Drive Chains

Design Considerations

Drive chains are used for power transmission and speed reduction. Horsepower, which is 33,000 foot-pounds of work per minute, is the unit of measurement of power.

Horsepower (mechanical)

$$HP = \frac{T(RPM)}{63{,}000}$$

$$HP = \frac{P(FPM)}{33{,}000}$$

Where:

T = Torque (in.-lb.)
P = Net chain pull (lbs.)
RPM = Shaft speed (rev./min.)
FPM = Chain speed (ft./min.)

Chain Speed (In FPM)

$$FPM = \frac{RPM\text{ (no. of teeth) (pitch in inches)}}{12}$$

Horsepower (electric motor)

$$HP\text{ (3 Phase)} = \frac{\text{Volts} \times \text{Amperes} \times 1.732 \times \text{Efficiency} \times \text{Power Factor}}{746}$$

$$HP\text{ (1 Phase)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Efficiency} \times \text{Power Factor}}{746}$$

Alignment

Accurate alignment of shafts and sprocket tooth faces provides uniform distribution of the load across the entire chain width. Uniform distribution of the load contributes substantially to optimum drive life. Be sure that the shaft, bearings, and foundations are suitable to maintain the initial alignment. Periodic maintenance should include an inspection of alignment to ensure optimum chain life.

Arrangement

Drive chains are ideally installed with the shaft in the horizontal position, as shown in Figures 1 and 2.

Figure 1

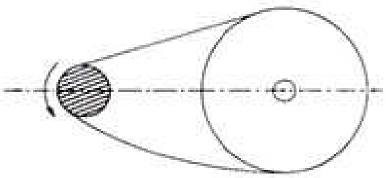


Figure 2

When chains are installed at angles approaching the shaft vertical position, they elongate quickly and may slip off the sprockets. In such cases, make sure the sprockets are adjusted properly. (See Figures 3 and 4.)

Figure 3

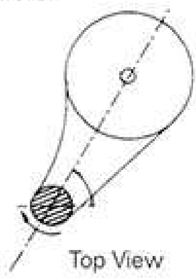
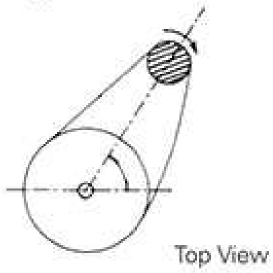


Figure 4

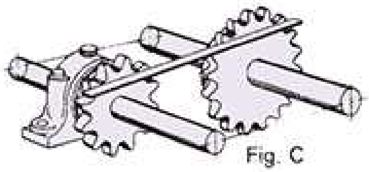


Position of Sprockets

The two shafts should be parallel and the sprockets should be firmly installed. Use a straight edge to check that the two sprockets are installed along the same horizontal level. This is illustrated in Figures 5 and 6.

Figure 5

Figure 6



Lubrication

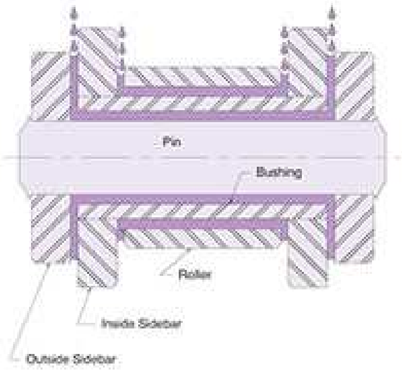
Lubrication Increases the Service Life

One of the most important factors in getting the best possible performance out of your drive chain is proper lubrication. No matter how well a transmission system is designed, if it is not properly lubricated, its service life will be shortened.

Lubrication

Wear between the pin and bushing causes drive chain to elongate. These parts should, therefore, be well lubricated, as shown in Figure 7. The gap between the inside sidebar and the outside sidebar on the slack side of the chain should be filled with oil. This oil forms a film which minimizes wear on the pin and bushing, thus increasing the chain's service life. It also reduces noise and acts as a coolant when the chain runs at high speeds.

Figure 7



Suggested Lubricants

Only high quality oil should be used to lubricate the drive chain. Neither heavy oil nor grease is suitable. The viscosity of the oil used will depend on the chain size, chain speed, and ambient temperature. The lubricants suggested for specific temperature ranges are shown in Table 1.

Table 1 — Lubrication Table

Temperature (°F)	Suggested Lubricant
20° - 40°	SAE 20
40° - 100°	SAE 30
100° - 120°	SAE 40
120° - 140°	SAE 50

Lubrication Systems

The following lubricating systems are suggested:

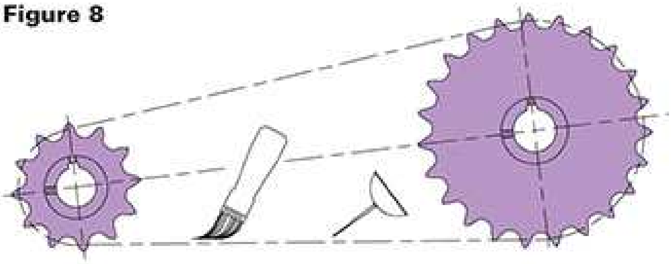
Drip Lubrication

Use a simple casing and supply oil by drip feed. Each strand of chain should receive 15 to 120 drops of oil per minute depending on the chain speed.

Manual Lubrication

On the slack side of the chain apply oil with an oil filler or brush in the gap between the pin link sidebar and roller link sidebar. (See Figure 8.) Reapply every eight hours or as often as necessary to prevent the bearing area of the chain from becoming dry.

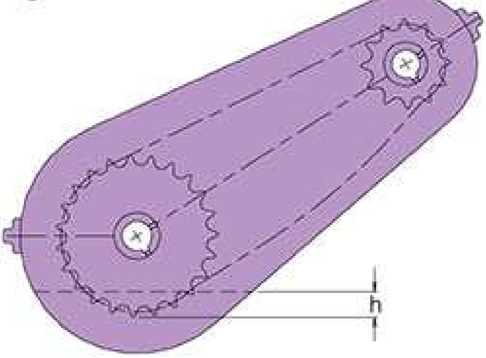
Figure 8



Oil Bath Lubrication

Install the chain in a leak-free casing (Figure 9). The oil depth (h) should extend only to the middle point of the pin end. The oil will be adversely affected by the generated heat if the oil depth is too great.

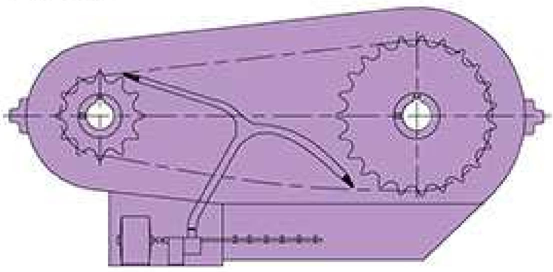
Figure 9



Lubrication Using a Pump (Oil Stream)

Use a leak-free casing. Circulate the oil with a pump. The number of supply holes should be one more than the number of strands of chain. Supply a constant amount of oil to each hole (Figure 10). The oil should also be cooled in this process.

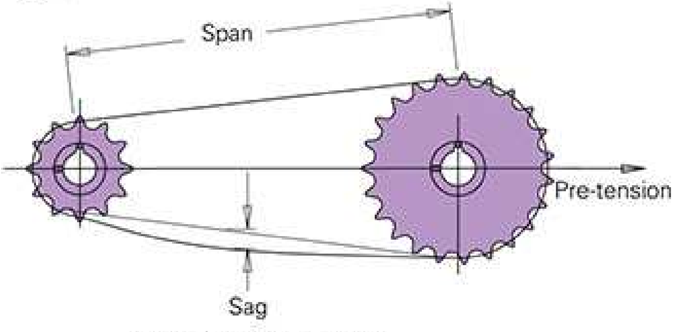
Figure 10



Catenary Sag

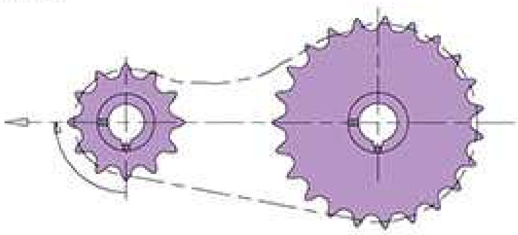
Pre-tension on the slack strand should be adequate to hold chain inward on the sprocket tooth profile. The 3% catenary sag distance on the slack strand achieves correct pre-tension levels, illustrated in Figure 11.

Figure 11



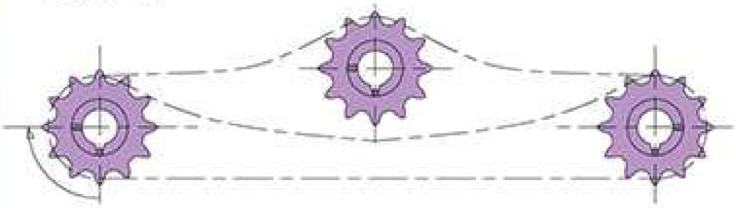
Attention should be paid to the following arrangements. If the slack side is on top, it is necessary to eliminate excessive chain slack. When the center distance is short, chain slack should be adjusted by increasing the center distance illustrated in Figure 12.

Figure 12



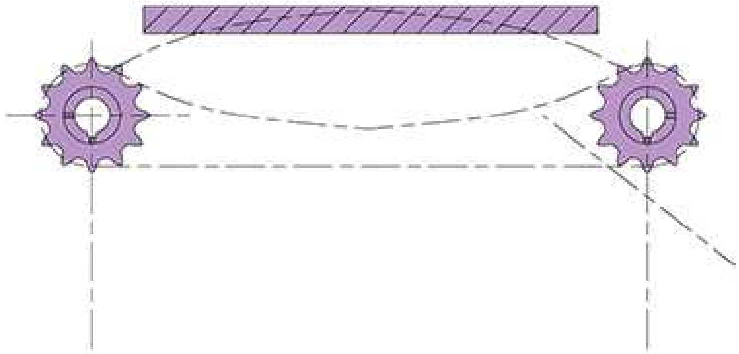
When the center distance is long, chain slack should be adjusted by installing an idler, illustrated in Figure 13.

Figure 13



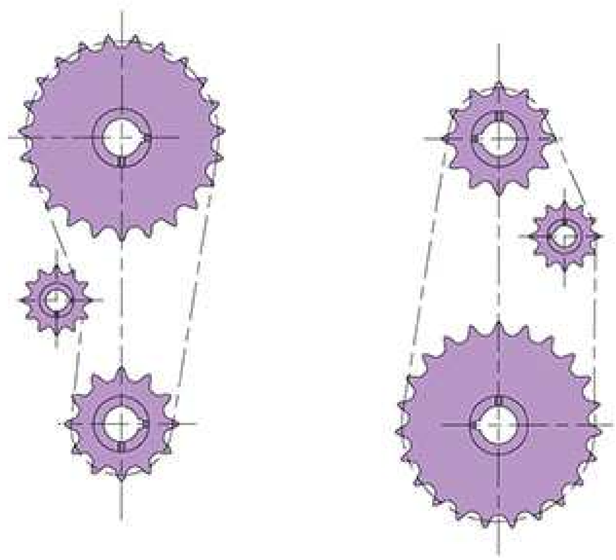
If vibration occurs due to high chain speed, install a guide. This is shown in Figure 14.

Figure 14



If the centerline is vertical, install an idler which functions automatically to eliminate extra chain slack. If the driving shaft is on the lower side, an idler must be installed, as shown in Figure 15.

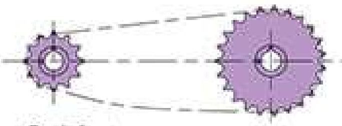
Figure 15



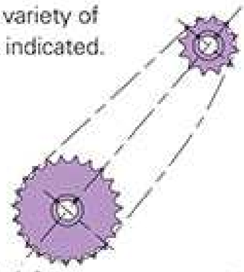
Drive Chain Arrangements

The position of the drive and driven sprockets can greatly affect the life of the chain drive. Figure 16 illustrates a variety of arrangements with favorable and unfavorable features indicated.

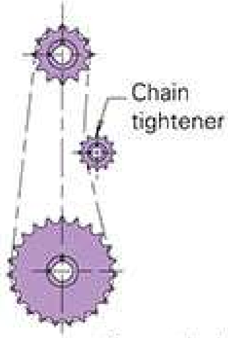
Figure 16



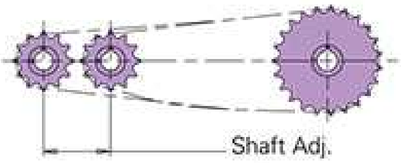
Satisfactory arrangement for drives with short centers.



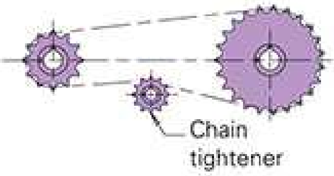
Satisfactory arrangement for drives with short centers.

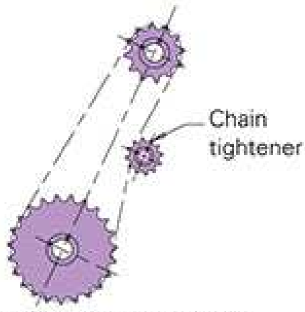


Best arrangement for vertical drives where means for adjusting slack is possible.

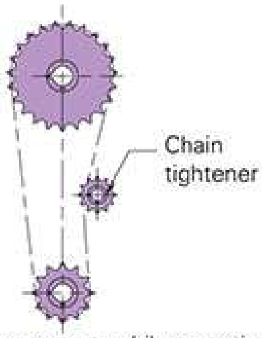


It is best to have one shaft adjustable as shown directly above. Or use a chain tightener as shown in the lower arrangement.

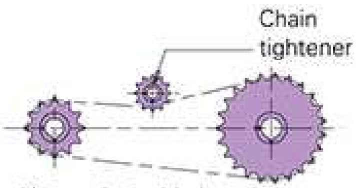




For drives on steep inclines some means must be provided to adjust slack side tension.



This arrangement, while sometimes used, is not as satisfactory as that shown above.



When slack side is on top some means must be provided to adjust slack side tension.

Unsatisfactory arrangement. (No adjustment is provided.)

Direction of Travel

The travel direction affects the wear life of offset drive chains. Figure 17 illustrates the general rule for chain travel direction. It is as follows: The narrow or roller end of links on the tight side should travel toward the small sprocket, regardless if it is a drive or driven sprocket.

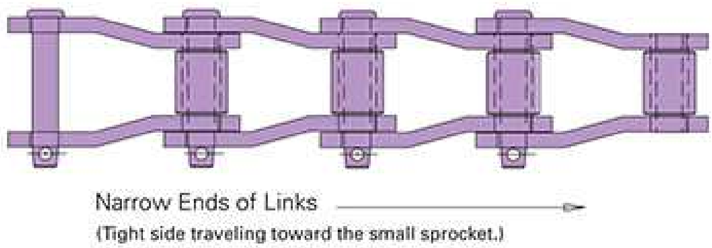
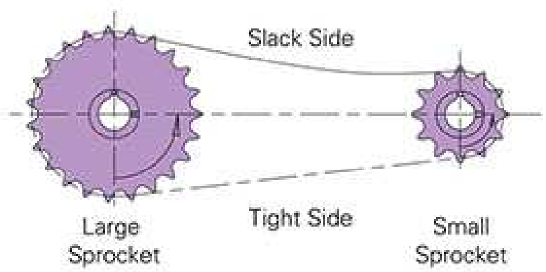
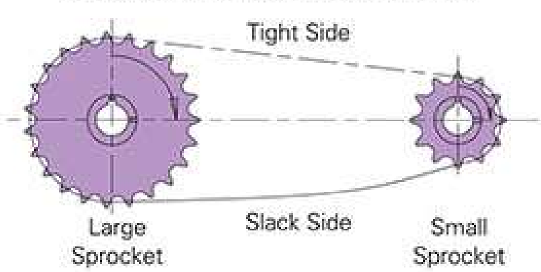


Figure 17





Chain Elongation

You can estimate the remaining chain life by determining chain elongation. This is illustrated in Figure 18. Measure chain elongation in the following manner.

1. Locate a straight section of chain that is under tension.
2. Using a vernier or scale, measure the inside (L1) and outside (L2) of the pins at both ends of the measured links.
3. Calculate the measurement (L) using the formula:

$$L = \frac{(L1 + L2)}{2}$$

4. Calculate chain elongation.

$$\text{Chain elongation} = \frac{\text{Measured length - Standard length} \times 100\%}{\text{Standard length}}$$

Where:

Standard length = Chain pitch x Number of links

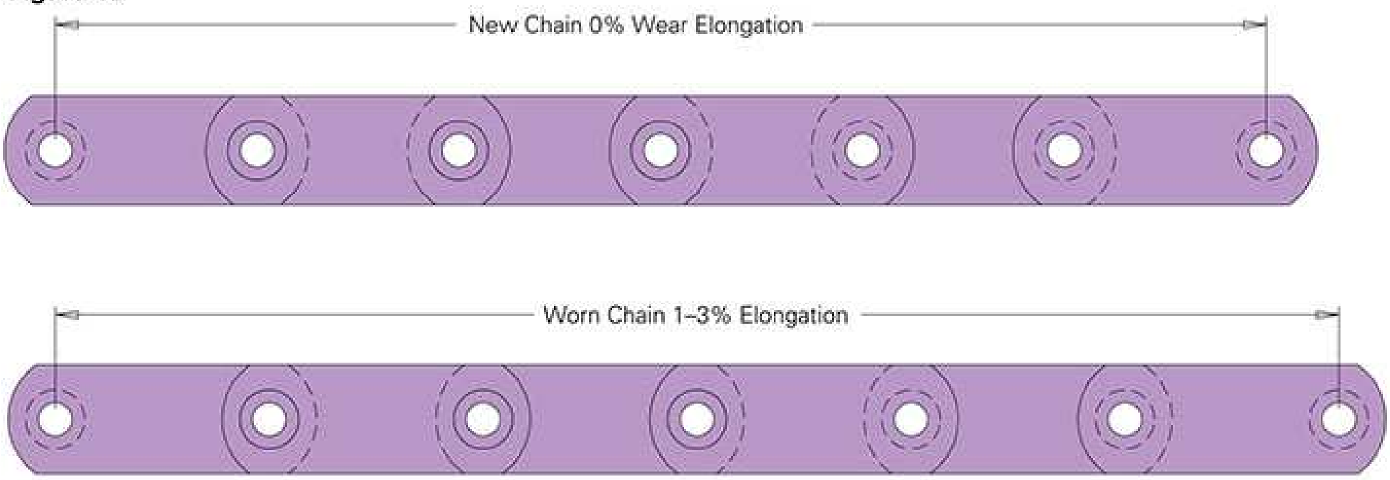
When Chains Should Be Replaced

Replace drive chains corresponding to the number of sprocket teeth as shown in Table 2.

Table 2 — Drive Chain Replacement (Full Wrap)

% Chain Elongation	Number of Teeth in Large Sprocket
1	≥ 140
2	> 72
3	≤ 72

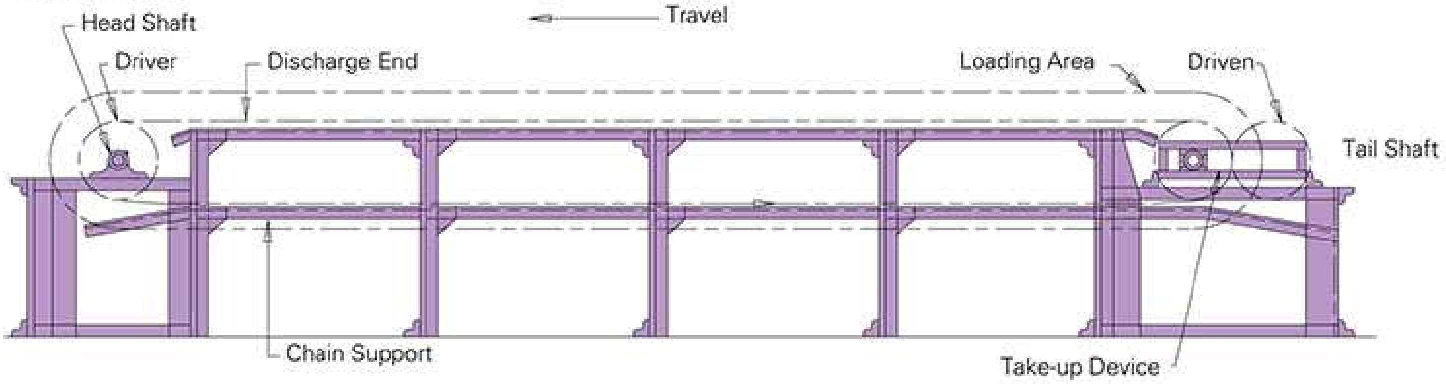
Figure 18



NOTES

Roller Conveyor Chains

Figure 1



Roller Conveyor Chains are used to transfer bulk or unit product from one point to another. A typical conveyor frame is shown in Figure 1.

Design Considerations

Drive End

Apply driving power to the discharge end of a conveyor so that only the carrying run is under maximum tension. Apply power to the head sprocket through another chain and sprocket.

Pre-tension and Take-ups

Provide take-ups in all conveyor installations to ensure slack for installation and maintenance and to compensate for elongation due to wear. Install the catenary take-up at the head end of the conveyor; install all other take-ups at the foot or loading end of the conveyor.

Points to Consider

1. Ensure that chain is always engaged with at least three sprocket teeth.
2. For long conveyors, use take-up devices to eliminate chain slack. Take-up stroke = (C x 0.02) + S

Where:

C = Center distance between sprockets

S = Catenary sag allowance

For conveyors shorter than 50 feet, consult Union Engineering.

(***Note:*** The above equation is for conveyors longer than 50 ft.)

Long Shaft Center Distances

For unusually long shaft centers, either use two conveyors with a transfer point or use bearing roller chain. Contact Union Engineering for more information.

Return Chain Supports

On chain conveyors more than fifteen feet long, support the return strand on a track or guide to minimize pulsation and whip and to prevent the sagging chain from striking obstacles.

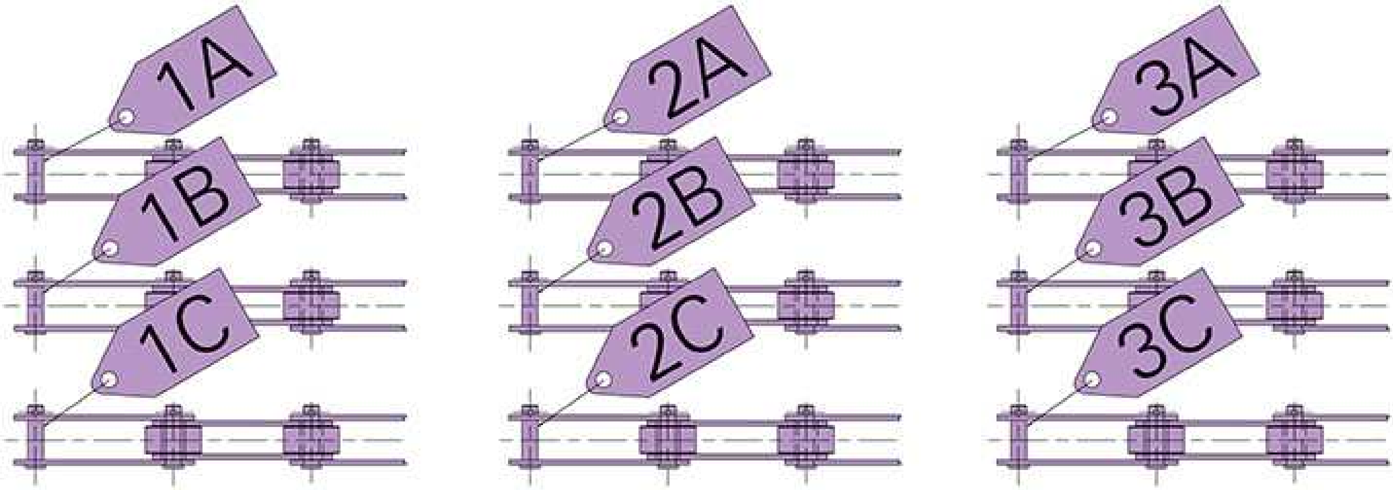
Operating Temperatures

Standard conveyor chain can be operated normally in ambient temperatures between 15˚F and 140˚F. Select the appropriate chain for conditions outside of this range, including operation in freezing chambers or heat-treatment ovens.

Matched Strands

For multiple strand operation, specify "matched and tagged chain" along with the number of strands required. The factory will match the chain for uniform length and accurate attachment alignment. In this multiple strand case, all sprocket teeth on the head shaft should be aligned. Strand matching and tagging are shown in Figure 2.

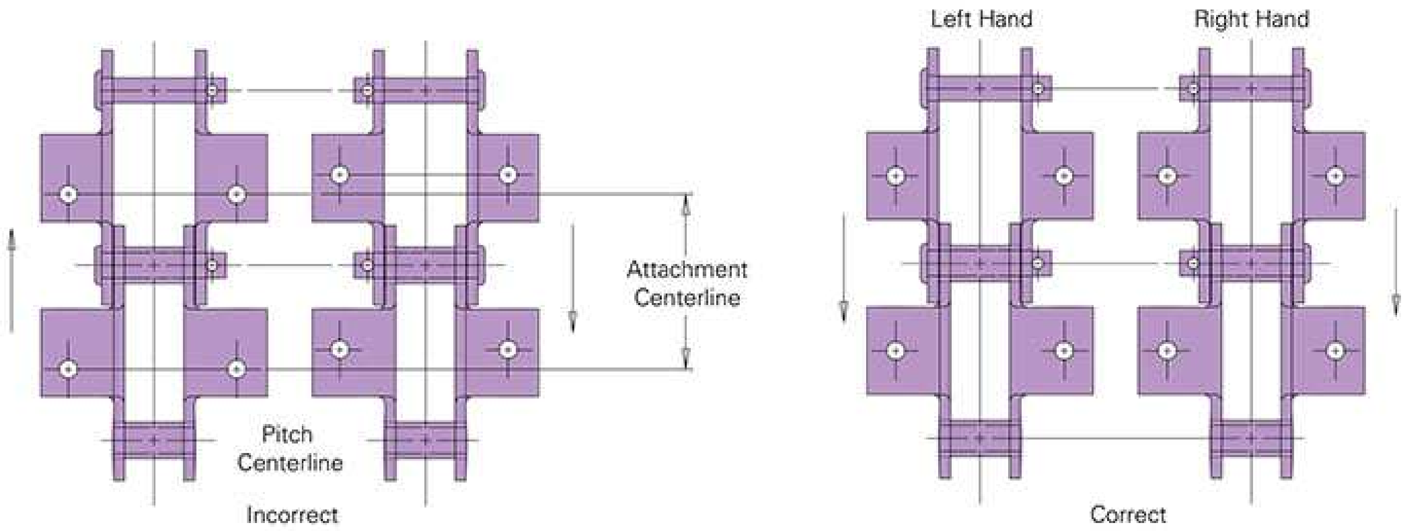
Figure 2



Right- and Left-hand Strands

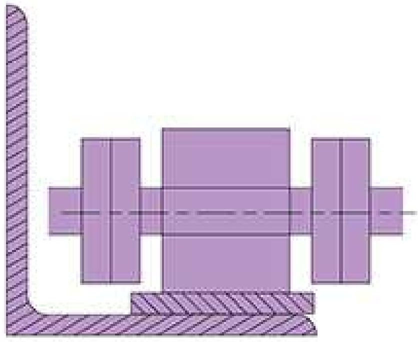
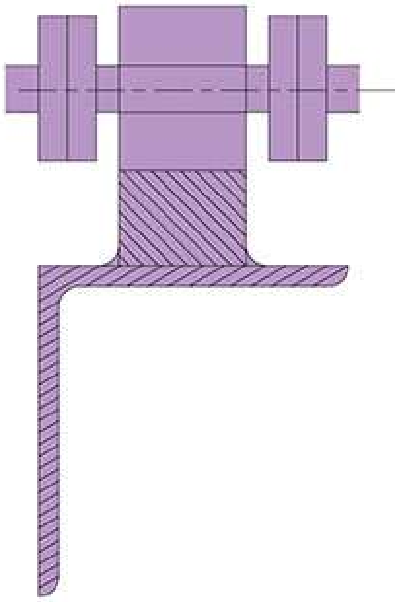
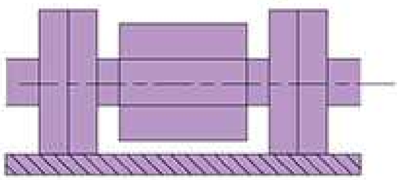
Right- and left-hand strands are required in all multiple strand installations where the chain attachments, slots, or lugs are not symmetrical. Many conveyors must have cotters on the inside to clear guide rails and angle frames with the pin head on the outside, see Figure 3.

Figure 3



Rail Layout and Roller Type

Table 1 — Construction Considerations

<table>
<tr><th>Method of Chain Travel</th><th>Type of Roller</th><th>Features</th></tr>
<tr><td>Chain Rolling (Horizontal or Vertical)
</td><td>Carrier roller type
•Heavy in chain weight
•Greater allowable roller load
•Less roller wear</td><td>•Smooth operation
•Less vibration
•Lower friction and less power required
•Generally used for lengths more than 35 ft. and speeds greater than 70 ft./min.</td></tr>
<tr><td>Chain Rolling
</td><td rowspan="2">Small roller type
•Lightweight
•Lower allowable roller load</td><td>•Generally used for lengths less than 35 ft. and speeds less than 70 ft./min.</td></tr>
<tr><td>Chain Sliding
</td><td>•Suitable for impact conditions
•Suitable for dirty conditions
•Economical
•Impact resistant
•Greater power required</td></tr>
</table>

Roller Conveyor Speeds

Conveyor speed is dictated by the nature of the load, how it is loaded and unloaded on the conveyor, and what is done to the load during conveying. Table 2 shows the basic conveyors and their typical operating speeds.

Table 2 — Typical Operating Speeds

Conveyor	Speed (ft./min.)
Continuous bucket elevator	75 to 150
Centrifugal bucket elevator	200 to 300
Slat or flat top conveyor	50 to 150
Carrier conveyor[1]	50 to 150
Assembly line conveyor	5 to 15
Drag and scraper conveyors	50 to 100
Apron conveyors	10 to 60

[1]Material conveyed directly on chain

Roller Conveyor Installation and Operation

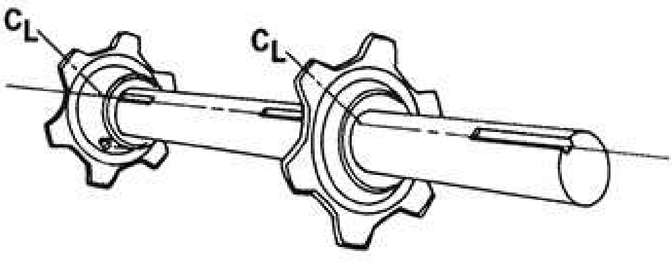
Shaft Alignment

Shaft alignment is ensured by rigidly supporting shafts in properly designed bearings. Align the shafts horizontally with a leveling device. Head and tail shafts must be parallel and at 90° to the direction of travel of the conveyor. Take-ups provide the means for shaft alignment and chain tension adjustment.

Sprocket Alignment

Sprockets must be in a line and not offset on the shafts. When two or more strands of chain operate as a single unit, as in a double-strand conveyor, the sprocket teeth on the head shaft must be timed to pick up the load on each chain simultaneously. First align the keyways in the shaft. Then align the keyways of the sprockets on tooth centerline. Sprockets should be "keywayed-in-line and matched in pairs." Since the tail shaft is an idling shaft, key it to only one sprocket. The other sprocket is held in alignment by set collars and is allowed to turn freely. In this way the sprocket can position itself if uneven wear takes place in the chain strands.

Headshaft Sprockets Keyed In Line



Chain

Place the chain around the sprockets with the free ends meeting one another. When assembling straight sidebar chains, insert the connecting link and then the closing bar over the pins. Drive the closing bar onto both pins at the same time, taking care not to bend the link. Most chains are designed with a "press-fit" between the pins and sidebars. Do not grind away a pin end so that it fits loosely in the chain sidebar.

Freedom from Interference

The chain should not come into contact with adjacent objects. Clearance should provide for normal chain sag and take-up movement. Guides and tracks should be smooth and free of foreign objects.

Start-Up

Adjust the chain tension. For high-temperature applications, adjust the chain while cold. Jog the conveyor through one complete cycle. Start the conveyor and run with no load, making certain that all chain joints flex freely.

For oil-lubricated applications, lubricate each chain joint well with a good grade of nondetergent petroleum base oil. The oil should be applied between the sidebars at each joint and be of a viscosity such that it will flow freely into the pin-bushing area. Grease may be used if it can be forced directly into the pin-bushing area.

A break-in running period of 8 to 12 hours under no load will allow the chain joints to seat properly. After this initial running period adjust take-ups again to compensate for initial elongation of chain.

Chain Tension

Make sure you have the correct amount of chain slack; when the chain is too tight the working parts of the chain carry a much heavier load.

Frequency of Adjustment

The chain will elongate at the beginning of operation due to slight distortion of its component parts. After this initial change in the chain, it elongates slightly, but constantly, due to normal wear. Maintain the proper chain tension by adjustments made according to the following suggested schedule (Table 3).

Table 3 — Suggested Adjustment Schedule

Time in Operation	Frequency of Adjustment
Week 1	Once a day
Weeks 2-4	Twice a week
After week 4	Twice a month

Note: This frequency schedule is based on eight hours of operation per day. For longer operation days, adjust the schedule accordingly.

Even Adjustment of Take-up

Even adjustment of take-up can be easily obtained with screw type or counter-weight take-ups. Where two parallel chains are adjusted by two independently operated take-ups, ensure even stroke on both the left and right side. An uneven adjustment will cause an overload when the link plate and the side of the sprocket teeth interfere with each other.

Insufficient Take-up Adjustment

If the chain is still too long after the take-up adjustment, take out one or two pitches to shorten the chain.

Loading Conveyors

Support the loading area as much as possible to minimize loading shock to the system. Reduce impact by loading as gently as possible. Slide load onto the conveyor when possible to reduce surges caused by rough loading. Unload a conveyor before shutting it down. Starting a loaded conveyor places extra strain on the system. Run the conveyor occasionally during extended shut-down periods to keep the system free from corrosion.

Installation of Bucket Elevator Chains, Sprockets, and Traction Wheels

Position foot take-ups at the top position of travel and head take-ups at the bottom position to provide maximum adjustment once the chain is installed.

Install chain from the top of the elevator casing when possible. Assemble the chain to form a single strand without buckets attached. Establish a lifting point slightly off center of the strand so that one leg is long enough to go around the foot sprocket and up to the inspection door.

Lower the chain from its lifting point into the elevator casing. Once the longer leg has been drawn around the foot sprocket and up close to the inspection door, block the head sprocket from moving. Disconnect the lifting hook and re-connect it to the long leg of the chain about two links short of the end. Draw chain ends together and attach them with the connecting pin. Adjust take-ups to create proper tension on the chain. Install buckets through rear panel door. Be sure to prick punch the bolt threads at the nuts to prevent them from loosening.

Adjust take-ups or check functioning of gravity take-ups before putting elevator into operation. Start the elevator chain by jogging the system through one complete cycle. Then run the chain for about four hours without a load. After this break-in period, begin regular operation.

Of Special Note

- Material should not be allowed to build up in the boot by overloading. Properly regulating flow, within the capacity of the buckets, will extend service life and prevent surging caused by the buckets digging out the boot.
- During normal operation start the elevator empty. This prevents overload of the chain and alleviates the danger of backrun.
- For traction wheels, securely mount the solid or split hub to the shaft. Bolt the traction wheel segments or segmental rim sprockets in place loosely. Tighten with a torque wrench. All segmental rim bolts must have nuts tightened to not more than the maximum torque values suggested on page C-34.

Special Environments

Standard conveyor chain can be operated normally in ambient temperatures between 15°F and 140°F without trouble.

When the chain is operated in very low or high temperatures, or in an abrasive or corrosive atmosphere, the following should be taken into account (Table 4).

(1) Under very low or high temperatures:
Chain must be selected in a different manner when it is operated in freezing chambers, cold areas, when it passes through a heat-treatment furnace, or is affected by heat from the material conveyed.

(2) In wet conditions:
When chain is exposed to water, e.g., in a sterilizer or water screen, excessive wear due to insufficient lubrication and rust may shorten chain life. In these cases, a larger chain size provides less bearing pressure and stainless steel or plated chain will provide rust prevention.

(3) In corrosive conditions:
When chain is exposed to an acidic or alkaline solution and/or operated in a corrosive atmosphere, excessive wear may occur due to chemical corrosion on the chain parts in addition to mechanical wear. Hydrogen embrittlement may also occur in an acidic atmosphere. Conveyor chain is more affected by acid than alkali. In special cases, electrochemical corrosion may occur on the chain due to sea or mine water. Refer to Table 6 "Corrosion Resistance Guide" for the corrosion resistance of various materials.

(4) In dusty conditions:
When conveyor chain is operated in dusty conditions, e.g., in the presence of coke, metal powder, and sand, etc. the chain wears more because foreign material gets between the parts of the chain and also the engaging surfaces of the sprocket teeth and chain. In such cases, select a larger chain size to reduce the bearing pressure or choose a chain especially designed for high wear resistance.

The foregoing information is intended to provide general guidelines for conveyor chain selection. Please consult Union Chain for specific application problems.

Table 4 — Considerations for Use in Special Environments

Temperatures	Chain Selection	Caution
-60°F ~ -20°F	•-20°F or less, ANSI 300 Series stainless steel chains and 600 Series stainless steel chains are suggested. •Carbon chains are not suggested.	(1) Low temperature embrittlement may occur on link plates of carbon steel chain. (2) Freezing of lubricant. (3) Rust due to water condensation. (4) Seizure due to freezing.
-20°F ~ 15°F	The chain should be selected on the basis of the corrected working load, Table 5.	
140°F ~ 300°F	Special lubrication is required.	
300°F ~ 480°F	The chain should be selected on the basis of the corrected working load, below. Selection of the next larger pitch chain over the originally selected one is suggested.	(1) Excessive wear due to decrease of hardness of pin and bushing. (2) Poor lubrication due to deterioration and carbonization.
480°F or greater	Consult Union Engineering.	

Table 5 — Corrected Working Load

Temperature	Corrected Working Load
-20°F ~ -4°F	(Maximum allowable load in catalog) x 0.25
-4°F ~ 15°F	(Maximum allowable load in catalog) x 0.3
15°F ~ 300°F	(Maximum allowable load in catalog) x1.0
300°F ~ 390°F	(Maximum allowable load in catalog) x 0.75
390°F ~ 480°F	(Maximum allowable load in catalog) x 0.5

Corrosion Resistance Guide

Determine the corrosion-resistant properties of materials using this information as a guide. When making final specifications of chain, be sure to consider all operating conditions. If you have any questions, contact Union Engineering. This table shows properties of materials at 68°F unless otherwise noted.

Fluid	Steel	300 Stainless Steel	400 Stainless Steel	600 Stainless Steel	UHMW	Delrin or EPC78 STP
Acetic Acid (5%)	N	R	R	L	R	N
Acetic Acid (10%)	N	R	R	*	R	R
Acetone	N	R	R	N	R	R
Alcohol	R	R	R	R	R	R
Ammonia Water	L	R	R	*	*	R
Aqueous Ammonia	L	R	R	R	R	R
Beer	L	R	R	R	R	R
Benzene	R	R	R	R	L	R
Boric Acid (5%)	N	R	R	*	*	*
Butyric Acid	*	R	R	*	*	R
Calcium Hydroxide (20% Boiling Point)	*	R	R	*	*	R
Calcium Hypochlorite	N	R	N	*	*	N
Caustic Soda (25%)	N	R	R	R	R	R
Carbolic Acid	*	R	R	*	*	N
Carbon Tetrachloride	L	L	L	L	L	R
Carbonated Water	N	R	R	R	R	R
Chlorine Gas (wet)	N	N	N	N	*	*
Citric Acid	N	R	L	L	R	L
Formaldehyde	R	R	R	R	*	R
Formic Acid	N	R	R	N	R	N
Formic Acid Aldehyde	R	R	R	R	R	R
Fruit Juice	N	R	L	L	R	R
Gasoline	R	R	R	R	L	R
Glycerin	R	R	R	*	*	R
Hydrochloric Acid (2%)	N	N	N	N	N	N
Hydrogen Peroxide (30%)	N	R	L	L	R	N
Hypochlorite Soda	N	N	N	N	R	N
Iodine	N	N	N	N	N	N
Kerosene	R	R	R	R	R	L
Lactic Acid	N	R	L	L	R	R
Methyl-Ethyl-Propyl-Butyl Alcohol	R	R	R	R	*	R
Milk	L	R	R	R	R	R
Nitric Acid (5%)	N	R	R	L	L	N
Oils (Vegetable and Mineral)	R	R	R	R	R	R
Oxalic Acid	N	R	L	*	*	*
Paraffin	R	R	R	R	R	R
Petroleum	R	R	R	R	R	R
Phosphoric Acid	N	L	N	N	N	N
Potassium Permanganate	*	R	R	*	*	R
Sea Water	N	L	L	L	R	R
Soapy Water	L	R	R	R	R	R
Sodium Bicarbonate	*	R	R	*	*	R
Sodium Carbonate (saturation) Boiling Point	*	R	R	*	*	*
Sodium Chloride	N	R	L	L	R	R
Sodium Hypochlorite (10%)	N	N	N	N	*	N
Sodium Sulfate (saturation)	*	R	R	*	*	*
Soft Drinks	L	R	R	R	R	R
Sulfuric Acid	N	L	N	N	N	N
Vegetable Juice	L	R	R	R	R	R
Vinegar	N	L	N	N	R	L
Water	L	R	R	R	R	R
Whiskey	L	R	R	R	R	R
Wine	L	R	R	R	R	R

R = Resistant; L = Less resistant; N = Not resistant; * = Unavailable

Maintenance Check Points

Check Points	Comments
Centering	A high precision guide rail is essential to ensure proper centering of the conveyor. If centering is not accurate (with no side guide rail), the conveyor chain will wobble and weave resulting in shorter conveyor chain life.
Sprocket alignment	When two or more sprockets are installed in a row, be sure to align the position of the sprocket teeth. If the sprocket teeth are not properly aligned, the working load will not be equally divided and will cause the chain to twist.
Take-up	If take-ups on both sides are uneven, the conveyor chain will not engage smoothly with the sprocket.
Initial chain tension	Maintain adequate chain slack. If chain tension is too high, loss of power will result. This is a dangerous situation and if too loose, the chain will climb the sprocket.
Trial run	Trial run after installation should be made under no load conditions by switching on and off several times intermittently. After inspection, continuous operation may begin.
Stopping conveyor	Stop conveyor under no load conditions, or remaining material will impose an overload when the conveyor starts again.
Lubrication	Lubricate conveyor chain periodically, unless the chain does not require lubrication. Lubrication of reducer, bearing, and driving roller chain is essential.
Securing conveyor parts	Parts fastened to the conveyor such as buckets, aprons, slats, etc., are apt to loosen due to vibration. Pay careful attention to fastening nuts and bolts securely. Be sure to check periodically.
Amount of chain slack	Regularly check and adjust the amount of chain slack.
Temperature and prevention of freezing	When differences in temperatures (summer and winter or between day and night in the winter) are very severe, conveyor damage may occur. Under these circumstances, operate the conveyor carefully, taking any variations in temperature into account.
Conveyor record of use and maintenance	After installing the conveyor, keep a record of the expected capacity to be conveyed, conveyor speed, r.p.m. of main shaft, electric current, voltage, working hours, actual conveying capacity, inspection date, lubricating date, details of trouble, etc. This will serve as protection against unexpected accidents. This record will also be convenient for maintenance and repairs.

Troubleshooting

Problem	Possible Causes	What to Do
Excessive noise	•Misalignment of sprocket •Loose casings or bearings •Too little or too much slack •Chain and/or sprocket wear •Inadequate lubrication or no lubrication •Chain pitch size too large	•Realign sprockets and shafts •Tighten set-bolts •Adjust centers or idler take-up •Replace chain and/or sprocket •Lubricate properly •Replace with correct chain size
Chain vibration	•Resonance to the vibration cycle of machine to be installed •High load fluctuation	•Change vibration cycle of chain or machine •Use torque converter or fluid coupling
Wear on inside of link plate and one side of sprocket teeth	•Misalignment	•Realign sprockets and shafts
Chain climbs sprockets	•Excessive chain slack •Heavy overload	•Adjust centers or idler take-up •Reduce load or install stronger chain
Broken pins, bushings or rollers or heavy wear of pins, bushings or rollers	•Chain speed too high for pitch and sprocket size •Heavy shock or suddenly applied loads •Material build-up in sprocket tooth pockets •Inadequate lubrication •Chain or sprocket corrosion	•Use shorter pitch chain or install larger diameter sprockets •Reduce shock load or install stronger chain •Remove material build-up or install side gashed sprockets •Lubricate properly •Install anti-corrosive chain or sprockets
Chain clings to sprocket	•Center distance too big or high load fluctuation •Excessive chain slack	•Adjust the center distance or install idler take-up •Same as above
Chain gets stiff	•Misalignment •Inadequate lubrication •Corrosion •Excessive load •Material build-up in chain joint •Peening of link plate edges	•Realign sprockets and shafts •Lubricate properly •Replace with anti-corrosive chain •Reduce load or replace with chain of suitable strength •Shield drive from foreign matter •Check for chain interference
Breakage of link plate	•Subjected to shock load •Vibration •Inertia load is too large	•Reduce shock (e.g., install a shock absorber) •Install a device to absorb vibration (e.g., tightener, idler wheel) •Chain section should be checked (increase number of strands or select next larger size chain)
Camber (curved tracking of straight faced roller chains on long conveyors where chain strands are rigidly attached)	•Head shaft sprocket misalignment •Track or rail out of level due to previous chain travel wear •Higher chain tension on one strand than the other strands •Chain strand lengths are different	•Realign head sprockets •Level track or rails •Balance conveyed material load between strands •Specify measured matched and tagged strands

Lubrication

Proper lubrication reduces wear, maximizes horsepower, and helps reduce chain pulsation.

Important points of lubrication are shown in Figure 4.

- Between sidebars (for pin and bushing lubrication).
- Between roller and sidebar (for lubrication of roller and bushing).

Factors to Consider when Lubricating Roller Conveyor Chain

For large diameter rollers or outboard rollers lubricate by self-lubricating sintered metal bushings or by pressure through a grease fitting. Lubrication through pin heads or through rods is suggested only for chains with more than 3/4" pin or rod diameter. When this method is used on through rods, lock collars are provided in place of cotter pins. In severe applications rollers may be equipped with anti-friction bearings that have grease fittings or removable caps for grease packing.

Lubrication with grease requires pressure fittings to port the grease through chain joints. The following examples are methods of porting grease lubrication (Figure 5).

Figure 4

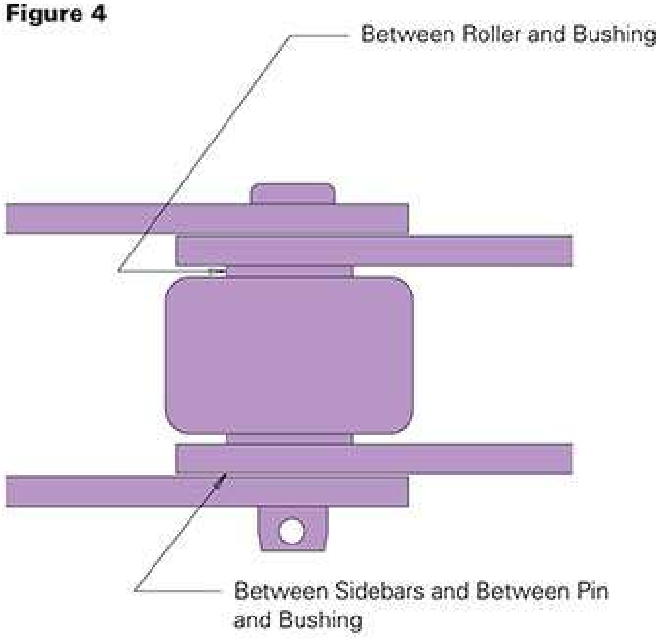
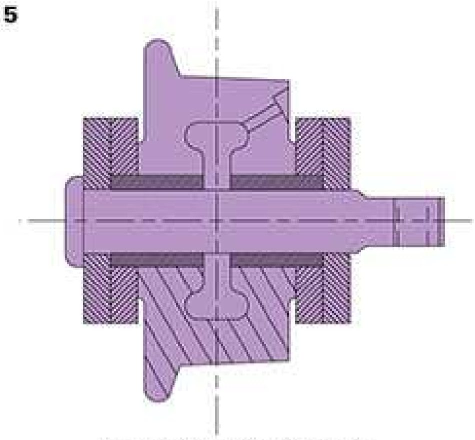
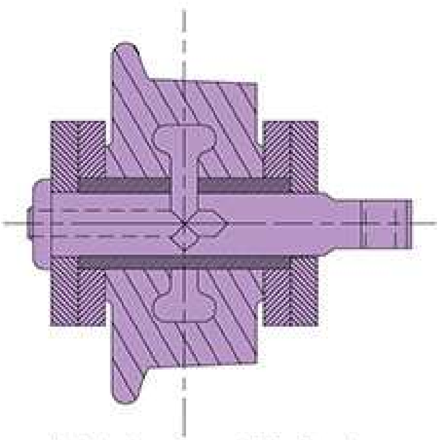


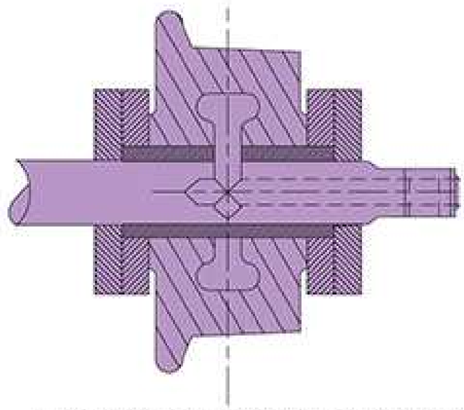
Figure 5



Lubrication through Roller

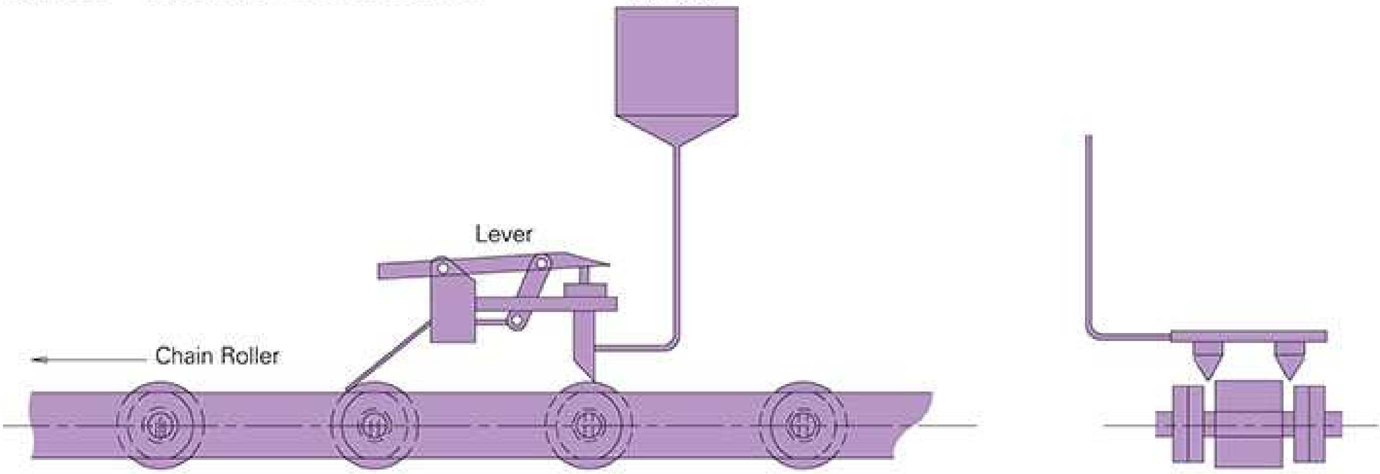


Lubrication through Pin Head



Lubrication through Pin End or Through Rod

Figure 6 — Automatic Drip Lubrication



Automatic Lubrication

Use automatic lubrication to save labor or when manual lubrication is not possible due to the location of the chain.

The automatic drip system shown in Figure 6 utilizes the chain roller as a cam. The roller pushes a pump as it passes by and causes the oil to drip.

Use a mist-type lubricator when the conveyor chain is used as an overhead trolley conveyor or when the chain requires many points to be lubricated.

For coil conveyor chain, an automatic grease feeder is suggested.

Lubrication is ineffective for bulk conveyors that convey powdery and granular materials. It will not work for flow or trough conveyors where the chain buries itself in the material as it moves and dust or other particles become embedded in the chain clearances.

Inspection

Lubrication

- Manual: Carefully follow lubrication schedule.
- Drip: Inspect the filling of oiler cups and the rate of feed. Check that the feed cups are not clogged and are properly positioned over the chain.
- Bath: Inspect the oil level and check that there is no sludge. Drain, flush and refill the system as the application requires.

If the chains have not been lubricated properly, the joints may have a brownish (rusty) color and the pins of the connecting link of the chain, when removed, may be a discolored brown. The pins may also be roughened, grooved, or galled. Properly lubricated chains will not show the brownish color at the joints; they will be brightly polished with a high luster.

- Check wear on link plates and sides of sprocket teeth indicating misalignment.
- Check shaft and sprocket alignment to prevent wear.
- Check wear on working faces of sprocket teeth. As the system runs these faces should develop a bright, polished appearance. Scratches, galls, grooves, or visible changes in tooth form are probably caused by lubrication failure or overloading.
- Check and adjust chain tension. An elongation of as much as five percent indicates that the chain is riding near its limit of allowable height on the sprocket teeth. A gradual increase in chain length is the result of normal wear. A sudden increase in slack indicates one or more of the following:
  - Lubrication failure
  - Excessive overloading or shock
  - Displacement of shaft bearings
  - Displacement or failure of take-ups
- Check the chain to be sure it is free from dirt, grit or other abrasive material. Clean the chain periodically.
- Check guides, tracks, and the area below the conveyor for buildup of material or dirt which will cause interference or binding of the chain. Exit and entry points of guides and tracks must permit the chain to pass with a minimum amount of impact or interference. Roller chain tracks can be over-lubricated, forcing the rollers to slide rather than roll.
- Exceptionally low chain conveyor speed coupled with high drag friction will occasionally cause surging. A slight increase in speed will correct this problem if the friction can not be reduced.
- Inspect apron and pan bead openings. If the beads have been wedged apart or otherwise distorted, fine material may bleed into moving parts and cause excessive wear.

Chain Pitch Elongation

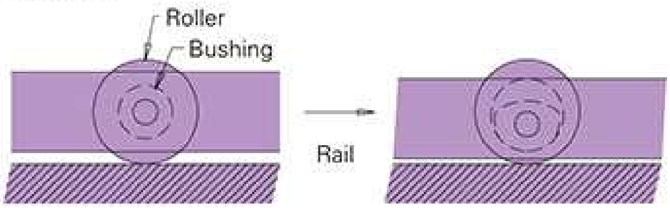
As the bearing parts wear, the chain elongates causing the chain to climb to the top of the sprockets and inhibit smooth articulation. This is shown in Figure 7. Conveyor chains should be replaced when chain elongation equals 3% to 4%.

Figure 7

Life of Roller Conveyor Chain and Sprockets

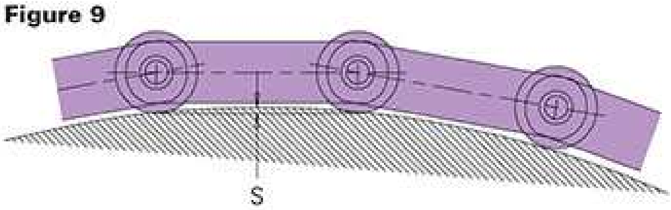
The chain has reached the end of its service life when, due to track wear, rollers do not project from sidebars. The under surface edge of the sidebar may actually touch the track in some cases, causing a significant change in friction and resulting in higher chain tension (Figure 8).

Figure 8



Wear must be inspected even more often with a curved section of rail than with horizontal sections. Decrease the allowed wear amount for a curved section by a dimension equivalent to "S" (Figure 9).

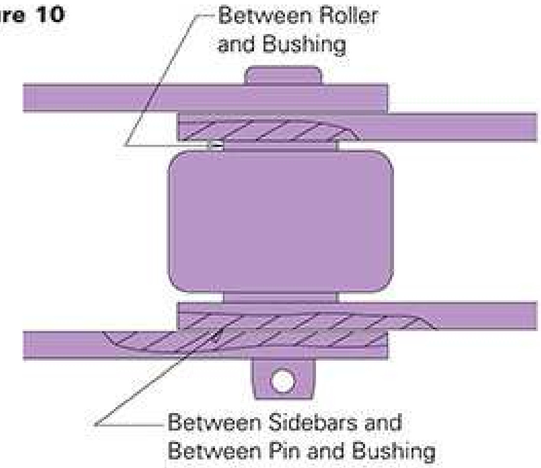
Figure 9



Wear on Rail Curved Section

Chains should be replaced when the bushing wear, due to conveying abrasive materials, exceeds one-third of the wall thickness. Reciprocal friction between inner and outer sidebars and contact between the side surface of the roller and the inside surface of sidebars cause wear, as shown in Figure 10.

Figure 10

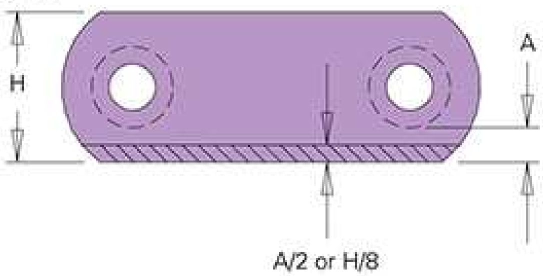


Replace chain when wear exceeds 1/3 of the original plate thickness.

When sidebar wear appears faster than wear of other component parts, misalignment of the conveyor is usually at fault. To ensure proper alignment, check the alignment of driving and driven sprockets, the alignment of shafts in horizontal and vertical planes, and the preciseness of leveling.

The service life of a chain that slides directly in the conveyed material or on a steel plate casing should end when the worn section equals A/2 or H/8, as shown in Figure 11.

Figure 11



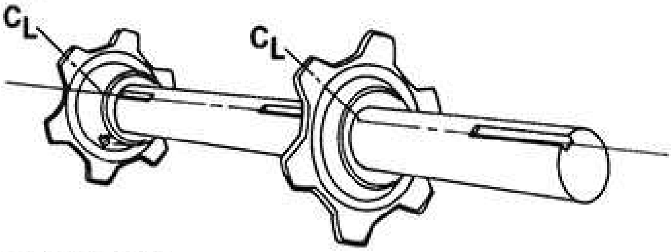
Never insert a new link in a chain that has been appreciably elongated by wear. Do not install new chain on badly worn sprockets.

Protect the chain during long periods of idleness. If the chain is to be stored, remove it from the sprockets, clean and re-oil it and cover it with heavy grease. Store the chain where it will be protected from moisture and mechanical injury. Before placing the conveyor in service again, thoroughly clean the chain and sprockets to remove the protective grease and then re-lubricate the chain.

Sprockets

Sprockets Keyed In Line
Key driving sprockets on a double-strand chain conveyor or elevator on the head shaft and with the teeth of one sprocket directly in line with teeth of the other. Order "keyed-in-line" and "matched in pairs" to obtain this feature. Key one foot shaft sprocket on its shaft so that the shaft will turn in its bearings. Allow the other sprocket to turn freely, holding it in position by means of set collars. The sprocket can then position itself automatically if uneven wear takes place in the chain strands (Figure 1).

Figure 1



Sprocket Size
Use the largest diameter conveyor sprocket that space and economics permit. This minimizes chain speed variations and pulsations and reduces wear to the chain and sprocket.

Sprocket Terminology

Chain Interaction
Schedule replacement of sprockets and/or chain by assessing the chain-sprocket interaction. If the chain enters and exits smoothly without hanging up or snapping into place, replacement is not necessary. If a chain starts to hang up on the sprocket, reverse or replace the sprocket before damaging chain overload conditions can develop.

Reversible
If the sprockets are symmetrical from side to side they can be reversed. Almost all sprockets are reversible.

New Chain
New or reversed sprockets are required with any new chain. New sprockets will ensure proper chain interaction and will also provide maximum wear performance.

Visual Observation
Carefully observe the wear patterns on chains and sprockets. Wear patterns that are smooth and even indicate good chain-sprocket interaction; unbalanced or severe wear indicates that the system needs maintenance.

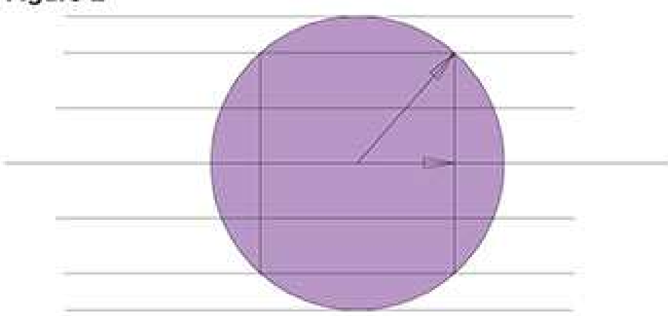
Attachment Clearance
Be sure that any attachment in the area between, above, or below the sidebars will not interfere with the sprocket.

Relief Pocket
In applications where material build-up may occur, the bottom of the tooth pocket is beveled on the side to allow the material to "squeeze" out.

Chordal Action
A sprocket is a collection of chords, or straight segments, that approximate a circle. With more teeth the chords approximate a circle better; with fewer teeth the chords do not approximate a circle as well.

The lineal output from a chordal form is not constant. The square in a circle shown in Figure 2 represents a four-tooth sprocket. Note that the distance from the center to the corner is different than from the center to the middle of the side. The corner would be the equivalent of the chain joint center; the side would be equivalent to the chain centerline at mid-pitch.

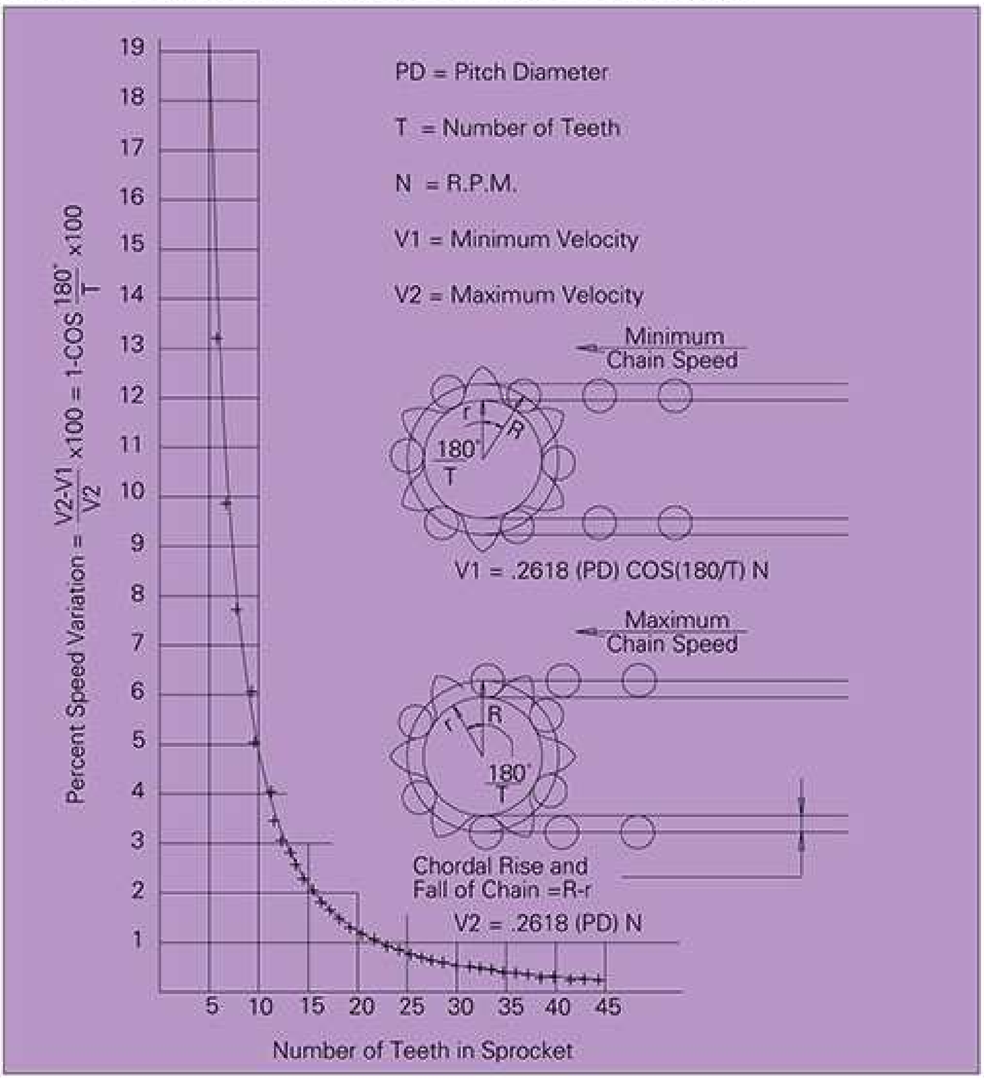
Figure 2



The resulting velocity variations are a function of the number of teeth, as shown in Figure 3. Due to these variations, care should be taken in considering sprockets with less than 12 teeth.

D – ENGINEERING INFORMATION

Figure 3 — Variations in Chain Speed Due to Chordal Action



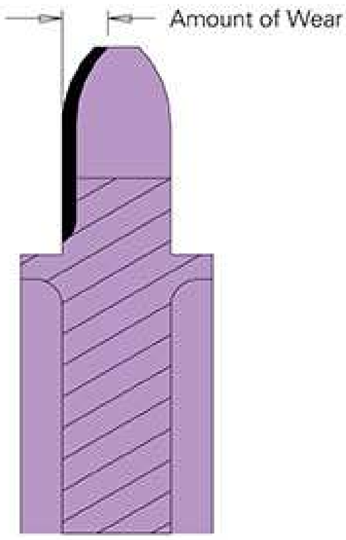
Sprocket Life

When sprockets are worn, the chain tends to cling to the sprockets or vibrate. The amount of allowable wear depends on the conveyor type and chain size. Wear to a depth of 0.12" (3 mm) to 0.24" (6 mm) is usually a sign that the existing sprocket should be replaced, illustrated in Figure 4.

If the sprocket teeth are worn, the alignment may be incorrect. Proper axial alignment of the sprockets will help reduce or even eliminate wear of sprocket teeth, illustrated in Figure 5.

Figure 4 — Sprocket Wear

Figure 5 — Sprocket Tooth Wear



Density of Materials

The weights represent, in many cases, the weights of materials as settled or packed in bins, while lower weights should generally be figured for materials as slightly agitated or fluffed by handling in elevators, screw conveyors, etc.

Material	Avg. Wgt. of One Cu. ft. (lbs.)	Angle of Repose
Alcohol, proof spirit	58	
Aluminum, cast, pure	160	
Anthracite, broken, loose	55	27
Asbestos	175	
Ash, American White, dry (wood)	47	
Ashes of soft coal, solidly packed	40	40
Asphaltum	87	
Barytes	180	
Batch, Glass	90	
Beans	48	
Benzine	50	
Bauxite, Crushed	80	
Brass (copper and zinc), cast	519	
Brick, best pressed	134	
Brick, common and hard	112-125	
Brick, fire	144	
Brickwork, cement	112	
Bronze, copper 8, tin 1 (gun metal)	552	
Cedar	24	
Cement, Portland, per barrel, net, 376 pounds	100	
Cement, Portland, standard proportioning	100	
Chalk	156	
Char	45	
Charcoal of pines and oaks	20- 38	
Cherry, perfectly dry	44	
Chestnut wood, dry	38	
Cinder, blast furnace	57	
Cinders (coal, ashes and clinkers)	40	25-40
Clay, dry, in lump, loose	75	25-45
Clinker, cement	80-95	
Coal, bituminous, solid	84	
Coal bituminous, broken, of any size, piled	44-52	35
Coal, Steam	50	
Coke, Breeze	25-34	
Coke, Refiners	35-40	
Coke, loose, good quality	23-32	30-45
Concrete, conglomerate, with Portland cement	143-150	
Concrete, gravel, with Portland cement	150	
Concrete, loose, unrammed, weights 5 to 25% lighter, varying with consistency		
Copper, cast	542	
Copper, rolled	555	
Corn, shelled	45	
Corn, meal	40	
Cork, dry	15	
Cotton seed	25	
Cotton seed cake, cracked	41	
Cotton seed hulls	12	
Cotton seed meal	35	
Cullet	80-120	
Cypress	38	
Earth, common load, perfectly dry, loose	72-80	30-45
Earth, common load, perfectly dry, shaken	82-92	30-45
Elm, perfectly dry	42	
Feldspar, powdered	75	
Fir	35	
Fir, Eastern	25	
Flax seed	45	
Flour, 196 pounds per barrel, net	35-40	
Fuller's earth	35-45	
Glass	163	
Granite, solid	166	
Granite, broken	96	
Gravel	100	30-40
Gypsum, under 1" crushed	80-100	
Gypsum, powdered	60-80	
Hay, baled	24	
Hemlock, perfectly dry	25	

Density of Materials (continued)

Material	Avg. Wgt. of One Cu. ft. (lbs.)	Angle of Repose	Material	Avg. Wgt. of One Cu. ft. (lbs.)	Angle of Repose
Hides, green, 85 pounds each	—		Pine, Yellow Northern, perfectly dry	34	
Hickory, perfectly dry	50		Poplar, dry	32	
Ice	56		Quartz	90-100	
Iron, cast	446		Salt, coarse	45	
Iron, wrought	480		Salt, dry, fines	80	
Lead, commercial	709.6		Sand, damp	117-130	
Lignumvitae (dry)	41-83		Sand, dry	90-110	
Limestone, loose	96		Sandstone, quarried and piled	86	
Limestone and Marble	105		Sawdust	13	
Lime, quick	95		Shales	92	
Lime, quick, ground, well shaken	64		Slag	160 -180	
Lime, hydrated	20-45		Slag, furnace, granulated	53	
Locust, dry	46		Slate	175	
Magnesium	109		Slurry, cement	90	
Mahogany	56		Soda	42	
Mahogany Honduras	35		Soda ash	32-67	
Manganese	500		Spruce, dry	25	
Maple, dry	44		Steel	486.5	
Marble, crushed	90		Straw, baled	24	
Marl	79		Sugar, refined	55	
Oak, live, perfectly dry, .88-1.02	72		Sulphur	125	
Oak, white, perfectly dry	50		Tar	62.4	
Oats	26		Tin, cast, 7.2	455	
Oil, linseed	59		Trap rock, crushed	97-107	
Oil, petroleum	51		Turpentine, 300 pounds per barrel	—	
Oil, olive and whale	58		Walnut, Black, perfectly dry	41	
Ore, zinc, crushed	160		Water, pure rain, distilled, at 32 degrees F., Bar. 30 inches	62.417	
Ore, soft iron	150	35	Water, sea	64.08	
Oxide, Iron Sponge	28-50		Wheat	48	
Phosphate acid	62		Zinc or Spelter, cast	428	
Phosphate Pebble	100				
Phosphate rock	85				
Pine, white, perfectly dry	32				
Pine, Yellow Southern, perfectly dry	41				

Properties of Steels—Strength of Materials

Relation of Hardness to Strength of Steel. Approximate relation of various hardnesses due to influence of size, composition, and heat treatment

Brinell		Rockwell					Brinell		Rockwell				
Dia. in Mm. 3,000-Kg. Load 10-Mm. Ball	Hardness Number Std. Ball	Diamond Pyramid Hardness No. 50 Kg. Load	C-Scale, 150-Kg. Load 120-Deg. Diamond Cone	B-Scale, 100-Kg. Load 1/16 In. Dia. Ball	Shore Sclero-Scope Number	Tensile Stgth., 1,000 Lbs. per Sq. In.	Dia. in Mm. 3,000 Kg. Load 10-Mm. Ball	Hardness Number	Vickers (Firth Diamond) Hardness Number	C-Scale, 150-Kg. Load 120-Deg. Diamond Cone	B-Scale, 100-Kg. Load, 1/16 In. Dia. Ball	Shore Sclero-scrope Number	Tensile Stgth., 1,000 Lbs. per Sq. In.
2.25	*745	1,050	68		100	368	3.85	248	261	24	101	37	122
2.30	*710	780	63		87	350	3.90	241	253	23	100	36	118
2.35	*682	737	62		84	340	3.95	235	247	22	99	35	115
2.40	*653	697	60		81	330	4.00	229	241	21	98	34	111
2.45	*627	667	59		79	323	4.05	223	234	19	97	33	108
2.50	*601	640	57		77	309	4.10	217	228	18	96	33	105
2.55	*578	615	56		75	297	4.15	212	222	16	96	32	102
2.60	*555	591	55	120	73	285	4.20	207	218	15	95	32	100
2.65	*534	569	54	119	71	274	4.25	201	212	14	94	31	98
2.70	*514	547	53	119	70	263	4.30	197	207	13	93	30	95
2.75	495	539	52	117	69	259	4.35	192	202	12	92	29	93
2.80	477	516	50	117	67	247	4.40	187	196	10	91	28	90
2.85	461	495	49	116	65	237	4.45	183	192	9	90	28	89
2.90	444	474	47	115	63	226	4.50	179	188	8	89	27	87
2.95	429	455	46	115	61	217	4.55	174	182	6	88	26	85
3.00	415	440	45	114	59	210	4.60	170	178	5	87	26	83
3.05	401	425	43	113	58	202	4.65	167	175	4	86	25	81
3.10	388	410	42	112	56	195	4.70	163	171	3	85	25	79
3.15	375	396	40	112	54	188	4.80	156	163	1	83	24	76
3.20	363	383	39	110	52	182	4.90	149	156		81	23	73
3.25	352	372	38	110	51	176	5.00	143	150		79	22	71
3.30	341	360	37	109	50	170	5.10	137	143		76	21	67
3.35	331	350	36	109	48	166	5.20	131	137		74	20	65
3.40	321	339	34	108	47	160	5.30	126	132		72	20	63
3.45	311	328	33	108	46	155	5.40	121	127		70	19	60
3.50	302	319	32	107	45	150	5.50	116	122		68	18	58
3.55	293	309	31	106	43	145	5.60	111	117		66	15	56
3.60	285	301	30	106	42	141	5.70	107	107		64		55
3.65	277	292	29	105	41	137	5.80	103	103		61		53
3.70	269	284	28	104	40	133	5.90	99	99		59		51
3.75	262	276	27	103	39	129	6.00	95	95		56		49
3.80	255	269	25	102	38	126							

*Tungsten carbide ball
(ASTM-SAE-ASM Joint Committee)

Working Loads (Pounds)

Horse-power	Linear Speed in Feet per Minute												
	12 1/2	25	50	100	200	300	400	500	600	700	800	900	1,000
1/4	660	330	165	83	42	28	21	17	14	12	11	9	8
1/2	1,320	660	330	165	83	55	42	33	28	24	21	18	17
3/4	1,980	990	495	248	124	83	62	50	41	36	31	27	25
1	2,640	1,320	660	330	165	110	83	66	55	47	42	37	33
1-1/2	3,960	1,980	990	495	248	165	124	99	83	71	62	55	50
2	5,280	2,640	1,320	660	330	220	165	132	110	94	83	73	66
2-1/2	6,600	3,300	1,650	825	413	275	206	165	137	118	103	92	83
3	7,920	3,960	1,980	990	495	330	248	198	165	141	124	110	99
4	10,560	5,280	2,640	1,320	660	440	330	264	220	189	165	147	132
5	13,200	6,600	3,300	1,650	825	550	413	330	275	236	206	183	165
7-1/2	19,800	9,900	4,950	2,475	1,238	825	619	495	413	354	310	275	248
10	26,400	13,200	6,600	3,300	1,650	1,100	825	660	550	471	412	367	330
15	39,600	19,800	9,900	4,950	2,475	1,650	1,238	990	825	707	619	550	495
20	52,800	26,400	13,200	6,600	3,300	2,200	1,650	1,320	1,100	943	825	734	660
25	66,000	33,000	16,500	8,250	4,125	2,750	2,063	1,650	1,375	1,178	1,031	917	825
30	79,200	39,600	19,800	9,900	4,950	3,300	2,475	1,980	1,650	1,414	1,238	1,100	990
35	92,400	46,200	23,100	11,550	5,775	3,850	2,888	2,310	1,925	1,650	1,444	1,283	1,155
40	105,600	52,800	26,400	13,200	6,600	4,400	3,300	2,640	2,200	1,885	1,650	1,464	1,320
50	132,000	66,000	33,000	16,500	8,250	5,500	4,125	3,300	2,750	2,357	2,062	1,833	1,650
60	158,400	79,200	39,600	19,800	9,900	6,600	4,950	3,960	3,300	2,829	2,475	2,200	1,980
75	198,000	99,000	49,500	24,750	12,390	8,250	6,195	4,950	4,125	3,536	3,098	2,750	2,475
100	264,000	132,000	66,000	33,000	16,500	11,000	8,250	6,600	5,500	4,714	4,125	3,667	3,300
125	330,000	165,000	82,500	41,250	20,625	13,750	10,313	8,250	6,875	5,893	5,157	4,583	4,125
150	396,000	198,000	99,000	49,500	24,750	16,500	12,375	9,900	8,250	7,071	6,188	5,500	4,950
175	462,000	231,000	115,500	57,750	28,875	19,250	14,438	11,550	9,625	8,250	7,219	6,417	5,775
200	528,000	264,000	132,000	66,000	33,000	22,000	16,500	13,200	11,000	9,429	8,250	7,333	6,600
250	660,000	330,000	165,000	82,500	41,250	27,500	20,625	16,500	13,750	11,786	10,313	9,167	8,250
300	792,000	396,000	198,000	99,000	49,500	33,000	24,750	19,800	16,500	14,143	12,375	11,000	9,900
350	924,000	462,000	231,000	115,000	57,750	38,500	28,875	23,100	19,250	16,500	14,438	12,833	11,500
400	1,056,000	528,000	264,000	132,000	66,000	44,000	33,000	26,400	22,000	18,857	16,500	14,667	13,200

Torque Values (Inch Pounds)

RPM	Horsepower									
	1/8	1/4	1/2	3/4	1	1 1/2	2	2 1/2	3	5
0.10	78,871	157,562	315,125	472,687						
0.20	39,390	78,781	157,562	236,343	315,125	472,687				
0.30	26,260	52,520	105,040	157,562	210,083	315,125	420,166			
0.40	19,695	39,390	78,781	118,171	157,562	236,343	315,125	393,906	472,682	
0.50	15,756	31,512	63,025	94,537	126,050	189,075	252,100	315,125	378,150	
0.60	13,130	26,260	52,520	78,781	105,040	157,562	210,083	262,604	315,125	
0.70	11,254	22,508	45,017	67,526	90,035	135,053	180,071	225,089	270,107	450,178
0.80	9,847	19,695	39,390	59,085	78,781	118,171	157,562	196,953	236,343	393,906
0.90	8,753	17,507	35,013	52,520	70,027	105,041	140,055	175,069	210,083	350,138
1.00	7,878	15,756	31,512	47,268	63,025	94,537	126,050	157,562	189,075	315,125
1.25	6,302	12,605	25,210	37,815	50,420	75,630	100,840	126,050	151,260	252,100
1.50	5,252	10,504	21,008	31,512	42,016	63,025	84,033	105,041	126,050	210,083
1.75	4,501	9,003	18,006	27,010	36,014	54,021	72,028	90,035	108,042	180,071
2.00	3,929	7,878	15,756	23,634	31,512	47,268	63,025	78,781	94,537	157,562
2.50	3,151	6,302	12,604	18,907	25,210	37,815	50,420	63,025	76,630	126,050
3.00	2,626	5,252	10,504	15,756	21,008	31,512	42,016	52,520	63,025	105,041
4.00	1,969	3,939	7,878	11,817	15,756	23,634	31,512	39,406	47,268	78,781
5.00	1,575	3,151	6,302	9,453	12,605	18,907	25,210	31,512	37,815	63,025
6.00	1,313	2,626	5,252	7,878	10,504	15,756	21,008	26,260	31,512	52,520
7.00	1,125	2,250	4,501	6,752	9,003	13,505	18,007	22,508	27,010	45,017
8.00	984	1,969	3,939	5,908	7,878	11,817	15,756	19,695	23,634	39,390
9.00	875	1,750	3,501	5,252	7,002	10,504	14,005	17,506	21,008	35,013
10.00	787	1,575	3,151	4,726	6,302	9,453	12,605	15,756	18,907	31,512
12.00	656	1,313	2,626	3,939	5,252	7,878	10,504	13,130	15,756	26,260
14.00	562	1,125	2,250	3,376	4,501	6,752	9,003	11,254	13,505	22,508
16.00	492	984	1,969	2,954	3,939	5,908	7,878	9,847	11,817	19,695
18.00	437	874	1,750	2,626	3,501	5,252	7,002	8,753	10,504	17,506
20.00	393	787	1,575	2,363	3,151	4,826	6,302	7,878	9,453	15,756
25.00	315	630	1,260	1,890	2,521	3,781	5,042	6,302	7,563	12,605
30.00	262	525	1,050	1,575	2,100	3,151	4,201	5,232	6,302	10,504
40.00	197	394	787	1,181	1,575	2,363	3,151	3,940	4,726	7,878
50.00	157	315	630	945	1,260	1,890	2,521	3,151	3,781	6,302
60.00	131	262	525	787	1,050	1,575	2,100	2,626	3,151	5,252
70.00	112	225	450	675	900	1,350	1,800	2,250	2,701	4,501
80.00	98	196	393	590	787	1,181	1,575	1,969	2,363	3,939
90.00	87	175	350	525	700	1,050	1,400	1,750	2,100	3,501
100.00	78	157	315	472	630	945	1,260	1,575	1,890	3,151

D – ENGINEERING INFORMATION

Torque Values (Inch Pounds) (Continued)

RPM	Horsepower									
	7 1/2	10	15	20	25	30	35	40	50	75
1.00	472,687									
1.25	878,150									
1.50	815,125	420,166								
1.75	270,107	360,142								
2.00	236,343	315,125	472,687							
2.50	189,075	252,100	378,150							
3.00	157,562	210,083	315,125	420,166						
4.00	118,171	157,562	236,343	315,125	393,906	472,687				
5.00	94,537	126,050	189,075	252,100	315,125	378,150	441,175			
6.00	78,781	105,041	157,562	210,083	262,604	315,125	367,645	420,166		
7.00	67,526	90,035	135,053	180,071	225,089	270,107	315,125	360,143	450,178	
8.00	59,058	78,781	118,171	157,562	196,953	236,343	275,734	315,125	393,906	
9.00	52,520	70,027	105,041	140,055	175,069	210,083	245,097	280,111	350,138	
10.00	47,268	63,025	94,537	126,050	157,562	189,075	220,587	252,100	315,125	472,687
12.00	39,390	52,520	78,781	105,041	131,302	157,562	183,823	210,083	262,604	393,906
14.00	33,733	45,017	67,526	90,035	112,544	135,053	157,562	180,071	225,089	337,633
16.00	29,543	39,390	39,058	78,781	98,476	118,172	137,867	157,562	196,953	295,429
18.00	26,260	35,013	52,520	70,027	87,534	105,041	122,548	140,055	175,069	262,604
20.00	23,634	31,512	47,268	63,025	78,781	94,537	110,293	126,050	157,562	236,343
25.00	18,907	25,210	37,815	50,420	63,025	75,630	88,235	100,840	126,050	189,075
30.00	15,756	21,008	31,512	42,016	52,520	63,025	73,529	84,033	105,041	157,562
40.00	11,817	15,756	23,634	31,512	39,390	47,268	55,146	63,025	78,781	118,172
50.00	9,453	12,605	18,907	25,210	31,512	37,815	44,117	50,420	63,025	94,537
60.00	7,878	10,504	15,756	21,008	26,260	31,512	36,764	42,016	52,520	78,781
70.00	6,752	9,003	13,505	18,007	22,508	27,010	31,512	36,014	45,017	67,526
80.00	5,908	7,878	11,817	15,756	19,695	23,634	27,573	31,512	39,390	59,086
90.00	5,252	7,002	10,504	14,005	17,506	21,008	24,509	28,011	35,013	52,520
100.00	4,726	6,302	9,453	12,605	15,756	18,907	22,058	25,210	31,512	47,268

Shaft Selection

Refer to Selection Charts 1 and 2 developed by the American Society of Mechanical Engineers to simplify selection. Use the charts in conjunction with the Service Factors shown in Table 1 to modify the selection for conditions under which the shaft will operate.

Important factors to consider when calculating shaft size:

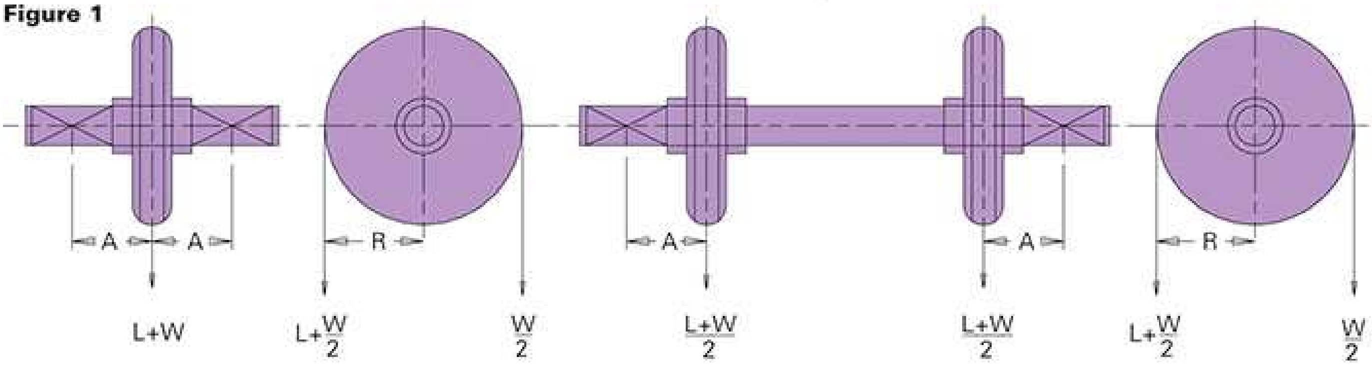
a. The shaft is subject to a bending moment and a torsional moment.

b. A bending moment is that force which tends to bend a shaft.

c. Torsional moment is that force which tends to twist a shaft.

d. Shaft size is determined by the combined action of the bending and the torsional moments.

Figure 1



L = Total unbalanced load in pounds.
W = Total suspended weight of elevator (chain, buckets, etc.,) pounds.
R = Radius of wheel in inches.

B = Bending moment.
T = Torsional moment.

$B = A\,\frac{L+W}{2}$ inch pounds.

$T = R \times L$ inch pounds.

Selection Procedure

1. Compute the bending moment from the formula shown in Figure 1.
2. Determine the service factor for the bending that will suit conditions from Table 1.
3. Compute the torsional moment from the formula, shown in Figure 1.
4. Determine the service factor for torsion that will suit conditions from Table 1.
5. Draw a vertical line across Selection Chart 1 or 2 from the point where the bending moment intersects its selected service factor line.
6. Draw a horizontal line up Selection Chart 1 or 2 from the point where the bending moment intersects its selected service factor line.
7. The intersection of above lines will give required shaft size.
8. For shafts not weakened by keyways, multiply the shaft size obtained by 0.91 for the corrected shaft size. See note embedded in Selection Chart 2.

Horsepower may be computed directly from the right-hand side of Selection Charts by correcting the figure in line with the horizontal torsional moment line by the speed in RPM.

Table 1 — Service Factors

Service Factors	For Bending	For Torsion
Stationary Shafts Gradually applied loads Suddenly applied loads	 1.0 1.5 - 2.0	 1.0 1.5 - 2.0
Rotating Shafts Gradually applied or steady loads	1.5	1.0
Suddenly Applied Loads Minor shock only	1.5 - 2.0	1.0 - 1.5
Suddenly Applied Loads Heavy shocks	2.0 - 2.5	1.5 - 2.5

Chart 1 — Quick Selection

Note: All shaft size selections shown are based on the ASME code, ASA-BITC. This standard is not favored for most applications. A new code, ANSI B106, supersedes ASA-BITC. ANSI-B106 is based on fatigue theory which accounts for combined stresses due to reverse.

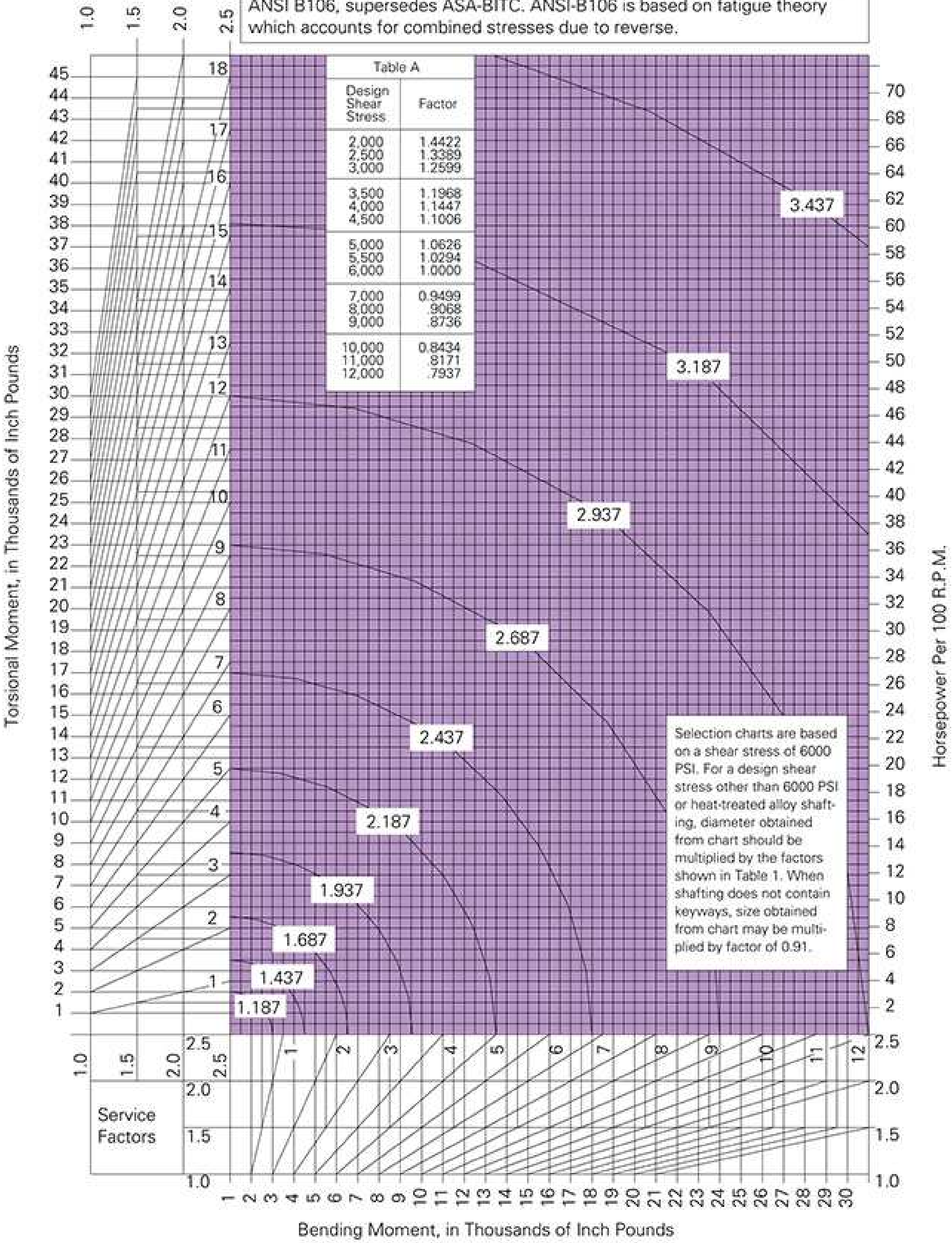


Table A

Design Shear Stress	Factor
2,000	1.4422
2,500	1.3389
3,000	1.2599
3,500	1.1968
4,000	1.1447
4,500	1.1006
5,000	1.0626
5,500	1.0294
6,000	1.0000
7,000	0.9499
8,000	.9068
9,000	.8736
10,000	0.8434
11,000	.8171
12,000	.7937

D – ENGINEERING INFORMATION

Chart 2 — Shaft Selection

Note: All shaft size selections shown are based on the ASME code, ASA-BITC. This standard is not favored for most applications. A new code, ANSI B106, supersedes ASA-BITC. ANSI-B106 is based on fatigue theory which accounts for combined stresses due to reverse.

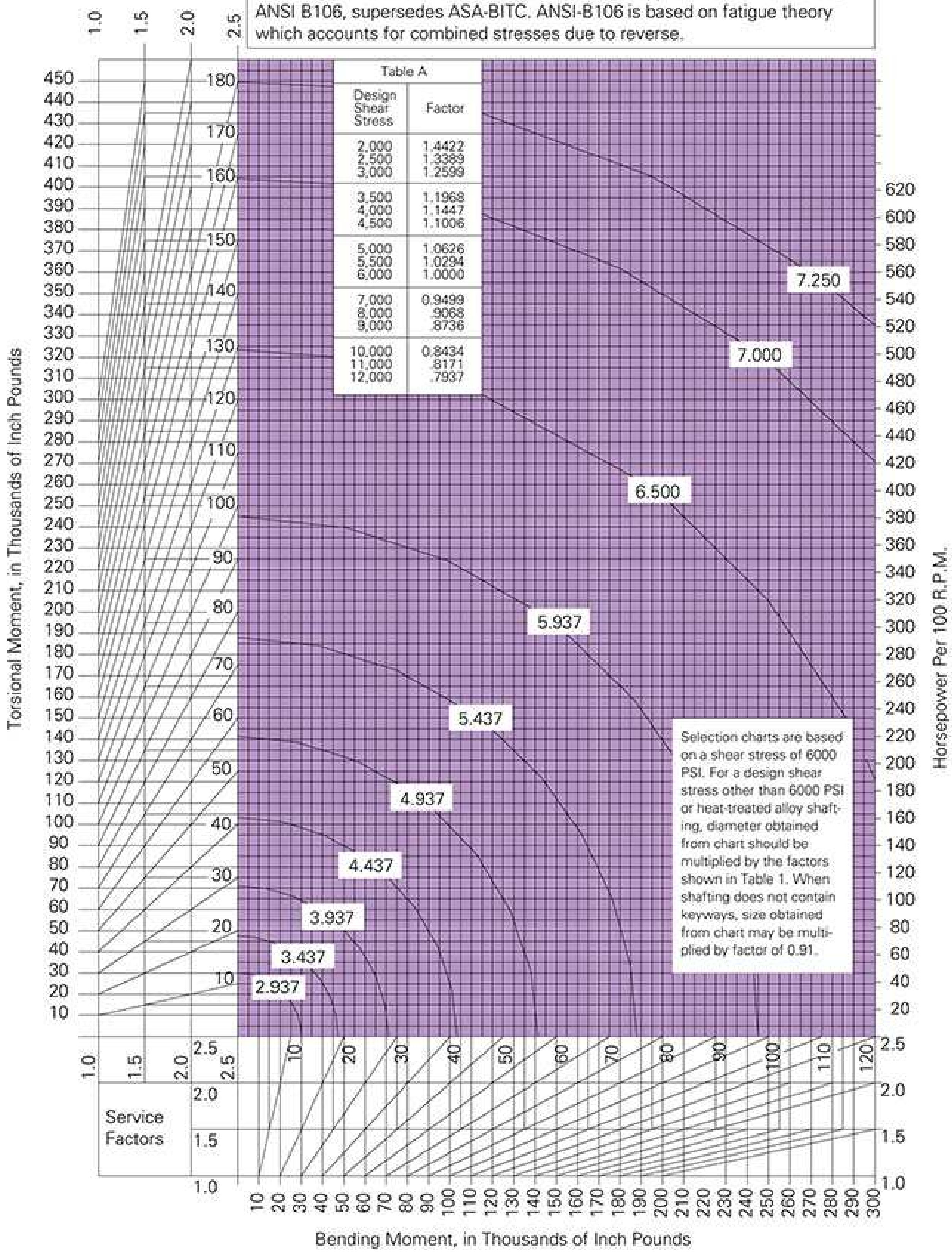


Table A

Design Shear Stress	Factor
2,000	1.4422
2,500	1.3389
3,000	1.2599
3,500	1.1968
4,000	1.1447
4,500	1.1006
5,000	1.0626
5,500	1.0294
6,000	1.0000
7,000	0.9499
8,000	.9068
9,000	.8736
10,000	0.8434
11,000	.8171
12,000	.7937

Selection charts are based on a shear stress of 6000 PSI. For a design shear stress other than 6000 PSI or heat-treated alloy shafting, diameter obtained from chart should be multiplied by the factors shown in Table 1. When shafting does not contain keyways, size obtained from chart may be multiplied by factor of 0.91.

Helpful Formulas

Horsepower

Horsepower equals 33,000 foot pounds per minute, or 550 foot pounds per second. In terms of chain load and speed

$$HP = \frac{\text{Working Load} \times \text{Ft. per Min.}}{33{,}000}$$

$$\text{or } HP = \frac{\text{Working Load} \times T \times P \times \text{R.P.M.}}{396{,}000}$$

Where:
T = Number of sprocket teeth
P = Chain pitch

Chain Rolling Friction

$$f_r = f_s \frac{d}{D}$$

Where:
f_r = Coefficient of rolling friction
f_s = Coefficient of sliding friction
d = Bushing outside diameter
D = Roller outside diameter

Chain Working Load

When the horsepower input is known and the chain working load is desired, this can be calculated as follows:

$$\text{Working Load} = \frac{HP \times 33{,}000}{\text{Ft. per Min.}}$$

$$\text{or Working Load} = \frac{HP \times 396{,}000}{T \times P \times \text{R.P.M.}}$$

Factor of Safety

Factor of Safety is determined as follows:

$$F.S. = \frac{\text{Chain Average Ultimate Strength}}{\text{Chain Working Load}}$$

Chain Speed

Chain Speed can be determined from the following formula:

$$\text{Chain Speed (ft. per min.)} = \frac{T \times \text{R.P.M.}}{K}$$

Where:
T = Number of sprocket teeth
K = Pitches of chain per foot

Chain Bearing Pressure

Chain Bearing Pressure can be figured as follows:

$$\text{Bearing Pressure (lbs. per sq. in.)} = \frac{\text{Working Load}}{L \times D}$$

Where:
L = Bushing length
D = Pin diameter

Torque in Inch Pounds

Torque in Inch Pounds is converted into HP by:

$$\frac{\text{Torque} \times \text{R.P.M.}}{63{,}000} = \text{Horsepower}$$

Torque in Foot Pounds

Torque in Foot Pounds is converted into HP by:

$$\frac{\text{Torque} \times \text{R.P.M.}}{5{,}250} = \text{Horsepower}$$

Kilowatts to HP

To convert Kilowatts to HP:

1 K.W. = 1 1/2 HP (approx.)

$$HP = \frac{K.W.}{.746 \times \text{Efficiency}}$$

Efficiency = .9 for generators
Efficiency = .87 for motors (3 phase)

Chain Lengths in Pitches (Approx.)

$$\text{Chain Length} = \frac{S}{2} + 2C + \frac{.0253\, D^2}{C}$$

Where:
S = Sum of teeth, both sprockets
C = Center distance in pitches
D = Difference in number of teeth both sprockets