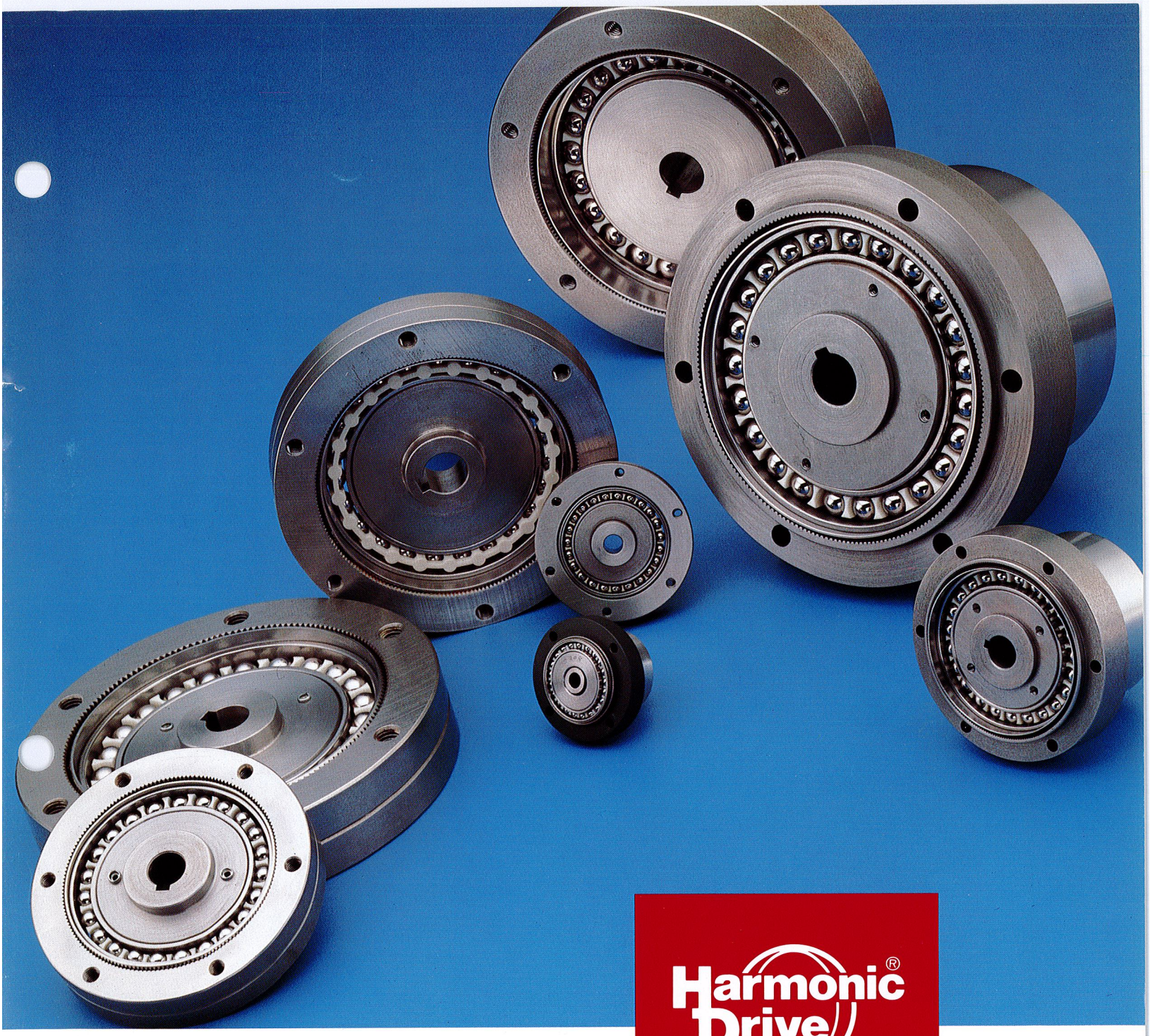


Harmonic® Drive

CUP and PANCAKE COMPONENT GEAR SETS

The Advantages of Harmonic Drive Gearing

Because it consists of only three simple parts, Harmonic Drive gearing offers design engineers the freedom to integrate drive components directly into machines or equipment. Harmonic Drive is a pure torque couple with all concentric elements and requires less space and less bulky support structures than conventional gearing.

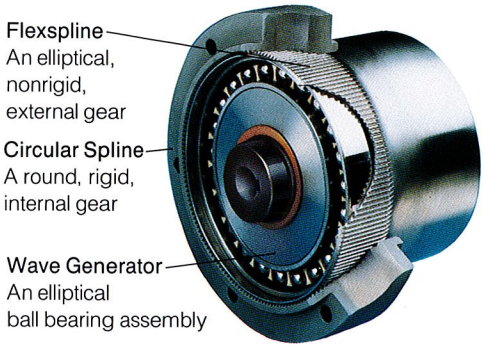
Harmonic Drive's precision and performance are ideal in applications requiring accurate positioning or precise motion control.

Low or Zero Backlash
Natural gear preload and almost pure radial tooth engagement allow standard Harmonic Drive gearing to operate with essentially zero backlash for the entire gear life without preload adjustments or significant wear.

Efficiencies as High as 90%
Measured on actual shaft-to-shaft losses rather than tooth losses (as with other gearing), standard Harmonic Drive gearing efficiencies are normally in the 80 – 90% range.

Simple Support Requirements
Since torque is transmitted by pure couple, Harmonic Drive gearing does not generate radial loads and, therefore, can be used with much simpler bearings and less structural support than other forms of gearing.

HDC CUP COMPONENT GEAR SET



High Single-Stage Ratios From 50:1 Up
Depending on size, Harmonic Drive products offer ratios from 50:1 (60:1 for standard products) to as high as 320:1. Using compound drives, much higher ratios can be achieved.

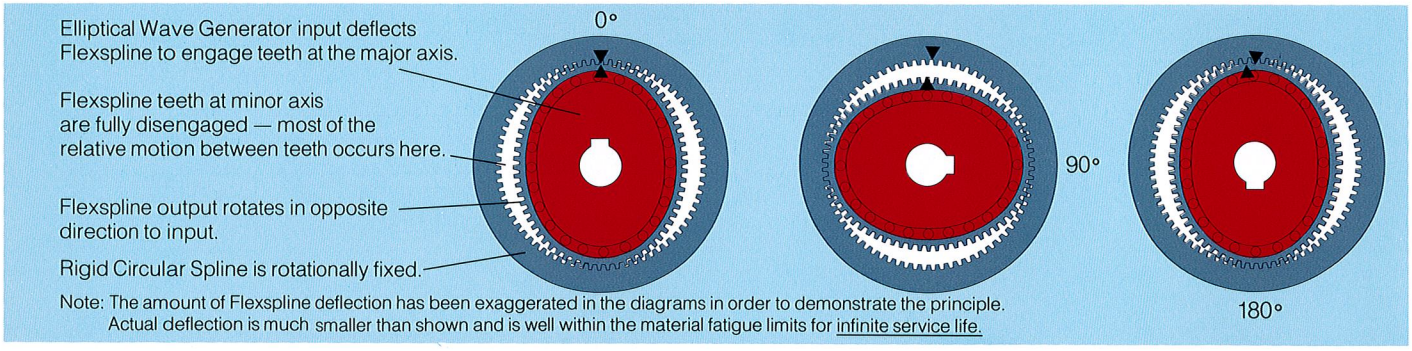
Torque Equal to Drives Twice as Large
Pound for pound, no other mechanical power transmission can compare with Harmonic Drive gearing for torque capacity.

Excellent Positional Accuracy and Repeatability
Harmonic Drive gearing's design ensures that approximately 10% of the total teeth are engaged at any point in time, minimizing the effect of tooth-to-tooth error. Accuracies as fine as 30 arc seconds are achievable in some sizes. Repeatabilities are in the arc second range.

Design Flexibility
Harmonic Drive gearing allows designers multiple input/output possibilities in speed reduction and speed increasing applications. Concentric shafting makes it ideal for differential designs.

Long Life and High Reliability
Proven in years of industrial, military, and other applications, Harmonic Drive gearing has an average life of over 15,000 hours at rated loads. In addition, the tooth mesh is unaffected by the impact of stepping motors or frequent starts, stops, and reversals.

Principle of Operation

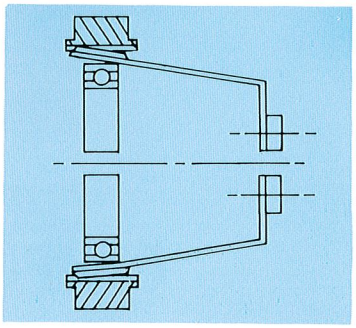


Note: The amount of Flexspline deflection has been exaggerated in the diagrams in order to demonstrate the principle. Actual deflection is much smaller than shown and is well within the material fatigue limits for infinite service life.

The teeth on the nonrigid Flexspline and the rigid Circular Spline are in continuous engagement. Since the Flexspline has two teeth fewer than the Circular Spline, one revolution of the input causes relative motion between the Flexspline and the Circular Spline equal to two teeth. With the Circular Spline rotationally fixed, the Flexspline rotates in the opposite direction to the input at a reduction ratio equal to one-half the number of teeth on the Flexspline.

This relative rotation may be seen by examining the motion of a single Flexspline tooth over one-half an input revolution. The tooth is fully engaged when the major axis of the Wave Generator input is at 0°. When the Wave Generator's major axis rotates to 90°, the tooth is fully disengaged. Full reengagement occurs in the adjacent Circular Spline tooth space when the major axis is rotated to 180°. This motion repeats as the major axis rotates another 180° back to 0°, thereby producing the two tooth advancement per input revolution.

All tabulated Harmonic Drive gear reduction ratios assume output through the Flexspline with the Circular Spline rotationally fixed.



However, any drive element may function as the input, output, or fixed member.

Zero Backlash
All Harmonic Drive cup-type gearing products have zero backlash at the gear mesh.

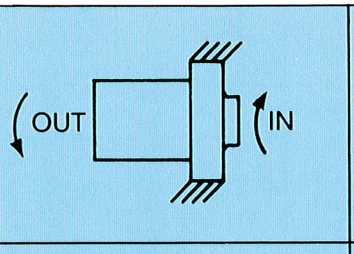
Under most circumstances, this zero backlash lasts beyond the expected life of the drive. This unusual characteristic is due to the unconventional tooth path combined with a slight cone angling of the teeth caused by deflection of the cup walls. Together, these factors produce preload and ensure very little sliding and no relative motion between teeth at the points where most of the torque is transferred.

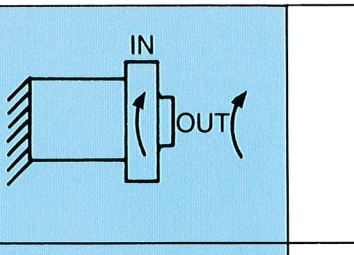
While a small amount of backlash occurs at the oldham input coupling, because of the high ratios involved, this backlash becomes negligible when measured at the output. Even this backlash can be eliminated by coupling directly to the Wave Generator. Please consult the factory for methods and guidelines.

© 1989 Harmonic Drive

Input/Output Versatility

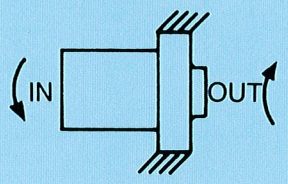
1.
Speed Reducer: Circular Spline stationary. Wave Generator input. Flexspline output. Ratio as tabulated.

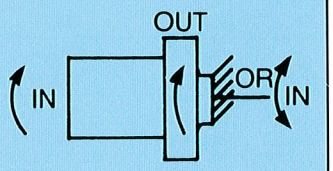




4.
Speed Increaser: Flexspline stationary. Circular Spline input. Wave Generator output. Ratio as tabulated plus 1.

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

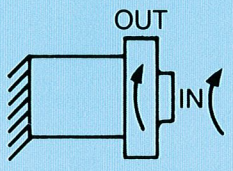


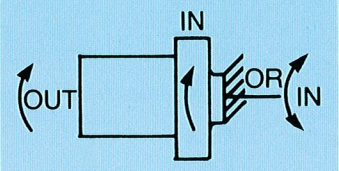


5.
Speed Reducer/Differential: Wave Generator stationary. Flexspline input. Circular Spline output.

$$\text{Ratio} = \frac{\text{Tabulated Ratio}}{\text{Tabulated Ratio} + 1}$$

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

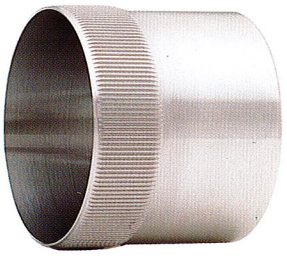


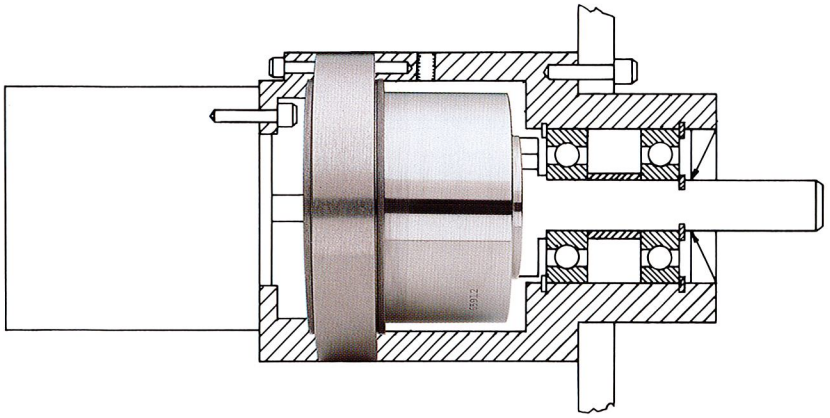


6.
Speed Increaser/Differential: Wave Generator stationary. Circular Spline input. Flexspline output.

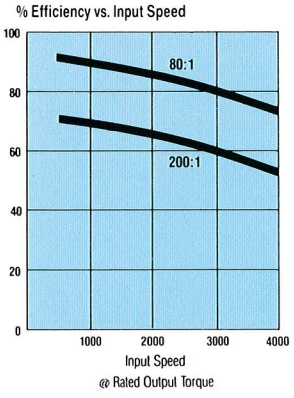
$$\text{Ratio} = \frac{\text{Tabulated Ratio} + 1}{\text{Tabulated Ratio}}$$

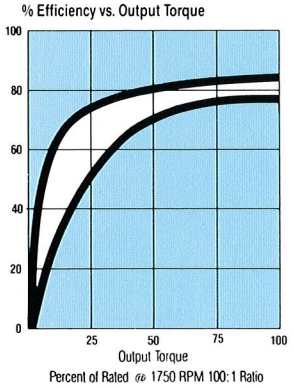
Installed Relationship





Cup Efficiencies

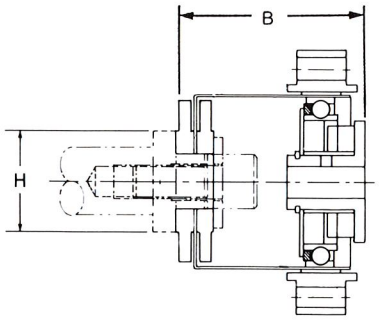




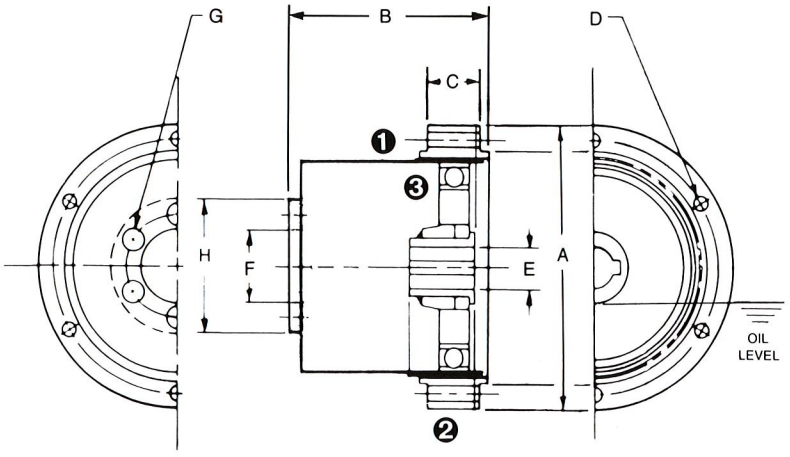
Dimensions Inches (mm)

HDC Size	A Circular Spline OD	B Overall Length	C Circular Spline Width	D Number of Circular Spline Holes	E Wave Generator Hub ID	F Flexspline Pilot Diameter	G Number of Flexspline Holes	H Flexspline Hub OD	Weight lbs (kg)
10	1.480 (37.59)	1.095 (27.81)	0.280 (7.11)	4	0.188 (4.78)	0.313 (7.95)	—	0.560 (14.22)	0.170 (0.08)
1C	2.000 (50.80)	1.410 (35.81)	0.380 (9.65)	6	0.250 (6.35)	0.437 (11.10)	6	0.830 (21.08)	0.300 (0.14)
3C	2.630 (66.80)	1.880 (47.75)	0.500 (12.70)	6	0.375 (9.53)	0.626 (15.90)	6	1.240 (31.50)	0.628 (0.28)
5C	3.280 (83.31)	2.310 (58.67)	0.630 (16.00)	6	0.500 (12.70)	0.781 (19.84)	6	1.550 (39.37)	1.200 (0.54)
1M	4.250 (107.95)	2.960 (75.18)	0.810 (20.57)	6	0.500 (12.70)	1.063 (27.00)	6	2.000 (50.80)	2.600 (1.18)
2M	5.250 (133.35)	3.640 (92.46)	1.000 (25.40)	6	0.625 (15.88)	1.281 (32.54)	6	2.500 (63.50)	5.100 (2.31)
4M	6.630 (168.40)	4.450 (113.03)	1.090 (27.69)	6	0.625 (15.88)	1.625 (41.28)	6	3.120 (79.25)	9.000 (4.08)
8M	8.630 (219.20)	5.790 (147.07)	1.440 (36.58)	6	0.875 (22.23)	2.094 (53.19)	6	4.000 (101.60)	20.300 (9.21)
15M	10.630 (270.00)	7.190 (182.63)	1.880 (47.75)	8	1.125 (28.58)	2.563 (65.10)	6	5.000 (127.00)	38.600 (17.51)

NOTE: Dimensions are for reference only. Required specification prints furnished on request. It is recommended that our engineering staff be given the opportunity to review application approaches since the full extent of design options is more than can be conveniently described in this brochure.



HDC 10



HDC 1C — 15M

❶ FLEXSPLINE ❷ CIRCULAR SPLINE ❸ WAVE GENERATOR

Ratings Table[1]

HDC SIZE	PITCH DIA. IN.	RATIO[3]	NO-LOAD STARTING TORQUE (TYP.) oz-in (Ncm)	MAX INPUT RPM (Oil)	STD. W/G INPUT INERTIA lb-in² (kg-cm²)	INPUT 3500 RPM I/P H.P.	O/P SPEED	OUTPUT TORQUE lb-in	Nm
10	**1.0**	**60**	0.6 (0.4)	15,000	.003 (.009)	0.02	58.3	25	2.8
		80				0.02	43.8	26	2.9
1C	**1.4**	**60**	1.0 (0.7)	12,000	.011 (.032)	0.06	58.3	81	9.2
		72				0.06	48.6	81	9.2
		80				0.06	43.8	81	9.2
		100				0.05	35.0	81	9.2
3C	**2.0**	**60**	2.5 (1.8)	11,200	.058 (.169)	0.22	58.3	280	31.6
		80				0.20	43.8	280	31.6
		100				0.16	35.0	300	33.9
		120				0.14	29.2	300	33.9
		140				0.12	25.0	300	33.9
		160				0.11	21.9	300	33.9
5C	**2.5**	**60**	5.0 (3.5)	9,000	.165 (.481)	0.38	58.3	490	55.4
		80				0.34	43.8	490	55.4
		100				0.28	35.0	490	55.4
		120				0.24	29.2	490	55.4
		140				0.21	25.0	490	55.4
		160				0.19	21.9	490	55.4
		180				0.18	19.4	490	55.4
		200				0.16	17.5	490	55.4
1M	**3.2**	**60**	11.0 (7.8)	7,000	.610 (1.779)	0.77	58.3	990	111.9
		80				0.70	43.8	990	111.9
		100				0.57	35.0	990	111.9
		120				0.50	29.2	990	111.9
		140				0.44	25.0	990	111.9
		160				0.39	21.9	990	111.9
		180				0.36	19.4	990	111.9
		200				0.33	17.5	990	111.9
2M	**4.0**	**60**	20.0 (14.1)	5,600	1.750 (5.104)	1.62	58.3	1,645	185.9
		80				1.38	43.8	1,645	185.9
		100				1.23	35.0	2,070	233.9
		120				1.07	29.2	2,070	233.9
		140				0.94	25.0	2,070	233.9
		160				0.84	21.9	2,070	233.9
		180				0.77	19.4	2,070	233.9
		200				0.71	17.5	2,070	233.9
4M	**5.0**	**60**	40.0 (28.3)	4,500	5.060 (14.758)	3.03	58.3	3,085	348.6
		80				2.59	43.8	3,085	348.6
		100				2.26	35.0	3,855	435.6
		120				1.96	29.2	3,855	435.6
		140				1.72	25.0	3,855	435.6
		160				1.55	21.9	3,855	435.6
		180				1.41	19.4	3,855	435.6
		200				1.31	17.5	3,855	435.6
8M	**6.5**	**60**	88.0 (92.1)	3,500	19.600 (57.167)	5.55	58.3	6,260	707.4
		80				4.74	43.8	6,260	707.4
		100				4.11	35.0	7,150[4]	808.0[4]
		120				3.56	29.2	7,150[4]	808.0[4]
		140				3.13	25.0	7,150[4]	808.0[4]
		160				2.82	21.9	7,150[4]	808.0[4]
		180				2.57	19.4	7,150[4]	808.0[4]
		200				2.38	17.5	7,150[4]	808.0[4]
15M	**8.0**	**60**	160.0 (113.0)	2,800	51.500 (150.208)				
		80							
		100							
		120							
		140							
		160							
		180							
		200							

NOTES:
1) Output Torque ratings are based on a B-10 Life of 3000 hours.
2) Repetitive momentary or continuous running load not to exceed Maximum Output Torque rating.

INPUT 1750 RPM				INPUT 1000 RPM				INPUT 500 RPM			MAXIMUM OUTPUT TORQUE[2]		STATIC TORQUE LIMIT		RATCHET TORQUE LIMIT	
I/P H.P.	O/P SPEED	OUTPUT TORQUE lb-in	Nm	I/P H.P.	O/P SPEED	OUTPUT TORQUE lb-in	Nm	O/P SPEED	OUTPUT TORQUE lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm
0.01	29.2	30	3.4	0.01	19.2	30	3.4	8.3	30	3.4	30	3.4	50	5.7	50	5.7
0.01	21.9	40	4.5	0.01	14.4	40	4.5	6.3	40	4.5	40	4.5	70	7.9	80	9.0
0.04	29.2	102	11.5	0.03	19.2	119	13.4	8.3	119	13.4	119	13.4	202	22.8	140	15.8
0.04	24.3	102	11.5	0.03	16.0	119	13.4	6.9	119	13.4	119	13.4	202	22.8	200	22.6
0.03	21.9	102	11.5	0.02	14.4	125	14.1	6.3	140	15.8	140	15.8	238	26.9	200	22.6
0.03	17.5	102	11.5	0.01	11.5	125	14.1	5.0	155	17.5	180*	20.3*	306	34.6	200	22.6
0.15	29.2	355	40.1	0.10	19.2	430	48.6	8.3	470	53.1	470	53.1	1,280	144.6	1,120	126.6
0.12	21.9	355	40.1	0.08	14.4	430	48.6	6.3	470	53.1	470	53.1	1,240	140.1	1,260	142.4
0.11	17.5	375	42.4	0.07	11.5	450	50.9	5.0	570	64.4	690	78.0	1,620	183.1	1,260	142.4
0.09	14.6	375	42.4	0.07	9.6	450	50.9	4.2	570	64.4	900	101.7	1,970	222.6	1,260	142.4
0.08	12.5	375	42.4	0.06	8.2	450	50.9	3.6	570	64.4	1,120*	126.6*	2,250	254.3	1,120	126.6
0.07	10.9	375	42.4	0.05	7.2	450	50.9	3.1	570	64.4	1,120*	126.6*	2,480	280.2	1,120	126.6
0.27	29.2	620	70.1	0.19	19.2	750	84.8	8.3	830	93.8	830	93.8	2,570	290.4	1,580	178.5
0.21	21.9	620	70.1	0.15	14.4	750	84.8	6.3	830	93.8	830	93.8	2,310	261.0	2,050	231.7
0.18	17.5	620	70.1	0.14	11.5	750	84.8	5.0	940	106.2	1,240	140.1	3,050	344.7	2,050	231.7
0.16	14.6	620	70.1	0.12	9.5	750	84.8	4.2	940	106.2	1,690	191.0	3,800	429.4	2,050	231.7
0.14	12.5	620	70.1	0.10	8.2	750	84.8	3.6	940	106.2	1,900	214.7*	4,270	482.5	2,050	231.7
0.12	10.9	620	70.1	0.09	7.2	750	84.8	3.1	940	106.2	1,700	192.1*	4,650	525.5	1,900	214.7
0.11	9.7	620	70.1	0.08	6.4	750	84.8	2.8	940	106.2	1,580*	178.5*	5,060	571.8	1,580	178.5
0.10	8.8	620	70.1	0.06	5.8	750	84.8	2.5	940	106.2	1,580*	178.5*	5,320	601.2	1,580	178.5
0.54	29.2	1,245	140.7	0.38	19.2	1,500	169.5	8.3	1,830	206.8	1,830	206.8	4,920	556.0	4,000	452.0
0.41	21.0	1,245	140.7	0.29	14.4	1,500	169.5	6.3	1,830	206.8	1,830	206.8	4,520	510.8	5,000	565.0
0.36	17.5	1,245	140.7	0.27	11.5	1,500	169.5	5.0	1,890	213.6	2,640	298.3	5,800	655.4	5,000	565.0
0.31	14.6	1,245	140.7	0.23	9.6	1,500	169.5	4.2	1,890	213.6	3,410	385.3	7,220	815.9	5,000	565.0
0.27	12.5	1,245	140.7	0.21	8.2	1,500	169.5	3.6	1,890	213.6	4,700*	531.1*	8,270	934.5	4,700	531.1
0.24	10.9	1,245	140.7	0.18	7.2	1,500	169.5	3.1	1,890	213.6	4,700*	531.1*	9,190	1038.5	4,700	531.1
0.22	9.7	1,245	140.7	0.17	6.4	1,500	169.5	2.8	1,890	213.6	4,000*	452.0*	9,950	1124.4	4,000	452.0
0.21	8.8	1,245	140.7	0.16	5.8	1,500	169.5	2.5	1,890	213.6	4,000*	452.0*	10,610	1198.9	4,000	452.0
0.90	29.2	2,075	234.5	0.59	19.2	2,500	282.5	8.3	2,760	311.9	2,760	311.9	7,330	828.3	6,600	745.8
0.85	21.0	2,075	234.5	0.45	14.4	2,500	282.5	6.3	2,760	311.9	2,760	311.9	6,980	788.7	9,000	1017.0
0.75	17.5	2,610	294.9	0.52	11.5	3,145	355.4	5.0	3,960	447.5	4,070	459.9	9,450	1067.9	9,000	1017.0
0.65	14.6	2,610	294.9	0.49	9.6	3,145	355.4	4.2	3,960	447.5	5,060	571.8	11,120	1256.6	8,300	937.9
0.57	12.5	2,610	294.9	0.43	8.2	3,145	355.4	3.6	3,960	447.5	6,130	692.7	13,150	1486.0	8,300	937.9
0.51	10.9	2,610	294.9	0.38	7.2	3,145	355.4	3.1	3,960	447.5	7,200	813.6	14,640	1654.3	7,200	813.6
0.47	9.7	2,610	294.9	0.35	6.4	3,145	355.4	2.8	3,960	447.5	6,600*	745.8*	15,790	1784.3	6,600	745.8
0.44	8.8	2,610	294.9	0.33	5.8	3,145	355.4	2.5	3,960	447.5	6,600*	745.8*	17,010	1922.1	6,600	745.8
1.69	29.2	3,890	439.6	1.11	19.2	4,690	530.0	8.3	5,110	577.4	5,110	577.4	13,910	1571.8	15,500	1751.5
1.34	21.9	3,890	439.6	0.85	14.4	4,690	530.0	6.3	5,110	577.4	5,110	577.4	13,060	1475.8	19,000	2147.0
1.29	17.5	4,860	549.2	0.93	11.5	5,860	662.2	5.0	6,500	734.5	6,500	734.5	16,860	1905.2	19,000	2147.0
1.21	14.6	4,860	549.2	0.92	9.6	5,860	662.2	4.2	7,375	833.4	9,500	1073.5	20,900	2361.7	17,000	1921.0
1.07	12.5	4,860	549.2	0.80	8.2	5,860	662.2	3.6	7,375	833.4	11,200	1265.6	24,150	2729.0	17,500	1921.0
0.96	10.9	4,860	549.2	0.72	7.2	5,860	662.2	3.1	7,375	833.4	13,100	1480.3	26,830	3031.8	17,000	1921.0
0.88	9.7	4,860	549.2	0.66	6.4	5,860	662.2	2.8	7,375	833.4	15,500*	1751.5*	28,830	3257.8	15,500	1751.5
0.82	8.8	4,860	549.2	0.62	5.8	5,860	662.2	2.5	7,375	833.4	15,500*	1751.5*	31,190	3524.5	15,500	1751.5
3.42	29.2	7,885	891.0	2.25	19.2	9,500	1073.5	8.3	10,200	1152.6	10,200	1152.6	27,750	3135.8	24,000	2712.0
2.63	21.9	7,885	891.0	1.73	14.4	9,500	1073.5	6.3	10,200	1152.6	10,200	1152.6	26,350	2977.6	30,000	3390.0
2.54	17.5	9,010	1018.1	1.96	11.5	10,860	1227.2	5.0	13,680	1545.8	15,300	1728.9	36,130	4082.7	30,000	3390.0
2.26	14.6	9,010	1018.1	1.70	9.6	10,860	1227.2	4.2	13,680	1545.8	19,300	2180.9	42,370	4787.8	27,000	3051.0
1.98	12.5	9,010	1018.1	1.50	8.2	10,860	1227.2	3.6	13,680	1545.8	23,000	2599.0	49,400	5582.2	27,000	3051.0
1.78	10.9	9,010	1018.1	1.34	7.2	10,860	1227.2	3.1	13,680	1545.8	26,600	3005.8	54,510	6159.6	24,000	2712.0
1.62	9.7	9,010	1018.1	1.23	6.4	10,860	1227.2	2.8	13,680	1545.8	24,000*	2712.0*	59,210	6690.7	24,000	2712.0
1.52	8.8	9,010	1018.1	1.14	5.8	10,860	1227.2	2.5	13,680	1545.8	24,000*	2712.0*	64,040	7236.5	24,000	2712.0
5.96	29.2	13,715	1549.8	3.92	19.2	16,530	1867.9	8.3	18,200	2056.6	18,200	2056.6	48,040	5428.5	50,000	5650.0
4.57	21.9	13,715	1549.8	3.00	14.4	16,530	1867.9	6.3	18,200	2056.6	18,200	2056.6	45,640	5157.3	65,000	7345.0
5.14	17.5	17,780	2009.1	3.41	11.5	21,425	2421.0	5.0	26,000	2938.0	26,000	2938.0	61,800	6983.4	65,000	7345.0
4.45	14.6	17,780	2009.1	3.42	9.6	21,425	2421.0	4.2	26,995	3050.4	33,600	3976.8	74,500	8418.5	60,000	6780.0
3.91	12.5	17,780	2009.1	2.99	8.2	21,425	2421.0	3.6	26,995	3050.4	40,800	4610.4	87,870	9929.3	60,000	6780.0
3.51	10.9	17,780	2009.1	2.70	7.2	21,425	2421.0	3.1	26,995	3050.4	47,900	5412.7	98,830	8907.8	55,000	6215.0
3.21	9.7	17,780	2009.1	2.47	6.4	21,425	2421.0	2.8	26,995	3050.4	50,000*	5650.0*	107,870	12189.3	50,000	5650.0
2.99	8.8	17,780	2009.1	2.30	5.8	21,425	2421.0	2.5	26,995	3050.4	50,000*	5650.0*	115,180	13015.3	50,000	5650.0

3) Bold Face indicates standard ratios.
4) Thermal Limited. 60% duty cycle recommended with on time not exceeding 30 minutes. Ratings are based on AGMA Service Factor of 1. (See description of Maximum Output Torque in "Limits" section of Page 5.)

*Denotes Maximum Torque Output limited by ratcheting

Limits

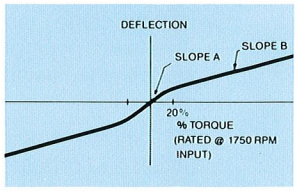
Maximum Output Torque
This is the maximum allowable output torque that can be continuously developed with dynamic torque applied through the input.

Static Torque Limit
The static torque limit is the maximum allowable torque that can be applied to the output in a back drive mode with the input Wave Generator locked.

Ratchet Torque Limit
The ratchet torque limit is the maximum output torque to which the drive will react under dynamic overload conditions. Ratcheting, or slippage of one tooth of the Flexspline/Circular Spline gear mesh, is essentially the result of excessive radial deflection of the elements of the drive caused by a torque induced tooth separating load.
Caution: Repeated ratcheting will lead to ultimate drive failure.

Spring Rate

Typical spring rate values for standard units are shown in the accompanying chart. By specifying the K option, the units will be individually tested to ensure that the minimum values are met.
The optimized spring rate values shown are practical upper limits. Spring rates up to these values can be ordered as options. In general, as spring rates increase, no-load starting torque will also rise. Consult the factory for details.



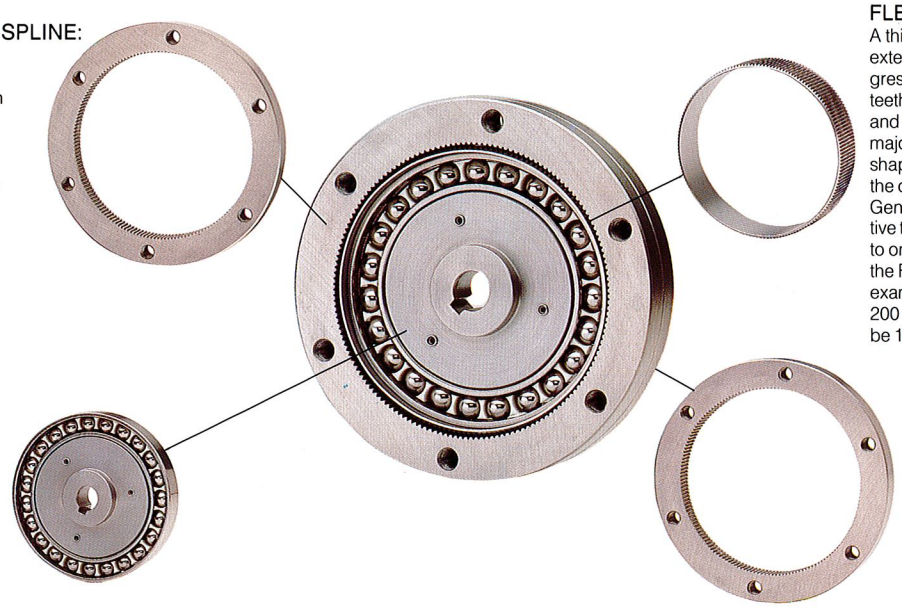
NOTE: Even standard Harmonic Drive spring rate values compare favorably to other power transmission forms in similar ratio ranges.

Typical Torsional Spring Rates
(lb-in/radian)

HDC Size	Slope A		Slope B
	Optimized (X 10^6)	Guaranteed K Min (X 10^6)	(X 10^6)
10	.005	.003	.012
1C	.015	.008	.040
3C	.048	.023	.120
5C	.110	.045	.234
1M	.250	.092	.515
2M	.480	.184	.960
4M	.900	.345	1.88
8M	2.00	.792	4.12
15M	3.80	1.47	7.68

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 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. The Flexspline rotates in the opposite direction of the Wave Generator. 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 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.

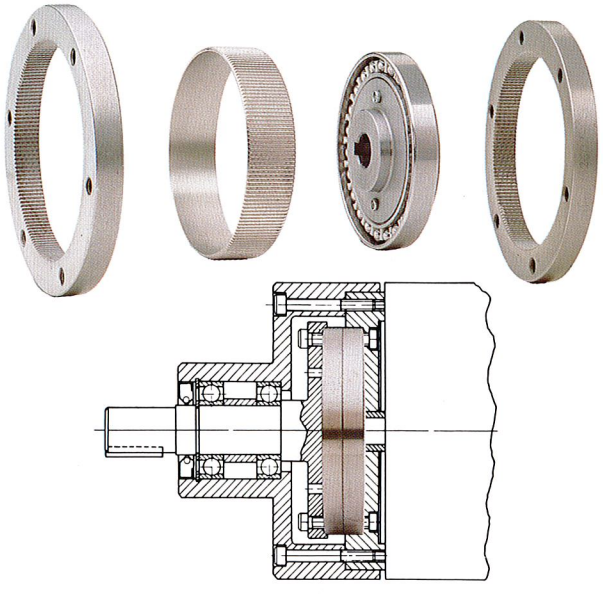
- Ratios from 80:1 to 160:1 in standard products
- Dual ratios in the same envelope to as high as 40,000:1
- Low backlash

HDF Pancake gearing consists of two Circular Splines which mesh with a common Flexspline to create an extremely axially compact, single-stage gear reduction. The Static Circular Spline turns at the same ratio that it would if it were used in a cup drive, i.e., two teeth, per input revolution. The Dynamic Circular Spline rotates with the Flexspline at a 1:1 ratio and becomes the output member.

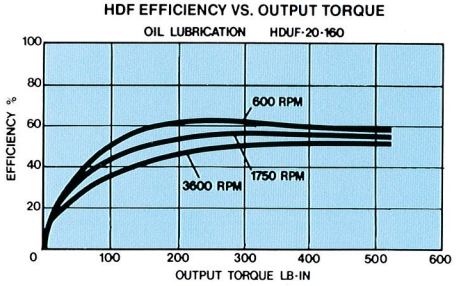
HDF Pancake gearing is recommended for light-duty speed reduction and phasing/differential applications. Other Pancake gearing models are available for heavier-duty applications. (See data sheets enclosed in accompanying folder.)

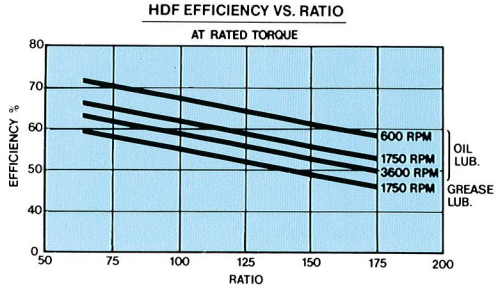
Backlash
Unlike cup component gearing, pancake gearing does exhibit some backlash at the tooth mesh. With pancake gearing, there is no cone angling of the Flexspline teeth as a result of deflection as in cup-type gearing, (see zero-backlash illustration on page 2), therefore, some minor relative motion is possible between teeth during operation. Because pancake gearing consists of two Circular Splines, each with a different number of teeth, clearance must be allowed for meshing with the Flexspline teeth on the same pitch line. Backlash is typically in the 10 to 35 arc minute range.

Installed Relationship

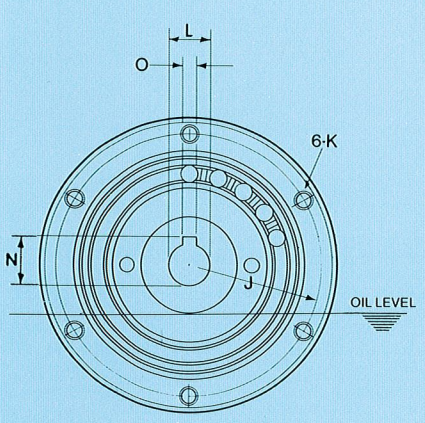


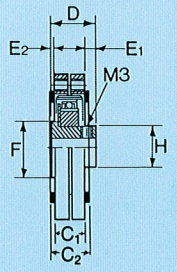
Pancake Efficiencies



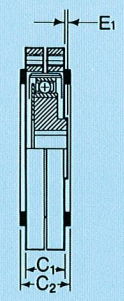


Dimensions (mm)





SIZE 14



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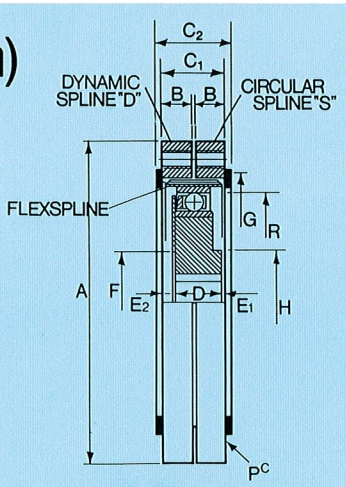
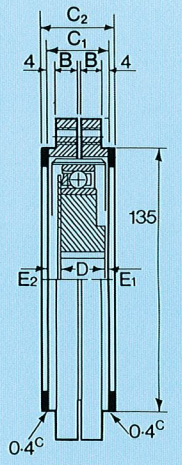


SIZES 25, 32, and 40



SIZE 50

SIZE	A	B	C_1	C_2	D	E_1	E_2	F	G	H	J	K	L	N	O	P	R MAX.	APPROXIMATE WEIGHT LBS.	APPROXIMATE WEIGHT KGS.
14	50	5	10.5	11.4	15*	3.75*	.75*	18*	36	14*	44	M3	6*	—	—	0.2	32	0.2	.091
20	70	6	12.5	14.4	11.4	0.95*	2.05*	20	53	20	60	M4	9	10.4	3	0.2	47	0.7	.318
25	85	8	16.5	18.4	12.8	0.35	3.35	24	66	25	75	M5	11	12.8	4	0.2	59	1.3	.590
32	110	10	20.5	22.4	15.6	0.95	3.95	34	84	36	100	M6	14	16.3	5	0.2	77	2.3	1.043
40	135	13	27.0	30.4	19.4	1.8	5.8	40	103	42	120	M8	14	16.3	5	0.4	95	4.4	1.996
50	170	12	33.0	36.4	23.2	2.9*	6.9*	50	135	54	150	M10	19	21.8	6	0.4	119	7.3	3.311

NOTE: Dimensions are for reference only. Required specification prints furnished on request. It is recommended that our engineering staff be given the opportunity to review application approaches since the full extent of design options is more than can be conveniently described in this brochure.

NOTE: C_2 dimensions include hardened wear washers supplied with pancake gear sets. (See specification prints.)

Ratings Table[1]

HDF SIZE	RATIO[4]	MAXIMUM INPUT RPM Grease	MAXIMUM INPUT RPM Oil	OUTPUT TORQUES @ INPUT RPM 3500 lb-in	3500 Nm	1750 lb-in	1750 Nm	500 lb-in	500 Nm	MAXIMUM OUTPUT TORQUE[3] lb-in	MAXIMUM OUTPUT TORQUE[3] Nm	APPROXIMATE WAVE GENERATOR INERTIA lb-in²	APPROXIMATE WAVE GENERATOR INERTIA Kg-cm²	MAXIMUM BACKLASH (arc min.)
14	80	3500	6000	44	5	56	6	85	10	90	10	0.011	0.033	36
	100			44	5	56	6	85	10	90	10			34
	110			44	5	56	6	85	10	90	10			31
20	80	2200	6000	195	22	246	28	250	28	250	28	0.049	0.144	33
	100			195	22	246	28	300	34	300	34			28
	120			195	22	246	28	350	40	350	40			26
	160			195	22	246	28	370	42	390	44			22
25	80	2000	5000	320	36	406	46	425	48	425	48	0.124	0.362	28
	100			320	36	406	46	600	68	600	68			25
	120			320	36	406	46	615	69	700	79			21
	160			320	36	406	46	615	69	780	88			19
32	80	500	4500	640	72	810	92	950	107	950	107	0.45	1.31	23
	100			640	72	810	92	1200	136	1200	136			20
	120			640	72	810	92	1230	139	1400	158			18
	160			640	72	810	92	1230	139	1550	175			15
40	80	1250	4500	1350	153	1705	193	1700	192	1700	192	1.17	3.43	23
	100			1350	153	1705	193	2400	271	2400	271			18
	120			1350	153	1705	193	2585	292	2700	305			16
	160			1350	153	1705	193	2585	292	3100	350			11
50	80	1000	3500	2525	285	3180	359	3100	350	3100	350	3.39	9.89	16
	100			2525	285	3180	359	4200	475	4200	475			16
	120			2525	285	3180	359	4825	545	5200	588			14
	160			2525	285	3180	359	4825	545	5800	655			8

NOTES: 1) Output Torques based on B-10 Life of 3000 hours.
2) Thermal limited. 50% duty cycle recommended with on time not exceeding 15 minutes.
3) This torque is not to be exceeded under any circumstances including momentary overload.
4) Consult factory for special high ratios up to approximately 40,000:1.

HARMONIC DRIVE APPLICATION CONSIDERATIONS

Harmonic Drive gearing, as presented in this brochure, is available in two different component configurations — cup and pancake. The selection of configuration depends on the application for which the gearing is to be used.

In certain applications where these considerations are important, both cup and pancake Harmonic Drive gearing components offer advantages over spur, helical, or worm gearing. However, in choosing the best product for an application, the designer should be aware of the trade-offs involved. While pancake components provide the advantages of smaller size, lighter weight, and lower cost, these advantages may be offset by the improved accuracy, zero backlash, higher efficiency, and simpler mounting requirements of cup components.

The chart below provides a comparison of cup (HDC) and pancake (HDF) components for each of the application considerations.

Selection Factor	Cup	Pancake
High ratio	1	1
Compactness	2	1
Low backlash	1	2
Spring rate	1	1
Accuracy	1	2
Life expectancy	1	2
Torque vs. weight and size	1	2
Efficiency	1	2
Ability to withstand frequent stops, starts, and reversals	1	2
Mounting simplicity	1	2
Cost	2	1

Legend: 1 = First Choice 2 = Second Choice

NOTE: Where a "1" appears on both types, the choice depends on the specific application.

The above data is for informational purposes only. Proper selection of components depends on a thorough analysis of the application. A Harmonic Drive field or application engineer will be happy to assist you in selecting the proper component configuration and drive arrangement for your specific application.

Harmonic Drive
A Division of Quincy Technologies, Inc.
51 Armory Street, Wakefield, MA 01880 USA
TEL: (617) 245-7802
FAX: (617) 246-4944 TELEX: 94-9442

Form HDC/HDF 12/89 25M

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