FORMULAS SPUR GEARS

TO FIND:-	MODULE	IMPERIAL
PCD	= No. of TEETH x MOD (mm)	$= \frac{\text{No. of TEETH}}{\text{DP}}$ (ins)
ØD	= (No. of TEETH + 2) x MOD (mm)	$= \frac{\text{No. of TEETH} + 2}{\text{DP}}$ (ins)
DP	$= \frac{25.4}{\text{MODULE}}$	$= \frac{\pi}{\text{CP"}}$
MODULE	$= \frac{\text{CP}}{\pi}$ (mm)	$= \frac{25.4}{\text{DP}}$
No. of TEETH	= PCD ÷ MODULE (mm)	= PCD” x DP
CP	= MODULE x π (mm)	$= \frac{\pi}{\text{DP}}$ (ins)
ADDENDUM	= MODULE (mm)	$= \frac{1}{\text{DP}}$ (ins)
DEDENDUM	= 1.4 x MOD (0.25-1 MOD); = 1.25 x MOD (1.25-8 MOD)	$= \frac{1.4}{\text{DP}}$ (100-24 DP); $= \frac{1.25}{\text{DP}}$ (20-6 DP)

CORRECTED TEETH FOR 8 - 17 TEETH ON REQUEST OR WHERE LISTED

Corrected PCD	= (No. of Teeth + 1) x MOD [(No. of Teeth + 1) / DP]
Corrected ØD	= (No. of Teeth + 3) x MOD [(No. of Teeth + 3) / DP]

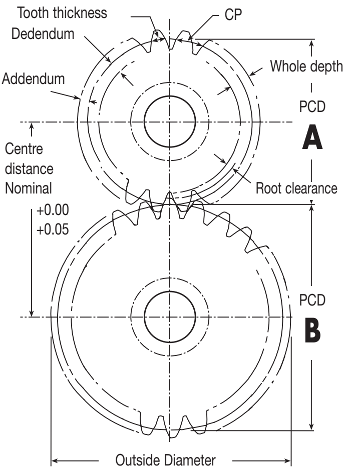
Our SPUR GEARS are made to give 0.07-0.3* Approx. backlash at standard centres. Housing centres should be nominal +0.00 +0.05mm.

$$= \frac{\text{PCD (A)} + \text{PCD (B)}}{2}$$

* Depends on pitch

FROM NOMINAL CENTRES mm	INCREASE IN BACKLASH mm
0.005	0.0037
0.010	0.0074
0.015	0.0111
0.020	0.0148
0.025	0.0185
0.030	0.0221
0.035	0.0259
0.040	0.0295
0.045	0.0328
0.050	0.0370

Whole depth = Addendum + Dedendum



FORMULAS
HELICAL GEARS

Made to give 0.07-0.3mm approx. backlash at standard centres. Housing centres should be nominal +0.00 - +0.05mm.*

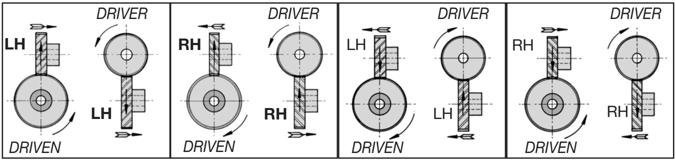
TO FIND:-	MODULE	IMPERIAL
P.C.D.	$= \dfrac{\text{No. of TEETH} \times \text{MOD}}{\text{COS. HELIX}∢}$ (mm)	$= \dfrac{\text{No. of TEETH}}{\text{DP} \times \text{COS. HELIX}∢}$ (ins)
ØD	= PCD + (2 x MOD) (mm)	$= \text{PCD.} + \dfrac{2}{\text{DP}}$
DP (NORMAL)	$= \dfrac{25.4}{\text{MODULE}}$	$= \dfrac{\pi}{\text{CP}}$
MODULE	$= \dfrac{\text{CP}}{\pi}$ (mm)	$= \dfrac{25.4}{\text{DP}}$
No. of TEETH	$= \dfrac{\text{PCD} \times \text{COS.}∢°}{\text{MODULE}}$ (mm)	= (DP x COS. ∢°) x PCD
CP (NORMAL)	= MODULE x π (mm)	$= \dfrac{\pi}{\text{DP}}$ (ins)
ADDENDUM	= MODULE	$= \dfrac{1}{\text{DP}}$ (ins)
Lead	$= \dfrac{\text{PCD} \times \pi}{\text{TAN } ∢}$	

Where HELIX∢ = HELIX Angle

** dependent on pitch*

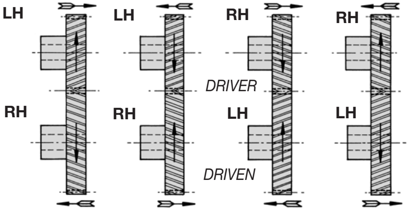
CROSSED AXIS

LEFT hand runs with LEFT hand.
RIGHT hand runs with RIGHT hand.



PARALLEL AXIS

LEFT hand runs with RIGHT hand.



General Direction of Force

LOAD CALCULATIONS SPUR & HELICAL

SPUR GEARS, BSI 436 : 1940

ALLOWABLE TANGENTIAL LOAD, 20° P.A.

Xb	=	Speed factor for strength
Xc	=	Speed factor for wear
Y	=	Strength factor
Z	=	Zone factor
Sc*	=	Material rating (surface stress)
Sb*	=	Material rating (bending stress)
K	=	Pitch factor DP $^{0.8}$ power
F	=	Face width (inches)
DP	=	$\frac{25.4}{MOD}$

WEAR

$$\frac{Xc\ Z\ Sc\ F}{K}\ \text{lbs.}$$

STRENGTH

$$\frac{Xb\ Y\ Sb\ F}{DP}\ \text{lbs.}$$

1N = 0.2248 lbs

Allowable tangential teeth load lbs $= \frac{\text{Torque lbs ins x 2}}{\text{pcd"}}$

The lowest of the four values for pinion and wheel gives the gear rating. The normal rating for gears is based on 12 hours/day.

Torque lbs ins x .113 = Torque Nm

$1\ \text{lb} = 1\text{N x .2248} = \frac{1\text{kg}}{2.20462}$

$\frac{\text{Torque Nm}}{.113} = \text{Torque lbs Ins}$

HELICAL GEARS, BSI 436 : 1940

ALLOWABLE TANGENTIAL LOAD OF 30° HELIX ANGLE, 20° P.A.

Xb	=	Speed Factor for Strength
Xc	=	Speed Factor for Wear
Y	=	Strength Factor
Z	=	Zone Factor
Sc*	=	Material Rating (surface stress)
Sb*	=	Material Rating (bending stress)
K	=	Pitch Factor DP $^{0.8}$ Power
F	=	Face Width (inches)
α	=	Helix Angle
DP	=	$\frac{25.4}{MOD}$

WEAR

$$\frac{Xc\ Z^*\ Sc\ F}{K}\ \text{lbs.}$$

*for other helix angles multiply Z by 0.75 $\sec^2 \alpha$

STRENGTH

$$\frac{Xb\ Y^*\ Sb\ F}{DP}\ \text{lbs.}$$

*for other helix angles multiply Y by 1.33 $\cos^2 \alpha$

1.33 Cos^2 17°45’ = **1.206**

0.75 Sec^2 17°45’ = **0.862**

Cos = Cosine
Sec = Secant

* Please refer to **Material Strength** page for values.

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SPEED FACTORS SPUR & HELICAL

X_c FOR WEAR

Rpm	RUNNING TIME (hours per day)							
	1	2	4	6	8	12	18	24
.5	2.60	2.10	1.65	1.45	1.31	1.16	1.00	0.90
1	2.14	1.80	1.44	1.25	1.15	1.00	0.86	0.78
3	1.80	1.44	1.14	1.0	0.90	0.78	0.67	0.62
6	1.57	1.25	0.97	0.87	0.79	0.68	0.60	0.54
10	1.43	1.13	0.90	0.79	0.72	0.63	0.54	0.48
30	1.18	0.92	0.73	0.64	0.58	0.51	0.43	0.40
60	1.02	0.82	0.64	0.57	0.52	0.45	0.39	0.35
100	0.935	0.735	0.585	0.515	0.470	0.410	0.350	0.320
200	0.825	0.650	0.520	0.460	0.415	0.360	0.310	0.280
400	0.730	0.580	0.460	0.400	0.360	0.320	0.270	0.250
500	0.700	0.550	0.440	0.380	0.350	0.305	0.260	0.240
600	0.680	0.530	0.425	0.370	0.340	0.290	0.250	0.230
800	0.635	0.500	0.400	0.350	0.320	0.270	0.240	0.220
1000	0.610	0.480	0.380	0.335	0.305	0.260	0.230	0.210
2000	0.520	0.415	0.325	0.290	0.260	0.220	0.200	0.180
3000	0.450	0.355	0.280	0.250	0.225	0.195	0.170	0.155
4000	0.415	0.325	0.260	0.225	0.207	0.180	0.155	0.145
5000	0.380	0.305	0.240	0.210	0.190	0.165	0.145	0.132
7000	0.340	0.270	0.215	0.190	0.170	0.150	0.130	0.118
10000	0.305	0.240	0.190	0.165	0.152	0.130	0.115	0.105

X_b FOR STRENGTH

Rpm	RUNNING TIME (hours per day)				
	1	3	6	12	24
.6	1.06	0.9	0.82	0.73	0.67
1	1.00	0.86	0.77	0.70	0.64
4	0.90	0.76	0.69	0.63	0.57
10	0.80	0.69	0.63	0.57	0.52
30	0.70	0.61	0.55	0.48	0.45
50	0.65	0.56	0.51	0.46	0.42
80	0.62	0.53	0.48	0.43	0.39
100	0.600	0.510	0.430	0.410	0.375
200	0.525	0.425	0.405	0.360	0.330
400	0.435	0.400	0.360	0.320	0.295
500	0.420	0.380	0.345	0.310	0.285
600	0.415	0.370	0.330	0.300	0.275
800	0.410	0.345	0.310	0.285	0.255
1000	0.385	0.330	0.295	0.270	0.245
2000	0.325	0.285	0.255	0.230	0.210
3000	0.285	0.245	0.220	0.200	0.180
4000	0.260	0.225	0.200	0.182	0.165
5000	0.240	0.208	0.185	0.168	0.152
7000	0.215	0.185	0.165	0.150	0.138
10000	0.192	0.165	0.148	0.135	0.120

SPUR GEARS, 20°P.A.

Z

No. of Teeth in Gear	NUMBER OF TEETH ON PINION													
	400	200	150	100	80	60	50	40	30	26	20	15	12	10
10	1.09	1.08	1.08	1.07	1.07	1.06	1.05	1.05	1.04	1.03	1.02	0.97	0.92	0.85
12	1.40	1.38	1.36	1.34	1.32	1.28	1.26	1.25	1.24	1.22	1.19	1.10	1.01	0.92
15	1.84	1.79	1.75	1.69	1.64	1.58	1.53	1.48	1.43	1.41	1.34	1.21	1.10	0.97
20	2.48	2.39	2.32	2.20	2.12	2.00	1.89	1.75	1.68	1.63	1.53	1.34	1.19	1.02
26	3.09	2.94	2.85	2.64	2.53	2.36	2.23	2.06	1.88	1.80	1.63	1.41	1.22	1.03
30	3.50	3.32	3.16	2.90	2.76	2.54	2.40	2.30	1.98	1.88	1.68	1.43	1.24	1.04
40	4.27	3.95	3.79	3.50	3.27	2.93	2.76	2.53	2.30	2.06	1.75	1.48	1.25	1.05
50	4.95	4.58	4.30	3.84	3.65	3.28	3.00	2.76	2.40	2.23	1.89	1.53	1.26	1.05
60	5.60	5.11	4.81	4.21	3.89	3.57	3.28	2.93	2.54	2.36	2.00	1.58	1.28	1.06
80	7.00	6.14	5.62	5.00	4.57	3.89	3.65	3.27	2.76	2.53	2.12	1.64	1.32	1.07
100	8.00	6.88	6.34	5.51	5.00	4.21	3.84	3.50	2.90	2.64	2.20	1.69	1.34	1.07
150	—	8.32	7.44	6.34	5.62	4.81	4.30	3.79	3.16	2.85	2.32	1.75	1.36	1.08
200	—	—	8.32	6.88	6.14	5.11	4.58	3.95	3.32	2.94	2.39	1.79	1.38	1.08
400	—	—	—	8.00	7.00	5.60	4.95	4.27	3.50	3.09	2.48	1.84	1.40	1.09
Rack	—	—	—	9.70	8.40	6.50	5.50	4.65	3.70	3.20	2.55	1.90	1.47	1.12

HELICAL GEARS FOR 30° HELIX ANGLE, 20°P.A.

For other helix angles, multiply zone factor by 0.75 x Sec^2 helix angle.

NOTE *0.75 x Sec^2 17° 45' = 0.826*

Z

No. of Teeth in Gear	NUMBER OF TEETH ON PINION														
	Rack	400	200	150	100	80	60	50	40	30	26	20	15	12	10
10	2.03	1.95	1.88	1.85	1.76	1.74	1.64	1.58	1.50	1.45	1.40	1.29	1.18	1.09	1.00
12	2.35	2.26	2.19	2.16	2.06	1.99	1.89	1.81	1.71	1.61	1.55	1.44	1.28	1.17	1.09
15	2.80	2.70	2.61	2.55	2.44	2.36	2.25	2.16	2.01	1.83	1.74	1.61	1.43	1.29	1.18
20	3.43	3.35	3.24	3.18	3.00	2.90	2.70	2.56	2.39	2.16	2.03	1.82	1.60	1.43	1.27
26	4.27	4.10	3.90	3.80	3.58	3.42	3.14	2.96	2.74	2.44	2.29	2.02	1.73	1.54	1.38
30	4.89	4.69	4.47	4.27	3.95	3.76	3.46	3.22	2.93	2.61	2.44	2.17	1.83	1.60	1.45
40	6.11	5.80	5.48	5.18	4.72	4.44	3.98	3.70	3.34	2.92	2.72	2.38	2.00	1.72	1.52
50	7.47	6.74	6.30	6.00	5.41	4.94	4.47	4.18	3.70	3.20	2.94	2.55	2.14	1.81	1.58
60	8.42	7.38	6.83	6.50	5.83	5.35	4.76	4.39	3.93	3.38	3.12	2.66	2.22	1.87	1.64
80	10.88	8.89	7.94	7.50	6.70	6.15	5.42	4.94	4.42	3.74	3.41	2.87	2.36	1.98	1.75
100	—	10.67	9.26	8.40	7.35	6.71	5.88	5.36	4.67	3.94	3.60	2.97	2.43	2.05	1.78
150	—	—	11.30	10.00	8.42	7.50	6.50	5.92	5.07	4.24	3.84	3.17	2.52	2.14	1.84
200	—	—	—	11.20	9.17	8.00	6.88	6.20	5.33	4.37	3.96	3.25	2.68	2.19	1.88
400	—	—	—	—	10.55	9.11	7.48	6.67	5.68	4.63	4.14	3.35	2.69	2.26	1.94
Rack	—	—	—	—	—	10.92	8.50	7.34	6.00	4.91	4.36	3.44	2.81	2.36	—

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STRENGTH FACTORS SPUR & HELICAL

HELICAL GEARS WITH 30° HELIX ANGLE, 20° P.A. AND 20° P.A. SPUR GEARS

Y

For other helix angles, multiply zone strength by 1.33 x Cos^2 helix angle. NOTE: 1.33 x Cos^2 17° 45' = 1.206

No. of Teeth in Gear	NO. OF TEETH ON MATING GEAR OR PINION														
	Rack	400	200	150	100	80	60	50	40	30	26	20	15	12	10
10	.600	.585	.580	.579	.575	.573	.568	.566	.563	.561	.558	.554	.548	.542	.533
12	.658	.639	.630	.625	.618	.614	.605	.600	.597	.593	.591	.585	.573	.562	.550
15	.714	.697	.687	.681	.670	.664	.653	.646	.638	.631	.626	.617	.598	.580	.563
20	.770	.750	.738	.731	.720	.713	.698	.686	.677	.652	.642	.626	.605	.579	.562
26	.813	.790	.776	.768	.753	.742	.725	.699	.671	.633	.627	.614	.595	.572	.551
30	.838	.813	.796	.788	.772	.759	.738	.716	.677	.623	.611	.602	.582	.560	.543
40	.876	.854	.837	.824	.803	.788	.761	.736	.693	.642	.607	.574	.555	.535	.518
50	.900	.872	.858	.848	.822	.806	.776	.752	.705	.644	.620	.582	.544	.517	.490
60	.913	.883	.865	.856	.833	.815	.783	.758	.716	.654	.630	.590	.549	.523	.500
80	.928	.896	.875	.863	.839	.821	.791	.765	.728	.673	.645	.602	.562	.533	.511
100	.931	.897	.875	.864	.840	.822	.793	.767	.734	.683	.661	.613	.571	.541	.518
150	.930	.893	.870	.858	.835	.820	.780	.770	.740	.697	.676	.628	.584	.552	.533
200	.928	.889	.867	.855	.833	.818	.793	.771	.743	.703	.681	.638	.591	.561	.537
400	.924	.882	.861	.850	.828	.814	.791	.772	.747	.713	.695	.654	.607	.576	.550
Rack	—	.869	.850	.839	.820	.808	.789	.767	.755	.728	.714	.684	.642	.606	.582

The *zone factor* (Z) is a factor dependent on the total contact between mating teeth and the radii of curvature of the tooth surfaces.

Internal Gears - The zone factor for internal gears shall be equal to that for the same combination of external teeth multiplied by:-

$$\left(\frac{R+1}{R-1}\right) \text{0.8 Power}$$

R=Ratio

The *Strength Factor* (Y) is a factor dependent on the number of teeth in contact, the cantilever strength of an individual tooth, and the distribution of load over the face of the tooth.

Internal Gears - The strength factor for the pinion gearing with an internal gear shall be the same as that for a pinion of the same number of teeth gearing with a rack. The strength factor for the internal gear shall be the same as that of a rack gearing with a pinion having the same number of teeth as the actual pinion, multiplied by:-

$$\left(1 + \frac{3}{T}\right)$$

where T is the number of teeth in the internal gear.

Idler Gears The idler gears in which the teeth make contact on one side with the driving gears and on the other with the driven gears, should be calculated on the normal basis for wear, but the speed co-efficient used in calculating the load capacity for strength must be half the normal value.

Multiple Contact - If a gear makes contact on the same set of flanks with more than one other gear, the equivalent running time per day is to be taken as the sum of those applying to the separate mating gears.

GEAR LUBRICATION

Given the variety of gear types, service requirements, environmental influences and service temperature ranges, the choice of lubricant is an important factor for the service reliability and service life of the machine concerned. The following are recommended, on the basis of DIN 51 509 (Selection of Lubricants for Gears):-

1. At peripheral velocities up to v = 2 m/s:
High-consistency adhesive lubricants are used on large open gears.

2. At peripheral velocities up to v = 4 m/s:
Here, splash-lubrication using a soft gear-grease is customary into which the gear wheel dips

3. At peripheral velocities up to v = 15 m/s:
Here it is oil splash-lubrication which predominates

4. At peripheral velocities above v = 15 m/s:
In this range, oil spray lubrication is required in most cases.

FORMULAS BEVEL GEARS

TO FIND:-	PINION	WHEEL
PCD	$d = \frac{n}{DP}$ (ins) or n x mod (mm) n = No. of teeth.	$D = \frac{N}{DP}$ (ins) or N x mod (mm) N = No. of teeth.
PITCH ANGLE (for 90° shaft angle)	$Y = \tan^{-1}\frac{n}{N}$ (deg)	$\Gamma = 90 - Y$ (deg)
PITCH ANGLE (for shaft angle <90°)	$Y = \tan^{-1}\left[\frac{\sin\Sigma}{\left(\frac{N}{n}\right) + \cos\Sigma}\right]$ Σ = SHAFT ANGLE	$\Gamma = \Sigma - Y$
PITCH ANGLE (for shaft angle > 90°)	$Y = \tan^{-1}\left[\frac{\sin(180 - \Sigma)}{\frac{N}{n} - \cos(180 - \Sigma)}\right]$	$\Gamma = \Sigma - Y$
CONE DISTANCE	$Ao = \frac{D}{2 \sin\Gamma}$	See Pinion * *see note*

** A pitch angle (Σ) greater than 90° indicates an internal gear. Please contact Technical to determine if the gear can be cut.*

FORMULAS - WORMS & WHEELS

TO FIND:-	MODULE	IMPERIAL
ØD	(2 x MODULE) + PCDmm	$\frac{2 + PCD''}{DP}$
TANGENT OF THE LEAD ANGLE	$\frac{\text{MODULE x No. of STARTS}}{\text{PCD}}$	$\frac{\text{CP'' x No. of STARTS}}{\text{PCD x } \pi}$
CENTRE DISTANCE	$\frac{\text{PCD (Worm) + PCD (Wheel)}}{2}$ in mm	$\frac{\text{PCD'' (Worm) + PCD'' (Wheel)}}{2}$

TO FIND:-	MODULE	IMPERIAL
THROAT Ø	= (No. of TEETH + 2) x MOD (mm)	$= \frac{\text{No. of TEETH + 2}}{\text{DP}}$ (inches)
TIP Ø	= (No. of TEETH + 3) x MOD (mm)	$= \frac{\text{No. of TEETH + 3}}{\text{DP}}$ (inches)
P.C.D.	= No. of TEETH x MOD (mm)	$= \frac{\text{No. of TEETH}}{\text{DP}}$ (inches)
REDUCTION RATIO	$= \frac{\text{No. of TEETH in WHEEL}}{\text{No. of STARTS in WORM}}$	

Our WORMS and WORMWHEELS are made to give 0.08 - 0.15mm backlash at standard centres.
Housing centres should be nominal +0.00 +0.05mm.

$$\text{CENTRE DISTANCE} = \frac{\text{PCD (WORM) + PCD (WHEEL)}}{2}$$

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LOAD CALCULATIONS
BEVELS

BEVEL GEARS, BSI 545 : 1949

ALLOWABLE TANGENTIAL LOAD AT PITCH RADIUS

Xc	=	Speed factor for wear
Z	=	Zone factor (see chart)
Sc*	=	Material rating (surface stress)
Sb*	=	Material rating (bending stress)
K	=	Pitch factor DP $^{0.8}$ power
F	=	Face width (inches)
Xb	=	Speed for strength
Y	=	Strength factor
C	=	Cone distance (inches)
P	=	DP

WEAR

$$\frac{Xc\ Sc\ Z\ F}{K \times 1.33} \times \left(\frac{C - F}{1.1 \times C}\right) \text{ lbs.}$$

STRENGTH

$$\frac{Xb\ Sb\ Y\ F}{P} \times \left(\frac{C - F}{1.1 \times C}\right) \text{ lbs.}$$

Based on 12 hour day.

$$\text{Cone Distance } C = \frac{\text{PCD" of Gear}}{2 \times \text{Sin Pitch Angle of Gear}}$$

$$\text{Allowable tangential load at PCR} = \frac{\text{Torque lbs ins} \times 2}{\text{PCD"}} \text{ lbs}$$

Pitch Angle of Gear = 90° – Pitch Angle of Pinion

$$\text{Pitch Angle of Pinion} = \tan^{-1} \frac{\text{No. of Teeth Pinion}}{\text{No. of Teeth Gear}}$$

The lowest of the four values for pinion and wheel gives the gear rating. The normal rating for gears is based on 12 hours/day.

hrs per day Approx.	Total hours life	Wear multiply by	Strength multiply by
0	0	3.0	2.0
0.5	100	2.91	1.89
1	1000	2.38	1.55
3	5000	1.66	1.27
6	10000	1.35	1.14
12	26000	1.0	1.0
24	52000	0.79	0.9

Gear torque =

$$\frac{\text{allowable Tangential Load} \times \text{PCD"}}{2}$$

Allowable Tangential Load =

$$\frac{\text{Gear Torque} \times 2}{\text{PCD}}$$

* Please refer to **Material Strength** page for values.

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BEVEL GEARS

ZONE FACTORS Z

maximum ratio 4:1 Gleason

No. of Teeth in Gear	NUMBER OF TEETH IN MATING GEAR												
	15	16	19	20	24	25	26	30	32	45	48	60	72
15	1.800	1.850	2.050	2.100	2.245	2.250	2.255	2.350	2.380	2.450	2.500	2.600	—
16	1.850	1.950	2.235	2.240	2.260	2.265	2.265	2.455	2.500	2.650	2.700	2.740	—
19	2.050	2.235	2.300	2.355	2.600	2.600	2.650	2.750	2.755	3.000	3.000	3.100	3.150
20	2.100	2.240	2.355	2.450	2.730	2.740	2.750	2.770	2.755	3.200	3.300	3.350	3.400
24	2.245	2.260	2.600	2.730	2.850	2.900	2.950	3.200	3.250	3.600	3.650	3.750	3.800
25	2.250	2.265	2.600	2.740	2.900	2.900	3.050	3.250	3.300	3.750	3.750	3.800	3.950
26	2.255	2.265	2.650	2.750	2.950	3.050	3.200	3.400	3.450	3.800	3.850	4.000	4.100
30	2.350	2.455	2.750	2.770	3.200	3.250	3.400	3.650	3.700	4.100	4.200	4.500	4.700
32	2.380	2.500	2.755	2.775	3.250	3.300	3.450	3.700	3.700	4.200	4.300	4.700	4.850
45	2.450	2.650	3.000	3.200	3.600	3.750	3.800	4.100	4.200	5.000	5.200	5.800	5.950
48	2.500	2.700	3.000	3.300	3.650	3.750	3.850	4.200	4.300	5.200	5.400	5.900	6.100
60	2.600	2.740	3.100	3.350	3.750	3.800	4.000	4.500	4.700	5.800	5.900	6.600	7.000
72	—	—	3.150	3.400	3.800	3.950	4.100	4.700	4.850	5.950	6.100	7.000	7.700

STRENGTH FACTORS Y

No. of Teeth in Gear	NUMBER OF TEETH IN MATING GEAR					
	15	20	30	40	60	80
15	.625	.660	.670	.705	.710	—
20	.585	.625	.705	.730	.745	.750
30	.570	.620	.710	.765	.795	.810
40	.580	.625	.715	.770	.825	.840
60	.600	.640	.720	.765	.830	.860
80	—	.650	.720	.760	.790	.855

SPEED FACTORS X_c FOR WEAR

Rpm	Xc	Rpm	Xc	Rpm	Xc	Rpm	Xc
1	1.00	10	.635	200	.375	2000	.230
2	0.88	20	.550	400	.330	4000	.180
4	0.77	40	.485	600	.310	6000	.165
6	0.70	60	.460	800	.285	8000	.140
8	0.67	100	.425	1000	.275	10000	.125

SPEED FACTORS X_b FOR STRENGTH

Rpm	Xc	Rpm	Xc	Rpm	Xc	Rpm	Xc
1	.66	10	.570	200	.375	2000	.230
2	.64	20	.525	400	.330	4000	.180
4	.62	40	.480	600	.310	6000	.165
6	.59	60	.460	800	.285	8000	.140
8	.58	100	.425	1000	.275	10000	.125

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LOAD CALCULATIONS
WORMS & WHEELS

BSI 721 : 1937

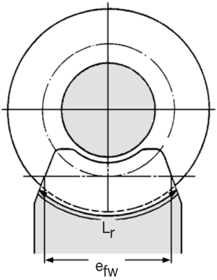
TORQUE CAPACITY (based on 12 hour day)		
Xc	=	Speed factor for wear (see chart)
0.18	=	Constant value
Sc	=	Material rating - surface stress (see tables)
Sb	=	Material rating - bending stress (see tables)
efw	=	Effective face width of wheel
Xb	=	Speed factor for strength
1.8	=	Constant value
M	=	Addendum in inches
D	=	Wheel PCD"
Lr	=	Length at root of wheel teeth in inches
Cosα	=	Cosine of lead angle of worm

WEAR

$0.18\ Sc\ Xc\ efw\ D^{1.8}$ lbs. Ins.

STRENGTH

$1.8Sb\ Xb\ Lr\ M\ D\ Cos\alpha$ lbs. ins.



Rubbing Speed Feet/Minute $= \dfrac{\text{Worm pcd" } \times \pi \times \text{RPM}}{12} \times$ secant lead angle

$$\textbf{efw} = 2 \times \sqrt{\text{Addendum"}\left(\text{Worm O/D" } - \text{Addendum"}\right)}$$

$$\textbf{Lr} = 2 \times \theta° \times \frac{\text{Worm O/D}}{2} \times 0.01745$$

$$\text{Cos}\theta = \left(\frac{\text{PCD of Worm"}}{\text{O/D of Worm"}}\right)$$

$$\text{Angle } \theta° = \text{Cos}^{-1}\,\theta$$

Note : The lowest of the four values for Worm and Wheel gives the gear rating.

	RUNNING TIME (hours per day)											
	Xc and Xb to be divided by factors below for different hrs/day											
	1/6	1/4	1/2	1	2	3	4	6	8	10	18	24
Wear	—	0.38	0.42	0.47	0.55	0.62	0.68	0.78	0.87	0.94	1.15	1.24
Strength	0.50	0.54	0.56	0.59	0.64	0.68	0.72	0.79	0.87	0.94	1.15	1.24

SPEED FACTORS

WORMS & WHEELS

Xc FOR WEAR

RPM of Worm & Wheel	RUBBING SPEED (ft/min)								
	1	4	10	40	100	200	600	1000	2000
2500	.19	.17	.165	.145	.13	.118	.099	.090	.078
2000	.21	.185	.18	.155	.140	.13	.107	.097	.085
1000	.26	.24	.23	.195	.175	.16	.135	.125	.106
800	.27	.25	.24	.21	.19	.175	.15	.135	.115
500	.32	.3	.28	.245	.23	.20	.17	.155	.135
200	.42	.38	.36	.32	.28	.260	.220	.20	.17
100	.48	.46	.43	.37	.34	.31	.26	.23	.20
40	.58	.55	.51	.45	.40	.36	.31	.28	.24
20	.65	.6	.56	.50	.45	.41	.34	.32	.27
10	.71	.7	.61	.54	.48	.44	.37	.34	.29
2	.82	.8	.71	.65	.57	.54	.45	.42	.36

Xb FOR STRENGTH

RPM	Speed Factor	RPM	Speed Factor	RPM	Speed Factor	RPM	Speed Factor
10	0.560	**90**	0.420	**500**	0.310	**3000**	0.200
15	0.540	**100**	0.415	**600**	0.300	**3500**	0.190
20	0.520	**150**	0.384	**700**	0.290	**4000**	0.180
30	0.500	**200**	0.365	**800**	0.280	**4500**	0.175
40	0.480	**250**	0.350	**900**	0.270	**5000**	0.170
50	0.460	**300**	0.340	**1000**	0.260	**6000**	0.160
60	0.450	**350**	0.335	**1500**	0.240	**7000**	0.150
70	0.440	**400**	0.330	**2000**	0.225	**8000**	0.140
80	0.430	**450**	0.320	**2500**	0.210	**9000**	0.135

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BENDING AND SURFACE STRESS FACTORS WORMS & WHEELS

Wheel

	WHEEL Materials	Bending Stress Factor Sb Pounds per Sq. In.	Find surface stress factor Sc for wheel, under worm material classification letter A	B	C	D	E
A	Phosphor Bronze Sand Cast	7,000	—	600*	600	700	1400*
	Phosphor Bronze Chill Cast	8,500	—	800*	800	900	1600
	Phosphor Bronze Centrifugally Cast	10,000	—	1000*	1000	1100	2000
B	Cast Iron (Gray)	6,000	900*	600*	600	600	750

HPC 'standard' wheels use sand cast PB2
For 'standard' hardened worms use 1400 Sc value for wheels

Worm

	WORM Materials	Bending Stress Factor Sb Pounds per Sq. In.	Find surface stress factor Sc for wheel, under worm material classification letter A	B	C	D	E
C	0.4% Carbon Steel Normalised	20,000	1400	900†	—	—	—
D	0.55% Carbon Steel Normalised	22,000	2000	1100†	—	—	—
E	Low-carbon CasehardeningSteel	27,000	6000	4000†	—	—	—
	3.5% Nickel Casehardening Steel	40,000	6500	4000†	—	—	2000†
	5% Nickel Casehardening Steel	47,000	7000	4000†	—	—	2000†
	3.5% Nickel Chromium Casehardening Steel	47,000	7000	4000†	—	—	2000†
	High Nickel-chrom Casehardening Steel	47,000	8000	4000†	—	—	2000†

NOTE: Section E - hardened, ground and polished.

HPC Standard Worms Unhardened - Sc = 1400 Sb = 17,000
Hardened - Sc = 6000 Sb= 27,000

* Maximum permissible rubbing speeds, 500 feet per minute.
† Should not be used except for hand operated gearing.

EFFICIENCY
WORMS & WHEELS

Excluding bearing and oil churning losses. Values are based on PB2 Wheels and case hardened and ground and polished worms lubricated by mineral oil. The efficiency may be improved after the “running in” period. *NOTE: As HPC standard worms are not hardened ground and polished lower efficiency values can be expected.*

$$\text{Efficiency (\%)} = \left[\frac{\text{TAN}\,\lambda^\circ}{\text{TAN}\,(\theta^\circ+\lambda^\circ)}\right] \text{X } 100$$

$\theta^\circ = \text{TAN}^{-1}\ f$

λ° = Lead Angle

f = Coefficient of friction

$$\text{INPUT TORQUE} = \frac{\text{Output Torque}}{\text{Ratio}} \times \frac{100}{\text{Efficiency}}$$

$$\text{OUTPUT TORQUE} = \frac{\text{Input Torque} \times \text{Ratio} \times \text{Efficiency}}{100}$$

Coefficients of Friction for Worm Gearing							
Rubbing Speed Ft. per min.	Coeffi-cients of Friction	Rubbing Speed Ft. per min.	Coeffi-cients of Friction	Rubbing Speed Ft. per min.	Coeffi-cients of Friction	Rubbing Speed Ft. per min.	Coeffi-cients of Friction
30	0.073	**180**	0.045	**550**	0.028	**1600**	0.0175
40	0.070	**190**	0.044	**600**	0.027	**1700**	0.0170
50	0.066	**200**	0.043	**650**	0.026	**1800**	0.0165
60	0.062	**225**	0.041	**700**	0.026	**1900**	0.0165
70	0.060	**250**	0.040	**750**	0.025	**2000**	0.0160
80	0.058	**275**	0.038	**800**	0.024	**2100**	0.0160
90	0.056	**300**	0.036	**850**	0.023	**2200**	0.0155
100	0.054	**325**	0.035	**900**	0.023	**2300**	0.0150
110	0.052	**350**	0.034	**950**	0.022	**2400**	0.0150
120	0.051	**375**	0.033	**1000**	0.022	**2500**	0.0150
130	0.050	**400**	0.033	**1100**	0.021	**2600**	0.0145
140	0.049	**425**	0.032	**1200**	0.020	**2700**	0.0145
150	0.048	**450**	0.031	**1300**	0.019	**2800**	0.0140
160	0.047	**475**	0.030	**1400**	0.019	**2900**	0.0140
170	0.046	**500**	0.030	**1500**	0.018	**3000**	0.0140

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