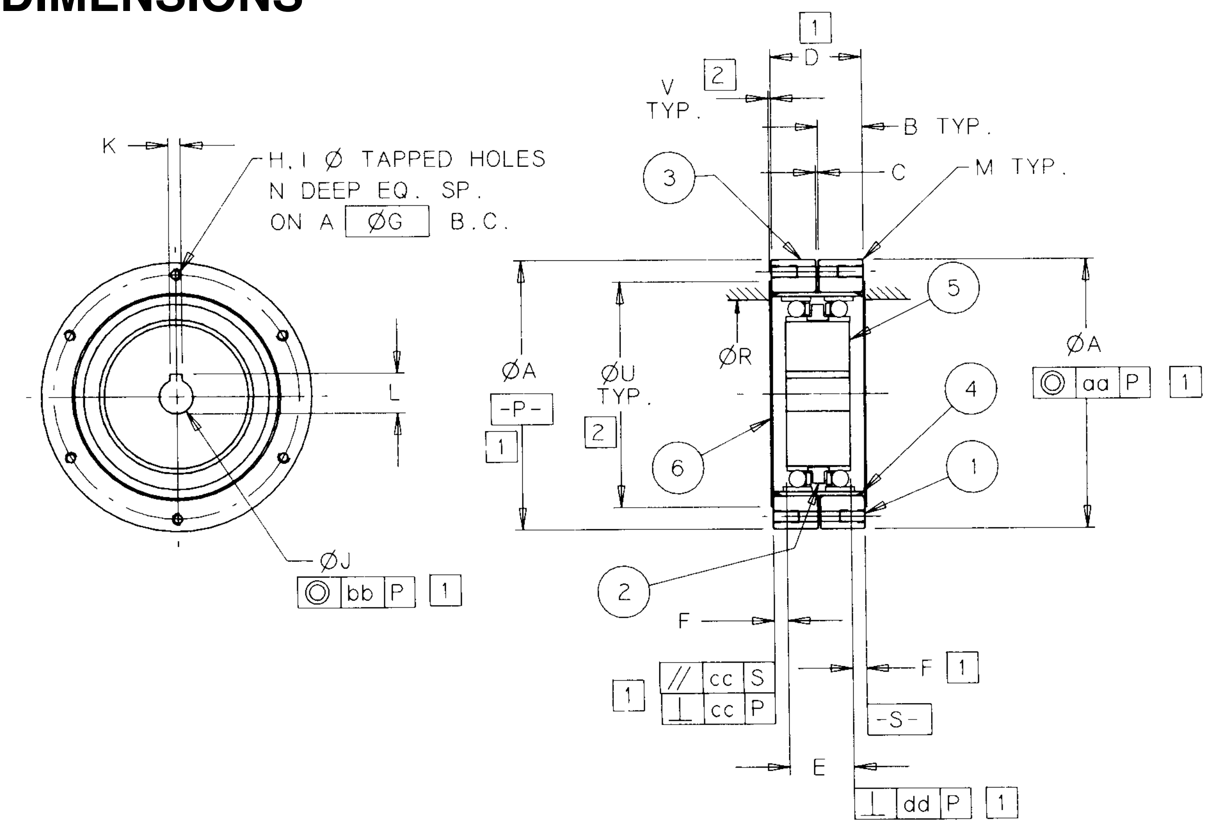
Item ⑥ Hardened wear washer. [See ass’y notes pg. 5]

B. Dimensions marked [1] established interface and installation requirements and must be maintained under all operating conditions. [See ass’y notes pg. 5]

C. Dimensions marked [2] are to locate wear washers, item 6 in correct position. [See ass’y notes pg. 5]

D. HDF 50 can be located on the outside diameter of the circular spline dimension A or on the pilot diameter dimension V.

HDR DIMENSIONS



NOTE: ALL DIMENSIONS IN MM

	UNIT SIZE					
	20	25	32	40	50	65
ØA	$70^{-0.019}_{-0}$	$85^{-0.022}_{-0}$	$110^{-0.022}_{-0}$	$135^{-0.025}_{-0}$	$170^{-0.025}_{-0}$	$215^{-0.029}_{-0}$
B	12	14	18	21	26	35
C	1	1	1	1	1	1
D	25	29	37	43	53	71
E	17.3	20	25.9	31.5	39.1	50.5
F	3.85	4.5	5.55	5.75	6.95	10.25
GØ	60	75	100	120	150	195
H	6	6	6	6	6	6
I	M3-.5	M4-.7	M5-.8	M6-1	M8-1.25	M10-1.5
JØ	$9^{+0.015}_{+0}$	$11^{+0.018}_{+1}$	$14^{+0.018}_{+0}$	$14^{+0.018}_{+0}$	$19^{+0.021}_{+0}$	$24^{+0.021}_{+0}$
K	$3^{\pm0.0125}$	$4^{\pm0.0150}$	$5^{\pm0.0150}$	$5^{\pm0.0150}$	$6^{\pm0.0150}$	$8^{\pm0.0180}$
L	10.4	12.8	16.3	16.3	21.8	27.3
M	0.4	0.4	0.4	0.4	0.4	0.4
N	6	8	10	12	16	20
RØ	47	59	77	95	119	150
UØ	54.8	69.7	92.6	111.4	135	177
V	$1^{+0.13}$	$1^{+0.13}$	$1^{+0.13}$	$1.78^{+0.13}$	$1.78^{+0.13}$	$1.78^{+0.13}$
aa	0.016	0.016	0.017	0.019	0.024	0.027
dd	0.010	0.012	0.012	0.012	0.015	0.015
cc	0.017	0.024	0.026	0.026	0.028	0.034
bb	0.013	0.016	0.016	0.017	0.021	0.025
WEIGHT KGF	0.5	0.8	1.7	3.0	6.0	12.0
WEIGHT LB	1.1	1.8	3.7	6.6	13.2	26.5

A. Item ① Static circular spline
Marked 'S'

Item ② Spacer

Item ③ Dynamic circular spline
Marked 'D'

Item ④ Flexspline

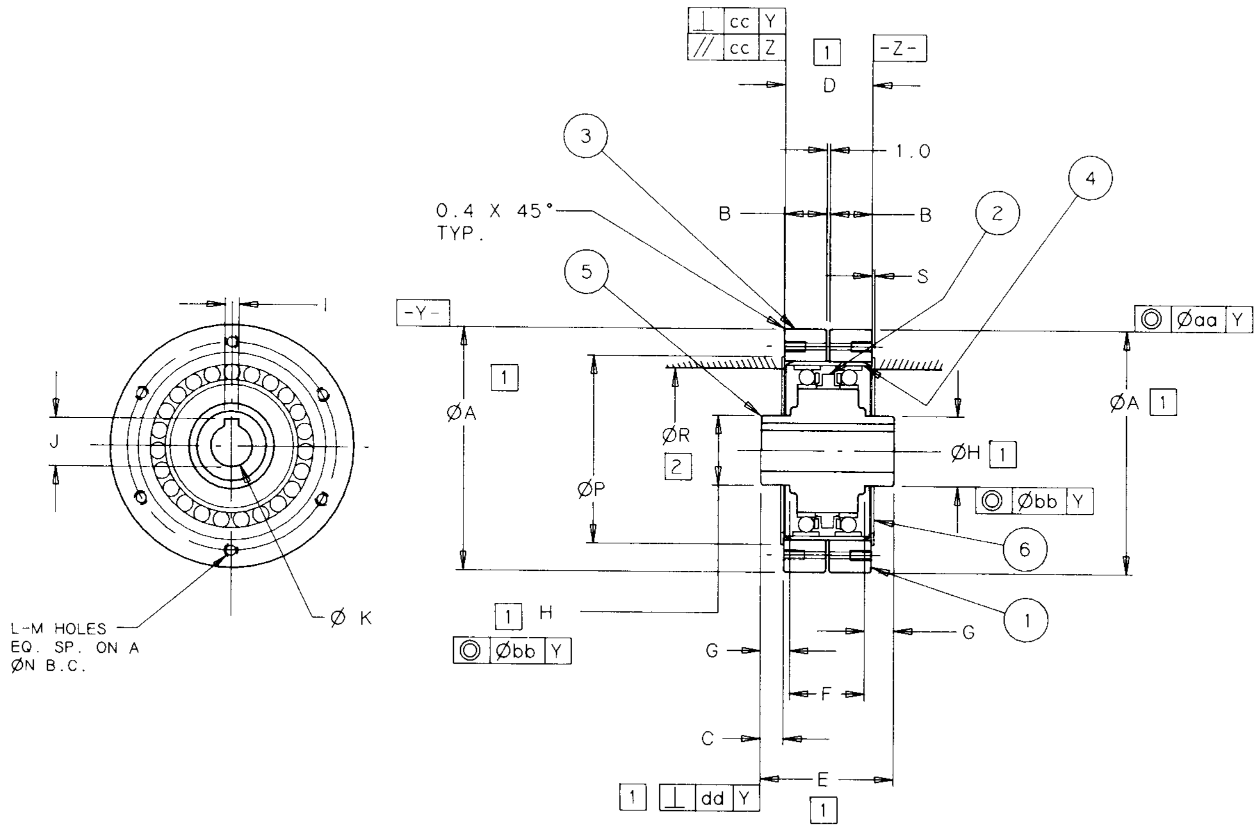
Item ⑤ Wave Generator

Item ⑥ Wear Washers.
See ass'y notes pg. 5

B. Dimensions marked [1] established interface and installation requirements and must be maintained under all operating conditions.
See ass'y notes pg. [5]

C. Dimensions marked [2] are necessary to locate wear washers, item ⑥ in correct position.
See ass'y notes pg. 5

HDA DIMENSIONS



NOTE: ALL DIMENSIONS IN MM

	UNIT SIZE					
	20	25	32	40	50	65
AØ	$70^{-0.010}_{-0.040}$	$85^{-0.012}_{-0.047}$	$110^{-0.012}_{-0.047}$	$135^{-0.014}_{-0.054}$	$170^{-0.014}_{-0.054}$	$215^{-0.015}_{-0.061}$
B	12	14	18	21	26	35
C	6.5	5.5	6.5	12.5	12.5	8
D	25	29	37	43	53	71
E	38	40	50	68	78	87
F	21.5	25	30	44	54	59
G	8.25	7.5	10	12	12	14
HØ	$20^{+0.009}_{-0.004}$	$30^{+0.009}_{-0.004}$	$40^{+0.011}_{-0.005}$	$50^{+0.011}_{-0.005}$	$60^{+0.012}_{-0.007}$	$70^{+0.012}_{-0.007}$
I	$4^{\pm0.015}$	$6^{\pm0.015}$	$8^{\pm0.018}$	$10^{\pm0.018}$	$12^{\pm0.0215}$	$14^{\pm0.0215}$
J	13.8	22.8	33.3	38.3	43.3	53.8
KØ	$12^{+0.018}$	$20^{+0.021}$	$30^{+0.021}$	$35^{+0.025}$	$40^{+0.025}$	$50^{+0.025}$
L	6	6	6	6	6	6
M	M3 X 6 DP	M4 X 8 DP	M5 X 10 DP	M6 X 12 DP	M8 X 16 DP	M10 X 20 DP
NØ	60	75	100	120	150	195
PØ	$54^{\pm0.5}$	$69.4^{\pm0.5}$	$92^{\pm0.5}$	$111^{\pm0.5}$	$134.4^{\pm0.5}$	$176^{\pm0.5}$
RØ	47	59	77	95	119	150
S	0.8	0.8	0.8	1.6	1.6	1.6
aa	0.016	0.016	0.017	0.019	0.024	0.027
bb	0.013	0.016	0.016	0.017	0.021	0.025
cc	0.017	0.024	0.026	0.026	0.028	0.034
dd	0.010	0.012	0.012	0.012	0.015	0.015
WEIGHT KGF	0.6	1.0	2.0	3.6	7.2	14
WEIGHT LB	1.3	2.2	4.4	7.9	16	31

A. Item ① Static circular spline
Marked 'S'

Item ② Spacer

Item ③ Dynamic circular spline
Marked 'D'

Item ④ Flexspline

Item ⑤ Wave Generator

Item ⑥ Wear Washers.
See ass'y notes pg. 5

B. Dimensions marked 1 established interface and installation requirements and must be maintained under all operating conditions.
See ass'y notes pg. 5

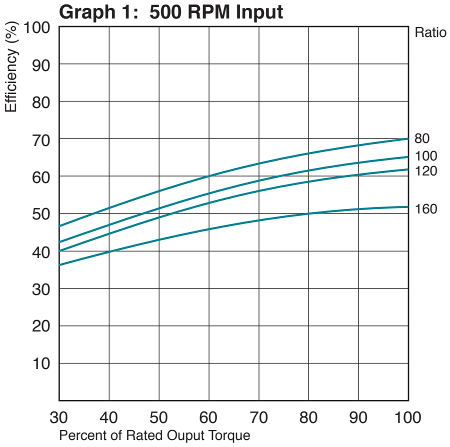
C. Dimensions marked 2 are necessary to locate wear washers, item ⑥ in correct position.
See ass'y notes pg. 5

EFFICIENCY

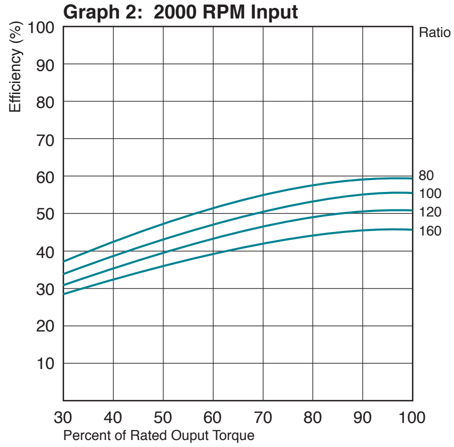
The efficiency of Pancake Gear Sets varies with speed, ratio, lubrication, and temperature. The following graphs show the approximate measured values of efficiency against percentage of rated torque. These values can be adjusted by a temperature factor (Graph 7); however, extremes of temperature or excessively low loading should be referred to our Engineering Department.

HDF

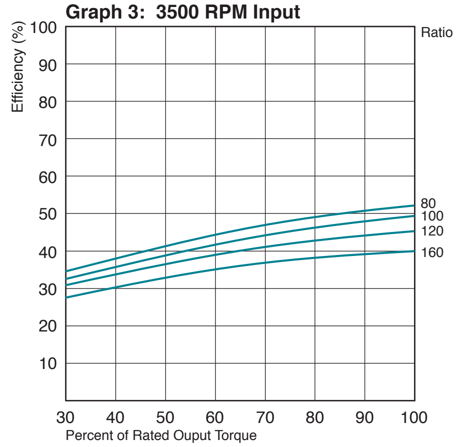
Graph 1: 500 RPM Input



Graph 2: 2000 RPM Input



Graph 3: 3500 RPM Input



The efficiency of a gear set is defined as:

$$\text{Efficiency} = \left[\frac{\text{Torque Out}}{\text{Torque In x Ratio}}\right] \text{x } 100\%$$

Graphs 1-6 show efficiency against the percent of rated output torque used for any particular application and gear set size.

Example

Estimate the efficiency of an HDR 40 with 100:1 ratio which will transmit an output torque of 1800 lb. in with an input speed of 2000RPM.

1. From step 2 page 4

$$T_r = \left[\frac{2000}{1750}\right]^{1/3} \text{x 1800 lb in} = \text{1881 lb in}$$

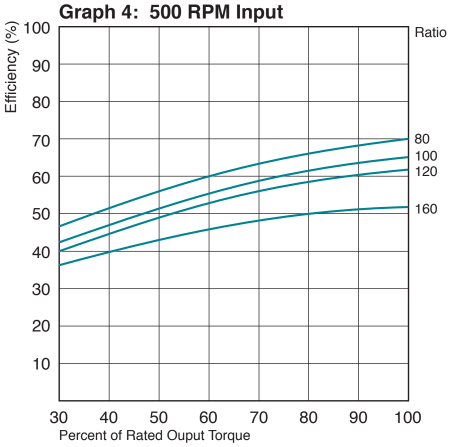
2. Rated torque a 1750 RPM from page 3 = 2610 lb. in.
3. Percent of rated torque used for application

$$= \left[\frac{1881}{2610}\right] \text{x } 100 = 72\%$$

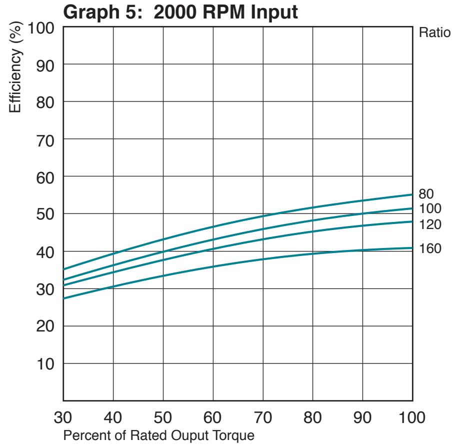
4. From graph 5, efficiency a 72% of rated torque= 47%

HDR & HDA

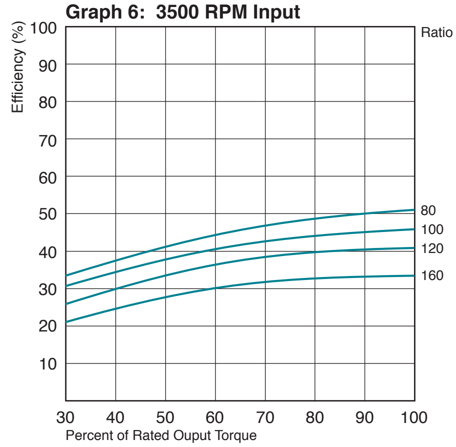
Graph 4: 500 RPM Input



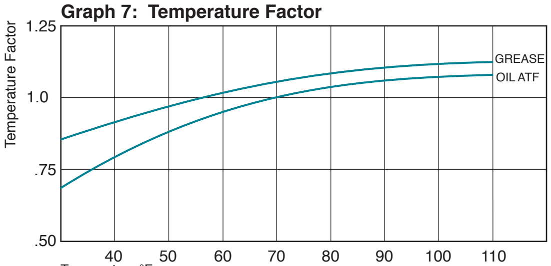
Graph 5: 2000 RPM Input



Graph 6: 3500 RPM Input



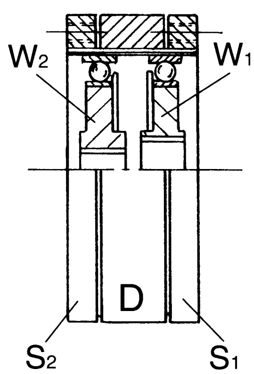
Graph 7: Temperature Factor



Multiply the efficiency from the graph 1-6 by the temperature factor from graph 7.

HDB Phasing Differential Gear Sets

Harmonic Drive HDB gear sets allow easy and direct phasing of rotating elements and are ideally suited for web presses and other machines requiring constant monitoring and adjustment while they are in motion.



Drive Power

Essentially two HDF pancake gear sets mounted back to back with dynamic splines connected, the HDB provides a 1:1 through ratio from a primary drive source to secondary elements of a machine with optional speed or position adjustment.

Power is applied to S_1 the first of three ring gears called circular splines. Torque is transmitted from the first circular spline to the third circular spline S_2 through two gear ratios.

The first ratio is a slight speed increase between S_1 and the middle circular spline D.

The second ratio is a very slight speed reduction between the D spline and the S_2 circular spline.

When the two wave generators W_1 and W_2 are stationary, the increasing and decreasing ratios offset each other and the S_1 and S_2 circular splines rotate in the same direction and at the same speed. Power circulates from the S_1 input to the S_2 output at a 1:1 ratio with an efficiency of approximately 99%.

Features

- For dynamic registration of rotating elements
- A 1:1 differential with high-ratio trim adjustment
- Ideal differential for roll registration or angular shaft phasing
- Compact, low-backlash design for end-of-roll mounting

Trim

With one wave generator W_1 rotationally fixed, a second wave generator W_2 can be rotated to create, a high ratio advance or retardation (depending on direction) of S_2 relative to the S_1 circular spline.

Output speed or position can be accurately adjusted with the machine in motion. The output speed of S_2 while trim is being applied can be calculated with the following equation:

$$N_{S2} = N_{S1} \pm \left[\frac{N_{W2}}{(R+1)}\right]$$

Where N=speed
R=tabulated ratio

It is possible to attach both wave generators to different drive sources.

For example, W_2 could be driven by a servomotor for high speed automated trim and W_1 to a hand crank for low speed manual trim.

Sufficient holding torque must be applied to the trim shaft to prevent rotation. This can be calculated from the following equation

$$\text{Control Torque} = \frac{\text{System Output Torque (max)}}{\text{Ratio x 0.5}}$$

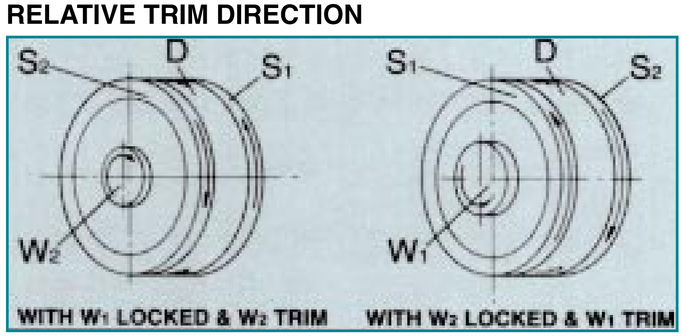
Ratio

Standard ratios are as shown in the rating table page 3, however, other ratios are available on a custom basis (consult our engineering department)

Ratings

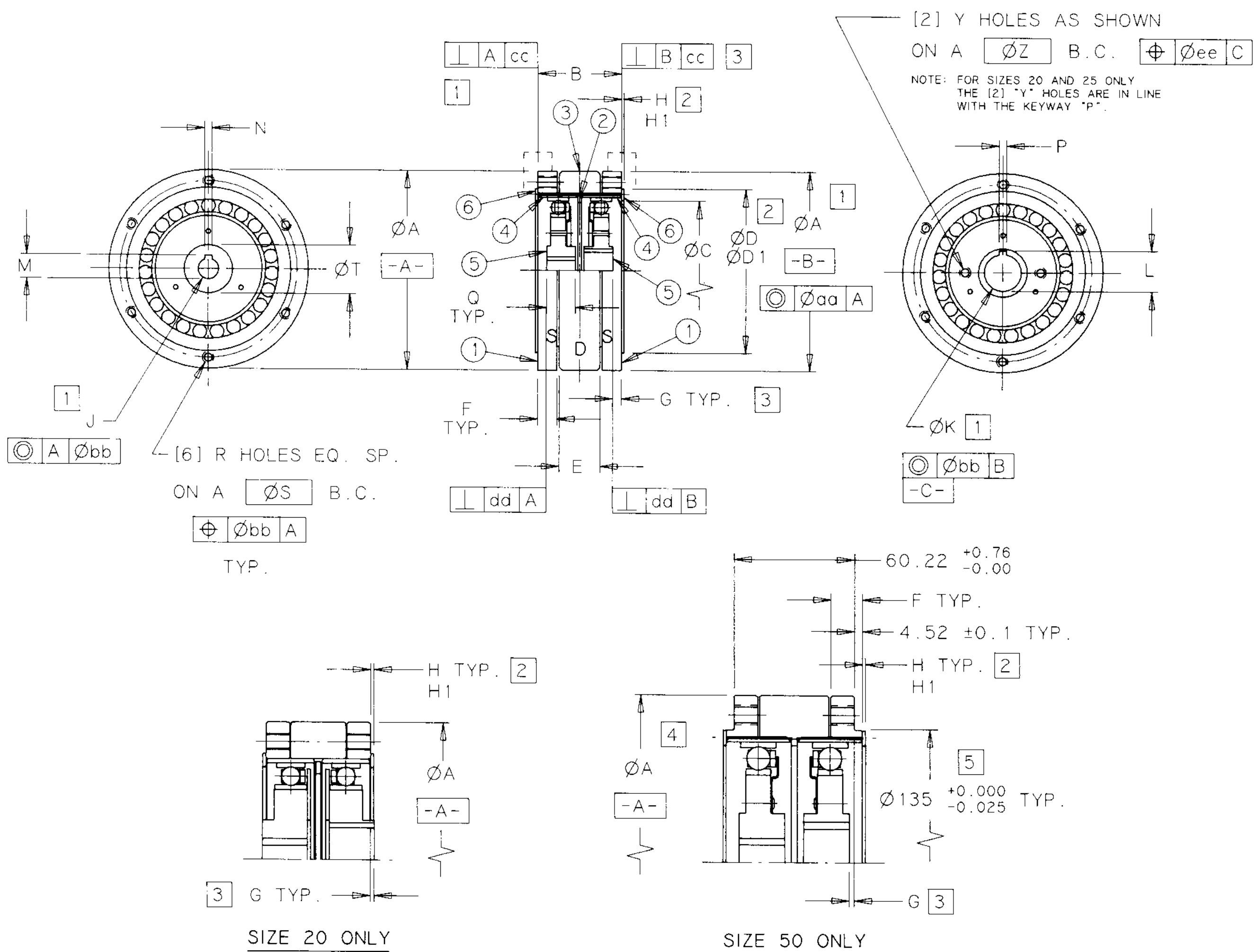
Torque ratings are as the equivalent size HDF pancake gear set (see page 3).

RELATIVE TRIM DIRECTION



These examples show the displacement of the circular splines S_1 and S_2 **relative to each other** when the wave generator is rotated in the direction of the arrow. Actual rotational direction will depend on the direction of the main input drive.

HDB DIMENSIONS



A. Item ① Static Circular Spline Marked 'S'

Item ② Spacer

Item ③ Dynamic Circular Spline Marked 'D'

Item ④ Flexspline

Item ⑤ Wave Generator

Item ⑥ Wear washer

B. Dimensions marked 1 established interface & installation requirements and must be maintained under all operating conditions

C. Dimensions marked 2 are necessary to locate wear washers item ⑥ in correct position See ass'y notes

	UNIT SIZE				
	20	25	32	40	50
ØA	$70^{-0.018}$	$85^{-0.022}$	$110^{-0.025}$	$134^{-0.025}$	$170^{-0.025}$
B	$26.5^{+0.25}$	$34.8^{\pm0.25}$	$42^{+0.6}$	$56.5^{+0.8}$	—
ØC	$47^{\pm0.51}$	$59^{\pm0.51}$	$77^{\pm0.51}$	$95^{\pm0.51}$	$119^{\pm0.51}$
ØD	$54^{\pm0.51}$	$69.4^{\pm0.51}$	$92.1^{\pm0.51}$	$111.1^{\pm0.51}$	$134.4^{\pm0.51}$
ØD1	$54.7^{+0.51}$	$70.2^{+0.51}$	$92.9^{+0.38}$	$92.9^{+0.38}$	$135.2^{+0.38}$
E	$14^{\pm0.1}$	$18^{\pm0.1}$	$20.9^{\pm0.1}$	$28^{\pm0.1}$	$35^{\pm0.2}$
F	$6^{\pm0.1}$	$8^{\pm02}$	$10^{\pm0.2}$	$13^{\pm0.2}$	$13^{\pm0.2}$
G	$1.8^{\pm.51}$	$3.27^{\pm.51}$	$3.95^{\pm.51}$	$1.95^{\pm.51}$	$1.4^{\pm.51}$
H	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$1.57^{\pm0.13}$	$1.57^{\pm0.13}$
H1	$.94^{+0.13}$	$.94^{+0.13}$	$.94^{+.013}$	$1.69^{+0.13}$	$1.69^{+0.13}$
ØJ	$9^{+0.015}$	$11^{+0.018}$	$14^{\pm0.020}$	$14^{\pm0.020}$	$19^{\pm0.020}$
ØK	$16^{+0.013}$	$19^{+0.013}$	$25^{+0.020}$	$25^{+0.020}$	$35^{+0.023}$
L	$17.4^{\pm0.10}$	$20.8^{+0.10}$	$27.3^{+0.20}$	$27.3^{+0.20}$	$38.3^{+0.20}$
M	$10.4^{+0.10}$	$12.8^{+0.10}$	$16.3^{+0.10}$	$16.3^{+0.10}$	$21.8^{+0.10}$
N	$3^{\pm0.0125}$	$4^{\pm0.013}$	$5^{\pm0.013}$	$5^{\pm0.013}$	$6^{\pm0.013}$
P	$3^{\pm0.0125}$	$4^{\pm0.013}$	$5^{\pm0.013}$	$5^{\pm0.013}$	$10^{\pm0.023}$
Q	11.4	12.8	15.6	19.4	23.2
R	M4 x 0.7	M5 x 0.8	M6 x 1	M8 x 1.25	M10 x 1.5
ØS	60	75	100	120	150
ØT	20	28	36	32	50
Y	M4 x 0.7	M4 x 0.7	M6 x 1.0	M8 x 1.25	M8 x 1.25
ØZ	27	35	44	48	65
aa	0.07	0.076	0.078	0.088	0.098
bb	0.013	0.015	0.015	0.018	0.020
cc	0.018	0.023	0.025	0.025	0.025
dd	0.010	0.013	0.013	0.013	0.015
ee	0.250	0.250	0.250	0.250	0.250
WEIGHT lb/kgf	1.50/70	2.70/1.23	4.70/2.14	9.00/4.09	15.30/6.9

NOTE:
ALL DIMENSIONS IN MM

ALIGNMENT & ASSEMBLY

HDB differentials are supplied as component sets only and are not self contained power transmissions. Suitable housings with bearing supports, oil reservoirs and seals must be provided.

Circular Splines
Both S1 & S2 circular splines must be supported with a suitable bearing arrangement to maintain specified dimensions and tolerances under all load conditions.

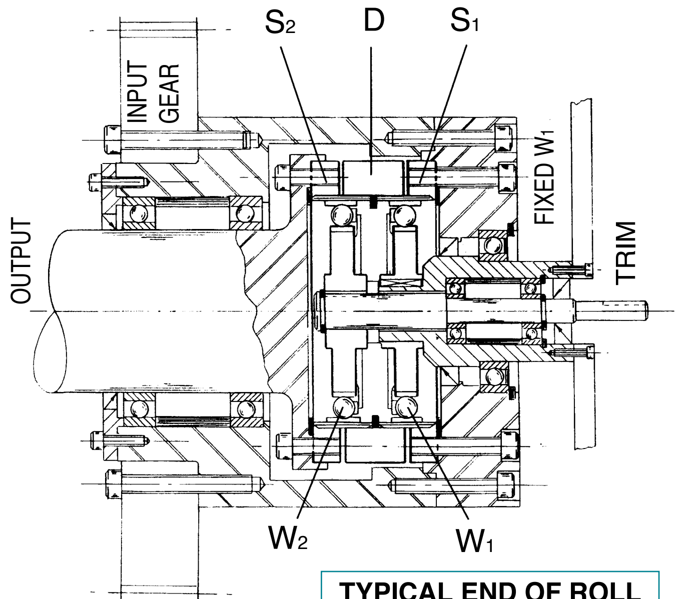
Overhung loads from an external source require a suitable two bearing or four point contact bearing support.

Axial restraint in both directions must maintain the gap between each of the three circular splines.

Flexspline
Hardened wear washers are provided to prevent axial displacement of the flexspline. These may be discarded If the customer supplied components in the vicinity of the flexspline are a minimum hardness of Rc45.

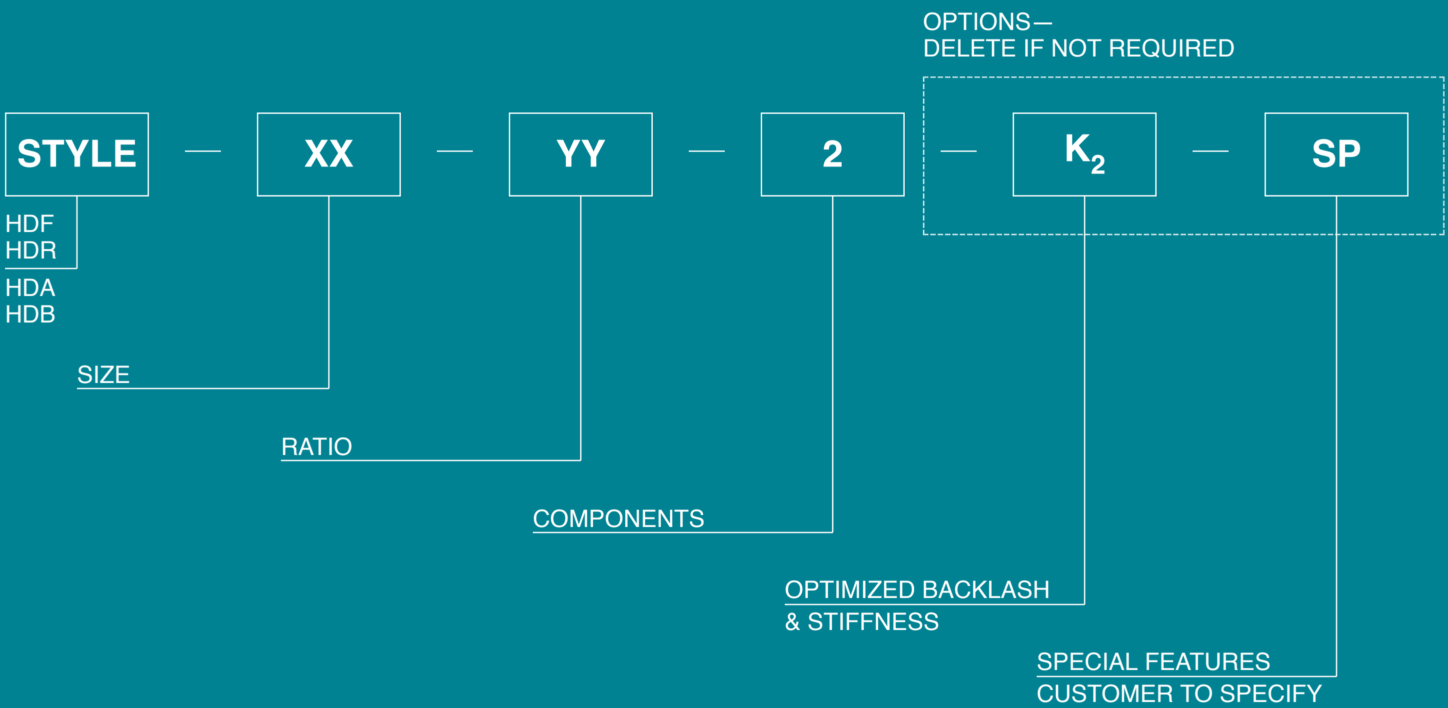
Wave Generator
The wave generator bearings should not be used to support a shaft.

Axial restraint in both directions should be provided.



TYPICAL END OF ROLL PHASING DIFFERENTIAL

ORDERING DETAILS



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