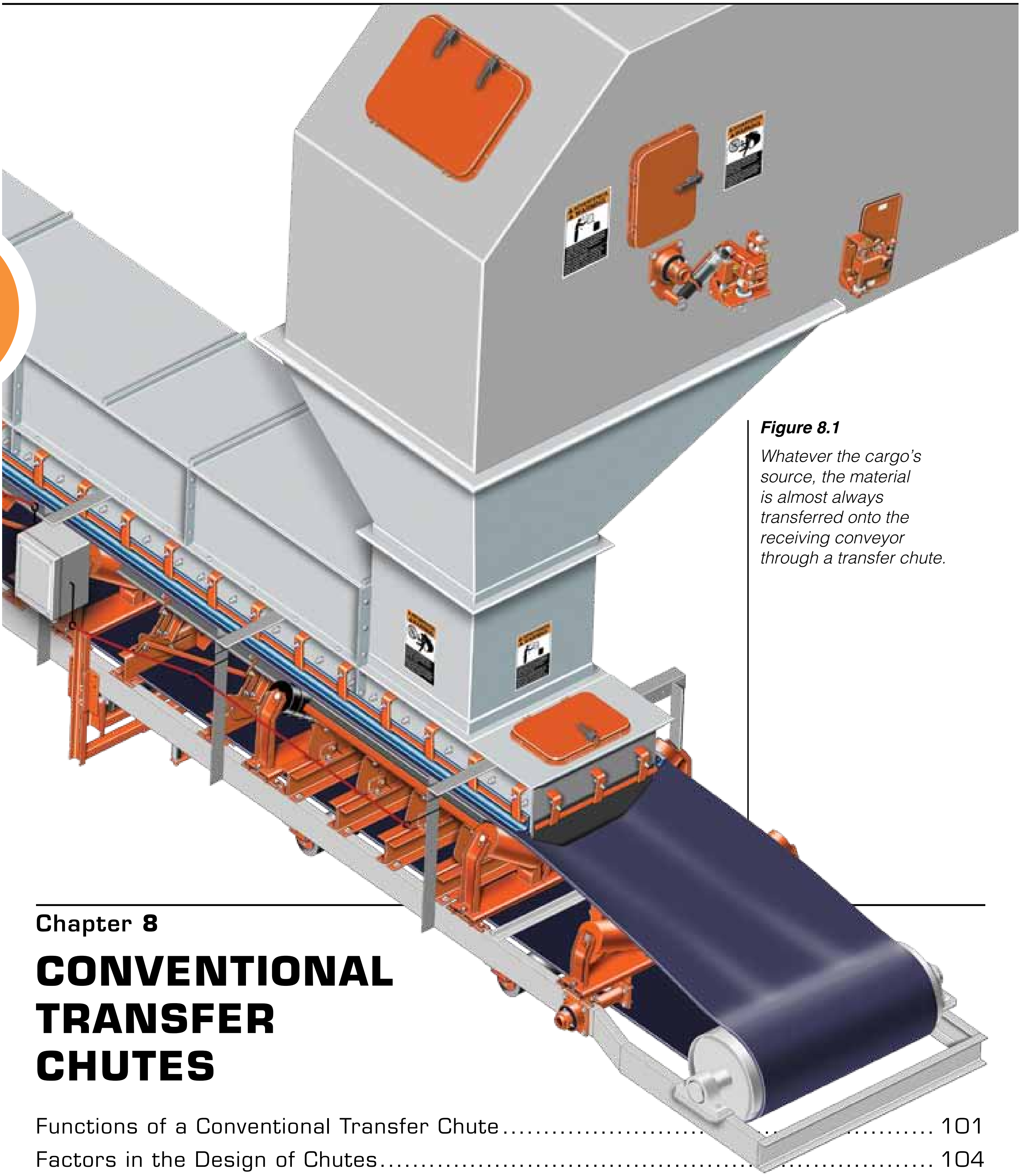


Figure 8.1

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

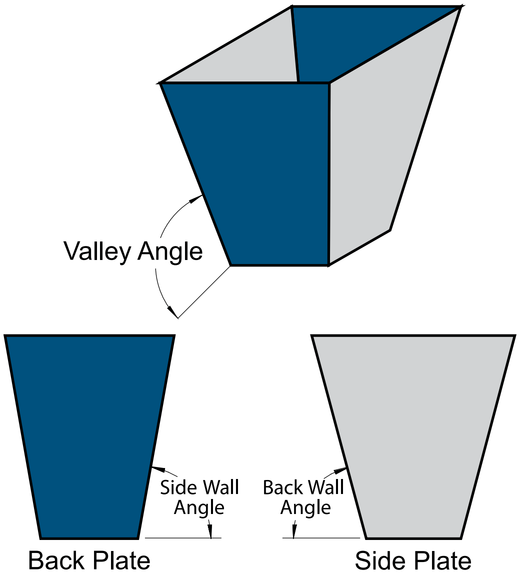


Figure 8.5

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.

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.)*

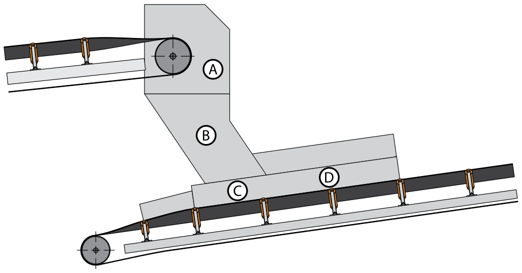
FACTORS IN THE DESIGN OF CHUTES

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

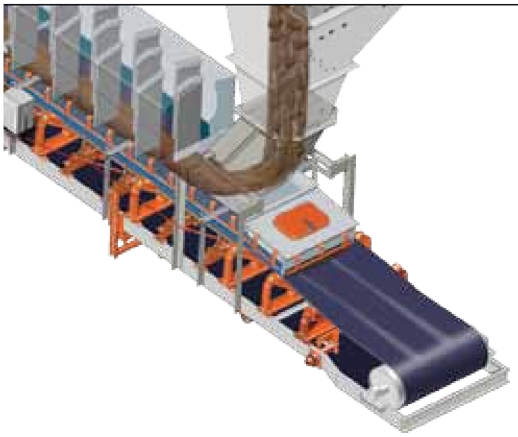


Figure 8.11

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.

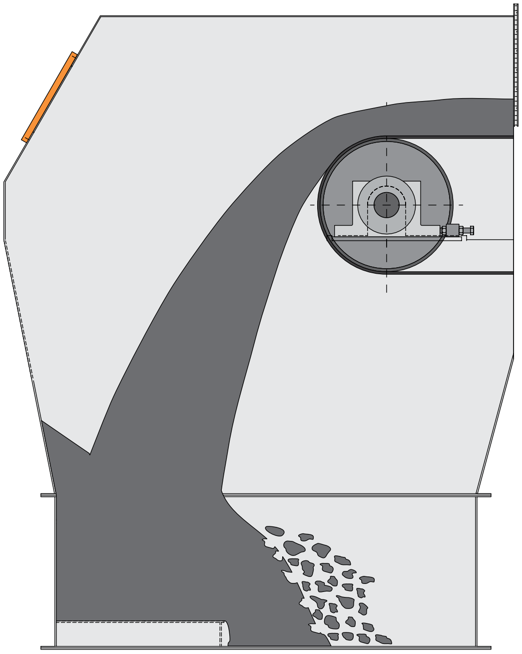


Figure 8.15

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.

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.

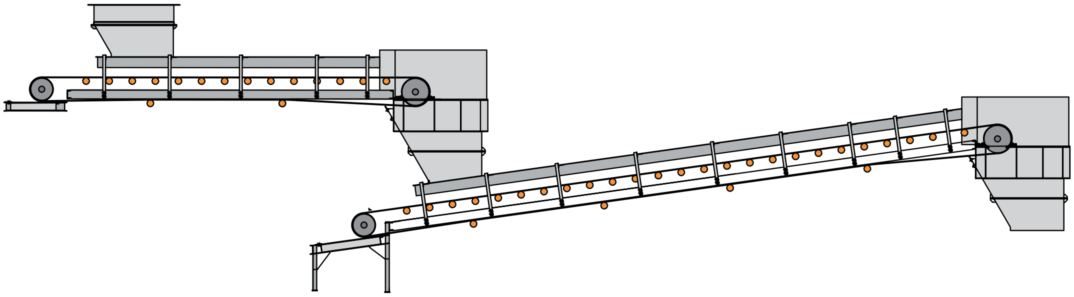


Figure 8.21

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

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.

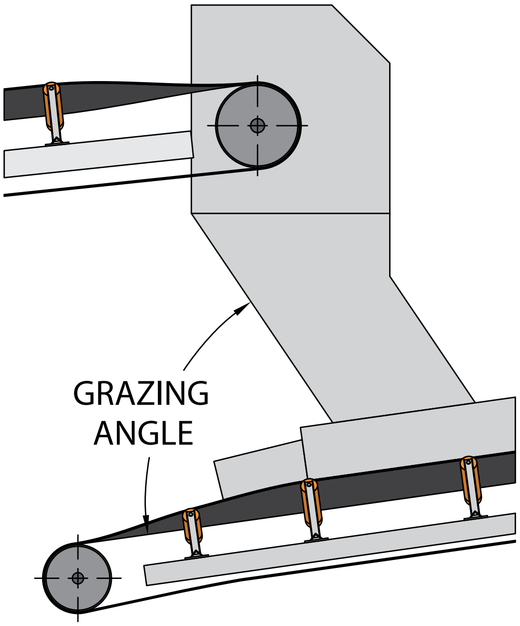


Figure 8.23

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

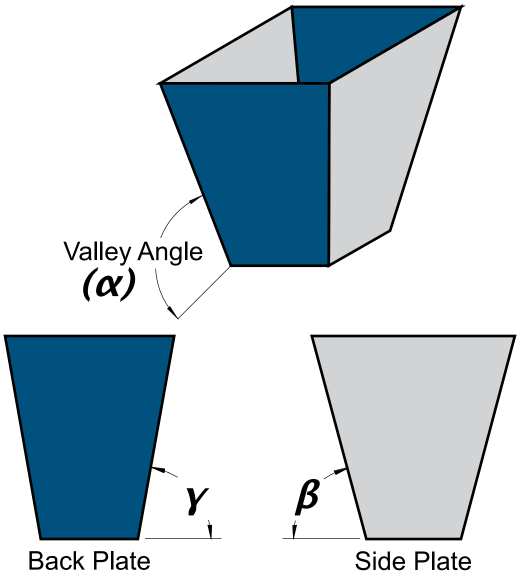
The transfer chute should be adequately sloped to prevent material from bouncing excessively after it lands on the receiving conveyor, which can increase dust generation and impact damage.

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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