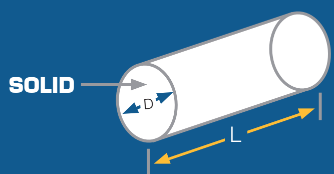
INERTIA (WK^2)

The factor WK^2 is the weight in lbs (W) of an object multiplied by the square of the radius of gyration (K). The unit measurement of the radius of gyration is in feet. The inertia of solid steel shafting per inch of shaft length is given in the gray table below. To calculate for hollow shafts, take the difference between the inertia values of D_o and D_i as the value per inch. For shafts of materials other than steel, multiply the value for steel by the factor in the shaft material table.

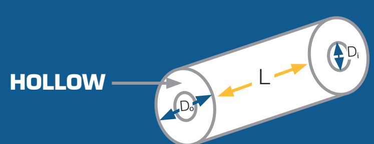
Mass Density - ρ (in/lb³)

ρ (aluminum) = .0924
ρ (bronze) = .320
ρ (cast iron) = .260
ρ (steel) = .282

Shaft Material	Factor
Rubber	.121
Nylon	.181
Aluminum	.348
Bronze	1.135
Cast Iron	.922

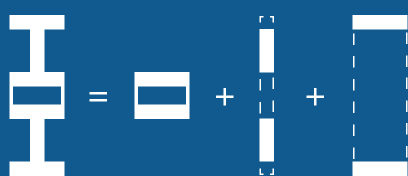


$$WK^2 = .000682 \times \rho \times L \times D^4$$



$$WK^2 = .000682 \times \rho \times L \times (D_o^4 - D_i^4)$$

The inertia of complex, concentric rotating parts is calculated by breaking the part up into simple rotating cylinders, calculating their inertia and summing their values, as shown.



$$WK^2 = WK_1^2 + WK_2^2 + WK_3^2$$

INERTIA OF STEEL SHAFTING

(per inch of length)

Diameter (in)	WK^2 (lb_m ft²)	Diameter (in)	WK^2 (lb_m ft²)	Diameter (in)	WK^2 (lb_m ft²)	Diameter (in)	WK^2 (lb_m ft²)
1/2	.00001	3 1/4	.021	6 1/4	.296	9 1/4	1.41
2/3	.00004	3 1/2	.029	6 1/2	.345	9 1/2	1.55
3/4	.00006	3 3/4	.038	6 3/4	.402	9 3/4	1.75
1	.0002	4	.049	7	.464	10	1.93
1 1/4	.0005	4 1/4	.063	7 1/4	.535	10 1/4	2.13
1 1/2	.001	4 1/2	.079	7 1/2	.611	10 1/2	2.35
1 3/4	.002	4 3/4	.098	7 3/4	.699	10 3/4	2.58
2	.003	5	.120	8	.791	11	2.83
2 1/4	.005	5 1/4	.146	8 1/4	.895	11 1/4	3.09
2 1/2	.008	5 1/2	.177	8 1/2	1.00	11 1/2	3.38
2 3/4	.011	5 3/4	.210	8 3/4	1.13	11 3/4	3.68
3	.016	6	.250	9	1.27	12	4.00

Objects in linear motion

$$F = \frac{W\Delta V}{1933t}$$

Where:
F = Force required (lb)
W = Weight (lb)
ΔV = Change in velocity (fpm)
t = Time to accelerate load (sec)

Accelerating torque and force of rotating objects

$$T = \frac{(WK^2)\,\Delta N}{308t}$$

Where:
T = Torque required (lb-ft)
WK^2 = Total inertia to be accelerated (lb-ft²)
ΔN = Change in speed (rpm)
t = Time to accelerate load (sec)

Moment of inertia for solid cylinder rotating about its own axis

$$WK^2 = \tfrac{1}{2} WR^2$$

Where:
WK^2 = Moment of inertia (lb-ft²)
W = Weight of object (lb)
R = Radius of the cylinder (ft)

Material in linear motion with a continuous fixed relation to a rotational speed (e.g. conveyor system)

$$WK^2 = W\left(\frac{V}{2\pi N}\right)^2$$

Where:
WK_L^2 = Linear inertia (lb-ft²)
W = Weight of material (lb)
V = Linear velocity (fpm)
N = Rotational speed of shaft (rpm)

Reflected inertia of a load through a speed reduction means (e.g. gear, chain or belt system)

$$WK_R^2 = \frac{WK_L^2}{R_r^2}$$

Where:
WK_R^2 = Reflected inertia (lb-ft²)
WK_L^2 = Load inertia (lb-ft²)
R_r = Reduction ratio

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