# Gear Engineering Data

## Spur Gear
## Gear Formulas
## Drive Selection
## Horsepower and Torque
## Tables

# Gear Selection

## Stock Spur Gear Drive Selection

When designing a stock gear drive using the horsepower tables in this catalog, the following steps must be taken:

I. Find out these five necessary things:

a. Exact center distance in inches
b. Ratio and speeds
c. Service factor (from page G-84)
d. Actual horsepower
e. Bore sizes of both gears

II. Determine Design Horsepower using formula:

$$DHP = HP \times SF$$

Where: DHP = Design Horsepower

HP = Actual Horsepower

SF = Service Factor (from page G-84)

III. Determine Pitch Diameters using the formulas:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

$$PD_2 = PD_1 \times Ratio$$

Where: $PD_1$ = Pitch Diameter of Pinion (small gear)

$PD_2$ = Pitch Diameter of Gear (large gear)

CD = Center Distance

IV. Check the Center Distance:

$$CD = \frac{PD_1 + PD_2}{2}$$

V. Select Pitch from Horsepower tables on pages G-25 — G-27.

VI. Check Selected pitch for necessary Pitch Diameters.

VII. Check Horsepower capacity of Large Gear.

VIII. Check maximum bore capacity of selected Gears.

# Spur Gear Drive Selection II (Other Than Stock)

When designing a gear drive when horsepower and speeds exceed the stock gear tables on pages G-25 – G-27, the following steps must be taken:

I. We must obtain all of the following data:

a. Exact center distance in inches
b. Ratio and speeds
c. Service factor (from page G-84)
d. Actual horsepower
e. Bore sizes of both gears

II. Determine Design Horsepower using formula:

$$DHP = HP \times SF$$

Where: DHP = Design Horsepower

HP = Actual Horsepower

SF = Service Factor (from page G-84)

III. Determine Pitch Diameters using the formulas:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

$$PD_2 = PD_1 \times Ratio$$

Where: $PD_1$ = Pitch Diameter of Pinion (small gear)

$PD_2$ = Pitch Diameter of Gear (large gear)

CD = Center Distance

IV. Determine velocity using the formula:

$$V = .262 \times PD \times RPM$$

Where: V = Velocity in feet per minute @ pitch line

PD = Pitch Diameter

RPM = Revolutions per minute of either gear*

V. Determine approximate pitch using the formula:

$$DP = \sqrt{\frac{3.1416 \times S \times 3 \times V \times .25}{DHP \times 27.5\ (1200 + V)}}$$

Where: DP = Diametral Pitch

S = Safe Static Stress per Square Inch of material (see table one, page G-84)

V = Velocity in FPM

DHP = Design Horsepower

Note: To round off answers, go to the nearest DP (standard DP's larger than 3 DP are: 1 DP, 1¼ DP, 1½ DP, 1¾ DP, 2 DP, 2½ DP)

VI. Determine number of teeth on both gears:

$$N = PD \times DP$$

Where: N = Number of teeth

PD = Pitch Diameter of gear

DP = Diametral Pitch of gear

NOTE: Velocities of both gears will always be the same. When using the above formula make sure to use the proper speed (RPM) with the proper pitch diameter.

## Spur Gear Drive Selection II
## (Other Than Stock)

VII. Determine Face Width:

$$F = DP\left(\frac{\frac{DHP \times 33{,}000}{V}}{SY\left(\frac{600}{600 + V}\right)}\right)$$

Where: F = Face Width

DP = Diametral Pitch

V = Velocity in FPM

S = Safe Static Stress per Square Inch of material (Table 1, page G-84)

Y = Outline formula from Table 2, page G-84

Note: To round off each answer, go to the next one inch.

VIII. Check HP rating of selected pinion using the formula:

$$HP = \frac{LV}{33{,}000}$$

Where: $L = \frac{SYF}{DP} \times \frac{600}{600 + V}$

From horsepower formulas on page G-83.

Note: If the horsepower capacity is below the design horsepower, the following options can be taken:
A. Harden pinion (check gear HP capacity first)
B. Increase face
C. Increase pitch

## Center Distance, Pitch Diameters and Ratios of Spur Gears

To determine the pitch diameters of a gear set, we must find two basic things:

1. Required ratio

2. Required center distance

Knowing this, first figure out the pitch diameter of the pinion (smaller gear) using the formula:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

Where: $PD_1$ = Pitch Diameter of the Pinion

CD = Center Distance

Then, find the pitch diameter of the larger gear, $PD_2$, by using the formula:

$$PD_2 = PD_1 \times Ratio$$

Then check the center distance by using the formula:

$$CD = \frac{PD_1 + PD_2}{2}$$

# Horsepower Formulas

See page G-84 for tables one, two and three

**Engineering Data**
Lewis Formula (with Barth Revision)

L = Load in pounds at pitch line

S = Safe static stress per square inch of material (see table one)

DP = Diametral Pitch

F = Face width of gear

Y = Strength factor based on Pressure Angle and Number of Teeth (See table two)

V = Velocity in feet per minute
$V = .262 \times PD \times RPM$

PD = Pitch Diameter

RPM = Revolutions Per Minute

HP = Horsepower

$$L = \frac{SFY}{DP} \times \frac{600}{600 + V}$$

Maximum allowable torque (T) that should be imposed on a gear will be the safe tooth load (L) multiplied by

$$\frac{DP}{2} \text{ or } T = \frac{L \times PD}{2}$$

The safe Horsepower capacity of the gear (at a given RPM) can be calculated from $HP = \frac{T \times RPM}{63{,}025}$
or directly from (L) and (V):

$$*HP = \frac{LV}{33{,}000}$$

$$\text{For a known HP, } T = \frac{63025 \times HP}{RPM}$$

For NON-METALLIC GEARS, the modified Lewis Formula shown below may be used with (S) values of 6000 PSI for Phenolic Laminated material.

$$L = \frac{SFY}{DP}\left(\frac{150}{200 + V} + .25\right)$$

* Apply SERVICE FACTOR (table three) for required horsepower.

# Gear Standards

## Table One

### (S) Average values in pounds per square inch

| Material | S |
|---|---|
| Steel — .40 Carbon | 25000 |
| — .20 Carbon | 20000 |
| Steel — .40 Carbon Heat Treated | 35000 |
| Cast Iron | 12000 |
| Bronze | 10000 |
| Non-Metallic | 6000 |

## Table Two

### Outline factor Y for use with Diametral Pitch

| Number of Teeth | 14½ P.A. Involute | 20 P.A. Involute | Number of Teeth | 14½ P.A. Involute | 20 P.A. Involute |
|---|---|---|---|---|---|
| 10 | .176 | .201 | 26 | .308 | .344 |
| 11 | .192 | .226 | 28 | .314 | .352 |
| 12 | .210 | .245 | 30 | .318 | .358 |
| 13 | .223 | .264 | 35 | .327 | .373 |
| 14 | .235 | .276 | 40 | .336 | .389 |
| 15 | .245 | .289 | 45 | .340 | .399 |
| 16 | .255 | .295 | 50 | .346 | .408 |
| 17 | .264 | .302 | 60 | .355 | .421 |
| 18 | .270 | .308 | 70 | .360 | .429 |
| 19 | .277 | .314 | 80 | .363 | .436 |
| 20 | .283 | .320 | 90 | .366 | .442 |
| 21 | .289 | .326 | 100 | .368 | .446 |
| 22 | .292 | .330 | 150 | .375 | .458 |
| 23 | .296 | .333 | 200 | .378 | .463 |
| 24 | .302 | .337 | RACK | .390 | .484 |
| 25 | .305 | .340 | | | |

## Table Three

### Service factors

### Multiply required horsepower by service factor recommended for type of service

| Type of Load | Intermittent or 3 Hours per Day | 8-10 Hours per Day | Continuous 24 Hours per Day |
|---|---|---|---|
| UNIFORM | 0.80 | 1.00 | 1.25 |
| LIGHT SHOCK | 1.00 | 1.25 | 1.50 |
| MEDIUM SHOCK | 1.25 | 1.50 | 1.80 |
| HEAVY SHOCK | 1.50 | 1.80 | 2.00 |

# Spur Gear Dimensional Formulas Diametral Pitch

## Rules and Formulas For Spur Gear Calculations

### Diametral Pitch
**Diametral Pitch is the Number of Teeth to Each Inch of the Pitch Diameter.**

| To Find | Having | Rule | Formula |
|---|---|---|---|
| The Diametrical Pitch | The Circular Pitch | Divide 3.1416 by the Circular Pitch | $DP = \frac{3.1416}{CP}$ |
| The Diametrical Pitch | The Pitch Diameter and the Number of Teeth | Divide the Number of Teeth by Pitch Diameter | $DP = \frac{N}{PD}$ |
| The Diametrical Pitch | The Outside Diameter and Number of Teeth | Divide the Number of Teeth plus 2 by Outside Diameter | $DP = \frac{N+2}{D}$ |
| Pitch Diameter | The Number of Teeth and the Diametral Pitch | Divide Number of Teeth by the Diametral Pitch | $PD = \frac{N}{DP}$ |
| Pitch Diameter | The Number of Teeth and Outside Diameter | Divide the product of Outside Diameter and Number of Teeth by Number of Teeth plus 2 | $PD = \frac{OD \times N}{N+2}$ |
| Pitch Diameter | The Outside Diameter and the Diametral Pitch | Subtract from the Outside Diameter the Quotient of 2 Divided by the Diametral Pitch | $PD = OD - (2 \div DP)$ |
| Pitch Diameter | Addendum and the Number of Teeth | Multiply Addendum by the Number of Teeth | $PD = s \times N$ |
| Outside Diameter | The Number of Teeth and the Diametral Pitch | Divide number of Teeth plus 2 by the Diametral Pitch | $OD = \frac{N+2}{DP}$ |
| Outside Diameter | The Pitch Diameter and the Diametral Pitch | Add to the Pitch Diameter the quotient of 2 divided by the Diametral Pitch | $D = PD + \frac{2}{P}$ |
| Outside Diameter | The Pitch Diameter and the Number of Teeth | Divide the Number of Teeth plus 2 by the quotient of Number of Teeth divided by Pitch Diameter | $D = \frac{N+2}{N \div PD}$ |
| Outside Diameter | The Number of Teeth and Addendum | Multiply the Number of Teeth plus 2 by Addendum | $D = (N+2)A$ |
| Number of Teeth | The Pitch Diameter and the Diametral Pitch | Multiply the Pitch Diameter by the Diametral Pitch | $N = PD \times DP$ |
| Number of Teeth | The Outside Diameter and the Diametral Pitch | Multiply Outside Diameter by the Diametral Pitch and subtract 2 | $N = DP - 2$ |
| Thickness of Tooth | The Diametral Pitch | Divide 1.5708 by the Diametral Pitch | $t = \frac{1.5708}{DP}$ |
| Addendum | The Diametral Pitch | Divide 1 by the Diametral Pitch | $A = \frac{1}{DP}$ |
| Dedendum | The Diametral Pitch | Divide 1.157 by the Diametral Pitch | $A+L = \frac{1.157}{DP}$ |
| Working Depth | The Diametral Pitch | Divide 2 by the Diametral Pitch | $WD = \frac{2}{DP}$ |
| Whole Depth | The Diametral Pitch | Divide 2.157 by the Diametral Pitch | $WD = \frac{2.157}{DP}$ |
| Clearance | The Diametral Pitch | Divide .157 by the Diametral Pitch | $L = \frac{.157}{DP}$ |
| Clearance | Thickness of Tooth | Divide Thickness of Tooth at Pitch Line by 10 | $L = \frac{t}{10}$ |

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

# Diametral Pitch Tooth Dimensions

## Dimensions of Standard Full-depth Teeth

### Diametral Pitches and Equivalent Circular Pitches

| Diametral Pitch | Circular Pitch | Module | Arc Thickness of Tooth on Pitch Line | Addendum | Working Depth of Tooth | Dedendum or Depth of Space Below Pitch Line | Whole Depth of Tooth* |
|---|---|---|---|---|---|---|---|
| ½ | 6.2832 | 50.8 | 3.1416 | 2.0000 | 4.0000 | 2.3142 | 4.3142 |
| ¾ | 4.1888 | 33.8667 | 2.0944 | 1.3333 | 2.6666 | 1.5428 | 2.8761 |
| 1 | 3.1416 | 25.4 | 1.5708 | 1.0000 | 2.0000 | 1.1571 | 2.1571 |
| 1¼ | 2.5133 | 20.32 | 1.2566 | 0.8000 | 1.6000 | 0.9257 | 1.7257 |
| 1½ | 2.0944 | 16.9333 | 1.0472 | 0.6666 | 1.3333 | 0.7714 | 1.4381 |
| 1¾ | 1.7952 | 14.5143 | 0.8976 | 0.5714 | 1.1429 | 0.6612 | 1.2326 |
| 2 | 1.5708 | 12.7 | 0.7854 | 0.5000 | 1.0000 | 0.5785 | 1.0785 |
| 2¼ | 1.3963 | 11.2889 | 0.6981 | 0.4444 | 0.8888 | 0.5143 | 0.9587 |
| 2½ | 1.2566 | 10.16 | 0.6283 | 0.4000 | 0.8000 | 0.4628 | 0.8628 |
| 2¾ | 1.1424 | 9.2364 | 0.5712 | 0.3636 | 0.7273 | 0.4208 | 0.7844 |
| 3 | 1.0472 | 8.4667 | 0.5236 | 0.3333 | 0.6666 | 0.3857 | 0.7190 |
| 3½ | 0.8976 | 7.2571 | 0.4488 | 0.2857 | 0.5714 | 0.3306 | 0.6163 |
| 4 | 0.7854 | 6.35 | 0.3927 | 0.2500 | 0.5000 | 0.2893 | 0.5393 |
| 5 | 0.6283 | 5.08 | 0.3142 | 0.2000 | 0.4000 | 0.2314 | 0.4314 |
| 6 | 0.5236 | 4.2333 | 0.2618 | 0.1666 | 0.3333 | 0.1928 | 0.3595 |
| 7 | 0.4488 | 3.6286 | 0.2244 | 0.1429 | 0.2857 | 0.1653 | 0.3081 |
| 8 | 0.3927 | 3.175 | 0.1963 | 0.1250 | 0.2500 | 0.1446 | 0.2696 |
| 9 | 0.3491 | 2.8222 | 0.1745 | 0.1111 | 0.2222 | 0.1286 | 0.2397 |
| 10 | 0.3142 | 2.54 | 0.1571 | 0.1000 | 0.2000 | 0.1157 | 0.2157 |
| 11 | 0.2856 | 2.3091 | 0.1428 | 0.0909 | 0.1818 | 0.1052 | 0.1961 |
| 12 | 0.2618 | 2.1167 | 0.1309 | 0.0833 | 0.1666 | 0.0964 | 0.1798 |
| 13 | 0.2417 | 1.9538 | 0.1208 | 0.0769 | 0.1538 | 0.0890 | 0.1659 |
| 14 | 0.2244 | 1.8143 | 0.1122 | 0.0714 | 0.1429 | 0.0826 | 0.1541 |
| 15 | 0.2094 | 1.6933 | 0.1047 | 0.0666 | 0.1333 | 0.0771 | 0.1438 |
| 16 | 0.1963 | 1.5875 | 0.0982 | 0.0625 | 0.1250 | 0.0723 | 0.1348 |
| 17 | 0.1848 | 1.4941 | 0.0924 | 0.0588 | 0.1176 | 0.0681 | 0.1269 |
| 18 | 0.1745 | 1.4111 | 0.0873 | 0.0555 | 0.1111 | 0.0643 | 0.1198 |
| 19 | 0.1653 | 1.3368 | 0.0827 | 0.0526 | 0.1053 | 0.0609 | 0.1135 |
| 20 | 0.1571 | 1.27 | 0.0785 | 0.0500 | 0.1000 | 0.0579 | 0.1079 |
| 22 | 0.1428 | 1.1545 | 0.0714 | 0.0455 | 0.0909 | 0.0526 | 0.0980 |
| 24 | 0.1309 | 1.0583 | 0.0654 | 0.0417 | 0.0833 | 0.0482 | 0.0898 |
| 26 | 0.1208 | 0.9769 | 0.0604 | 0.0385 | 0.0769 | 0.0445 | 0.0829 |
| 28 | 0.1122 | 0.9071 | 0.0561 | 0.0357 | 0.0714 | 0.0413 | 0.0770 |
| 30 | 0.1047 | 0.8467 | 0.0524 | 0.0333 | 0.0666 | 0.0386 | 0.0719 |
| 32 | 0.0982 | 0.7938 | 0.0491 | 0.0312 | 0.0625 | 0.0362 | 0.0674 |
| 34 | 0.0924 | 0.7471 | 0.0462 | 0.0294 | 0.0588 | 0.0340 | 0.0634 |
| 36 | 0.0873 | 0.7056 | 0.0436 | 0.0278 | 0.0555 | 0.0321 | 0.0599 |
| 38 | 0.0827 | 0.6684 | 0.0413 | 0.0263 | 0.0526 | 0.0304 | 0.0568 |
| 40 | 0.0785 | 0.635 | 0.0393 | 0.0250 | 0.0500 | 0.0289 | 0.0539 |

*NOTE: Dimensions listed are for HOB CUT TEETH ONLY. Shaper cut teeth may be slightly larger. Consult factory for exact measurement.

### All Gears In Stock Are Diametral Pitch

# Spur Gear Dimensional Formulas Circular Pitch

## Rules and Formulas For Spur Gear Calculations

### Circular Pitch

**Circular Pitch is the Distance from the Center of One Tooth to the Center of the Next Tooth, Measured Along the Pitch Circle.**

| To Find | Having | Rule | Formula |
|---|---|---|---|
| The Circular Pitch | The Diametral Pitch | Divide 3.1416 by the Diametral Pitch | $CP = \frac{3.1416}{DP}$ |
| The Circular Pitch | The Pitch Diameter and the Number of Teeth | Divide Pitch Diameter by the product of .3183 and Number of Teeth | $CP = \frac{PD}{.3183N}$ |
| The Circular Pitch | The Outside Diameter and the Number of Teeth | Divide Outside Diameter by the product of .3183 and Number of Teeth plus 2 | $CP = \frac{OD}{.3183\ N + 2}$ |
| Pitch Diameter | The Number of Teeth and the Circular Pitch | The continued product of the Number of Teeth, the Circular Pitch and .3183 | PD = N X CP .3183 |
| Pitch Diameter | The Number of Teeth and the Outside Diameter | Divide the product of Number of Teeth and Outside Diameter by Number of Teeth plus 2 | $PD = \frac{N \times OD}{N + 2}$ |
| Pitch Diameter | The Outside Diameter and the Circular Pitch | Subtract from the Outside Diameter the product of the Circular Pitch and .6366 | PD = OD – (CP .6366) |
| Pitch Diameter | Addendum and the Number of Teeth | Multiply the Number of Teeth by the Addendum | PD = NA |
| Outside Diameter | The Number of Teeth and the Circular Pitch | The continued product of the Number of Teeth plus 2, the Circular Pitch and .3183 | D = (N + 2) CP .3183 |
| Outside Diameter | The Pitch Diameter and the Circular Pitch | Add to the Pitch Diameter the product of the Circular Pitch and .6366 | D = PD + (CP .6366) |
| Outside Diameter | The Number of Teeth and the Addendum | Multiply Addendum by Number of Teeth plus 2 | D = A (N + 2) |
| Number of Teeth | The Pitch Diameter and the Circular Pitch | Divide the product of Pitch Diameter and 3.1416 by the Circular Pitch | $N = \frac{PD\ 3.1416}{CP}$ |
| Thickness of Tooth | The Circular Pitch | One-half the Circular Pitch | $t = \frac{CP}{2}$ |
| Addendum | The Circular Pitch | Multiply the Circular Pitch by .3183 or $s = \frac{DP}{N}$ | A = CP × .3183 |
| Dedendum | The Circular Pitch | Multiply the Circular Pitch by .3683 | A + L = CP × .3683 |
| Working Depth | The Circular Pitch | Multiply the Circular Pitch by .6366 | WD = CP × .6366 |
| Whole Depth | The Circular Pitch | Multiply the Circular Pitch by .6866 | D = CP × .6866 |
| Clearance | The Circular Pitch | Multiply the Circular Pitch by .05 | L = C × .05 |
| Clearance | Thickness of Tooth | One-Tenth theThickness of Tooth at Pitch Line | $L = \frac{t}{10}$ |

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

**Circular Pitch Gears Made To Order Only**

# Circular Pitch
# Tooth Dimensions

## Dimensions of Standard Full-depth Teeth

### Circular Pitches and Equivalent Diametral Pitches

| Circular Pitch | Diametral Pitch | Module | Arc Thickness of Tooth on Pitch Line | Addendum | Working Depth of Tooth | Dedendum or Depth of Space Below Pitch Line | Whole Depth of Tooth |
|---|---|---|---|---|---|---|---|
| 4 | 0.7854 | 32.3402 | 2.0000 | 1.2732 | 2.5464 | 1.4732 | 2.7464 |
| 3½ | 0.8976 | 28.2581 | 1.7500 | 1.1140 | 2.2281 | 1.2890 | 2.4031 |
| 3 | 1.0472 | 24.2552 | 1.5000 | 0.9549 | 1.9098 | 1.1049 | 2.0598 |
| 2¾ | 1.1424 | 22.2339 | 1.3750 | 0.8753 | 1.7506 | 1.0128 | 1.8881 |
| 2½ | 1.2566 | 20.2117 | 1.2500 | 0.7957 | 1.5915 | 0.9207 | 1.7165 |
| 2¼ | 1.3963 | 18.1913 | 1.1250 | 0.7162 | 1.4323 | 0.8287 | 1.5448 |
| 2 | 1.5708 | 16.1701 | 1.0000 | 0.6366 | 1.2732 | 0.7366 | 1.3732 |
| 1⅞ | 1.6755 | 15.1595 | 0.9375 | 0.5968 | 1.1937 | 0.6906 | 1.2874 |
| 1¾ | 1.7952 | 14.1488 | 0.8750 | 0.5570 | 1.1141 | 0.6445 | 1.2016 |
| 1⅝ | 1.9333 | 13.1382 | 0.8125 | 0.5173 | 1.0345 | 0.5985 | 1.1158 |
| 1½ | 2.0944 | 12.1276 | 0.7500 | 0.4775 | 0.9549 | 0.5525 | 1.0299 |
| 1⅞ | 2.1855 | 11.6223 | 0.7187 | 0.4576 | 0.9151 | 0.5294 | 0.9870 |
| 1⅜ | 2.2848 | 11.1169 | 0.6875 | 0.4377 | 0.8754 | 0.5064 | 0.9441 |
| 1⅝ | 2.3936 | 10.6116 | 0.6562 | 0.4178 | 0.8356 | 0.4834 | 0.9012 |
| 1¼ | 2.5133 | 10.1062 | 0.6250 | 0.3979 | 0.7958 | 0.4604 | 0.8583 |
| 1⅜ | 2.6456 | 9.6010 | 0.5937 | 0.3780 | 0.7560 | 0.4374 | 0.8154 |
| 1⅛ | 2.7925 | 9.0958 | 0.5625 | 0.3581 | 0.7162 | 0.4143 | 0.7724 |
| 1⅛ | 2.9568 | 8.5904 | 0.5312 | 0.3382 | 0.6764 | 0.3913 | 0.7295 |
| 1 | 3.1416 | 8.0851 | 0.5000 | 0.3183 | 0.6366 | 0.3683 | 0.6866 |
| 15/16 | 3.3510 | 7.5798 | 0.4687 | 0.2984 | 0.5968 | 0.3453 | 0.6437 |
| ⅞ | 3.5904 | 7.0744 | 0.4375 | 0.2785 | 0.5570 | 0.3223 | 0.6007 |
| 13/16 | 3.8666 | 6.5692 | 0.4062 | 0.2586 | 0.5173 | 0.2993 | 0.5579 |
| ¾ | 4.1888 | 6.0639 | 0.3750 | 0.2387 | 0.4775 | 0.2762 | 0.5150 |
| 11/16 | 4.5696 | 5.5586 | 0.3437 | 0.2189 | 0.4377 | 0.2532 | 0.4720 |
| ⅔ | 4.7124 | 5.3903 | 0.3333 | 0.2122 | 0.4244 | 0.2455 | 0.4577 |
| ⅝ | 5.0265 | 5.0532 | 0.3125 | 0.1989 | 0.3979 | 0.2301 | 0.4291 |
| 9/16 | 5.5851 | 4.5479 | 0.2812 | 0.1790 | 0.3581 | 0.2071 | 0.3862 |
| ½ | 6.2832 | 4.0426 | 0.2500 | 0.1592 | 0.3183 | 0.1842 | 0.3433 |
| 7/16 | 7.1808 | 3.5373 | 0.2187 | 0.1393 | 0.2785 | 0.1611 | 0.3003 |
| ⅖ | 7.8540 | 3.2340 | 0.2000 | 0.1273 | 0.2546 | 0.1473 | 0.2746 |
| ⅜ | 8.3776 | 3.0319 | 0.1875 | 0.1194 | 0.2387 | 0.1381 | 0.2575 |
| ⅓ | 9.4248 | 2.6947 | 0.1666 | 0.1061 | 0.2122 | 0.1228 | 0.2289 |
| 5/16 | 10.0531 | 2.5266 | 0.1562 | 0.0995 | 0.1989 | 0.1151 | 0.2146 |
| 2/7 | 10.9956 | 2.3100 | 0.1429 | 0.0909 | 0.1819 | 0.1052 | 0.1962 |
| ¼ | 12.5664 | 2.0213 | 0.1250 | 0.0796 | 0.1591 | 0.0921 | 0.1716 |
| 2/9 | 14.1372 | 1.7967 | 0.1111 | 0.0707 | 0.1415 | 0.0818 | 0.1526 |
| ⅛ | 15.7080 | 1.6170 | 0.1000 | 0.0637 | 0.1273 | 0.0737 | 0.1373 |
| 3/16 | 16.7552 | 1.5160 | 0.0937 | 0.0597 | 0.1194 | 0.0690 | 0.1287 |
| 1/6 | 18.8496 | 0.5053 | 0.0833 | 0.0531 | 0.1061 | 0.0614 | 0.1144 |

**All Circular Pitch Gears Are Made-To-Order**

# Spur Gear Dimensional Formulas Module

## Rules and Formulas
## For Module (Metric) Spur Gear Calculations

### (Module Represents the Amount of Pitch Diameter per Tooth)

| To Find | Having | Rule | Formula |
|---|---|---|---|
| Metric Module | Pitch Diameter and Number of Teeth | Divide Pitch Diameter in Millimeters by the Number of Teeth | $M = \frac{PD\ (Millimeters)}{N}$ |
| Metric Module | Circular Pitch in Millimeter | Divide Circular Pitch in Millimeters by Pi (3.1416) | $M = \frac{C\ (Millimeters)}{3.1416}$ |
| Metric Module | Diametral Pitch | Divide 25.4 by Diametral Pitch | $M = \frac{25.4}{DP}$ |
| Metric Module | Outside Diameter and Number of Teeth | Divide Outside Diameter (in Millimeters) by the Number of Teeth plus 2 | $M = \frac{OD}{N + 2}$ |
| Pitch Diameter | Module and Number of Teeth | Multiply Module by Number of Teeth | PD (In MM)= M × N |
| Pitch Diameter | Number of Teeth and Outside Diameter | Divide the product of Outside Diameter and No. of Teeth by No. of Teeth plus 2 | $PD = \frac{OD \times N}{N + 2}$ |
| Pitch Diameter | Outside Diameter and the Module | Multiply Module by 2 and Subtract from Outside Diameter | PD = OD - 2M |
| Outside Diameter | Module and Number of Teeth | Number of Teeth plus 2 Multiplied by Module | OD (In MM) = (N + 2) x M |
| Diametral Pitch | Module | Divide 25.4 by Module | $DP = \frac{25.4}{M}$ |
| Circular Pitch | Module | Multiply Module by Pi (3.1416) | CP (In MM) = M × 3.1416 |
| Addendum | Module Known | The Addendum equals the Module | A = M |
| Whole Depth | Module Known | Multiply 2.157 by Module | WD (In MM) = 2.157 × M |
| Thickness of Tooth | Module and Outside Diameter | Multiply Pitch Diameter (in Millimeters) by the Sine of the Angle of 90 Divided by the Number of Teeth | $t\ (In\ MM) = PD\ (MM) \times Sine\ \frac{90}{N}$ |
| English Module | Pitch Diameter in Inches and Number of Teeth | Divide Pitch Diameter in Inches by Number of Teeth | $M = \frac{PD\ (Inches)}{N}$ (Answer in Fraction) |

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

# Module Pitch
# Tooth Dimensions

## Tooth Dimensions Based Upon Module System

**(One millimeter equals 0.03937 inch)**

| Module, DIN Standard Series | Equivalent Diametral Pitch | Circular Pitch | | Addendum, Millimeters | Dedendum, Millimeters† | Whole Depth,† Millimeters | Whole Depth,‡ Millimeters |
|---|---|---|---|---|---|---|---|
| | | Millimeters | Inches | | | | |
| 0.30 | 84.667 | 0.943 | 0.0371 | 0.30 | 0.350 | 0.650 | 0.647 |
| 0.40 | 63.500 | 1.257 | 0.0495 | 0.40 | 0.467 | 0.867 | 0.863 |
| 0.50 | 50.800 | 1.571 | 0.0618 | 0.50 | 0.583 | 1.083 | 1.079 |
| 0.60 | 42.333 | 1.885 | 0.0742 | 0.60 | 0.700 | 1.300 | 1.294 |
| 0.70 | 36.286 | 2.199 | 0.0865 | 0.70 | 0.817 | 1.517 | 1.510 |
| 0.80 | 31.750 | 2.513 | 0.0989 | 0.80 | 0.933 | 1.733 | 1.726 |
| 0.90 | 28.222 | 2.827 | 0.1113 | 0.90 | 1.050 | 1.950 | 1.941 |
| 1.00 | 25.400 | 3.142 | 0.1237 | 1.00 | 1.167 | 2.167 | 2.157 |
| 1.25 | 20.320 | 3.927 | 0.1546 | 1.25 | 1.458 | 2.708 | 2.697 |
| 1.50 | 16.933 | 4.712 | 0.1855 | 1.50 | 1.750 | 3.250 | 3.236 |
| 1.75 | 14.514 | 5.498 | 0.2164 | 1.75 | 2.042 | 3.792 | 3.774 |
| 2.00 | 12.700 | 6.283 | 0.2474 | 2.00 | 2.333 | 4.333 | 4.314 |
| 2.25 | 11.289 | 7.069 | 0.2783 | 2.25 | 2.625 | 4.875 | 4.853 |
| 2.50 | 10.160 | 7.854 | 0.3092 | 2.50 | 2.917 | 5.417 | 5.392 |
| 2.75 | 9.236 | 8.639 | 0.3401 | 2.75 | 3.208 | 5.958 | 5.932 |
| 3.00 | 8.466 | 9.425 | 0.3711 | 3.00 | 3.500 | 6.500 | 6.471 |
| 3.25 | 7.815 | 10.210 | 0.4020 | 3.25 | 3.791 | 7.041 | 7.010 |
| 3.50 | 7.257 | 10.996 | 0.4329 | 3.50 | 4.083 | 7.583 | 7.550 |
| 3.75 | 6.773 | 11.781 | 0.4638 | 3.75 | 4.375 | 8.125 | 8.089 |
| 4.00 | 6.350 | 12.566 | 0.4947 | 4.00 | 4.666 | 8.666 | 8.628 |
| 4.50 | 5.644 | 14.137 | 0.5566 | 4.50 | 5.250 | 9.750 | 9.707 |
| 5.00 | 5.080 | 15.708 | 0.6184 | 5.00 | 5.833 | 10.833 | 10.785 |
| 5.50 | 4.618 | 17.279 | 0.6803 | 5.50 | 6.416 | 11.916 | 11.864 |
| 6.00 | 4.233 | 18.850 | 0.7421 | 6.00 | 7.000 | 13.000 | 12.942 |
| 6.50 | 3.908 | 20.420 | 0.8035 | 6.50 | 7.583 | 14.083 | 14.021 |
| 7.00 | 3.628 | 21.991 | 0.8658 | 7.00 | 8.166 | 15.166 | 15.099 |
| 8.00 | 3.175 | 25.132 | 0.9895 | 8.00 | 9.333 | 17.333 | 17.256 |
| 9.00 | 2.822 | 28.274 | 1.1132 | 9.00 | 10.499 | 19.499 | 19.413 |
| 10.00 | 2.540 | 31.416 | 1.2368 | 10.00 | 11.666 | 21.666 | 21.571 |
| 11.00 | 2.309 | 34.558 | 1.3606 | 11.00 | 12.833 | 23.833 | 23.728 |
| 12.00 | 2.117 | 37.699 | 1.4843 | 12.00 | 14.000 | 26.000 | 25.884 |
| 13.00 | 1.954 | 40.841 | 1.6079 | 13.00 | 15.166 | 28.166 | 28.041 |
| 14.00 | 1.814 | 43.982 | 1.7317 | 14.00 | 16.332 | 30.332 | 30.198 |
| 15.00 | 1.693 | 47.124 | 1.8541 | 15.00 | 17.499 | 32.499 | 32.355 |
| 16.00 | 1.587 | 50.266 | 1.9790 | 16.00 | 18.666 | 34.666 | 34.512 |
| 18.00 | 1.411 | 56.549 | 2.2263 | 18.00 | 21.000 | 39.000 | 38.826 |
| 20.00 | 1.270 | 62.832 | 2.4737 | 20.00 | 23.332 | 43.332 | 43.142 |
| 22.00 | 1.155 | 69.115 | 2.7210 | 22.00 | 25.665 | 47.665 | 47.454 |
| 24.00 | 1.058 | 75.398 | 2.9685 | 24.00 | 28.000 | 52.000 | 51.768 |
| 27.00 | 0.941 | 84.823 | 3.339 | 27.00 | 31.498 | 58.498 | 58.239 |
| 30.00 | 0.847 | 94.248 | 3.711 | 30.00 | 35.000 | 65.000 | 64.713 |
| 33.00 | 0.770 | 103.673 | 4.082 | 33.00 | 38.498 | 71.498 | 71.181 |
| 36.00 | 0.706 | 113.097 | 4.453 | 36.00 | 41.998 | 77.998 | 77.652 |
| 39.00 | 0.651 | 122.522 | 4.824 | 39.00 | 45.497 | 84.497 | 84.123 |
| 42.00 | 0.605 | 131.947 | 5.195 | 42.00 | 48.997 | 90.997 | 90.594 |
| 45.00 | 0.564 | 141.372 | 5.566 | 45.00 | 52.497 | 97.497 | 97.065 |
| 50.00 | 0.508 | 157.080 | 6.184 | 50.00 | 58.330 | 108.330 | 107.855 |
| 55.00 | 0.462 | 172.788 | 6.803 | 55.00 | 64.163 | 119.163 | 118.635 |
| 60.00 | 0.423 | 188.496 | 7.421 | 60.00 | 69.996 | 129.996 | 129.426 |
| 65.00 | 0.391 | 204.204 | 8.040 | 65.00 | 75.829 | 140.829 | 140.205 |
| 70.00 | 0.363 | 219.911 | 8.658 | 70.00 | 81.662 | 151.662 | 150.997 |
| 75.00 | 0.339 | 235.619 | 9.276 | 75.00 | 87.495 | 162.495 | 161.775 |

† Dedendum and total depth when clearance = 0.1666 x module, or one-sixth module.
‡ Total Depth equivalent to American standard full-depth teeth. (Clearance = 0.157 x Module.)

# Bevel & Miter Gear Formulas

| To Find | Rule | Formula |
|---|---|---|
| Pitch Diameter | Divide Number of Teeth by Diametral Pitch | $\text{Pitch Diameter} = \frac{\text{Number of Teeth}}{\text{Diametral Pitch}}$ |
| Tangent of Pitch Angle Of Driven | Divide Number of Teeth in Driven by Number of Teeth in Driver | $\text{Tangent Pitch Angle of Driven} = \frac{\text{Number of Teeth in Driven}}{\text{Number of Teeth in Driver}} = \text{Ratio}$ |
| Pitch Angle of Driver | Subtract Pitch Angle of Driven from 90 Degrees | Pitch Angle Of Driver = 90 Degrees - Pitch Angle of Driven |
| Pitch Cone Radius | Divide Pitch Diameter by Twice the Sine of the Pitch Angle | $\text{Pitch Cone Radius} = \frac{\text{Pitch Diamter}}{2 \times \text{Sine Pitch Angle}}$ |
| Tangent of Addendum Angle | Divide Addendum by the Pitch Cone Radius | $\text{Tangent of Addendum Angle} = \frac{\text{Addendum}}{\text{Pitch Cone Radius}}$ |
| Face Angle | Add Addendum Angle to Pitch Angle | Face Angle = Addendum Angle + Pitch Angle |
| Tangent of Dedendum Angle | Divide Dedendum by the Pitch Cone Radius | $\text{Tangent of Dedendum Angle} = \frac{\text{Dedendum}}{\text{Pitch Cone Radius}}$ |
| Root Angle | Subtract Dedendum Angle from Pitch Angle | Root Angle = Pitch Angle - Dedendum Angle |
| Angular Addendum | Multiply Addendum by Cosine of Pitch Angle | Angular Addendum = Addendum × Cosine Pitch Angle |
| Outside Diameter | Add 2 Angular Addenda to Pitch Diameter | Outside Diameter = 2 Angular Addenda × Pitch Diamter |
| Mounting Distance | Add one-half the Pitch Diameter of Mating to Pitch Line | $\text{Mounting Distance} = \frac{\text{Pitch Diameter of Mate}}{2} + \text{Backing to Pitch Line}$ |
| Distance From Cone Center to Crown | Multiply one-half Outside Diameter by Co-tangent of Face Angle | $\text{Cone Center to Crown} = \frac{\text{Outside Diameter}}{2} \times \text{Co-Tangent Face Angle}$ |
| Backing to Crown | Subtract Cone Center to Crown from Mounting Distance | Backing to Crown = Mounting Distance - Cone Center to Crown |
| Ratio | Divide Teeth in Driven by Teeth in Driver | $\text{Ratio} = \frac{\text{Number of Teeth in Driven}}{\text{Number of Teeth in Driver}}$ |

# Formula For Worm Gears

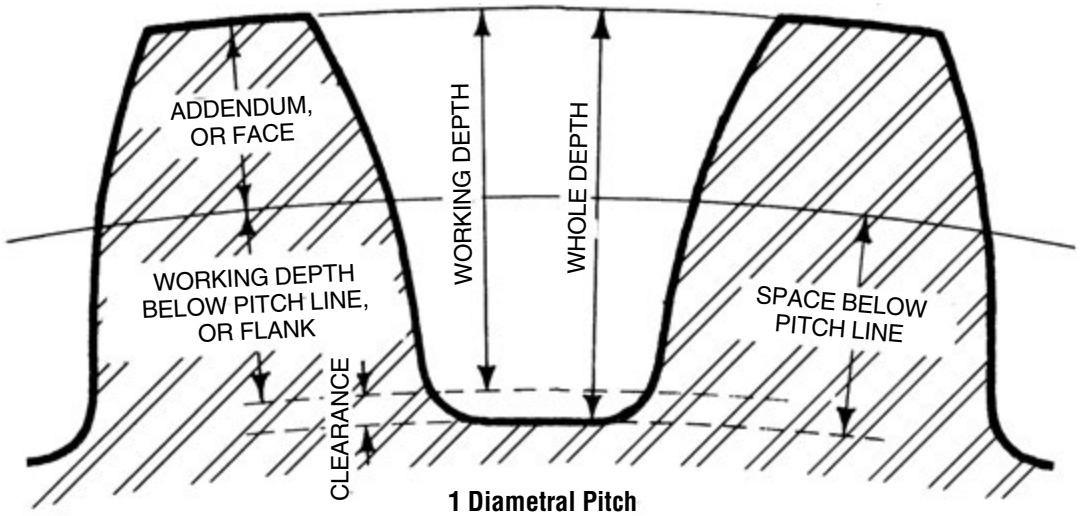
## (Based On Diametral Pitch)

| To Find | Rule | Formula |
|---|---|---|
| Worm Gear Pitch Diameter | Divide Number of Teeth by Diametral Pitch | $\text{Pitch Diameter} = \frac{\text{Number of Teeth in Worm Gear}}{\text{Diametral Pitch}}$ |
| Worm Gear Throat Diameter | Add 2 Addenda to Pitch Diameter | $\text{Throat Diameter} = (2 \times \text{Addendum}) + \text{Pitch Diameter}$ |
| Worm Gear Outside Diameter | Add 3 Addenda to Pitch Diameter | $\text{Outside Diameter} = (3 \times \text{Addendum}) + \text{Pitch Diameter}$ |
| Worm Pitch Diameter | Subtract the Worm Gear Pitch Diameter from Twice the Center Distance | $\text{Worm Pitch Diameter} = (2 \times \text{Center Distance}) - \text{Worm Gear Pitch Diameter}$ |
| Worm Outside Diameter | Add 2 Addenda to Worm Pitch Diameter | $\text{Worm Outside Diameter} = \text{Worm Pitch Diameter} + 2 \times \text{Addendum}$ |
| Worm Lead | Divide 3.1416 by Diametral Pitch and Multiply by Number of Threads in Worm | $\text{Worm Lead} = \frac{3.1416}{\text{Diametral Pitch}} \times \text{Number of Threads in Worm}$ |
| Co-Tangent of Worm Helix Angle | Multiply Worm Pitch Diameter by Diametral Pitch and Divide by Number of Worm Threads | $\text{Co-Tangent Worm Helix Angle} = \frac{\text{Worm Pitch Diameter} \times \text{Diametral Pitch}}{\text{Number Worm Threads}}$ |
| Center Distance | Add Worm Pitch Diameter to Worm Gear Pitch Diameter and Divide Sum by 2 | $\text{Center Distance} = \frac{\text{Worm Pitch Diameter} + \text{Worm Gear Pitch Diameter}}{2}$ |
| Ratio | Divide Number of Teeth in Worm Gear by Number of Worm Threads | $\text{Ratio} = \frac{\text{Number of Teeth in Worm Gear}}{\text{Number of Worm Threads}}$ |

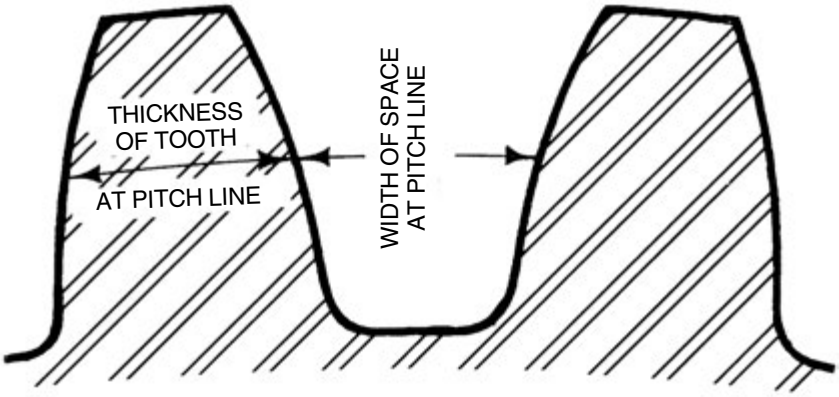
NOTE: Tooth data (Addendum, Full Depth, Etc.) is same as for Spur Gears.

# Cut Spur Gears
# 14½° P.A.

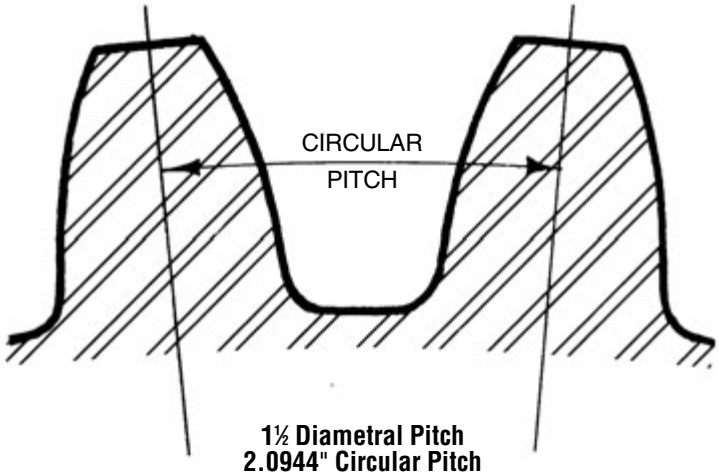
## Comparative Sizes of Involute Gear Teeth




**1 Diametral Pitch**
**3.1416" Circular Pitch**



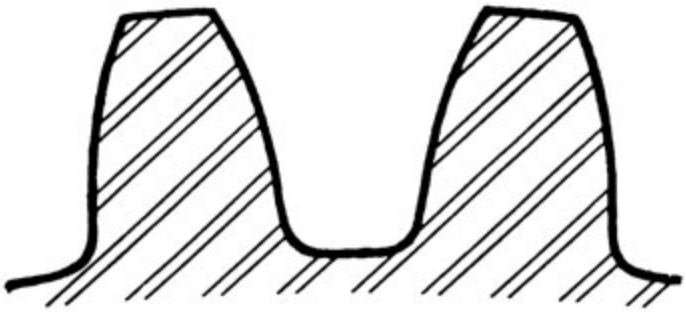

**1¼ Diametral Pitch**
**2.5133" Circular Pitch**



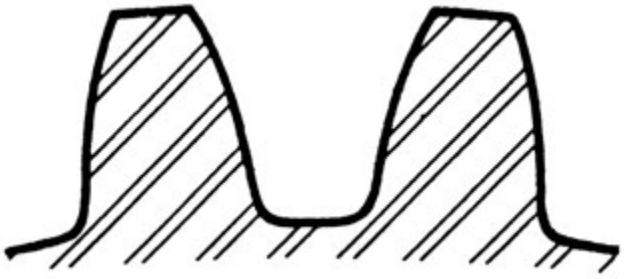

**1½ Diametral Pitch**
**2.0944" Circular Pitch**

# Cut Spur Gears
# 14½° P.A.

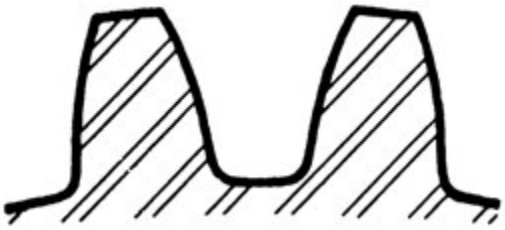
## Comparative Sizes of Involute Gear Teeth



1¾ Diametral Pitch
1.7952" Circular Pitch

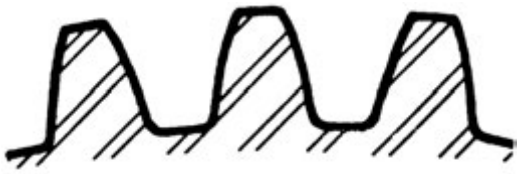


2 Diametral Pitch
1.5708" Circular Pitch



2½ Diametral Pitch
1.2566" Circular Pitch

3 Diametral Pitch
1.0472" Circular Pitch



3½ Diametral Pitch
.8976" Circular Pitch

4 Diametral Pitch
.7854" Circular Pitch

5 Diametral Pitch
.6283" Circular Pitch

6 Diametral Pitch
.5236" Circular Pitch

# Cut Spur Gears
# 14½° P.A.

## Comparative Sizes of Involute Gear Teeth

7 Diametral Pitch
.4488" Circular Pitch

8 Diametral Pitch
.3927" Circular Pitch

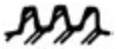
10 Diametral Pitch
.3142" Circular Pitch

12 Diametral Pitch
.2618" Circular Pitch

14 Diametral Pitch
.2244" Circular Pitch

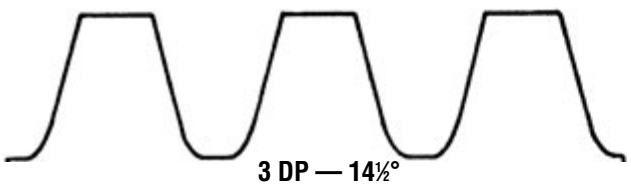
16 Diametral Pitch
.1963" Circular Pitch

18 Diametral Pitch
.1745" Circular Pitch



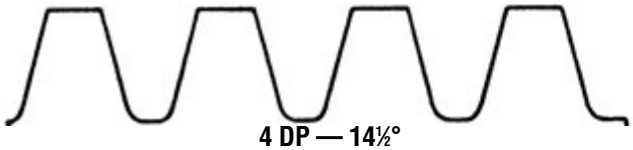
20 Diametral Pitch
.1571" Circular Pitch

## Gear Rack Comparison — 14½ and 20°

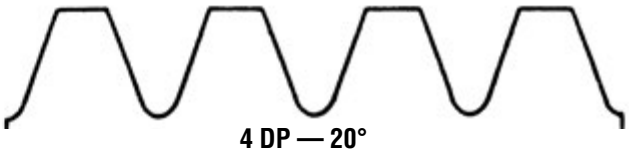


3 DP — 14½°

3 DP — 20°

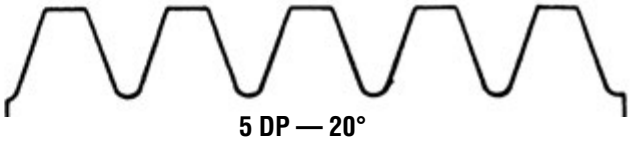


4 DP — 14½°

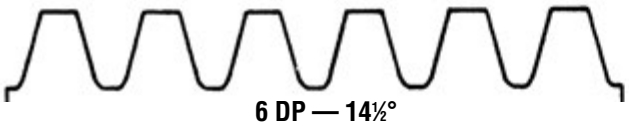


4 DP — 20°

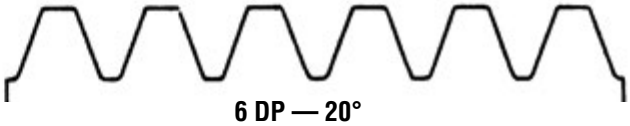
5 DP — 14½°



5 DP — 20°



6 DP — 14½°



6 DP — 20°

# Gear Materials

## Stock Steel Gears

Martin steel gears are manufactured from high quality carbon steel material. This material is used for strength and good hardening characteristics. These gears may be hardened by any method acceptable to good practice such as flame or induction hardening. Flame hardening is preferred so that only the teeth are hardened. Distortion is virtually eliminated and the bore is left soft for subsequent work.

## Cast Gears

Martin cast iron gears are manufactured from high quality close grained controlled specification irons.

## Reboring of Stock Gears

Most of Martin's Stock Gears may be rebored. The maximum recommended bore size is given for each gear. In reboring gears, care must be taken to hold the bore concentric with the pitch diameter. In most cases this would require a great amount of time. To cut costly set-up time when reboring, Martin holds the outside diameter of its gears concentric with the bore which in turn is concentric with the pitch diameter. The outside diameter is held to a closer total indicator reading than the pitch diameter. In the finer pitches, care should be taken not to distort the outside diameter when chucking.

Martin's steel gears are machined all over.

Rebore or rework may be accomplished by chucking on the hub. Concentricity must be controlled in order for gears to run at maximum efficiency.