SECTION 3

RETURN RUN OF THE BELT

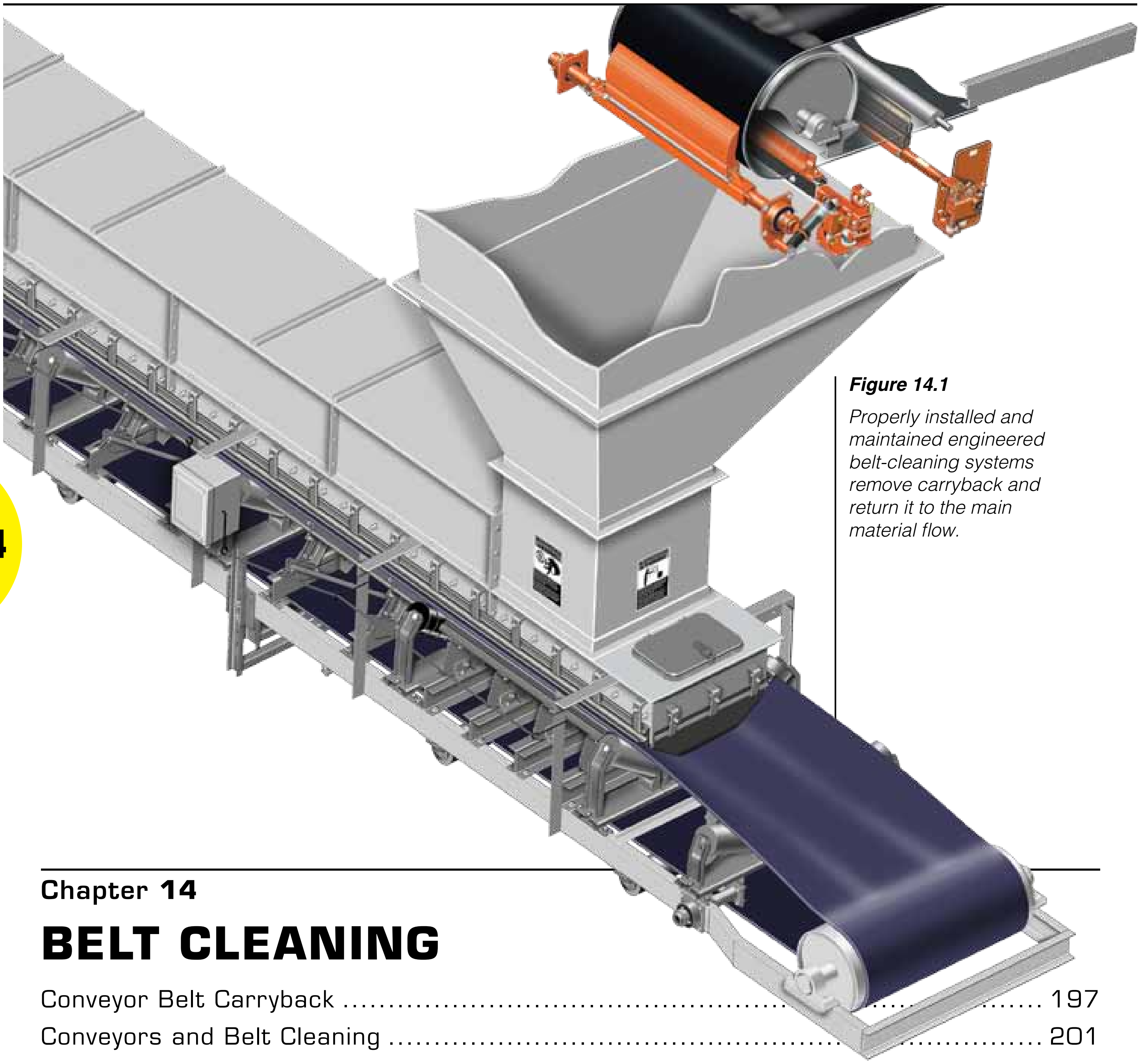

Figure 14.1

Properly installed and maintained engineered belt-cleaning systems remove carryback and return it to the main material flow.

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Chapter 14

BELT CLEANING

In this Chapter...

In this chapter, we focus on different types of belt cleaners: their design, applications, installation, and maintenance. We discuss the nature and cost of carryback, belt cleaners' use in reducing carryback, and methods to assess their performance in doing so. In Advanced Topics, we provide equations to determine additional power needed when using belt cleaners.

The normal process of carrying bulk material on a belt conveyor results in a separation of the load into a layer of moist fines resting on the belt, with coarser, dryer material above the fines, and the largest lumps on top. The lumps, most of the coarse material and some of the fines discharge in the normal trajectory; a portion of the coarse grit and fines will cling to the belt. Known as carryback, this residual material is carried back on the belt as it returns to the tail pulley. As the particles dry, they lose cohesive and adhesive strength and are then dislodged by the return rollers and bend pulleys. Most of the material eventually falls from the belt, accumulating in piles under the belt; building up on the return idlers, pulleys, and conveyor structure; or becoming airborne dust.

The cleanup of fugitive materials, such as carryback, is an activity associated with many serious accidents. Removing carryback that accumulates on equipment and the ground can be labor- and equipment-intensive, often requiring crews of people and expensive equipment or services such as loaders and vacuum trucks.

Properly installed and maintained engineered belt-cleaning systems can be economically justified to mitigate this problem by removing carryback and returning it to the main material flow (**Figure 14.1**).

CONVEYOR BELT CARRYBACK

Carryback as Fugitive Material

Carryback, material that adheres to the belt past the discharge point of the head pulley, accounts for much of the fugitive material present in any conveyor system. Like transfer-point spillage, carryback presents serious problems for conveyor systems, creating consequences in maintenance, downtime, and plant efficiency. These problems present themselves as accumulations of fugitive material, leading to belt mistracking, shortened belt-life, premature component failures, and other problems that create conveyor downtime and expensive repairs. Accumulations of fugitive material on the ground or as clouds of dust in the air present fire and explosion hazards; slip, trip, and fall hazards; and health hazards. They also may become a magnet for unwanted attention from neighbors and regulatory agencies. No matter where it lands, carryback is a leading cause and indicator of conveyor inefficiencies.

To control the damage and expense that carryback creates, conveyor belt-cleaning systems are installed. Typically, belt-cleaning systems are one or more scrapers mounted at or near the discharge (head) pulley to remove residual fines adhering to the belt as it passes around the head pulley (**Figure 14.2**).

The Nature of Carryback

Carryback is typically the belt's cargo in its worst state. Carryback particles are normally smaller in size with higher moisture content than the conveyed material in general. Vibration of the belt as it rolls over the idlers creates a settling action. The smallest

Figure 14.2

Typical belt-cleaning systems feature one or more scrapers mounted at or near the discharge (head) pulley to remove residual fines.

fines, along with excess moisture, sift to the bottom of the pile where they can create an adhesive mixture that clings to the belt. Removed from the belt, this mixture will attach to other surfaces, including the belt-cleaning system and the vertical walls of the chute (**Figure 14.3**). When allowed to dry, these accumulations can become concrete-hard and reduce belt-cleaning efficiency, damage the belt or other equipment, and lead to chute plugging problems (**Figure 14.4**).

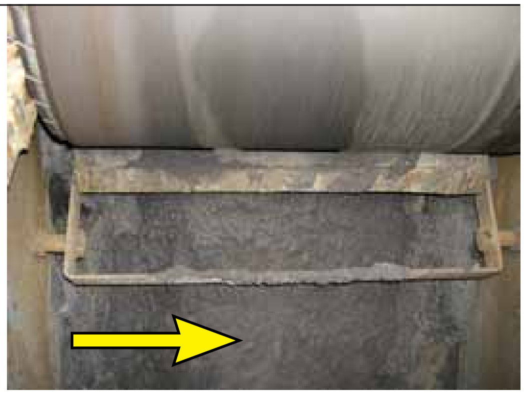

Figure 14.3

Removed from the belt, carryback can attach to other surfaces, including the belt-cleaning system and the vertical walls of the chute.

Figure 14.4

Allowed to dry, carryback accumulations can become concrete-hard and reduce belt-cleaning efficiency, damage the belt or other equipment, and lead to chute plugging problems.

Figure 14.5

Released carryback material builds up on idlers, creating out-of-round components that lead to belt mistracking.

The Cost of Carryback

Carryback is often a more cumbersome and costly problem than transfer-point spillage. Because it can drop off at any point along the conveyor return, fugitive carryback will require cleaning crews to work along the full length of the conveyor. This makes its removal more extensive and expensive than the more localized cleanup of spillage.

Released carryback material builds up on idlers, creating out-of-round components that contribute to belt mistracking (**Figure 14.5**). It works its way into bearings, increasing friction and leading to bearing failures. A large German lignite-mining firm calculated that it replaced 12 percent of the return idlers in its operation every year. Roughly 30 percent of those replacements were caused by wear in the support ring or face of the idler, wear that originated due to the release of material along the belt line.

Because carryback accumulates unevenly on the rolling components of the conveyor, it causes belt mistracking, leading to material spillage and to off-center loading of conveyors. Conveyor belt mistracking leads to shortened belt-life, excessive labor costs for maintenance and cleanup, unscheduled downtime, and safety hazards.

Measuring the Amount of Carryback

To better understand the carryback problem, the amount of material that clings to the belt and is carried back should be quantified. When the problem can be quantified, it is easier to determine how effective the installed belt-cleaning systems are, and what efforts, in the form of additional cleaning systems and improved cleaner maintenance schedules, are necessary. Carryback is measured as the dry weight of material in grams per square meter (oz/ft^2) of the portion of the belt surface carrying material. The bulk-materials handling industry in Australia has been a leader in designing and using systems to accurately assess the amount of carryback on a given belt. These systems have been used to evaluate the success of belt-cleaning equipment, to aid in the design of new equipment, and to monitor belt-cleaning performance contracts.

There are several ways to determine the amount of carryback. A small sample can be collected from a section of the belt, using a putty knife to manually scrape carryback material from the stopped (locked out) belt. By scraping a measured area, collecting the material in a pan or on a plastic sheet, and then weighing the material, a value for carryback per unit area can be calculated. One drawback to this method is that in the process of stopping the belt, the amount and character of the carryback will change.

A method developed by belt-cleaning pioneer Dick Stahura utilized a carryback collection pan affixed with scraper blades (**Figure 14.6**). This pan was designed to be held against the return side of the moving belt to remove residual material and collect it in the pan. Due to safety concerns, this method has been automated, resulting in a carryback gauge as developed by Australia's University of Newcastle Research Associates, Ltd, (commonly known as the TUNRA Group) for the International Conveyor Technology (ICT) group. This ICT Carryback Gauge has the ability to sample the entire width of the belt using a moving sampler that traverses the belt at a constant rate for a predetermined amount of time (**Figure 14.7**).

These testing methods provide a snapshot of carryback levels and cleaning performance for a given interval of time. Changes in material specifications, throughput, or climate conditions can dramatically alter the amount of material remaining on the belt; therefore, a program to periodically determine carryback should be implemented.

Carryback Calculations

By accepting this collected sample as an average amount of carryback or by taking several samples and averaging them for more accurate results, it is possible to determine the mean amount of carryback present on the belt and the expected variance as the standard deviation (**Figure 14.8**).

A seemingly modest amount of one gram (0.035 oz) of carryback removed from a section of belting indicates there would be a substantial amount of carryback remaining on this belt, material that could be

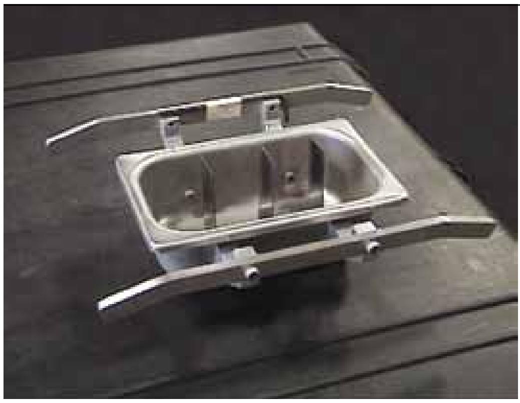

Figure 14.6

Belt-cleaning pioneer Dick Stahura developed a carryback collection pan affixed with scraper blades.

Figure 14.7

The ICT Carryback Gauge uses a moving sampler that traverses the belt at a constant rate for a predetermined amount of time.

Figure 14.8

By accepting this collected sample as an average amount of carryback or by taking several samples and averaging them for more accurate results, it is possible to determine the mean amount of carryback present on the belt and the expected variance as the standard deviation.

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released from the belt and then accumulate under this single conveyor (**Figure 14.9**).

This one gram of material collected from the conveyor would be the same amount of material as found in the small packets of artificial sweetener found on tables in many restaurants. However, with the belt length, width, and speed seen in modern conveyors, this small amount of carryback becomes tons of material left on the belt per year. This will then drop from the belt all along the conveyor return, fouling equipment and creating a mess that takes time, effort, and money to fix.

The one gram of material used in the above example represents a small quantity of carryback and would indicate to some this belt is already clean. More typically, the actual measurement of material on conveyor belts shows carryback in the range of 7 to 250 grams per square meter (0.2 to 7.3 oz/1.2 yd^2). This material becomes airborne dust and/or accumulates in piles under the conveyor or in buildups on and around rolling components.

A more "scientific" measurement would be to sample the belt right after the discharge point and then sample the belt again right before it enters the load zone on the conveyor. In addition to showing how much material adheres to the belt past the discharge, this would yield a measurement of how much carryback drops from the belt during the return run. Not only is this material lost to the process, but this carryback collects on return idlers and pulleys and creates future maintenance problems.

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Figure 14.9

Even a modest amount of carryback left on the belt can accumulate to significant piles under the conveyor.

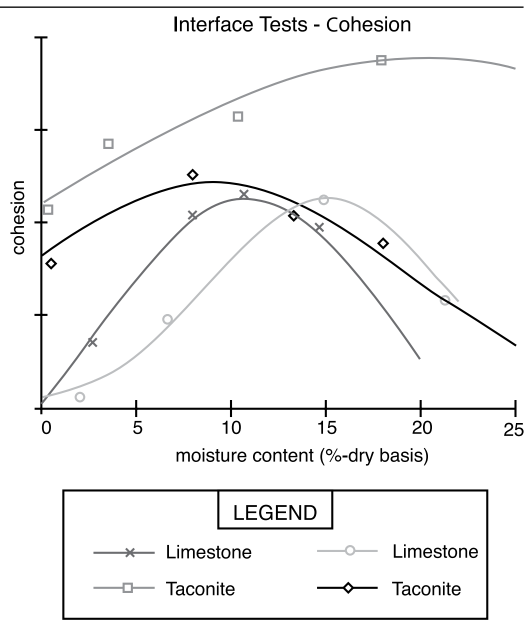

Figure 14.10

Testing has shown that cohesion and adhesion increase as moisture increases until enough moisture has been applied to begin fluidizing the material and reducing the cohesion. The exact variation in adhesion and cohesion with moisture content will vary from material to material and from site to site. Note: Moisture content is the % of weight loss between the wet material and the material after it has dried.

Analyzing the Material

Testing the bulk material is useful in determining how it will behave on the belt. This behavior depends on a number of parameters: bulk density, interface friction, interface cohesion, interface adhesion, and the condition of the belt itself. Testing has shown that for most (if not all) materials, cohesion (sticking to itself) and adhesion (sticking to the belt) increase as moisture increases. This behavior occurs to a critical point, as shown in a bell-shaped curve, until enough moisture has been applied to begin fluidizing the material and reducing the cohesion (**Figure 14.10**). The exact variation in adhesion and cohesion with moisture content will vary from material to material and from site to site.

Testing to determine the adhesion of a material to the belt can be omitted, as it can be found mathematically from the values of friction and cohesion. An optimal cleaning pressure can be determined using these results and belt-cleaner specifics (cleaning angle, blade profile, and blade composition). Advanced modeling techniques are used to predict the number of belt cleaners at a given blade-to-belt pressure necessary to remove the carryback layer from the conveyor belt. *(See Chapter 25: Material Science, for more information on bulk-material testing.)*

The important thing to remember is that eventually the conveyor will see the "worst-case material" during the life of the belt.

CONVEYORS AND BELT CLEANING

The Rise of Engineered Belt-Cleaning Systems

For many years, belt cleaners were home-made affairs, often a slab of rubber, a left-over piece of used belting, or a discarded piece of lumber wedged into the structure or held against the belt by a counterweight (**Figure 14.11**). These systems proved to be unwieldy, cumbersome, and generally ineffective. Plant operating requirements necessitated the use of wider, faster, more deeply troughed, and more heavily-loaded conveyors. These requirements led to the development of engineered belt-cleaning systems to protect the plant's investment by extending the service-life of expensive belts and other conveyor components. These systems usually consist of a structural support (mainframe), cleaning element (blade), and tensioner.

Engineered cleaning systems are designed to reduce space requirements by enabling the cleaner to be installed in the discharge chute. By simplifying blade replacement, maintenance time and labor requirements are minimized. By incorporating advanced materials such as plastics, ceramics, and tungsten carbide, service-life of the blade is extended further, reducing maintenance requirements. By engineering the blade's edge and improving the tensioning devices that hold the cleaning edge against the belt, cleaning performance is enhanced. Through the use of engineered cleaning systems, the adhesive mass of fines and moisture traveling on the return side of the belt can be almost completely removed.

Monitoring Cleaner Performance

The ability to measure carryback allows for the development of a belt-cleaning performance specification for a given material-handling facility and bulk material. A complete specification will detail the performance required in terms of the average carryback for the facility. The supplier must be required to design, supply, install, commission, and maintain the belt-cleaning system, guaranteeing average carryback levels are not exceeded.

After the belt-cleaning system is installed, carryback tests should be conducted to assess the performance of the belt-cleaning system. An ongoing testing and record-keeping program will yield information on periodic maintenance requirements and provide payback data for cleaning system maintenance and upgrade opportunities.

By monitoring belt-cleaning performance through carryback testing, the facility can assess the savings of possibly upgrading to more efficient cleaning systems.

Performance analysis and maintenance programs, implemented by in-house departments, are seldom seen as a priority, due to the overwhelming challenges otherwise presented to the facility. The easiest way to get results from an investment in belt-cleaning equipment is by awarding a service contract to a specialist in the supply, installation, maintenance, and analysis of belt-cleaning systems.

Designing Conveyors for Effective Cleaning

When considering the construction of new conveyors, it is desirable to include in the design requirements a specification for belt-cleaner performance. This specification should include an allowance for the amount of carryback measured in grams

Figure 14.11

For many years, belt-cleaning systems were homemade.

per square meter (oz/ft^2) passing the cleaning system. Plant owners should demand, and engineers should design, conveyor systems with adequate cleaner systems to ensure carryback is maintained below the level specified in the contract. It would encourage the conveyor system designer to include adequate space for installation and maintenance of the belt-cleaning system and to include components on the conveyor that are compatible with the goal of effective belt cleaning.

A common problem in the employment of belt-cleaning devices occurs when insufficient space is provided in the design of the head frame and housing for an adequate multiple belt-cleaner system. This commonly occurs because conveyor engineers have not taken into account the true nature of the conveyed material, particularly when it is in its worst condition. Conveyor engineers should design for clearance and access according to the Conveyor Equipment Manufacturers Association's (CEMA) recommendations, and the design should allow the belt-cleaner manufacturer to fit and mount the appropriate system, including cutting the holes in the chute after erection and belt installation.

A key to effective belt cleaning is mating the blade to the belt. It stands to reason that the better the blade matches the belt profile, the better it will clean. Anything making it more difficult for the blade to stay in contact with the belt as it moves past the belt cleaner must be avoided in the design of a conveyor system. These undesirable factors include wing pulleys, out-of-round pulleys, and poorly-selected or poorly-installed lagging. Any pulsation or vibration of the belt's surface lowers cleaning efficiency and adversely affects the life of the belt.

Vulcanized splices are the preferred method of splicing the belt in order to provide optimal performance of the belt-cleaning system. Improperly installed mechanical fasteners can catch on belt cleaners and cause them to jump and vibrate, or "chatter." Mechanical splices should always be recessed according to the manufacturer's recommendations in order to avoid unnecessary damage to the cleaner and the splice.

After installing a belt cleaner, periodic inspection, adjustment, and maintenance are required to maintain effective performance. Just as cleaners must be designed for durability and simple maintenance, conveyors themselves must be designed to enable easy service, including required clearances for access.

Figure 14.12

To eliminate problems caused by a dirty belt contacting the return idlers, a conveyor "turnover" brings the clean surface of the belt into contact with the return idlers.

Belt Turnovers

To eliminate problems caused by a dirty belt contacting the return idlers, a conveyor belt can be twisted 180 degrees after it passes the discharge point. This "turnover" puts the belt's cargo-carrying side up and brings the clean surface of the belt into contact with the return idlers (**Figure 14.12**). Theoretically, the carryback should remain on the belt as it moves along the return run. The belt must be turned back 180 degrees when it enters the tail section in order to properly position the belt top cover as it enters the load zone. The distance required to accomplish the 180-degree turnover of the belt is from 12 to 20 times the belt width at both ends of the conveyor.

Turnovers require a special structure and rollers using additional vertical space under the conveyor. Consequently, turnovers are usually justifiable on only long overland conveyors.

Another concern is that carryback will dry out and could become airborne all along the return run.

The act of twisting the belt causes the dirty side of the belt to contact the turnover rollers. Because this takes place at the point where idler alignment and cleanliness are most crucial, fugitive material here is particularly problematic. To minimize the carryback released when the belt is twisted, an effective belt-cleaning system must be installed at the conveyor's discharge. It is often more cost effective to install an advanced cleaning system such as a wash box than to install a turnover system.

Belting and Belt Cleaners

The condition of the belt will have a dramatic influence on the performance of the belt-cleaning system. It is difficult to clean a belt that has become cracked, frayed, delaminated, or gouged due to exposure to the elements, chemical attack, or belt misalignment. Belt cleaning can be made difficult by patterns on the belt surface such as those seen in polyvinyl chloride (PVC) belting. In both of these cases, the only effective method to remove residual material is by washing the belt.

Some belting manufacturers continue the ill-advised embossing of identification numbers and corporate logos into the top covers of the belts (**Figure 14.13**). It is easy to appreciate the marketing value of this practice. However, it is just as easy to recognize the difficulties that these emblems in the top covers of the belts can create in effectively cleaning and sealing the conveyor systems. A better practice is to brand the belts on the bottom cover side.

Steel-cable belts often show on their surface the pattern of the cables hidden inside the rubber. This gives the effect of hard and soft streaks in the belt. To remove the "streaks," cleaning pressure is increased beyond what is necessary, so wear in the belt cover and the cleaning blades accelerates.

All methods of belt cleaning and all blade materials will wear the belt's top cover to some degree. At least one manufacturer of belting incorporates a factor for this wear into the design of the top cover. It is generally accepted that it is better to wear the belt slowly by installing belt-cleaning systems than to wear it rapidly by dragging it through dirt and across the non-rotating or damaged idlers that arise when the belt is not cleaned. In reality, a well-designed cleaning system has much less negative effect on belt cover-life than does the loading of the material onto the belt. Top cover selection should be governed by the considerations of material loading rather than worries over belt cleaning.

Sometimes a conveyor belt in generally "good condition" will suffer from a longitudinal groove damage that renders conventional cleaning methods less effective. This longitudinal damage could arise from many sources, including a lump of material or tramp iron wedged against the belt. To improve cleaning efficiency, the groove could be dressed by applying a urethane patch to fill the groove. This patching compound may need to be reapplied several times during the life of the belt. Localized cleaning with an air knife, brush cleaner, or alternate device may also be a solution for keeping the belt in service longer.

The Impact of Cleaning on Belt-Life

The question of how much the use of an engineered belt-cleaning system against the moving belt will shorten the service-life of a belt is worthy of some consideration.

Figure 14.13

Some belting manufacturers emboss corporate logos into the belts' top covers, creating problems in cleaning and sealing conveyor systems.

The mechanisms of wear depend a great deal on the amount of heat generated in the blade and top cover. Field observations indicate, particularly for elastomeric blade materials, the highest wear rate to both blade and belt occurs when there is no material on the belt.

"Belt Cleaners and Belt Top Cover Wear," a research study by R. Todd Swinderman and Douglas Lindstrom, has examined the issue of whether belt cleaners adversely affect the life of the belting *(Reference 14.1)*. The results of this study showed a belt cleaner can induce wear of the belt, but the rate of wear was still less than allowing the belt to run through abrasive carryback without benefit of cleaners.

Similar results were reported in a study that compared belt-life and belt-failures in facilities using engineered cleaning and sealing systems to those in facilities that did not use these systems. Performed in India, this survey reviewed over 300,000 hours of operation on 213 belts in facilities handling lignite, limestone, and iron ore. This study showed that facilities using the engineered cleaning and sealing systems had belts that lasted an average of 150 percent longer (and required only 50 percent of the cleanup labor) than belts in the facilities not equipped with engineered cleaning and sealing systems. This survey of operating facilities echoes the laboratory research indicating that while belt-cleaning systems do introduce some wear to the belt cover, the end result is "the cleaner the belt, the longer it will last."

Figure 14.14

To minimize the release of carryback into the plant, belt cleaning should take place as far forward on the conveyor's return run as possible.

CLEANING SYSTEM DESIGN

The Basics of Effective Cleaning Systems

The basics for installing an effective belt-cleaning system include the following criteria: far forward, out of the material flow, and with minimal risk to the belt.

Far Forward

To minimize the release of carryback into the plant, belt cleaning should take place as far forward on the conveyor's return run as possible (**Figure 14.14**). Typically, at least one cleaner is installed at a point where the belt is still in contact with the head pulley. Normally, this cleaner is installed on the face of the head pulley, just below the point where the material leaves the belt. This position, called the primary position, provides a significant advantage in that the carryback is immediately returned to the main material flow. This reduces the potential for release onto rolling components and into the plant environment. With the cleaners tensioned against the belt and the belt still against the head pulley, control of the blade-to-belt pressure is more precise. The head pulley provides a firm surface against which to mount the cleaner.

Utilizing the space available and mounting the first cleaner in what is considered the primary position creates more space available for the installation of one or more cleaners in the secondary and tertiary positions. As with the primary cleaner, the farther forward each added cleaner is installed, the less chance there is for carryback to escape and the less need there is for devices like dribble chutes or scavenger conveyors to return recovered material to the flow.

Out of the Material Flow

It is important that cleaners are installed out of the flow of the material and that the material cleaned from the belt does not adhere and build up on the blades or structure (**Figure 14.15**).

A cleaner installed in the trajectory of the material may experience premature wear on the support frame and the back of the blades, making it necessary to change the blades before the cleaning edge is worn out. Preferred placement of a cleaner in the primary position involves installing the cleaner so the blade tip is below the horizontal centerline of the pulley.

A cleaner installed outside the material trajectory can still acquire a buildup of material that adheres to its outside surfaces. Cleaners should be designed to minimize the chance for material adhesion. This is accomplished by avoiding flat surfaces and pockets that can capture material and by utilizing non-stick materials for cleaner construction. In the proper environment, water sprayed on the surface of the belt—or on the cleaners—assists in softening the material and minimizing material buildup. *(See Chapter 24: Belt-Washing Systems.)*

With Minimal Risk to the Belt

An essential consideration in the selection of a belt-cleaning device is minimizing any risk that the cleaner could damage the belt or a splice, the very systems it was installed to protect. Belt-cleaning systems must be designed so the blade is capable of moving away from the belt when a splice, damaged section of belt, or other obstruction moves past the cleaner with the belt. The cleaner's tensioning systems, particularly on the primary cleaner where the angle of attack is more acute, should include a mechanism to provide relief from the shock of the splice impact.

An aggressive primary cleaner with a lot of cleaning pressure will have a tendency to more quickly wear away the top cover of the belt. These cleaners inherently provide an increased risk of catching on a protruding splice or flap of belt.

Care should be taken in choosing an appropriate material to put in contact with the belt. Materials such as strips of used belting should never be applied as a belt-cleaning or sealing material, because they may include steel cables or abrasive fines. These embedded materials cause excessive wear of the belt's top cover.

Belt-Cleaner Design Principles

Although other belt-cleaning systems—most notably brush and pneumatic systems—are available, most belt cleaners are blade cleaners: They use a blade to scrape material away from the belt's surface. These devices require an energy source—such as a spring, a compressed air reservoir, or a twisted elastomeric element—to hold the cleaning edge against the belt. The blade that directly contacts the belt is subject to abrasive wear; it must be periodically readjusted and eventually replaced to maintain cleaning performance.

Coverage of the Belt

Typically, the blades of a cleaner do not cover the full width of the belt, because the full width of the belt is not typically used to carry material. CEMA specifies the minimum blade coverage based on belt width (**Table 14.1**).

Various belt-cleaner manufacturers have their own standard or typical blade coverage. Many manufacturers allow for more than the minimum coverage, but rarely does the blade width need to be equal to or greater than the belt width.

For improved cleaning, the carrying width of the material on the belt should be observed or calculated and matched by the cleaner's width.

In some cases, providing a blade width that is wider than the material load on the

Figure 14.15

Belt cleaners should be installed out of the flow of the material.

Table 14.1

Minimum Belt-Cleaner Blade Coverage

Metric Standard Belt Sizes* (mm)

Belt Width	Minimum Cleaner Coverage
300	200
500	330
650	430
800	530
1000	670
1200	800
1400	930
1600	1070
1800	1200
2000	1330
2200	1470
2400	1600
2600	1730
2800	1870
3000	2000
3200	2130

Imperial Standard Belt Sizes (in.)

Belt Width	Minimum Cleaner Coverage
18	12
24	16
30	20
36	24
42	28
48	32
54	36
60	40
72	48
84	56
96	64
108	72
120	80

*Modeled after CEMA; *Metric measurements are based on standard metric belt sizes, not conversions of Imperial sizes.*

Figure 14.16

Top: In a situation where the blade is wider than the material flow, the center of the blade may wear quicker than the outer edges.

Bottom: As the center of the blade wears, it allows material to pass inside the tip; the outer edges will be held away from the material and so do not wear.

belt can lead to undesirable wear patterns. The center section of the blade will wear faster than the portion of the blade on the outside section of the belt, because there is more abrasive cargo material in the center. The outside portion of the cleaning blade will then hold the center section of the blade away from the belt. Carryback can then flow between the belt and the blade, accelerating wear on this center section of the blade (**Figure 14.16**).

The material on the belt also provides a lubrication and cooling effect for the blade; therefore, care should be taken to prevent covering too much of the belt. Without this lubrication effect, a buildup of heat on the outside edge can cause the blade to fail and/or damage the belt.

Reducing blade coverage on the belt can help alleviate the problem of heat. However, care should be taken when reducing blade coverage, especially on a cupped belt. If the belt curls over the edge of a cleaner blade, it is exposed to the sharp edge of the blade. Some cleaners use a more flexible, nonmetallic blade on their outer edges to avoid this problem. Another solution is to flatten the belt with the use of hold-down rolls (**Figure 14.17**).

In some applications, the blade must be as wide as or wider than the belt. A cleaner used as a squeegee to dry a belt may need to be the full width of the belt to catch all the wet areas. Some materials like fly ash tend to spread on the belt or flow horizontally across the belt cleaner. In this case, if the blade does not extend to the full width, material can build up between the belt and the cleaner support shaft, where it can harden and damage the belt.

Single or Multiple Blade Segments

A multiple-blade design with individual spring or elastomer support on each individual cleaning blade will keep each blade in proper cleaning tension against the belt, yet allow each blade to yield to a lower pressure than the tensioning device's total applied force. In other words, narrow blades can match up better against the belt, follow changes in surface contour, bounce away from the belt for splice passage, and return to cleaning position more easily than a single, monolithic blade. This means a multiple-blade design will be more efficient and safer for the cleaner and the belt.

New developments in urethane have improved the ability of single-blade primary cleaners to maintain contact with the belt.

There are a number of materials used for cleaner blades, ranging from rubber and urethane to mild and stainless steels. Blades are available with inserts of tungsten carbide or fillers such as glass beads to enhance abrasion resistance and cleaning performance.

Cleaner manufacturers have extended the range of urethane materials available to provide improved performance for specific conditions, including improved resistance to abrasion, heat, chemicals, or humidity. In some cases, the unique combination of characteristics in a specific application requires a comparative testing program to determine the best material for that application.

Angle of Attack

The angle of attack for the cleaning blades against the belt is a subject of importance. Generally speaking, there are two alternatives: positive-rake (or peeling) blades and negative-rake (or scraping) blades (**Figure 14.18**). With a positive rake, the blades are opposed to the direction of belt travel (**Figure 14.19**); with a negative-rake cleaning angle, the blades are inclined in the direction of travel, typically at an angle of 3 to 15 degrees from the vertical depending on the type of splice (**Figure 14.20**). Blades installed in a position that is vertical, or perpendicular to the belt, at the point of installation are said to have a zero-rake angle.

Metal blades in a positive-rake position are quickly honed to razor sharpness by the moving belt and can cause expensive dam-

Figure 14.17

One solution to a belt curling over the edge of the cleaner is to flatten the belt with the use of hold-down rolls.

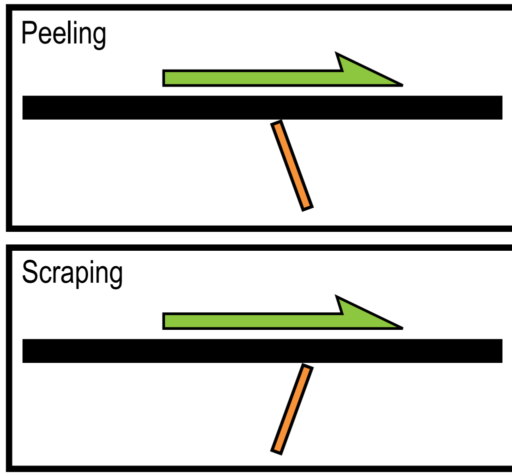

Figure 14.18

The angle of attack for the cleaning blades against the belt is a subject of importance. Generally speaking, there are two angles of attack for belt cleaning: positive-rake (or peeling) blades and negative-rake (or scraping) blades.

Figure 14.19

Blades with a positive rake are opposed to the direction of belt travel.

Figure 14.20

Blades with a negative-rake cleaning angle are inclined in the direction of travel.

age if they are knocked out of alignment. Positive-rake blades are occasionally subject to high-frequency vibration that causes the blades to "chatter," repeatedly jabbing their sharpened edges into the belt cover.

Negative-rake blades allow material to build up on the inclined cleaning edge, which can force the blade away from effective cleaning contact; however, all belt cleaners, regardless of the angle of attack, are subject to buildup absent regular cleaning and service (**Figure 14.21**). With a negative-rake blade, the upstream edges of the cleaning blade will not bite into the belt surface, even if held against the belt with excess pressure.

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A general opinion is that a positive rake is acceptable for primary cleaners, which are applied at very low pressures against the belt. However, it is advisable to use negative-rake blades in secondary and tertiary locations where higher blade-to-belt cleaning pressures and use of metal blades present more risk to the belt, splice, and cleaner itself.

SELECTING A BELT-CLEANING SYSTEM

Selecting a belt cleaner for a given application requires the assessment of a number of factors. The following is the basic information that a supplier would need in order to recommend a suitable belt-cleaning system:

Figure 14.21

Negative-rake blades allow material to build up on the inclined cleaning edge, which can force the blade away from effective cleaning contact; however, all belt cleaners, regardless of the angle of attack, are subject to buildup absent regular cleaning and service.

A. Belt width and speed

B. Width of the cargo on the belt

C. Pulley diameter

D. Material characteristics (including lump size, moisture content, temperature, abrasiveness, and corrosiveness)

E. Conveyor length

Conveyor length is a significant variable, as the undulating action of the belt as it moves over the idlers causes the fines to settle through the material and become compacted on the belt. On long overland conveyors, this effect can be significant. For this reason, longer conveyors are almost always harder to clean than shorter belts.

Short belts or belts that are allowed to run empty for long periods of time can suffer problems with the heat generated by the belt cleaner. A blade in contact with the belt will create heat due to the friction of the belt against the blade. Belts that are allowed to run for long periods without a cargo can cause heat to build up in the blade and the blade-holding mechanism, reducing blade-life or damaging the holder. If the belt is short, the top cover of the belt may not dissipate the heat and will degrade. A belt cleaner provided with high tension against the belt will aggravate this problem to the point in which the blade may stick to the belt when the belt stops.

Additional variables that may affect the ultimate performance of the selected system and so should be reviewed in the selection of a cleaning system include:

A. Space available for installation and service

B. The possibility of changes in material characteristics (e.g., from wet and sticky to dry and dusty)

C. Severe temperature extremes

D. Cuts, gouges, rips, or cracks in the belt surface from age or abuse

E. Numerous, non-recessed, or damaged mechanical splices

F. Belt vibration, from material buildup on head pulleys and other rolling components, making it difficult to keep a cleaner in contact with the belt

G. Material that will adhere to or entangle the cleaning device

H. Material accumulation in the dribble chute

Other considerations in the development of a supplier proposal and the evaluation of that proposal include:

A. Level of cleaning performance desired/required

B. Level of maintenance required/available

C. Level of installation expertise required/available

D. Initial price versus cost of ownership

E. Manufacturer's record (including service capabilities and performance guarantees)

There are a number of "shortcuts" available to help match a belt-cleaning system to an application, including on-line selector systems that analyze material characteristics and conveyor specifications to provide a belt-cleaner recommendation.

Information Required for Specifying a Cleaning System

In a paper presented to the 2004 Annual Meeting of the Society for Mining, Metallurgy, and Exploration (SME), R. Todd Swinderman listed the basic information to be supplied by an end-user requesting a proposal for a belt-cleaning system and the information that should be provided by a cleaning-system manufacturer in a proposal to the end-user customer.

The user's request for proposal shall include:

A. Hours of operation of the conveyor system

B. Rated tons per hour of the system

C. Percentage of time the conveyor is conveying material while running

D. Belt brand and description: belt width, age, condition, and tracking

E. Belt speed and whether it is one directional or reversing; if reversing, the percent of use in each direction

F. Temperature, humidity, and other environmental or operating conditions that may effect the operation or life of belt-cleaning equipment

G. Material specification according to the CEMA STANDARD 550 *Classification of Bulk Solids Standard*

H. Level of belt cleaning that is to be obtained in grams per square meter (oz/ft^2) on the carrying portion of the return run of the conveyor belt

I. Pulley diameter and the pulley lagging condition, type, and thickness

The equipment supplier's proposal shall include:

A. Recommendation for the appropriate system to meet the user's required level of cleaning performance

B. Statement of the expected average life and cost of wear parts

C. An allowance for changes in the cleaning performance over time, as the conditions of the belt or the bulk material change

D. Test method, test equipment, and the reference location to be used to measure performance; test equipment designed to produce repeatable results that are representative of the entire carrying width and length of the belt; test method and test equipment documented so that the tests can be repeated

E. Installation instructions

F. Required maintenance procedures and intervals

G. Guarantee of performance

H. Terms and conditions of payment

A Cleaner Suitable for All Conveyors?

A review of the marketplace shows there

are many competing designs for cleaning systems. This poses the question: Why has the industry not settled on one successful design that can provide acceptable results in all applications?

An engineer for a major mining company wrote in a summary of the various belt cleaners installed at his operations:

> Due to the diverse materials with their greatly differing physical properties as well as the diverse environmental conditions in open cast mining, there is currently no universally applicable belt cleaner, which would fulfill the requirements of all situations without problems.

This writer was discussing only one company's open cast lignite mines in Germany. This is a challenging application to be sure, but it is only one of the myriad of environments belt cleaners are required to endure. The universe of belt-cleaner applications is so much broader—including great varieties of materials, conditions, and conveying systems—that it requires a number of different choices.

The problem is to provide a cleaning system that is adjustable to fit most of these situations. Indeed, one of the problems in developing a universal cleaning system is that each equipment manufacturer, each conveyor engineer, and plenty of plant maintenance personnel have their own ideas on how to properly clean a conveyor belt. With so many different variables in applications, each of these designs has found some level of success.

Plant engineers or maintenance workers who design and install a belt cleaner of their own design would stop by every day to ensure it was working properly. By paying close attention to the cleaner, periodically adjusting the blade-to-belt tension and knocking off any material buildup, the designer would ensure its performance would at least equal many of the commercial cleaning systems presently available. The key element allowing this system to achieve acceptable cleaning performance was probably the heightened level of service. Regardless of a belt cleaner's design, all belt-cleaning systems will function better given regular maintenance attention.

Cleaning Systems for "Worst-Case" Materials

Conveyor cleaning systems should not be designed to match only the limited challenges of "normal" operating conditions. Rather, they should be designed to stand up to the worst possible applications that may be encountered. If 99 percent of the time the conveyed material is dry, the day will surely come when the material becomes wet and sticky, and the cleaning system may not be adequate for the challenge. This single event could cost several times more than what was "saved" by designing for the "normal" operating conditions. With a cleaning system designed for "worst-case" conditions, the over-design will likely provide the benefit of improved wear-life and reduced service requirements when operating conditions are normal. When the conditions change for the worse, the cleaning system can stand up to the challenge.

It takes some work to analyze material in its worst state condition, but any sophisticated belt-cleaning-system manufacturer will have completed such tests to understand material behaviors and provide the best product to handle many different operating conditions.

SYSTEMS APPROACH TO BELT CLEANING

The Need for a System

State-of-the-art in belt-cleaning technology recommends that more than one "pass" at the belt should be made in order to safely and effectively remove carryback material. Like shaving, it is safer and more effective to make a series of gentle strokes over the surface than one "all at once," high-pressure, aggressive-angle assault.

It is usually most effective to install a multiple-cleaner system, composed of a primary cleaner and at least one secondary cleaner (**Figure 14.22**). The primary cleaner is installed on the head pulley using low blade-to-belt pressure to remove the top layer and majority of the carryback. This allows the secondary cleaner, tensioned at optimum belt-cleaning pressure, to perform final, precision removal of adhering fines without being overloaded with a mass of carryback. The two styles of cleaners are given different responsibilities in the task of cleaning the belt and so are designed and constructed differently. Many conveyors can be addressed with the dual-cleaning system (**Figure 14.23**); however, there are applications that will need additional belt cleaners to achieve maximum carryback removal under all conditions (**Figure 14.24**).

The phrase "multiple-cleaning systems" can refer to any combination, ranging from the commonly seen primary-cleaner and secondary-cleaner system to more sophisticated systems that include one or more pre-cleaners and one or more secondary and/or tertiary cleaners. A conveyor system with a large head pulley allows the installation of more than one pre-cleaner in the primary cleaner position. Where it is necessary to get a very clean belt, the primary cleaner and secondary cleaners could be supplemented with a belt-washing system that incorporates water sprays, belt cleaners, and belt wipers that "squeegee" the belt dry. *(See Chapter 24: Belt-Washing Systems.)*

In addition to providing improved cleaning, a multiple-cleaner system increases the time between required service sessions. Two cleaners, each applied with a somewhat lower blade-to-belt pressure, should extend cleaner blade-life longer than a cleaner applied with higher pressure to provide the sole cleaning benefit.

A successful multiple-cleaning system is one that fits into the conveyor structure, achieves the desired level of cleaning, and minimizes maintenance requirements.

Primary Cleaners

The primary cleaner, sometimes called the pre-cleaner or the doctor blade, is installed on the face of the head pulley just below the trajectory of the material discharging from the belt (**Figure 14.25**). This position allows the material removed from the belt to fall in with the main cargo as it leaves the belt, minimizing any overloading of the dribble chute or other reclamation system.

Figure 14.22

A multiple-cleaner system, composed of a primary cleaner and at least one secondary cleaner, is often the most effective system.

Figure 14.23

Many conveyors can be satisfactorily cleaned with a dual-cleaning system.

Figure 14.24

Some applications will need additional belt cleaners to achieve maximum carryback removal.

Pre-cleaners, with low blade pressure but an aggressive angle of attack, are installed to shear the coarse grit off the carryback layer (**Figure 14.26**). This clears away most of the carryback and enables the secondary cleaner to remove additional, underlying material.

The primary-cleaner blade should be installed in a positive-rake position, inclined against the movement of the belt and pulley, typically at an angle between 30 to 45 degrees to a line tangent to the belt's surface at the point of contact. Rather than blocking the path of the material, a pre-cleaner diverts the material away from the belt so it can return to the main material flow or move down the back of the cleaner into the discharge (**Figure 14.27**). Using this low angle of attack, in combination with elastomer pre-cleaner blades applied with light pressure against the belt, results in low wear rates for both the blade and the belt surface. If the angle of attack were greater (i.e., a zero-rake angle or negative-rake position), more pressure would be required to hold the blade in position against the onslaught of material. Increasing the pressure increases the risk of damage to the belt.

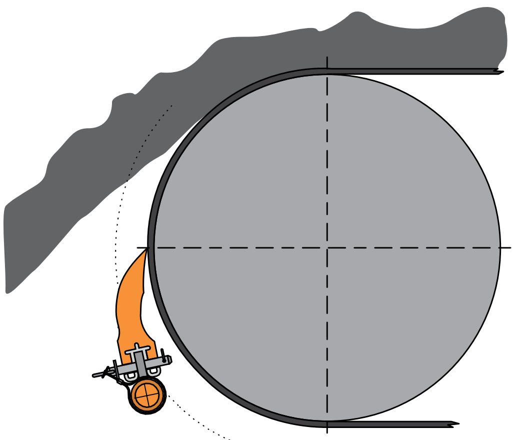

Figure 14.25

The primary cleaner, sometimes called the pre-cleaner or the doctor blade, is installed on the face of the head pulley just below the trajectory of the material discharging from the belt.

Figure 14.26

Pre-cleaners, with an aggressive angle of attack but low blade pressure, shear off the top of the carryback layer.

Figure 14.27

Rather than blocking the path of the material, a pre-cleaner diverts the material away from the belt to return to the main material flow.

To minimize the risk to the belt, the splice, and the cleaner from even a lightly-tensioned blade held in a positive-rake position, pre-cleaners usually use blades of resilient elastomer, such as urethane or rubber, rather than metal. A blade-to-belt pressure of approximately 14 kilopascals (2 lb_f /in.^{2}) combines cleaning performance with safety for the belt. This low blade-to-belt pressure means that the system will be able to relieve—that is, to bounce the blade away from the belt—when an obstruction such as a mechanical splice moves past the cleaning edge, thus reducing the risk of damage. Properly applied cleaning pressure improves blade-life and reduces belt wear. Too little pressure allows material to slide between the blade and the belt, where it can become trapped and impart wear on both. Too much pressure accelerates wear and increases energy required to move the belt.

In order to achieve an acceptable level of cleaning with only a single pre-cleaner (unsupported by any secondary or additional cleaners), it would typically be necessary to tension the blade against the belt with higher blade-to-belt pressure than should be recommended for the preservation of belt-life.

Pre-cleaner characteristics include wear area, constant-angle cleaning, and constant-area cleaning.

Wear Area

One property that should be defined in any pre-cleaner is the amount of blade material that can be worn away by the belt. This is called wear area. This area can be found by laying out the blade and head pulley in a drafting software package. The mounting distance, center of blade rotation, and head-pulley diameter should be based on manufacturer specifications. The blade is rotated into the head pulley to the 100 percent wear-life and the interfering area calculated (**Figure 14.28**). This wear area allows for comparison of blade designs, because blade-life is neither a function of belt coverage nor individual blade widths.

Constant-Angle Cleaning

To overcome the problem of the blade angle changing as the blade wears, a radially-adjusted belt cleaner can incorporate a specifically designed curved blade. This design has been termed "CARP" for Constant Angle Radial Pressure. With a "CARP" blade design, the cleaning angle remains the same throughout the life of the blade. This "constant angle" design has the obvious advantage of maintaining cleaner efficiency throughout the service-life of the blade.

Constant-Area Cleaning

Many new cleaner blades are designed with a tip that has a small contact area against the belt. This tip or "point" allows the blade to "wear in" quickly, to achieve a good fit to the belt, regardless of the diameter of the head pulley.

As cleaner blades wear, the surface area of the blade touching the belt increases. This causes a reduction in blade-to-belt pressure and a corresponding decline in cleaner efficiency. Therefore, the system's tensioner requires adjustment (retensioning) to provide the additional pressure for consistent cleaning performance. It would be better to design cleaners that do not suffer from this gradual increase of blade-to-belt area (**Figure 14.29**). When combined with tensioner design, the CARP principle described above has proven capable of minimizing the change in area throughout a blade's wear-life.

Secondary Cleaners

Secondary cleaners are defined as any cleaner located in the secondary position on the return run of the belt (**Figure 14.30**). The secondary position is the area from just past the point where the belt leaves contact with the head pulley to just before the belt contacts the snub pulley. This location is still within the discharge or dribble chute, allowing the removed carryback to return to the main material flow by gravity.

As the pre-cleaner performs the initial rough cleaning, the secondary cleaner is

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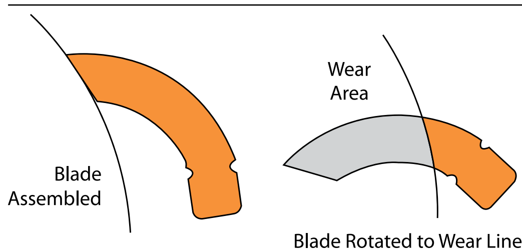

Figure 14.28

The wear area of an elastomer pre-cleaner blade is an indicator of the life of the blade.

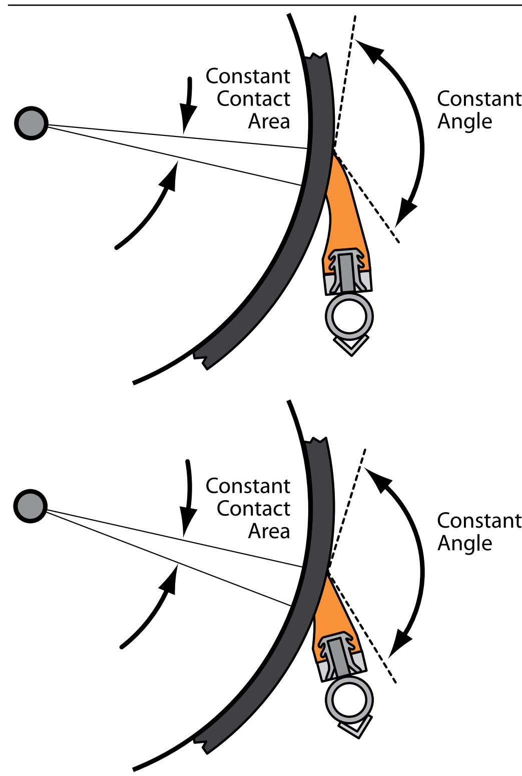

Figure 14.29

A Constant Angle Radial Pressure (CARP) blade is designed to maintain the cleaning angle through all stages of its blade-life. As cleaner blades wear, the surface area of the blade touching the belt should remain constant.

dedicated to performing the fine cleaning of the material that has passed by the primary cleaner. More than one secondary cleaner may be required to achieve the desired level of cleanliness.

The positioning of additional cleaner(s) is important. The closer the removal of carryback is performed to the conveyor's discharge point, the smaller the risk of problems with the buildup of fines in the dribble chute. The best position for a secondary cleaner is to contact the belt a short distance— 50 to 100 millimeters (2 to 4 in.) —past the point where the belt leaves the head pulley (**Figure 14.31**). This allows the secondary cleaner to scrape against a firm surface for more effective material removal.

If conveyor structural members, space limitations, or poor mechanical splices make it impossible to install a cleaner in the preferred position, secondary cleaners should be mounted where the material will be returned to the material flow: that is, where the cleaned material will fall within the chute. But if a secondary cleaner is installed in a position where its pressure against the belt changes the belt's line of travel, cleaning performance will be less effective (**Figure 14.32**). In this case, increasing applied pressure serves only to alter the belt line more, without improving cleaning performance. Hold-down rolls or other devices should be installed to maintain a stable belt line.

The angle of attack of the secondary cleaner blade to the belt is an important consideration. Metal- or ceramic-tipped blades in a positive-rake position are quickly honed to extreme sharpness by the belt's movement. These sharpened blades raise the risk that an adjustment made by an untrained operator may result in too much pressure or the incorrect angle being applied for the cleaner to quickly release from belt obstructions like mechanical splices. The result could be damage to the belt, splice, or the belt cleaner itself. Consequently, when obstructions or mechanical splices are present or anticipated, it is recommended that secondary blades be angled in the direction of the belt's travel—a negative-rake angle—rather than opposing the belt in a positive-rake position. Testing has indicated that an angle of 7 to 15 degrees in the direction of belt travel maintains cleaning efficiency while allowing easier passage of obstructions (**Figure 14.33**).

A moving belt does not present a consistent and uniform surface. Narrow, independent blades that are individually suspended

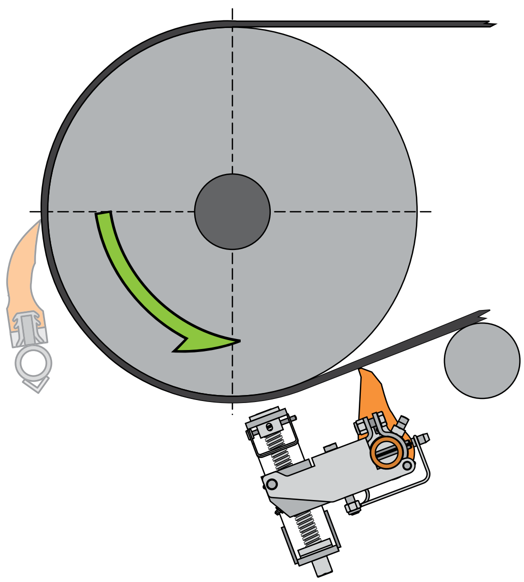

Figure 14.30

Secondary cleaners are defined as any cleaner located in the area from just before the point where the belt leaves contact with the head pulley to just past the belt contacts the snub pulley.

Figure 14.31

The best location for a secondary cleaner is to contact the belt a short distance— 50 to 100 millimeters (2 to 4 in.)—past the point where the belt leaves the head pulley.

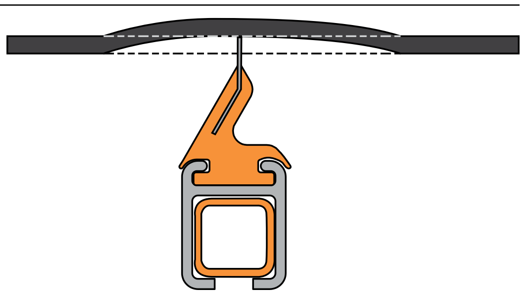

Figure 14.32

Cleaning performance will be less effective if a secondary cleaner is installed in a position where its pressure changes the belt's line of travel.

have the best potential to remain in precise contact as the changing belt surface passes across the cleaning edge. It is also beneficial if these individual blades can pivot, or rock, from side to side to instantly adjust to the changing contours of the belt surface. Research indicates that a cleaner formed from a line of individual, independent blades each 75 to 200 millimeters (3 to 8 in.) wide is well suited for effective secondary cleaning.

The Bureau of Mines' study, *Basic Parameters of Conveyor Belt Cleaning*, points out that the initial blade-wear occurs at the edges where individual blades adjoin *(Reference 14.2)*. The testing showed material would pass through the spaces between the adjacent blades and slowly enlarge these spaces. This passage, in turn, accelerated blade wear and allowed more material to pass. To minimize this erosive wear, an overlapping blade pattern can be used, created by an alternating long-arm/short-arm pattern (**Figure 14.34**). This prevents "stripes" of carryback down the belt created by gaps between the blades. Alternately, two cleaners with blades in a line can be installed with the gaps offset.

Secondary-cleaner blades themselves can be of a hard material—ceramic or tungsten carbide, for example—that resists the buildup of heat stemming from the friction against the belt's surface. Some operations prefer to avoid application of a metal blade against the belt, so a variety of urethane formulations have been developed for secondary cleaners.

One secondary-cleaner design applies the natural resilience, or "spring," of the elastomer used in the blades to reduce the need for cleaner adjustment. These urethane blades are forced against the belt, so they "flex" in the direction of belt travel (**Figure 14.35**). Over time, the blade's resilience continues to push the blade tip against the belt, even as the blade is being worn away by the movement of belt and material. This makes the blades self-adjusting and so reduces the need for follow-up service for adjustment (**Figure 14.36**).

Tertiary Cleaners

Tertiary cleaners are sometimes applied for final cleaning. The tertiary location for cleaners is normally considered as the area past the snub pulley and outside the discharge chute (**Figure 14.37**). This location is outside the area that allows the easy return of material to the main material flow, which requires the use of an auxiliary chute or scavenger conveyor. There may be multiple cleaners applied in this location to achieve the results required by the operation (**Figure 14.38**).

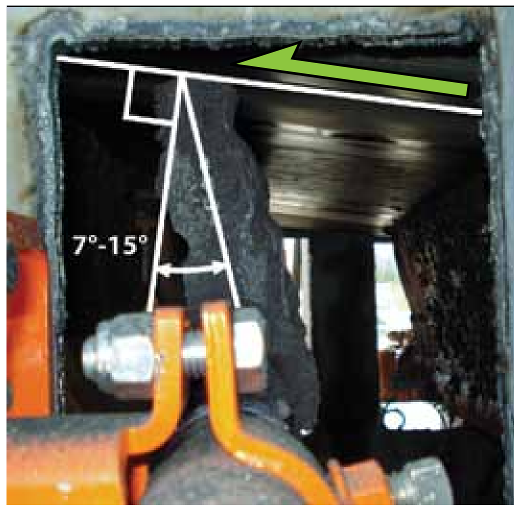

Figure 14.33

An angle of 7 to 15 degrees rake in the direction of belt travel maintains cleaning efficiency while allowing easier passage of obstructions.

Figure 14.34

To avoid "stripes" of carryback created by gaps between the blades, an overlapping blade pattern, created by an alternating long-arm/short-arm pattern, can be used.

Figure 14.35

This cleaner incorporates urethane blades that are forced against the belt, so they "flex" in the direction of belt travel.

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Figure 14.36

Over time, the resilience of the urethane blade continues to push the blade tip against the belt, even as the blade is being worn by the movement of the belt, making the blade self-adjusting.

Figure 14.37

The location for tertiary cleaners is the area past the snub pulley and outside the discharge chute.

Figure 14.38

There may be multiple cleaners installed outside the area that allows the easy return of material to the main material flow, which requires the use of an auxiliary chute or scavenger conveyor.

Figure 14.39

Specialty cleaners and belt-washing systems are often located in the tertiary position.

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The tertiary cleaner is normally used to clean off water and small particles that pass around or between the secondary-cleaner blades. Specialty cleaners and wash boxes or additional secondary-style cleaners are often located in the tertiary position (**Figure 14.39**). Squeegee blades to remove moisture—from the material or applied in the course of belt cleaning—are typically installed in the tertiary position (**Figure 14.40**).

One problem that can be seen with a tertiary cleaner is heat buildup. If the belt is clean or dry before it reaches the tertiary cleaner, the blade(s) in the tertiary cleaner may accumulate heat, allowing the material in the blade or blade holder to break down or damage the surface of the belt. A multiple-cleaning system should be carefully checked to eliminate this possibility. The use of a fine water spray to lubricate the belt and reduce the strength of the carryback is very effective in increasing tertiary cleaner efficiency and maintenance intervals. *(See Chapter 24: Belt-Washing Systems.)*

Matching Cleaner to Application

The increasing sophistication of belt-cleaner design has allowed the development of cleaning systems to conform to the needs of each specific or specialized application. These alternative designs include specialized materials for cleaner construction, such as urethanes, intended for high-temperature, high-moisture, or high-abrasion conditions. In addition, there are a variety of cleaning systems engineered to match special challenges, ranging from light-duty food-grade conveyors to heavy-duty mine applications.

Mine-Grade Belt Cleaners

The high material volumes, fast speeds, wide belts, and large-diameter pulleys seen in many mining operations pose special challenges for belt-cleaning systems. The removal of overburden in some German lignite mines features conveyors with belt widths up to 3200 millimeters (126 in.) wide, operating at speeds of 10,5 meters per second (2067 ft/min). To withstand these abusive conditions, extra-heavy-duty mine-grade belt-cleaner systems have been developed (**Figure 14.41**). These systems are marked by massive mainframes to withstand large lumps and high volumes of material, massive blades to provide extended wear-life, and durable tensioning systems to reduce the need for system maintenance (**Figure 14.42**).

The high speed of these conveyors makes it difficult to use secondary cleaners effectively. The higher operating speeds and resultant higher vibration of these belts, combined with higher blade-to-belt pressure typical of a secondary cleaner, produce both higher wear and added risk to both the belt and cleaner. As a result, these applications may feature two pre-cleaners on the head pulley; the pulleys are normally large enough to allow this practice (**Figure 14.43**).

Crust Breakers

In applications such as the handling of crushed ore in copper and other hardrock mines, or in the conveying of overburden in lignite mining, moist material particles can sift down to the bottom of the conveyed load and stick to the belt with such strong adhesion that this material will refuse to be thrown from the conveyor at the discharge. Instead, this paste-like material will adhere to the belt as it passes the pulley in a layer 75 to 100 millimeters (3 to 4 in.) or more thick. This crust of material can quickly overwhelm a conventional cleaning system, leading to poor cleaning performance and shortened cleaner-life and risking the productivity of the entire material-handling system.

To overcome this problem, some operations will install a "crust breaker." This cleaning edge is installed on the head pulley just below the material trajectory. Here it serves as a doctor blade to limit the amount of material that gets through to the conventional pre-cleaner installed just below (**Figure 14.44**). Fabricated from ceramic-covered metal plates, the crust

Figure 14.40

Squeegee blades to remove moisture from the belt are typically installed in the tertiary position.

Figure 14.41

To withstand abusive conditions, extra-heavy-duty mine-grade systems have been developed.

Figure 14.42

Mine-grade belt cleaners are marked by heavy-duty mainframes, massive blades to provide extended wear-life, and durable tensioning systems.

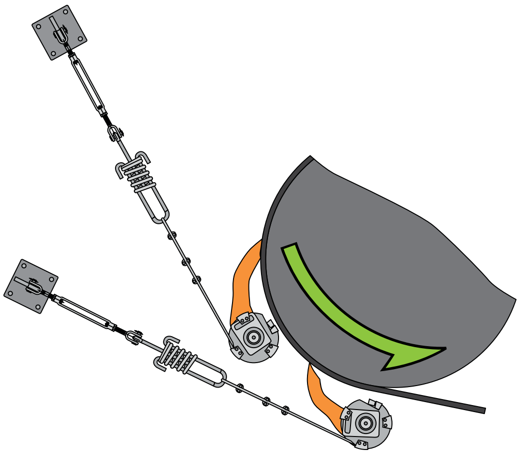

Figure 14.43

To avoid using secondary cleaners on high-speed/high-vibration belts, some operations may use two pre-cleaners on large head pulleys.

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Figure 14.44

A crust breaker serves as a doctor blade to limit the amount of material that gets through to the conventional pre-cleaner installed just below.

Figure 14.45

Specialized reversing belt cleaners have been developed for conveyors that run in two directions or have substantial rollback.

Figure 14.46

Typically, reversing belt cleaners are designed with a blade that is installed perpendicular to the belt and capable of deflecting a modest amount—7 to 15 degrees—in both directions of belt motion.

Figure 14.47

Their vertical installation and tensioning allows reversing cleaners to be installed on one-direction belts in narrow spaces where secondary cleaners with a trailing-arm design would not fit.

breaker's cleaning edge is installed so it is close to, but does not touch, the belt. That way, it reduces the amount of material that reaches the pre-cleaner and that could pass behind the pre-cleaner to damage (or overload) the secondary cleaner. With the "crust breaker" installed in advance of the conveyor's pre-cleaner, the conventional cleaners can provide improved cleaning and longer blade-life.

Cleaners for Reversing Belts

Some conveyors run in two directions or have substantial rollback, so it is critical that cleaners installed on these systems work well in either direction of operation, or at least are not damaged by belt reversal. Specialized cleaners have been developed for reversing belts (**Figure 14.45**). These cleaners are usually installed perpendicular to the belt and so are tensioned vertically into the belt surface. Typically, the cleaners are designed with a blade that is capable of deflecting a modest amount—7 to 15 degrees—in either direction of belt motion (**Figure 14.46**).

Of course, reversing cleaners could be installed on one-direction belts. A feature of reversing belt cleaners that encourages their use on non-reversing belts is their vertical installation and tensioning. This feature allows the reversing cleaner to be installed in narrow spaces where secondary cleaners with a trailing-arm design would not fit (**Figure 14.47**).

Food-Grade-Cleaning Systems

Some cleaning systems are engineered especially for the small pulleys and slower belt speeds common to food-processing plants. Constructed of food-grade materials and able to withstand the operation's frequent washdown cycle and cleaning chemicals, these systems are a match for food-processing applications (**Figure 14.48**).

Cleaners for Chevron Belts

Belts with ribs, cleats, or chevrons are used to convey materials that would slide back as the load moves up an incline.

These raised elements pose problems when attempting to remove carryback. Belt cleaners that utilize blades with "fingers" that have the ability to walk over the obstructions are required for cleaning chevron-style belts (**Figure 14.49**). This design can effectively clean chevrons/ribs/cleats up to 20 millimeters (0.75 in.) tall (**Figure 14.50**).

Cleaners for Pocket Belts

Belts with very deep cleats and/or sidewalls handling sticky materials are difficult to clean. The most common way of cleaning these belts is to beat the belt with a linear vibrator or rotating beater-bar-style cleaner when the belt is upside down and horizontal on the return run. These systems require frequent maintenance and are only partially effective.

Pulley Cleaners

It is possible for fugitive material to fall onto the clean side of the belt during its return run and for this fugitive material to then accumulate on the conveyor's snub or bend pulleys. To keep the belt tracking true, it is then necessary to install pulley-cleaning devices. To clean adhering material from a pulley, a scraper with an elastomer blade is mounted slightly below the pulley's horizontal centerline on the side of the pulley away from the belt (**Figure 14.51**). This will allow removed material to fall into a receptacle or accessible area for removal.

Rotary-Brush Cleaners

Cleaning systems composed of a rotating brush applied against the belt can be used effectively on dry materials (**Figure 14.52**). These systems can be free-wheeling (turned by the motion of the belt), but they are more effective when driven by an electric motor. Brush cleaners often encounter problems with sticky or moist materials that build up in the bristles of the brush (**Figure 13.53**). A beater bar or comb can be installed to assist in clearing the buildup from the bristles.

Figure 14.48

Designed for the pulley sizes and belt speeds typical of food-processing industries, food-grade belt cleaners are a match for food-processing applications.

Figure 14.49

Cleaners utilizing blades with "fingers" that have the ability to walk over obstructions are required for cleaning chevron-style belts.

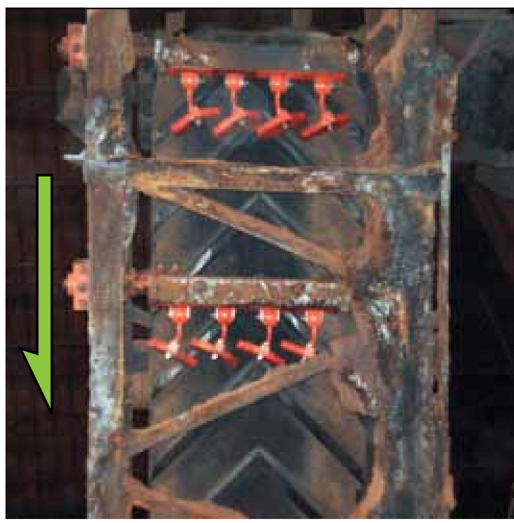

Figure 14.50

The "fingers" allow the belt-cleaner blades to effectively clean chevrons/ribs/cleats. Note: photo taken from below conveyor.

Figure 14.51

To remove carryback from a pulley, a belt cleaner with an elastomer blade is mounted slightly below the pulley's horizontal centerline on the side of the pulley away from the belt.

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Pneumatic (Air-Knife) Cleaners

An air-knife belt-cleaning system directs a stream of compressed or fan-produced pressurized air to shear off carryback (**Figure 14.54**). Air-knife cleaners can be mounted in the primary, secondary, or tertiary positions. These cleaners are of interest because they do not contact the belt.

Figure 14.52

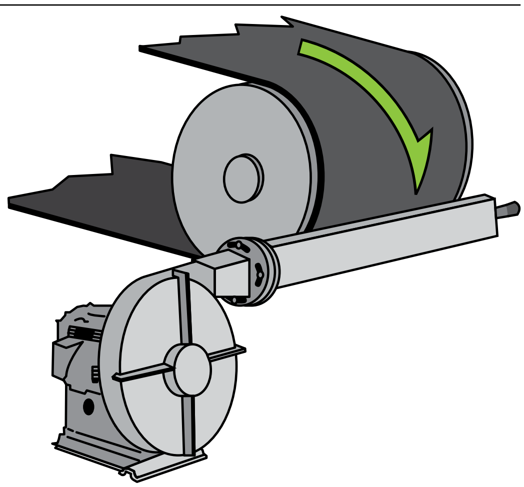
Cleaning systems composed of a rotating brush applied against the belt can be used effectively on dry materials.

Figure 14.53

Brush cleaners often encounter problems with sticky or moist materials that build up in the bristles of the brush.

Figure 14.54

An air-knife belt-cleaning system directs a stream of compressed or fan-produced pressurized air to shear off carryback.



An air-knife system can be effective in removing dry materials and is sometimes used on very wet materials with low adhesion in applications like coal cleaning plants. When used on dry materials, such as alumina, these systems are part of a dust pick-up station, with the dust blown by the air knife into a dust-collector hood. Air-knife systems can be used to dry belts that have been wetted from material moisture or from water added to improve belt-cleaning efficiency, as in a wash-box system. *(See Chapter 24: Belt-Washing Systems for a more thorough, detailed discussion about wash-box systems.)*

The disadvantages of air-knife systems include the continuing expense of providing air to the knife and problems with the plugging of the air outlet(s). On dry materials, they can create additional airborne dust. With wet materials, splatter will build up on chute walls.

The Use of Water in Belt Cleaning

In many applications, an increase in moisture level of the carryback material is directly related to increased adhesion to the belt, so it increases the difficulty of handling and removing the material. This effect is seen with increases in moisture content up to a specific level—unique to each material—at which point the adhesion then drops off. Therefore, the use of water is a major advantage in cleaning conveyor belts handling almost any material.

The use of a simple spray bar just behind the primary cleaner or in front of the secondary cleaner will do many things to improve the cleaning process (**Figure 14.55**). A small amount of water sprayed against the belt immediately after the pre-cleaner aimed at the underside of the blade will act as a release agent, moistening the belt and material and reducing adhesion to most surfaces. It also serves as a coolant to the secondary-cleaner blades to prevent the "baking on" of the material. As a bonus, the life of cleaning blades can be extended by the lubricating action of the water.

On belts that can run empty for long periods of time, belt-cleaner blades will generate heat due to the friction between the belt surface and the tip of the blade. The faster the belt speed, the quicker the heat is generated. The use of a water spray to lubricate the belt will eliminate this problem by reducing the friction and cooling the blade.

These spray bars might not need to apply much more than a mist to the belt surface. Any excess water left on the belt after the secondary cleaners can be removed by the use of a soft urethane "water-squeegee blade" as a tertiary-cleaning system (**Figure 14.56**).

The results gained by the correct application of water in belt-cleaning systems more than justify its consideration in most material-handling operations. In a paper presented to the 1990 International Coal Engineering Conference in Australia, J.H. Planner reported that adding a water spray to various conventional cleaning systems raised cleaning efficiency from the 85 percent range to the 95 percent range *(Reference 14.3)*. *(See Chapter 24: Belt-Washing Systems.)*

BLADE-TO-BELT PRESSURE

Optimal Cleaning Pressure

A key factor in the performance of any cleaning system is its ability to sustain the force required to keep the cleaning edge against the belt. Blade-to-belt pressure must be controlled to achieve optimal cleaning with a minimal rate of blade wear.

There is a popular misconception that the harder the cleaner is tensioned against the belt, the better it will clean. Research has demonstrated this is not true. A 1989 study by the Twin Cities Research Center of the U.S. Bureau of Mines examined the issue of optimizing the blade-to-belt pressure to offer the best level of cleaning without increasing blade wear, belt damage, and/or conveyor power requirements. This research is published in *Basic Parameters of Conveyor Belt Cleaning (Reference 14.2)*. The study evaluated the cleaning effectiveness and wear characteristics of various steel blades by holding them perpendicular to a running belt with measured amounts of pressure to remove a moistened sand/lime mixture. The study found that the amount of carryback and blade wear both decrease as blade pressure is increased up to an optimum blade pressure. The study established this optimum secondary blade-to-belt pressure at 76 to 97 kilopascals (11–14 $lb_f/in.^2$) of blade-to-belt pressure (**Figure 14.57**). Increasing pressure beyond this range raises blade-to-belt friction, thus shortening blade life, increasing belt wear, and increasing power consumption without improving cleaning performance. An over-tensioned blade normally exhibits accelerated, but even, wear; some discoloration or "scorch" marks; and belt top-cover particles in carryback baked on the blade.

Operating a belt cleaner below this optimum pressure provides less effective cleaning and can cause rapid blade wear. A belt cleaner barely touching the belt may appear to be in working order from a distance; whereas in reality, material is being forced between the blade and the belt at high velocity. This passage of

Figure 14.55

The use of a simple spray bar just behind the primary cleaner or in front of the secondary cleaner will improve the cleaning process.

Figure 14.56

Any excess water on the belt after the secondary cleaners can be removed by the use of a soft urethane "water-squeegee blade" as a tertiary-cleaning system.

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material between the belt and the blade creates channels of uneven wear on the face of the blade. As material continues to pass between the blade and the belt, these channels increase in size, rapidly wearing the blade. A blade that has been under-tensioned will normally exhibit a jagged edge with wear lines on the wear surface.

The Bureau of Mines study also reported cleaning effectiveness decreased over time because of uneven blade wear. Grooves worn into the blade edge allow the passage of carryback that cannot be eliminated by increasing the blade-to-belt contact pressure. The report noted: "Once a cleaner blade's surface is damaged, no realistic level of blade-to-belt pressure will allow the blade to conform to the belt's surface for proper cleaning."

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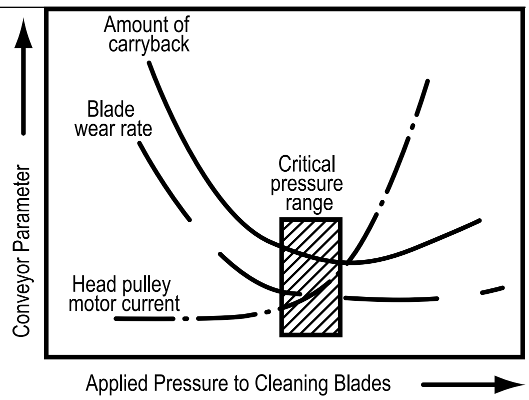

Figure 14.57

The study found that the amount of carryback and blade wear both decrease as blade pressure is increased, up to an optimum blade-to-belt contact pressure of 76 to 97 kilopascals (11–14 $lb_f/in.^2$).

Figure 14.58

More sophisticated tensioning systems include engineered air-spring systems plumbed to the plant's compressed-air supply.

Figure 14.59

Tensioning systems should allow the cleaning edge to relieve away from the belt in order to allow passage of mechanical splices and other obstructions.

Tensioning Systems/Devices

Blade-to-belt cleaning pressure is maintained by a tensioning device. These tensioners range in sophistication from concrete block counterweights and locking collars to torque storage couplings and engineered air-spring systems plumbed to the plant's compressed air supply (**Figure 14.58**). The reason for choosing a specific tensioner depends on the conveyor specification as well as plant preferences.

All tensioning systems should be designed to allow the cleaning edge to relieve itself away from the belt in order to allow passage of mechanical splices and other obstructions. Tensioners should be self-relieving to minimize risk of injury to personnel or equipment if the blades are "pulled through" by obstructions or holes in the belt (**Figure 14.59**).

A tensioning device should be designed to be compatible with the cleaner in order to provide a consistent blade-to-belt pressure throughout the life of the blade. When cleaner adjustment and re-tensioning are required, the tensioner should allow this maintenance to be performed simply, without requiring tools or more than one service worker.

Some cleaners use the resilience of a urethane blade, when compressed and locked into position, to supply the cleaning pressure (**Figure 14.60**). When installed, these blades are deflected by being forced against the belt. As the blade wears, it "stands taller" to maintain cleaning pressure. Because the blade itself supplies both cleaning pressure and shock-absorbing capacity, the cleaner does not need a conventional tensioner. Instead, the blade assembly is forced against the belt, and the mainframe is locked into position, slightly compressing the blades to set the initial blade-to-belt pressure.

Linear or Radial Adjustment

There are competing theories for belt-cleaner adjustment. There are linearly-adjusted cleaners that are pushed up (in a line) against the belt, and radially-adjusted cleaners that are installed with a mainframe as an axis and rotated into position (**Figure 14.61**).

Radially-adjusted cleaners have several practical advantages over the linear design. They are easier to install, can be adjusted from one side of the belt, and can more readily rotate away from the belt to absorb the shock inherent in belt motion and splice passage.

Linearly-adjusted cleaners generally require access to both sides to provide even adjustment (**Figure 14.62**). Because of this, the tensioners for these cleaners often have some form of powered adjustment, such as an air bag, that can be remotely controlled. Linear tensioners maintain a constant-cleaning angle as the blade wears and can be designed to allow for easy withdrawal of the cleaner for maintenance without removing the tensioner.

In addition, some hybrid systems incorporate vertical tensioning with a radial relief mechanism (**Figure 14.63**).

Maintaining the angle of the blades against the belt is important for ensuring effective cleaning. If the angle of contact is altered by blade wear, cleaner performance will similarly "decay." A well-designed belt cleaner must control the cleaning angle across its wear-life.

CLEANER INSTALLATION

A critical ingredient in the performance of any belt-cleaning system is its installation. Improper installation will have an adverse effect on how the cleaner performs; it will reduce blade-life and cleaning efficiency. The installation instructions from the manufacturer should be closely followed.

Figure 14.60

Some cleaners use the resilience of a urethane blade to supply the cleaning pressure.

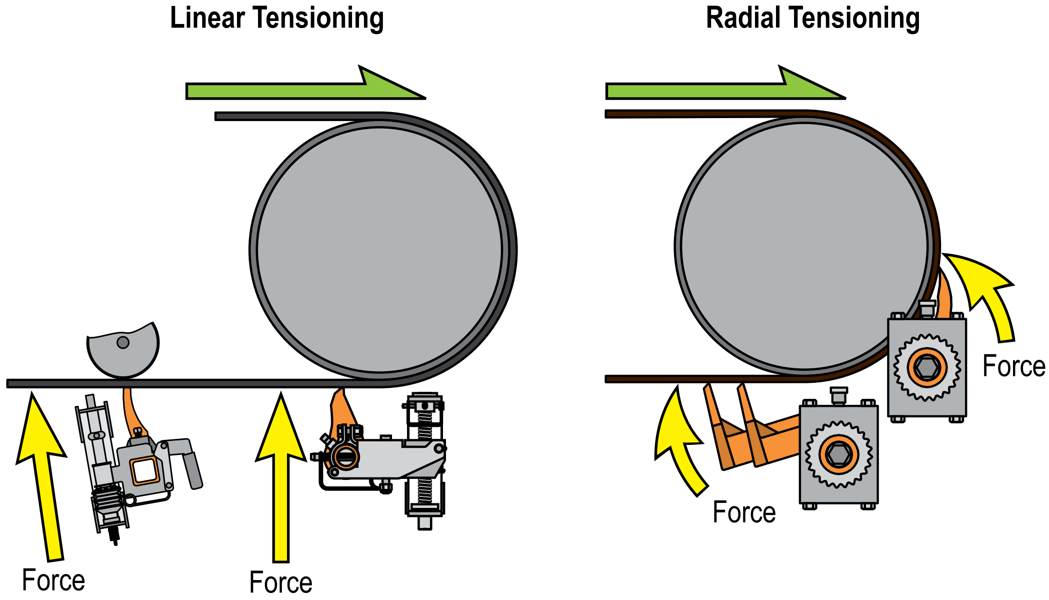

Figure 14.61

Linearly-adjusted cleaners are pushed up (in a line) against the belt; radially-adjusted cleaners are rotated into position with the mainframe as an axis.

Considerations affecting the installation position of a belt cleaner include:

A. Cleaner design

B. Tensioner and mounting requirements

C. Bolting or welding the cleaner in place

D. Installation on chutewall or hung from stringer

E. Position of conveyor structural beams, bearings, and drives

Figure 14.62

Linearly-adjusted cleaners generally require access to both sides of the belt to provide even adjustment.

Figure 14.63

Some hybrid systems incorporate vertical tensioning with a radial relief mechanism.

Figure 14.64

Placing the cleaner at the proper distance from the belt helps avoid "pull through," in which the belt pulls the cleaner all the way around into an inverted position, which usually results in a bent mainframe.

Regardless of the brand of belt cleaner, the critical factor in cleaner installation is that the cleaner support frame be installed at the correct distance from the surface of the belt. Placing the cleaner at the proper distance from the belt helps avoid "pull through" problems, in which the belt pulls the cleaner into the belt and all the way around into an inverted position, which usually results in a bent mainframe (**Figure 14.64**). Maintaining the proper dimension places the blades at the correct angle of attack against the belt for the best cleaning, proper blade wear, and longest life. The correct distance will be different from cleaner style to cleaner style.

It is strongly recommended that the manufacturer install and maintain the belt cleaners on both new and retrofit applications, because most performance problems with new belt-cleaner systems are due first to improper installation and second to lack of maintenance. Using the manufacturer (or manufacturer-approved contractors) for installation makes certain of proper installation and continued performance.

Troubleshooting Cleaner Installation

If a cleaning system is performing poorly, but the blades do not show excessive wear and the tensioner is set correctly, other problems may be present. These problems might include:

A. The support frame is not parallel to the pulley.

B. The cleaner is not installed the proper distance from the belt surface.

C. The pressure applied to the cleaner is changing the belt line.

D. The blades are not centered on the belt.

Any of these factors will impair a cleaner's ability to remove carryback. The cleaner's operators or installation manual should be reviewed to determine the appropriate corrective actions.

Belt Flap and Belt Cleaning

Belt flap can create problems in belt cleaning. Belt flap is an oscillation of the belt and is most often seen on the low-tension (return) side of the conveyor. This vibration has been measured with amplitudes as large as 25 millimeters (1 in.). The movement can be so strong that it destroys belt cleaners or plows and shortens the bearing-life of return idlers. The amplitude of the vibration can make it difficult to keep the blades in contact with the belt, thus reducing the cleaning effects. To control belt flap, the spacing of return idlers can be varied or a hold-down roller can be used to try to quiet the belt.

Pre-Cleaner "Heeling"

Pre-cleaners are designed to have the tip of the blade contact the belt first. As the tip wears, the primary cleaner normally rotates into the belt to maintain contact between the blade and the belt. However, problems can arise when an elastomer pre-cleaner blade is mounted too close to the belt. A primary cleaner installed in this manner, regardless of the blade's design, will have the heel of the blade tip contact the belt first. This "heeling" creates a gap between the belt and the blade tip (**Figure 14.65**). Conveyed material collects in this gap, and the accumulation forces the blade away from the belt. Once the blade is pushed away from the belt, larger amounts of material then pass between the belt and the blade, greatly increasing wear on the blade and belt and decreasing cleaning efficiency. The solution is to maintain the proper installation distance, so that the leading edge of the blade first contacts the belt.

The Problem with Over-Tensioning

Optimal cleaning efficiency results from the combination of the right scraping angle and adequate tension against the belt. As noted in the Bureau of Mines paper *Basic Parameters of Conveyor Belt Cleaning*, increasing the blade-to-belt pressure of a cleaner does not necessarily improve cleaning performance *(Reference 14.2)*. Increasing the pressure can reduce cleaning efficiency and shorten wear-life. Even when properly installed, if an elastomeric pre-cleaner blade is over-tensioned, the force is shifted from the entire contact area toward the heel of the blade. This results in a "mini heeling" situation and frequently can cause the blade to wear to a thin flap at the tip that can reduce cleaning efficiency (**Figure 14.66**).

If a secondary cleaner is over-tensioned, its cleaning angle may be changed to the point in which carryback is trapped in the wedge-shaped region between the blade and belt (**Figure 14.67**). This will create a

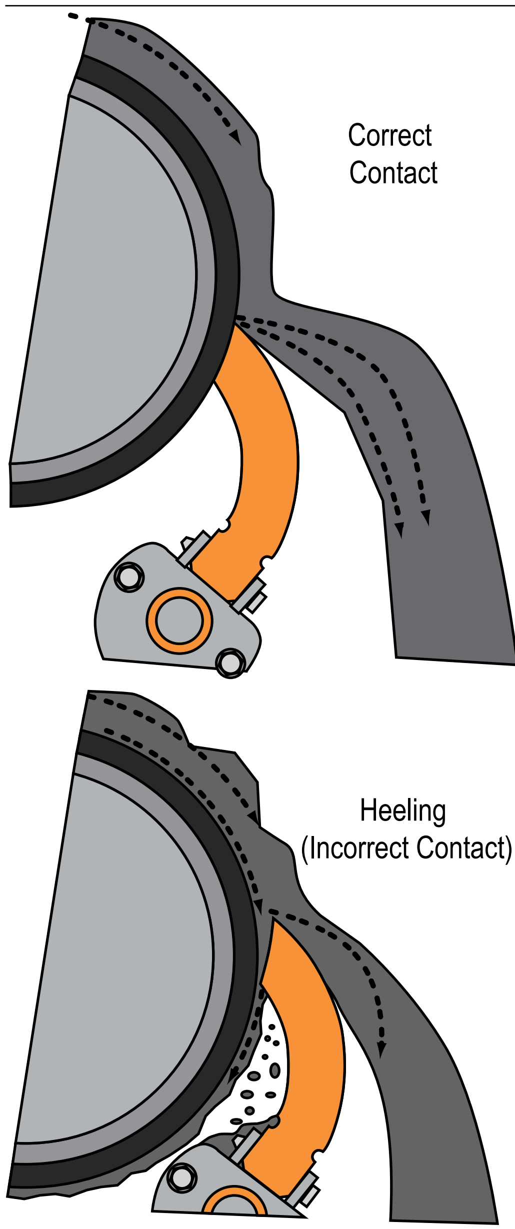

Figure 14.65

"Heeling"—when the heel of the pre-cleaner blade contacts the belt first—creates a gap between the belt and the blade tip; material will collect in this gap and force the blade away from the belt.

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Figure 14.66

When an elastomeric pre-cleaner blade is over-tensioned, the force is shifted from the entire contact area toward the heel of the blade. This can cause the blade to wear to a thin flap at the tip, reducing cleaning efficiency.

Figure 14.67

If a secondary cleaner is over-tensioned, its cleaning angle may be changed to the point in which carryback becomes trapped between the blade and belt, pushing the belt up and reducing the effective cleaning pressure.

Figure 14.68

It is not unusual for carryback material to adhere to the surface of a vertical, low-friction liner.

Figure 14.69

A cleaner encapsulated with a sticky or dried accumulation of material cannot function properly.

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buildup of material that will push the belt up and reduce the effective cleaning pressure. Material will pass between the blade and belt, again resulting in a poor cleaning efficiency and increased blade and belt wear.

Handling Material Cleaned from the Belt

The fact that carryback clings to the belt past the discharge point indicates that it has different characteristics from the rest of the conveyor cargo. The particles are finer and have higher moisture content, so they have different flow qualities from those typical of the main body of material. It is not unusual for carryback material to adhere to the surface of a vertical, low-friction liner (**Figure 14.68**). Even after its removal from the belt, carryback presents problems in capture, handling, and disposal.

Because of the characteristics of carryback material, it is usually best to locate the belt cleaners as close to the discharge point as possible. Returning as much carryback as possible back to the main material flow reduces the need to handle this difficult material outside of the process. The sticky fugitive material that carries back farther along the belt may build up within the chute or need to be handled by dribble chutes or scavenger conveyors, thus increasing the costs and complexity of the material-handling system. To ensure effective cleaning performance, the buildup of material on the cleaner or dribble chute must be prevented. A cleaner that becomes encapsulated with a sticky or dried accumulation of material cannot function properly (**Figure 14.69**).

Collecting and returning the carryback to the main material body can present a serious complication in the design of discharge chutes. Ideally, the conveyor's main discharge chute is sufficiently large so the material cleaned from the belt can fall through the same chute, where it is reunited with the main stream of material. But in many cases, auxiliary chutes or systems need to be added.

Dribble Chutes

On conveyors where the cleaning systems are positioned so the material removed from the belt does not freely return to the main material body, a dribble chute, or fines chute, is usually required. This is a separate part of the discharge chute that directs the removed carryback back into the main material flow. This auxiliary chute must be large enough and designed with a steep enough wall angle to ensure the material falls away from the cleaning system and prevents the encapsulation of the cleaner in these sticky materials. It is advisable to install a dribble chute with an angle as near vertical as possible and to line it with a low-friction material such as Ultra-High Molecular Weight (UHMW) polyethylene. It may be useful to incorporate flow aids to help in moving the carryback material away from the cleaners.

One way to solve the problem of buildup on a dribble chute is to create a dynamic sub-floor inside the chute. This can be accomplished by mounting a sheet of smooth, low-friction, abrasion-resistant plastic such as UHMW polyethylene, parallel to the chute floor with one end unsecured, so the sheet is free to move. A vibrator is mounted to this sheet, providing a dynamic action to prevent material buildup (**Figure 14.70**). Because this vibrating sheet is isolated from the steel chutework by a rubber cushion, there is very little force applied to the structure to cause metal fatigue (**Figure 14.71**).

An alternative system could include a flexible curtain or sheet of rubber used as a chute liner, which is periodically "kicked" with the discharge from an air cannon. This flexes the liner, causing any adhered material to drop away. *(See Chapter 9: Flow Aids.)*

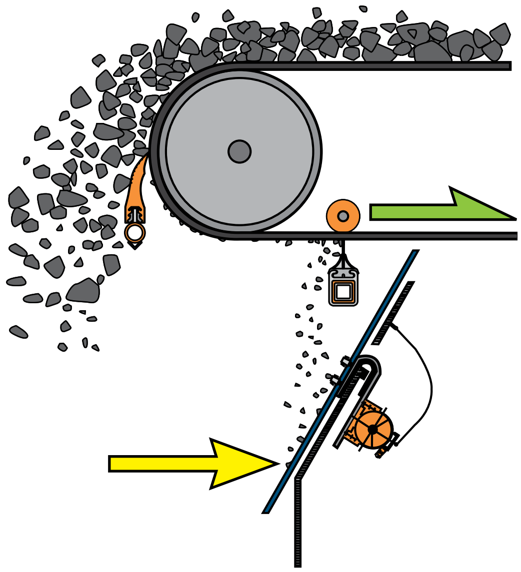

Figure 14.70

An electric vibrator can be mounted to a sheet of low-friction plastic to create a vibrating dribble chute.

Figure 14.71

By isolating the vibrating sheet from the steel chutework with a rubber cushion, there is very little force applied to the structure to cause metal fatigue.

Figure 14.72

A powered plow or push conveyor can be used to move material cleaned from the belt back to the main material stream.

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Access into the dribble chute should be provided to allow personnel to clear build-ups and provide a periodic wash down to prevent blockages.

Scavenger Conveyors

When a separate dribble chute is impractical, it may be beneficial to provide a scavenger conveyor (**Figure 14.72**). This is a smaller auxiliary conveyor, installed below the main system, that returns the cleanings to the main material flow. Small screw conveyors, scraper-chain conveyors, electrical or hydraulic plow or push conveyors, and vibratory conveyors are commonly used as scavenger systems (**Figure 14.73**).

An advantage of scavenger conveyors is that they allow the placement of several tertiary belt cleaners in a location more convenient for service. The material cleaned from the belt can be transported, even uphill, back into the main chute. The main disadvantage of these systems is they represent the addition of another piece of mechanical equipment that must be periodically cleaned and maintained.

Figure 14.73

Vibratory conveyors are often seen as scavenger systems.

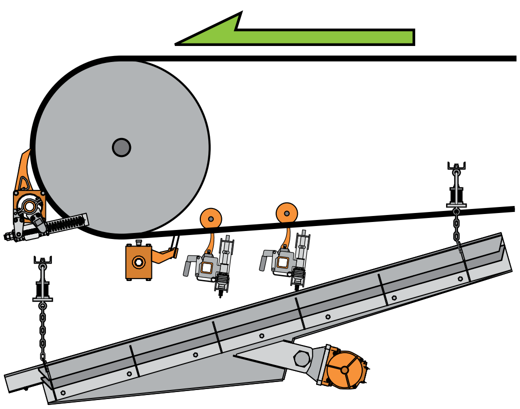

Figure 14.74

After installing a belt cleaner, periodic inspection, adjustment, and maintenance are required.

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SYSTEM MAINTENANCE

The Importance of Maintenance

Even the best-designed and most efficient belt-cleaning system requires maintenance and adjustment on a regular basis, or its performance will deteriorate over time. Proper maintenance of belt-cleaning systems reduces wear on the belt and cleaner blades, prevents damage, and ensures efficient cleaning action. Lack of maintenance on belt-cleaner systems not only produces a failure to clean effectively but also adds considerable risk to the conveyor system.

Conveyor designers and cleaner manufacturers must both design their equipment to simplify these vital maintenance activities. Maintenance requirements and procedures should be reviewed during the selection process for a cleaning system. Advance planning for cleaner service will allow maintenance activities to be performed expeditiously and will translate into improved belt cleaning and minimum downtime. Service chores that are simple and "worker-friendly" are more likely to be performed on a consistent basis.

After installing a belt cleaner, periodic inspection, adjustment, and maintenance are required (**Figure 14.74**). Just as cleaners must be designed for durability and simple maintenance, conveyors must be designed to enable easy service, including required clearances for access. Elements that can be incorporated into a conveyor belt-cleaning system to improve maintenance procedures include:

A. Adequate service access with ample clearances and work spaces, as recommended by CEMA

B. Access windows with easy-to-operate doors installed on both sides of the pulley, in line with the axis of the belt cleaners

C. Cleaning elements that slide in and out for service without requiring removal of the mainframe

D. Components including blades and

mainframe that resist corrosion and abuse

E. Components that allow the quick performance of required service—that can be adjusted or replaced with simple hand tools without waiting for a maintenance crew with power tools to perform the work

Mandrel-mounting systems that allow slide-in/slide-out positioning of a cleaner assembly offer an opportunity for faster service (**Figure 14.75**). Some facilities have made arrangements allowing this service to be performed while the belt is running, assuming the appropriate regulatory and safety committee approvals are granted and proper personnel training is supplied.

All applicable safety rules should be followed when performing any cleaning system maintenance procedure. Only trained and certified personnel following appropriate lockout / tagout / blockout / testout procedures should be considered for these practices.

Tips for Belt-Cleaner Maintenance

If plant management and personnel devote energy and attention to maintaining the cleaner's performance, they will be repaid with more efficient cleaning. It is usually best to assign belt-cleaning system maintenance to dedicated plant personnel or specialty contractors, because they will then have a commitment to maintaining the system.

The problem is that most in-house inspections never happen, and when they do occur, they are "walk by" inspections by people who are not trained in what to look for or how to maintain the cleaners. Most managers will feel this is a simple task that should be done in-house; the truth is that cleaner maintenance is never a priority, so rarely is it done. The use of outside specialty contractors ensures that belt-cleaner maintenance is done properly. Specialty contractors often notice other developing conveyor system or component problems that can be avoided.

While specific maintenance instructions are provided for each cleaner and tensioner by its manufacturer, there are regular and routine procedures that should be performed at specific intervals.

Manufacturer recommended and required local safety procedures must be followed when performing maintenance on belt-cleaning systems.

Daily: Remove Accumulated Material from the Cleaner

With the belt stopped, clean off any material that has gathered between the cleaner blades and the belt or that has built up on the arms of secondary cleaners. Often, a rotation of the cleaner away from the belt followed by a few sharp raps of the blades back into the stopped belt will dislodge this material. In other conditions, a quick rinse with a water hose or high-pressure spray will remove the buildup and allow inspection of the blades.

Weekly: Check Cleaner Performance

Check the work of the cleaning system. Carryback remaining on the belt could indicate worn out blades or improper tension.

Weekly: Check Blade Wear

Inspect the cleaning elements for wear. Some brands of blades incorporate a vis-

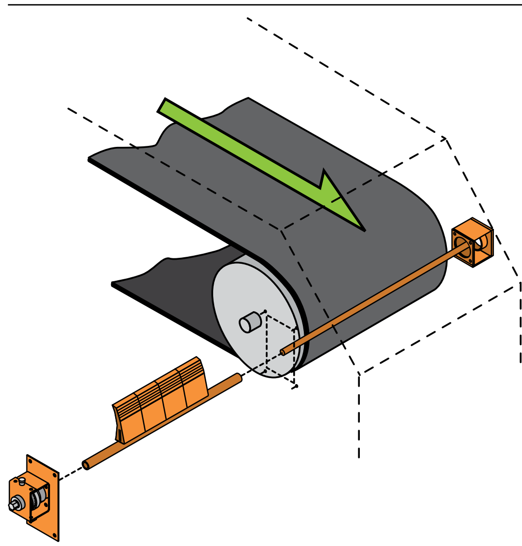

Figure 14.75

Mandrel-mounting systems that allow slide-in/slide-out positioning of a cleaner assembly offer an opportunity for faster service.

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ible wear line; for others, a check of the manual will be needed to ascertain the limits of safe and effective wear.

Weekly: Check Tensioner Adjustment

The most critical element in maintaining cleaner performance is keeping the cleaning edge tensioned against the belt. As blades wear, the tensioner may need to be adjusted to accommodate the blade's shorter length. The manual for each tensioner should provide specific instructions for re-tensioning.

ASSESSING BELT-CLEANER PERFORMANCE

Improving Belt-Cleaning Performance

There are a number of tactics that can be applied to upgrade the performance of a plant's belt-cleaning system. A general program for improving belt-cleaner performance might include:

A. Follow the manufacturer's instructions

Ensure systems are installed and maintained to the manufacturer's recommendations. Observe the recommended maintenance interval.

B. Standardize and systemize

Standardizing to one brand or style of cleaner on all conveyors in a plant and/or all plants in a company will simplify procedures and minimize spares. If there are different belts and materials in the operation, consider adopting one cleaner platform plant-wide that allows for altering the cleaner by application or as bulk-material properties change. Some manufacturers offer cartridge-style cleaner platforms that facilitate customization while minimizing the number of mainframe and tensioner systems. In addition, cleaner maintenance practices can be systemized—either by managing them inside the plant or by outsourcing maintenance to a specialized contractor—to improve execution and accountability.

C. Raise the bar

Continuously upgrade performance requirements. Expect a clean plant and demand performance. Find a supplier that will guarantee their product and work with them to understand the cleaning process. Implement cleaning performance measurements, such as blade-life testing to improve blade selection or carryback testing to check performance. Consider installing additional cleaners on problem conveyors.

Another strategy to optimize a cleaner installation is to perform research. It is now possible to analyze cleaning systems to identify the blade-to-belt pressure that optimizes both cleaning efficiency and blade-life. To make optimization easier, some belt cleaners are marked with wear percentages molded into the blades; tensioning systems have been developed that provide continuous and constant spring pressure.

The optimization process consists of setting the cleaning pressure at a given level and recording the length of time and/or the total amount of conveyed material it takes for the blade to reach the 25-percent wear indicator. The pressure is then adjusted and the cleaner used until it wears to the next 25-percent wear indicator. Cleaning efficiency must also be measured, using the quantitative methods discussed earlier in this chapter or visual qualitative measurements. In this way, the plant can determine what pressure provides the longest blade-life while maintaining acceptable cleaning efficiency.

The results will vary from application to application, and even from conveyor to conveyor within the same plant. One German lignite mine found that a higher cleaning pressure resulted in a longer blade-life; a similar operation reported that lower pressures resulted in longer blade-life while still maintaining acceptable levels of cleaning.

Goals for Belt Cleaning

Belt cleaning is a process, and like any other process, the results follow a curve (**Figure 14.76**). The amount of material removed is proportional to the amount of "effort" put into it. This "effort" could be money, cleaning pressure, number of cleaners, or a combination of these.

This cleaning process curve can be shown on a graph where the effort of removing carryback for a certain cleaning percentage is measured against the cost of that amount of carryback (including cleanup, maintenance, idler replacement, and the value of lost material). At some point along the curve, the expense for installing, operating, and maintaining additional cleaning systems is greater than the cost of leaving the remaining material on the belt (**Figure 14.77**).

The costs for a belt-cleaning system that could achieve a cleanliness level of "100 percent" would probably outweigh the system's benefits. A significant amount of the carryback that remains on the belt past cleaning systems with a high level of cleaning will stay on the belt throughout the conveyor's return run. This material will still be on the belt when the conveyor reenters the load zone. Consequently, it might not be worth the expense of cleaning it all off.

Even more important, to clean "100 percent" by mechanical scraping alone, the cleaner(s) would be applied with so much pressure the cleaners would endanger the belt cover. And regardless of the efficiency of the cleaning system, some carryback will remain on the belt trapped in small cracks and grooves in the belt's surface. Therefore, it is impossible to reach "100 percent" cleaning.

It is best to have goals for belt cleaning that are reasonable and obtainable for the operation of the plant. With proper equipment selection and continuing maintenance, reasonable goals will let a facility show suitable improvements and return on investment. Cleaning systems should be designed, installed, and maintained to meet actual operating requirements with an acceptable level of carryback.

Developing a Standard for Belt-Cleaning System Performance

The amount of carryback remaining on a belt is more dependent upon the characteristics of the bulk material and the physical parameters of the conveyor system than it is on tonnage of material conveyed or other factors. R. Todd Swinderman proposed a performance-based standard for belt cleaning in a paper presented to the 2004 Annual Meeting of the Society for Mining, Metallurgy, and Exploration (SME) *(Reference 14.4)*. The purpose of his proposal was to propose a standard method for specifying belt-cleaner systems based on user expectations and equipment performance over time. His paper proposing three levels of cleaning performance is detailed below. *(See Chapter 31: Performance Measurements for the Swinderman Scale.)*

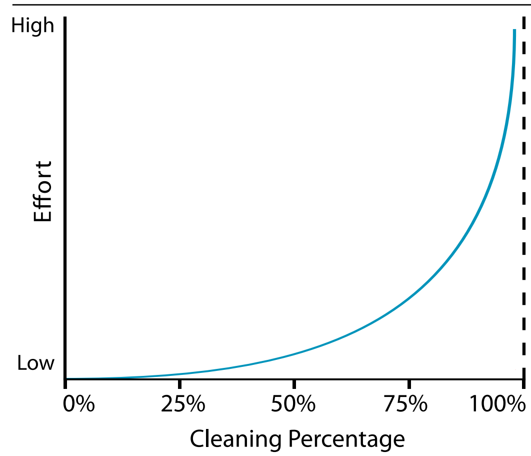

Figure 14.76

Belt cleaning is a process, and like any other process, the results follow a curve.

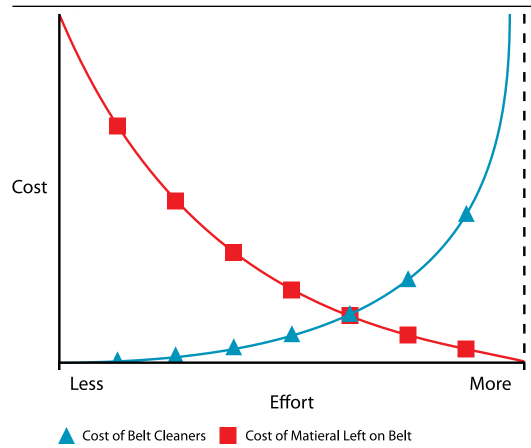

Figure 14.77

At some point along the declining curve representing the amount of material removed and the cost of that carryback, the cost of installing and maintaining additional cleaning systems is greater than the cost of leaving the remaining material on the belt.

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Level I cleaning is generally specified when concerns about carryback are not critical. Cleaning systems normally associated with achieving Level I performance are single- or double-cleaner systems with one-piece blades receiving poor to average maintenance. Frequent cleanup of the carryback that falls from the conveyor return will likely be required. Level I would be specified for materials that are easy to remove from the belt, in operations that transport low tonnages of material, in plants that are intermittent in operation, or where carryback can be easily cleaned up and returned to the process.

Level II cleaning is generally specified when carryback is of concern but does not create a significant safety or environmental problem. Cleaning systems normally associated with Level II performance would be multiple-cleaner systems with segmented blades undergoing maintenance at the manufacturer's specified interval. Level II cleanliness would be specified for high-volume operations, for operations where the spilled material has moderate value, or where manual cleanup under the conveyers once per week is acceptable.

Level III cleaning is generally specified when concerns about carryback are critical. Concerns range from safety to environmental to product contamination. Cleaning systems normally associated with achieving a Level III performance are multiple-cleaner systems in conjunction with at least one low-volume water spray. Difficult-to-clean bulk materials may require the use of a wash-box system with multiple cleaners using a combination of low-volume water sprays to lubricate the cleaners and high-volume sprays to keep the wash box and discharge piping freely flowing. Level III performance would be specified where prevention of spillage is required, contamination of cargo on the belt is a concern, the bulk material has a high value per ton, or where cleanup under the conveyors once a month is acceptable.

The Swinderman paper noted the higher the level of cleanliness desired, the more sophisticated the cleaning system and the better its performance will need to be (**Table 14.2**).

TYPICAL SPECIFICATIONS

A. In general

a. It is important to design conveyor belt-cleaning systems for the problems presented by the "worst-case" material conditions, rather than for "normal" operating conditions. This will allow cleaning systems to better handle changes in the materials.

b. Belt cleaners should be installed as close to the material discharge point as possible, ensuring effective cleaning by supporting the cleaning ele-

Table 14.2

The Mean Level of Carryback Allowed to Remain on the Cleaned Portion of the Belt

Level of Cleaning	Level I	Level II	Level III
Mean Carryback Level (Dry Weight g/m^2)	250	100	10
Mean Carryback Level (Dry Weight oz/ft^2)	0.82	0.33	0.03

Notes:

1. Because environmental and operating conditions vary, the level of cleaning is based on the mean of a standard distribution curve that will be unique to each conveyor and bulk material. Therefore, the mean of the measurements from all similar systems conveying similar bulk materials in a facility is to be used in measuring the total belt-cleaner performance.

2. Carryback factors (Cb_f), the percentage of material that ultimately falls from the belt and accumulates below the conveyor, has been measured to average 75% of the measured carryback at Level I, 50% at Level II, and 25% at Level III (Reference 14.5).

ments against a firm surface.

c. Belt cleaners should be installed outside the material trajectory and positioned so that cleaned materials cannot build up on the blades and structures.

d. Belt-cleaning systems should be designed to provide less than full-belt-width coverage to allow for minor variations in belt tracking and provide optimum blade-to-belt contact.

e. Each head pulley should have a belt-cleaning system consisting of (at a minimum) a primary cleaner and a secondary cleaner with provisions for the addition of tertiary cleaners.

f. The cleaning systems shall be designed to allow simple maintenance and blade-replacement procedures. Periodic maintenance should be performed as per manufacturers' recommendations to keep the belt cleaners operating at peak performance.

B. Primary cleaners

a. Primary cleaners perform the initial rough cleaning. They should be designed with flexible (elastomer) blades and radial-adjustment tensioning devices.

b. Primary cleaners should be installed on the face of the head pulley just below the trajectory of the material, utilizing a positive-rake cleaning angle.

c. Primary-cleaner blades should incorporate a constant-cleaning angle and area design.

d. Pre-cleaners should be designed for use on one-directional and reversing belts.

e. Reversing belts should have a pre-cleaner installed on each discharge pulley.

C. Secondary cleaners

a. Secondary cleaners remove the majority of the material that passes by the pre-cleaner's blades. Secondary blades should contact the belt just past the point where the belt has left the head pulley. Alternatively, the cleaners can be located behind the head pulley with a hold-down roll above the blades. The hold-down roll should be a minimum of 100 millimeters (4 in.) in diameter.

b. Secondary-cleaner blades should be designed to contact the belt in a negative-rake position.

c. The blades should be constructed of tungsten carbide or similar abrasion-resistant material.

d. On one-directional belts, the cleaners should be adjusted with a radial-adjustment tensioning device, and on reversing belts with a vertical-spring tensioner.

e. Reversing belts should have a reversing secondary cleaner installed as close as possible to each terminal (discharge) pulley.

D. Tertiary cleaners

a. Space should be planned in the design of conveyor load zones for the possible addition of tertiary cleaners.

b. Tertiary cleaners should utilize a separate dribble chute or scavenger conveyor to return the carryback to the main material flow.

E. Other

a. Necessary utilities (water, electricity, compressed air) should be available at points convenient to the belt-cleaner installation.

b. Clearances and access in accordance with CEMA recommendations should be provided in the conveyor design.

ADVANCED TOPICS

Belt Cleaners and Power Requirements

Applying belt cleaners increases the drag against the belt and raises a conveyor's power consumption (**Equations 14.1** and **14.2**).

A study by R. Todd Swinderman published in *Bulk Solids Handling* has examined how much power the application of a belt cleaner consumes from a conveyor's overall drive power *(Reference 14.6)*. The power requirement is calculated for the belt width actually contacted by the cleaner. In most cases, cleaning blades do not contact the full width of the conveyor belt.

The paper considers a belt 900 millimeters (36 in.) wide moving at speeds of 0,5; 2,0; 3,5; and 5,0 meters per second (100, 400, 700, and 1000 ft/min). Blade coverage of the cleaners against the belt is 762 millimeters (30 in.). The power consumption added to the conveyor's drive by the tensioning of various types of belt cleaners ranges from 0,14 to 3,8 kilowatts (0.2 to 5.1 hp) (**Table 14.3**).

An application is calculated using a commercially available conveyor engineering computer software program. The specifications used in the program are: a belt 1200 millimeters (48 in.) wide, operating at 3,0 meters per second (600 ft/min), conveying 1350 tons per hour (1500 st/h) of coal for a distance of 90 meters (300 ft) at an incline of 14 degrees. The weight of the

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Equation 14.1

Calculating Tension Added to the Belt due to the Belt Cleaner

$$\Delta T_{BC} = l_{BC} \cdot \mu_{BC} \cdot F_{BC}$$

Given: *A belt 900 millimeters (36 in.) wide has a cleaner on the head pulley. The cleaner exerts a force of 0,088 newtons per millimeter (0.5 lb_f/in.) on the belt, and the coefficient of friction is 0,6.* ***Find:*** *Tension added to the belt due to the cleaner.*

Variables		Metric Units	Imperial Units
ΔT_{BC}	Tension Added to the Belt due to the Cleaner	newtons	pounds-force
μ_{BC}	Friction Coefficient	0,6	0.6
F_{BC}	Normal Force Between Belt and Cleaner per Length of Cleaner	0,088 N/mm	0.5 lb_f/in.
l_{BC}	Length of Cleaner Blade	900 mm	36 in.

Metric: $\Delta T_{BC} = 900 \cdot 0,6 \cdot 0,088 = 47,5$

Imperial: $\Delta T_{BC} = 36 \cdot 0.6 \cdot 0.5 = 10.8$

ΔT_{BC}	Tension Added to the Belt due to the Cleaner	47,5 N	10.8 lb_f

Equation 14.2

Calculating Power Consumption Added to the Belt Drive

$$P = \Delta T_{BC} \cdot V \cdot k$$

Given: *A belt cleaner adds 47,5 newtons (10.8 lb_f) tension to a belt traveling 3 meters per second (600 ft/min).* ***Find:*** *The power consumption added to the drive due to the cleaner.*

Variables		Metric Units	Imperial Units
P	Power Consumption Added to Belt Drive	kilowatts	horsepower
ΔT_{BC}	Tension Added to the Belt due to the Cleaner *(Calculated in* ***Equation 14.1****)*	47,5 N	10.8 lb_f
V	Belt Speed	3 m/s	600 ft/min
k	Conversion Factor	1/1000	1/33000

Metric: $P = \dfrac{47,5 \cdot 3}{1000} = 0,14$

Imperial: $P = \dfrac{10.8 \cdot 600}{33000} = 0.2$

P	Power Consumption Added to Belt Drive	0,14 kW	0.2 hp

belt is specified as 22,3 kilograms per meter (15 lb_m/ft), and idlers are spaced every 600 millimeters (24 in.). This conveyor would require a total drive power of 107 kilowatts (143 hp).

If 1,2 kilograms per square meter (0.25 lb_m/ft^2) of carryback were present on the belt, this would amount to 10,9 additional tons per hour (12 st/h) of load. By itself this additional load would require very little additional power to carry: 1 kilowatt (1.3 hp) additional power, for a total of 108 kilowatts (144 hp). Conveyor problems do not arise from the power consumed by the weight of the carryback, but rather from the impact on the conveyor hardware of this carryback as it is released into the environment.

A single frozen impact idler set would require approximately 1,2 kilowatts (1.6 hp) of additional power. One seized steel idler set can demand as much as 0,27 kilowatts (0.36 hp) additional power. This study also notes that a 25 millimeter (1 in.) layer of carryback on a single return roller can add as much as 0,32 kilowatt (0.43 hp) to the conveyor's drive requirements.

These additional power requirements for the problems arising from fugitive material should be compared to the power requirements of a typical dual-cleaning system. Continuing the example above, for a 1200-millimeter (48-in.) belt traveling 3 meters per second (600 ft/min) and incorporating a dual-cleaning system, the power requirement would be 1,3 kilowatts (1.7 hp) for the pre-cleaner and 2,1 kilowatts (2.8 hp) for the secondary cleaner.

The combined additional power consumption of 3,4 kilowatts (4.5 hp) required for the use of an effective multiple-cleaner system represents an increase of only three percent over the 107 kilowatts (143 hp) required for the conveyor without any cleaners. This "conveyor power penalty" applied by the belt-cleaning system is only a little more than the power consumed at the rate of 0,27 kilowatts (0.36 hp) for a single seized idler set or 0,32 kilowatts (0.43 hp) required by 25 millimeters (1 in.) of accumulation of material on a single return roller.

As noted by Swinderman, the consequences of not installing and properly maintaining effective belt cleaners proves a more serious drain of conveyor drive power through the added friction caused by idlers with material accumulations or seized bearings.

Belt Cleaning and Dust Control

Carryback is a major source of dust in conveying. This dust is created when the dirty side of the belt interacts with idlers and belt pulleys. Belt cleaners greatly reduce the overall generation of dust in the conveying of bulk materials, because they reduce the total amount of material carried back on the return run of the belt. As belt-cleaner designs have improved, the overall

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Table 14.3

Power Consumption Added to Conveyor Drive Requirement by Various Types of Belt Cleaners

	Belt Speed, m/s (ft/min)			
	0,5 (100)	2 (400)	3,5 (700)	5 (1000)
Blade Type	kW (hp)	kW (hp)	kW (hp)	kW (hp)
Urethane-Bladed Pre-Cleaner	0,14 (0.2)	0,52 (0.7)	0,97 (1.3)	1,34 (1.8)
Metal-Bladed Secondary Cleaner	0,22 (0.3)	0,89 (1.2)	1,57 (2.1)	2,24 (3.0)
Urethane-Bladed Secondary Cleaner	0,37 (0.5)	1,49 (2.0)	2,68 (3.6)	3,80 (5.1)

Note: All testing performed utilizing tension supplied by Martin Engineering to recommended cleaning pressure level of dust originating as carryback has been reduced to the point in which belt cleaners have become a critical passive method of dust control. This advanced topic will offer a method to estimate the reduction in dust that can potentially be released from the belt into the environment.

Moisture Content and Particle Size

The dustiness of a bulk material is related to air velocity, particle size, and cohesiveness (**Figure 14.78**).

Several factors influence the dustiness of a given bulk material. The factors most important to this discussion are moisture content and particle size. Generally, additional moisture content increases the material's particle size and cohesiveness. As the particle size and cohesiveness increase, the Dustiness Index decreases. A decrease in dustiness is seen with moisture levels as low as 2.5 percent; most materials having a moisture content of 16 percent or more will have a Dustiness Index that is effectively zero. Particle size is also a significant variable; generally, bulk materials with particles over 100 microns (0.0039 in.) have a very low Dustiness Index *(Reference 14.7)*. In general, if the carryback has, on average, more than 16 percent moisture, and the particle size is greater than 100 microns (0.0039 in.), very little dust reduction can be expected from belt cleaning.

Carryback is usually high in moisture content, because the undulating action of the belt causes the fines and moisture to migrate toward the belt surface. The typical moisture content of carryback is from 15 percent to 50 percent. The particle-size distribution of carryback is dependent upon where it is measured and the type of belt cleaner used. If there are multiple belt cleaners, the size of carryback particles that pass each successive cleaner will become smaller (**Table 14.4**). For a typical dual system, the average particle size passing a pre-cleaner with elastomeric blades is on the order of 1000 microns (0.039 in.), with a range from 1 micron (3.93×10^{-5} in.) to 5 millimeters (0.2 in.). The average size of particles passing a secondary cleaner with hard metal blades will be on the order of 50 microns (0.00196 in.), with a range from 1 micron (3.93×10^{-5} in.) to 250 microns (0.0098 in.).

Belts that Run Empty

It is evident that a set of conditions of low moisture and small particle size must exist for dust to be released from carryback. Most of the time, carryback is of sufficient moisture content to agglomerate the smaller particles, sticking to the belt and preventing the release of dust. Much of the dust generated by belt cleaners and downstream components, such as idlers and bend pulleys, occurs when the belt is

Figure 14.78

Relationship in Creating Airborne Dust

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

Table 14.4

Characteristics of Carryback that Passes the Cleaning System

Belt-Cleaning System	Belt Cleaners Disengaged	Urethane-Bladed Pre-Cleaner Only Engaged	Pre-Cleaner (with Urethane Blade) and Metal Blade Secondary Cleaner Engaged
Size of Particles	Large, Small, and Fine Particles (10 mm to 1 micron)	Small and Fine Particles (5 mm to 1 micron)	Fine Particles (250 microns to 1 micron)
Moisture Content	Lowest Moisture Content (~15%)	Increased Moisture Content (~30%)	Very Wet (~50%)

Notes: Conveyed Material: Crushed limestone, 200 mm (8 in.) minus. Belt Speed: 2 m/sec (394 ft/min). Collection Time for Each Sample: 30 seconds allowed to run for prolonged periods of time without materials being conveyed. If the belt runs long enough without cargo, the carryback on the belt dries, and its particle size is reduced by contact with rolling components. Under these conditions, the majority of the carryback will be released into the environment in the form of dust. Of course, there are exceptions, such as when handling very dry materials like alumina; however, for coals and most minerals, belt cleaning greatly reduces the dust generated, by removing most of the carryback from the belt.

A case in point is demonstrated by the bunker-room conveyor system at a coal-fired power plant. The plant would leave these conveyors running when it was not actively loading coal. When coal was not being loaded, the airborne dust would diminish and the air clear. However, after running unloaded long enough for the material on the belt to dry, the level of dust in the air would climb again. When the belt was empty, the carryback dried out and was dislodged from the belt into the air by the return rollers, belt cleaners, and other components. When the loading of the conveyors began again, the dust level would actually decrease, because the cargo contained incidental moisture and dust-suppression chemicals (**Figure 14.79**).

While this example does not represent results from before and after installation of belt cleaners, it does show that the periods of highest dust generation correspond to the times when the conveyor was running without coal on the belt. One of the things that can be deduced from these results is that when the belt runs empty, the carryback eventually dries out. The dry carryback is then available to become airborne dust, with most of this dust released in a short period of time when the moisture content of the carryback presumably reaches a critical low value. It is evident that a significant gain in dust control would have been achieved if the plant simply turned off the conveyor when not conveying coal. When the belt is allowed to run empty, the carryback dries out, and the belt cleaner takes the fine dry material from the belt, as do the return idlers.

Estimating the Dust Avoided by Belt Cleaning

Presumably, the dust created within the chute is dealt with by the conveyor's passive or active dust-control system(s); the amount of dust generated by the belt on the return

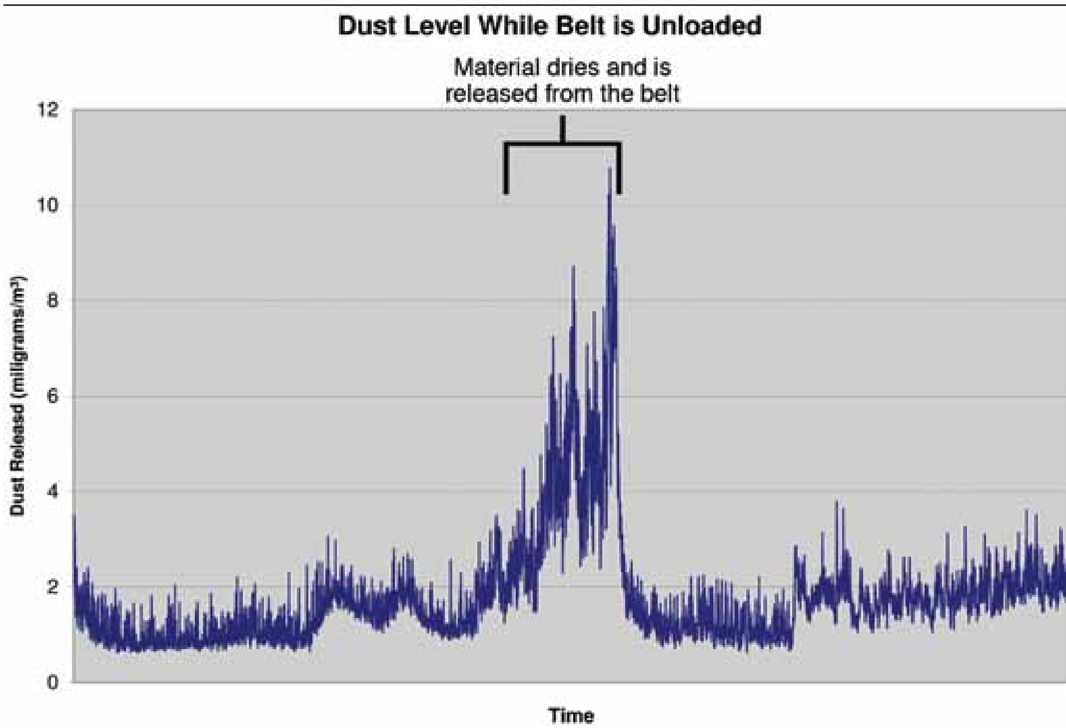

Figure 14.79

Dust emissions from a power plant tripper belt increased for an interval of time after the belt ran unloaded for enough time to allow the carryback material to dry out and become dislodged from the belt.

run is directly proportional to the amount of carryback on the belt. Conditions change continuously in bulk-materials handling, making it difficult to calculate a precise value for dust created by the conveying process or avoided by belt cleaning. Calculating the amount of dust that could be released requires a number of assumptions and estimates; without actual application-specific data, it is basically a theoretical exercise. Using the same assumptions and estimates, it can be shown that installing a sufficient belt-cleaning system, maintaining it properly, and not allowing the belt to run empty for prolonged periods will result in a significant reduction in dust potentially escaping from the conveyor.

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A Sample Problem

A typical conveyor in a mining or power-generation application with no belt-cleaning system installed will suffer carryback at an average of 500 grams per square meter (1.6 oz/ft^2) on the belt surface that is carrying cargo. Adding a properly installed and maintained dual-cleaning system will reduce the carryback to less than 100 grams per square meter (0.3 oz/ft^2). More advanced systems—using more cleaners or a belt-washing station—can reduce carryback further to 10 grams per square meter (0.03 oz/ft^2). Whereas 10 grams per square meter (0.03 oz/ft^2) may seem like a high value, it must be considered that a single scratch in the belt surface that is 0,14 millimeter (0.006 in.) wide and 0,14 millimeter (0.006 in.) deep can contain 10 grams (0.4 oz) of material (with a specific gravity of 1.0) per meter (3 ft) of belt length. It can be assumed, based on the level of cleaning, that from 25 percent to 75 percent of the carryback left on the belt after belt cleaning is "hiding" in the belt in cracks, holes, and general surface roughness *(Reference 14.4)*.

The other primary factors needed to make an estimate of the dust generation of belt cleaning are belt speed and operating hours. To reduce the number of calculations and charts required, a standard belt speed of 1 meter per second (200 ft/min) is used; other belt speeds can be extrapolated linearly—for example, a belt speed of 3 meters per second (600 ft/min) means three times the values at 1 meter per second (200 ft/min).

Sample Calculations

Assumptions

The assumptions (**Table 14.5**) are based on typical values for carryback and experience in measuring performance of belt-cleaning systems under a wide variety of conditions in coal and hard rock mining. To be conservative, it is assumed that the Dustiness Index is 100 percent and that all carryback in this example is 100 microns (0.0039 in.) or less; therefore, all carryback is potential airborne dust. Levels I, II and III represent standard categories for carryback that roughly correspond to 1 cleaner, 2 cleaners, and 3 cleaners or a belt-washing system, respectively.

Table 14.5

Example Assumptions

Assumptions	Level of Belt Cleaning			
	No Cleaners	**Level I**	**Level II**	**Level III**
Carryback g/m^2 (oz/ft^2)	500 (1.6)	250 (0.8)	100 (0.3)	10 (0.03)
Carryback Factor	88%	75%	50%	25%
Particle Size µm (in.)	100 (0.004) minus	100 (0.004) minus	100 (0.004) minus	100 (0.004) minus
Width of Belt Cleaned	67%	67%	67%	67%
Belt Speed m/s (ft/min)	1,0 (200)	1,0 (200)	1,0 (200)	1,0 (200)

Definitions

The following definitions are used to provide explanation for the assumptions:

A. Carryback

Carryback is the dry weight of material adhering to the belt after the belt discharges its cargo. The amount of carryback on the belt can be measured using a carryback gage and subsequent laboratory procedures. If the adhesion properties of the bulk material are known, a better estimate of the amount of carryback on the belt can be made *(Reference 14.8)*. With no cleaners engaged, the assumption for this example is that the carryback will be 500 grams per square meter (1.639 oz/ft^2) of belt surface cleaned.

B. Carryback factor

The carryback factor is the estimated percentage of carryback that will be dislodged from the belt downstream from the belt cleaners by components such as return idlers and bend pulleys. The cleaner the belt is, the lower will be percentage of carryback that will fall from the belt, because either the remaining carryback is captured in cracks and damages in the belt or the particles have sufficient adhesive strength to remain on the belt surface.

C. Particle size

For this example, it is assumed that 100 percent of the carryback is small enough to become airborne dust. In actual practice, a sieve analysis can be performed to determine the percentage of the carryback particles that are small enough to become potential airborne dust and the results of the calculations multiplied by the percentage of particles less than 100 microns (0.0039 in.).

D. Width of belt cleaned

Only a portion of the belt is in contact with the bulk material, and this is the width that must be cleaned of carryback. The assumption is that the CEMA "rule of thumb" of two/thirds belt width for skirtboard spacing is a reasonable estimate for this variable. The actual width can be measured and used in place of this assumption.

E. Belt speed

Belt speed is the speed of the belt in meters per second (ft/min). A value of 1.0 meters per second (200 ft/min) is used for this example. Results for other belt speeds can be extrapolated by multiplying by the actual belt speed in meters per second (ft/min). The same extrapolation is possible with the time period (minutes to hours, days, weeks, etc.) and belt width, because the relationship to carryback quantities generated is linear.

Equation

Calculation can determine the amount of potential dust generated from carryback (**Equation 14.3**). Additional calculations can be made for various belt widths and levels of cleaning performance, with the rest of the variables remaining the same (**Figure 14.80**). As can be seen for the example above, the reduction in potential dust is 89 percent by installing a system that will achieve Level II cleaning. Typically, a system that will achieve a Level II cleaning performance consists of at least one precleaner and one secondary cleaner, both properly selected and sized for the application. The dust loading can be determined by calculating the amount of air flowing through the transfer point per minute and adding the dust generated per minute *(Reference 14.9)*.

Conclusion

A major source of dust is conveyors that are allowed to run empty for long periods of time. As the belt runs empty, the carryback dries out and is more easily released into the environment by contact with components such as return idlers and bend pulleys. By reducing carryback, engineered belt-cleaning systems reduce the potential amount of dust released into the conveyor system and the environment significantly.

The proper installation and maintenance of belt cleaners inside the containment housing is critical in maintaining cleaning effectiveness and mitigating dust generation. If actual measurements are available for the critical variables, a reasonable engineering estimate of the dust released by the belt after belt cleaning can be calculated.

Equation 14.3

Calculating Potential Dust Generated

$$DG = BW \cdot Cb_f \cdot DI \cdot BS \cdot WC \cdot Cb \cdot k$$

Given: *A belt 1500 millimeters (60 in.) wide is carrying material at a speed of 1,0 meter per second (200 ft/min). The carryback factor is 88 percent, the dust index is 100 percent, and the width cleaned is 67 percent. The carryback level for no cleaners is 500 grams per square meter (1.639 oz/ft²).* ***Find:*** *The potential dust generated.*

Variables		Metric Units	Imperial Units
DG	Dust Generated	kilograms per minute	pounds-mass per minute
BW	Belt Width	1500 mm	60 in.
Cb_f	Carryback Factor	0,88 (88%)	0.88 (88%)
DI	Dustiness Index	1,0 (100%)	1.0 (100%)
BS	Belt Speed	1,0 m/s	200 ft/min
WC	Width Cleaned	0,67 (67%)	0.67 (67%)
Cb	Carryback	500 g/m²	1.639 oz/ft²
k	Conversion Factor	0,00006	0.00521
Metric: $DG = 1500 \cdot 0{,}88 \cdot 1 \cdot 1 \cdot 0{,}67 \cdot 500 \cdot 0{,}00006 = 26.5$			
Imperial: $DG = 60 \cdot 0.88 \cdot 1 \cdot 200 \cdot 0.67 \cdot 1.639 \cdot 0.00521 = 60.4$			
DG	Dust Generated	26,5 kg/min	60.4 lb_m/min

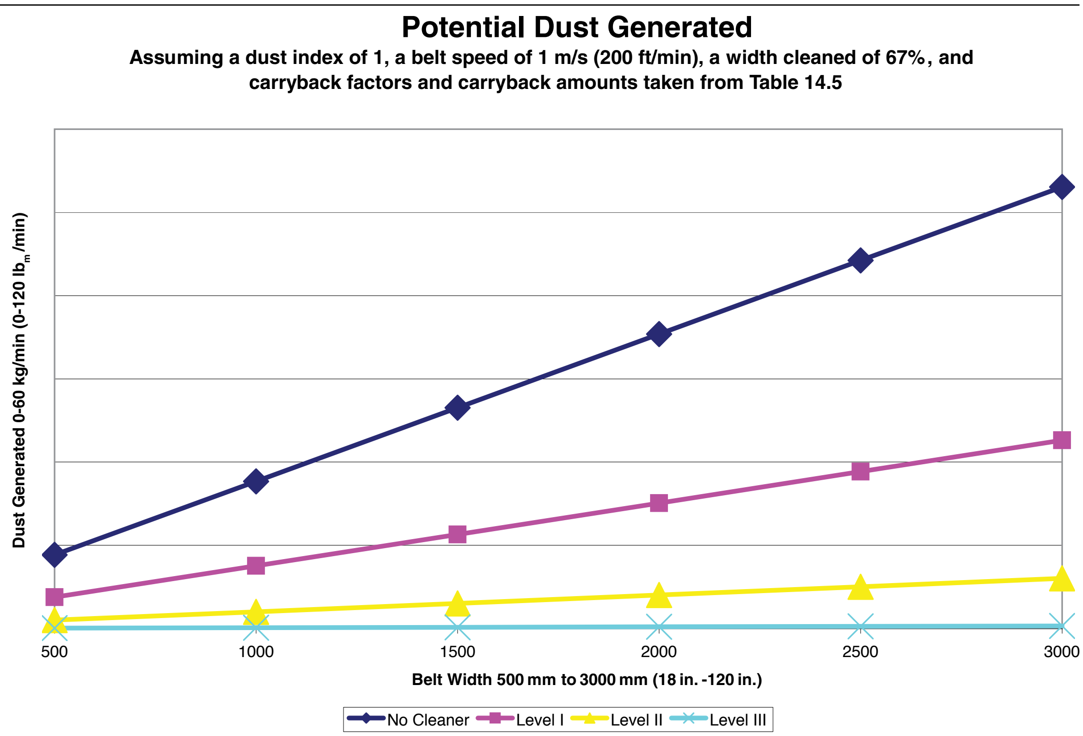

Figure 14.80

Potential dust generated for different belt widths and cleaning levels.

SAFETY CONCERNS

Failure to install appropriate belt-cleaning systems or maintain them is frequently the root cause of many of the accidents that occur when personnel are cleaning around moving conveyors.

Great care must be taken when observing or inspecting belt-cleaner systems. It is recommended that only trained and qualified personnel install and maintain belt-cleaning and their related systems. The manufacturer's manual usually provides important information, and industry groups such as CEMA provide safety information and standardized warning signage.

A pre-job safety analysis, commonly called a JSA, should be completed prior to the installation or maintenance of belt cleaners or the cleanup of any accumulation of fugitive material. Some topics to cover in a JSA are:

A. Lockout / tagout / blockout / testout procedures must be followed.

B. No maintenance or adjustment procedures should be attempted while the conveyor is running without strict compliance with national, state, local, and in-house safety regulations.

C. Belt cleaners installed in elevated positions or over hazardous areas, such as a barge load-out over a river, may require special precautions such as fall-protection systems.

D. Maintenance of belt cleaners in enclosed areas requires that confined-space procedures be followed.

E. Chutes often contain equipment, such as flow-aid devices and samplers, which can start automatically. All devices must be locked out / tagged out / blocked out /tested out separately from the main conveyor drive to prevent injury to employees.

F. Belt cleaners are often located in areas subject to accumulations of fugitive materials and accumulations of grease, water, or trash that can create slip and trip hazards. These accumulations should be removed before beginning maintenance procedures.

G. Warning stickers that are no longer readable should be replaced.

H. Manufacturer recommended and required local safety procedures must be followed when performing maintenance on belt-cleaning systems.

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BENEFITS OF CARRYBACK CONTROL

In Closing...

Belt cleaners come in a variety of types and materials and must be selected to fit the application and material conditions. For effective cleaning, selection should be accomplished by specialists experienced with their design and the characteristics of the material to be conveyed.

When properly selected, installed, and maintained, engineered belt-cleaning systems can be effective in reducing carryback. Reducing spillage and dust, in turn, reduces maintenance and accidents, many of which occur when workers are cleaning up fugitive materials. Reducing carryback also protects the belt and conveyor components from damage, extending their service-life and preventing further spillage caused by belt wander.

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Looking Ahead...

This chapter about Belt Cleaning, the first chapter in the section Return Run of the Belt, discussed ways to remove carryback to prevent fugitive material from falling from the belt on the return run. The following two chapters, Pulley-Protection Plows and Belt Alignment, continue this section and describe additional methods to reduce spillage.

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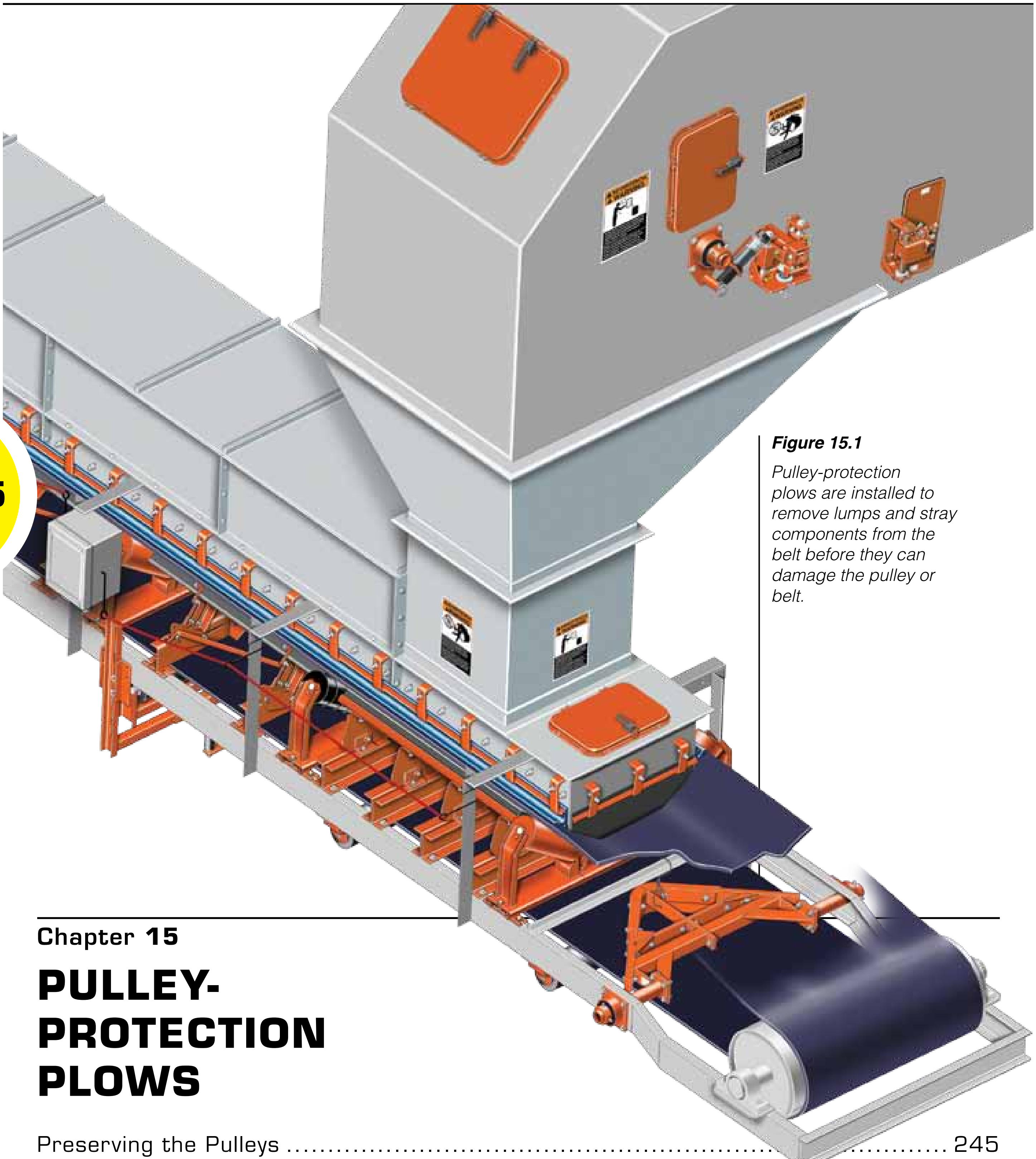

Figure 15.1

Pulley-protection plows are installed to remove lumps and stray components from the belt before they can damage the pulley or belt.

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Chapter **15**

PULLEY-PROTECTION PLOWS

In this Chapter…

This chapter examines the use of pulley-protection plows as a form of low-cost “insurance” against damage to the belt and pulley. It looks at the need for such plows and the damage that can occur without them along with considerations to keep in mind when selecting and placing pulley-protection plows.

Pulley-protection plows are devices that block any large lumps or stray conveyor components, such as idler rollers, belt-cleaner blades, or other tramp iron, from becoming trapped between the belt and the tail or other pulley(s) where they can damage the pulley or belt (**Figure 15.1**). Protection plows, while not designed as belt cleaners, can remove fugitive materials with a simple, low-pressure scraping that directs the material off the return belt much like a snowplow cleans a road.

As the conveyor belt returns from its discharge point (typically the head pulley) to its loading zone, it will pass over a number of pulleys. These return-side rolling components include the take-up pulley, the snub pulley(s), and, right before the belt reaches the loading zone, the tail pulley. Occasionally along its return run, the belt will collect and carry a lump of spilled material, tramp iron, or even a stray conveyor component to the tail pulley on the non-carrying side of the belt. If these objects are not removed from the belt, they can become trapped between and damage the pulley and the belt. This is why pulley-protection plows—commonly called tail plows—are installed near the tail of the conveyor, their most prevalent mounting location (**Figure 15.2**).

PRESERVING THE PULLEYS

Threats to the Pulley and the Conveyor

The entrapment of anything between the belt and the pulley can do significant damage to a conveyor system (**Figure 15.3**). When fugitive material is trapped between the belt and the pulley, one or more failures are likely to occur:

A. Degradation of the fugitive material

If the material fails, it will break up into fines and be carried between the belt and the pulley. Material trapped in this location can allow the belt to slip against the pulley, causing the non-carrying underside of the belt to wear. Even small particles and fines can wear and grind away on the less durable, more easily-damaged inside surface of the belt. Furthermore, material that builds up on tail pulleys will cause belt wander that in turn can damage the belt edge and/or the conveyor structure.

B. Failure of the belt

Any material entrapped between the pulley and the belt has the potential for forcing its way out through the top cover of the belt, particularly if the material is a lump with sharp edges. This material creates an uneven belt surface and can be a starting point for longitudinal and profile rips, holes, or edge gouges along the length of the belt.

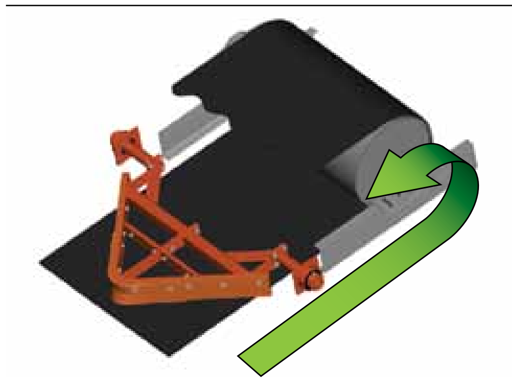

Figure 15.2

The most common location for pulley-protection plows is at the tail of the conveyor.

Figure 15.3

Entrapment of material between the pulley and the belt can damage the pulley and/or the belt.

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C. Failure of the pulley

If the material and the belt do not fail, the face of the tail pulley is likely to be damaged. A damaged pulley will lead to belt misalignment or damage and pulley slippage.

The most damaging problem arising from the entrapment of material between the belt and tail pulley is the fact that it can become a repeating phenomenon. Once a piece of material reaches the pulley, it can be pinched between the belt and pulley, carried around the pulley's rotation, and then ejected back onto the return side of the belt. Once there, it will again travel toward the pulley to be consumed again (**Figure 15.4**). In essence, if it initially fails to break something, the lump will keep trying until a failure occurs or the lump is removed from the belt. If the material is strong enough, it could destroy the entire tail-pulley section of a conveyor and damage the belt.

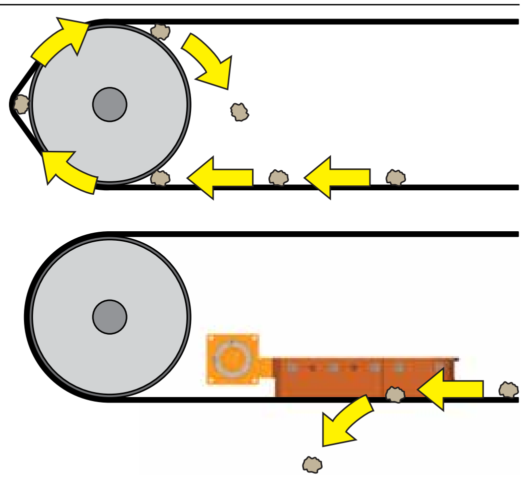

Figure 15.4

Top: A lump captured between the pulley and the belt can be carried around the pulley and ejected back onto the belt to become captured again.

Bottom: A pulley-protection plow will remove lumps from the belt to prevent their capture.

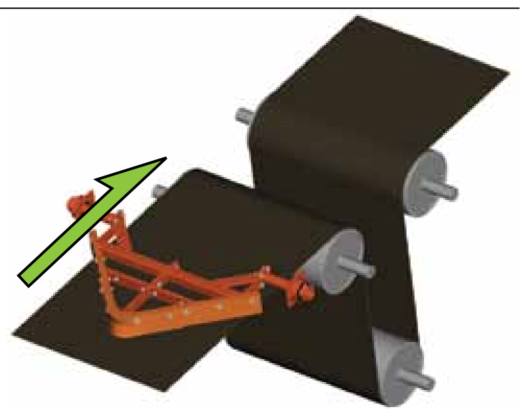

Figure 15.5

Usually installed at the tail pulley, plows can also be installed to protect the take-up or other pulleys.

Avoiding Pulley Damage

In a conveyor system, where stability is a key to the control of fugitive material, any damage to the belt or pulley can adversely affect the system's performance. By eliminating possible sources of damage to the conveyor, the entire system is improved and the risks of dust and spillage are drastically reduced.

The basic protection against this trapping of material between the belt and pulley is control of loading. The correct trajectory and drop height for material, along with the relationship between the speed of the loading material and the speed of the moving belt, are factors that help settle the load, reduce agitation, and minimize material spillage. Maintaining proper alignment of the belt is also required to reduce spillage that can drop material onto the return side of the belt.

An additional method available for preventing cargo from falling onto the belt return is to enclose or cover the return belt with decking. On long conveyors, this can turn into an expensive proposition; therefore, decking is rarely applied at locations other than near the loading zone. Even with decking applied to the full run of a conveyor, material could accumulate on top of the decking and eventually spill onto the return run of the conveyor, creating the need for a pulley-protection device.

With ideal installations, and regardless of other precautions, there is still the possibility that lost components or conveyed material will spill onto the inside of the belt. Consequently, there is a need for a system to prevent these items from damaging the conveyor's rolling components. These pulley-protection plows are most commonly installed at the tail pulley, but depending on the characteristics of the specific material and the individual conveyor, they may also be useful to protect the take-up or other pulleys (**Figure 15.5**).

This is a Job for a Plow

A pulley-protection plow removes fugitive materials with a simple, low-pressure scraping that directs the material off the belt much like a snowplow cleans a road. Instead of cleaning fines off the belt, the primary mission of a plow is to block any large lumps or stray conveyor components, such as idler rollers, belt-cleaner blades, or other tramp iron, from entering the tail pulley where they can damage the belt (**Figure 15.6**).

A plow that is installed slightly above the belt has the potential to capture a lump of material against the belt and, therefore, risks surface abrasion and damage with the possibility of ripping the belt. Pulley-protection plows are usually designed to float on the belt's surface, using either the weight of the plow or a tensioning mechanism to hold the plow with a slight pressure, 13 to 20 kilopascals (2 to 3 lb_f /in.^{2}), against the belt. These plows are built of heavy-duty construction and tall enough to keep fast moving materials from going over the top of the plow.

More than Lumps?

If the belt is carrying significant quantities of fines or slime on its inside surface, an additional step of providing a return belt-cleaning system should be taken. At the expense of consuming additional conveyor drive power, this system would provide effective removal of material, reducing the risk of belt slip and material accumulation on the pulley.

A pulley-protection plow utilized for cleaning fines from the belt should be located in a position, such as right under the load point, to scrape the spillage off the belt and discharge the material where it can be easily collected. Care should be taken when discharging fugitive materials in the area of the tail pulley, as it can create a number of other problems, including material buildup below the conveyor. As with any belt cleaner, removed material that piles up under the conveyor can lead to premature wear of the belt top cover.

CONSTRUCTION AND PLACEMENT OF PLOWS

Plow Construction

Pulley-protection devices are usually designed as a linear or V-shaped plow using a steel frame with a rubber, urethane, or plastic blade that directs any fugitive material off the belt. To prevent large lumps from "jumping" the plow and becoming hung up in the plow's suspension, in the conveyor structure, or between the belt and pulley, plows should stand as tall as the largest lump conveyed, with a minimum height of 100 millimeters (4 in.). In the case of high-speed belts, it may be advantageous to increase the height of the plow to one-half the total height of the pulley it is protecting. It is beneficial to cover the "interior space" of the plow to prevent material from becoming caught in the plow itself.

The plow should include a safety cable, which would attach to a point above and in front of its leading edge. In the event of a mounting failure, this cable would prevent the plow from traveling into the pulley and causing the damage the plow is trying to prevent.

On belt conveyors that travel in one direction only, the return belt cleaner is usually a "V"-plow (**Figure 15.7**). The point of the "V" is toward the head pulley so that any loose material carried on the belt's inside surface would be deflected off the conveyor by the wings of the plow.

If the belt has a reversing operation or suffers significant rollback, the installed device should be a diagonal plow that pro-

Figure 15.6

A V-plow is installed so the point of the "V" is toward the head pulley, deflecting belt-borne material off the belt with a low-pressure scraping action.

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vides cleaning protection in both directions (**Figure 15.8**). Diagonal plows are normally installed across the belt at an angle of 45 degrees to the direction of travel (**Figure 15.9**). If the belt operates in two directions, where either pulley can serve as the tail pulley, then a diagonal plow should be installed at each end of the conveyor.

Placement of Pulley Protection

Plows should be carefully located so that the material removed from the belt does not create a hazard as it falls or where it accumulates.

Just as it is important to have a roller above a secondary belt cleaner that provides downward pressure to keep the cleaner from pushing the belt up, it is important to have one or two pressure rollers below the pulley-protection plow installation. In this case, the mission is to prevent the plow from changing the belt line by pushing the belt down so that material can pass underneath the blade. Depending on the space available, this can be a single idler roller placed directly under the plow or a pair of return idlers, one installed before the plow and one after.

Like any other conveyor component that will be in contact with the belt, the installation of a pulley-protection device will increase the friction against the moving belt. Consequently, this drag will increase the conveyor's drive power requirements.

In the sixth edition of *BELT CONVEYORS for BULK MATERIALS*, the Conveyor Equipment Manufacturers Association (CEMA) offers a recommended setting of 2 pounds-force per inch of belt width as the normal force for plow-to-belt pressure. (The metric equivalent is 0,35 newtons per millimeter of belt width.) This pressure can be converted into power consumption using formulas (**Equation 15.1**).

Selection Considerations for Pulley Protection

When specifying a pulley-protection device, there are a number of factors that should be considered. A plow should:

A. Provide firm but flexible pressure

Firm but flexible pressure will allow the device to clean the belt surface. The intent of the device is to remove material effectively and efficiently yet adjust automatically to accommodate for the wear of its blade and fluctuations in belt movement, speed, and path.

B. Be securely mounted

The plow must be firmly mounted in order to minimize the risk of it breaking away from its installation to endanger the conveyor components it was installed to protect. The installation should include a safety cable to protect the conveyor system should the plow installation fail (**Figure 15.10**).

Figure 15.7

A V-plow is used on belts that travel in only one direction.

Figure 15.8

On reversing conveyors, a diagonal plow will provide cleaning protection in both directions of operation.

Figure 15.9

Diagonal plows are installed across the belt at an angle of 45 degrees to the direction of travel.

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$P = BW \cdot f_c \cdot V \cdot f \cdot k$			
Given: *A urethane plow on a 900-millimeter (36-in.) belt traveling at 3 meters per second (600 ft/min).* ***Find:*** *The power added to the drive due to the plow.*			
Variables		**Metric Units**	**Imperial Units**
P	Power Consumption Added to Belt Drive	kilowatts	horsepower
BW	Belt Width	900 mm	36 in.
f_c	Load per Belt Width (Per CEMA)	0,35 N/mm	2 lb_f/in.
V	Belt Speed	3 m/s	600 ft/min
f	Friction Coefficient *(Per CEMA STANDARD 575-2000)*	0,5 (UHMW) 1,0 (Urethane) 1,0 (Rubber)	0.5 (UHMW) 1.0 (Urethane) 1.0 (Rubber)
k	Conversion Factor	1/1000	1/33000
Metric: $P = \frac{900 \cdot 0,35 \cdot 3 \cdot 1}{1000} = 0,945$ **Imperial:** $P = \frac{36 \cdot 2 \cdot 600 \cdot 1}{33,000} = 1.3$			
P	Power Consumption Added to Belt Drive	0,945 kW	1.3 hp

Equation 15.1

Power Consumption of a Pulley-Protection Plow

C. Be designed for ease of installation

The plow should be easy to install to minimize downtime of the system during the installation procedure. For example, the device should fit within the conveyor structure without requiring extensive modifications to the device or the structure.

D. Be designed with a durable, easily replaceable blade

In order to provide a long service-life and allow fast maintenance, the blade should be fabricated of a material suited to withstand application conditions, and it should be attached so it can be easily removed and replaced when worn.

E. Be readily accessible

The plow should be installed in an area where it can be observed during operation and easily maintained.

TYPICAL SPECIFICATIONS

One or more low-pressure pulley-protection plows should be positioned on the return side of the belt to remove fugitive material before it can become entrapped between the belt and a rolling component according to the following specifications:

A. Flexible pressure

If the device is designed to contact the belt surface, the design should allow the plow or cleaner to "float" across the belt surface with a firm but flexible pressure.

B. Safety cable

The device must be fitted with a safety cable to protect the belt and pulley should an unexpected mount failure occur.

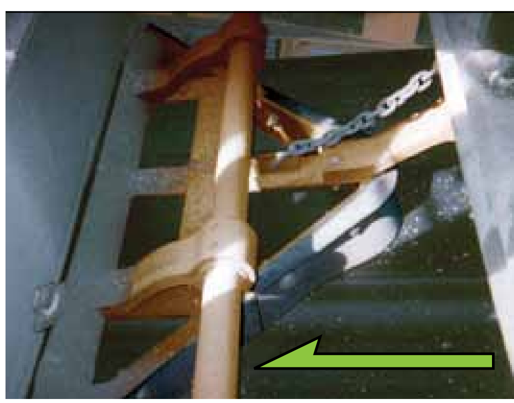

Figure 15.10

A safety chain provides protection in the event of a failure of the plow mount.

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C. Replaceable blade

The design should incorporate an easily replaceable blade of rubber, plastic, or urethane.

D. Full belt coverage

The plow blade should provide full coverage of the belt to prevent material lumps from "slipping around" the plow on the outside.

E. Location

The plow should be located so that the material cleaned from the belt can be safely ejected from the conveyor without hitting the stringer, other components, or walkways; it should be in a location that is safe and convenient for cleanup.

F. Unidirectional conveyors

On unidirectional conveyors, a "V"-plow should be installed between the last return idler and the tail pulley. Additional devices might be required to protect other pulleys or clean the bottom cover of the belt.

G. Reversing conveyors

On reversing conveyors, diagonal return plows should be installed on both ends of the conveyor and mounted across the belt at a 45-degree angle.

ADVANCED TOPICS

The impact caused by a lump of material or other objects carried on the belt can be quite large if conditions such as high belt speeds and large lump sizes are present. These large impact forces must be considered when selecting equipment, especially in view of the continuing demand to increase belt speeds.

The only variable controllable by the designer of a plow is the spring constant (k) in that component. This variable is the ability of the plow blade to absorb, cushion, or deflect a moving lump without damage. In the same way that dropping an egg onto a mattress (rather than a concrete floor) reduces impact force, the use of "softer" materials in blades and the incorporation of springs or other flexible elements in the plow mounting increases the chance the plow will withstand the lump's impact forces. As an example, a lump of material weighing 2,25 kilograms (5 lb_m) traveling on a belt moving 3 meters per second (600 ft/min) will strike a plow with a force of 815 newtons (183 lb_f). However, if that lump traveling at the same speed hits a plow equipped with a blade that has twice the impact absorption properties, it will strike with a force of only 199 newtons (45 lb_f). This reduced force of impact results in

SAFETY CONCERNS

Because tail-protection plows are positioned on the return run or non-carrying side of the belt and near the tail pulley, they are often in enclosed and nearly inaccessible locations. This makes them difficult to service and even poses a safety risk for personnel performing an inspection.

Safety concerns are paramount when the conveyor is in operation. It is important that great care be taken to avoid entanglement in rotating equipment when performing an inspection. No service procedures should be attempted while the conveyor is running. Proper lockout / tagout / blockout / testout procedures should be practiced prior to working on conveyors and/or their components to ensure the belt does not move.

Warning signs should be placed at all plow locations indicating pinch points. Care should also be taken, as objects can be thrown from the belt by the plow.

lower requirements for the strength of the plow, which in turn reduces the cost of the equipment.

An understanding of these impact forces, combined with new developments in design, allows an operation to more closely match the application to the design of the pulley-protection plow. This allows a more cost-effective selection of a protection system that meets performance requirements. A plow manufacturer should be able to calculate the impact forces for applications and determine the appropriate pulley-protection plow. There may be heavier objects that can strike the plow, such as teeth from loader buckets and fallen conveyor rollers, but the vast majority of impacts would be within the strength capabilities of the plow.

PULLEY PROTECTION AS CHEAP INSURANCE

In Closing...

While most pulley-protection devices are fairly simple devices, some innovations demonstrate the advantages of using engineered systems rather than homemade scrapers. Through innovations in design and construction, pulley-protection plows are available to provide the benefits of an engineered system while minimizing the initial investment (**Figure 15.11**). These engineered systems can provide a long-term solution that provides savings through improved performance, extended service-life, and reduced maintenance expenses rather than the false economies of the homemade unit. With today's use of computer-aided design systems to develop new conveyors, engineered plows can be positioned during an early phase of the conveyor's engineering process. Engineered systems ensure there is space to install, operate, inspect, and maintain a pulley-protection plow.

Figure 15.11

Engineered pulley-protection plows provide savings through improved performance, extended service-life, and reduced maintenance expenses.

Installed between a pulley and the nearest return idler, pulley-protection devices represent a form of low-cost "insurance" when weighed against the out-of-pocket costs of conveyor maintenance, damage, and possible premature replacement of the belt and/or pulley.

Looking Ahead...

In looking at methods to control dust and spillage, two topics have been addressed that relate to the Return Run of the Belt: Belt Cleaning and, in this chapter, Pulley-Protection Plows. The third and final chapter in this section will address Belt Alignment.

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REFERENCES

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

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

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

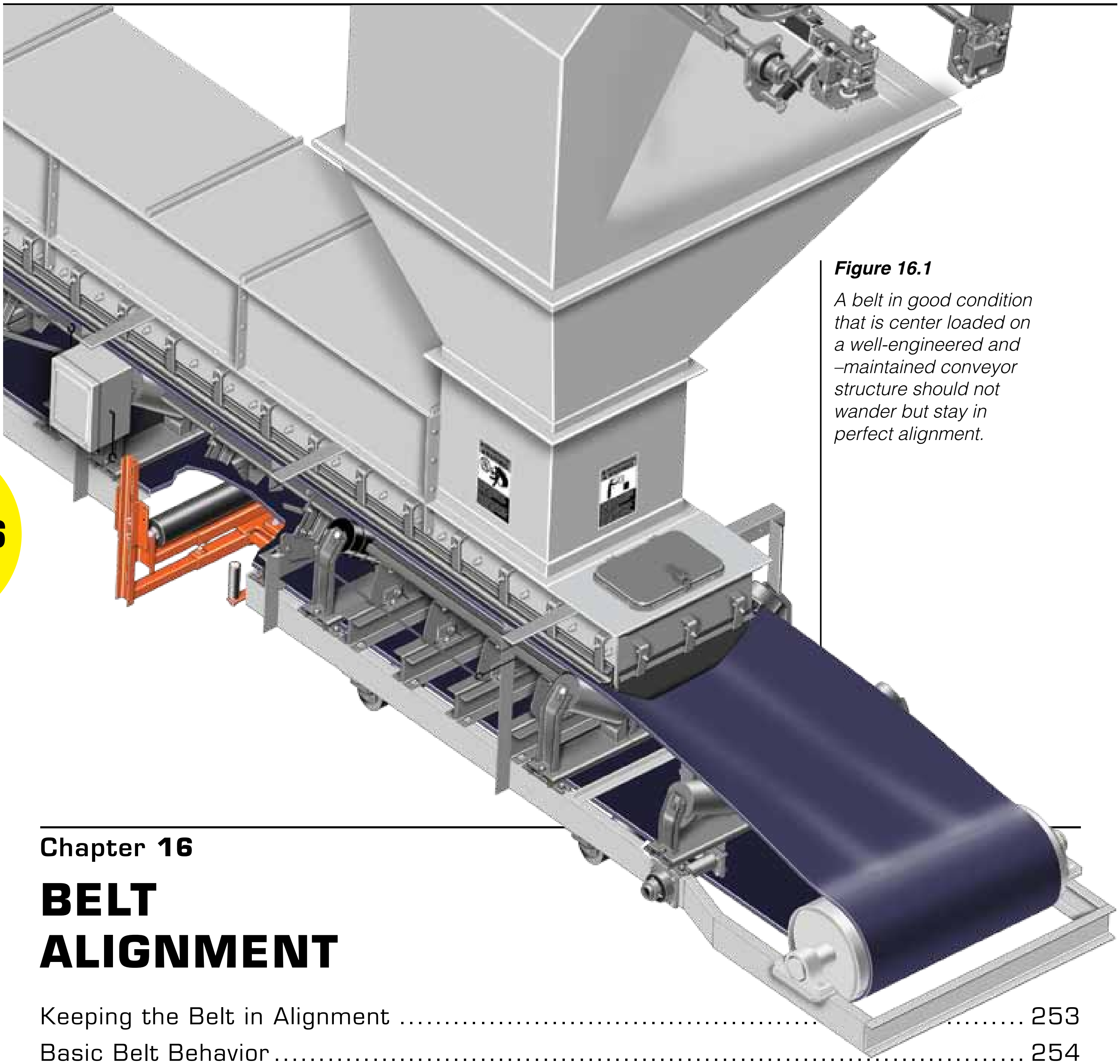

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Figure 16.1

A belt in good condition that is center loaded on a well-engineered and –maintained conveyor structure should not wander but stay in perfect alignment.

Chapter **16**

BELT ALIGNMENT

In this Chapter…

In this chapter, we focus on belt alignment and its relationship to fugitive materials: causes of mistracking as well as techniques to train the belt. We also discuss uses of belt-training hardware and installation of devices for belt training. Finally, equations used to calculate power consumption for belt-trainers are provided.

In an ideal world, a belt would be in good condition and center loaded and the conveyor structure would be well-engineered and -maintained; under those conditions, the belt would not wander but stay in perfect alignment (**Figure 16.1**).

However, belts that wander from the desired path are an everyday fact of life in many bulk-materials handling operations. A conveyor belt that wanders can cause material spillage, component failure, and costly damage to the belt and structures (**Figure 16.2**). A belt that runs to one side of the structure can greatly reduce its service-life, because it abrades one or both edges, becomes stretched, or folds over on itself (**Figure 16.3**). A wandering belt can run against steel chutes and structural members until the belt, other components, and steel structures are damaged, often beyond repair (**Figure 16.4**). Worse yet, belt-wander problems have contributed to fatalities.

In many ways, proper belt alignment is a precursor to, and a fundamental requirement for, resolving many of the fugitive-material problems discussed in this book. In this chapter, we will discuss many of the problems that cause a belt to wander and suggest solutions.

KEEPING THE BELT IN ALIGNMENT

Many terms are used when discussing the topic of belt wander. The terms tracking and training are often used interchangeably, as are their counterparts wander and misalignment. Here, training is defined as a procedure to make the conveyor belt track (or travel) on the centerline of the conveyor structure, both empty and fully loaded. Wander and mistracking can be defined as the tendency of the belt centerline to move from the conveyor structure's centerline, and misalignment is the amount that the belt wanders.

Belt tracking must be controlled before spillage can be eliminated; if the belt wanders to one side, or back and forth, as it passes through the loading zone, material is more readily released under the skirtboard seal on either (or both) sides (**Figure 16.5**). Belt mistracking is managed by "training

Figure 16.2

A conveyor belt that wanders out from underneath the sealing system can cause material spillage, component failure, and costly damage to its belt and structures.

Figure 16.3

A belt that runs to one side of the structure can greatly reduce its service-life, because it abrades one or both edges, becomes stretched, or folds over on itself.

Figure 16.4

A wandering belt can run against steel chutes and structural members until the belt, other components, and steel structures are damaged, often beyond repair.

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the belt" and by installing components designed to limit or correct wander.

When a belt mistracks, it can cause large amounts of material spillage. These spillage piles can cause trip hazards. If an overhead conveyor mistracks, it can rain material of any size down on workers. The potential for worker injury and all of the associated costs would indicate that it is in an operation's best interest to solve the problem of mistracking belts (**Figure 16.6**).

Figure 16.5

Belt tracking must be controlled before spillage can be eliminated.

Figure 16.6

When a belt mistracks, it can cause large amounts of material spillage.

BASIC BELT BEHAVIOR

Despite all of its various causes, mistracking is still unnecessary. It is a problem that can be controlled or, better yet, corrected. Understanding the basic patterns of belt behavior and undertaking a set of procedures to carefully align the conveyor's structure and components to correct fluctuations in the belt's path can, in most cases, prevent belt wander.

Belt behavior is based on simple principles. These serve as the guidelines for belt training, which is the process of adjusting conveyor structure, rolling components, and load conditions to correct any tendency for the belt to run off-center.

The fundamental rule of conveyor belt tracking is this: The belt will move toward the side that has more friction, or the side that reaches the friction first (**Figure 16.7**). When a side of the belt encounters that friction, that side of the belt moves slower. The belt's other side moves faster; a force imbalance occurs, which pivots the belt toward the slower moving side.

For example, if an idler set is installed at an angle across the stringers, the belt will move toward the side it reaches first. If one end of the idler set is higher than the other, the belt will climb to the higher side (because, as the belt is laid down on top of the idlers, it touches the higher side first).

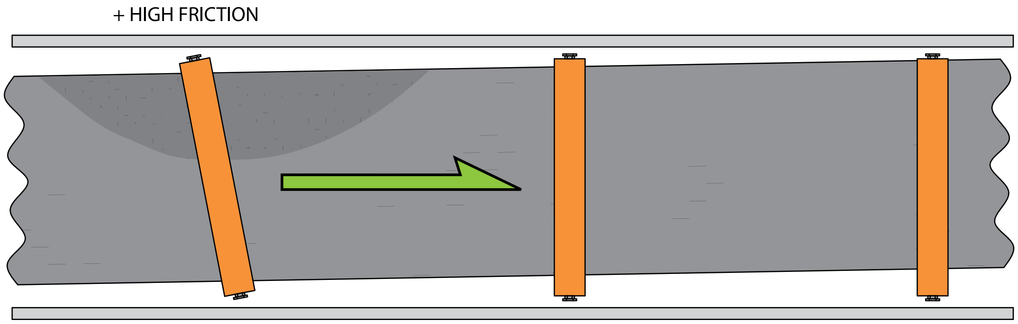

Figure 16.7

The fundamental rule of conveyor belt tracking is that the belt moves toward the high-friction side of the belt.

This can be demonstrated very simply by laying a round pencil on a flat surface, such as a table. If a book is laid across the pencil and gently pushed away from the experimenter, the book will shift to the left or right depending upon which end of the pencil is closer to the person doing the pushing: that is, the end the book is contacting first (**Figure 16.8**). This basic rule is true for both flat idlers and troughed idler sets.

In addition, troughed idlers exert a powerful tracking force. With their troughed configuration, a portion of each belt edge is held aloft. A gravitational force is exerted on that raised portion. If the belt is not centered in the set of rollers, the force on the higher edge will be greater than the force on the other side, steering the belt toward the center of the troughed idler set. This gravitational tracking force is so pronounced that bulk conveyors usually depend upon it as their major tracking influence.

Another constant rule of belt tracking is that the tracking of the belt at any given point is more affected by the idlers and other components upstream (the places the belt has already passed) than the components downstream (which the belt has not yet reached). This means at any point where mistracking is visible, the cause is at a point the belt has already passed. Consequently, corrective measures should be applied some distance before the point where the belt shows visible mistracking (**Figure 16.9**).

With these basic rules in mind, operators and maintenance personnel can make the adjustments to the conveyor that will bring the belt path into alignment.

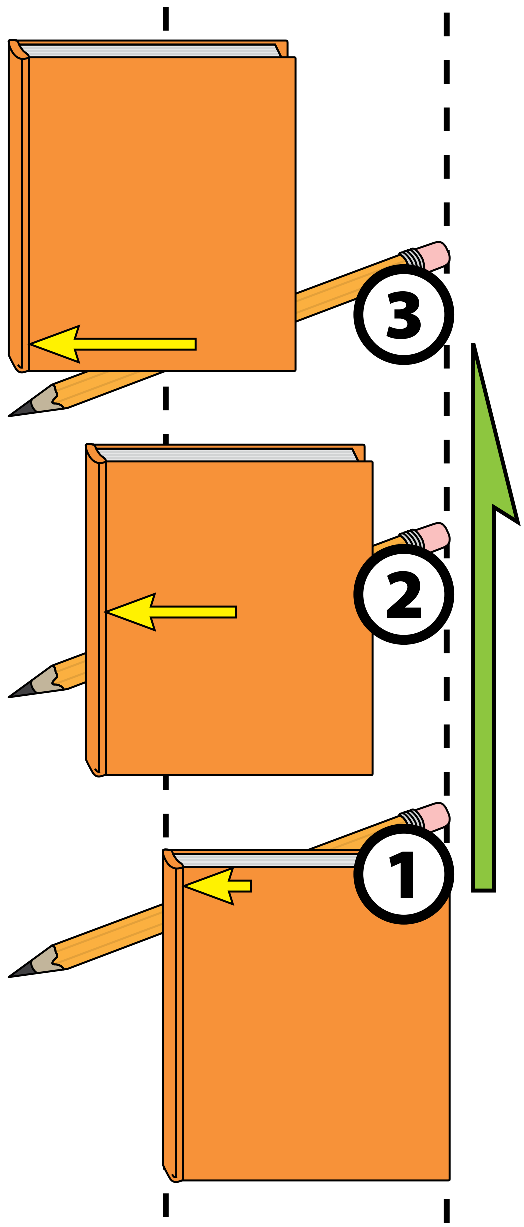

Figure 16.8

The basic rule of belt training can be demonstrated by laying a book on top of a round pencil. When pushed away, the book will shift to the left or right depending upon which end of the pencil is closer to the person doing the pushing: that is, the end the book is contacting first.

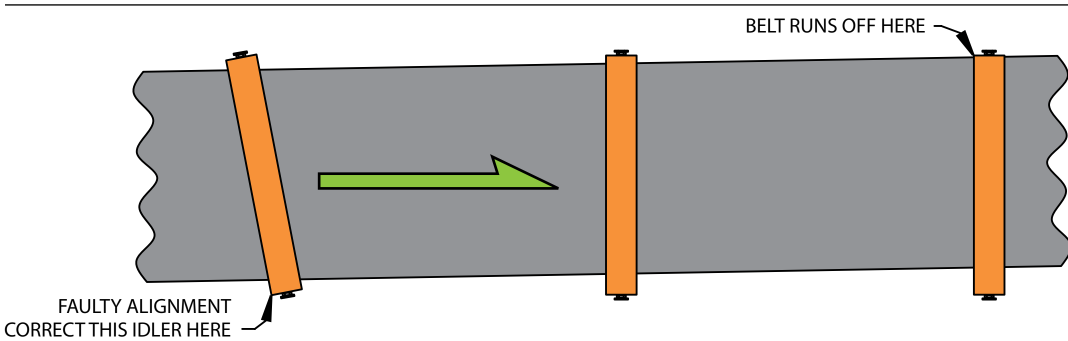

Figure 16.9

Because mistracking takes place after the point of cause, corrective measures should be applied some distance before the point where the mistracking is visible.

CAUSES OF MISTRACKING

The Avoidable Problem of Belt Wander

To properly train a conveyor, the first step is to survey the existing system to understand the state of the structure and components and to determine the causes of mistracking.

As Clar Cukor noted in the undated Georgia Duck (now Fenner Dunlop) monograph *Tracking (Reference 16.1)*:

> The problem of tracking should be approached from a systems point of view. The belt may well be at fault—however, it is more likely merely reacting to a structural defect or maladjustment in the system....[A conveyor belt] is flexible and if designed, manufactured, slit and cut properly, will "go where directed" by the conveyor system as designed and built. The conveyor belt serves as an indicator and should be so regarded.

Belt wander can be caused by a number of problems. Factors contributing to belt wander include misalignment of conveyor components, off-center loading of cargo, accumulation of fugitive material on rolling components, poor belt splices, structural damage caused by inattentive heavy-equipment operators, ground subsidence, and many others. And these problems may occur in any combination, greatly complicating the process of correction.

In spite of the complexity of these problems, they are solvable. Misaligned components can be straightened, chutes can be redesigned to load the cargo in the center of the belt, material accumulations can be prevented or removed, belt splices can be improved, and operators can be trained. The challenge comes in identifying which of the long list of possibilities is the specific cause of a given belt's problems. Once the cause of mistracking is identified, it can be corrected.

Causes of Mistracking

In many cases, the cause of mistracking can be determined from the form the mistracking takes. When all portions of a belt run off-center at one certain part of the conveyor length, the cause is probably in the alignment or leveling of the conveyor structure, idlers, or pulleys in that area. If one or more sections of the belt mistrack at all points along the conveyor, the cause is more likely in the belt construction, in the splice(s), or in the loading of the belt. If the belt mistracks when full and then tracks in the center when empty or vice versa, the cause is usually off-center loading or buildup in the chute that creates varying loading situations.

The most common causes of mistracking can be split into three groups: faults with the belt or its splices; faults with the conveyor structure, components, or the environment; and faults with material loading.

Faults with the Belt or its Splices

A. Belting
   a. The belt is bowed, cambered, or cupped.
   b. There are defects or damage in the carcass (plies or cords) of the belt.
   c. The belt edge or cover is damaged.
   d. There is belt degradation from exposure to the elements or to chemicals.

B. Manufacturing and application
   a. The belt is poorly matched to the structure or application.
   b. The belt has a "bow" or "camber" from its manufacturing process.
   c. The belt was not stored properly.

C. Splices
   a. There was poor installation of a vulcanized or mechanical splice, resulting in a splice that is not square to the belt.
   b. A belt was formed from several pieces joined at the wrong ends, resulting in a camber or crooked section.

   c. Different types, thicknesses, or widths of belt have been spliced together.
   d. The belt has splices that are damaged or coming apart.

Faults with the Conveyor Structure, Components, or the Environment

A. Structure
   a. The structure was not accurately aligned during its construction.
   b. The structure has settled on one side through ground subsidence.
   c. The structure has been damaged from plugged chutes, fires, or collisions with mobile equipment.

B. Components
   a. Rolling components (idlers and pulleys) are not aligned in all three axes.
   b. The gravity take-up is misaligned.
   c. Idler rolls have seized or been removed.
   d. Material buildup or wear has altered the profile of idlers or pulleys.

C. Environment
   a. The conveyor is subjected to high winds.
   b. Rain, frost, or ice and snow buildup altered the friction on one side of the belt.
   c. The sun shines on one side of the conveyor.

Faults with Material Loading

A. The load is not centered on the receiving belt.

B. The load is segregated, with larger lumps on one side of the belt.

C. There is intermittent loading on a belt that is tracked for a constant load.

Sometimes, a combination of these problems will produce belt wander, and the root cause will not be evident. However, if a sufficient number of belt revolutions are observed, the belt's running pattern generally will become clear, and the cause of mistracking will be disclosed. When a pattern does not emerge, the usual causes for belt mistracking are an unloaded belt that does not trough well or a belt that is unevenly loaded.

Wander Due To Faults with Splices or the Belt

Improper belt splicing is a significant cause of mistracking. If the belt is not spliced squarely, the belt will wander back and forth on the conveyor structure. This can usually be seen at the tail pulley. The belt will wander the same amount each time the splice reaches the tail pulley, only to return to its original position after passage of the splice. If the splice is bad enough, it can negate all alignment efforts. The solution is to resplice the belt squarely. *(See Chapter 5: Conveyors 101—Splicing the Belt.)*

A second significant cause of belt mistracking is a cupped belt. A cupped belt will track poorly because of differences in friction as it lays in the troughed idlers. Belt cupping is almost always a result of unequal shrinkage between the top and bottom covers of fabric belts. Heat, chemicals, trough angles, and over-tensioning can also cause belt cupping. This problem can usually be avoided by keeping the proper aspect ratio between top and bottom cover thicknesses: usually 3:1 or less. In some cases, the belt will cup as the top cover rubber properties change as the result of aging or exposure to chemicals. A cupped belt is hard to make track consistently, because tracking depends upon the friction between the belt and the rolling components. If the belt is so badly damaged that the contact area is reduced, the ability of the components to keep the belt in line is also reduced.

While manufacturing defects in the belt or failures of components are often blamed for many belt-alignment problems, most of these problems can be traced to improper application of the belt. A belt that is poorly matched to the application will usually track poorly on the structure.

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Wander Due to Structural and Component Problems

To be able to keep the belt running straight, the structure must be properly erected and corrected if damaged. Most structural damage occurs when the conveyor structure is struck by mobile equipment. Structural damage can also occur as the result of corrosion or a settling of the foundations.

It is equally important that the components be properly installed and maintained in relation to the belt for reliable belt travel. One major source of belt wander is gravity take-up systems that are out of alignment or that have too much side-to-side movement, or "slop." The take-up pulley, like all other main pulleys, must remain in alignment with the belt throughout the take-up's travel, or the belt will mistrack.

Rotating components can have a significant mistracking effect on the belt. Rotating components that have become frozen or inoperative due to material buildup or those with material accumulations that alter their circumference can be major contributors to erratic belt tracking. Consequently, transfer points should be engineered, constructed, and maintained to prevent material spillage. An effective multiple-cleaner belt-cleaning system should be installed to prevent material carryback. If necessary, cleaners can be installed to clean snub, take-up, and other pulleys. *(See Chapter 14: Belt Cleaning.)*

Figure 16.10

A belt that is not loaded in the center will mistrack, running the risk of damage to belt and structure.

Wander Due To Environmental Conditions

Strong winds on one side of the conveyor can provide enough force to move the belt off its center line or even blow the belt off the idlers. The solution is to install retaining rings known as "wind hoops" over the conveyor to keep the belt in place, provide a windbreak on the windward side, or enclose the entire conveyor.

Should rain, ice, or snow be blown onto one side of the conveyor, the result would be a difference in friction on the idlers. This difference may be enough to push lightly-loaded belts off the proper path. Even the difference created when the sun warms one side of a belt in the morning is enough to cause a belt to wander. Here again, the solution would be some form of conveyor cover.

In some cases, the conveyor's design was not sufficiently strong to withstand lateral winds, and the entire conveyor will sway back and forth in high winds. The path of a belt can also be greatly influenced by a slight shift of the take-up pulley due to crosswind.

Wander from Loading Faults

Mistracking that arises from loading problems is generally easy to spot, because the belt will run in one position when loaded and another position when unloaded (**Figure 16.10**). This observation may be confused on older conveyors where years of adjustments performed to "fix" the belt's path have altered the natural track of the belt.

The load's center of gravity will seek the lowest point of the troughing idlers (**Figure 16.11**). When the belt is not center-loaded, the weight of the cargo pushes the belt off-center toward the conveyor's more lightly-loaded side. This can be corrected by proper loading-chute arrangements, or through the use of deflectors, grids, or chute bottoms that can be adjusted to correct the placement of the load on the belt. *(See Chapter 8: Conventional Transfer Chutes.)*

Wander on Reversing Belts

Reversing conveyors can be a special source of frustration. When the belt direction is reversed, the tension areas in the belting change location in relation to the drive pulley and loading area(s). Imagine having a conveyor that has a head drive, and at the flip of a switch, it becomes the tail drive. When the top side of the belt is running toward the drive pulley, the tight side of the belt is on top. However, when the belt is reversed and the top side is running away from the drive pulley, the tight side is now on the bottom. The carrying side of the conveyor actually changes from being pulled to being pushed. A belt being pushed is inherently more unstable than a belt being pulled; thus, it is more difficult to train.

This poses especially difficult problems, because all of the components now contribute differently to the tracking problems. The belt may run fine in one direction and wander all over when reversed, because different sets of rollers and pulleys control the steering of the belt. In order to overcome this type of problem, the system should be surveyed to determine which components are out of alignment. Corrections should be made as required to get all rotating components in alignment.

Other problems encountered and aggravated by reversing belts relate to off-center loading, multiple load points, and loading different materials on the same belt. Off-center loading can greatly aggravate tracking problems on reversing belts, especially if the load is applied closer to one end of the conveyor than to the other. This can be corrected by proper loading-chute design and the use of adjustable deflectors, grids, and chute bottoms that can be adjusted to correct the placement of the load on the belt.

Different materials on the same reversing belt can also cause problems. Suppose the belt has been "set" to track with a material with a specific bulk density. Now, reverse the direction of travel and introduce a material with a different bulk density, and all of the previously-applied training adjustments may be wrong. In order to overcome this type of problem, a survey of the structure should be conducted to determine if the take-up pulley counterweight is insufficient or if the components are out of alignment, and corrections should be made as required.

Problems with Traveling Conveyors

Conveyor systems that move (such as bucket-wheel reclaimers, traveling stackers, or tripper belts) are greatly influenced by the rail structure on which they ride. For instance, if one rail is higher or lower at a given point than the parallel point on the other rail, the traveling conveyor can tip or rock (sometimes several millimeters (in.) on tall structures), leading to belt-mistracking problems.

Many times this problem is overlooked when trying to find the cause of belt mistracking and the resultant damage. The "traveler" part of the system might be parked in an area where the rails are level when a survey is performed. The survey results then would show everything to be in alignment; however, when the traveling system is moved to a different location, the belt mistracks, because the supporting structure is not level.

The rail systems must also be checked for parallel alignment. Improper alignment may cause the carrying wheels to "ride up" on the inside or outside of the rail, causing the same effect as one rail point being higher than its opposite counterpart.

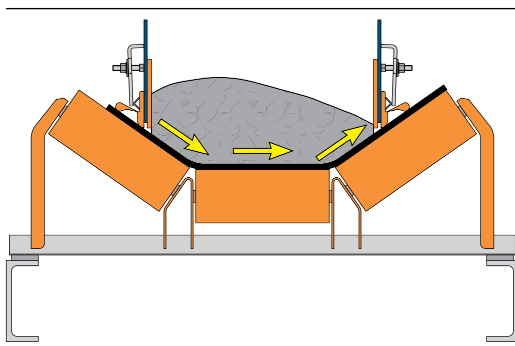

Figure 16.11

When the belt is not center-loaded, the weight of the cargo pushes the belt off-center toward the conveyor's more lightly-loaded side.

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INVESTIGATING THE PROBLEM: THE SURVEY

The first, and most important, step in training a conveyor is to check and align the structure. The best way to begin this process is to make a detailed survey of existing conditions and the original design criteria. This allows measured corrections to be made returning the system to original specifications, rather than adopting an unplanned "let's 'tweak' the idlers a little more today" approach.

The traditional method of checking alignment has been to stretch a piano wire from one end of the conveyor to the other and use this wire as a baseline to take the measurements to evaluate alignment. However, this method has a number of potential problems. For example, the wire is vulnerable to shifts in its line. Changes in ambient temperature from the warmth of the sun, or even the actual weight of the wire itself, can stretch the wire, changing the line. Another problem is that there is no accurate way to measure a 90-degree angle from the wire. If the wire moves when touched when laying a ruler or square against it, the accuracy of subsequent measurements is destroyed.

Now, high technology, in the form of beams of light from a laser transit set in parallel to the conveyor structure, provides an unobstructed and repeatable reference for the alignment of the conveyor-structure components (**Figure 16.12**).

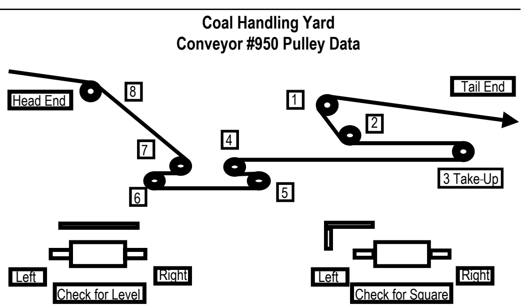
This laser-surveying technology avoids the problems encountered with the old "piano wire" technique. The laser generates a perfectly straight beam with an effective range of 150 meters (500 ft), with multiple set-ups allowing unlimited distance. To check objects set at angles to the baseline, prisms can be used to bend the beam. With a laser transit, the survey crew is no longer trying to measure a perpendicular line; they have created one. Since a laser beam cannot be touched, it cannot be moved accidentally when taking readings from it.

Most operations do not have the equipment and expertise to properly conduct a laser survey. Therefore, it is in the best interest of the operation to hire a specialty contractor or service with the hardware and experience to conduct this survey. A specialty contractor will laser survey the belt, inscribe a permanent series of benchmarks or alignment points, create a detailed report, and offer recommendations as to how to correct the major tracking problems.

The report should tell which components are out of alignment and by how much, so the plant maintenance crew or the specialty contractor can adjust these components to improve the belt's tracking (**Figure 16.13**). By doing repeat surveys of the same conveyor at regular intervals—annually, for example—plant management can provide a regular check of the condition of the conveyor structure. The survey will tell if the structure is deteriorating or if other circumstances—such as subsidence of the ground under the conveyor or change in

Figure 16.12

The beam of light from a laser transit provides an unobstructed and repeatable reference for the alignment of the conveyor-structure components.



Pulley Number	Level: Left Side	Level: Right Side	Square: Left Side	Square: Right Side
1	0.000	0.000	0.125	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	1.125
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.500
6	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000

For "Level" a positive number indicates that side is higher.
For "Square" a positive number indicates that side is farther forward.

Figure 16.13

The laser-survey report will tell which components are out of alignment and by how much, so the plant maintenance crew or the specialty contractor can adjust these components to improve the belt's tracking.

the counterweight mass—are occurring. This information can be used to prevent unexpected shutdowns and subsequent loss of production by alerting the plant's engineering and maintenance staff to problems as they develop.

TRAINING THE BELT

Getting the belt to track in the center of the conveyor's structure and components is a process of adjusting idlers and loading conditions to correct any tendency of the belt to run outside the desired path. The first step is to get the structure into alignment with the belt's theoretical centerline, as identified in the system survey. Once the structure is aligned, all the pulleys and idlers must be aligned so they are level and square to the center line. Then attention can be given to getting the belt to run true.

When training a belt, only one person should be in charge of the procedure. When more than one person adjusts the conveyor at the same time, it can lead to conflicting "corrections" that make the belt's path more difficult to correct. It is important that records be kept, noting the conveyor's problem areas and detailing the corrective steps taken. This will prevent, or at least identify, the problems arising from correction, re-correction, over-correction, and counter-correction when problems return to a specific area.

Procedure for Training

The following is a step-by-step process for training the belt to correct for component alignment and loading problems.

Determine Areas of Belt Tension

Adjustments to components in the low-tension areas have the highest impact on correcting the path of the belt. By identifying and starting in the low-tension areas, the training process can have the greatest impact with the least amount of changes. In high-tension areas, there is too much tension on the belt for relatively minor adjustments to have significant impact on the belt path. Belt tension is usually highest at the drive pulley (**Figure 16.14**). The area of lowest tension will vary on the location of the snub and take-up pulleys. The low-tension areas are completely dependent on the individual conveyor and must be identified for each application. Conveyor Equipment Manufacturers Association's (CEMA) *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, or an experienced conveyor engineer can be consulted for additional information.

It is important to make sure the take-up weight is applying the correct tension required by the current belt and capacity ratings. If the belt is inadequately or improperly tensioned by the take-up pulley, it is likely to have severe variations in its path.

Determine Locations of Mistracking

It is best if inspection for mistracking begins with the first rolling component directly after the highest-tension area (typically where the belt leaves the drive pulley), as the tension will usually be lower in that area, and continues along the path of the belt until a point where the belt is visibly off track.

It is important to remember that the track of the belt at any given point is affected more by the idlers and other components upstream (the points the belt has already passed) than the components downstream (the points the belt has not yet reached). This means where mistracking is visible, the cause of mistracking is at a point the belt has already passed.

Therefore, corrective measures should be applied at points the belt passes before the area where it shows visible mistracking. The movement of one idler generally has its greatest training effect in an area within 5 to 8 meters (15 to 25 ft) downstream.

Train the Belt

The conveyor must be locked out / tagged out / blocked out / tested out before making any adjustment to components or belt tension to correct mistracking.

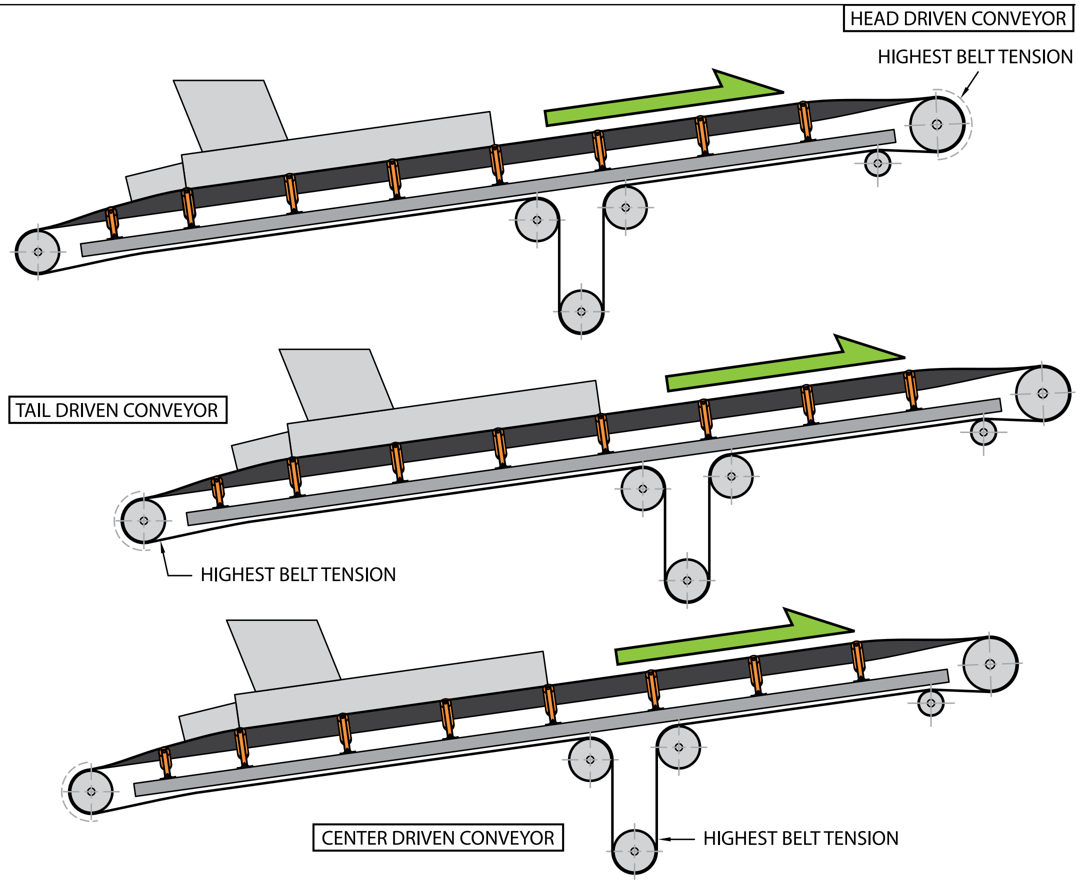


Figure 16.14

Belt tension is usually highest as the belt enters the drive pulley; areas of low tension will vary depending on the location of the snub and take-up pulleys. To train a belt, start inspection for mistracking directly behind the highest-tension area (where the belt leaves the drive pulley).

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To correct the belt's running path, it is necessary to start in the areas of lower tension and move around the conveyor, making adjustments to idlers to move the belt back into the center. Then, following the route of the belt from the driven pulley toward the next rolling component in sequence, the belt path can be corrected by adjusting the idlers, one place at a time.

Figure 16.15

The most basic technique for training a belt is shifting the idler axis with respect to the path of the belt, commonly called "knocking the idlers."

Starting with the first or second idler set before a point where the belt is visibly off track, the idler should be skewed in a direction opposite the misalignment. Then, the conveyor should be restarted to check for the belt's running alignment. The conveyor needs to be run to evaluate the effect of the correction, but it is important to wait two or three complete revolutions of the belt before further adjustments are made.

It is best to shift only one idler at a time, as pivoting additional idlers may cause over-correction or competing corrections. If the observation shows the belt path has been over-corrected, the path should be restored by moving the original idler back, rather than shifting additional idlers.

The belt should be tracked empty all the way around the conveyor, making especially sure the belt is centered as it enters the loading zone and discharge zone.

Techniques for Training the Belt

The most basic training technique is to adjust idlers. Training a belt by using its return and carrying idlers is accomplished by shifting the idler axis with respect to the path of the belt. This is commonly called "knocking the idlers," because the idler base is shifted with a blow from a hammer (**Figure 16.15**).

Training a belt by shifting the position of one or more idlers is the same as steering a bicycle with its handlebars (**Figure 16.16**). When you pull one end of the handlebars (or the idler) toward you, the bicycle (or belt) turns in that direction. This is in keeping with the basic rule of belt training: The belt will steer to the side of the idler it touches first.

This handlebar principle of steering is sound, but only if the belt makes good contact with all three troughing rollers. So before training a belt, it is necessary to check to be sure the belt is troughing well at all points along the carrying side, even when unloaded. If the belt does not "sit down" in the trough, there may be a problem with its compatibility with the structure (**Figure 16.17**). A belt that is too thick and not suitable for a given conveyor might never track correctly.

Adjustments to the idlers should be small. Research at Australia's University of Newcastle has shown that once an idler is skewed past a certain point, it will not correct the belt path more, because the belt slides across the idler like a car skidding across a patch of ice *(Reference 16.2)*.

Obviously, such shifting of idlers is effective for only one direction of belt travel. A shifted idler that has a correcting influence when the belt runs in one direction will likely misdirect the belt when the conveyor is running in the other direction.

For unidirectional conveyors, shifting the position of idlers has benefits in belt training. However, there are drawbacks as well. It should be obvious that a belt might be made to run straight with half the idlers knocked one way and the other half knocked in the opposite direction, but this would be at the expense of increasing rolling friction between belt and idlers. Idlers turned in all different directions in an effort to train the belt create extra friction, resulting unnecessarily in increased wear in the bottom belt cover and increased power consumption.

Adjustments should be made to idlers only—never to pulleys. Pulleys should be kept level with their axis 90 degrees to the intended path of the belt.

Other Techniques to Center the Belt

Another approach to centering the belt is to tilt the carrying idlers slightly, up to two degrees, in the direction of belt travel. The friction of the belt on the wing rollers creates a centering force that is directed to the centerline of the belt. This can be done by simply inserting flat metal washers beneath

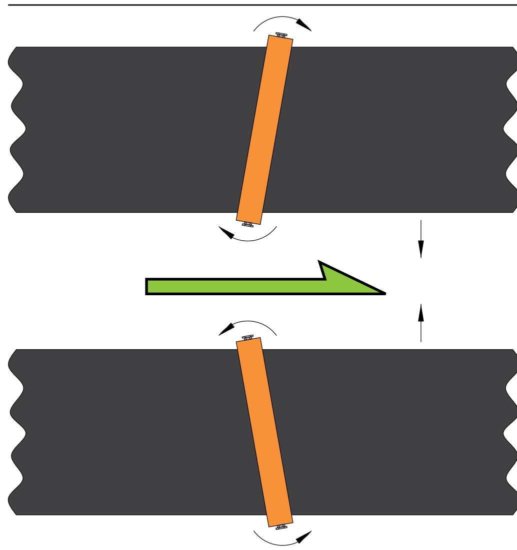

Figure 16.16

Training a belt by shifting the position of one or more idlers is the same as steering a bicycle. When you pull one end of the handlebars (or the idler) toward you, the bike (or belt) turns in that direction.

Figure 16.17

For a belt to track well, it must trough well along the conveyor's carrying side. If the belt does not "sit down" in the trough, it might never track correctly.

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the back side of the idler frame. Many idler manufacturers build this tilt into their products. Just as with "knocking" the idlers, there is a limit to the effectiveness of this technique, and it does increase the power consumption of the conveyor and wear on the belt bottom cover and idlers (**Figure 16.18**).

An ill-advised method to center the belt as it approaches the tail pulley is to slightly skew in opposite directions (**Figure 16.19**) or raise opposite ends of the two return rolls nearest the tail pulley (**Figure 16.20**). The theory is that this deliberately-induced mistracking in opposite directions produces competing forces that work to center the belt. Though this may sound reasonable in the abstract, the practical application of it is problematic. This method incorporates instability into a system when the goal for optimum operation is stability. It could be argued that there is enough of a problem with getting the system square in order to run true, without adding two more variables in the form of deliberately-misaligned idlers.

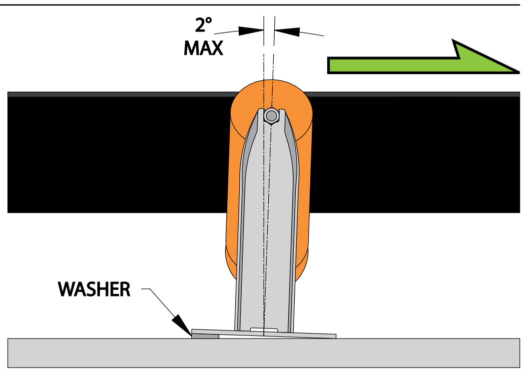

Figure 16.18

Tilting carrying idlers by inserting flat metal washers beneath the back side of the idler will increase the centering force.

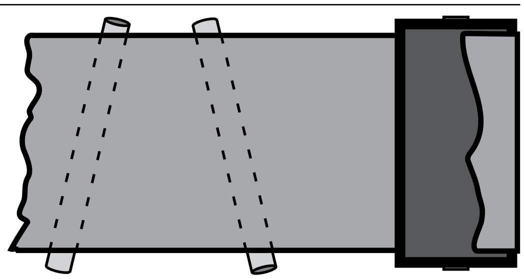

Figure 16.19

An ill-advised method to center the belt as it approaches the tail pulley is to slightly skew the two closest return rolls in opposite directions.

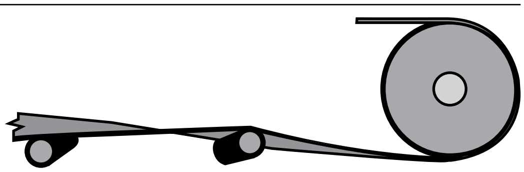

Figure 16.20

Raising the opposite ends of the two returns rollers nearest the tail pulley is an ill-advised method to help center the belt.

Training the Belt at Start-Up of New Conveyors

If a new conveyor system has been designed and built in accordance with sound engineering and installation practice, the belt will probably track at start-up on a path close to the desired one. There may be minor variations from the ideal structure that result in the belt not tracking perfectly; however, in these circumstances, the variations should be relatively minor, so the belt can be operated without damage long enough for a training procedure to take place.

The first movement of the belt through a new conveyor should be slow and intermittent, so any tendency of the belt to wander may be quickly recognized and the belt stopped before damage occurs. The first alterations must be made at points where the belt is in immediate danger of damage. Once the belt is clear of danger points, the conventional sequence for belt training, as noted previously, can be followed.

Insufficient attention at start-up can create problems, including serious runoff and edge damage, belt creasing or fold-over, spillage, and damage to other conveyor components. For conveyor start-up, observers should be positioned at locations where trouble might be expected or where the belt is at greatest risk—where it enters the discharge and loading chutes. These "spotters" should have a radio, telephone, or, at a minimum, a pull-rope emergency-stop switch within easy reach.

In severe cases, it may be necessary to shut the conveyor down, make any adjustments indicated, and reposition the belt before a new start-up is undertaken.

Training of Replacement Belts

A new belt—whether new belting on a new conveyor or a replacement belt on an established system—often has to be gradually "worn in" like a new pair of shoes. It is relatively rare to pull a new belt onto an existing conveyor, splice it together, push the conveyor's start button, and have the belt track down the middle of the structure. All new systems must be run for several hours before the final training of the belt to run in the idlers and stretch the belt.

Some new belts will tend to run to one side in one or more portions of their length because of a permanent camber or a temporary unequal distribution of tension arising from the storage, handling, or stringing of the belt. In many cases, operation of the belt under tension for a break-in period will correct this condition. Loading the belt to 60 percent capacity will help the belt fit the conveyor.

The conveyor structure may not be neutral to the new belt, particularly in the case of a new belt going onto an existing conveyor. If numerous training adjustments have been made over time to correct the mistracking of the previous belt, these adjustments may have to be "undone" to allow the new belt to track correctly.

Training Feeder Belts

Feeder belts are normally short, high-tension, slow-moving belts that use flat rollers or picking-style idlers on the carrying side. A square splice is critical for tracking on these belts, and the head and tail pulleys must be perfectly aligned. Training can be done on only the return, or slack, side of a feeder belt because of the construction and high loads on the carrying side. If needed, a single training device can be placed in the center of the return where there is some slack in the belt to allow the training device to function.

Training Reversing Belts

None of the techniques such as knocking or tilting the idlers is effective on reversing belts. Any correction made to track a reversing belt in one direction will have the opposite mistracking effect when the belt reverses. This makes reversing belts one of the most difficult belt-training challenges. Consequently, all idlers and pulleys must be in perfect alignment and the splice must be square to make the system as clean or neutral as possible. Only training devices designed for reversing belts should be installed.

HARDWARE FOR TRAINING THE BELT

Most conveyors need some tracking correction to account for unexpected or environment-induced belt wander. There are also occasions when the training procedure is not successful at providing a long-term solution to a mistracking problem. As a result, the operation is faced with repeating the training procedure on a frequent (sometimes daily) basis or installing some form of mechanical belt-training system to reduce this requirement. Engineered training solutions are devices that sense the position of a belt and, through a mechanism or geometry change, actively adjust the belt's path.

Belt Misalignment Switches

While not a corrective device, a belt misalignment switch is a hardware system that offers some control over belt tracking. These switches are electro-mechanical sensors that send a signal when activated by the mistracking belt. These switches are installed at intervals along the length of the conveyor on both sides of the belt near the outer limit of safe belt travel. When the belt moves too far in either direction, it pushes over the lever arm to activate a switch or send a signal interrupting the conveyor's power circuit, stopping the belt so the operator has the opportunity to make corrections (**Figure 16.21**). In many cases, plant personnel will need to walk the conveyor to manually reset the switch before operation can begin again. Some devices have the ability to send multiple signals: the first one an alarm indicating a pre-set amount of belt wander, and the second signal cutting drive power due to a more serious tracking problem.

Of course, the tripping of a belt misalignment switch is a signal indicating something is wrong with the conveyor system. It is like a light on a car instrument panel that shows red when the engine is too hot. It is possible to ignore this light, to reset the switch and resume conveyor operations, but both the car's warning light and the conveyor misalignment switch should serve as a warning that there may be more serious, more expensive, possibly catastrophic problems. Conveyor stoppages can be a nuisance and very costly; each outage creates downtime and lost production. Belt misalignment switches are not a solution to the problem of misaligned belts; they are an indicator of a severe problem.

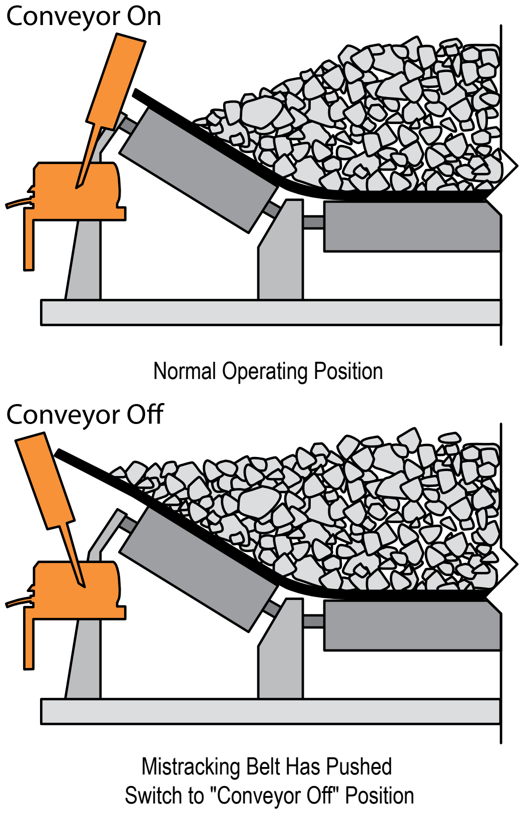

Figure 16.21

When the belt moves too far in either direction, the misalignment switch will activate a switch or send a signal interrupting the conveyor's power circuit, stopping the belt.

Figure 16.22

The first impulse may be to install some sort of barrier to keep the belt away from obstacles.

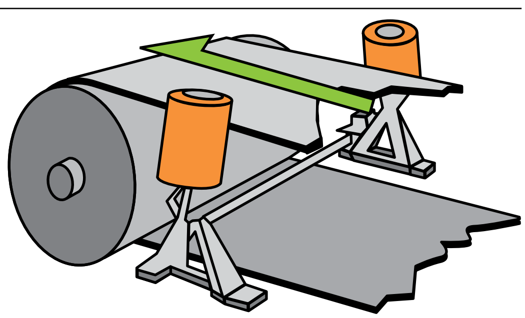

Figure 16.23

Vertical edge guides place a spool or roller on a simple frame close to the belt edge to keep the belt away from the conveyor structure.

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Passive Tracking Solutions

Vertical Edge Guides

The first impulse on seeing a wandering belt may be to install some sort of barrier to keep the belt straight, or at least keep it away from obstacles (**Figure 16.22**). One version of this simple approach to minor tracking problems is the vertical edge guide (**Figure 16.23**). These devices place a spool or roller on a simple frame close to the belt edge. The vertical edge guides are installed in a position approximately perpendicular to the belt's path to keep the belt edge away from the conveyor structure. These side guides do not train the belt. Rather than preventing belt wander, they perform a damage-control function, allowing the belt to strike a rolling surface rather than unyielding structural steel. Vertical edge guides are most effective on short, low-tension belt installations where the belt can be forced to stay in position through brute force on the edge of the belt. Vertical edge guides can allow severe belt or structure damage when the belt rides up over the guide into the structure or the guide causes the belt to roll over on itself. Vertical edge guides should not be used to compensate for persistent misalignment problems. They are not particularly effective on very thin belts.

"Vee" Idlers

Another hardware addition that can help remedy belt wander is the installation of "Vee" idlers on the belt return; they are becoming popular on longer, high-tension conveyors. They are available in two versions: traditional "Vee" rollers (**Figure 16.24**) and inverted "Vee" rollers (**Figure 16.25**). Both systems form the belt into a trough to assist in steering it into the center. They rely on a centering force to correct the belt path, so they place added stress on the belt, which can lead to damage. These systems are more expensive and require somewhat more maintenance than a conventional return idler.

"Crowned" Pulleys

Pulleys that have larger diameters at the center than at the edges are sometimes used to provide a centering effect (**Figure 16.26**). These "crowned" pulleys operate from the basic tracking principle, also. As the raised portion of the pulley (the crown) touches the belt first, it steers the belt into the center. The outer sections of the belt on both sides then produce a force driving it toward the center. If the belt is centered, these forces cancel each other out. If the belt misaligns and the belt wanders to one side of the pulley, the friction force will be greater on that side, acting to push the belt back toward the center.

Crowned pulleys are most effective on conveyors with short, low-tension belts. With higher-tension or steel-cable belts, little steering effect is obtained from the crown of the pulley. That is because the centering force created is smaller in magnitude than the forces of mistracking and most of the contact force between the belt and pulley is on the outer edges of the pulley due to the transition of the belt. Crowned pulleys are most effective where there is a long unsupported span—four times the belt width or greater—approaching the pulley. As this spacing is not often possible on the carrying side of the conveyor, the use of crowned head pulleys is relatively ineffective and may not be worth the stress it produces in the belt. They are somewhat more effective when used as a conveyor's tail pulley. *(See Chapter 6: Before the Loading Zone.)* Another problem with crowned pulleys is that they can create ineffective belt cleaning, because the cleaning blade(s) may not mate properly with the whole belt surface.

Dynamic Training Solutions

There are a number of dynamic belt-tracking systems: systems that when activated move a component to correct the belt path. These belt-training systems are designed to "self-align." That means the force of the mistracking belt causes an idler to reposition itself, creating a steering action that directs the belt back into the center.

As with adjusting fixed idlers, the correcting force of a skewed idler approaches a limit as the skew angle of the idler increases. All trainers will eventually reach this limit. It is more effective to stimulate quick, low-angle corrections of belt mistracking than to wait for one larger angle.

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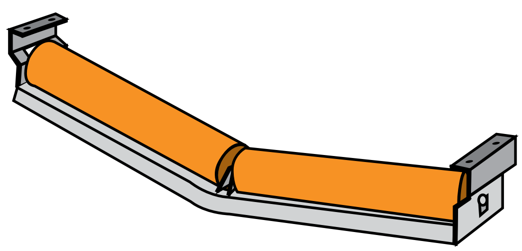

Figure 16.24

Traditional "Vee" idlers form a trough to keep the belt centered.

Figure 16.25

Although installed in an attempt to keep the return run of the belt in alignment, inverted "Vee" idlers risk damage to the belt.

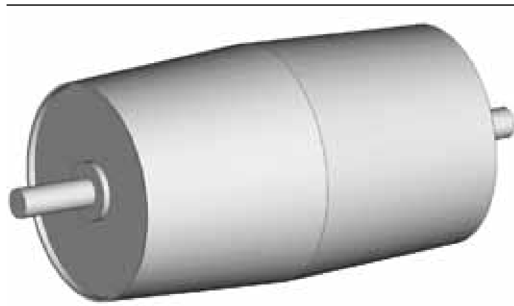

Figure 16.26

Pulleys with a "crown," or larger diameters at the center than at the edges, are sometimes used to provide a centralizing effect.

Many tracking solutions carry the seeds for their own destruction. Because they are designed to move to provide a correcting influence on the belt path, they are particularly vulnerable to the accumulations of fugitive material. Piles of spillage can block their range of motion or seize the pivot bearing (**Figure 16.27**). This can lock the belt-training idler into a position where it functions as a "misalignment" idler. It now pushes the belt out of the proper track, creating (or worsening) the problem it was installed to correct. To correct the now misaligned system, the maintenance crew may tie the training idler into (approximately) the right position (**Figure 16.28**). In such case, when a tracking solution is not capable of functioning properly, it is better to remove it, rather than to just "tie it off."

All these systems work under the disadvantage of being "after the fact:" They correct mistracking after it has occurred. A certain amount of wander must happen before the required correction can take place. But these systems do function as a form of insurance against a problem becoming so severe that the belt suffers costly damage before the mistracking can be discovered and corrected.

Figure 16.27

Piles of spillage can block a training idler's range of motion or seize its pivot bearing.

Figure 16.28

To correct a misaligned system, a training idler is sometimes "tied-off"—secured into what is thought to be the right position. But changes in conditions will likely render this position incorrect.

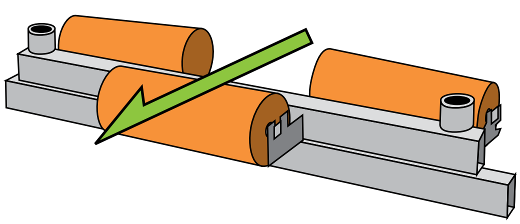

Figure 16.29

The in-line sensing-roll trainer has a carrying roll on a central pivot bearing with vertical guide rolls mounted on both sides of the belt in line with the roller.

In-Line Sensing-Roll Trainers

The simplest belt-trainer design, the in-line sensing-roll trainer, has a carrying roll in a framework mounted on a central pivot bearing (**Figure 16.29**). Vertical guide rolls that act as sensors to the belt's path are mounted on both sides of the belt in line with the roller, with their centerline running through the idler's pivot point. Movement of the belt against either of these sensing rolls causes that roll to move in the direction of the belt misalignment. This pivots the entire idler. In keeping with the basic rule of tracking that the belt always moves toward the side it contacts first, the pivoted idler then steers the out-of-track belt back to the proper path.

Yet these in-line sensing rollers have almost no leverage. They require considerable force from the edge of the moving belt to create a correction. With this design, the belt wanders from side to side; the correcting action is caused by the belt literally slamming into one side or the other. When the correcting action takes place, the idler may "kick over" with such force that the belt is then directed all the way over to the other side of the structure; the belt, in turn, contacts the roller on the other side of the tracking idler, which corrects the belt path back in the other direction. Because the tracking idler has a single, central pivot point, belt movement to one side brings the opposite guide roll into a hard, pinching contact against the belt, which can lead to edge damage. The belt can be kept constantly in motion, back and forth between the two sides, risking edge damage and overuse of the pivot bearing.

Leading Sensing-Roll Trainers

The most common belt-training design has a carrying roll (or troughing set) held in a framework that is mounted on a central pivot bearing (**Figure 16.30**). Guide rolls are mounted on short arms and positioned 25 to 75 millimeters (1 to 3 in.) from the belt on both sides. The rolls are positioned in advance of the pivoting roller; hence the designation leading sensing-roll trainers (**Figure 16.31**). Some designs tilt the pivot shaft slightly in the direction of belt travel to improve the sensitivity of the trainer. Leading sensing-roll trainers are available designed for use both on the upper (or carrying) side of the belt and on the lower (or return) side.

Movement of the belt against either guide roll causes the steering idler to pivot, correcting the belt path back toward the center. Again, as the belt always moves toward the side it contacts first, the pivoted roll steers the out-of-track belt back to the proper path.

Sensing rollers installed on short arms in advance of the steering idler have slightly more leverage than the in-line sensing idlers, but they still require considerable force from the belt edge to cause correction. Consequently, this trainer design suffers from all the delay, pinching, and fugitive-material problems of the in-line sensing idler.

The leading sensing-roll trainer is the most popular and most common tracking idler. It is supplied as original equipment on almost all new conveyors sold. It is typically installed at intervals of approximately 30 meters (100 ft) on both the carrying and return sides.

In the field, however, these trainers are commonly seen in two unsatisfactory conditions. The first condition is "frozen" from material accumulations or corrosion of the center pivot (**Figure 16.32**). This problem can be solved with better maintenance or a higher quality pivot point. The second condition is "tied off"— locked in place with a rope or wire—so the training device is the equivalent of a "knocked" idler (**Figure 16.33**). The reason these are "tied

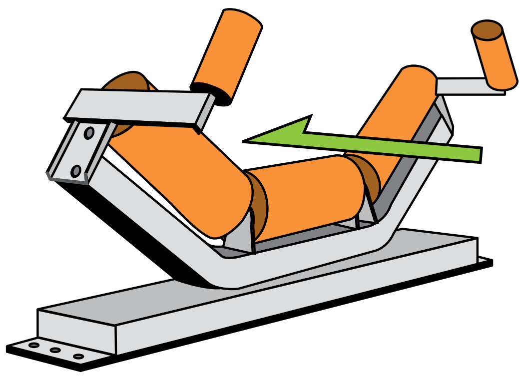

Figure 16.30

The most common belt-training design, the leading sensing-roll trainer, has a central idler mounted on a pivot bearing; guide rolls are positioned on short arms on both sides in advance of the positioning roller.

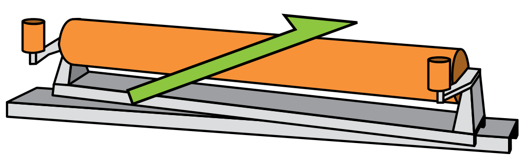

Figure 16.31

On a leading sensing-roll trainer, the guide rolls are mounted on short arms in advance of the pivoting roller.

Figure 16.32

Leading sensing-roll belt trainers are subject to material accumulation that can "freeze" the trainers in place.

Figure 16.33

To control erratic movement, belt trainers are often "tied off" or locked in place with a rope or wire.

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off" originates in the design. The sensing rolls swing in an arc about the center pivot; therefore, the rolls must be spaced far enough apart to not pinch the belt when the rolls reach extreme positions. As the pivot becomes fixed in position from material accumulation, lack of maintenance, or corrosion, the idler will not react until the belt has mistracked a distance equal to this wide spacing. Consequently, the idler oversteers and, therefore, becomes an unstable control system. The idlers often overreact, providing unpredictable results, and, as a result, they are frequently "tied off."

Torsion-Spring Trainers

The torsion-spring trainer is an improved version of the leading sensing-roll trainer (**Figure 16.34**). This system removes one sensing roll and incorporates a spring into the pivot (**Figure 16.35**). This spring keeps the one remaining sensing roll in contact with the belt edge at all times. As the belt mistracks in either direction, the idler will compensate by pivoting and steering the belt.

Figure 16.34

The torsion-spring trainer uses only one sensing roll that is in continuous contact with the belt.

Figure 16.35

The torsion-spring trainer incorporates a spring into its pivot point.

Figure 16.36

Multi-pivot belt trainers use a torque-multiplying system to supply a mechanical advantage to improve belt path correction.

These spring-loaded leading-sensor trainers tend to have the sensing rolls installed on long arms in advance of the steering idler. This creates more leverage and a greater mechanical advantage in converting belt wander into steering torque. There is no delay in reaction of this trainer, due to the fact that the sensing roll is in constant contact with the belt. There is also no pinching, because there is only one sensing roll. Because of the constant "fine-tuning" action of the idler, it is harder for fugitive material to accumulate to the point it can impede the pivoting action of the tracking device.

One drawback of this trainer is the fact that it cannot function with a troughed idler set. In addition, because the single roller is in constant contact with the belt, this roller is subject to more frequent replacement than those on leading sensing-roll trainers.

Multi-Pivot Belt Trainers

There is another belt-tracking system that uses the force of the wandering belt to position a steering idler and so correct the path. This device uses a multiple-pivot, torque-multiplying system to supply a mechanical advantage to improve belt-path correction (**Figure 16.36**).

This style of training device transfers the motion of mistracking to the steering idler through a unique parallel linkage (**Figure 16.37**). This requires less force to initiate the correction, and as it steers, it needs less force to turn the belt. Belt training becomes a continuous, active, precise fine-tuning of the belt path. This design is available in models for the troughed (or carrying side) or the return side of the conveyor (**Figure 16.38**).

This multiple-pivot training device uses guide rolls that are set very close—6 millimeters (1/4 in.) from the belt (**Figure 16.39**). With the rollers set at the edge of the belt, the device can sense smaller movements of the belt and make corrections after very slight misalignments. Rather than waiting for a powerful mistracking force, the multi-pivot belt-training device adjusts constantly, reacting to smaller forces and providing continuous, precise corrections of the steering roller.

The sensing rollers of the multi-pivot trainer use longer arms to increase the distance from the guide rolls to the steering idler. This allows the unit's torque arm to act as a force multiplier, increasing the mechanical advantage of the steering action. As a result, this belt-training system can correct the belt line with one-half the force required for conventional tracking idlers.

Unlike the other training devices, the multiple-pivot device is installed so the belt crosses the steering roller before it reaches the guide rollers (**Figure 16.40**). This means the guide rolls adjust the "corrected" belt path rather than the mistracking belt path. The result is a roller that is continuously working to prevent the belt from moving very far from the proper path. The multi-pivot design allows the rollers to move perpendicular to the structure's centerline while directing the steering idler to the proper angle, instead of pivoting and pinching the belt edge.

Variations of Multi-Pivot Belt Trainers

Several manufacturers have created a slight modification to the multi-pivot belt-training device (**Figure 16.41**). These use the same force amplification geometry, but the idler slides laterally as well as pivoting. With the sliding-idler system, the sensing roll has to overcome the resistance to pivoting as well as the friction force of trying to move an idler from under a belt. This greatly decreases the overall steering force of this training system.

Free-Pivoting Trainers

Manufacturers have developed training idlers in which the steering roll also serves as the sensing roll. With this design, there is a bearing in the center of the roll, so the ends of the roll can pivot around the axis of the roller as well as rotate. The pivot shaft is usually tilted in the direction of

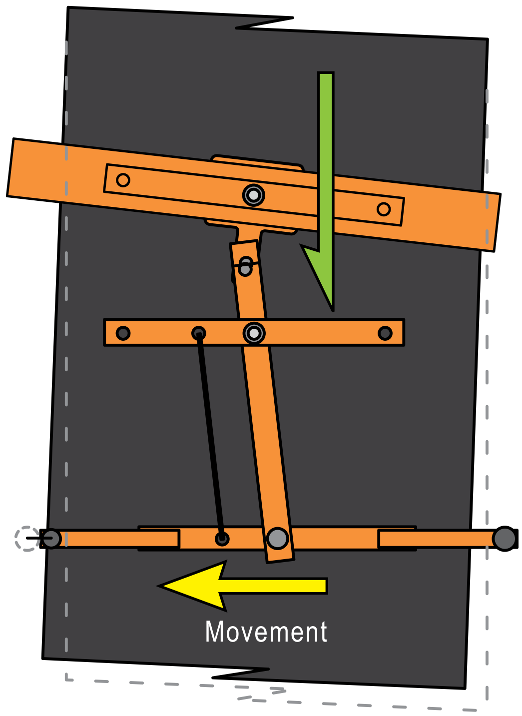

Figure 16.37

Because it transfers the motion of mistracking to the steering idler through a unique parallel linkage, the multi-pivot system requires less force to initiate the correction, and as it steers, it needs less force to turn the belt.

Figure 16.38

The multi-pivot trainer is available in models for the troughed (or carrying side) or the return side of the conveyor.

Figure 16.39

With the rollers set at the edge of the belt, the multiple-pivot training devices can sense smaller movements of the belt and make corrections after very slight misalignments.

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belt travel to improve the sensitivity of this type of training idler. Some manufacturers have used a rubber-covered tapered roll to improve the performance of this tracking solution (**Figure 16.42** and **16.43**).

When the belt wanders to one side of the roll, it creates a larger friction force on that side. The trainer's roll will pivot in reaction, moving in the direction that the larger force is pushing it. In accordance with the basic principle of belt steering, the pivoting roll will steer the belt back toward the center. When the belt is moving, the force on each side of the idler evens out, and the idler moves back into a position that is perpendicular to the path of the belt.

While this solution is effective and has very few moving parts, it still contains a complex bearing structure that is susceptible to airborne dust. As the forces that cause the unit to pivot are very small, the unit must be very free to pivot. Such freedom allows the unit to be influenced by many different environmental conditions, thus causing it to pivot when the belt is not wandering.

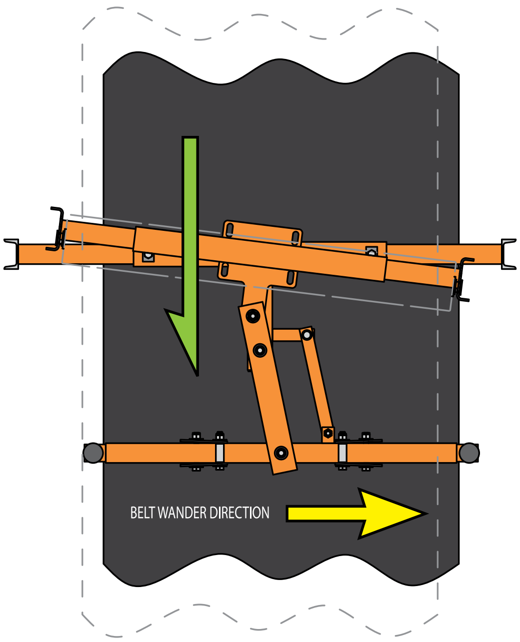

Figure 16.40

With the multiple-pivot training devices, the belt crosses the steering roller before it reaches the guide rollers. This way, the guide rolls adjust the "corrected" belt path rather than the mistracking belt path.

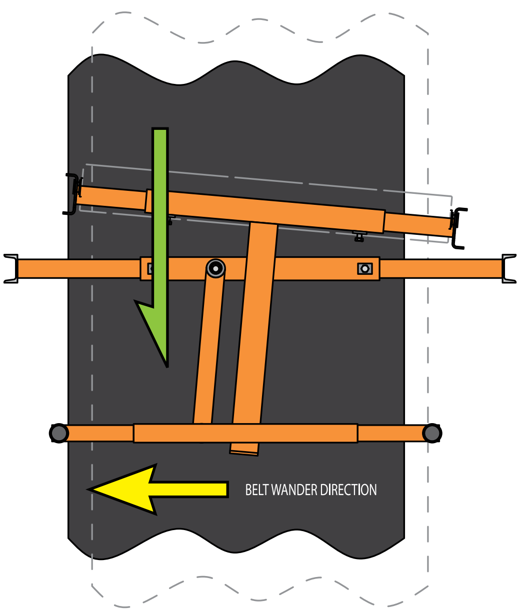

Figure 16.41

Some multi-pivot belt-training devices feature rollers that slide laterally as well as pivot.

Figure 16.42

Some manufacturers use a rubber-covered tapered roll to improve the performance of the free-pivoting trainer.

Trainers for Reversing Conveyors

Conveyors that run in two directions have always been the "last frontier" of belt tracking. With reversing conveyors, even experienced plant personnel are hesitant to adjust the idlers and perform the maintenance "tricks" typically used to train wandering belts. Conventional belt-training devices cannot be used, all for the same reason: because what works to centralize a belt's path when it runs in one direction may have the opposite effect when the belt direction is reversed. A pivoted idler that correctly steers the belt when the conveyor is operating in one way will work to mistrack a belt moving in the opposite direction.

Some manufacturers have developed trainers for reversing belts. The in-line sensing-roll trainers will correctly steer these belts, because the sensors are not direction dependent. The torsion-spring trainer can be modified to accommodate reversing belts. Adding a second arm and sensor in the opposite direction allows the torsion-spring trainer to switch sensing arms based on the direction of the belt movement (**Figure 16.44**).

These reversing trainers will have the benefits and shortcomings associated with their use on one-direction conveyors.

INSTALLATION OF BELT-TRAINING DEVICES

Training devices can be installed at any point the belt path needs adjustment. They should be installed approximately three to four times the width of the belt in advance of the point of the mistracking. The conveyor must be locked out / tagged out / blocked out / tested out before installing a belt trainer.

The typical places belt-training devices are installed include (**Figure 16.45**):

A. Just before the belt enters the tail pulley, to ensure it is centered on the pulley and into the loading zone

B. Shortly after the loading zone, to make sure the loaded belt is tracking in the center

C. Just before the discharge pulley, to make sure the belt is in the center before it enters the enclosure and discharges the cargo

Dynamic training devices can be installed over the entire length of conveyor, especially to cover any problems. Training devices may need to be installed to correct the path at any place the belt enters an enclosure. They should not be positioned so close together that they will "compete," or contradict each other's steering action. There should be 21 to 50 meters (70 to 150 ft) between units, depending on the severity of the mistracking problem (**Figure 16.46**).

Figure 16.43

A rubber-covered roll improves the performance of this belt-training device.

Figure 16.44

Adding a second arm and sensor in the opposite direction allows the torsion-spring trainer to be used on reversing belts.

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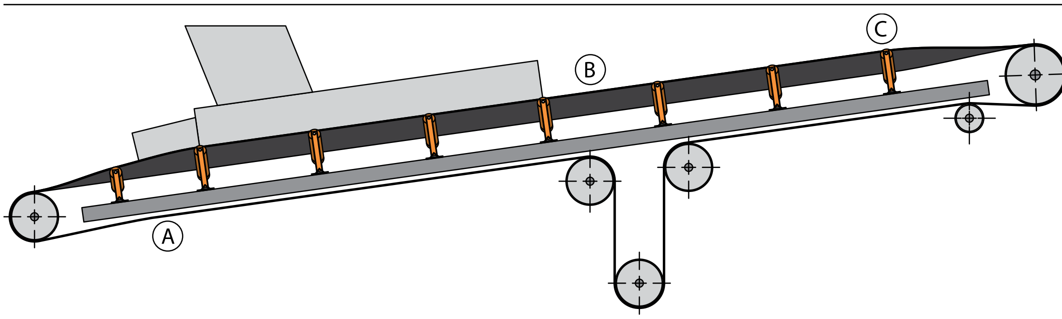

Figure 16.45

The typical places training devices are installed include:
A. Just before the belt enters the tail pulley
B. Shortly after the loading zone
C. Just before the discharge pulley

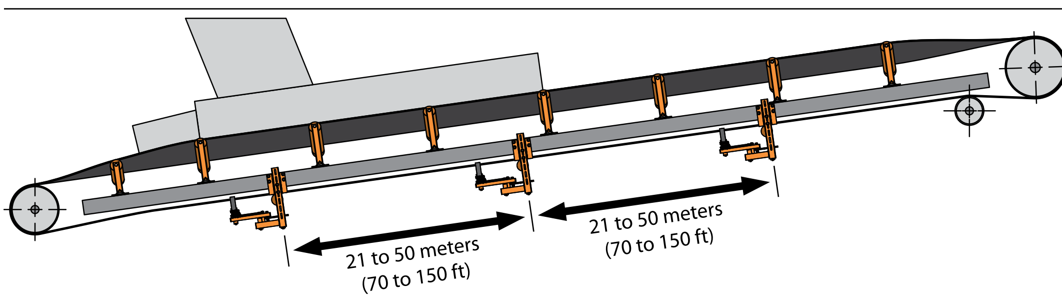

Figure 16.46

Belt trainers should be positioned from 21 to 50 meters (70 to 150 ft) apart to prevent them competing or contradicting each other's steering action.

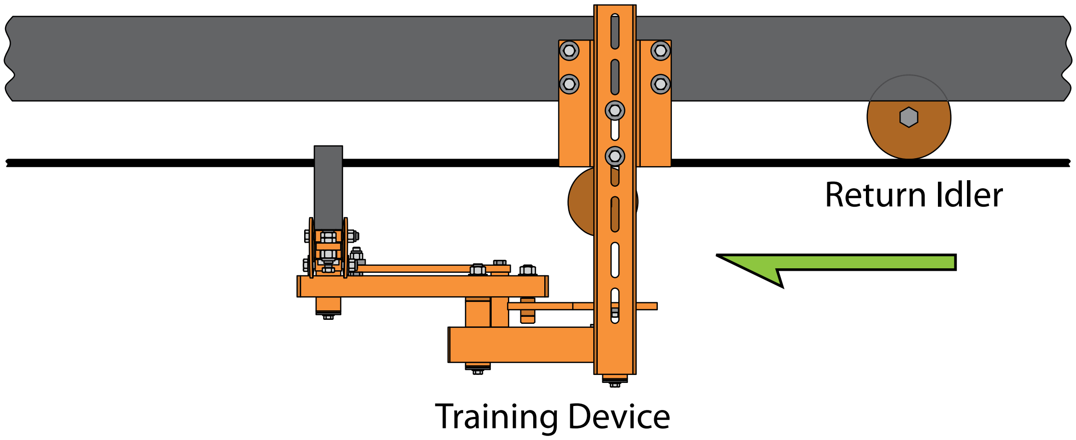

Figure 16.47

To improve the performance of return belt-tracking systems, a return idler can be installed before the device above the belt to increase the training idler's grip on the belt.

When installing any form of dynamic training device, the center roll is typically elevated 12 to 19 millimeters (1/2 to 3/4 in.) higher than the rolls of the adjacent conventional idlers. This increases the belt's pressure on the tracking device and improves the corrective action. This is applicable to both troughed (carrying side) and flat (return side) self-aligning idlers. Some training-idler manufacturers build this feature into their various models.

Another technique to improve the performance of return belt-training systems is to reinstall a conventional return idler upstream of the tracking device above the belt to push the belt down, increasing the pressure on the training idler, allowing it to work more effectively (**Figure 16.47**).

Rubber-covered rollers are often useful on belt-tracking devices, particularly where the material is slippery or the belt wet from the climate or the process. These rollers may require replacement more often than "steel can" rollers, but may be necessary to achieve the friction needed to steer the belt.

SYSTEM MAINTENANCE

Tracking a conveyor is a maintenance function. Because a belt is moving and under load, belt training is subject to problems/corrections, requiring on-going inspection and probably maintenance.

Once a belt is properly trained, an operation should include checks on its alignment as part of the on-going maintenance program. The belt's alignment should be reviewed on a regular basis, and minor corrections should be made as needed and documented.

Mechanical training devices should also be inspected regularly. Most mechanical training devices contain moving parts that are vulnerable to contamination. The devices should be inspected to determine that all parts are free to move and the device is still tracking the belt properly. *(See Chapter 27: Conveyor System Survey.)*

Maintenance personnel should look for conditions out of the ordinary or things that have changed that might affect belt

SAFETY CONCERNS

In some facilities, it is common to make adjustments to correct belt tracking while the conveyor is in operation. However, a responsible safety program will always recommend that the conveyor be locked out / tagged out / blocked out / tested out before making adjustments to components or the belt tension in order to correct mistracking. While adhering to this practice may require several shutdowns and start-ups of the belt to observe the effect of corrections, it is the safe way to train the belt.

alignment. Changes could be anything such as the addition of a new piece of equipment, a large dent in the structure where a piece of heavy equipment collided with the conveyor, or changes in material condition that affect loading patterns. As seen above, misalignment has many causes, and small disturbances can manifest in a major mistracking incident.

TYPICAL SPECIFICATIONS

Belt-Training Device

A. Belt trainer(s)

To control the path of the belt and prevent belt mistracking, one or more belt-training devices will be installed on the conveyor.

B. Belt-path correction

The belt-training devices will sense any mistracking of the moving belt and use the force of that mistracking to articulate an idler. This idler will steer the belt back into the center of the structure.

C. Location

To keep the belt centered in the conveyor loading zone, one belt-training device will be installed on the conveyor return as the belt enters the tail pulley. To make certain the loaded belt is centered properly, a second belt-training device will be installed at the exit end of the loading zone. Additional training devices will be located along the conveyor as required to correct belt wander.

ADVANCED TOPICS

Power Consumption and Belt Trainers

Any alteration in a conveyor's rolling equipment, from skewing idlers to installing special mechanical training devices, has implications for the system's power requirements.

There are several styles of training idlers, all designed to exert a centering force on the belt perpendicular to its direction of travel. This centering force must be considered in calculation of the power consumption of the conveyor.

Analyzing the power consumption of a training idler requires knowledge of the load on the idler. This load is due to the weight of the belt and any component of the belt tension arising from the idler misalignment. In operation, the typical training idler can pivot from 2 to 5 degrees. It is common practice to install training idlers 12 to 19 millimeters (1/2 to 3/4 in.) above the standard idlers. This results in greater load on these idlers, which creates enough centering force to influence the travel of the loaded belt. This extra load is described by The Conveyor Equipment Manufacturers Association (CEMA) in *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*, as idler misalignment load (IML).

When an idler is pivoted, it will exert a force on the belt in a direction perpendicular to the pivoted idler. This is called the

$$Tr = PIW \cdot BW \cdot \tan \phi$$

Given: *A 450-millimeter (18-in.) belt with a tension of 17,5 newtons per millimeter (100 lb_f/in.) travels over an idler that is pivoted 3,5 degrees.* ***Find:*** *The misalignment force due to the idler.*

Variables		Metric Units	Imperial Units
Tr	Misalignment Force	newtons	pounds-force
PIW	Belt Tension per Unit of Belt Width	17,5 N/mm	100 lb_f/in.
BW	Belt Width	450 mm	18 in.
ϕ	Idler Misalignment	3,5°	3.5°
Metric: $Tr = 17{,}5 \cdot 450 \cdot \tan 3{,}5 = 481$			
Imperial: $Tr = 100 \cdot 18 \cdot \tan 3.5 = 110$			
Tr	Misalignment Force	481 N	110 lb_f

Equation 16.1

Calculating Misalignment Force

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misalignment force and can be calculated (**Equation 16.1**).

The component of the misalignment force in the direction of belt travel is called the misalignment drag force and can also be calculated (**Equation 16.2**).

The misalignment drag force is used to find the power required to compensate for a tracking idler (**Equation 16.3**).

This additional power requirement should be multiplied by the number of tracking idlers installed.

It is interesting to note that an 1800-millimeter (72-in.) belt with 175 newtons per millimeter (500 PIW) slack-side tension would have a centering force of approximately 9640 newtons (2200 lb_f) and a centering force component in the direction of travel of approximately 589 newtons (134 lb_f). A tracking idler on this belt would require 1,177 kilowatts (1.6 hp) per tracking idler.

If the training idler becomes frozen and is neither rotating nor pivoting, it can add a substantial power requirement.

The power consumed by the tracking solutions should be considered when selecting a tracking solution. While some methods of training may be effective, the solution could draw more power than the drive of the conveyor can deliver. Most engineering companies include a healthy safety factor to account for unknowns such as this when designing a conveyor, but it is in an operation's best interest to verify its conveyor(s) have sufficient power to handle these increased loads.

Equation 16.2

Calculating Misalignment Drag Force

$$Tm = Tr \cdot \sin \phi$$

Given: *A misalignment force of 481 newtons (110 lb_f) and an idler pivot of 3,5 degrees.* ***Find:*** *The misalignment drag force.*

Variables		Metric Units	Imperial Units
Tm	Misalignment Drag Force	newtons	pounds-force
Tr	Misalignment Force *(Calculated in Equation 16.1)*	481 N	110 lb_f
ϕ	Idler Misalignment	3,5°	3.5°
Metric: $Tm = 481 \cdot \sin 3{,}5° = 29$			
Imperial: $Tm = 110 \cdot \sin 3.5° = 6.7$			
Tm	Misalignment Drag Force	29 N	6.7 lb_f

Equation 16.3

Calculating Power to Compensate for a Training Idler

$$P = Tm \cdot V \cdot f \cdot k$$

Given: *A misaligned idler exerts 29 newtons (6.7 lb_f) on a conveyor system. The belt is traveling at 2 meters per second (400 ft/min). The interface friction between the belt and the idler is 1.* ***Find:*** *The power added to the drive due to the training idler.*

Variables		Metric Units	Imperial Units
P	Power Added to Belt Drive	kilowatts	horsepower
Tm	Misalignment Drag Force *(Calculated in Equation 16.2)*	29 N	6.7 lb_f
V	Belt Speed	2,0 m/s	400 ft/min
f	Friction Coefficient	1,0	1.0
k	Conversion Factor	1/1000	1/33000
Metric: $P = \frac{29 \cdot 2 \cdot 1}{1000} = 0{,}058$			
Imperial: $P = \frac{6.7 \cdot 400 \cdot 1}{33000} = 0.081$			
P	Power Added to Belt Drive	0,058 kW	0.081 hp

BELTS IN THE REAL WORLD

In Closing...

In the real world, conveyor belts wander. But allowing a belt to chronically mistrack can lead to personal injury, release of fugitive materials, and belt and structural damage. However, training a belt without some knowledge of the effects of the training actions can result in increased energy usage, component failure, and belt damage.

There are a variety of self-aligning idlers that can help control belt tracking. But it is wise to note that conveyor operations should not depend on these training idlers to overcome gross misalignment of conveyor structure or significant and continuing loading problems. The continuous working of a training idler indicates more serious problems that should be identified and corrected. It is much better to discover what the real problem is and make the necessary corrections.

While belt wander is a complex problem, it can be controlled by systematically and proactively identifying the root causes of mistracking and eliminating them. Training a belt is a skill that takes time to learn and is best left to a qualified and experienced employee or specialty contractor.

Looking Ahead...

This chapter about Belt Alignment, the last chapter in the section Return Run of the Belt, explained how fugitive materials can cause belt mistracking and how, in turn, belt mistracking can cause increased fugitive material. The following chapter, Dust Management Overview, begins the next section about Dust Management.

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