CROSS+MORSE

Power Transmission Solutions

Drive Design

Roller Chain Drive Design

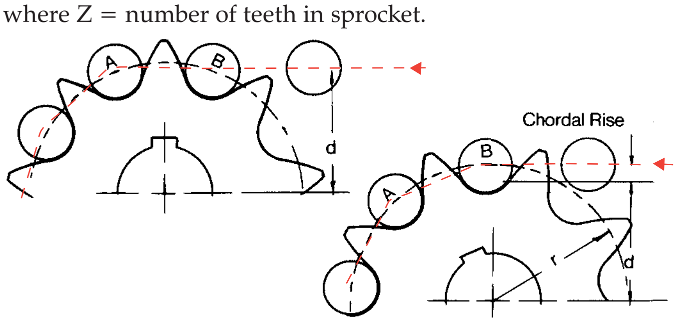
Roller Chain by nature of its design is capable of transmitting high torque loads, and provides the ideal drive media for the connection of slow to medium speed shafts located on extended centres.
The selection and application is reasonably simple by following normal engineering practices, but there are points of good design practice specific to Roller Chain Drives, and consideration of these will ensure successful drive design.

• Numbers of Teeth in Sprockets

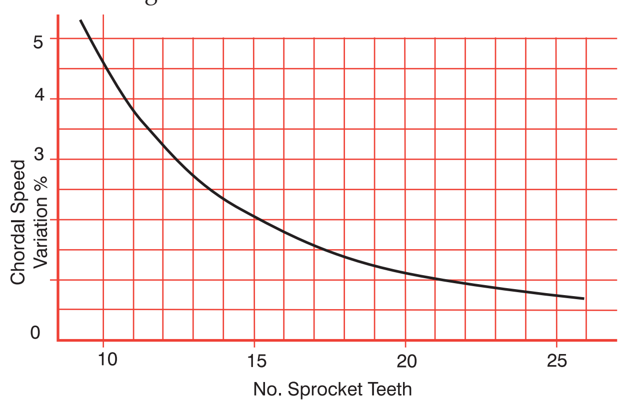
Chordal Action:- As a chain engages and disengages with a sprocket there is a rise and fall of each link, and a velocity variation. These are due to chordal action caused by the chain forming a polygon on the sprocket. In the diagrams below as Roller B approaches the sprocket it follows the chordal line of Roller A. Once engaged it is caused to rise following the arc of the pitch circle. As the chain unwraps from the sprocket the reverse occurs. As well as inducing a vibration into the chain, the linear velocity of the chain is varied from a minimum on effective radius d to a maximum on the pitch circle radius r. The level of this cyclic speed variation can be determined:-

$$\text{Chordal velocity variation} = 100\left[1 - \cos\frac{180}{Z}\right]\ \%$$

where Z = number of teeth in sprocket.



Chordal action is unavoidable, but its magnitude and effect can be minimised by using sprockets with high numbers of teeth, the value becoming insignificant on drives with 25 tooth sprockets or larger.



% Speed Variation due to Chordal Action

Odd Numbers of Teeth:- As most drives have a chain with an even number of pitches, using an odd number teeth in the sprockets will assist uniform wear distribution for both chain and sprocket. An exception to this is for 1:1 ratio drives where even tooth sprockets are preferred to minimise the effects of chordal action on the drive.

Number of Teeth in Large Sprocket:- It is recommended that chainwheels should have a maximum of 114 teeth. This limitation is due to mis-matching of worn chain with large sprockets which increases with the number of teeth in the sprocket. A simple formula to indicate percentage of chain wear a sprocket can accommodate is:-

$$\frac{200\%}{Z}$$

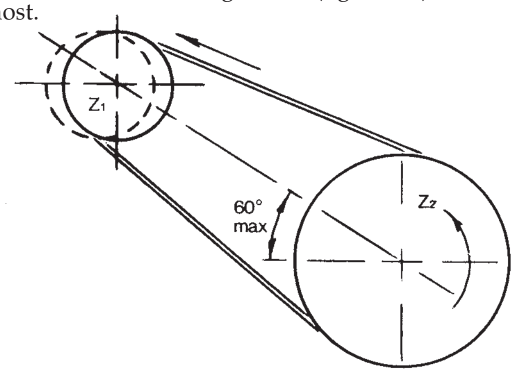
It is normally considered good practice to replace chain if wear elongation exceeds 2%.
It is considered good practice that the sum of teeth on drives and driven sprocket should not be less than 50.

• Drive Ratio

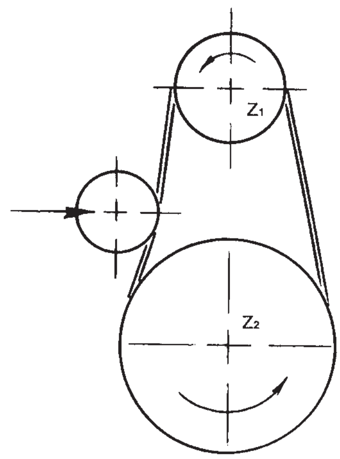
Roller Chain operates at high efficiency on drives with reduction ratios up to 3:1, but can be used effectively for drives up to 5:1 reduction. Higher ratios are not recommended but on some very slow speed drives reductions up to 10:1 have been used. High drive ratios require sprockets with large number of teeth, which restrict maximum chain wear with a resultant reduction in chain life. For reduction ratios above 5:1 consideration should be given to two-stage drive with idler shaft.

• Drive Arrangements

It is preferred to use Roller Chain on drives with horizontal shafting, although vertical shaft drives can be accommodated. Shaft centres may be displaced horizontal at an incline, or vertical, with each arrangement having its own specific requirement. Horizontally displaced shafts, and drives with centres inclination up to 60°, are the best and most common arrangements. On inclined drives the driver can be either above (as illustrated) or below the driven sprocket, but it is preferable to have the driving strand (tight side) of the chain uppermost.



For vertically displaced shaft drives, including drives with an inclination of over 60° to the horizontal, additional maintenance is required to ensure chain is always correctly adjusted, and for this reason automatic means of chain adjustment is recommended for these arrangements. It is always preferred to have the driver sprocket above the driven sprocket, as chain wear creates reduced contact on the lower sprocket.



Roller Chain is not recommended for drives with vertical shafts, but providing the drive is well engineered, and certain basic rules followed, a satisfactory drive can be achieved. As the chain is supported by its side-plates on the sprockets, it is essential to use sprockets with high numbers of teeth (minimum 25 teeth) to spread the load. To minimise catenary side loads on the chain shaft centres should be kept to a minimum (30 pitches max), and multistrand chains used where possible. For slow speed drives (up to 1 M/S) special chain guides are available to support simplex chain for longer centre drives. It is imperative that chains are maintained in correct tension at all times, if acceptable life is to be achieved, and to minimise the effects of wear, chain selection should be made with an additional design factor of 2.

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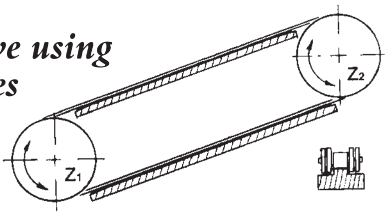
• *Shafts Centre Distance*

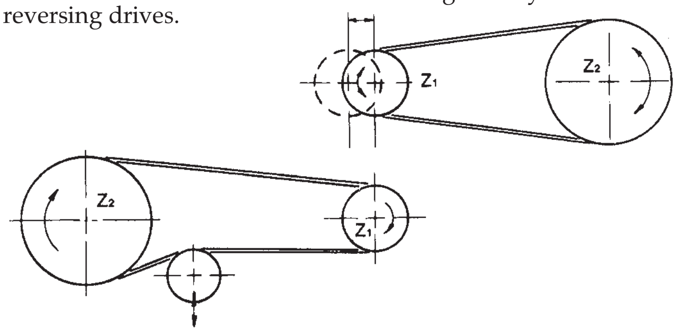
For optimum chain life shaft centres within the range 30 to 50 times chain pitch should be used, refer to page 9. Drives with centres up to 80 times pitch will perform satisfactorily providing adequate adjustment of chain tension is available. For very long centres, consideration should be given using two stage drive with idler, or alternatively for lightly loaded, slow speed (up to 1 m/s) drives, supporting both strands of chain on chain guides.

Long Centre Drive using Supporting Guides

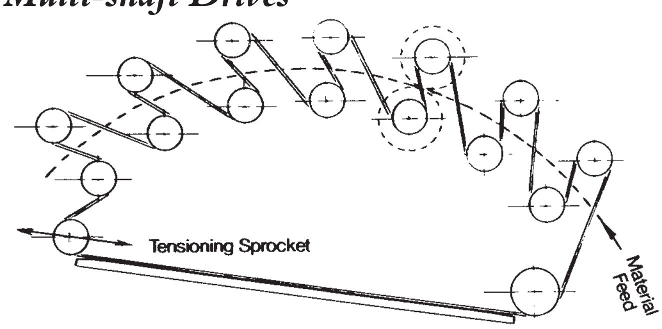


• *Centre Distance Adjustment*

When designing a chain drive ability to adjust the position of one shaft to compensate for chain wear, should be included, ideally equal to a minimum of 2 pitches of chain. If this is not possible, correction for chainwear can be achieved by the incorporation of adjustable idler or sprung loaded tensioner on the slack strand of the chain. Automatic adjustment for chain wear is recommended for drives with an inclination of more than 60° to the horizontal, see sketch. Idler or tensioner sprockets should be applied to the outside of the unloaded strand of the chain close to the driven sprocket, but allowing at least 5 pitches free length of chain between idler and sprocket at all times. Ideally at least 3 pitches of chain should engage with idler sprockets. Automatic tensioners cannot be used on reversing drives, or applications where high torque reversals could be encountered. Idlers also are not generally suitable for reversing drives.



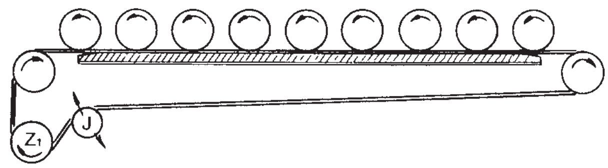
Multi-shaft Drives



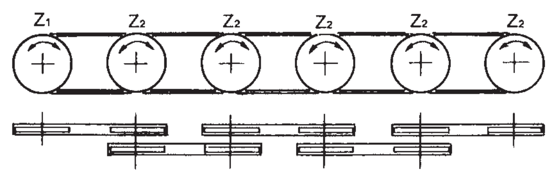
Typical Serpentine Drive
Drive to 7 pairs rollers in film process m/c

Roller Chain is often used to connect a number of shafts within one drive. Three arrangements are most common. Serpentine drives have the chain laced through a number of sprockets, so that some can be driven contra-rotation to the others.

These drives suffer high rates of wear due to the number of sprockets involved, and combined with necessary long chain length require inclusion of an idler with a lot of adjustment, within the drive. Sometimes a number of adjustable idlers are used.



Light live roller conveyor drives can be powered using a single loop of chain with sprockets running on top. The chain should be supported on plastic chain guide to maintain constant contact with sprockets, alternatively where rollers are well spaced idler sprockets can be positioned opposite between each pair of sprockets, this increasing the angle of contact on the driven sprockets. The small contact between driven sprocket and chain requires that torque on any one roller should never exceed 15% of rated power for the drive. Chain speed should never exceed 1 m/s. An advantage of this layout is that the driven sprockets and shafts can be easily removed.



Powered live roller conveyors usually have the rollers connected by coupled simple drives, often with the use of double simple sprockets. To keep chain loads to a minimum it is preferable to connect input drive to centre roller, this keeping wear to a minimum. A simple chain drive operates with an efficiency of 98%, therefore an allowance of 2% should be made for power loss in each loop of chain in determining chain selection and drive motor requirements.

• *Elevated Temperature and Stainless Steel Chains*

Standard Roller Chain loses some of its performance capability at elevated temperatures, and also is more prone to corrosion problems. Hardness of pins and bushes become reduced affecting operating life. At temperatures over 170°C chain drive capacity is reduced, and this must be included in drive selection by applying the factor f_3 from the table below. Standard Chain should not be used in temperatures over 250°C. For elevated temperature applications it is preferable to select Stainless Steel Chains, with standard series suitable on applications to 325°C, and 300 series chain for temperatures to 500°C Stainless Steel Chain has lower wear resistance at all temperature, and therefore factor f_3 in table blow should be applied when making chain selection.

Factor f_3 (Stainless and Elevated Temperature)

Temperature	Standard Roller Chain	Stainless Roller Chain	300 Series Stainless
-5 to 170°C	1.0	2.0	2.6
170 to 200°C	1.35	2.3	2.75
200 to 250°C	2.0	2.6	2.9
250 to 325°C	–	2.75	3.2
325 to 425°C	–	–	4.0
425 to 500°C	–	–	5.0

Useful formulae: The following formulae can be used in the Design and Selection of Chain Belt Drives.

$$\text{Power (kW)} = \frac{\text{Torque Nm x rev/min}}{9550}$$

$$\text{Belt/Chain Speed (M/sec)} = \frac{\text{Z x p x r.p.m.}}{60{,}000}$$

Z = No. Teeth in Sprocket or Pulley
p = Belt/Chain pitch mm

Further design formulae and conversion tables are provided in the catalogue appendix.

Roller Chain Drive Selection

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Selection Procedure for Chain Drives with Two Sprockets

This selection procedure and the chain ratings will provide for a life expectancy of 15,000 hours for drives which incorporate a method of adjustment for wear, are operating in a clean environment at normal ambient temperatures, and subject to proper maintenance and adequate lubrication at all times. In order to use the selection procedure it is first necessary to assemble all data relevant to the application, which should include:-

a. Power to be transmitted.
b. Input shaft speed, and output speed required or drive ratio.
c. Type of driver and driven equipment.
d. Centres and layout of shafts.
e. Shaft diameters.
f. Environmental conditions.

Selection Procedure

The correct size of chain for an application can be made by reference to Selection Charts relating shaft speed and design power. The design power P_d is determined from the motor power P and application factors, f_1, f_2 and f_3 if applicable.

$P_d = P\ f_1, f_2\ (f_3)$ Where f_1 = Service Factor
f_2 = Sprocket Size Factor
f_3 = Temperature Factor also stainless steel chains refer to Page 6.

1. Service Factor - f_1

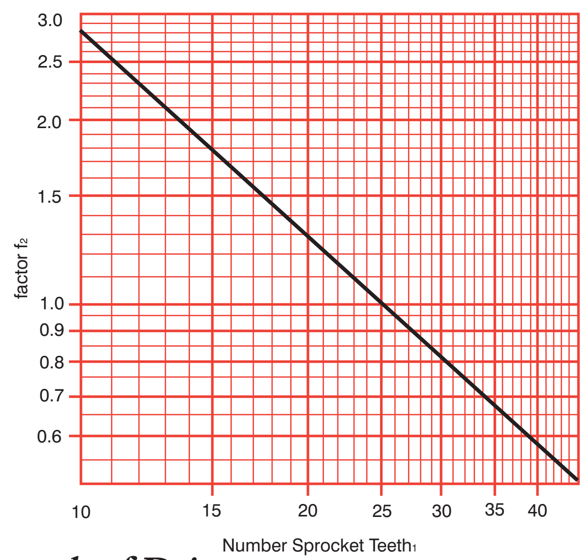
The service factor f_1 can be determined from details of the driver and driven equipment by selection from the table below. The service factor is applied to take into consideration the source of power, nature of the load, load inertia strain or shock, and the average hours per day of service. Normal duty drives are those with relatively little shock or load variation. Examples of typical drivers and driven equipment, are given at the bottom of the page.

2. Sprocket Sizes - f_2

The sprocket sizes are determined by the drive ratio required.

$$\text{Drive Ratio } i = \frac{\text{R.P.M. High Speed Shaft } n_1}{\text{R.P.M. Low Speed Shaft } n_2} = \frac{\text{No. Teeth Large Sprocket } Z_2}{\text{No. Teeth Small Sprocket } Z_1}$$

Suitable sprockets can be selected from Ratio Table Page 8 with consideration given to the following.
Unless shaft speeds are very low it is advisable to use a minimum of 17 tooth sprockets. If the drive operates at high speeds or is subject to impulse load sprockets should have at least 25 teeth and should be hardened.
For low ratio drives, sprockets with high numbers of teeth minimise joint articulation, and bearing loads, thus extending chain life. On drives where ratios exceed 5:1 the designer should consider using compound drives for maximum service life.
Having selected the number of teeth of the sprockets factor f_2 can be determined from the table below.



Application factor f_1 - Service Factor

Characteristics of Driven Machine	Characteristics of Driver		
	Smooth Running	Slight Shock	Moderate Shock
Smooth Running	1.0	1.1	1.3
Moderate Shock	1.4	1.5	1.7
Heavy Shock	1.8	1.9	2.1

Example of Drivers

Smooth Running	Electric Motors Steam and Gas Turbines Internal Combustion Engines with Hydraulic Coupling
Slight Shock	Internal Combustion Engines with 6 Cylinders or more with Mechanical Coupling
Moderate Shock	Internal Combustion Engines with less than 6 Cylinders with Mechanical Coupling

Examples of Driven Machines

The following list classifies common driven mechanisms into their various duty ratings, given as a guide to assist in the final determination of the actual operating characteristics

Bakery Machinery .... Moderate Shock
Brick and Clay Machinery .... Heavy Shock
Centrifuges .... Heavy Shock
Compressors:
  Centrifugal and Rotary .... Smooth
  Reciprocating .... Heavy Shock
Conveyors:
  Apron, Bucket, Elevator, Pan .... Heavy Shock
  Belt (Uniformly Loaded) .... Smooth
  Flight, Screw .... Heavy Shock
Cotton Oil Plants .... Heavy Shock
Cranes .... Moderate to Heavy Shock
Crushing Machinery .... Heavy Shock
Fans and Blowers:
  Centrifugal or Induced Draft .... Moderate Shock
  Mine Fans, Positive Blowers .... Heavy Shock
  Propellers .... Heavy Shock

Flour, Feed or Cereal Mill Machinery:
  Separators, Sifters, Purifiers .... Smooth
  Roller Mills, Grinders .... Moderate Shock
Generators and Exciters .... Moderate Shock
Laundry Machinery .... Moderate Shock
Liquid Agitators, Paddles or Propeller .... Smooth
Mills .... Heavy Shock
Paper Machinery:
  Agitators, Calendars, Dryers, Jordan Engines Moderate Shock
  Beaters, Chippers, Nash Pumps, Washers, Winder Drums, Yankee Dryers .... Heavy Shock
Printing Machinery .... Smooth
Pumps:
  Centrifugal, Gear, Rotary .... Moderate Shock
  Dredge, Duplex, Triplex, ... Heavy Shock
Rubber Plant Machinery .... Heavy Shock
Textile Machinery .... Smooth

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3. *Chain Size Selection*

Having determined values for factors f_1, f_2 and f_3 (if applicable), the design Power can be determined.

$$P_d = P \bullet f_1 \bullet f_2 \, (f_3)$$

By relating the design Power P_d with the rotational speed of the small sprocket n_1 on the Capacity Chart pp10/11 the correct size of chain for the application can be selected.
Use the Capacity Charts to select the smallest pitch of simplex chain which will transmit the design Power, as this normally provides the most economic selection. However, other factors should also be considered when making this selection.

a. The preferred centre distance ranges between 30 and 50 times the chain pitch, and there should always be a minimum arc of contact of the chain on the small sprocket of 120°; or for sprockets with low numbers of teeth a minimum of 5 teeth in contact. The following are preferred centre distances against chain pitch.

Chain Pitch	8mm	3/4"	1/2"	5/8"	3/4"	1"
Min.Centres	240	280	380	470	570	760
Max. Centres	400	480	640	800	960	1270

Chain Pitch	1 1/4"	1 1/2"	1 3/4"	2"	2 1/2"	3"
Min.Centres	950	1140	1320	1500	1900	2275
Max. Centres	1590	1920	2250	2550	3200	3850

There will always be a minimum arc of contact of 120° if the centre distance in pitches is greater than 0.32x the difference in numbers of teeth of driven and driver sprocket.

b. When a compact drive is required, then a multiplex chain of a smaller pitch should be used with resultant reduction in chain wheel diameters.

The Capacity Charts are based on drives of uniform operation without over loads, shocks or frequent starts, using a 25 tooth pinion, and can be used to select drives with corrected design Power where:-

a. The chain drive consists of two chain wheels mounted on parallel, horizontal shafts.
b. The drive has a maximum speed reduction of 3:1.
c. The operating temperature is within the range -5°C to 70°C.
d. The chainwheels are correctly aligned and the chain maintained in correct adjustment at all times. Refer to page 13.
e. An adequate supply of clean lubricant is maintained.
f. The chain is of rivetted construction without any crank links.
g. The chain has a length of 120 pitches. A shorter chain length will still be suitable to transmit the powers indicated, but the wear life will be proportionally reduced. Chains of longer length give little improvement in overall life, and chains over 150 pitches should only be used when shaft speeds are low.

4. *Check Drive Selection*

Check with sprocket dimensions pp 32/58 to ensure sprocket will accommodate shaft sizes. If shaft diameters exceed maximum bore of selected sprockets it will be necessary to increase numbers of teeth in sprockets or select larger pitch chain.
Check that sprocket diameters and chain clearance requirements can be accommodated within the space envelope. If dimensions are restricted select multi-strand chains of smaller pitch.

5. *Determine Chain Length and Actual Centre Distance*

Refer to page 9 for calculations of chain length. Note that for all drives the shaft centres should be at least 2mm greater than half the sum of the sprocket outside diameters; and for drives with ratio greater than 3:1 centres should be minimum of the summation of the sprocket pitch circle diameters

Ratios possible with Stock Sizes

	Number of Teeth - Driver Sprocket																			
Number of Teeth - Driven Sprocket	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	30
11	1.22	1.10	1.00																	
12	1.33	1.20	1.09	1.00																
13	1.44	1.30	1.18	1.08	1.00															
14	1.56	1.40	1.27	1.17	1.08	1.00														
15	1.67	1.50	1.36	1.25	1.15	1.07	1.00													
16	1.78	1.60	1.45	1.33	1.23	1.14	1.07	1.00												
17	1.89	1.70	1.55	1.42	1.31	1.21	1.13	1.06	1.00											
18	2.00	1.80	1.64	1.50	1.38	1.29	1.20	1.13	1.06	1.00										
19	2.11	1.90	1.73	1.58	1.46	1.36	1.27	1.19	1.12	1.06	1.00									
20	2.22	2.00	1.82	1.67	1.54	1.43	1.33	1.25	1.18	1.11	1.05	1.00								
21	2.33	2.10	1.91	1.75	1.61	1.50	1.40	1.31	1.23	1.17	1.10	1.05	1.00							
22	2.44	2.20	2.00	1.83	1.69	1.57	1.47	1.38	1.29	1.22	1.16	1.10	1.05	1.00						
23	2.56	2.30	2.09	1.92	1.77	1.64	1.53	1.44	1.35	1.28	1.21	1.15	1.10	1.05	1.00					
24	2.67	2.40	2.18	2.00	1.85	1.71	1.60	1.50	1.41	1.33	1.26	1.20	1.14	1.09	1.04	1.00				
25	2.78	2.50	2.27	2.08	1.92	1.79	1.67	1.56	1.47	1.39	1.32	1.25	1.19	1.14	1.09	1.04	1.00			
26	2.89	2.60	2.36	2.17	2.00	1.86	1.73	1.63	1.53	1.44	1.37	1.30	1.24	1.18	1.13	1.08	1.04	1.00		
27	3.00	2.70	2.45	2.25	2.08	1.93	1.80	1.69	1.59	1.50	1.42	1.35	1.29	1.23	1.17	1.12	1.08	1.04	1.00	
28	3.11	2.80	2.54	2.33	2.15	2.00	1.87	1.75	1.65	1.56	1.48	1.40	1.33	1.27	1.22	1.16	1.12	1.08	1.04	
29	3.22	2.90	2.64	2.42	2.23	2.07	1.93	1.81	1.71	1.61	1.53	1.45	1.38	1.32	1.26	1.21	1.16	1.12	1.07	
30	3.33	3.00	2.73	2.50	2.31	2.14	2.00	1.88	1.76	1.67	1.58	1.50	1.43	1.36	1.30	1.25	1.20	1.15	1.11	1.00
32	3.56	3.20	2.91	2.67	2.46	2.28	2.13	2.00	1.88	1.78	1.68	1.60	1.52	1.45	1.39	1.33	1.28	1.23	1.19	1.07
35	3.89	3.50	3.18	2.92	2.69	2.50	2.33	2.19	2.06	1.94	1.84	1.75	1.67	1.59	1.52	1.46	1.40	1.34	1.30	1.17
38	4.22	3.80	3.45	3.17	2.92	2.71	2.53	2.38	2.24	2.11	2.00	1.90	1.81	1.73	1.65	1.58	1.52	1.46	1.41	1.27
40	4.44	4.00	3.64	3.33	3.08	2.86	2.67	2.50	2.35	2.22	2.10	2.00	1.90	1.82	1.74	1.67	1.60	1.54	1.48	1.33
45	5.00	4.50	4.09	3.75	3.46	3.21	3.00	2.81	2.65	2.50	2.37	2.25	2.14	2.04	1.96	1.88	1.80	1.73	1.67	1.50
57	6.33	5.70	5.18	4.75	4.38	4.07	3.80	3.56	3.35	3.17	3.00	2.85	2.71	2.59	2.48	2.37	2.28	2.19	2.11	1.90
76	8.44	7.60	6.91	6.33	5.85	5.43	5.07	4.75	4.47	4.22	4.00	3.80	3.62	3.45	3.30	3.17	3.04	2.92	2.81	2.53
95		9.50	8.64	7.92	7.31	6.79	6.33	5.94	5.59	5.28	5.00	4.75	4.52	4.32	4.13	3.96	3.80	3.65	3.52	3.17
114				9.50	8.77	8.14	7.60	7.12	6.71	6.33	6.00	5.70	5.43	5.18	4.96	4.75	4.56	4.38	4.22	3.80

Chain Length and Centre Distance Calculations

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For chain drives incorporating two sprockets, and given an approximate shaft centre distance, the following procedures can be used to determine chain length and actual centre distance.

A. Determining number of pitches in chain.

1. For drives where sprockets have same number of teeth.

Chain Length Pitches LC $= 2\dfrac{Ao}{p} + z$

2. For drives where sprockets have different number of teeth.
   a. Divide the centre distance Ao mm by pitch chain p mm to obtain C
   b. Add teeth in the small sprocket Z_1 to the teeth in the larger sprocket Z_2 to obtain .... S
   c. Subtract the teeth in the small sprocket Z_1 from the teeth in the large sprocket Z_2 to obtain value .... D
   From the table below obtain corresponding value .... K
   d. Chain lengths in pitches $L_C = 2C + \dfrac{S}{2} + \dfrac{K}{C}$

3. The calculated chain length L_C will need to be rounded to the nearest whole number of pitches, with preference to even numbers to avoid the use of crank link connectors. Where tensioners are to be used in the drive the calculated chain length should also be increased to obtain actual length L_A. To convert to length in feet or metres, use conversion table below.

4. To obtain actual centre distance, A, having decided on the actual chain length, L_A pitches, the following formula can be used.

$$A = p\left[\frac{L_A - S/2 + \sqrt{[L - S/2]^2 - 8K}}{4}\right]$$

This provides a reasonably accurate result, but for fixed centre drives some correction will be required, and for these you are advised to use conversion tables or consult Cross+Morse Technical Department.

Where:-

A = Actual Centre Distance (mm)
Ao = Approx. Shaft Centres (mm)
L_C = Calculated Chain Length Pitches
L_A = Actual Number of Pitches
p = Chain Pitch (mm)
Z_1 = Number of Teeth in Small Sprocket
Z_2 = Number of Teeth in Large Sprocket

Example:

Given: $Z_1 = 25$, $Z_2 = 60$, p = ½ inch = 12.7mm.
Approx. Centre Distance Ao = 610mm.

Determine:
(a) Chain length L_C to nearest even number of pitches.
(b) Centre distance based on actual number of pitches L_A.

Solution:
1. C = 610 ÷ 12.7 = 48.03
2. S = 25 + 60 = 85
3. D = 60 – 25 = 35, corresponding K = 31.03
4. $L_C = (2 \times 48.03) + \dfrac{85}{2} + \dfrac{31.03}{48.03} = 139.21$ pitches
5. $L_A =$ 140 pitches (nearest even number).
6. Actual Centre Distance A

$$= 12.7\left[\frac{140 - 85/2 + \sqrt{[140 - 85/2]^2 - 8 \times 31.03}}{4}\right]$$

= 615.056mm.

½ inch Pitch Chain operating in 60 and 25 Tooth Sprockets will require 140 pitches of chain for a nominal Centre Distance of 615.05mm.

D	K	D	K	D	K	D	K	D	K	D	K
1	.03	26	17.12	51	65.88	76	146.31	101	258.39	126	402.14
2	.10	27	18.47	52	68.49	77	150.18	102	263.54	127	408.55
3	.23	28	19.86	53	71.15	78	154.11	103	268.73	128	415.01
4	.41	29	21.30	54	73.86	79	158.09	104	273.97	129	421.52
5	.63	30	22.80	55	76.62	80	162.11	105	279.27	130	428.08
6	.91	31	24.34	56	79.44	81	166.19	106	284.67	131	434.69
7	1.24	32	25.94	57	82.30	82	170.32	107	290.01	132	441.36
8	1.62	33	27.58	58	85.21	83	174.50	108	295.45	133	448.07
9	2.05	34	29.28	59	88.17	84	178.73	109	300.95	134	454.83
10	2.53	35	31.03	60	91.19	85	183.01	110	306.50	135	461.64
11	3.06	36	32.83	61	94.25	86	187.34	111	312.09	136	468.51
12	3.65	37	34.68	62	97.37	87	191.72	112	317.74	137	475.42
13	4.28	38	36.58	63	100.54	88	196.16	113	323.44	138	482.39
14	4.96	39	38.53	64	103.75	89	200.64	114	329.19	139	489.41
15	5.70	40	40.53	65	107.02	90	205.17	115	334.99	140	496.47
16	6.48	41	42.58	66	110.34	91	209.76	116	340.84	141	503.59
17	7.32	42	44.68	67	113.71	92	214.40	117	346.75	142	510.76
18	8.21	43	46.84	68	117.13	93	219.08	118	352.70	143	517.98
19	9.14	44	49.04	69	120.60	94	223.82	119	358.70	144	525.25
20	10.13	45	51.29	70	124.12	95	228.61	120	364.76	145	532.57
21	11.17	46	53.60	71	127.69	96	233.44	121	370.86	146	539.94
22	12.26	47	55.95	72	131.31	97	238.33	122	377.02	147	547.36
23	13.40	48	58.36	73	134.99	98	243.27	123	383.22	148	554.83
24	14.59	49	60.82	74	138.71	99	248.26	124	389.48	149	562.36
25	15.83	50	63.33	75	142.48	100	253.30	125	395.79	150	569.93

Chain Length Conversion Data

Chain Pitch (ins)	Pitches/ft	Pitches/Metre	Chain Pitch (ins)	Pitches/ft	Pitches/Metre	Chain Pitch (ins)	Pitches/ft	Pitches/Metre	Chain Pitch (ins)	Pitches/ft	Pitches/Metre
¼"	48	157.480	⅝"	19.2	62.992	1¼"	9.6	31.496	2"	6.0	19.685
⅜"	32	104.987	¾"	16	52.493	1½"	8	26.247	2½"	4.8	15.748
½"	24	78.740	1"	12	39.370	1¾"	6.857	22.497	8mm	38.1	125.000

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Chain Drive Selection Power Rating Graph - British Standard Chains

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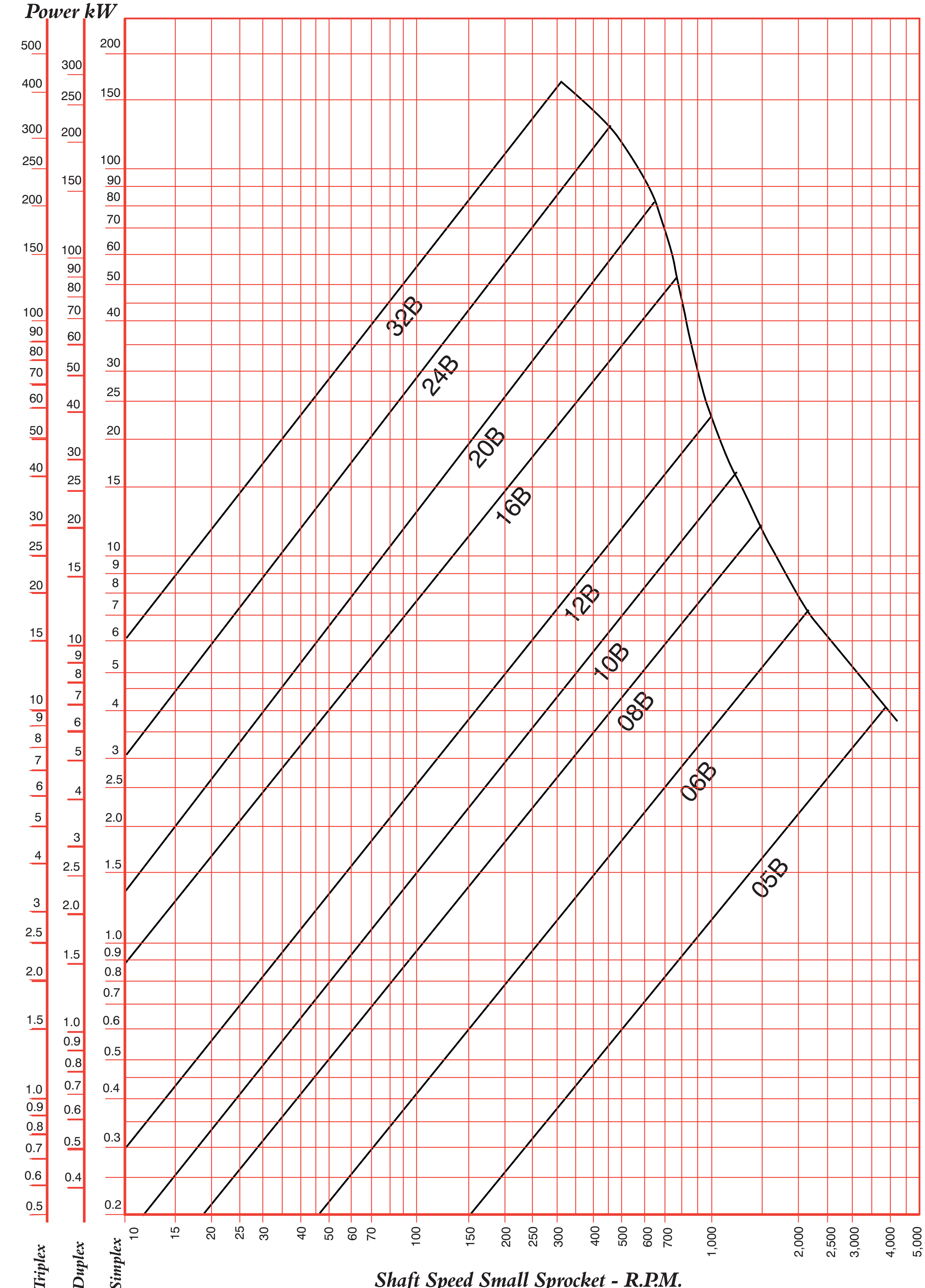

Chain Drive Selection Power Rating Graph - American Standard Chains

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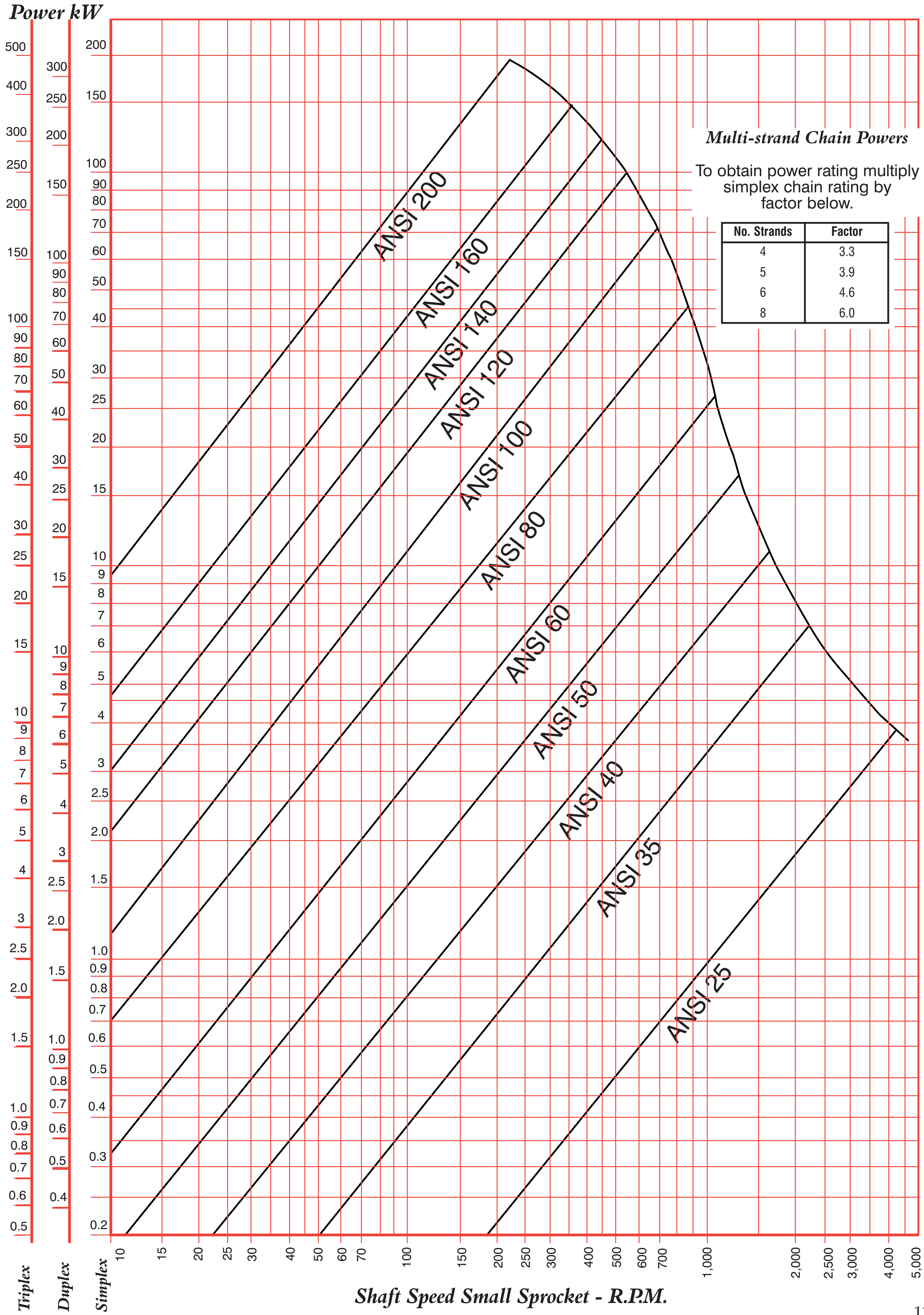

Multi-strand Chain Powers

To obtain power rating multiply simplex chain rating by factor below.

No. Strands	Factor
4	3.3
5	3.9
6	4.6
8	6.0

Chain Lubrication

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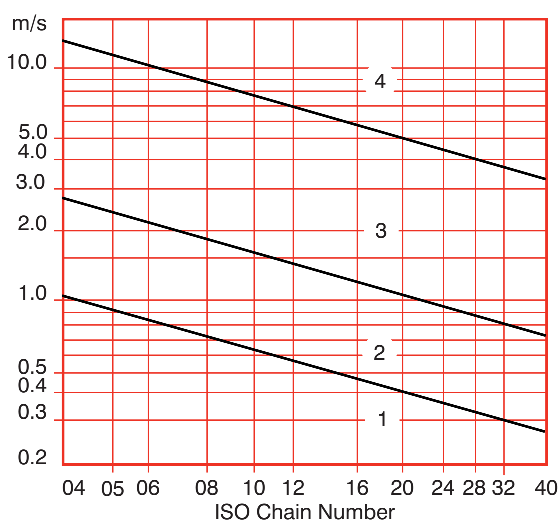
Lubrication Systems

An adequate supply of lubrication is necessary to ensure a satisfactory wear life for any chain drive. Roller chain when supplied is coated in a heavy petroleum grease to provide protection until installation. For some slow, light load applications this lubrication is adequate providing a short wear life can be accepted, but for the majority of applications an oil lubrication system to provide further lubrication will be required, the type being dependant on chain size, loads and operating speed.
When oil is applied to a roller chain a separating wedge of fluid is formed in the operating joints, similar to journal bearings, thereby minimising metal to metal contact. When applied in sufficient volume the oil also provides effective cooling and impact dampening at higher speeds. Chain life will vary appreciably depending on the lubrication system used, and therefore it is important that lubrication recommendations are complied with.The chain rating tables used for selection only apply for drives lubricated in line with the following recommendations. Chain drives should be encased for protection from dirt and moisture, and oil supplies should be kept free of contamination. A good quality, petroleum-based, non detergent thin oil should be used, and changed periodically (Max. 3000 hours operating life). Heavy oils and greases are not recommended for most applications, because they are too stiff to enter the small spaces between precision chain components. The following table indicates correct lubricant viscosity for various ambient temperatures.

Temperature ˚C	Oil Viscosity	Commercial Grade
–5 to +5	VG 68	SAE 20
5 to 25	VG 100	SAE 30
25 to 45	VG 150	SAE 40
45 to 70	VG 220	SAE 50

There are four basic types of lubrication for chain drives, the correct one being determined by chain size and speed. This provides for the minimum lubrication requirements, but the use of a higher type (i.e. type 3 instead of type 2) will normally be beneficial to chain life and performance. The correct type can be selected from graph below of chain speed against chain size. Refer to page 6 for chain speed calculation.



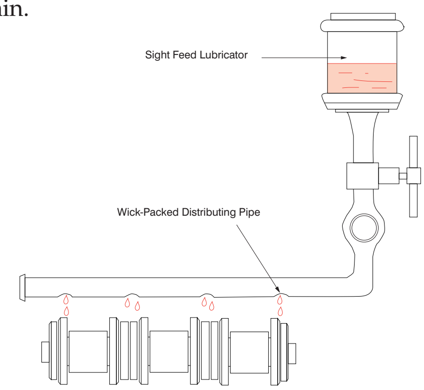
Type 1 - Manual Lubrication

Oil is applied with a brush or oil-can at least once every 8 hours of operation. The volume and frequency of application should be sufficient to keep the chain wet with oil and prevent overheating or discolouration of lubricant in the chain joints.
The use of aerosol-can lubricant is often satisfactory on slow speed drives. It is important that the lubricant used is of a type specified for roller chains, most of which include P.T.F.E. or other additive to reduce friction.

Caution - Manual types of lubrication must never be applied while drive is in operation.

Type 2 - Drip Feed Lubrication

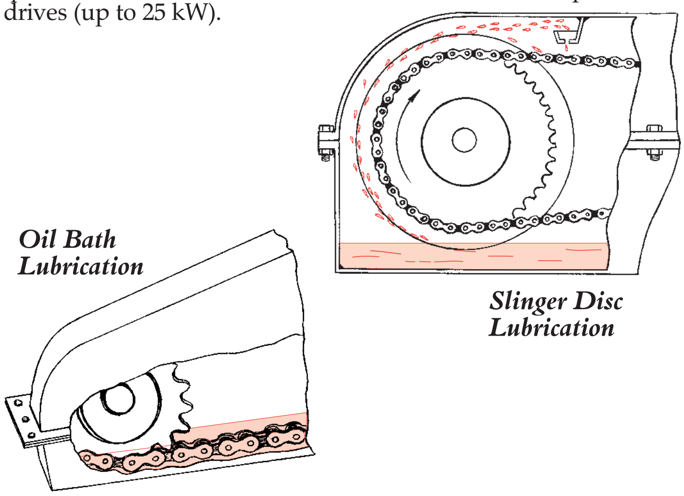
Oil drops are directed between the link plate edges from a drip lubricator. Volume and frequency should be sufficient to prevent discolouration of lubricant in the chain joints. Precaution must be taken against misdirection of the drops by wind from the passing chain.



Type A - Drip Feed Lubrication

Type 3 - Oil Bath or Disc Lubrication

With oil bath lubrication the lower strand of the chain passes through a bath of oil in an enclosed chain case. The oil level must be carefully controlled to be between the pitch line and top of the chain at it lowest point. Adequate sump capacity is required to avoid overheating the oil, as a guide capacity in litres should at least equal half weight of chain Kg/m. This form of lubrication is most effective when the lower strand of chain is the slack strand.
With disc lubrication the chain operates above the oil level. A disc picks up oil and slings it against a collector plate from which it collects in a trough to drip onto the chain. The disc must be sized to produce rim speeds between 4 and 40 m/s. Generally disc slinger systems are only capable of delivering small quantities of oil and thus should be restricted to lower power drives (up to 25 kW).



Type 4 - Forced Feed Lubrication

Oil is pressure fed from a circulating pump, or central lubrication system, via a spray bar, onto the chain. The spray bar should have holes 3mm dia. positioned over the side plates of the chain (see sketch for drip feed), so as to direct the oil between the side plates. The spray bar should be located inside the chain loop close to the driven sprocket and approximately 5cm from the slack strand of the chain, with oil holes directed to deliver oil onto the chain as it enters the driven sprocket.
Oil flow rate should be a minimum of 3.5 litres/min per strand width of chain. Oil reservoir capacities should be a minimum of 3 times oil flow rate, and lubrication system should include a full flow oil filter.
For lubrication requirements outside the above recommendations consult Cross+Morse Engineering Department.

Chain Drive Installation and Maintenance

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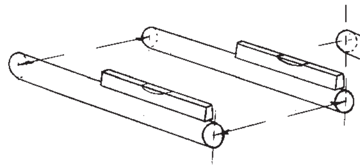
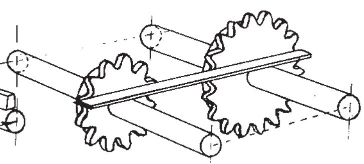
Alignment of Shafts and Sprockets

Although Roller Chain provides a flexible connection of shafts, careful and accurate installation is necessary for trouble free operation.
The shafts must be rigidly supported by suitable bearing assemblies, and must be accurately aligned. The use of a spirit level is recommended to ensure shafts are horizontally aligned.Measurement between shafts at their extremities will determine parallelism. On fixed centre designs, manufacturing tolerance should ensure total shaft misalignment can never exceed 0.1%. Sprockets should have tight fit on shafts, with close fit keys and set screws to ensure rigid mounting, and should be located close to the support bearing. Sprocket alignment can be checked by a straight edge on the tooth faces, or for longer centre drives a taut wire. Ideally sprockets should be in-line, but if not, misalignment must never exceed 4% pitch of chain or severe damage will be caused to the drive.
Accurate alignment of shafts and sprockets ensures uniform load distribution across chain width. Alignment should be checked periodically for maximum chain life. When replacement chain is installed check sprockets for abnormal wear which indicates misalignment.



Aligning Shafts



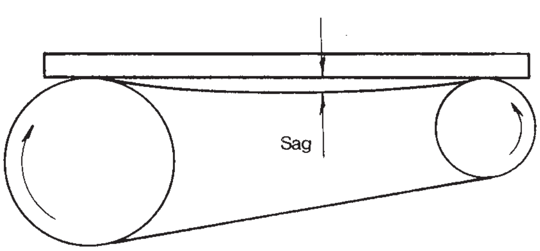
Aligning Sprockets

Chain Installation

If centre distance adjustment is available centres should be reduced to a minimum to assist with chain installation. Wrap chain around the two sprockets and bring the ends together around the larger sprocket in mesh with the teeth which will hold the links in correct position. The connecting link can then be inserted, care being taken to ensure that for duplex and triplex chains the centre link plates are fitted. Where spring clip connecting links are used the closed end of the spring clip must face the direction of rotation. For high speed drives or drives working in arduous conditions it is preferable to use a rivetting connecting link. This can be installed in the same manner, but the back of the link must be rigidly supported whilst the interference fit outer link is fitted and the pins rivetted over.

Chain Tension

To obtain the full life of a chain drive some means of chain length adjustment is necessary. The preferred method is by moving one of the shafts, but if this is not possible an adjustable or sprung loaded idler sprocket engaging with the outside of the slack strand of chain is recommended. Where manual adjustment is required this should be carried out regularly. The total slack in the chain can be determined by counter rotating the sprockets so one strand is taut, and then measuring the total sag between chain and a straight edge midway between the sprockets. For horizontal drives this sag should be 1 - 2% of the centre distance, for vertical drives it should be only 0.5 to 1%



Matched Chains

Combination of powers and speeds sometimes require the use of paired transmission chains operating on double multi-strand sprockets. For these transmission applications chains are built up from shorter sections which are accurately measured and graded for length. Chains from one grade are then used to form a matched pair of chains complete or in handling sections. Chains are suitably identified to ensure correct installation on site. Many light conveying applications use a pair of transmission chains with attachments. As these chains are often connected by the equipment the attachments carry, matching of the chains is required. There are two levels of matching available:
Simple pairing:- Determines that the length of two strands of chain are the same, this being suitable for short run conveyors.
Selective Pairing:- Involves the accurate measurement of handling lengths, usually 3m long which are then paired and identified for assembly into the total matched pair of chains.

Maintenance of Chain Drives

For slow speed drives employing manual lubrication of the chain, frequent access to the drive is made for relubrication. Whilst lubricating the chain visual inspection of both chain and sprockets for abnormal wear and damage should be made, also apparent levels of sag observed.
For higher speed drives employing automated methods of lubrication regular checks of oil levels will be required to ensure they never fall below minimum levels. The frequency of these checks will vary with operating conditions for each drive, and can only be determined by experience. With oil bath lubrication, it is important to check more frequently as bath lubrication is effective only within a narrow band of oil level.
It is good preventative maintenance to make routine external inspection of the machinery to ensure it is running smoothly, and recommended that detailed inspection to be made at least 3 times a year. After the first 500 hours of operation oil should be changed and a complete inspection made and centres adjusted if applicable. Oil should then be changed at least once a year or earlier if it is discoloured or contaminated. At oil changes, make a complete examination of chain, sprockets, shafts, bearings, seal and lubrication system, also check alignment and sag, and correct as necessary.
For efficient, reliable operation of chain drives it is recommended to replace the chains when elongation due to wear exceeds 2%.If maintenance records of centre distance adjustment are kept it can be determined when the chain will require replacing, as centres will also have increased by more than 2%. Otherwise it will be necessary to remove the chain from the drive and measure it over a whole number of pitches approx. 600mm length for chains below 1 inch pitch or, 1200mm for longer pitch chains, at a load of 1% of the catalogue tensile strength. Replace chain if length greater than:- 1.02Xp where X = number pitches measured. If a chain has not worn in excess of 2%, but there is insufficient adjustment available on the drive to correctly tension the chain, it can be shortened in length by the removal of a number of pitches. It is not good practice to introduce new components into a well worn chain, as this will cause uneven running with subsequent damage, and for this reason it is always preferred to reduce the chain length by an even number of pitches, unless an offset link was fitted from original installation. To reduce a normal chain assembly, incorporating a connecting link, by two pitches remove the first outer link away from the connecting link using the chain breakers illustrated on page 37.

Caution

Chain drives can be dangerous if not handled correctly. Whilst drives are in operation chain cases and guards should be secured in place to prevent any contact. Prior to removal of guards ensure that power source has been switched off and isolated.
When removing, replacing, or altering a chain always:-

1. Wear protective clothing appropriate including safety glasses, gloves and shoes.
2. Use correct tools, and ensure they are in good working order.
3. Support the chain and sprockets to avoid sudden movement.
4. Release all tensioning devices.
5. Ensure chain construction is fully understood.

When chain is removed and inspected never re-use any damaged chain or component.

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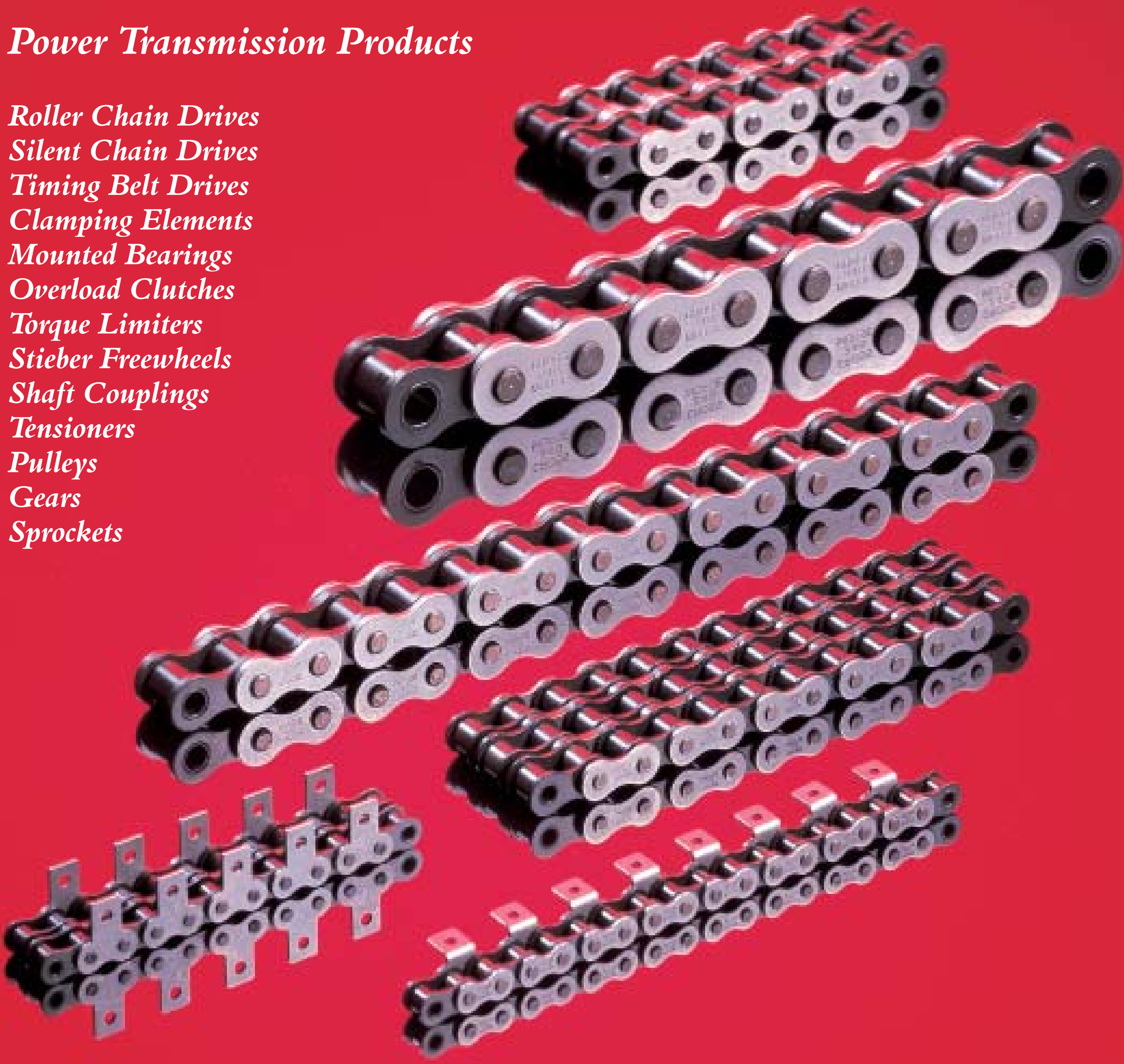

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