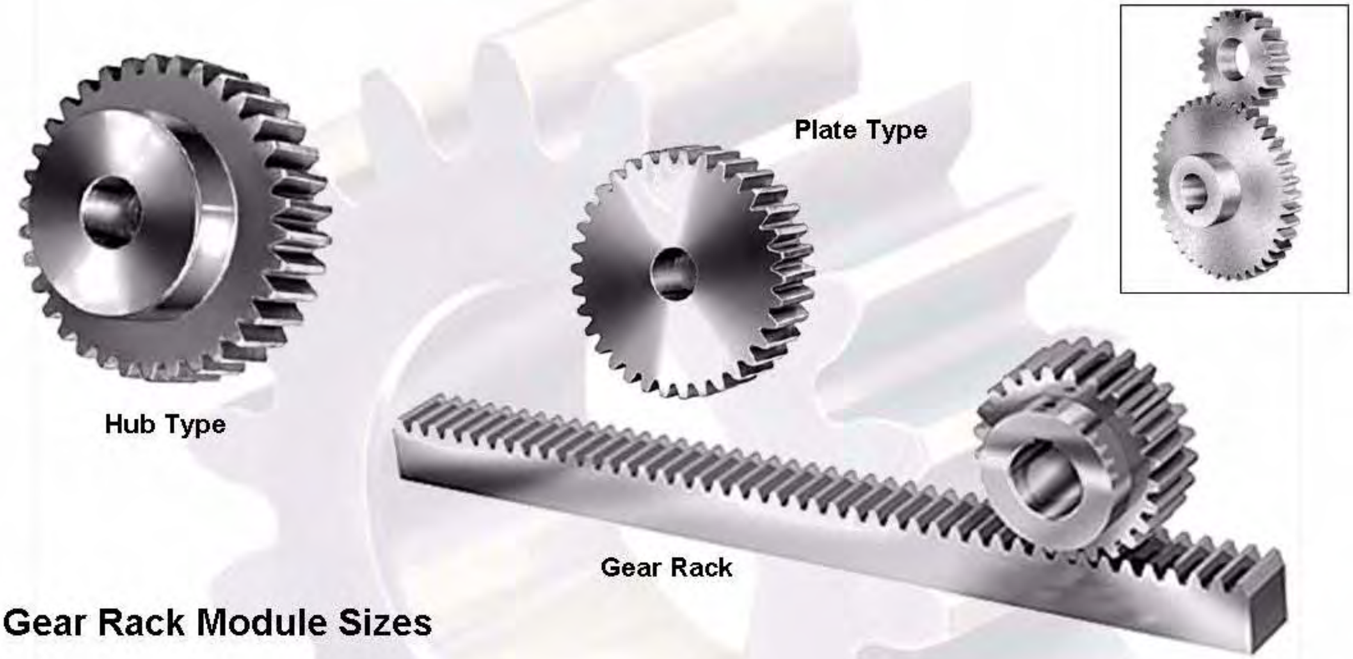
Metric Spur Gears & Racks

Module Sizes 1-8

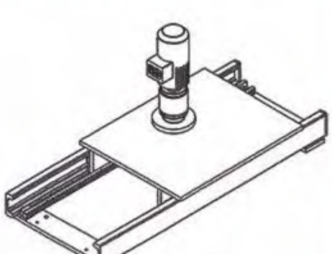


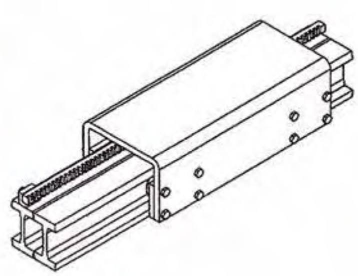
Gear Rack Module Sizes

Bore Types & Options

Pilot Bore | Bored to Size with keyway & set screw | Interference fit | Keyless locking device | Weld-On Hub & Tapered Bushing | Bolt on Hub for Bushing

Applications - Linear Motion Control





Spur Gear and Gear Rack Basics

There are a wide range of parameters that influence the selection of gears. Strength of the gear tooth is one of the most important factors. This is also known as the bending strength of the tooth as allowed by the stress at the tooth root under load from the mating gear. Surface durability is another, which can be described as the allowable tangential force transmitted safely at the pitch circle. Proper lubrication of the gears will also enhance the life of the working gears and extend service life. Selecting the proper lubricant and ensuring adequate re-lubrication is also an important consideration.

Surface speed of the mating gears is another factor to consider. Unlike enclosed gears that are typically flooded in a lubricant, open gears are more subject to contamination and less lubricant. Other factors that influence selection include operating temperature, moisture, gear alignment, duty cycle and application shock loads.

As speeds increase, whether on mating circular gears for rotational motion or for gear racks and pinion gears that create linear motion, higher speeds may require ground gears for more precise and quiet movement. Minimizing the backlash, which is the space between the non-contact side of mating gear teeth, may require gears sets with a precision fit.

Experience also plays an important role especially when evaluating design improvements. Consider existing applications and results, concerning life and tooth wear can be a good guide to improve similar applications. Gear life is generally extended with hardened teeth, when contamination has been minimized and when proper lubrication has been maintained. Therefore, no one selection criteria can yield the ideal size, so considering all the possible application conditions will yield the best product choice. The following selection criteria will discuss typical gear tooth physical parameters and terms. These are industry standard terms, and intended to form a basis for gear selection. Gears transmit torque and can maintain a rotational or linear speed. Hence they are very popular and an inexpensive choice for power transmission or for controlling linear motion.

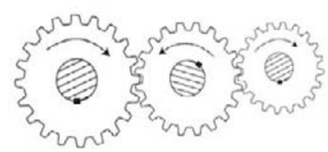
The gears in this catalog are 20° pressure angle and are metric by design. They are available with and without a hub and can fit onto the shaft by a variety of ways. The formulas and selection criteria will be the same regardless of whether inch or metric parameters. Metric gears are necessary for proper part replacement on European equipment and suggested for use on machinery destined for global end use markets where metric replacements may be found easier.

Hub Type

Plate Type

Typical applications include Machine Tools, Heavy Machinery, Packaging Equipment, Lifts, Positioning Equipment, Robotics, Linear Control Equipment and more.

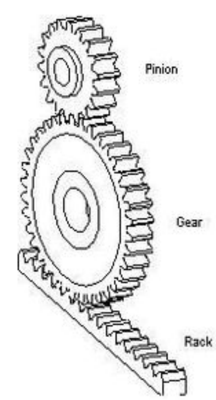
So whether controlling rotational motion, or converting rotational to linear motion, or even clockwise to counter clockwise movement, spur gears offer an economical means for controlling, converting and managing motion efficiently and effectively.



Gear Terms

Addendum: The height of the tooth measured above the pitch cicle.
Backlash: The play (distance) between mating teeth at the pitch cicle.
Center Distance: The distance between centers of mating gears.
Circular Pitch: Arc length of the pitch circle between the centers of other corresponding points of adjacent teeth. Circular Pitch = 3.14159 / Diametral Pitch.
Clearance: The radial distance or separation between the top of one tooth and the bottom of the mating tooth space.
Crown: The face of each gear tooth having a slight outward bulge and thinner on each end. This feature helps accommodate slight misalignments of gear teeth or shafts on which they are mounted.
Dedendum: The depth of the tooth measured below the pitch circle.
Diametral Pitch: The ratio of the number of teeth to the number of inches of pitch diameter. Diametral Pitch = 3.14159 / Circular Pitch.

External Gears: Gears with teeth cut on the outside.
Face Width: The axial tooth length.
Tooth Flank: The surface between the pitch circle and the bottom of the tooth space.
Flank: The working, or contacting, side of the gear tooth.
Gear Center: The center of the pitch circle of the gear.
Gear Ratio: The ratio of the number of teeth in mating gear sets. Usually it is the number of teeth in the driven gear divided by the number of teeth in driving gear.
Line of Centers: Connects the centers of the pitch circles of two mating gears
Outside Diameter: (External gears) The distance from the top of one tooth to the top of a tooth opposite measured through the axis of the gear. Outside Diameter = Number of Teeth + 2 / Diametral Pitch.
Pitch: The distance between similar, equally spaced tooth surfaces along a given line or curve.
Pitch Circle: Circle where mating gear contact occurs. Pitch circles are tangent in mating gears.
Pitch Diameter: The diameter of the pitch circle. Pitch Diameter = Number of Teeth / Diametral Pitch.



Point of Contact: Any point at which two tooth profiles touch each other.
Pressure Angle: The angle between a tangent to the tooth profile and a line perpendicular to the pitch surface. Standard gears are either 14-1/2ø or 20ø degree.
Root Diameter: The distance from the bottom of one tooth to the bottom of a tooth opposite measured through the axis of the gear.
Tooth Thickness: The thickness of a tooth at the pitch circle.
Tooth Surface Area: The contact sides or faces of a gear tooth, or the area including the tooth face and the tooth flank.
Shaft Angle: The angle between the axis of two non-parallel gear shafts. This is often referred to as misalignment.
Spur Gears: Gears with straight teeth are always parallel to the axis of rotation.

Spur Gear Selection

Formulas & Criteria

The following criteria will provide a guide to gear selection. Steel spur gears in this catalog are from C45 (C1045) material not hardened. Know there can be many factors in selecting the right and exact gear to match expectations, requirements and criteria. There may be many parameters that impact the selection of gears. Below are some of the basic parameters that will begin to help select the right gear. For a loading guide, the rolling stress load on the tooth σ = 589 N/mm^2 and allowable bending stress σ = 200 N/mm^2.

Gear Strength: Choose the spur gear based on gear strength. The permissible bending strength of a gear is referred to as the allowable tangential force at the pitch circle and relates to the allowable load on the tooth and resulting bending stress in the root of the tooth under load.

Surface Durability is the safe force on the tooth without any occurrence of surface failures. Lubrication will be an important consideration for the teeth that mesh to keep working surfaces lubricated. Speed of the gears in mesh will also play a role as will the type of lubrication.

Selection: The next step is to make an estimated selection based on the torque load. Allowable torque for each gear is listed in the catalog pages for each gear. Different manufacturers may use different loading criteria based on service factors and material stress levels. These published Torque ratings are intended as a guide.

Gear Size is generally proportional to the load capacity. A hardened gear will have more load capacity, but may have less flexibility for absorbing or allowing shock loads or other application requirements. Ground gears will also improve positioning accuracy.

Load or Service Factors for external dynamic loads will also influence the operation and life of the gear. The following service factors that can be applied to the load will help extend service life.

Lubrication: For peripheral speeds less than 0.5 m/s grease will suffice, for peripheral speeds above 0.5 m/s oil should be considered. Safety Factors should be considered for safe working loads.

Speeds: C45 Spur Gears that are milled (un-ground) can be applied at rim speeds up to 12 m/s. As a comparison, ground gears can be applied to 25 m/s. Hardened gears that are milled usually have max limits of 8 m/s due to tooth distortion from the tooth hardening process. Consider multiple stages of gear sets for high reductions.

Noise considerations: milled gears are quietest when held to 5 m/s rim speed. Ground gears would be suggested for more continuous operation primarily for minimizing noise. Also low speed applications, manual drives, pinions with 8-12 teeth can be used. For gears with higher demands, 25 teeth or more should be used.

Selection Formulas (Metric & Inch Units)

Description	Formula	Dimension (Units)
Number of Teeth	$z = Dp / m$	—
Module	$m = p / \pi = Dp / z$	—
Pitch Diameter	$Dp = z \cdot m$	mm
Tooth Pitch	p	mm
Face Width	h	
Addendum Dia.	$D_e = (z + 2) \cdot m$	mm
Pressure Angle	α	degree
Gear Ratio	$r = z_2 / z_1 = n_1 / n_2$	
Center Distance	$c = (Dp_1 + Dp_2) / 2 = (z_1 + z_2) \cdot m / 2$	mm
Torque	$T = 9950 \cdot P / n$	Nm
Power	P	kw
Speed	n	rpm
Rim Speed	$v = (Z_1 \cdot m \cdot n_1) / 19100$ $= \pi \cdot D_e \cdot n / 60{,}000$	m/sec
Pi	$\pi = 3.1415$	
E-modulus	$2.1 \cdot 10^5$	N/mm^2
Horsepower	$HP = (T_1 \times n) / 63025$	HP
Torque	T_1	in - lbs
Troque	$T_1 = F \times R$	in - lbs
Radius or moment arm	R	in
Force	F	lbs
Inch		
Linear Motion (Rack & Pinion) Formulas		
Acceleration	$a = V / t$	m/sec^2
Time	t	sec
Tangential Acceleration Force (for lifting axis)	$F_T = (m \cdot g) + (m \cdot a)$	lb
Tangential Acceleration Force (for driving axis)	$F_T = (m \cdot g \cdot \mu) + (m \cdot a)$	lb
Coeffieient of Friction of axis	μ	—
Mass	m	lb • sec^2 / in
Acceleration due to gravity	g	386 in / sec^2

Note: Metric gear ratings are in metric units. Standard Gear formulas and HP-Torque formulas are to the left and formula conversion factors are given below. Care should be taken to insure unit conversions are accurate.

Service Factors

Drive	Uniform Load Factor	Medium Shock Load Factor	Heavy Shock Load Factor
Uniform	1.0	1.25	1.75
Light Shock	1.25	1.5	2.0
Medium Shock	1.5	1.75	2.25

Conversion Factors:

1 Newton N = 0.2248 lbs
1 Newton N = 0.102 Kg
1 Kilogram kg = 2.2 lbs
1 HP = 0.746 Kikowatt (kw)
1 meter m = 3.28 Ft = 39.4 inches
1 inch = 25.4mm