The anatomy of a basic FlexLink conveyor

Built from components
The basic FlexLink conveyor consists of the following components:

- Drive unit
- Idler end unit
- Conveyor beam
- Bends (plain bends or wheel bends)
- Slide rail
- Chain
- Guide rail system
- Support system

Many accessory components are available, such as drip trays, front piece, angle plates, etc.
**Basic dimensions**

The following characters are recommended when specifying conveyor dimensions:

- \( H \) = height to the chain surface.
- \( h \) = free height to the lowest part of the drive unit.
- \( A, B \) = length from the end of the conveyor to the other end or to the centre of a bend.
- \( L_1, L_2 \) = beam cut lengths after the length of end units and bends have been taken into consideration.
- \( R \) = radius of wheel bends and plain bends.
- \( W \) = width between guide rails (approximately 5 mm clearance on each side of the product is recommended).

All dimensions refer to the centre of the conveyor. The dimensions are in millimeters unless otherwise specified.
Basic designation knowledge

The FlexLink designation system for conveyor components is based on four letters followed by suffixes indicating the features of the specific component, such as dimensions, angles, left or right, etc.

1. A standard FlexLink designation name always starts with the letter X.
2. The second letter indicates the product group: XS, XL, XM, XH, XK, XB, XT – the seven types of conveyor systems from FlexLink.
3. The third letter indicates the component group. Within each of the seven conveyor systems, the same letter indicates the same component group. For example, the letter T means chain in all FlexLink conveyor sizes. The dimensions of the chain will of course vary for each system.

The following letters are used for the third letter in the designation system:
- T = Chains
- C = Conveyor beams
- E = End units
- B = Bends
- R = Guide rails
4. The fourth letter indicates the special feature of the component, for example if the chain has a cleat and what type of cleat it is, if the motor is suspended, etc.
5. The suffix normally contains letters or numbers representing some product parameter, such as length.

Example:
The component name XMBP 45 R500 means:
- X = a FlexLink product, since it starts with an X
- M = belonging to the XM conveyor system
- B = a bend
- P = a plain bend
- 45 = the angle of the bend is 45°
- R500 = the radius of the bend is 500 mm

Exceptions
There are several exceptions to the basic system of designations. For example, the product group is sometimes defined by a fifth letter, for example the stainless steel version of XL is indicated by XL..X (XL Series X).

The FlexLink structural systems XC and XF use other combinations for the third and fourth letter. For example, B here represents a structural beam.

Some less frequent products carry numeric designations, normally beginning with 39... or 50... FlexLink modules use a more complex designation system, and are normally specified using configuration software.

Will a FlexLink conveyor do the job?

Conveyor data summary

<table>
<thead>
<tr>
<th>FlexLink type</th>
<th>Data of goods conveyed</th>
<th>Conveyor data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum item weight (horizontal transport)</td>
<td>Maximum item weight (vertical transport)</td>
</tr>
<tr>
<td>XS</td>
<td>10–80 mm</td>
<td>2 kg</td>
</tr>
<tr>
<td>XL/XL X</td>
<td>15–140 mm</td>
<td>10 kg</td>
</tr>
<tr>
<td></td>
<td>30–300 mm*</td>
<td>1 kg</td>
</tr>
<tr>
<td>XM/XM X</td>
<td>20–200 mm</td>
<td>15 kg</td>
</tr>
<tr>
<td></td>
<td>40–300 mm*</td>
<td>2 kg*</td>
</tr>
<tr>
<td>XH/XH X</td>
<td>25–300 mm</td>
<td>20 kg</td>
</tr>
<tr>
<td>XK</td>
<td>50–300 mm</td>
<td>30 kg</td>
</tr>
<tr>
<td>XB</td>
<td>70–400 mm</td>
<td>15 kg</td>
</tr>
<tr>
<td>XT</td>
<td>–400 mm</td>
<td>30 kg</td>
</tr>
<tr>
<td>EM</td>
<td>–188 mm</td>
<td>2 kg</td>
</tr>
</tbody>
</table>

*Applies to vertical wedge conveyor.
Conveyor size comparison chart

Simplified end views of FlexLink conveyor beams, drawn to the same relative scale. Numeric values are widths in millimeters.


A checklist for conveyor projects

Before starting to create a detailed technical solution for a system, it is a good idea to ensure that the application is suitable for a FlexLink conveyor system. There are certain factors that set limits for the maximum product weight and size, the transportation speed, etc.

By means of the following checklist, it is possible to get a first indication if the application is suitable. Even if your application is out of bounds for one or two of these factors, there may be a functioning solution to the problem. FlexLink does not set any hard rules, everything should be tested before the application idea is rejected.

Item weight maximum 30 kg?

*Horizontal transport*

In a horizontal conveyor, the maximum weight of the individual products conveyed is limited mainly by the desire to keep wear of the slide rails at an acceptable level.

*Vertical transport*

In a conveyor with cleated links for vertical transport, the maximum weight of the individual products is limited by the strength of the cleats and the life of the slide rails.

*Maximum weight on conveyor*

The total maximum weight is mainly limited by the drive unit capacity and by the tensile strength of the chain.

Item width maximum 400 mm?

The maximum width of the goods conveyed depends on the shape of the goods and on the location of the centre of gravity.

*Transportation speed maximum 60 m/minute?*

The maximum conveyor speed depends on the total load and on the drive unit capacity. It is important to have this in mind: the higher the speed, the more the wear on the chain, the more the power required, and the higher the sound level.

Conveyor length maximum 40 m?

The maximum length of a conveyor is depending on the tension in the chain (that is the total load), the speed, and the capacity of the drive unit.

Very high or low temperature?

A FlexLink conveyor can operate continuously at environment temperatures from –20 °C to +60 °C. Temperatures up to 100 °C can be tolerated for short periods (cleaning, rinsing).

Quiet operation required?

The noise level of the conveyor depends mainly on the speed. Careful mounting and fastening of slide rail to get smooth “transfers” help to reduce the noise level.

Conveyor-friendly environment?

Sometimes there are environmental factors that have to be taken into consideration when designing the conveyor. Such factors are for example: the temperature of the product, metal chips from the production stage before the conveyor transport, or chemical fluids. A wet environment will result in PA-PE products such as slide rail type H and the return beam of hygienic conveyor XMY swelling in dimension.

Hygienic demands?

For some applications there are hygienic demands that have to be taken into consideration when designing a conveyor system, e.g. how to clean the conveyor.
When to calculate?
It is important to calculate and compare the maximum chain tension and the capacity of the drive unit in the following situations:
- High load
- Accumulation
- Vertical conveyor
- High speed
- Long conveyor
- Conveyor which includes horizontal or vertical plain bends
- Frequent starts and stops (high service factor).

About friction
Friction between chain and product
In most cases, the coefficient of friction for contact between plain chain and product is between 0.1 and 0.35. Always measure the friction between the chain and the actual product. The typical friction between roller top chain and product (inner friction in rollers) is in the order of 0.05 to 0.08. The actual friction coefficients depend on surface smoothness.

For inclines exceeding 5° (1:10) it is necessary to use a cleated chain. Chain sizes XL, XM, and XH are available with high friction tops, suitable for inclines up to 30° (1:2).

Friction between chain and slide rail
The coefficient of friction is normally the lower value at the startup of a new conveyor. It will increase as the contact surfaces wear in. Lubrication will reduce the coefficient of friction.

<table>
<thead>
<tr>
<th>Material</th>
<th>Designation</th>
<th>Friction coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (HDPE, black)</td>
<td>XL 25</td>
<td>0.10–0.25</td>
</tr>
<tr>
<td></td>
<td>XSCR 25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XBCR 25</td>
<td></td>
</tr>
<tr>
<td>Polyethylene, ultra high molecular</td>
<td>XL 25 U</td>
<td>0.10–0.25</td>
</tr>
<tr>
<td>weight (UHMW-PE, white)</td>
<td>XSCR 25 U</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XKCR 25 U</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XWCR 25 U</td>
<td></td>
</tr>
<tr>
<td>Polyamide-polyethylene (PA PE, grey)</td>
<td>XL 25 H</td>
<td>0.10–0.25</td>
</tr>
<tr>
<td>Polyvinylidene (PVDF, yellow/white)</td>
<td>XL 25 P</td>
<td>0.15–0.35</td>
</tr>
<tr>
<td></td>
<td>XSCR 25 P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XWR 25 P</td>
<td></td>
</tr>
<tr>
<td>Stainless steel</td>
<td>XL 3 TA</td>
<td>0.15–0.35</td>
</tr>
</tbody>
</table>

High speed applications (60–100 m/min)
Conveyor speeds over 60 m/min require special design considerations. Since the amount of material lost due to abrasive wear is directly related to distance travelled, higher speeds will result in faster wear and require more frequent maintenance. Careful attention to design details will reduce the rate of wear, increasing the amount of run time between replacement of wear parts. The primary wear parts of a FlexLink conveyor are the slide rail and the conveyor chain. Design parameters to be considered are:

Load
A major factor affecting wear is the load on the conveyor. The chain tension at the drive is an indicator of the total load on the conveyor. Chain tension for high speed applications can only be a fraction of the maximum traction force of the drive unit. Always do chain tension calculations for high speed applications. The following recommendations include methods to reduce the load on the conveyor.

Bends
Wheel bends should be utilized whenever possible. If the application cannot accommodate wheel bends, plain bends with radii of at least 1000 mm should be used. The extra support rail should be used on the inside of all horizontal plain bends. PVDF slide rail should be used on the inside of horizontal plain bends and on all vertical bends because of the amount of heat generated in this area. Also, when using plain bends, do not make a total change in direction of more than 90 degrees with any one conveyor.

Conveyor length
High speed conveyors should be limited to a total length of 15 m. This is only a guideline. It can be higher for straight running conveyors with light loads, but should be reduced for heavy loads with plain bends.

Motor control
All high speed conveyor motors should be equipped with soft starting and stopping motor controls. Conveyors should be programmed to shut off when an upstream or downstream interference interrupts product flow.

Lubrication
A very small amount of lubrication can have a significant effect on the performance and reliability of any conveyor system, but is especially effective in high speed applications. One drop of silicone on the slide rail per hour of run time is enough to reduce wear to almost nothing. In applications where silicone is prohibitive, other lubricants can be used just as effectively. Be sure to investigate chemical compatibility when choosing a lubricating agent. Any conveyor running faster than 80 m/min. should be lubricated.
Other considerations

The higher the speed of the conveyor the more important it is to maintain the chain slack at the drive (see “Maintenance” on page 25). The inspection interval should also be reduced since minor maladjustments can result in very rapid wear. Ear sound protection will be required for anyone working in close proximity to a high speed conveyor. The following chart shows the expected noise contribution of high speed conveyors measured from 1 m away.

Technical data

Drive units

<table>
<thead>
<tr>
<th>Drive unit</th>
<th>Maximum traction force, N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>XS</td>
</tr>
<tr>
<td>End</td>
<td>500</td>
</tr>
<tr>
<td>Double</td>
<td>500</td>
</tr>
<tr>
<td>Intermediate</td>
<td>–</td>
</tr>
<tr>
<td>Catenary</td>
<td>–</td>
</tr>
<tr>
<td>Horizontal bend</td>
<td>200</td>
</tr>
</tbody>
</table>

Chains

General specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (plain chain) kg/m</td>
<td>0,70</td>
<td>0,75</td>
<td>1,2</td>
<td>1,7</td>
<td>2,2</td>
<td>2,0</td>
</tr>
<tr>
<td>Tensile strength at 20 °C, N</td>
<td>4000</td>
<td>4000</td>
<td>6000</td>
<td>6000</td>
<td>10000</td>
<td>6000</td>
</tr>
<tr>
<td>For other temperatures: see below</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible working tension at 20 °C, N</td>
<td>500</td>
<td>500</td>
<td>1250</td>
<td>1250</td>
<td>2500</td>
<td>1250</td>
</tr>
<tr>
<td>Also see diagram, page 14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness H_KB</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Water absorption after 24 h at 20 °C</td>
<td>0,2 %</td>
<td>0,2 %</td>
<td>0,2 %</td>
<td>0,2 %</td>
<td>0,2 %</td>
<td>0,2 %</td>
</tr>
</tbody>
</table>

Chain strength and expansion vs. temperature

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>–20</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength factor</td>
<td>1,2</td>
<td>1,1</td>
<td>1,0</td>
<td>0,9</td>
<td>0,8</td>
<td>0,6</td>
<td>0,5</td>
<td>0,3</td>
</tr>
<tr>
<td>Linear expansion %</td>
<td>–0,4</td>
<td>–0,2</td>
<td>0</td>
<td>0,2</td>
<td>0,5</td>
<td>0,8</td>
<td>1,0</td>
<td>1,3</td>
</tr>
</tbody>
</table>
**Introduction**

This section of the FlexLink engineering handbook contains

- selection guidelines to assist you in selecting the right system for your application
- basic technical information that applies to FlexLink product lines XS, XL, XM, XH, XK, and XB.

**Selection procedure**

The selection guidelines are based on thousands of successful FlexLink installations world-wide. The following basic procedure is recommended when selecting a suitable FlexLink size.

1. Make a preliminary system selection based on the general recommendations below.
2. Make an outline of the conveyor, with bends, drive units, etc. shown.

Then check the system as follows:

3. Calculate the total load based on product weight, distance between products, accumulation distance, and conveyor length.
4. Determine the service factor by specifying the frequency of starts and stops. The service factor will be used as a derating factor when calculating the permissible load.
5. Calculate the chain tension from the formulae on the following pages.
6. Compare the resulting chain tension with the capacity of the chain and drive unit selected. If the capacity is not sufficient for your application, shorten the conveyor if possible, or select a system with higher capacity.

For additional information please consult your local FlexLink representative.

**Basic system selection**

The six standard FlexLink chain sizes XS (44 mm), XL (63 mm), XM (83 mm), XH (103 mm), XK (102 mm), and XB (175/295 mm) together cover a wide product range. To select the right chain size for your application, consider the following.

**Product dimensions**

A product can be much wider than the chain. If the point of balance is located in the centre of the product, the width of the product can be three to four times the width of the chain. Supporting guide rails may be necessary. Testing is recommended.

**Product weight**

Product weight is important when selecting chain size. Each chain has a maximum traction force. If several heavy items are to be conveyed, you must calculate the traction force required. If products are to be accumulated (stopped in a queue, with the chain moving), the traction force is increased even more. The “Technical data” section includes formulas for chain tension calculations.

**Conveyor functions available**

Most conveyor functions are available in all six sizes. Note however that there are differences with regard to drive unit variants and chain types. Sizes XL and XM include components for vertical wedge conveyors.

**Floor space available**

Sometimes the floor space will require use of the smallest conveyor possible.

**Compatibility with other equipment**

In some applications, interfacing with other equipment could be made easier by using one of the FlexLink sizes rather than other sizes. Some manufacturers have designed equipment with direct connection to FlexLink conveyors.
Chain tension calculations

Why calculate?
There are at least two reasons why you should estimate or calculate the maximum tension of the chain before you decide on a conveyor configuration:

- Drive unit capacity
- Tension limit of conveyor chain

In most cases, both the drive unit capacity and the tension limit of the chain far exceed the requirements of the application. This is true for short, low-speed conveyors and for light loads. If you are in doubt, however, always calculate!

Drive unit capacity limit
The required motor output power \( P \) depends on

- Traction force \( F \)
- Chain speed \( v \)

The following equation applies:

\[
P [W] = \frac{1}{60} \times F [N] \times v [\text{m/min}]\]

The maximum permissible traction force of the various drive units is shown in the following table:

<table>
<thead>
<tr>
<th>Drive unit</th>
<th>Maximum traction force N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>XS</td>
</tr>
<tr>
<td>End</td>
<td>500</td>
</tr>
<tr>
<td>Double</td>
<td>500</td>
</tr>
<tr>
<td>Intermediate</td>
<td></td>
</tr>
<tr>
<td>Catenary</td>
<td></td>
</tr>
<tr>
<td>Horizontal bend</td>
<td>200</td>
</tr>
</tbody>
</table>

Chain tension limit
See diagrams 1 and 2.

Diagram 1

Max permissible chain tension versus conveyor length

Diagram 2

Max permissible chain tension versus conveyor speed.

Service factor
The maximum permissible chain tension (see diagrams 1 and 2) depends on the number of conveyor starts and stops per hour. Many conveyors run continuously, whereas others start and stop frequently. It is obvious that frequent starts and stops increase the stress on the chain.

The service factor (see table below) is used to derate for high frequency of starts and stops and for high chain speeds. Divide the tension limit obtained from the graphs by the service factor to get the derated tension limit. A high service factor can be reduced by providing a soft start/stop function.

<table>
<thead>
<tr>
<th>Operating conditions</th>
<th>Service factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low to moderate speed or max. 1 start/stop per hour</td>
<td>1.0</td>
</tr>
<tr>
<td>Max. 10 starts/stops per hour</td>
<td>1.2</td>
</tr>
<tr>
<td>Max. 30 starts/stops per hour</td>
<td>1.4</td>
</tr>
<tr>
<td>High speed, heavy load, or more than 30 starts/stops per hour</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Important
The chain tension calculations are made to ensure that the capacity of the drive unit is sufficient, but not excessive, in relation to the strength and friction of the chain. The calculations do not take into account the increased wear resulting from the higher friction in plain bends.
Chain tension calculations (continued)

Chain tension
The tension building up in the chain can be divided into several components:

1 Friction between unloaded chain and slide rails, for example on the underside of the conveyor beam.

2 Friction between loaded chain and slide rails (Figure A).

3 Friction between accumulating products and top surface of chain (Figure B).

4 Gravity force acting on products and chain in inclines and verticals (Figure C).

5 Added friction in plain bends. This friction is proportional to the chain tension on the low-tension side of the bend. This means that the actual friction depends on the position of the bend in the conveyor (Figure D).

Traction force
The traction force F required to move the chain depends on the following factors:

Conveyor length.............................. L
Product gravity load per m ..................... q_p
Accumulation .................................. q_pa
Chain gravity load per m...................... q_c
Friction coefficient
Between chain and slide rail ................. \( \mu_r \)
Between chain and products ................. \( \mu_p \)
Bend factor, \( \alpha^\circ \) plain bend (hor./vert.) ........ \( k \alpha \)
Inclination angle................................. \( \beta \)

Bend factors
Each plain bend introduces a bend factor \( k \alpha \). This factor is defined as the ratio between chain tension measured just after the bend and that measured before the bend. The bend factor depends on

- the amount of direction change of the bend (angle \( \alpha \))
- the coefficient of friction, \( \mu_r \), for the friction between chain and slide rails.

When the conveyor is dry and clean, the friction coefficient, \( \mu_r \), will be close to 0.1.

The bend factor must be used since the frictional force of a plain bend depends not only on the chain and product weight and the coefficient of friction, but also on the actual tension of the chain through the bend. This tension causes additional pressure to the conveyor beam and slide rail from the chain. The additional force is directed towards the centre of the bend.

Calculation of this additional force is more complicated, since the chain tension varies through the conveyor, being maximum at the “pull” side of the drive unit, and virtually zero at the inlet of the return chain. The bend factor provides a means of including the added friction in bends into the calculations.

The same bend factors apply to horizontal and vertical plain bends. See the table.

Note
Horizontal plain bends should only be used in exceptional cases. For normal applications, use wheel bends.
Basic calculation procedure

Chain tension for FlexLink chains is determined by use of successive calculations. A number of elementary cases can be combined to cover most situations. The general idea will be shown by means of examples on the following pages. When calculating the chain tension, follow these steps:

Divide the conveyor

Divide the conveyor into a number of elementary sections. Start at the end farthest away from the drive unit. Each section should consist of a straight piece of conveyor up to and including the next plain bend (horizontal or vertical).

Wheel bends are considered equivalent to straight sections. This means that a conveyor without plain bends can be treated as one elementary section.

Calculate the sum of forces and multiply by bend factor

Start at elementary section \( L_1 \) at the end farthest away from the drive unit. For each successive elementary section \( L_k \): calculate the traction force \( F_k \) required to move the chain along the elementary section.

1. Calculate the sum of all counteracting forces:
   - Transport friction. See Figure A, page 15.
   - Accumulation friction (if any). See Figure B, page 15.
   - Gravity (inclined/vertical conveyor). See Figure C, page 15.

   The counteracting force \( F_{k-1} \) of the previous section. (The first section has no such counteracting force, hence when calculating \( F_1 \), make \( F_0 \) equal to zero.)

2. Multiply the sum of forces by the bend factor. See Figure D, page 15. (If the section does not include any plain bends, the bend factor is equal to 1.)

Repeat the calculation up to and including the section with the drive unit. The resulting force is the traction force required to move the conveyor.

Horizontal conveyor with no plain bends

If the conveyor contains no plain bends, the whole conveyor can be treated as one straight section with a total length of \( L \) from idler end unit to drive unit. Use the following formulas. (Symbols: see page 16.)

Without accumulation:

\[
F = L(q_c + q_p)\mu_r
\]

With accumulation:

\[
F = L[(q_c + q_{pa})\mu_r + q_{pa}\mu_p]
\]

Horizontal conveyor with plain bends

Divide the conveyor into elementary sections, each including one vertical or horizontal plain bend. For each elementary section (length \( L_k \)), use the following formulas, starting with section \( L_1 \). (Symbols: see page 16.)

Without accumulation:

\[
F_k = [F_{k-1} + L_k(q_c + q_p)\mu_r]k\alpha_1
\]

With accumulation:

\[
F_k' = [F_{k-1} + L_k((q_c + q_{pa})\mu_r + q_{pa}\mu_p)]k\alpha_1
\]

Repeat with all conveyor sections, until you obtain the total traction force required at the drive unit.

Examples

The examples on the following pages provide approximate values of the resulting chain tension. To get more accurate values, the influence of the return chain on the bottom side of the beam must be considered. In most cases, this influence can be ignored. However, if the conveyor includes several plain bends, or if the goods weigh less than two times the chain per unit of length, a complete calculation must be made. For a complete calculation, start at the return side of the drive unit.

If the tension is too high

If the calculated traction force exceeds the chain capacity or the drive unit capacity, some modification will be necessary.

- Shorten the conveyor.
  In some cases, the layout could be changed so that the conveyor becomes shorter.
- Divide the conveyor into two separate conveyors with individual drive units.
Calculation example 1: Horizontal conveyor

Horizontal conveyor with two plain bends

The first example is a horizontal conveyor with three straight parts and two plain bends (one 45° and one 30°).

Conveyor data:
Conveyor type .............................................. XL
Conveyor speed v ........................................ 18 m/min
Start/stops.................................................... 50 /hour
Total length................................................... 15 m
Friction coefficient µr .................................... 0,1
Friction coefficient µp ................................... 0,2
Load due to chain weight qc ............................. 7,4 N/m
Load due to product weight Transport (qp):
Five 1 kg items per m ................................ 49 N/m
Accumulation (qpa):
Ten 1 kg items per m ................................. 98 N/m

Divide the conveyor
Start by dividing the conveyor into three elementary sections. Then start at the section farthest away from the drive unit “pull” side.

Section 1

a) Without accumulation:
F_1 = [F_0 + L_1 (q_c + q_p) \mu_r] k \alpha_1
F_1 = [0 + 4,4 \times (7,4+49) \times 0,1] \times 1,3
= 32,3 N

b) With accumulation on the whole of L_1:
F_1' = [F_0 + L_1 (q_c + q_p a) \mu_r + L_1 q_p a \mu_p] k \alpha_1
F_1' = [0 + 4,4 \times (7,4+98) \times 0,1 + 4,4 \times 98 \times 0,2] \times 1,3
= 172,4 N

F_2 = [F_1 + L_2 (q_c + q_p) \mu_r] k \alpha_2
F_2 = [32,3 + 5,3 \times (7,4+49) \times 0,1] \times 1,2
= 74,6 N

Section 2

a) Without accumulation:
F_2 = [F_1 + L_2 (q_c + q_p) \mu_r] k \alpha_2
F_2 = [32,3 + 5,3 \times (7,4+98) \times 0,1 + 5,3 \times 98 \times 0,2] \times 1,2
= 230,5 N

Section 3

Sections 1–2 cause a counteracting force F_2 (or F_2') which must be added.

a) Without accumulation:
F_3 = F_2 + L_3 (q_c + q_p) \mu_r
F_3 = 74,6 + 6 \times (7,4+49) \times 0,1
= 108,4 N

b) With accumulation on the whole of L_3:
F_3' = F_2 + L_3 (q_c + q_p a) \mu_r + L_3 q_p a \mu_p
F_3' = 74,6 + 6 \times (7,4+98) \times 0,1 + 6 \times 98 \times 0,2
= 255,4 N

c) With accumulation on L_3a and transport on L_3b (L_3a + L_3b = L_3):
F_3'' = F_2 + [L_3a (q_c + q_p a) + L_3b (q_c + q_p)] \mu_r + L_3a q_p a \mu_p
F_3'' = 74,6 + [2,5 \times (7,4+98) + 3,5 \times (7,4+49)] \times 0,1 + 2,5 \times 98 \times 0,2
= 169,7 N
Calculation example 1: Horizontal conveyor (continued)

Comparison with rating

The result of the calculations can now be compared with the maximum permissible chain tension. It is necessary to check tension with regard to a) conveyor length (diagram 1, page 14) and b) conveyor speed (diagram 2, page 14). The calculated value shall be compared with the lower of the two values obtained.

Tension limit

The maximum chain tension for a 15 m XL conveyor is 500 N (diagram 1, page 14).

The maximum chain tension for a conveyor speed of 18 m/min is 400 N (diagram 2, page 14). The lower value, 400 N, is the basic tension limit. With a start/stop frequency of 50 per hour, the service factor is 1.6 (see table on page 15). This means that the basic tension limit must be derated to 400/1.6 = 250 N.

Summary

a) Without accumulation:
This conveyor will operate with a chain tension well below the maximum permissible value.
b) With accumulation on the whole of L_3:
F_3 = 255,4 N (>250 N).
This conveyor should be redesigned. If possible, shorten the accumulation distance, reduce the speed, or switch to an XM conveyor.
c) With accumulation on 2,5 m of L_3:
F_3 = 169,7 N (<250 N).
This conveyor will operate with a chain tension well below the maximum permissible value.

Calculation example 2: Inclined conveyor

Conveyor with two vertical bends

The second example is an inclined conveyor with three straight parts and two 60° vertical bends.

Conveyor data:

Conveyor type .............................................. XL
Total length ................................................... 8 m
Conveyor speed v......................................... 5 m/min
Start/stops .................................................... 10 /hour
Friction coefficient μr .................................... 0,1
Load due to chain weight q_c ......................... 7,4 N/m
Load due to product weight q_p ...................... 49 N/m

Divide the conveyor

Start by dividing the conveyor into three elementary sections. Then start at the section farthest away from the drive unit “pull” side.
Section 2

Section 1 causes a counteracting force $F_1$ which must be added. Gravity forces in the bend are ignored.

$$F_2 = [F_1 + L_{2a}(q_c+q_p)(\mu_r \cos \beta + \sin \beta) + L_{2b}(q_c+q_p)\mu_f]k\alpha$$

$$F_2 = [35.5 + 2 \times (7.4+49) \times (0.1 \times 0.5+0.87) + 0.5 \times (7.4+49) \times 0.1] \times 1.4 = 198.9 \text{ N}$$

*(Special case: section 2 is vertical)*

The same formulas can be used when calculating the chain tension of a vertical conveyor. In a vertical conveyor (with two 90° vertical bends) angles $\alpha$ and $\beta$ are both 90°. Since $\sin 90^\circ = 1$ and $\cos 90^\circ = 0$, the formula is simplified to:

$$F_2 = [F_1 + L_{2a}(q_c+q_p) + L_{2b}(q_c+q_p)\mu_f]k\alpha$$

indicating that the gravity component is the only force acting along the vertical section. Gravity forces in the bend are ignored.

Section 3

Sections 1–2 cause a counteracting force $F_2$ which must be added to the friction obtained from the basic formula:

$$F_3 = F_2 + L_3(q_c+q_p)\mu_f$$

$$F_3 = 198.9 + 2 \times (7.4+49) \times 0.1 = 210.2 \text{ N}$$

*Comparison with rating*

The result of the calculations can now be compared with the maximum permissible chain tension.

*Tension limit*

The maximum chain tension for an 8 m XL conveyor is 500 N (diagram 1, page 14). The maximum chain tension for a conveyor speed of 5 m/min is also 500 N (diagram 2, page 14). With a start/stop frequency of 10 per hour the service factor is 1.2 (see table on page 15). This means that the basic tension limit must be derated to $500/1.2 = 416 \text{ N}$.

*Summary*

Since $F_3$ is calculated to 210.2 N (<416 N), this conveyor will operate with a chain tension well below the maximum permissible value.
**Effective track lengths**

**Track length definition**

The following tables list the effective track lengths for various FlexLink components. These should be considered when determining how much conveyor chain is required in a system. The lengths are rounded up to the nearest 50 mm.

The effective track length is the total length of chain required through a bend or drive unit. The value for two-way chain applies when the chain returns on the bottom side.

### End drive units

![End drive unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way chain</td>
<td>0,80</td>
<td>0,80</td>
<td>0,80</td>
<td>0,85</td>
<td>0,80</td>
<td></td>
</tr>
</tbody>
</table>

### Intermediate drive units

![Intermediate drive unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way chain</td>
<td>0,65</td>
<td>0,80</td>
<td>1,00</td>
<td>1,00</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### Catenary drive units

![Catenary drive unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way chain</td>
<td>–</td>
<td>0,80</td>
<td>1,00</td>
<td>1,00</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### Horizontal bend drive units

![Horizontal bend drive unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-way chain</td>
<td>0,65</td>
<td>0,65</td>
<td>0,65</td>
<td>0,70</td>
<td>0,85</td>
<td>–</td>
</tr>
</tbody>
</table>

### Idler end units

![Idler end unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way chain</td>
<td>0,50</td>
<td>0,50/0,80</td>
<td>0,80</td>
<td>0,80</td>
<td>0,85</td>
<td>0,80</td>
</tr>
</tbody>
</table>

### 90° idler units

![90° idler unit](image)

<table>
<thead>
<tr>
<th>Effective track length (m)</th>
<th>XS</th>
<th>XL</th>
<th>XM</th>
<th>XH</th>
<th>XK</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-way chain</td>
<td>–</td>
<td>0,40</td>
<td>0,60</td>
<td>0,65</td>
<td>0,70</td>
<td>–</td>
</tr>
<tr>
<td>2-way chain</td>
<td>–</td>
<td>0,70</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
For XB, only 2-way chain is applicable. R300 is only available for XM and XH.
Good knowledge of vertical transport solutions is essential since elevated conveyors is one of FlexLink’s main competitive advantages. There are several solutions to vertical transportation:

- Plain chain: maximum 5° slope
- Friction top chain: up to 25°
- Cleated chain: 5°–90°
- Wedge conveyor: 5°–90°

**Plain chain**

Plain chain can be used up to 5°±2° slopes, depending on the friction coefficient between product and chain.

**Friction top chain**

Friction top chain increases the friction between product and chain and can often be used up to 25° slopes.

**Cleated chain**

Plain chain with cleated links at regular intervals permits vertical transport up to 90°. For angles near 90° it is necessary to use a front piece to prevent items from falling off the conveyor.

**Methods for feeding items to a cleated chain**

The transported items can be fed to the cleated chain

- manually
- by means of a pusher (automation)
- using roller cleats

Using a FlexLink chain with roller cleat links ensures that the items do not remain on top of a cleat.

**Example 1.**

**Elevator conveyor for boxes (120 boxes/minute)**

The inclination of 15° helps the products to enter between the cleats before the vertical bend, resulting in fewer bumps for heavy products. The inclination also reduces the angle of the vertical bend which gives lower chain tension.

**Example 2.**

**Elevator conveyor for boxes (max 15 kg boxes)**

In the example, roller top link XMTL 83×46 R or XHTL 103×46 R can be used.

The speed of the elevator should be at least 1.5 times the production speed.

**Example 3. Lowerator**

A lowerator can be designed with the same concept as for an elevator, except that the straight section must be longer in order to prevent bumping of products. A brush can be used to slow down the boxes, helping them to fit in between the cleats.

To use a slope link at lowerators can be a more simple solution.
Vertical transport solutions (continued)

Wedge conveyor

A wedge conveyor uses two conveyor tracks facing each other to provide fast and gentle transport, horizontally as well as vertically. The chain has flexible cleats to carry the product without damaging it.

The wedge chain conveyor is most suitable for products with length/width ratio 1:1 to 4:1. The products must be reasonably uniform in size but not too soft or flexible.

Read more about wedge conveyors in section “Engineering guidelines – wedge conveyors” on page 27.

Product transfer solutions

Moving products from one conveyor to another can be done using

- end transfer
- side transfer
- perpendicular transfer.

End transfer

End transfer solutions require a minimum of extra space. Plain chain or friction top chain can be used. Note that small products will not be able to pass unless a bridge is used.

Side transfer

Side transfer can only be used with plain chain.

- Needs a low type of guide rail.
- Common support for both conveyors.
- Not recommended when using friction top chain.

If the feeding conveyor has a cleated chain, transfers can be made as in the figure, if the product is higher than the cleat. If not, the conveyor can be tilted for the out-feed (B).

Perpendicular transfer

It is possible to transfer products perpendicular to the receiving conveyor. The product should be at least 20% longer than its width in order to have a safe transfer.

An automation system is needed to stop products on one of the conveyors in order to avoid interference of products, so called “bridges”.

FlexLink®
General safety and design considerations

Introduction
When designing a conveyor system, it is necessary to consider all of its aspects in order to achieve an operational installation which is reasonably safe for all people involved in its use or maintenance. For conveyors the chain is generally the critical factor to consider with guarding.

Safeguarding
All pinch and shear points as well as other exposed moving parts that present a hazard to people at their workstations or their passageways must be safeguarded. Overhead conveyors must be guarded to prevent objects falling. Cleated conveyor chains are more hazardous in creating more pinch and shear points than plain conveyor chains.

Safeguarding can be achieved by:

- Location
  Locate the hazardous area wherever possible out of the area occupied by personnel.

- Guards
  Mechanical barriers preventing entry into the hazardous area, or protecting against falling objects.

- Control devices
  Machine controls which prevent or interrupt hazardous operations/conditions.

- Warnings
  Instructions, warning labels, or sound/light signals which alert to hazardous conditions.

Safeguarding should be designed to minimize discomfort or difficulties to the operator. Bypassing or overriding the safeguarding during operation should be difficult.

Special attention
When correctly applied, the FlexLink family of components are safe to use and maintain. It is, however, necessary for those responsible for design, installation, operation, and maintenance of the FlexLink installation to be aware of certain areas where special attention is required.

All drive units with slip clutch
- Before adjusting the slip clutch, it is necessary to remove all objects from the chain to remove any remaining chain tension.
- Adjustment should be conducted in accordance with the maintenance procedures specified.
- All drive units with the exception of direct drive units are fitted with transmission chain covers. These covers must be fitted before unit is operated.

Note: The slip clutch is not a personnel safety device, but a device to protect the conveyor equipment. Systems with cleated chains should incorporate drive units with slip clutch.

End drive units
- The chain slack (catenary) of the end drive units must be maintained during the system lifetime.
- If side plates are fitted, the chain must be shortened if it becomes visible below the level of the side plates.

For coupled drive units, safety protection should be applied to the connecting shaft.

Intermediate drive units
The area near the guides for the return loop of the chain should not be accessible during conveyor operation.

Catenary drive units
The “bridge” area where the chain goes down into the drive should not be accessible during conveyor operation.
General safety and design considerations (continued)

**Horizontal bend drive units**

The drive wheel and the transmission chain should not be accessible during the conveyor operation.

**Idler units**

The opening between the links when they turn round the idler roller could be a risk. Idler ends should not be accessible during conveyor operation wherever possible. Protective covers for the idler end units are available.

**Wheel bends**

Guarding may be required at wheel bends depending upon location of bends and load applied to the conveyor.

**Cleated chains and roller top chains**

- Any application incorporating cleated chains and roller top chains requires careful safety consideration. Pinch and shear points are generated throughout the assembly of the incorporated components, therefore generous guarding should always be employed to fully protect within user operating limitations.

**Maintenance**

The routine maintenance of FlexLink conveyors should also include procedures to ensure that any guarding remains securely fastened and effective if not interlocked via control system etc.

FlexLink components are continuously reviewed to improve performance either by design modification or material upgrade. In all these reviews user safety is our first consideration.

The design review procedure as recommended under the Machinery Directive 98/37/EEC is followed and all associated technical data is retained at the manufacturer’s address.

**Chain**

The chains are made of acetal resin which has an excellent combination of strength, wear resistance, chemical resistance, impact strength and temperature range.

Chain failures like breakage and high wear might occur if the actual chain pull is higher than the permissible chain pull. There is also a big risk for slip-stick at high chain pulls.

There is an arrow on the side of all chain links showing the proper running direction for the chain. The chain should run without pre-tension. Pre-tension might result in uncontrolled chain pull and lead to chain failure. For this reason it is important that there is a visible chain slack at the drive unit when the conveyor is running.

The chain has a good impact strength. A broken link is a sign that something is wrong along the conveyor. Frequent failures can be attributed to broken cleated links caused by jamming at the loading or unloading of the conveyor.

- There is a higher risk of product damage when using cleated chains. Special attention must be given to operator access in the event of product becoming trapped or similar.

**Chain elongation**

The chain is made of an elastic material. In addition to the elastic elongation, the chain will exhibit elongation because of material creeping. The magnitude of the elongation depends on the chain pull. The elongation will show up at the take up side of the drive unit. Too much chain slack may cause wear at the chain entry point in the drive unit. Regular inspections of the chain elongation are important. The chain should be shortened after a run-in time of 50 hours. Further inspections should be made after 250 and 500 hours and then every 500 hours. Frequent inspections are more important if the conveyor is long or has large/heavy loads.

It is important to replace broken or damaged chain links, or the broken link might damage the slide rail or the feed-in guides for the return chain at the drive unit.
FlexLink Configura® is FlexLink’s graphical product configuration software. Based on a two-dimensional drawing of a production lay-out, FlexLink Configura® calculates the project and creates a three-dimensional picture automatically. The program contains all the necessary product information and creates the quotation. In addition, the program knows the options and restrictions for each individual product. It is compatible with FlexCad and with the FlexLink e-Services on Internet. End-user licences are available. For more information, please contact FlexLink Systems.

More information

Materials
See the FlexLink product catalogue 5147, Appendix D.

Noise levels
See the FlexLink product catalogue 5147, Appendix E.

The FlexLink website

http://www.flexlink.com
The start page when you look for company facts and basic product information. Links to local sites, e-services and technical library.