

SECTION 10 TOOTH THICKNESS

There are direct and indirect methods for measuring tooth thickness. In general, there are three methods:

- Chordal Thickness Measurement
- Span Measurement
- Over Pin or Ball Measurement

10.1 Chordal Thickness Measurement

This method employs a tooth caliper that is referenced from the gear's outside diameter. Thickness is measured at the pitch circle. See **Figure 10-1**.

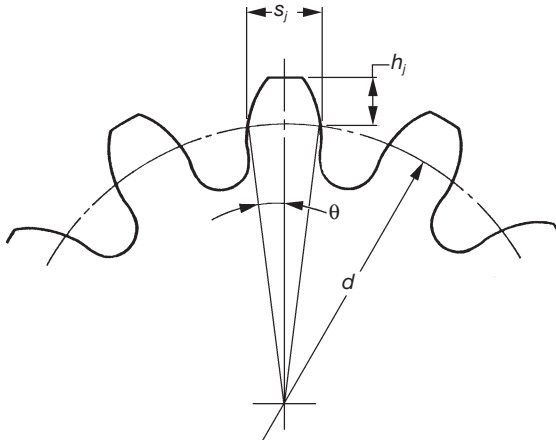


Fig. 10-1 Chordal Thickness Method

10.1.1 Spur Gears

Table 10-1 presents equations for each chordal thickness measurement.

Table 10-1 Equations for Spur Gear Chordal Thickness

No.	Item	Symbol	Formula	Example
1	Circular Tooth Thickness	s	$\left(\frac{\pi}{2} + 2x \tan \alpha\right)m$	$m = 10$ $\alpha = 20^\circ$ $z = 12$ $x = +0.3$ $h_a = 13.000$
2	Half of Tooth Angle at Pitch Circle	θ	$\frac{90}{z} + \frac{360x \tan \alpha}{\pi z}$	$s = 17.8918$ $\theta = 8.54270^\circ$
3	Chordal Thickness	s_j	$zm \sin \theta$	$s_j = 17.8256$
4	Chordal Addendum	h_j	$\frac{zm}{2}(1 - \cos \theta) + h_a$	$h_j = 13.6657$

10.1.2 Spur Racks And Helical Racks

The governing equations become simple since the rack tooth profile is trapezoid, as shown in **Table 10-2**.

Table 10-2 Chordal Thickness of Racks

No.	Item	Symbol	Formula	Example
1	Chordal Thickness	s_j	$\frac{\pi m}{2}$ or $\frac{\pi m_n}{2}$	$m = 3$ $\alpha = 20^\circ$ $s_j = 4.7124$
2	Chordal Addendum	h_j	h_a	$h_a = 3.0000$

NOTE: These equations are also applicable to helical racks.

10.1.3 Helical Gears

The chordal thickness of helical gears should be measured on the normal surface basis as shown in **Table 10-3**. **Table 10-4** presents the equations for chordal thickness of helical gears in the radial system.

10.1.4 Bevel Gears

Table 10-5 shows the equations of chordal thickness for a Gleason straight bevel gear.

Table 10-6 presents equations for chordal thickness of a standard straight bevel gear.

If a standard straight bevel gear is cut by a Gleason straight bevel cutter, the tooth angle should be adjusted according to:

$$\text{tooth angle } (^\circ) = \frac{180^\circ}{\pi R_e} \left(-\frac{s}{2} + h_f \tan \alpha \right) \quad (10-1)$$

This angle is used as a reference in determining the circular tooth thickness, s , in setting up the gear cutting machine.

Table 10-7 presents equations for chordal thickness of a Gleason spiral bevel gear.

The calculations of circular thickness of a Gleason spiral bevel gear are so complicated that we do not intend to go further in this presentation.

10.1.5 Worms And Worm Gears

Table 10-8 presents equations for chordal thickness of axial module worms and worm gears.

Table 10-9 contains the equations for chordal thickness of normal module worms and worm gears.

10.2 Span Measurement Of Teeth

Span measurement of teeth, s_m , is a measure over a number of teeth, z_m , made by means of a special tooth thickness micrometer. The value measured is the sum of normal circular tooth thickness on the base circle, s_{bn} , and normal pitch, $p_{en}(z_m - 1)$.

10.2.1 Spur And Internal Gears

The applicable equations are presented in **Table 10-10**.

Figure 10-4 shows the span measurement of a spur gear. This measurement is on the outside of the teeth.

For internal gears the tooth profile is opposite to that of the external spur gear. Therefore, the measurement is between the inside of the tooth profiles.

10.2.2 Helical Gears

Tables 10-11 and **10-12** present equations for span measurement of the normal and the radial systems, respectively, of helical gears.

Table 10-3 Equations for Chordal Thickness of Helical Gears in the Normal System

No.	Item	Symbol	Formula	Example
1	Normal Circular Tooth Thickness	s_n	$\left(\frac{\pi}{2} + 2x_n \tan \alpha_n\right) m_n$	$m_n = 5$ $\alpha_n = 20^\circ$ $\beta = 25^\circ 00' 00''$
2	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z}{\cos^3 \beta}$	$z = 16$ $x_n = +0.2$
3	Half of Tooth Angle at Pitch Circle	θ_v	$\frac{90}{z_v} + \frac{360x_n \tan \alpha_n}{\pi z_v}$	$h_a = 6.0000$ $s_n = 8.5819$ $z_v = 21.4928$
4	Chordal Thickness	s_j	$z_v m_n \sin \theta_v$	$\theta_v = 4.57556^\circ$ $s_j = 8.5728$
5	Chordal Addendum	h_j	$\frac{z_v m_n}{2} (1 - \cos \theta_v) + h_a$	$h_j = 6.1712$

Table 10-4 Equations for Chordal Thickness of Helical Gears in the Radial System

No.	Item	Symbol	Formula	Example
1	Normal Circular Tooth Thickness	s_n	$\left(\frac{\pi}{2} + 2x_t \tan \alpha_t\right) m_t \cos \beta$	$m = 4$ $\alpha_t = 20^\circ$ $\beta = 22^\circ 30' 00''$
2	Number of Teeth in an Equivalent Spur Gear	z_v	$\frac{z}{\cos^3 \beta}$	$z = 20$ $x_t = +0.3$
3	Half of Tooth Angle at Pitch Circle	θ_v	$\frac{90}{z_v} + \frac{360x_t \tan \alpha_t}{\pi z_v}$	$h_a = 4.7184$ $s_n = 6.6119$ $z_v = 25.3620$
4	Chordal Thickness	s_j	$z_v m_t \cos \beta \sin \theta_v$	$\theta_v = 4.04196^\circ$ $s_j = 6.6065$
5	Chordal Addendum	h_j	$\frac{z_v m_t \cos \beta}{2} (1 - \cos \theta_v) + h_a$	$h_j = 4.8350$

NOTE: Table 10-4 equations are also for the tooth profile of a Sunderland gear.

Table 10-5 Equations for Chordal Thickness of Gleason Straight Bevel Gears

No.	Item	Symbol	Formula	Example
1	Circular Tooth Thickness Factor (Coefficient of Horizontal Profile Shift)	K	Obtain from Figure 10-2 below	$m = 4$ $\alpha = 20^\circ$ $\Sigma = 90^\circ$ $z_1 = 16$ $z_2 = 40$ $\frac{z_1}{z_2} = 0.4$ $K = 0.0259$
2	Circular Tooth Thickness	s_1 s_2	$\pi m - s_2$ $\frac{\pi m}{2} - (h_{a1} - h_{a2}) \tan \alpha - Km$	$h_{a1} = 5.5456$ $h_{a2} = 2.4544$ $\delta_1 = 21.8014^\circ$ $\delta_2 = 68.1986^\circ$ $s_1 = 7.5119$ $s_2 = 5.0545$ $s_{j1} = 7.4946$ $s_{j2} = 5.0536$ $h_{j1} = 5.7502$ $h_{j2} = 2.4692$
4	Chordal Thickness	s_j	$s - \frac{s^3}{6d^2}$	
5	Chordal Addendum	h_j	$h_a + \frac{s^2 \cos \delta}{4d}$	

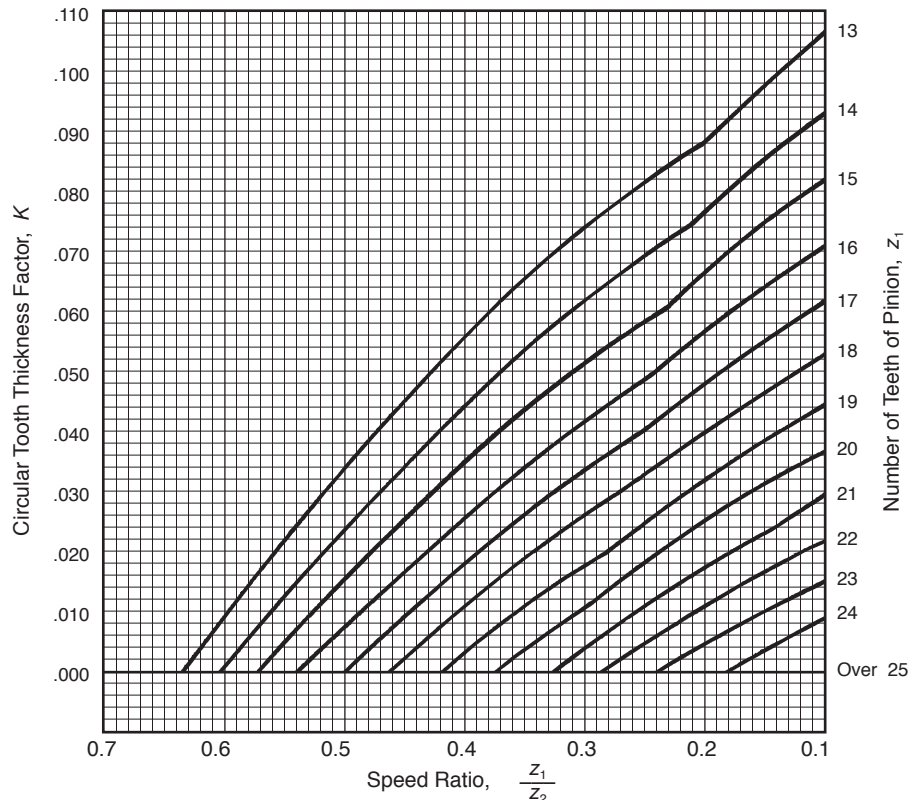


Fig. 10-2 Chart to Determine the Circular Tooth Thickness Factor K for Gleason Straight Bevel Gear (See Table 10-5)

Table 10-6 Equations for Chordal Thickness of Standard Straight Bevel Gears

No.	Item	Symbol	Formula	Example
1	Circular Tooth Thickness	s	$\frac{\pi m}{2}$	$m = 4$ $\alpha = 20^\circ$ $\Sigma = 90^\circ$
2	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z}{\cos \delta}$	$z_1 = 16$ $d_1 = 64$ $h_a = 4.0000$
3	Back Cone Distance	R_v	$\frac{d}{2 \cos \delta}$	$\delta_1 = 21.8014^\circ$ $s = 6.2832$ $\delta_2 = 68.1986^\circ$
4	Half of Tooth Angle at Pitch Circle	θ_v	$\frac{90}{z_v}$	$z_{v1} = 17.2325$ $R_{v1} = 34.4650$ $z_{v2} = 107.7033$ $R_{v2} = 215.4066$
5	Chordal Thickness	s_j	$z_v m \sin \theta_v$	$\theta_{v1} = 5.2227^\circ$ $s_{j1} = 6.2745$ $\theta_{v2} = 0.83563^\circ$ $s_{j2} = 6.2830$
6	Chordal Addendum	h_j	$h_a + R_v (1 - \cos \theta_v)$	$h_{j1} = 4.1431$ $h_{j2} = 4.0229$

Table 10-7 Equations for Chordal Thickness of Gleason Spiral Bevel Gears

No.	Item	Symbol	Formula	Example
1	Circular Tooth Thickness Factor	K	Obtain from Figure 10-3	$\Sigma = 90^\circ$ $z_1 = 20$ $h_{a1} = 3.4275$ $K = 0.060$ $p = 9.4248$ $s_1 = 5.6722$
2	Circular Tooth Thickness	s_1 s_2	$p - s_2$ $\frac{p}{2} - (h_{a1} - h_{a2}) \frac{\tan \alpha_n}{\cos \beta_m} - Km$	$m = 3$ $z_2 = 40$ $h_{a2} = 1.6725$ $\alpha_n = 20^\circ$ $\beta_m = 35^\circ$ $s_2 = 3.7526$

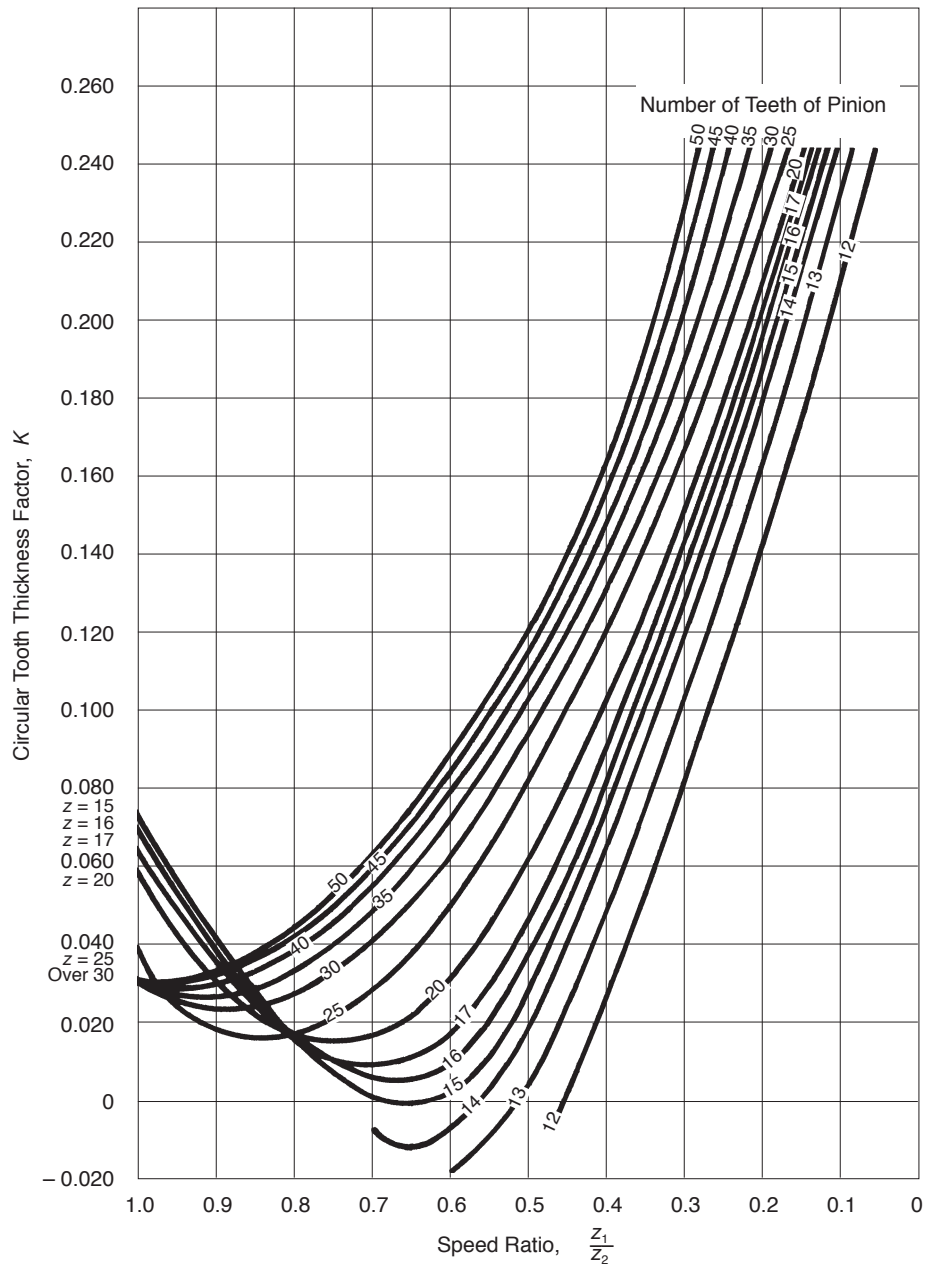


Fig. 10-3 Chart to Determine the Circular Tooth Thickness Factor K for Gleason Spiral Bevel Gears

Table 10-8 Equations for Chordal Thickness of Axial Module Worms and Worm Gear

No.	Item	Symbol	Formula	Example
1	Axial Circular Tooth Thickness of Worm Radial Circular Tooth Thickness of Worm Gear	s_{x1} s_{x2}	$\frac{\pi m_x}{2}$ $(-\frac{\pi}{2} + 2x_{x2} \tan \alpha_x) m_x$	$m_x = 3$ $\alpha_n = 20^\circ$ $z_w = 2$ $d_1 = 38$ $a_x = 65$ $z_2 = 30$ $d_2 = 90$
2	No. of Teeth in an Equivalent Spur Gear (Worm Gear)	z_{v2}	$\frac{z_2}{\cos^3 \gamma}$	$x_{x2} = +0.33333$ $h_{a1} = 3.0000$ $h_{a2} = 4.0000$
3	Half of Tooth Angle at Pitch Circle (Worm Gear)	θ_{v2}	$\frac{90}{z_{v2}} + \frac{360 x_{x2} \tan \alpha_x}{\pi z_{v2}}$	$\gamma = 8.97263^\circ$ $\alpha_x = 20.22780^\circ$ $s_{x1} = 4.71239$ $s_{x2} = 5.44934$ $z_{v2} = 31.12885$ $\theta_{v2} = 3.34335^\circ$
4	Chordal Thickness	s_{j1} s_{j2}	$s_{x1} \cos \gamma$ $z_v m_x \cos \gamma \sin \theta_{v2}$	$s_{j1} = 4.6547$ $s_{j2} = 5.3796$ $h_{j1} = 3.0035$ $h_{j2} = 4.0785$
5	Chordal Addendum	h_{j1} h_{j2}	$h_{a1} + \frac{(s_{x1} \sin \gamma \cos \gamma)^2}{4d_1}$ $h_{a2} + \frac{z_v m_x \cos \gamma}{2} (1 - \cos \theta_{v2})$	

Table 10-9 Equations for Chordal Thickness of Normal Module Worms and Worm Gears

No.	Item	Symbol	Formula	Example
1	Axial Circular Tooth Thickness of Worm Radial Circular Tooth Thickness of Worm Gear	s_{n1} s_{n2}	$\frac{\pi m_n}{2}$ $(-\frac{\pi}{2} + 2x_{n2} \tan \alpha_n) m_n$	$m_n = 3$ $\alpha_n = 20^\circ$ $z_w = 2$ $d_1 = 38$ $a_x = 65$ $z_2 = 30$ $d_2 = 91.1433$
2	No. of Teeth in an Equivalent Spur Gear (Worm Gear)	z_{v2}	$\frac{z_2}{\cos^3 \gamma}$	$x_{n2} = 0.14278$ $h_{a1} = 3.0000$ $h_{a2} = 3.42835$
3	Half of Tooth Angle at Pitch Circle (Worm Gear)	θ_{v2}	$\frac{90}{z_{v2}} + \frac{360 x_{n2} \tan \alpha_n}{\pi z_{v2}}$	$\gamma = 9.08472^\circ$ $s_{n1} = 4.71239$ $s_{n2} = 5.02419$ $z_{v2} = 31.15789$ $\theta_{v2} = 3.07964^\circ$
4	Chordal Thickness	s_{j1} s_{j2}	$s_{n1} \cos \gamma$ $z_v m_n \cos \gamma \sin \theta_{v2}$	$s_{j1} = 4.7124$ $h_{j1} = 3.0036$ $s_{j2} = 5.0218$ $h_{j2} = 3.4958$
5	Chordal Addendum	h_{j1} h_{j2}	$h_{a1} + \frac{(s_{n1} \sin \gamma)^2}{4d_1}$ $h_{a2} + \frac{z_v m_n \cos \gamma}{2} (1 - \cos \theta_{v2})$	

Table 10-10 Span Measurement of Spur and Internal Gear Teeth

No.	Item	Symbol	Formula	Example
1	Span Number of Teeth	z_m	$z_{mth} = zK(f) + 0.5$ See NOTE Select the nearest natural number of z_{mth} as z_m .	$m = 3$ $\alpha = 20^\circ$ $z = 24$ $x = +0.4$
2	Span Measurement	s_m	$m \cos \alpha [\pi (z_m - 0.5) + z \operatorname{inv} \alpha] + 2x_m \sin \alpha$	$z_{mth} = 3.78787$ $z_m = 4$ $s_m = 32.8266$

NOTE:

$$K(f) = \frac{1}{\pi} [\sec \alpha \sqrt{(1 + 2f)^2 - \cos^2 \alpha} - \operatorname{inv} \alpha - 2f \tan \alpha] \quad (10-2)$$

where $f = \frac{x}{z}$

Table 10-11 Equations for Span Measurement of the Normal System Helical Gears

No.	Item	Symbol	Formula	Example
1	Span Number of Teeth	z_m	$z_{mth} = zK(f, \beta) + 0.5$ See NOTE Select the nearest natural number of z_{mth} as z_m .	$m_n = 3$, $\alpha_n = 20^\circ$, $z = 24$ $\beta = 25^\circ 00' 00''$ $x_n = +0.4$ $\alpha_s = 21.88023^\circ$
2	Span Measurement	s_m	$m_n \cos \alpha_n [\pi (z_m - 0.5) + z \operatorname{inv} \alpha_t] + 2x_n m_n \sin \alpha_n$	$z_{mth} = 4.63009$ $z_m = 5$ $s_m = 42.0085$

NOTE:

$$K(f, \beta) = \frac{1}{\pi} \left[\left(1 + \frac{\sin^2 \beta}{\cos^2 \beta + \tan^2 \alpha_n} \right) \sqrt{(\cos^2 \beta + \tan^2 \alpha_n)(\sec \beta + 2f)^2 - 1} - \operatorname{inv} \alpha_t - 2f \tan \alpha_n \right] \quad (10-3)$$

where $f = \frac{x_n}{z}$

Table 10-12 Equations for Span Measurement of the Radial System Helical Gears

No.	Item	Symbol	Formula	Example
1	Span Number of Teeth	z_m	$z_{mth} = zK(f, \beta) + 0.5$ See NOTE Select the nearest natural number of z_{mth} as z_m .	$m_t = 3, \alpha_t = 20^\circ, z = 24$ $\beta = 22^\circ 30' 00''$ $x_t = +0.4$ $\alpha_n = 18.58597^\circ$
2	Span Measurement	s_m	$m_t \cos \beta \cos \alpha_n [\pi (z_m - 0.5) + z \operatorname{inv} \alpha_t] + 2x_t m_t \sin \alpha_n$	$z_{mth} = 4.31728$ $z_m = 4$ $s_m = 30.5910$

NOTE:

$$K(f, \beta) = \frac{1}{\pi} \left[\left(1 + \frac{\sin^2 \beta}{\cos^2 \beta + \tan^2 \alpha_n} \right) \sqrt{(\cos^2 \beta + \tan^2 \alpha_n)(\sec \beta + 2f)^2 - 1} - \operatorname{inv} \alpha_t - 2f \tan \alpha_n \right] \quad (10-4)$$

$$\text{where } f = \frac{x_t}{z \cos \beta}$$

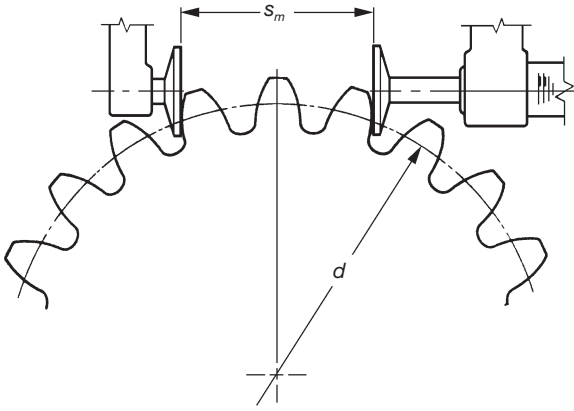


Fig. 10-4 Span Measurement of Teeth (Spur Gear)

There is a requirement of a minimum blank width to make a helical gear span measurement. Let b_{min} be the minimum value for blank width. See **Figure 10-5**. Then

$$b_{min} = s_m \sin \beta_b + \Delta b \quad (10-5)$$

where β_b is the helix angle at the base cylinder,

$$\begin{aligned} \beta_b &= \tan^{-1}(\tan \beta \cos \alpha_t) \\ &= \sin^{-1}(\sin \beta \cos \alpha_n) \end{aligned} \quad (10-6)$$

From the above, we can determine that $\Delta b > 3$ mm to make a stable measurement of s_m .

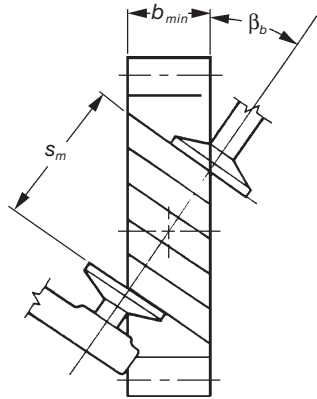


Fig. 10-5 Blank Width of Helical Gear

10.3 Over Pin (Ball) Measurement

As shown in **Figures 10-6** and **10-7**, measurement is made over the outside of two pins that are inserted in diametrically opposite tooth spaces, for even tooth number gears; and as close as possible for odd tooth number gears.

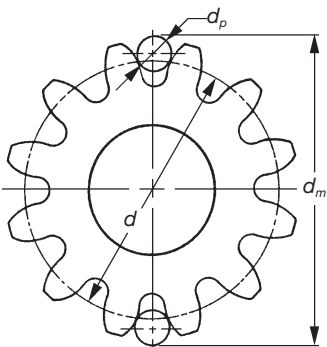


Fig. 10-6 Even Number of Teeth

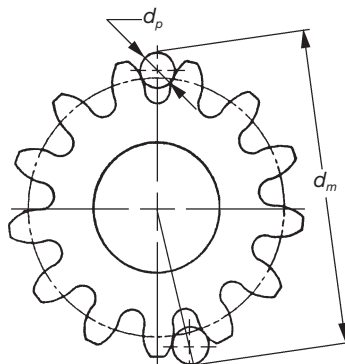


Fig. 10-7 Odd Number of Teeth

The procedure for measuring a rack with a pin or a ball is as shown in **Figure 10-9** by putting pin or ball in the tooth space and using a micrometer between it and a reference surface. Internal gears are similarly measured, except that the measurement is between the pins. See **Figure 10-10**. Helical gears can only be measured with balls. In the case of a worm, three pins are used, as shown in **Figure 10-11**. This is similar to the procedure of measuring a screw thread. All these cases are discussed in detail in the following sections.

Note that gear literature uses “over pins” and “over wires” terminology interchangeably. The “over wires” term is often associated with very fine pitch gears because the diameters are accordingly small.

10.3.1 Spur Gears

In measuring a gear, the size of the pin must be such that the over pins measurement is larger than the gear's outside diameter. An ideal value is one that would place the point of contact (tangent point) of pin and tooth profile at the pitch radius. However, this is not a necessary requirement. Referring to **Figure 10-8**, following are the equations for calculating the over pins measurement for a specific tooth thickness, s , regardless of where the pin contacts the tooth profile:

For even number of teeth:

$$d_m = \frac{d \cos \phi}{\cos \phi_1} + d_p \quad (10-7)$$

For odd number of teeth:

$$d_m = \frac{d \cos \phi}{\cos \phi_1} \cos\left(\frac{90^\circ}{z}\right) + d_p \quad (10-8)$$

where the value of ϕ_1 is obtained from:

$$\operatorname{inv} \phi_1 = \frac{s}{d} + \operatorname{inv} \phi + \frac{d_p}{d \cos \phi} - \frac{\pi}{z} \quad (10-9)$$

When tooth thickness, s , is to be calculated from a known over pins measurement, d_m , the above equations can be manipulated to yield:

$$s = d \left(\frac{\pi}{z} + \operatorname{inv} \phi_c - \operatorname{inv} \phi + \frac{d_p}{d \cos \phi} \right) \quad (10-10)$$

where

$$\cos \phi_c = \frac{d \cos \phi}{2R_c} \quad (10-11)$$

For even number of teeth:

$$R_c = \frac{d_m - d_p}{2} \quad (10-12)$$

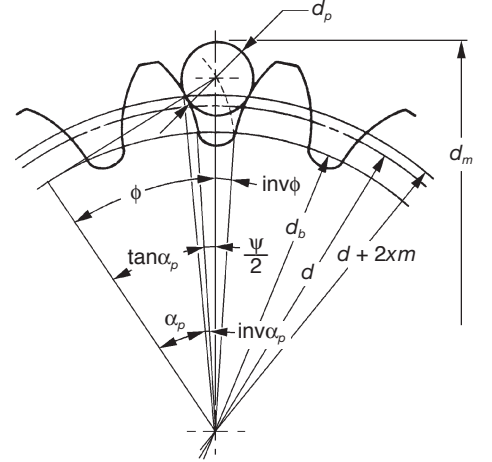


Fig. 10-8 Over Pins Diameter of Spur Gear

For odd number of teeth:

$$R_c = \frac{d_m - d_p}{2\cos\left(\frac{90^\circ}{z}\right)} \quad (10-13)$$

In measuring a standard gear, the size of the pin must meet the condition that its surface should have the tangent point at the standard pitch circle. While, in measuring a shifted gear, the surface of the pin should have the tangent point at the $d + 2xm$ circle. The ideal diameters of pins when calculated from the equations of Table 10-13 may not be practical. So, in practice, we select a standard pin diameter close to the ideal value. After the actual diameter of pin d_p is determined, the over pin measurement d_m can be calculated from Table 10-14.

Table 10-15 is a dimensional table under the condition of module $m = 1$ and pressure angle $\alpha = 20^\circ$ with which the pin has the tangent point at $d + 2xm$ circle.

10.3.2 Spur Racks And Helical Racks

In measuring a rack, the pin is ideally tangent with the tooth flank at the pitch line.

The equations in Table 10-16 can, thus, be derived. In the case of a helical rack, module m , and pressure angle α_n in Table 10-16, can be substituted by normal module, m_n , and normal pressure angle, α_n , resulting in Table 10-16A.

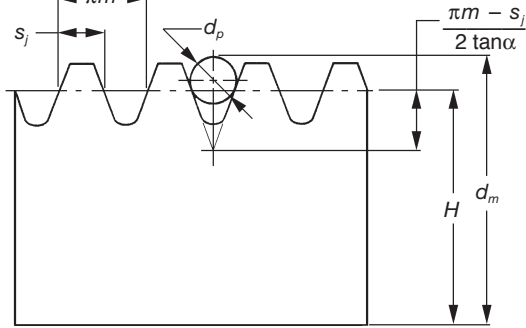


Fig. 10-9 Over Pins Measurement for a Rack Using a Pin or a Ball

10.3.3 Internal Gears

As shown in Figure 10-10, measuring an internal gear needs a proper pin which has its tangent point at $d + 2xm$ circle. The equations are in Table 10-17 for obtaining the ideal pin diameter. The equations for calculating the between pin measurement, d_m , are given in Table 10-18.

Table 10-19 lists ideal pin diameters for standard and profile shifted gears under the condition of module $m = 1$ and pressure angle $\alpha = 20^\circ$, which makes the pin tangent to the pitch circle $d + 2xm$.

10.3.4 Helical Gears

The ideal pin that makes contact at the $d + 2x_n m_n$ pitch circle of a helical gear can be obtained from the same above equations, but with the teeth number z substituted by the equivalent (virtual) teeth number z_v .

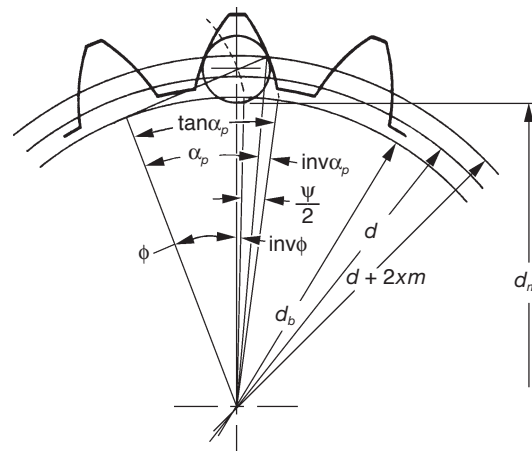


Fig. 10-10 Between Pin Dimension of Internal Gears

Table 10-20 presents equations for deriving over pin diameters.

Table 10-21 presents equations for calculating over pin measurements for helical gears in the normal system.

Table 10-22 and Table 10-23 present equations for calculating pin measurements for helical gears in the radial (perpendicular to axis) system.

10.3.5 Three Wire Method Of Worm Measurement

The teeth profile of Type III worms which are most popular are cut by standard cutters with a pressure angle $\alpha_c = 20^\circ$. This results in the normal pressure angle of the worm being a bit smaller than 20° . The equation below shows how to calculate a Type III worm in an AGMA system.

$$\alpha_n = \alpha_c - \frac{90^\circ}{z_w} \frac{r}{r_c \cos^2 \gamma + r} \sin^3 \gamma \quad (10-14)$$

where:

- r = Worm Pitch Radius
- r_c = Cutter Radius
- z_w = Number of Threads
- γ = Lead Angle of Worm

The exact equation for a three wire method of Type III worm is not only difficult to comprehend, but also hard to calculate precisely. We will introduce two approximate calculation methods here:

- (a) Regard the tooth profile of the worm as a linear tooth profile of a rack and apply its equations. Using this system, the three wire method of a worm can be calculated by Table 10-24.

These equations presume the worm lead angle to be very small and can be neglected. Of course, as the lead angle gets larger, the equations' error gets correspondingly larger. If the lead angle is considered as a factor, the equations are as in Table 10-25.

- (b) Consider a worm to be a helical gear.

This means applying the equations for calculating over pins measurement of helical gears to the case of three wire method of a worm. Because the tooth profile of Type III worm is not an involute curve, the method yields an approximation. However, the accuracy is adequate in practice.

Tables 10-26 and 10-27 contain equations based on the axial system.

Tables 10-28 and 10-29 are based on the normal system.

Table 10-28 shows the calculation of a worm in the normal module system. Basically, the normal module system and the axial module system have the same form of equations. Only the notations of module make them different.

10.4 Over Pins Measurements For Fine Pitch Gears With Specific Numbers Of Teeth

Table 10-30 presents measurements for metric gears. These are for standard ideal tooth thicknesses. Measurements can be adjusted accordingly to backlash allowance and tolerance; i.e., tooth thinning.

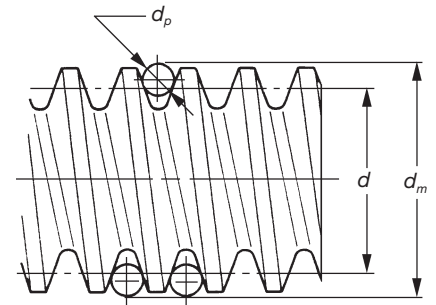


Fig. 10-11 Three Wire Method of a Worm

Table 10-13 Equations for Calculating Ideal Pin Diameters

No.	Item	Symbol	Formula	Example
1	Half Tooth Space Angle at Base Circle	$\frac{\psi}{2}$	$\left(\frac{\pi}{2z} - \text{inv}\alpha \right) - \frac{2x \tan\alpha}{z}$	$m = 1$ $\alpha = 20^\circ$ $z = 20$ $x = 0$ $\frac{\psi}{2} = 0.0636354$ $\alpha_p = 20^\circ$ $\phi = 0.4276057$ $d_p = 1.7245$
2	The Pressure Angle at the Point Pin is Tangent to Tooth Surface	α_p	$\cos^{-1} \left[\frac{zm \cos\alpha}{(z + 2x)m} \right]$	
3	The Pressure Angle at Pin Center	ϕ	$\tan\alpha_p + \frac{\psi}{2}$	
4	Ideal Pin Diameter	d_p	$zm \cos\alpha \left(\text{inv}\phi + \frac{\psi}{2} \right)$	

NOTE: The units of angles $\psi/2$ and ϕ are radians.

Table 10-14 Equations for Over Pins Measurement for Spur Gears

No.	Item	Symbol	Formula	Example
1	Actual Diameter of Pin	d_p	See NOTE	Let $d_p = 1.7$, then: $\text{inv}\phi = 0.0268197$ $\phi = 24.1350^\circ$ $d_m = 22.2941$
2	Involute Function ϕ	$\text{inv}\phi$	$\frac{d_p}{mz \cos\alpha} - \frac{\pi}{2z} + \text{inv}\alpha + \frac{2x \tan\alpha}{z}$	
3	The Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	
4	Over Pins Measurement	d_m	Even Teeth $\frac{zm \cos\alpha}{\cos\phi} + d_p$ Odd Teeth $\frac{zm \cos\alpha}{\cos\phi} \cos \frac{90^\circ}{z} + d_p$	

NOTE: The value of the ideal pin diameter from **Table 10-13**, or its approximate value, is applied as the actual diameter of pin d_p here.

Table 10-15 The Size of Pin which Has the Tangent Point at $d + 2xm$ Circle of Spur Gears

Number of Teeth z	Coefficient of Profile Shift, x $m = 1, \alpha = 20^\circ$							
	- 0.4	- 0.2	0	0.2	0.4	0.6	0.8	1.0
10	—	1.6348	1.7886	1.9979	2.2687	2.6079	3.0248	3.5315
20	1.6231	1.6599	1.7245	1.8149	1.9306	2.0718	2.2389	2.4329
30	1.6418	1.6649	1.7057	1.7632	1.8369	1.9267	2.0324	2.1542
40	1.6500	1.6669	1.6967	1.7389	1.7930	1.8589	1.9365	2.0257
50	1.6547	1.6680	1.6915	1.7248	1.7675	1.8196	1.8810	1.9516
60	1.6577	1.6687	1.6881	1.7155	1.7509	1.7940	1.8448	1.9032
70	1.6598	1.6692	1.6857	1.7090	1.7392	1.7759	1.8193	1.8691
80	1.6614	1.6695	1.6839	1.7042	1.7305	1.7625	1.8003	1.8438
90	1.6625	1.6698	1.6825	1.7005	1.7237	1.7521	1.7857	1.8242
100	1.6635	1.6700	1.6814	1.6975	1.7184	1.7439	1.7740	1.8087
110	1.6642	1.6701	1.6805	1.6951	1.7140	1.7372	1.7645	1.7960
120	1.6649	1.6703	1.6797	1.6931	1.7104	1.7316	1.7567	1.7855
130	1.6654	1.6704	1.6791	1.6914	1.7074	1.7269	1.7500	1.7766
140	1.6659	1.6705	1.6785	1.6900	1.7048	1.7229	1.7444	1.7690
150	1.6663	1.6706	1.6781	1.6887	1.7025	1.7195	1.7394	1.7625
160	1.6666	1.6706	1.6777	1.6877	1.7006	1.7164	1.7351	1.7567
170	1.6669	1.6707	1.6773	1.6867	1.6989	1.7138	1.7314	1.7517
180	1.6672	1.6708	1.6770	1.6858	1.6973	1.7114	1.7280	1.7472
190	1.6674	1.6708	1.6767	1.6851	1.6960	1.7093	1.7250	1.7432
200	1.6676	1.6708	1.6764	1.6844	1.6947	1.7074	1.7223	1.7396

Table 10-16 Equations for Over Pins Measurement of Spur Racks

No.	Item	Symbol	Formula	Example
1	Ideal Pin Diameter	d_p'	$\frac{\pi m - s_j}{\cos\alpha}$	$m = 1$ $\alpha = 20^\circ$ $s_j = 1.5708$ Ideal Pin Diameter $d_p' = 1.6716$
2	Over Pins Measurement	d_m	$H - \frac{\pi m - s_j}{2 \tan\alpha} + \frac{d_p}{2} \left(1 + \frac{1}{\sin\alpha} \right)$	Actual Pin Diameter $d_p = 1.7$ $H = 14.0000$ $d_m = 15.1774$

Table 10-16A Equations for Over Pins Measurement of Helical Racks

No.	Item	Symbol	Formula	Example
1	Ideal Pin Diameter	d_p'	$\frac{\pi m_n - s_j}{\cos\alpha_n}$	$m_n = 1$ $\alpha_n = 20^\circ$ $s_j = 1.5708$ $\beta = 15^\circ$ Ideal Pin Diameter $d_p' = 1.6716$
2	Over Pins Measurement	d_m	$H - \frac{\pi m_n - s_j}{2 \tan\alpha_n} + \frac{d_p}{2} \left(1 + \frac{1}{\sin\alpha_n} \right)$	Actual Pin Diameter $d_p = 1.7$ $H = 14.0000$ $d_m = 15.1774$

Table 10-17 Equations for Calculating Pin Size for Internal Gears

No.	Item	Symbol	Formula	Example
1	Half of Tooth Space Angle at Base Circle	$\frac{\psi}{2}$	$\left(\frac{\pi}{2z} + \text{inv}\alpha\right) + \frac{2x \tan\alpha}{z}$	$m = 1$ $\alpha = 20^\circ$ $z = 40$ $x = 0$ $\frac{\psi}{2} = 0.054174$ $\alpha_p = 20^\circ$ $\phi = 0.309796$ $d_p = 1.6489$
2	The Pressure Angle at the Point Pin is Tangent to Tooth Surface	α_p	$\cos^{-1} \left[\frac{zm \cos\alpha}{(z + 2x)m} \right]$	
3	The Pressure Angle at Pin Center	ϕ	$\tan\alpha_p - \frac{\psi}{2}$	
4	Ideal Pin Diameter	d_p	$zm \cos\alpha \left(\frac{\psi}{2} - \text{inv}\phi \right)$	

NOTE: The units of angles $\psi/2$ and ϕ are radians.

Table 10-18 Equations for Between Pins Measurement of Internal Gears

No.	Item	Symbol	Formula	Example
1	Actual Diameter of Pin	d_p	See NOTE	Let $d_p = 1.7$, then: $\text{inv}\phi = 0.0089467$ $\phi = 16.9521^\circ$ $d_m = 37.5951$
2	Involute Function ϕ	$\text{inv}\phi$	$\left(\frac{\pi}{2z} + \text{inv}\alpha\right) - \frac{d_p}{zm \cos\alpha} + \frac{2x \tan\alpha}{z}$	
3	The Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	
4	Between Pins Measurement	d_m	Even Teeth $\frac{zm \cos\alpha}{\cos\phi} - d_p$ Odd Teeth $\frac{zm \cos\alpha}{\cos\phi} \cos \frac{90^\circ}{z} - d_p$	

NOTE: First, calculate the ideal pin diameter. Then, choose the nearest practical actual pin size.

Table 10-19 The Size of Pin that is Tangent at Pitch Circle $d + 2xm$ of Internal Gears

Number of Teeth z	Coefficient of Profile Shift, x $m = 1, \alpha = 20^\circ$							
	- 0.4	- 0.2	0	0.2	0.4	0.6	0.8	1.0
10	—	1.4789	1.5936	1.6758	1.7283	1.7519	1.7460	1.7092
20	1.4687	1.5604	1.6284	1.6759	1.7047	1.7154	1.7084	1.6837
30	1.5309	1.5942	1.6418	1.6751	1.6949	1.7016	1.6956	1.6771
40	1.5640	1.6123	1.6489	1.6745	1.6895	1.6944	1.6893	1.6744
50	1.5845	1.6236	1.6533	1.6740	1.6862	1.6900	1.6856	1.6732
60	1.5985	1.6312	1.6562	1.6737	1.6839	1.6870	1.6832	1.6725
70	1.6086	1.6368	1.6583	1.6734	1.6822	1.6849	1.6815	1.6721
80	1.6162	1.6410	1.6600	1.6732	1.6810	1.6833	1.6802	1.6718
90	1.6222	1.6443	1.6612	1.6731	1.6800	1.6820	1.6792	1.6717
100	1.6270	1.6470	1.6622	1.6729	1.6792	1.6810	1.6784	1.6716
110	1.6310	1.6492	1.6631	1.6728	1.6785	1.6801	1.6778	1.6715
120	1.6343	1.6510	1.6638	1.6727	1.6779	1.6794	1.6772	1.6714
130	1.6371	1.6525	1.6644	1.6727	1.6775	1.6788	1.6768	1.6714
140	1.6396	1.6539	1.6649	1.6726	1.6771	1.6783	1.6764	1.6714
150	1.6417	1.6550	1.6653	1.6725	1.6767	1.6779	1.6761	1.6713
160	1.6435	1.6561	1.6657	1.6725	1.6764	1.6775	1.6758	1.6713
170	1.6451	1.6570	1.6661	1.6724	1.6761	1.6772	1.6755	1.6713
180	1.6466	1.6578	1.6664	1.6724	1.6759	1.6768	1.6753	1.6713
190	1.6479	1.6585	1.6666	1.6724	1.6757	1.6766	1.6751	1.6713
200	1.6491	1.6591	1.6669	1.6723	1.6755	1.6763	1.6749	1.6713

Table 10-20 Equations for Calculating Pin Size for Helical Gears in the Normal System

No.	Item	Symbol	Formula	Example
1	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z}{\cos^3\beta}$	$m_n = 1$ $\alpha_n = 20^\circ$ $z = 20$ $\beta = 15^\circ 00' 00''$ $x_n = +0.4$ $z_v = 22.19211$ $\frac{\psi_v}{2} = 0.0427566$ $\alpha_v = 24.90647^\circ$ $\phi_v = 0.507078$ $d_p = 1.9020$
2	Half Tooth Space Angle at Base Circle	$\frac{\psi_v}{2}$	$\frac{\pi}{2z_v} - \text{inv}\alpha_n - \frac{2x_n \tan\alpha_n}{z_v}$	
3	Pressure Angle at the Point Pin is Tangent to Tooth Surface	α_v	$\cos^{-1} \left(\frac{z_v \cos\alpha_n}{z_v + 2x_n} \right)$	
4	Pressure Angle at Pin Center	ϕ_v	$\tan\alpha_v + \frac{\psi_v}{2}$	
5	Ideal Pin Diameter	d_p	$z_v m_n \cos\alpha_n \left(\text{inv}\phi_v + \frac{\psi_v}{2} \right)$	

NOTE: The units of angles $\psi_v/2$ and ϕ_v are radians.

Table 10-21 Equations for Calculating Over Pins Measurement for Helical Gears in the Normal System

No.	Item	Symbol	Formula	Example
1	Actual Pin Diameter	d_p	See NOTE	Let $d_p = 2$, then $\alpha_t = 20.646896^\circ$ $\text{inv}\phi = 0.058890$ $\phi = 30.8534$ $d_m = 24.5696$
2	Involute Function ϕ	$\text{inv}\phi$	$\frac{d_p}{m_t z \cos \alpha_n} - \frac{\pi}{2z} + \text{inv}\alpha_t + \frac{2x_t \tan \alpha_n}{z}$	
3	Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	
4	Over Pins Measurement	d_m	Even Teeth: $\frac{zm_t \cos \alpha_t}{\cos \beta \cos \phi} + d_p$ Odd Teeth: $\frac{zm_t \cos \alpha_t}{\cos \beta \cos \phi} \cos \frac{90^\circ}{z} + d_p$	

NOTE: The ideal pin diameter of Table 10-20, or its approximate value, is entered as the actual diameter of d_p .

Table 10-22 Equations for Calculating Pin Size for Helical Gears in the Radial System

No.	Item	Symbol	Formula	Example
1	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z}{\cos^3 \beta}$	$m_t = 3$ $\alpha_t = 20^\circ$ $z = 36$ $\beta = 33^\circ 33' 26.3''$ $\alpha_n = 16.87300^\circ$ $x_t = +0.2$ $z_v = 62.20800$ $\frac{\psi_v}{2} = 0.014091$ $\alpha_v = 18.26390$ $\phi_v = 0.34411$ $\text{inv}\phi_v = 0.014258$ $d_p = 4.2190$
2	Half Tooth Space Angle at Base Circle	$\frac{\psi_v}{2}$	$\frac{\pi}{2z_v} - \text{inv}\alpha_n - \frac{2x_t \tan \alpha_t}{z_v}$	
3	Pressure Angle at the Point Pin is tangent to Tooth Surface	α_v	$\cos^{-1} \left(\frac{z_v \cos \alpha_n}{z_v + 2 \frac{x_t}{\cos \beta}} \right)$	
4	Pressure Angle at Pin Center	ϕ_v	$\tan \alpha_v + \frac{\psi_v}{2}$	
5	Ideal Pin Diameter	d_p	$z_v m_t \cos \beta \cos \alpha_n \left(\text{inv}\phi_v + \frac{\psi_v}{2} \right)$	

NOTE: The units of angles $\psi_v / 2$ and ϕ_v are radians.

Table 10-23 Equations for Calculating Over Pins Measurement for Helical Gears in the Radial System

No.	Item	Symbol	Formula	Example
1	Actual Pin Diameter	d_p	See NOTE	$d_p = 4.2190$ $\text{inv}\phi = 0.024302$ $\phi = 23.3910$ $d_m = 114.793$
2	Involute Function ϕ	$\text{inv}\phi$	$\frac{d_p}{m_t z \cos \beta \cos \alpha_n} - \frac{\pi}{2z} + \text{inv}\alpha_t + \frac{2x_t \tan \alpha_t}{z}$	
3	Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	
4	Over Pins Measurement	d_m	Even Teeth: $\frac{zm_t \cos \alpha_t}{\cos \phi} + d_p$ Odd Teeth: $\frac{zm_t \cos \alpha_t}{\cos \phi} \cos \frac{90^\circ}{z} + d_p$	

NOTE: The ideal pin diameter of Table 10-22, or its approximate value, is applied as the actual diameter of pin d_p here.

Table 10-24 Equations for Three Wire Method of Worm Measurement, (a)-1

No.	Item	Symbol	Formula	Example
1	Ideal Pin Diameter	d_p'	$\frac{\pi m_x}{2 \cos \alpha_x}$	$m_x = 2$ $\alpha_n = 20^\circ$ $z_w = 1$ $d_1 = 31$ $\gamma = 3.691386^\circ$ $\alpha_x = 20.03827^\circ$ $d_p' = 3.3440$; let $d_p = 3.3$ $d_m = 35.3173$
2	Three Wire Measurement	d_m	$d_1 - \frac{\pi m_x}{2 \tan \alpha_x} + d_p \left(1 + \frac{1}{\sin \alpha_x} \right)$	

Table 10-25 Equations for Three Wire Method of Worm Measurement, (a)-2

No.	Item	Symbol	Formula	Example
1	Ideal Pin Diameter	d_p'	$\frac{\pi m_n}{2 \cos \alpha_n}$	$m_x = 2$ $\alpha_n = 20^\circ$ $z_w = 1$ $d_1 = 31$ $\gamma = 3.691386^\circ$ $m_n = 1.99585$ $d_p' = 3.3363$; let $d_p = 3.3$ $d_m = 35.3344$
2	Three Wire Measurement	d_m	$d_1 - \frac{\pi m_n}{2 \tan \alpha_n} + d_p \left(1 + \frac{1}{\sin \alpha_n} \right) - \frac{(d_p \cos \alpha_n \sin \gamma)^2}{2d_1}$	

Table 10-26 Equation for Calculating Pin Size for Worms in the Axial System, (b)-1

No.	Item	Symbol	Formula	Example
1	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z_w}{\cos^3(90 - \gamma)}$	$m_x = 2$ $\alpha_n = 20^\circ$ $z_w = 1$
2	Half Tooth Space Angle at Base Circle	$\frac{\psi_v}{2}$	$\frac{\pi}{2z_v} - \text{inv}\alpha_n$	$d_1 = 31$ $\gamma = 3.691386^\circ$ $z_v = 3747.1491$
3	Pressure Angle at the Point Pin is Tangent to Tooth Surface	α_v	$\cos^{-1}\left(\frac{z_v \cos\alpha_n}{z_v}\right)$	$\frac{\psi_v}{2} = -0.014485$
4	Pressure Angle at Pin Center	ϕ_v	$\tan\alpha_v + \frac{\psi_v}{2}$	$\alpha_v = 20^\circ$ $\phi_v = 0.349485$
5	Ideal Pin Diameter	d_p	$z_v m_x \cos\gamma \cos\alpha_n \left(\text{inv}\phi_v + \frac{\psi_v}{2}\right)$	$\text{inv}\phi_v = 0.014960$ $d_p = 3.3382$

NOTE: The units of angles $\psi_v/2$ and ϕ_v are radians.

Table 10-27 Equation for Three Wire Method for Worms in the Axial System, (b)-2

No.	Item	Symbol	Formula	Example
1	Actual Pin Size	d_p	See NOTE 1	Let $d_p = 3.3$
2	Involute Function ϕ	$\text{inv}\phi$	$\frac{d_p}{m_x z_w \cos\gamma \cos\alpha_n} - \frac{\pi}{2z_w} + \text{inv}\alpha_t$	$\alpha_t = 79.96878^\circ$ $\text{inv}\alpha_t = 4.257549$
3	Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	$\text{inv}\phi = 4.446297$ $\phi = 80.2959^\circ$
4	Three Wire Measurement	d_m	$\frac{z_w m_x \cos\alpha_t}{\tan\gamma \cos\phi} + d_p$	$d_m = 35.3345$

NOTE: 1. The value of ideal pin diameter from **Table 10-26**, or its approximate value, is to be used as the actual pin diameter, d_p .
2. $\alpha_t = \tan^{-1}\left(\frac{\tan\alpha_n}{\sin\gamma}\right)$

Table 10-28 Equation for Calculating Pin Size for Worms in the Normal System, (b)-3

No.	Item	Symbol	Formula	Example
1	Number of Teeth of an Equivalent Spur Gear	z_v	$\frac{z_w}{\cos^3(90 - \gamma)}$	$m_n = 2.5$ $\alpha_n = 20^\circ$ $z_w = 1$
2	Half of Tooth Space Angle at Base Circle	$\frac{\psi_v}{2}$	$\frac{\pi}{2z_v} - \text{inv}\alpha_n$	$d_1 = 37$ $\gamma = 3.874288^\circ$ $z_v = 3241.792$
3	Pressure Angle at the Point Pin is Tangent to Tooth Surface	α_v	$\cos^{-1}\left(\frac{z_v \cos\alpha_n}{z_v}\right)$	$\frac{\psi_v}{2} = -0.014420$
4	Pressure Angle at Pin Center	ϕ_v	$\tan\alpha_v + \frac{\psi_v}{2}$	$\alpha_v = 20^\circ$ $\phi_v = 0.349550$
5	Ideal Pin Diameter	d_p	$z_v m_n \cos\alpha_n \left(\text{inv}\phi_v + \frac{\psi_v}{2}\right)$	$\text{inv}\phi_v = 0.0149687$ $d_p = 4.1785$

NOTE: The units of angles $\psi_v/2$ and ϕ_v are radians.

Table 10-29 Equations for Three Wire Method for Worms in the Normal System, (b)-4

No.	Item	Symbol	Formula	Example
1	Actual Pin Size	d_p	See NOTE 1	$d_p = 4.2$
2	Involute Function ϕ	$\text{inv}\phi$	$\frac{d_p}{m_n z_w \cos\alpha_n} - \frac{\pi}{2z_w} + \text{inv}\alpha_t$	$\alpha_t = 79.48331^\circ$ $\text{inv}\alpha_t = 3.999514$
3	Pressure Angle at Pin Center	ϕ	Find from Involute Function Table	$\text{inv}\phi = 4.216536$ $\phi = 79.8947^\circ$
4	Three Wire Measurement	d_m	$\frac{z_w m_n \cos\alpha_t}{\sin\gamma \cos\phi} + d_p$	$d_m = 42.6897$

NOTE: 1. The value of ideal pin diameter from **Table 10-28**, or its approximate value, is to be used as the actual pin diameter, d_p .
2. $\alpha_t = \tan^{-1}\left(\frac{\tan\alpha_n}{\sin\gamma}\right)$

TABLE 10-30 METRIC GEAR OVER PINS MEASUREMENT
Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle

No. of Teeth	Module 0.30				Module 0.40				No. of Teeth
	Wire Size = 0.5184mm; 0.0204 Inch				Wire Size = 0.6912mm; 0.0272 Inch				
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
5	1.500	0.0591			2.000	0.0787			5
6	1.800	0.0709			2.400	0.0945			6
7	2.100	0.0827			2.800	0.1102			7
8	2.400	0.0945			3.200	0.1260			8
9	2.700	0.1063			3.600	0.1417			9
10	3.000	0.1181			4.000	0.1575			10
11	3.300	0.1299			4.400	0.1732			11
12	3.600	0.1417			4.800	0.1890			12
13	3.900	0.1535			5.200	0.2047			13
14	4.200	0.1654			5.600	0.2205			14
15	4.500	0.1772			6.000	0.2362			15
16	4.800	0.1890			6.400	0.2520			16
17	5.100	0.2008			6.800	0.2677			17
18	5.400	0.2126	6.115	0.2408	7.200	0.2835	8.154	0.3210	18
19	5.700	0.2244	6.396	0.2518	7.600	0.2992	8.528	0.3357	19
20	6.000	0.2362	6.717	0.2644	8.000	0.3150	8.956	0.3526	20
21	6.300	0.2480	7.000	0.2756	8.400	0.3307	9.333	0.3674	21
22	6.600	0.2598	7.319	0.2881	8.800	0.3465	9.758	0.3842	22
23	6.900	0.2717	7.603	0.2993	9.200	0.3622	10.137	0.3991	23
24	7.200	0.2835	7.920	0.3118	9.600	0.3780	10.560	0.4157	24
25	7.500	0.2953	8.205	0.3230	10.000	0.3937	10.940	0.4307	25
26	7.800	0.3071	8.521	0.3355	10.400	0.4094	11.361	0.4473	26
27	8.100	0.3189	8.808	0.3468	10.800	0.4252	11.743	0.4623	27
28	8.400	0.3307	9.122	0.3591	11.200	0.4409	12.163	0.4789	28
29	8.700	0.3425	9.410	0.3705	11.600	0.4567	12.546	0.4939	29
30	9.000	0.3543	9.723	0.3828	12.000	0.4724	12.964	0.5104	30
31	9.300	0.3661	10.011	0.3941	12.400	0.4882	13.348	0.5255	31
32	9.600	0.3780	10.324	0.4065	12.800	0.5039	13.765	0.5419	32
33	9.900	0.3898	10.613	0.4178	13.200	0.5197	14.150	0.5571	33
34	10.200	0.4016	10.925	0.4301	13.600	0.5354	14.566	0.5735	34
35	10.500	0.4134	11.214	0.4415	14.000	0.5512	14.952	0.5887	35
36	10.800	0.4252	11.525	0.4538	14.400	0.5669	15.367	0.6050	36
37	11.100	0.4370	11.815	0.4652	14.800	0.5827	15.754	0.6202	37
38	11.400	0.4488	12.126	0.4774	15.200	0.5984	16.168	0.6365	38
39	11.700	0.4606	12.417	0.4888	15.600	0.6142	16.555	0.6518	39
40	12.000	0.4724	12.727	0.5010	16.000	0.6299	16.969	0.6681	40
41	12.300	0.4843	13.018	0.5125	16.400	0.6457	17.371	0.6833	41
42	12.600	0.4961	13.327	0.5247	16.800	0.6614	17.769	0.6996	42
43	12.900	0.5079	13.619	0.5362	17.200	0.6772	18.158	0.7149	43
44	13.200	0.5197	13.927	0.5483	17.600	0.6929	18.570	0.7311	44
45	13.500	0.5315	14.219	0.5598	18.000	0.7087	18.959	0.7464	45
46	13.800	0.5433	14.528	0.5720	18.400	0.7244	19.371	0.7626	46
47	14.100	0.5551	14.820	0.5835	18.800	0.7402	19.760	0.7780	47
48	14.400	0.5669	15.128	0.5956	19.200	0.7559	20.171	0.7941	48
49	14.700	0.5787	15.421	0.6071	19.600	0.7717	20.561	0.8095	49
50	15.000	0.5906	15.729	0.6192	20.000	0.7874	20.972	0.8257	50
51	15.300	0.6024	16.022	0.6308	20.400	0.8031	21.362	0.8410	51
52	15.600	0.6142	16.329	0.6429	20.800	0.8189	21.772	0.8572	52
53	15.900	0.6260	16.622	0.6544	21.200	0.8346	22.163	0.8726	53
54	16.200	0.6378	16.929	0.6665	21.600	0.8504	22.573	0.8887	54
55	16.500	0.6496	17.223	0.6781	22.000	0.8661	22.964	0.9041	55
56	16.800	0.6614	17.530	0.6901	22.400	0.8819	23.373	0.9202	56
57	17.100	0.6732	17.823	0.7017	22.800	0.8976	23.764	0.9356	57
58	17.400	0.6850	18.130	0.7138	23.200	0.9134	24.173	0.9517	58
59	17.700	0.6969	18.424	0.7253	23.600	0.9291	24.565	0.9671	59
60	18.000	0.7087	18.730	0.7374	24.000	0.9449	24.974	0.9832	60
61	18.300	0.7205	19.024	0.7490	24.400	0.9606	25.366	0.9987	61
62	18.600	0.7323	19.331	0.7610	24.800	0.9764	25.774	1.0147	62
63	18.900	0.7441	19.625	0.7726	25.200	0.9921	26.166	1.0302	63
64	19.200	0.7559	19.931	0.7847	25.600	1.0079	26.574	1.0462	64
65	19.500	0.7677	20.225	0.7963	26.000	1.0236	26.967	1.0617	65
66	19.800	0.7795	20.531	0.8083	26.400	1.0394	27.375	1.0777	66
67	20.100	0.7913	20.826	0.8199	26.800	1.0551	27.767	1.0932	67
68	20.400	0.8031	21.131	0.8319	27.200	1.0709	28.175	1.1093	68
69	20.700	0.8150	21.426	0.8435	27.600	1.0866	28.568	1.1247	69
70	21.000	0.8268	21.731	0.8556	28.000	1.1024	28.975	1.1408	70
71	21.300	0.8386	22.026	0.8672	28.400	1.1181	29.368	1.1562	71
72	21.600	0.8504	22.332	0.8792	28.800	1.1339	29.776	1.1723	72
73	21.900	0.8622	22.627	0.8908	29.200	1.1496	30.169	1.1877	73
74	22.200	0.8740	22.932	0.9028	29.600	1.1654	30.576	1.2038	74
75	22.500	0.8858	23.227	0.9144	30.000	1.1811	30.969	1.2193	75
76	22.800	0.8976	23.532	0.9265	30.400	1.1969	31.376	1.2353	76
77	23.100	0.9094	23.827	0.9381	30.800	1.2126	31.770	1.2508	77
78	23.400	0.9213	24.132	0.9501	31.200	1.2283	32.176	1.2668	78
79	23.700	0.9331	24.428	0.9617	31.600	1.2441	32.570	1.2823	79
80	24.000	0.9449	24.732	0.9737	32.000	1.2598	32.977	1.2983	80
81	24.300	0.9567	25.028	0.9853	32.400	1.2756	33.370	1.3138	81
82	24.600	0.9685	25.333	0.9973	32.800	1.2913	33.777	1.3298	82
83	24.900	0.9803	25.628	1.0090	33.200	1.3071	34.171	1.3453	83
84	25.200	0.9921	25.933	1.0210	33.600	1.3228	34.577	1.3613	84
85	25.500	1.0039	26.228	1.0326	34.000	1.3386	34.971	1.3768	85
86	25.800	1.0157	26.533	1.0446	34.400	1.3543	35.377	1.3928	86
87	26.100	1.0276	26.829	1.0562	34.800	1.3701	35.771	1.4083	87
88	26.400	1.0394	27.133	1.0682	35.200	1.3858	36.177	1.4243	88
89	26.700	1.0512	27.429	1.0799	35.600	1.4016	36.572	1.4398	89
90	27.000	1.0630	27.733	1.0919	36.000	1.4173	36.977	1.4558	90
91	27.300	1.0748	28.029	1.1035	36.400	1.4331	37.372	1.4713	91
92	27.600	1.0866	28.333	1.1155	36.800	1.4488	37.778	1.4873	92
93	27.900	1.0984	28.629	1.1271	37.200	1.4646	38.172	1.5029	93
94	28.200	1.1102	28.933	1.1391	37.600	1.4803	38.578	1.5188	94
95	28.500	1.1220	29.230	1.1508	38.000	1.4961	38.973	1.5344	95
96	28.800	1.1339	29.533	1.1627	38.400	1.5118	39.378	1.5503	96
97	29.100	1.1457	29.830	1.1744	38.800	1.5276	39.773	1.5659	97
98	29.400	1.1575	30.134	1.1864	39.200	1.5433	40.178	1.5818	98
99	29.700	1.1693	30.430	1.1980	39.600	1.5591	40.573	1.5974	99
100	30.000	1.1811	30.734	1.2100	40.000	1.5748	40.978	1.6133	100
101	30.300	1.1929	31.030	1.2217	40.400	1.5906	41.373	1.6289	101
102	30.600	1.2047	31.334	1.2336	40.800	1.6063	41.778	1.6448	102
103	30.900	1.2165	31.630	1.2453	41.200	1.6220	42.174	1.6604	103
104	31.200	1.2283	31.934	1.2572	41.600	1.6378	42.579	1.6763	104
105	31.500	1.2402	32.230	1.2689	42.000	1.6535	42.974	1.6919	105
106	31.800	1.2520	32.534	1.2809	42.400	1.6693	43.379	1.7078	106
107	32.100	1.2638	32.831	1.2925	42.800	1.6850	43.774	1.7234	107
108	32.400	1.2756	33.134	1.3045	43.200	1.7008	44.179	1.7393	108
109	32.700	1.2874	33.431	1.3162	43.600	1.7165	44.574	1.7549	109

Continued on following page

TABLE 10-30 (Cont.) METRIC GEAR OVER PINS MEASUREMENT
Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle

No. of Teeth	Module 0.30 Wire Size = 0.5184mm; 0.0204 Inch				Module 0.40 Wire Size = 0.6912mm; 0.0272 Inch				No. of Teeth
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
110	33.000	1.2992	33.734	1.3281	44.000	1.7323	44.979	1.7708	110
111	33.300	1.3110	34.031	1.3398	44.400	1.7480	45.374	1.7864	111
112	33.600	1.3228	34.334	1.3517	44.800	1.7638	45.779	1.8023	112
113	33.900	1.3346	34.631	1.3634	45.200	1.7795	46.175	1.8179	113
114	34.200	1.3465	34.934	1.3754	45.600	1.7953	46.579	1.8338	114
115	34.500	1.3583	35.231	1.3871	46.000	1.8110	46.975	1.8494	115
116	34.800	1.3701	35.534	1.3990	46.400	1.8268	47.379	1.8653	116
117	35.100	1.3819	35.831	1.4107	46.800	1.8425	47.775	1.8809	117
118	35.400	1.3937	36.135	1.4226	47.200	1.8583	48.179	1.8968	118
119	35.700	1.4055	36.431	1.4343	47.600	1.8740	48.575	1.9124	119
120	36.000	1.4173	36.735	1.4462	48.000	1.8898	48.979	1.9283	120
121	36.300	1.4291	37.032	1.4579	48.400	1.9055	49.375	1.9439	121
122	36.600	1.4409	37.335	1.4699	48.800	1.9213	49.780	1.9598	122
123	36.900	1.4528	37.632	1.4816	49.200	1.9370	50.176	1.9754	123
124	37.200	1.4646	37.935	1.4935	49.600	1.9528	50.580	1.9913	124
125	37.500	1.4764	38.232	1.5052	50.000	1.9685	50.976	2.0069	125
126	37.800	1.4882	38.535	1.5171	50.400	1.9843	51.380	2.0228	126
127	38.100	1.5000	38.832	1.5288	50.800	2.0000	51.776	2.0384	127
128	38.400	1.5118	39.135	1.5407	51.200	2.0157	52.180	2.0543	128
129	38.700	1.5236	39.432	1.5524	51.600	2.0315	52.576	2.0699	129
130	39.000	1.5354	39.735	1.5644	52.000	2.0472	52.980	2.0858	130
131	39.300	1.5472	40.032	1.5761	52.400	2.0630	53.376	2.1014	131
132	39.600	1.5591	40.335	1.5880	52.800	2.0787	53.780	2.1173	132
133	39.900	1.5709	40.632	1.5997	53.200	2.0945	54.176	2.1329	133
134	40.200	1.5827	40.935	1.6116	53.600	2.1102	54.580	2.1488	134
135	40.500	1.5945	41.232	1.6233	54.000	2.1260	54.976	2.1644	135
136	40.800	1.6063	41.535	1.6352	54.400	2.1417	55.380	2.1803	136
137	41.100	1.6181	41.832	1.6469	54.800	2.1575	55.777	2.1959	137
138	41.400	1.6299	42.135	1.6589	55.200	2.1732	56.180	2.2118	138
139	41.700	1.6417	42.433	1.6706	55.600	2.1890	56.577	2.2274	139
140	42.000	1.6535	42.735	1.6825	56.000	2.2047	56.980	2.2433	140
141	42.300	1.6654	43.033	1.6942	56.400	2.2205	57.377	2.2589	141
142	42.600	1.6772	43.335	1.7061	56.800	2.2362	57.780	2.2748	142
143	42.900	1.6890	43.633	1.7178	57.200	2.2520	58.177	2.2904	143
144	43.200	1.7008	43.935	1.7297	57.600	2.2677	58.580	2.3063	144
145	43.500	1.7126	44.233	1.7414	58.000	2.2835	58.977	2.3219	145
146	43.800	1.7244	44.535	1.7534	58.400	2.2992	59.381	2.3378	146
147	44.100	1.7362	44.833	1.7651	58.800	2.3150	59.777	2.3534	147
148	44.400	1.7480	45.135	1.7770	59.200	2.3307	60.181	2.3693	148
149	44.700	1.7598	45.433	1.7887	59.600	2.3465	60.577	2.3849	149
150	45.000	1.7717	45.735	1.8006	60.000	2.3622	60.981	2.4008	150
151	45.300	1.7835	46.033	1.8123	60.400	2.3780	61.377	2.4164	151
152	45.600	1.7953	46.336	1.8242	60.800	2.3937	61.781	2.4323	152
153	45.900	1.8071	46.633	1.8360	61.200	2.4094	62.178	2.4479	153
154	46.200	1.8189	46.936	1.8479	61.600	2.4252	62.581	2.4638	154
155	46.500	1.8307	47.233	1.8596	62.000	2.4409	62.978	2.4794	155
156	46.800	1.8425	47.536	1.8715	62.400	2.4567	63.381	2.4953	156
157	47.100	1.8543	47.833	1.8832	62.800	2.4724	63.778	2.5109	157
158	47.400	1.8661	48.136	1.8951	63.200	2.4882	64.181	2.5268	158
159	47.700	1.8780	48.433	1.9068	63.600	2.5039	64.578	2.5424	159
160	48.000	1.8898	48.736	1.9187	64.000	2.5197	64.981	2.5583	160
161	48.300	1.9016	49.033	1.9305	64.400	2.5354	65.378	2.5739	161
162	48.600	1.9134	49.336	1.9424	64.800	2.5512	65.781	2.5898	162
163	48.900	1.9252	49.633	1.9541	65.200	2.5669	66.178	2.6054	163
164	49.200	1.9370	49.936	1.9660	65.600	2.5827	66.581	2.6213	164
165	49.500	1.9488	50.234	1.9777	66.000	2.5984	66.978	2.6369	165
166	49.800	1.9606	50.536	1.9896	66.400	2.6142	67.381	2.6528	166
167	50.100	1.9724	50.834	2.0013	66.800	2.6299	67.778	2.6684	167
168	50.400	1.9843	51.136	2.0132	67.200	2.6457	68.181	2.6843	168
169	50.700	1.9961	51.434	2.0249	67.600	2.6614	68.578	2.6999	169
170	51.000	2.0079	51.736	2.0368	68.000	2.6772	68.981	2.7158	170
171	51.300	2.0197	52.034	2.0486	68.400	2.6929	69.378	2.7314	171
172	51.600	2.0315	52.336	2.0605	68.800	2.7087	69.781	2.7473	172
173	51.900	2.0433	52.634	2.0722	69.200	2.7244	70.178	2.7629	173
174	52.200	2.0551	52.936	2.0841	69.600	2.7402	70.581	2.7788	174
175	52.500	2.0669	53.234	2.0958	70.000	2.7559	70.979	2.7944	175
176	52.800	2.0787	53.536	2.1077	70.400	2.7717	71.381	2.8103	176
177	53.100	2.0906	53.834	2.1194	70.800	2.7874	71.779	2.8259	177
178	53.400	2.1024	54.136	2.1313	71.200	2.8031	72.181	2.8418	178
179	53.700	2.1142	54.434	2.1431	71.600	2.8189	72.579	2.8574	179
180	54.000	2.1260	54.736	2.1550	72.000	2.8346	72.981	2.8733	180
181	54.300	2.1378	55.034	2.1667	72.400	2.8504	73.379	2.8889	181
182	54.600	2.1496	55.336	2.1786	72.800	2.8661	73.782	2.9048	182
183	54.900	2.1614	55.634	2.1903	73.200	2.8819	74.179	2.9204	183
184	55.200	2.1732	55.936	2.2022	73.600	2.8976	74.582	2.9363	184
185	55.500	2.1850	56.234	2.2139	74.000	2.9134	74.979	2.9519	185
186	55.800	2.1969	56.536	2.2258	74.400	2.9291	75.382	2.9678	186
187	56.100	2.2087	56.834	2.2376	74.800	2.9449	75.779	2.9834	187
188	56.400	2.2205	57.136	2.2495	75.200	2.9606	76.182	2.9993	188
189	56.700	2.2323	57.434	2.2612	75.600	2.9764	76.579	3.0149	189
190	57.000	2.2441	57.736	2.2731	76.000	2.9921	76.982	3.0308	190
191	57.300	2.2559	58.036	2.2849	76.400	3.0079	77.382	3.0465	191
192	57.600	2.2677	58.336	2.2967	76.800	3.0236	77.782	3.0623	192
193	57.900	2.2795	58.636	2.3085	77.200	3.0394	78.182	3.0780	193
194	58.200	2.2913	58.936	2.3203	77.600	3.0551	78.582	3.0938	194
195	58.500	2.3031	59.236	2.3321	78.000	3.0709	78.982	3.1095	195
196	58.800	2.3150	59.536	2.3440	78.400	3.0866	79.382	3.1253	196
197	59.100	2.3268	59.836	2.3558	78.800	3.1024	79.782	3.1410	197
198	59.400	2.3386	60.136	2.3676	79.200	3.1181	80.182	3.1568	198
199	59.700	2.3504	60.436	2.3794	79.600	3.1339	80.582	3.1725	199
200	60.000	2.3622	60.736	2.3912	80.000	3.1496	80.982	3.1883	200
201	60.300	2.3740	61.035	2.4029	80.400	3.1654	81.379	3.2039	201
202	60.600	2.3858	61.335	2.4147	80.800	3.1811	81.780	3.2197	202
203	60.900	2.3976	61.635	2.4266	81.200	3.1969	82.180	3.2354	203
204	61.200	2.4094	61.935	2.4384	81.600	3.2126	82.580	3.2512	204
205	61.500	2.4213	62.235	2.4502	82.000	3.2283	82.980	3.2669	205
240	72.000	2.8346	72.737	2.8637	96.000	3.7795	96.982	3.8182	240
280	84.000	3.3071	84.737	3.3361	112.000	4.4094	112.983	4.4481	280
300	90.000	3.5433	90.737	3.5723	120.000	4.7244	120.983	4.7631	300
340	102.000	4.0157	102.738	4.0448	136.000	5.3543	136.983	5.3930	340
380	114.000	4.4882	114.738	4.5172	152.000	5.9843	152.984	6.0230	380

Continued on following page

TABLE 10-30 (Cont.) METRIC GEAR OVER PINS MEASUREMENT
Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle

No. of Teeth	Module 0.50				Module 0.75				No. of Teeth
	Wire Size = 0.8640mm; 0.0340 Inch				Wire Size = 1.2960mm; 0.0510 Inch				
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
5	2.500	0.0984			3.750	0.1476			5
6	3.000	0.1181			4.500	0.1772			6
7	3.500	0.1378			5.250	0.2067			7
8	4.000	0.1575			6.000	0.2362			8
9	4.500	0.1772			6.750	0.2657			9
10	5.000	0.1969			7.500	0.2953			10
11	5.500	0.2165			8.250	0.3248			11
12	6.000	0.2362			9.000	0.3543			12
13	6.500	0.2559			9.750	0.3839			13
14	7.000	0.2756			10.500	0.4134			14
15	7.500	0.2953			11.250	0.4429			15
16	8.000	0.3150			12.000	0.4724			16
17	8.500	0.3346			12.750	0.5020			17
18	9.000	0.3543	10.192	0.4013	13.500	0.5315	15.288	0.6019	18
19	9.500	0.3740	10.660	0.4197	14.250	0.5610	15.990	0.6295	19
20	10.000	0.3937	11.195	0.4407	15.000	0.5906	16.792	0.6611	20
21	10.500	0.4134	11.666	0.4593	15.750	0.6201	17.499	0.6889	21
22	11.000	0.4331	12.198	0.4802	16.500	0.6496	18.296	0.7203	22
23	11.500	0.4528	12.671	0.4989	17.250	0.6791	19.007	0.7483	23
24	12.000	0.4724	13.200	0.5197	18.000	0.7087	19.800	0.7795	24
25	12.500	0.4921	13.676	0.5384	18.750	0.7382	20.513	0.8076	25
26	13.000	0.5118	14.202	0.5591	19.500	0.7677	21.303	0.8387	26
27	13.500	0.5315	14.679	0.5779	20.250	0.7972	22.019	0.8669	27
28	14.000	0.5512	15.204	0.5986	21.000	0.8268	22.805	0.8978	28
29	14.500	0.5709	15.683	0.6174	21.750	0.8563	23.524	0.9261	29
30	15.000	0.5906	16.205	0.6380	22.500	0.8858	24.308	0.9570	30
31	15.500	0.6102	16.685	0.6569	23.250	0.9154	25.028	0.9854	31
32	16.000	0.6299	17.206	0.6774	24.000	0.9449	25.810	1.0161	32
33	16.500	0.6496	17.688	0.6964	24.750	0.9744	26.532	1.0446	33
34	17.000	0.6693	18.208	0.7168	25.500	1.0039	27.312	1.0753	34
35	17.500	0.6890	18.690	0.7358	26.250	1.0335	28.036	1.1038	35
36	18.000	0.7087	19.209	0.7563	27.000	1.0630	28.813	1.1344	36
37	18.500	0.7283	19.692	0.7753	27.750	1.0925	29.539	1.1629	37
38	19.000	0.7480	20.210	0.7957	28.500	1.1220	30.315	1.1935	38
39	19.500	0.7677	20.694	0.8147	29.250	1.1516	31.041	1.2221	39
40	20.000	0.7874	21.211	0.8351	30.000	1.1811	31.816	1.2526	40
41	20.500	0.8071	21.696	0.8542	30.750	1.2106	32.544	1.2813	41
42	21.000	0.8268	22.212	0.8745	31.500	1.2402	33.318	1.3117	42
43	21.500	0.8465	22.698	0.8936	32.250	1.2697	34.046	1.3404	43
44	22.000	0.8661	23.212	0.9139	33.000	1.2992	34.819	1.3708	44
45	22.500	0.8858	23.699	0.9330	33.750	1.3287	35.548	1.3995	45
46	23.000	0.9055	24.213	0.9533	34.500	1.3583	36.320	1.4299	46
47	23.500	0.9252	24.700	0.9725	35.250	1.3878	37.051	1.4587	47
48	24.000	0.9449	25.214	0.9927	36.000	1.4173	37.821	1.4890	48
49	24.500	0.9646	25.702	1.0119	36.750	1.4469	38.552	1.5178	49
50	25.000	0.9843	26.215	1.0321	37.500	1.4764	39.322	1.5481	50
51	25.500	1.0039	26.703	1.0513	38.250	1.5059	40.054	1.5769	51
52	26.000	1.0236	27.215	1.0715	39.000	1.5354	40.823	1.6072	52
53	26.500	1.0433	27.704	1.0907	39.750	1.5650	41.556	1.6360	53
54	27.000	1.0630	28.216	1.1109	40.500	1.5945	42.324	1.6663	54
55	27.500	1.0827	28.705	1.1301	41.250	1.6240	43.057	1.6952	55
56	28.000	1.1024	29.216	1.1502	42.000	1.6535	43.824	1.7254	56
57	28.500	1.1220	29.706	1.1695	42.750	1.6831	44.558	1.7543	57
58	29.000	1.1417	30.217	1.1896	43.500	1.7126	45.325	1.7845	58
59	29.500	1.1614	30.706	1.2089	44.250	1.7421	46.060	1.8134	59
60	30.000	1.1811	31.217	1.2290	45.000	1.7717	46.826	1.8435	60
61	30.500	1.2008	31.707	1.2483	45.750	1.8012	47.561	1.8725	61
62	31.000	1.2205	32.218	1.2684	46.500	1.8307	48.326	1.9026	62
63	31.500	1.2402	32.708	1.2877	47.250	1.8602	49.062	1.9316	63
64	32.000	1.2598	33.218	1.3078	48.000	1.8898	49.827	1.9617	64
65	32.500	1.2795	33.709	1.3271	48.750	1.9193	50.563	1.9907	65
66	33.000	1.2992	34.218	1.3472	49.500	1.9488	51.328	2.0208	66
67	33.500	1.3189	34.709	1.3665	50.250	1.9783	52.064	2.0498	67
68	34.000	1.3386	35.219	1.3866	51.000	2.0079	52.828	2.0799	68
69	34.500	1.3583	35.710	1.4059	51.750	2.0374	53.565	2.1089	69
70	35.000	1.3780	36.219	1.4260	52.500	2.0669	54.329	2.1389	70
71	35.500	1.3976	36.710	1.4453	53.250	2.0965	55.066	2.1679	71
72	36.000	1.4173	37.219	1.4653	54.000	2.1260	55.829	2.1980	72
73	36.500	1.4370	37.711	1.4847	54.750	2.1555	56.567	2.2270	73
74	37.000	1.4567	38.220	1.5047	55.500	2.1850	57.330	2.2571	74
75	37.500	1.4764	38.712	1.5241	56.250	2.2146	58.067	2.2861	75
76	38.000	1.4961	39.220	1.5441	57.000	2.2441	58.830	2.3161	76
77	38.500	1.5157	39.712	1.5635	57.750	2.2736	59.568	2.3452	77
78	39.000	1.5354	40.220	1.5835	58.500	2.3031	60.331	2.3752	78
79	39.500	1.5551	40.713	1.6029	59.250	2.3327	61.069	2.4043	79
80	40.000	1.5748	41.221	1.6229	60.000	2.3622	61.831	2.4343	80
81	40.500	1.5945	41.713	1.6422	60.750	2.3917	62.570	2.4634	81
82	41.000	1.6142	42.221	1.6622	61.500	2.4213	63.331	2.4934	82
83	41.500	1.6339	42.714	1.6816	62.250	2.4508	64.070	2.5225	83
84	42.000	1.6535	43.221	1.7016	63.000	2.4803	64.832	2.5524	84
85	42.500	1.6732	43.714	1.7210	63.750	2.5098	65.571	2.5815	85
86	43.000	1.6929	44.221	1.7410	64.500	2.5394	66.332	2.6115	86
87	43.500	1.7126	44.714	1.7604	65.250	2.5689	67.072	2.6406	87
88	44.000	1.7323	45.222	1.7804	66.000	2.5984	67.832	2.6706	88
89	44.500	1.7520	45.715	1.7998	66.750	2.6280	68.572	2.6997	89
90	45.000	1.7717	46.222	1.8198	67.500	2.6575	69.333	2.7296	90
91	45.500	1.7913	46.715	1.8392	68.250	2.6870	70.073	2.7588	91
92	46.000	1.8110	47.222	1.8591	69.000	2.7165	70.833	2.7887	92
93	46.500	1.8307	47.715	1.8786	69.750	2.7461	71.573	2.8178	93
94	47.000	1.8504	48.222	1.8985	70.500	2.7756	72.333	2.8478	94
95	47.500	1.8701	48.716	1.9179	71.250	2.8051	73.074	2.8769	95
96	48.000	1.8898	49.222	1.9379	72.000	2.8346	73.834	2.9068	96
97	48.500	1.9094	49.716	1.9573	72.750	2.8642	74.574	2.9360	97
98	49.000	1.9291	50.223	1.9773	73.500	2.8937	75.334	2.9659	98
99	49.500	1.9488	50.716	1.9967	74.250	2.9232	76.075	2.9951	99
100	50.000	1.9685	51.223	2.0166	75.000	2.9528	76.834	3.0250	100
101	50.500	1.9882	51.717	2.0361	75.750	2.9823	77.575	3.0541	101
102	51.000	2.0079	52.223	2.0560	76.500	3.0118	78.334	3.0840	102
103	51.500	2.0276	52.717	2.0755	77.250	3.0413	79.076	3.1132	103
104	52.000	2.0472	53.223	2.0954	78.000	3.0709	79.835	3.1431	104
105	52.500	2.0669	53.717	2.1149	78.750	3.1004	80.576	3.1723	105
106	53.000	2.0866	54.223	2.1348	79.500	3.1299	81.335	3.2022	106
107	53.500	2.1063	54.718	2.1542	80.250	3.1594	82.076	3.2314	107
108	54.000	2.1260	55.223	2.1742	81.000	3.1890	82.835	3.2612	108
109	54.500	2.1457	55.718	2.1936	81.750	3.2185	83.577	3.2904	109

Continued on following page

TABLE 10-30 (Cont.)

METRIC GEAR OVER PINS MEASUREMENT

Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle

No. of Teeth	Module 0.50				Module 0.75				No. of Teeth
	Wire Size = 0.8640mm; 0.0340 Inch				Wire Size = 1.2960mm; 0.0510 Inch				
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
110	55.000	2.1654	56.224	2.2135	82.500	3.2480	84.335	3.3203	110
111	55.500	2.1850	56.718	2.2330	83.250	3.2776	85.077	3.3495	111
112	56.000	2.2047	57.224	2.2529	84.000	3.3071	85.836	3.3794	112
113	56.500	2.2244	57.718	2.2724	84.750	3.3366	86.578	3.4086	113
114	57.000	2.2441	58.224	2.2923	85.500	3.3661	87.336	3.4384	114
115	57.500	2.2638	58.719	2.3118	86.250	3.3957	88.078	3.4676	115
116	58.000	2.2835	59.224	2.3317	87.000	3.4252	88.836	3.4975	116
117	58.500	2.3031	59.719	2.3511	87.750	3.4547	89.578	3.5267	117
118	59.000	2.3228	60.224	2.3710	88.500	3.4843	90.330	3.5565	118
119	59.500	2.3425	60.719	2.3905	89.250	3.5138	91.078	3.5858	119
120	60.000	2.3622	61.224	2.4104	90.000	3.5433	91.832	3.6156	120
121	60.500	2.3819	61.719	2.4299	90.750	3.5728	92.579	3.6448	121
122	61.000	2.4016	62.224	2.4498	91.500	3.6024	93.337	3.6747	122
123	61.500	2.4213	62.719	2.4693	92.250	3.6319	94.079	3.7039	123
124	62.000	2.4409	63.225	2.4892	93.000	3.6614	94.837	3.7337	124
125	62.500	2.4606	63.720	2.5086	93.750	3.6909	95.579	3.7630	125
126	63.000	2.4803	64.225	2.5285	94.500	3.7205	96.337	3.7928	126
127	63.500	2.5000	64.720	2.5480	95.250	3.7500	97.080	3.8222	127
128	64.000	2.5197	65.225	2.5679	96.000	3.7795	97.837	3.8519	128
129	64.500	2.5394	65.720	2.5874	96.750	3.8091	98.580	3.8811	129
130	65.000	2.5591	66.225	2.6073	97.500	3.8386	99.337	3.9109	130
131	65.500	2.5787	66.720	2.6268	98.250	3.8681	100.080	3.9402	131
132	66.000	2.5984	67.225	2.6467	99.000	3.8976	100.837	3.9700	132
133	66.500	2.6181	67.720	2.6662	99.750	3.9272	101.581	3.9992	133
134	67.000	2.6378	68.225	2.6860	100.500	3.9567	102.338	4.0290	134
135	67.500	2.6575	68.721	2.7055	101.250	3.9862	103.081	4.0583	135
136	68.000	2.6772	69.225	2.7254	102.000	4.0157	103.838	4.0881	136
137	68.500	2.6969	69.721	2.7449	102.750	4.0453	104.581	4.1174	137
138	69.000	2.7165	70.225	2.7648	103.500	4.0748	105.338	4.1472	138
139	69.500	2.7362	70.721	2.7843	104.250	4.1043	106.081	4.1764	139
140	70.000	2.7559	71.225	2.8041	105.000	4.1339	106.838	4.2062	140
141	70.500	2.7756	71.721	2.8237	105.750	4.1634	107.582	4.2355	141
142	71.000	2.7953	72.225	2.8435	106.500	4.1929	108.338	4.2653	142
143	71.500	2.8150	72.721	2.8630	107.250	4.2224	109.082	4.2946	143
144	72.000	2.8346	73.226	2.8829	108.000	4.2520	109.838	4.3243	144
145	72.500	2.8543	73.721	2.9024	108.750	4.2815	110.582	4.3536	145
146	73.000	2.8740	74.226	2.9223	109.500	4.3110	111.338	4.3834	146
147	73.500	2.8937	74.721	2.9418	110.250	4.3406	112.082	4.4127	147
148	74.000	2.9134	75.226	2.9616	111.000	4.3701	112.839	4.4425	148
149	74.500	2.9331	75.722	2.9812	111.750	4.3996	113.582	4.4718	149
150	75.000	2.9528	76.226	3.0010	112.500	4.4291	114.339	4.5015	150
151	75.500	2.9724	76.722	3.0205	113.250	4.4587	115.083	4.5308	151
152	76.000	2.9921	77.226	3.0404	114.000	4.4882	115.839	4.5606	152
153	76.500	3.0118	77.722	3.0599	114.750	4.5177	116.583	4.5899	153
154	77.000	3.0315	78.226	3.0798	115.500	4.5472	117.339	4.6196	154
155	77.500	3.0512	78.722	3.0993	116.250	4.5768	118.083	4.6489	155
156	78.000	3.0709	79.226	3.1191	117.000	4.6063	118.839	4.6787	156
157	78.500	3.0906	79.722	3.1387	117.750	4.6358	119.583	4.7080	157
158	79.000	3.1102	80.226	3.1585	118.500	4.6654	120.339	4.7378	158
159	79.500	3.1299	80.722	3.1780	119.250	4.6949	121.083	4.7671	159
160	80.000	3.1496	81.226	3.1979	120.000	4.7244	121.839	4.7968	160
161	80.500	3.1693	81.722	3.2174	120.750	4.7539	122.584	4.8261	161
162	81.000	3.1890	82.226	3.2373	121.500	4.7835	123.339	4.8559	162
163	81.500	3.2087	82.722	3.2568	122.250	4.8130	124.084	4.8852	163
164	82.000	3.2283	83.226	3.2766	123.000	4.8425	124.840	4.9149	164
165	82.500	3.2480	83.723	3.2962	123.750	4.8720	125.584	4.9443	165
166	83.000	3.2677	84.226	3.3160	124.500	4.9016	126.340	4.9740	166
167	83.500	3.2874	84.723	3.3355	125.250	4.9311	127.084	5.0033	167
168	84.000	3.3071	85.226	3.3554	126.000	4.9606	127.840	5.0331	168
169	84.500	3.3268	85.723	3.3749	126.750	4.9902	128.584	5.0624	169
170	85.000	3.3465	86.227	3.3947	127.500	5.0197	129.340	5.0921	170
171	85.500	3.3661	86.723	3.4143	128.250	5.0492	130.084	5.1214	171
172	86.000	3.3858	87.227	3.4341	129.000	5.0787	130.840	5.1512	172
173	86.500	3.4055	87.723	3.4537	129.750	5.1083	131.585	5.1805	173
174	87.000	3.4252	88.227	3.4735	130.500	5.1378	132.340	5.2102	174
175	87.500	3.4449	88.723	3.4930	131.250	5.1673	133.085	5.2396	175
176	88.000	3.4646	89.227	3.5129	132.000	5.1969	133.840	5.2693	176
177	88.500	3.4843	89.723	3.5324	132.750	5.2264	134.585	5.2986	177
178	89.000	3.5039	90.227	3.5522	133.500	5.2559	135.340	5.3284	178
179	89.500	3.5236	90.723	3.5718	134.250	5.2854	136.085	5.3577	179
180	90.000	3.5433	91.227	3.5916	135.000	5.3150	136.840	5.3874	180
181	90.500	3.5630	91.723	3.6112	135.750	5.3445	137.585	5.4167	181
182	91.000	3.5827	92.227	3.6310	136.500	5.3740	138.340	5.4465	182
183	91.500	3.6024	92.723	3.6505	137.250	5.4035	139.085	5.4758	183
184	92.000	3.6220	93.227	3.6704	138.000	5.4331	139.840	5.5055	184
185	92.500	3.6417	93.724	3.6899	138.750	5.4626	140.585	5.5349	185
186	93.000	3.6614	94.227	3.7097	139.500	5.4921	141.340	5.5646	186
187	93.500	3.6811	94.724	3.7293	140.250	5.5217	142.086	5.5939	187
188	94.000	3.7008	95.227	3.7491	141.000	5.5512	142.841	5.6236	188
189	94.500	3.7205	95.724	3.7687	141.750	5.5807	143.586	5.6530	189
190	95.000	3.7402	96.227	3.7885	142.500	5.6102	144.341	5.6827	190
191	95.500	3.7598	96.727	3.8082	143.250	5.6398	145.091	5.7122	191
192	96.000	3.7795	97.227	3.8278	144.000	5.6693	145.841	5.7418	192
193	96.500	3.7992	97.727	3.8475	144.750	5.6989	146.591	5.7713	193
194	97.000	3.8189	98.227	3.8672	145.500	5.7283	147.341	5.8008	194
195	97.500	3.8386	98.727	3.8869	146.250	5.7579	148.091	5.8303	195
196	98.000	3.8583	99.227	3.9066	147.000	5.7874	148.841	5.8599	196
197	98.500	3.8780	99.727	3.9263	147.750	5.8169	149.591	5.8894	197
198	99.000	3.8976	100.227	3.9460	148.500	5.8465	150.341	5.9189	198
199	99.500	3.9173	100.727	3.9656	149.250	5.8760	151.091	5.9485	199
200	100.000	3.9370	101.227	3.9853	150.000	5.9055	151.841	5.9780	200
201	100.500	3.9567	101.724	4.0049	150.750	5.9350	152.587	6.0073	201
202	101.000	3.9764	102.224	4.0244	151.500	5.9646	153.337	6.0369	202
203	101.500	3.9961	102.724	4.0443	152.250	5.9941	154.087	6.0664	203
204	102.000	4.0157	103.224	4.0640	153.000	6.0236	154.837	6.0959	204
205	102.500	4.0354	103.725	4.0837	153.750	6.0531	155.587	6.1255	205
240	120.000	4.7244	121.228	4.7728	180.000	7.0866	181.842	7.1591	240
280	140.000	5.5118	141.229	5.5602	210				

Continued on following page

TABLE 10-30 (Cont.)

METRIC GEAR OVER PINS MEASUREMENT**Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle**

No. of Teeth	Module 0.80				Module 1.00				No. of Teeth
	Wire Size = 1.3824mm ; 0.0544 Inch				Wire Size = 1.7280mm ; 0.0680 Inch				
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
5	4.000	0.1575			5.000	0.1969			5
6	4.800	0.1890			6.000	0.2362			6
7	5.600	0.2205			7.000	0.2756			7
8	6.400	0.2520			8.000	0.3150			8
9	7.200	0.2835			9.000	0.3543			9
10	8.000	0.3150			10.000	0.3937			10
11	8.800	0.3465			11.000	0.4331			11
12	9.600	0.3780			12.000	0.4724			12
13	10.400	0.4094			13.000	0.5118			13
14	11.200	0.4409			14.000	0.5512			14
15	12.000	0.4724			15.000	0.5906			15
16	12.800	0.5039			16.000	0.6299			16
17	13.600	0.5354			17.000	0.6693			17
18	14.400	0.5669	16.307	0.6420	18.000	0.7087	20.384	0.8025	18
19	15.200	0.5984	17.056	0.6715	19.000	0.7480	21.320	0.8394	19
20	16.000	0.6299	17.912	0.7052	20.000	0.7874	22.390	0.8815	20
21	16.800	0.6614	18.666	0.7349	21.000	0.8268	23.332	0.9186	21
22	17.600	0.6929	19.516	0.7684	22.000	0.8661	24.395	0.9604	22
23	18.400	0.7244	20.274	0.7982	23.000	0.9055	25.442	0.9977	23
24	19.200	0.7559	21.120	0.8315	24.000	0.9449	26.400	1.0394	24
25	20.000	0.7874	21.881	0.8615	25.000	0.9843	27.351	1.0768	25
26	20.800	0.8189	22.723	0.8946	26.000	1.0236	28.404	1.1183	26
27	21.600	0.8504	23.487	0.9247	27.000	1.0630	29.359	1.1559	27
28	22.400	0.8819	24.326	0.9577	28.000	1.1024	30.407	1.1971	28
29	23.200	0.9134	25.092	0.9879	29.000	1.1417	31.365	1.2349	29
30	24.000	0.9449	25.928	1.0208	30.000	1.1811	32.410	1.2760	30
31	24.800	0.9764	26.697	1.0511	31.000	1.2205	33.371	1.3138	31
32	25.600	1.0079	27.530	1.0839	32.000	1.2598	34.413	1.3548	32
33	26.400	1.0394	28.301	1.1142	33.000	1.2992	35.376	1.3928	33
34	27.200	1.0709	29.132	1.1469	34.000	1.3386	36.415	1.4337	34
35	28.000	1.1024	29.905	1.1773	35.000	1.3780	37.381	1.4717	35
36	28.800	1.1339	30.734	1.2100	36.000	1.4173	38.418	1.5125	36
37	29.600	1.1654	31.508	1.2405	37.000	1.4567	39.385	1.5506	37
38	30.400	1.1969	32.336	1.2731	38.000	1.4961	40.420	1.5913	38
39	31.200	1.2283	33.111	1.3036	39.000	1.5354	41.389	1.6295	39
40	32.000	1.2598	33.937	1.3361	40.000	1.5748	42.422	1.6701	40
41	32.800	1.2913	34.714	1.3667	41.000	1.6142	43.392	1.7083	41
42	33.600	1.3228	35.539	1.3992	42.000	1.6535	44.423	1.7490	42
43	34.400	1.3543	36.316	1.4298	43.000	1.6929	45.395	1.7872	43
44	35.200	1.3858	37.140	1.4622	44.000	1.7323	46.425	1.8278	44
45	36.000	1.4173	37.918	1.4929	45.000	1.7717	47.398	1.8661	45
46	36.800	1.4488	38.741	1.5252	46.000	1.8110	48.426	1.9066	46
47	37.600	1.4803	39.521	1.5559	47.000	1.8504	49.401	1.9449	47
48	38.400	1.5118	40.342	1.5883	48.000	1.8898	50.428	1.9854	48
49	39.200	1.5433	41.122	1.6190	49.000	1.9291	51.403	2.0237	49
50	40.000	1.5748	41.943	1.6513	50.000	1.9685	52.429	2.0641	50
51	40.800	1.6063	42.724	1.6821	51.000	2.0079	53.405	2.1026	51
52	41.600	1.6378	43.544	1.7143	52.000	2.0472	54.430	2.1429	52
53	42.400	1.6693	44.326	1.7451	53.000	2.0866	55.407	2.1814	53
54	43.200	1.7008	45.145	1.7774	54.000	2.1260	56.431	2.2217	54
55	44.000	1.7323	45.927	1.8082	55.000	2.1654	57.409	2.2602	55
56	44.800	1.7638	46.746	1.8404	56.000	2.2047	58.432	2.3005	56
57	45.600	1.7953	47.529	1.8712	57.000	2.2441	59.411	2.3390	57
58	46.400	1.8268	48.347	1.9034	58.000	2.2835	60.433	2.3793	58
59	47.200	1.8583	49.130	1.9343	59.000	2.3228	61.413	2.4178	59
60	48.000	1.8898	49.948	1.9664	60.000	2.3622	62.434	2.4580	60
61	48.800	1.9213	50.732	1.9973	61.000	2.4016	63.414	2.4966	61
62	49.600	1.9528	51.548	2.0295	62.000	2.4409	64.435	2.5368	62
63	50.400	1.9843	52.333	2.0603	63.000	2.4803	65.416	2.5754	63
64	51.200	2.0157	53.149	2.0925	64.000	2.5197	66.436	2.6156	64
65	52.000	2.0472	53.934	2.1234	65.000	2.5591	67.417	2.6542	65
66	52.800	2.0787	54.750	2.1555	66.000	2.5984	68.437	2.6944	66
67	53.600	2.1102	55.535	2.1864	67.000	2.6378	69.419	2.7330	67
68	54.400	2.1417	56.350	2.2185	68.000	2.6772	70.438	2.7731	68
69	55.200	2.1732	57.136	2.2494	69.000	2.7165	71.420	2.8118	69
70	56.000	2.2047	57.951	2.2815	70.000	2.7559	72.438	2.8519	70
71	56.800	2.2362	58.737	2.3125	71.000	2.7953	73.421	2.8906	71
72	57.600	2.2677	59.551	2.3445	72.000	2.8346	74.439	2.9307	72
73	58.400	2.2992	60.338	2.3755	73.000	2.8740	75.422	2.9694	73
74	59.200	2.3307	61.152	2.4075	74.000	2.9134	76.440	3.0094	74
75	60.000	2.3622	61.939	2.4385	75.000	2.9528	77.423	3.0482	75
76	60.800	2.3937	62.752	2.4706	76.000	2.9921	78.440	3.0882	76
77	61.600	2.4252	63.539	2.5015	77.000	3.0315	79.424	3.1269	77
78	62.400	2.4567	64.353	2.5336	78.000	3.0709	80.441	3.1670	78
79	63.200	2.4882	65.140	2.5646	79.000	3.1102	81.425	3.2057	79
80	64.000	2.5197	65.953	2.5966	80.000	3.1496	82.441	3.2457	80
81	64.800	2.5512	66.741	2.6276	81.000	3.1890	83.426	3.2845	81
82	65.600	2.5827	67.553	2.6596	82.000	3.2283	84.442	3.3245	82
83	66.400	2.6142	68.342	2.6906	83.000	3.2677	85.427	3.3633	83
84	67.200	2.6457	69.154	2.7226	84.000	3.3071	86.442	3.4032	84
85	68.000	2.6772	69.942	2.7536	85.000	3.3465	87.428	3.4420	85
86	68.800	2.7087	70.754	2.7856	86.000	3.3858	88.443	3.4820	86
87	69.600	2.7402	71.543	2.8167	87.000	3.4252	89.429	3.5208	87
88	70.400	2.7717	72.355	2.8486	88.000	3.4646	90.443	3.5608	88
89	71.200	2.8031	73.144	2.8797	89.000	3.5039	91.429	3.5996	89
90	72.000	2.8346	73.955	2.9116	90.000	3.5433	92.444	3.6395	90
91	72.800	2.8661	74.744	2.9427	91.000	3.5827	93.430	3.6784	91
92	73.600	2.8976	75.555	2.9746	92.000	3.6220	94.444	3.7183	92
93	74.400	2.9291	76.345	3.0057	93.000	3.6614	95.431	3.7571	93
94	75.200	2.9606	77.156	3.0376	94.000	3.7008	96.444	3.7970	94
95	76.000	2.9921	77.945	3.0687	95.000	3.7402	97.432	3.8359	95
96	76.800	3.0236	78.756	3.1006	96.000	3.7795	98.445	3.8758	96
97	77.600	3.0551	79.546	3.1317	97.000	3.8189	99.432	3.9147	97
98	78.400	3.0866	80.356	3.1636	98.000	3.8583	100.445	3.9545	98
99	79.200	3.1181	81.146	3.1947	99.000	3.8976	101.433	3.9934	99
100	80.000	3.1496	81.956	3.2266	100.000	3.9370	102.446	4.0333	100
101	80.800	3.1811	82.747	3.2577	101.000	3.9764	103.433	4.0722	101
102	81.600	3.2126	83.557	3.2896	102.000	4.0157	104.446	4.1120	102
103	82.400	3.2441	84.347	3.3208	103.000	4.0551	105.434	4.1509	103
104	83.200	3.2756	85.157	3.3526	104.000	4.0945	106.446	4.1908	104
105	84.000	3.3071	85.948	3.3838	105.000	4.1339	107.435	4.2297	105
106	84.800	3.3386	86.757	3.4156	106.000	4.1732	108.447	4.2696	106
107	85.600	3.3701	87.548	3.4468	107.000	4.2126	109.435	4.3085	107
108	86.400	3.4016	88.358	3.4786	108.000	4.2520	110.447	4.3483	108
109	87.200	3.4331	89.149	3.5098	109.000	4.2913	111.436	4.3872	109

Continued on following page

TABLE 10-30 (Cont.)

METRIC GEAR OVER PINS MEASUREMENT

Pitch Diameter and Measurement Over Wires for External,
Module Type Gears, 20-Degree Pressure Angle

No. of Teeth	Module 0.80				Module 1.00				No. of Teeth
	Wire Size = 1.3824mm ; 0.0544 Inch				Wire Size = 1.7280mm ; 0.0680 Inch				
	Pitch Diameter		Meas. Over Wire		Pitch Diameter		Meas. Over Wire		
	mm	Inch	mm	Inch	mm	Inch	mm	Inch	
110	88.000	3.4646	89.958	3.5416	110.000	4.3307	112.447	4.4271	110
111	88.800	3.4961	90.749	3.5728	111.000	4.3701	113.436	4.4660	111
112	89.600	3.5276	91.558	3.6046	112.000	4.4094	114.447	4.5058	112
113	90.400	3.5591	92.349	3.6358	113.000	4.4488	115.437	4.5448	113
114	91.200	3.5906	93.158	3.6676	114.000	4.4882	116.448	4.5846	114
115	92.000	3.6220	93.950	3.6988	115.000	4.5276	117.437	4.6235	115
116	92.800	3.6535	94.758	3.7306	116.000	4.5669	118.448	4.6633	116
117	93.600	3.6850	95.550	3.7618	117.000	4.6063	119.438	4.7023	117
118	94.400	3.7165	96.359	3.7937	118.000	4.6457	120.448	4.7421	118
119	95.200	3.7480	97.150	3.8248	119.000	4.6850	121.438	4.7810	119
120	96.000	3.7795	97.959	3.8566	120.000	4.7244	122.449	4.8208	120
121	96.800	3.8110	98.751	3.8878	121.000	4.7638	123.438	4.8598	121
122	97.600	3.8425	99.559	3.9197	122.000	4.8031	124.449	4.8996	122
123	98.400	3.8740	100.351	3.9508	123.000	4.8425	125.439	4.9385	123
124	99.200	3.9055	101.159	3.9826	124.000	4.8819	126.449	4.9783	124
125	100.000	3.9370	101.951	4.0138	125.000	4.9213	127.439	5.0173	125
126	100.800	3.9685	102.759	4.0456	126.000	4.9606	128.449	5.0571	126
127	101.600	4.0000	103.552	4.0768	127.000	5.0000	129.440	5.0960	127
128	102.400	4.0315	104.360	4.1086	128.000	5.0394	130.450	5.1358	128
129	103.200	4.0630	105.152	4.1398	129.000	5.0787	131.440	5.1748	129
130	104.000	4.0945	105.960	4.1716	130.000	5.1181	132.450	5.2146	130
131	104.800	4.1260	106.752	4.2028	131.000	5.1575	133.440	5.2536	131
132	105.600	4.1575	107.560	4.2346	132.000	5.1969	134.450	5.2933	132
133	106.400	4.1890	108.353	4.2659	133.000	5.2362	135.441	5.3323	133
134	107.200	4.2205	109.160	4.2976	134.000	5.2756	136.450	5.3721	134
135	108.000	4.2520	109.953	4.3289	135.000	5.3150	137.441	5.4111	135
136	108.800	4.2835	110.760	4.3606	136.000	5.3543	138.450	5.4508	136
137	109.600	4.3150	111.553	4.3919	137.000	5.3937	139.441	5.4898	137
138	110.400	4.3465	112.360	4.4236	138.000	5.4331	140.451	5.5296	138
139	111.200	4.3780	113.153	4.4549	139.000	5.4724	141.442	5.5686	139
140	112.000	4.4094	113.961	4.4866	140.000	5.5118	142.451	5.6083	140
141	112.800	4.4409	114.754	4.5179	141.000	5.5512	143.442	5.6473	141
142	113.600	4.4724	115.561	4.5496	142.000	5.5906	144.451	5.6870	142
143	114.400	4.5039	116.354	4.5809	143.000	5.6299	145.442	5.7261	143
144	115.200	4.5354	117.161	4.6126	144.000	5.6693	146.451	5.7658	144
145	116.000	4.5669	117.954	4.6439	145.000	5.7087	147.443	5.8048	145
146	116.800	4.5984	118.761	4.6756	146.000	5.7480	148.451	5.8445	146
147	117.600	4.6299	119.554	4.7069	147.000	5.7874	149.443	5.8836	147
148	118.400	4.6614	120.361	4.7386	148.000	5.8268	150.451	5.9233	148
149	119.200	4.6929	121.155	4.7699	149.000	5.8661	151.443	5.9623	149
150	120.000	4.7244	121.961	4.8016	150.000	5.9055	152.452	6.0020	150
151	120.800	4.7559	122.755	4.8329	151.000	5.9449	153.443	6.0411	151
152	121.600	4.7874	123.561	4.8646	152.000	5.9843	154.452	6.0808	152
153	122.400	4.8189	124.355	4.8959	153.000	6.0236	155.444	6.1198	153
154	123.200	4.8504	125.162	4.9276	154.000	6.0630	156.452	6.1595	154
155	124.000	4.8819	125.955	4.9589	155.000	6.1024	157.444	6.1986	155
156	124.800	4.9134	126.762	4.9906	156.000	6.1417	158.452	6.2383	156
157	125.600	4.9449	127.555	5.0219	157.000	6.1811	159.444	6.2773	157
158	126.400	4.9764	128.362	5.0536	158.000	6.2205	160.452	6.3170	158
159	127.200	5.0079	129.156	5.0849	159.000	6.2598	161.444	6.3561	159
160	128.000	5.0394	129.962	5.1166	160.000	6.2992	162.452	6.3958	160
161	128.800	5.0709	130.756	5.1479	161.000	6.3386	163.445	6.4348	161
162	129.600	5.1024	131.562	5.1796	162.000	6.3780	164.453	6.4745	162
163	130.400	5.1339	132.356	5.2109	163.000	6.4173	165.445	6.5136	163
164	131.200	5.1654	133.162	5.2426	164.000	6.4567	166.453	6.5533	164
165	132.000	5.1969	133.956	5.2739	165.000	6.4961	167.445	6.5923	165
166	132.800	5.2283	134.762	5.3056	166.000	6.5354	168.453	6.6320	166
167	133.600	5.2598	135.556	5.3369	167.000	6.5748	169.445	6.6711	167
168	134.400	5.2913	136.362	5.3686	168.000	6.6142	170.453	6.7107	168
169	135.200	5.3228	137.157	5.3999	169.000	6.6535	171.446	6.7498	169
170	136.000	5.3543	137.962	5.4316	170.000	6.6929	172.453	6.7895	170
171	136.800	5.3858	138.757	5.4629	171.000	6.7323	173.446	6.8286	171
172	137.600	5.4173	139.563	5.4946	172.000	6.7717	174.453	6.8682	172
173	138.400	5.4488	140.357	5.5259	173.000	6.8110	175.446	6.9073	173
174	139.200	5.4803	141.163	5.5576	174.000	6.8504	176.453	6.9470	174
175	140.000	5.5118	141.957	5.5889	175.000	6.8898	177.446	6.9861	175
176	140.800	5.5433	142.763	5.6206	176.000	6.9291	178.453	7.0257	176
177	141.600	5.5748	143.557	5.6519	177.000	6.9685	179.446	7.0648	177
178	142.400	5.6063	144.363	5.6836	178.000	7.0079	180.454	7.1045	178
179	143.200	5.6378	145.157	5.7149	179.000	7.0472	181.447	7.1436	179
180	144.000	5.6693	145.963	5.7466	180.000	7.0866	182.454	7.1832	180
181	144.800	5.7008	146.758	5.7779	181.000	7.1260	183.447	7.2223	181
182	145.600	5.7323	147.563	5.8096	182.000	7.1654	184.454	7.2620	182
183	146.400	5.7638	148.358	5.8409	183.000	7.2047	185.447	7.3011	183
184	147.200	5.7953	149.163	5.8726	184.000	7.2441	186.454	7.3407	184
185	148.000	5.8268	149.958	5.9039	185.000	7.2835	187.447	7.3798	185
186	148.800	5.8583	150.763	5.9356	186.000	7.3228	188.454	7.4194	186
187	149.600	5.8898	151.558	5.9668	187.000	7.3622	189.447	7.4586	187
188	150.400	5.9213	152.363	5.9986	188.000	7.4016	190.454	7.4982	188
189	151.200	5.9528	153.158	6.0298	189.000	7.4409	191.448	7.5373	189
190	152.000	5.9843	153.963	6.0615	190.000	7.4803	192.454	7.5769	190
191	152.800	6.0157	154.763	6.0930	191.000	7.5197	193.454	7.6163	191
192	153.600	6.0472	155.563	6.1245	192.000	7.5591	194.454	7.6557	192
193	154.400	6.0787	156.364	6.1560	193.000	7.5984	195.454	7.6951	193
194	155.200	6.1102	157.164	6.1875	194.000	7.6378	196.454	7.7344	194
195	156.000	6.1417	157.964	6.2190	195.000	7.6772	197.454	7.7738	195
196	156.800	6.1732	158.764	6.2505	196.000	7.7165	198.455	7.8132	196
197	157.600	6.2047	159.564	6.2820	197.000	7.7559	199.455	7.8525	197
198	158.400	6.2362	160.364	6.3135	198.000	7.7953	200.455	7.8919	198
199	159.200	6.2677	161.164	6.3450	199.000	7.8346	201.455	7.9313	199
200	160.000	6.2992	161.964	6.3765	200.000	7.8740	202.455	7.9707	200
201	160.800	6.3307	162.759	6.4078	201.000	7.9134	203.449	8.0098	201
202	161.600	6.3622	163.559	6.4393	202.000	7.9528	204.449	8.0492	202
203	162.400	6.3937	164.359	6.4708	203.000	7.9921	205.449	8.0885	203
204	163.200	6.4252	165.159	6.5023	204.000	8.0315	206.449	8	