10th. October 2003

Notes on the Selection and Care of Chains

Chain Selection

There are many chains, differing in style, materials and heat treatments, within industry
The most important consideration to be made is in the correct selection of chain to suit a particular application.
The correct chain choice will ensure that there are no breakages, or problems to be encountered during service, assuming that the applicational details remain constant.
Such problems are not only very expensive, but also very disruptive to the production process.
If breakage does occur, and the correct chain has been chosen from the strength standpoint, then it could be due to the other major causes of breakage, which are abrasion and corrosion.
These two effects can cause thinning of the main load bearing components of pin and bush, down to such an extent that eventually, the components will not withstand the forces acting upon it, and breakage occurs.
Abrasion can be a problem in many areas, and of course, depends upon the cleanliness of the product being handled, or the environmental conditions, which in turn could give rise to serious problems.
Severe corrosion can again be experienced in many applications, and then this would lead to the possibility of consideration in using a corrosion resistant material such as stainless steel. However, the grade of stainless steel normally used for the articulating components, allows for a heat treatment process to be undertaken, but this leads to a compromise situation between hardness, for wear resistance, and corrosion resistance. Coupled to this, is the necessity for the stainless steel components to be kept wet for lubrication purposes, or the wear rate in dry conditions is faster than for standard materials.
Therefore, because of the increase in cost, the applicational conditions must be suitable for the use of stainless steel components, and an acceptable increase in performance noted, to offset the extra expense.
Some applications could experience a combination of both abrasion and corrosion, so consideration of the applicational conditions and requirements must be borne in mind when the final chain selection is made.
Styles of chain should also be a consideration, and these can start at the simple cast chain designs, through the steel bushed chains and onto the steel roller chains. The steel roller chains are generally considered for applications of high loading and/or with long conveyor centres, where the lower frictional demands results in a lower strength chain being required.
Chains are sometimes chosen by their U.T.S. (Ultimate Tensile Strength) rating, but this basis of selection does not always give the best results.
Chains should be chosen by their stated Allowable Chain Pull figure.
This figure can also be called the maximum theoretical loading that is to be applied to the chain, ensuring that the pressure created between the chain pin and the chain bush does not exceed generally accepted levels.
When this figure is taken in combination with the appropriate working condition and speed correction factors, then it allows for the best means of correct chain size selection, to achieve good wear life.
The attached charts should give some guidelines to the differing chain styles generally used within industry, and show some of their advantages and disadvantages, and may assist in making the correct selection.
Chains of varying styles do overlap in terms of rated working loads, so understanding the best design requirements for the application is also necessary.
Further areas that can greatly assist in trouble free running are in a good inspection and maintenance procedure, and also consideration of good gearing characteristics with the mating sprockets.

General Guidelines For Chain Styles

Steel Conveyor Roller Chains

	Advantages	Disadvantages
Standard Materials	**Smaller in size than cast or forged chains for a given working load** **Rolling friction decreases the chain strength and conveyor power requirements** **Very adaptable for differing attachments**	**Articulating components suffer from any corrosive conditions (Induction hardened pins have been found to resist corrosion better than non-induction hardened pins)**
With Lubricated Pin	**Helps in resisting corrosion**	**Corrosion resistance is not assured** **Increase in maintenance costs, because of increase in labour time required** **Adequate lubrication is dependant upon human factor** **Contamination of product by the grease may not be acceptable**
Stainless Steel Articulating Components	**Best solution for corrosive resistance** **Negligible maintenance costs**	**Lubrication essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)**

General;

Possible that any new chains could be based on existing components. Therefore, there may be no costly tooling.
Material quality is assured.
Rolling friction decreases the required chain strength over sliding friction. Therefore, a lighter chain is required for a given duty.
Steel chains are more adaptable for attachments and modification.
Flanged rollers, to be used as guides, can be fitted if required, to lessen the need for wear strips or guide plates.
Chain rollers have shoulders on the side faces to lessen the tendancy of packing between the roller and the sideplates.

Steel Bushed Chains (Non-Roller Design)

	Advantages	Disadvantages
Standard Materials	**Simple design(Minimal articulating components** **Generally, attachments available as for the steel roller range**	**Sliding friction could increase the chain strength and conveyor power requirements** **Articulating components suffer from any corrosive conditions**
Centre Link Fitted with Stainless Steel Bush and with Stainless Steel Pin	**Articulating area is corrosion resistant**	**Lubrication essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)**

General;

Possible that any new chains could be based on existing components. Therefore, there may be no costly tooling.
Material quality is assured.
Non roller type chain, and therefore friction values are higher than for a roller type chain. Stronger and larger chains may be required for a given duty.
Simple design with minimal components, could be most cost effective answer for a particular application.

Combination Chain (Cast Centre Link with Steel Outer Sideplates)

	Advantages	Disadvantages
Standard Materials	**Simple design (Minimal articulating components)**	**Generally, larger sizes than steel chains are required for a given duty, when using standard bearing area loading** **Sliding friction could increase the chain strength and conveyor power requirements** **Greater general casting tolerances than for steel chains** **Attachment modifications generally restricted to outer sidebars (modifications to centre casting could mean expensive pattern costs)** **Articulating components suffer from any corrosive conditions**
Corrosion Resistant Centre and Stainless Steel Pins	**Helps in resisting corrosion**	**Corrosion resistance not assured** **essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)**
Centre Link Fitted with Stainless Steel Bush and with Stainless Steel Pin	**Articulating area corrosion resistant**	**Lubrication essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)** **Larger size chain may be required for equivalent strength, in order to accommodate the bush**

General;

Non roller type chain, and therefore friction values are higher than for a roller type chain. Stronger and larger chains may be required for a given duty.
Modifications to the centre link may be difficult, and could lead to expensive pattern changes.
Simple design with minimal components could be most cost effective solution.

Block Link Chains (With Cast or Forged Centre Link)

	Advantages	Disadvantages
Standard Materials	**Simple design (Minimal articulating components)**	**Generally, larger sizes than steel chain are required for a given duty, when using standard bearing area loading** **Heavy** **Sliding friction could increase the chain strength and conveyor power requirements** **Greater general casting tolerances** **Attachment modifications restricted to outer sidebars (Modifications to centre casting could mean expensive pattern costs)** **Articulating components suffer from any corrosive conditions**
Centre Link Fitted with Bush	**Larger working loads available from equivalent strength chains, due to higher permitted bearing area loading**	**Larger size chain may be required for equivalent strength, in order to accommodate the bush** **Still liable to corrosion attack**
Centre Link Fitted with Stainless Steel Bush and Stainless Steel Pin	**Articulating area corrosion resistant**	**Lubrication essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)** **Larger size chain may be required for equivalent strength, in order to accommodate the bush**

General;

Non roller type chain, and therefore friction values are higher than for a roller type chain. Stronger and larger chains may be required for a given duty.
Modifications to the centre link may be difficult, and could lead to expensive pattern changes

Standard Cast Malleable or Cast Steel Chains

	Advantages	Disadvantages
Standard Materials	**Simplest design – only links and pins**	**Generally, larger sizes than steel chain are required for a given duty, when using standard bearing loading** **Sliding friction could increase the chain strength and conveyor power requirements** **Greater general casting tolerances** **Attachment modifications could mean expensive pattern changes** **Articulating components suffer from any corrosive conditions**
Link Fitted with Bush	**Larger working loads available from equivalent strength chains, due to higher permitted bearing area loading**	**Larger size chain may be required for equivalnt strength, in order to accommodate the bush** **Still liable to corrosion attack**
Link Fitted with Stainless Steel Bush and Stainless Steel Pin	**Articulating area corrosion resistant**	**Lubrication essential (However, lubricant is only necessary to keep components wet. Therefore, steam or water spray aimed at chain is ideal)** **Larger size chain may be required for equivalent strength, in order to accommodate the bush**

General;

Non roller type chain, and therefore friction values are higher than for a roller type chain.
Stronger and larger chains may be required for a given duty.
Modifications to the link could lead to expensive pattern changes.
The simplest chain design.

Conclusions;

The sizes and the working loads of chains required are dependant upon the duty involved, and therefore there could be no standard chain suitable for all applications.
Roller chains have a frictional value less than for non roller chains, and for a given duty, a smaller chain may be possible because of the lower strength requirements.
In the long term, stainless steel components are the most economical in corrosive conditions. The only stipulation is that the components must be kept wet by either lubrication, or with water or steam.
Modifications are much easier with steel chains.

For an equivalent size chain, the allowable working loads are greater for a steel chain, because of their greater allowable bearing area loading.
Greater strength can usually be obtained from a steel chain, because of the greater material and heat treatment choices available.
Steel chains generally offer the greater degree of material integrity and accuracy.
Cast chains are the most simplistic, but the choice and attachment availability is limited.
Steel bushed chains have few components, have material and heat treatment choice and attachment availability as for the steel roller chains, but being of a non roller design, may require higher strength and create greater conveyor power requirements.

Maximising Chain Life

As soon as the new chain is installed and is operating, wear commences and during the first few days chain stretch will occur as the chain adjusts to the sprockets, after that, initial period a slower rate of wear,(pitch elongation) normally transpires.
Understanding chain wear and appreciating basic principles of good installation, operation and maintenance will result in good maximum chain life.
We hope the following information will help you to deal with any chain and sprocket operational problems that may arise.

Chain Wear

Excessive wear is easy to detect, as the chain when travelling around the sprocket will appear as if it were about to " fall off". The chain may be noisy in operation and it is necessary to continually adjust chain tension until only the removal of one or several links will permit the chain to continue in operation. To avoid breakdowns it is important to establish a regular chain inspection, which should include measuring and recording the chain pitch before excessive wear results in lost down time.
Chain wear is the result of either mechanical type (abrasion of mating chain components), or outside influences such as corrosion or other application factors.
In service, chain wear is generally noticed in two areas: -

Pitch Elongation: (or Chain stretch)

This is caused by wear between the pin diameter and the bush inside diameter.
When this elongation goes beyond acceptable parameters, then sprocket malgearing, and even jumping of sprocket teeth may result.
Ewart sprockets are designed to accept 5% pitch elongation (although larger sprockets may not – due to the unacceptably high tooth required), and therefore, it would be recommended that chain be replaced when the chain pitch extends 3-4% above the stated catalogue pitch.
Also, it must be remembered that due to the necessary design difference between straight, and cranked (offset) sidebar chains, then pitch elongation is seen in differing forms.
Cranked sidebar chains wear evenly on every pitch, whilst straight sidebar chains are seen to wear unequally between inner and outer chain pitches, as far as sprocket gearing is concerned.
But generally, say for 6" pitch chains, when measured over a number of pitches, if the average dimension per pitch is 6.18" (3%) then replacement should be considered.

Component Wear

Generally chain pins are produced from through hardened material (together with or without induction hardening), whilst chain bushes are produced from case hardening material.
Whilst case depths can vary due to component size and wall thickness, the general rule that case depths of 0.030" – 0.040" are most common could be used.
Therefore, as wear would be very much accelerated once the case has worn away, replacement would be necessary once 0.030" has worn from either chain bush inside or outside faces.
For the chain pin, replacement should be considered once 10% of the original diameter has been worn away.
Chain rollers can be case hardened, and again case depths of 0.030" – 0.040" are normal, but Ewart's can offer their standard range of chain rollers to be of a through hardening material, in order to achieve a more consistent wear rate, without any noticeable difference in the rate of wear.
Replacement should be considered if inside or outside diameter shows wear of 0.060" – 0.080", or if flat spots on the outside diameter are noted, or if excessive clearance with the chain bush is noted. This could be so severe that sidebars can be seen dragging on the guideways.
Sidebars do not normally require replacing, unless either damaged, or suffering with severe corrosion.

However, it should be recognised that the pin and bush components have interference fits with the sidebar holes, and therefore, component diameters should not be reduced to make the fit easier. Indeed, if components are found to rotate in the sidebar after fitting, then it must be concluded that damage has occurred, and replacements must be made.
Ewarts, like most major chain manufacturers, do not recommend replacing components, but we must be realistic enough to appreciate that it is a common occurrence.
Also, we must realise that customers' also rotate components, in order to present a new bearing surface to the direction of thrust.
We therefore cannot recommend a certain number of times that components can be replaced or rotated, as this depends upon the care taken to replace the first time. It is possible that a second set may be possible, but this can only be judged at the time, and would be dependent upon component fits.

Sprockets

Sprockets are designed to enable correct gearing with the chain, so therefore new chain should only be used in conjunction with new sprockets, or at least sprockets still in good condition.
Worn sprockets can cause premature failure of new chain, and therefore ignoring sprocket condition, and replacement, could be false economy.
It should be remembered, that most sprocket tooth profiles are equal on both sides of the tooth, and therefore, when one face is worn, they could be turned to allow a new unworn face to be presented.
When taking receipt of new sprockets, it is a good idea to test that the chain wraps itself cleanly around the sprocket, and also to check that if sprockets are ordered matched, to ensure that keyways are machined in line with respect to the sprocket teeth.
Generally chain and component life is dependent upon correct chain selection, controlling the working environment, and carrying out good maintenance procedure.
Chain selection, loading and speed are all very much inter related, but a major consideration would be to keep chain speed to as low as practicable, as high speed can be as much a cause of rapid chain wear as other factors.
Correct sprocket design is extremely important, because the whole of the conveyor / elevator installation depends on the chain / sprocket interaction, by converting either rotational force into pulling power, or pulling power into rotational force.
In order to successfully achieve this transference of force, then the chain and sprockets must be compatible with the correct gearing characteristics, as poor gearing could lead to either inferior chain performance, or premature chain failure.
A correctly designed sprocket tooth form should absorb the working chain tension, whilst accommodating a reasonable amount of chain wear, and should also allow for trouble free engagement and disengagement of the chain.
Ewart's sprockets are designed to accept up to 5% pitch elongation, although the larger the sprocket, the less likely this figure is to be in fact, due to the tooth height that would be necessary. This is why Ewart recommend that the chain be replaced after 3% pitch elongation.
As can be appreciated, it is false economy to ignore the sprocket tooth condition, as indeed it is with correct alignment, and matching of the sprockets in general. Sprockets maintained in good condition will assist in achieving both improved chain performance, and in giving improved chain life.
In order to assist in achieving these aims, Ewart's produce their plate sprockets in material to B.S. 970 grade 080A42 (Centre plate), and B.S. 4360 grade 43A for the bosses. The material choice then allows for the centre plate tooth profile to be flame hardened to a value of 350 BHN. (37.5 Rc) surface minimum, and to a depth of 1/8", although actual results show that hardness values of 40 Rc + are generally achieved.
Chain and sprockets work together in order to give a correctly matched installation, and forgetting the sprocket condition could lead to disappointment in chain performance.

Extending Chain Life

This is unachievable without preventative maintenance, incorporating regular and systematic inspection of chain, sprockets and the conveyor system.
When inspecting chain drives or conveyors, look for the following conditions and take corrective action if required:

1 - Chain Cleanliness
Chains have to be protected from abrasive or corrosive materials.

2 - Chain Travel Direction
Correct installation.
Cranked offset roller chains(narrow head of link leading ensures reduced wear).
Cranked non-roller (open end leading).

3 - Lubrication.
Reduces wear between moving parts. Not all chains are suitable for lubrication especially in dirty, abrasive atmosphere.

4 - Poor Fit of Chain on Sprockets.

5 - Excessive Chain Stretch/Elongation
Chain has tendency to jump sprocket teeth.

6 - Excessive Wear on Outside of Links.
Marks on sidebars, or chain pins suggestion fouling of chain on conveyor structure.

7 - Discolouration of Chain
May indicate corrosion.

8 - Chain Surge ,Irregular Movement
Caused by many factors, sprockets, method of conveyor loading, alignment, conveyor structure faults, take up tension, "seized rollers"

9 - Chain Twist
Alignment problems, caused by uneven wear, tension.

10 - Loose Chain Components and Chain Attachments
Check pin cotters, chain bushes.

11 - Incorrect Chain Tension
Excessive tension promotes faster chain wear.

12 - Conveyor Structure, Chain Wear Strips
Poor condition – more chain wear.

13-Sprockets
a - Wear on sides due to misalignment
b - Tooth wear (indicated by hooked teeth)
c - Broken teeth
d - Irregular movement of sprockets on shafts
e - Drum/traction wheel slippages

If you require more detailed information on any of the above, contact us and we will be pleased to assist in any of your chain problems

CONVEYORS

General comments on Chain maintenance

Chains, whether sliding or rolling, require guide rails for support, and these require positioning correctly to allow for the correct chain travel into it's correct gearing arrangement with sprocket.
Generally, the top chain strand should be positioned, so as to allow for the chain to be lifted into it's gearing position, whilst the bottom strand should be allowed to drop slightly from it's gearing position.
Both the top and bottom strand guides should take into account the chain being at the lowest point of it's gearing position.
That is, the top strand when the pitch chord is in a horizontal position, and the bottom strand when it is coincidental with the sprocket Pitch Circle Diameter.
Once the guides are in a satisfactory location, then problems in the conveyor operation require consideration of other areas.
The following charts cover areas suggested to be checked during the maintenance programme, in order to assist in the smooth running of the conveyor, and therefore, obtaining the maximum chain life.

Check List Explanation;

1/ Worn wear strips can increase friction, and induce out of square and uneven loading on the articulating components.
Badly grooved and worn wear strips can allow the chain sidebars to drag, and again friction is increased.
Increasing friction then places extra loading on the chain and it's components, and this increases the wear rate.

2/ Unmatched sprockets (or incorrectly fitted sprockets) can place unequal loading on the chains, and again increase the wear rate.

3/ Wear strips giving the chain incorrect alignment with the sprockets, could lead to gearing problems, uneven loading, increased wear rate, and even chain breakage.

4/ Distorted or loose slats/ aprons can allow trash to fall onto the return strand.
This trash can then become trapped within the chain, which in turn can cause roller seizure and sliding , and hence increased loading and wear.
If the trash were to affect the pin/bush areas, then increased articulating loading would result, and again increased loading and wear.
In the case of carrier applications especially, trapped trash can yield corrosive juices into the chain parts, and then there is the complication of the onset of corrosion.
Air or steam jets could be positioned close to, and before the tail sprocket/drum, to ensure the chain is clean prior to articulating around the sprocket.
Whilst air is preferable, steam is sometimes more readily available, but has the disadvantage of possibly starting the corrosion process, but then could be followed by a drip feed lubrication system onto the chain.
To try and prevent trash from entering, consideration could be given to the installation of a metal deflector canopy over the conveyor return strands.

5/ Thoroughly cleaning the chains periodically, prevents any possible material build up and could prevent the possible onset of corrosion.

6/ Fouling of any side panels by pin heads would cause uneven loading , and therefore, uneven chain wear.

7/ Any scrapers should not foul the deck plates, as not only would this lead to extra loading on the chains, but would apply extra forces on the scraper/chain attachment points, and this could lead to distortion and breakage.

8/ Scraper ends should not foul the side structure, as again this could cause uneven loading on the chains, or extra loading on the chain/attachment points.

9/ Ensure as much as possible that conveyed material is evenly spread across and along the conveyor system, to even out the loading on the running gear.

Other Areas for consideration;

A/ Ensure that the chains used in the application are still suitable, when any increase in capacity occurs.

B/ Any change in the chains used within a particular application, may require modifications to the conveyor structure to suit.

C/ Lubrication can be supplied for pins and bushes if required.

If the points raised are addressed, then decreased downtime and increased chain life may result.

Suggestions for Conveyor Chain Maintenance

1/ Head and tail shafts are to be square and parallel

2/ Double strand chains are to have the sprockets matched and fitted as pairs

3/ Check wear strips for wear and replace as necessary

4/ Check wear strips to ensure correct chain alignment with sprockets

5/ Check that chain pin heads are not fouling any side plates

6/ For scraper conveyors, check that the scrapers are not fouling any side structure, or the deck plates
Also, check that stub shafts and tail shafts do not restrict scraper articulation
Check that with wear on roller chains, the chain sidebars do not foul the wear strips

7/ On slat / apron conveyors, check for distorted or loose slats and rectify or replace

8/ Remove trash or material ingress from chain where possible

9/ Check that material is evenly loaded across conveyor

10/ In the case of a horizontal or nearly horizontal conveyor, there is no natural tension in the return strand of chain at the point where it leaves the driving sprocket, so that applied tension is required to keep the chain down on the teeth of the drive sprocket. This is usually done by means of tensioning screws arranged to adjust the position of the sliding bearings in which the tail shaft is carried. Care should be taken that the applied tension is not too great, and that it is merely sufficient to keep the chain correctly seated on the driving sprocket.

Checks for Drive Chains

1/ Head and tail shafts to be square and parallel

2/ Check that the chain is not fouling any structure

3/ Check chain tension

4/ Lubricate with good quality oil

5/ Note that a cranked roller chain design runs with the narrow end of the link leading

Chain Pull and Power Calculations

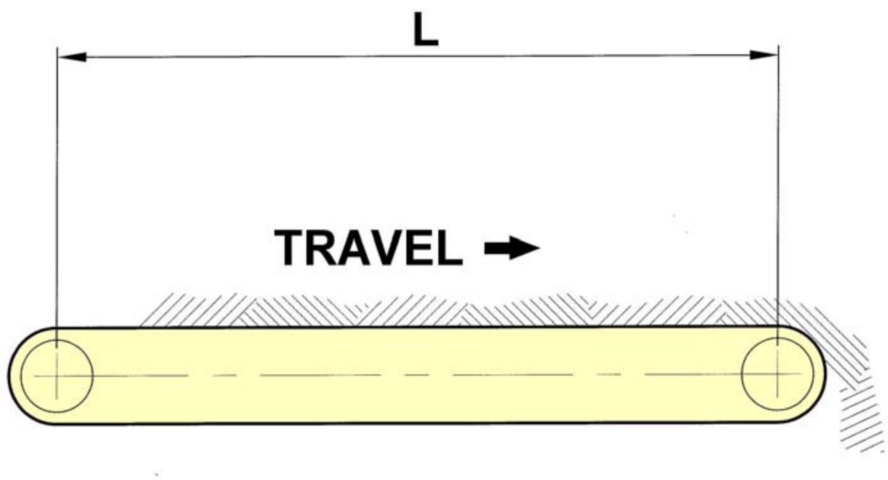
The maximum chain pull and power requirements may be calculated using the formula for the appropriate conveyor layout.
The power calculated will be the power required at the headshaft.
For the motor horse power requirements, the theoretical power calculated at the headshaft should be multiplied by 1.5, to cover losses in the drive system.
Where the material is conveyed between fixed skirts, the calculated value of P must be increased by an additional allowance calculated from the formula shown.

Symbols		
P	Chain Pull	Lb f
Pt	Total Chain Pull	Lbf
C	Conveyor Capacity	Tons / Hr
M	Material Weight per Conveyor Unit Length	
	$= 37.3 \times \frac{C}{S}$	Lb / Ft
W	Weight of Chain + Slats / Scrapers, Etc. per Unit Length	Lb / Ft
S	Conveyor Speed	Ft / Min
L	Horizontal Centre Distance	Ft
H	Vertical Centre Distance	Ft
A	Horizontal Section of Partially Inclined Conveyor	Ft
B	Horizontal Distance of Conveyor Incline	Ft
CD	Conveyor Material Depth $= \frac{5376 \times C}{CW \times MD \times S}$	ins
CW	Conveyor Width	ins
fc	Chain Friction - Loaded Strand	
fr	Chain Friction - Return Strand	
fm	Material Friction	
MD	Material Density	Lb / Cu.Ft

Average values for the coefficient of friction can be taken from the list below. They apply to clean, moderate temperature working conditions.

Chain sliding	**= 0.33**
Rolling – up to 2.1/2” dia. Roller dry	**= 0.20**
Rolling – up to 2.1/2” dia. Roller lubricated	**= 0.15**
Rolling – 2.1/2” – 3.1/2” dia. Roller dry	**= 0.16**
Rolling – 2.1/2” – 3.1/2” dia. Roller lubricated	**= 0.12**
Rolling – 3.1/2” – 6” dia. Roller dry	**= 0.12**
Rolling – 3.1/2” – 6” dia. Roller lubricated	**= 0.08**

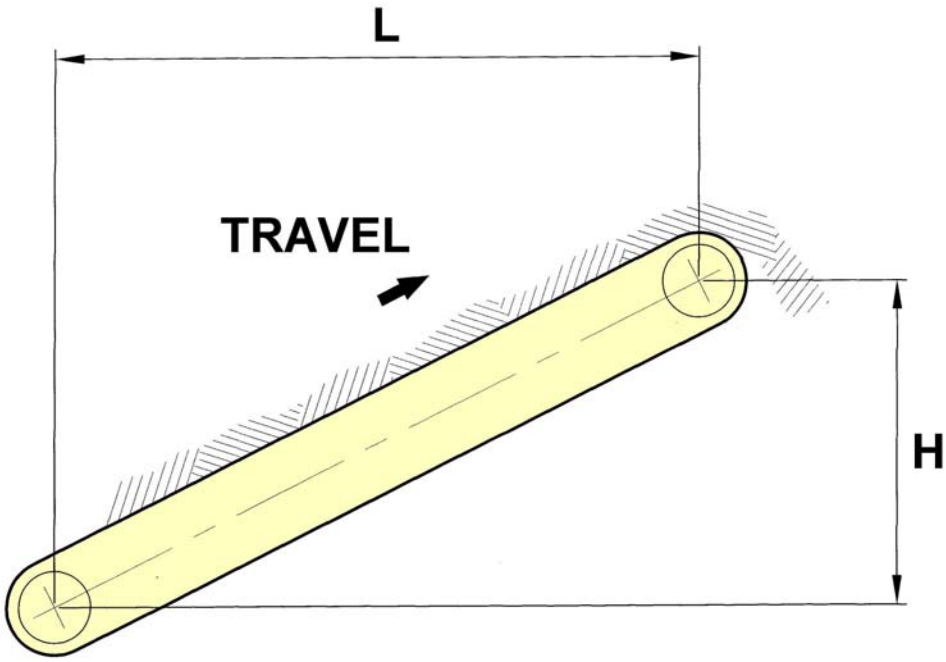
Horizontal Conveyors



$$P = MLfm + WLfc + 1.2WLfr$$

$$\text{Horse Power (at Headshaft)} = \frac{1.2SP}{33000}$$

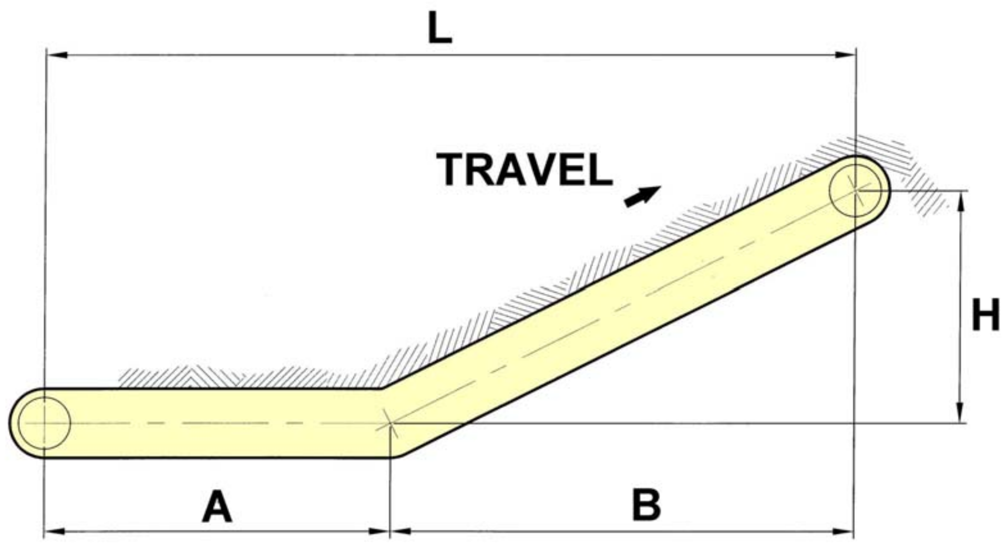
Inclined Conveyors



$$P = MLfm + MH + W(Lfc + H) + \{1.2W(Lfr^{*} - H)\}$$

$$\text{Horse Power (at Headshaft)} = \frac{1.2S[P - \{W(H - {}^{*}Lfr)\}]}{33000}$$

Partially Inclined Conveyors



$$P = MLfm + MH + W(Lfc + H) + 1.2WAfr + \{1.2W(Bfr^{*} - H)\}$$

$$\text{Horse Power (at Headshaft)} = \frac{1.2S[P - \{W(H - {}^{*}Bfr)\}]}{33000}$$

NOTE;

Where the term * in the chain pull and power formula give a negative value, they should be regarded as zero.
Consequently, the whole term designated thus { } is zero.

Additional Chain Pull

$$= \frac{MD \times L \times CD^2}{1000} \quad Lb$$

THIS ADDITIONAL CHAIN PULL SHOULD BE ADDED TO CHAIN PULL P BEFORE CALCULATING THE POWER REQUIRED AT THE HEADSHAFT.

When calculating a specific chain pull, apply the appropriate service factor and speed factor from the following tables to obtain the equivalent chain pull.
If this figure should exceed the allowable pull listed for any pre-selected chain, then a higher rated chain is required.

CHAIN SERVICE FACTOR

CONDITION OF LOADING	GENERAL WORKING CONDITIONS					
	CLEAN , MODERATE WORKING TEMPERATURE		FAIRLY DUSTY ,MODERATE WORKING TEMPERATURE		EXPOSED TO WEATHER, ABRASIVE,MILDLY CORROSIVE, HIGHER TEMPERATURES	
WORKING HOURS PER DAY	0 - 10	Over 10	0 - 10	Over 10	0 - 10	Over 10
UNIFORM OR STEADY	1.0	1.2	1.2	1.4	1.4	1.7
INFREQUENT MODERATE SHOCK	1.2	1.4	1.4	1.7	1.7	2.0
INFREQUENT HEAVY SHOCK	1.5	1.8	1.8	2.2	2.1	2.5
FREQUENT HEAVY SHOCK	1.8	2.2	2.2	2.6	2.5	3.0

SPEED CORRECTION FACTORS

Cast and Combination Chains

No. TEETH ON DRIVING SPROCKET	SPEED OF CHAIN IN FT / MIN									
	10	20	30	40	50	60	70	80	90	100
8	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4
10	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.3
12	0.9	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1
16	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
20	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
24	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Steel Chains

No. TEETH ON DRIVING SPROCKET	SPEED OF CHAIN IN FT / MIN									
	10	20	30	40	50	60	70	80	90	100
8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3
10	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1
12	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0
16	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
20	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9
24	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8

Material Weight Examples

MATERIAL	AVERAGE WEIGHT LB. / Cu. Ft.	MATERIAL	AVERAGE WEIGHT LB. / Cu. Ft.
Alum. Lumpy	50 - 60	Coke, Sized	23 - 32
Ashes, Dry – ½” and under	35 - 40	Coke, Mixed	25 - 35
Ashes, Wet – ½” and under	45 - 50	Coke, Breeze	25 - 35
Ashes, Dry – 3” and under	35 - 40	Cottonseed, Undelinted	18 - 25
Ashes, Wet – 3” and under	45 - 50	Grains	38 - 45
Bagasse	10	Gravel, Dry, Screened	90 - 100
Bagasse, Wet	40	Ice, Crushed	35 - 45
Beans, Whole	45 - 50	Lime, Ground	55 - 65
Cane, Chopped	18 - 20	Lime, Pebble	55 - 60
Cane, Shredded	20	Sand, dry	90 - 110
Cement, Portland	75 - 85	Sand, Damp	110 - 130
Cement, Clinker	75 - 80	Sand, Foundry, Shakeout	85 - 95
Coal, Anthracite Nuts	50 - 55	Sand, Foundry, Prepared	90 - 100
Coal, Anthracite, run of mine	50 - 55	Sawdust	10 - 13
Coal, Bituminous, Sized	45 - 55	Stone, Dust	75 - 85
Coal, Bituminous, run of mine	45 - 55	Stone, Screened Lumps	85 - 90
Coal, Bituminous, Slack, Dry	40 - 50	Stone, Lumps and Fines	85 - 90
Coal, Bituminous, Slack, Wet	50 - 60	Wood, Chips	12 - 20

CONVEYORS WITHIN THE PROCESS INDUSTRY

The following data covers the use of acetal and malleable iron crate conveyor chains within the process industries.
The maximum chain pull and power requirements can be calculated using the following formula, utilising the appropriate factors, as necessary.
Bends should be placed as far away from the head shaft as possible.
When using 50mm or 1700 chains with turnwheels, calculate as for a straight conveyor, and multiply the result by 1.12^n (where n = number of turns)

Symbols		Units
CP	Chain Pull	Kgf
C	Conveyor Centres	M
W	Chain Weight per Metre of Conveyor	Kg / M
M	Product Weight per Metre of Conveyor	Kg / M
S	Conveyor Speed	M / Min
Fc	Friction (Chain / Conveyor Bed)	-
Ft	Temperature Factor	-
D	Duty Factor	-
B	Bend Factor	-
N	Number of Bends	-
Fp	Friction (Product / Chain)	-
L	Length of Accumulation	M

NOTE:

If there are NO bends on the conveyor circuit, then make B and N =1
If there is NO accumulation on the conveyor, then make Fp and L =1

$$CP = [\{ C \times Fc (M + 2W) + (M \times Fp \times L) \} \times B \times N \times Ft \times D]$$

$$HP\ (KW) = \frac{[\{ (CP \times 2.204) \times (S \times 3.281) \} \times 1.5 \times 0.746]}{33000}$$

FRICTION FACTORS (Fc)

CHAIN	CONVEYOR BED	FACTOR
DRY	STAINLESS STEEL	0.22
WET	STAINLESS STEEL	0.13
DRY	POLYETHYLENE	0.27
WET	POLYETHYLENE	0.10

FRICTION FACTORS (Fp)

PRODUCT	FACTOR
METAL CANS	0.18
PLASTIC CARTONS	0.20
CARDBOARD	0.30
WAX BOARD	0.35

BEND FACTOR (B)

TURN ANGLE (DEGREES)	FACTOR
30	1.2
45	1.4
90	1.5
180	2.0

TEMPERATURE FACTOR (Ft)

TEMPERATURE RANGE (DEG. C)	FACTOR
- 40 TO - 20	0.8
- 20 TO - 0	0.9
0 TO + 60	1.0
+ 60 TO + 90	1.5
+ 90 TO + 105 (Dry Applications)	2.0
+ 90 TO + 105 (Wet Applications)	2.67

DUTY FACTOR (D)

DUTY	FACTOR
STEADY	1.00
STOP / START - OCCASIONALLY	1.25
STOP / START - 6 PER HOUR	1.50
STOP / START - 12 PER HOUR	1.75
STOP / START - FREQUENTLY	2.00

CHEMICAL RESISTANCE CHART FOR ACETAL MATERIAL

CHEMICAL	RESISTANCE CODE AT 23 DEG. CENT.
Acetic Acid – 20%	B
Acetone	B
Ammonia	A
Beer	A
Beverages, Soft Drinks	A
Benzine	A
Bleach	C
Bromine Water	C
Carbon Tetrachloride	A
Chlorine	C
Citric Acid	B
Formaldehyde	A
Formic Acid	C
Glucose	A
Hydraulic Fluid	A
Hydrochloric Acid	C
Hydrocyanic Acid	C
Hydrogen Peroxide – 3%	A
Iodine	A
Kerosene	A
Milk	A
Motor oil	A
Nitric Acid	C
Oils (Vegetable and Mineral)	A
Phosphoric Acid – 25%	C
Soap Water	A
Sodium Hydroxide – 10%	A
Sodium Hypochloride (Bleach)	C
Sulphuric Acid – 3%	A
Sulphuric Acid – 10%	C
Vinegar	B
Water (Fresh and Salt)	A

A = LITTLE ATTACK **B = SLIGHT ATTACK**

C = BAD ATTACK, DO NOT USE IN THIS ENVIRONMENT

DRIVE CHAINS

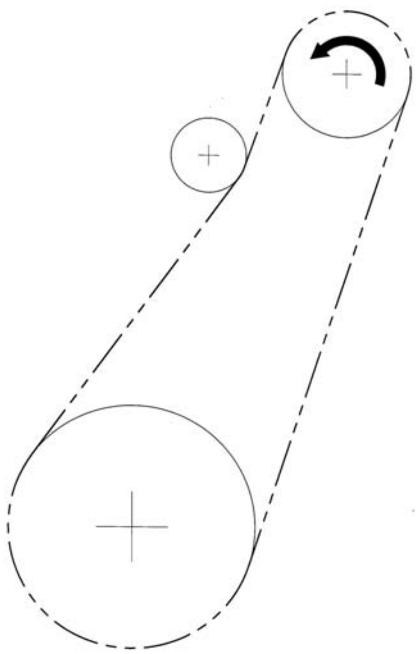
Chains for power transmission can be of either steel or malleable construction, and where the loading and the speed are not excessive (say 400 Ft / Min), then a malleable chain may be preferred.
Cranked sided chains should be arranged to travel thus;

A/ Roller end leading – Roller Chains

B/ Open end leading – Non Roller Chains

(See diagrammatic sketches for detailed explanation)

Chains for drives generally operate at higher speeds than for conveyors and elevators, and therefore, shorter pitch chains are necessary.
Power is the product of force and speed, so that when the speed is very low, the pull in the chain will be relatively very high.
For higher speeds, the chain pitch should be as short as possible, whilst the longer pitches are generally used for lower speeds, and thus heavier loading.
The smaller sprocket should be as large as is practicable, but preferably not less than 12 teeth.
For preference, a chain drive should be arranged as nearly horizontal as possible, and vertical drives should be avoided.
The slack side of the chain should be properly tensioned, as too much tension will cause undue wearing of both the chain and the sprockets. But, too little tension may allow a chain to jump the sprocket teeth, or could cause damage by allowing the links to ride up the teeth, and if the speed is high, then shock loads due to whipping may result.
A steeply inclined drive should be fitted with some means of adjusting the tension in the slack side. Such drives need tighter chains than for horizontal installations, but for the best results, tension should still be as low as possible, not being more than is necessary to keep the chain on the sprocket.

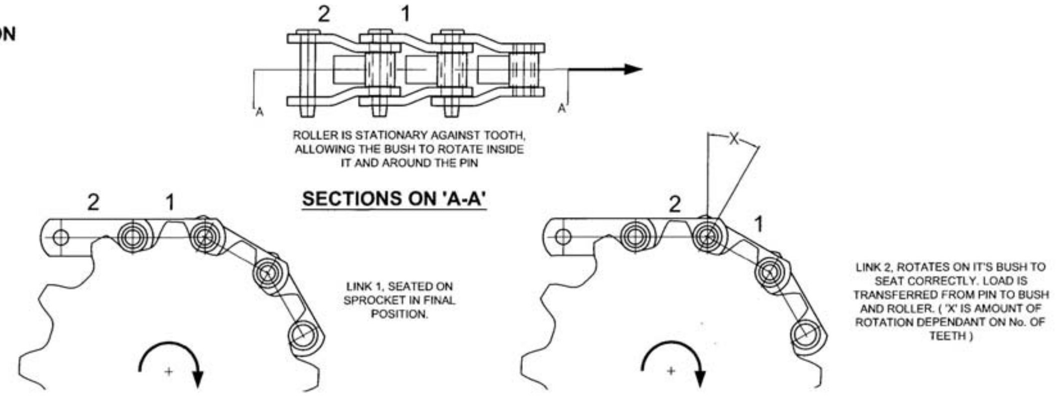


A jockey sprocket engaging with the slack side of the drive near to the driving sprocket forms a convenient method of applying slack side tension.

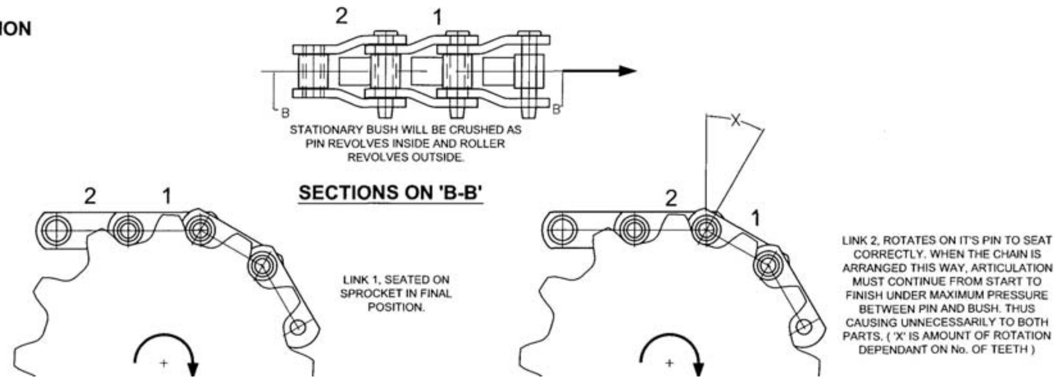
Direction of Travel

Roller Chains

CORRECT DIRECTION

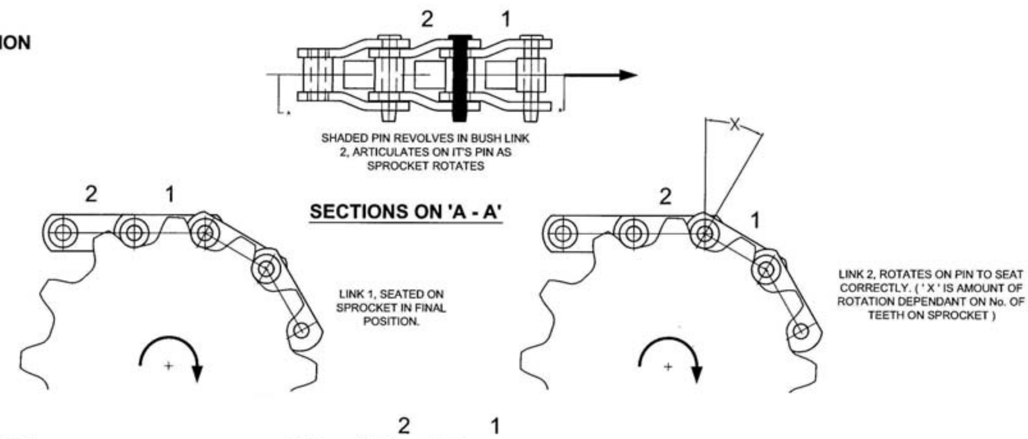


INCORRECT DIRECTION

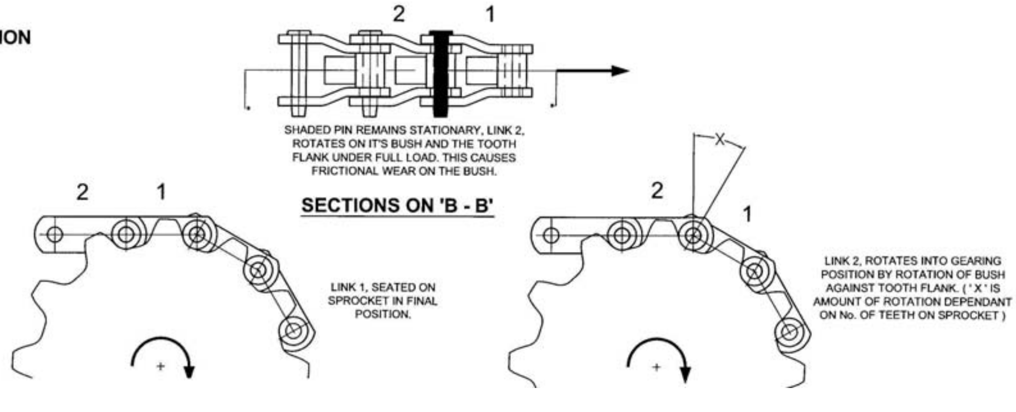


Non Roller Chains

CORRECT DIRECTION



INCORRECT DIRECTION



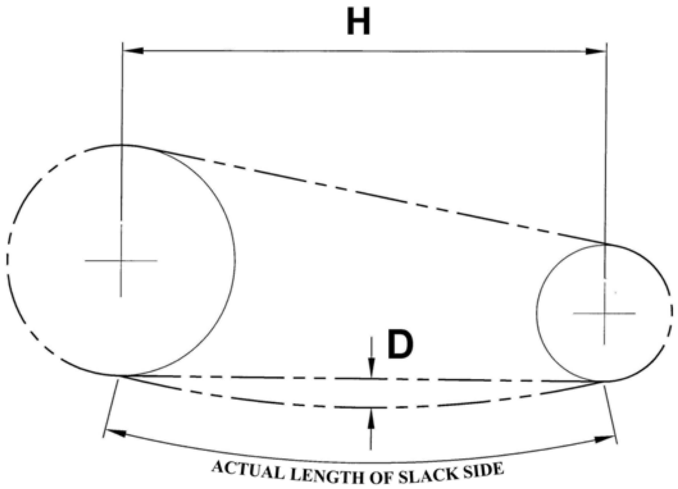
The following formulae may be found useful in determining the chain required for a particular application.
The calculated chain pull should be less that the allowable pull figures to be found in the chain tables.

Chain Pull

$$P = \frac{HP \times 33000}{V} \qquad \text{where } V = \frac{\text{No.teeth} \times \text{RPM} \times \text{chain pitch (ins)}}{12}$$

Symbols		Units
P	Chain Pull	Lbf
HP	Motor Horse Power	--
V	Chain Speed	Ft / Min

Slack Side Tension



For a drive approximately horizontal, the deflection or sag in the slack side may be determined by the following.

Symbols		Units
D	Deflection or Sag	Ins
H	Horizontal Span	Ins
S	Excess Chain or Difference between Actual Slack Side Length and the Horizontal Span	Ins
Pc	Catenary Pull	Lbs
W	Weight per Foot of Chain	Lbs

$$D = \sqrt{0.375\ H\ S}$$

An approximation of a suitable amount of allowable sag may be taken as 2% of the sprocket centres.

Catenary Pull

It should be remembered that the less the amount of sag , the greater will be the catenary pull.
In approximately horizontal drives of moderate centres, an excess of chain equal to one pitch will result in a catenary pull of sufficient magnitude to keep the chain on the sprocket teeth, at the standard pressure angles, even though the friction between chain and sprockets would be very low, as in a well lubricated steel roller chain.
The catenary pull in the slack side of an approximately horizontal drive may be found from the following.

$$Pc = \frac{W (H^2 + 8D^2)}{96D}$$

Length of Chain

The length of chain needed for a given drive may be found from;

Symbol		Units
L	Required Length	Pitches
C	Sprocket Centres	Pitches
N	Number of Teeth on Large Sprocket	-
n	Number of Teeth on Smaller Sprocket	-

$$L = 2C + \frac{N + n}{2} + \frac{(\frac{N - n}{2\pi})^2}{C} \text{ pitches}$$

The above formula will obviously give the theoretically correct chain length, but will not be to the exact pitch length. The next nearest exact pitch length should be used in the application, and the difference between these two figures can then be used in the formulas quoted before.

ELEVATORS

Chains can be utilised in differing designs of elevator, which can generally be categorised into the following styles.

A/ <u>Centrifugal Discharge</u> – uses either single or double chain strands (double strand would be preferable for buckets 16" long and over.
These are probable the most common form of elevator, and handle a wide range of materials.
They should not be used for light fluffy materials, or those that would resist dredging or digging.
They operate at generally higher speeds than the other designs(say 180 – 250 Ft / Min.) and the discharge of material is a result of centrifugal force.

B/ <u>Positive Discharge or Dump Type</u> - uses double chain strands.
These operate at much lower speeds, and are ideal for handling light, fluffy, fragile and sluggish materials.
These elevators must use double strands of chain, which are attached to the ends of the buckets. This then allows the descending chains to engage on deflector sprockets positioned below reatively large head sprockets.
During the passage of the bucket from the head shaft to the deflector sprocket, they become inverted and the material falls by gravity into the discharge chute.

C/ <u>Continuous Non Overlapping</u> – uses either single or double chain strands (double strand would be preferable for buckets 18" long and over.
These also operate at slower speeds (say 100 – 120 Ft / Min), with the buckets being of a special design and fitted continuously on the chain.
The discharge of the material is then by hitting and sliding off the back of the preceeding bucket.
The depth of the bucket then determines the pitch of the chain required.
They are most suitable in handling light, friable materials, and those containing large lumps.

<u>Chain Pull – Vertical Bucket Elevator</u>

The maximum pull in the chain on a vertical elevator is at the top of the ascending strand, and is the sum of the following;
The weight of the ascending strand(s) of chain
The weight of the buckets on it
The weight of the material in them
An allowance for the dredging action of the buckets through the material in the boot.

<u>Note;</u>

The dredging allowance is independent of the height of the elevator, but does depend on the weight of the material being handled, and the size of the bucket, so the following equations are to be used for the allowance to be made.

Symbols		Units
A	Allowance for Spaced Bucket Elevators	Lbs
Ac	Allowance for Continuous Bucket Elevators	Lbs
W	Weight of Contents of each Bucket	Lbs
S	Bucket Spacing	Ins

It will be noticed that the allowance for the continuous bucket elevators is less than that for spaced bucket elevators. This is because there is little or no dredging in continuous bucket elevators if they are properly fed.

$$A = \frac{360 \times W}{S}$$

OR

$$Ac = \frac{120 \times W}{S}$$

Once the above Chain Pull has been calculated, then this figure should be multiplied by the appropriate service and speed factors (to be found in the Conveyor Section), in order to arrive at the Effective Chain Pull.
The selected chain should then have an allowable chain pull, equal to or in excess of, this calculated Effective Chain Pull.

Power to Drive – Vertical Elevator

It will be appreciated that the weight of the chain and buckets on the ascending strand will be balanced by the same weights on the descending strand, and therefore, the Horse Power is only required to lift the material in the buckets and to overcome dredging.

Symbol		Units
D	Pitch Circle Diameter of Sprocket	Ins
Wm	Weight of Material in the Buckets on the Ascending Strand	Lbs
N	Speed of Sprocket Shaft	Revs / Min
A or Ac	Dredging Allowance (see above)	Lbs

$$HP = \frac{D\,(Wm + A)\,N}{2 \times 63025}$$

The figure found above is for the horse power required at the top shaft, and the size of the driving motor should have an allowance to account for losses in the reduction gearing system and frictional losses.
A figure of twice the theoretical horse power at the top shaft may be required to allow for the starting power needed.

Chain Pull - Inclined Bucket Elevator

As for the vertical elevator above, the chain maximum pull occurs as the ascending chain enters the top sprocket. It is equal to the static pull acting in the line of the chain, plus the force required to overcome friction by either skidding or rolling with the guides. Also, as for the vertical elevator, an allowance should be made for dredging.

Symbol		Units
W	Total weight of chain, skidders, and contents of the buckets	Lbs
Ø	Angle of inclination	Degrees
µ	Coefficient of friction between skidders and guides	-
A or Ac	Allowance for dredging (see above)	Lbs

$$P = W (\sin Ø + \mu \cos Ø) + A \text{ Lbs}$$

Again, as for the vertical elevator, the above requires the application of the service and the speed correction factors to arrive at the Effective Chain Pull figure.

Power to Drive – Inclined Elevator

The power required at the top shaft to drive an inclined elevator can be found by the following.

Symbol		Unit
D	Pitch Circle Diameter of Sprocket	Ins
P_1	Pull at the top of the ascending strand of chain	Lbs
P_2	Wg = Weight of chain, buckets and skidders on descending strand	Lbs
	= Wg (sin Ø - µ cos Ø)	
A or Ac	Allowance for Dredging (see above)	Lbs
N	Speed of Sprocket Shaft	Rev / Min

Spaced Bucket Elevator

$$H\,P = \frac{D (P_1 - P_2 + A)^N}{2 \times 63025}$$

Continuous Bucket Elevator

$$H\,P = \frac{D (P_1 - P_2 + Ac)^N}{2 \times 63025}$$

As before, this figure should be increased to find the drive motor size.

Chain Tension in Elevators

The bottom shafts of elevators are normally carried in sliding bearings, which are generally operated by tension screws.
Sometimes this tension gear is misused, so the following comments may be found useful.
It is essential that an elevator chain, together with the buckets, are constrained to a proper path through the boot and not allowed to wander to either side, nor be forced upwards by the material in the boot. The bottom sprocket serves this purpose, if its position is adjusted so that it nestles comfortably in the loop of the chain. It should not be forced hard down so as to add tension to both the ascending and the descending strands of chain. Such applied tension is unnecessary to the correct working of the elevator, and could actually cause considerable harm by increasing wear on both the chain and the top sprocket. The natural tension at the top of the descending strand of a vertical or a steeply inclined elevator is far greater than is necessary for correct gearing at the top sprocket.