Taper Turning

Introduction

- Taper: constant change in diameter of a cylinder
  - Self-holding vs. self-releasing taper parts
  - Machined for appearance, weight reduction, or clearance

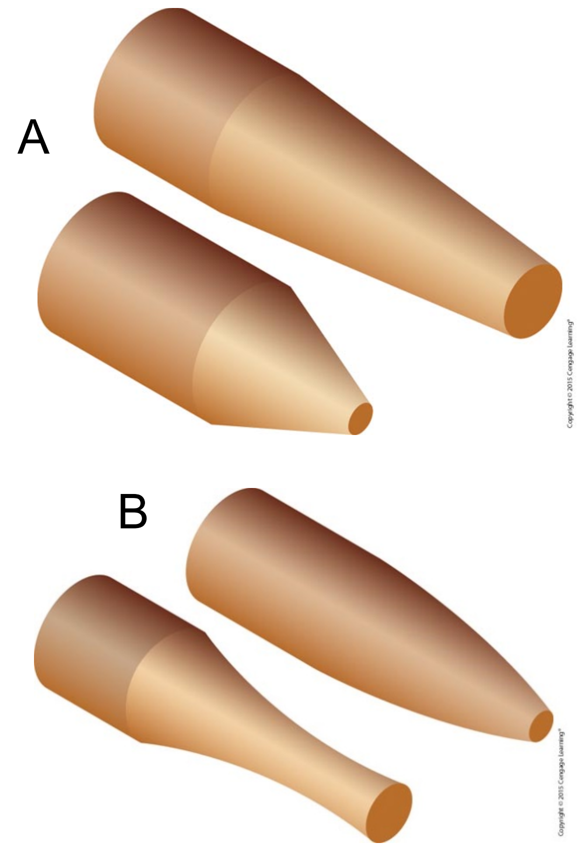

FIGURE 5.5.1 The parts in A are tapered because they each have a constant rate of diameter change. The parts in B are bell-shaped and not considered tapers.

Taper

- Uniform change in diameter of workpiece measured along its axis
- Inch system expressed in taper per foot, taper per inch, or degrees
- Metric system expressed as ratio of 1 mm per unit of length
- Provides rapid and accurate method of aligning machine parts and easy method of holding tools

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Machine Tapers

- Classified by American Standards Association
  - Self-holding tapers
  - Steep or self-releasing tapers

Self-Holding Tapers

- Remain in position because of the wedging action of the small taper angle
- Most common forms
  - Morse, the Brown & Sharpe, .750-in.-per-ft taper
- Smaller sizes provided with tang to help drive the cutting tool
- Larger sizes employ tang drive with shank held in by key or key drive with shank held draw bolt

Steep Tapers

- 3.500 in. taper per foot (tpf)
- Formerly called standard milling machine taper
- Used mainly for alignment of milling machine arbors and accessories
- Has key drive and uses draw-in bolt to hold it securely in milling machine spindle

Standard Tapers

- Morse taper
  - Approximaely .625-in tpf, eight sizes #0 to #7
  - Used for drills, reamers, and lathe center shanks
- Brown & Sharpe taper
  - .502-in. tpf, sizes from #4 to #12
  - Used on Brown and Sharpe machines
- Jarno taper
  - .600-in. tpf, sizes from #2 to #20
- Standard taper pins
  - Used for positioning and holding parts together
  - ¼ tpf, standard sizes range from #6/0 to #10

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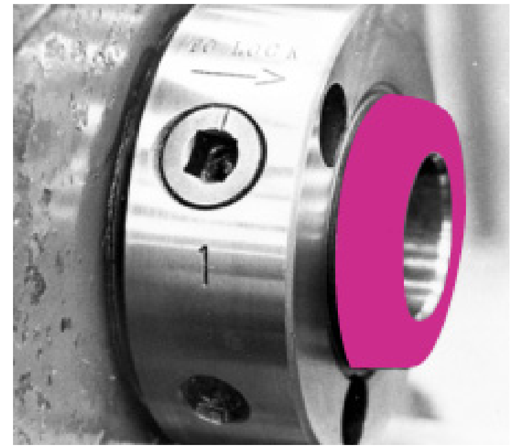
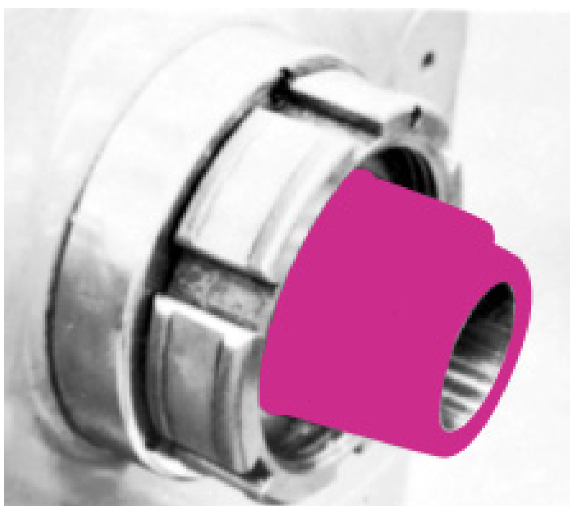
Table 54.1: Basic dimensions of self-holding tapers

Portion of table shown in textbook

Two Types of Lathe Spindle Nose Tapers



- Type D-1
  - Short tapered section and used on
    cam-lock spindles

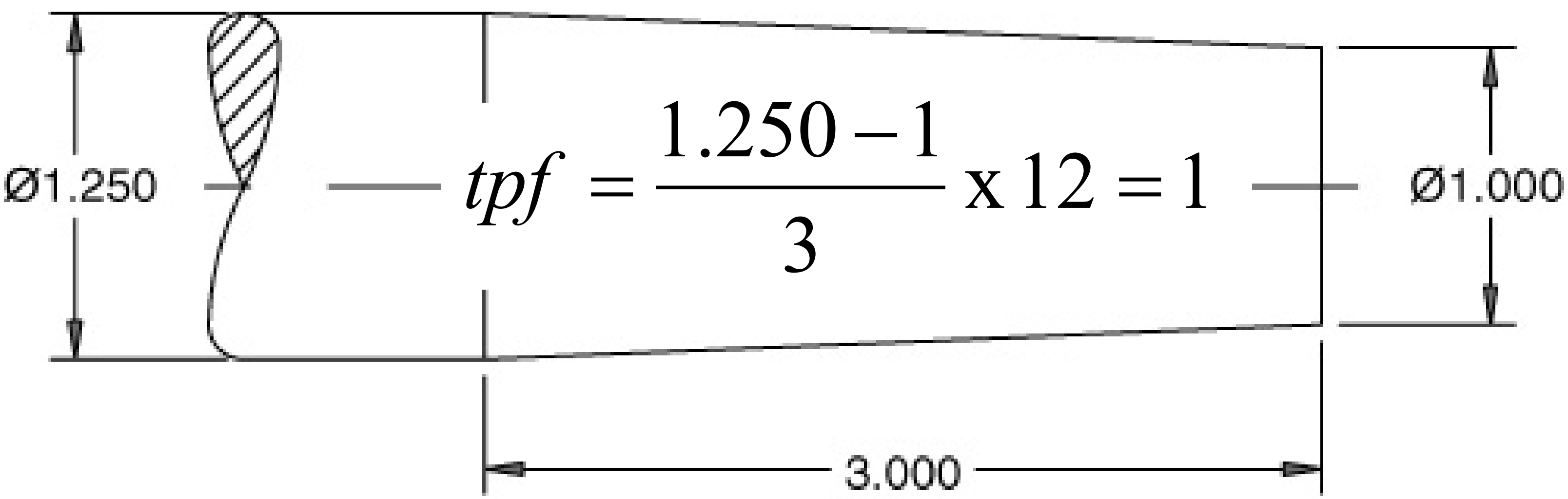


- Type L
  - Taper of 3.500-in./ft
  - Longer taper than Type D-1
  - Chuck held on by treaded lock ring fitted on spindle
  - Key drive used

Taper Calculations: TPF

$$tpf = \frac{D - d}{l} \text{ x } 12$$

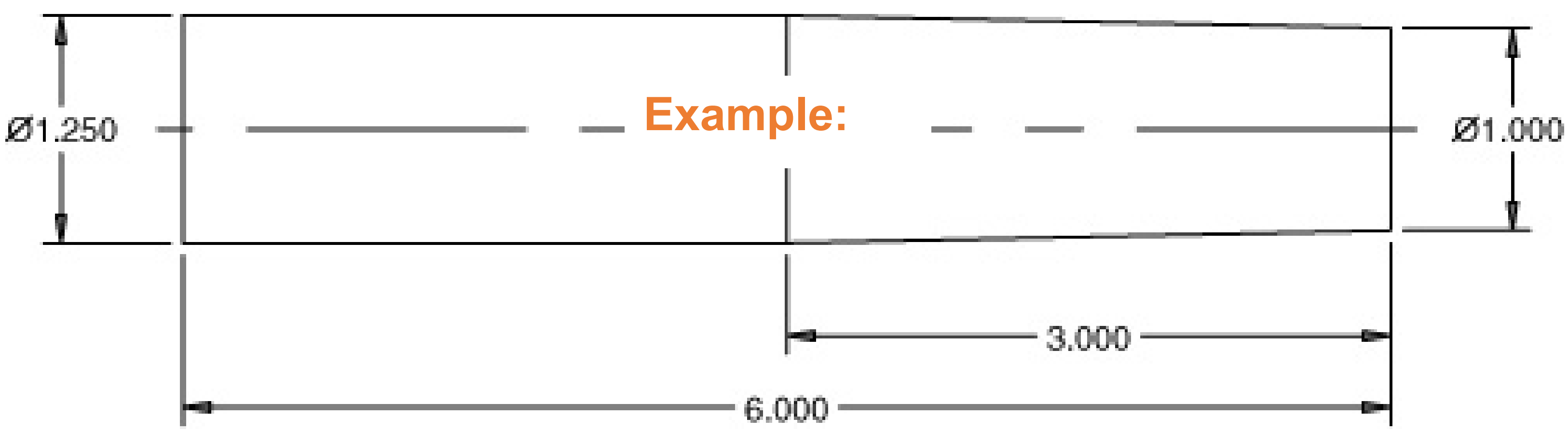
Example:



$$tpf = \frac{1.250 - 1}{3} \text{ x } 12 = 1$$

To Calculate the Tailstock Offset

$$\text{Tailstock offset} = \frac{tpf \text{ x length of work}}{24}$$



Simplified Formula

$$\text{Taper per inch} = \frac{\text{taper per foot}}{12}$$

$$\text{Tailstock offset} = \frac{\text{taper per inch x overall length (OL)}}{2}$$

$$\text{Tailstock offset} = \frac{\text{OL}}{\text{TL}} \text{ x } \frac{(\text{D - d})}{2}$$

Inch Taper Attachment Offset Calculations

- Most tapers cut on lathe with taper attachment are expressed in tpf
- If tpf of taper not given, it may be calculated:

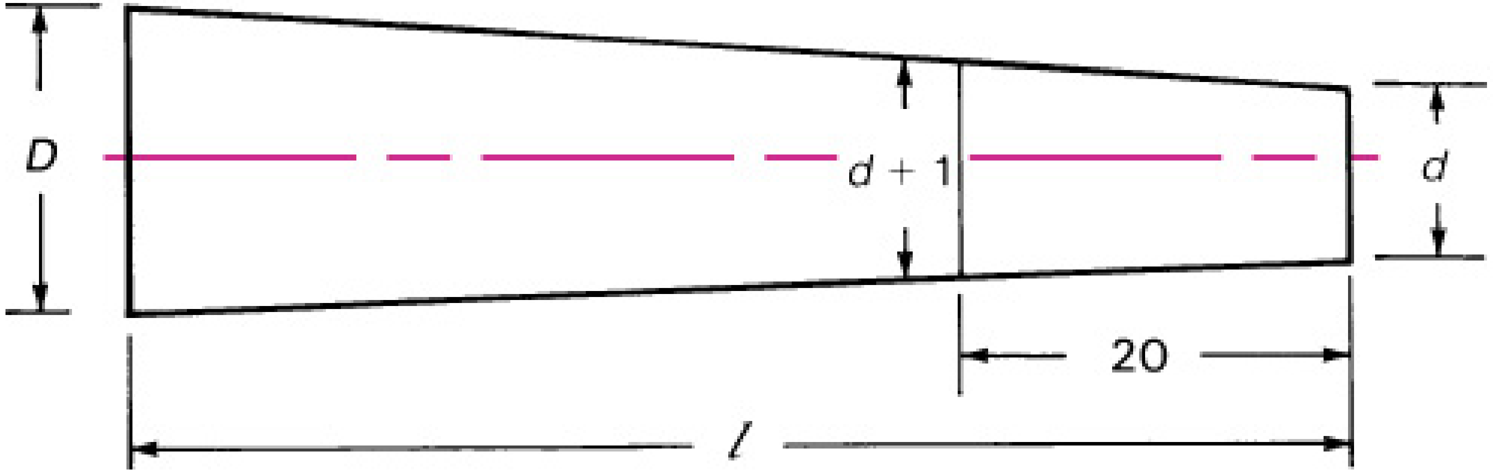
$$tpf = \frac{(D - d) \times 12}{TL} = \frac{(1.375 - .9375) \times 12}{7}$$

Calculate the *tpf* for a taper with the following dimensions:
large diameter (*D*), 1.375; small diameter (*d*), .9375;
length of tapered section (*TL*), 7 in.

Metric Tapers

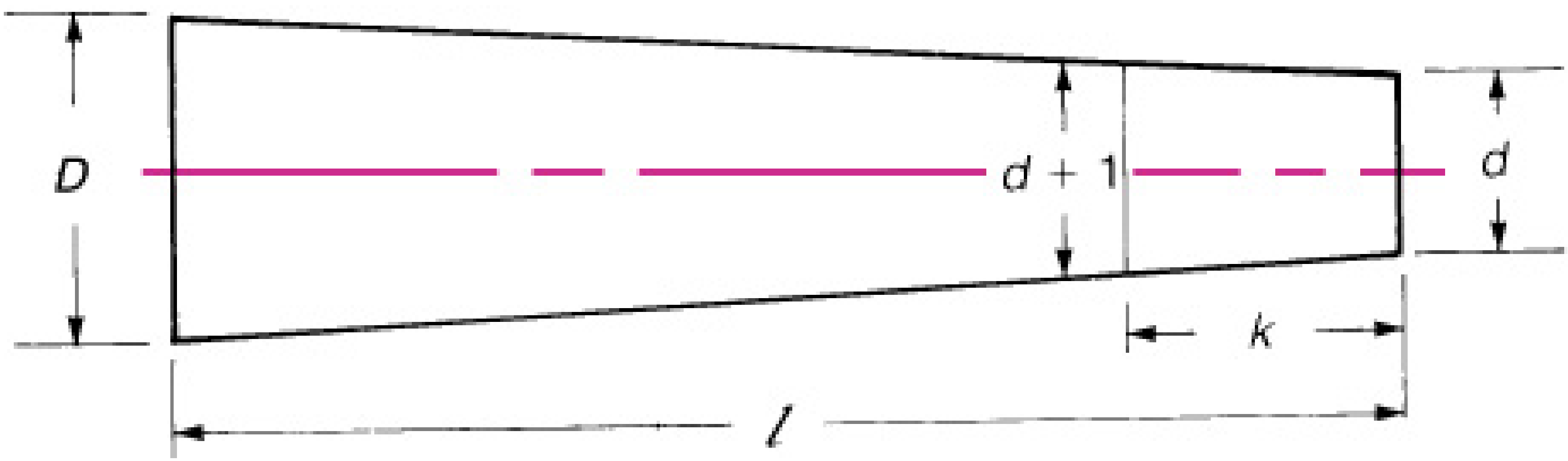
- Expressed as ratio of 1 mm per unit of length

Work would taper 1 mm in a distance of 20 mm ratio of 1:20



Metric Taper Calculations

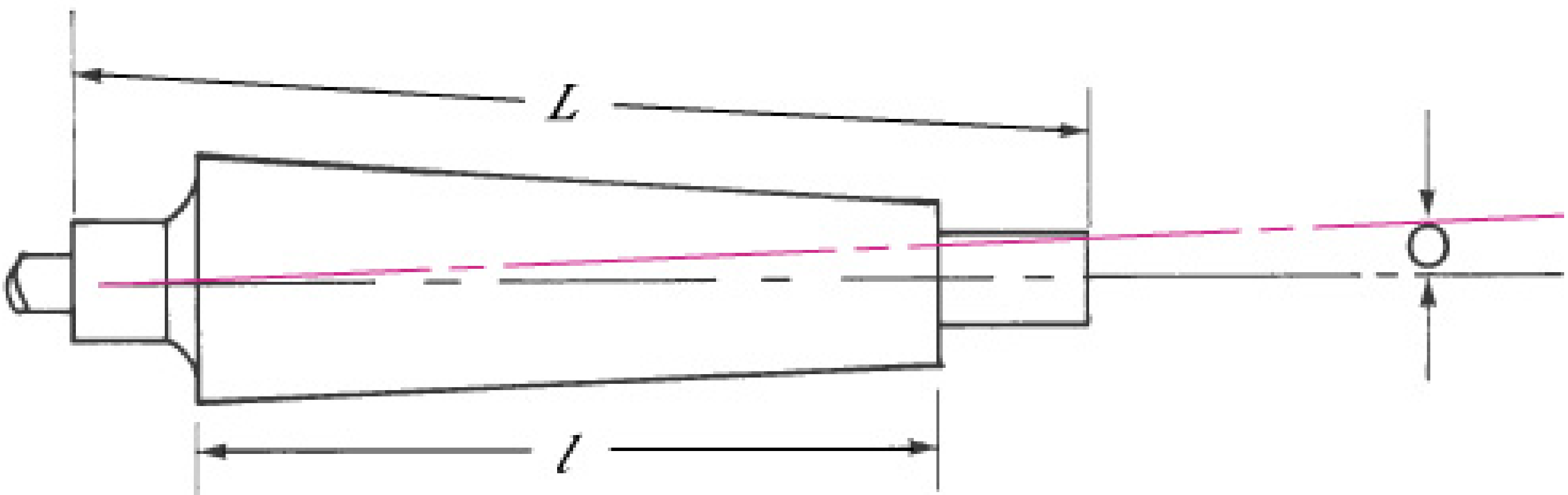
d = small diameter
k = unit length of taper
l = total length of taper
D = large diameter



Metric Tailstock Offset Calculations

- If taper turned by offsetting tailstock, amount of offset O is calculated as follows:

$$\text{Offset} = \frac{D - d}{2 \times l} \times L$$



Example: Metric Tailstock Offset

Solution:

$$D = d + \frac{l}{k}$$

$$= 20 + \frac{60}{30} = 20 + 2$$

$$= 22mm$$

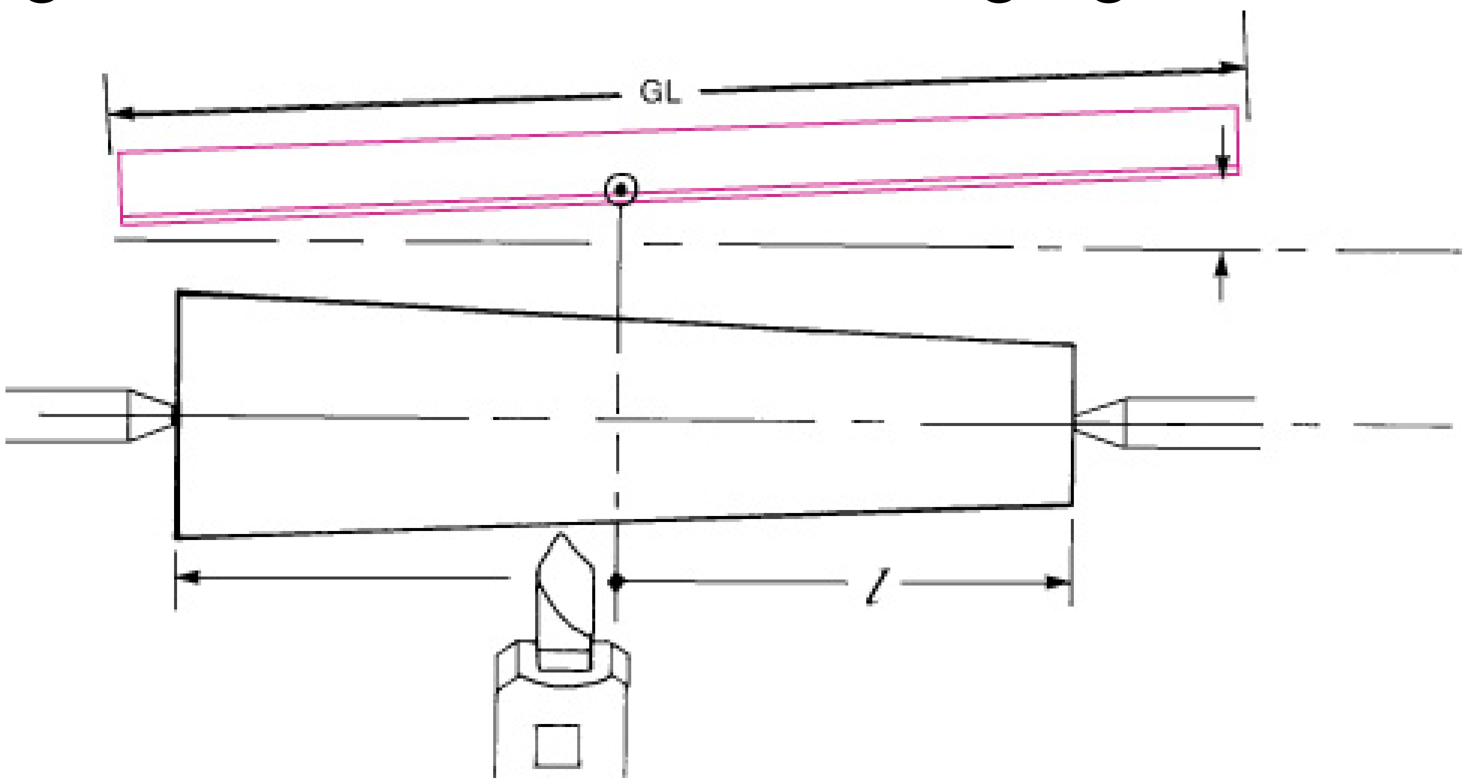
$$\text{Offset} = \frac{D - d}{2 \text{ x } l} \text{ x L}$$

$$= \frac{22 - 20}{2 \text{ x } 60} \text{ x } 300$$

$$= 5 \text{ mm}$$

Metric Taper Attachment Offset Calculations

1. When taper attachment used to turn taper, amount guide bar set over is one-half angle given on drawing.



2. If angle of taper not given on drawing, use following formula to find amount of guide bar setover:

$$\text{Guide bar setover} = \frac{D - d}{2} \times \frac{GL}{l}$$

Typical Taper Specifications

- Angular specification
  - Included vs. centerline
- Rate-of-change
  - Ratio diameter change over length (TPI/TPF)

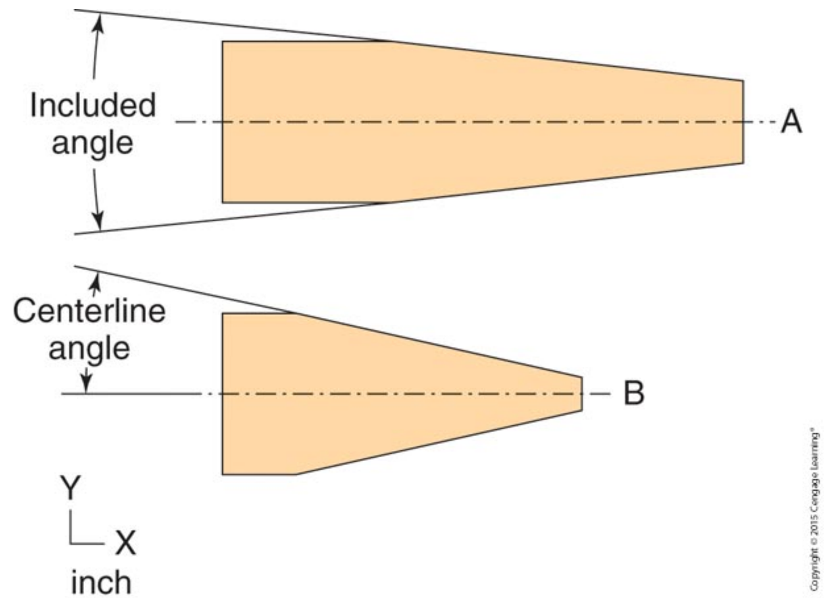


FIGURE 5.5.2 (A) A taper specified by an included angle, and (B) by a centerline angle.

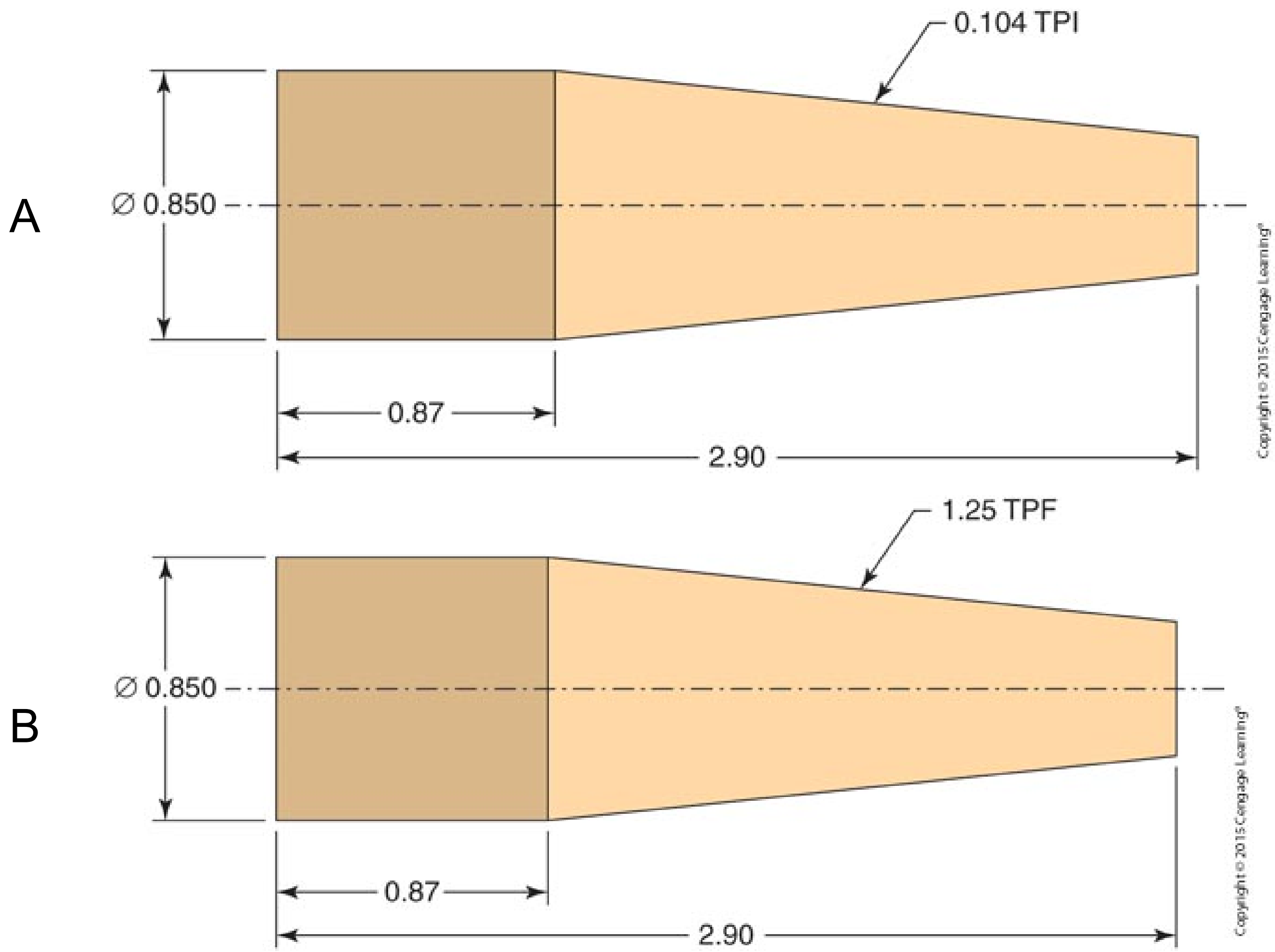


FIGURE 5.5.3 (A) Taper specified by TPI (taper per inch). (B) Taper specified by TPF (taper per foot). Both of these specifications would produce parts with the same dimensions.

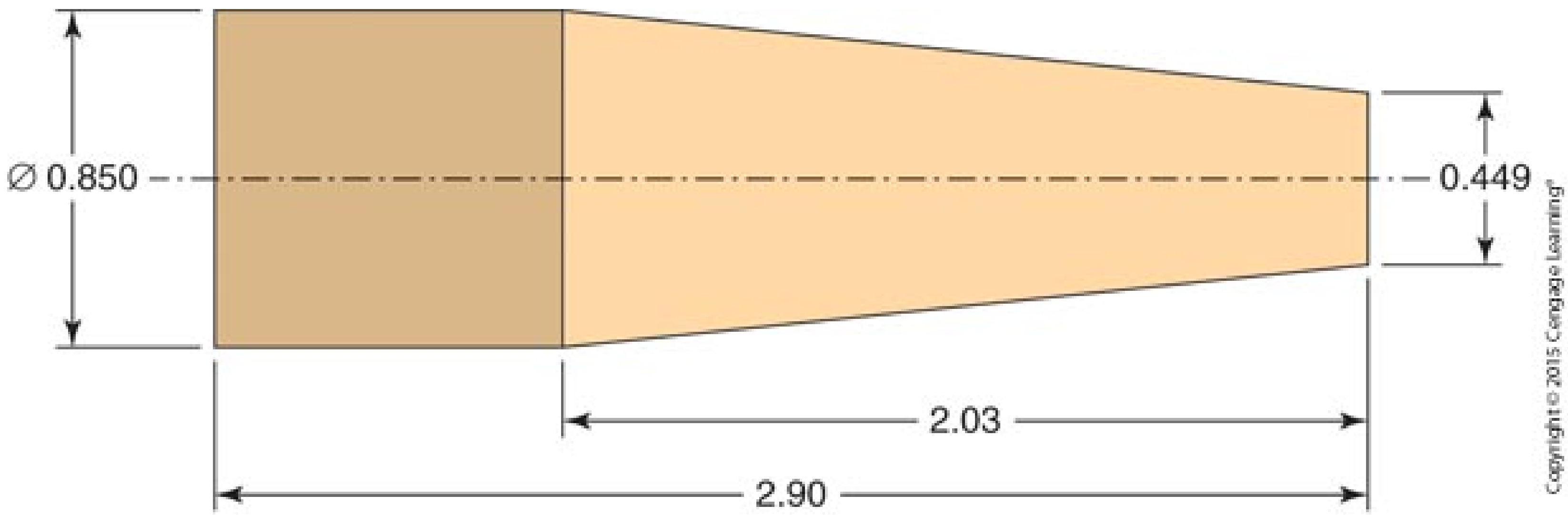


FIGURE 5.5.4 A taper specified by end diameters and length.

Taper Dimensions, and Calculations

- Converting TPI or TPF to an Angular Dimension
- Converting an Angular Dimension to TPI or TPF

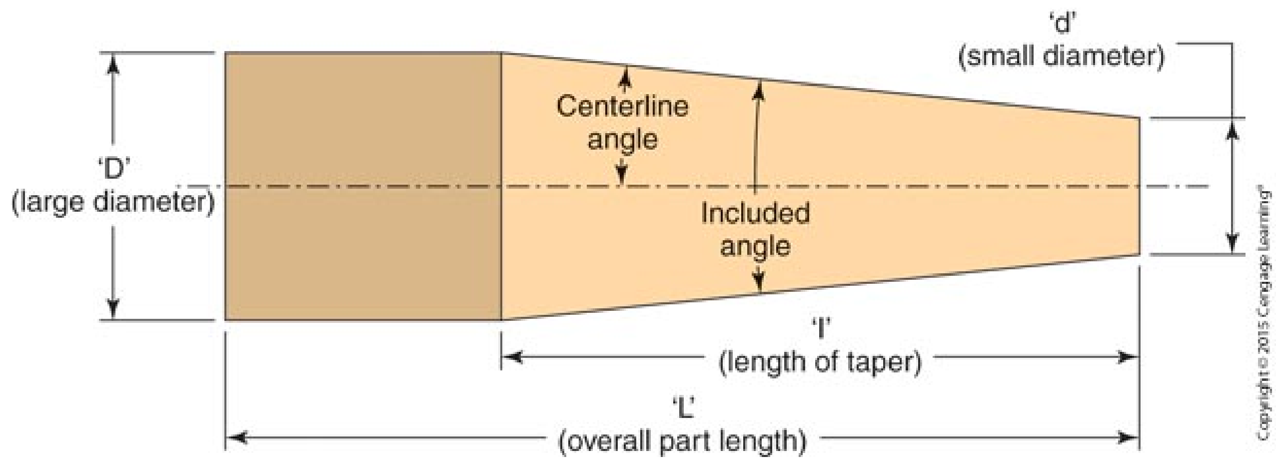
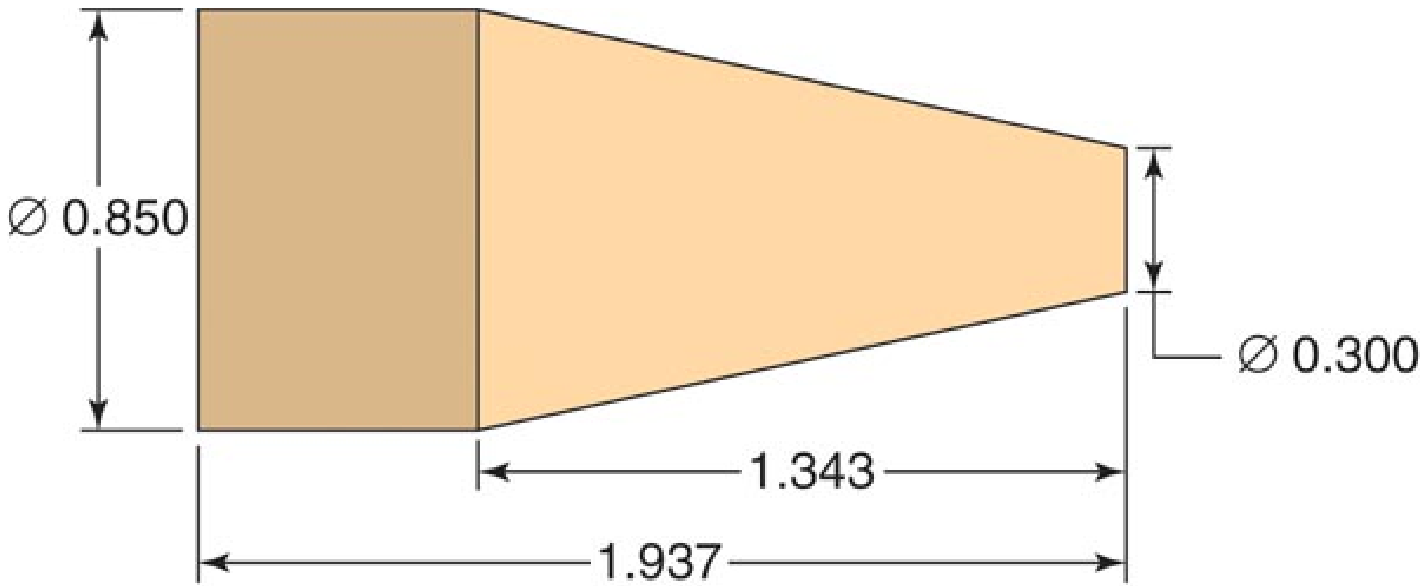


FIGURE 5.5.5 Summary of commonly used taper dimensions.



Determine TPI and TPF.

$D = 0.850,\ d = 0.300,\ l = 1.344$

$$TPI = \frac{D - d}{l}$$

$$TPI = \frac{0.850 - 0.300}{1.343}$$

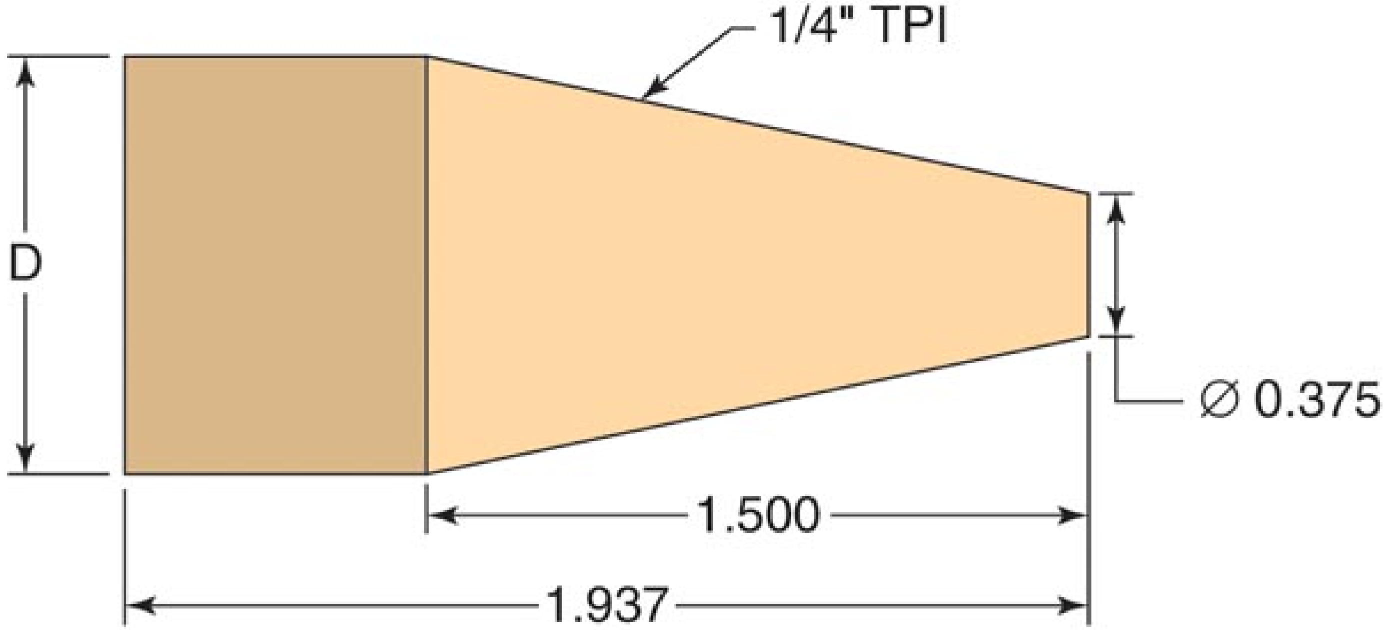
$$TPI = \frac{0.550}{1.343}$$

$$TPI = 0.4095$$

$$TPF = TPI \times 12$$

$$TPF = 0.4095 \times 12$$

$$TPF = 4.914$$



Determine *D*.

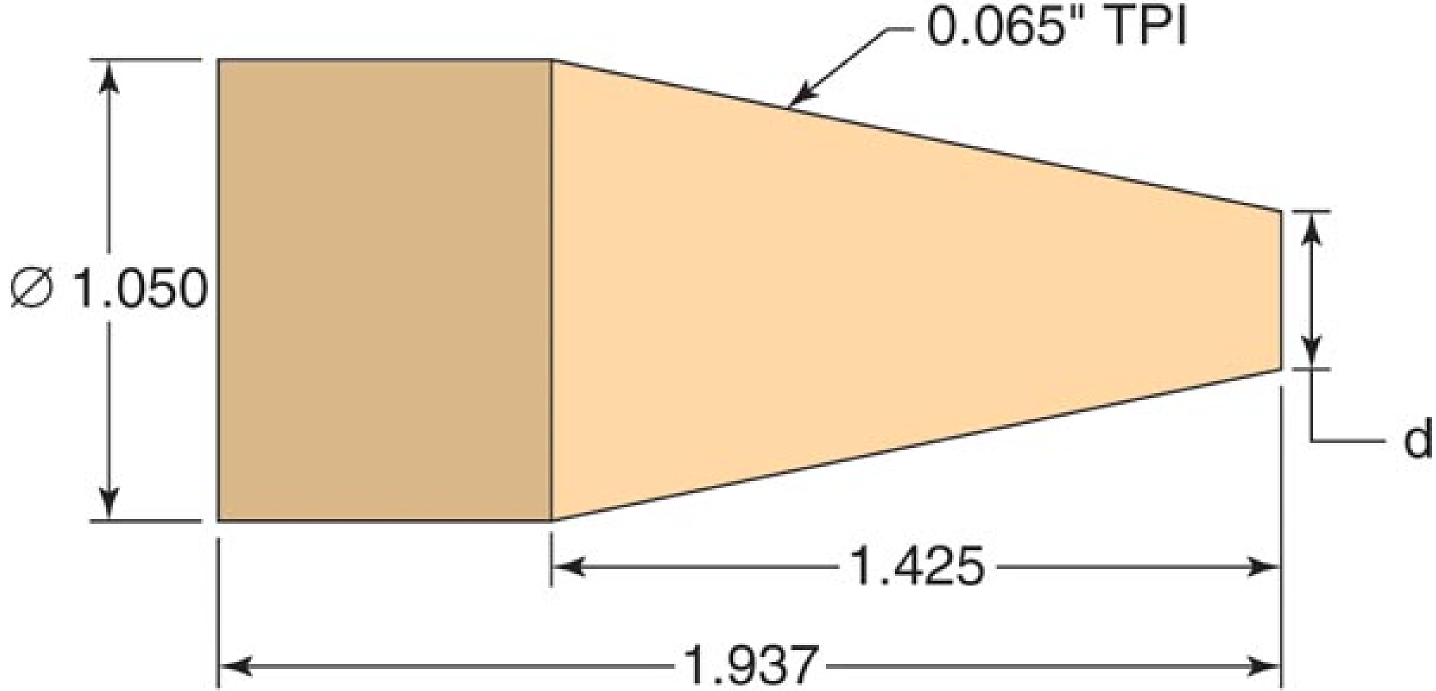
TPI = 1/4" or 0.250, *d* = 0.375, *l* = 1.500

$$0.250 = \frac{D - 0.375}{1.500}$$

$$0.250 \times 1.500 = D - 0.375$$

$$0.375 = D - 0.375$$

$$D = 0.750$$



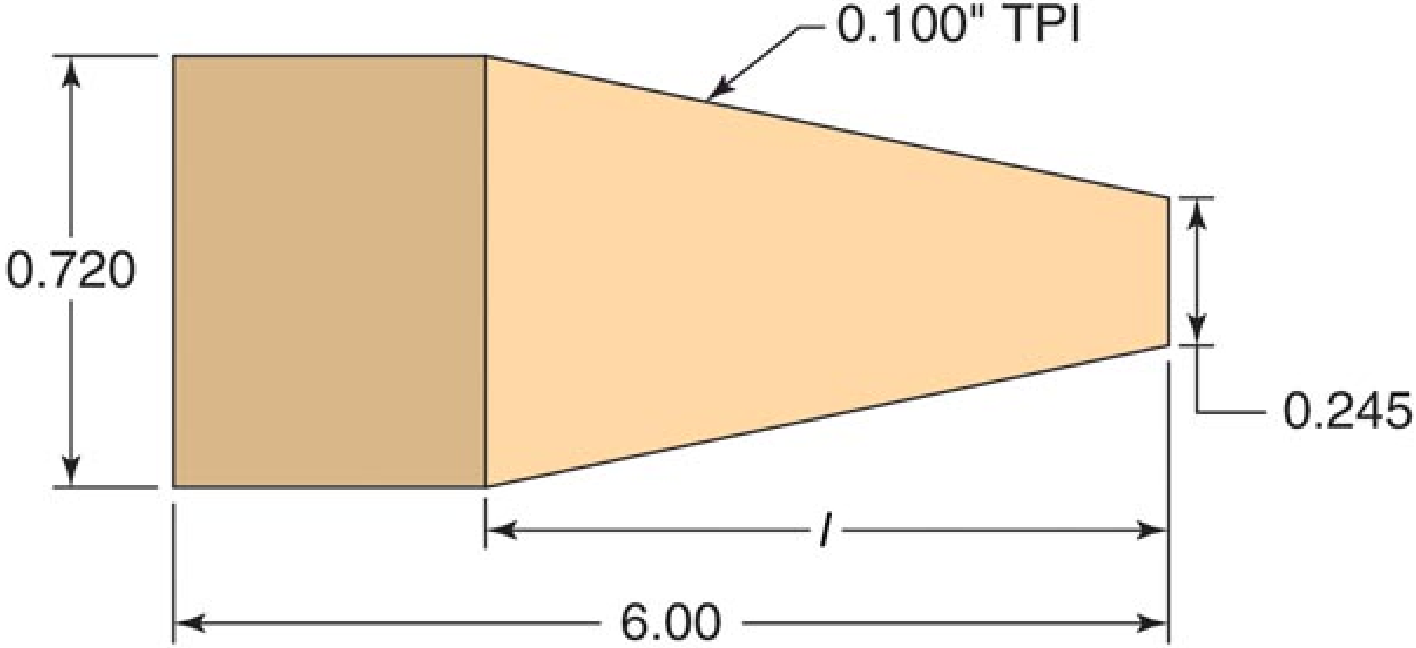
Determine *d*.

$$0.065 = \frac{1.050 - d}{1.425}$$

$$0.065 \times 1.425 = 1.050 - d$$

$$0.0926 = 1.050 - d$$

$$d = 0.9574$$



Determine l.

$TPI = 0.100$, $D = 0.720$, $d = 0.245$

$$0.100 = \frac{0.720 - 0.245}{l}$$

$0.1l = 0.720 - 0.245$

$0.1l = 0.475$

$l = 4.75$

$TPI = \frac{D - d}{l}$ $TPI = \frac{TPF}{12}$	To determine taper per inch (TPI), subtract the small end diameter (d) from the large end diameter (D) and divide by the length of the taper (l). If taper per foot is known, determine taper per inch by dividing taper per foot (TPF) by 12.
$TPF = \left(\frac{D - d}{l}\right) \times 12$ $TPF = TPI \times 12$	To determine taper per foot, subtract the small end diameter (d) from the large diameter (D), divide by the length (l) of taper in inches, and then multiply by 12. If TPI is known, multiply the TPI by 12.
$D = (TPI \times l) + d$	To determine large end diameter of a part if taper per inch, small end diameter, and length of taper are known, multiply the taper per inch (TPI) by the length of the taper (l), and add the small diameter (d).
$d = D - (TPI \times l)$	To determine small end diameter of a part if taper per inch, large end diameter, and length of taper are known, multiply the taper per inch (TPI) by the length (l) of the taper, and subtract that answer from the large diameter (D).
Centerline angle = *Arctan* $(TPF \div 24)$	To determine angle to centerline given taper per foot, first divide taper per foot (TPF) by 24. The answer is the tangent of the angle.
Included angle = *Arctan* $(TPF \div 12)$	To determine included angle given taper per foot, first divide taper per foot (TPF) by 12. The answer is the tangent of the angle.
$TPF = 24\ (Tan X)$	To determine taper per foot given centerline angle, multiply the tangent of the centerline angle by 24.
$TPF = 12\ (Tan X)$	To determine taper per foot given included angle, multiply the tangent of the included angle by 12.

FIGURE 5.5.8 Summary of frequently used taper formulas.