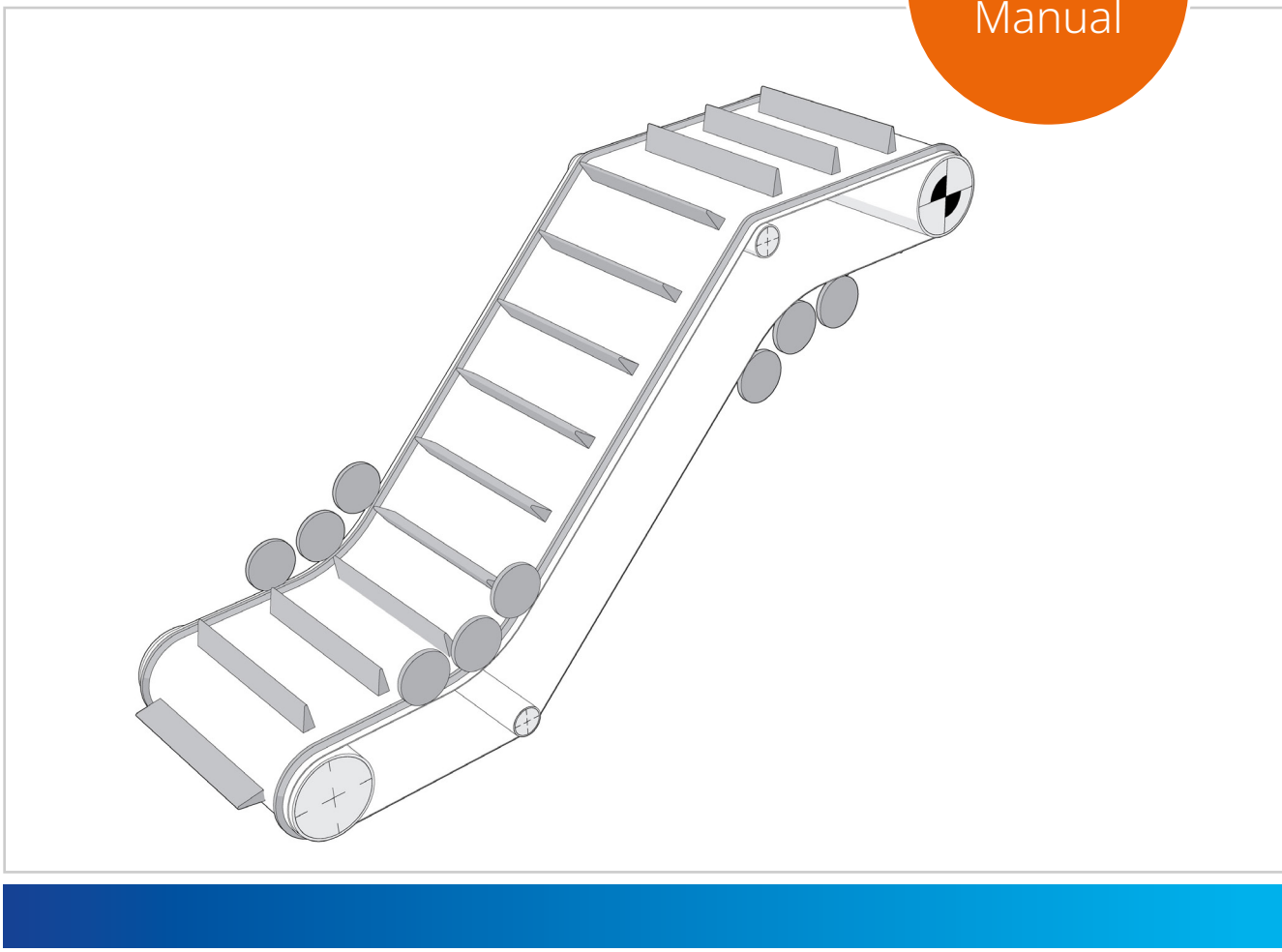
Ammeraal Beltech

EN

Technical Manual



Inclined Belted Conveyors

Innovation and Service in Belting

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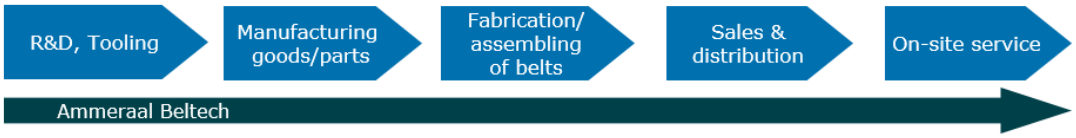
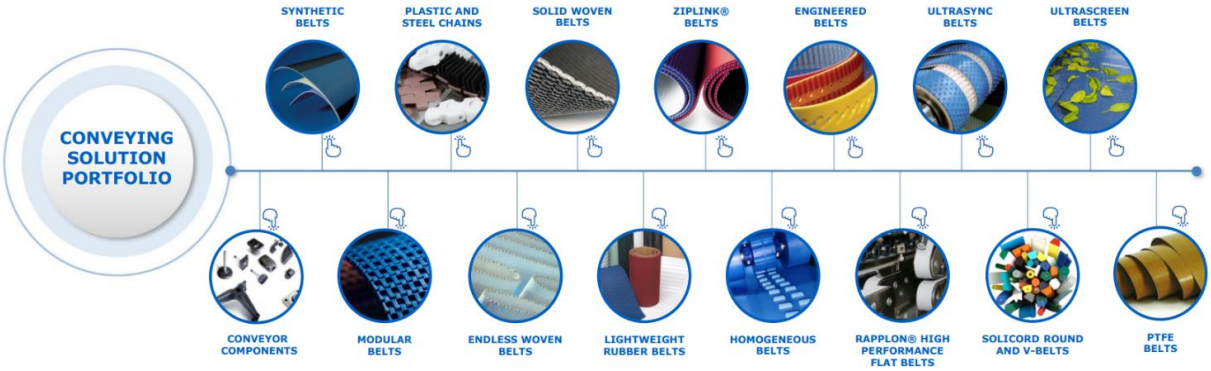
1. Introduction

Ammeraal Beltech is a global leader in middle and light weight belting. Ammeraal Beltech provides services and solutions to help process and convey a wide variety of products. Our solid base is a close cooperation with customers and control over the full value chain: development, manufacturing, fabrication, sales, and service. The Ammeraal Beltech group and affiliated companies operate globally. We offer belting products and services to save our customers time and money. Whether our customers are conveying or processing products, Ammeraal Beltech has the right solution.

Image 1: full value chain and extensive product range



Ammeraal Beltech offers a comprehensive belting range.



2. About this manual

The available floor space of a production plant is often limited. This means processing and transportation of products sometimes needs to take place at various levels. Inclined belt conveyors convey products from one level to another. Inclined conveyors simply convey products for example, to the next floor or bring a product up so that it can be discharged into a hopper of bag filling equipment, a container, a silo, or a truck.

This manual is about inclined belted conveyors. When we say inclined, we also mean declined, since most of the time both are inextricably connected. It covers the technical principles of the assorted designs of incline conveyors. This engineering guide contains recommendations for the design of incline conveyors. It is not meant to be exhaustive. Basic sketches are used for clarification. These sketches might be out of proportion to show some details more clearly. Spiral conveyors are not in the scope of this manual.

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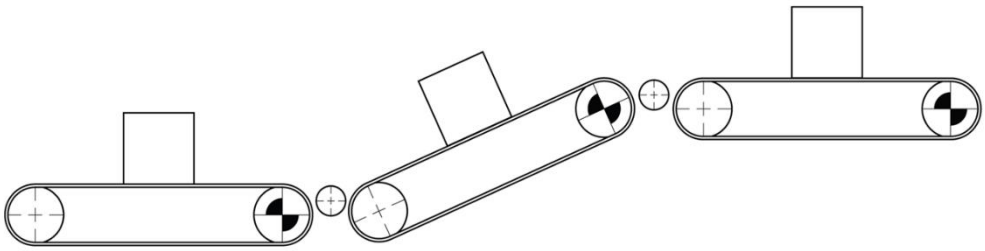
3. Assorted designs of inclined conveyors

The simplest design for an inclined conveyor is straight conveyor that is placed at an angle (see image 3). At the loading zone the product is conveyed or poured on the incline conveyor by the downstream conveyor. When transporting piece goods, the discharge point of the inclined conveyor can be at the same level as the previous, upstream conveyor, or placed above it. When conveying bulk goods, the discharge point must be placed above the hopper of the next upstream conveyor.

Image 3
inclined conveyor



A horizontal-incline, L-conveyor has a loading zone in the horizontal plane combined with an inclined part combined into one conveyor, see image 4. This conveyor design eliminates one conveyor drive and one transfer point from one conveyor to the other. This makes the handling of the products more gentile. The drive drum of an inclined conveyor should be positioned at the top. The drive of an inclined conveyor can be equipped with a backstop to prevent a fully loaded belt from starting to move backward.

Image 4
horizontal-incline conveyor, L-conveyor

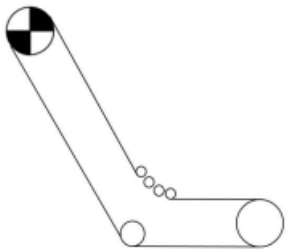


Image 5
nose-over-conveyor, L-conveyor

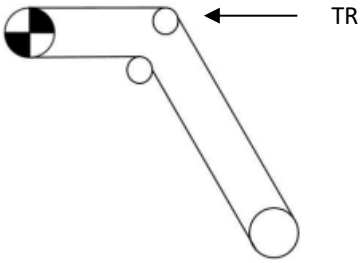


Image 5 shows a nose-over conveyor design that has a discharge point in the horizontal plane. Such a conveyor design enables a smooth transition of the products from incline to the horizontal plane.

A Z-conveyor or swanneck conveyor can be seen as a combination of a horizontal-incline conveyor and a nose-over conveyor, see image 6. This conveyor design makes it possible to have both the loading zone and the discharge point at the same level as the connecting conveyors that are on a different level. In chapter 9 we will discuss the design of swanneck conveyors in more detail.

Image 6
swanneck conveyor, Z-layout

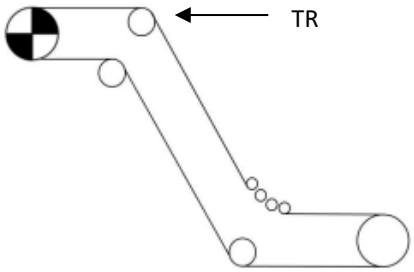
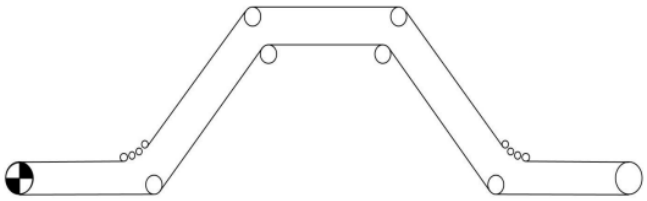


Image 7
walkthrough conveyors or double-L or double nose-over

Rarer is a walkthrough-incline conveyor design, see image 7. Connecting two conveyors that are on the same level while allowing traffic of products or personnel underneath.



For transportation of goods to a different level while using the smallest possible floorspace, pocket or bucket elevators are used, see image 8 and 9. Buckets or cleats that are attached to the belt make it possible to carry the product upward vertically. In chapter 10. Bucket elevators contains specific recommendations for the design of bucket elevator conveyors and pocket belt elevators.

Image 8
pocket belt elevator

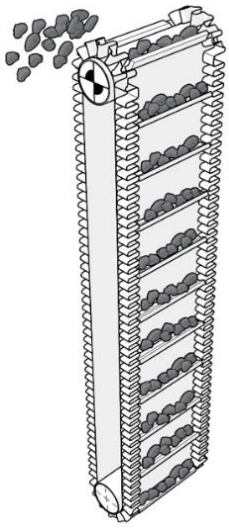
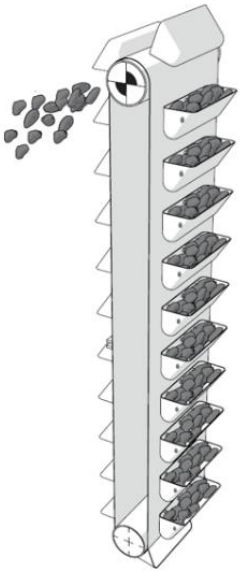


Image 9
bucket elevator



The drive drum of an inclined conveyor must be positioned at the top.

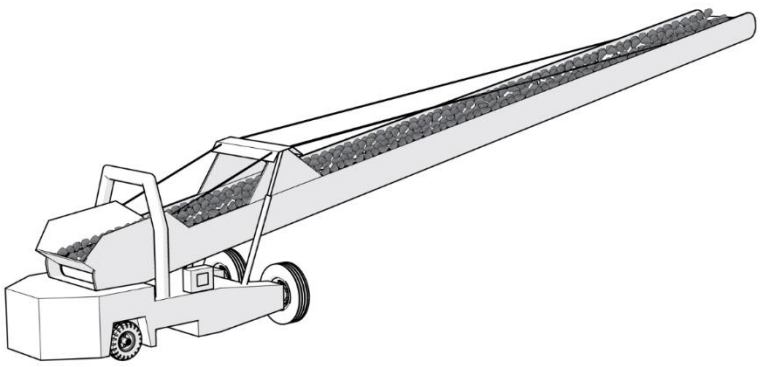
4. Inclined conveyors in different industries

In this chapter we give some examples of the many industries where inclined and declined conveyors are used. The agriculture industry, food industry, plastic industry in airport and logistics, recycling, metal, building materials, textile and almost any other industry where conveyor belts are used.

4.1 Store loader

Agriculture, typically is an industry of rough, often heavily polluted outdoors applications. A typical inclined conveyor in agriculture is a store loader, see image 10. For example, potatoes are transported upward to be put in storage. The conveyor is mobile, it can move forward, backward and from left to right while filling the storage room. The angle of incline is adjustable so as the product is piled up to the point of discharge, the discharge point can be moved upward while keeping falling height of the product to a minimum. Typically rubber or PVC belts with chevron shaped cleats are used. Conveyors like this have a troughed belt support in the upper part. Belts must be lateral flexible and should have the top- and back side coated to protect the fabric tension members from dirt, moisture, and excessive wear.

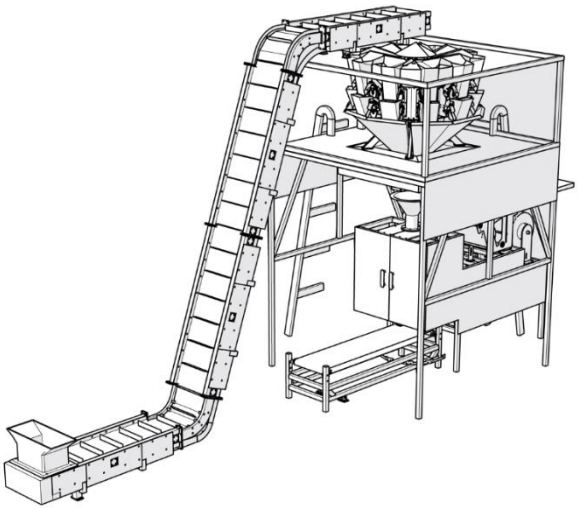
Image 10
store loader



4.2 Weighing-filling unit

Food industry, food products like chips and snacks and conveyed upward to be discharged into a weighing unit to be packed into a container or bag, see image 11. Applications like this require extra attention to cleanability and hygiene when designing the conveyor and choosing the belt type. The preferred belt type is food grade and has a non-adhesive, light blue color. It will have Amseal closed edges and is possibly of an anti-microbial quality.

Image 11
feeding food products into a weighing-filling unit



4.3 Moulded plastic parts

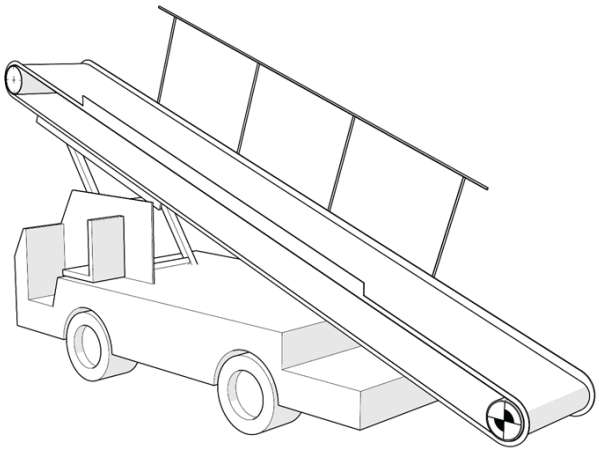
Inclined conveyors for transporting plastic moulded parts that are ejected from the mould, away from under the injection moulder up into a container (see image 12) require a lateral stable belt carcass to keep the belt into the concave bend of the conveyor. The belt of choice must be able to withstand the impact of the products falling from the mould onto the belt. The mass and temperature of the product could play a role when choosing the correct belt type for this application.

Image 12
Inclined conveyor for moulded parts

4.4 Aviation baggage loader

Airports have baggage handling systems that convey baggage from the drop-off point to the gate. At the gate baggage handlers manually put the baggage onto carriers that bring it to the airplane. At the airplane again, baggage handlers manually put the baggage onto an inclined conveyor (see image 13) that brings it up to the cargo hull of the airplane. Since this type of inclined conveyor must be able to operate in wet circumstances often rubber belts are used. The belt support is flat, so preferably the belt carcass is lateral stable. The rubber topside has a super grip profile to increase the friction between product and belt. The belt support is a smooth steel slider bed, so the back side of the belt is of a low friction fabric.

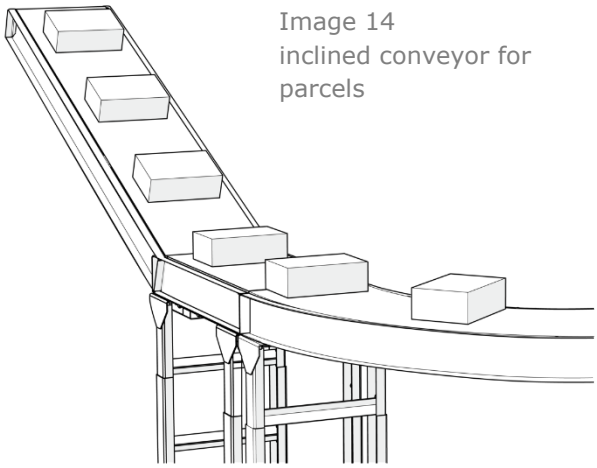
Image 13
aircraft baggage loader



4.5 Logistic centers

Logistic and mail distribution centers have large conveyor installations with many conveyors that collect, sort, and convey the mail and parcels to trucks that bring the product to the next destination. These are indoor conveyor installations that also have inclined conveyors bringing product to a different level, see image 14. For the inclined conveyors in this industry typically reinforced, lateral stable, synthetic belts with a soft PVC top layer or rubber package handling belts are used.

Image 14
inclined conveyor for parcels



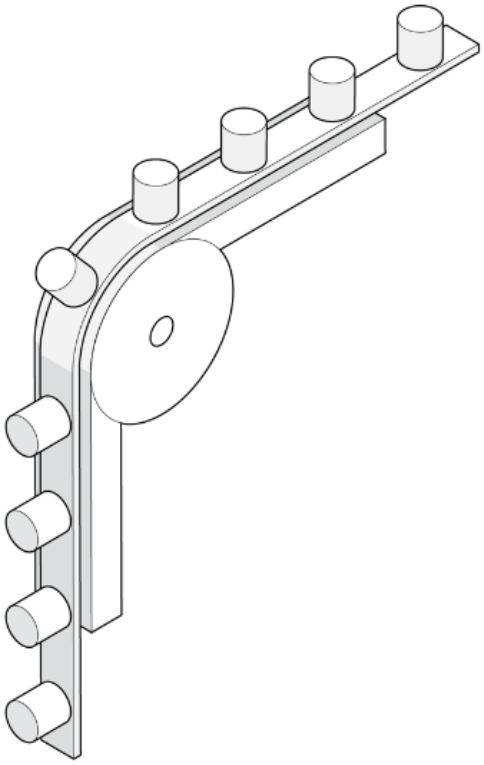
Synthetic belts with a somewhat softer PVC top layer that is often profiled with a super grip of longitudinal profile to prevent dust and dirt reducing the friction between product and belt.

4.6 Magnetic conveyors

When conveying light ferrous metal products such as cans, lids, batteries, metal parts and scrap metal, belted magnetic conveyors can be used for inclined and declined conveying, see image 15. At the inclined or declined part of the conveyor the magnetic field from the slider bed keeps the product in place on the belt so that it does not slide or fall. The magnetic strength needed is determined by many factors such as angle of incline, product weight and magnetic properties. Depending on the application either permanent magnets or electromagnets can be used. Provided the magnetic field is strong enough to hold the weight of the products, products can be transported from horizontal to incline, to vertical or upside-down. These types of conveyors are not suitable for accumulation of products on the belt.

Often belts with a wear and cut resistant top cover are used for magnetic belt conveyors, since the product is metal and could have sharp edges. The belt should have a low friction bottom side because the magnetic force pulling the products towards the slider bed can be quite strong.

Image 15. magnetic belt conveyor

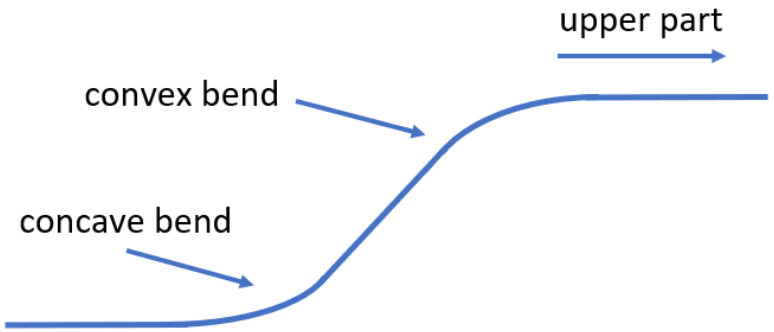


5 Conveyor layout

5.1 Transfer from horizontal to inclined

Looking at the point where product transport in the horizontal plane changes to inclined transport, the product needs some help to make this transfer. A feeder belt feeds the product to the inclined belt conveyor. The layout can be such that these are two separate belted conveyors or a horizontal and an inclined conveying are combined into one, like L-conveyors or Z-conveyors. L- and Z-conveyors have a bend in the vertical direction. The bend from horizontal to inclined is the concave bend, the bend from inclined back to horizontal is a convex bend, see image 16.

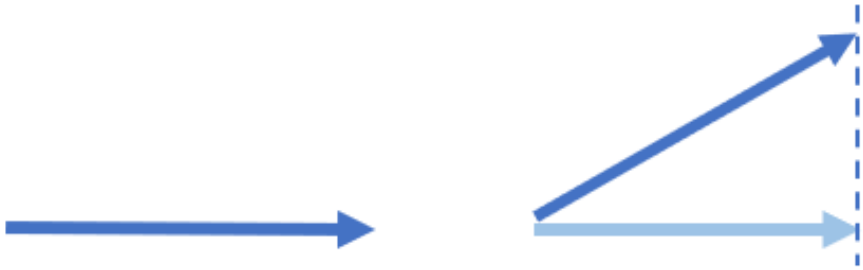
Image 16
concave and convex bends



5.2 Product slippage

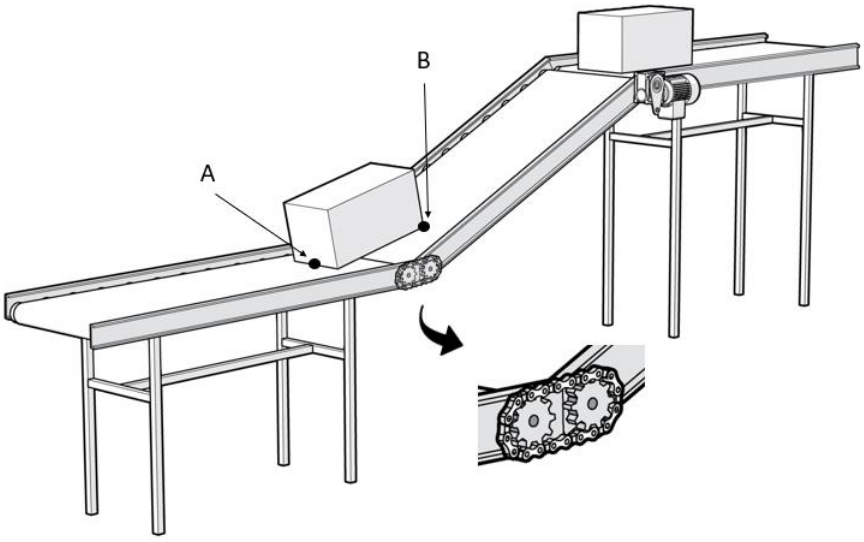
If a product like for example a box is in transition from the horizontal to the inclined conveyor, like shown in image 18, the relative speed between the contact points of the box and the belt in spot A and B are not the same. A point A the box has a horizontal speed that is higher than the horizontal speed at point B (image 17). Because of this, there is slippage between product and belt, at least at one of the two points. The steeper the angle of incline, the greater the slip between product and belt. During the transition of the product getting from horizontal to the full angle of incline the amount of slip changes from zero to maximum them back to zero again.

Image 17
V horizontal



In a setup with two separate
conveyors as shown in image 18, the inclined conveyor should have a belt with a high friction top cover. The belt of choice for the horizontal feeder conveyor should have a low friction top surface to allow some degree of slip between belt and product. In this way the risk of damage to the product and excessive wear of the belt is kept to a minimum.

Image 18
transfer of box
horizontal to inclined

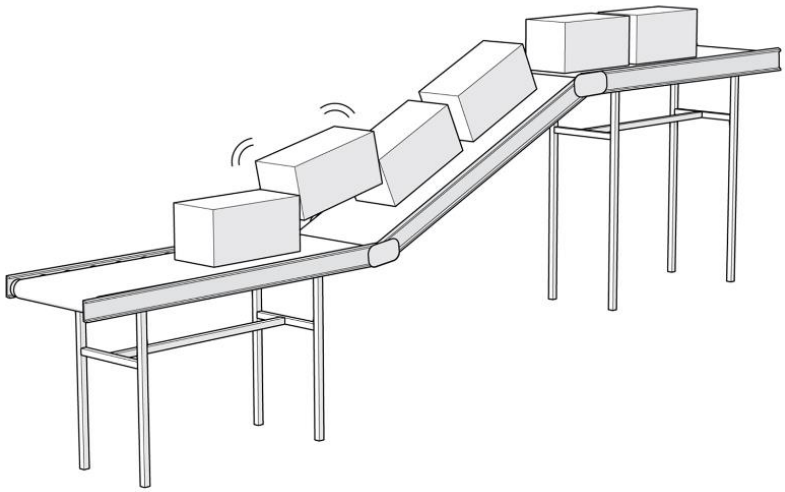


To reduce the number of separate conveyors and with it also the number of transfer points a good option would be an L-conveyor design also called nose-over conveyor. Eliminating both the transfer points, at the bottom and at the top is possible with a swanneck conveyor also called a Z-conveyor.

5.3 Staggered product

A straightforward way to power a separate feeder conveyor would be a chain drive that is driven from the tail pulley of the inclined conveyor, see image 19. Choosing different sprockets gives the option to have the feeder belt running at a lower speed than the inclined belt, to space the products and prevent them from getting staggered.

Image 19
of staggered boxes



5.4 Convex bends

At the top of an incline conveyor transportation changes to the horizontal plane. Depending on the type of product and the angle of incline it could be undesirable to make the full transition from inclined to horizontal in just one bend. An angle of incline of 30 degrees could require a smoother transition in two convex bends of 15 degrees, as shown in image 39.

Transportation of a box from a horizontal conveyor belt to an inclined conveyor belt will cause some product slippage.

Avoid staggering products in a concave bend.

If necessary, split up large convex bends into smaller ones.

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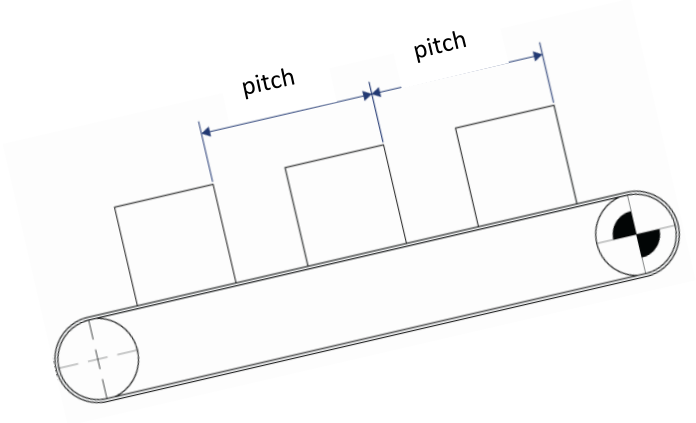
5. Capacity of an inclined conveyor

For a smooth continuous flow of product in a production line it is important that the capacity of an incline or decline conveyor matches the capacity of the connecting conveyors and that of the required production capacity. The capacity of an incline conveyor for piece goods is, just like a horizontal conveyor, stated in the number of products conveyed per unit of time. Provided there is no slip between the product and the belt surface, the pitch of the products in the direction of belt travel together with the belt speed together determine the capacity of a conveyor for piece goods.

Image 20
piece good and pitch, inclined



*Capacity piece goods = pitch of the goods * belt speed*

6. Angle of incline

7.1 Angle of incline and gravity

Conveyors at an angle of incline of 20 degrees or less are called inclined conveyors. Conveyors with an angle of incline between 20 and 90 degrees are called steep incline conveyors, see image 21 and 22. Elevator belts have an angle of incline of 90 degrees, we discuss this specific type of conveyor in chapter 10 bucket elevators.

Image 21
Inclined

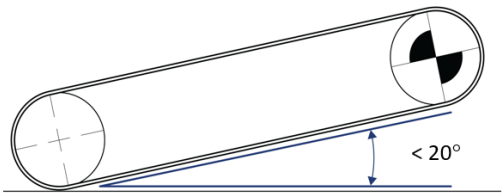
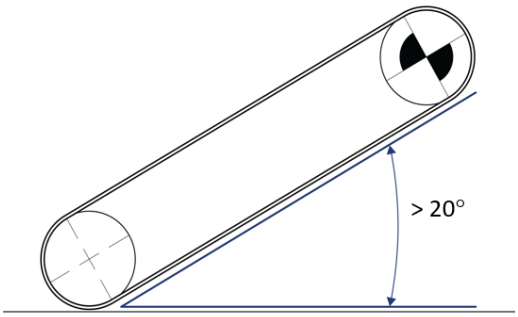


Image 22
steep inclined



7.2 Coefficient of friction

As a reference for the coefficient friction between belt and product the COF between belt and bare steel is given on the data sheet of a belt type. The COF on the data sheet of a belt helps to compare how much grip a certain belt cover has on a product compared to belts with a different top cover. We need to keep in mind that the actual COF of a certain application could be different from what is given on the data sheet of a belt. The type of product, wear and tear of the belt surface, pollution, dust, wind, moisture, and temperature are all of influence on the actual COF between belt and product. The below table in image 23 gives an indication of the maximum angle of incline per type of conveyor belt.

Image 23
Table indication of maximum angle of incline.

Indication of maximum angle of incline

Belt type	Indication of max. angle of incline in degrees
High friction top cover (e.g. Soft PVC or (silicone) rubber)	< 20°
Embossed top cover (e.g. A32 of A42 supergrip)	< 40°
transverse belt accessories (e.g. ropes or cleats)	> 40°
bucket elevators (for bulk materials)	vertical

Image 24
profile A32

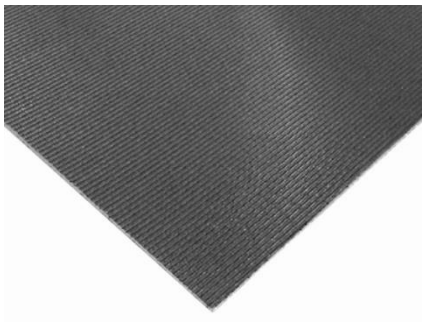


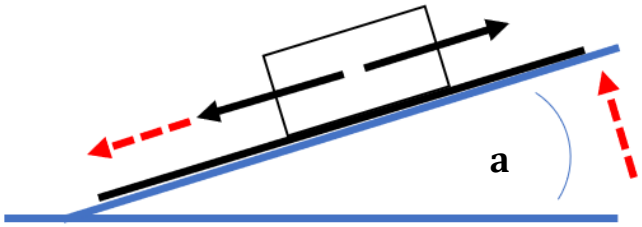
Image 25
profile A42

Variables like wear of the belt surface, pollution, dust, wind, moisture, and temperature are all of influence of the actual COF between belt and product.

7.3 A simple test

To get a better idea of the maximum angle of incline of a certain product in combination with the top surface of a belt of a specific material, hardness, and surface finish it is advised to perform this simple test, see image 26. Place a piece of belt on a flat support bed that can be placed at an angle. Place the product on top of the belt and slowly increase the angle of incline. The maximum angle of incline is smaller than the angle at which the product starts to slide downwards. One must keep in mind that in practice also the type of belt support, vibrations of the conveyor and start-stop conditions play a role.

Image 26
maximum angle of inclination test



A smooth slider bed support will allow a steeper angle of incline than a roller support, see image 27 and 28. The reason for this is that the center-to-center distance and minor differences in height between the rollers will cause a certain vibration between belt and product.

Image 27
roller support

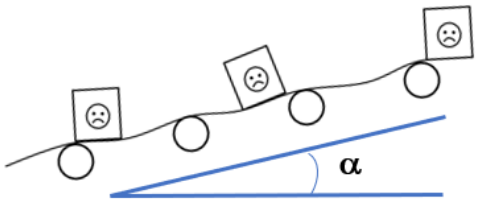
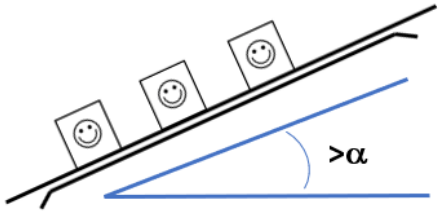
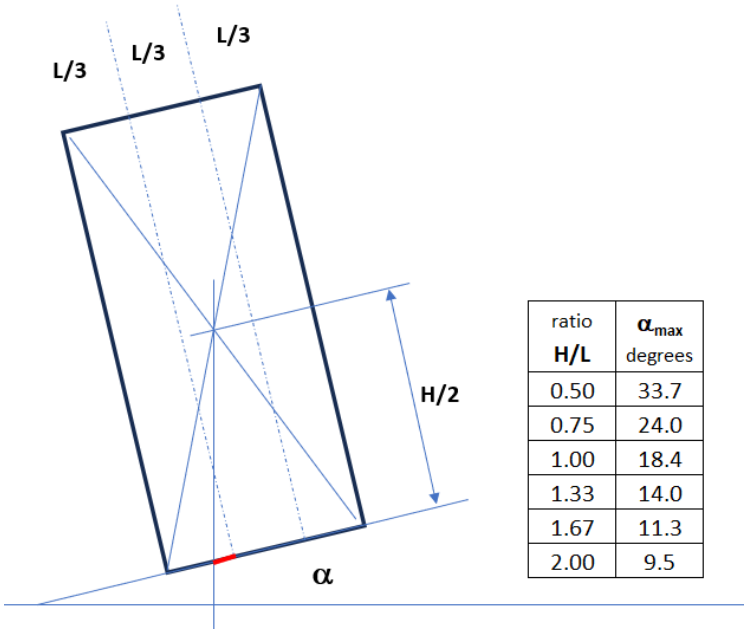


Image 28
slider bed support



It is not just the friction between product and belt that determines the maximum angle of incline. The angle of incline is also limited because a product like box may tumble down if the angle is too steep. A box with a uniform weight distribution will not tumble down if the angle of incline < a_{max}. a_{max} is the angle at which the line of gravity intersects with the bottom of the box at less than L/3 from the bottom corner. Image 29 shows a box at an angle of incline that makes the box unstable.

Image 29
unstable box



ratio **H/L**	**α_{max}** degrees
0.50	33.7
0.75	24.0
1.00	18.4
1.33	14.0
1.67	11.3
2.00	9.5

7.4 Cleated belts

When increasing the angle of incline, at some point even the most grippy belt surface does not create enough friction between belt and product to convey it upwards securely. In that case adding a physical barrier to the belt surface, like a lateral cleat could be an option to prevent fallback of the product. As shown in image 30 there are diverse types of cleats, cleats made from ropes, straight cleats, cleats at an angle, bend cleats and finger cleats. Cleats can also be placed at a different angle than square to the direction of belt travel, like chevron cleats or cup-shaped cleats. Images 31 and 32 show some of the different possibilities of cleat placement.

Image 30
diverse types of cleats

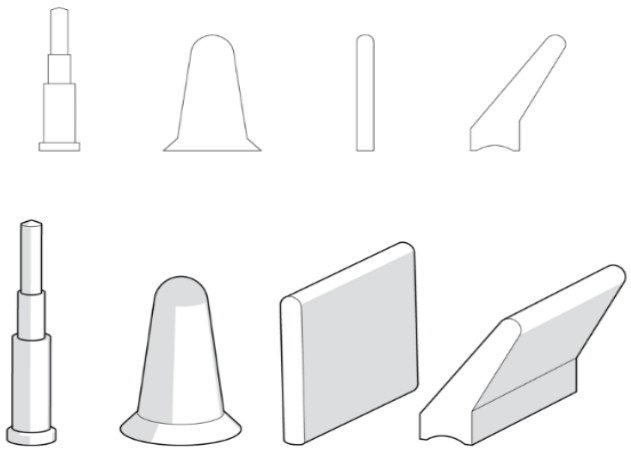


Image 31
cleats fitted in different shapes

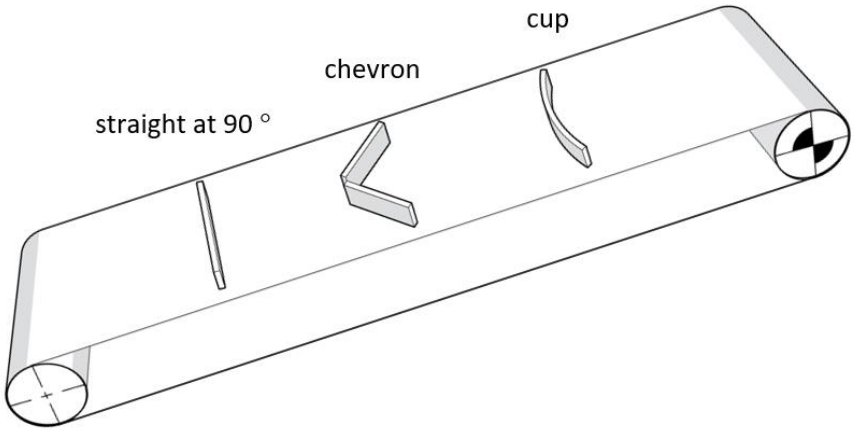
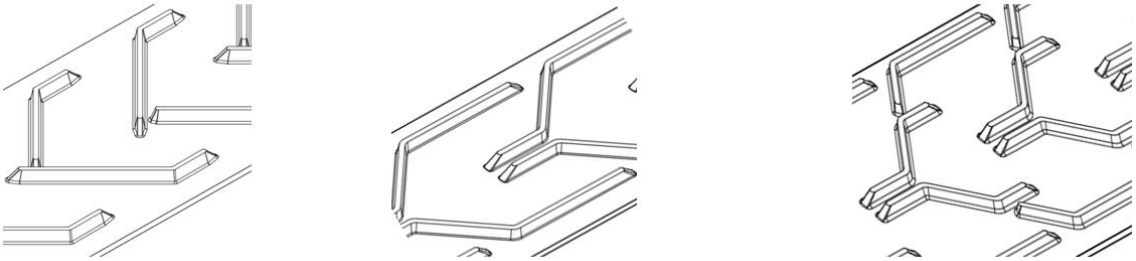


Image 32
different chevron cleats, rubber belting



7.5 Minimum pulley diameter

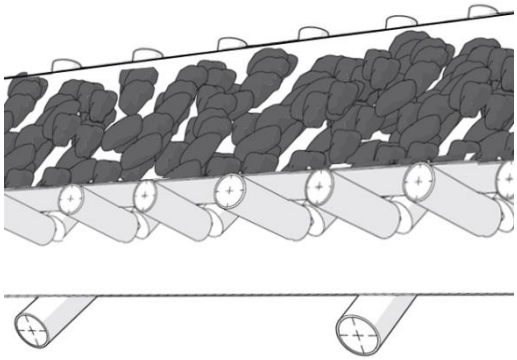
When adding an accessory like cleats and Bordoflex to the configuration of a conveyor belt we need to keep in mind that this might increase the minimum pulley diameter of that belt configuration. Different accessories have a different impact on the minimum pulley diameter of a belt, the type of material, shape, hardness, thickness, and height of that accessory all play a role in the pulley factor of a certain accessory. The pulley factor of an accessory is given on the technical data sheet of that accessory. With the pulley factor and the angle of wrap when (back) flexing over a pulley the minimum pulley diameter can be calculated. In the manual Conveyor Belt Accessories, we will elaborate on the calculation of the minimum pulley diameter for flexing and back flexing of a conveyor belt with accessories.

8. Bulk goods

8.1 Capacity of a conveyor for bulk goods

The capacity of conveyors for bulk goods is often expressed in weight of volume per unit of time, for example 25 tons/hour (= 55.115 lb./hour). In this case the capacity of the conveyor is determined by the volume or weight of the product per length unit of the conveyor and the belt speed.

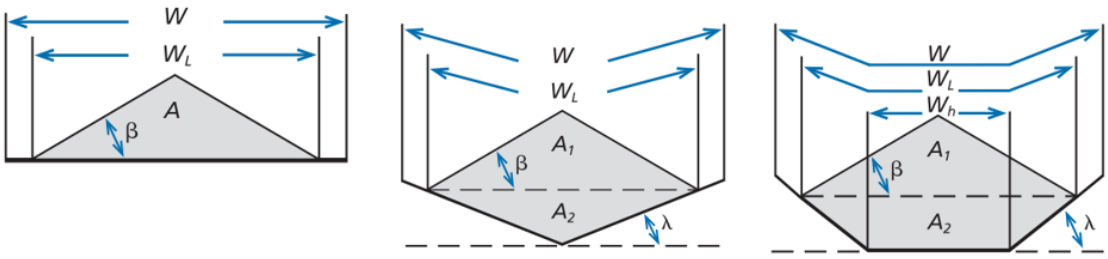
Image 33
bulk good, inclined



8.2 Loading angle

When the product is loaded onto the belt every different bulk good takes on its own 'natural' loading angle. Every type of bulk good has its maximum advised belt speed and its specific dynamic loading angle, indicated with b in image 34. Ammeraal Beltech has several calculation tools available to calculate the capacity of an inclined conveyor for piece or bulk goods.

Image 34
dynamic loading angle



To increase the capacity and to minimize product spillage of bulk goods often a trough shaped belt supports are used. When choosing a belt type for a conveyor with a trough shaped belt support one must bear in mind the lateral stability of a belt. Lateral stable belts are suitable for flat belt support only. When running a lateral stable belt in a trough support, the belt might not be able to follow the trough shape or the belt carcass could be damaged, the belt could even break.

8.3 AmCalc

Information about the capacity of bulk conveyors can be found in the brochure Calculation Guidelines from Ammeraal Beltech, together with AmmCalc the belt load can be calculated. If you require assistance with making these type calculations, you can contact the Central Product Management at Ammeraal Beltech.

8.4 Maximum angle of incline

When increasing the angle of incline above a certain maximum product will no longer be conveyed upward securely. For example, moist sand can be conveyed at a quite steep angle of incline, while potatoes will roll backward at a much lower angle of incline. The maximum angle of incline is different for every type of bulk good.

The available floorspace for a conveyor could make it necessary to increase the angle of incline above the maximum angle of incline of a specific bulk good. Above the maximum angle of incline a bulk good can only be conveyed securely when the belt is equipped with cleats and corrugated side walls (Bordoflex). Bordoflex should be 10 mm higher than the cleats, so that when supporting the belt with flat rollers in the return part the belt runs on top of the reinforced corrugated side walls. Belts with cleats and Bordoflex are called pocket belts (see image 35). In necessary specific measures should be taken to prevent leakage of product between cleat and side walls.

Similar to a conveyor with a pocket belt are conveyors with a cleated belt where the sidewalls are a part of the conveyor frame (see image 36). As the product is being conveyed upward, it will drag against the static side walls. The side walls are placed close to either side of the cleats to prevent leakage of product between the cleats and the static side walls. The side wall should be adjustable in lateral position to accommodate fabrication tolerances of replacement belts.

Image 35
pocket belt

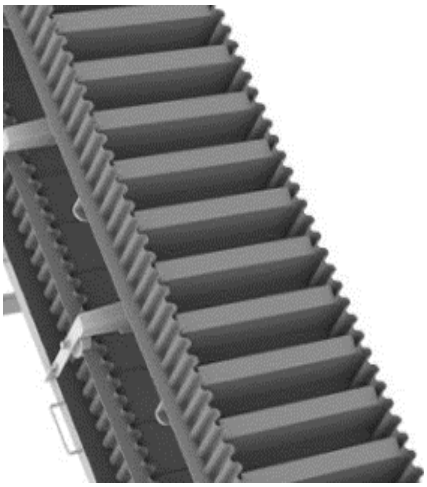
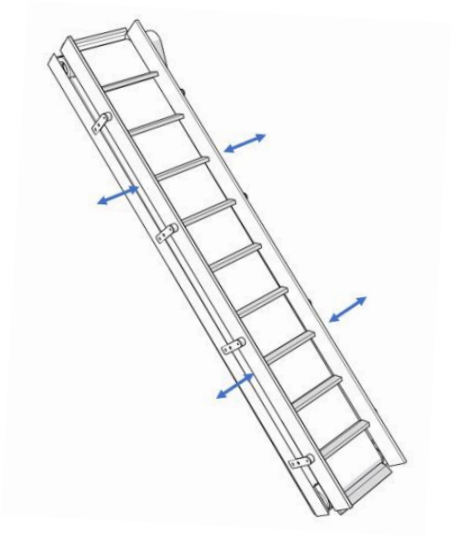


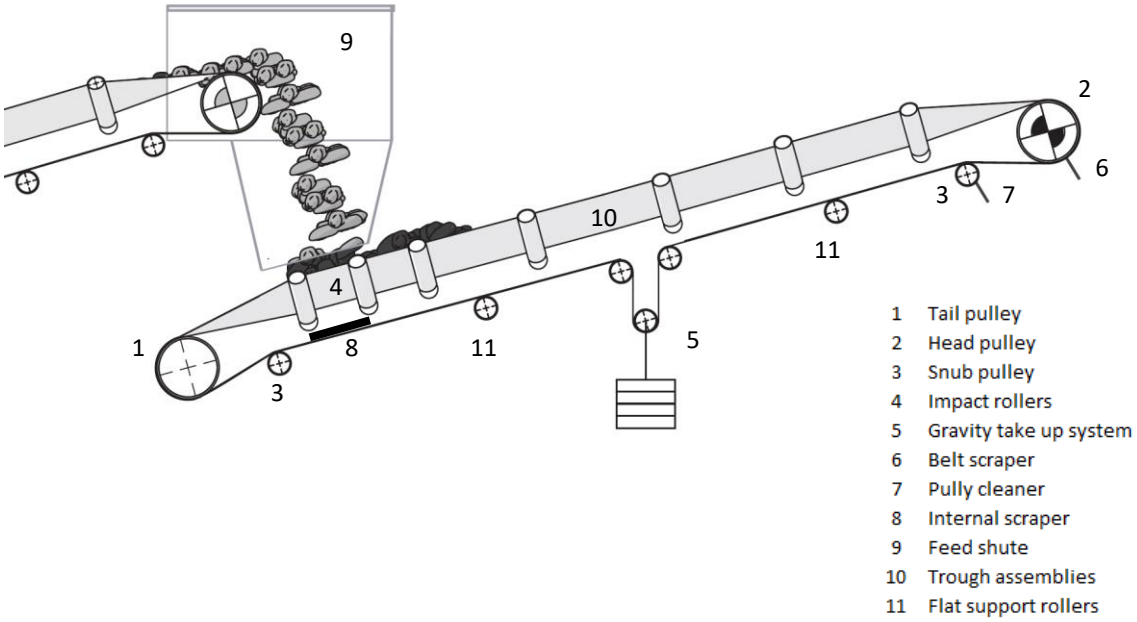
Image 36
cleated belt with static side walls



8.5 Parts of a bulk conveyor

Inclined conveyors for bulk goods are often used in medium and heavy applications in industries like agriculture, raw food products and other raw materials. Image 37 shows the various parts of such a conveyor.

Image 37
inclined bulk conveyor



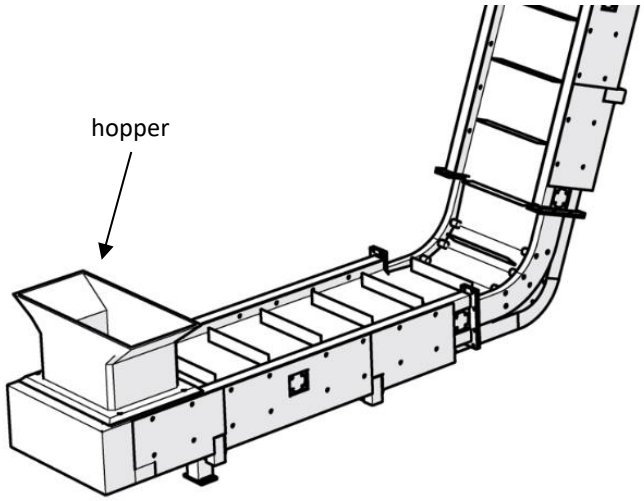
8.6 The loading zone and hopper

An area of special interest of a conveyor for bulk goods is the loading zone. This is where product spillage is most likely to happen. At the loading zone the bulk good is poured from a silo or another product container onto the conveyor belt. To cushion the impact of the product falling on to the belt at the loading zone, in this area the belt is often supported by impact slider bars or impact rollers that a close center-to-center distance.

In order to prevent product spillage as much as possible a set of measures can be taken. The product is poured into the hopper (image 38), which is guiding the product to drop between the sides of the belt. The sides of the belt are sealed with side skirts. The side skirts are there to prevent product from leaking between the hopper and the belt.

The product should not fill the hopper so that the cleats do not pull the bulk good out of a hopper.

Image 38
hopper at loading zone



8.7 The belt

The belt type of choice for a bulk conveyor with troughed roller support should be a lateral flexible belt with a coated top and backside. In outdoor applications rubber belts are often used. The elasticity, moisture resistance and impact resistance of rubber make this material ideal for medium and heavy outdoor applications. Food grade synthetic belts for transportation of bulk goods are often found in light and medium applications. Like transportation of food products: potatoes, sugar, salt, and grain.

9. Swanneck conveyors

Swanneck conveyors or Z-conveyors transport goods to a different level. This type of conveyor combines the feeding part, inclined part, and the outfeed part all into one conveyor (see image 11 and 39). This way two transfer points are eliminated, and products have a smooth travel from one level to the next. Looking at swanneck conveyors from a belting point of view there are some aspects of the conveyor that we need to take into consideration, like for example the position of the drive drum, the concave and convex bends and the rollers that keep the belt into position at the concave bend.

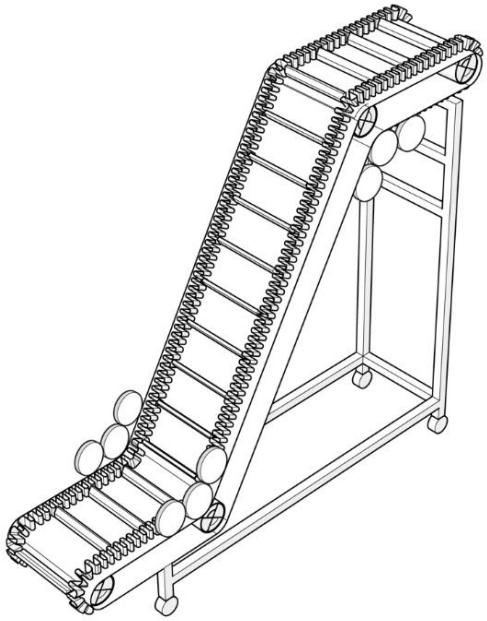
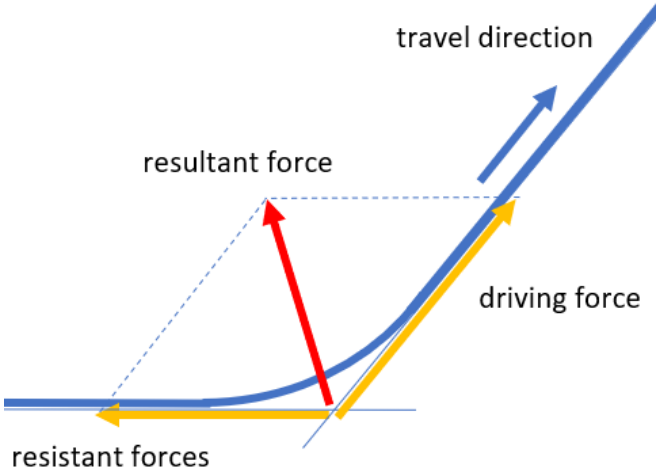


Image 39
swanneck conveyor

9.1 Drive drum

The drive drum must be positioned at the top (head drive), consequently the concave bend with the highest belt tension is the one in the upper part of the belt. The resultant force of the driving force and the forces resisting the belt to move makes the belt want to lift out of the concave bend, see image 40. Lagging the drive drum allows for a lower pretension. A lower pretension means that the total belt tension will also be lower. If the total belt tension is kept to a minimum, the resultant force pulling the belt out of the concave bend is also kept to a minimum.

Image 40
resultant force



9.2 Concave bends

A concave bend is where is a bend in the vertical plane where the belt has to back-flex over the top side of the belt. A swanneck conveyor has two concave bends, one in the upper part and one in the return part. As this type of belt is usually fitted with accessories like cleats, Bordofex, and sometimes longitudinal profiles. As discussed in chapter 7.4 the minimum pulley diameter of the configured belt needs to be checked.

9.3 Retaining rollers

Specific measures must be taken to prevent the belt from coming out of the concave bend. At either side of the belt several retaining rollers, or one large wheel must be placed. If the top side of the belt is hard and wear resistant and both the belt speed and the belt tension are low, static slider shoes can be used. However, rollers are preferred since that solution gives the lowest drag, belt tension, and wear and tear of the belt. For plied synthetic belting in light and medium heavy applications, a minimum radius of the concave bends of 350 mm is advised.

If a belt is held in place with several rollers instead of one wheel-roller, smaller rollers divide the angle of incline into angles of maximum 15 degrees. Never retain a belt in its concave bend with less than 3 rollers at either side of the concave bend, see image 41. The minimum lateral clearance between the rollers and Bordoflex is 10 mm. The minimum width of the roller wheel, rollers or slide-shoes is 50 mm, for swanneck conveyors of 750 mm wide the minimum is 70 mm. The edge of the rollers facing the Bordoflex must be beveled 5x45° or rounded with a radius of 5 mm (see image 42).

Image 41
concave bend, retaining rollers

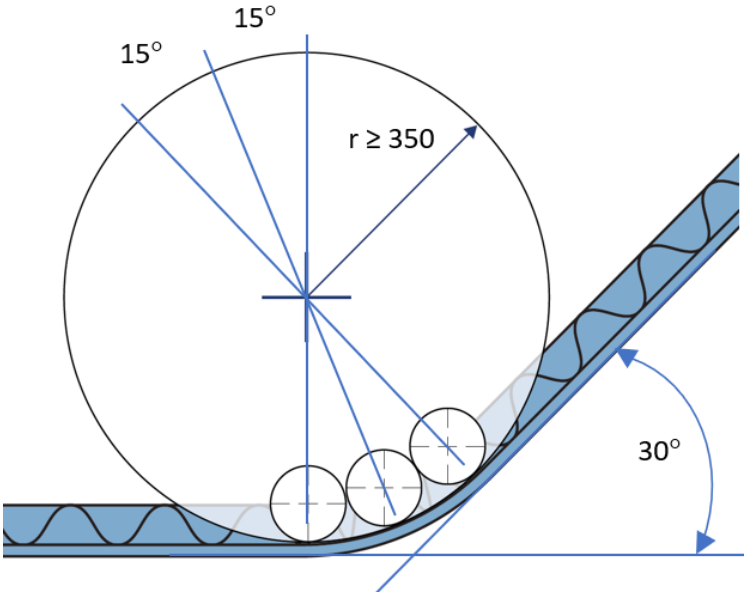


Image 42
profiled retaining roller

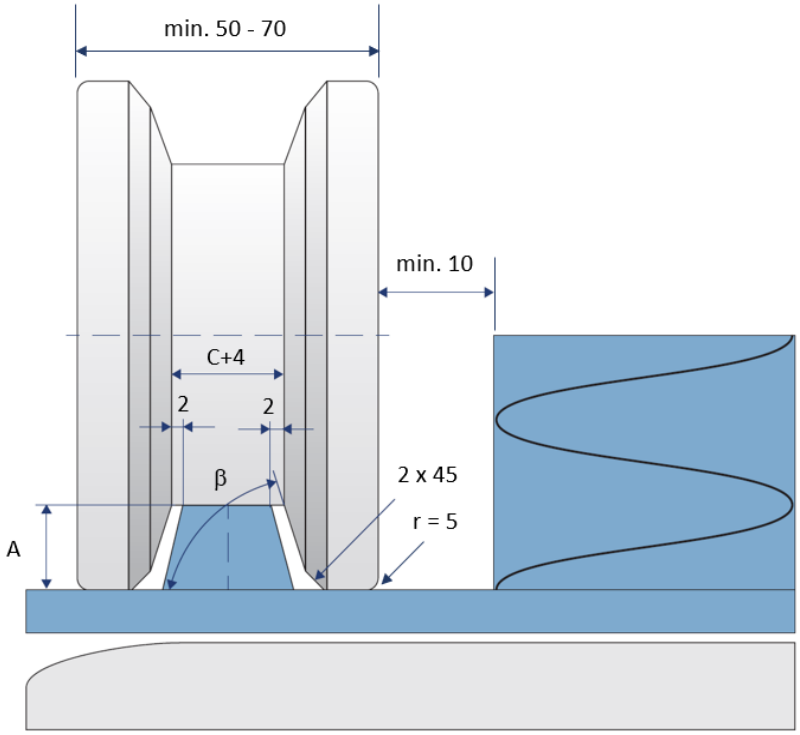


Image 43
Table rope dimentions

Vee ropes

		6x4	8x5	10x6	13x8	17x11	22x14	30x16
A	mm	4	5	6	8	11	14	16
B	mm	6	8	10	13	17	22	30
C	mm	4	5	5.5	7.5	9.5	12.5	20
β	°	76	73	69	71	71	71	73

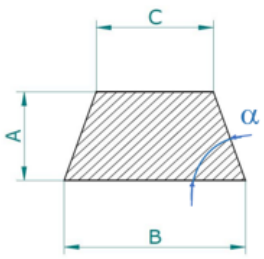
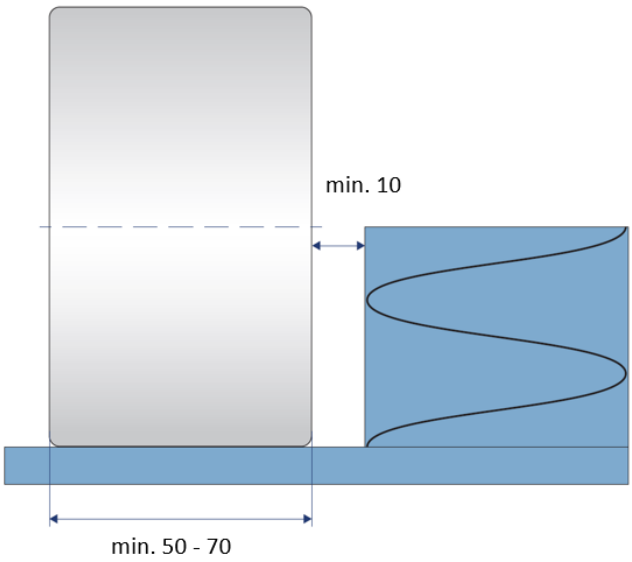


Image 44
flat retaining roller



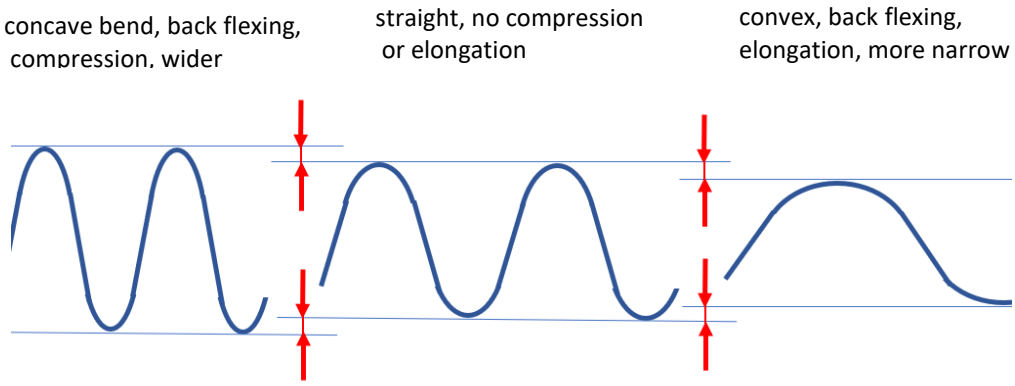
In some applications profiled rollers are used, to provide not only vertical hold-down forces but also to provide extra lateral forces to keep the belt in place. In the concave bend the V-profiles on the top side of the belt are compressed. Also, for that reason there needs to be lateral clearance between the V-profile on the belt and the profiled roller. The belt and profile are held into the groove of the rollers with slider strips of rollers at the backside of the belt, see image 42.

To prevent damage to the sides of the belt from the hold down force of the rollers. The rollers must be rounded at the inside of the conveyor, see image 42. The rollers must be covered at the top, to prevent product from getting between the belt and rollers.

Belt tension elongates a belt if a belt is elongated it also gets narrower. The reduction of the belt width is about one third of the elongation. This means if a belt is elongated at 0.6 % the reduction of width is approximately 0.6 /3 = 0.2%. Especially when constructing wide swanneck conveyors this should be considered. Reduction of the belt width due to belt tension, belt fabrication tolerances and tolerances of the conveyor frame make clearance between rollers and belt parts necessary. It is advised to make the lateral position of the side rollers adjustable.

Some applications require the ends of the cleats to be attached to the Bordoflex side walls. One should keep in mind that the width of the bordoflex changes when rounding the concave and convex bends of a swanneck conveyor. Compressing the bordoflex in the concave bend makes the Bordoflex wider while The Bordoflex is elongated at de convex bend, making it narrower. This variation stresses the connection between cleats and Bordoflex, see image 45.

Image 45
Bordoflex elongation, compression



9.4 Belt tracking

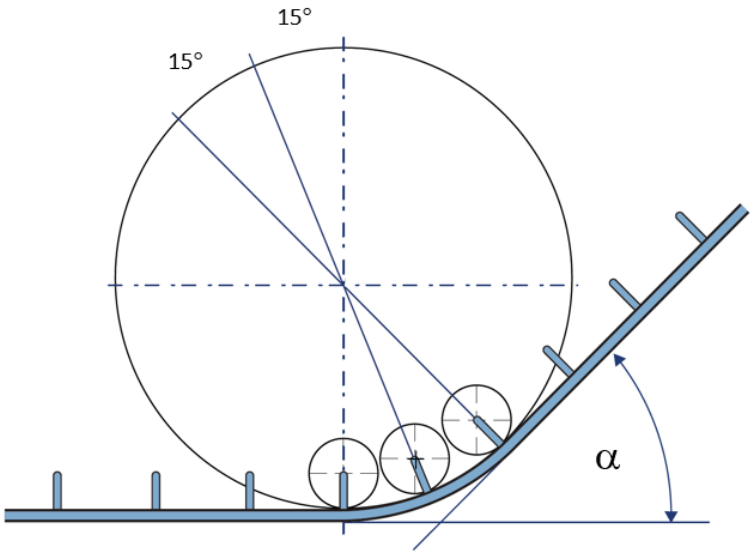
The options for tracking the belt on a swanneck conveyor are similar to tracking a regular conveyor belt. Crowning the drive and the tail drum are highly effective tools to center a swanneck belt. For crowning to be an affective tracking tool a minimum belt tension of 0.2% is required. The support roller at the convex bend at the top can function as a tracking roller. Also, the support rollers in the convex bends, indicated with TR in image 5 and 6, can be used to further support proper belt tracking.

9.5 Lateral stiffness of the belt

The lateral stiffness of a belt for a swanneck conveyor together with the rollers at the side keep the belt from coming out of the concave bend. The belt type of choice is a two, but even better a three ply extra lateral stable belt. Stiff cleats like thick solid TPU cleats or better still fabric reinforced cleats increase the lateral stability of the configured belt. We advise cleats to be placed with a center-to-center distance that equals the distance of the retainer rollers in the concave bend as shown in image 46.

If the center-to-center distance of the cleats is less than the width of the press used to splice the belt endless, one cleat must be placed over the splice area after splicing. In practice the center-to-center distance of cleats is not smaller than 100 mm.

Image 46
cleats in concave bend



Cleats in a curve or chevron shape contribute less to the lateral stability of the belt than straight lateral cleats.

Center-to-center distance of the cleats = center-to-center distance of the retainer rollers and not smaller than 100 mm

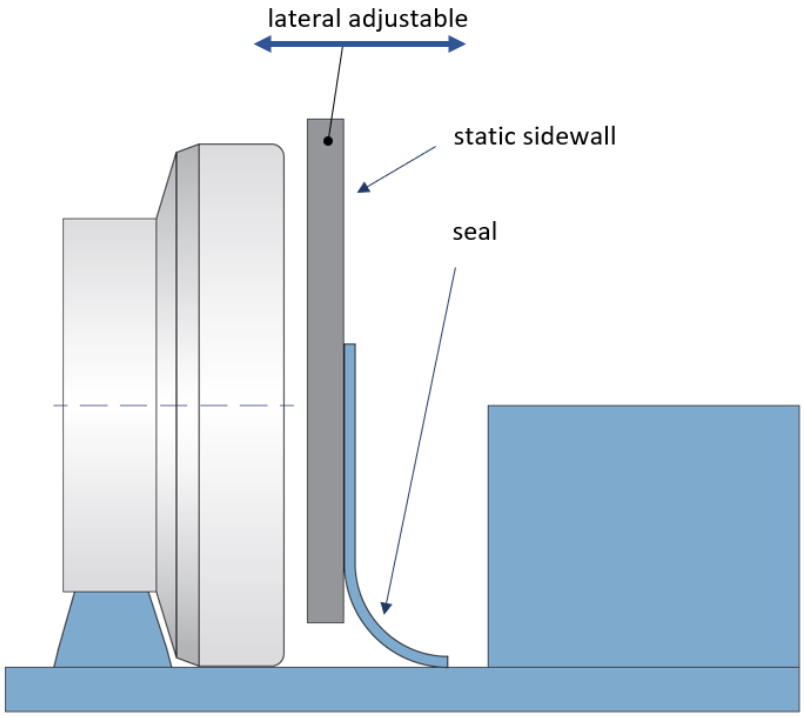
9.6 Belt splice.

The preferred splice in a swanneck conveyor is a step splice. The reason for this is that a belt with a finger-overlap-finger splice is less lateral stable in the splice area.

9.7 Static sidewalls

Some conveyor designs have static sidewalls that are attached to the conveyor frame, see image 47. Sidewalls like that should be positioned as close to the cleats as possible to prevent product leaking downwards and to have the side rollers positioned as close to the cleats as possible optimizing lateral stability. The nature of the product being conveyed sometimes makes it necessary to have a seal between the sidewall and the belt. The lateral position of the sidewalls must be adjustable see image 47.

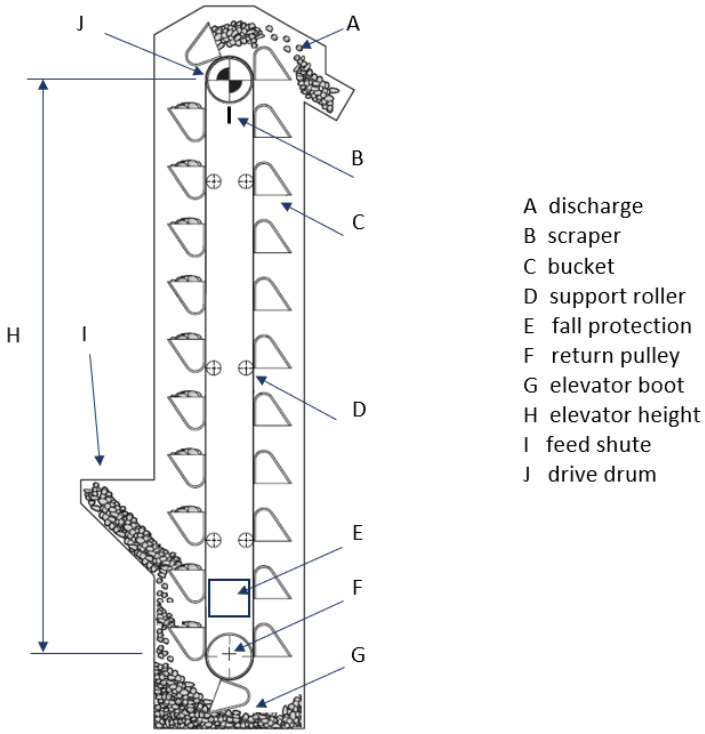
Image 47
static sidewall



10. Bucket elevators

The function of a bucket elevator is to transport bulk goods vertically. Examples of bulk goods are sand, gravel, chippings, coal, cement, fertilizer, grain, flour, salt, and sugar. A belted bucket elevator is a vertical conveyor with buckets attached to a conveyor belt. At the loading point the product is poured into buckets and/or scooped up by buckets. The product is then conveyed vertically upward and discharged when rounding the upper drum. Depending on the type of product and the belt speed the product is discharged from the buckets by just gravity, by centrifugal forces or a combination of the two. Image 48 shows the parts of a bucket elevator that are most relevant for belt suppliers.

Image 48
bucket elevator



10.1 Buckets

Bucket elevators with a gravity discharge have a continuous bucket placement (image 51), the buckets are placed close to each other. Bucket elevators with gravity discharge run at a low belt speed of less than 1.2 m/s. Whereas elevators with a centrifugal discharge run with a belt speed over 1.2 m/s and have a spaced bucket placement (image 52). In both cases the buckets are bolted to conveyor belt with specially designed bolts, nuts, and washers (image 53). In case the product that is conveyed is hot it is advised to place a temperature insulating material between the buckets and the belt surface, especially in the case of metal buckets.

There are several types of buckets the material, shape and size of choice depends on

the type of product: is it fine, coarse, or lumpy? Does it flow well or is it sticky? Food products require food grade buckets. The table in image 49 and image 50 give an indication of what bucket design to use in what application.

Image 49
table of belt speed gravitational and centrifugal discharge

belt speed m/s	belt speed category	type of discharge	loading	product	bucket type, DIN
< 1	low	gravitational	direct or scoop	heavy powdery, granular, ballast, earth, cement, coal, sand, gravel	deep, back wall curved DIN 15234, DIN 15235
1 - 2	high	centrifugal	direct or scoop	sand, fertilizer, cane sugar, cement, gypsum	flat, flat rounded, medium deep DIN 15232, DIN 15233
> 2	very high	centrifugal	direct or scoop	free flowing, light, easy to scoop, grain, seeds, grit, flour, poudery	flat, flat rounded, medium deep DIN 15231, DIN15232

Image 50
DIN buckets

Image 51
continuous bucket placement,
gravity discharge

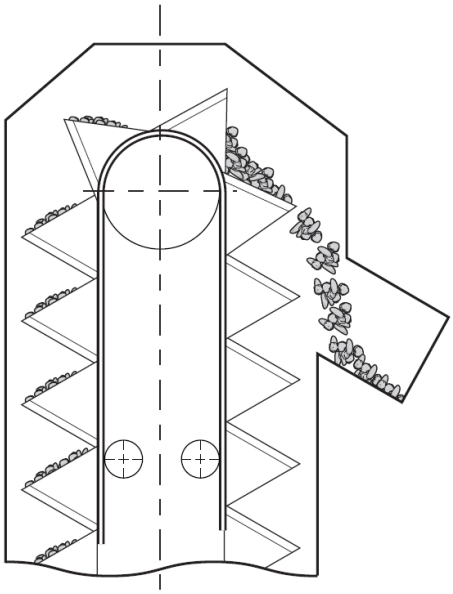


Image 52
spaced bucket placement
centrifugal discharge

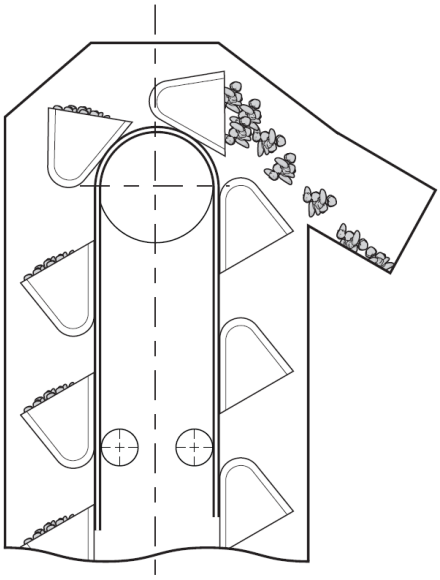
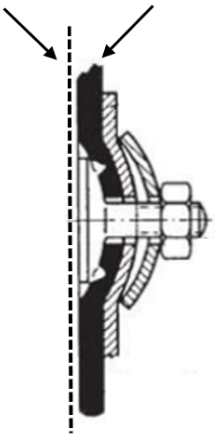


Image 53
bolts and washers

Elevator belt bolt, nut, and washer
According to DIN 15237

Flat at the back side Belt material
of the belt



10.2 The elevator belt

The belt type used in light and medium weight elevator applications are often high strength, tear resistant fabric reinforced rubber or synthetic belts with 2 or more fabric reinforcement plies. Elevator belts have a top- and bottom coating to protect the layers of reinforcement. In more heavy applications steel cord reinforced rubber belts are used. In all cases the belt of choice should meet the specific application requirements, such as for example food approvals, flame retardancy or ATEX-requirements.

Synthetic elevator belts with multiple plies have the advantage of having low elongation compared to mono-ply (solid woven) synthetic belts and rubber fabric reinforced elevator belts. Often the available take-up length is limited, for that reason elevator belts with high elongation must often be shortened.

10.3 Loading the buckets.

There are two ways of filling the buckets with product. One is simply to scoop up the product from the bottom of the elevator, see image 54. This is only possible when the product is loose and free flowing. The other method, for less free flowing products, is to directly load the product into buckets. With direct loading product is loaded into the buckets from above and the material that is spilled is not scooped up by the buckets but transported back up by for example a screw-conveyor, see image 55.

Image 54
scoop loading

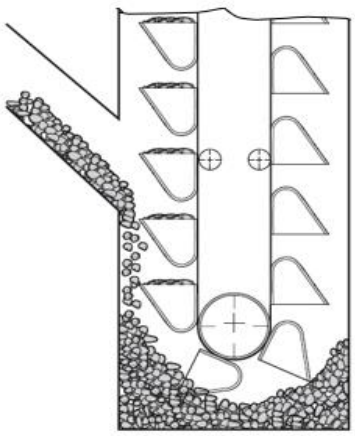
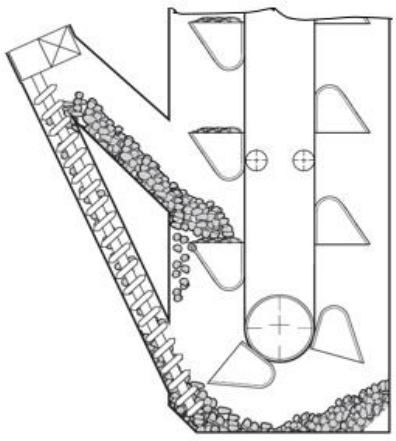


Image 55
direct loading



10.4 Calculation of a bucket elevator belt

When calculating the belt tension in a certain elevator belt application with the calculation tool from Ammeraal Beltech a safety factor of 10 is applied. This means a safe working load for an elevator belt is 10% of the breaking strength (=tensile strength) of the belt. Bucket elevator belts can be endlessed by means of a hot splice, mechanical fasteners an oil-well splice or for example a but strap splice. All these types of slices, provided they have been executed correctly, offer enough strength to operate at the safe working load. The operating conditions such as an elevated temperature, contact with chemicals or conditions the cause excessive wear could make it necessary to increase the safety factor. Some bucket elevators are placed outdoors to fill large silos. When operating in cold conditions it is advised to start the elevator belt slowly to give it the opportunity to warm up. In both warm and cold conditions, the mechanical properties of a conveyor belt are reduced.

10.5 Endlessing bucket elevator belts

Hot (vulcanized) splices can only be used when there is sufficient take-up length available, so that the belt does not have to be shortened to maintain the pretension needed to drive the belt free of slippage.

Oil-well splices are commonly used, see image 58. They do not influence the minimum pulley diameter of the belt as much as a lap joint or a butt strap joint would (image 56 and 57).

Image 56
lap joint

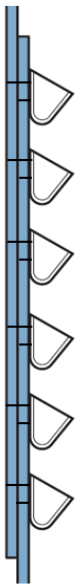


Image 57
butt strap joint

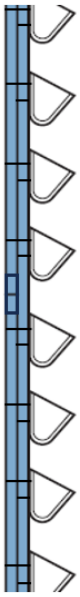
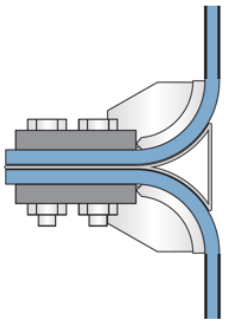


Image 58
oil-well splice



10.6 Drive drum and support rollers

The top pulley is also the drive drum. It can be lagged to increase friction and prevent slippage. It should be large enough to meet the specifications of the belt manufacturer. Support rollers (image 48, D) are fitted to support the backside of the elevator belt.

If the drive drum at the top of the conveyor is not lagged a scraper (image 48, B) can be used to keep product from building up on the surface of the drive drum and causing belt misalignment. The drive drum is often crowned to support belt tracking.

10.7 Other conveyor parts

Most bucket elevators suffer from product falling to the bottom of the elevator. Product spills over the edge of the buckets and when it is discharged into the discharge shute. To prevent product from getting between the belt and the return pulley as much as possible, a falling protection is fitted. Additionally, the return pulley (image 48, F) at the bottom side of the bucket elevator is often of an open cage design.

Infeed and discharge shutes; Depending on the type of product the discharge shute can be fitted with a protective wear lagging. A system to detect if a plugged shute will stop the conveyor to prevent damage to belt, buckets, or other conveyor parts.

10.8 Monitoring systems and back stop

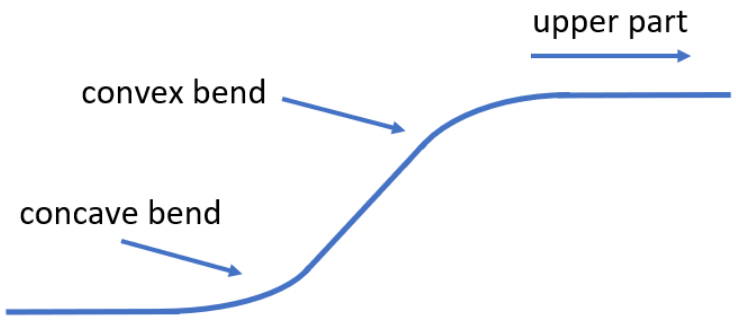
Bucket elevators are completely encased conveyor systems. Because of this that operators do not easily detect problems and malfunctions. For that reason, bucket elevators are often fitted with multiple monitoring systems to detect belt slippage, misalignment, plugged shutes, an elevated operating temperature, belt tensioning weight switched to detect when the belt tension is too low.

A bucket elevator should be equipped with a backstop, preventing the belt from starting to run backward when fully loaded. Even with all the systems in place a regular and thorough check of the complete elevator system is necessary.

11. Summary

11.1 Summary inclined conveying general

- Transportation of a box from a horizontal conveyor belt to an inclined conveyor belt will cause some product slippage.
- Avoid staggering products in a concave bend.
- If necessary, split up large convex bends into smaller ones.
- The feeder belt should have a lower coefficient of friction to the product than the inclined belt.
- If necessary, split up large convex bends into smaller ones of for example 15° degrees.
- Don’t fill a hopper so that the cleats have to pull the bulk product out of the hopper.
- Application factors like wear of the belt surface, pollution, dust, wind, moisture, and temperature are of influence on the actual COF between belt and product.
- A smooth slider bed support offers a larger maximum angle of inclination than a roller support.
- A box with a uniform weight distribution will not tumble down if the angle of incline is smaller than the angle at which the line of gravity intersects with the bottom of the box over 1/3 of the base.



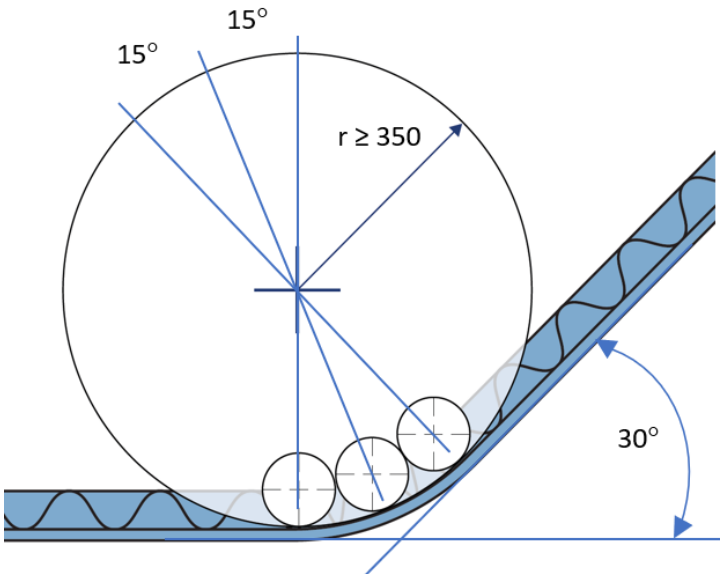
Indication of maximum angle of incline

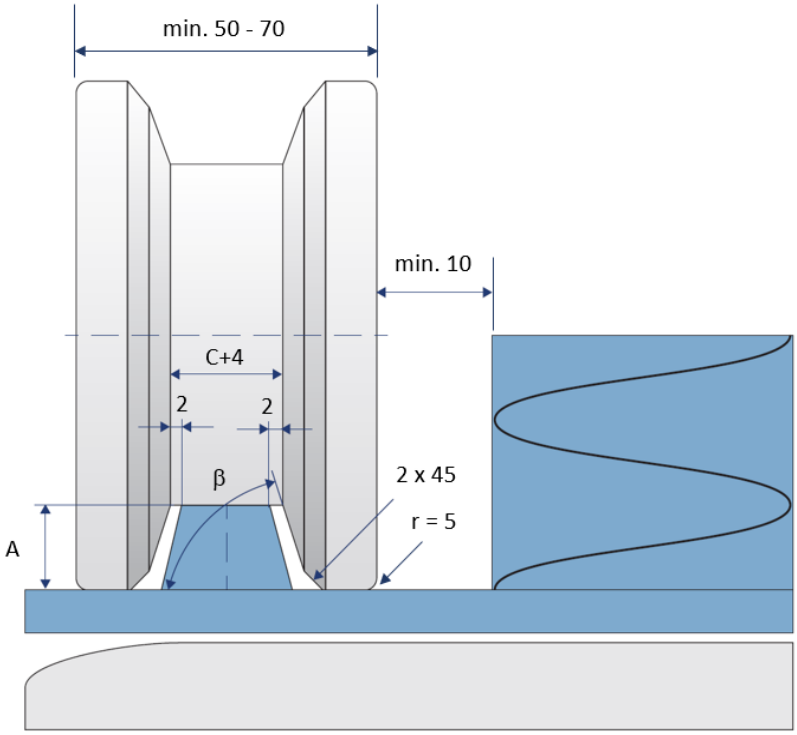
Belt type	Indication of max. angle of incline in degrees
High friction top cover (e.g. Soft PVC or (silicone) rubber)	< 20°
Embossed top cover (e.g. A32 of A42 supergrip)	< 40°
transverse belt accessories (e.g. ropes or cleats)	> 40°
bucket elevators (for bulk materials)	vertical

11.2 Summary swanneck conveyors

- For swan neck conveyors, use extra lateral stable belts of 2 or more plies.
- Use stiff, reinforced cleats.
- There should always be at least two cleats in the concave bend of the belt.
- In practice the center-to-center distance of cleats is not smaller than 100 mm
- The minimum radius of a concave bend Ø 350 mm.
- Place retainer rollers a large retainer wheel at both sides of the belt.
- Using low friction slider shoes instead of retainer rollers is only an option when the top cover of the belt is wear resistant and the belt speed is low.
- If retainer rollers are applied, use a minimum of 3 rollers to divide the 180°- the angle of incline into multiple angles of maximum 15° degrees.
- Apply a minimum of 10 mm clearance between retainer rollers and Bordoflex.
- Belt tension elongates a belt, at the same time the belt gets narrower. Belt width reduction = 1/3 * belt elongation.
- Height of the Bordoflex = height of the cleats + 10 mm.
- Stiff (reinforced) cleats.
- To support the lateral stability of the belt it is advised to place the cleats at a center-to-center distance that equals the distance of the retainer rollers in the concave bend.

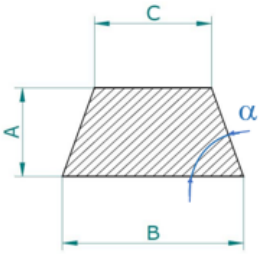
- Use straight lateral cleats, instead of curved or chevron cleats to optimize the lateral stability of the belt.
- The rollers have a minimum width of 50 mm. For swanneck conveyors of 750 mm wide the minimum width of the rollers is 70 mm.
- The rollers should have beveled edges (5 x 45°) or rounder edges r = 5 mm.
- V-profiles and profiled rollers help to keep the belt in the concave bend.
- Mind that angle of the profiled rollers match that of the V-profile used and have clearance.
- Retainer rollers must be adjustable in lateral position.
- Apply a cover over the side rollers to prevent product from getting between the rollers and the belt.
- Conveyors designed with static sidewalls must have a seal to prevent pollution from product leaking under the static sidewalls.
- Static side walls should be adjustable in center-to-center distance.
- Crown the drive drum and the tail pulley to support belt tracking.
- The support rollers in the convex bends can be made adjustable to support belt tracking.
- Belts for applications with a concave bend must be endlessed with a step splice.
- When flexing a Bordoflex it gets narrower, when back flexing it gets wider.
- Static side walls must be adjustable in lateral position.

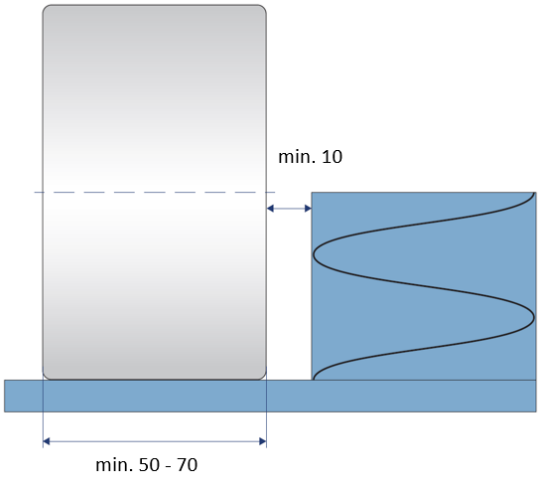


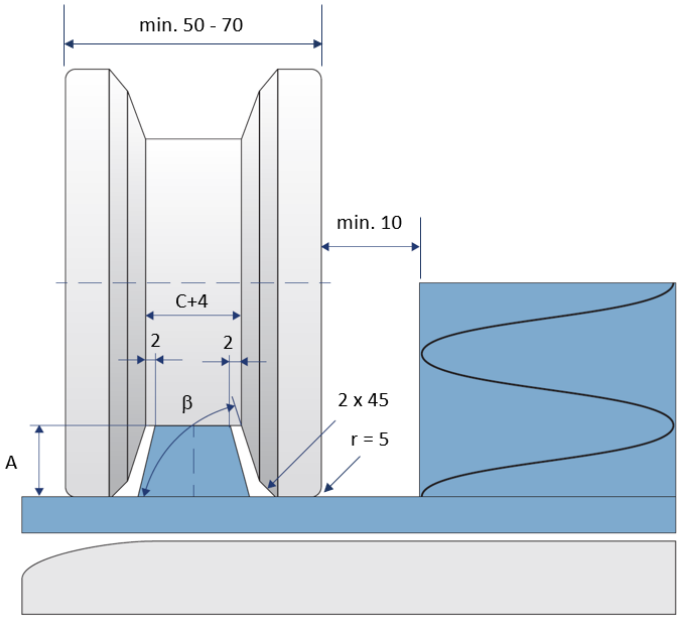


Vee ropes

		6x4	8x5	10x6	13x8	17x11	22x14	30x16
A	mm	4	5	6	8	11	14	16
B	mm	6	8	10	13	17	22	30
C	mm	4	5	5.5	7.5	9.5	12.5	20
β	°	76	73	69	71	71	71	73







Vee ropes

		6x4	8x5	10x6	13x8	17x11	22x14	30x16
A	mm	4	5	6	8	11	14	16
B	mm	6	8	10	13	17	22	30
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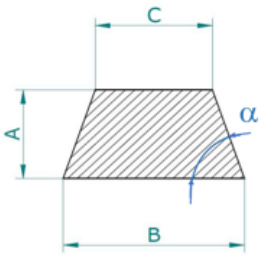
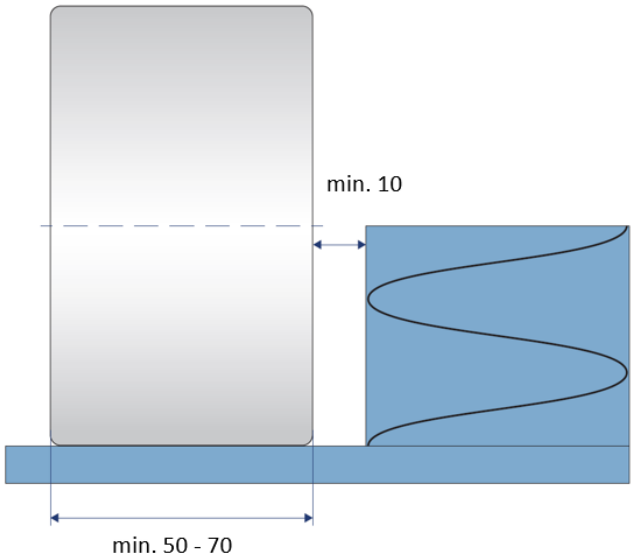
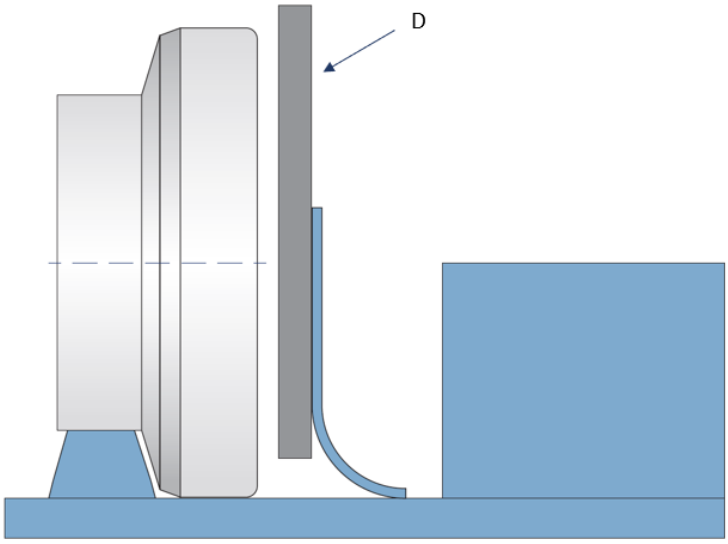
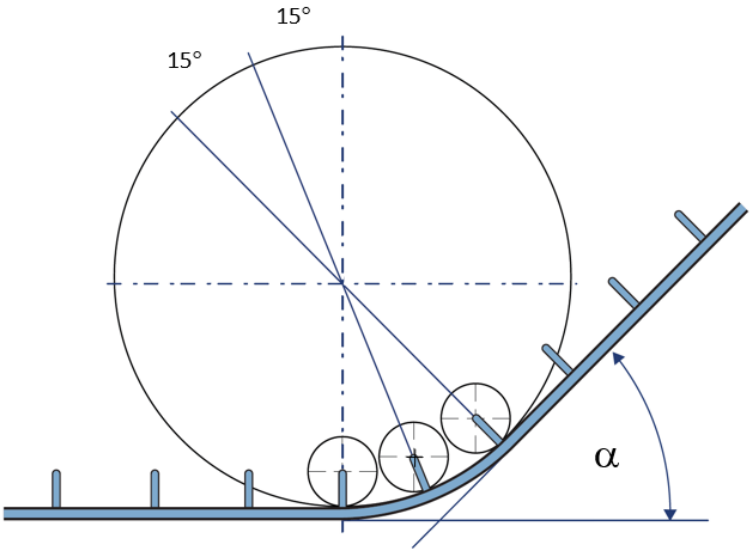
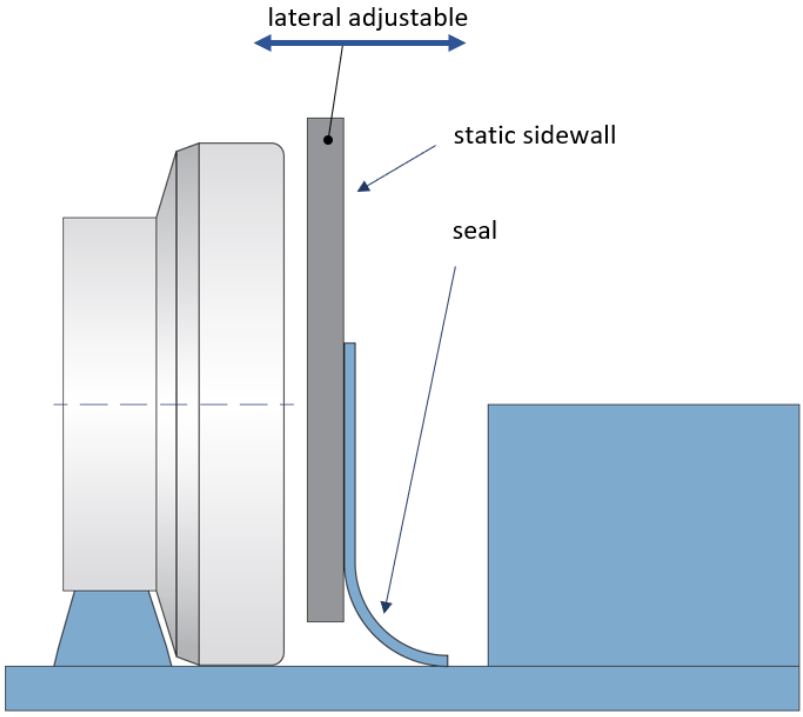
β	°	76	73	69	71	71	71	73





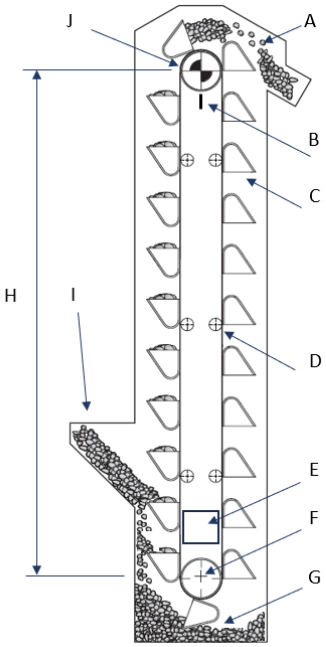






11.3 Summary bucket elevators

- Bucket elevators with gravity discharge have continuous bucket placement.
- Bucket elevators with gravity discharge run at a belt speed < 1.2 m/s.
- Bucket elevators with centrifugal discharge have spaced bucket placement.
- Bucket elevators with centrifugal discharge run at a belt speed > 1.2 m/s.
- The drive drum can be lagged to increase friction with the elevator belt.
- If the drive drum is not lagged, a scraper can be applied.
- The tail drum is often of an open cage design to dispose of prevent product from getting between belt and drum causing belt misalignment.
- Crown the drive drum and the tail pulley to support belt tracking.
- The tail drum at the bottom is used to tension the elevator belt.
- The tail drum at the bottom is often of an open cage design to
- An oil-well splice is most common for endlessing an elevator belt.
- For elevator belt calculations a safety factor of 10 is applied. This means the safe working load is 10% of the breaking strength of the belt.
- At more demanding applications, such as elevated operating temperatures, the safety factor must be increased.
- A well-designed bucket elevator has several safety systems in place that monitor things like: belt slippage, misalignment, plugged shutes, operating temperature, belt tension switches and a backstop system.



A discharge
B scraper
C bucket
D support roller
E fall protection
F return pulley
G elevator boot
H elevator height
I feed shute
J drive drum

belt speed m/s	belt speed category	type of discharge	loading	product	bucket type, DIN
< 1	low	gravitational	direct or scoop	heavy powdery, granular, ballast, earth, cement, coal, sand, gravel	deep, back wall curved DIN 15234, DIN 15235
1 - 2	high	centrifugal	direct or scoop	sand, fertilizer, cane sugar, cement, gypsum	flat, flat rounded, medium deep DIN 15232, DIN 15233
> 2	very high	centrifugal	direct or scoop	free flowing, light, easy to scoop, grain, seeds, grit, flour, poudery	flat, flat rounded, medium deep DIN 15231, DIN15232

Oil-well splice