# Engineering Data

# Glossary of Terms

**Angular Misalignment** - A measure of the angle between two shafts. The angle of error between two shafts is the amount of angular misalignment.

**Axial Misalignment** - A change in the gap between the shaft ends from their position when the coupling was installed. Also called end float.

**Backlash** - The amount of free movement between two rotating mating parts. If one half of an elastomeric coupling or universal joint is held rigid, the other half can be turned a slight amount. The freedom of movement, or looseness, is the backlash and may be expressed in degrees, or in thousandths of an inch. Backlash is not the same as stiffness or windup.

**Donut** - The elastomeric element in Centaflex and Saga couplings.

**Drop out** - The spacer coupling is often referred to as a dropout coupling. The dropout section is the portion that fits between the coupling hubs and is approximately equal in length to the space between shaft ends. It can be removed or "dropped-out" without disturbing the driving or driven equipment.

**Elastomer** - Resilient materials through which the power is transmitted. They are in some way attached or mated to the coupling halves. They are usually made of rubber, synthetic rubber, or plastic materials.

**Flex Links** - Metallic, flexible members of "all metal" couplings such as Deltaflex which take the place of elastomeric elements. Power is transmitted through these metallic members and they provide for angular, and some-times parallel, misalignment.

**Inserts** - The elastomeric flexing element of the coupling. An insert may be referred to as a spider, load cushion, sleeve, donut or elastomer depending on the function or history of the product line.

**Load Cushion** - Rectangular blocks made of synthetic rubber and certain plastics, which are the elastomeric element in type 'C' and 'H' Jaw couplings.

**Open Center** - A type of spider with a hole in the middle that allows the shafts of the driver and driven to be positioned within a short distance.

**Parallel Misalignment** - A measure of the offset between two shafts. Catalog information shows the angular and parallel misalignment tolerable in each coupling group. Both extremes should not exist if the alignment is within the bounds stated.

**RSB** - Rough Stock Bore, also called pre-bore.

**Runout** - A measure of the amount that a cylindrical body is off its true center. When a coupling half is rotated on its shaft, the outside diameter of the coupling may be slightly "off to one side". A dial indicator, which measures movement in thousandths of an inch, is used to measure runout. Runout or eccentricity is expressed as Total Indicator Reading (TIR).

**Sleeve** - The elastomeric element in VIRTUS ES type couplings. This term is also used to describe the flexible element which contains the internal teeth on a Gear coupling. This type of sleeve is either continuous or flanged.

**Spacer** - The portion of a flexible coupling or U-joint which spans the gap between ends of the shafts. Spacer couplings are used when the distance from one end of a shaft to the next is greater than the distance between a normal coupling spacing. The "normal" spacing of shafts when a jaw type coupling is used is approximately equal to the thickness of a spider or length of the jaw. Special "spacers" may be used when the shaft spacing cannot be bridged by a standard coupling.

**Spider** - The elastomeric element of a flexible coupling, usually with 4 or 6 "legs".

**Standards** - Tolerances set by a variety of organizations around the world, such as:

**ANSI** - American National Standards Institute

**ASME** - American Society of Mechanical Engineers

**SAE** - Society of Automotive Engineers

**DIN** - Deutsche Industrial Normen

**JIS** - Japanese Industrial Standard

**AGMA** - American Gear Manufacturers Association

**NEMA** - National Electric Manufacturers Association

**IEC** - International Electrical Code

**Tightening Torque** - The torque required to properly seat a set screw, cap screw or bolt in an assembly of any kind. Applied to a set screw, for example, it is the force applied to the wrench multiplied by the approximate length of the wrench in inches or feet. Catalog and instruction sheet values for tightening torque are provided for most VIRTUS products.

**Tolerances** - The allowable variation in nominal dimensions specified. For example the tolerance in a bore may be plus .001 ( One thousandths of an inch.) If the nominal bore is .875 (7/8 ) and the tolerance of .001 is added, then:

$$.875$$
$$\underline{+.001}$$
$$.876$$

Thus the allowable dimension of the bore would be .875 /.876 .

**Torsional Stiffness** - A measure of the torque required to create an amount of deflection about the coupling axis of rotation. It may be visualized as a twisting action. It is most obvious in couplings which transfer torque through rubber or plastic elements; although, "all metal" couplings such as Deltaflex or gear couplings also twist under applied torque. Stiffness is expressed in in-lb/radian.

**Windup** - The amount of twist of the coupling measured as an angle per unit of torque.

# Drawing Notations

*For all VIRTUS dimensional drawings.*

| Description | Symbol | Description | Symbol |
|---|---|---|---|
| Axial Play/End Float | AP | Length | L |
| Bolt Circle Diameter | BC DIA | Sleeve Length | LS |
| Between Shaft Ends | BSE | Length thru Bore | LTB |
| Clearance to Align Coupling | CAC | Overall Length | OAL |
| Counter Bore Diameter | CBD | Outer Diameter | OD |
| Collar Diameter | CD | Projection | P |
| Continuous Sleeve Length | CDL | Removal Clearance | R |
| Clearance | CL | Ring Diameter | RD |
| Diameter | D | Spacer | S |
| Counter Bore Depth | DC | Sleeve Diameter | SD |
| Face to Face | F | Screw Locations | SL |
| Flange Diameter | FD | Spacer Thickness | ST |
| Flange Length | FL | Screw Size | T |
| Floating Shaft Length | FSL | Taper Bore | TB |
| Gap | G | Thickness | TH |
| Hole Size | H | Taper Length | TL |
| Hub Diameter | HD | Tooth Spacing | TS |
| Hub Length | HL | Tooth Width | TW |
| Height | HT | Width | W |
| Inner Diameter | ID | | |

# IMPORTANT SAFETY INSTRUCTIONS

## ⚠ WARNING

■ When using VIRTUS products, you must follow these instructions and take the following precautions. Failure to do so may cause the power transmission product to break and parts to be thrown with sufficient force to cause severe injury or death.

-Refer to this VIRTUS Catalog for proper selection, sizing, horsepower, torque range, and speed range of power transmission products, including elastomeric elements for couplings. Follow the installation instructions included with the product, and in the individual product catalogs for proper installation of power transmission products. Do not exceed catalog ratings.

-During start up and operation of power transmission product, avoid sudden shock loads. Coupling assembly should operate quietly and smoothly. If coupling assembly vibrates or makes beating sound, shut down immediately, and recheck alignment. Shortly after initial operation and periodically thereafter, where applicable, inspect coupling assembly for: alignment, wear of elastomeric element, bolt torques, and flexing elements for signs of fatigue. Do not operate coupling assembly if alignment is improper, or where applicable, if elastomeric element is damaged, or worn to less than 75% of its original thickness.

-For variable speed drives, variable speed pulley rim speeds must never exceed 10,500 feet per minute. Companion pulley speeds beyond the ratings contained in this catalog are not recommended. For Fixed Center Drives, do not start until a torque arm bracket is installed. Failure to install torque arm bracket will cause torque arm to rotate rapidly and may cause severe injury from moving parts. Do not attempt to disassemble spring loaded pulley because parts may be thrown with sufficient force to cause injury or death.

■ Do not use any of these power transmission products for elevators, man lifts, or other devices that carry people. If the power transmission product fails, the lift device could fall resulting in severe injury or death.

■ For all power transmission products, you must install suitable guards in accordance with OSHA and American Society of Mechanical Engineers Standards. Do not start power transmission product before suitable guards are in place. Failure to properly guard these products may result in severe injury or death from personnel contacting moving parts or from parts being thrown from assembly in the event the power transmission product fails.

■ If you have any questions, contact the VIRTUS Engineering.

# Couplings Preselection Comparisons

| Selection Criterion | COUPLING TYPE | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | JAW | ES | MINIATURE (Beam) | NYLON SLEEVE GEAR | GEAR | GRID | DISC | DELTAFLEX | UNIFLEX | CENTAFLEX (Donut) | SAGA | UNIVERSAL JOINTS |
| Shaft Size Range –inch (MM) | .125 to 7.00 (4 to 178) | .375 to 5.50 (9 to 140) | .125 to .50 (3 to 12) | .313 to 1.625 (8 to 41) | .625 to 54.0 (15 to 1372) | .500 to 16.313 (14 to 414) | 0 to 15.94 (0 to 400) | .438 to 5 (11 to 127) | .125 to 1.50 (3 to 38) | .31 to 5.00 (7 to 130) | 1.188 to 4.750 (30 to 120.65) | .250 to 2.00 (6 to 50) |
| Torque Range –in–lbs. (Nm) | 3.5 to 170,000 (10.4 to 19,209) | 60 to 72,480 (6.78 to 8,189) | 1.35 to 16.5 (0.2 to 1.9) | 162 to 1,420 (18 to 160) | 2,520 to 54,390,000 (284 to 6,144,982) | 422 to 2,700,000 (48 to 306,000) | 504 to 7,699,500 (57 to 870,000) | 750 to 33,000 (84 to 3,728) | 18 to 1,890 (2 to 213.5) | 88 to 44,200 (10 to 5,000) | 350 to 20,000 (40 to 22.60) | 110 to 65,400 (12 to 7,389) |
| Maximum Angular Misalignment Capability (Degrees) | 1° to 1.3° | 1° | 5° | 3° to 5° | 1.5° | .25° | .15° | 6° | 4.5° | 3° | 3° | 25° |
| Temperature Range (std. element) | -40° to 212°F (-40° to 100°C) | -30° to 275°F (-34° to 135°C) | -40° to 200°F (-40° to 93°C) | -13° to 150°F (-25° to 66°C) | -40° to 225°F (-40° to 107°C) | -40° to 250°F (-40° to 121°C) | -40° to 536°F (-40° to 280°C) | -40° to 300°F (-40° to 149°C) | -40° to 250°F (-40° to 121°C) | -40° to 194°F (-40° to 90°C) | -60° to 200°F (-50° to 93°C) | -40° to 225°F (-40° to 107°C) |
| Reactionary Loads due to Misalignment (Low-Medium-High) | Medium | Low | Low | Medium | Medium | Medium | Low | Low | Low | Medium | Low | High |
| Torque to O.D. Capability | Good | Fair | Poor | Fair | Excellent | Good | Excellent | Good | Fair | Good | Fair | Excellent |
| Speed Capability | Good | Fair | Good | Fair | Excellent | Good | Excellent | Fair | Good | Fair | Good | Fair |
| Torsional Stiffness (Low-Medium-High) | Low | Low | Medium | High | High | Medium | High | High | Medium | Low | Low | High |
| Ease of Installation/ Maintenance | Excellent | Excellent | Excellent | Excellent | Fair | Fair | Fair | Fair | Excellent | Fair | Good | Fair |
| Chemical Resistance | Good | Good | Excellent | Good | Fair | Fair | Excellent | Excellent | Excellent | Fair | Fair | Fair |
| Adaptable to Several Designs | Excellent | Excellent | Poor | Poor | Excellent | Good | Excellent | Good | Fair | Good | Good | Good |
| Damping Capacity | Good | Excellent | Poor | Poor | Poor | Good | Poor | Poor | Poor | Excellent | Excellent | Poor |

Excellent, Good, Fair, and Poor are relative ratings.

## A Brief Tutorial on Misalignment

The function of a coupling is to connect driving and driven equipment. In addition, a coupling serves to protect costly equipment from the effects of misalignment, shock loads, vibration and shaft end float. Of these factors, the most common is misalignment and end float (also known as axial misalignment).

Misalignment is a condition created by two shafts whose axes are not in the same straight line. There are three forms of misalignment: parallel, angular, or the combination of the two. End float is the relative motion of two shaft ends.

Parallel misalignment occurs when the axes of the connected shafts are parallel, but not in the same straight line (fig. 1). Angular misalignment occurs when the axes of the shafts intersect at the center point of the coupling (fig. 2). End float occurs when one shaft moves along it's axis relative to the other shaft. (fig. 3)

Misalignment can result from a combination of manufacturing tolerances, poor installation practices, thermal growth or shrinkage, foundation movement, and/or component wear. The combination of angular and parallel misalignment within a system may be more detrimental to the coupling and equipment than either of the individual misalignment. Axial misalignment- result of either thrust loads, reaction loads, or heat generated movement - compounds the problem. Understanding the amount of misalignment that the coupling must handle or installing a coupling where it exceeds a maximum rated misalignment can result in premature coupling failure and/or significant equipment damage.

## Misalignment and Coupling Failure

The life expectancy of a coupling is affected by the degree of misalignment. The larger the misalignment, the shorter the life of the coupling as shown in fig.5. Misalignment may causes heat generation, fatigue, and an increase in wear in bearings of the drive and driven components.
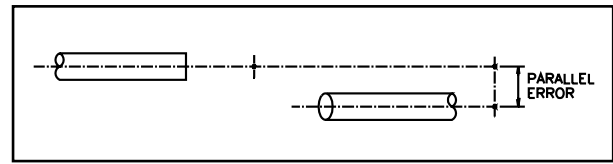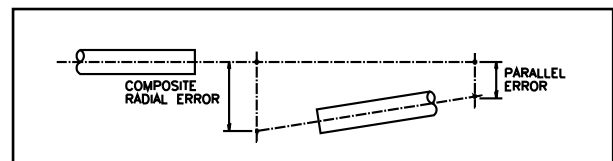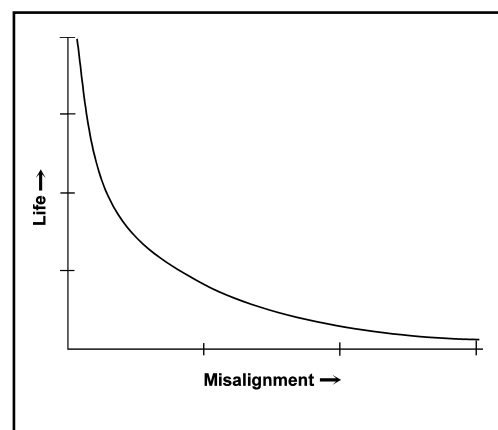


PARALLEL MISALIGNMENT
FIGURE 1
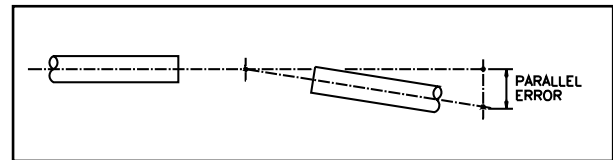


ANGULAR MISALIGNMENT
FIGURE 2
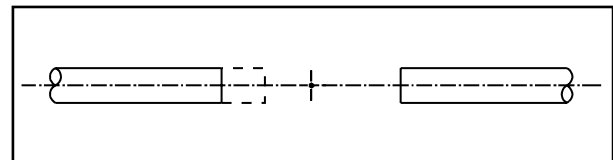


AXIAL MISALIGNMENT
FIGURE 3



COMPOSITE RADIAL MISALIGNMENT
FIGURE 4



LIFE VERSUS MISALIGNMENT
FIGURE 5

## When Misalignment Can Not be Measured

When it is not possible to measure the misalignment of a system, or in designing a new system, the following method can be used to estimate angular, parallel and combined misalignment. Each type of misalignment is first calculated and then the results are combined.

To calculate the maximum angular misalignment, the distance (L) and angle (a) must be known or estimated (see example below). First, calculate the angular misalignment noting the critical plane or midpoint of the shaft ends. Second, using the maximum parallel misalignment, be sure to consider both horizontal and vertical directions (Fig.3). Maximum parallel misalignment occurs when the shafts are diagonally opposed. Third, combine the results.

## Worked example

Calculate the worst possible composite alignment misalignment when:

$$\alpha1 \text{ max} = \pm0.4°$$
$$\alpha2 \text{ max} = \pm0.4°$$

| | |
|---|---|
| L max = 3 in. | L max = 75 mm (LH and RH shafts) |
| P1 max = 0.008 in. | P1 max = 0.2 mm |
| P2 max = 0.008 in. | P2 max = 0.2 mm |

1. Worst possible angular misalignment (Fig. 1) $= \alpha1 + \alpha2$

   $= 0.4° + 0.4°$

   $= 0.8°$

2. Maximum radial misalignment (Fig. 2) = R1 + R2

   Since $\alpha1$ and $\alpha2$ are equal, R1 = R2

   | Calculate for 2(R1) | $= 2 (\tan \alpha1 \times L)$ |
   |---|---|
   | $= 2 (\tan \alpha1 \times L)$ | $= 2 (\tan 0.4 \times 75)$ |
   | $= 2 (\tan 0.4 \times 3)$ | $= 2 (0.007 \times 75)$ |
   | $= 2 (0.007 \times 3)$ | $= 1.05$ mm |
   | $= 0.042$ in. | |

3. Maximum parallel misalignment P3 (Fig. 3) $= \sqrt{P_1^2 + P_2^2}$

   | $= \sqrt{0.008^2 + 0.008^2}$ | $= \sqrt{0.2^2 + 0.2^2}$ |
   |---|---|
   | $= 0.0113$ inches | $= 0.28$ mm |

4. Worst possible misalignment (Fig. 4) $R_C = R_1 + R_2 + P_3$

   | $= 0.042 + 0.0113$ | $= 1.05 + 0.28$ |
   |---|---|
   | $= 0.0533$ in. | $= 1.33$ mm |

*Note:* How relatively minor angular misalignments can produce disproportionate radial misalignments. In this example, they account for approximately 80% of the worst possible composite misalignment.

## Summary

| | |
|---|---|
| Worst possible angular misalignment | $= \alpha_1 + \alpha_2$ (Fig. 1) |
| Maximum radial misalignment | $= R_1 + R_2$ (Fig. 2) |
| Maximum parallel misalignment $\sqrt{(P_1^2 + P_2^2)}$ | $= P_3$ (Fig. 3) |
| Worst possible composite radial misalignment | $R_C = R_1 + R_2 + P_3$ (Fig. 4) |

*Figures 1 through 4 represent that $\alpha_1 = \alpha_2$ and $P_1 = P_2$, and that L is the same*
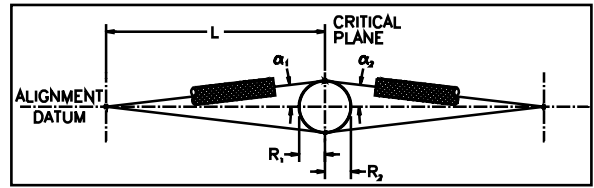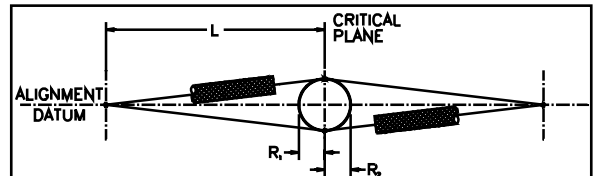*for LH and RH shafts.*



**FIGURE 1**



**FIGURE 2**
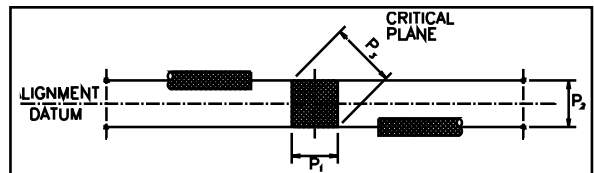


**FIGURE 3**
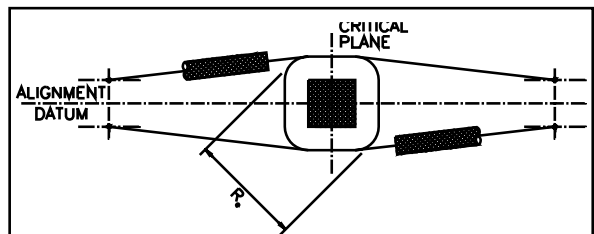


**FIGURE 4**

## *Formulas and Equations*

### Horsepower

One HP is the rate of work required to raise 33,000 pounds one foot in one minute.

$$HP = \frac{Force \times FPM}{33,000}$$

$$HP = \frac{Torque\ (in\ pound\text{-}inches) \times RPM}{63,025}$$

$$HP = \frac{Torque\ (in\ pound\text{-}feet) \times RPM}{5,252}$$

*FPM = Feet per minute*

*RPM = Revolutions per minute*



ONE HORSEPOWER [ONE KW]
ONE FOOT PER MINUTE [.305 METER PER MIN.]
33,000 LBS [11,163 KG]

### Horsepower per Hundred RPM

When the HP is given and the RPM, N, is known, HP/C is:

$$HP/C = \frac{HP \times 100}{N}$$

Once HP/C is known, HP @ *N* RPM is found by HP=HP/C x N

### *Example:*

15 HP @ 1750 RPM is:

$$HP/C = \frac{15 \times 100}{1750} = .85\ HP\ per\ 100\ RPM\ (HP/C)$$

Using .85 HP/C, the HP rating @ 800 RPM is:

$$\frac{.85}{100} \times 800 = .85 \times 8 = 6.8\ HP$$

$$KW = \frac{Nm \times RPM}{9,550}$$

### Kilowatts

One KW is the rate of work required to raise 11,163 kg 0.305 meter in one minute.

$$TQ = F\ (force) \times R\ (radius)$$

### *Inch example:*

20 HP at 100 RPM = 12,605 pound-inches Torque

$$Torque\ (in\text{-}lb) = \frac{63,025 \times HP}{RPM}$$

$$= Force \times Lever\ Arm\ (in\ inches)$$

### Torque

The twisting or turning effort around a shaft tending to cause rotation. Torque is determined by multiplying the applied force by the distance from the point where force is applied to the shaft center.

$$Torque\ (ft\text{-}lb) = \frac{5,252 \times HP}{RPM}$$

$$= Force \times Lever\ Arm\ (in\ feet)$$

*Force = Working load in pounds*

*Lever Arm = Distance from the force to the center of rotation in inches or feet.*

### Conversions

KW x 1.341 = HP
HP x 0.7457 = KW
Nm x 0.737562 = ft-lb
Nm x 8.85 = in-lb
ft-lb x 1.356 = Nm
in-lb x 0.113 = Nm
HP x 550 = ft-lb/sec

### *Metric example:*

10 KW at 100 RPM = 955 Nm:

$$Torque\ (Nm) = \frac{KW \times 9,550}{RPM}$$

*Force = Working load in Newtons*

*Lever Arm = Distance from the Force to the center of rotation in millimeters.*

## Formulas and Equations
### *Overhung Loads*

An overhung load is a bending force imposed on a shaft due to the torque transmitted by V-drives, chain drives and other power transmission devices, other than flexible couplings.

Most motor and reducer manufacturers list the maximum values allowable for overhung loads. These values should be compared with the load actually imposed by the connected drive.

Weights of the drive components are usually negligible. The formulas are based on the assumption that the load is applied at a point equal to one shaft diameter from the bearing face. Factor F, shown at right, depends on the type of drive used.

$$F = \begin{cases} 1.00 \text{ for single chain drives} \\ 1.10 \text{ for timing belt drives} \\ 1.25 \text{ for spur or helical gear or double chain drives} \\ 1.50 \text{ for V-belt drives} \\ 2.50 \text{ for flat belt drives} \end{cases}$$

### *Inch example:*
Find the overhung load imposed on a reducer by a double chain drive transmitting 7 HP @ 30 RPM. The pitch diameter of the sprocket is 10 in.; service factor is 1.3.

*Solution:*

$$O.H.L = \frac{(63,025)\ (7 \times 1.3)\ (1.25)}{(30)\ (5)} = 4,779.4 \text{ lbs.}$$

$$O.H.L. = \frac{63,025 \times HP \times F}{N \times R}$$

$HP$ = *Transmitted HP x service factor*
$N$ = *RPM of shaft*
$R$ = *Radius of sprocket, pulley, etc.*
$F$ = *Factor*

### *Metric example:*
Find the overhung load imposed on a reducer by a double chain drive transmitting 10 KW @ 30 RPM. The pitch diameter of the sprocket is 254 mm; service factor is 1.3.

*Solution:*

$$O.H.L = \frac{(376)\ (10 \times 1.3)\ (1.25)}{(30)\ (1.27)} = 160 \text{ N}$$

$$O.H.L. = \frac{376 \times KW \times F}{N \times R}$$

$KW$ = *Transmitted KW x service factor*
$N$ = *RPM of shaft*
$R$ = *Radius of sprocket, pulley, etc. (mm)*
$F$ = *Factor*

## *Formulas and Equations*
### Horsepower/Speed/Torque Relationships

| HP | | Speed (RPM) | | Torque | |
|---|---|---|---|---|---|
| Constant | — | Increases | ↑ | Decreases | ↓ |
| Constant | — | Decreases | ↓ | Increases | ↑ |
| Increases | ↑ | Constant | — | Increases | ↑ |
| Decreases | ↓ | Constant | — | Decreases | ↓ |
| Increases | ↑ | Increases | ↑ | Constant | — |
| Decreases | ↓ | Decreases | ↓ | Constant | — |

## *Electrical Formulas*

| To Find | Alternating Current | | To Find | Alternating or Direct Current |
|---|---|---|---|---|
| | Single-phase | Three-phase | | |
| Amperes when horsepower is known | $\dfrac{HP \times 746}{E \times Eff \times pf}$ | $\dfrac{HP \times 746}{1.73 \times E \times Eff \times pf}$ | Amperes when voltage and resistance are known | $\dfrac{E}{R}$ |
| Amperes when kilowatts are known | $\dfrac{KW \times 1,000}{E \times pf}$ | $\dfrac{KW \times 1,000}{1.73 \times E \times pf}$ | Voltage when resistance and current are known | $IR$ |
| Amperes when Kva are known | $\dfrac{Kva \times 1,000}{E}$ | $\dfrac{Kva \times 1,000}{1.73 \times E}$ | Resistance when voltage and current are known | $\dfrac{E}{I}$ |
| Kilowatts | $\dfrac{I \times E \times pf}{1,000}$ | $\dfrac{1.73 \times I \times E \times pf}{1,000}$ | **General Information (Approximation)** *(All values at 100% load)* | |

**General Information (Approximation)**
*(All values at 100% load)*

At 1,800 RPM, a motor develops 36 in-lb per HP.

At 1,200 RPM, a motor develops 54 in-lb per HP.

| Kva | $\dfrac{I \times E}{1,000}$ | $\dfrac{1.73 \times I \times E}{1,000}$ |
|---|---|---|

At 575 volts, a three-phase motor draws 1 amp per HP.

At 460 volts, a three-phase motor draws 1.25 amp per HP.

| Horsepower = (Output) | $\dfrac{I \times E \times Eff \times pf}{746}$ | $\dfrac{1.73 \times I \times E \times Eff \times pf}{746}$ |
|---|---|---|

At 230 volts, a three-phase motor draws 2.5 amp per HP.

At 230 volts, a single-phase motor draws 5 amp per HP.

At 115 volts, a single-phase motor draws 10 amp per HP.

I = Amperes; E = Volts; Eff = Efficiency; pf = power factor; Kva = Kilovolt amperes; KW = Kilowatts; R = Ohms

**Temperature conversion**

Deg. C = (Deg. F - 32) x 5/9

Deg. F = (Deg. C x 9/5) + 32

## *Motor Amps @ Full Load1*

| HP | Alt. Current | | DC | HP | Alt. Current | | DC | HP | Alt. Current | | DC | HP | Alt. Current | | DC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Single-Phase | Three-Phase | | | Single-Phase | Three-Phase | | | Single-Phase | Three-Phase | | | Single-Phase | Three-Phase | |
| $^1/_2$ | 4.9 | 2.0 | 2.7 | 5 | 28 | 14.4 | 20 | 25 | — | 60 | 92 | 75 | — | 180 | 268 |
| 1 | 8.0 | 3.4 | 4.8 | $7^1/_2$ | 40 | 21.0 | 29 | 30 | — | 75 | 110 | 100 | — | 240 | 355 |
| $1^1/_2$ | 10.0 | 4.8 | 6.6 | 10 | 50 | 26.0 | 38 | 40 | — | 100 | 146 | 125 | — | 300 | 443 |
| 2 | 12.0 | 6.2 | 8.5 | 15 | — | 38.0 | 56 | 50 | — | 120 | 180 | 150 | — | 360 | 534 |
| 3 | 17.0 | 8.6 | 12.5 | 20 | — | 50.0 | 74 | 60 | — | 150 | 215 | 200 | — | 480 | 712 |

**Note:** 1. Values are for all speeds and frequencies @ 230 volts. Amperage other than 230 volts can be figured:

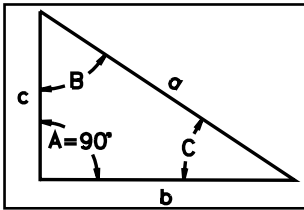$$V = \frac{230 \times Amp\ from\ Table}{New\ Voltage}$$

*Example:*

For 60 HP, three-phase @ 550 volts: $\dfrac{(230 \times 150)}{550} = 62$ amps

Power factor estimated @ 80 percent for most motors. Efficiency is usually 80 to 90 percent.

## *Trigonomic Formulas*
### *Angles and sides of right angle triangles*



### To find angles

| To find | Formulas |
|---------|----------|
| C | $\frac{c}{a}$ = Sine C |
| C | $\frac{b}{a}$ = Cosine C |
| C | $\frac{c}{b}$ = Tangent C |
| C | $\frac{b}{c}$ = Cotangent C |
| C | $\frac{a}{b}$ = Secant C |
| C | $\frac{a}{c}$ = Cosecant C |
| B | $\frac{b}{a}$ = Sine B |
| B | $\frac{c}{a}$ = Cosine B |
| B | $\frac{b}{c}$ = Tangent B |
| B | $\frac{c}{b}$ = Cotangent B |
| B | $\frac{a}{c}$ = Secant B |
| B | $\frac{a}{b}$ = Cosecant B |

### To find sides

| To find | Formulas | |
|---------|----------|--|
| a | $\sqrt{b^2 + c^2}$ | — |
| a | c x Cosecant C | $\frac{c}{\text{Sine C}}$ |
| a | c x Secant B | $\frac{c}{\text{Cosine B}}$ |
| a | b x Cosecant B | $\frac{b}{\text{Sine B}}$ |
| a | b x Secant C | $\frac{b}{\text{Cosine C}}$ |
| b | $\sqrt{a^2 - c^2}$ | — |
| b | a x Sine B | $\frac{a}{\text{Cosecant B}}$ |
| b | a x Cosine C | $\frac{a}{\text{Secant C}}$ |
| b | c x Tangent B | $\frac{c}{\text{Cotangent B}}$ |
| b | c x Cotangent C | $\frac{c}{\text{Tangent C}}$ |
| c | $\sqrt{a^2 - b^2}$ | — |
| c | a x Cosine B | $\frac{a}{\text{Secant B}}$ |
| c | a x Sine C | $\frac{a}{\text{Cosecant C}}$ |
| c | b x Cotangent B | $\frac{b}{\text{Tangent B}}$ |
| c | b x Tangent C | $\frac{b}{\text{Cotangent C}}$ |

### Formulas for finding functions of angles

| | |
|--|--|
| $\frac{\text{Side opposite}}{\text{Hypotenuse}}$ = Sine | |
| $\frac{\text{Side adjacent}}{\text{Hypotenuse}}$ = Cosine | |
| $\frac{\text{Side opposite}}{\text{Side adjacent}}$ = Tangent | |
| $\frac{\text{Side adjacent}}{\text{Side opposite}}$ = Cotangent | |
| $\frac{\text{Hypotenuse}}{\text{Side adjacent}}$ = Secant | |
| $\frac{\text{Hypotenuse}}{\text{Side opposite}}$ = Cosecant | |

### Formulas for finding sides of right triangles with an angle and side known

| To find | |
|---------|--|
| To find length of opposite side | Hypotenuse x Sine |
| | Hypotenuse / Cosecant |
| | Side adjacent x Tangent |
| | Side adjacent / Cotangent |
| To find length of adjacent side | Hypotenuse x Cosine |
| | Hypotenuse / Secant |
| | Side opposite x Cotangent |
| | Side opposite / Tangent |
| To find length of hypotenuse | Side opposite x Cosecant |
| | Side opposite / Sine |
| | Side adjacent x Secant |
| | Side adjacent / cosine |

## *Trigonomic Formulas*

### *Triangle*
Area = Base x 1/2 perpendicular height

### *Sphere*
Area of surface = Square of diameter x 3.1416
Volume = Cube of diameter x 0.5236

### *Cube*
Area of surface = Square of side x 6
Volume = Cube of side
Diagonal = Side x 1.732

### *Cylinder*
Area of curved surface = Diameter x length x 3.1416
Volume = Square of diameter x length x 0.7854

### *Cone*
Area of curved surface = Base diameter x slant height x 1.5708
Volume = Base diameter squared x perpendicular height x 0.2618
    (Or: Area of base x 1/3 perpendicular height)

### *Circle*
Area = Square of diameter x 0.7854 (Or: Square of radius x 3.1416)
Circumference = Diameter x 3.1416
Diameter = Circumference x 0.3183
Doubling diameter increases area four times; tripling diameter increases area nine times, etc.

### *Square*
Area = Square of side
Diagonal = Side x 1.4142
Side = Diagonal x 0.7071

### *Square inscribed in circle*
Side of square = Diameter of circle x 0.7071
    (Or: Circumference of circle x 0.2251)
Diameter of circle = Side of square x 1.4142
Circumference of circle = Side of square x 4.4429

### *Square and circle with equal area*
Side of square = Diameter of circle x 0.8862
Diameter of circle = Side of square x 1.128
Circumference of circle = Side of square x 3.545

### *Rectangle*
Area = Length x width
Diagonal = Square root of width2 + length2

# Engineering Data

**VIRTUS**
*Power Transmission*

## Conversion Tables and Charts

| Given | Multiply by | To find | Given | Multiply by | To find |
|---|---|---|---|---|---|
| Acres | 43,560 | Square feet | Cubic meter | 1,000 | Liter |
| Acres | 4,046.8564 | Square meters | Cubic yards | 27 | Cubic feet |
| Acres | $1.562 \times 10^{-3}$ | Square miles | Cubic yards | 0.7645548 | Cubic meter |
| Atmospheres | 76 | Cm of mercury | Cubic yards | 201.974 | Gallons (U.S.) |
| Atmospheres | 33.89854 | Feet of water | Cubic yards/minutes | 0.45 | Cubic feet/second |
| Atmospheres | 29.92 | Inches of mercury | Cubic yards/minutes | 3.366234 | Gallons (U.S.)/sec. |
| Atmospheres | 14.69595 | Pounds/square inch | Degree | 0.017453 | Radian |
| BTU | 251.996 | Calorie | Degree/second | 0.166667 | Revolution/minute |
| BTU | 778.169 | Foot-pounds-force | Fathom | 6 | Feet |
| BTU | $3.9302 \times 10^{-4}$ | Horsepower-hours | Feet of water | 0.0295 | Atmospheres |
| BTU | 0.252 | Kilogram-calories | Feet of water | 0.8826 | Inches of mercury |
| BTU | 107.586 | Kilogram-meters | Feet of water | 304.8 | Kilograms/sq. meter |
| BTU | $2.9307 \times 10^{-4}$ | Kilowatt-hours | Feet of water | 62.43 | Pounds/square foot |
| BTU | 1,055.056 | Joule | Feet of water | 0.4335 | Pounds/square inch |
| BTU / minutes | 12.96 | Foot-pounds/second | Feet/minute | 0.508 | Centimeter/second |
| BTU / minutes | 0.0235809 | Horsepower | Feet/minute | 0.01667 | Feet/second |
| BTU / minutes | 0.0175843 | Kilowatts | Feet/minute | 0.01829 | Kilometers/hour |
| BTU / minutes | 17.5769 | Watts | Feet/minute | 0.3048 | Meters/minute |
| Centimeters | 0.3937008 | Inches | Feet/minute | 0.01136 | Miles/hour |
| Centimeters | 0.01 | Meters | Feet/second | 30.48 | Centimeters/second |
| Centimeters | 10 | Millimeters | Feet/second | 1.097 | Kilometers/hour |
| Cm of mercury | 0.01316 | Atmospheres | Feet/second | 0.5921 | Knots |
| Cm of mercury | 0.4461 | Feet of water | Feet/second | 18.29 | Meters/minute |
| Cm of mercury | 136 | Kg/square meter | Feet/second | 0.6818 | Miles/hour |
| Cm of mercury | 27.85 | Pounds/square foot | Feet/second | 0.01136 | Miles/minute |
| Cm of mercury | 0.1934 | Pounds/square inch | Ferkin (U.S.) | 9 | Gallons (U.S.) |
| Coulomb | 1 | Ampere-second | Foot | 30.48 | Centimeter |
| Cubic centimeter | 0.06102 | Cubic inches | Foot | 12 | Inch |
| Cubic centimeter | 0.001 | Liter | Foot | 0.3048 | Meter |
| Cubic centimeter | 1000 | Cubic millimeter | Foot-pounds | 1.356 | NewtoNmeter |
| Cubic centimeter | 0.0353 | Cubic feet | Foot-pounds-force | $1.286 \times 10^{-3}$ | BTU |
| Cubic feet | 1,728 | Cubic inches | Foot-pounds-force | $5.050 \times 10^{-7}$ | Horsepower-hours |
| Cubic feet | 0.0283168 | Cubic meters | Foot-pounds-force | 1.35582 | Joules |
| Cubic feet | 0.037037 | Cubic yard | Foot-pounds-force | 0.1383 | Kilogram-meters |
| Cubic feet | 6.228835 | Gallons (British) | Foot-pounds-force | $0.766 \times 10^{-5}$ | Kilowatt-hours |
| Cubic feet | 7.480519 | Gallons (U.S.) | Foot-pounds/minute | $1.286 \times 10^{-3}$ | BTU/minute |
| Cubic feet | 28.316847 | Liters | Foot-pounds/minute | 0.01667 | Foot-pounds/second |
| Cubic feet | 25.71405 | Quarts (U.S. dry) | Foot-pounds/minute | $3.03 \times 10^{-4}$ | Horsepower |
| Cubic feet/hour | 7.865791 | Cubic cm/second | Foot-pounds/minute | $2.26 \times 10^{-5}$ | Kilowatts |
| Cubic feet/hour | 0.4719474 | Liter/minute | Foot-pounds/second | $7.717 \times 10^{-2}$ | BTU/minute |
| Cubic feet/minute | 0.1246753 | Gallons (U.S.)/sec. | Foot-pounds/second | $1.818 \times 10^{-3}$ | Horsepower |
| Cubic feet/pound | 0.0624279 | Cubic meter/kilogram | Foot-pounds/second | 1.355818 | Watts |
| Cubic meter | 35.31467 | Cubic feet | Gallon (British) | 9.632619 | Cubic feet/hour |
| Cubic meter | 1.307951 | Cubic yards | Gallon (British) | 0.2727654 | Cubic meter/hour |
| Cubic meter | 264.1721 | Gallons (U.S.) | Gallons (U.S.)/minute | 8.020834 | Cubic feet/hour |

# Engineering Data

## Conversion Tables and Charts

| Given | Multiply by | To find | Given | Multiply by | To find |
|---|---|---|---|---|---|
| Gallons (U.S.)/minute | 0.2271247 | Cubic meter/hour | Inches of mercury | 0.4912 | Pounds/square inch |
| Gallon (dry) | 268.8025 | Cubic inch | Inches of water | 0.002458 | Atmospheres |
| Gallons (liquid) | 3,785.412 | Cubic centimeters | Inches of water | 0.07355 | Inches of mercury |
| Gallons (liquid) | 0.1336805 | Cubic feet | Inches of water | 25.4 | Kilograms/sq. meter |
| Gallons (liquid) | 231 | Cubic inches | Inches of water | 0.5781 | Ounces/square inch |
| Gallons (liquid) | $4.951 \times 10^{-3}$ | Cubic yards | Inches of water | 5.202 | Pounds/square foot |
| Gallons (liquid) | 0.8326742 | Gallons (British) | Inches of water | 0.03613 | Pounds/square inch |
| Gallons (liquid) | 3.785412 | Liters | Inch-pounds | 0.11298 | NewtoNmeters |
| Gallons (liquid) | 8 | Pints (liquid) | Joule | 0.000948 | BTU |
| Gallons (liquid) | 4 | Quarts (liquid) | Kilograms | 9.81 | Newtons |
| Gallons water | 8.3453 | Pounds of water | Kilograms | 2.2046226 | Pounds |
| Gallons water/minute | 6.0086 | Tons of water/24 hrs. | Kilograms | $1.102 \times 10^{-3}$ | Tons (short) |
| Gallons—Imperial | 1.20095 | Gallons—U.S. | Kilograms | $10^3$ | Grams |
| Gallons—U.S. | 0.83267 | Gallons—Imperial | Kilograms-calories | 3.968 | BTU |
| Gallons (U.S.)/minute | $2.228 \times 10^{-3}$ | Cubic feet/second | Kilograms-calories | 3086 | Foot-pounds |
| Gallons (U.S.)/minute | 8.020834 | Cubic feet/hour | Kilograms-calories | $1.558 \times 10^{-3}$ | Horsepower-hours |
| Gallons (U.S.)/minute | 0.06308 | Liters/second | Kilograms-calories | $1.162 \times 10^{-3}$ | Kilowatt-hours |
| Grams | $10^{-3}$ | Kilograms | Kilometers | 3,280.84 | Feet |
| Grams | 0.0352739 | Ounces | Kilometers | $10^3$ | Meters |
| Grams | 0.03215 | Ounces (troy) | Kilometers | 0.6213712 | Miles |
| Grams | $2.205 \times 10^{-3}$ | Pounds | Kilometers | 1,094 | Yards |
| Grams (troy) | $2.0833 \times 10^{-3}$ | Ounces (troy) | Kilometers/hour | 54.68 | Feet/minute |
| Grams/centimeter | $5.6 \times 10^{-3}$ | Pounds/inch | Kilometers/hour | 0.9113 | Feet/second |
| Grams/cubic cm | 62.43 | Pounds/cubic foot | Kilometers/hour | 0.53996 | Knots |
| Grams/cubic cm | 0.03613 | Pounds/cubic inch | Kilometers/hour | 16.67 | Meters/minute |
| Grams/liter | 8.345 | Pounds/1,000 gallons | Kilometers/hour | 0.6214 | Miles/hour |
| Grams/liter | 0.062427 | Pounds/cubic foot | Killowatt-hours | 3,415 | BTU |
| Grams/liter | 1,000 | Parts/million | Killowatt-hours | $2.655 \times 10^6$ | Foot-pounds |
| Horsepower | 42.4072 | BTU/minute | Killowatt-hours | 1.341 | Horsepower-hours |
| Horsepower | 33,000 | Foot-pounds/minute | Killowatt-hours | $3.6 \times 10^6$ | Joule |
| Horsepower | 550 | Foot-pounds/second | Killowatt-hours | 860.5 | Kilogram-calories |
| Horsepower | 1.014 | Horsepower (metric) | Killowatt-hours | $3.67 \times 10^5$ | Kilogram-meters |
| Horsepower | 0.7457 | Kilowatts | Kilowatts | 56.869 | BTU/minute |
| Horsepower | 745.7 | Watts | Kilowatts | 44,253.7 | Foot-pounds/minute |
| Horsepower (boiler) | 33,479 | BTU/hour | Kilowatts | 737.6 | Foot-pounds/second |
| Horsepower (boiler) | 9.8095 | Kilowatt | Kilowatts | 1.34102 | Horsepower |
| Horsepower-hours | 2,547 | BTU | Kilowatts | 14.3308 | Kg-calories/minute |
| Horsepower-hours | $1.98 \times 10^6$ | Foot-pounds | Kilowatts | $10^3$ | Watts |
| Horsepower-hours | $2.737 \times 10^5$ | Kilogram-meters | Knots | 1.150779 | Miles (statute)/hour |
| Horsepower-hours | 0.7457 | Kilowatt-hours | League (statute) | 3 | Miles (statute) |
| Inch | 25.4 | Millimeters | Light year | $5.8785 \times 10^{12}$ | Miles |
| Inches of mercury | 0.03342 | Atmospheres | Liters | $10^3$ | Cubic centimeters |
| Inches of mercury | 1.133 | Feet of water | Liters | 0.03531 | Cubic feet |
| Inches of mercury | 345.3 | Kilograms/sq. meter | Liters | 61.02 | Cubic inches |
| Inches of mercury | 70.73 | Pounds/square foot | Liters | $10^{-3}$ | Cubic meters |

# Engineering Data

## Conversion Tables and Charts

| Given | Multiply by | To find | Given | Multiply by | To find |
|---|---|---|---|---|---|
| Liters | $1.308 \times 10^{-3}$ | Cubic yards | NewtoNmeter | 0.737562 | Foot-pound-force |
| Liters | 0.2642 | Gallons | NewtoNmeter | 8.85 | Inch-pound-force |
| Liters | 2.113 | Pints (liquid) | Newtons | 0.22481 | Pounds |
| Liters | 0.908 | Quarts (dry) | Ounces | 0.0625 | Pounds |
| Liters | 1.0567 | Quarts (liquid) | Ounces | 28.349527 | Grams |
| Liters/minute | $5.886 \times 10^{-4}$ | Cubic feet/second | Ounces | 0.9115 | Ounces (troy) |
| Liters/minute | 13.19815 | Gallons (British)/hour | Ounces | $2.79 \times 10^{-5}$ | Tons (long) |
| Liters/minute | $4.403 \times 10^{-3}$ | Gallons/second | Ounces | $2.835 \times 10^{-5}$ | Tons (metric) |
| Liters/second | 2.11888 | Cubic feet/minute | Ounces (fluid) | 1.805 | Cubic inches |
| Meters | 100 | Centimeters | Ounces (fluid) | 0.02957 | Liters |
| Meters | 3.2808399 | Feet | Ounces (fluid) | 30 | Milliliters |
| Meters | 39.37 | Inches | Ounces (fluid) | 1.040843 | Ounces (British fluid) |
| Meters | $10^{-3}$ | Kilometers | Ounces (troy) | 0.08333 | Pounds (troy) |
| Meters | $10^{3}$ | Millimeters | Ounces (troy) | 31.103481 | Grams |
| Meters | 1.093613 | Yards | Ounces (troy) | 1.09714 | Ounces (avoir) |
| Meters/minute | 1.667 | Centimeters/second | Ounces/square inch | 0.0625 | Pounds/square inch |
| Meters/minute | 3.281 | Feet/minute | Parts/million | 0.0584 | Grains/U.S. gallon |
| Meters/minute | 0.05468 | Feet/second | Parts/million | 0.07016 | Grains/Imperial gal. |
| Meters/minute | 0.06 | Kilometers/hour | Parts/million | 8.345 | Pounds/million gal. |
| Meters/minute | 0.03728 | Miles/hour | Pascal | 0.0208854 | Pounds-force/sq. ft. |
| Meters/second | 3.281 | Feet/second | Pounds | 16 | Ounces |
| Meters/second | 3.6 | Kilometers/hour | Pounds | 0.0005 | Tons (short) |
| Meters/second | 0.06 | Kilometers/minute | Pounds | 453.5924 | Grams |
| Meters/second | 2.236936 | Miles/hour | Pounds | 1.21528 | Pounds (troy) |
| Mil | 0.001 | Inch | Pounds | 14.5833 | Ounces (troy) |
| Mil | 0.0254 | Millimeter | Pounds | 4.45 | Newtons |
| Miles | 5,280 | Feet | Pounds of water | 0.01602 | Cubic feet |
| Miles | 1.609 | Kilometers | Pounds of water | 27.68 | Cubic inches |
| Miles | 1,760 | Yards | Pounds of water | 0.1198 | Gallons |
| Miles/hour | 44.7 | Centimeters/second | Pounds of water/min. | $2.67 \times 10^{-4}$ | Cubic feet/second |
| Miles/hour | 88 | Feet/minute | Pounds (troy) | 12 | Ounces (troy) |
| Miles/hour | 1.467 | Feet/second | Pounds (troy) | 373.24177 | Grams |
| Miles/hour | 0.86898 | Knots | Pounds (troy) | 0.822857 | Pounds (avoir) |
| Miles/hour | 26.82 | Meters/minute | Pounds (troy) | 13.1657 | Ounces (avoir) |
| Miles/minute | 2,682 | Centimeters/second | Pounds (troy) | $3.6735 \times 10^{-4}$ | Tons (long) |
| Miles/minute | 88 | Feet/second | Pounds (troy) | $4.1143 \times 10^{-4}$ | Tons (short) |
| Miles/minute | 1.609 | Kilometers/minute | Pounds (troy) | $4.1667 \times 10^{-3}$ | Tons (metric) |
| Milligrams | $10^{-3}$ | Grams | Pounds/cubic foot | 0.01602 | Grams/cubic cm |
| Milligrams/liter | 1 | Parts/million | Pounds/cubic foot | 16.02 | Kgs/cubic meter |
| Milliliters | 0.0610237 | Cubic inch | Pounds/cubic foot | $5.787 \times 10^{-4}$ | Pounds/cubic inch |
| Milliliters | 0.0338142 | Fluid ounces | Pounds/cubic inch | 27.68 | Grams/cubic cm |
| Milliliters | $10^{-3}$ | Liters | Pounds/cubic inch | $2.768 \times 10^{4}$ | Kgs./cubic meter |
| Millimeters | 0.1 | Cenitmeters | Pounds/cubic inch | 1,728 | Pounds/cubic foot |
| Millimeters | 0.03937 | Inches | Pounds/foot | 1.488 | Kilograms/meter |
| Minutes (angle) | $2.909 \times 10^{-4}$ | Radians | Pounds/inch | 178.6 | Grams/centimeter |

# Engineering Data

## Conversion Tables and Charts

| Given | Multiply by | To find | Given | Multiply by | To find |
|---|---|---|---|---|---|
| Pounds/square foot | 0.01602 | Feet of water | Square meters | 1.196 | Square yards |
| Pounds/square foot | 4.883 | Kgs/square meter | Square miles | $27.88 \times 10^6$ | Square feet |
| Pounds/square foot | $6.945 \times 10^{-3}$ | Pounds/square inch | Square miles | 2.59 | Square kilometers |
| Pounds/square inch | 0.068046 | Atmospheres | Square miles | $3.098 \times 10^6$ | Square yards |
| Pounds/square inch | 2.307 | Feet of water | Square millimeters | 0.01 | Square centimeters |
| Pounds/square inch | 2.03602 | Inches of mercury | Square millimeters | $1.55 \times 10^{-3}$ | Square inches |
| Pounds/square inch | 703.1 | Kgs/square meter | Square yards | 9 | Square feet |
| Psi | 1 | Pound-force/sq. inch | Square yards | 0.8361 | Square meters |
| Quarts (dry) | 67.200625 | Cubic inches | Square yards | $3.228 \times 10^{-7}$ | Square miles |
| Quarts (dry) | 1.101 | Liters | Temp. (°C+17.78) | 1.8 | Temperature (°F) |
| Quarts (liquid) | 57.75 | Cubic inches | Temp. (°F-32) | 0.55556 ($^5/_9$) | Temperature (°C) |
| Quarts (liquid) | 0.9463 | Liter | Therm | 100,000 | BTU |
| Quarts (liquid) | 0.8326742 | Quart (British) | Tons (long) | 1,016.0469 | Kilograms |
| Quarts (liquid) | 0.859367 | Quart (dry) | Tons (long) | 1.016047 | Tons (metric) |
| Radians | 57.29578 | Degrees | Tons (long) | 2,240 | Pounds |
| Radians | 3,437.747 | Minutes | Tons (long) | 1.12 | Tons (short) |
| Radians/second | 57.3 | Degrees/second | Tons (metric) | $10^3$ | Kilograms |
| Radians/second | 0.1592 | Revolutions/second | Tons (metric) | 2,205 | Pounds |
| Radians/second | 9.549297 | Revolutions/minute | Tons (short) | 2,000 | Pounds |
| Revolutions | 360 | Degrees | Tons (short) | 32,000 | Ounces |
| Revolutions | 6.283 | Radians | Tons (short) | 907.18486 | Kilograms |
| Revolutions/minute | 6 | Degrees/second | Tons (short) | 2,430.56 | Pounds (troy) |
| Revolutions/minute | 0.1047 | Radians/second | Tons (short) | 0.89287 | Tons (long) |
| Revolutions/minute | 0.01667 | Revolutions/second | Tons (short) | 29,166 | Ounces (troy) |
| Revolutions/second | 360 | Degrees/second | Tons (short) | 0.90718 | Tons (metric) |
| Revolutions/second | 6.283 | Radians/second | Watts | 0.05692 | BTU/minutes |
| Revolutions/second | 60 | Revolutions/minute | Watts | 44.26 | Foot-pounds/minute |
| Square centimeters | $10^{-4}$ | Square meters | Watts | 0.7376 | Foot-pounds/second |
| Square feet | 144 | Square inches | Watts | $1.341 \times 10^{-3}$ | Horsepower |
| Square feet | 0.0929 | Square meters | Watts | 0.01434 | Kg-calories/minute |
| Square feet | $3.587 \times 10^{-3}$ | Square miles | Watts | $10^{-3}$ | Kilowatts |
| Square feet | 0.11111 ($^1/_9$) | Square yards | Watts-hours | 3.41214 | BTU |
| Square inches | 6.452 | Square centimeters | Watts-hours | 2,655 | Foot-pounds-force |
| Square inches | $6.944 \times 10^{-3}$ | Square feet | Watts-hours | $1.341 \times 10^{-3}$ | Horsepower-hours |
| Square inches | 645.2 | Square millimeters | Watts-hours | 3,600 | Joules |
| Square kilometers | $10.76 \times 10^6$ | Square feet | Watts-hours | 0.8605 | Kilogram-calories |
| Square kilometers | $10^6$ | Square meters | Watts-hours | 367.1 | Kilogram-meters |
| Square kilometers | 0.3861 | Square miles | Watts-hours | $10^{-3}$ | Kilowatt-hours |
| Square kilometers | $1.196 \times 10^6$ | Square yards | Yards | 36 | Inches |
| Square meters | 10.76 | Square feet | Yards | 0.9144 | Meters |
| Square meters | $3.861 \times 10^{-7}$ | Square miles | | | |

# Engineering Data

## Conversion Tables and Charts

*Inch-Millimeter Equivalents*

| Fraction | Decimal | mm |
|---|---|---|
|  | .00004 | .001 |
|  | .00039 | .01 |
|  | .00079 | .02 |
|  | .001 | .025 |
|  | .00118 | .03 |
|  | .00157 | .04 |
|  | .00197 | .05 |
|  | .002 | .051 |
|  | .00236 | .06 |
|  | .00276 | .07 |
|  | .003 | .0762 |
|  | .00315 | .08 |
|  | .00354 | .09 |
|  | .00394 | .1 |
|  | .004 | .1016 |
|  | .005 | .1270 |
|  | .006 | .1524 |
|  | .007 | .1778 |
|  | .00787 | .2 |
|  | .008 | .2032 |
|  | .009 | .2286 |
|  | .00984 | .25 |
|  | .01 | .254 |
|  | .01181 | .3 |
| 1/64 | .01563 | .3969 |
|  | .01575 | .4 |
|  | .01969 | .5 |
|  | .02 | .508 |
|  | .02362 | .6 |
|  | .025 | .635 |
|  | .02756 | .7 |
|  | .0295 | .75 |
|  | .03 | .762 |
| 1/32 | .03125 | .7938 |
|  | .0315 | .8 |
|  | .03543 | .9 |
|  | .03937 | 1 |
|  | .04 | 1.016 |
| 3/64 | .04687 | 1.191 |
|  | .04724 | 1.2 |
|  | .05 | 1.27 |
|  | .05512 | 1.4 |
|  | .05906 | 1.5 |
|  | .06 | 1.524 |
| 1/16 | .06250 | 1.5875 |
|  | .06299 | 1.6 |
|  | .06693 | 1.7 |
|  | .07 | 1.778 |
|  | .07087 | 1.8 |
|  | .075 | 1.905 |
| 5/64 | .07813 | 1.9844 |
|  | .07874 | 2 |
|  | .08 | 2.032 |
|  | .08661 | 2.2 |
|  | .09 | 2.286 |
|  | .09055 | 2.3 |
| 3/32 | .09375 | 2.3812 |
|  | .09843 | 2.5 |
|  | .1 | 2.54 |
|  | .10236 | 2.6 |
| 7/64 | .10937 | 2.7781 |

| Fraction | Decimal | mm |
|---|---|---|
|  | .11811 | 3 |
| 1/8 | .1250 | 3.175 |
|  | .13780 | 3.5 |
| 9/64 | .14063 | 3.5719 |
|  | .150 | 3.810 |
| 5/32 | .15625 | 3.9688 |
|  | .15748 | 4 |
| 11/64 | .17188 | 4.3656 |
|  | .1750 | 4.445 |
|  | .17717 | 4.5 |
| 3/16 | .18750 | 4.7625 |
|  | .19685 | 5 |
|  | .20 | 5.08 |
| 13/64 | .20313 | 5.1594 |
|  | .21654 | 5.5 |
| 7/32 | .21875 | 5.5562 |
|  | .2250 | 5.715 |
| 15/64 | .23438 | 5.9531 |
|  | .23622 | 6 |
| 1/4 | .250 | 6.35 |
|  | .25591 | 6.5 |
| 17/64 | .26563 | 6.7469 |
|  | .275 | 6.985 |
|  | .27559 | 7 |
| 9/32 | .28125 | 7.1438 |
|  | .29528 | 7.5 |
| 19/64 | .29688 | 7.5406 |
|  | .30 | 7.62 |
| 5/16 | .3125 | 7.9375 |
|  | .31496 | 8 |
| 21/64 | .32813 | 8.3344 |
|  | .33465 | 8.5 |
| 11/32 | .34375 | 8.7312 |
|  | .350 | 8.89 |
|  | .35433 | 9 |
| 23/64 | .35938 | 9.1281 |
|  | .37402 | 9.5 |
| 3/8 | .375 | 9.525 |
| 25/64 | .39063 | 9.9219 |
|  | .39370 | 10 |
|  | .400 | 10.16 |
| 13/32 | .40625 | 10.3188 |
|  | .41339 | 10.5 |
| 27/64 | .42188 | 10.7156 |
|  | .43307 | 11 |
| 7/16 | .43750 | 11.1125 |
|  | .450 | 11.430 |
|  | .45276 | 11.5 |
| 29/64 | .45313 | 11.5094 |
| 15/32 | .46875 | 11.9062 |
|  | .47244 | 12 |
| 31/64 | .48438 | 12.3031 |
|  | .49213 | 12.5 |
| 1/2 | .50 | 12.7 |
|  | .51181 | 13 |
| 33/64 | .51563 | 13.0969 |
| 17/32 | .53125 | 13.4938 |
|  | .53150 | 13.5 |
| 35/64 | .54688 | 13.8906 |

| Fraction | Decimal | mm |
|---|---|---|
|  | .550 | 13.970 |
|  | .55118 | 14 |
| 9/16 | .56250 | 14.2875 |
|  | .57087 | 14.5 |
| 37/64 | .57813 | 14.6844 |
|  | .59055 | 15 |
| 19/32 | .59375 | 15.0812 |
|  | .600 | 15.24 |
| 39/64 | .60938 | 15.4781 |
|  | .61024 | 15.5 |
| 5/8 | .6250 | 15.875 |
|  | .62992 | 16 |
| 41/64 | .64063 | 16.2719 |
|  | .64961 | 16.5 |
|  | .650 | 16.51 |
| 21/32 | .65625 | 16.6688 |
|  | .66929 | 17 |
| 43/64 | .67188 | 17.0656 |
| 11/16 | .68750 | 17.4625 |
|  | .68898 | 17.5 |
|  | .700 | 17.78 |
| 45/64 | .70313 | 17.8594 |
|  | .70866 | 18 |
| 23/32 | .71875 | 18.2562 |
|  | .72835 | 18.5 |
| 47/64 | .73438 | 18.6531 |
|  | .74803 | 19 |
| 3/4 | .750 | 19.050 |
| 49/64 | .76563 | 19.4469 |
|  | .76772 | 19.5 |
| 25/32 | .78125 | 19.8438 |
|  | .78740 | 20 |
| 51/64 | .79688 | 20.2406 |
|  | .800 | 20.320 |
|  | .80709 | 20.5 |
| 13/16 | .81250 | 20.6375 |
|  | .82677 | 21 |
| 53/64 | .82813 | 21.0344 |
| 27/32 | .84375 | 21.4312 |
|  | .84646 | 21.5 |
|  | .850 | 21.590 |
| 55/64 | .85938 | 21.8281 |
|  | .86614 | 22 |
| 7/8 | .875 | 22.225 |
|  | .88583 | 22.5 |
| 57/64 | .89063 | 22.6219 |
|  | .900 | 22.860 |
|  | .90551 | 23 |
| 29/32 | .90625 | 23.0188 |
| 59/64 | .92188 | 23.4165 |
|  | .92520 | 23.5 |
| 15/16 | .93750 | 23.8125 |
|  | .94488 | 24 |
|  | .950 | 24.130 |
| 61/64 | .95313 | 24.2094 |
|  | .96457 | 24.5 |
| 31/32 | .96875 | 24.6062 |
|  | .98425 | 25 |
| 63/64 | .98438 | 25.0031 |
| 1 | 1.00000 | 25.4 |

# Engineering Data

## Sleeve and Flexible Element Chemical Resistance Chart

**Legend:** A = Fluid has little or no effect; B = Fluid has minor to moderate effect; C = Fluid has severe effect; — = No data available

| Resistance to: | NBR ("SOX") | Urethane | Hytrel | EPDM | Neoprene |
|---|---|---|---|---|---|
| Acetone | C | C | B | A | B |
| Ammonia Anhydrous | — | — | — | A | A |
| Ammonium Hydroxide Solutions | C | C | A | A | A (158°F) |
| ASTM oil No. 1 | A | A | A | C | A |
| ASTM oil No. 3 | A | B | A | C | B-C (158°F) |
| ASTM reference fuel A | A | A | A | C | B |
| ASTM reference fuel B | A | B | A | C | C |
| ASTM reference fuel C | B | C | B | C | C |
| Benzene | C | C | B | C | C |
| Butane | A | A | A | C | A |
| Carbon Tetrachloride | C | C | C | C | C |
| Chlorobenzene | C | C | C | C | C |
| Chloroform | C | C | C | C | C |
| Chromic Acid 10-50% | C | C | — | C | C |
| Dowtherm A or E solvent | — | — | — | C | C |
| Ethyl Alcohol | C | C | A | A | A (158°F) |
| Ethylene Glyco | A | B | A | A | A (158°F) |
| Fuel Oil | A | C | — | C | A |
| Gasoline | A | B | A | C | B |
| Glycerine | A | C | A | A | A |
| Hydraulic Oils | | | | | |
|   (Petroleum Based) | A | A | A | C | A-B |
| Hydrochloric Acid, 37% | | | | | |
|   (cold) | C | C | C | A | A-B |
| Hydrogen Peroxide, 90% | C | — | — | C | C |
| Isopropyl Alcohol | B | C | A | A | A-B |
| Kerosene | A | B | A | C | B-C |
| Lacquer Solvents (MEK) | C | C | C | C | C |
| Lubricating Oils | B | — | A | C | B |
| Methyl Alcohol | C | C | A | A | A |
| Mineral Oil | A | A | A | C | B |
| Naphtha | C | C | A | C | C |
| Nitric Acid, 10% | C | C | B | B | B |
| Nitrobenzene | C | C | C | C | C |
| Phenol | C | C | B | C | C |
| Phosphoric Acid, 20% | C | A | — | A | B |
| Phosphate Esters | — | — | A | C | C |
| Pickling Solution | | | | | |
|   (20% Nitric Acid, 4% HP) | C | C | C | C | C |
| Soap Solutions | A | A | A | A | A(158°F) |
| Sodium Hydroxide, 20% | B | B | A | A | B |
| Stearic Acid | B | A | A | B | B (158°F) |
| Sulfuric Acid, up to 50% | C | C | A | B | A-B (158°F) |
| Sulfuric Acid, 50% to 80% | C | C | C | B | B-C |
| Tannic Acid, 10% | A | — | A | A | A-B |
| Toluene | C | C | A | C | C |
| Trichloroethylene | C | C | B | C | C |
| Turpentine | A | C | — | C | C |
| Water | A | — | B (158°F) | A (158°F) | A (212°F) |
| Xylene | C | C | B | C | C |

## Metric Clearance-fit Bore and Keyway Standards

*Bore Tolerances per DIN 7154, H7; Keyway Tolerances per DIN 6885, Js9*

| Bore mm | Keyway mm | Height mm | Bore Min. | Bore Max. | Keyway Min. | Keyway Max. | T Min. | T Max. |
|---|---|---|---|---|---|---|---|---|
| 8 | 2 | 1 | 8.000 | 8.015 | 1.9875 | 2.0125 | 9.000 | 9.100 |
| 9 | 3 | 1.4 | 9.000 | 9.015 | 2.9875 | 3.0125 | 10.400 | 10.500 |
| 10 | 3 | 1.4 | 10.000 | 10.015 | 2.9875 | 3.0125 | 11.400 | 11.500 |
| 11 | 4 | 1.8 | 11.000 | 11.018 | 3.9850 | 4.0150 | 12.800 | 12.900 |
| 12 | 4 | 1.8 | 12.000 | 12.018 | 3.9850 | 4.0150 | 13.800 | 13.900 |
| 14 | 5 | 2.3 | 14.000 | 14.018 | 4.9850 | 5.0150 | 16.300 | 16.400 |
| 15 | 5 | 2.3 | 15.000 | 15.018 | 4.9850 | 5.0150 | 17.300 | 17.400 |
| 16 | 5 | 2.3 | 16.000 | 16.018 | 4.9850 | 5.0150 | 18.300 | 18.400 |
| 17 | 5 | 2.3 | 17.000 | 17.018 | 4.9850 | 5.0150 | 19.300 | 19.400 |
| 19 | 6 | 2.8 | 19.000 | 19.021 | 5.9850 | 6.0150 | 21.800 | 21.900 |
| 20 | 6 | 2.8 | 20.000 | 20.021 | 5.9850 | 6.0150 | 22.800 | 22.900 |
| 22 | 6 | 2.8 | 22.000 | 22.021 | 5.9850 | 6.0150 | 24.800 | 24.900 |
| 24 | 8 | 3.3 | 24.000 | 24.021 | 7.9820 | 8.0180 | 27.300 | 27.500 |
| 25 | 8 | 3.3 | 25.000 | 25.021 | 7.9820 | 8.0180 | 28.300 | 28.500 |
| 28 | 8 | 3.3 | 28.000 | 28.021 | 7.9820 | 8.0180 | 31.300 | 31.500 |
| 30 | 8 | 3.3 | 30.000 | 30.021 | 7.9820 | 8.0180 | 33.300 | 33.500 |
| 32 | 10 | 3.3 | 32.000 | 32.025 | 9.9820 | 10.0180 | 35.300 | 35.500 |
| 35 | 10 | 3.3 | 35.000 | 35.025 | 9.9820 | 10.0180 | 38.300 | 38.500 |
| 38 | 10 | 3.3 | 38.000 | 38.025 | 9.9820 | 10.0180 | 41.300 | 41.500 |
| 40 | 12 | 3.3 | 40.000 | 40.025 | 11.9785 | 12.0215 | 43.300 | 43.500 |
| 42 | 12 | 3.3 | 42.000 | 42.025 | 11.9785 | 12.0215 | 45.300 | 45.500 |
| 45 | 14 | 3.8 | 45.000 | 45.025 | 13.9785 | 14.0215 | 48.800 | 49.000 |
| 48 | 14 | 3.8 | 48.000 | 48.025 | 13.9785 | 14.0215 | 51.800 | 52.000 |
| 50 | 14 | 3.8 | 50.000 | 50.025 | 13.9785 | 14.0215 | 53.800 | 54.000 |
| 52 | 16 | 4.3 | 52.000 | 52.030 | 15.9785 | 16.0215 | 56.300 | 56.500 |
| 55 | 16 | 4.3 | 55.000 | 55.030 | 15.9785 | 16.0215 | 59.300 | 59.500 |
| 58 | 16 | 4.3 | 58.000 | 58.030 | 15.9785 | 16.0215 | 62.300 | 62.500 |
| 60 | 18 | 4.4 | 60.000 | 60.030 | 17.9785 | 18.0215 | 64.400 | 64.600 |
| 62 | 18 | 4.4 | 62.000 | 62.030 | 17.9785 | 18.0215 | 66.400 | 66.600 |
| 65 | 18 | 4.4 | 65.000 | 65.030 | 17.9785 | 18.0215 | 69.400 | 69.600 |
| 68 | 20 | 4.9 | 68.000 | 68.030 | 19.9740 | 20.0260 | 72.900 | 73.100 |
| 72 | 20 | 4.9 | 72.000 | 72.030 | 19.9740 | 20.0260 | 76.900 | 77.100 |
| 75 | 20 | 4.9 | 75.000 | 75.030 | 19.9740 | 20.0260 | 79.900 | 80.100 |
| 78 | 22 | 5.4 | 78.000 | 78.030 | 21.9740 | 22.0260 | 83.400 | 83.600 |
| 80 | 22 | 5.4 | 80.000 | 80.030 | 21.9740 | 22.0260 | 85.400 | 85.600 |
| 82 | 22 | 5.4 | 82.000 | 82.035 | 21.9740 | 22.0260 | 87.400 | 87.600 |
| 85 | 22 | 5.4 | 85.000 | 85.035 | 21.9740 | 22.0260 | 90.400 | 90.600 |
| 88 | 25 | 5.4 | 88.000 | 88.035 | 24.9740 | 25.0260 | 93.400 | 93.600 |
| 90 | 25 | 5.4 | 90.000 | 90.035 | 24.9740 | 25.0260 | 95.400 | 95.600 |
| 92 | 25 | 5.4 | 92.000 | 92.035 | 24.9740 | 25.0260 | 97.400 | 97.600 |
| 95 | 25 | 5.4 | 95.000 | 95.035 | 24.9740 | 25.0260 | 100.400 | 100.600 |
| 98 | 28 | 6.4 | 98.000 | 98.035 | 27.9740 | 28.0260 | 104.400 | 104.600 |
| 100 | 28 | 6.4 | 100.000 | 100.035 | 27.9740 | 28.0260 | 106.400 | 106.600 |
| 102 | 28 | 6.4 | 102.000 | 102.035 | 27.9740 | 28.0260 | 108.400 | 108.600 |
| 105 | 28 | 6.4 | 105.000 | 105.035 | 27.9740 | 28.0260 | 111.400 | 111.600 |
| 108 | 28 | 6.4 | 108.000 | 108.035 | 27.9740 | 28.0260 | 114.400 | 114.600 |
| 110 | 28 | 6.4 | 110.000 | 110.035 | 27.9740 | 28.0260 | 116.400 | 116.600 |

## Metric Interference-fit Bore and Keyway Standards
*Bore Tolerances per ISO R286, P7; Keyway Tolerances per DIN 6885, JS9*

| Bore mm | Keyway mm | Height mm | Bore Min. | Bore Max. | Keyway Min. | Keyway Max. | T Min. | T Max. |
|---|---|---|---|---|---|---|---|---|
| 10 | 3 | 1.4 | 9.976 | 9.989 | 2.9875 | 3.0125 | 11.400 | 11.500 |
| 11 | 4 | 1.8 | 10.971 | 10.991 | 3.9850 | 4.0150 | 12.800 | 12.900 |
| 12 | 4 | 1.8 | 11.971 | 11.989 | 3.9850 | 4.0150 | 13.800 | 13.900 |
| 14 | 5 | 2.3 | 13.971 | 13.989 | 4.9850 | 5.0150 | 16.300 | 16.400 |
| 16 | 5 | 2.3 | 15.971 | 15.989 | 4.9850 | 5.0150 | 18.300 | 18.400 |
| 18 | 6 | 2.8 | 17.971 | 17.989 | 5.9850 | 6.0150 | 20.800 | 20.900 |
| 20 | 6 | 2.8 | 19.965 | 19.986 | 5.9850 | 6.0150 | 22.800 | 22.900 |
| 22 | 6 | 2.8 | 21.965 | 21.986 | 5.9850 | 6.0150 | 24.800 | 24.900 |
| 25 | 8 | 3.3 | 24.965 | 24.986 | 7.9820 | 8.0180 | 28.300 | 28.500 |
| 28 | 8 | 3.3 | 27.965 | 27.986 | 7.9820 | 8.0180 | 31.300 | 31.500 |
| 30 | 8 | 3.3 | 29.965 | 29.986 | 7.9820 | 8.0180 | 33.300 | 33.500 |
| 35 | 10 | 3.3 | 34.958 | 34.983 | 9.9820 | 10.0180 | 38.300 | 38.500 |
| 40 | 12 | 3.3 | 39.958 | 39.983 | 11.9785 | 12.0215 | 43.300 | 43.500 |
| 45 | 14 | 3.8 | 44.958 | 44.983 | 13.9785 | 14.0215 | 48.800 | 49.000 |
| 50 | 14 | 3.8 | 49.958 | 49.983 | 13.9785 | 14.0215 | 53.800 | 54.000 |
| 55 | 16 | 4.3 | 54.949 | 54.979 | 15.9785 | 16.0215 | 59.300 | 59.500 |
| 60 | 18 | 4.4 | 59.949 | 59.979 | 17.9785 | 18.0215 | 64.400 | 64.600 |
| 70 | 20 | 4.9 | 69.949 | 69.979 | 19.9740 | 20.0260 | 74.900 | 75.100 |
| 80 | 22 | 5.4 | 79.949 | 79.979 | 21.9740 | 22.0260 | 85.400 | 85.600 |
| 90 | 25 | 5.4 | 89.941 | 89.976 | 24.9740 | 25.0260 | 95.400 | 95.600 |
| 100 | 28 | 6.4 | 99.941 | 99.976 | 27.9740 | 28.0260 | 106.400 | 106.600 |
| 110 | 28 | 6.4 | 109.941 | 109.976 | 27.9740 | 28.0260 | 116.400 | 116.600 |
| 120 | 32 | 7.4 | 119.941 | 119.976 | 31.9690 | 32.0310 | 127.400 | 127.600 |
| 140 | 36 | 8.4 | 139.932 | 139.972 | 35.9690 | 36.0310 | 148.400 | 148.700 |
| 160 | 40 | 9.4 | 159.932 | 159.972 | 39.9690 | 40.0310 | 169.400 | 169.700 |
| 180 | 45 | 10.4 | 179.932 | 179.972 | 44.9690 | 45.0310 | 190.400 | 190.700 |
| 200 | 45 | 10.4 | 199.921 | 199.967 | 44.9690 | 45.0310 | 210.400 | 210.700 |
| 220 | 50 | 11.4 | 219.921 | 219.967 | 49.9690 | 50.0310 | 231.400 | 231.700 |
| 250 | 56 | 12.4 | 249.921 | 249.967 | 55.9630 | 56.0370 | 262.400 | 262.700 |
| 280 | 63 | 12.4 | 279.912 | 279.964 | 62.9630 | 63.0370 | 292.400 | 292.700 |
| 300 | 70 | 14.4 | 299.912 | 299.964 | 69.9630 | 70.0370 | 314.400 | 314.700 |
| 350 | 80 | 15.4 | 349.902 | 349.959 | 79.9630 | 80.0370 | 365.400 | 365.700 |
| 400 | 90 | 17.4 | 399.902 | 399.959 | 89.9565 | 90.0435 | 417.400 | 417.700 |
| 450 | 100 | 19.5 | 449.892 | 449.955 | 99.9565 | 100.0435 | 469.500 | 469.800 |
| 500 | 100 | 19.5 | 499.892 | 499.955 | 99.9585 | 100.0435 | 519.500 | 519.800 |

## U.S. Customary Clearance-fit Bore and Keyway Standards — Core Products

*Bore and Keyway Tolerances per AGMA 9002-A86. Bore Tolerances per AGMA -9002-A86; Keyway tolerances per ANSI B17.1*

| Nominal bore diameter | Bore +0.001/-0.000 | Keyway width +0.002/-0.000 | Keyway height Reference | "T"-DIM +0.010/-0.000 |
|---|---|---|---|---|
| $3/8$ | 0.3750 | 0.0938 | 0.0469 | 0.421 |
| $7/16$ | 0.4375 | 0.0938 | 0.0469 | 0.484 |
| $1/2$ | 0.5000 | 0.1250 | 0.0625 | 0.560 |
| $9/16$ | 0.5625 | 0.1250 | 0.0625 | 0.623 |
| $5/8$ | 0.6250 | 0.1875 | 0.0938 | 0.709 |
| $11/16$ | 0.6875 | 0.1875 | 0.0938 | 0.773 |
| $3/4$ | 0.7500 | 0.1875 | 0.0938 | 0.837 |
| $13/16$ | 0.8125 | 0.1875 | 0.0938 | 0.900 |
| $7/8$ | 0.8750 | 0.1875 | 0.0938 | 0.964 |
| $15/16$ | 0.9375 | 0.2500 | 0.1250 | 1.051 |
| 1 | 1.0000 | 0.2500 | 0.1250 | 1.114 |
| $1 1/16$ | 1.0625 | 0.2500 | 0.1250 | 1.178 |
| $1 1/8$ | 1.1250 | 0.2500 | 0.1250 | 1.241 |
| $1 3/16$ | 1.1875 | 0.2500 | 0.1250 | 1.304 |
| $1 1/4$ | 1.2500 | 0.2500 | 0.1250 | 1.367 |
| $1 5/16$ | 1.3125 | 0.3125 | 0.1563 | 1.455 |
| $1 3/8$ | 1.3750 | 0.3125 | 0.1563 | 1.518 |
| $1 7/16$ | 1.4375 | 0.3750 | 0.1875 | 1.605 |
| $1 1/2$ | 1.5000 | 0.3750 | 0.1875 | 1.669 |
| $1 9/16$ | 1.5625 | 0.3750 | 0.1875 | 1.732 |
| $1 5/8$ | 1.6250 | 0.3750 | 0.1875 | 1.796 |
| $1 11/16$ | 1.6875 | 0.3750 | 0.1875 | 1.859 |
| $1 3/4$ | 1.7500 | 0.3750 | 0.1875 | 1.922 |
| $1 13/16$ | 1.8125 | 0.5000 | 0.2500 | 2.032 |
| $1 7/8$ | 1.8750 | 0.5000 | 0.2500 | 2.096 |
| $1 15/16$ | 1.9375 | 0.5000 | 0.2500 | 2.160 |
| 2 | 2.0000 | 0.5000 | 0.2500 | 2.223 |

| Nominal bore diameter | Bore +0.0015/-0.000 | Keyway width +0.002/0.000 | Keyway height Reference | "T"-DIM +0.010/0.000 |
|---|---|---|---|---|
| $2 1/16$ | 2.0625 | 0.5000 | 0.2500 | 2.287 |
| $2 1/8$ | 2.1250 | 0.5000 | 0.2500 | 2.350 |
| $2 3/16$ | 2.1875 | 0.5000 | 0.2500 | 2.414 |
| $2 1/4$ | 2.2500 | 0.5000 | 0.2500 | 2.477 |

| Nominal bore diameter | Bore +0.0015/-0.000 | Keyway width +0.003/-0.000 | Keyway height Reference | "T"-DIM +0.010/-0.000 |
|---|---|---|---|---|
| $2 5/16$ | 2.3125 | 0.625 | 0.3125 | 2.587 |
| $2 3/8$ | 2.3750 | 0.625 | 0.3125 | 2.651 |
| $2 7/16$ | 2.4375 | 0.625 | 0.3125 | 2.714 |
| $2 1/2$ | 2.5000 | 0.625 | 0.3125 | 2.778 |
| $2 9/16$ | 2.5625 | 0.625 | 0.3125 | 2.841 |
| $2 5/8$ | 2.6250 | 0.625 | 0.3125 | 2.905 |
| $2 11/16$ | 2.6875 | 0.625 | 0.3125 | 2.968 |
| $2 3/4$ | 2.7500 | 0.625 | 0.3125 | 3.032 |
| $2 13/16$ | 2.8125 | 0.7500 | 0.3750 | 3.142 |
| $2 7/8$ | 2.8750 | 0.7500 | 0.3750 | 3.205 |

| Nominal bore diameter | Bore +0.0015/-0.000 | Keyway width +0.003/-0.000 | Keyway height Reference | "T"-DIM +0.010/-0.000 |
|---|---|---|---|---|
| $2 15/16$ | 2.9375 | 0.7500 | 0.3750 | 3.269 |
| 3 | 3.0000 | 0.7500 | 0.3750 | 3.332 |
| $3 1/16$ | 3.0625 | 0.7500 | 0.3750 | 3.396 |
| $3 1/8$ | 3.1250 | 0.7500 | 0.3750 | 3.459 |
| $3 3/16$ | 3.1875 | 0.7500 | 0.3750 | 3.523 |
| $3 1/4$ | 3.2500 | 0.7500 | 0.3750 | 3.586 |
| $3 5/16$ | 3.3125 | 0.8750 | 0.4375 | 3.696 |
| $3 3/8$ | 3.3750 | 0.8750 | 0.4375 | 3.760 |
| $3 7/16$ | 3.4375 | 0.8750 | 0.4375 | 3.823 |
| $3 1/2$ | 3.5000 | 0.8750 | 0.4375 | 3.887 |
| $3 9/16$ | 3.5625 | 0.8750 | 0.4375 | 3.950 |
| $3 5/8$ | 3.6250 | 0.8750 | 0.4375 | 4.014 |
| $3 11/16$ | 3.6875 | 0.8750 | 0.4375 | 4.077 |
| $3 3/4$ | 3.7500 | 0.8750 | 0.4375 | 4.141 |
| $3 13/16$ | 3.8125 | 1.0000 | 0.5000 | 4.251 |
| $3 7/8$ | 3.8750 | 1.0000 | 0.5000 | 4.314 |
| $3 15/16$ | 3.9375 | 1.0000 | 0.5000 | 4.378 |
| 4 | 4.0000 | 1.0000 | 0.5000 | 4.441 |

| Nominal bore diameter | Bore +0.002/-0.000 | Keyway width +0.003/-0.000 | Keyway height Reference | "T"-DIM +0.010/-0.000 |
|---|---|---|---|---|
| $4 1/16$ | 4.0625 | 1.0000 | 0.5000 | 4.505 |
| $4 1/8$ | 4.1250 | 1.0000 | 0.5000 | 4.568 |
| $4 3/16$ | 4.1875 | 1.0000 | 0.5000 | 4.632 |
| $4 1/4$ | 4.2500 | 1.0000 | 0.5000 | 4.695 |
| $4 5/16$ | 4.3125 | 1.0000 | 0.5000 | 4.759 |
| $4 3/8$ | 4.3750 | 1.0000 | 0.5000 | 4.822 |
| $4 7/16$ | 4.4375 | 1.0000 | 0.5000 | 4.885 |
| $4 1/2$ | 4.5000 | 1.0000 | 0.5000 | 4.949 |

| Nominal bore diameter | Bore +0.002/-0.000 | Keyway width +0.004/-0.000 | Keyway height Reference | "T"-DIM +0.010/-0.000 |
|---|---|---|---|---|
| $4 9/16$ | 4.5625 | 1.2500 | 0.6250 | 5.105 |
| $4 5/8$ | 4.6250 | 1.2500 | 0.6250 | 5.169 |
| $4 11/16$ | 4.6875 | 1.2500 | 0.6250 | 5.233 |
| $4 3/4$ | 4.7500 | 1.2500 | 0.6250 | 5.296 |
| $4 13/16$ | 4.8125 | 1.2500 | 0.6250 | 5.360 |
| $4 7/8$ | 4.8750 | 1.2500 | 0.6250 | 5.424 |
| $4 15/16$ | 4.9375 | 1.2500 | 0.6250 | 5.487 |
| 5 | 5.0000 | 1.2500 | 0.6250 | 5.551 |
| $5 1/16$ | 5.0625 | 1.2500 | 0.6250 | 5.614 |
| $5 1/8$ | 5.1250 | 1.2500 | 0.6250 | 5.678 |
| $5 3/16$ | 5.1875 | 1.2500 | 0.6250 | 5.741 |
| $5 1/4$ | 5.2500 | 1.2500 | 0.6250 | 5.805 |
| $5 5/16$ | 5.3125 | 1.2500 | 0.6250 | 5.868 |
| $5 3/8$ | 5.3750 | 1.2500 | 0.6250 | 5.931 |
| $5 7/16$ | 5.4375 | 1.2500 | 0.6250 | 5.995 |
| $5 1/2$ | 5.5000 | 1.2500 | 0.6250 | 6.058 |

***Note:*** Check the VIRTUS price list for bores and keyways normally stocked at factory or warehouse.

## U.S. Customary Interference-fit Bore and Keyway Standards

**BORE AND KEYWAY TOLERANCES PER AGMA 9002-A86**

| Nominal bore diameter | Actual AGMA interference fit | Keyway size Nominal | Keyway size Decimal | | Nominal bore diameter | Actual AGMA interference fit | Keyway size Nominal | Keyway size Decimal | |
|---|---|---|---|---|---|---|---|---|---|
| 1/2 | 0.499/0.4995 | 1/8 x 1/16 | 0.1250 | 0.0625 | 3 1/8 | 3.122/3.1235 | 3/4 x 3/8 | 0.7500 | 0.3750 |
| 5/8 | 0.624/0.6245 | 3/16 x 3/32 | 0.1875 | 0.0938 | 3 1/4 | 3.247/3.2485 | 3/4 x 3/8 | 0.7500 | 0.3750 |
| 3/4 | 0.749/0.7495 | 3/16 x 3/32 | 0.1875 | 0.0938 | 3 3/8 | 3.372/3.3735 | 7/8 x 7/16 | 0.8750 | 0.4375 |
| 7/8 | 0.874/0.8745 | 3/16 x 3/32 | 0.1875 | 0.0938 | 3 1/2 | 3.497/3.4985 | 7/8 x 7/16 | 0.8750 | 0.4375 |
| 1 | 0.999/0.9995 | 1/4 x 1/8 | 0.2500 | 0.1250 | 3 5/8 | 3.622/3.6235 | 7/8 x 7/16 | 0.8750 | 0.4375 |
| 1 1/8 | 1.124/1.1245 | 1/4 x 1/8 | 0.2500 | 0.1250 | 3 3/4 | 3.747/3.7485 | 7/8 x 7/16 | 0.8750 | 0.4375 |
| 1 1/4 | 1.249/1.2495 | 1/4 x 1/8 | 0.2500 | 0.1250 | 3 7/8 | 3.872/3.8735 | 1 x 1/2 | 1.0000 | 0.5000 |
| 1 3/8 | 1.374/1.3745 | 5/16 x 5/32 | 0.3125 | 0.1563 | 4 | 3.997/3.9985 | 1 x 1/2 | 1.0000 | 0.5000 |
| 1 1/2 | 1.499/1.4995 | 3/8 x 3/16 | 0.3750 | 0.1875 | 4 1/4 | 4.2465/4.248 | 1 x 1/2 | 1.0000 | 0.5000 |
| 1 5/8 | 1.623/1.624 | 3/8 x 3/16 | 0.3750 | 0.1875 | 4 1/2 | 4.4965/4.498 | 1 x 1/2 | 1.0000 | 0.5000 |
| 1 3/4 | 1.748/1.749 | 3/8 x 3/16 | 0.3750 | 0.1875 | 4 3/4 | 4.7465/4.748 | 1 1/4 x 5/8 | 1.2500 | 0.6250 |
| 1 7/8 | 1.873/1.874 | 1/2 x 1/4 | 0.5000 | 0.2500 | 5 | 4.9965/4.998 | 1 1/4 x 5/8 | 1.2500 | 0.6250 |
| 2 | 1.998/1.999 | 1/2 x 1/4 | 0.5000 | 0.2500 | 5 1/4 | 5.246/5.2475 | 1 1/4 x 5/8 | 1.2500 | 0.6250 |
| 2 1/8 | 2.123/2.124 | 1/2 x 1/4 | 0.5000 | 0.2500 | 5 1/2 | 5.496/5.4975 | 1 1/4 x 5/8 | 1.2500 | 0.6250 |
| 2 1/4 | 2.248/2.249 | 1/2 x 1/4 | 0.5000 | 0.2500 | 5 3/4 | 5.746/5.7475 | 1 1/2 x 3/4 | 1.5000 | 0.7500 |
| 2 3/8 | 2.373/2.374 | 5/8 x 5/16 | 0.625 | 0.3125 | 6 | 5.996/5.9975 | 1 1/2 x 3/4 | 1.5000 | 0.7500 |
| 2 1/2 | 2.498/2.499 | 5/8 x 5/16 | 0.625 | 0.3125 | 6 1/4 | 6.246/6.2475 | 1 1/2 x 3/4 | 1.5000 | 0.7500 |
| 2 5/8 | 2.623/2.624 | 5/8 x 5/16 | 0.625 | 0.3125 | 6 1/2 | 6.496/6.4975 | 1 1/2 x 3/4 | 1.5000 | 0.7500 |
| 2 3/4 | 2.748/2.749 | 5/8 x 5/16 | 0.625 | 0.3125 | 6 3/4 | 6.746/6.7475 | 1 3/4 x 3/4 | 1.7500 | 0.7500 |
| 2 7/8 | 2.873/2.874 | 3/4 x 3/8 | 0.7500 | 0.3750 | 7 | 6.996/6.9975 | 1 3/4 x 3/4 | 1.7500 | 0.7500 |
| 3 | 2.998/2.999 | 3/4 x 3/8 | 0.7500 | 0.3750 | | | | | |

*Note:* For shaft sizes 1/2 through 6 1/2, square keyways are preferred. For shaft sizes over 6 1/2, rectangular keyways are preferred.

| Shaft Diameter (inches) Over | Shaft Diameter (inches) Thru | Bore Dimensions Nominal shaft diameter less: | Bore Dimensions Bore Tolerance |
|---|---|---|---|
| — | 1 1/2 | .001 | +.0005-.000 |
| 1 1/2 | 3 | .002 | +.0010-.000 |
| 3 | 4 | .003 | +.0015-.000 |
| 4 | 5 | .0035 | +.0015-.000 |
| 5 | 7 | .004 | +.0015-.000 |
| 7 | 8 | .005 | +.002-.000 |
| 8 | 9 | .0055 | +.002-.000 |
| 9 | 12 | .006 to .008 | +.002-.000 |
| 12 | 20 | .009 to .012 | +.0025-.000 |

*2 3/16 inch bore example:*
Nominal shaft = 2.1875
less .002 + .001 bore
total = 2.1855/2.1865

*Notes:*
1. Consult VIRTUS when considering fits other than these.
2. Complies with AGMA 9002-A86 through 9-inch shaft diameter. There is no industry standard above that.

# Engineering Data

VIRTUS
Power Transmission

## IEC Quick Reference Chart

| IEC Frame | Type | Foot Mounting A | B | C | H | Shaft D | E | B5 Flange LA | M | N | P | S | T | B14 Face M | N | P | S | T | GeneralT L | AC | AD | HC | XX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63 | 300 | 100 / 3.937 | 80 / 3.150 | 40 / 1.570 | 63 / 2.480 | 11 / 0.433 | 23 / 0.906 | 8 / 0.313 | 115 / 4.528 | 95 / 3.740 | 140 / 5.512 | 9 / 0.354 | 3 / 0.118 | 75 / 2.953 | 60 / 2.362 | 90 / 3.540 | M5 | 2.5 / 0.098 | * | 119 / 4.690 | 102 / 4 ; 116d / 4.567d | 121 / 4.760 ; 136d / 5.375d | 13 / 0.500 ; 22d / 0.880d |
| 71 | 300 / 400 | 112 / 4.409 | 90 / 3.543 | 45 / 1.770 | 71 / 2.800 | 14 / 0.551 | 30 / 1.181 | 8 / 0.313 | 130 / 5.118 | 110 / 4.331 | 160 / 6.299 | 10 / 0.393 | 3.5 / 0.138 | 85 / 3.347 | 70 / 2.756 | 105 / 4.130 | M6 | 2.5 / 0.098 | * | 119 / 4.690 ; 145d / 5.690d | 102 / 4 | 131 / 5.140 ; 149d / 5.880d | 18 / 0.690 ; 21d / 0.844d |
| 80 | 400 / 500 | 125 / 4.921 | 100 / 3.937 | 50 / 1.969 | 80 / 3.150 | 19 / 0.748 | 40 / 1.575 | 13 / 0.500 | 165 / 6.496 | 130 / 5.118 | 200 / 7.874 | 11 / 0.430 | 3.5 / 0.138 | 100 / 3.937 | 80 / 3.150 | 120 / 4.724 | M6 | 3 / 0.118 | * | 145 / 5.690 ; 168d / 6.614d | 116 / 4.510 ; 130 / 5.120 | 152 / 6 ; 162d / 6.380d | 22 / 0.880 ; 21d / 0.844d |
| 90 | S / L | 140 / 5.511 | 100 / 3.937 (S) ; 125 / 4.921 (L) | 56 / 2.205 | 90 / 3.543 | 24 / 0.945 | 50 / 1.969 | 13 / 0.500 | 165 / 6.496 | 130 / 5.118 | 200 / 7.874 | 12 / 0.472 | 3.5 / 0.138 | 115 / 4.530 | 95 / 3.740 | 140 / 5.512 | M8 | 3 / 0.118 | * | 168 / 6.614 ; 144d / 5.687d | 130 / 5.120 ; 107d / 4.250d | 173 / 6.810 ; 165d / 6.531d | 22 / 0.880 ; 21d / 0.844d |
| 100 | S / L | 160 / 6.300 | 112 / 4.409 (S) ; 140 / 5.512 (L) | 63 / 2.480 | 100 / 3.937 | 28 / 1.102 | 60 / 2.362 | 14 / 0.562 | 215 / 8.465 | 180 / 7.087 | 250 / 9.840 | 14 / 0.560 | 4 / 0.160 | 130 / 5.108 | 110 / 4.331 | 160 / 6.299 | M8 | 3.5 / 0.138 | * | 200 / 7.875 | 149 / 5.875 ; 153d / 6.060d | 180 / 7.906 ; 239d / 9.440d | 27 / 1.062 |
| 112 | S / M | 190 / 7.480 | 114 / 4.488 (S) ; 140 / 5.512 (M) | 70 / 2.760 | 112 / 4.409 | 28 / 1.102 | 60 / 2.362 | 14 / 0.562 | 215 / 8.465 | 180 / 7.087 | 250 / 9.840 | 14 / 0.560 | 4 / 0.160 | 130 / 5.108 | 110 / 4.331 | 160 / 6.299 | M8 | 3.5 / 0.138 | * | 200 / 7.875 | 149 / 5.875 | 214 / 8.437 | 27 / 1.062 |
| 132 | S / M | 216 / 8.504 | 140 / 5.512 (S) ; 178 / 7.008 (M) | 89 / 3.504 | 132 / 5.197 | 38 / 1.496 | 80 / 3.150 | 14 / 0.562 | 265 / 10.433 | 230 / 9.055 | 300 / 11.811 | 14 / 0.560 | 4 / 0.160 | 165 / 6.496 | 130 / 5.118 | 200 / 7.874 | M8 | 3.5 / 0.138 | * | 243 / 9.562 | 187 / 7.375 | 256 / 10.062 | 27 / 1.062 |
| 160 | M / L | 254 / 10 | 210 / 8.268 (M) ; 254 / 10 (L) | 108 / 4.252 | 160 / 6.299 | 42 / 1.654 | 110 / 4.331 | 20 / 0.787 | 300 / 11.811 | 250 / 9.842 | 350 / 13.780 | 19 / 0.748 | 5 / 0.200 | 215 / 8.465 | 180 / 7.087 | 250 / 9.840 | M12 | 4 / 0.160 | * | 329 / 12.940 | 242 / 9.510 | 329 / 12.940 | 35 / 1.375 |
| 180 | M / L | 279 / 10.984 | 241 / 9.488 (M) ; 279 / 10.984 (L) | 121 / 4.764 | 180 / 7.087 | 48 / 1.890 | 110 / 4.331 | | 300 / 11.811 | 250 / 9.842 | 350 / 13.780 | 19 / 0.748 | 5 / 0.200 | — | — | — | — | — | * | 395 / 15.560 | 333 / 13.120 | 372 / 14.640 | 51 / 2.008 |
| 200 | L / M | 318 / 12.520 | 267 / 10.512 (L) ; 305 / 12.008 (M) | 133 / 5.236 | 200 / 7.874 | 55 / 2.165 | 110 / 4.331 | | 350 / 13.780 | 300 / 11.811 | 400 / 15.748 | 19 / 0.748 | — | — | — | — | — | — | * | 441 / 17.375 | 359 / 14.125 | 416 / 16.375 | 63 / 2.500 |
| 225 | S / M | 356 / 14.016 | 286 / 11.260 (S) ; 311 / 12.244 (M) | 149 / 5.866 | 225 / 8.858 | 60 / 2.362 | 140 / 5.512 | | 400 / 15.748 | 350 / 13.780 | 450 / 17.716 | 19 / 0.748 | — | | | | | | * | 495 / 19.488 | 383 / 15.079 | 483 / 19.016 | 63 / 2.500 |
| 250 | S / M | 406 / 15.984 | 311 / 12.244 (S) ; 349 / 13.740 (M) | 168 / 6.614 | 250 / 9.843 | 70 / 2.756 | 140 / 5.512 | — | — | — | — | — | | — | — | — | — | — | * | 520 / 20.472 | 457 / 17.992 | 513 / 20.197 | 63 / 2.500 |
| 280 | S / M | 457 / 17.992 | 368 / 14.488 (S) ; 419 / 16.496 (M) | 190 / 7.485 | 280 / 11.025 | 80 / 3.150 | 170 / 6.693 | | | | | | | | | | | — | * | 616 / 24.252 | 497 / 19.567 | 581 / 22.874 | 63 / 2.500 |
| 315 | S / M | 508 / 20 | 406 / 16 (S) ; 457 / 18 (M) | 216 / 8.500 | 315 / 12.400 | 85 / 3.346 | 170 / 6.693 | | | | | | | | | | | — | * | 759 / 29.900 | 683 / 26.880 | 682 / 26.840 | 102 / 4 |
| 355 | S / L | 610 / 24 | 500 / 19.690 (S) ; 630 / 24.800 (L) | 254 / 10 | 355 / 13.980 | 85 / 3.346 | 170 / 6.693 | | | | | | | | | | | — | * | 759 / 29.900 | 683 / 26.880 | 719 / 28.320 | 102 / 4 |

**LEGEND**

Metric dimensions (millimeters) in bold.
Inch dimensions in plain type.

d = DC Motors

1 mm = 0.03937 inches
1 inch = 25.40 mm

*Note:* * indicates that this dimension varies depending upon manufacturer

# Engineering Data

## IEC Motor Frame Dimensions
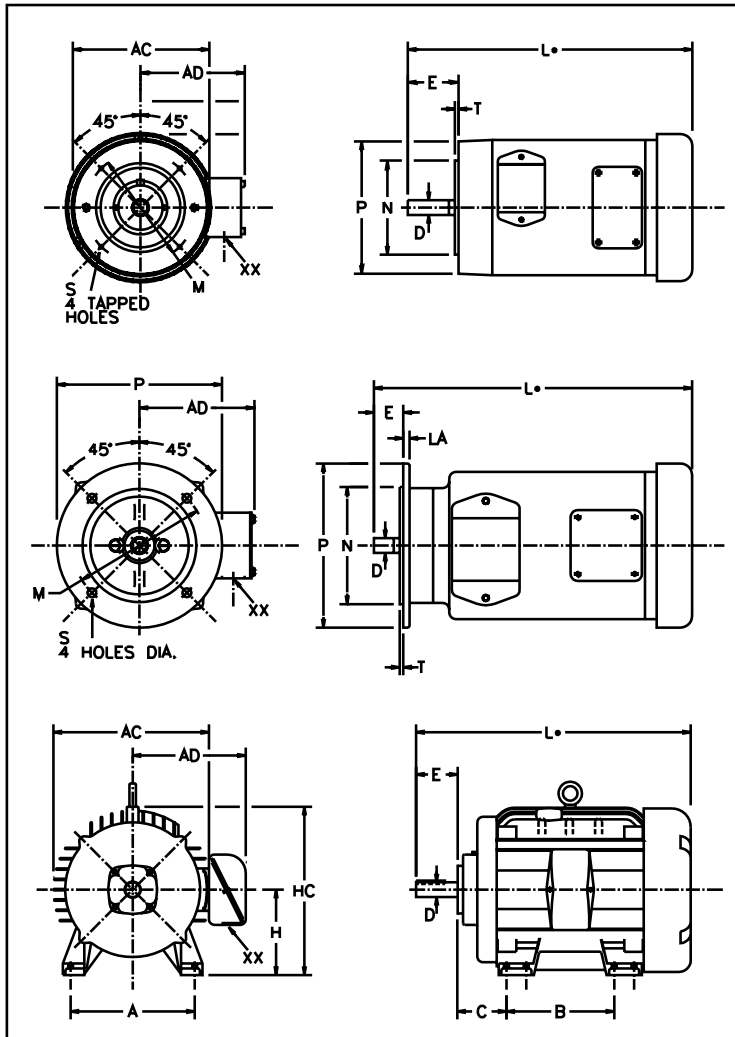


| Key and Keyseat Dimensions | | | | |
|---|---|---|---|---|
| Frame | D | G | F | GD |
| 63 | 11 | 8.5 | 4 | 4 |
| 71 | 14 | 11 | 5 | 5 |
| 80 | 19 | 15.5 | 6 | 6 |
| 90 | 24 | 20 | 8 | 7 |
| 100 | 28 | 24 | 8 | 7 |
| 112 | 28 | 24 | 8 | 7 |
| 132 | 38 | 33 | 10 | 8 |
| 160 | 37 | 42 | 12 | 8 |
| 180 | 48 | 42.5 | 14 | 9 |
| 200 | 55 | 49 | 16 | 10 |
| 225 | 60 | 53 | 18 | 11 |
| 250 | 70 | 67.5 | 20 | 12 |
| 280 | 80 | 71 | 22 | 14 |
| 315 | 85 | 76 | 22 | 14 |
| 355 | 85 | 76 | 22 | 14 |
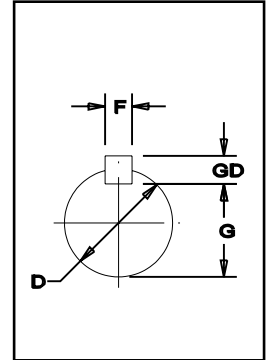
*Note:*   Drawings represent standard TEFC general purpose motors.
Dimensions are for reference only.

# Engineering Data

## NEMA Quick Reference Chart—Inch

| NEMA Frame | D | E | 2F | H | N | O | P | U | V | AA | AB | AH | AJ | AK | BA | BB | BD | XO | TAP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | $2\frac{5}{8}$ | $1\frac{3}{4}$ | $1\frac{11}{16}$ | $\frac{9}{32}$* | $1\frac{1}{2}$ | 5 | $4\frac{11}{16}$ | $\frac{3}{8}$ | $1\frac{1}{8}$ | $\frac{3}{8}$ | $4\frac{1}{32}$ | $1\frac{5}{16}$ | $3\frac{3}{4}$ | 3 | $2\frac{1}{16}$ | $\frac{1}{8}$ | $4\frac{5}{8}$ | $1\frac{9}{16}$ | $\frac{1}{4}$-20 |
| 48 | 3 | $2\frac{1}{8}$ | $2\frac{3}{4}$ | $\frac{11}{32}$* | $1\frac{7}{8}$ | $5\frac{7}{8}$ | $5\frac{11}{16}$ | $\frac{1}{2}$ | $1\frac{1}{2}$ | $\frac{1}{2}$ | $4\frac{3}{8}$ | $1\frac{11}{16}$ | $3\frac{3}{4}$ | 3 | $2\frac{1}{2}$ | $\frac{1}{8}$ | $5\frac{5}{8}$ | $2\frac{1}{4}$ | $\frac{1}{4}$-20 |
| 56 | $3\frac{1}{2}$ | $2\frac{7}{16}$ | 3 | $\frac{11}{32}$* | $2\frac{7}{16}$ | $6\frac{7}{8}$ | $6\frac{5}{8}$ | $\frac{5}{8}$ | $1\frac{7}{8}$ | $\frac{1}{2}$ | 5 | $2\frac{1}{16}$ | $5\frac{7}{8}$ | $4\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{1}{8}$ | $6\frac{1}{2}$ | $2\frac{1}{4}$ | $\frac{3}{8}$-16 |
| 56H |  |  | 5 |  | $2\frac{1}{8}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 143T | $3\frac{1}{2}$ | $2\frac{3}{4}$ | 4 | $\frac{11}{32}$ | $2\frac{1}{2}$ | $6\frac{7}{8}$ | $6\frac{5}{8}$ | $\frac{7}{8}$ | $2\frac{1}{4}$ | $\frac{3}{4}$ | $5\frac{1}{4}$ | $2\frac{1}{8}$ | $5\frac{7}{8}$ | $4\frac{1}{2}$ | $2\frac{1}{4}$ | $\frac{1}{8}$ | $6\frac{1}{2}$ | $2\frac{1}{4}$ | $\frac{3}{8}$-16 |
| 145T |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 182 |  |  | $4\frac{1}{2}$ |  | $2\frac{11}{16}$ |  |  | $\frac{7}{8}$ | $2\frac{1}{4}$ |  | $2\frac{1}{8}$ | $2\frac{1}{8}$ | $5\frac{7}{8}$ | $4\frac{1}{2}$ |  | $\frac{1}{8}$ | $6\frac{1}{2}$ |  | $\frac{3}{8}$-16 |
| 184 | $4\frac{1}{2}$ | $3\frac{3}{4}$ | $5\frac{1}{2}$ | $\frac{13}{32}$ | $2\frac{11}{16}$ | $8\frac{11}{16}$ | $7\frac{7}{8}$ | $\frac{7}{8}$ | $2\frac{1}{4}$ | $\frac{3}{4}$ | $5\frac{7}{8}$ | $2\frac{1}{8}$ | $5\frac{7}{8}$ | $4\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{1}{8}$ | $6\frac{1}{2}$ | $2\frac{3}{8}$ | $\frac{3}{8}$-16 |
| 182T |  |  | $4\frac{1}{2}$ |  | $3\frac{9}{16}$ |  |  | $1\frac{1}{8}$ | $2\frac{3}{4}$ |  | $2\frac{5}{8}$ | $7\frac{1}{4}$ | $8\frac{1}{2}$ |  | $\frac{1}{4}$ | 9 |  | $\frac{1}{2}$-13 |
| 184T |  |  | $5\frac{1}{2}$ |  | $3\frac{9}{16}$ |  |  | $1\frac{1}{8}$ | $2\frac{3}{4}$ |  | $2\frac{5}{8}$ | $7\frac{1}{4}$ | $8\frac{1}{2}$ |  | $\frac{1}{4}$ | 9 |  | $\frac{1}{2}$-13 |
| 213 |  |  | $5\frac{1}{2}$ |  | $3\frac{1}{2}$ |  |  | $1\frac{1}{8}$ | 3 |  | $2\frac{3}{4}$ |  |  | $3\frac{1}{2}$ | $\frac{1}{4}$ | 9 |  | $\frac{1}{2}$-13 |
| 215 | $5\frac{1}{4}$ | $4\frac{1}{4}$ | 7 | $\frac{13}{32}$ | $3\frac{1}{2}$ | $10\frac{1}{4}$ | $9\frac{9}{16}$ | $1\frac{1}{8}$ | 3 | $\frac{3}{4}$ | $7\frac{3}{8}$ | $2\frac{3}{4}$ | $7\frac{1}{4}$ | $8\frac{1}{2}$ |  |  |  | $2\frac{3}{4}$ | $\frac{1}{2}$-13 |
| 213T |  |  | $5\frac{1}{2}$ |  | $3\frac{7}{8}$ |  |  | $1\frac{3}{8}$ | $3\frac{3}{8}$ |  | $3\frac{1}{8}$ |  |  |  |  |  |  |  |
| 215T |  |  | 7 |  | $3\frac{7}{8}$ |  |  | $1\frac{3}{8}$ | $3\frac{3}{8}$ |  | $3\frac{1}{8}$ |  |  |  |  |  |  |  |
| 254U |  |  | $5\frac{1}{4}$ |  | $4\frac{1}{16}$ |  |  | $1\frac{3}{8}$ | $3\frac{3}{4}$ |  | $3\frac{1}{2}$ |  |  |  |  |  |  |  |
| 256U | $6\frac{1}{4}$ | 5 | 10 | $\frac{17}{32}$ | $4\frac{1}{16}$ | $12\frac{7}{8}$ | $12\frac{15}{16}$ | $1\frac{3}{8}$ | $3\frac{3}{4}$ | 1 | $9\frac{5}{8}$ | $3\frac{1}{2}$ | $7\frac{1}{4}$ | $8\frac{1}{2}$ | $4\frac{1}{4}$ | $\frac{1}{4}$ | 10 | — | $\frac{1}{2}$-13 |
| 254T |  |  | $8\frac{1}{4}$ |  | $4\frac{5}{16}$ |  |  | $1\frac{5}{8}$ | 4 |  | $3\frac{3}{4}$ |  |  |  |  |  |  |  |
| 256T |  |  | 10 |  | $4\frac{5}{16}$ |  |  | $1\frac{5}{8}$ | 4 |  | $3\frac{3}{4}$ |  |  |  |  |  |  |  |
| 284U |  |  | $9\frac{1}{2}$ |  | $5\frac{1}{8}$ |  |  | $1\frac{5}{8}$ | $4\frac{7}{8}$ |  | $4\frac{5}{8}$ |  |  |  |  |  |  |  |
| 286U |  |  | 11 |  | $5\frac{1}{8}$ |  |  | $1\frac{5}{8}$ | $4\frac{7}{8}$ |  | $4\frac{5}{8}$ |  |  |  |  |  |  |  |
| 284T | 7 | $5\frac{1}{2}$ | $9\frac{1}{2}$ | $\frac{17}{32}$ | $4\frac{7}{8}$ | $14\frac{5}{8}$ | $14\frac{5}{8}$ | $1\frac{7}{8}$ | $4\frac{5}{8}$ | $1\frac{1}{2}$ | $13\frac{1}{8}$ | $4\frac{3}{8}$ | 9 | $10\frac{1}{2}$ | $4\frac{3}{4}$ | $\frac{1}{4}$ | $11\frac{1}{4}$ | — | $\frac{1}{2}$-13 |
| 286T |  |  | 11 |  | $4\frac{7}{8}$ |  |  | $1\frac{7}{8}$ | $4\frac{5}{8}$ |  | $4\frac{3}{8}$ |  |  |  |  |  |  |  |
| 284TS |  |  | $9\frac{1}{2}$ |  | $3\frac{3}{8}$ |  |  | $1\frac{5}{8}$ | $3\frac{1}{4}$ |  | 3 |  |  |  |  |  |  |  |
| 286TS |  |  | 11 |  | $3\frac{3}{8}$ |  |  | $1\frac{5}{8}$ | $3\frac{1}{4}$ |  | 3 |  |  |  |  |  |  |  |
| 324U |  |  | $10\frac{1}{2}$ |  | $5\frac{7}{8}$ |  |  | $1\frac{7}{8}$ | $5\frac{5}{8}$ |  | $5\frac{3}{8}$ |  |  |  |  |  |  |  |
| 326U |  |  | 12 |  | $5\frac{7}{8}$ |  |  | $1\frac{7}{8}$ | $5\frac{5}{8}$ |  | $5\frac{3}{8}$ |  |  |  |  |  |  |  |
| 324T | 8 | $6\frac{1}{4}$ | $10\frac{1}{2}$ | $\frac{21}{32}$ | $5\frac{1}{2}$ | $16\frac{1}{2}$ | $16\frac{1}{2}$ | $2\frac{1}{8}$ | $5\frac{1}{4}$ | 2 | $14\frac{1}{8}$ | 5 | 11 | $12\frac{1}{2}$ | $5\frac{1}{4}$ | $\frac{1}{4}$ | $13\frac{3}{8}$ | — | $\frac{5}{8}$-11 |
| 326T |  |  | 12 |  | $5\frac{1}{2}$ |  |  | $2\frac{1}{8}$ | $5\frac{1}{4}$ |  | 5 |  |  |  |  |  |  |  |
| 324TS |  |  | $10\frac{1}{2}$ |  | $3\frac{15}{16}$ |  |  | $1\frac{7}{8}$ | $3\frac{3}{4}$ |  | $3\frac{1}{2}$ |  |  |  |  |  |  |  |
| 326TS |  |  | 12 |  | $3\frac{15}{16}$ |  |  | $1\frac{7}{8}$ | $3\frac{3}{4}$ |  | $3\frac{1}{2}$ |  |  |  |  |  |  |  |
| 364U |  |  | $11\frac{1}{4}$ |  | $6\frac{3}{4}$ |  |  | $2\frac{1}{8}$ | $6\frac{3}{8}$ |  | $6\frac{1}{8}$ |  |  |  |  |  |  |  |
| 365U |  |  | $12\frac{1}{4}$ |  | $6\frac{3}{4}$ |  |  | $2\frac{1}{8}$ | $6\frac{3}{8}$ |  | $6\frac{1}{8}$ |  |  |  |  |  |  |  |
| 364T | 9 | 7 | $11\frac{1}{4}$ | $\frac{21}{32}$ | $6\frac{1}{4}$ | $18\frac{1}{2}$ | $18\frac{1}{4}$ | $2\frac{3}{8}$ | $5\frac{7}{8}$ | $2\frac{1}{2}$ | $15\frac{1}{16}$ | $5\frac{5}{8}$ | 11 | $12\frac{1}{2}$ | $5\frac{7}{8}$ | $\frac{1}{4}$ | $13\frac{3}{8}$ | — | $\frac{5}{8}$-11 |
| 365T |  |  | $12\frac{1}{4}$ |  | $6\frac{1}{4}$ |  |  | $2\frac{3}{8}$ | $5\frac{7}{8}$ |  | $5\frac{5}{8}$ |  |  |  |  |  |  |  |
| 364TS |  |  | $11\frac{1}{4}$ |  | 4 |  |  | $1\frac{7}{8}$ | $3\frac{3}{4}$ |  | $3\frac{1}{2}$ |  |  |  |  |  |  |  |
| 365TS |  |  | $12\frac{1}{4}$ |  | 4 |  |  | $1\frac{7}{8}$ | $3\frac{3}{4}$ |  | $3\frac{1}{2}$ |  |  |  |  |  |  |  |
| 404U |  |  | $12\frac{1}{4}$ |  | $7\frac{3}{16}$ |  |  | $2\frac{3}{8}$ | $7\frac{1}{8}$ |  | $6\frac{7}{8}$ |  |  |  |  |  |  |  |
| 405U |  |  | $13\frac{3}{4}$ |  | $7\frac{3}{16}$ |  |  | $2\frac{3}{8}$ | $7\frac{1}{8}$ |  | $6\frac{7}{8}$ |  |  |  |  |  |  |  |
| 404T | 10 | 8 | $12\frac{1}{4}$ | $\frac{13}{16}$ | $7\frac{5}{16}$ | $20\frac{5}{16}$ | $20\frac{1}{8}$ | $2\frac{7}{8}$ | $7\frac{1}{4}$ | 3 | 18 | 7 | 11 | $12\frac{1}{2}$ | $6\frac{5}{8}$ | $\frac{1}{4}$ | $13\frac{7}{8}$ | — | $\frac{5}{8}$-11 |
| 405T |  |  | $13\frac{3}{4}$ |  | $7\frac{5}{16}$ |  |  | $2\frac{7}{8}$ | $7\frac{1}{4}$ |  | 7 |  |  |  |  |  |  |  |
| 404TS |  |  | $12\frac{1}{4}$ |  | $4\frac{1}{2}$ |  |  | $2\frac{1}{8}$ | $4\frac{1}{4}$ |  | 4 |  |  |  |  |  |  |  |
| 405TS |  |  | $13\frac{3}{4}$ |  | $4\frac{1}{2}$ |  |  | $2\frac{1}{8}$ | $4\frac{1}{4}$ |  | 4 |  |  |  |  |  |  |  |
| 444U |  |  | $14\frac{1}{2}$ |  | $8\frac{5}{8}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $2\frac{7}{8}$ | $8\frac{5}{8}$ |  | $19\frac{9}{16}$ | $8\frac{3}{8}$ |  |  |  |  |  |  |
| 445U |  |  | $16\frac{1}{2}$ |  | $8\frac{5}{8}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $2\frac{7}{8}$ | $8\frac{5}{8}$ |  | $19\frac{9}{16}$ | $8\frac{3}{8}$ |  |  |  |  |  |  |
| 444T |  |  | $14\frac{1}{2}$ |  | $8\frac{1}{2}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $3\frac{3}{8}$ | $8\frac{1}{2}$ |  | $19\frac{9}{16}$ | $8\frac{1}{4}$ |  |  |  |  |  |  |
| 445T |  |  | $16\frac{1}{2}$ |  | $8\frac{1}{2}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $3\frac{3}{8}$ | $8\frac{1}{2}$ |  | $19\frac{9}{16}$ | $8\frac{1}{4}$ |  |  |  |  |  |  |
| 447T | 11 | 9 | 20 | $\frac{13}{16}$ | $8\frac{15}{16}$ | $22\frac{15}{16}$ | $23\frac{3}{4}$ | $3\frac{3}{8}$ | $8\frac{1}{2}$ | 3 | $21\frac{11}{16}$ | $8\frac{1}{4}$ | 14 | 16 | $7\frac{1}{2}$ | $\frac{1}{4}$ | $16\frac{3}{4}$ | — | $\frac{5}{8}$-11 |
| 449T |  |  | 25 |  | $8\frac{15}{16}$ | $22\frac{15}{16}$ | $23\frac{3}{4}$ | $3\frac{3}{8}$ | $8\frac{1}{2}$ |  | $21\frac{11}{16}$ | $8\frac{1}{4}$ |  |  |  |  |  |  |
| 444TS |  |  | $14\frac{1}{2}$ |  | $5\frac{3}{16}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $2\frac{3}{8}$ | $4\frac{3}{4}$ |  | $19\frac{9}{16}$ | $4\frac{1}{2}$ |  |  |  |  |  |  |
| 445TS |  |  | $16\frac{1}{2}$ |  | $5\frac{3}{16}$ | $22\frac{7}{8}$ | $22\frac{3}{8}$ | $2\frac{3}{8}$ | $4\frac{3}{4}$ |  | $19\frac{9}{16}$ | $4\frac{1}{2}$ |  |  |  |  |  |  |
| 447TS |  |  | 20 |  | $4\frac{15}{16}$ | $22\frac{15}{16}$ | $23\frac{3}{4}$ | $2\frac{3}{8}$ | $4\frac{3}{4}$ | 4NPT | $21\frac{11}{16}$ | $4\frac{1}{2}$ |  |  |  |  |  |  |
| 449TS |  |  | 25 |  | $4\frac{15}{16}$ | $22\frac{15}{16}$ | $23\frac{3}{4}$ | $2\frac{3}{8}$ | $4\frac{3}{4}$ | 4NPT | $21\frac{11}{16}$ | $4\frac{1}{2}$ |  |  |  |  |  |  |

**ED-20**

*Note:* * indicates Slot
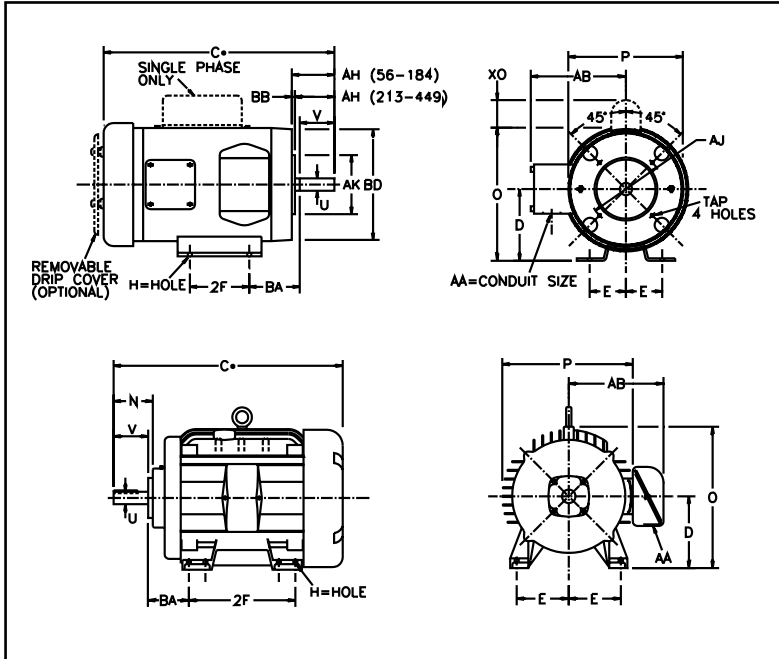
**VIRTUS**
*Power Transmission*
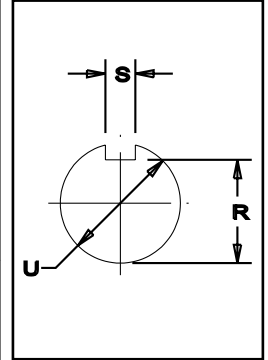
## NEMA Motor Frame Dimensions



**Note:** Drawings represent standard TEFC general purpose motors. Dimensions are for reference only.

| NEMA Shaft | Keyseat Dimensions | |
|---|---|---|
| U | R | S |
| 3/8 | 21/64 | FLAT |
| 1/2 | 29/64 | FLAT |
| 5/8 | 33/64 | 3/16 |
| 7/8 | 49/64 | 3/16 |
| 1 1/8 | 63/64 | 1/4 |
| 1 3/8 | 1 13/64 | 5/16 |
| 1 5/8 | 1 13/32 | 3/8 |
| 1 7/8 | 1 19/32 | 1/2 |
| 2 1/8 | 1 27/32 | 1/2 |
| 2 3/8 | 2 1/64 | 5/8 |
| 2 1/2 | 2 3/16 | 5/8 |
| 2 7/8 | 2 29/64 | 3/4 |
| 3 3/8 | 2 7/8 | 7/8 |
| 3 7/8 | 3 5/16 | 1 |



| NEMA C-Face | BA Dimensions |
|---|---|
| 143-5TC | 2 3/4 |
| 182-4TC | 3 1/2 |
| 213-5TC | 4 1/4 |
| 254-6TC | 4 3/4 |

| 5000 Frame | D | E | 2F | H | O | P | U | V | AA | AB | BA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5007S | 12 1/2 | 10 | 22 | 15/16 | 26 27/32 | 30 | 2 1/2 | 6 1/2 | 4-NPT | 26 7/8 | 8 1/2 |
| 5007L | 12 1/2 | 10 | 22 | 15/16 | 26 27/32 | 30 | 3 7/8 | 11 1/8 | 4-NPT | 26 7/8 | 8 1/2 |
| 5009S | 12 1/2 | 10 | 28 | 15/16 | 26 27/32 | 30 | 2 1/2 | 6 1/2 | 4-NPT | 26 7/8 | 8 1/2 |
| 5009L | 12 1/2 | 10 | 28 | 15/16 | 26 27/32 | 30 | 3 7/8 | 11 1/8 | 4-NPT | 26 7/8 | 8 1/2 |
| 5011S | 12 1/2 | 10 | 36 | 15/16 | 26 27/32 | 30 | 2 1/2 | 6 1/2 | 4-NPT | 26 7/8 | 8 1/2 |
| 5011L | 12 1/2 | 10 | 36 | 15/16 | 26 27/32 | 30 | 3 7/8 | 11 1/8 | 4-NPT | 26 7/8 | 8 1/2 |

## Frames Prior to 1963

| Frame | D | E | F | N | U | V | BA |
|---|---|---|---|---|---|---|---|
| 66 | 4 1/8 | 2 15/16 | 2 1/2 | 2 1/4 | 3/4 | 2 1/4 | 3 1/8 |
| 203 204 | 5 | 4 | 2 3/4 3 1/4 | 2 7/16 | 3/4 | 2 | 3 1/8 |
| 224 225 | 5 1/2 | 4 1/2 | 3 3/8 3 3/4 | 3 1/4 | 1 | 3 | 3 1/2 |
| 254 | 6 1/4 | 5 | 4 1/8 | 3 7/16 | 1 1/8 | 3 3/4 | 4 1/4 |
| 284 | 7 | 5 1/2 | 4 3/4 | 4 1/4 | 1 1/4 | 3 3/4 | 4 3/4 |
| 324 326 | 8 | 6 1/4 | 5 1/4 6 | 5 3/8 | 1 5/8 | 4 7/8 | 5 1/4 |
| 364 365 | 9 | 7 | 5 5/8 6 1/8 | 5 5/8 | 1 78/83 | 5 3/8 | 5 7/8 |
| 404 405 | 10 | 8 | 6 1/8 6 7/8 | 6 3/8 | 2 1/8 | 6 1/8 | 6 5/8 |
| 444 445 | 11 | 9 | 7 1/4 8 1/4 | 7 1/8 | 2 3/8 | 6 7/8 | 7 1/2 |
| 504 505 | 12 1/2 | 10 | 8 9 | 8 5/8 | 2 7/8 | 8 3/8 | 8 1/2 |