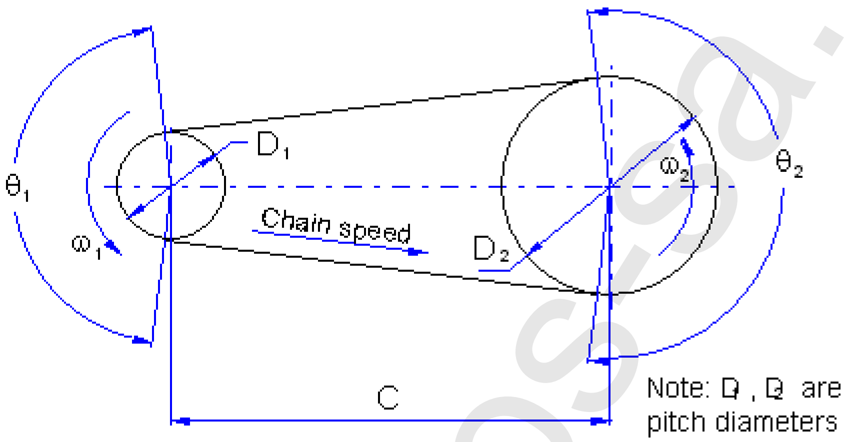
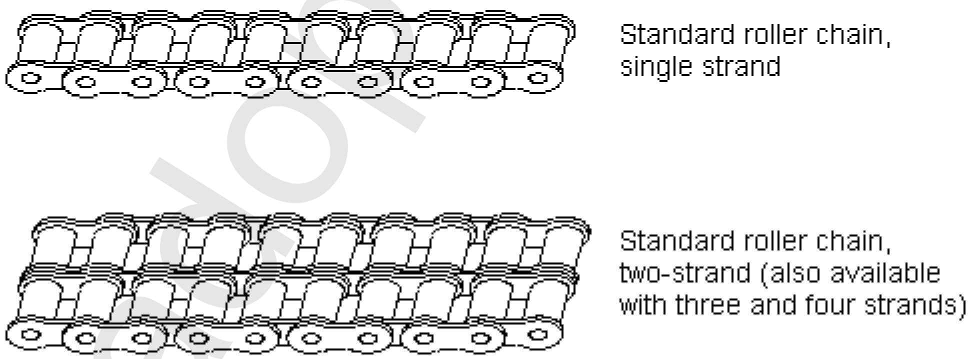
A chain is a power transmission element made as a series of pin-connected links. The design provides for flexibility while enabling the chain to transmit large tensile forces. When transmitting power between rotating shafts, the chain engages mating toothed wheels, called sprockets.

Basic chain drive geometry



The most common type of chain is the *roller chain*, in which the roller on each pin provides exceptionally *low friction* between the chain and the sprockets. Other types include a variety of extended link designs used mostly in conveyor applications.

Roller chain styles



Roller chain is classified by its pitch, the distance between corresponding parts of adjacent links. The pitch is usually illustrated as the distance between the centers of adjacent pins. Standard roller chain carries a size designation from 40 to 240. The digits (other than the final zero) indicate the pitch of the chain in eighths of an inch. For example, the no. 100 chain has a pitch of 10/8 or in. A series of heavy-duty sizes, with the suffix H on the designation (60H-240H), has the same basic dimensions as the standard chain of the same number except for thicker side plates. In addition, there are the smaller and lighter sizes: 25, 35, and 41.

Manufacturers supply the average tensile strengths of the various chain sizes. These data can be used for very low speed drives or for applications in which the function of the chain is to apply a tensile force or to support a load. It is recommended that only 10% of the average tensile strength be used in such applications. For power transmission, the rating of a given chain size as a function of the speed of rotation must be determined.

A variety of attachments are available to facilitate the application of *roller chain* to conveying or other material handling uses. Usually in the form of extended plates or tabs with holes provided, the *chain attachments* make it easy to connect rods, buckets, parts pushers, part support devices, or conveyor slats to the chain.

The rating of chain for its power transmission capacity considers three modes of failure:

1. Fatigue of the link plates due to the repeated application of the tension in the tight side of the chain
2. Impact of the rollers as they engage the sprocket teeth
3. Galling between the pins of each link and the bushings on the pins.

The ratings are based on empirical data with a smooth driver and a smooth load (service factor = 1.0) and with a rated life of approximately 15,000 h. The important variables are the pitch of the chain and the size and rotational speed of the smaller sprocket. Lubrication is critical to the satisfactory operation of a *chain drive*. Manufacturers recommend the type of lubrication method for given combinations of chain size, sprocket size, and speed.

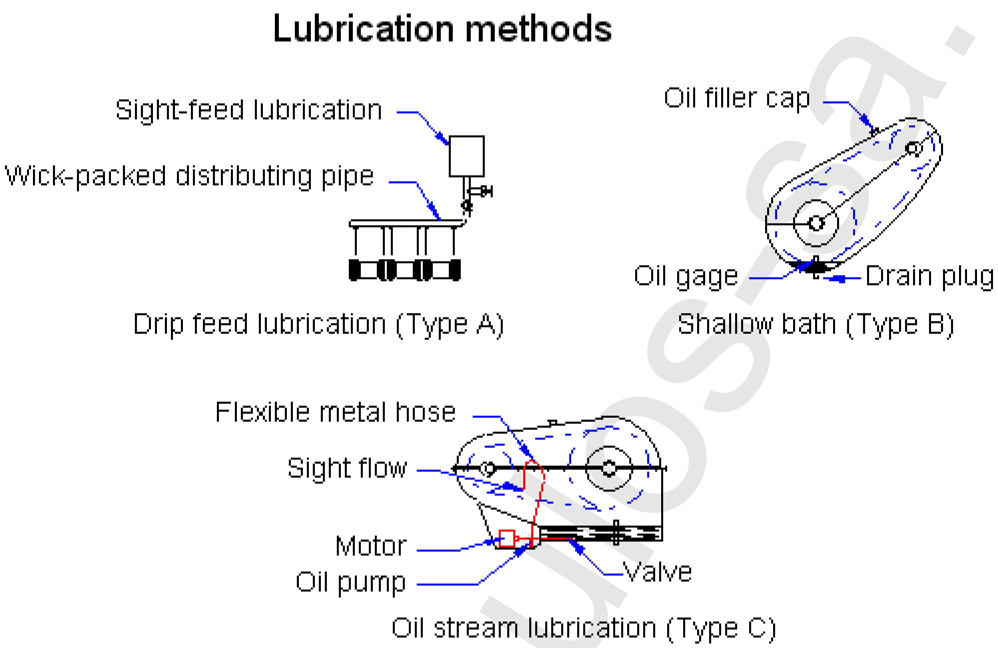
<u>The standard sizes of chain are</u>:

- no. 25 (1/4 in)
- no. 35 (0.375 in)
- no. 40 (1/2 in)
- no. 41 (1/2 in)
- no. 50 (0.625 in)
- no. 60 (3/4 in)
- no. 80 (1.00 in)
- no. 100 (1.25 in)
- no. 120 (1.5 in)
- no. 140 (1.75 in)
- no. 160 (2 in)
- no. 180 (2.25 in)
- no. 200 (2.5 in)
- no. 240 (3 in)

These are typical of the types of data available for all chain sizes in manufacturers' catalogs. Notice these features of the data:
"The ratings are based on the speed of the smaller sprocket."
For a given speed, the power capacity increases with the number of teeth on the chain sprocket. Of course, the larger the number of teeth, the larger the diameter of the

sprocket. Note that the use of a chain with a small pitch on a large sprocket produces the quieter drive.

For a given sprocket size (a given number of teeth), the power capacity increases with increasing speed up to a point; then it decreases. Fatigue due to the tension in the chain governs at the low to moderate speeds; impact on the sprockets governs at the higher speeds. Each sprocket size has an absolute upper-limit speed due to the onset of galling between the pins and the bushings of the chain. This explains the abrupt drop in power capacity to zero at the limiting speed.



The manufacturers' ratings are for a single strand of chain. Although multiple strands do increase the power capacity, they do not provide a direct multiple of the single-strand capacity. The capacity for 2, 3, and 4 strand systems are 1.7, 2.5 and 3.3 respectively.

The manufacturers' ratings are for a service factor of 1.0. The designer must specify a service factor for a given application based on the type of driver and load for that system.

<u>The following are general recommendations for designing chain drives:</u>

- The minimum number of teeth in a sprocket should be 17 unless the drive is operating at a very low speed, under 100 rpm.
- The maximum speed ratio should be 7.0, although higher ratios are feasible. Two or more stages of reduction can be used to achieve higher ratios.
- The center distance between the sprocket axes should be approximately 30 to 50 pitches (30 to 50 times the pitch of the chain).
- The arc of contact of the chain on the smaller sprocket should be no smaller than 120°.
- The larger sprocket should normally have no more than 120 teeth.

- The preferred arrangement for a chain drive is with the centerline of the sprockets horizontal and with the tight side on top.
- The chain length must be an integral multiple of the pitch, and an even number of pitches is recommended.

The center distance should be made adjustable to accommodate the chain length and to take up for tolerances and wear. Excessive sag on the slack side should be avoided, especially on drives that are not horizontal. A convenient relation between center distance (C), chain length (L), number of teeth in the small sprocket ( ), and number of teeth in the large sprocket ( ), expressed in pitches, is

$$L = 2C + \frac{N_2 + N_1}{2} + \frac{(N_2 - N_1)^2}{4\pi^2 C}$$

The exact theoretical *center distance* for a given chain length, again in pitches, is

$$C = \frac{1}{4}\left[L - \frac{N_2 + N_1}{2} + \sqrt{\left[L - \frac{N_2 + N_1}{2}\right]^2 - \frac{8(N_2 - N_1)^2}{4\pi^2}}\right]$$

The theoretical center distance assumes no sag in either the tight or the slack side of the chain, and thus it is a maximum. Negative tolerances or adjustment must be provided.

The pitch diameter of a sprocket with N teeth for a chain with a pitch of p is

$$D = \frac{p}{\sin(180^\circ / N)}$$

The minimum sprocket diameter and therefore the minimum number of teeth in a sprocket are often limited by the size of the shaft on which it is mounted. Check the sprocket catalog.

Source:

Robert L. Mott "*Machine Elements in Mechanical Design*" ISBN: 0-13-061885-3

2003 by Prentice Hall, Inc.