SECTION 2

LOADING THE BELT

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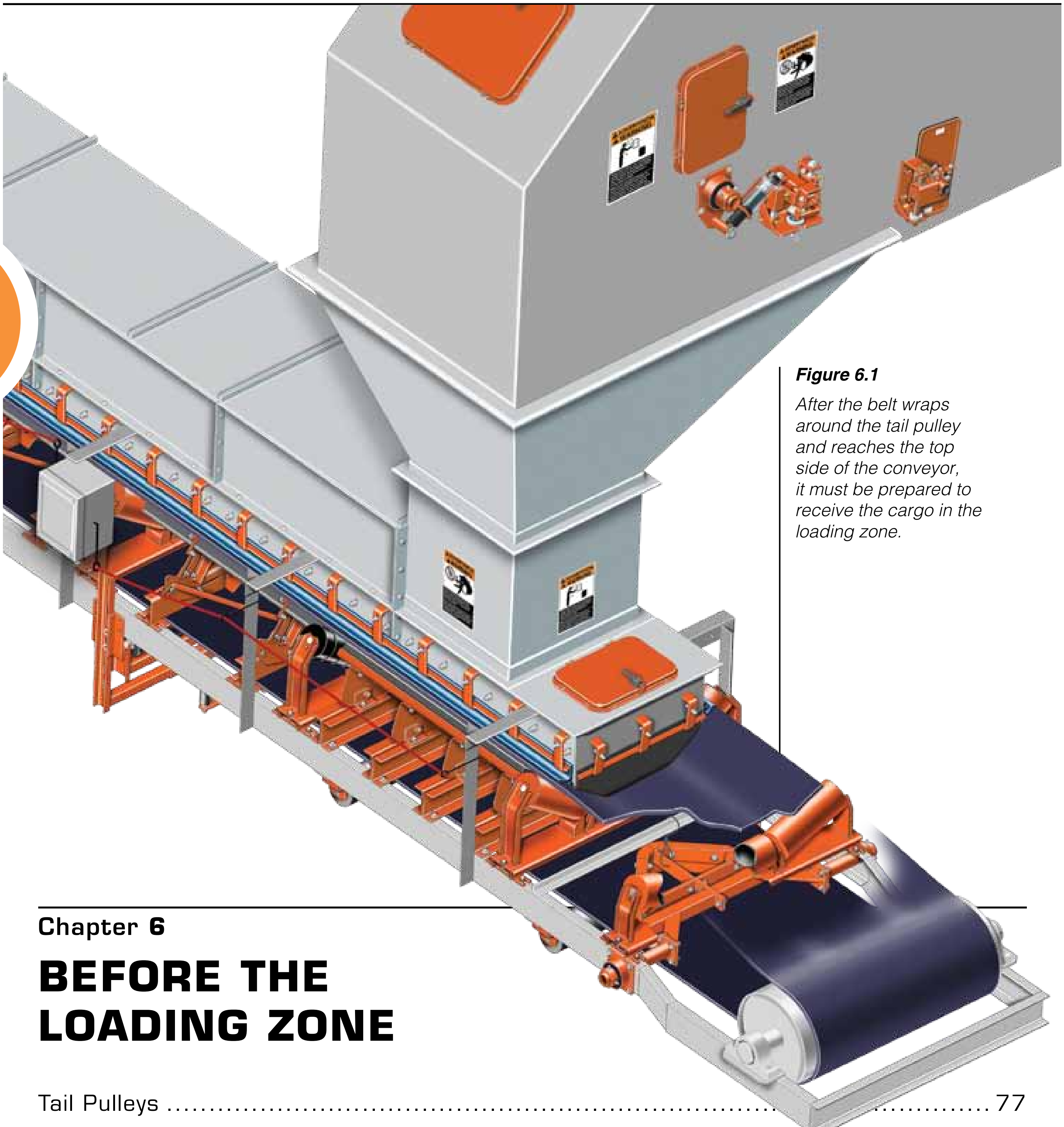

Figure 6.1

After the belt wraps around the tail pulley and reaches the top side of the conveyor, it must be prepared to receive the cargo in the loading zone.

Chapter 6

BEFORE THE LOADING ZONE

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In this Chapter...

Before a conveyor belt can be loaded, it must be transformed into the shape that will carry the bulk materials. This chapter examines transition areas, the areas between the terminal pulleys and the first fully-troughed idlers, looking at how a belt is formed into a trough and the importance of utilizing the proper transition distance to change the belt shape. The chapter also examines tail pulleys, looking at proper pulley configuration and location. Also considered are techniques to prevent the escape of fugitive material at the tail of the conveyor.

At the end of the conveyor's return run, the belt wraps around the tail pulley and moves up onto the top, or carrying side. It is here the belt must be prepared to receive cargo before entering the loading zone (**Figure 6.1**). These preparations include stabilizing the belt path, centering the belt on the structure, shaping the belt into the desired profile for load carrying, and sealing the back and edges of the load zone to prevent spillage.

Care must be taken in accomplishing these tasks in order to minimize fugitive material—material that has escaped from the conveyor and the process—both in the transition area and the conveying process, as well as preserving the equipment and preparing the conveyor for maximum efficiency.

In many plants, this area of the conveyor system is notorious for spillage problems and for employee injuries. This chapter will discuss ways to properly transform the belt from flat to troughed for loading and back to flat at the discharge without increasing fugitive material and employee risk.

TAIL PULLEYS

Centering the Belt

Having the belt in the center of the conveyor structure as it goes into the loading zone is critical. If the belt is not properly centered when it receives the load, the force of loading will increase belt misalignment and compound other problems encountered on the conveyor's carrying side.

The area between the pulley and the load zone is too short and the belt has too much tension to allow for mistracking correction here, so belt-centering devices are installed on the conveyor's return to make sure the belt is centered as it enters (and exits) the tail pulley. If the belt, centered at its entry to the tail pulley, mistracks between the pulley and the load zone, most likely the problem is that the pulley is out of alignment. If the tail pulley is straight and a tracking device is installed, the belt should be centered in the load zone. *(See Chapter 16: Belt Alignment.)*

Tail Pulleys: Wings and Wraps

Wing-type tail pulleys are often installed as a method to reduce the risk of belt damage from the entrapment of lumps of material between the belt and the pulley. Wing pulleys feature vanes that resemble the paddle wheel on a steamboat (**Figure 6.2**). This design allows material that would otherwise become trapped between a solid pulley and the belt to pass through the pulley face. Between the pulley's crossbars are inclined, valley-shaped recesses that prevent fine or granular material from being caught between the tail pulley and the return belt. These valleys provide a self-cleaning function; that is, there is little surface area on which material can accumulate, and the rotation of the pulley throws the material off the pulley's face (**Figure 6.3**). If the

Figure 6.2

Wing pulleys incorporate vanes like the paddle wheel of a steamboat.

conveyor is likely to spill some of its cargo onto the return belt, the wing pulley can act as an effective device for removing this spillage without belt damage, although proper sealing of the belt at the load zone along with installation of a pulley-protection plow is the preferred solution.

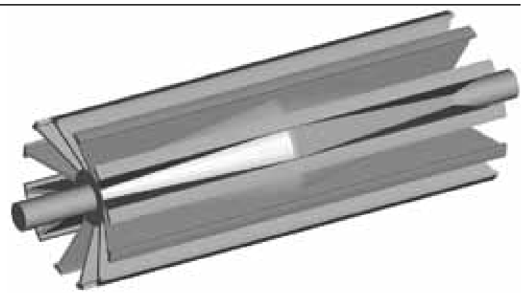

Figure 6.3

The valleys in the wing pulley serve to cast out material accumulations.

Figure 6.4

Lumps of material can be caught in the valleys of the wing pulley.

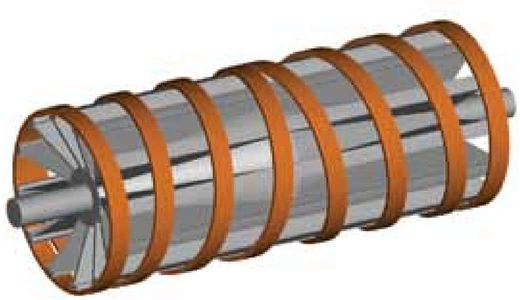

Figure 6.5

A wrapped pulley will eliminate the vibration of the wing pulley while still preventing material accumulation.

Figure 6.6

A steel band wrapped in a spiral around the pulley can eliminate some of the problems of the wing pulley.

Wing-type pulleys are also seen on gravity take-ups, where they offer the same benefits and limitations.

Despite their design intention, wing-type tail pulleys are still subject to buildup and entrapment and often do not provide the desired protection. They are most successful on slow-moving belts where cleaning and sealing are not critical requirements. Larger lumps of material can become wedged in the "wings" of the pulley, potentially causing the damage the pulley was designed to avoid (**Figure 6.4**).

Wing-type tail pulleys with less than the manufacturer's recommended minimum bend radius can cause damage to the conveyor belt's carcass.

The most significant drawback of wing pulleys is the oscillating action they introduce to the belt path. The wings on the pulley introduce a pulsating motion that destabilizes the belt path and adversely affects the belt-sealing system. It is counterproductive to design a transfer point that emphasizes belt stability to minimize fugitive material and then install a winged tail pulley that introduces instability into the system. The Conveyor Equipment Manufacturers Assocation (CEMA) recommends that wing pulleys not be used on belts traveling over 2,25 meters per second (450 ft/min).

A better choice than the conventional winged tail pulley is a spiral-wrapped tail pulley (**Figure 6.5**). These pulleys have an additional steel strip wrapped in a spiral around the pulley circumference. The steel band is wrapped over the top of the wings in two spirals, converging in the center from each end of the pulley. Wrapping the band(s) of steel around the wing pulley allows the pulley to provide the self-cleaning function but eliminates the "bounce" imparted to the belt.

Spiral-wrapped wing pulleys are sometimes installed as original equipment on new conveyor installations. Existing wing pulleys can be upgraded with narrow, 50 to 75 mm (2 to 3 in.), steel strips welded around the outside edge of the wings (**Figure 6.6**).

The best solution to preventing material buildup on tail pulleys is to use a solid flat steel pulley, protected by a cleaning device located directly in front of the pulley (**Figure 6.7**). This diagonal or V-type plow should be located just prior to the tail pulley on the non-carrying side of the belt to remove any fugitive material that may be carried on the inside of the belt. *(See Chapter 15: Pulley-Protection Plows.)*

Crowned Pulleys

A straight-faced pulley is the same diameter across the face of the pulley. A crown-faced pulley changes in diameter from the outer edges to the center of the pulley, with the center being slightly larger than the edges (**Figure 6.8**).

Crowned pulleys are sometimes used at the conveyor tail as it is widely believed that the crowned face will improve the tracking of the belt as it goes around the pulley and into the loading zone. However, this is not always true, and there are instances where the crown face of the pulley can actually damage the belt.

Crown-faced pulleys should never be used in a high-tension area of the belt. This is usually the driven pulley. The driven pulley may be at the head end, the tail end, or, with a center drive, anywhere along the return side of the conveyor. In these high-tension areas, the additional diameter in the center of the pulley adds additional stress to the center of the belt and may cause carcass and lagging damage. The exception to this is when the rated tension of the belt is 35 kilonewtons per meter (200 PIW) or less; then a crowned pulley may be used anywhere in the system.

In lower tension areas of the belt, crowned-faced pulleys may have a slight influence on belt tracking. However, if there are serious problems with the belt such as belt cupping, belt camber, or idler-junction failure, no amount of pulley crown will track the belt. It is always best to identify the cause of the mistracking and cure the problem. *(See Chapter 16: Belt Alignment.)*

Crown pulleys also present problems with belt cleaners mounted on the face of the discharge pulley.

CONVEYORS FLAT AND TROUGHED

Flat Belts

Many bulk materials can be carried on flat belts. Flat belts are particularly common for materials with a steep angle of repose, the angle that a freely formed pile of material will make. Materials with angles of repose above 30 degrees are materials suitable for flat belts and range from irregular, granular, or lumpy materials like coal, stone, and ore, to sluggish materials that are typically irregular, stringy, fibrous, and interlocking, such as wood chips and bark (**Figure 6.9**). When maintaining the same edge distance with materials with a low angle of repose, the volume of material conveyed is reduced; therefore, materials with a low angle of repose generally require the belt to be troughed.

Figure 6.7

A plow is positioned in front of the pulley to protect the pulley from lumps of material.

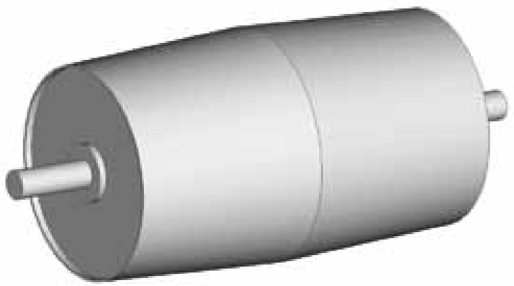

Figure 6.8

A crowned pulley is slightly larger in the center than at the edges.

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Flat belts are especially effective when the load, or a portion of the load, is to be discharged from the belt at intermediate points by plows or deflector plates.

Belt feeders use flat belts almost exclusively. This is because feeders are generally very short, and they must fit into operations where there is little room to form the belt into a trough. Feeders typically operate with very high loads and use heavy-duty idlers. Many feeder belts can reverse direction. To move a large material load, feeder belts often run at high tension, making it difficult to trough a belt. In addition, the high head load of belt feeders makes sealing difficult. This difficulty can be overcome by leaving generous edge distances and operating at slower speeds; then spillage from these belt feeders can be controlled. In many cases, these belts are equipped with a skirtboard and a sealing system along their full length. Other feeder belts incorporate dual chutewall design, where a space is left between the interior chutewall installed with a wear liner and an outside chutewall that includes the belt's edge seal (**Figure 6.10**).

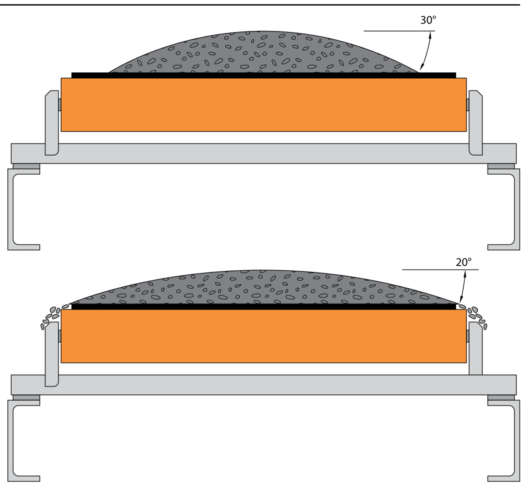

Figure 6.9

Materials with a high angle of repose can be carried on flat belts. For materials with a low angle of repose, carrying the same volume of material would result in spillage off the belt; therefore, materials with a low angle of repose generally require the belt to be troughed.

Figure 6.10

Some belt feeders incorporate a dual wall system with space between the wear liner and the outside chutewall.

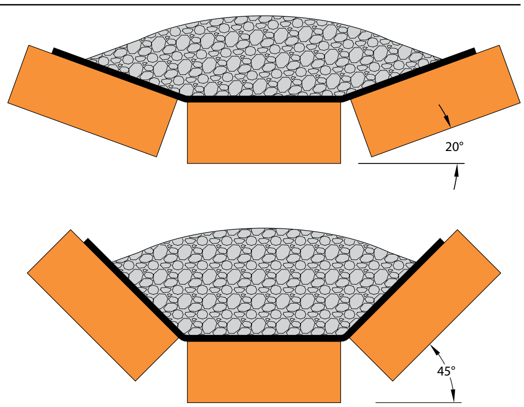

Figure 6.11

Forming the belt into a trough generally increases the capacity of the conveyor.

Flat belts do not require the transition areas or suffer the transition problems encountered by troughed conveyors. However, most of the other conveyor components and problems discussed in this book will apply to flat belt conveyors.

Troughed Conveyors

For most materials and most conveyors, the forming of the belt into a trough provides the benefit of a generous increase in the belt's carrying capacity (**Figure 6.11**).

Typical Trough Angles

The standard trough angles in Europe are 20, 30, and 40 degrees; in North America, trough angles of 20, 35, and 45 degrees are common (**Figure 6.12**). However, with an ever-increasing global economy, one might find conveyors of any trough angle in any location around the world. At one time, the 20-degree trough was standard, but the deeper troughs have become more common as improvements in belt design and construction allow greater bending of belt edges without premature failure. In some special applications, such as high-tonnage mining, catenary idlers with a 60-degree trough are used to reduce spillage and impact damage.

Longer, higher speed conveyors may require the use of a thick belt, often with steel cords in the carcass. As a result, these belts may have less trough capability. Because of the lower bend requirements and the resulting reduction of stress in the belt, a 20-degree trough permits the use of the thickest belts, thereby allowing the heaviest materials and largest lumps to be carried.

Troughing angles steeper than 20 degrees are usually specified when the material has a low angle of repose. Higher troughing angles are suitable for a very broad range of applications. Higher trough angles work best when allowances are made for constraints such as limitations in transition distance and the requirement for exposed edge distance for skirt sealing.

While they offer the benefit of greater capacity, troughed belts also present some limitations. An area that can present problems, if not properly considered during the conveyor design and belting specification process, is the longer transition distance required to prevent stress at the belt edges. Other disadvantages of the steeper trough angles include a greater vulnerability to the effect of wind and higher potential for damage to the belt.

Troughing the belt typically makes a positive contribution to belt tracking. Another benefit of a troughed belt includes improved ability to contain material as a result of reduced edge spillage and loss due to wind.

Generally speaking, the selection of the angle of trough to be used on any conveyor is in most cases determined by the requirement to use the least expensive, and hence the narrowest, belt possible to transport the required tonnage of material.

FORMING THE TROUGH

Transition

On a typical conveyor, the belt is troughed for the carrying portion of its journey and returned to a flat configuration for the return run. Consequently, at a terminal (head or tail) pulley, the belt must be converted from flat to troughed shape or from troughed back to flat. This changing of the belt's profile is commonly called the transition (**Figure 6.13**). Transitions exist

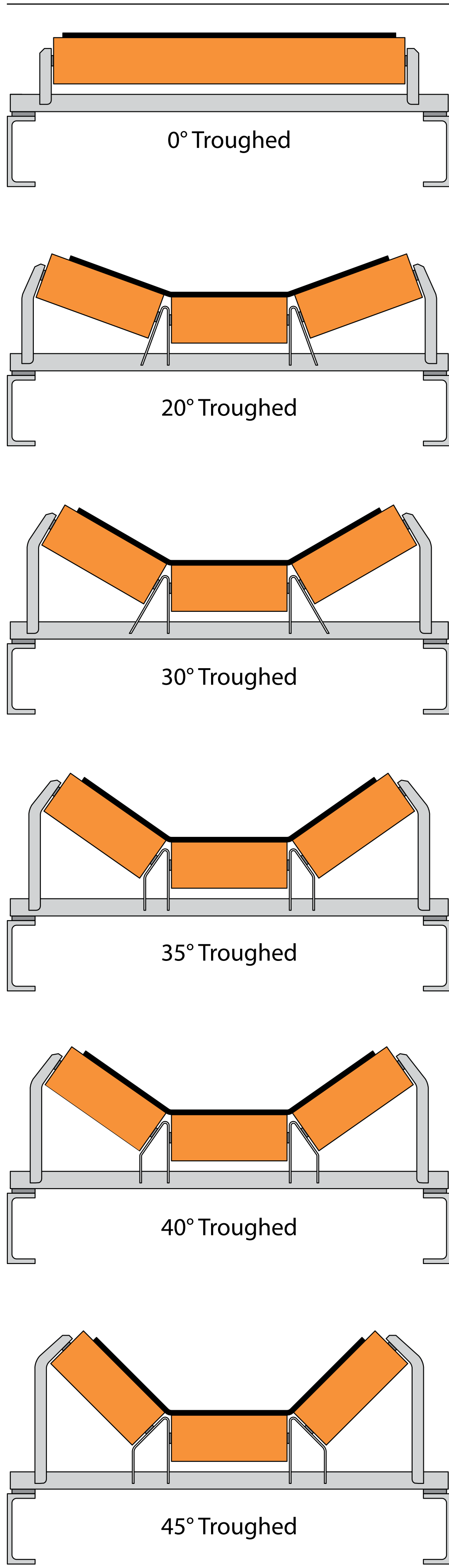

Figure 6.12

The standard angles for conveyor trough vary around the world.

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at the tail (loading) and head (discharge) pulley locations of a troughed conveyor and can occur in other areas of the conveyor, such as at a tripper head.

The distance from the centerline of the terminal pulley to the first fully-troughed idler is called the transition distance. This area poses more potential risk to the belt than any other area of the conveyor. In changing from a flat belt to a fully-troughed profile, tension at the sides of the belt is greater than at the center. The outer one-third of the belt must stretch and travel farther than the center one-third. This can cause the splice, either mechanical or vulcanized, to fail at the belt edges. In addition, the plies of the belt can separate due to this stress.

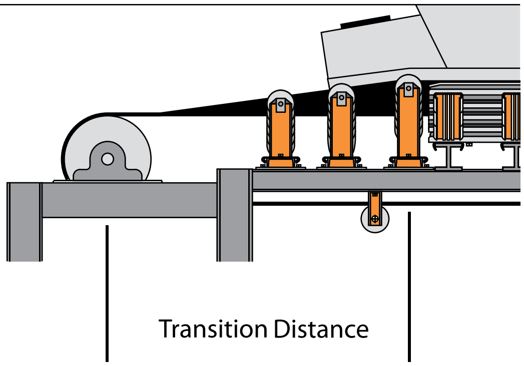

Figure 6.13

The distance from the terminal (tail or head) pulley to the first fully-troughed idler is called the transition distance; the belt is changed from flat to troughed or from troughed to flat in this area.

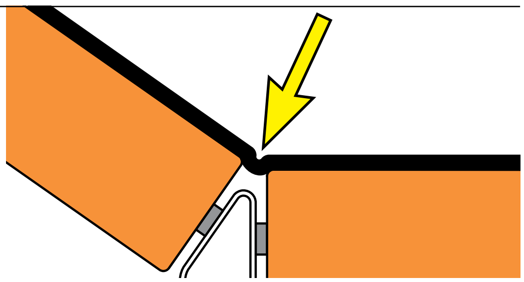

Figure 6.14

Too short a transition distance can result in creases at the junction where the center roller joins the wing rollers.

Figure 6.15

The damage caused by junction-joint failure appears in two parallel lines above the joint between the center roller and wing rollers.

Figure 6.16

One sign of junction-joint failure can be the belt assuming a "W" or "M" configuration.

The transition distance, the spacing allowed for this change in the belt's contour, must be sufficient at each terminal pulley. Otherwise, the belt will experience extreme stress in the idler junctions (the points on a troughed idler set where the horizontal roller meets the inclined rollers). Because the outer third of the belt is stretched farther, the result may be a crease in the idler junction that may eventually tear along the entire length of belt (**Figure 6.14**). Also, if the elasticity of the carcass is slightly exceeded, the belt may not tear but rather stretch beyond its limits, leading to belt-tracking problems. If the transition distance is too short, an excessive difference between edge and center tensions can overcome the belt's lateral stiffness. This can force the belt down into the trough, so it buckles through the center or catches in the idler junctions where the rollers of the idler join (**Figure 6.15**). The first sign of idler-junction failure will be noticed as a "W" or "M" fold or shape in the belt's return side (**Figure 6.16**). The increased edge tension seen in the belt from having too short a transition area will place an increased load on the outer bearings of the troughing idlers and could lead to premature idler failure.

Belt tension can be kept within safe limits by maintaining the proper transition distance between the pulley and the first fully-troughed idler, thus minimizing the stress induced in the belt.

To properly support the belt at these transitions, idlers with intermediate angles should be used between the terminal pulley and the first fully-troughed idler. These transition idlers will allow the belt to gently change its profile to the proper trough angle. Strain on the belt at the idler junction is then minimized since it has been spread over several idlers and a greater distance.

Transition Distance

The distance required for a belt's transition varies with the amount of troughing required, the belt thickness, the construction of the belt, the type of carcass (steel cable or fabric), and the rated tension of the belt. A transition distance must be selected to provide at least the minimum distance for the belt selected.

The heavier the belt carcass, the more it will resist being placed in a troughed configuration and the longer the required transition distance. This is easy to understand if one remembers that a string stretched down the center of the conveyor will be shorter than the string placed on the outside edge of the idlers. The outer edges of the belt must travel farther than the middle of the belt. The higher the trough angle, the more the edges are stretched and the greater the distance required to reach that angle.

The transition distance required is a function of the construction of a belt. When engineering a new conveyor, the belting should be selected to match the material load and conveyance length characteristics of the conveyor. The transition distance of the system would then be designed to match the requirements of the selected belting. However, a more likely scenario is that, due to space constraints and cost considerations, the belting will be selected to match the transition distance engineered into the steel conveyor structure. Either way, however, the belting manufacturer should be consulted when determining the recommended transition distance.

In the case of replacement belting for existing conveyors, the belt should be selected to match the transition distance provided in the conveyor structure. In no case should a belt be placed on a conveyor where the transition distance is too short for the belt.

It is highly recommended that the supplier of the belt be contacted to ensure that the transition distance of the existing structure is compatible with the belt. Charts identifying the recommended transition distance as a function of the rated belt tension for both fabric and steel cord belts at the various trough angles are published in manufacturers' literature and by CEMA in *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*.

Transition Idlers

Depending on the distance, one or more transitional idlers should be used to support the belt between the terminal pulley and the first fully-troughed idler.

It is good practice to install several transition idlers supporting the belt to gradually change from a flat profile to a fully-troughed contour (**Figure 6.17**). Transition idlers can be manufactured at specific intermediate angles (between flat and fully troughed), or they can be adjustable to fit various positions (**Figure 6.18**). For example, it would be good practice to place a 20-degree troughing idler as a transition

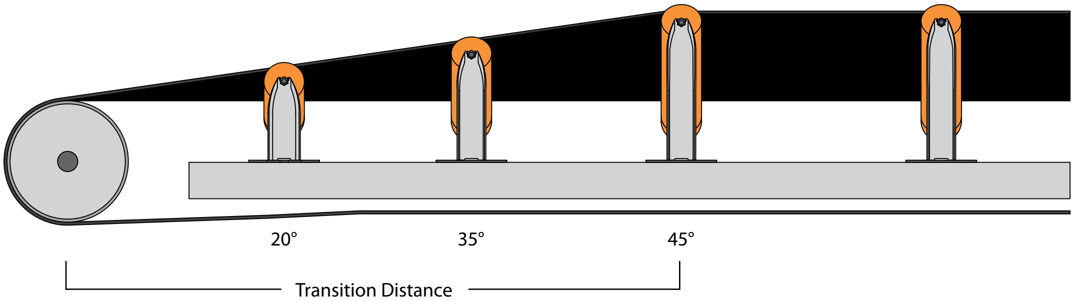

Figure 6.17

Several transition idlers should be installed between the pulley and the first fully-troughed idler.

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idler forward of a 35-degree troughing idler, and both a 20-degree and a 35-degree idler in front of a 45-degree idler. CEMA recommends that all transition idlers use metal rollers.

It is also important to the stability of the belt and the sealability of the transfer point that the transition idler closest to the terminal pulley be installed so the top of the pulley and the top of the idler's center roll are in the same horizontal plane. This is referred to as a full-trough transition.

Half-Trough Pulley Depth

To shorten the required transition distance, the conveyor designer may be tempted to use a "half-trough" transition arrangement which calls for the raising of the tail pulley. By elevating the pulley so its top (where the belt comes off the pulley) is in line with the midpoint of the wing rollers (rather than in line with the top of the center roller), the required transition distance can be reduced roughly in half (**Figure 6.19**). This technique is usually employed to shorten the transition distance to avoid an obstruction or to save a small amount of conveyor length.

In the past, this half-trough arrangement has been accepted by CEMA and belting manufacturers as a way to avoid excessive strain at the idler joint as a belt transforms, particularly when fitting a conveyor into a limited space. However, problems can arise with the half-trough design, including the belt lifting off the idlers when it is traveling unloaded (**Figure 6.20**). While a half-troughed belt is being loaded, peaks and surges in the rate of material flow will dramatically change the belt line and prevent the transfer point from being effectively sealed. These shifts in the belt line create a "pumping action" that acts as a fan to push out airborne dust. In addition,

Figure 6.18

Some idler frames are manufactured with multiple mounting holes for the wing rollers to allow their use as transition idlers.

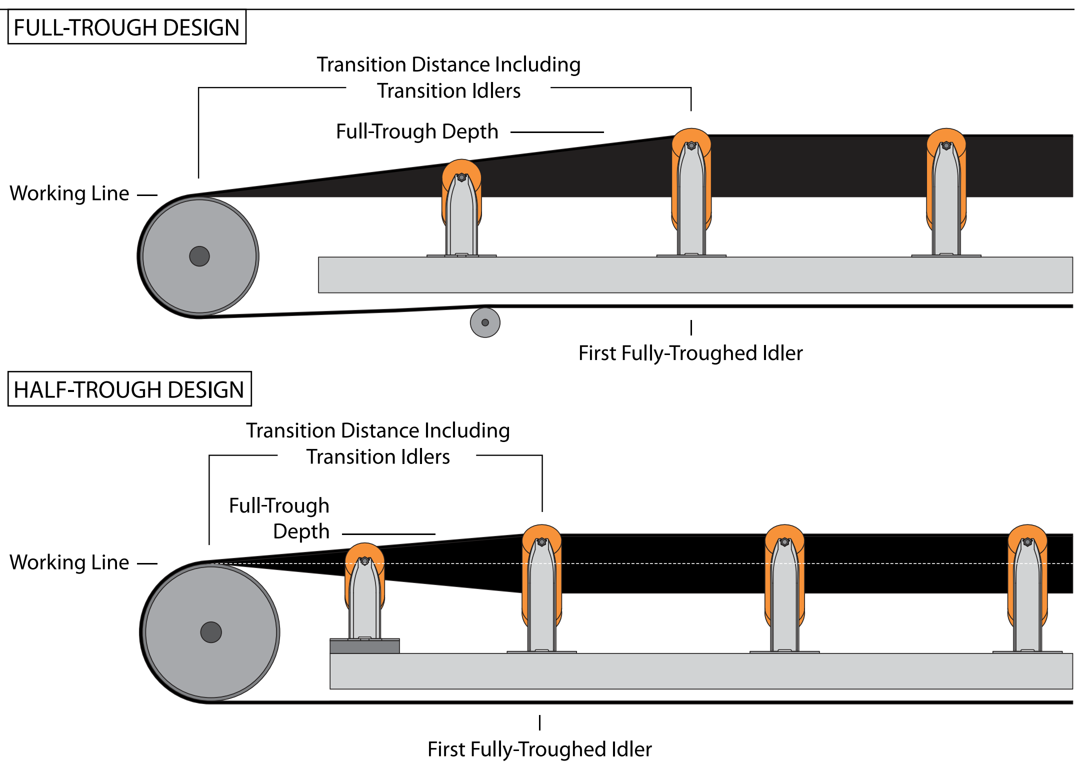

Figure 6.19

In the half-trough design, (bottom), raising the tail pulley so the belt is in line with the midpoint of the wing rollers allows the transition distance to be shortened. However, this can create other problems.

this design can cause the belt to buckle in the transition area. Loading the belt when it is deformed in this manner makes effective sealing impossible and increases belt wear due to increased levels of impact and abrasion on the "high spots" in the belt.

Solving the problems created by a half-trough pulley depth is more complicated than merely lowering the tail pulley to line up with the center roll of the idlers. The minimum transition distance must be maintained: As the pulley moves down, it must also be moved further away from the first fully-troughed idler. If this is not possible, other modifications should be made, such as the reduction of the trough angle in the loading area to shorten the required transition distance. The belt can then be changed to a higher trough angle outside the load zone. Another approach would be to adopt a very gradual transition area. Both of these techniques are discussed below in Advanced Topics.

A better practice, and the current CEMA recommendation, is to use the fully-troughed arrangement where the pulley is in line with the top of the center roll in the idler set. This requires a longer transition distance, but greatly improves the stability of the belt as it enters the loading zone and, as a result, improves the sealability of the transfer point.

Loading in the Transition Area

Loading the belt while it is undergoing transition is bad practice and should be avoided. The area where the load is introduced to the belt should begin no sooner than the point where the belt is fully troughed and properly supported by a slider bed or by the midpoint of the first set of fully-troughed idlers. A better solution is to introduce the load 300 millimeters (12 in.) or so beyond this fully-troughed point in order to accommodate any bounce-back of material caused by turbulence.

If loading is performed while the belt is still transitioning into the troughed configuration, the load is dropped onto a slightly larger area with non-parallel sides. This larger area increases pressure on the side skirts and increases wear on the belt and liners as the belt forms its full trough. In addition, since the belt in the transition area is changing in contour, it will not have the stable belt profile required for effective sealing.

Material bouncing off other material and the walls of the chute can deflect behind the intended load point. Therefore, the trajectory of the material needs to be designed to contact the belt far enough in front of the tail pulley to prevent material from flooding the transition area. The provision of adequate belt support in the loading zone ensures that the belt maintains the flat surface that is critical for effective sealing.

SEALING AT THE ENTRY AREA

Sealing Systems

Sealing of the belt entry in the load zone is often a problem (**Figure 6.21**). The turbulence of material as it is loaded can cause some particles to bounce or roll backward toward the tail of the conveyor.

Figure 6.20

Using the half-trough design can cause the belt to rise off the idlers (particularly when unloaded).

Figure 6.21

Providing an effective seal at the back of the loading zone can be a problem.

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Material will bounce back out of the load zone and roll down the conveyor, accumulating on the pulley, the bearing supports, or on the floor near the tail pulley.

Figure 6.22

Simple back seals of rubber or plastic have generally proven ineffective.

Figure 6.23

If the tail seal is forced too tightly against the belt, a "belt cleaning effect" will scrape material off the belt to pile up at the back of the load zone.

Figure 6.24

If the conveyor is inclined, material will roll down the belt and pile up on the floor.

Figure 6.25

Sealing at the corners of the loading zone is difficult, allowing material to spill and dust to leak out.

In an attempt to solve this problem, a sealing system of some sort is applied at the back of the loading chute. Typically, this seal is a curtain or wall, fabricated from a sheet of plastic or rubber (**Figure 6.22**). This seal can create as many problems as it solves.

If the seal at the belt entry into the chutework is applied too loosely, material will continue to escape out the back of the loading zone, down the transition area, and onto the floor. If a sealing system is placed tightly enough against the belt to prevent leakage out the back of the loading zone, the seal may instead act as a belt cleaner. In this instance, the seal will scrape any material that has remained adhered to the belt during the journey back from the discharge pulley. The material removed by this "belt cleaner effect" will then accumulate at the point where the belt enters the loading zone (**Figure 6.23**) or, if the conveyor is inclined, roll down the belt to pile up at the tail of the conveyor (**Figure 6.24**).

Sealing the corners of the chute behind where the belt is loaded is difficult due to high material pressures and significant air movement that can carry dust out of the transfer point (**Figure 6.25**). This difficulty in sealing the entry area is compounded by any dynamic vibrations in the belt line created by fluctuations in belt tension resulting from "peaks and valleys" in material loading or from the use of a wing-type tail pulley. Wing pulleys should be avoided for this reason.

Multiple-Barrier Sealing Box

An effective approach is to seal the area behind the load zone with a multiple-barrier sealing box (**Figure 6.26**). Attached to the back wall of the loading chute, this box connects the chute to the area where the belt is flat as it crosses the tail pulley. In the ideal situation, the tail box would be extended to the flat surface of the tail pulley making sealing more effective and easier to maintain (**Figure 6.27**). A tail-sealing box is often installed on the transition area when retrofitting existing conveyors. For new conveyors, this is not recommended, because it is difficult to seal the transition bend.

A sealing strip is installed on the outside of the back wall, the wall closest to the tail pulley, of the sealing box (**Figure 6.28**). Deflected by and in the direction of belt motion, this strip forms a one-way seal that prevents material escape out the back of the loading zone and off the tail of the conveyor. As this strip lies on the belt with only gentle pressure, it avoids the belt cleaner effect. Material adhering to the belt can pass under the seal without being "cleaned" off the belt.

On its sides, the box should be fitted with a low-maintenance, multiple-layer skirtboard seal to prevent material spillage over the edges of the belt. The tail-sealing box should incorporate the beginning of the conveyor, so the sealing strip runs continuously from the tail-sealing box to the exit end of the skirtboard (**Figure 6.29**). This continuous seal eliminates the problems with sealing the high-pressure corners of the impact zone.

The top of the tail-sealing box should include an access door to allow the return of any fugitive material to the conveyor (**Figure 6.30**).

TYPICAL SPECIFICATIONS

A. Transition

The conveyor design should incorporate sufficient transition distance and transition idlers to allow the belt to be fully troughed before any material is loaded onto the belt.

B. "Full trough" height

The tail pulley should be placed at a "full trough" height, so that the belt coming off the pulley is in line with the center roller of the troughed idler set.

C. Tailgate-sealing box

A tailgate-sealing box with an effective seal at the tail pulley end of the enclo-

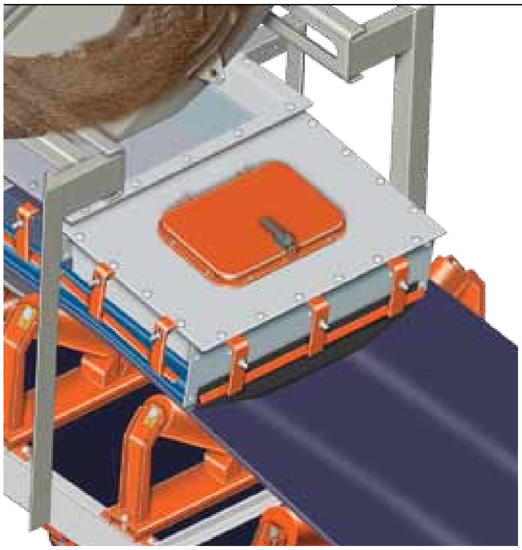

Figure 6.26

Tail-sealing boxes are installed to prevent material from falling out the back of the conveyor loading zone.

Figure 6.27

A tail-sealing box is often installed on the transition area when retrofitting existing conveyors. For new conveyors, this is not recommended because it is difficult to seal the transition bend.

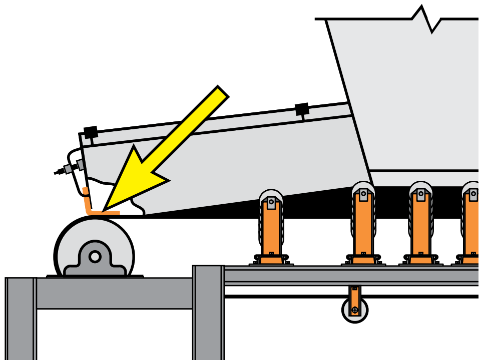

Figure 6.28

A sealing strip should be installed on the outside of the back wall of the sealing box, closest to the tail pulley.

Figure 6.29

The belt edge-sealing systems should extend in a continuous strip from tail-sealing box to the end of the skirted area.

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Figure 6.30

An access door in the tail-sealing box will allow any spilled material to be returned to the conveyor.

sure should be installed on the fully troughed belt to prevent the escape of fugitive material from the back of the load zone.

D. Skirtboard-sealing strip

Effective sealing on the belt edges at the sides of the tail-sealing box will be provided by extending the skirtboard-sealing strip from the box through the transfer load zone as a single continuous sealing strip, without a joint or seam that might leak material.

ADVANCED TOPICS

Two-Stage Transition Areas

For many years, the recommendation has been that the belt should be fully troughed before the load is introduced. A variation on this thinking is the idea that it is more critical that the belt be stable (e.g., not undergoing transition) when it is loaded than that it be fully troughed when it is loaded. Given a conveyor where there is a very short distance between the tail pulley and the loading zone, it may be better to partially trough the belt in the area between the tail pulley and the load zone, and then complete the transition after the belt has been loaded (**Figure 6.31**). In order for this to provide any benefit, the belt line must be stabilized with improved support structures, such as impact cradles and side-support cradles, and the edges must be effectively sealed after the belt's initial troughing. Raising the belt edges to the final trough angle can be performed after the load is on the belt.

For conveyors with inadequate space in the traditional transition area between the tail pulley and the load chute, this method provides the benefit of a higher troughing angle without creating the instability of loading while the belt is undergoing transition.

Gradual Transitions

Another method to deal with the problem of too short a transition distance is the use of a very gradual transition. Rather than risk damage by troughing the belt too quickly, the belt is troughed over an extended distance, the length of the load zone. This makes the change so gradual as to be almost unnoticeable.

In one case, the belt profile was changed from flat to a 35-degree trough over a 12-meter (40-ft) transition area. This conveyor was perhaps a special circumstance with a long transfer point incorporat-

SAFETY CONCERNS

Because of the numerous pinch points in the area of the conveyor tail, employees can easily become caught in the moving belt at this location. In addition, with this area contributing to spillage problems, shoveling accidents are likely to occur. Proper lockout / tagout / blockout / testout procedures should be used prior to performing any maintenance or cleanup work in this area. Employees should never work on or shovel onto a moving conveyor.

Proper guards and safety labels on all rotating equipment and pinch points are required; guards should not be removed or disabled while the conveyor is in operation.

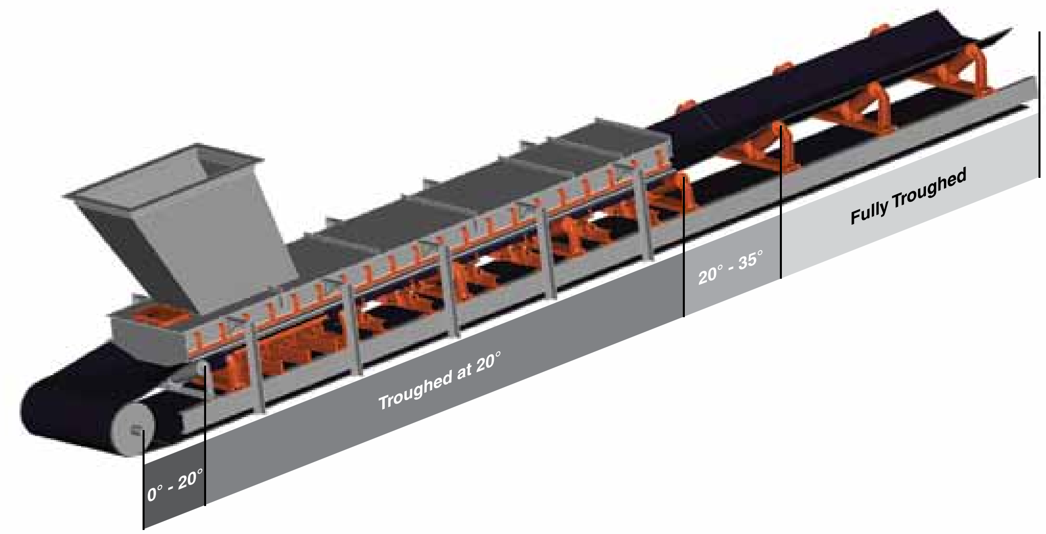

Figure 6.31

In a two-stage transition area, the belt is partially troughed before it is loaded. After the cargo is placed, the belt goes through another transition that increases the trough angle.

6

ing multiple load zones, a thick belt, and minimal distance between the tail pulley and the first loading zone. The key for this technique is to maintain belt support to provide a straight line for the trough. Rather than use specially designed components, this gradual troughing change was accomplished by installing conventional components in a "racked" or slightly out-of-alignment fashion. Belt-support cradles incorporating sufficient adjustment to accommodate a deliberate "out-of-alignment" installation were used in combination with troughing idlers with adjustable angles.

PROTECT YOUR TAIL

In Closing...

While the tail section of a conveyor belt is relatively simple, and the components are generally taken for granted, this section of the conveyor could be one of the most important. If care is not taken in alignment, tail-pulley type, transition distance, and sealing, the negative effects can downgrade the performance of the entire conveyor system.

Looking Ahead...

This chapter, Before the Loading Zone, began the discussion of Loading the Belt by examining tail pulleys and transition areas along with techniques to prevent the escape of fugitive material at the tail of the conveyor. The following chapters will address other aspects of belt loading, beginning with Air Control.

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6.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS*, *Sixth Edition*. Naples, Florida.

6.2 The website http://www.conveyorbeltguide.com is a valuable and non-commercial resource covering many aspects of belting.

6.3 Any manufacturer and most distributors of conveyor products can provide a variety of materials on the construction and use of their specific products.

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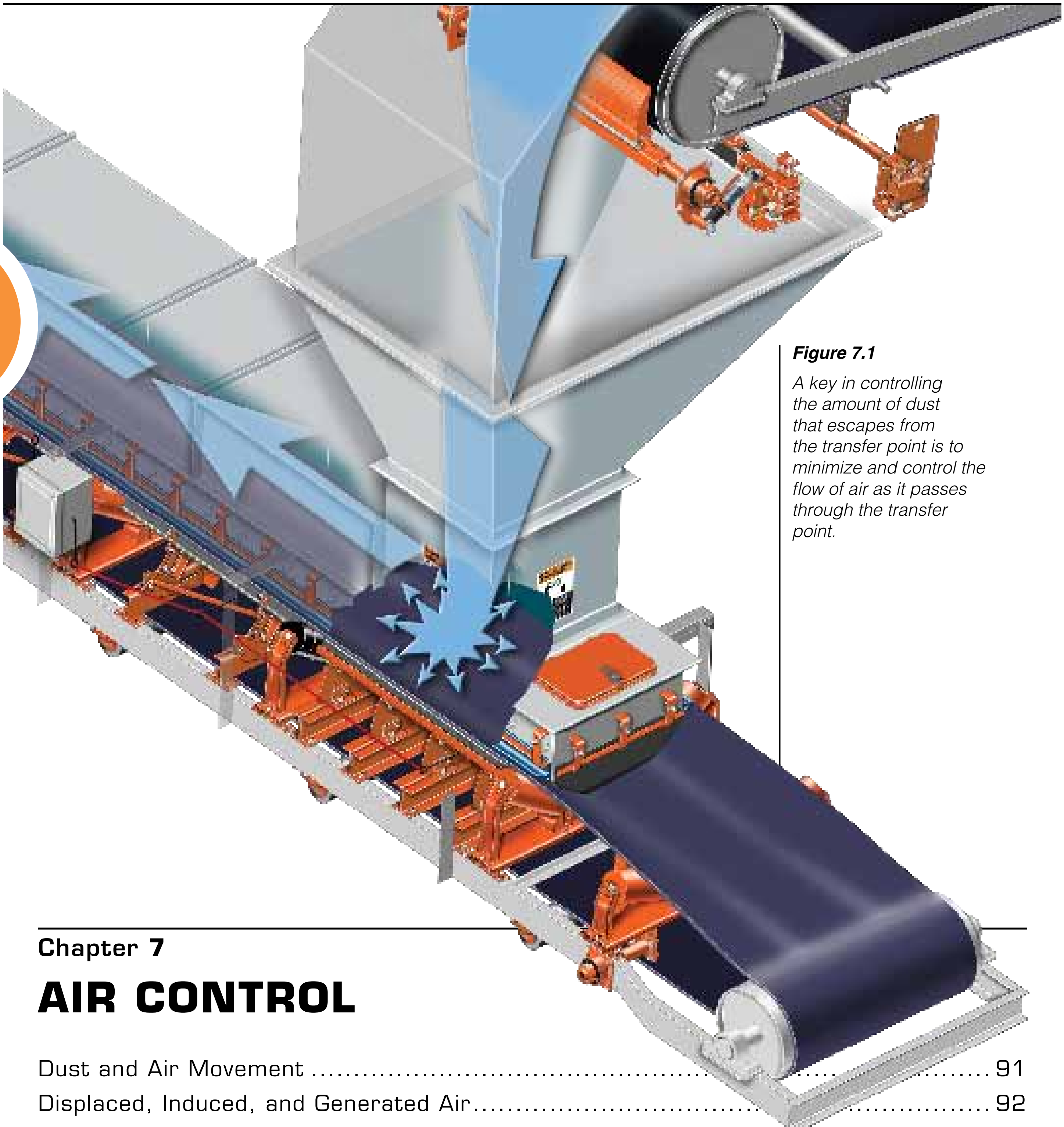

Figure 7.1

A key in controlling the amount of dust that escapes from the transfer point is to minimize and control the flow of air as it passes through the transfer point.

Chapter 7

AIR CONTROL

In this Chapter…

In this chapter, we look at the importance of controlling air movement to control the escape of airborne dust. Equations to calculate the amount of displaced air, induced air, and generated air are presented, along with their relationship to the total airflow. Methods to measure air velocity and volume are also discussed. Four design parameters, along with several additional techniques, for controlling the air to minimize airborne dust are explained. Finally, maintenance and safety concerns are included.

Conveyor loading zones and discharge points are prime sources for the creation and release of airborne dust. The amount of dust created in a transfer point depends on a number of factors, including the nature of the material carried, the height of drop onto the belt, and the speeds and angles of unloading and loading belts. A key in controlling the amount of dust that escapes from the transfer point is to minimize and control the flow of air as it passes through the transfer point (**Figure 7.1**).

DUST AND AIR MOVEMENT

To Control Dust, Control Air

As materials move on a conveyor and through the transfer point, they carry a stream of air in and with them. With sufficient velocity, this air stream can pick fine particles out of the material body and carry them along with the materials, or it can spread them outside the enclosures of the conveyor.

The conditions that determine whether or not fine materials become airborne are air velocity, particle size, and cohesion of the bulk materials. These characteristics contribute to the amount of dust generated by the following intuitive, relative relationship: The amount of dust generated is proportional to air velocity, as divided by the factors of particle size and material cohesiveness (**Figure 7.2**). Where one or more of these parameters is a given, the ability to control dust depends on altering one or both of the other characteristics. If air velocity is increased, but particle size and cohesiveness remain constant, then airborne dust will increase. If air velocity remains constant, and particle size or cohesiveness is increased, the amount of airborne dust will be reduced. If velocity remains constant, and particle size or cohesiveness is decreased, then the amount of airborne dust will increase.

When the size of particles being conveyed cannot be changed, the velocity of the air or the cohesive force of the particles must be altered in order to minimize the emission of dust. *(See Chapter 19: Dust Suppression for information about changing the cohesive force of particles.)* Control of the air movement into and out of a conveyor transfer point will not reduce the dust created inside that transfer point, but it will have a significant effect on the amount of dust that is carried out of the transfer point. Limiting the positive pressure released by a transfer point will have significant benefits in the control of fugitive materials.

Air Movement through Transfer Points

The volume of air that moves through a transfer is directly related to the size of the transfer-point enclosure, the openings in the enclosure, and the presence of other process equipment. The cost of the components of a conveyor's dust-management system is directly related to the volume of air that is pulled through the system. Therefore, an understanding and control of air movement is fundamental to efficient and economical dust control through the design of the transfer point.

$$\text{Dust Generated} \propto \frac{\text{Air Velocity}}{\text{Particle Size} \bullet \text{Cohesiveness}}$$

Figure 7.2

Relationship in Creating Airborne Dust

Ideally, a slight negative pressure is to be desired inside the enclosure. This condition would pull air into the enclosure so that fines and airborne dust are retained in the structure, rather than carried out. Typically, this is difficult, if not impossible, to achieve consistently without an active dust-collection system. The airflow, created by the equipment above the transfer point and the movement of materials through the transfer point, creates a positive pressure through the system, creating an outward flow of air from the transfer point. This is most true in a conveyor loading zone, because the impact of materials on the receiving belt drives out the air with a significant "splash." The greater the impact, the stronger the air current away from the impact area will be. If this positive pressure is not addressed with control of material flow, adequate pressure relief, or dust-collection systems, the particles of dust will be carried out of the transfer point on the outward flow of air.

DISPLACED, INDUCED, AND GENERATED AIR

Calculating the Airflow

Airflow can be measured or calculated. The following is offered as a theoretical, yet workable method. The conditions of any specific combination of conveyor design and material flow can affect the results significantly.

There are three sources for the air movement that might be present around or through a given transfer point: displaced air, induced air, and generated air.

The total airflow in a given transfer point can be calculated by adding the displaced air, induced air, and generated air (**Equation 7.1**).

Displaced Air

The first category is displaced air. A simple explanation of displaced air starts with a coffee cup. When coffee is poured into this cup, the air inside is displaced by the coffee. This same effect occurs when materials enter a loading chute: The air that filled the chute is pushed out, displaced by the materials. The amount of air displaced from the chute is equal to the volume of materials placed into the chute. The movement of materials through a transfer point will always produce displaced air that can be calculated by the load (amount of materials conveyed) and bulk density (**Equation 7.2**).

Induced Air

Induced air is present in conveyor loading zones whenever bulk materials are moving, because bulk materials have a certain amount of entrapped air and carry a small amount of air with them as they travel on the belt. As the materials leave the head pulley in a normal trajectory, the material stream expands, pulling air into

Equation 7.1

Total Airflow Calculation

$$Q_{tot} = Q_{dis} + Q_{ind} + Q_{gen}$$

Given: *A transfer point is attached to a crusher that generates 0,77 cubic meters per second (1625 ft³/min) of air. The displaced air is 0,06 cubic meters per second (133 ft³/min) and the air induced is 0,055 cubic meters per second (117 ft³/min).* ***Find:*** *The total air movement.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Airflow	cubic meters per second	cubic feet per minute
Q_{dis}	Displaced Air	0,06 m³/s	133 ft³/min
Q_{ind}	Induced Air	0,055 m³/s	117 ft³/min
Q_{gen}	Generated Air (If Present)	0,77 m³/s	1625 ft³/min

Metric: $Q_{tot} = 0{,}06 + 0{,}055 + 0{,}77 = 0{,}885$

Imperial: $Q_{tot} = 133 + 117 + 1625 = 1875$

Q_{tot}	Total Airflow	0,885 m³/s	1875 ft³/min

the new voids. Each particle of material gives energy to an amount of air, pulling the air along with the material stream. When the product lands and compresses back into a pile, this induced air is released, causing substantial positive pressure flowing away from the center of the load zone. If this positive pressure is not addressed with proper transfer-point design or relief systems, the dust fines will be carried out of the system on the current of air.

An example of induced air would be when one turns on the water in a shower, the stream of water from the shower head spreads out. This moving water pulls a volume of air along with it. This air current can be noticed in the movement of the shower curtain towards the flow of water.

The factors influencing the amount of induced air at a conveyor transfer point include the quantity of materials, the size of the particles of conveyed materials, the speed of the belt, the height of the material drop, and the size of the opening(s) in the head chute which allow air to be taken into the enclosure. Induced air can be calculated from these factors (**Equation 7.3**).

The most controllable factor in controlling induced air is the size of the opening in the head chute (A_u) through which the air induction occurs. The smaller the opening(s) for air to enter the system, the smaller will be the value of A_u and the smaller the volume of air that will escape or need to be exhausted. (Note: A_u is the size of the belt entry to the head chute enclosure, rather than the size of doors downstream at the loading zone or on the skirted section of the receiving conveyor.)

An easy and cost-effective method to reduce the amount of induced air is to reduce the size of all openings in the head chute. This would include sealing the open areas where the belt enters and leaves the head chute, as well as placing seals on pulley shafts and putting doors over belt cleaner and other inspection openings.

Generated Air

Other sources of moving air are those devices that feed the conveyor load zone. This includes equipment such as crushers, wood chippers, hammer mills, or any device with a turning motion that creates a fan-like effect, pushing air into the transfer point. While not present in all transfer points, this generated airflow can be the most severe of all air movements.

Other devices that must be considered, if present, would be air cannons, vibrators,

$$Q_{dis} = \frac{k \cdot L}{\rho}$$

Given: *A transfer chute is carrying 180 tons per hour (200 st/h) of material that is 800 kilograms per cubic meter (50 lb_m/ft^3).* **Find:** *The displaced air.*

Variables		Metric Units	Imperial Units
Q_{dis}	Displaced Air	cubic meters per second	cubic feet per minute
L	Load (amount of material conveyed)	180 t/h	200 st/h
ρ	Bulk Density	800 kg/m³	50 lb_m/ft^3
k	Conversion Factor	0,277	33.3

Metric: $Q_{dis} = \frac{0{,}277 \cdot 180}{800} = 0{,}062$

Imperial: $Q_{dis} = \frac{33.3 \cdot 200}{50} = 133$

Q_{dis}	Displaced Air	0,062 m³/s	133 ft³/min

Equation 7.2

Displaced Air Calculation

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and compressed-air hoses, used to promote material flow. This type of air movement can be measured using air velocity and volume gauges, such as Pitot tubes and manometers. It might be simpler for the end-user to contact the equipment's manufacturer to obtain a calculation of the air output by various pieces of equipment. Depending upon the crusher, manufacturers estimate the air generated for various types (**Table 7.1**).

Since generated air can be a significant amount, the amount of generated air should be obtained from the manufacturer of the equipment, or the flow can be calculated by multiplying the exhaust area times the air velocity, measured while the equipment is in operation.

AIR VELOCITY AND VOLUME

Air Velocity

Air flows from a high- to a low-pressure zone because of the pressure difference. While there are a number of variables that can cause dust to remain in the material steam—including particle sizes, material cohesiveness, and moisture content—in general, dust particles have a pickup velocity in the range of 1,0 to 1,25 meters per second (200 to 250 ft/min). That means that air moving over a bed of material at this speed can pick up dust off the surface and carry it away.

A good design parameter for the sizing of the exit chutes of load zones is to maintain the exit area air velocity below

Equation 7.3

Induced Air Calculation

$$Q_{ind} = k \cdot A_u \cdot \sqrt[3]{\frac{RS^2}{D}}$$

Given: *A transfer chute is carrying 180 tons per hour (200 st/h) and has an open-end area of 0,046 square meters (0.5 ft²). The material with average diameters of 0,075 meters (0.25 ft) falls 1,25 meters (4 ft).* ***Find:*** *The induced air.*

Variables		Metric Units	Imperial Units
Q_{ind}	Volume of Induced Air	cubic meters per second	cubic feet per minute
A_u	Head Chute Open Area	0,046 m²	0.5 ft²
R	Rate of Material Flow	180 t/h	200 st/h
S	Height of Material Free Fall	1,25 m	4 ft
D	Average Material Diameter	0,075 m	0.25 ft
k	Conversion Factor	0,078	10

Metric: $Q_{ind} = 0{,}078 \cdot 0{,}046 \cdot \sqrt[3]{\frac{180 \cdot 1{,}25^2}{0{,}075}} = 0{,}055$

Imperial: $Q_{ind} = 10 \cdot 0.5 \cdot \sqrt[3]{\frac{200 \cdot 4^2}{0.25}} = 117$

Q_{ind}	Volume of Induced Air	0,055 m³/s	117 ft³/min

Table 7.1

Approximate Levels of Generated Air from Various Types of Crushers

Type of Crusher	At Crusher Feed per 300 millimeters (12 in.) Opening Width	At Crusher Discharge per 300 millimeters (12 in.) Conveyor Width
Jaw Crusher	850 m³/h (500 ft³/min)	850 m³/h (500 ft³/min)
Gyratory Crusher	850 m³/h (500 ft³/min)	1700 m³/h (1000 ft³/min)
Hammermills and Impactors	850 m³/h (500 ft³/min)	2550 m³/h (1500 ft³/min)

1,0 meters per second (200 ft/min). Higher velocities may allow the air current to pick up particles of material and hold them in suspension in the air, making containment, collection, or suppression more difficult.

Checking Air Velocity and Volume

The quantity of air flowing through the transfer point each minute can be calculated from measurements (**Equation 7.4**). To calculate the volume of moving air, multiply the measured air speed leaving each open area of the transfer point—including the belt exit, tail box, sides of the belt, dust pickups, and other openings—by the area of each opening. These air flows are then added to produce a total air flow. These measurements must be taken while the transfer point is in operation. The air velocity measurements can be performed with a relatively inexpensive handheld anemometer; the area can be measured with a tape measure (**Figure 7.3**).

As additional airflow through the transfer-point enclosure can be produced by crushers, vibrating screens, feeders, and other process and handling equipment, it will be necessary to measure the air velocity while these devices are in operation as well.

This air volume calculation should be compared to the computations of the air volume (**Equation 7.1**). If a major discrepancy exists, the airflow calculated from measured air velocity (**Equation 7.4**) should ALWAYS be used.

CONTROLLING THE AIR

Controlling Air Movement

A complete system to control dust at conveyor transfer points is based upon four design parameters:

A. Limit the amount of air entering the enclosure

Preventing air from entering the enclosure at the head pulley of the discharging conveyor is possible without sophisticated or expensive changes. Conventional rubber curtains can be installed at the belt's entrance and exit, and other openings, such as around the pulley shafts, can be sealed. Perhaps the easiest thing that can be done to limit the intake of air at the discharge end of conveyors is to make sure inspection doors are all closed.

Figure 7.3

Air measurements can be performed with a relatively inexpensive handheld anemometer and a ruler.

$$Q_{tot} = A \cdot V$$

Given: *The air velocity coming out of a transfer point is measured at 4,3 meters per second (850 ft/min). The transfer-point enclosure has a total cross-sectional area of 0,19 square meters (2 ft²).*
Find: *The total airflow.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Air Movement	cubic meters per second	cubic feet per minute
A	Cross-Sectional Area of Transfer-Point Enclosure	0,19 m²	2 ft²
V	Velocity of Air	4,3 m/s	850 ft/min

Metric: $Q_{tot} = 0{,}19 \cdot 4{,}3 = 0{,}81$

Imperial: $Q_{tot} = 2 \cdot 850 = 1700$

Q_{tot}	Total Air Movement	0,81 m³/s	1700 ft³/min

Equation 7.4

Air Quantity Calculation

B. Limit the spreading of the material stream

As it moves through the transfer point, each particle or lump of material acts on the air in the enclosure, carrying some of the air along with it. Keeping the materials in a consolidated stream as they leave the head pulley and move through the transfer point can be done with deflectors or engineered hoods and spoons. A deflector may create material flow problems, whereas engineered hoods and spoons are less likely to create flow problems. The more materials and the faster the movement, the greater is the need for an engineered chute. *(See Chapter 22: Engineered Flow Chutes.)*

C. Limit the material drop height

In a conventional conveyor discharge, the materials free fall. This disperses the materials, making the stream larger and able to take more air with it, because air fills the voids created within the spreading materials. When the materials land on the next belt, the entrained air is pushed away from the pile, creating a positive pressure. The further the materials fall, the greater the force of landing; hence, the greater will be the outward pressure of air. Limiting the drop height addresses this problem. Limiting the drop height usually involves moving the conveyors closer together. This is an incredibly complicated process to implement once a conveyor is installed; however, it is relatively easy to minimize the drop height in the system design.

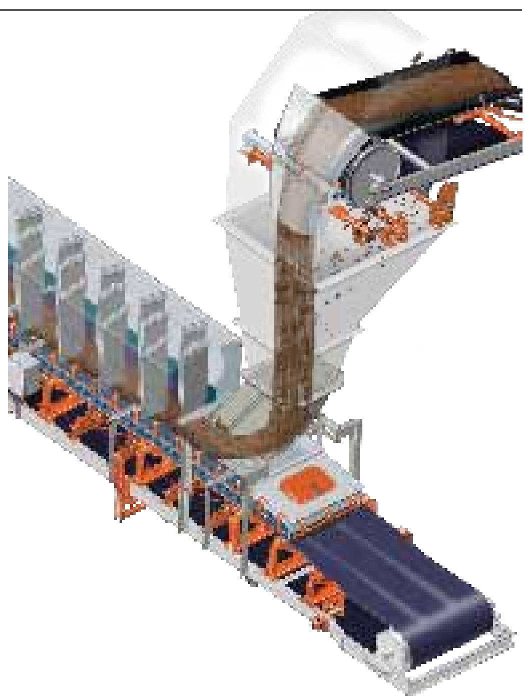

Figure 7.4

By confining the material stream, a "hood and spoon" chute minimizes the air entrained with the material, so it reduces airborne dust.

D. Limit the air speed inside the enclosure to below the pickup velocity of the dust particles

Conventional conveyor enclosures behave like large ducts moving air. As such, the cross-sectional area of the duct, formed by the conveyor chute and skirtboard, can be increased or decreased to change the velocity of the air flowing through the enclosure. *(See Chapter 11: Skirtboards, especially Advanced Topics for sample problems to determine velocity.)*

Hood and Spoon Systems

Preventing the materials from spreading out when they leave the discharge pulley will significantly reduce the amount of air that is pulled in as induced air. Chutes employing a "hood and spoon" design, to confine the stream of moving materials, reduce the airflow (**Figure 7.4**). The hood minimizes the expansion of the material body, deflecting the stream downward. The spoon provides a curved loading chute that provides a smooth line of descent, so the materials slide down to the receptacle, whether that is a vessel or the loading zone of another conveyor. The spoon "feeds" the materials evenly and consistently, controlling the speed, direction, and impact level of the materials in the load zone. Paradoxically, the design of the hood and spoon depends upon gravity and friction to maintain the speed of the material flow through the chute. In some installations, there may not be sufficient drop height to use this technique to control dust.

By reducing the velocity and force of material impact in the load zone, to approximate the belt speed and direction, this system mitigates splash when materials hit the receiving conveyor. Therefore, there is less dust and high velocity air escaping. As the materials are deposited gently on the belt, there is minimal tumbling or turbulence of the materials on the belt. There is less impact in the loading zone, which will reduce impingement damage to the belt. Because there is minimal tumbling or turbulence of the materials and lower side forces, the skirted length can be shorter and sealed more effectively.

Gravity and the flow of materials will tend to keep the hood and spoon from building up and plugging the chute. Sometimes, there is not enough space to include both the hood and spoon in the design. In some cases with free-flowing materials, only a spoon is used to change the direction of the stream, to minimize belt abrasion and skirt side pressure. Spoons are prone to backing up, or flushing, if the characteristics of the bulk materials are variable. Some compensation can be designed into the spoon for variability of materials.

The main perceived drawback to using the "hood and spoon" concept is the price of these specially-designed components. Even so, where they can be applied and maintained, a full cost analysis will show significant cost-saving benefits in reduced dust, spillage, and belt wear.

This "hood and spoon" system works best when the material stream is kept as close as possible to continuous flow. The design minimizes the amount of expansion of the material profile, to reduce induced air and provide consistent flow. As the materials fall, the gravity-induced increase in speed allows the gradual reduction in the cross-sectional area of the chute without increasing the risk of plugs inside the chute. Variations in the rate of materials loading onto the belt may conflict with the design of the ideal hood and spoon, so some compromises in the chute design may be required.

Hood and spoon designs are a typical feature of engineered flow chutes, developed using material properties and continuum mechanics, and verified through Discrete Element Modeling (DEM) method. The success of this system may well eliminate the need for "baghouse" dust-collection systems in some operations. *(See Chapter 22: Engineered Flow Chutes.)*

Settling Zones

Settling zone is the name used for the covered skirtboard length including, if required, an additional enclosed volume of the load zone after the product has been placed onto the belt. The settling zone is usually an enlarged portion of the covered skirtboard area at the transfer point (**Figure 7.5**). This extra volume slows the air and allows most of the dust to settle and cleaner air to escape.

The size of a settling zone should be determined by six factors: width and speed of the belt, chute width, amount of airflow, depth of the material bed, and diameter of the largest lump of material that may pass through the settling zone. As any one or more of these factors increase, the size of the settling zone must also increase. Calculations to determine the size of a settling zone are for air space only—the area above the cargo. When calculating the cross-sectional area of the chute exit, subtract the area occupied by the body of material to find the area of the settling zone. *(See Chapter 11: Skirtboards for sample problems in calculating the proper size of a skirted area, including settling zone.)*

Figure 7.5

The settling zone is usually an enlarged portion of the covered skirtboard area at the transfer point that slows the air and allows the conveyed product to settle and cleaner air to escape.

In addition to increasing the size of the settling zone, another way to slow down the air in the settling zone is the installation of rubber curtains as baffles. *(See Chapter 18: Passive Dust Control for more information about dust curtains.)*

SYSTEM MAINTENANCE

For effective control of air within (and escaping from) a transfer point, it is important that holes be closed, whether the opening arises from rust or wear or from an opened door. Maintenance of the components, such as wear liners and deflectors, inside the transfer point is critical to minimizing disruption of the materials and airflow.

Because of the need to control air movement—and the resulting dust—to maintain a clean, safe, and productive workplace, many companies outsource maintenance of passive and active dust-control systems to specialty contractors.

TYPICAL SPECIFICATIONS

Typical specifications have been developed for the design of a transfer point's skirted area (including tail seal, skirtboard, and settling zone) as appropriate for control of spillage and air movement. *(See Chapter 6: Before the Loading Zone and Chapter 11: Skirtboards.)*

Figure 7.6

Installation of a piece of old belting as a curtain between the carrying run and the return side can reduce air induction at the belt entry.

ADVANCED TOPICS

Changing Head Chute Open Areas and Drop Heights to Minimize Induced Air

Volume of induced air (Q ind) is a function of the open-end area (A_u), rate of flow (R), drop height (S), and average material diameter (D) (**Equation 7.3**). The open-end area and the drop height are the only things that can realistically be varied. Those two variables have different mathematical impacts on the induced air. A reduction in open-end area of 5 percent will yield a 4.27 percent reduction in induced air. However, a 5 percent reduction in drop height yields only a 3.42 percent reduction in induced air. The cost to reduce open-end area is usually far less than the cost to reduce drop height. This lower cost and higher effect makes reducing open-end area to limit the amount of air flowing into a conveyor belt a priority.

It should be noted that if the open-end area is reduced by 5 percent and the drop height is reduced by 5 percent, the induced air is reduced by 6.84 percent.

Restricting Air Movement at the Entry to the Head Chute

In addition to the techniques already mentioned, another method employed to minimize induced air is to cover the inbound portion of the conveyor for several feet before it enters the head chute. This increases the resistance to air entering the openings and, thus, reduces airflow.

One technique to reduce air induction at the belt entry is the installation of a piece of old belting as a curtain between the carrying run and the return side (**Figure 7.6**). Placed across from one chutewall to the other, this curtain acts as a wall, enclosing the head pulley and reducing air movement.

SAFETY CONCERNS

It is important to follow the established safety rules for personal protective equipment (PPE), confined-space entry, and exposure to dust created by bulk-materials handling in the workplace.

In applications where the danger of explosion or fire exists, the established procedures for minimizing the risk should be followed.

AIR CONTROL ≈ DUST CONTROL

In Closing...

Dust is carried out of a transfer point by the current of air created by the passage of bulk materials through that transfer point (**Figure 7.7**). Although there will be dust created without air currents, the escape of dust will be minimized without a current of air. The more control a transfer point (or an entire operation) establishes over air movement, the more control it will have over the escape of airborne dust.

Looking Ahead...

This chapter, Air Control, is the second chapter in the section of Loading the Belt, following the topics of tail pulleys and transition areas in Before the Loading Zone. The following two chapters continue the discussion in this section of reducing spillage and dust by focusing on material control: Chapter 8 looks at Conventional Transfer Chutes, and Chapter 9 examines Flow Aids.

Figure 7.7

Dust is carried out of a transfer point by the current of air created by the passage of bulk materials through that transfer point.

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7.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS*, *Sixth Edition*. Naples, Florida.

7.2 Any manufacturer and most distributors of conveyor products can provide a variety of materials on the construction and use of their specific products.

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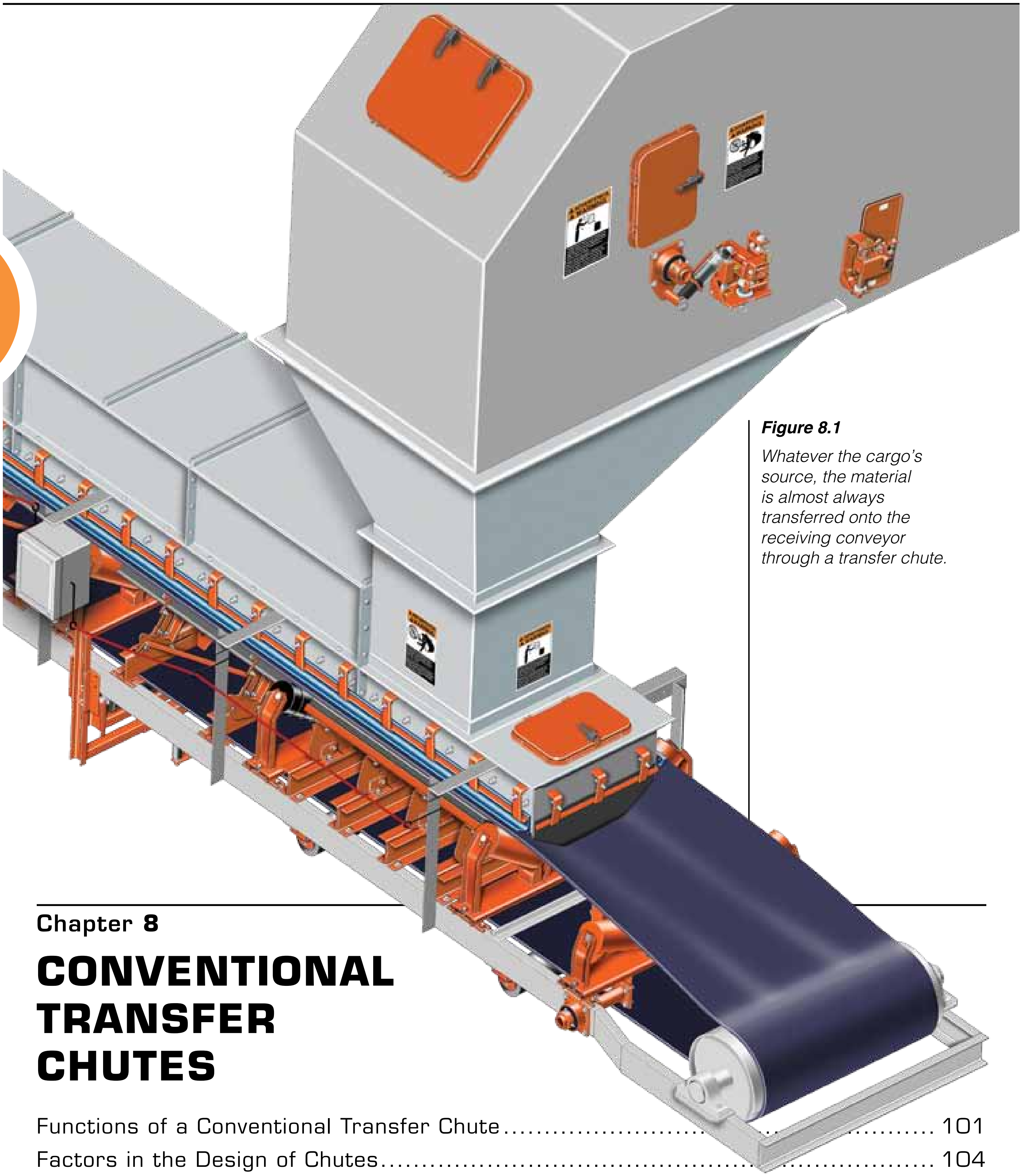

Figure 8.1

Whatever the cargo's source, the material is almost always transferred onto the receiving conveyor through a transfer chute.

Chapter 8

CONVENTIONAL TRANSFER CHUTES

In this Chapter…

In this chapter, we focus on conventional transfer chutes: their function, design, and specifications. We discuss a variety of methods that can be used to safely manage material flow, decrease wear, and control airflow to minimize dust and spillage and preserve the life of the chute. An equation for calculating valley angles is also included.

A conveyor receives its cargo from other conveyors, storage containers, feeders, mobile equipment, rail cars, or other materials-handling systems. Although the sources may vary, the materials are almost always transferred to the receiving conveyor through a device called a transfer chute (**Figure 8.1**). This chapter covers conventional transfer chute design.

Because each material and each application has its own characteristics, an effective transfer chute must be more than just a hollow vessel through which material is channeled. A well-designed chute will control the flow path of the material, prevent blockages, and minimize spillage and dust, thereby reducing plant maintenance costs. The designer of an effective chute must take into consideration not only the bulk-material characteristics, which may vary over time, but also the material's interaction with various parts of the overall system.

FUNCTIONS OF A CONVENTIONAL TRANSFER CHUTE

A conventional transfer chute accomplishes its purpose when it achieves the following objectives (**Figure 8.2**):

A. Provide the transfer of the bulk material at the specified design rate without plugging

B. Protect personnel from injury

C. Minimize escape of fugitive materials

D. Return belt scrapings to the main material flow

E. Be service-friendly

Because conveyors usually do not stand alone but are part of complex systems, compromise is often necessary during design. Consequently, these objectives are not absolute requirements but rather the goals for the design of an effective transfer chute.

There are many "rules of thumb" for designing conventional transfer chutes based on experience and engineering principles. Sometimes these rules overlap or conflict. Chute design is a combination of science and art, so it is always wise to consult a conveyor engineer experienced in design systems for specific bulk-materials handling applications. *(See Chapter 22: Engineered Flow Chutes for a discussion about advanced chute design.)*

Transferring the Material

The primary function of a transfer chute is to reliably transfer the bulk material at the specified rate of flow. If the material will not flow reliably through the chute, then meeting any or all other objectives is irrelevant.

Bulk materials should flow through a transfer chute evenly and consistently. A transfer chute that places surges of material onto the conveyor belt poses a number of problems for the conveyor system. Periodic heavy deposits of material on the belt may cause the center of gravity to shift and the belt to track off-center. Surge loading also has the potential to over-stress the components of the conveyor system, particularly the drive motor or the belt-support system, and may lead to plugging problems if the cross-sectional area of the chute is too small.

Figure 8.2

A well-designed conventional transfer chute provides the transfer of the bulk material at the specified design rate without plugging, while minimizing risk to personnel and the escape of fugitive material.

New methods, such as computer-based Discrete Element Modeling (DEM) method, are now available to verify that material will flow reliably. The vast majority of conventional chutes are still designed based on long-used "rules of thumb."

Protecting Personnel

While open transfers are common in some industries such as aggregate and underground mining, the trend in conventional chute design is to enclose the transfer point as much as possible from the discharge pulley to some distance along the receiving conveyor. Simply enclosing the transfer point is an effective way to contain the bulk material, reduce the escape of fugitive materials, limit noise, and prevent the exposure of personnel to the conveyor's numerous pinch points.

Minimizing the Escape of Fugitive Materials

The size of the enclosure is often based on the space available, which can lead to a less than desirable design. The transfer chute should be large enough to allow any service that might be required. It should also be large enough to reduce dust emissions by allowing sufficient volume to reduce the positive pressure and the velocity of the air flowing in and through the transfer.

There are a number of interrelated design elements that affect the creation of fugitive materials in the form of dust and spillage. A key factor in reducing material escape is the placement of the cargo in the center of the belt.

Off-center loading—placing the cargo predominantly on one side of the belt—is a problem at many transfer points that contributes to generation of fugitive materials (**Figure 8.3**). The problem is most common on non-linear transfer points, where the material's direction of travel is changed. Off-center loading can also be found on in-line transfer points, where material has accumulated within the transfer chute or when changes in material characteristics (such as moisture content, particle size, or speed) have altered the material's trajectory, resulting in material being piled deeper on one side of the receiving belt. This displacement causes tracking problems and may result in spillage over the edge of the belt outside the transfer point (**Figure 8.4**).

Although the ideal is to design a transfer chute to prevent the problems associated with off-center loading, there are solutions that can be implemented within the loading zone to compensate for it. Training idlers and other belt-aligning systems are limited in their ability to counter the effects of off-center loading. Installation of corrective measures, such as deflectors or flow aids within the loading zone, in combination with belt-aligning systems, provides an effective approach. *(See Chapter 16: Belt Alignment for more information.)*

A number of fixtures—such as deflectors, liners, baffles, shapers, screens, grizzly bars, or rock boxes—can be placed within the transfer chute to help direct the flow of material and provide a balanced loading pattern; they are discussed later in this

Figure 8.3

Off-center loading—placing the cargo predominantly on one side of the belt—is a problem at many transfer points that contributes to generation of fugitive materials.

Figure 8.4

Off-center loading results in material being piled deeper on one side of the receiving belt, leading in turn to tracking problems and material spillage.

chapter. The geometry of loading gates or chutework should be calculated during the design of the chute, based on expected material flow patterns, to promote centering of the load.

Returning Belt Scrapings to the Material Flow

Belt cleaners are installed at the discharge pulley to remove residual material that has adhered to the belt beyond the discharge point.

The material removed by cleaners should be returned to the main material flow so that it does not build up on the walls of the head chute or other components. Consequently, a large dribble chute that encloses the belt-cleaning system with steep walls is usually required to accommodate the removed material and direct it back into the main material stream. Carryback has high adhesion, so whenever possible, the dribble chute should have steep, almost vertical walls.

Accomplishing this design objective may require the use of oversize chutes, low-friction chute liners, and/or auxiliary devices such as vibrating dribble chutes, air cannons, and scavenger conveyors. *(See Chapter 14: Belt Cleaning.)*

When designing a transfer, it should be kept in mind that the shallowest angle is the valley angle between two chutewalls (**Figure 8.5**). The steeper the valley angles need to be to minimize the adherence of carryback, the steeper the wall angles must be. To achieve a given valley angle, wall angles with even steeper pitch(es) are needed. Whenever possible, the corners should be rounded to reduce opportunities for the buildup of fines.

Being Service Friendly

Designing the transfer chute so that components can be easily accessed for service is critical to efficient maintenance. Often this is as simple as designing the structure to accommodate the preferred location of components or providing a means for lifting heavy sections of chute wall or other components to be serviced. Many suppliers provide service-friendly arrangements of their components only to have these features canceled out by the design of the structure or by the placement of utility piping and conduits or other components (**Figure 8.6**).

Simply providing sufficient space for access and setting the work platforms at heights convenient for service will go a long way toward making a transfer chute service-friendly. The Conveyor Equipment Manufacturers Association's (CEMA) *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, provides recommended clearances around chutes. *(See also Chapter 26: Conveyor Accessibility.)*

It is often necessary to put scaffolds or work platforms inside the transfer chute for

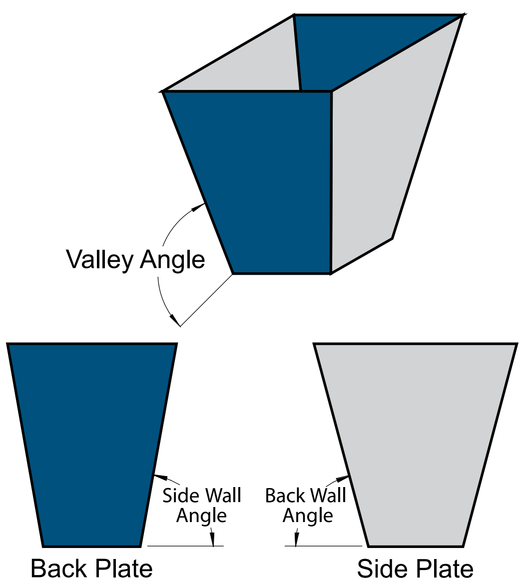

Figure 8.5

In transfer-point design, the shallowest angle is the valley angle between two chutewalls.

Figure 8.6

A conveyor can have its service-friendly capabilities canceled out by the placement of utility piping and conduits and other components.

8

maintenance. It is not unusual for the setup and teardown of the scaffold to take longer than the maintenance task. Installing brackets or pockets to accommodate work platforms inside the chute (away from the material flow) is an effective practice that will save a considerable amount of time.

Designing the transfer chute so that maintenance on critical components can be performed without confined-space entry or "hot work" permits will improve maintenance productivity.

A transfer chute that is easy to maintain and clean will be one that is maintained and cleaned, leading to more production and less downtime. *(See Chapter 26: Conveyor Accessibility and Chapter 28: Maintenance for more information.)*

FACTORS IN THE DESIGN OF CHUTES

Conventional Transfer-Chute Design

Conventional transfer-chute design is normally done by an experienced designer or bulk-materials handling engineer using industry-accepted "rules of thumb." Many engineering firms establish their own design rules; many industries have developed consistent approaches to chute design that solve issues particular to their needs. While these various rules may vary, there is general agreement on at least the order of magnitude for many of the design requirements for conventional chute design. Guidelines for the design of conventional transfer chutes have been published in a number of references. The following is a brief summary of some of the more common design rules and approaches.

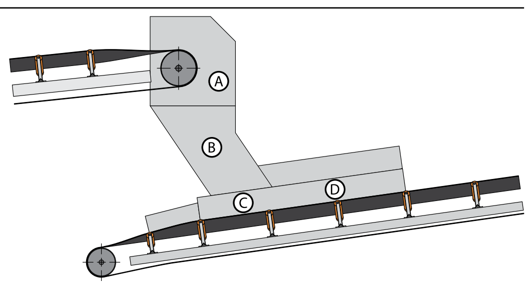

Figure 8.7

A conventional transfer chute usually consists of the following basic parts: A) Head Chute, B) Drop Chute, C) Loading Chute, and D) Settling Zone.

A conventional transfer chute usually consists of the following basic parts (**Figure 8.7**):

A. Head chute

The area surrounding the head pulley of the feeding conveyor

B. Drop chute

The area where the material is in freefall

C. Loading chute

The area where the material comes in contact with the receiving belt (also called the load zone)

D. Settling zone

While not technically part of the transfer chute, an extension of the chutework attached to the transfer chute to settle airborne dust

System Parameters

The following are the minimum parameters a designer must have before starting to design a transfer chute between two belt conveyors:

A. Rated capacity—tons per hour (st/h)

B. Ambient operating environment ranges

C. Bulk density as conveyed—kilograms per cubic meter (lb_m/ft^3)

D. Loose bulk density—kilograms per cubic meter (lb_m/ft^3)

E. Bulk-material classification—size distribution, material characteristics, and any special conditions

F. Discharge and receiving belt widths, speeds, and trough angles

G. Cross-sectional area of the load on the belt—square meters (ft^2)

H. Process flow sheet showing sequence of conveyors

I. General arrangement drawing showing plan and elevation views, critical dimensions, and the planned relationship between the discharge and receiving conveyors

Many times, the listed capacity for conveyors is down-rated 10 to 20 percent from its actual engineered capacity, for several reasons. De-rating the capacity allows for surge loads, reduces spillage, and provides a factor of safety in meeting the specified throughput. When sizing transfer chutes, the conveyor's full load and cross-sectional area should be used.

The material's angle of repose is often used in conventional drop chute design to represent the angle of internal friction and interface friction values of the bulk material. The angle of repose is also used for establishing the minimum slope of chutewalls and the height of the material pile on the inside of the skirtboard. In addition, the angle of repose is often used for calculating the head load or weight of material on a belt that must be started with a full hopper above it. While widely used for these purposes, using the angle of repose for these calculations is often unsatisfactory, because the angle of repose does not represent the ability of the bulk material to adhere to itself or chutewalls.

A better course would be testing the properties of the actual material as it is conveyed through the system. This material testing will establish the range of bulk-material properties that the drop chute must accommodate. It will also help eliminate the most common mistakes made in the design of transfer chutes: the assumptions of maximum lump size and the differences between bulk density as conveyed and loose bulk density. *(See Chapter 25: Material Science for additional information on material properties and testing.)*

Material Trajectory

The path the bulk material takes as it is discharged from the delivery conveyor is called the trajectory. Trajectory is affected by the speed of the belt, the angle of inclination of the discharging belt, and the profile of the material on the belt. In conventional transfer-chute design, the trajectory is plotted and used as a starting point for estimating where the material stream will first impact the head chutewall. From there, the material stream is assumed to be reflected from the chutewall much like a light beam being bent with a series of mirrors. CEMA's *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, provides a detailed discussion of calculating and plotting material trajectories.

The most common mistakes made at this stage of design are developing an incorrect initial material trajectory and failing to consider the effects of friction when plotting subsequent reflections of the material stream from the transfer chutewalls.

The current thinking in transfer-chute design is to control the stream of bulk material and not allow it to free fall from the discharge to the receiving belt. With this controlled approach, the designer assumes the material cross section does not fan out or open up significantly. Drop heights are minimized to help reduce material degradation, dust creation, and wear on the receiving belt.

This approach requires some knowledge of the friction values between the bulk material and transfer chute materials. DEM method is being used in conventional chute design as an aid to the designer in assessing the effects of changing properties, such as the coefficient of friction. There are several DEM software packages on the market designed for this purpose.

Distance, Angle, and Overlap between Conveyors

Ideally, all belt-to-belt transfers would be in-line: The discharging and receiving belts would run in the same direction (**Figure 8.8**). This type of transfer allows for sufficient belt overlap in order to avoid loading on the transition area of the receiving belt, where the belt goes from flat at the tail pulley to its full trough angle. Transitioning in this manner also makes it relatively easy to place the material on the receiving belt with the load moving in the direction of the belt, thus reducing unnecessary wear and spillage. In-line transfers are often incorporated into systems in order to reduce the length of the conveyor when insufficient drive power or tension is available for a single belt, to extend the length of the conveyor system, or to accommodate mechanisms to blend, crush, or separate the material.

Figure 8.8

With in-line conveyor transfers, the discharging and receiving belts would run in the same direction.

Figure 8.9

A non-linear transfer may be required to accommodate changes in material flow direction required by site restriction or to allow for material separation or stockpiling.

Figure 8.10

Off-center material loading may push the belt out from under the skirting, allowing the sealing strip to drop down where the belt runs against the seal.

More typically, a change in the direction of the material movement is required as one conveyor loads onto another (**Figure 8.9**). A non-linear transfer may be required to accommodate changes in material flow direction, to allow for diverting the material for stockpiling, or for splitting the material for separation.

Problems associated with non-linear transfer points include: difficulty in maintaining the material's proper speed, trajectory, and angle; problems controlling dust and spillage; and issues of increased wear on (and the resulting higher cost for replacement of) transfer-point components.

If material is loaded on the belt in a direction that is not in line with movement of the receiving belt, wear patterns may become visible on the inside of the head (discharge) chute. These patterns will correspond to the path the material takes as it bounces off the inside of the chute as it tries to attain the direction and speed of the moving belt. Although turbulence may not be visible as the load exits the skirted area, the ricocheting movement of the material within the transfer chute accelerates wear on liners, skirtboard, and sealing systems. The force of the loading material may mistrack the belt and push it out from under the skirting on one side of the belt, allowing the sealing strip to drop down and preventing the belt from returning to its centered position. The belt will attempt to return to its center as material loading changes, forcing the belt into contact with the sealing strip and cutting through the strip, resulting in significant spillage opportunities (**Figure 8.10**).

Fortunately, a number of strategies and components can be employed to guide the flow of material into the desired direction of travel and load it onto the center of the receiving belt.

The most common mistakes made in the transfer chute design stage include not providing enough overlap of the conveyors. This leads to loading on the belt transition and not allowing enough room for installing belt cleaners. Without attention to proper conveyor design, including sufficient overlap, the operation is burdened with a conveyor that plugs often, generates loads of fugitive material, and creates excessive wear problems.

Loading in the transition area of the receiving belt is done in an attempt to reduce costs by saving a few meters of conveyor length. It is recognized that this practice creates numerous problems in loading, sealing, and belt wear and should be avoided.

It should be noted that in order to reduce the load absorption requirements and dust creation opportunities of a conveyor transfer system, drop height should be kept at a minimum; however, engineered hood and spoon designs use gravity to maintain material flow speed (**Figure 8.11**) and often require greater drop heights in order to implement them. Engineered spoons provide many benefits and should be considered as part of the original design or as part of the requirement of a future retrofit. *(See Chapter 22: Engineered Flow Chutes.)*

Design Considerations of the Transfer Chute

The volume of the head (discharge) chute around the discharge pulley is usually dictated by the general arrangement of the conveyors, access requirements for service, and the initial material trajectory.

Head pulley diameter and face width help determine the width and height of the head chute. The space between the chutewall and the pulley rim should be small enough that large lumps are not able to pass from the carrying side to the return and are not caught between the pulley and the chutewall. A typical space is 50 to 75 millimeters (2 to 3 in.) per side. Maintenance of the pulley and pulley lagging as well as access to the shaft bushings should be considered in making this decision.

The head chute should start at the last full transition idler on the delivering conveyor to help contain any fugitive material that might fall from the belt as the belt changes from troughed to flat on the head pulley. The inlet area of the head chute should be controlled with dust curtains on the carrying sides and barrier seals on the belt return side, because these areas are key factors for controlling the amount of air flowing through the transfer chute (**Figure 8.12**).

Once the bulk-material flow direction has been changed by the first contact with the head chute, material is often channeled into drop (transition) chutes. These drop chutes can be extended with duct-like chutes that place the material stream into proper alignment with the receiving conveyor. All of these drop chutes need to be steep enough to prevent the bulk material from sticking to the walls; they also need to be large enough to prevent plugging.

It is commonly accepted that the drop chute cross-sectional area should be a minimum of four times the cross-sectional area of the material profile. It is also commonly

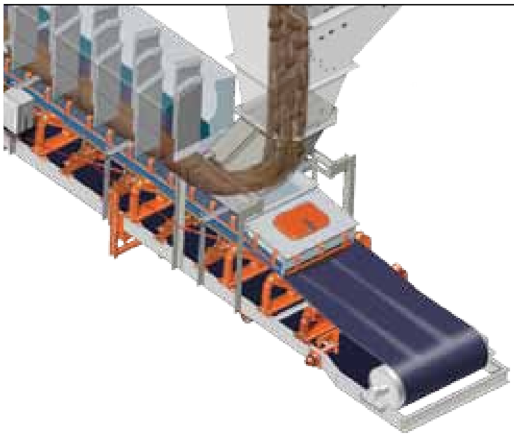

Figure 8.11

Engineered hood and spoon designs use gravity to maintain material flow speed.

Figure 8.12

To control the air flowing through the chute, the inlet area should be controlled with dust curtains on the carrying side and barrier seals on the belt return side.

accepted that the minimum dimensions for width and/or depth should be at least 2.5 times the largest lump expected to pass through the chute. Many designers increase these ratios based on their experience with particular materials. In some cases, where the bulk material is uniform in size and free flowing, these ratios can be reduced, especially when the chute is engineered using the specific properties of the bulk material being conveyed.

The loading (receiving) chute width should be designed to maintain the minimum belt edge necessary for sealing and accommodating mistracking. *(See Chapter 11: Skirtboards.)*

The most common mistake made at this stage of design is making too abrupt a transition between the drop chute and the loading chute, creating chutewall angles that promote buildup leading to plugging. Current design practice is to use valley angles at a minimum of 60 degrees, with 75 degrees preferred (**Figure 8.5**).

Managing Wear and Material Flow

The transfer chute is usually designed for full flow and a consistent material path. However, the flow of a bulk material through the chute will change as the material changes properties, the tonnage changes, the chute wears, or the bulk material builds up on the chutewall.

Deflectors

Deflectors may be used inside a transfer chute to absorb impact and minimize wear, starting at the point where the material trajectory first meets the head chute (**Figure 8.13**). It is important to provide enough clearance between a deflector and the head pulley of the discharging conveyor to prevent large lumps from blocking the passage or cohesive material from adhering to the plate, which could cause the transfer chute to plug.

Figure 8.13

Deflectors may be used inside a chute to absorb impact and minimize wear.

Once the material flow leaves the first point of contact with the chute, it may be necessary to fine-tune the flow of the material on start-up of the system. Deflectors, or "kicker plates," are often included in the original plan or installed at start up to steer the material flow.

During the start-up of a new conveyor system, it is common practice to install deflectors within the loading chute to help center the load. The process of getting a desired flow path through the chute is often one of trial and error. These deflector plates should be field-adjustable so they can be repositioned to achieve the desired effect. They should be accessible to allow efficient replacement. Inspection and access points are critical to observing and maintaining the proper direction for deflected materials.

Load placement may be enhanced with deflectors installed on the inside surface of the loading chute to direct lumps of material toward the center of the load zone. Center-loaded lumps are less likely to slip off the edges of the belt or damage the skirtboard seals.

Deflector wear liners inside the bottom of the loading chute next to the belt may reduce the problems associated with off-center loading. One or more deflectors or impact plates may be necessary to retard the forward momentum of the material, redirect it in the proper direction, and center the load on the receiving belt. These liners feature a bend or angle that turns the material toward the center of the belt and away from the belt edges. Deflector wear liners should be used with care, because they may contribute to other problems, such as material entrapment and transfer chute choking.

Popular ways to manage the flow of bulk materials through the transfer chute and minimize impact are installation of scalping bars or the use of rock boxes.

Scalping, or Grizzly, Bars

Scalping bars—also called a grizzly or grizzly bars—within the transfer chute allow the fines to pass through first to form a protective bed on the belt. The lumps, which are unable to pass between the bars, slide down the incline and land on the belt on a cushion formed by the previously deposited fines. Plants use grizzlies like a grate at truck dumps or other installations to keep oversize lumps away from conveyor systems (**Figure 8.14**).

Rock Boxes

Rock boxes consist of a ledge inside the drop chute where a pile of the conveyed material accumulates (**Figure 8.15**). Subsequent material moving through the chute flows over or deflects off this pocket of captive material. Abrasive force is shifted from the chutework to the accumulated bed of material, and the overall drop height is reduced and impact force dissipated as material bounces off the material on the ledge (**Figure 8.16**).

Rock ladders, composed of a series of baffles, or "mini" rock boxes, are used to reduce impact and control material velocity over drops of greater distance (**Figure 8.17**). Rock ladder shelves are typically arranged on alternating sides of the chute, so the material never has a free drop of more than 1,5 to 2 meters (5 to 6 ft).

Rock boxes and rock ladders are most appropriate for chutes handling materials such as sand, gravel, or hard rock (**Figure 8.18**). The boxes are most successfully used if physical conditions and flow rates do not change over time, because it is important that the flowing material move consistently across the buildup in the rock box. Care must be taken to accurately judge the cohesive characteristics of the material (under wet conditions, for example) in order to avoid accumulations that can choke the chute. Rock boxes should not be used in transfer points handling fragile bulk materials that might suffer degradation or materials with large lumps that can block or choke the flow; nor should they be used if a conveyor will carry more than one material.

Figure 8.14

Scalping bars—also called a grizzly or grizzly bars—within the chute allow the fines to pass through first to form a protective bed on the belt. Plants use grizzlies to keep oversize lumps away from the conveyor systems.

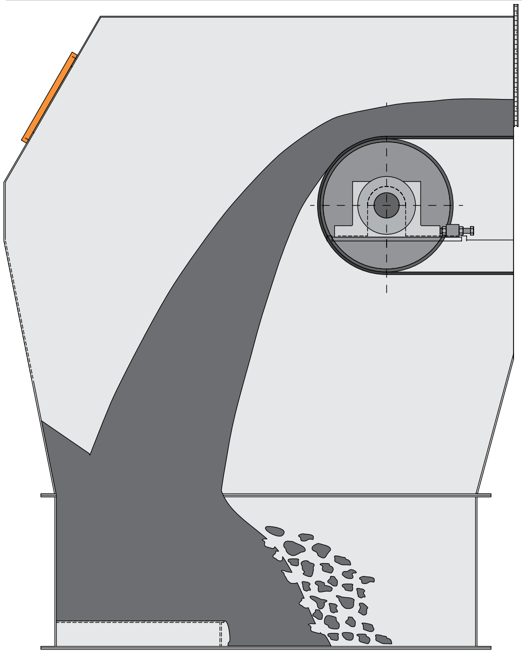

Figure 8.15

A rock box consists of a ledge inside the chute where a pile of the conveyed material accumulates.

Figure 8.16

Rock boxes shift the abrasion from the moving material from the chutework to the bed of material, and impact force is dissipated as material bounces off the material on the ledge.

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Impact Plates or Grids

Another method of diverting flow and absorbing impact within the transfer chute is the use of impact plates or grids in the material path (**Figure 8.19**). An impact plate is placed inside the chute to absorb the force of the moving material stream. Impact plates are often used in angular transfers where high belt speeds are present and circumstances (such as available space and budgets) prevent the engineering of ample chutes.

Figure 8.17

Rock ladders are a series of baffles, or "mini" rock boxes, used to reduce impact and control material velocity over drops of greater distance.

Figure 8.18

Rock boxes and rock ladders are most appropriate for chutes handling materials such as sand, gravel, or hard rock. Note: looking down the chute from the head pulley.

Figure 8.19

Impact plates are placed in the material path inside a loading chute to divert flow and absorb impact.

Some impact grids are designed to catch material to develop a material-on-material impact that preserves the chutewalls. Subsequent material bounces off the captured material without actually hitting the grid or the chutewall. The gap between the head pulley and the impact plate should be carefully considered to minimize problems from oversize rocks or tramp material becoming hung up between the pulley and the plate, or from the buildup of cohesive or high-moisture materials that can choke the transfer chute.

The selection of appropriate materials and careful attention to design and positioning of impact plates and grids may significantly improve the life of these wear components.

Wear Liners

The constant impact and sliding of material against the sides of the transfer chute is the main source of wear in a chute. In addition to the grids, rock boxes, and impact plates discussed above, one way to reduce wear of the chute itself is the use of sacrificial liners inside the chute. Liners may also be installed to reduce wall friction and/or material adhesion. In selecting a material for use as a liner, the goal is to select a material that will both resist abrasion and enhance flow. *(See Chapter 12: Wear Liners for more information.)*

Loading the Receiving Belt

Another phenomenon that occurs at transfer points where material falls vertically onto a high-speed belt is called pooling. Material not yet moving at belt speed piles up on the belt and creates a "pool" of material in the loading zone (**Figure 8.20**). When a lump of material drops onto the belt, it bounces and tumbles, dissipating the energy supplied by the previous conveyor and from its fall until the lump is caught by the motion of the receiving belt. In the meantime, the material can bounce off the pool or pile toward the side or rear of the conveyor, resulting in spillage. The greater the difference between velocity of the material stream and the speed of the receiving belt, the longer and deeper the pool of material. As this body of "pooled" material grows, it becomes increasingly difficult to maintain a sealed, spillage-free transfer point and control belt cover wear.

A speed-up conveyor can be used to remedy this condition (**Figure 8.21**). Another solution is the use of a curved gate, ramp, or spoon to control the speed and direction of the material stream until it reaches the speed and direction of the receiving belt (**Figure 8.22**). These curved loading chutes steer the material flow, "pouring" it onto the center of the receiving belt. The smoother positioning of the load on the receiving conveyor reduces the movement of the material to the edges of the belt and releases less energy and air movement, minimizing dust. The angle at which the chute descends from the unloading structure onto the receiving belt should be flat enough to prevent lumps from bouncing excessively after they land on the belt. A chute with as low as possible valley angle, combined with proper load direction and speed, allows the lumps to strike the belt at a grazing angle (**Figure 8.23**). This allows the material to bounce gently as it is carried in the direction of belt movement rather than rebound back into the face of the incoming material stream. A curved chute reduces the risk of damage to the belt and minimizes material degradation and dust generation.

It should be noted, however, that if the chute angle is too flat, the material stream might slow to the point that it can accumulate on shut down, build up, and eventually plug the chute. Typical valley angles for conventionally designed chutes are between 60 and 75 degrees from the receiving belt line (**Figure 8.5**).

Managing Air Flow

A well-designed and constructed transfer chute can significantly reduce airborne dust by limiting the creation of induced air movement. The skirtboard sections should be large enough to provide a plenum that stills air currents and reduces the positive pressures that can carry airborne particles out of the enclosure. *(See Chapter 7: Air Control and Chapter 11: Skirtboards for more information.)*

The enclosure should be spacious enough to permit a significant reduction in the speed of air currents and, therefore, allow airborne particles to settle back into the load before the conveyor leaves the enclosure.

Chute Structure

The transfer chute is typically fabricated from plates of mild steel or stainless steel, with selection depending on the conveyed material and the conditions in the facility.

Figure 8.20

Pooling occurs when belt cargo that is not yet moving at belt speed piles up in the loading zone.

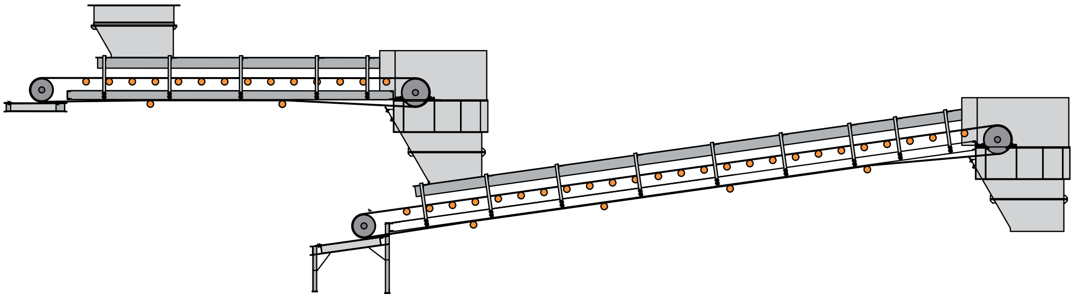

Figure 8.21

A speed-up conveyor can be used to raise the velocity of the material until it reaches the proper speed and direction.

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The selection of transfer chute plate thickness depends on the characteristics and volume of material moving through the chute, the structural strength requirements, and the margin for wear if the chute will not be fitted with a replaceable liner system. Local codes usually govern the structural design of chutes, but it is up to the designer to consider all the loads that may be present. Some of the more important loads are the weight of the chute, accumulations of fugitive materials, snow and ice, the weight of a chute full of bulk materials, and wind loads. Work platforms around the chute need to be sturdy enough to handle maintenance activities.

Figure 8.22

A curved gate, ramp, or spoon can place the material stream on the receiving belt with the proper speed and direction.

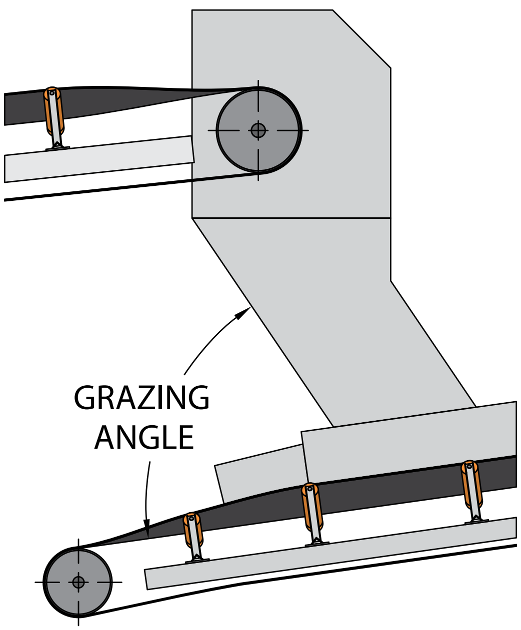

Figure 8.23

The angle at which the chute descends from the unloading structure onto the receiving belt should be flat enough so the material strikes the belt at a grazing angle, to prevent excessive bounce of the lumps.

Figure 8.24

Despite the best intentions and practices of chute designers, there are occasions when material will accumulate inside transfer chutes.

Transfer chutes should be fabricated in sections that are convenient for transport and subsequent erection on site. For retrofit systems, chute sections must also be designed to fit through available openings to reach the construction site.

Care must be exercised in the construction of transfer chutes to avoid imperfections in the surface that might disrupt the material flow and negate the careful engineering that went into the design. Variations of ± 3 millimeters (1/8 in.) may present problems when matching sections of wear liner or truing up the chutework to the belt. The investment of time in a precise chute installation will be returned many times over through improved efficiency, simplified maintenance, and reduced fugitive material.

Despite the best intentions and practices of transfer chute designers, there are occasions when material will accumulate in transfer chutes. Materials with high levels of moisture may adhere to walls or even freeze during winter operations (**Figure 8.24**). Continuous operation may compress the material encrustation more firmly onto the chutewall, allowing for additional material buildup and possibly leading to complete chute blockage. During the chute design process, it is wise to make provisions for future requirements for flow-aid devices, such as vibrators or air cannons. *(See Chapter 9: Flow Aids and Chapter 22: Engineered Flow Chutes.)*

Chute Access

An enclosed transfer chute must have openings to allow for visual inspection and doors for worker entry, and there must be a clear path for workers to reach these openings. Inspection openings, such as hinged access doors, should be positioned away from the flow of material yet located where personnel can observe material movement and inspect for wear (**Figure 8.25**).

Screens or guards should be positioned to protect workers observing material flow from pinch points and rolling components. Covers or doors should be corrosion resistant and provide a dust-tight seal. Safety barriers should be in place to prevent material from escaping the chute and to keep personnel from reaching into the material trajectory.

Often forgotten in the design of transfer chutes is the provision for some method of access to replace liners inside the chute or to maintain belt cleaners.

Consideration of future service requirements is particularly important on transfer chutes too small for personnel to work inside. Fabricating chutes in sections for easy disassembly is one approach to maintenance. *(See Chapter 26: Conveyor Accessibility.)*

TYPICAL SPECIFICATIONS

A. Direction

In general, the transfer chute should be designed to direct the material in the direction of the receiving conveyor and center it on the belt.

B. Drop height

The drop height from the discharge system to the receiving conveyor should be as short as possible while providing

Figure 8.25

Inspection and access doors should be positioned out of the flow of material yet located where personnel can observe material movement and inspect for wear.

SAFETY CONCERNS

Safety considerations require that access be limited so personnel cannot enter the chute until appropriate safety procedures are followed, including lockout / tagout / blockout / testout procedures of both discharging and receiving conveyors. No one should enter chutes without proper training in confined-space safety procedures.

The structural and liner components of transfer chutes tend to be large and heavy and should be handled with appropriate equipment and due care.

If flow-aid devices (such as air cannons) are installed, proper de-energization and lockout / tagout / blockout / testout procedures must be followed for this equipment prior to service.

Personnel working in, on, or around transfer chutes must be aware of the potential for falling materials, either cargo from the belt above or buildup on the chutewalls. It is recommended that the chute be inspected and thoroughly cleaned before entering for any reason.

It is important to pay attention to safety procedures when working around nuclear devices installed on transfer chutes for level detection or on-line bulk-material analysis.

Chutes and their structures should be grounded to prevent the buildup of static electricity.

adequate space for equipment installation and maintenance.

C. Speed

Material from the discharge should be loaded so it is moving at the same speed as the receiving conveyor is traveling.

D. Slope

The transfer chute should be adequately sloped to prevent material from bouncing excessively after it lands on the receiving conveyor, which can increase dust generation and impact damage.

E. Volume

The volume of the drop chute should be at least four times that of the load stream of the feed conveyor. The transfer sections should be large enough to provide a plenum to minimize air currents.

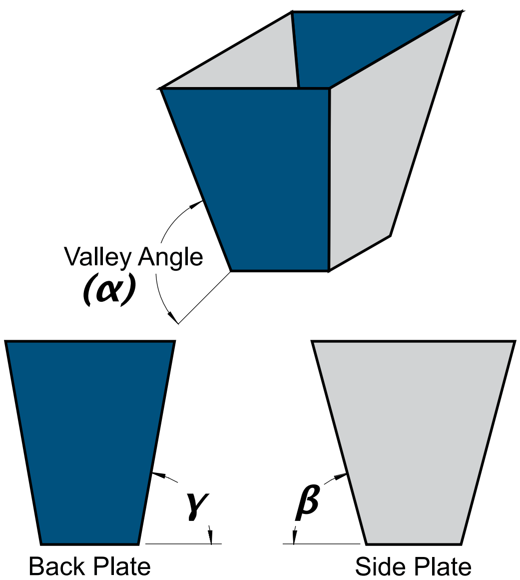

Figure 8.26

The valley angle is the angle created by the side wall joining with the back wall.

ADVANCED TOPICS

Chute Width

The belt is 1200 millimeters (48 in.) wide with 30-degree troughing idlers. What is the recommended chute width where the chute matches up with the skirtboards?

The CEMA 2/3 rule results in a chute 800 millimeters (32 in.) wide.

Another method to determine the recommended distance between the skirtboards is based on the amount of belt edge necessary for an effective seal and accomodation of belt wander. The recommended skirtboard width for a belt 1200 millimeters (48 in.) wide with a 30-degree troughing angle is 894 millimeters (35.2 in.). *(See Chapter 11: Skirtboards.)* The difference between the CEMA method and the belt-edge method is more pronounced for very narrow and very wide belts.

Calculating Valley Angles

A new chute with a minimum valley angle of 60 degrees was required. A side wall angle of 75 degrees and a back wall angle of 60 degrees were selected, because these angles were within the recommended range (**Figure 8.26**). The equation can be used to check the design (**Equation 8.1**).

In this example, the valley angle is approximately 57 degrees, so the designer should reconsider the design of the chute to maintain a minimum of 60 degrees as required. If the angles were changed to 65 degrees and 75 degrees, the valley angle would be 61 degrees, which would be steep enough to maintain flow.

Equation 8.1

Calculating Valley Angles

$$\alpha = \operatorname{arc\,cot}\left(\sqrt{\cot^2(\beta) + \cot^2(\gamma)}\right)$$

Given: *A designer has selected a side wall angle of 75° and a back wall angle of 60°.*
Find: *The valley angle of the chute.*

α	Valley Angle	degrees
β	Back Wall Angle to Horizontal	60°
γ	Side Wall Angle to Horizontal	75°

$$\alpha = \operatorname{arc\,cot}\left(\sqrt{\cot^2(60) + \cot^2(75)}\right) = 57.5$$

α	Valley Angle	57.5°

It should be noted that the valley angle will never be greater than the smaller of the other two angles (back wall and side wall).

The design would be an iterative process of selecting wall angles based on geometry and calculating the valley angle. If the valley angle is not appropriate, different wall angles should be selected and the valley angle calculated for the selected angles. This process is repeated until the wall angles fit within the geometry available and the valley angle is in the correct range based on the material.

THE WORK OF CHUTEWORK

In Closing...

Designed correctly, conventional transfer chutes offer an effective method to safely transfer material from one elevation to another, with minimal fugitive material and low maintenance requirements. Incorporating the items discussed in this chapter into the plans will provide both the designer and end user with suitable tools to understand how chutes operate from a practical level and how to design or modify them for improved performance.

Looking Ahead...

This chapter about Conventional Transfer Chutes, the third chapter in the section Loading the Belt, focused on the transfer chute and methods to manage material flow to reduce spillage and dust. The following chapter continues this section with a discussion about Flow Aids.

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8.4 Taylor, H.J. (1989). *Guide to the Design of Transfer Chutes and Chute Linings for Bulk Materials*. The Mechanical Handling Engineers' Association.

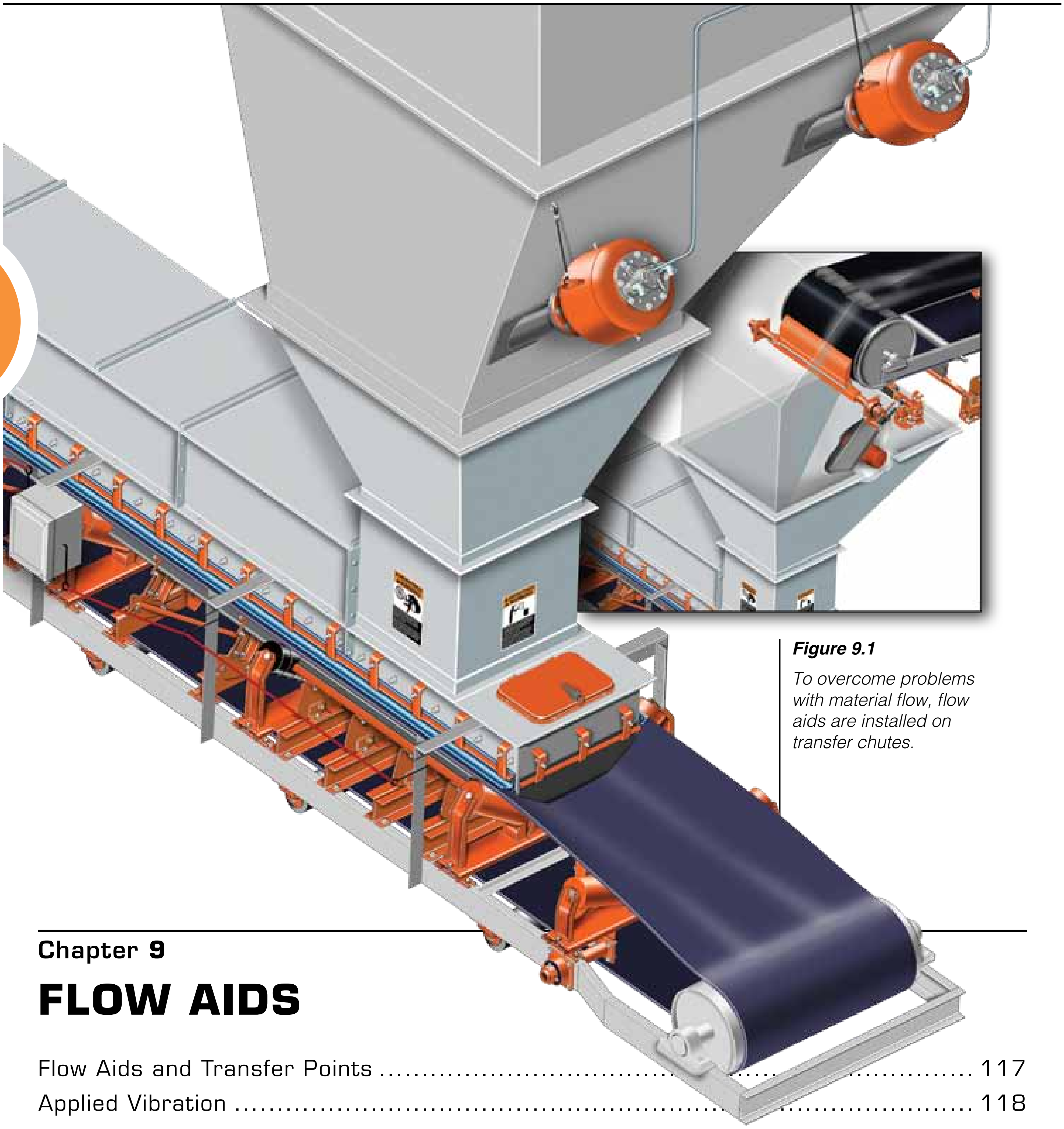

Figure 9.1

To overcome problems with material flow, flow aids are installed on transfer chutes.

Chapter 9

FLOW AIDS

In this Chapter...

In this chapter, we discuss various methods to promote the flow of materials through chutes. These flow aids include both linear and rotary vibrators, air cannons, aeration systems, chute linings, and soft-chute designs. Considerations for selection of the type of flow aid for a particular application, sizing, installation, and maintaining flow aids are offered, along with safety procedures.

Transfer chutes must be designed to accommodate and facilitate the flow of materials they will be handling. But even if the application is ideal and the engineer experienced, changes in material characteristics and/or system demand can create problems with material flow. To overcome these problems, a variety of devices called flow aids are utilized (**Figure 9.1**).

There is a wide range of material characteristics and operating conditions that make the use of flow aids in the original design a practical option. To design a chute that would handle every material situation is virtually impossible. Many times, the most economical solution to sustain the flow with changing material and operating conditions is to include flow-aid devices in the original design. Materials with high moisture-content can adhere to walls or even freeze during winter operations. Continuous operation can serve to compress the material encrustation even more firmly onto the wall. Bulk materials can change in characteristics as the operation progresses through the seam or stockpile. In some cases, the chute can become completely blocked by just a small change in any of these parameters.

Flow aids are installed to promote the flow of materials through a chute or vessel. Because they will affect a conveyor's loading, flow-aid devices can also impact spillage and dust. The accidental, or intended, breakdown of buildup can produce surges, producing overloading, spillage, and mistracking. By designing active flow aids into a chute, the operation gains a level of control over the material flow that is impossible to obtain with static approaches, like low-friction liners, alone.

FLOW AIDS AND TRANSFER POINTS

What is a Flow Aid?

Flow-aid devices are systems used to stimulate or enhance the movement of bulk materials. They can be as simple as an impacting piston vibrator on a chutewall to dislodge material buildup, or as sophisticated as a multiple air-cannon system discharging automatically on a timed cycle to prevent material buildup. Flow-aid devices include rotary or linear vibrators, low-pressure air cannons, and aeration devices, as well as low-friction linings and soft-chute designs. These systems can be combined in any number of ways.

The age-old solution for breaking loose blockages and removing accumulations from chutes and storage vessels was to pound the outside of the walls with a hammer or other heavy object (**Figure 9.2**). However, the more the walls are pounded, the worse the situation becomes, because the bumps and ridges left in the wall from the hammer strikes form ledges that start additional material accumulations (**Figure 9.3**).

A better solution is the application of a flow-aid device to the chute. These devices supply energy precisely where needed to reduce the friction of the walls and break up the material to keep the material moving to the discharge opening.

Figure 9.2

The traditional solution for improving flow from chutes and storage vessels was to pound the outside of the walls with a battering ram, hammer, or other heavy object.

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This chapter explores the various methods to promote material flow in a chute. This discussion centers on flow aids applied to conveyor loading and discharge chutes; this information, and these technologies, can also be applied to applications on other material process and storage vessels, including silos, bins, hoppers, bunkers, screens, feeders, cyclones, and heat exchangers.

Flow Aids on Transfer Points

Using material characteristics and process requirements to design a chute to flow efficiently is certainly the best practice. However, materials are unpredictable. The source of the material may change due to economic reasons, or weather conditions can drastically alter its flow characteristics. In these situations, it is a simple and cost-effective approach to apply flow aids to maintain material flow.

In some cases, flow aids are original equipment, incorporated in the design of a system to stabilize flow rates or eliminate anticipated problems. As an example, a flow aid might be designed into a system to move material through a chute that, due to height restrictions, does not have a steep enough angle to maintain consistent material movement. In other cases, flow aids are retrofit components, added to a materials-handling system to overcome problems that were not anticipated in the original design, or that have recently appeared, perhaps due to changes in the condition of the material, the process, or the equipment.

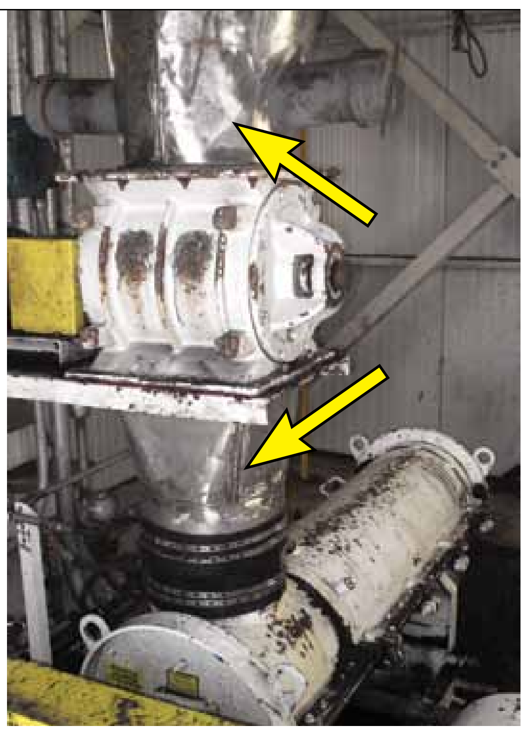

Figure 9.3

The more the walls are pounded, the worse the situation becomes, because the bumps and ridges left in the wall from the hammer strikes form ledges that start additional material accumulations.

It is wise to incorporate channel mountings for vibrators, or nozzle mounts for air cannons, when a chute is in the fabrication stage. If a problem should arise later, because material characteristics have changed or other unforeseen problems have occurred, it will be a simple matter to install a flow-aid device to remedy the problem.

It is critical that the steel chute and support structure are sound, because the operation of these flow-aid devices can create potentially damaging stress on the structure. A properly designed and maintained chute will not be damaged by the addition of flow aids.

It is important that any flow-aid device be used only when the discharge is open and material can flow from the chute. If used when the discharge is closed, the energy of the flow aid may pack the material more tightly, making flow more problematic when the discharge is opened and causing damage to the bin. The best practice is for the flow aid to be controlled by timers or sensors to prevent any flow-retarding buildup of material. This saves energy, reduces noise, and improves safety, because the flow aid runs only when needed.

APPLIED VIBRATION

Vibrators perform the same function as thumping on the outside of a bottle of ketchup: They reduce the cohesion between the material particles and the adhesion between the particles and the wall to increase the flow of material out of the bottom.

The relationship between the bulk material and the frequency of vibration best suited to stimulate that material is proportional to particle size. As a general rule, the smaller the particle, the better it responds to higher vibration frequencies. The relationship between amplitude of vibration and the bulk material is based on cohesive and adhesive forces. As the particle size increases, the amplitude required to cause the bulk material to move increases. Particles that are fine and free flowing (low cohesive) tend to respond well to small amplitudes of vibration; free-flowing particles that are larger respond better to larger amplitudes. Particles that are sticky tend to build up in solid masses that respond well to low-frequency high-amplitude vibration. Generally, the direction of the rotation or the stroke of the vibrator's mass should be in the direction of desired flow of the material.

Linear Vibrators

Linear vibrators activate the material inside a chute or bin by using heavy blows on the outside of the structure's steel walls. In fact, the earliest form of vibration was a hammer. The act of pounding on the chute or bin wall overcomes the adhesive force between the material and the wall surface. However, this hammering on the bin or chutewall often leads to damage to the wall surface (**Figure 9.4**). The marks left on the wall by the hammer, often called "hammer rash," will continue and expand the problem the blow of the hammer was supposed to overcome. In addition, the swinging of the sledgehammer poses the risk of injuries to plant personnel. The piston vibrator was developed to produce this effect without actually swinging a hammer (**Figure 9.5**).

A pneumatic piston (or linear) vibrator uses plant air to move a piston back and forth inside a casing (**Figure 9.6**). In some vibrators, this piston may strike the wall; in other designs, it merely oscillates with enough mass to flex the wall. In both cases, the vibrator provides energy through the wall to the material inside the structure. This force—more controlled than a hammer strike—breaks the adhesion between the material and the wall, so the material will flow out of the structure.

Linear vibration is the best solution for sticky, coarse, high-moisture materials. A convenient test is to take a handful of material and squeeze it into a ball. If the material readily remains in the ball after the fist is opened, linear vibration is probably the best choice.

A piston vibrator would be mounted on the outside of the vessel or chute at the point of the buildup or blockage on the inside. Often these vibrators are attached to a steel channel that is mounted on the chutewall (**Figure 9.7**). This mount spreads the force out over a larger area of the structure to maximize the efficiency

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Figure 9.4

Hammering on the bin or chutewall leads to damage to the wall surface, often called "hammer rash."

Figure 9.5

The piston vibrator was developed to produce this pounding effect without actually swinging a hammer.

Figure 9.6

A pneumatic piston (linear) vibrator uses plant air to move a piston back and forth inside a casing to produce a vibratory force.

while preserving the structure from fatigue. Most linear vibrators are driven by plant air and can be controlled remotely, with a solenoid, or locally, with a manual on/off valve.

The vibrator for a particular application is selected according to the weight and characteristics of material in the chute or sloped portion of a bin or hopper (**Table 9.1**). The general "rule of thumb" for

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Table 9.1

Typical Vibrator Sizes by Weight of Material Inside the Chute

Maximum Weight of Bulk Material in Chute kg (lb_m)	**Vibrator Force Required** N (lb_f)	**Diameter of Piston in Linear Vibrator** mm (in.)	**Bin Wall Thickness Range** mm (in.)	**Mounting Channel Suggested Length** mm (in.)
1315 (2900)	~1300 (~300)	32 (1.25)	1,6 to 3,2 (1/16 to 1/8)	900 (36)
2223 (4900)	~2250 (~500)	50 (2)	4,8 to 6,4 (3/16 to 1/4)	900 (36)
4445 (9800)	~4450 (~1000)	75 (3)	6,4 to 9,5 (1/4 to 3/8)	900 (36)
9979 (22000)	~10000 (~2200)	100 (4)	9,5 to 12,7 (3/8 to 1/2)	1800 (72)

Table 9.2

Vibrator Force Outputs Based on Bulk Density

Bulk Density	**Force Ratios**
Above 1440 kg/m³ (90 lb_m/ft^3)	1 newton per 0,7 kg (1 lb_f/7 lb_m)
Between 640-1440 kg/m³ (40-90 lb_m/ft^3)	1 newton per 1,0 kg (1 lb_f/10 lb_m)
Below 640 kg/m³ (40 lb_m/ft^3)	1 newton per 0,3 kg (1 lb_f/3 lb_m)

Note: As stated previously, fine, dry materials respond well to high-frequency/low-amplitude vibration, where as larger particles and wet materials respond better to low-frequency/high-amplitude vibration.

Equation 9.1

Linear Vibrator Output Force Requirement

$$LF = \frac{Wt_t}{k_a}$$

Given: *4100 kilograms (9000 lb_m) of dry material is plugging a conveyor load chute.* ***Find:*** *The linear force required from a vibrator to encourage flow in the given chute.*

Variables		**Metric Units**	**Imperial Units**
LF	Linear Force Required	newtons	pounds-force
k_a	Application Factor *The Application Factor comes from the Rule of Thumb for Vibrator Application.*	1,025 (dry material) 0,82 (wet material)	10 (dry material) 8 (wet material)
Wt_t	Weight of Material in Influenced Area	4100 kg	9000 lb_m

Metric: $LF = \frac{4100}{1,025} = 4000$

Imperial: $LF = \frac{9000}{10} = 900$

LF	Linear Force Required	4000 N	900 lb_f

typical vibrator applications is to apply 1 newton per 1 kilogram (1 lb_f /10 lb_m) of material weight inside the chute. This general rule assumes that the material is flowable and has a density less than 1440 kilograms per cubic meter (90 lb_m/ft^3).

More force will be needed for materials of high density or moisture or of low density. While the ratio above is acceptable for materials between 640-1440 kilograms per cubic meter (40-90 lb_m/ft^3), materials with higher or lower bulk densities require different ratios (**Table 9.2**).

The length of the mounting channel and the chutewall thickness best suited for these applications are also dependent on material weight and characteristics; applications outside the parameters given in the table may require specialized engineering.

The calculation of linear force is required for application of a vibrator on a chute (**Equation 9.1**).

After installation, air-powered vibrators must be tuned to the needs of the application by adjusting the air pressure and/or flow rate to maximize the effect on the bulk material.

Rotary Vibrators

In contrast to linear vibrators, other vibrators create a vibratory force through the rotation of an eccentric weight. These rotary vibrators create a powerful vibration much as a household washing machine does when its load is off-center. They supply an energy that is most suited to move fine, dry materials (**Figure 9.8**).

Rotary vibrators can be pneumatically-, hydraulically-, or electrically-powered: The choice for a given application is often determined by the energy supply most readily available at the point of installation.

In rotary pneumatic vibrators, a stream of air drives a mass in a circular orbit to create the vibration; in rotary hydraulic vibrators, it is a stream of hydraulic fluid that moves the mass. In rotary electric vibrators, eccentric weights are typically mounted on the ends of an electric motor rotor or shaft (**Figure 9.9**).

Rotary vibrators are available in a wide range of sizes and outputs, to match the specifics of each application. In addition, many rotary electric vibrators can be adjusted by altering the overlap of the eccentric weights—increasing or decreasing the amount of unbalance—to provide the desired amount of vibratory force.

Vibration can induce stress into metal structures, and the walls may need to be reinforced at the point(s) of application. Like

Figure 9.7

A piston vibrator should be installed on a steel channel that is mounted on outside of the chute at the point of the buildup.

Figure 9.8

Rotary vibrators create a powerful vibration through the rotation of an eccentric weight or mass around a central axis.

Figure 9.9

In rotary electric vibrators, weights are typically mounted on the ends of an electric motor rotor or shaft.

linear vibrators, rotary vibrators are typically installed on a mount plate or channel that spreads the vibratory energy (and the weight of the device) over a larger surface area (**Figure 9.10**).

Figure 9.10

Rotary vibrators are typically installed on a mount plate or channel that spreads the vibratory energy and the weight of the device over a larger surface area.

Figure 9.11

An air-cannon system is another solution to the buildup of material in transfer chutes.

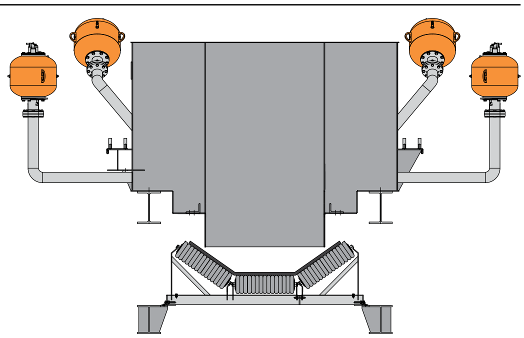


Figure 9.12

Air cannons use plant compressed air to create an eruption of air that will dislodge material buildup in chutes.

Figure 9.13

Some air-cannon systems feed air from one reservoir to a number of discharge nozzles.

Rotary vibrators designed for chutes or hoppers are usually sized based on a 1:10 ratio of output force to the mass of material inside the chute or sloped section of the bin. Generally, the finer the material, the higher the frequency needed to excite the material and make it flow.

On a chute, a rotary vibrator is typically installed in the lower one-fourth to one-third of the structure. If a second vibrator is required, it should be mounted 180 degrees from the first vibrator and halfway up the structure.

Rotary vibrators can be controlled automatically or manually, allowing use only when needed. Once installed, a vibrator must be “tuned” by adjusting its force and/or speed to give the optimum effect for each application.

AIR CANNONS

In addition to vibrators, another solution to buildup of material in transfer chutes is the installation of an air-cannon system (**Figure 9.11**).

Air cannons—sometimes referred to as blasters—use plant compressed air to create an eruption of air that will dislodge material buildup in chutes. Air cannons are simply reservoirs of stored compressed air with fast-acting discharge valves. When the valves are actuated, the air escapes very quickly, creating a wide area of influence (**Figure 9.12**). When strategically located and properly controlled, this blast of air will dislodge or prevent material buildup.

Nozzles and pipes of varying shapes are attached to the chutewall, and air cannons are connected to each nozzle. The nozzles should be positioned to direct the blast toward the outlet or direction of flow. Some systems use independent air reservoirs for each nozzle; other systems use one reservoir for several nozzles (**Figure 9.13**). The nozzles are embedded in the wall, so they can discharge under the layer of accumulated material (**Figure 9.14**). Care must be taken when installing the nozzles to avoid creating additional edges and corners that encourage buildup. The movement of the bulk material may wear the nozzles, and larger lump sizes can deform or destroy the nozzles.

The number of air cannons installed depends on the size and shape of the chute and the nature of the buildup. Typically, one air cannon can keep 1,5 to 2 square meters (15 to 20 ft^2) of chutewall free of material. Air cannons with air volume of 50 liters (1.75 ft^3) have shown good results in chute applications. Air cannons can be installed at several heights around the vessel of the installation.

Air cannons are available with a variety of sizes of air reservoirs and of discharge diameters, to supply the appropriate amount of force. The firing sequence for an air cannon installation must be adjusted for the specific circumstances of the installation, including the conditions of chute, material, and climate. After satisfactory results are obtained, the cannon(s) can be put on a timer or other automatic control, so the firing cycle will maintain material flow without the attention of plant personnel.

Discharge of the air cannon into the chute can cause an increase of positive pressure within the chute, so it can increase the escape of dust driven out of the chute or the loading zone. In many cases, air cannons are used on sticky materials that require more force than can be supplied by vibration but that will not create high levels of dust. The air generated by air cannons should be included in the generated air calculation. *(See Chapter 7: Air Control, Equation 7.1, Total Airflow Calculation)*

OTHER METHODS TO IMPROVE FLOW

Aeration Systems

Some fine-particle materials, such as flour or cornstarch, will de-aerate when stored—they will become compacted and hard. If they have been stored for too long a period, they will not flow efficiently. Adding low-pressure/high-volume air to the products will allow the materials to flow efficiently again. This is done using a positive displacement blower that supplies air to aeration diffusers, pads, or nozzles mounted inside the vessel (**Figure 9.15**). Some aeration devices rely on the air current alone; some vibrate with the airflow. Air from the pads will break the adhesion between the material and the chutewall for dry material. Wet, sticky materials or lumpy materials do not respond well to this system.

Chute Linings

Lining materials, such as ceramic and engineered plastics, can provide an economical solution to flow problems in a chute. High Density Polyethylene (HDPE), Ultra-High Molecular Weight (UHMW) polyethylene, and ceramics have all shown the ability to promote material flow. The selected material for the lining must be able to handle the levels of impact and/or sliding abrasion seen in the application.

Figure 9.14

The discharge nozzles for an air-cannon system are embedded in the chutewall, so they discharge under the layer of accumulated material.

Figure 9.15

Aeration nozzles can be mounted inside the chute to improve flow.

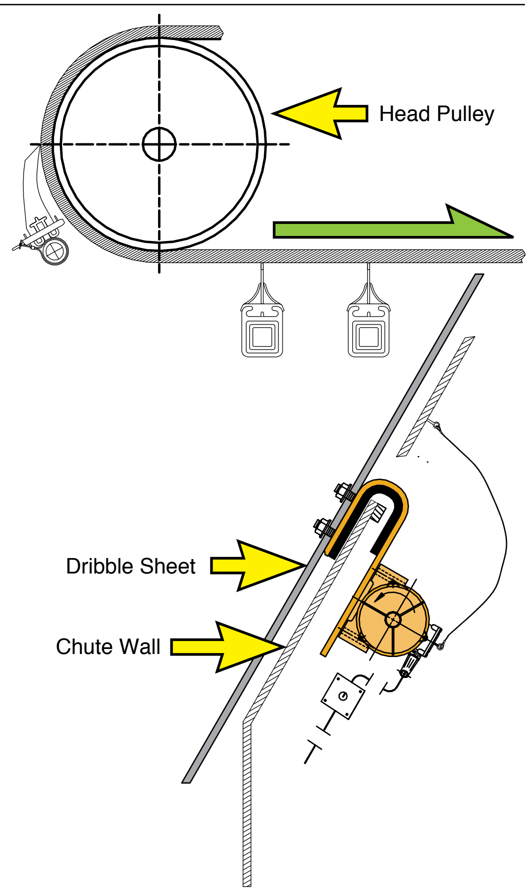
The engineered plastics are usually bolted to the chutewalls with countersunk and covered fasteners. One problem that must be addressed with plastic linings is the difference in their rates of expansion and contraction from the rates of the metal wall. The mounting system must accommodate this difference by allowing the plastic liners to move. If this is not done, the liner will buckle, impeding material flow and quickly wearing out.

Ceramic liners can be installed on metal chutes with glue, welding, or a combination of both techniques.

Proper installation of chute linings is critical to achieving the benefits of lower coefficients of friction. If the sheets or tiles are not installed properly, the ridges where they join may actually increase the effective coefficient of friction over that of steel, worsening the chute's flow properties. Testing of the liner and bulk material is recommended to determine the actual coefficient of friction and predict wear rates.

Figure 9.16

A vibrating dribble chute attaches a vibrator to a suspended sheet of plastic to keep the material in motion.



Soft-Chute Designs

Most chutes are made from rigid metal. However, there are instances in which the chute or its lining can be made of a flexible material. Extremely wet or sticky materials respond well to soft-wall-chute designs.

A soft-chute design uses a space frame made of channel or angle iron. Attached to this frame is a flexible material, such as rubber or conveyor belting. Many times, the natural vibration of the equipment (originating from the conveyor drive or other equipment connected to the system) will prevent material from sticking to the rubber lining.

Vibrators and air cannons can be used to assist a soft chute by activating the flexible lining. One example of using a vibrator to promote flow in a soft chute is a vibrating dribble chute, in which a suspended sheet of plastic becomes a false floor or wall in the chute (**Figure 9.16**). A vibrator is attached to this sheet to keep the material in motion. *(See Chapter 14: Belt Cleaning for information on vibrating dribble chutes.)*

Another technique uses the discharge of air cannons into the back of a flexible rubber blanket installed as a lining on the chutewall (**Figure 9.17**). When the cannons discharge, they give a "kick" to the blanket to dislodge material buildup, like shaking sand out of a towel at the beach. The blanket is secured only at the top. Normally, the blanket is installed on only the flatter, or less "free-flowing," side of the chute. The discharge pipe should be aimed so it inclines down from the cannon to the vessel outlet to prevent material from entering the cannon's discharge opening. This technique works well with wet or sticky materials.

SYSTEM MAINTENANCE

Flow-aid devices are relatively sensitive to proper location and operation. One of the main advantages of using flow aids is that an operation will obtain a level of control over the material flow in a chute

SAFETY CONCERNS

As with all plant equipment, vibrators and air cannons present their own unique safety concerns. Noise and falling or flying material are the primary hazards resulting from the use of flow aids. Noise can be controlled by using flow aids only when needed. Exposure to falling and flying material can be controlled by the location of the flow aid and proper procedures for controlling access to chutes incorporating flow aids. Manufacturer instructions should be followed carefully for the installation, operation, and maintenance of flow-aid systems.

Vibrators should be rigidly mounted to the wall of the structure. Channel mounts should be fastened to the chutewall by stitch welding, in which intervals of weld bead are separated by spaces (**Figure 9.18**). This stitch-welding technique is designed to prevent a failure in the joint from breaking all the way across the mount plate. A monthly inspection of the mount weld area should be made to inspect for cracks in the welds. A safety cable must be installed to prevent the vibrator from falling should its mount fail.

Proper lockout / tagout / blockout / testout procedures should be followed when working on a vibrator or mount.

The mounts and discharge pipes for air cannons should be rigidly attached to the chutewall. The air cannon should be rigidly attached to the mount. It is not recommended that the threaded connection between the mount pipe and the air reservoir be welded completely, as this creates a stressed area, allowing the threads to break.

A safety cable must attach the air reservoir to a structural member to prevent the air cannon from falling in the event of a mount failure (**Figure 9.19**).

Prior to performing any work on the air cannon, the air tank must be totally discharged of air, and the air line supply line shut-off valve must be locked in the closed position to prevent air from filling the tank. It is also wise to pull the pressure relief valve to ensure there is no air left in the air-cannon vessel. Air cannons that fire only in response to a positive pressure signal (and, therefore, cannot discharge accidentally when de-energized) are available.

All inspection and entry doors must be locked to prevent inappropriate entry. Proper vessel entry procedures must be followed, and the air cannons must be properly locked out and discharged before personnel can enter the chute. The chute or vessel must have correct signage, warning of hazards (**Figure 9.20**).

Because flow-aid devices often use compressed air or other energy sources that can create a stored energy hazard, it is critical to follow lockout / tagout / blockout / testout procedures. Even though buildup in a chute may still be in place, its hold on the chutewall might be weakened to the point that a slight disturbance during maintenance can cause it to fall. There is an electrical shock hazard when working on the control systems. The possibility of remote actuation during maintenance and testing must be considered and procedures put in place to prevent unintended actuation.

Areas where vibrators or air cannons are placed may require workers in the vicinity to use hearing protection. The type of vessel and the size of flow-aid system will greatly vary the sound levels. Sound readings should be taken and cautionary signage posted as required (**Figure 9.21**).

If air cannons or aeration devices are used on enclosed bins or chutes, the increase in air pressure must be determined and pressure relief built into the system.

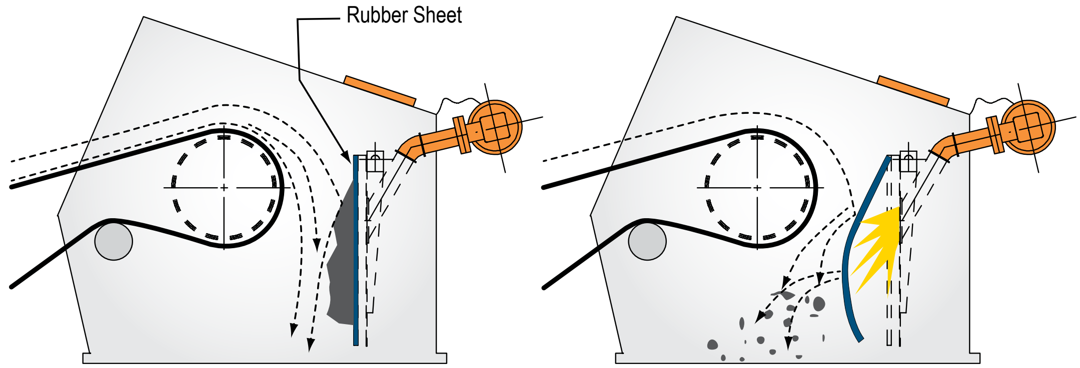


Figure 9.17

Another technique uses the discharge of an air cannon into the back of a flexible rubber blanket to dislodge material accumulations from inside the chute.

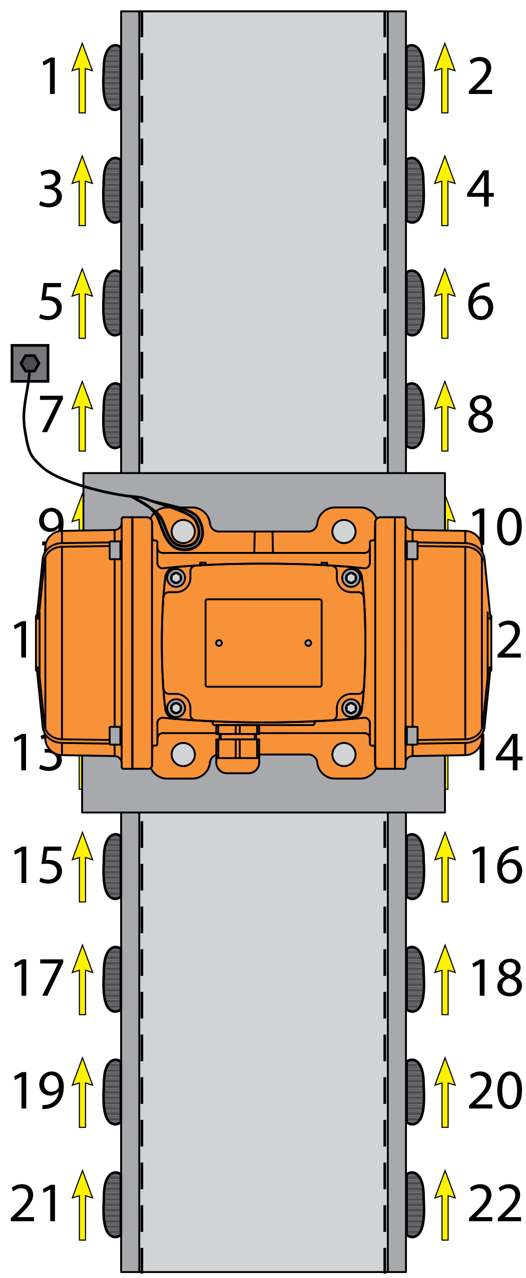


Figure 9.18

Vibrators and mounts should be fastened to the chutewall by stitch welding, in which intervals of weld bead are separated by spaces.

that is not possible any other way. This advantage can also become a problem, because it is very easy to adjust a flow aid out of its optimum operating settings. Often, workers will forget to record settings when doing maintenance, or they will try to adjust the flow aid in response to requests by the operators. This may result in poor performance in material movement, poor energy efficiency, and shorter life for the flow aid. If improperly mounted or adjusted, flow aids may not produce the desired effect and may even make the situation worse. An experienced specialty supplier can usually optimize the initial installation and control settings of a flow-aid system. These settings must be recorded for future reference.

Lack of required air pressure or volume will affect the performance. Keeping dirt and moisture out of the compressed air supply lines is critical for air-powered flow aids. Some pneumatic flow aids require lubrication; others do not. It is important to follow the manufacturers' requirements for air quality and treatment.

Flow aids are often located in areas where they are subject to falling material, impact from moving equipment, the elements, and vibration. Over time, these conditions may deteriorate the flow aid's supply lines and control systems. It is important to follow the manufacturers' recommendations for inspection and routine maintenance of the controls and supply lines.

Flow-aid devices deliver force to the chute and bulk material; over time, components will wear, or even break, under normal conditions. Most flow-aid devices can be rebuilt to extend their useful life. Because clearances and fits are critical to the proper operation of flow aids, it is recommended that flow-aid devices be rebuilt and repaired by the manufacturer—or that the manufacturer train plant maintenance personnel to properly rebuild the equipment.

Since flow aids usually operate intermittently, they may appear to be ready to work, when, in fact, they are not operating at optimum levels. The flow-aid device should be tested periodically, according to the manufacturer's suggestions, to make sure it is operating properly. An experienced specialty supplier can often tell from the sound or effect of the flow-aid device if it is in need of repair or adjustment.

APPLICATION OF FLOW AIDS

The typical characteristics and applications for various flow-aid systems can be compared (**Tables 9.3** and **9.4**).

In many cases, it is advantageous to "oversize" the flow-aid device—especially vibrators—by one model or unit size, so that the device can be turned down for its regular duties. If the requirements increase, a new vibrator does not need to be purchased.

There are generalized rules for sizing and positioning flow aids, but experience in diagnosing the problem and adjusting the flow aid for maximum effect is more art than science. The selection, installation, and control of flow aids are best done by a specialty supplier drawing on accumulated knowledge from numerous installations.

After a review of specific characteristics of any potential application, including the nature of the problem and the characteristics of the material, the choice of flow-aid type is often related to the available source of power at the point of application.

ADVANCED TOPICS

Sizing a Vibrator as a Flow Aid

Most vibrator manufacturers will provide the force output for their various units. The user is charged with determining the force required for a given application (**Equation 9.1**). From that force requirement the proper vibrator can be selected, using the manufacturers' technical data.

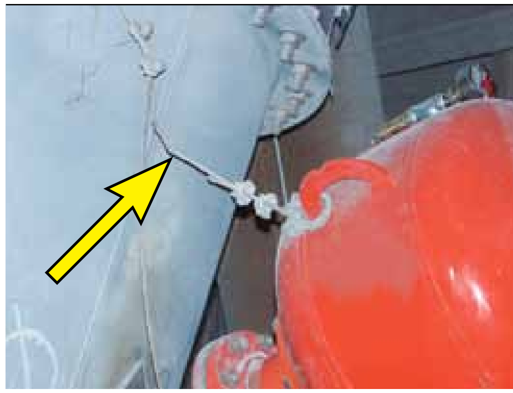


Figure 9.19

A safety cable must attach the air cannon's air reservoir to a structural member of the vessel.

Figure 9.20

Air-cannon systems require suitable safety signage and vessel entry procedures.

Figure 9.21

Many flow-aid devices require that noise protection signage be posted.

9

Table 9.3

Characteristics of Common Flow-Aid Devices

	Linear Vibrator	Rotary Vibrator	Air Cannon	Aerator
Electric		Yes		
Pneumatic	Yes	Yes	Yes	Yes
Hydraulic		Yes		
Variable Speed	Yes	Yes	Can discharge as often as air reservoir can be filled	Yes
Variable Force	Yes	Yes	Yes	Yes
Vibration Range (vpm)	1400 to 5500	Pneumatic Vibrators 3000 to 25000 vpm Electric Vibrators 600 to 3600 rpm		

Table 9.4

Suitable Applications for Flow Aids by Material Characteristics

Material Characteristic	Linear Vibrator	Rotary Vibrator	Air Cannon	Aerator
Light Fluffy		X		X
Small Particles		X		X
Large Particles	X		X	
Sticky Fines	X		X	
Explosive Materials*	X	X	X	
Interlocking Particles			X	
Thick Buildup of Material	X		X	

** Contact the manufacturer for products and accessories specifically designed for hazardous duty rating and locations.*

FLOW AIDS AID FLOW

In Closing...

Any kind of flow-aid system has to be properly engineered to provide a benefit to an operation. Material specifications; process characteristics; and the number, size, and location of devices are all critical elements in an efficient flow-aid system. If not properly engineered and applied for an application, flow-aid devices can create additional problems.

Looking Ahead...

This chapter about Flow Aids, the fourth chapter in the section Loading the Belt, presents flow aids as a means to improve flow. The following chapter continues this section and focuses on Belt Support.

REFERENCES

9.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*. Naples, Florida.

9.2 Any manufacturer and most distributors of conveyor products can provide a variety of materials on the construction and use of their specific products.

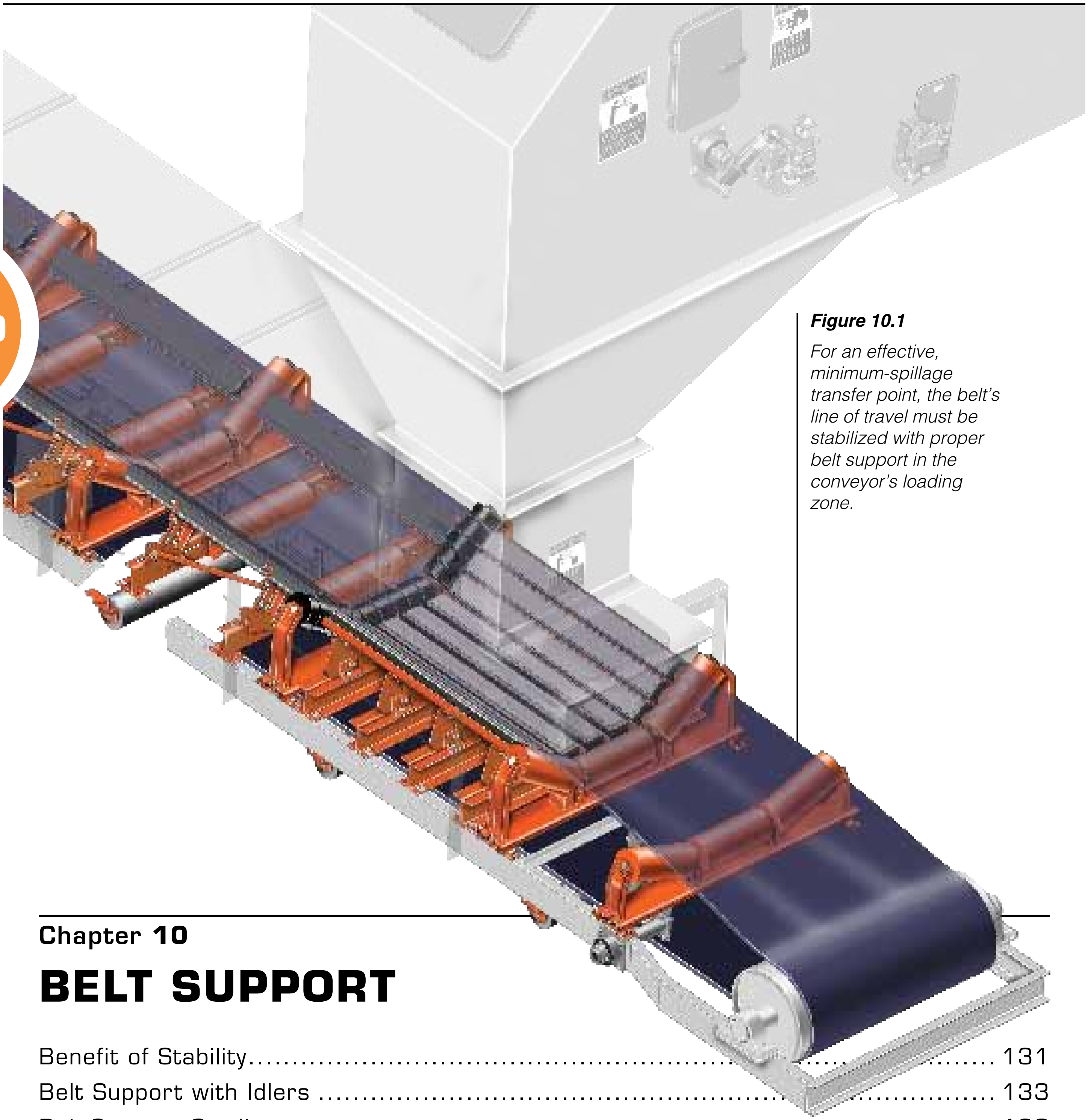


Figure 10.1

For an effective, minimum-spillage transfer point, the belt's line of travel must be stabilized with proper belt support in the conveyor's loading zone.

Chapter 10

BELT SUPPORT

In this Chapter…

This chapter focuses on belt support in the conveyor load zone to prevent the escape of fugitive materials and to prevent damage to the belt and other components. Topics covered include idlers, slider beds, and impact cradles, as well as several alternative methods for maintaining a stable belt line. Equations to calculate power requirements needed for belt support are provided.

The building of an efficient conveyor load zone is like the construction of a house: It starts with a good foundation. For a house, the foundation consists of the footings and/or walls of the basement; in a conveyor belt system, the foundation is a stable, sag-free belt line.

For a conveyor to control dust and spillage, the design engineer must do whatever is practical to keep the belt's line of travel consistently steady and straight. While there are many factors that influence the belt's running line both inside and outside the loading zone, a key ingredient is the provision of proper belt support.

For an effective, minimum-spillage transfer point, it is essential that the belt's line of travel be stabilized with proper belt support in the loading zone (**Figure 10.1**).

BENEFIT OF STABILITY

A flat, sag-free belt line in the skirted area is essential to successfully sealing the load zone (**Figure 10.2**). Ideally, the belting should be kept flat, as if it were running over a table that prevented movement in any direction except in the direction the cargo needed to travel; it would eliminate sag and be easier to seal.

Belt sag, when viewed from the side of the transfer point, is the vertical deflection of the belt from a straight line as drawn across the top of the two adjacent idlers (**Figure 10.3**). The shape of the sagging belt is assumed to be a catenary curve, a natural curve formed when a cable is suspended by its endpoints.

If the belt sags between idlers below the loading zone or flexes under the stress of loading, fines and lumps will work their way out the sides of the conveyor, dropping onto the floor as spillage or becoming airborne as a cloud of dust. Worse, these materials can wedge into entrapment points where they can gouge the belt or damage the sealing system and other components, worsening the spillage problem. A small amount of belt sag—sag that is barely apparent to the naked eye—is enough to permit fines to become entrapped, leading to abrasive wear on the skirtboard-sealing system and the belt surface. A groove cut into the belt cover along the entire length of the belt in the skirted area can usually be attributed to material captured in entrapment points (**Figure 10.4**). When belt sag is prevented, the number and size of

Figure 10.2

A flat, sag-free belt line in the skirted area is essential to successfully sealing the load zone.

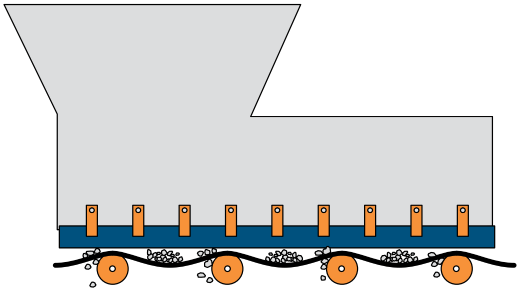


Figure 10.3

Belt sag is a vertical deflection of the belt from a straight line as drawn across the top of the two adjacent idlers.

Figure 10.4

A groove cut into the belt cover along the entire length of the belt in the skirted area can usually be attributed to material captured in entrapment points.

entrapment points are reduced, therefore reducing the possibility of belt damage.

In order to prevent spillage and reduce the escape of dust particles, belt sag must be eliminated wherever practical to the extent possible. It is particularly important to control sag in the conveyor's loading zone, where the cargo constantly undergoes changes in weight. These changes in load carry fines and dust out of the sealing system and push particles into entrapment points between the wear liner or skirt seal and the belt.

Methods to Control Sag

One method for reducing belt sag along the entire length of the conveyor is to increase the belt tension. There are drawbacks to this, however, such as increased drive power consumption and additional stress on the belt, splice(s), and other components. When utilizing additional tension to reduce sag, the maximum rated tension of the belting should never be exceeded.

After achieving the belt tension required by the conveyor belt and the load on the system, the recommended method for reducing belt sag is to improve the conveyor's belt-support system (**Figure 10.5**).

Proper Belt Support

The key to a stable, sag-free line of belt travel is proper support. The amount of support needed is determined by the unique characteristics of each individual conveyor, its loading zone(s), and its material load. The factors to be assessed include the trough angle and speed of travel of the conveyor being loaded, the weight of the material, the largest lump size, the material drop height, and the angle and speed of material movement during loading.

Figure 10.5

To reduce belt sag, improve the conveyor's belt-support system.

It is essential that the belt be stabilized throughout the entire length of the load zone. Support systems extended beyond what is minimally required will provide little harm other than an incidental increase in conveyor power requirements. A belt-support system that is left shorter than required can lead to fluctuations in the belt's stability at the end of the support system, potentially creating spillage problems that will render the installed belt-support system almost pointless. Belt support is like money: It is much better to have a little extra than to fall a little short.

Basics of Building Belt Support

It is essential that the stringers—the conveyor's support structure upon which all other components are installed—are straight and parallel for proper belt support. If not, they should be straightened or replaced. Laser surveying is the preferred method for checking stringer alignment. *(See Chapter 16: Belt Alignment.)*

Footings must provide a rigid support structure to prevent stringer deflection. The amount of material being loaded and the level of impact forces must be considered to prevent excessive deflection under load. Properly spaced stringers tied to rigid footings ensure a good base for the remaining structure.

Conveyor Equipment Manufacturers Association (CEMA) provides a valuable resource for construction standards for conveyors and loading zones: "Conveyor Installation Standards for Belt Conveyors Handling Bulk Materials" *(Reference 10.1)*.

There are a number of techniques and components that can be used, independently or in combination, to control belt sag by improving belt support in the loading zone. They include idlers, belt-support cradles, and impact cradles.

BELT SUPPORT WITH IDLERS

The basic means of support for a conveyor belt is idlers. An idler consists of one or more rollers—with each roller containing one or more bearings to ensure it is free rolling. The rollers are supported by, or suspended from, a framework installed across the conveyor stringers (**Figure 10.6**). Idlers are the most numerous of conveyor components, in terms of both the number used on a particular conveyor and the number of styles and choices available. There are many types, but they all share the same responsibilities: to shape and support the belt and cargo, while minimizing the power needed to transport the materials.

The Idler Family

Idlers are classified according to roll diameter, type of service, operating condition, belt load, and belt speed; they are rated on their load-carrying capacity based on calculated bearing life. CEMA uses a two-character code that expresses the idler classification and implied load rating, with a letter-based code followed by idler diameter in inches, resulting in classes from B4 to F8 (**Table 10.1**). Other regions may have different classification systems.

Regardless of the codes and classifications, the key is to make sure each conveyor is consistent throughout—that all idlers on a given conveyor conform to the same standards and, ideally, are supplied by the same manufacturer.

There is a wide variety of general categories of idlers, depending on their intended application.

Carrying Idlers

Carrying idlers provide support for the belt while it carries the material. They are available in flat or troughed designs. The flat design usually consists of a single horizontal roll for use on flat belts, such as belt feeders.

Figure 10.6

An idler consists of one or more rollers, each with one or more bearings. The rollers are supported by, or suspended from, a framework installed across the conveyor stringers.

Table 10.1

Idler Classifications (Based on CEMA Standards)

CEMA Idler Classification	Roll Diameter		Belt Width		Description
	mm	in.	mm	in.	
B4	102	4	450-1200	18-48	Light Duty
B5	127	5	450-1200	18-48	
C4	102	4	450-1500	18-60	Medium Duty
C5	127	5	450-1500	18-60	
C6	152	6	600-1500	24-60	
D5	127	5	600-1800	24-72	
D6	152	6	600-1800	24-72	
E6	152	6	900-2400	36-96	Heavy Duty
E7	178	7	900-2400	36-96	
F6	152	6	1500-2400	60-96	
F7	178	7	1500-2400	60-96	
F8	203	8	1500-2400	60-96	

Metric dimensions are conversions by Martin Engineering; belt widths may not be actual metric belt sizes.

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Figure 10.7

The troughed idler set usually consists of three rolls—one horizontal roll in the center with inclined (or wing) rolls on either side.

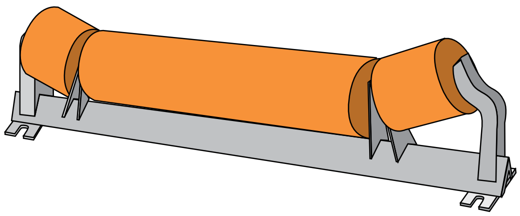

Figure 10.8

“Picking” idlers incorporate a longer center roll and shorter inclined rollers to supply a large cargo area.

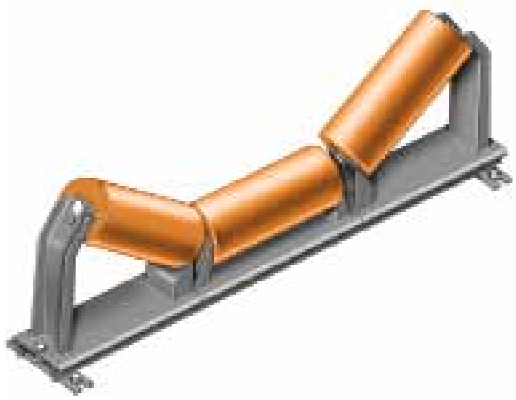

Figure 10.9

With in-line idlers, the centerlines of the three rolls are aligned.

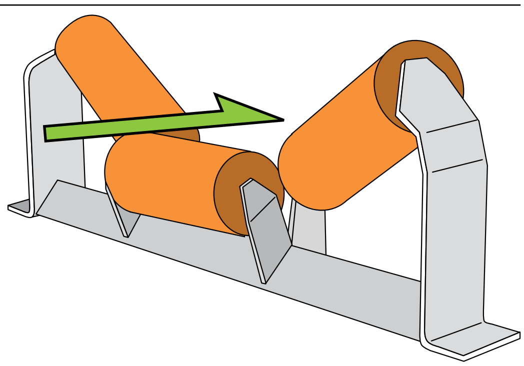

Figure 10.10

Offset idlers, with the center roller placed on a centerline different from the wing rolls, can reduce the overall height of the idler set.

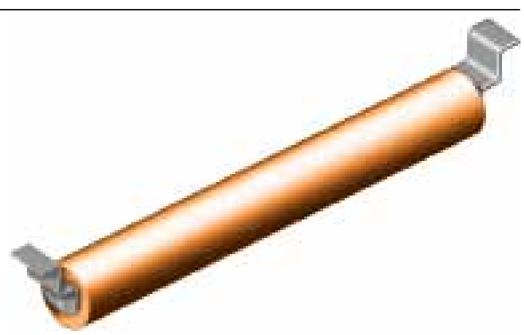

Figure 10.11

Used to support the belt on its way back to the loading zone, return idlers normally consist of a single horizontal roll hung from the underside of the conveyor stringers.

The troughed idler usually consists of three rolls—one horizontal roll in the center with inclined (or wing) rolls on either side (**Figure 10.7**). The angle of the inclined rollers from horizontal is called the trough angle. Typically, all three rolls are the same length, although there are sets that incorporate a longer center roll and shorter inclined rollers called “picking” idlers. This design supplies a larger flat area to carry material while allowing inspection or “picking” of the cargo (**Figure 10.8**).

Troughed idler sets are available as in-line idlers (**Figure 10.9**)—the centerlines of the three rolls are aligned—and offset idlers—the center roll has a centerline different from the wing rollers, usually with the belt passing over the center roller in advance of the wing rollers (**Figure 10.10**). Offsetting the idlers can reduce the overall height of the idler set and, accordingly, is popular in underground mining applications, where headroom is at a premium. Offset idlers eliminate the gap between the rollers, reducing the chance of a type of belt damage called junction-joint failure.

Return Idlers

Return idlers provide support for the belt on its way back to the loading zone after unloading the cargo. These idlers normally consist of a single horizontal roll hung from the underside of the conveyor stringers (**Figure 10.11**). V-return idlers, incorporating two smaller rolls, are sometimes installed to improve belt tracking (**Figure 10.12**).

Training Idlers

There are a number of designs for training idlers that work to keep the belt running in the center of the conveyor structure. Typically, these idlers are self-aligning: They react to any mistracking of the belt to move into a position that will attempt to steer the belt back into the center (**Figure 10.13**). They are available for both carrying side and return side application. *(See Chapter 16: Belt Alignment.)*

Belt-training idlers should never be installed under the carrying side of the belt in the load zone, as they sit higher than the adjacent regular carrying idlers and raise the belt as they swivel.

Impact Idlers

Rubber-cushioned impact idlers are one solution for absorbing impact in the belt's loading zone (**Figure 10.14**). These idlers use rollers composed of resilient rubber disks to cushion the force of loading. Impact idlers typically have the same load rating as standard idlers, because they utilize the same shafts and bearings. The rubber covers absorb some of the energy to provide the benefit of shock absorption.

One disadvantage of using impact rollers in the load zone is that each idler supports the belt only at the top of the roller. No matter how closely spaced, the rounded shape of the roller and the ability of the rubber to deflect under the load will allow the conveyor belt to oscillate or sag away from the ideal flat profile (**Figure 10.15**). This sag allows and encourages the escape or entrapment of fugitive material. The space interval between impact rollers offers little protection from tramp materials dropping from above and penetrating the belt.

Even impact idlers are subject to impact damage, suffering damaged bearings and rollers from "too large" lumps or unusual impacts (**Figure 10.16**). Idlers with worn or seized bearings cause the belt to run erratically, allowing mistracking and spillage over the sides of the belt. Idlers damaged from severe impact or seized due to fugitive material increase the conveyor's power consumption significantly. In many cases, it becomes more effective to absorb impact with impact cradles, as discussed below.

Idler Spacing

The spacing between the rolling components has a dramatic effect on the idlers' support and shaping missions. Idlers placed too far apart will not properly support the belt nor enable it to maintain the desired profile. Placing idlers too close together will

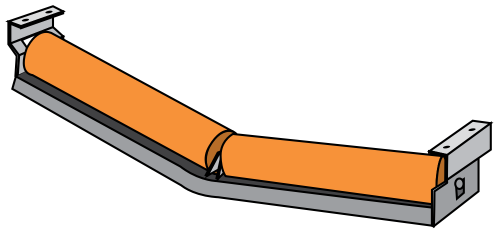

Figure 10.12

V-return idlers, incorporating two smaller rolls, are sometimes installed to improve belt tracking.

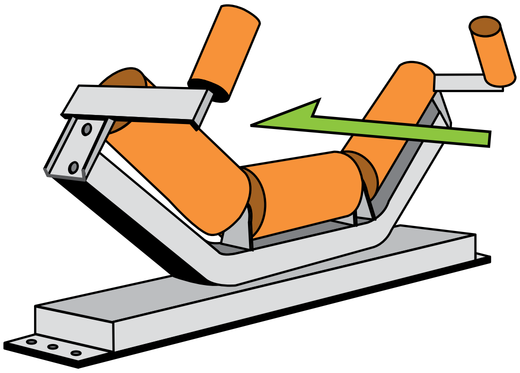

Figure 10.13

Available for both the carrying side and return side of the conveyor, training idlers self-align to steer the belt back into the proper path.

Figure 10.14

Impact idlers use rollers composed of resilient rubber disks to cushion the force of loading.

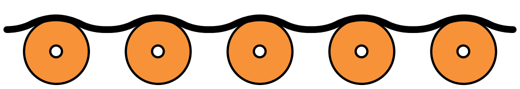

Figure 10.15

The rounded shape of the roller and the ability of the rubber to deflect under the load will allow the conveyor belt to oscillate or sag away from the ideal flat profile.

Figure 10.16

Although designed to cushion loading forces, impact idlers are subject to impact damage, suffering damaged bearings, rollers, or bent frames from "too large" lumps or unusual impacts.

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improve belt support and profile, but will increase conveyor construction costs and may lead to an increase in the conveyor's power consumption.

Normally, idlers are placed close enough to support a fully loaded belt so it will not sag excessively between them. If the belt is allowed too much sag, the load shifts as it is carried up and over each idler and down into the valley between. This shifting of the load increases belt wear and power consumption. The sag also encourages material spillage. CEMA has published tables of recommended idler spacing for applications outside the loading zone (**Table 10.2**).

The spacing of return idlers is determined by belt weight, because no other load is supported by these idlers and sag-related spillage is not a problem on this side of the conveyor. Typical return idler spacing is 3 meters (10 ft).

Idlers in the Skirted Area

The basic and traditional way to improve belt support, and so reduce belt sag under a loading zone or anywhere else along the conveyor, is to increase the number of idlers. By increasing the number of idlers in a given space—and consequently decreasing the space between the idlers—the potential for belt sag is reduced (**Figure 10.17**). Idlers can usually be positioned so that their rolls are within 25 millimeters (1 in.) of each other (**Figure 10.18**).

However, this method is not without drawbacks. As the idlers are packed more tightly, it becomes more difficult to service them. Idler sets are typically maintained by laying the framework over on its side to allow the rolls to be lubricated or replaced. If the idlers are closely spaced, there is no room available for the idler set to be laid on its side to allow the maintenance to be performed (**Figure 10.19**). To reach one set of idlers, one or more adjacent sets must be removed, creating a "falling domino" chain reaction.

Figure 10.17

The traditional method to reduce belt sag under a loading zone is to increase the number of idlers in a given space, consequently decreasing the space between the idlers.

Table 10.2

Recommended Idler Spacing for Applications Outside the Loading Zone as Published by CEMA

Return Idler Spacing	Belt Width	Carrying Side Idler Spacing Outside the Loading Zone — Weight of Material Handled in Kilograms per Cubic Meter (lb_m/ft^3): 480 (30)	800 (50)	1200 (75)	1600 (100)	2400 (150)	3200 (200)
m (ft)	m (in.)	m (ft)	m (ft)	m (ft)	m (ft)	m (ft)	m (ft)
3,0 (10.0)	457 (18)	1,7 (5.5)	1,5 (5.0)	1,5 (5.0)	1,5 (5.0)	1,4 (4.5)	1,4 (4.5)
3,0 (10.0)	610 (24)	1,5 (5.0)	1,4 (4.5)	1,4 (4.5)	1,2 (4.0)	1,2 (4.0)	1,2 (4.0)
3,0 (10.0)	762 (30)	1,5 (5.0)	1,4 (4.5)	1,4 (4.5)	1,2 (4.0)	1,2 (4.0)	1,2 (4.0)
3,0 (10.0)	914 (36)	1,5 (5.0)	1,4 (4.5)	1,2 (4.0)	1,2 (4.0)	1,1 (3.5)	1,1 (3.5)
3,0 (10.0)	1067 (42)	1,4 (4.5)	1,4 (4.5)	1,2 (4.0)	1,1 (3.5)	0,9 (3.0)	0,9 (3.0)
3,0 (10.0)	1219 (48)	1,4 (4.5)	1,2 (4.0)	1,2 (4.0)	1,1 (3.5)	0,9 (3.0)	0,9 (3.0)
3,0 (10.0)	1372 (54)	1,4 (4.5)	1,2 (4.0)	1,1 (3.5)	1,1 (3.5)	0,9 (3.0)	0,9 (3.0)
3,0 (10.0)	1524 (60)	1,2 (4.0)	1,2 (4.0)	1,1 (3.5)	0,9 (3.0)	0,9 (3.0)	0,9 (3.0)
2,4 (8.0)	1829 (72)	1,2 (4.0)	1,1 (3.5)	1,1 (3.5)	0,9 (3.0)	0,8 (2.5)	0,8 (2.5)
2,4 (8.0)	2134 (84)	1,1 (3.5)	1,1 (3.5)	0,9 (3.0)	0,8 (2.5)	0,8 (2.5)	0,6 (2.0)
2,4 (8.0)	2438 (96)	1,1 (3.5)	1,1 (3.5)	0,9 (3.0)	0,8 (2.5)	0,6 (2.0)	0,6 (2.0)

Metric conversions added by Martin Engineering; belt widths may not be actual metric belt sizes.

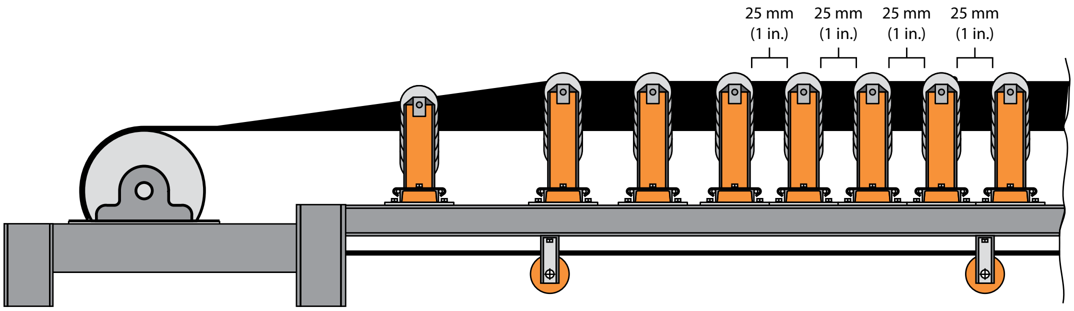

Figure 10.18

Idlers can usually be positioned so that their rolls are within 25 millimeters (1 in.) of each other.

Track-Mounted Idlers

Track-mounted idlers that slide into position are a solution to the problems in servicing closely-spaced idlers. These idlers are mounted on a steel beam that forms a track, allowing the individual rollers to be installed or removed with a slide-in/slide-out movement perpendicular to the path of the conveyor (**Figure 10.17** and **Figure 10.20**). Idlers used in track-mounted configurations can be steel rollers or rubber ring impact-style rollers. With track-mounted idlers, each individual roller, or each set, can be serviced without laying the frame on its side or raising the belt.

The track upon which idlers (and/or other belt-support components) slide provides a supplement to the conveyor structure. This track could be incorporated into the design of the conveyor as part of the structure (**Figure 10.21**). Incorporating a slide-in-place system during the conveyor's design stage allows the use of modular belt-support structures, idlers, cradles, or combination units and simplifies component installation. This is particularly beneficial on wide belts, where large components might otherwise require cranes or other heavy equipment for installation.

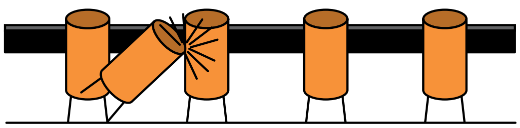

Figure 10.19

If the idlers are closely spaced, there is no room available for the idler set to be laid on its side for maintenance.

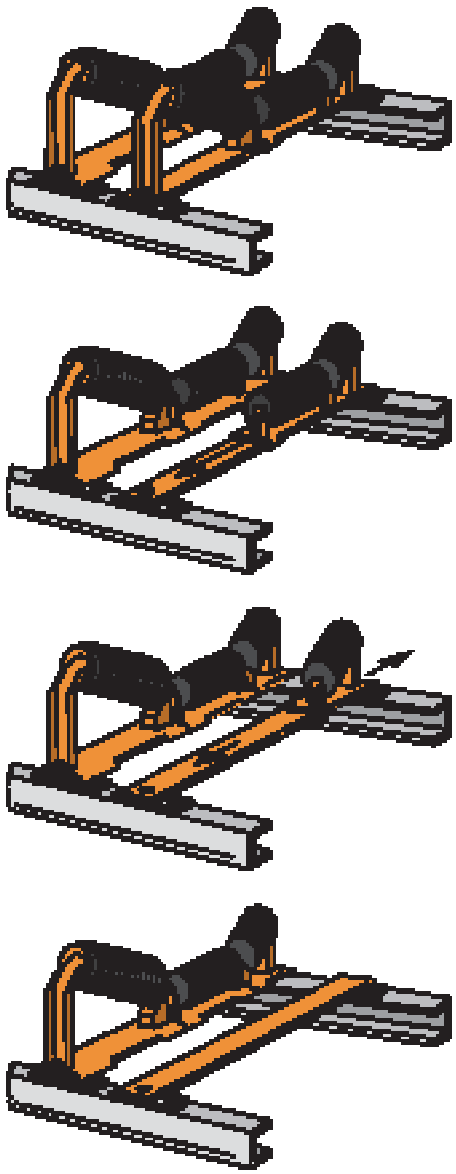

Figure 10.20

Track-mounted idlers solve the problems in servicing closely-spaced idlers by allowing the individual rollers to be installed or removed with a slide-in/slide-out movement.

Tips for Idler Installation

When installing idlers in a transfer point, they should be square with the stringers and aligned horizontally and vertically across the conveyor. Variations will cause entrapment points, capturing material that will lead to belt damage and spillage. Laser surveying can be used to ensure the alignment of all rolling components. *(See Chapter 16: Belt Alignment.)*

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Idler standards have tolerances for roll diameter, roundness (or "run out"), center roll height, and trough angle. Even a slight difference in an idler's dimensions—the difference from one manufacturer to another—can create highs and lows in the belt line, making it impossible to provide effective sealing. Idlers must be aligned with care and matched so as not to produce humps or valleys in the belt. Idlers should be checked for concentricity; the more they are out of round, the greater is the tendency for the belt to flap or bounce. Only idlers supplied by the same manufacturer and of the same roll diameter, class, and trough angle should be used in the skirted area of a conveyor.

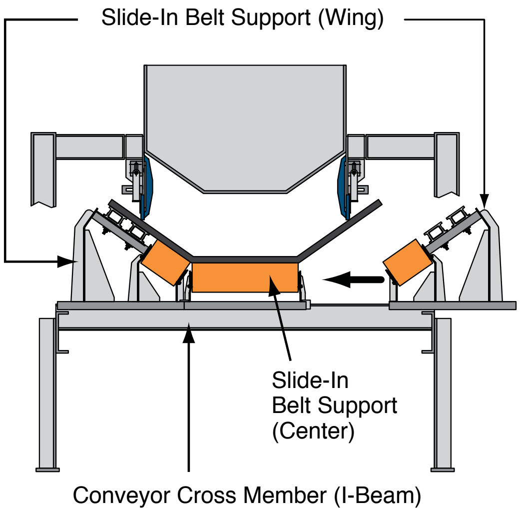

Figure 10.21

The track upon which idlers slide can be incorporated into the design of the conveyor as part of the structure.

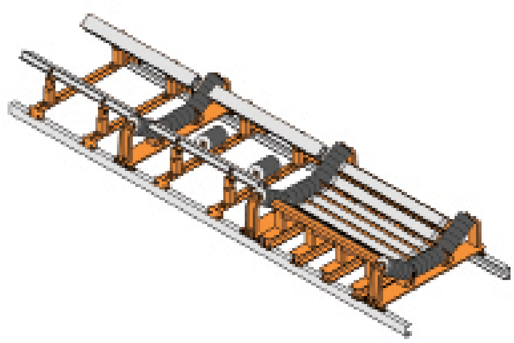

Figure 10.22

To provide the flat table that allows effective sealing, many conveyors use cradles instead of idlers in the conveyor loading zone.

Figure 10.23

"Side rail" edge support places one or more low-friction bars on both sides of the conveyor directly under the skirtboard seal.

BELT-SUPPORT CRADLES

So important is the "flat table" concept to good sealing that many designers now use cradles in place of idlers under conveyor loading zones (**Figure 10.22**). Instead of using an idler's rolling "cans," cradles use some variety of low-friction bars to support the belt profile.

In this discussion of belt-support systems, the terms cradle, bed, or saddle should be considered synonymous.

All belt-support cradles perform two functions—controlling belt sag in the load zone to curtail spillage and providing a slick surface upon which the belt can ride. In addition, impact cradles reduce belt damage by absorbing the forces from the landing of material on the belt. Other benefits of the use of cradles under the transfer point include a reduction in moving parts and elimination of required lubrication. The modular design of the typical cradle system allows the belt support to be extended as far as the circumstances require.

Edge-Seal-Support Cradles

Edge-sealing-support systems are designed to provide continuous support of the belt and maintain a straight belt profile at the belt edges.

One form of edge-seal support is a "side rail" configuration. This system places one or more low-friction bars on both sides of the conveyor directly under the skirtboard seal (**Figure 10.23**). The bars function to support the sides of the belt, allowing effective sealing of the belt edge.

Each edge-seal cradle installation may be one or more cradles long, depending on the length of the transfer point, the speed of the belt, and other conveyor characteristics.

The top of these bars should be installed in line with the top of the entry and exit idlers, to avoid the creation of entrapment points (**Figure 10.24**). When multiple edge-sealing cradles are used, idlers should be placed between the cradles.

On faster, wider, more heavily loaded belts, the edge-seal cradles may need more than one bar on each side to support the belt edge. On wider belts, it is often necessary to add a center support roll or an additional low-friction bar under the middle of the belt (**Figure 10.25**).

Edge-support slider bars can be manufactured from low-friction plastics such as Ultra-High Molecular Weight (UHMW) polyethylene. These materials provide a low-drag, self-lubricating surface that reduces heat accumulation and undue wear on either the belt or the bar. One proprietary design features bars formed in an "H" or "box" configuration, allowing for the use of both the top and bottom surfaces (**Figure 10.26**).

At conveyor speeds above 3,8 meters per second (750 ft/min), the heat created by the friction of the belt can reduce the performance of the plastic bars. Consequently, the use of stainless steel support bars has found acceptance in these applications. Stainless steel bars should also be incorporated in applications with service temperatures above 82 degrees Celsius (180º F).

Safety regulations may limit the choice of materials used in bar support systems. Most countries have regulations requiring anti-static and/or fire–resistant materials used in contact with the belt in underground applications. Other regional or plant requirements may govern materials to be used.

The low-friction bars should be supported in a mounting frame that is adjustable, to allow easy installation, alignment, and maintenance. This frame should accommodate various idler combinations and chutewall widths and allow for adjustment due to wear.

The bars should be held in the support position without the risk of the mounting hardware and fasteners coming into contact with the belt. For example, the bolts holding the bars in place should be installed parallel rather than perpendicular to the belt (**Figure 10.27**).

An edge-support cradle may add incrementally to the friction of the belt and to the conveyor's power requirements. However, this marginal increase in energy consumption is more than offset by the elimination of the expenses for cleanup of skirt leakage, entrapment-point damage to the belt, and unexpected downtime necessary for idler maintenance or belt replacement.

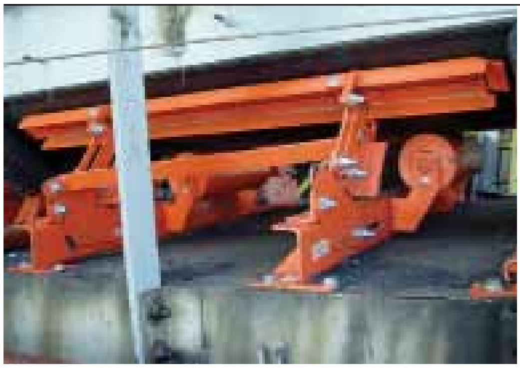

Figure 10.24

To avoid the creation of entrapment points, the top of the belt-support bars should be installed in line with the top of the entry and exit idlers.

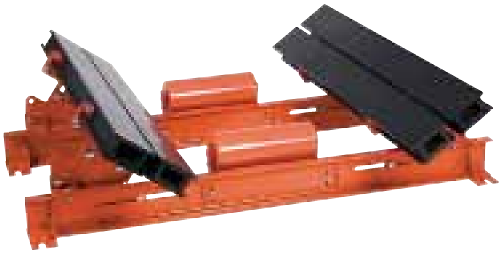

Figure 10.25

On wider belts, it may be necessary to add additional support rolls or low-friction bars in the center of the support cradle.

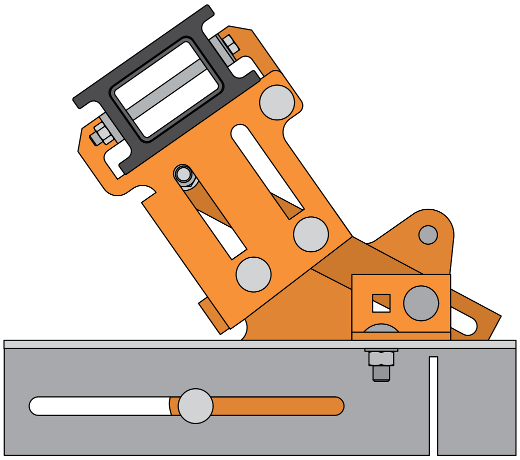

Figure 10.26

One proprietary cradle features bars formed in an "H" or "box" configuration, allowing the use of both the top and bottom surfaces.

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Impact Cradles

Nothing can damage a conveyor's belting and transfer-point components and create material leakage as rapidly and dramatically as impact in the loading zone from heavy objects or lumps with sharp edges (**Figure 10.28**). Whether arising from long material drops or large lumps—or boulders, timber, or scrap metal—these impacts will damage components like idlers and sealing strips. Impact can also create a "ripple" effect on the belt, de-stabilizing its line of travel and increasing the spillage of material. Heavy or repeated impacts can also damage the belt cover and weaken its carcass. Consequently, system engineers do a variety of things to reduce impact levels in loading zones, including the inclusion of engineered chutes, rock boxes, or designs that load fines before lumps.

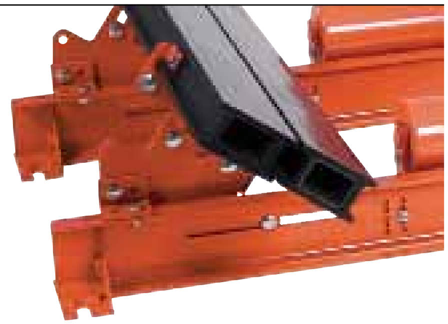

Figure 10.27

The bars should be held in the support position without the risk of the mounting hardware and fasteners coming into contact with the belt.

Figure 10.28

Impact in the loading zone from long material drops or large lumps can damage components and create spillage.

However, in many cases, it is not possible to totally eliminate impact, so it becomes necessary to install some sort of energy-absorbing system under the loading zone. If one were to lay a belt on a concrete floor and strike it with an ax or a hammer, the belt would be damaged. However, if one would place layers of foam between the belt and the floor, the belt would be somewhat protected. This is the way an impact belt-support system protects the belt under severe impact loading conditions.

Figure 10.29

Impact cradles are installed directly under the material drop zone to bear the brunt of the shock of the material hitting the belt.

Impact cradles are installed directly under the material-drop zone to bear the brunt of the shock of the material hitting the belt as it loads (**Figure 10.29**). These cradles are usually composed of a set of individual impact-absorbing bars assembled into a steel support framework. The bars are composed of durable elastomeric materials that combine a slick top surface—allowing the belt to skim over it to minimize friction—and one or more sponge-like secondary layers to absorb the energy of impact (**Figure 10.30**).

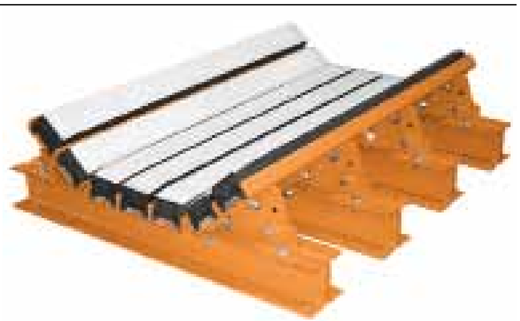

Figure 10.30

Impact cradles are composed of a steel framework holding a set of impact-absorbing bars. The bars combine a slick top surface and one or more sponge-like secondary layers to absorb the energy of impact.

Some manufacturers align a group of long bars—typically 1,2 meters (4 ft) in length—into a cradle, with the bars running parallel to the direction of belt travel. Other manufacturers use shorter modular segments that align to form a saddle that is perpendicular to belt travel. These saddles are typically 300 millimeters (12 in.) in width. The number of cradles and saddles required is determined by the length of the impact zone. The number of bars required in a given cradle or saddle is determined by the width of the conveyor belt.

Some systems feature a slick top surface and a cushioned lower layer permanently attached; others feature separate components that are put together at the application. Impact cradles are available in a track-mounted design, which simplifies replacement of bars when required (**Figure 10.31**).

The limit to the amount of impact that can be absorbed by the belt in combination with an impact cradle is based on the belt's ability to resist crushing energy. For loading zones with the highest levels of impact, the entire impact-cradle installation can be mounted on a shock-absorbing structure, such as springs or air cushions. While this does reduce the stiffness of the entire loading zone and so absorbs impact force, it has the drawback of allowing some vertical deflection of the belt in the skirted area, making it harder to seal the load zone.

Standard for Impact Cradles

CEMA STANDARD 575–2000 provides an easy-to-use rating system for impact cradles utilized in bulk-materials handling applications. This system gives manufacturers and users a common rating system to reduce the chance for misapplication.

The cradle-classification system is based on the impact energy created by the bulk material to establish a duty rating for the given application. The impact-force requirement is determined for each application by calculating the worst-case impact. For a given application, the impact from both the single largest lump (**Equation 10.1**) (**Figure 10.32**) and a continuous homogeneous flow (**Equation 10.2**) (**Figure 10.33**) should be calculated. Most applications will use the larger of these two forces. The reference numbers for impact force are then used to select one of the three ratings from a chart (**Table 10.3**).

The equations used by CEMA are generally accepted as reasonable approximations of impact forces. The CEMA

Figure 10.31

Impact cradles are available in a track-mounted design, which simplifies replacement of bars when required.

$$F_I = W + \sqrt{2 \cdot k \cdot W \cdot h_d}$$

Given: *A lump of material with a weight (force) of 475 newtons (100 lb$_f$) drops 4 meters (13 ft) onto an impact cradle with an overall spring constant of 1000000 newtons per meter (70000 lb$_f$/ft).* ***Find:*** *The impact force created by the lump of material.*

Variables		Metric Units	Imperial Units
F_I	Impact Force	newtons	pounds-force
k	Spring Constant of System that is Absorbing the Impact	1000000 N/m	70000 lb$_f$/ft
W	Weight (Force) of the Largest Lump of Material	475 N	100 lb$_f$
h_d	Drop Height	4 m	13 ft

Metric: $F_I = 475 + \sqrt{2 \cdot 1000000 \cdot 475 \cdot 4} = 62119$

Imperial: $F_I = 100 + \sqrt{2 \cdot 70000 \cdot 100 \cdot 13} = 13591$

F_I	Impact Force	62119 N	13591 lb$_f$

Equation 10.1

Calculating Impact Force from a Single Lump of Material (CEMA STANDARD 575-2000)

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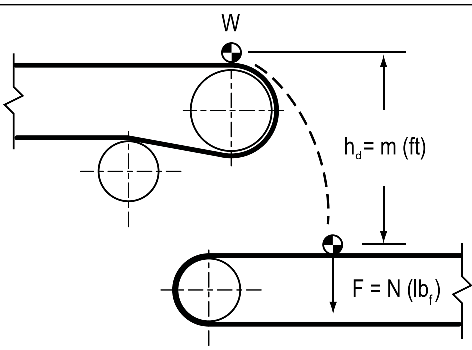
STANDARD notes that the impact from a maximum lump size almost always yields the highest impact force and, therefore, should govern the impact rating specified for a given application. A completely thorough analysis would involve adding the force absorbed by the lump with the force absorbed by a stream and cross referencing the force value.

The dimensions for cradle construction are based on CEMA's long-established idler-classification system. They include the ratings: B, C, D, E, or F, followed by the nominal idler diameter as measured in inches (e.g., 5, 6, or 7).

Cradles with Bars and Rollers

A number of "combination cradle" designs are available, which use bars for a continuous seal at the belt edge but also incorporate rollers under the center of the belt (**Figure 10.34**). These hybrid designs are popular as a way of combining the low power consumption of rollers with the flat sealing surface of impact or slider bars. With a hybrid design, the running friction is kept low by supporting the center of the belt with conventional rollers. This reduces the power consumption of the conveyor. The belt edge is continuously supported, eliminating belt sag between the idlers. This reduces spillage to a mini-



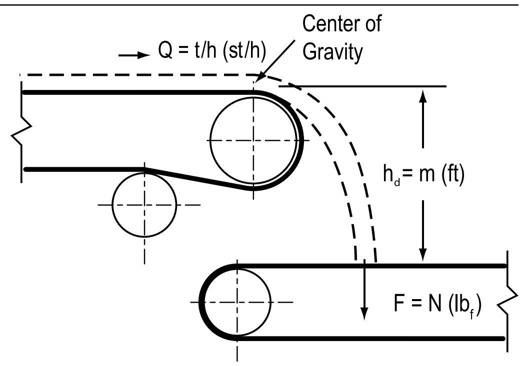


Figure 10.32 (left)

Impact Calculation from the Single Largest Lump

Figure 10.33 (right)

Impact Calculation from a Continuous Homogeneous Flow

Equation 10.2

Calculating Impact Force from a Stream of Material (CEMA STANDARD 575-2000)

$$F_s = k \cdot Q \cdot \sqrt{h_d}$$

Given: *A stream of material drops 4 meters (13 ft) onto an impact cradle at the rate of 2100 tons per hour (2300 st/h).* ***Find:*** *The impact force created by the stream of material.*

Variables		Metric Units	Imperial Units
F_s	Impact Force	newtons	pounds-force
Q	Material Flow	2100 t/h	2300 st/h
h_d	Drop Height	4 m	13 ft
k	Conversion Factor	1,234	0.1389

Metric: $F_s = 1{,}234 \cdot 2100 \cdot \sqrt{4} = 5183$

Imperial: $F_s = 0.1389 \cdot 2300 \cdot \sqrt{13} = 1152$

F_s	Impact Force	5183 N	1152 lb_f

Table 10.3

CEMA STANDARD 575-2000 Impact Bed/Cradle Rating System

Code	Rating	Impact Force (N)	Impact Force (lb_f)
L	Light Duty	<37800	<8500
M	Medium Duty	37800-53400	8500-12000
H	Heavy Duty	53400-75600	12000-17000

Metric conversions added by Martin Engineering.

mum. Since the central rollers operate in a virtually dust-free environment, the life of idler bearings and seals is extended, thus reducing long-term maintenance costs. These designs are most commonly seen on high-speed conveyors operating above 3,8 meters per second (750 ft/min) or applications where there is a heavy material load that would create high levels of friction in the center of the conveyor.

Another possibility is to use cradles incorporating impact bars in the center with short picking idlers closely spaced on the wings. Here the design intention is to provide superior impact cushioning in the center of the belt, while reducing friction on the belt edges.

CRADLE INSTALLATION

Multiple-Cradle Systems

It is often appropriate to install combination systems, incorporating both impact-absorbing cradles and seal-support cradles (**Figure 10.35**). As many impact cradles as necessary should be installed to support the belt to the end of the impact zone. Side-seal-support cradles then complete the system over the distance required to stabilize the load in the skirted area.

These systems provide an efficient way to combine optimum belt support with maximum cost-efficiency in system construction and power consumption.

Cradle Alignment

The impact cradle is usually installed so that the bars in the center of the cradle are set slightly—12 to 25 millimeters (0.5 to 1 in.)— below the normal unloaded line of the belt (**Figure 10.36**). This allows the belt to absorb some of the force of impact when the material loading deflects it down onto the cradle, while avoiding continuous friction and wear on the bars. The wing bars—the bars on the sides of the cradle—should be installed in line with the entry, exit, and intermediate idlers to prevent belt sag and entrapment points (**Figure 10.37**). It is important that the bar directly under the steel chute or skirtboard wall be precisely aligned with the wing idlers.

Cradles can be welded or bolted to the stringers; it may be better to bolt the systems in place, as this will allow more efficient maintenance. Some impact cradles are available in a track-mounted design, which simplifies cradle installation or the replacement of bars when required.

Figure 10.34

"Combination cradles" use bars for a continuous seal at the belt edge and rollers under the center of the belt.

Figure 10.35

Combination systems, incorporating both impact-absorbing cradles and seal-support cradles, can be installed to provide a stable belt line.

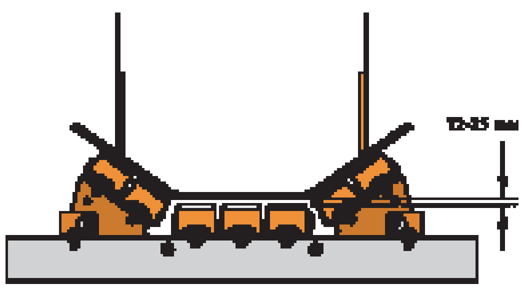


Figure 10.36

Impact cradles are usually installed so that the bars in the center of the cradle are set 12 to 25 millimeters (0.5 to 1 in.) below the normal unloaded line of the belt.

Figure 10.37

The wing bars of an impact cradle should be installed in line with the entry, exit, and intermediate idlers to prevent belt sag and entrapment points.

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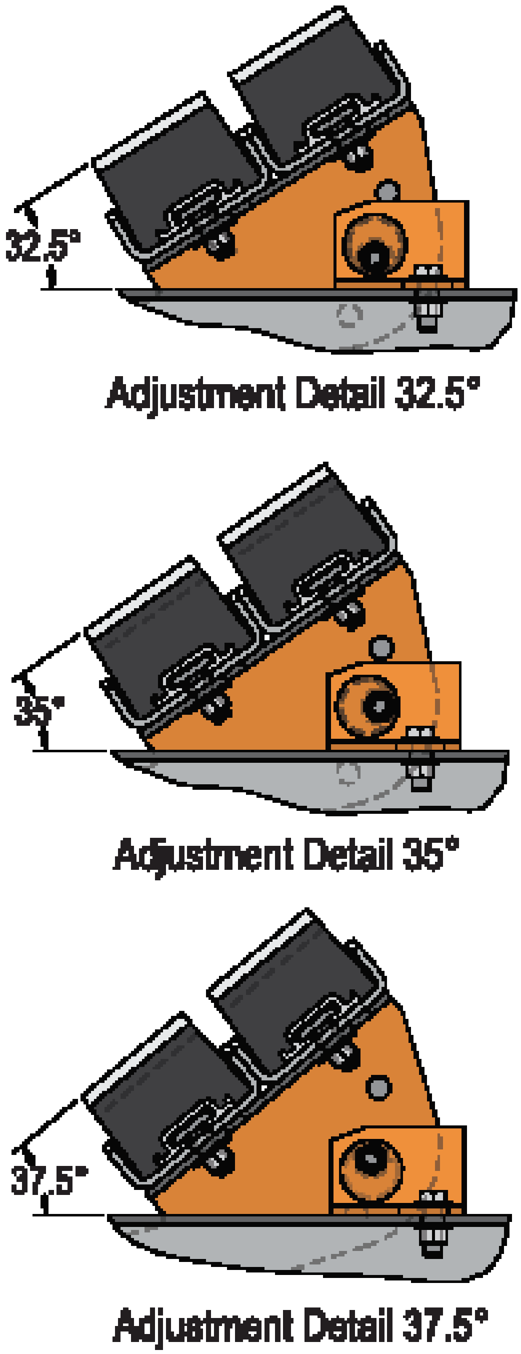

Figure 10.38

A well-designed impact cradle will simplify installation with the use of adjustable wing supports, which allow the cradle to be placed under the belt before its sides are raised to the appropriate trough angle. Note: adjustment range for a 35° troughing angle is ± 2.5°.

Figure 10.39

When two or more cradles are installed, the use of intermediate idlers—idlers placed between the adjacent cradles—is recommended.

Installation of impact cradles is simplified through the use of adjustable wing supports, which allow the cradle to be slid under the belt in a flat form; the sides are then raised to the appropriate trough angle (**Figure 10.38**). It is important that the cradle be designed to allow some simple means of adjustment of bar height and angle. This will enable the cradle to work with idlers of varying manufacturers and allow compensation for wear.

Idlers Between Cradles

When two or more cradles are installed, the use of intermediate idlers—that is, idlers placed between the adjacent cradles—is recommended (**Figure 10.39**). Installing an idler set between two cradles (or putting each cradle between two idlers) will reduce the drag of the conveyor belt over the bars. This reduces the conveyor's power consumption. In addition, the heat buildup in the bars will be reduced, giving the bars and belt longer life expectancies.

Idlers should be specified before and after each 1200 millimeter (4 ft) cradle; the number of idler sets required for a given transfer point is the same as the number of cradles required plus one. To ensure uniformity for a stable belt line, all of these idlers should be of the same manufacturer with the same size roller. Impact idlers should be used between cradles under the loading zone; conventional idlers can be used outside the impact area. Track-mounted idlers should be used between cradles to allow for ease of maintenance.

In some impact areas, it may be acceptable to go as far as 2,4 meters (8 ft) between intermediate idlers. These applications might include long loading zones where it is difficult to predict the location of the impact and where rollers might be damaged by point-impact loading. These would also include transfer points under quarry and mine dump hoppers, at pulp and paper mills where logs are dropped onto belts, or at recycling facilities that see heavy objects ranging from car batteries to truck engines dropped on conveyors.

ALTERNATIVE METHODS OF BELT SUPPORT

This book discusses several methods of alternative conveying systems. *(See Chapter 33: Considerations for Specialty Conveyors.)* In addition, there are other methods of supporting conventional belting on more-or-less conventional conveyor structures.

Catenary Idlers

Catenary idlers, sometimes called garland idlers, are sets of rollers—typically, three or five—linked together on a cable, chain, or other flexible connection and suspended from the conveyor structure below the belt (**Figure 10.40**). These idler sets swing freely under the forces of loading material, acting to absorb impact and centralize the load. Their flexible mounting allows the idlers to be quickly moved or serviced and provides some amount of self-centering.

Catenary idlers are typically seen in very heavy-duty applications such as conveyors seeing high impact levels and large volumes of material. Typical installations would include conveyors under the discharge of bucket wheel excavators and under the loading zones of long overland conveyors carrying run-of-mine material (**Figure 10.41**). Catenary idlers are also commonly used in the metalcasting industry.

However, the "bounce" and swing of catenary idlers and the changes this motion can add to the belt path, particularly when the material is loaded off-center, must be considered when engineering a conveyor system (**Figure 10.42**). As the catenary idler swings, the belt moves from side to side. This allows the escape of fugitive material out the sides of the loading zone and creates mistracking that exposes belt edges to damage from the conveyor structure (**Figure 10.43**). Consequently, greater edge distance must be left outside the skirtboard to allow for sealing.

Air-Supported Conveyors

Another concept for stabilizing the belt path is the air-supported belt conveyor. These conveyors replace carrying-side idlers and cradles with a trough-shaped plenum below the belt. The belt is supported by a film of air that is released from the plenum (**Figure 10.44**). *(See Chapter 23: Air-Supported Conveyors.)*

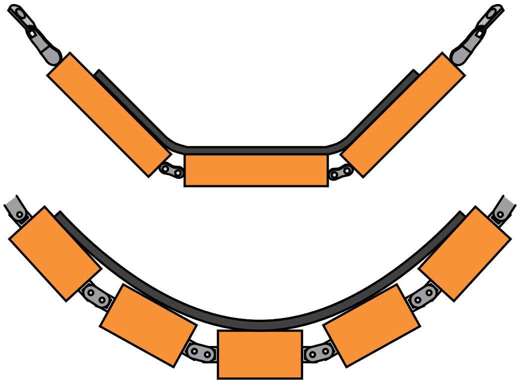

Figure 10.40

Catenary idlers, sometimes called garland idlers, are sets of rollers—typically, three or five—linked together on a cable, chain, or other flexible connection and suspended from the conveyor structure below the belt.

Figure 10.41

Typical installation of catenary idlers include conveyors under the discharge of bucket wheel excavators and under the loading zones of long overland conveyors carrying run-of-mine material.

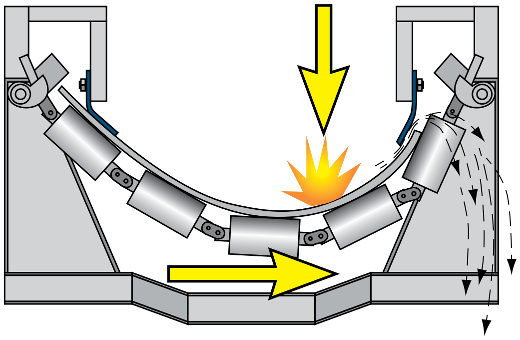

Figure 10.42

Their suspension allows catenary idlers to bounce and swing under loading impact, changing the belt path and making sealing difficult.

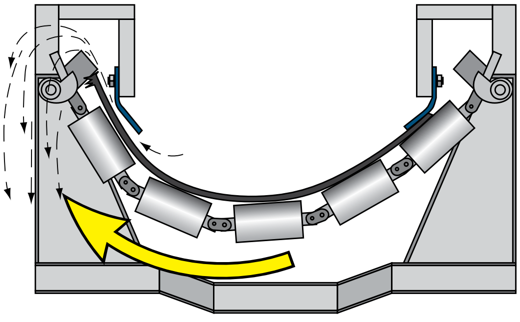

Figure 10.43

As the catenary idler swings, the belt moves from side to side, allowing the escape of fugitive material out the sides of the loading zone and creating mistracking.

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10

SYSTEM MAINTENANCE

A key to providing the proper line and stability for a conveyor is the maintenance on the belt-support systems. Proper maintenance of these components will keep the belt from developing unwanted dynamic action that would defeat the belt-support system's ability to control fugitive materials.

The maintenance procedures required for a conveyor belt-support system will vary by the construction and components of the particular system, but should include the following:

A. Inspection of rolling components—including pulleys and idler "cans" (rollers)—for wear and operation (Do they still roll?)

B. Replacement of "stalled," "seized," damaged, or worn rollers

C. Lubrication of bearings in rolling components as appropriate—some idlers are manufactured as "sealed for life," so no lubrication would be required

D. Inspection of belt-support cradles

E. Adjustment of cradles to compensate for wear

F. Realignment and/or replacement of bars showing abuse or wear

G. Removal of material accumulations from rollers, frames, cradle structure, and support bars as required

It is important to refer to the manufacturer's instructions for the required maintenance for any specific component.

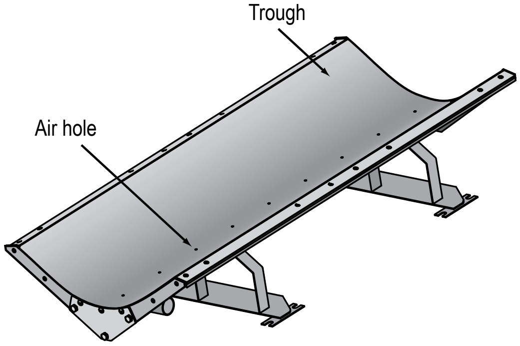

Figure 10.44

Air-supported conveyors stabilize the belt line by supporting the belt with a film of air rising from a trough-shaped pan.

Idlers should not be over-lubricated. This can damage the bearing seals, allowing fugitive materials to enter the bearing, increasing the friction while decreasing life. Excess oil and grease can spill onto the belt where it can attach to the cover, decreasing life. Excess grease can also escape onto handrails, walkways, or floors, making them slippery or hazardous. Idlers equipped with sealed "greased for life" bearings should not be lubricated.

It may be best to select the components of the belt-support system with ease of maintenance in mind. Otherwise, the time required to perform maintenance and/or the difficulty in executing these chores will reduce the likelihood that this essential maintenance will actually be performed.

TYPICAL SPECIFICATIONS

A perfectly flat and straight belt line in the skirted area is essential to successfully seal a transfer point. Belt sag should be minimized to no more than 3 millimeters (0.125 or 1/8 in.) through the load zone. Specifications include the following:

A. Impact cradles in load area

To absorb the shock of loading impact and to stabilize the belt line, full impact cradles should be used under the belt in the direct load area. The impact cradle section should be no longer than 1,2 meters (4 ft.) with an idler installed a minimum of every 1,2 meters.

B. Cradle installation in load area

The cradles should be designed to match the profile of the troughed belt and should be installed so that the bars in the center of the cradle are 12 to 25 millimeters (0.5 to 1 in.) below the normal unloaded track of the belt.

C. Track-mounted cradles

The bars should be installed in a cradle form designed for ease of installation and service without requiring the raising of the belt or the removal of adjacent idlers or the cradle itself. The cradle should be constructed in three track-mounted sections for ease of access and maintenance.

D. Edge-support bars and center-support rollers

In the skirted stabilization area directly after the loading point, seal-support cradles with low friction edge-support bars and center-support rollers should be used.

E. In line with idlers

The cradles should be designed in line with the entry and exit idlers, as well as any intermediate idlers.

F. Method for adjustment

The design should include a method for vertical and radial adjustment of the bar to the belt.

In all cases, the equipment selected must not only provide adequate belt support but must also be able to maintain the belt in constant contact with the skirting system to assure sealing efficiency.

ADVANCED TOPICS

Idler Spacing and Belt Sag

In *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, CEMA recommends that conveyor belt sag between idlers be limited to 2 percent for 35-degree idlers and 3 percent for 20-degree idlers *(Reference 10.2)*. The CEMA method refers to limiting sag outside the load zone to prevent spillage.

In the load zone, the sag must be much less than that recommended by CEMA to

SAFETY CONCERNS

Workers must be aware of the following hazards specific to the loading zone and trained to perform inspections, cleaning, and maintenance in a safe manner:

A. Pinch Points

A moving belt creates pinch or nip point hazards between the rotating and stationary components of the load zone.

B. Heavy Components

Many of the belt-support and load-zone components are heavy, creating lifting hazards.

C. Tight Quarters

Load zones are often in tight quarters with limited access, areas that are sometimes considered confined spaces.

D. Water, Snow, or Ice

Load zones are often in locations exposed to weather, so they are subject to accumulations of water, snow, or ice, creating additional slip, trip, and fall hazards.

E. Storage Area

The open area around the tail end of the conveyor and the load zone often becomes a storage area for spare and replaced equipment. This practice creates trip and fall hazards around load zones.

F. Auxiliary Equipment

Auxiliary equipment is often automated and can start without warning, creating potentially dangerous situations.

Established lockout /tagout / blockout / testout procedures must be followed before adjusting or maintaining any belt-support system. It is important to ensure the area is clear of obstructions and to follow all confined-space entry requirements.

prevent spillage; dusting; and wear of the belt, wear liner, and skirt seal. For example (**Equation 10.3**), using the CEMA method results in recommended maximum sag between idlers of 12,5 millimeters (0.5 in.) for 35-degree idlers and 19 millimeters (0.75 in.) for 20-degree idlers. This is clearly unacceptable sag for control of fugitive materials in the load zone.

Sag (ΔY_s) is proportional to the weight (force) of the belt and bulk material (W_b + W_m) [newtons (lb_f)] and the idler spacing (S_i) [millimeters (in.)], and it is inversely proportional to the minimum belt tension in the load zone (T_m) [newtons (lb_f)] (**Equation 10.3**). To control fugitive materials, it is recommended that the designer manage the belt tension and idler spacing in the load zone to keep belt sag at no more than 3 millimeters (0.12 in.) and preferably 0.0. Even with very little sag, if belt support is not continuous, fugitive materials can escape and cause wear.

The example (**Equation 10.3**) shows that with idler spacing of 600 millimeters (24 in.), there is 3,37 millimeter (0.135 in.) of sag. If the idler spacing in the example is reduced to 178 millimeters (7 in.), belt sag drops to 1,0 millimeter (0.039 in.).

If a belt-support system such as an impact cradle or air-supported conveyor section is used, idler spacing (S_i) can be assumed to be 0.0; the calculation then yields belt sag of 0.0, because there should be no sag when the belt is a continuous, flat surface.

Cradles and Power Requirements

Belt-support systems have a significant effect on the power requirements of a conveyor. Changes in belt support will have a particularly noticeable effect on short or under-powered systems. It is recommended that the theoretical power requirements of proposed changes in belt-support systems be calculated to ensure there is adequate conveyor drive power available to compensate for the additional friction placed on the conveyor.

Added kilowatts (hp) consumption can be calculated by determining the added belt tension, using the standard methods

Equation 10.3

Calculating Belt Sag

$$\Delta Y_s = \frac{(W_b + W_m) \cdot S_i \cdot k}{T_m}$$

Given: A belt that weighs 550 newtons per meter (38 lb_f/ft) is carrying 3000 newtons per meter (205 lb_f/ft) of material. The idlers are spaced at 600 millimeters (2 ft) and the tension in the area is 24000 newtons (5400 lb_f). Find: The belt sag.

Variables		Metric Units	Imperial Units
ΔY_s	Belt Sag	millimeters	inches
W_b	Weight (Force) of the Belt per Length of Belt	550 N/m	38 lb_f/ft
W_m	Weight (Force) of the Material per Length of Belt	3000 N/m	205 lb_f/ft
S_i	Idler Spacing	600 mm	2 ft
T_m	Belt Tension	24000 N	5400 lb_f
k	Conversion Factor	0,038	1.5

$$\text{Metric: } \Delta Y_s = \frac{(550 + 3000) \cdot 600 \cdot 0{,}038}{24000} = 3{,}37$$

$$\text{Imperial: } \Delta Y_s = \frac{(38 + 205) \cdot 2 \cdot 1.5}{5400} = 0.135$$

ΔY_s	Belt Sag	3,37 mm	0.135 in.

recommended by CEMA. The coefficient of friction of the new (or proposed) support systems, multiplied by the load placed on the belt support from belt weight, material load, and sealing system, equals the tension. There is no need to allow for the removal of idlers, the incline of the conveyor, or other possible factors, as estimates provided by this method will in most cases produce results higher than the power consumption experienced in actual use. In applications where there is a lubricant, such as water, consistently present, the actual power requirements may be one-half, or even less, of the amount estimated through these calculations.

The tension added by a skirtboard sealing-support system can be calculated (**Equation 10.4**).

The tension added by an impact bed can be calculated (**Equation 10.5**).

The tensions due to the impact bed and the support bed can be related to the power requirements added to the drive on a conveyor belt (**Equation 10.6**).

PAY NOW, OR PAY (MORE) LATER

In Closing...

Seemingly simple changes in a conveyor system such as changing the belt specification or adding belt support can result in dramatic changes in the drive power required.

In its sixth edition of *BELT CONVEYORS for BULK MATERIALS*, CEMA details a relatively complex formula for determining conveyor belt tension and power requirements. Current conveyor engineering computer software offers similar equations and, given the proper data, will perform the calculation.

The installation of improved belt-support systems can increase the conveyor's drive power requirements. However, the true implications of improved belt-support systems are seen when they are compared to the power consumption of a conveyor where idler bearings drag or the idlers themselves build up with material due to transfer-point spillage induced by belt sag.

As demonstrated by R. Todd Swinderman in the paper "The Conveyor Drive Power Consumption of Belt Cleaners" *(Reference 10.3)*, "Fugitive material can also impair the operation of conveyor systems, increasing power consumption significantly." For example, Swinderman calculated that a single frozen impact idler set would require approximately 1,2 kilowatt additional power (1.6 hp), while a seized steel idler set can demand as much as 0,27

$$\Delta T_S = (W_b \cdot L_b \cdot 0.1) + (F_{ss} \cdot 2 \cdot L_b)$$

Given: *A conveyor belt weighing 130 newtons per meter (9 lb_f/ft) is supported under the seal for 6 meters (20 ft). The seal presses on the belt with a force of 45 newtons per meter (3 lb_f/ft).*
Find: *Tension added to the belt due to the sealing support.*

Variables		Metric Units	Imperial Units
ΔT_s	Tension Added to the Belt due to the Sealing Support	newtons	pounds-force
W_b	Weight (Force) of the Belt per Length of Belt	130 N/m	9 lb_f/ft
F_{ss}	Rubber Strip Sealing Load	45 N/m	3 lb_f/ft
L_b	Length Belt Support	6 m	20 ft

Metric: $\Delta T_s = (130 \cdot 6 \cdot 0{,}1) + (45 \cdot 2 \cdot 6) = 618$

Imperial: $\Delta T_s = (9 \cdot 20 \cdot 0.1) + (3 \cdot 2 \cdot 20) = 138$

ΔT_s	Tension Added to the Belt due to the Sealing Support	618 N	138 lb_f

Equation 10.4

Calculating the Tension Added to the Belt due to Sealing Support

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Equation 10.5

Calculating Tension Added to the Belt due to the Impact Bed

$$\Delta T_{IB} = (W_b \cdot L_b) + (F_{ss} \cdot 2 \cdot L_b) + \left(\frac{Q \cdot L_b \cdot k}{V} \right)$$

Given: *A conveyor belt weighing 130 newtons per meter (9 lb_f/ft) is supported by an impact bed for 1,5 meters (5 ft). The seal presses on the belt with a force of 45 newtons per meter (3 lb_f/ft). The belt carries 275 tons per hour (300 st/h) and travels at 1,25 meters per second (250 ft/min).* ***Find:*** *Tension added to the belt due to the impact bed.*

Variables		Metric	Imperial
ΔT_{IB}	Tension Added to the Belt due to the Impact Bed	newtons	pounds-force
W_b	Weight (Force) of the Belt per Length of Belt	130 N/m	9 lb_f/ft
L_b	Length Belt Support	1,5 m	5 ft
F_{ss}	Rubber Strip Sealing Load	45 N/m	3 lb_f/ft
Q	Material Flow	275 t/h	300 st/h
V	Belt Speed	1,25 m/s	250 ft/min
k	Conversion Factor	2,725	33.33

Metric: $\Delta T_{IB} = (130 \cdot 1{,}5) + (45 \cdot 2 \cdot 1{,}5) + \left(\frac{275 \cdot 1{,}5 \cdot 2{,}725}{1{,}25} \right) = 1230$

Imperial: $\Delta T_{IB} = (9 \cdot 5) + (3 \cdot 2 \cdot 5) + \left(\frac{300 \cdot 5 \cdot 33.33}{250} \right) = 275$

ΔT_{IB}	Tension Added to the Belt due to the Impact Bed	1230 N	275 lb_f

Equation 10.6

Calculating the Power Consumption Added to the Belt Drive due to Sealing and Impact Support

$$P = (\Delta T_S + \Delta T_{IB}) \cdot V \cdot \mu_{ss} \cdot k$$

Given: *A conveyor belt traveling 1,25 meters per second (250 ft/min) is supported by an impact bed and a seal-support system that add 1230 newtons (275 lb_f) and 618 newtons (138 lb_f) respectively. The support systems use a UHMW sliding surface.* ***Find:*** *The power consumption added to the drive due to the sealing and impact support.*

Variables		Metric Units	Imperial Units
P	Power Consumption Added to Belt Drive	kilowatts	horsepower
ΔT_S	Tension Added to the Belt due to the Sealing Support *(Calculated in Equation 10.4)*	618 N	138 lb_f
ΔT_{IB}	Tension Added to the Belt due to the Impact Bed *(Calculated in Equation 10.5)*	1230 N	275 lb_f
V	Belt Speed	1,25 m/s	250 ft/min
μ_{ss}	Friction Coefficient Per CEMA 575-2000	0,5 – UHMW 1,0 – Polyurethane 1,0 – Rubber	0.5 – UHMW 1.0 – Polyurethane 1.0 – Rubber
k	Conversion Factor	1/1000	1/33000

Metric: $P = \frac{(618 + 1230) \cdot 1{,}25 \cdot 0{,}5}{1000} = 1{,}15$

Imperial: $P = \frac{(138 + 275) \cdot 250 \cdot 0.5}{33000} = 1.56$

P	Power Consumption Added to Belt Drive	1,15 kW	1.56 hp

kilowatts (0.36 hp). One idler with a 25 millimeter (1 in.) accumulation of material would add 0,32 kilowatt additional power (0.43 hp) to the conveyor's drive requirements. These additional requirements would be multiplied by the number of idlers affected.

The use of improved belt support and sealing techniques places additional requirements on conveyor drive systems. However, these additional requirements and costs will seem minor when compared to the power consumed by operating with one "frozen" idler or several idlers operating with a material accumulation. By implementing the proper belt-support systems, a plant can prevent the many and more costly problems that arise from the escape of fugitive material.

It would be better to design a system that incorporates the slightly elevated power consumption required to prevent spillage, rather than suffer the much higher power consumption and greater consequences that arise from fugitive material. The costs for installation and operation of proper belt-support systems represent an investment in efficiency.

Looking Ahead...

This chapter about Belt Support, the fifth chapter in the section Loading the Belt, discussed the importance of proper belt-support systems to maintain a stable belt line to prevent fugitive material and dust. The following three chapters continue this section and discuss additional ways to prevent spillage, focusing on Skirtboards, Wear Liners, and Edge-Sealing Systems.

REFERENCES

10.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). "Conveyor Installation Standards for Belt Conveyors Handling Bulk Materials." In *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, Appendix D, pp. 575–587. Naples, Florida.

10.2 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, p. 133. Naples, Florida.

10.3 Swinderman, R. Todd, Martin Engineering. (May 1991). "The Conveyor Drive Power Consumption of Belt Cleaners," *Bulk Solids Handling*, pp. 487–490. Clausthal-Zellerfeld, Germany: Trans Tech Publications.

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11

Figure 11.1

Skirtboards are the horizontal extensions on each side of the loading chute, used to contain the load on the belt until the cargo assumes a stable profile on the belt.

Chapter **11**

SKIRTBOARDS

Figure 11.2

Skirtboard usually extends out from the load point in the direction of material travel on both sides of the belt, confining and shaping the cargo until it has settled into the desired profile.

In this Chapter...

In this chapter, we discuss skirtboards and the functions they serve for reducing spillage and dust. We provide equations for determining proper length and width of skirtboards and give examples for both. We also include information about skirtboard construction.

Skirtboards are used to contain the load as the material is placed onto the belt until it assumes a stable profile (**Figure 11.1**). Skirtboards—which may be referred to in the industry as skirt plates, steel skirting, or sometimes merely chute or chutework—are almost always constructed of steel plate. In this book, the term skirtboard is used to define the construction material that extends out from the load point in the direction of material travel on both sides of the belt (**Figure 11.2**). The terms "rubber skirting," "skirtboard seal," "side wipers," "dust seal," "seal strips," "sealing," and "edge seal" refer to the elastomer strip installed on the metal skirtboard to prevent the escape of fines. *(See Chapter 13: Edge-Sealing Systems.)*

The primary purpose of skirtboard is to keep the load on the conveyor, preventing the material from spilling over the belt edge while the load is settled into the belt trough and has reached belt speed. The skirtboard of each transfer point must be engineered to match the characteristics of the material being transferred, the receiving conveyor, the drop height between the conveyors, and the way the transfer point is loaded and used.

Best practices in chute and skirtboard design now provide the opportunity for a much cleaner and more efficient material-handling system. This chapter discusses what has become the best practice for the design and application of transfer-point skirtboard systems.

SKIRTBOARD AND ITS JOB

The skirtboard and the wear liner placed inside the skirtboard combine with the elastomer sealing system to form a multiple-layer seal (**Figure 11.3**). The elastomer seal strips cannot and should not be expected to withstand significant material side pressures or contact with pieces of material larger than small fines. The skirtboard and wear liner form the first lines of defense and are intended to contain fugitive material and prevent any head pressure present in the system from placing the material in contact with, and thus prematurely wearing, the sealing system.

In addition, the skirtboard and its covering form a settling zone, which is used for effective dust management (**Figure 11.4**). In the settling zone, the current of air traveling with the moving stream of material is slowed and controlled, allowing airborne particles to fall back into the main material body (**Figure 11.5**).

Figure 11.3

Skirtboard combines with the transfer point's wear liner and sealing system to form an effective multiple-layer seal.

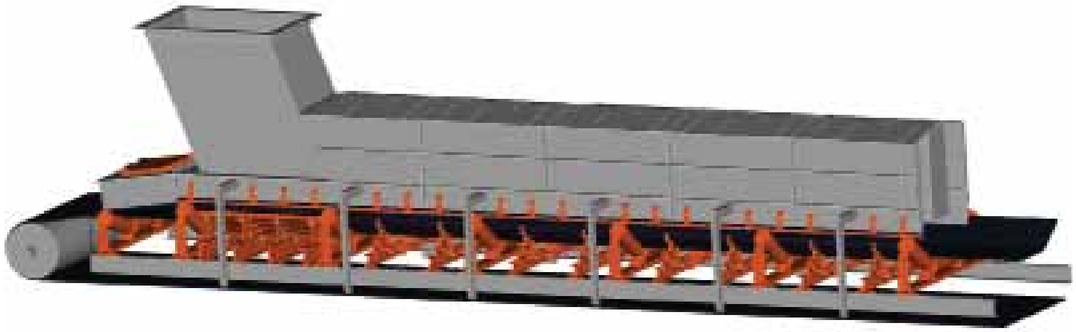

Figure 11.4

The settling zone is usually an enlarged portion of the covered skirtboard area at the transfer point.

Inadequately sized skirtboard always leads to poor conveyor performance in the forms of material spillage, fugitive material fines, excessive dust, and much higher operating costs for the end user. It is imperative that the skirtboard be designed properly in length and height so material can be contained and fugitive material controlled.

PROPER SKIRTBOARD SIZE

Skirtboard Length

Skirtboard length refers to the additional length of steel wall beyond the impact zone. The impact zone is the area of the loading chute if it was extended down to the belt.

Skirtboard should extend in the belt's direction of travel past the point where the material load has fully settled into the profile that it should maintain for the remainder of its journey on the conveyor.

Sometimes the load never becomes completely stable, and, consequently, skirtboard is required for the entire length of the conveyor. This is most common with very fine materials that are easily made airborne, materials that tend to roll, or conveyors with multiple load points. Belt feeders, typically short in length and loaded to nearly the full width of the belt, are commonly skirted for their full length.

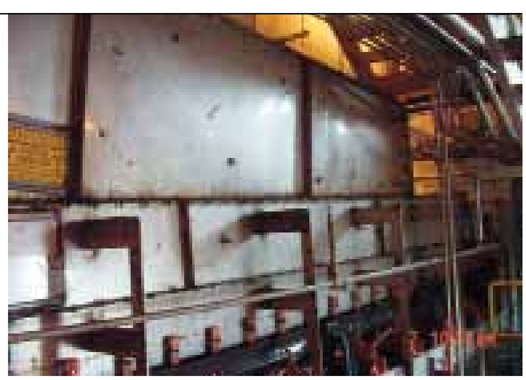

Figure 11.5

This settling zone slows the air and allows the conveyed product to settle and cleaner air to escape.

The minimum length for the skirtboard should be based on the total air movement and the speed of the belt, using the following guidelines:

A. Metric measurements

If airflow is under 0,5 cubic meters per second, the length of skirtboard is 0,6 meter for every 0,5 meter per second of belt speed. If airflow is greater than 0,5 cubic meters per second, the length of skirtboard is 0,9 meter for every 0,5 meter per second of belt speed.

B. Imperial measurements

If airflow is less than 1000 cubic feet per minute, the length of skirtboard is 2 feet of skirtboard for every 100 feet per minute of belt speed. If airflow is over 1000 cubic feet per minute, the length of skirtboard is 3 feet for every 100 feet per minute of belt speed. *(See Advanced Topics: Equation 11.1.)*

To prevent spillage or damage to the belt, skirtboard should end above an idler rather than between idlers (**Figure 11.6**). This in itself may increase the overall length of the skirtboard.

What may provide a more telling answer for skirtboard length is the need for enclosing the dust-suppression and/or dust-collection systems, as discussed elsewhere in this book. *(See Chapter 19: Dust Suppression and Chapter 20: Dust Collection.)* The walls of a dust-control enclosure can effectively serve as skirtboard, with the length necessary for effective dust-control systems generally providing more than what is required for load stabilization.

Penalties for increasing the length of skirtboard are the additional maintenance cost for longer liners and seals, a minimal increase in the cost of the steel for the walls, and a slight increase in the conveyor's power requirements. The extra power consumption results from the added friction created by the longer steel wall and the additional length of sealing strip installed. This is usually a modest increase that provides long-term benefits that greatly outweigh the minimal up-front cost. *(For more information about the power consumption of edge-sealing systems, see Chapter 13: Edge-Sealing Systems.)*

There are also times when conditions such as the incline of the belt, the shape of the conveyed product, or the depth of the material bed require the length of the skirted area to be increased substantially to prevent material spillage.

When in doubt, it is always better to have the skirtboard a little longer than is minimally required by the above equation. An extra 25 percent in additional settling area length is a recommendation that will improve dust control with only a minimal increase in power requirements and expense for steel.

When the conveyor incorporates multiple load zones, the calculation should use the total airflow from all loading points to establish the minimum dimensions of the settling zone after the last loading point.

Skirtboard Width

The distance between the two sides of the skirtboard is usually determined by belt capacity requirements; the space needed to establish an effective seal on the outside of the skirtboard is too often ignored.

The importance of designing the system so there is enough "free-belt" distance (between the outside of the skirtboard and outer belt edge) should not be understated. A conveyor designer must always consider the effect of possible belt wander on the ability to effectively seal between the stationary skirtboard system and the moving belt. By maintaining the largest possible "free-belt" distance, the designer can help eliminate a great deal of the common spillage and dusting problems often associated with the transfer of bulk materials from one conveyor to another. The benefits realized by maintaining the correct "free-belt" distance to allow a sealable skirtboard system will be further enhanced by incorporating the proper belt support under the skirtboard and by installing a highly effective skirtboard-sealing system. *(See Chapter 10: Belt Support and Chapter 13: Edge-Sealing Systems.)*

Because the act of troughing a belt works to diminish a belt's width, the phrase Effective Belt Width is used to represent the width of a troughed belt. This is not the carrying width (the distance between the skirtboard) but rather the measurement of the horizontal width of a troughed conveyor belt that is measured across the width parallel to the bottom roller (**Figure 11.7**).

Several standards are available for setting the distance between the skirtboards and thereby establishing the "free-belt" edge distance. The Conveyor Equipment Manufacturers Association (CEMA) and the Deutsches Institut für Normung (DIN 22101) have both established formulas that can be referenced.

Best practice indicates that in order to ensure adequate "free-belt" edge to properly apply edge seals and provide a tolerance for belt mistracking, the skirtboards should

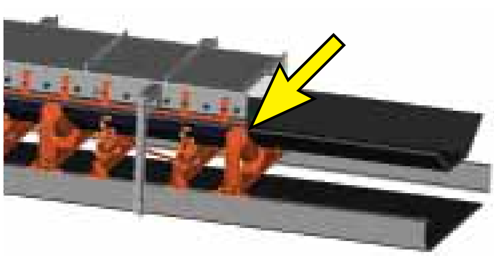

Figure 11.6

Steel skirtboards should end above an idler to prevent spillage or damage to the belt.

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Recommended Loading-Zone Design *Table 11.1*

I) Belt Width · II) Trough Angle · III) Effective Belt Width (*See Figure 11.7 "A"*) · IV) Recommended Chute Width (*See Figure 11.7 "B"*)

Units	I	II	III	IV
Metric (mm)	300	0°	300	NR
		20°	288	NR
		30°	273	NR
		35°	264	NR
		40°	253	NR
		45°	241	NR
	500	0°	500	270
		20°	480	264
		30°	455	NR
		35°	440	NR
		40°	422	NR
		45°	402	NR
	650	0°	650	420
		20°	624	408
		30°	592	393
		35°	572	383
		40°	549	372
		45°	523	360
	800	0°	800	570
		20°	768	552
		30°	729	529
		35°	704	515
		40°	675	499
		45°	644	481
	1000	0°	1000	770
		20°	960	744
		30°	911	711
		35°	879	691
		40°	844	668
		45°	805	642
	1200	0°	1200	970
		20°	1152	936
		30°	1093	894
		35°	1055	867
		40°	1013	837
		45°	966	803
	1400	0°	1400	1170
		20°	1344	1128
		30°	1275	1076
		35°	1231	1043
		40°	1182	1005
		45°	1127	964
	1600	0°	1600	1370
		20°	1536	1320
		30°	1457	1258
		35°	1407	1219
		40°	1350	1174
		45°	1288	1125
	1800	0°	1800	1570
		20°	1728	1512
		30°	1639	1440
		35°	1583	1395
		40°	1519	1343
		45°	1449	1286
	2000	0°	2000	1770
		20°	1920	1703
		30°	1821	1622
		35°	1759	1570
		40°	1688	1512
		45°	1609	1447
	2200	0°	2200	1970
		20°	2112	1895
		30°	2004	1804
		35°	1935	1746
		40°	1857	1681
		45°	1770	1608
	2400	0°	2400	2170
		20°	2304	2087
		30°	2186	1986
		35°	2111	1922
		40°	2026	1849
		45°	1931	1769
	2600	0°	2600	2370
		20°	2495	2279
		30°	2368	2169
		35°	2287	2098
		40°	2194	2018
		45°	2092	1930
	2800	0°	2800	2570
		20°	2687	2471
		30°	2550	2351
		35°	2462	2274
		40°	2363	2187
		45°	2253	2091
	3000	0°	3000	2770
		20°	2879	2663
		30°	2732	2533
		35°	2638	2450
		40°	2532	2356
		45°	2414	2252
	3200	0°	3200	2970
		20°	3071	2855
		30°	2914	2715
		35°	2814	2626
		40°	2701	2525
		45°	2575	2413
Imperial (in.)	18	0°	18.0	9.0
		20°	17.3	8.8
		35°	15.8	NR
		45°	14.5	NR
	24	0°	24.0	15.0
		20°	23.0	14.6
		35°	21.1	NR
		45°	19.3	NR
	30	0°	30.0	21.0
		20°	28.8	20.3
		35°	26.4	19.0
		45°	24.1	17.8
	36	0°	36.0	27.0
		20°	34.6	26.1
		35°	31.7	24.3
		45°	29.0	22.6
	42	0°	42.0	33.0
		20°	40.3	31.9
		35°	36.9	29.6
		45°	33.8	27.4
	48	0°	48.0	39.0
		20°	46.1	37.6
		35°	42.2	34.8
		45°	38.6	32.3
	54	0°	54.0	45.0
		20°	51.8	43.4
		35°	47.5	40.1
		45°	43.5	37.1
	60	0°	60.0	51.0
		20°	57.6	49.1
		35°	52.8	45.4
		45°	48.3	41.9
	72	0°	72.0	63.0
		20°	69.1	60.6
		35°	63.3	55.9
		45°	57.9	51.6
	84	0°	84.0	75.0
		20°	80.6	72.2
		35°	73.9	66.5
		45°	67.6	61.2
	96	0°	96.0	87.0
		20°	92.1	83.7
		35°	84.4	77.1
		45°	77.3	70.9
	108	0°	108.0	99.0
		20°	103.7	95.2
		35°	95.0	87.6
		45°	86.9	80.5
	120	0°	120.0	111.0
		20°	115.2	106.7
		35°	105.5	98.2
		45°	96.6	90.2

Notes: Dimensions were determined by calculation rather than field measurements. Metric measurements are rounded to the nearest millimeter. Imperial measurements are rounded to one decimal. Thickness of steel in chute or skirtboard is not considered. Three-piece troughing idlers of equal length are assumed. Belt edge distances in metric consider 90 mm for the side sealing + 25 mm for margin for belt misalignment. Belt edge distances in Imperial consider 3.5 in. for the side sealing + 1 in. for margin for belt misalignment. Particle size of the bulk material is not considered.

be located with a minimum of 115 millimeters (4.5 in.) of actual belt width on each side of the conveyor belt (**Table 11.1**).

The edge distance should be increased to a minimum of 150 millimeters (6.0 in.) when five roll catenary idlers are used in the load zone to compensate for the extra belt misalignment that is a characteristic of belts using catenary idlers.

The width of the skirtboard should be checked to ensure that the height of the material bed exiting the skirting area along with the material's angle of repose do not combine to create a spillage condition.

Skirtboard Height

Belt width and speed, material lump size, and air speed at the discharge must be considered when determining the height of the skirtboard required for a given transfer point.

The skirtboard should be tall enough to contain the material load when the belt is operating at normal capacity and to pass lumps without jamming. As the size of lumps included in the load goes up, so must skirtboard height; at minimum, the height must be sufficient to contain the largest pieces. The skirtboard should be tall enough to contain two of the largest pieces stacked on top of each other.

In the sixth edition of *BELT CONVEYORS for BULK MATERIALS*, CEMA has published tables specifying the minimum height for uncovered skirtboard on conveyors with 20-, 35-, and 45-degree idlers, carrying cargos of various sized lumps. In summary, it specifies approximately 300 millimeters (12 in.) is tall enough for particles of 50 millimeters (2 in.) or smaller, carried on flat or 20 degrees troughed belts up to 1800 millimeters (72 in.) wide, or for 35 degrees and 45 degrees troughed belts up to 1200 millimeters (48 in.) wide. The table specifies skirtboards with a minimum height of 825 millimeters (32.5 in.) for belts as wide as 2400 millimeters (96 in.) with lumps up to 450 millimeters (18 in.).

For materials that may create a dust problem, it is good practice to increase the height of the skirted area to serve as a plenum, a space that will reduce the positive air pressure. This area will serve to "still" the dust-laden air so that the particles can settle back onto the cargo of the conveyor.

For maximum dust control, the chutewalls (skirtboards) must be high enough to furnish a cross-sectional area in the load zone that provides a maximum air velocity above the product bed of less than 1 meter per second (200 ft/min). *(See Advanced Topics: Equation 11.2.)* This larger volume combined with multiple dust curtains provides an ample chamber to accommodate the positive pressures of air movement without most common bulk materials blowing out of the enclosure (**Figure 11.8**). In many circumstances, to achieve this limited airspeed, the skirtboard height must be increased to 600 millimeters (24 in.) or more. Very light materials with extremely small particles or dusty materials may require exit velocities as low as 0,25 meters per second (50 ft/min).

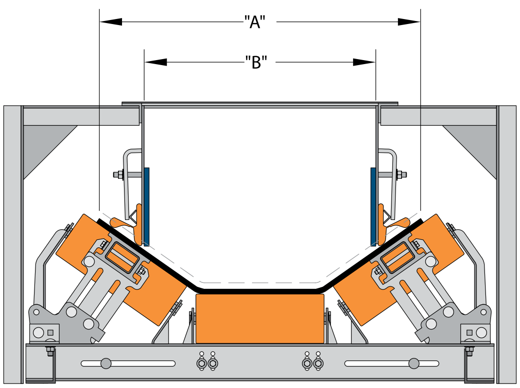

Figure 11.7

Effective Belt Width (A) is the width of the conveyor belt when troughed. The actual load-carrying distance (B) is then reduced by the requirement for edge sealing outside the skirtboard.

Figure 11.8

Skirtboard height can be increased to reduce airspeed, minimizing the positive pressures of air movement without most common bulk materials blowing out of the enclosure.

11

The skirtboard must still be tall enough to contain the cargo's largest lump if it is placed at the top of the material load profile. If the calculation does not yield a sufficient height, the calculated height should be replaced with a height of 2.5 times the largest lump.

Obviously, there is a practical limit to the height that a skirtboard can be made. If the settling zone/skirtboard height requirement becomes excessive, a dust-collection system that can account for the transfer point's total air movement and an active dust-control system (e.g., dust-suppression system or baghouse dust-collection system) will need to be installed.

Chutewalls need to be high enough and located so that dust exhaust pickups do not pull fines off the pile. The collectors may pull in so much material they quickly plug. If the skirtboard walls are not high enough, energy will be wasted removing dust that would have shortly settled on its own, and the dust-collection system will be larger and more expensive than necessary. *(See the discussion of settling zones in Chapter 18: Passive Dust Control.)*

SKIRTBOARD AS A SETTLING AREA

Covering the skirtboard with a steel or fabric system is recommended for dust control (**Figure 11.9**). Unless a specific reason exists not to cover it, the skirtboard should be enclosed with a cover, lid, or roof. The covering of the skirtboard is required to create the plenum needed to allow dust to settle and air movement to be stilled. A large plenum is useful in controlling the clouds of dust driven off by the forces of transferring the stream of material. *(See Chapter 7: Air Control and Chapter18: Passive Dust Control.)*

Figure 11.9

Covering the skirtboard with a steel or fabric system is recommended to create the plenum needed to allow dust to settle and air movement to be stilled.

The incorporation of properly-placed dust curtains within the skirtboard cover system will help slow airflow and significantly decrease the release of airborne dust from the exit end of the transfer point. *(See Chapter 18: Passive Dust Control for more information about dust curtains.)*

In addition, placing a "roof" over the skirtboard will contain the occasional lump of material that through some random circumstance comes through the loading chute onto the belt with force sufficient to "bounce" it completely off the belt.

CEMA recommends that these skirtboard covers should be slanted down from the loading chute to the skirtboard, allowing for material that is not yet moving at belt speed, to avoid material jams. In *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, CEMA provides tables for minimum heights of uncovered skirtboards and minimum belt width based on lump size. Generally accepted practice is to keep the skirt width and height at least 2.5 times the largest lump size. By keeping the skirtboards tall, two things are accomplished: avoiding material jams and providing a large area to dissipate air velocity and let dust settle.

Skirtboard coverings are not the semicircular "hoods" commonly seen along the run of a conveyor but are typically a flat roof between the two skirtboards. In most cases, a covering of steel is best. These covers can be clamped in place, allowing for inspection or maintenance. Fabric or rubber is most often applied to connect vibrating equipment to stationary chutes or skirtboards.

The covering should be designed so that it will support the weight of a worker, or it should be guarded and marked with "No Step" warnings, so nobody falls through the covering.

Openings in the skirtboard or covers should be provided for service and inspection; these openings should be provided with doors to prevent material escape and minimize the outflow of air.

SKIRTBOARD CONSTRUCTION

Clearance Above the Belt

Even under the most ideal conditions, steel skirtboards can be hazardous to the belt. Fluctuations in the belt's line of travel may allow the belt to move up against the steel, where it can be gouged or cut. In addition, material can wedge under the skirtboard to abrade the belt's surface.

It is critical to raise the bottom edge(s) of the skirtboard far enough above the conveyor so they never come in contact with the belt cover. As the distance above the belt increases, so does the difficulty in providing an effective seal. Skirtboard is sometimes installed with a clearance of several inches above the belt to facilitate belt replacement. When the steel is placed this far above the belt surface, it is virtually impossible to provide an effective seal on the outside of the skirtboards when there is side pressure.

An ineffective seal perpetuates itself. Material leaks out, accumulating on idlers, leading to mistracking and other problems that result in an unstable belt line. The belt flexes up and down and wanders from side to side. Plant engineers and maintenance staffs, mindful of the need to prevent the belt from coming into contact with the chutework, increase the belt-to-skirting clearance. This dramatically increases the difficulty in sealing the transfer point, resulting in increased spillage. This increased spillage results in a continuing vicious cycle of belt wander, rolling component failures, and increased operating costs.

The closer the steel and belt are placed together, the easier it is to maintain a seal between them. It is critical to provide relief in the direction of belt travel. The gap under the steel should form a wedge-shaped opening that allows conveyed material to ride along the steel skirting and sealing rubber, rather than become wedged into an opening by the ceaseless force of belt motion. The skirtboard should open gradually, both horizontally and vertically, from the loading point in the direction of belt travel to permit entrapped material to free itself (**Figure 11.10**).

It is recommended that the lower edges of the skirt plates be positioned 6 millimeters (1/4 or 0.25 in.) above the belt at the belt's entry into the loading zone. This dimension should be uniformly increased in the direction of belt travel to 9 to 12 millimeters (3/8 or 0.38 to 0.5 in.) as the belt exits the skirtboard (**Figure 11.11**). This close clearance cannot be accomplished unless the belt travel is stabilized within a plus-or-minus tolerance of 1,5 millimeters (1/16 or 0.063 in.) at the entry (tail pulley) end of the chute.

It is critical that the centerline of the skirtboard construction be in line with the centerline of the belt to prevent belt mistracking. If the two are not in line, the unequal forces from the cargo's center of gravity and the friction against the skirtboard will cause a chronic mistracking of the belt and accelerated wear on the wear liners and skirt seal. With the steel positioned close to the belt line, it is critical to the safety of the belt that the belt be prevented from rising up off the idlers during conveyor startup. This is one reason why the elevation of the tail pulley, commonly known as the half-trough arrangement, is not a good idea, as this practice encourages

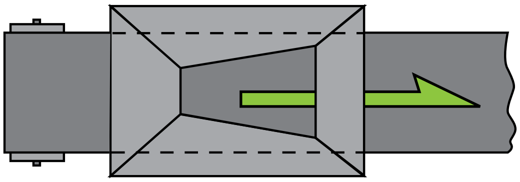

Figure 11.10

To reduce the risk entrapped material might gouge the belt, the skirtboard should open (or self-relieve) both horizontally and vertically in the direction of belt travel. (Illustration is exaggerated to show effect.)

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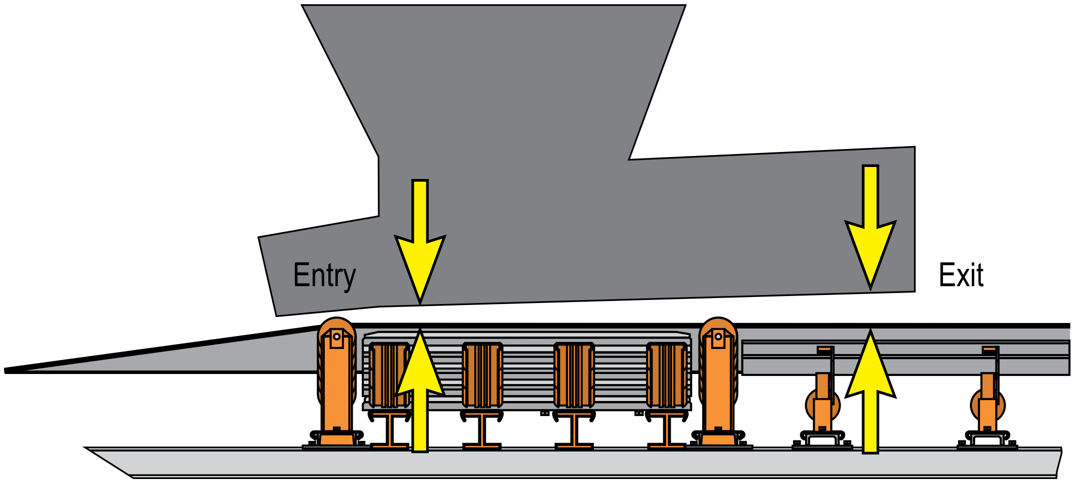

Figure 11.11

The lower edges of the skirt plates should be positioned 6 millimeters (1/4 or 0.25 inch) above the belt at the belt's entry into the loading zone. This dimension should be uniformly increased in the direction of belt travel to 9 to 12 millimeters (3/8 or 0.38 to 0.5 in.) as the belt exits the skirtboard.

the belt to rise. The employment of using a half-trough arrangement is generally done in the interest of shortening the transition distance. *(See Chapter 6: Before the Loading Zone for additional information about half-trough transitions.)* It is important that the belting specifications and tension be calculated correctly to minimize the risk of the belting lifting off the idlers. Hold-down rollers can be installed to keep the belt on the idlers.

Rough bottom edges or warped steel can create difficult conditions, capturing material to increase the drag on the conveyor drive and/or abrade the belt surface. Ceramic blocks or wear plates must be carefully installed to avoid jagged or saw-toothed edges that can trap material or damage the belt (**Figure 11.12**). The rule is to maintain a smooth flow surface on the bottom edge of the skirtboard and eliminate all entrapment points. Skirtboard steel and chute liners must be installed very carefully, with all seams well matched.

The gap left between the skirt and the belt surface should be sealed by a flexible, replaceable elastomer sealing system applied to the outside of the skirtboard. *(See Chapter 13: Edge-Sealing Systems.)*

Figure 11.12

Skirtboard should be installed so it maintains a smooth flow surface on the bottom edge of the skirtboard to eliminate all material entrapment points.

Skirtboard Construction

The strength and stability of the skirtboard are very important to its success. Many times conveyor skirtboard is supported by cantilever brackets that are not rigid enough to withstand the impact of material or the vibration of equipment. This risks a structural failure that endangers the belt and the transfer point itself.

The thickness of the skirtboard must be sufficient to withstand side pressures that may occur when the chute becomes plugged or the belt rolls backward. As it is located close to the belt, any movement of the skirtboard must be prevented to minimize the risks of damage.

Except in very light applications, the minimum thickness of mild steel used for skirtboard construction should be 6 millimeters (0.25 in.). On belts moving over 3,7 meters per second (750 ft/min) or 1300 millimeters (54 in.) or more wide, the minimum thickness should be 10 millimeters (3/8 in.). For applications with belts moving over 5 meters per second (1000 ft/min) or 1800 millimeters (72 in.) wide, the minimum thickness should be 12 millimeters (0.5 in.).

Skirtboards should be installed on structural steel supports on approximately 1,2-meter (48-in.) centers so the supports do not interfere with the spacing of, or access to, belt-support cradles and idlers. The most common support design is an angle iron "A-frame," installed on approximately the same spacing as the carrying idlers. These "A-frames" should be rigid and well-gusseted, and they should be installed far enough above the belt to allow easy access for the adjustment or replacement of the skirtboard seal (**Figure 11.13**).

At least one "A-frame" should be positioned at the beginning of the skirtboard and another at the end. Closer spacing should be considered in the conveyor's impact zone to the extent of doubling the support structure.

There are minimum sizes of angle iron that need to be used to construct these "A-frames" (**Table 11.2**). These specifications are best suited for low-density, free-flowing materials. For belt feeders, or for handling high-density materials like ore or concentrate, heavier steel and closer spacing is required.

It is important that proper clearance be provided between the bottom of the skirtboard supports and the belt to allow room for the installation and maintenance of a skirtboard seal and clamp system. The minimum clearance between the horizontal support and the belt at the skirtboard wall should be 230 millimeters (9 in.).

If there is dynamic vibration in the system caused from either belt movement or other operating machinery such as breakers, crushers, or screens, the skirtboard may need to be isolated from it.

These recommendations are for standard conveyor installations and normal duty ratings where the belt is approximately waist high and the idlers are standard width. For other applications, such as "double height" skirtboard or severe conditions, additional support structure may be required. A conveyor or structural engineer should be consulted for advice on skirtboard thicknesses and required supporting structures.

Skirtboard for Conveyors with Multiple Loading Points

Where a belt is loaded at more than one point along the conveyor's length, care must be used in the positioning of the skirtboard at the loading points. The skirtboard at the subsequent load points must be designed to allow the previously loaded material to pass freely, without being "plowed" off the belt by the skirtboard or chute steel of the following loading point.

Because it is impossible to rely on material being loaded evenly and centrally onto a conveyor with multiple load points, a certain amount of plowing and spillage of the material is probably inevitable. This fugitive material contributes to higher

Figure 11.13

Skirtboard must be properly supported, and the support structure must be far enough above the belt to allow access to the sealing system.

Table 11.2

Recommended Angle Iron Sizes for Skirtboard Supports

Conveyor Specifications	A-Frame Angle Iron Size
Below 3,7 m/s (750 ft/min) or 1400 mm (54 in.) wide	50 x 50 x 5 mm (2 x 2 x 3/16 in.)
3,7 m/s to 5 m/s (750 ft/min to 1000 ft/min) or 1400 mm to 1800 mm (54 to 72 in.) wide	75 x 75 x 6,4 mm (3 x 3 x 1/4 in.)
Over 5 m/s (1000 ft/min) or 1800 mm (72 in.) wide	75 x 75 x 9,5 mm (3 x 3 x 3/8 in.)

operating and cleanup costs as well as premature equipment failures. Therefore, it is a sound practice to incorporate continuous skirtboards.

When loading points are relatively close together, it is usually better to provide a continuous skirtboard between the two loading points and a deeper trough angle than would be normally used rather than use individual skirtboards at each loading point (**Figure 11.14**).

Another excellent approach for situations with multiple load zones would be the installation of an air-supported conveyor. Air-supported conveyors are uniquely suited for multiple load zones, as they require only a centered load, rather than conventional skirtboard or skirt seals (**Figure 11.15**). *(See Chapter 23: Air-Supported Conveyors.)*

Figure 11.14

When a conveyor has multiple loading points relatively close together, it may be best to provide a continuous skirtboard between the loading points.

Figure 11.15

Air-supported conveyors are uniquely suited for multiple load zones, as they require only a centered load, rather than conventional skirtboard or skirt seals.

SYSTEM MAINTENANCE

As skirtboard is basically a steel wall without moving parts, there is little preventive maintenance to be performed. If the skirtboard also functions as the wear liner, wear can be an issue. The skirtboard may be subject to corrosion and require periodic replacement. If the conveyor is subject to frequent jamming, the skirtboard may be deformed, increasing the chance of belt damage. Skirtboard covers should be secured in place and access doors closed after inspections and maintenance. Periodic checks should be performed to make sure the skirtboards are structurally capable of containing the bulk materials and properly positioned above the belt.

SAFETY CONCERNS

Even when properly installed with proper relief and without sawtooth edges, skirtboard still represents an unforgiving edge in close proximity to the moving belt. Care must be taken when working in the vicinity of the skirtboard to avoid becoming pinched or caught between moving components and the steel structure.

Even when constructed of steel, conveyor skirtboard covers are not intended as walkways and should not be used as work platforms. They should be guarded and marked with "No Step" warnings.

Cutting and welding are common maintenance procedures in the load zone. Established "hot work" and fire watch procedures should be followed. Chutes and covered skirtboard sections are often considered confined space and require workers to follow special precautions. *(See Chapter 2: Safety for information about confined space.)* Chutes and feeding equipment can contain large amounts of buildup or accumulation of loose bulk materials that can fall during maintenance. Established lockout / tagout / blockout / testout procedures must be followed.

TYPICAL SPECIFICATIONS

The following specifications are for conveyors that handle free-flowing and relatively uniform bulk materials, such as coal and crushed rock.

A. Transfer point

The transfer point will be equipped with steel skirtboards on either side of the belt as an extension of the chute.

B. Load settling

The skirtboards will be long enough to allow the load to settle into the profile to be carried.

C. Reduced air velocity

The skirtboard cross-sectional area will be sufficient to reduce the air velocity to 1,0 meter per second (200 ft/min) to allow dust to settle before the load exits the skirted area.

D. Covers

The skirtboard system will be fitted with covers to allow it to act as a plenum that allows dust to settle out of the air.

E. Free-belt area

The skirtboard will be designed to allow sufficient free-belt area on each side to allow for effective sealing.

F. Clearance above the belt

The bottom edge of the skirtboard should be installed 6 millimeters (0.25 in.) above the belt at the exit of the load zone, opening slightly to 9 to 12 millimeters (0.38 to 0.5 in.) at the exit.

G. No rising

The belt should be prevented from rising off its support structure, even when operating unloaded.

H. Construction

The skirtboard system will be solidly constructed with proper supports that do not interfere with the ability to install or maintain conveyor components, including belt-support cradles, idlers, or skirtboard-sealing systems.

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ADVANCED TOPICS

Sample Problems: Calculating Dimensions for Skirtboard / Settling Zone

There are equations to determine the appropriate minimum dimensions for the skirtboard at the transfer points in the four problems below (**Equation 11.1** Skirtboard Length and **Equation 11.2** Skirtboard Height). *(For Total Airflow in the sample problems, see Equation 7.1 or measure the total airflow.)*

Equation 11.1

Skirtboard Length

$l_{sb} = \frac{V \cdot CF}{k}$		Units: Metric	Units: Imperial
l_{sb}	Skirtboard Length (from loading zone to end of chute)	meters	feet
V	Belt Speed	m/s	ft/min
CF	Chute Factor	If Q_{tot} < 0,5 m³/s = 0,6	If Q_{tot} < 1000 ft³/min = 2
	(Q_{tot} = Total Airflow)	If Q_{tot} > 0,5 m³/s = 0,9	If Q_{tot} > 1000 ft³/min = 3
k	Conversion Factor	0,5	100

Equation 11.2

Skirtboard Height

$h_{sb} = \frac{Q_{tot}}{CW \cdot v}$		Units: Metric	Units: Imperial
h_{sb}	Skirtboard Height	meters	feet
Q_{tot}	Total Airflow	m³/s	ft³/min
CW	Chute (Skirtboard) Width	m	ft
v	Target Air Speed	m/s	ft/min

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Figure 11.16

Sample Problem #1

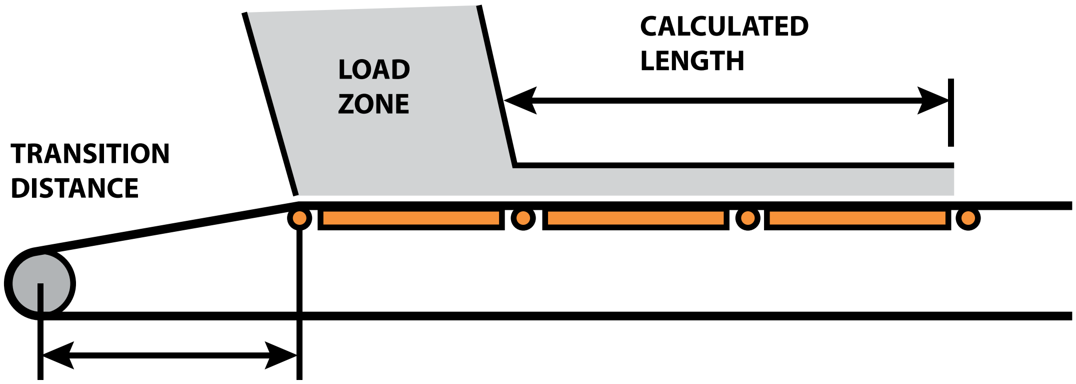

Table 11.3

(Figure 11.16)

Skirtboard Sample Problem #1				
Given:	Material	Sub-bituminous Coal	**Find:**	Minimum Skirtboard Length ***(Equation 11.1.1)***
	Belt Width	1 m (36 in.)		
	Belt Speed	3 m/s (600 ft/min)		Minimum Skirtboard Height ***(Equation 11.2.1)***
	Width of Skirtboard	0,6 m (2 ft)		
	Measured Airflow	0,56 m^3/s (1200 ft^3/min)		

Equation 11.1.1

Skirtboard Length Sample Problem #1

$$l_{sb} = \frac{V \cdot CF}{k}$$

Given: *Belt speed of 3 meters per second (600 ft/min) and an airflow of 0,56 cubic meters per second (1200 ft³/min).* ***Find:*** *Minimum Skirtboard Length.*

Variables		Metric Units	Imperial Units
V	Belt Speed	3 m/s	600 ft/min
CF	Chute Factor	0,9	3
k	Conversion Factor	0,5	100

Metric: $l_{sb} = \frac{3 \cdot 0,9}{0,5} = 5,4$ **Imperial:** $l_{sb} = \frac{600 \cdot 3}{100} = 18$

l_{sb}	Minimum Skirtboard Length (from loading zone to end of chute)	5,4 m	18 ft

Equation 11.2.1

Skirtboard Height Sample Problem #1

$$h_{sb} = \frac{Q_{tot}}{CW \cdot v}$$

Given: *An airflow of 0,56 cubic meters per second (1200 ft³/min), a chute (skirtboard) width of 0,6 meters (2 ft), and a target air velocity of 1 meter per second (200 ft/min).* ***Find:*** *Minimum Skirtboard Height.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Airflow	0,56 m^3/s	1200 ft^3/m
CW	Chute (Skirtboard) Width	0,6 m	2 ft
v	Target Air Speed	1 m/s	200 ft/min

Metric: $h_{sb} = \frac{0,56}{0,6 \cdot 1} = 0,93$ **Imperial:** $h_{sb} = \frac{1200}{2 \cdot 200} = 3.0$

h_{sb}	Minimum Skirtboard Height	0,93 m	3 ft

Note: In some real applications, calculated results may be impractical, so engineering judgment must be exercised.

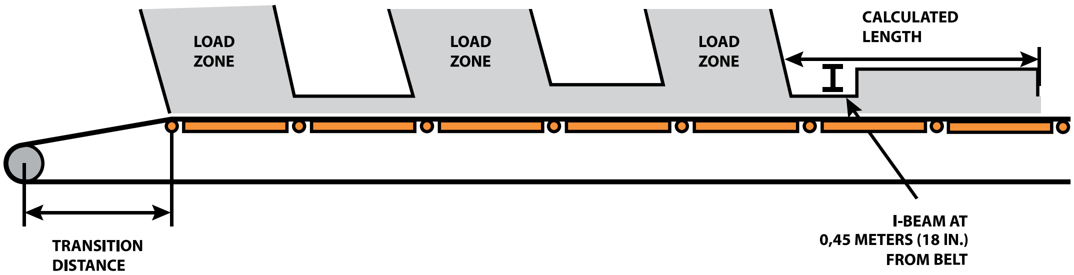

Figure 11.17

Sample Problem #2

Table 11.4

(Figure 11.17)

Skirtboard Sample Problem #2				
Given:	Material	Wood Chips	**Find:**	Minimum Skirtboard Length ***(Equation 11.1.2)***
	Belt Width	1,27 m (48 in.)		
	Belt Speed	3,5 m/s (700 ft/min)		Minimum Skirtboard Height ***(Equation 11.2.2)***
	Width of Skirtboard	1,0 m (3 ft)		
	Measured Airflow	0,28 m³/s (600 ft³/min) from each load zone; all load zones operate at once		

Equation 11.1.2

Skirtboard Length Sample Problem #2

$$l_{sb} = \frac{V \cdot CF}{k}$$

Given: *Belt speed of 3,5 meters per second (700 ft/min) and an airflow of 0,84 cubic meters per second (1800 ft³/min).* ***Find:*** *Minimum Skirtboard Length.*

Variables		Metric Units	Imperial Units
V	Belt Speed	3,5 m/s	700 ft/min
CF	Chute Factor	0,9	3
k	Conversion Factor	0,5	100
Metric: $l_{sb} = \frac{3{,}5 \cdot 0{,}9}{0{,}5} = 6{,}3$ **Imperial:** $l_{sb} = \frac{700 \cdot 3}{100} = 21$			
l_{sb}	Minimum Skirtboard Length (from loading zone to end of chute)	6,3 m	21 ft

Equation 11.2.2

Skirtboard Height Sample Problem #2

$$h_{sb} = \frac{Q_{tot}}{CW \cdot v}$$

Given: *An airflow of 0,84 cubic meters per second (1800 ft³/min), a chute (skirtboard) width of 1 meter (3 ft), and a target air velocity of 1 meter per second (200 ft/min).* ***Find:*** *Minimum Skirtboard Height.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Airflow	0,84 m³/s	1800 ft³/m
CW	Chute (Skirtboard) Width	1,0 m	3 ft
v	Target Air Speed	1 m/s	200 ft/min
Metric: $h_{sb} = \frac{0{,}84}{1{,}0 \cdot 1} = 0{,}84$ **Imperial:** $h_{sb} = \frac{1800}{3 \cdot 200} = 3$			
h_{sb}	Minimum Skirtboard Height	0,84 m	3 ft

Note: This extended height skirtboard **must** begin immediately downstream of the “I-beam” above the belt.

Note: In some real applications, calculated results may be impractical, so engineering judgment must be exercised.

Figure 11.18

Sample Problem #3

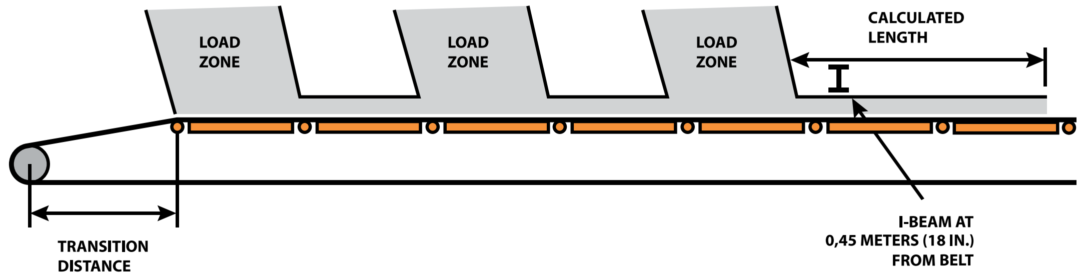

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Table 11.5

(Figure 11.18)

Skirtboard Sample Problem #3				
Given:	Material	Anthricite Coal	**Find:**	Minimum Skirtboard Length ***(Equation 11.1.3)***
	Belt Width	1,27 m (48 in.)		
	Belt Speed	3,5 m/s (700 ft/min)		Minimum Skirtboard Height ***(Equation 11.2.3)***
	Width of Skirtboard	1,0 m (3 ft)		
	Measured Airflow	0,28 m³/s (600 ft³/min) from each load zone; each load zone operates one at a time		

Equation 11.1.3

Skirtboard Length Sample Problem #3

$$l_{sb} = \frac{V \cdot CF}{k}$$

Given: *Belt speed of 3,5 meters per second (700 ft/min) and an airflow of 0,28 cubic meters per second (600 ft³/min).* ***Find:*** *Minimum Skirtboard Length.*

Variables		Metric Units	Imperial Units
V	Belt Speed	3,5 m/s	700 ft/min
CF	Chute Factor	0,6	2
k	Conversion Factor	0,5	100

Metric: $l_{sb} = \frac{3,5 \cdot 0,6}{0,5} = 4,2$ **Imperial:** $l_{sb} = \frac{700 \cdot 2}{100} = 14$

l_{sb}	Minimum Skirtboard Length (from loading zone to end of chute)	4,2 m	14 ft

Equation 11.2.3

Skirtboard Height Sample Problem #3

$$h_{sb} = \frac{Q_{tot}}{CW \cdot v}$$

Given: *An airflow of 0,28 cubic meters per second (600 ft³/min), a chute (skirtboard) width of 1 meter (3 ft), and a target air velocity of 1 meter per second (200 ft/min).* ***Find:*** *Minimum Skirtboard Height.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Airflow	0,28 m³/s	600 ft³/m
CW	Chute (Skirtboard) Width	1,0 m	3 ft
v	Target Air Speed	1 m/s	200 ft/min

Metric: $h_{sb} = \frac{0,28}{1,0 \cdot 1} = 0,28$ **Imperial:** $h_{sb} = \frac{600}{3 \cdot 200} = 1$

h_{sb}	Minimum Skirtboard Height	0,28 m	1 ft

Note: The skirtboard can fit below the "I-beam" above the belt.

Note: In some real applications, calculated results may be impractical, so engineering judgment must be exercised.

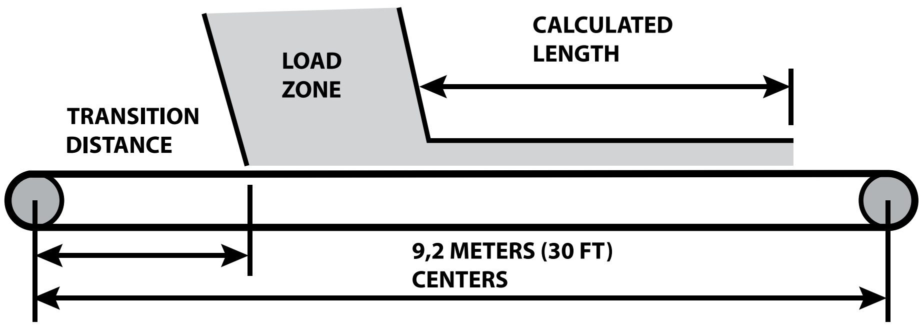

Figure 11.19

Sample Problem #4

Table 11.6

(Figure 11.19)

Skirtboard Sample Problem #4				
Given:	Material	Anthracite Coal	**Find:**	Minimum Skirtboard Length ***(Equation 11.1.4)***
	Belt Width	1,8 m (72 in.) (feeder belt)		
	Belt Speed	0,5 m/s (100 ft/min)		
	Material Depth	0,3 m (1 ft)		Minimum Skirtboard Height ***(Equation 11.2.4)***
	Width of Skirtboard	1,5 m (5 ft)		
	Flat Belt			
	Measured Airflow	0,047 m³/s (100 ft³/min)		

Equation 11.1.4

Skirtboard Length Sample Problem #4

$$l_{sb} = \frac{V \cdot CF}{k}$$

Given: *Belt speed of 0,5 meters per second (100 ft/min) and an airflow of 0,047 cubic meters per second (100 ft³/min).* ***Find:*** *Minimum Skirtboard Length.*

Variables		Metric Units	Imperial Units
V	Belt Speed	0,5 m/s	100 ft/min
CF	Chute Factor	0,6	2
k	Conversion Factor	0,5	100

Metric: $l_{sb} = \frac{0,5 \cdot 0,6}{0,5} = 0,6$ **Imperial:** $l_{sb} = \frac{100 \cdot 2}{100} = 2$

l_{sb}	Minimum Skirtboard Length (from loading zone to end of chute)	0,6 m	2 ft

Note: The skirtboard **must** extend the entire loaded length of the belt, because it also functions to keep the material on the belt.

Equation 11.2.4

Skirtboard Height Sample Problem #4

$$h_{sb} = \frac{Q_{tot}}{CW \cdot v}$$

Given: *An airflow of 0,047 cubic meters per second (100 ft³/min), a chute (skirtboard) width of 1,5 meters (5 ft), and a target air velocity of 1 meter per second (200 ft/min).* ***Find:*** *Minimum Skirtboard Height.*

Variables		Metric Units	Imperial Units
Q_{tot}	Total Airflow	0,047 m³/s	100 ft³/m
CW	Chute (Skirtboard) Width	1,5 m	5 ft
v	Target Air Speed	1 m/s	200 ft/min

Metric: $h_{sb} = \frac{0,047}{1,5 \cdot 1} = 0,03$ **Imperial:** $h_{sb} = \frac{100}{5 \cdot 200} = 0.1$

h_{sb}	Minimum Skirtboard Height	0,03 m	0.1 ft

Note: The height **must** be at least 0,3 meters (1 ft), because that is the height of the material on the belt.

Note: In some real applications, calculated results may be impractical, so engineering judgment must be exercised.

11

DRAWING A CONCLUSION ABOUT SKIRTBOARD

In Closing...

Skirtboard plays a key role in the control of both dust and spillage. By centering the cargo, properly designed skirtboard systems will reduce spillage; by forming a plenum for materials to settle out of the air, skirtboard helps prevent the escape of dust. Both are essential steps in the struggle to improve conveyor efficiency by total material control.

Looking Ahead...

This chapter about Skirtboards, the sixth chapter in the section Loading the Belt, focused on the use of skirtboards to reduce spillage and dust. Two chapters remain in this section: Chapter 12: Wear Liners and Chapter 13: Edge-Sealing Systems.

REFERENCES

11.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*. Naples, Florida.

11.2 The website http://www.conveyorbeltguide.com is a valuable and non-commercial resource covering many aspects of belting.

11.3 Any manufacturer and most distributors of conveyor products can provide a variety of materials on the construction and use of their specific products.

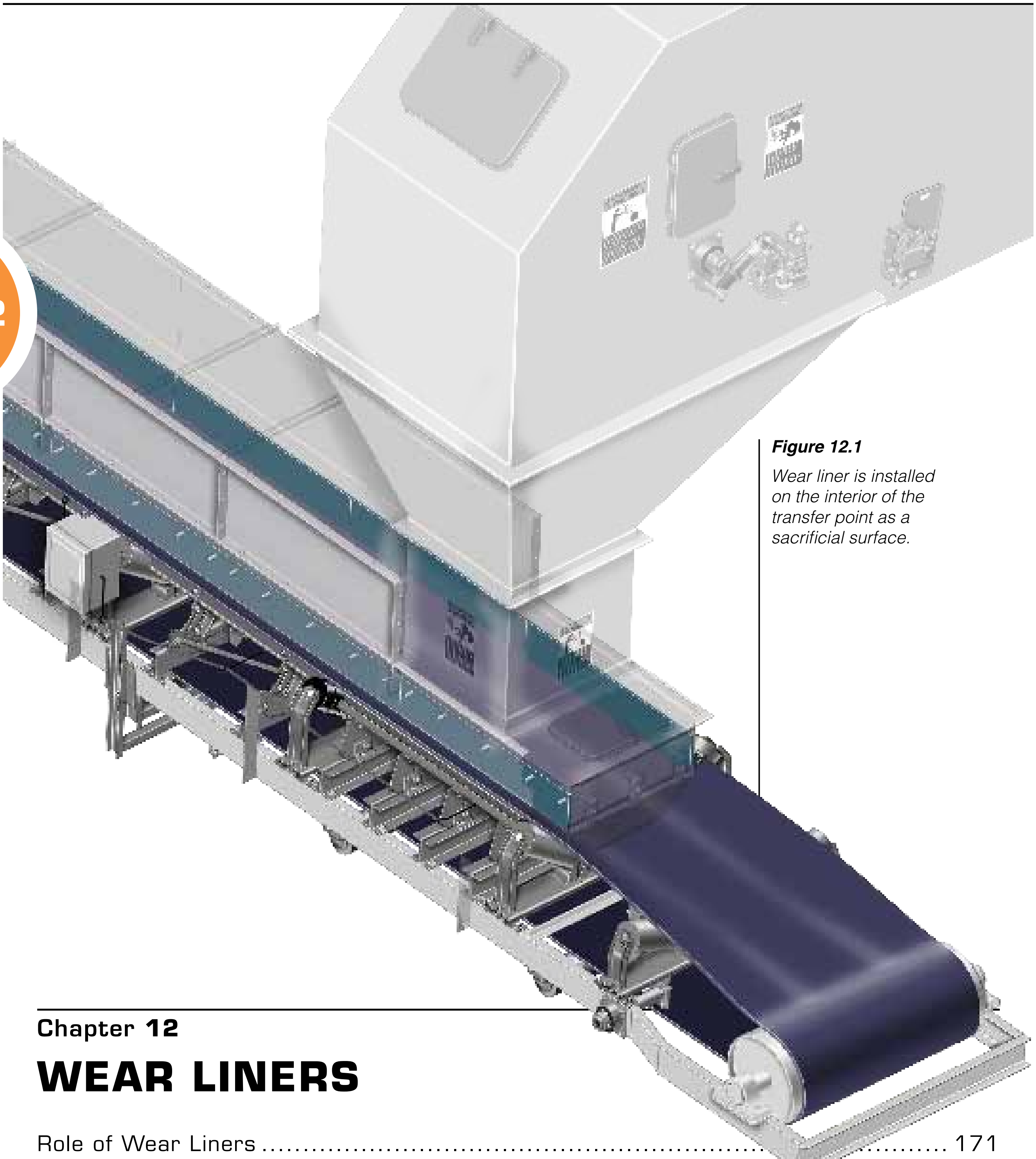

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Figure 12.1

Wear liner is installed on the interior of the transfer point as a sacrificial surface.

Chapter 12

WEAR LINERS

In this Chapter…

This chapter will cover the reasons for the installation of wear liner, the three styles of wear liners commonly used, and the various materials used as wear liners. We also discuss selection and correct installation techniques for wear liner in the skirtboard section of a transfer point.

Wear liner is a material installed on the interior of the transfer point as a sacrificial surface to be worn away by contact with the moving bed of material (**Figure 12.1**).

ROLE OF WEAR LINERS

In plans for a low-spillage transfer point, wear liner serves multiple purposes:

A. It provides a sacrificial, easily-replaceable wear surface to protect the walls of the chute and the skirtboard.

B. It helps center the material load.

C. It prevents the material load from applying high side forces onto the sealing strips, thereby improving the seal's service-life.

D. Some types of wear liners can reduce friction, impact, noise, and degradation of the bulk material.

The forces of material flowing through a transfer point and dropping onto a belt inside a traditional transfer area create tremendous outward pressures. Wear liner is installed to control this side pressure and protect the components of the transfer point. The wear liner is a key component in the containment of the conveyed material in the skirted area (**Figure 12.2**). This side pressure of the material, if uncontrolled, will push material fines and dust away from the center of the material pile and under the skirtboard, resulting in spillage.

Wear liners are installed on the inside of the skirtboard(s) to protect the skirting seal. They have the mission of separating the job of sealing from the function of load placement. By creating a dam between the material pile and the edge-sealing strips, the wear liners greatly reduce the side-loading forces that reach the sealing strips. With wear liners installed, the sealing strips do not have to act as a wall to contain the material load but rather act only as a seal, a purpose for which they are much more suited. This arrangement improves the effectiveness and life expectancy of the sealing system while reducing the risk of damage by material entrapment.

There are only a few instances where the installation of a wear liner will not greatly enhance the sealability of a transfer point and the life expectancy of its components. These would be very lightly-loaded belts or belts handling non-abrasive, low-density materials. In all other circumstances, properly installed and maintained wear liners will reduce the material side-loading forces to increase sealing efficiency and sealing-strip life.

TYPES OF WEAR LINERS

Configurations of Wear Liner

Four styles of wear liner are commonly seen today: straight, spaced, deflector, and tapered (**Figure 12.3**).

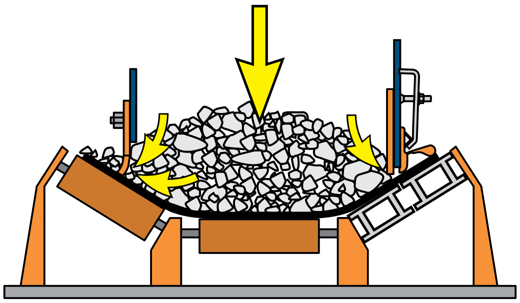

Figure 12.2

Without the protection offered by a wear liner, the elastomer sealing system is not strong enough to contain the forces that push material over the edge of the belt.

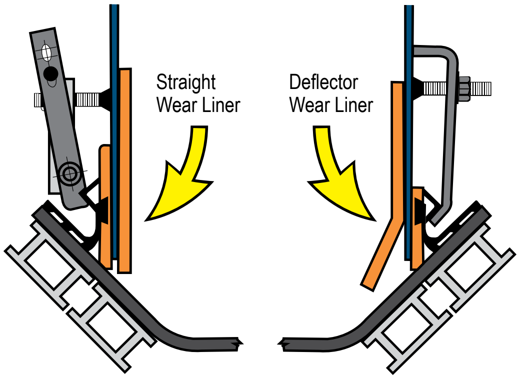

Figure 12.3

Left: Straight Wear Liner. Right: Deflector Wear Liner.

Straight Wear Liner

Straight wear liner has the capability of preventing side-loading forces on the skirting seals without choking the chute and constricting material flow. Straight wear liner has been used on all sizes of belts (**Figure 12.4**). The real benefit of straight wear liner is that it provides improved life and improved sealing effectiveness without closing down the effective load area. In an era when more and more production is asked of fewer and fewer resources, it is important to maximize system capacity by utilizing the full width of the loading chute and conveyor belt. Straight wear liner is a good choice to meet both current and future requirements for flow of most bulk materials.

Straight wear liner is also best for belts with multiple loading points, whether installed in one long transfer point or through several loading zones.

Figure 12.4

Straight wear liner improves sealing without choking the effective load area.

Spaced Wear Liner

A variation on straight wear liner installation technique is spaced wear liner (**Figure 12.5**). This hybrid technique can be used in applications where mechanical dust collection is present. To assist in sealing, the liners are not installed directly onto the wall of the skirtboard but rather separated slightly—25 to 50 millimeters (1 to 2 in.)—from it. The space between the skirtboard and the wear liner is used as negative pressure area. Fines and airborne dust in this area can be pulled from this space by the conveyor's dust-collection system.

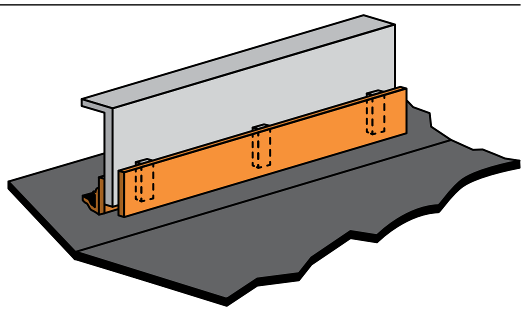

Figure 12.5

Spaced wear liner incorporates an open area behind the liner where dust collection can be applied.

This technique is better suited for use on new conveyor systems, so the requirement for the "free belt edge distance" can be engineered into the dimensions of the loading zone from the beginning without reducing the carrying capacity of the conveyor. While the dimensions of this space are not large, typically 25 to 50 millimeters (1 to 2 in.) of free space on each side of the conveyor, it is important in a spaced wear-liner installation that the liner be installed so its top edge is well above the height of the pile of material in the loading zone.

Figure 12.6

Deflector wear liner creates a free area between the liner and the sealing system.

Deflector Wear Liner

Deflector wear liner incorporates a bend so the bottom half of the liner is bent inward, toward the middle of the belt (**Figure 12.6**). This angle provides a "free" area between the rubber skirting and the wear liner. This area is useful, as fines that have worked their way under the bottom edge of the wear liner still have an area on the belt on which to travel; they are not automatically ejected from the system. These particles are contained by the sealing strip and have a path to travel down the belt to the exit area of the transfer point. The fines that work their way out to challenge the rubber seal are relatively free of applied forces; they are isolated from the downward and outward force of the material load.

The drawback of deflector wear liner is that it reduces the effective cross-sectional area of the skirtboard area. This, in turn, reduces the volume of material that can pass through the transfer point, and consequently may require adjustments in the chute dimensions or in a system's operating schedule to maintain a specified capacity. This consideration is particularly important on smaller belts—less than 750 millimeters (30 in.) wide—or belts running near capacity. By reducing the loading zone's cross section, deflector liner may also reduce the maximum allowable lump size, leading to material jams.

In addition, deflector wear liner should not be used in loading zones that see impact. In such applications, the liner faces higher wear and the opportunity for pieces of material to rebound off the belt and wedge into the deflector liner's open bottom area, creating the risk of belt abrasion. Deflector liner also concentrates the abrasive wear from material impact onto the "bent" area and "lip" of the liner. If the wear is concentrated in one spot, the wear can create an opening where lumps of material can build up, increasing the chances of belt abrasion (**Figure 12.7**).

Tapered Wear Liner

Tapered wear liner is usually cast from molybdenum (moly) steel for use in heavy-duty applications. The cross section of the casting is trapezoidal to reduce the gap at the concurrence of the belt, liner, and skirting seal while presenting sufficient wear thickness where the material impacts or slides along the skirted area. To keep the weight of individual castings to a reasonable weight for handling, the tapered wear liners are usually made 300 to 400 millimeters (12 to 16 in.) wide. Because cast wear liners are heavy and are supplied in short lengths, it is difficult to install them so the bottom edge is in a smooth, straight line. Poor installation can create pockets where bulk materials can be trapped and wear the belt.

Wear-Liner Materials

Straight and deflector wear liners are typically supplied as sheets of material, often 1200 millimeters (48 in.) long, 200 millimeters (8 in.) high, and 12 millimeters (1/2 or 0.5 in.) thick. Cast liners are usually supplied in pieces that are 300 to 400 millimeters (12 to 16 in.) wide, 200 to 500 millimeters (8 to 20 in.) high, and 25 to 75 millimeters (1 to 3 in.) thick. The liners can be supplied with pre-drilled holes to simplify field installation.

There are a number of materials suitable for use as wear liners (**Table 12.1**).

Mild Steel Wear Liner

Mild steel wear liner is commonly used on materials with very low abrasion or on belts with light loads or low operating hours. Materials such as sawdust, wood chips, and garbage would be good examples of material suitable for mild steel wear liners. In addition, projects with demands for low initial costs but which require good short-term results are also candidates for mild steel wear liner.

If the environment is damp or otherwise corrosive, the higher corrosion rate of mild steel may add additional friction to the material body in the loading zone.

Figure 12.7

Deflector liner also concentrates the abrasive wear from material impact onto the "bent" area and "lip" of the liner.

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Mild steel wear liner can be supplied in either the straight or deflector pattern.

Abrasion-Resistant Plate Wear Liner

Abrasion-resistant plate wear liner (AR plate) provides a much longer life than wear liner fabricated from mild steel. AR plate is a good, all-around wear liner, capable of handling more-abrasive materials such as sand, hard rock mining ores, and coal. The wear life may extend five to seven times longer than mild steel. AR plate is available in either straight or deflector styles.

Ceramic-Faced Wear Liner

Ceramic-faced wear liner is a good, long-term wear liner for continuously-operating belts carrying highly-abrasive material where impact is minimal. A mild steel backing plate faced with ceramic blocks is a good choice in these circumstances. These ceramic blocks are glued and/or plug welded to the mild steel backing, usually on the bottom 100 millimeters (4 in.) of the plate. On more heavily loaded belts, the ceramic blocks can also be applied higher up the backing plate to reduce wear.

Ceramic-faced wear liner has been shown to work well with coal and wood chips. Ceramic-faced wear liner can be supplied in both straight and deflector styles.

Any time liners are faced with castable materials, whether ceramic or alloys such as magnesium steel, extreme care must be taken to align the blocks during their installation on the steel plate. The bottom edge of the installation must be positioned with care to avoid pinch points and "stair steps" that can trap material.

Stainless Steel Wear Liner

Stainless steel wear liner is a choice that falls between mild steel and AR plate in abrasion resistance. The chemical resistance of stainless steel is often required for applications where the possibility of corrosion on mild steel or AR plate exists. The coefficient of friction between the bulk material and stainless steel varies significantly, and power requirements should be reviewed if retrofitting with stainless steel liners. Stainless steel wear liner can be supplied in both straight and deflector styles.

Table 12.1

Wear-Liner Materials

Lining Material	Initial Cost	Sliding Abrasion Resistance	Impact Resistance	Temperature Resistance	Low-Friction Quality
Mild Steel	Low	G	G	VG	NR
Abrasion-Resistant Plate	Medium	VG	G	VG	NR
Stainless Steel	High	G	G	E	VG
Chromium Carbide Overlay	Medium	E	G	VG	VG
Rubber	High	G	E	NR	NR
Polyurethane	High	E	E	NR	G
UHMW	Medium	G	NR	NR	E
Ceramic Tile					
Quarry Tiles	Low	G	NR	G	G
Vitrified Tiles	Low	VG	NR	VG	VG
Basalt Tiles	Medium	VG	G	VG	G
Alumina Tiles	High	E	G	E	G

Note: Performance Comparison of Possible Wear-Liner Materials. Ratings: E–Excellent; VG–Very Good; G–Good; NR–Not Recommended.

Chromium Carbide Overlay

Chromium carbide overlay is a very hard material suitable for conveyors seeing very high levels of abrasion. Alone, chromium carbide is very brittle, so it is overlaid onto a backing plate for installation. The backing plate can be of mild or stainless steel, depending on application requirements. The hard facing will rank between 53 and 65 Rockwell "C" hardness; some overlay materials "work harden" under contact with the cargo, so they score a 75 hardness on the Rockwell "C" scale. Also referred to as "clad plate," these materials are available in two designations: single-weld or double-weld pass. For wear liner applications, the double-weld pass grade is typically used. This material is not suited for high impact and, as a result, is used only in the straight style of wear liner.

Plastic Wear Liner

Plastic wear liners are a more recent development. Recently, wear liners composed of Ultra-High Molecular Weight (UHMW) polyethylene, or urethane have been installed. In many of these installations, the liner sits directly on the belt to control extremely fine, dusty materials. Slotted holes in the liner panels allow adjustment to keep the wear liner in contact with the belt.

Applications of UHMW as a wear liner show success with fine, powdery products such as sand, fly ash, and electric-arc furnace (EAF) dust. In addition, as UHMW is accepted by the U.S. Food and Drug Administration, it is suitable for use with powdery foodstuffs. Urethane liners are now being used successfully in gold-mining and ore-processing applications for their light weight and ease of replacement.

Plastic materials have been applied only as straight wear liners; the abrasion that would be seen in applications as a deflector design would dramatically reduce the service-life. Care should be taken to not install plastic liners in conditions that exceed the material's service temperature or that see a high belt speed; doing so could raise the liner's temperature to a softening point, shortening the material life.

Wear Liner for Curved Chutes

Many of these materials are also suitable for lining curved chutes for applications where there is a need for wear resistance or reduced friction. Examples would include ceramic tiles or AR plate used as a liner in a curved chute handling coal or UHMW used in a chute for wood chips.

Wear Liner Cost vs. Value

While the initial cost of a wear liner should be a significant consideration, it is more important that the material be selected on the basis of its performance and service-life. Factors that should also be considered include:

A. Friction coefficient

B. Resistance to material adhesion

C. Resistance to sliding-abrasion wear

D. Resistance to impact-abrasion wear

E. Resistance to corrosion

F. Attachment method

G. Installation cost

H. Maintenance cost

Choosing the correct material for use as a wear liner could increase the initial cost of the transfer point. However, the use of a liner material specifically tailored to a given application should produce a better return on investment when considering the labor of replacing prematurely worn liners and the increased time for cleanup of spilled material.

APPLYING WEAR LINERS

Application of Wear Liner

With the exception of UHMW and urethane wear liners, all wear-liner systems must be installed with a relieving angle from the entry area opening toward the exit area of the transfer point. The distance above the belt will vary with the product size. As with the skirtboard steel, the desire is for the liner to create a larger opening toward the exit of the loading zone to prevent material entrapment.

As stated earlier, UHMW and urethane wear liners are typically installed so the bottom edge will touch, or lie, on the belt.

At the entry area, the space between the belt and the bottom edge of the wear liner is generally in the range of 3 to 10 millimeters (1/8 to 3/8 in.), with the closer dimension specified for materials with smaller particle sizes. At the exit end, the distance will typically be 10 to 20 millimeters (3/8 to 3/4 in.). Again, the smaller distance is for finer materials, whereas the larger dimension is for materials containing larger lumps. Proper belt support to eliminate belt sag and vibration is essential to preserving the belt in the face of this narrow spacing.

Figure 12.8

Poorly-aligned wear liner creates material entrapment points.

Figure 12.9

Wear liner should be installed in a straight line that gradually opens toward the exit of the transfer point.

A word of caution: When joining pieces of wear liner, it is imperative the bottom edges line up smoothly without creating a jagged, “saw-toothed” pattern (**Figure 12.8**). If the bottom edges are not precisely aligned, entrapment points will be created. The conveyed material will then create exceptionally-high pressure points in these areas that will lead to material spillage or, even worse, wedges of material will accumulate into “teeth” that will abrade the belt. To prevent these buildups, the bottom edge of the wear liner should be straight, as if a string line were stretched from the entry to the exit of the transfer point (**Figure 12.9**). Again, relief from entrapment should be provided with a slight increase in the distance from the belt surface to the bottom edge as the belt moves toward the exit of the transfer point.

Installing Wear Liner

Wear plate can be applied by methods including bolts, welding, or a combination of both.

Wear liners are commonly installed with countersunk bolts that provide smooth surfaces on the interior face of the skirtboard. These bolts also allow the simple replacement of the liner. Liners can be welded

SAFETY CONCERNS

When installing wear liners, it is important to bear in mind that these are large panels, usually of steel, and may have sharp edges. They are heavy and usually awkward to handle, particularly when trying to maneuver and install them in the close quarters between the skirtboards on narrow conveyors. Proper lifting tackle and equipment to restrain the liners should be used while completing the installation.

The operation’s established lockout / tagout / blockout / testout procedures, confined-space regulations, and other appropriate safety policies should be followed.

into position, with the obvious drawback being the difficulty in replacing worn liners. Should the installation require that the wear liner be welded into position, care must be taken to use the correct welding materials and techniques to match the liner material.

Another installation technique calls for the wear liner to be plug welded from outside the transfer point (**Figure 12.10**). With this technique, holes are drilled or cut through the plated steel wall. Then the back of the liner is welded to the chute wall. This system provides installation without bolt heads or holes protruding into the loading zone to act as targets for material abrasion. The liner provides its full thickness for wear-life. At the end of the liner's life, replacement can be performed by cutting out the plug welds and installing new liners using the same holes.

When welding the liner in place, care must be taken to control the stress introduced into the lining metal. Abrasion-resistant plate, when applied as a liner, must be applied the same way a person would apply wallpaper. If a sheet of wallpaper is applied by securing the four outside edges first, big air bubbles will be trapped in the center of the sheet. A similar situation occurs if AR plate is installed in the same fashion, but instead of trapped air bubbles, residual stress will be created in the plate that will try to escape. When the structure starts to flex under normal operation, these stresses can introduce cracks in the wear liner. If not caught in time, a large section of liner can break off or the chute wall will bow.

To avoid this stress, it is important to use proper welding technique. The accepted "best practice" is called backstep or "back welding." It calls for stitch welding on the top of the plate (**Figure 12.11**). At each weld, the bead is drawn back toward the welded end. Correct welding rod selection is imperative to assure the strength and durability of the weld joint.

Careful attention must be paid to the strength of the conveyor structure when installing liners for the first time. Unless properly reinforced, the support structure could be too weak to support the added weight of liners, risking costly damage and downtime.

Chute Design for the Purpose of Maintenance

As with any enclosure, it is important to provide a simple way to inspect the interior. Doors through the chute wall or skirtboard must be included as a mechanism to inspect the condition of liners.

Ideally, the chute will be large enough to allow personnel inside to perform the work of installation and replacement. If the conveyor size is not such that there is room for personnel to work inside the transfer-point enclosure, the skirtboard and liner system should be designed so that the entire assembly can be opened, laid over on its back, or lifted off the structure. This would allow the replacement of the liner and the reinstallation of the wall assembly with minimum downtime, inconvenience, and cost.

It would be valuable to permanently install anchors for rigging at suitable locations above the skirtboard to allow easier lifting and placement of wear liner sheets.

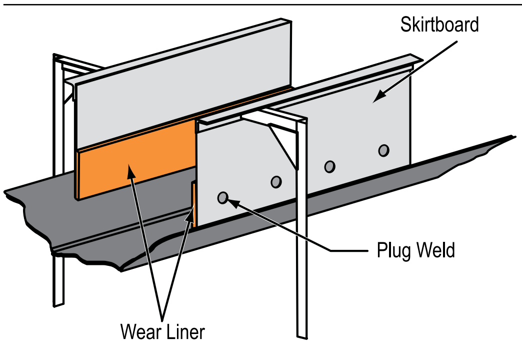

Figure 12.10

Wear liners can be installed from the outside of the skirtboard by plug welding.

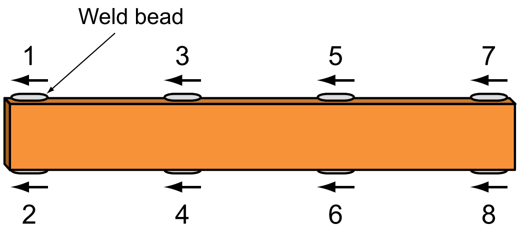

Figure 12.11

Backstep welding is "best practice" for the installation of wear liners to prevent warping.

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TYPICAL SPECIFICATIONS

A. Wear liner

The skirtboard will be equipped with a wear liner. Affixed to the interior of the skirtboard, this liner will protect the edge-sealing system from the side-loading forces of the material load.

B. Position

The wear liner will be positioned within 3 to 10 millimeters (1/8 to 3/8 in.) of the belt at the entry area and within 10 to 20 millimeters (3/8 to 3/4 in.) of the belt at the exit end of the transfer-point skirtboard.

C. Alignment

The bottom of liners will be precisely aligned to eliminate any jagged or "saw-toothed" edges, which can capture material.

D. Plug-welding technique

The wear liner will be installed using a plug-welding technique to prevent the intrusion of bolt holes into the liner material.

SELECTING A WEAR LINER FOR A SPECIFIC APPLICATION

In Closing...

The choice of the "best" liner material for a given application is usually specific to that given application, driven by the material conveyed and the system.

Sometimes the material choice is driven from higher up in the organization, where a corporate engineer has some experience—positive or negative—with a particular liner choice and so mandates (or forbids) the use of a specific material. Other times, a choice will be made to keep all materials uniform within a plant—to use existing material, or make future orders simpler—even in an application where the material specified is less than ideal.

There are many references, articles, and specialty suppliers of wear-liner materials to assist in choosing a liner for a specific application. Plant personnel will usually know what has been tried in an application, and they will know its track record. They will know what has worked, and perhaps more importantly, what has failed—or what was deemed too short-lived—in a specific application.

This institutional memory is a valuable tool in liner choice. But it should not be relied upon exclusively. This background knowledge should be compared against accurate records showing the dates of installation and the tonnage conveyed over a specific liner material in a given location. The record-keeping is the key to validating the wear-liner material choice made.

Looking Ahead...

This chapter about Wear Liners, the seventh chapter in the section Loading the Belt, discussed their use in a low-spillage transfer point. The following chapter, Edge-Sealing Systems, concludes this section.

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12.1 Conveyor Equipment Manufacturers Association (CEMA). (2005). *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*. Naples, Florida.

12.2 The website http://www.conveyorbeltguide.com is a valuable and non-commercial resource covering many aspects of belting.

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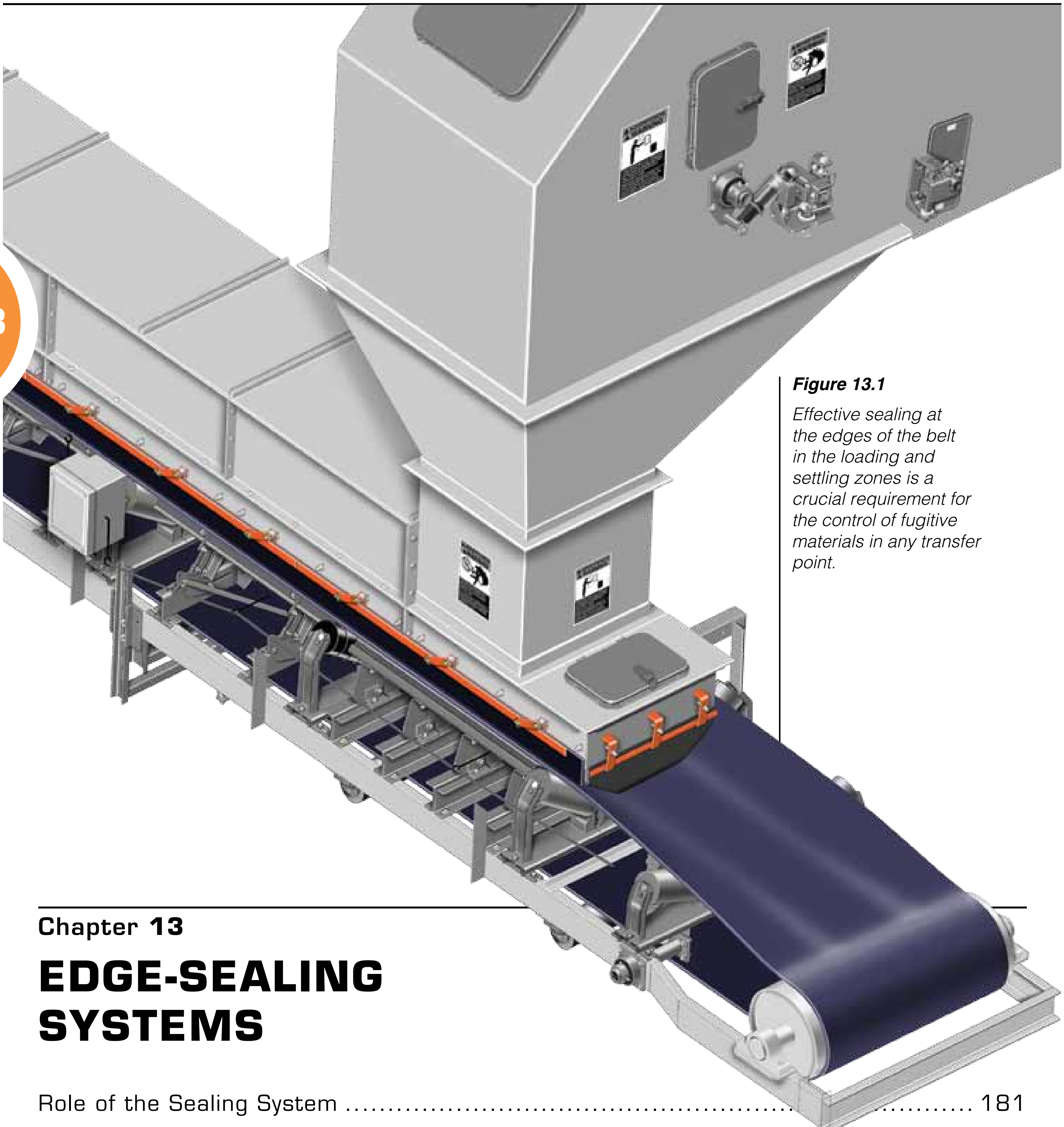

Figure 13.1

Effective sealing at the edges of the belt in the loading and settling zones is a crucial requirement for the control of fugitive materials in any transfer point.

Chapter **13**

EDGE-SEALING SYSTEMS

13

In this Chapter...

In this chapter, we conclude the discussion about sealing the loading zone of a transfer point with a focus on edge-sealing systems. Three main types of sealing systems are described, with advantages and disadvantages of each, along with various engineered systems. Guidelines for selection, installation, use, and maintenance of edge-sealing systems are also discussed. The chapter closes with equations for calculating additional power consumption required.

A crucial requirement in any transfer point designed for reduced spillage and high efficiency is an effective sealing system at the edges of the belt (**Figure 13.1**). The seal should start in the loading area and continue to the end of the settling zone. An edge-sealing system, typically a flexible elastomer strip, is installed on the outside of the skirtboard on both sides of the belt to bridge the gap between the steel structures and the moving belt.

Instead of the first step in preventing conveyor spillage, the skirtboard seal is the last chance to control fugitive material and prevent its release. Stabilizing the belt line, with properly installed belt support, and controlling the amount of material leakage, with a wear-liner system installed close to the belt, improve the performance of the belt's edge-sealing system. A flexible, multiple-layer system incorporating a level of self-adjustment provides effective material containment for a transfer point and improves the operation of the belt conveyor.

A functional edge-sealing system requires the use of belt support, skirtboards, wear liners, and an edge seal (**Figure 13.2**). Belt-support systems are discussed in Chapter 10, skirtboards in Chapter 11, and wear liners in Chapter 12. This chapter will focus primarily on the skirtboard, or edge, seal as the important final component in sealing the loading zone of a transfer point for the prevention of the escape of fine particles of fugitive material.

ROLE OF THE SEALING SYSTEM

What Sealing Systems Can and Cannot Do

In the past, a typical edge-sealing system was a vertical strip of elastomer clamped to the outside of the chute or skirtboard steel. The rubber sealing strip would bridge the gap from the steel to the belt, which was typically 25 to 50 millimeters (1 to 2 in.) or more.

This elastomer sealing strip was expected to perform an almost miraculous function. With the belt not properly supported, and/or no wear liner or worn out wear liner in place, the elastomer edge seal was required to contain the full weight of the material load while attempting to adjust for an undulating belt path. To ask flexible sealing strips alone to do more than contain light material or dust on the belt is asking for the unattainable. The material load will quickly abrade the sealing strip, or push it away from the skirtboard, and allow for the resumption of spillage (**Figure 13.3**).

In an attempt to stop the escape of particles, plant personnel continually adjust the sealing strips down to the belt, thereby increasing the sealing pressure and leading to several undesirable results. The increase in sealing pressure raises the conveyor's power requirements, sometimes to the

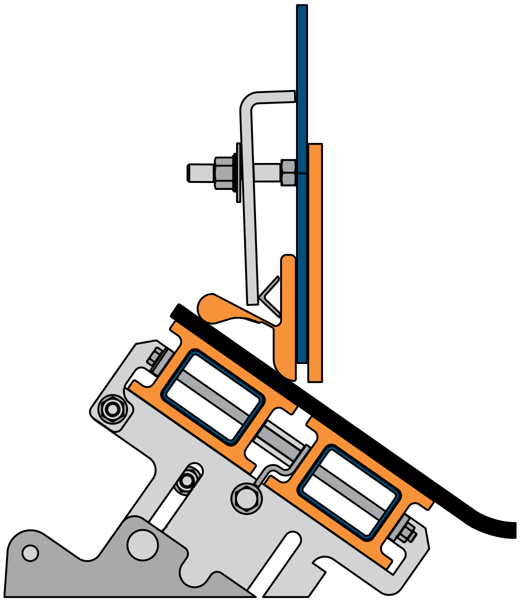

Figure 13.2

Effective sealing at the edge of the belt requires belt support, wear liners, skirtboards, and edge seal.

point in which it is possible to stall the belt. The increased friction causes heat buildup that will soften the elastomer sealing strip and shorten the elastomer's life, sometimes to the point in which the seal will virtually melt away. This increased wear is most obvious at the points where there is the highest pressure, typically directly above the idlers (**Figure 13.4**).

On a belt that is not properly supported in the load zone, the belt will sag between the idlers and allow material to become entrapped between the wear liner or the edge seal and the belt. The entrapped material greatly accelerates belt and edge-sealing system wear and increases the drive power requirement.

Figure 13.3

Without an effective sealing system, material will spill over the sides of the belt, shortening component life and increasing maintenance and cleanup chores.

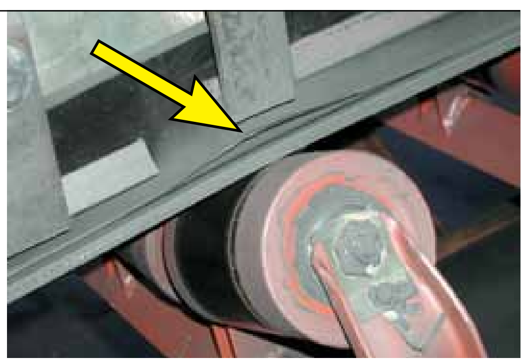

Figure 13.4

With the higher pressure, the seal wears faster and unevenly. The uneven wear, in the form of scallops, will be most obvious directly above the idlers where pressure is the highest.

Figure 13.5

The first skirtboard seals were fabricated in-house from readily-available materials such as used belting or large "barge" ropes. These primitive sealing systems were pushed down onto the belt edges or held in position by gravity.

Goal of a Sealing System

The goal of any sealing system is to contain conveyed material fines and dust on the belt. Desirable attributes include minimal seal-to-belt contact area and minimal seal-downward pressure, and reasonable life. Minimizing these items reduces drag against the conveyor, minimizes wear on the belt and the seal, and minimizes additional power required to drive the belt.

The job of sealing the edges of a conveyor load zone is a challenging one. Even in the best transfer points with the belt tracking properly on a stable line, the sealing system faces a certain amount of sideways pressure and vibration due to variations in loading and other conditions. The sealing system must be designed to conform to these fluctuations in belt travel to form an effective seal. The seal must be rugged enough to stand up to belt abrasion and splice impact without undue wear and without catching the splice. The sealing system should offer a simple adjustment mechanism to compensate for wear.

No sealing system can stand up for long in the face of abuse from the material load. If the seals are not sheltered from the material flow, both the effectiveness and the life of the sealing strips will be diminished. With the impact of the loading material onto a sealing system, the material forces the sealing strips down onto the belt, accelerating wear in both seal and belt. The transfer point should be constructed to avoid both loading impacts on the seals and material flow against the seals.

VERTICAL, INWARD, OR OUTWARD SEALING

Engineered Sealing Systems

The first skirtboard seals were fabricated in-house from readily available materials such as used belting or large "barge" ropes (**Figure 13.5**). These primitive sealing systems were pushed down onto the belt edges or held in position by gravity. While they were inexpensive, these systems were not very successful. They became impregnated with material that abraded the belt, and they lacked an easy method to adjust for wear. Eventually, the disappointing results of these homemade techniques led to the desire for, and design of, more effective systems.

Now, the state of the art in engineered transfer-point components has progressed from sealing strips that barely contained lumps of material to the current systems that prevent the escape of fines and even dust. A number of engineered sealing systems are now commercially available. In general, these systems consist of a long strip of elastomer, held against the lower edge of the skirtboard by an arrangement of clamps.

For effective sealing, it is critical that there be adequate free-belt distance. Free-belt distance—the amount of belt outside the skirtboard on both sides of the conveyor—provides the space available for the sealing system (**Figure 13.6**). Too often, in the interest of putting the greatest load on the narrowest belt, the free-belt distance is reduced. This invariably comes at the cost of sealing system effectiveness. *(For more information about free-belt distance and effective belt width, see Chapter 11: Skirtboards.)*

There are a number of different approaches to skirtboard sealing. A simple way to classify these systems is to describe where each contacts the belt: Some drop straight down from the skirtboard, some extend back inside the skirtboard, and some seal on the outside of the skirtboard.

Vertical Sealing

Vertical sealing systems typically use only a single rubber sealing strip (**Figure 13.7**). Often, one supplier offers a system of clamps, and another provides the rubber strip. Sometimes, a specially-shaped elastomer strip is installed; other times, strips of rubber or, worse, used belting are applied (**Figure 13.8**). The sealing system selected should always be less abrasion resistant than the top cover of the belt it is sealing.

A specific caution must be given against the use of any previously used or leftover belting as a skirting seal. Used belting is normally loaded with abrasive materials, such as sand, cinders, or fines, from its years of service. All belting, new or used, contain fabric reinforcement or steel cords that will grind away at the moving belt, wearing away the protective top cover and

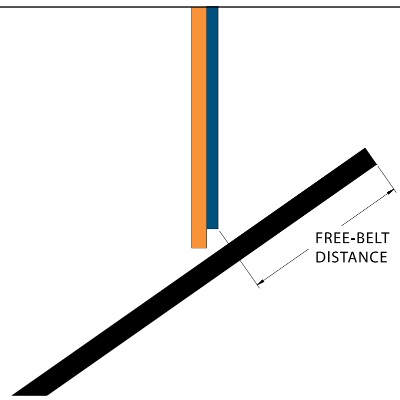

Figure 13.6

Free-belt distance—the amount of belt outside the skirtboard on both sides of the conveyor—provides the space available for the sealing system.

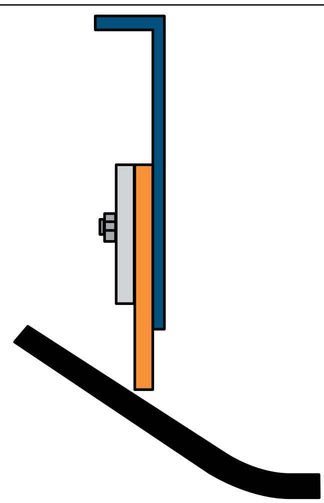

Figure 13.7

The vertical sealing systems typically use a rubber or elastomer strip which might have a special proprietary shape. A system of clamps is used to hold the skirtboard rubber in place.

Figure 13.8

Strips of rubber or, worse, used belting are sometimes seen. Regardless of the material used, the sealing system should always be less abrasion resistant than the top cover of the belt.

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leading to premature failure and costly replacement.

Another type of vertical sealing system uses a series of interlocking sealing blocks installed outside the skirtboard on a special mounting plate. The interlocking blocks can be moved downward (toward the belt) but resist upward movement (**Figure 13.9**). These blocks can be easily adjusted down to the belt using only a hammer; however, each block must be individually adjusted, and over-adjustment is a common problem. When over-adjusted, these blocks can easily stall a belt.

Main advantages of straight-up-and-down, or vertical, skirtboard seals are:

A. Low in cost

B. Narrow belt-edge distance (free-belt distance) requirements

C. Can be self adjusting

Main disadvantages of straight-up-and-down skirtboard seals are:

A. Often difficult to adjust accurately

B. Easily over-adjusted, causing premature wear

C. Prone to entrapping material, leading to belt damage

D. Susceptible to leakage of dust and fines

A third type of vertical edge-sealing system, designed to overcome many of the disadvantages associated with straight-up-and-down sealing, is the floating-sealing system. This system uses sealing strips mounted to the steel skirtboard on independent, freely-rotating link arms (**Figure 13.10**). The links allow the sealing strip to float on the belt, reacting to changes in the belt line while remaining in sealing contact with the belt (**Figure 13.11**). This design allows the sealing system to self-adjust, using its own weight to compensate for wear. The self-adjusting function allows this type of sealing system to overcome obstacles provided by inconsistencies in the belt line due to improper belt support or surges in the material loading.

Figure 13.9

One class of sealing systems is easily adjustable because it is made in segments. A series of modular sealing blocks are installed outside the skirtboard on a special mounting plate that allows the interlocking blocks to be moved downward (toward the belt) but resist upward movement.

Figure 13.10

One edge-sealing system that would be classified as straight-up-and-down is the floating-sealing system. This system uses sealing strips mounted to the steel skirtboard on independent, freely-rotating link arms.

Figure 13.11

This system allows the sealing system to self-adjust, using its own weight to compensate for wear or variations in travel.

Inward Sealing

Some sealing systems are clamped on the outside of the chute with the elastomer strip curled back under the steel. With these types of systems, the seal is formed on the inside of the skirtboard. Because the seal lies inward, the wear liner must be spaced far enough above the belt to allow for some free vertical movement of the seal (**Figure 13.12**). These inward systems have had some success on conveyors carrying light, fluffy materials and fine, non-abrasive materials, such as carbon black. Inward sealing systems are also useful as a temporary solution on belts with limited edge-sealing distance, where a lack of belting outside the skirtboard steel limits the space available for the application of a sealing system. These systems are sometimes useful in areas of high internal-chute pressure—under a rail car dump, for example—where, when properly applied, the material loaded on the seal would tend to assist in the sealing effort. It should be noted that the seal may wear quickly, and material trapped under the seal would tend to prematurely wear the belt's top cover.

Sealing inward is sometimes applied due to a belt with a severe mistracking problem, because the belt would be least likely to travel out from under this type of system. In this situation, it would be better to solve the mistracking issues rather than apply a seal to overcome the problem. *(See Chapter 16: Belt Alignment.)*

The protective benefit from the installation of wear liner can be neutralized when the sealing system reaches back under the skirtboard, placing the sealing strip inside the wear liner (**Figure 13.13**). The sealing strip is abraded by the material load, and material can more easily be entrapped against the belt.

Main advantages of inward skirtboard-sealing systems are:

A. Self-adjusting

B. Handle light, fluffy materials and fine, non-abrasive materials

C. Require limited edge distance (free-belt distance)

D. Handle high internal chute pressure

E. Handle severely mistracking belts

Principal disadvantages of inward skirtboard seals are:

A. Shorter life of the seal due to being in the material flow

B. Prone to material entrapment under the sealing strip leading to premature belt wear

C. Reduced load-carrying area of the belt due to the "rainbow" effect (**Figure 13.14**)

A hybrid of these systems combines the floating vertical-sealing system, described in

Figure 13.12

Some sealing systems are clamped on the outside of the chute with the sealing strip curled back under the steel to form a seal on the inside of the chutewall. Because the seal lies inward, the wear liner must be spaced far enough above the belt to allow for some free vertical movement of the seal.

Figure 13.13

The protective benefit from the installation of wear liner is somewhat neutralized when the sealing system reaches back under the chutewall to place the sealing strip on the inside of the steel enclosure. Inside the wear liner, the sealing strip can easily be damaged by the forces of the material load.

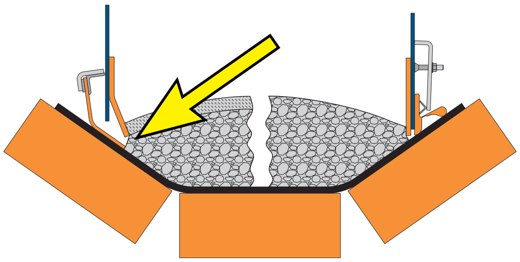

Figure 13.14

Inward skirtboard seals reduce the usable area of the belt by taking up space where the load could be carried. Due to a "rainbow" effect in the edges of the carrying area, capacity is reduced all the way across the belt.

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Vertical Sealing above, with an "L"-shaped rubber strip (**Figure 13.15**). The foot of the rubber "L" extends inward, under the skirtboard steel and wear liner, toward the bulk materials. This one-piece sealing system serves as both the material (lump) seal and a dust seal. The rubber "foot" improves the seal's resistance to side pressure from the belt cargo and increases the range of belt mistracking the sealing system can tolerate.

Figure 13.15

One hybrid of these systems combines the floating vertical-sealing system, described in Vertical Sealing above, with an "L"-shaped rubber strip. The foot of the rubber "L" extends inward, under the skirtboard steel and wear liner, toward the bulk materials.

Figure 13.16

The final variation in sealing systems are those systems that seal on the outside of the skirtboard steel.

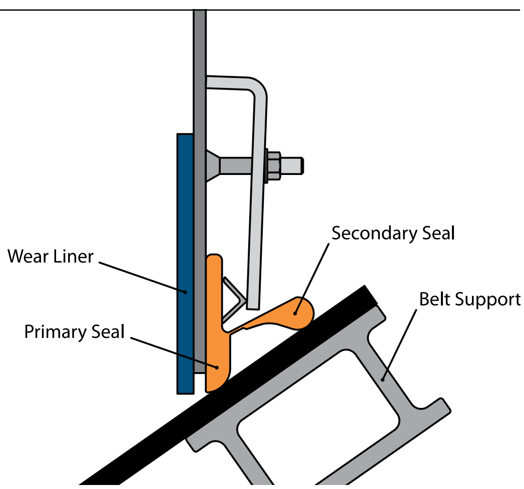

Figure 13.17

Multiple-layer sealing systems incorporate two layers: a primary strip that is pushed gently down to the belt to contain most particles, and a secondary strip that lies on the belt's outer edge to contain any fines or dust that push under the wear liner and primary strip.

This type of system is particularly useful for transfer points where the wear liner is installed 25 millimeters (1 in.) or more above the belt. This spacing is used to preserve the belt from being damaged by running up against the wear liner and is a common practice in some industries where conveyors and conditions are less than ideal, such as coal mining and aggregate production.

This hybrid system allows the seal to float on the belt, rising and falling with any belt movement, including splice passage. The low application pressure reduces wear in both the belt and sealing strip.

Outward Sealing

The final variations of edge-sealing systems are systems that seal on the outside of the skirtboard steel (**Figure 13.16**). The most effective design combines multiple-layer seal effectiveness with the simplicity of single-strip systems.

When conveyor maintenance workers prepare for cold weather activities, they dress in layers. They know it is better to put on multiple layers of clothing—undershirt, shirt, sweatshirt, and jacket—than to wear one thick layer. The same concept can be used for transfer-point sealing: It is better to work with several thin layers than with one thick, general-purpose layer. In sealing, the first layer is provided by the wear liner installed inside the chute. Extending down close to the belt, the wear liner keeps the large particles of material well away from the belt edge. *(See Chapter 12: Wear Liners.)* The next layer is provided by the sealing system.

Multiple-layer seal designs feature rugged single-strip elastomers manufactured with a molded-in flap that serves as a secondary seal (**Figure 13.17**). This outrigger, or secondary strip, typically forms one or more channels that would capture the fines and gently carry them along the belt before depositing them back into the main body of material.

The system's primary seal is clamped against the outside of the chutework, extending vertically down and lightly touching the belt. It is applied with light pressure onto the belt, and the clamp applies force horizontally toward the chute, rather than down onto the belt. Because the clamping force is horizontal, the primary strip contains the material without the application of high pressure on the belt that would increase wear and conveyor power consumption. This primary strip will contain most of the material that has escaped past the wear liner.

As an outrigger, the secondary seal requires only the force of its own elasticity to provide sealing pressure, and, consequently, will wear a long time without the need for adjustment.

Installing the preferred one-piece design is a simple procedure: Unroll the seal to the proper length, cut it, and attach it to the skirtboard using a clamping system. A one-piece seal avoids any unnecessary joints and the handling of multiple pieces. Sealing systems should be provided in different thicknesses, to handle different duty applications, and in different materials, to handle different needs such as food grade, high temperature, and underground applications.

Advantages of outward sealing are:

A. Long lasting, because they are positioned away from material flow and sheltered by the skirtboard and wear liner

B. Can be self-adjusting

C. Low required sealing pressure due to "labyrinth" or multiple-layer seal design

D. Adapt to existing clamp systems

Disadvantages of outward sealing are:

A. Require greater belt-edge distance (or free-belt distance)

B. Vulnerable to damage if belt mistracks from underneath the seal

CONSIDERATIONS FOR SUCCESSFUL SEALING

Edge Distance Requirements

Care must be taken in selecting an edge-sealing system that fits into the available area between the belt's edge and the steel skirtboard. Sealing strips should not extend out to the belt's edge, as it increases the risk of damage to the seal or the belt in the event of belt mistracking.

In general, 115 millimeters (4.5 in.) outside the skirtboard steel on each side of the loading zone is recommended as the minimum distance required to establish an effective seal. *(For additional information about edge distance, see Chapter 11: Skirtboards, especially Table 11.1)*.

Edge Seals and Belt Wander

All skirt-sealing systems are vulnerable to damage from a mistracking belt. If the belt wanders out from underneath one side of the skirtboard, the unsupported sealing strip hangs down below the line of the belt (**Figure 13.18**). When the belt moves back into a centered position, the seal will be abraded from contact with the edge of the moving belt or bent backward into an unnatural position and torn or worn away. Either outcome risks a significant increase in spillage. The keys to avoiding edge-seal damage are to provide adequate edge distance and to control belt tracking. *(See Chapter 16: Belt Alignment.)*

Figure 13.18

If the belt wanders out from underneath one side of the skirtboard, the unsupported sealing strip (green) hangs down below the line of the belt, leading to seal damage and spillage.

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Sealing System and Belt Cover Wear

A research project, published in the journal *Bulk Solids Handling* in 1995, examined to what extent engineered-belt cleaning and sealing systems increased or decreased belt wear *(Reference 13.1)*. This study tested the abrasion of several edge-sealing systems against typical conveyor belting. The conclusions of the study reported the use of more sophisticated belt cleaning and sealing systems with adequate maintenance can extend the life of the conveyor belt. Although belt wear is introduced by these devices, the amount of wear is approximately one-half the rate expected when the belt runs through accumulations of fugitive material resulting from the lack of, or failure of, cleaning and sealing systems.

Avoiding Grooves in the Belt

It is a common misconception that the sealing system must be "softer" than the belt cover to ensure the seal wears before the belt. It is possible to make seals from materials with a wide range of hardness and wear resistance that are appropriate for edge seals. To prevent the sealing strips from wearing the belt, the sealing strips should be composed of materials with lower abrasion resistance than the belt's top cover, ensuring the seal will wear before the belt cover. Abrasion resistance is not measured by durometer, a rating of hardness, but rather by an abrasion index, such as Pico, Deutches Instit für Normung (DIN), or Taber ratings.

Figure 13.19

Many belts suffer wear along the skirted area at a set distance in from either edge of the belt.

Many belts suffer wear along the skirted area at a set distance in from either edge of the belt (**Figure 13.19**). Often the sealing system is blamed for this wear; however, most often this wear is not caused by abrasion from the sealing strip. Rather, these grooves are started by the entrapment of fines and small lumps of material between the liner and the belt. This entrapped material begins scratching the belt's surface and gradually wears through the top cover. This entrapped material is most often seen on belts without proper belt support or on conveyors where material loading begins while the belt is in transition *(see Chapter 6: Before the Loading Zone)*, as the changes in belt shape makes it easy for material to be trapped under the skirtboard. Whenever determining the cause of a belt groove, it is

SAFETY CONCERNS

It is important to follow established lockout / tagout / blockout / testout procedures before any work is done to the edge-sealing strips or any other item on or near the conveyor belt. Manufacturer guidelines for inspection intervals and maintenance procedures should be followed.

Sealing strips should never be raised while the belt is running, because this will place the worker in close proximity to the moving belt. This action may also allow material lumps, fines, or dust to be ejected from the transfer point at the worker.

It is recommended that the area of the transfer point be guarded on both sides of the conveyor. The guards should prevent untrained personnel from adjusting the sealing strips or becoming trapped in the numerous pinch points of the transfer zone.

important to inspect conveyors and chutes located above the affected conveyor for leakage and spillage.

INSTALLATION AND MAINTENANCE

Installation Guidelines

A sealing system must form a continuous strip along the sides of the steel skirtboard. If simple, end-to-end butt joints are employed to splice lengths of sealing strip together, material eventually pushes between the adjoining surfaces and leaks out. An interlocking or overlapping joint is best to prevent this spillage. A better solution is to use sealing strips available as one continuous strip, without need for a seam or joint.

With all edge-sealing systems, it is a good idea to round off the seal's leading edge at the tail end of the conveyor where the belt enters the back of the loading zone (**Figure 13.20**). Presenting a rounded edge to the moving belt reduces the chance a mechanical belt fastener can catch the sealing strip, and either rip it or pull it off the chute.

Maintenance of the Sealing System

When specifying a skirt-sealing system, it is wise to consider its mechanism for adjusting and replacing the wearable rubber. As the conveyor runs, the heat generated by the friction of the belt against the skirting seal combines with the abrasive nature of the material fines to erode the sealing strip. To counter this wear, the sealing strip must periodically be adjusted down against the belt.

Applying too much downward pressure to the sealing system leads to additional power requirements to move the belt; it also leads to extra wear in both the belt and the seal.

If the procedures for the service of skirting rubber are cumbersome or complicated, three detrimental consequences are likely:

A. No adjustment

Adjustment does not happen at all, so the skirting sealing strips wear, gaps open, and leakage resumes.

B. Infrequent adjustment

Adjustment is made too infrequently, so spillage occurs intermittently.

C. Over-adjustment

The maintenance person or conveyor operator, to compensate for not making regular adjustments, will over-adjust the seal. Applying too much force down onto the belt risks damaging the belt or catching a splice and ripping out the entire section of sealing strip.

To prevent these problems, skirtboard-seal maintenance procedures should be as free of complications, tools, and downtime as possible.

Sealing systems that rest gently on the belt, using little more than the pressure of their own weight or the tension built into the design, can minimize the need for maintenance adjustment.

Some multiple-layer sealing systems provide a self-adjusting function, as the elastomeric memory maintains the sealing pressure. As the legs of the secondary strip wear, the natural resilience of the elastomer strip keeps it down on the belt, maintaining seal effectiveness.

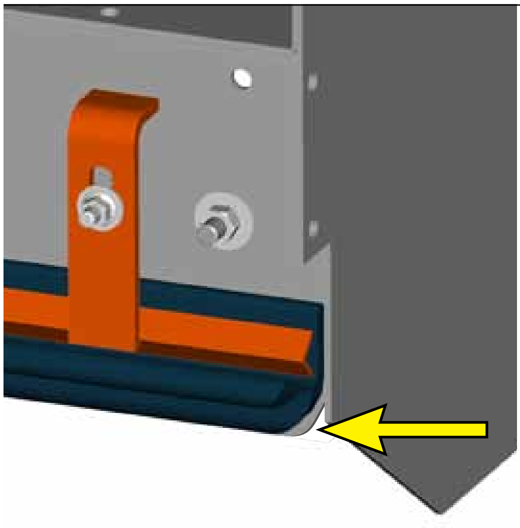

Figure 13.20

With all edge-sealing systems, it is a good idea to round off the seal's leading edge at the tail end of the conveyor where the belt enters the back of the loading zone.

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TYPICAL SPECIFICATIONS

A. Low-maintenance design

A skirtboard-sealing system should be installed on the conveyor transfer point to eliminate material spillage and provide a positive dust seal at the sides of the loading zone. This sealing system should be a low-maintenance design providing an effective seal without the application of downward pressure onto the belt.

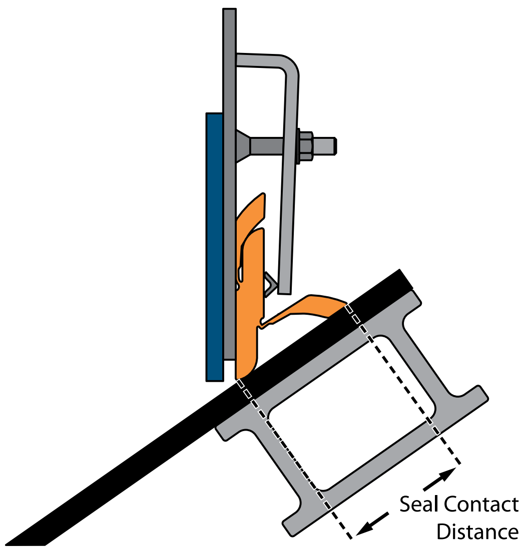

Figure 13.21

Seal-contact distance is the width of belt edge in contact with the edge seal.

B. Wear liners

It is recommended that appropriate wear liners be installed on the inside of the chute and skirtboard to protect the sealing system from material side-loading forces.

C. Self-adjustment function

To reduce maintenance intervals, the sealing system should be designed to self-adjust, with the system flexing to maintain sealing effectiveness in response to wear or changes in the belt's line of travel.

D. Single extended-length strip

The sealing strip should be supplied in a single extended-length strip (on each side of the conveyor) to provide a continuous seal without a seam.

E. Severity of the application

When selecting a skirtboard-sealing system, it is important to match the severity of the application. Factors such as belt speed, material load, and free-belt distance should be reviewed to make sure the application receives a suitable system (**Table 13.1**).

Table 13.1

Typical Comparative Selection Guide for Skirtboard Seal

Basic Characteristics of Sealing Systems	**Sealing System Type**		
	Inward Sealing	Vertical Sealing	Outward Sealing
May Sacrifice Cargo Capacity	Yes	No	No
Recommended Free-Belt Distance (Outside the Skirtboard)	≥ 115 mm (4.5 in.)	≥ 115 mm (4.5 in.)	≥ 115 mm (4.5 in.)
Seal-Contact Distance **(Figure 13.21)**	≥ 38 mm (1.5 in.)	≤ 51 mm (2 in.)	≈ 75 mm (3 in.)
Wear Liner Required	Yes	Yes	Yes
Wear-Liner Distance Above Belt	≥ 25 mm (1 in.)	≤ 25 mm (1 in.)	≤ 25 mm (1 in.)

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ADVANCED TOPICS

Special Designs of Sealing Systems

Some special circumstances require combination or hybrid sealing systems. In the case of a flat feeder belt where there is very fine material under high pressure, a variation of sealing outward in the conventional upright manner is commonly used.

Power Requirements of Sealing Systems

In order to be effective in keeping material on the belt, sealing systems must exert some pressure against the belt. This pressure will increase the drag against the belt and, therefore, increase the power consumption of the conveyor. The additional power requirement is directly dependent on the length and width of the seal and the pressure applied to the seal to keep it in contact with the belt. It is independent of the width of the belt.

The Conveyor Manufacturers Association (CEMA) *(Reference 13.2)* provides a formula for calculation of skirtboard-seal drag of generic rubber edge seals installed along both sides of a transfer point (**Equation 13.1**).

The tension (**Equation 13.1**) is related to the additional power required to drive the conveyor belt (**Equation 13.2**).

Note: this resistance is in addition to the drag of the material load against the skirtboards/wear liners.

In test facilities and field situations, it has been found that many skirtboard sealing-systems can be adjusted down onto the belt with very high levels of force. In these cases, actual tension should be measured to avoid underestimating the actual drag on the belt. Reasonable approximations for start-up requirements and the resulting forces have been measured in the field (**Table 13.2**) (**Equations 13.1** and **13.2**).

Operating power requirements are typically one half to two-thirds of start-up power requirements. If actual conditions are known, actual power requirements or tension should be measured or calculated and used in these equations.

Table 13.2

Force Between Belt and Sealing Strip with Various Sealing Systems

Effective Normal Force (F_{ss}) between Belt and Seal	F_{ss} Units	
	Metric	**Imperial**
Type of Skirting	**N/m**	**lb_f/ft**
Rubber Slab: SBR Rubber—60 to 70 Shore D	45	3
Self-Adjusting Flat Rubber: *Martin® Self-Adjusting Exterior Skirting – Heavy Duty* or similar	78	5.25
1-Piece Multi-Barrier: *Martin® ApronSeal™ Single Skirting – Performance Duty* or similar	30	2
1-Piece Multi-Barrier Heavy Duty: *Martin® ApronSeal™ Single Skirting – Heavy Duty* or similar	50	3.3

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THE FINAL STEP IN SPILLAGE CONTROL

In Closing...

Rather than being the first step in solving conveyor spillage, the skirtboard seal is the last chance to contain fugitive material and prevent its release. The better the job done with belt support and wear-liner systems to contain material and keep it away from the edge, the better the performance will be of the belt's edge-sealing system. A flexible, multiple-layer system incorporating some level of self-adjustment will provide effective material containment for a transfer point and improve the operations of the belt conveyor. Periodic inspection and maintenance will extend life, reduce damage, improve performance, and boost satisfaction. This will ensure that an operation receives optimum value for its investment in an engineered sealing system.

Equation 13.1

Calculation for Tension Added to Belt due to Skirtboard Seal

$$\Delta T_{ss} = n \cdot \mu_{ss} \cdot F_{ss} \cdot L$$

Given: *Rubber slab skirting installed on both sides over 6 meters (20 ft) of belt.* ***Find:*** *Tension added to the belt due to the skirtboard seal.*

Variables		Metric Units	Imperial Units
ΔT_{ss}	Tension Added to the Belt due to the Skirtboard Seal	newtons	pounds-force
n	Number of Skirtboard Seals	2	2
μ_{ss}	Friction Coefficient *(Per CEMA 575-2000)*	0,5 – UHMW 1,0 – Polyurethane 1,0 – Rubber	0.5 – UHMW 1.0 – Polyurethane 1.0 – Rubber
F_{ss}	Normal Force between Belt and Seal per Length	45 N/m *(Table 13.2)*	3 lb_f/ft *(Table 13.2)*
L	Length of Skirted Section of Conveyor	6 m	20 ft
Metric: ΔT_{ss} = 2 · 1 · 45 · 6 = 540			
Imperial: ΔT_{ss} = 2 · 1 · 3 · 20 = 120			
ΔT_{ss}	Tension Added to the Belt due to the Skirtboard Seal	540 N	120 lb_f

Equation 13.2

Calculation for Additional Power Required to Drive the Belt

$$P = \Delta T_{ss} \cdot V \cdot k$$

Given: *Rubber slab skirting installed on both sides over 6 meters (20 ft) of belt. Belt is traveling at 3 meters per second (600 ft/min).* ***Find:*** *The power added to the drive due to the skirtboard seal.*

Variables		Metric Units	Imperial Units
P	Power Added to Belt Drive	kilowatts	horsepower
ΔT_{ss}	Tension Added to the Belt due to the Skirtboard Seal *(Calculated in* ***Equation 13.1****)*	540 N	120 lb_f
V	Belt Speed	3 m/s	600 ft/min
k	Conversion Factor	1/1000	1/33000
Metric: $P = \frac{540 \cdot 3}{1000} = 1,6$			
Imperial: $P = \frac{120 \cdot 600}{33000} = 2.2$			
P	Power Added to Belt Drive	1,6 kW	2.2 hp

Looking Ahead...

This chapter about Edge-Sealing Systems concludes the section Loading the Belt and the discussion about sealing the loading zone of a transfer point to prevent the escape of fine particles and fugitive material. The following chapter begins the section related to the Return Run of the Belt with a discussion about Belt Cleaning; the following two chapters continue that section with information about Pulley-Protection Plows and Belt Alignment.

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