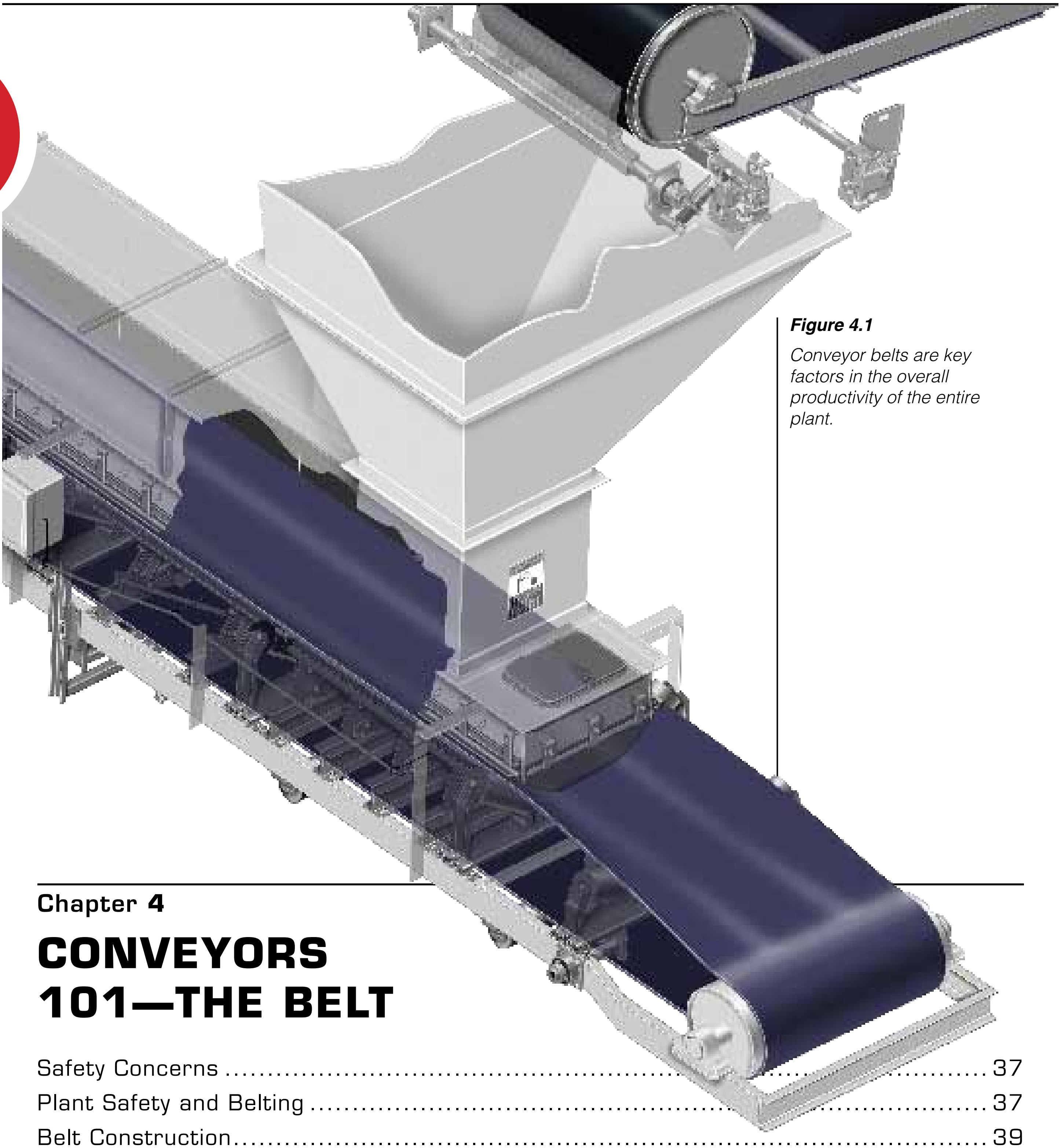

Figure 4.1

Conveyor belts are key factors in the overall productivity of the entire plant.

Chapter 4

CONVEYORS 101—THE BELT

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In this Chapter…

This chapter continues the discussion of the foundations of safe bulk-materials handling and the basics of conveyors by focusing on the construction and proper use of belts. Considerations for belt selection are included, along with the importance of proper storage and handling. In addition, various types of belt damage are discussed, as well as methods to repair and preserve the life of the belt.

A belt conveyor system is composed of many components; however, none is more important than the belt (**Figure 4.1**). The belting represents a substantial portion of the cost of the conveyor, and its successful operation may be the key factor in the overall productivity of the entire plant in which the conveyor is located. Therefore, the belting must be selected with care, and all possible measures should be employed to safeguard its usefulness.

This chapter focuses on the heavy-duty belting typically used in bulk-materials handling. The most common types of belting for bulk handling are made with covers of rubber or polyvinyl chloride (PVC) and an internal tensioning carcass of synthetic fabric or steel cables.

PLANT SAFETY AND BELTING

Conveyor Belt Fire Resistance

A conveyor belt fire is a significant risk. The belting itself can burn; however, it is the length and movement of the belt that poses risks that a belt can spread a fire over a great distance within a facility in a very short time.

Fires on conveyor belting are most commonly ignited by the heat generated from friction induced by a pulley turning against a stalled (or slipping) belt or by the belt moving over a seized idler. Other conveyor fires have occurred when hot or burning material is inadvertently loaded onto the belt. Best practices for minimizing the fire risk of any conveyor belt include:

A. Conducting regular belt examinations

B. Removing all accumulations of combustible materials along the conveyor belt

C. Correcting potential sources of fire such as seized rollers, overheated bearings, or belt misalignment

With this risk of fire, compounded by the toxic gases, thick smoke, and noxious fumes that can result from a conveyor fire, belting is regulated in those applications where

SAFETY CONCERNS

As with any moving machinery, the conveyor belt must be treated with respect and with the knowledge that it does cause injuries. There are a number of risks for personal injury from the conveyor belt that can lead to death or serious injury. Most of these concerns arise from the movement of the belt through the conveyor systems, such as contact burns and the risk of entrapment from contact with the moving belt. Particular care should be taken when observing a moving belt to look for damaged areas or check its tracking.

Rolls of belting are large and unwieldy and should be handled carefully. When transported, they should be secured so they cannot break loose, and they should be maneuvered with the appropriate equipment and safeguards.

Repairing a belt exposes workers to heavy lifting, sharp tools, and industrial chemicals. Appropriate lockout / tagout / blockout / testout procedures should be followed before beginning any work on or around the conveyor.

Appropriate PPE must be used, and manufacturers' procedures for handling chemicals must be followed.

these conditions are most dangerous—underground mining and, particularly, underground coal mining. Many countries replaced the earlier requirement for flame-retardant belting, belting that passes a smaller Bunsen Burner Test, by mandating the use of self-extinguishing belting in underground applications.

It should be noted that ALL conveyor belts will burn given sufficient heat and airflow. However, standardized laboratory tests have been accepted by governmental regulatory bodies to measure and categorize the burning characteristics of different conveyor belts. In very general terms, "self-extinguishing" is considered to be a belt that will not propagate a fire in a laboratory setting once the ignition source has been removed.

Self-extinguishing belting is higher in cost than flame-retardant belting. This cost premium is generally 10 to 50 percent, but it will vary depending on the carcass construction and cover gauges.

With the exception of the United States, fire-safety standards for conveyor belting are similar in the largest coal mining countries, including Australia, Canada, China, Germany, India, Indonesia, Poland, Russia, and South Africa. In Germany, for instance, strict requirements were implemented more than 30 years ago.

There are numerous international regulatory and advisory organizations and governmental agencies that provide guidance and direction. Those agencies include, but are not limited to: British Standards Institution (BSI), Conveyor Manufacturers Equipment Association (CEMA), Deutsches Institu für Normung (DIN), European Standards (EN), and the International Organization for Standardization (ISO).

The tests in these and most other countries include:

A. Drum Friction Test (DIN 22100 et. al)

The drum friction test measures whether the surface temperature remains under a required maximum after a specific time and under a specific tension. The test procedure simulates a belt slipping over a jammed pulley or a pulley rotating under a stationary conveyor belt. To pass this test, the surface temperature of the belting must remain below 325 degrees Celsius (617° F) with no flame or glow visible.

B. Surface Resistance Test (ISO 284/EN 20284/DIN 20284)

An electrostatic charge may build up on the conveyor belt surface and ignite a mixture of flammable gases and air. By keeping the surface resistance of the belting low (making the belt cover more conductive), the conveyor belt allows the charge to flow freely, eliminating the risk of sparks.

C. High-Energy Propane Burner Test (EN 12881)

To determine whether a conveyor belt will propagate fire, a belt sample 2,0 to 2,5 meters long by 1200 millimeters wide (80 to 100 in. by 48 in.) is ignited by a propane burner. After the ignition-source has been removed, the flames must self-extinguish within a certain amount of time, leaving a defined area of belt undamaged.

D. Laboratory Scale Gallery Test (DIN 22100 and 22118)

A specimen of belting 1200 millimeters long by 120 millimeters wide (48 in. by 4.8 in.) is placed over a propane burner. After the ignition source is removed, the flames must self-extinguish, and a defined undamaged length must remain.

In the United States, conveyor belt flammability standards can be considered less stringent than those used in other countries, because a total-system approach is taken to fire suppression. The US regulations include not only conveyor belting but air monitoring and motor-slip detection devices.

The present flame resistance requirement in the United States for applications for everything except underground coal mines, as published in the Code of Federal Regulations (CFR), is quite simple:

> Bunsen Burner Test. (CFR Part 30 Section 18.65)

A small (approximately 150 by 12 millimeters) (6 by ½ in.) piece of a belt is held over a Bunsen burner flame for one minute, after which time the flame is removed and an airflow applied for three minutes. After a set length of time, the duration of the flames is recorded. The average of four samples must not burn for more than one minute or exhibit afterglow for more than three minutes.

This test, which was implemented per the 1969 Federal Coal Mine Health and Safety Act, is similar to a standard for underground conveyor belts that was in force in Europe until the mid 1970's. However, with the advent of the more stringent regulations, flame-retardant belts have been allowed to be used in Europe only in applications above ground; self-extinguishing belts are required underground.

The United States now has a more stringent standard for flame-resistant belts in underground coal mines. In December 1992, the US Department of Labor, Mine Safety and Health Administration (MSHA), proposed a new rule for conveyor belt test requirements (Federal Register, Vol. 57, No. 248) that would bring safety standards up to the international level. Nearly ten years later, in July 2002, this proposed rule was withdrawn. The reasons cited for withdrawal were that the number of conveyor belt fires had significantly declined and that improvements in belt monitoring were being implemented.

Recommendations from the Mine Improvement and New Emergency Response (MINER) Act of 2006 resulted in a new rule for underground coal mines (CFR Part 30 Section 14.20) effective December 2008 that includes the Belt Evaluation Laboratory Test (BELT), a laboratory-scale flame resistance test based on the work done for the 1992 proposed rule. In order for a belt to pass the BELT method, it must have improved fire-resistant capability, which greatly limits flame propagation.

The test requires that three belt samples, approximately 152 by 23 centimeters (60 by 9 in.), be placed in a test chamber 168 centimeters (66 in.) long by 456 centimeters (18 in.) square. After applying the burner flame to the front edge of the sample for 5 minutes and the flame is extinguished, each tested sample must exhibit an undamaged portion across its entire width.

At the time of this writing, the final rule published by MSHA requires conveyor belts placed in service in underground coal mines to be more flame resistant than those previously required beginning December 31, 2009. The rule also requires existing belting to be replaced within ten years. MSHA or a reputable belting supplier can be contacted for additional, updated information.

Other Belting Safety Concerns

Other standards are sometimes in place. Some countries have even more stringent requirements regarding, for example, the belt's toxicity, hygiene, or cover roughness. The exact specifications can be found in the standards in a given geographic region or industry. Procedures and standards are offered under DIN, EN, ISO, BSI, CEMA, and other standards. Of course, it is imperative that the belting be compatible with the materials to be transported on it.

BELT CONSTRUCTION

The Belt Carcass

Conveyor belting is composed of two parts: the inside carcass and the outside covers. The carcass is the most important structural section of the belt, as it contains the tensile member to handle the load of cargo carried on the conveyor. The primary purpose of the carcass is to transmit the tension necessary to lift and move the loaded belt and to absorb the impact energy unleashed by the material as it is loaded onto the belt. No matter what belt-support system is employed, if the belt carcass cannot handle the initial impact energy, the belt will fail prematurely. The carcass must be adequate to allow proper splicing techniques and strong enough to handle the forces that occur in starting, moving, and stopping the loaded belt. The carcass also provides the stability necessary for proper support between idlers and for maintaining alignment.

Most carcasses are made of one or more plies of woven fabric, although heavy-duty belting may incorporate parallel steel cables to replace some or all of the fabric. Carcass fabric is usually made of yarns woven in a specific pattern. The yarns that run lengthwise, parallel to the conveyor, are referred to as warp yarns and are the tension-bearing members. The transverse or cross fibers are called weft yarns and are primarily designed for impact resistance, mechanical fastener holding, load support, and general fabric stability.

Years ago, conveyor belts typically used yarns made of cotton as the textile reinforcement. For improved cover adhesion and abuse resistance, a breaker fabric was often placed between the cover and the carcass. Throughout the 1960s and 1970s, carcass reinforcements underwent a change. Today, most belt carcasses are made with manmade fabrics such as nylon, polyester, or a combination of the two. These fabrics are superior to the older natural fabrics in nearly all respects, including strength, adhesion, abuse resistance, fastener holding, and flex life. Presently, fabrics incorporating aramid fibers are used for some applications in conveyor belting. The aramid fabrics offer high strength, low elongation, and heat resistance. Breaker fabrics are rarely used with these man-made fabrics, because little or no improvement is achieved.

Carcass Types

There are four types of belt carcasses:

A. Multiple-ply belting

Multiple-ply belting is usually made up of two or more plies, or layers, of woven cotton, rayon, or a combination of these fabrics, bonded together by an elastomer compound. Belt-strength and load-support characteristics vary according to the number of plies and the fabric used. The multiple-ply conveyor belt was the most widely used belt through the mid-1960s, but today it has been supplanted by reduced-ply belting.

B. Reduced-ply belting

Reduced-ply belts consist of carcasses with either fewer plies than comparable multiple-ply belts or special weaves. In most cases, the reduced-ply belt depends on the use of higher-strength synthetic textile fibers concentrated in a carcass of fewer plies to provide higher unit strength than in a comparable multiple-ply belt. The technical data available from belt manufacturers generally indicate that reduced-ply belting can be used for the full range of applications specified for multiple-ply belting.

C. Steel-cable belting

Steel-cable conveyor belts are made with a single layer of parallel steel cables completely embedded in the rubber as the tension element. The carcass of steel-cable belting is available in two types of construction. The all-gum construction uses only the steel cables and rubber; the fabric-reinforced construction has one or more plies of fabric above and/or below the cables but separated from the cables by the cable rubber. Both types have appropriate top and bottom covers. Steel-cable belting is produced using a broad range of cable diameters and spacing, depending primarily on the desired belt strength. Steel-cable belting is often used in applications requiring operating tensions beyond the range of fabric belts. Another application is on conveyors where, due to limitations in the distance the take-up system can travel, the belting cannot be allowed to stretch significantly.

D. Solid-woven belting

This type of belting consists of a single ply of solid-woven fabric, usually impregnated and covered with PVC with relatively thin top and bottom covers. The surface of PVC belts is often rough on purpose to aid in conveying on inclines, but the rough surface makes belt cleaning more difficult. The abrasion resistance of PVC is lower than rubber, so some solid-woven belts are made with a combination of a PVC core and rubber covers.

Top and Bottom Covers

Covers protect the carcass of the belt from load abrasion and any other conditions that could contribute to belt deterioration. The top and bottom covers of the conveyor belt provide very little, if any, structural strength to the belt. The purpose of the top cover is to protect the carcass from impact damage and wear. The bottom cover provides a friction surface for driving and tracking the belt. Usually, the top cover is thicker than the bottom cover and more durable for abrasion, impact damage, and wear, due to its increased potential for damage. Abrasion and cutting may be so severe that a top cover as thick as 18 millimeters (0.75 in.) or more is required. In any case, the goal of cover selection is to provide sufficient thickness to protect the carcass to the practical limit of carcass-life.

The covers can be made of a number of elastomers, including natural and synthetic rubbers, PVC, and materials specially formulated to meet special application requirements such as resistance to oil, fire, or abrasion.

Users might be tempted to turn a belt over when the carrying side has become worn. In general, it is better to avoid inverting the belt after deep wear on the top side. Turning the belt over presents an irregular surface to the pulley, resulting in poor lateral distribution of tension, and may lead to belt wander. Another problem is that there may be cargo fines embedded into what was formerly the belt's carrying surface; when the belt is turned over, this material is now placed in abrasive contact with pulley lagging, idlers, and other belt-support systems. In addition, after years of being troughed in one direction, the belt tends to take a "set" (a predisposition to a direction) and will resist the necessary reversing of trough needed to invert the belt. Sometimes this can take weeks to overcome and can lead to belt-tracking problems.

A specific mention must be made of the practice of some belting manufacturers of stamping their logo into the carrying surface of the belt (**Figure 4.2**). Even when near the belt edge, this recessed area becomes a trap for conveyed material, and the roughness of the area can abuse the belt-cleaning and sealing systems under which the embossed area will pass. It is recommended that users specify that these supplier logos be positioned on the return, non-carrying side of the belting.

Aspect Ratio

Whereas some belts have the same cover thickness on both sides, most belts are fabricated with the pulley-side cover somewhat thinner (lighter in gauge) than the carrying side of the belt, because of the difference in wear resistance needed. The difference in thickness between the top and bottom covers is referred to as a belt's aspect ratio. However, the difference in thickness between the two covers cannot be too great, or the belt may cup.

Figure 4.2

It is a bad practice for the belt manufacturer to emboss a logo into the carrying side of the belt, because carryback can become entrapped in the logo.

The problem with belts with poorly-designed aspect ratios is that the larger mass of rubber will shrink more than the smaller. Consequently, if a belt has an inordinately large top-to-bottom cover ratio, and the top cover shrinks due to age, exposure to ultraviolet light, or other factors, the belt will cup up, reducing the area of the bottom cover in contact with the idlers. This will make it more difficult to keep the belt running in alignment. This problem is most likely to occur when, in the interest of getting a thick top cover to extend service-life, a plant orders belting with a top cover that is too thick for the bottom cover. To provide consistent shrinkage and more consistent tracking, an aspect ratio of 1.5-to-1 is recommended for belts up to 900 millimeters (36 in.), with a 2-to-1 aspect ratio recommended for belts from 1000 to 1600 millimeters (42 to 60 in.). For belts above 1600 millimeters (60 in.) a 3-to-1 aspect ratio is recommended. Belting with a 3-to-1 aspect ratio is suitable for many purposes and is the ratio mostly commonly stocked at belting distributors.

Cleats, Ribs, Chevrons, and Lugs

Raised elements are sometimes used on a belt surface to assist in the carrying of material (**Figure 4.3**). These cleats, ribs, chevrons, and lugs are generally used to allow a conveyor to carry material at a higher angle of incline than would generally be possible with a flat belt. This is particularly useful with lumps or stones that could easily roll down an unobstructed incline.

Figure 4.3

Cleats, ribs, chevrons, and lugs are raised elements in a belt's surface that allow it to carry material at a higher angle of incline.

Cleats, or ribs, can be seen as walls or shelves installed perpendicular to the lines formed by the belt edges. Chevrons are in a V-shaped arrangement. Lugs are individual "islands" or pillars in the belt's surface. All are available in a variety of patterns and styles, with heights determined by the application. They can be molded integrally into the surface during the belt's original manufacture, or they can be bolted or vulcanized to the surface of the belting.

Bear in mind that the taller the cleats, ribs, chevrons, or lugs are, the more vulnerable they are to damage and the harder the belt is to clean and seal.

One way to increase traction between the belt and the conveyed material is to use a top cover that features inverted chevrons. Instead of extending above the belt cover, inverted chevrons are recessed into the top cover, like the tread on a tire. The grooves are cut into the belt cover with a router; the grooves can be at a chevron angle or straight across the belt 90 degrees to the edge. This design allows greater success in cleaning and sealing the belt with traditional systems, although it is possible to fill the recessed cleats with material.

Grades of Belting

Various national and international bodies have established rating systems for the belting used in general-purpose bulk-materials handling. Designed to provide a reference for end users as to what grades to use in different applications, the ratings specify different laboratory-test criteria without providing any guarantee of performance in a specific application.

In the United States, the Rubber Manufacturers Association (RMA) has established two standard grades of belting covers. RMA Grade I belting meets higher rubber tensile and elongation requirements, typically indicating improved cut and gouge resistance over the performance of Grade II covers. It should be noted that grade rating does not necessarily denote overall abrasion resistance.

The International Organization for Standardization (ISO) has similarly established a grading system under ISO 10247. This standard includes Category H (Severe Cut and Gouge Service), Category D (Severe Abrasion Service), and Category L (Moderate Service). Category H is roughly comparable to RMA Grade I; Categories D and L approximate RMA Grade II belting.

In addition, there are belting types manufactured to meet specific requirements of stressful applications, such as service with hot materials, in underground mines, or with exposure to oil or chemicals. As with most things, it is best to acquire an understanding of the operating conditions and then consult with reputable suppliers before selecting categories of belting.

Abrasion Resistance in Belting

There are two types of abrasion that occur on conveyor belts. One is caused by the material rubbing against the belt cover. As a woodworker sanding an object, this wear is relatively even under the influence of the material pressing against the surface. The actual rate of abrasion will depend on the nature of the material, as modified by the density of material loading and the speed of the belt. This is called impingement damage.

A more aggressive form of abrasion is the damage to the surface by sharp-edged materials that cut or gouge the belt. This is generally called impact damage.

There are two types of tests used to measure belt-cover wear. One is the ISO 4649 Types A and B Abrasion Test Methodology (formerly DIN 53516). This test uses a sample of the rubber cover and holds it against a rotating abrasive drum for a fixed interval. The cover sample is weighed before and after to calculate volume loss. The lower the number (the less material lost), the more resistance to abrasion.

A second method of testing is the Pico Abrasion Test, also referred to by the American Society for Testing and Materials (ASTM) as ASTM Test Method D2228. In this test, tungsten carbide knifes are used to abrade a small sample of the belt cover. As above, the sample is weighed before and after the procedure, and the weight loss is calculated. Results are given as an index, so the higher the number, the better the abrasion resistance.

Most references caution that neither test should be seen as a precise prediction of actual performance in field applications.

New Developments in Belting

A recent innovation is the development of energy-efficient belt covers. Called Low Rolling Resistant (LRR) Covers, these bottom covers reduce the tension required to operate the belt, because there is less roller indentation resistance as the belt moves over the idlers. According to manufacturers, this belting can produce operating energy consumption savings of 10 percent or more. The savings occur where the rubber belting meets the conveyor system’s idlers. The energy-efficient cover has less rolling resistance, because the bottom cover returns to a flat configuration more quickly than conventional belts, which deform as they go over the conveyor’s rolling components.

The manufacturers note that the benefits of this energy-efficient cover can best be realized on long horizontal conveyors utilizing wide, fully-loaded belts carrying high-density material, where the friction of the system is dominated by idler-related resistances. The LRR compound is at a premium cost over other cover compounds. However, on those installations where the benefits can be fully realized, the compound compensates for its additional expense through a reduction in power costs and, on new systems, by allowing the conveyor to be equipped with smaller motors, pulleys, gear boxes, shafts, bearings, idlers, and steel structures.

Users cannot assume that an LRR cover will reduce operating expenses, nor can they just specify LRR, as each belt is compounded for a specific application. The relationship between the power consumption with an LRR belt and temperature conditions is not linear, and there is typically a small window of application. A specific LRR bottom cover designed to save energy at 20 degrees may cost more to operate at 0 or 30 degrees, so each belt must be designed for the climate conditions of each application.

Another new development in belt construction is the use of non-stick belt covers, to prevent belt-borne carryback. This belting is created by applying a non-stick coating to the belting to prevent the accumulation of carryback material on the belt. This coating should reduce the need for belt cleaning, thereby extending belt-life by reducing cover wear. This coating is also resistant to oil and grease and unaffected by weathering and aging. It should be noted that conventional belt cleaners (scrapers) should be removed if using non-stick belting, as the “cleaning edge” of even “soft” urethane pre-cleaners might remove the coating.

Conveyors are designed as a system, and any changes from the original belt specification can adversely affect the operation of a conveyor. Belting manufacturers should be consulted to determine which belting type is most appropriate for any application.

Cut Edge or Molded Edge

There are two methods to create the edges on a belt: molded edges or cut edges.

A molded-edge belt is manufactured to the exact width specified for the belt, so the edges of the belt are enclosed in rubber. As a result, the carcass fabrics are not exposed to the elements. Because a molded-edge belt is made for a specific order, it will probably require a longer lead-time and is generally more costly than a cut-edge belt.

A cut-edge belt is manufactured and then cut or slit down to the specified width required to fulfill the order. Using this method, the manufacturer may hope to fill two or three customer orders out of one piece of belting produced. As a result, this makes cut-edge belting more cost-effective (hence economical) to manufacture, so this type of belt has become more common. The slitting to the specified width may occur at the time of manufacture, or it may be done when a belt is cut from a larger roll in a secondary operation, either at the manufacturer or at a belting distributor.

A cut-edge belt can be cut down from any larger width of belting. This makes it more readily available. However, there are some drawbacks. At the cut edge(s) of the belt, the carcass of the belt is exposed; therefore, the carcass is more vulnerable to problems arising from abusive environmental conditions in storage, handling, and use. In addition, the slitting process is vulnerable to problems. Dull slitting knives can lead to problems such as belt camber—a curve in the edge of the belt. In addition, there are the unknowns that come with buying used or re-slit belting, including its age, environmental exposure, and application history.

Steel-cable belting is manufactured to a pre-determined width, so it has molded edges. Fabric-ply belting is available with either a molded edge or a cut edge.

BELT SELECTION

Specifying a Belt

The selection and engineering of the proper belting is best left up to an expert, who might be found working for a belting manufacturer or distributor or as an independent consultant. A properly specified and manufactured belt will give optimum performance and life at the lowest cost. Improper selection or substitution can have a catastrophic consequence.

There are a number of operating parameters and material conditions that should be detailed when specifying a conveyor belt. Material conditions to be detailed include:

A. Thickness

Limit variations in thickness to a sliding scale of +/– 20 percent for thin covers such as 2,4 millimeters (0.094 in.), and +/– 5 percent for cover gauges greater than 19 millimeters (0.75 in.).

B. Camber or bow

Limit camber or bow to one-quarter of one percent (0.0025). This allows a camber or bow dimension of +/- 25 millimeters in 10 meters (0.75 in. in 25 feet). Camber is a convex edge of the belt; bow is a concave edge of the belt. RMA defines bow (and camber) as the ratio of the distance, midway between two points along the belt edge that are 15 to 30 meters (50 to 100 feet) apart, between the actual belt edge and a tape or string stretched straight between the two points. To express this in percent, calculate the ratio in hundredths and multiply by 100. For example, if 30 meters of belting was out of true by 450 millimeters (by 0,45 meters), this would equal a camber of 1.5 percent. In Imperial measurements, a distance of 18 inches (1.5 ft) over 100-foot length of belting would be a 1.5 percent camber.

C. Belt surface

Specify the belt surface to be smooth, flat, and uniform +/- 5 hardness points. Hardness is measured in the United States in Shore A Durometer. Readings range from 30 to 95 points—the higher the durometer number, the harder the compound. The International Rubber Hardness Degrees (IRHD) scale has a range of 0 to 100, corresponding to elastic modulus of 0 (0) and infinite (100), respectively.

D. Manufacturer's mark

Require the manufacturer's mark to be eliminated or molded into the bottom rather than the top cover, where it will not interfere with belt cleaning and sealing systems.

Operating parameters to be detailed when specifying a conveyor belt include:

A. Hours of operation loaded and unloaded
B. Details of the transfer point, including trough angle and transition distance, as well as information on material trajectory, drop height, and speed
C. Description of material to be handled as completely as possible, including lump sizes and material temperature range
D. Description of belt-cleaning system to be used
E. Description of chemical treatments (e.g., de-icing agents or dust suppressants) to be applied
F. Description of atmospheric contaminants (from nearby processes or other sources)
G. Specification of local weather extremes that the belt must withstand

Know Your Structure, Know Your Belt

Placing any belt on a conveyor structure without understanding the characteristics of the belt will impair the performance of the system and reduce the performance of the belt. There can be problems in the form of mistracking, shortened belt-life, damaged splices, unscheduled downtime, and added maintenance expenses.

A detailed analysis of the conveyor structure and rolling components is required to ensure that the belt used on the system is the right choice. It is recommended that all parameters be fully understood prior to selecting and installing a belt on an existing structure. It is always wise to consider the advice of belting suppliers.

Compatibility with Structure and Rolling Components

Buying belting is like buying clothing. To fit best, it must be tailored to the existing construction. Conveyor belts are designed for different capacities, lengths, widths, trough angles, and tensions. A belt must be compatible with the conveyor structure, and there is more to compatibility than belt width.

Unfortunately, this is not commonly understood at a plant's operating level. Too often, there is a "belting is belting" philosophy in place. This originates from an incomplete understanding of the complexity of the belting equation. This philosophy becomes practice at times when there is a need to economize or to provide a faster return to service. The typical response in these cases is to use belting from stock, either a leftover piece or a spare belt found in maintenance stores, or to use belting readily available from an outside source, like a belting distributor or a used-equipment dealer.

It is a false economy to use a "bargain" belt that is not fully compatible with the conveyor system. Incompatibility of belt to structure is a common problem leading to poor belt performance and a poor return on the belting investment. This incompatibility could well be the most common cause of the tracking problems seen on conveyors where a replacement belt has been installed or pieces have been added to the existing belting. Understanding the basics of compatibility is essential to ensuring good performance of the belt and conveyor.

Specifying a conveyor belt is an important undertaking. It is in an operation's best interest to allow an expert to take ownership of this part of the conveyor process. This expert will be familiar with the capabilities of the belts provided by manufacturers and know the proper questions to ask.

Belt-Tension Rating

Each belt is rated as to its strength—the amount of pulling force that it will withstand. The strength of a belt (or more accurately, the tension it is able to withstand) is rated in the United States in Pounds per Inch of Width, commonly abbreviated as PIW. In other parts of the world, the belt is rated in ultimate breaking-strength in the metric units of newtons per millimeter (N/mm) or kilonewtons per meter (kN/m).

The strength rating is a function of the reinforcement included in the carcass of the belt and the number of, and type of, material in the fabric plies, or, if it is a steel-cable belt, the size of the cables. As noted above, a belt's top and bottom covers provide very little of the belt's strength or tension rating.

The belt's strength, either carcass tension rating or ultimate breaking-strength, represents the amount of force that can be applied to the belting. Putting greater demands in the form of material load, take-up weight, and incline gravity against this belt would cause severe problems, including the possibility of breaking the belt. The higher the rated tension of the belt, the more critical the compatibility of the belt with the structure and rolling components becomes.

Each conveyor structure will require a belt with a specific tension rating. Factors affecting this decision are:

A. Length of structure
B. Incline angle of the conveyor
C. Desired capacity
D. Width of belt
E. Drag and inertia of rolling components

Minimum Bend Radius

Belting is designed with a minimum pulley size specified by the manufacturer. Bending a belt over a radius that is too small can damage the belt. This may result in separation of plies, ply failure, or cracking of the belt's top cover. Inadequate pulley size can also lead to the pullout of mechanical splices. The minimum pulley diameter is determined by the number and material of plies, whether steel or fabric-reinforced, the rated tension of the belt, and the thickness of the top and bottom cover.

When a conveyor system is originally designed, the desire to use a thicker belt on a conveyor system (to extend belt-life in the face of high impact levels in the loading zone, for example) may require the installation of larger-diameter pulleys.

A common mistake occurs when an operation notices some type of surface damage to the carrying side of the belt. The immediate reaction is to install an even thicker belt on the conveyor in the expectation of getting a longer service-life. If the thicker belt has a minimum pulley size that is larger than the pulleys on the structure, the belt may actually yield a shorter life, worsening the problem the thicker cover was selected to solve.

Trough Angle

Belts are troughed to allow the conveyor to carry more material. As the trough angle is increased, more material can be carried. All flat rubber or PVC belts can be formed into a trough by idlers. The type of belt carcass, the thickness of the belt, the width of the belt, and the tension rating of the belt determine the maximum trough angle. On belting manufacturers' technical data sheets, troughability is typically shown as the minimum belt width allowed for the various trough angles.

Exceeding the maximum trough angle of a particular belt can cause the belt to permanently deform into a cupped position. Cupping can make a belt difficult to seal, difficult to clean, and almost impossible to track. As the cupping increases, the surface contact between the conveyor's rolling components and the belt is reduced, diminishing the ability of the rolling component to steer the belt properly.

If the belt's troughability is exceeded, the belt may not form the trough correctly, creating sealing and tracking problems. If a belt is too stiff and will not properly trough, it will not steer (track) properly through the system. This will quickly evolve into spillage off the sides of the conveyor and damage to the edges of the belt (**Figure 4.4**).

Another problem that may occur if the belt's troughing capability is exceeded is damage to the top and bottom covers and to the carcass in the idler-junction area.

In addition, if the belt's troughability is not compatible with the troughing idlers, it might take more power to operate the conveyor than originally designed.

Transition Distance

The belt travels across the tail pulley in a flat position. As the belt leaves the tail pulley and moves into the loading zone, the belt edges are elevated, forming the trough

Figure 4.4

Exceeding its troughing capability can result in damage to the belt.

Figure 4.5

Transition idlers are used to raise the belt edges and form the trough that carries the cargo.

Figure 4.6

Junction-joint failure is caused by an improper transition distance (center of terminal pulley to first full troughing roll).

where the material is carried (**Figure 4.5**). This trough is formed with transition idlers—idlers set at angles between flat and the conveyor's final trough angle.

There is a similar, but reverse, transition area at the conveyor's head pulley, where the conveyor is taken from a troughed to a flat profile just before it reaches the discharge point.

As the belt is formed into a trough, the outer edges of the belt are stretched more than the center of the belt. If the transition is made over too short a distance, damage may occur in the idler-junction areas of the belt—the points over the intersection between the flat central roller and the angle wing roller (**Figure 4.6**).

It is common to see a conveyor that has a transition area that is shorter than what is required. There are a number of reasons for this: faulty engineering or failure to understand the importance of transition, lack of space, or desire to reduce costs. So it is even more critical not to increase the problem by applying a replacement belt that requires a longer transition distance.

Figure 4.7

Belting should be rolled carrying side out on a core with a square opening.

Figure 4.8

Storing conveyor belting on the ground is a bad practice that can lead to damage.

It might be possible to lengthen a conveyor's transition area. There are two ways to do this. One is moving the tail pulley back to extend the distance before the load zone. The second method is adapting a two-stage transition area, where the belt is partially troughed before it enters the loading zone and then completes its transition to the final trough angle after the cargo has been loaded. *(See Chapter 6: Before the Loading Zone.)*

More commonly, however, circumstances, such as lack of available space and limits of available budget, preclude lengthening a conveyor's transition area. The most common solution is to make sure the belting is suitable for the existing transition distance. It may not be the most economical solution when all costs—such as loading problems, increased edge tension, and belt damage—are included. A poorly designed transition area will increase costs and decrease the life of the belt.

BELT STORAGE AND HANDLING

The conveyor belt has long been the most economical and most efficient form of bulk-materials handling for many industries. However, if this important part of the plant is to perform as expected, it must be carefully stored and handled from the time of its manufacture until the time of its installation on the conveyor system. Improper storage techniques can lead to a damaged belt that will perform poorly when installed on the conveyor structure. As the length of storage time increases, and as the size of the roll of belting increases, so does the importance of following the correct procedures. The costs for handling, shipping, and storing the conveyor belt are minor compared to the purchase price of the belt; therefore, the correct procedures should be followed to protect the investment.

The following are the key storage and handling guidelines:

A. Rolled on a core

As the belt leaves the manufacturer or the supplier, the belt should be rolled carrying side out on a core with a square opening (**Figure 4.7**). The core gives the belt protection from being rolled into a diameter that is too small and protection when the belt is lifted through the center. It also provides a means for unrolling the belt onto the conveyor. The core size is determined by the manufacturer, based on the type, width, and length of the roll of belt. The core size can be smaller than the belt's minimum pulley diameter, as the rolled belt is not in a tensioned state. The lifting bar should be square to closely match the square opening in the core.

B. Properly supported

The conveyor belt should never be stored on the ground (**Figure 4.8**). Ground storage concentrates the weight of the roll onto the bottom surface. The belt carcass is compressed in this small area and not compressed equally from side to side. The carcass may be stretched more on one side or the other. This is a likely cause of belt camber, a banana-like curvature of the belt, running the length of the belt.

Under no circumstances should a roll of belting be stored on its side (**Figure 4.9**). The weight of the roll may cause that side of the belt to expand, creating camber problems. Moisture may migrate into the carcass through the cut edge of the belt, creating carcass problems or belt camber.

The belt should be supported in an upright position on a stand, off the ground (**Figure 4.10**). This places the stress of one-half of the roll's weight on the core, relieving the load on the bottom. This support stand can be utilized during shipping to better distribute the weight of the belt. The support stand can then be utilized in the plant for storage, or the belt can be transferred to an in-plant storage system that properly supports the roll. It is important that the roll be properly supported from the time of manufacture to the time of installation.

Figure 4.9

Storing a roll of belting on its side may lead to problems with camber.

Figure 4.10

Supporting the roll of belting on a cradle or stand will prevent uneven stress, whereas storing it on the ground is bad practice.

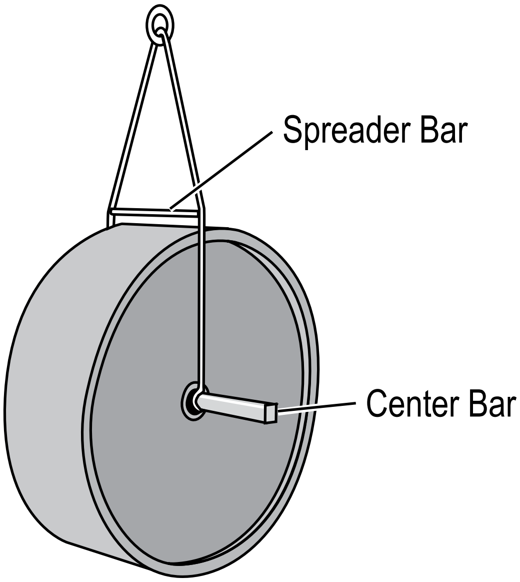


Figure 4.11

Using a spreader bar when lifting a roll of belting prevents damage to the belt edges.

C. Rotated on its stand

If the support stand is designed correctly, the roll of belt can be randomly rotated every 90 days. This will more evenly distribute the load throughout the carcass. The reel of belting should have been marked at the factory with an arrow to indicate the direction of rotation. Rotating the belt in the opposite direction will cause the roll to loosen and telescope.

D. Properly protected

During shipping and storage, the roll of belt should be covered with a tarp or wrapped in an opaque water-resistant material. Covering the roll of belting protects it from rain, sunlight, or ozone. The covering should remain in place during the entire storage process.

The roll of belt should be stored inside a building to protect it from the environment. The storage area should not contain large transformers or high-voltage lines that may create ozone and affect the belt. The building does not have to be heated, but it should be relatively weather tight.

Figure 4.12

Impact damage is caused by large, sharp material striking the belt, resulting in a random nicking, scratching, or gouging of the top cover.

Figure 4.13

Entrapment damage is usually seen as two grooves, one on each side of the belt, near the edge where the belt runs under the steel conveyor skirtboard.

E. Lifted correctly

When lifting a roll of belt, a square lifting bar of the correct size should be placed through the core. Slings or chains of the correct size for the weight of the roll should be used. A spreader bar should be utilized to prevent the chains or slings from damaging the edges of the conveyor belt (**Figure 4.11**).

Additional guidelines are given in ISO 5285; belting manufacturers can provide guidance for their specific products.

BELT DAMAGE

Extending Belt Life

As noted above, the cost of the belt will easily exceed the cost of other conveyor components and may reach the point where it approaches the cost of the steel conveyor structure. A key to providing a reasonable return on the investment in belting is avoiding damage and prolonging its service-life. Obviously, all systems installed around the conveyor—whether to feed it, receive material from it, or assist in its material transport function—must be designed to present the minimum risk to the belt.

Damage to belting can be a major drain on the profitability of operations using conveyors. This expense, which occurs regularly in plants around the world at costs of thousands of dollars, can often be prevented. Unfortunately, relatively little effort is put into the analysis of the life of the belt and the reasons for a belt not reaching its optimum life, because of the difficulty of identifying and measuring all the variables that affect belt-life.

The types of belt damage can be divided into two groups: normal wear and avoidable damage. Wear due to the normal operation of the conveyor can be managed and minimized to prolong the belt-life, but a certain amount of wear is considered acceptable. Perhaps avoidable damage cannot be totally prevented, but it can be minimized through proper equipment design and maintenance management.

The first step in preventing belt damage is to identify the cause or source(s) of the damage. A step-by-step analysis can almost always lead to the "culprit."

Types of Belt Damage

The following is a brief review of the major types of belt damage:

A. Impact damage

Impact damage is caused by large, sharp conveyed material striking the top cover of the belt. The result of this impact is a random nicking, scratching, or gouging of the top cover (**Figure 4.12**). A large frozen lump of coal may cause this type of damage. If the impact is severe enough, the belt can actually be torn completely through. This type of damage is usually seen under crushers or in mines on conveyors handling run-of-mine (ROM) material.

Long material drops without some method to help the belt absorb the energy can also lead to impact damage. *(See Chapter 8: Conventional Transfer Chutes and Chapter 10: Belt Support.)*

B. Entrapment damage

Entrapment damage is usually seen as two grooves, one on each side of the belt, near the edge where the belt runs under the steel conveyor skirtboard (**Figure 4.13**). Many times this damage will be blamed on pressure from a skirtboard-sealing system. However, extensive study has shown this type of belt damage is more likely due to the entrapment of conveyed material between the sealing system and the conveyor belt.

This material entrapment occurs when the belt is allowed to sag below the normal belt line and away from the sealing system. Material becomes wedged into this "pinch point," forming a spearhead to gouge or abrade the surface of the belt as it moves past (**Figure 4.14**). This leads to any of several negative events:

a. Scalloping

The trapped material will form a high-pressure area, causing excessive wear on the sealing system (seen as scalloping in the seal at each idler).

b. Grooves

Grooves will be worn along the entire length of the belt under the skirtboard (**Figure 4.15**).

c. Material spillage

Material will be forced off the sides of the belt, leading to piles of material spillage under the load zone.

Figure 4.14

Material becomes wedged into this "pinch point," forming a spearhead to gouge or abrade the surface of the belt as it moves past.

Figure 4.15

Trapped material can wear grooves along the entire length of the belt under the skirtboard.

Figure 4.16

Damage to the belt edge is a sign of the belt mistracking into the conveyor structure.

Material entrapment can also be caused when the skirting is placed inside the chutewall in the path of the material flow. Not only does this arrangement cause material entrapment and belt damage, it also reduces the cross-sectional area of the chutewall, in turn reducing conveyor capacity. This same damage can be seen when installing leftover or used belting as a dust seal, as the carcass is more abrasive than the belt cover and will wear the cover away. Incorrectly installed wear liners can also cause entrapment points, creating this type of wear.

One way to prevent sag is to use bar support systems to support the belt and stabilize the path in the entire skirted area. *(See Chapter 10: Belt Support.)*

C. Belt-edge damage

Edge damage is usually seen as frayed edges on one or both sides of the belt (**Figure 4.16**). If edge damage is not identified and corrected, it can be severe enough to actually reduce the width of the belt to a point where it will no longer carry the rated capacity of the conveyor.

Belt mistracking is probably the leading cause of belt-edge damage. There are numerous reasons why a belt might mistrack. These causes range from out-of-alignment conveyor structures, off-center belt loading, accumulations of material on rolling components, or even the effect of the sun on one side of the belt.

There are many techniques and technologies that can be used to train the belt. These would include laser surveying of the structure, adjustment of idlers to counter the belt's tendency to mistrack, and installation of self-adjusting belt-training idlers that use the force of the belt movement to steer the belt's path.

The key to good belt tracking is to find the cause for the mistracking and then remedy that cause, rather than spending time and money turning one idler one direction and another idler a different direction in pursuit of better tracking. *(See Chapter 16: Belt Alignment.)*

Figure 4.17

Another form of damage seen at the belt edge is delamination, in which the plies of the carcass separate or the covers pull away from the carcass.

Figure 4.18

Abrasion from material loading will be seen as wear in the top cover in the load carrying area of the belt.

D. Belt delamination

Another form of damage seen at the belt edge is delamination, in which the plies of the carcass separate, or the covers pull away from the carcass (**Figure 4.17**). This can be caused by belting being wrapped around pulleys that are too small. The entry of moisture, chemicals, or other foreign materials into the edge of the belt can contribute to this problem.

E. Worn top cover

Damage to the top cover is seen when the top cover of the belt is worn in the load carrying area of the belt or even across the entire top (**Figure 4.18**). Several factors can contribute to worn top covers.

One cause can be abrasion from material loading. There is an abrasive or grinding action on the belt cover created from the material falling onto the moving belt.

Another cause can be carryback. This is material that clings to the conveyor belt past the discharge and then drops off along the conveyor return. If not controlled, this fugitive material can build up on the ground, in confined spaces, and on rolling components. These accumulations can quickly build to a point where the belt runs through a pile of fugitive material that wears away the top cover. This damage will happen more quickly when the materials have sharp-edged particles and higher abrasion levels.

Faulty belt-cleaner selection and improper cleaner mounting can also lead to top-cover damage. Belt cleaners must be mounted properly to avoid chattering. Belt-cleaner chatter can quickly remove the top cover of the belt if not corrected immediately.

Research has shown that even properly installed belt-cleaning systems can cause some wear on the cover of the belt. This would qualify as a portion of the "normal wear" of the belt. With properly tensioned cleaning devices, this wear is modest and has been shown to be less than the abrasion from one idler seizing due to material buildup.

Slow moving, feeder-type belts that convey materials from vessels under high "head loads" can also suffer top-cover damage. Reducing this downward pressure from the material load onto the belt will reduce the potential for damage.

F. Rips and grooves from foreign objects

Damage in the form of rips and grooves is caused by stray pieces of metal, ranging from packing-crate strapping to the teeth from loader buckets (**Figure 4.19**).

These metal pieces can become wedged into the conveyor structure, forming a knife to gouge or slit the belt. This damage can be the most difficult type to control, because it occurs very quickly and often with catastrophic effects. There are a number of ways to minimize, but not totally eliminate, the amount of "tramp iron" in the material flow. These methods include grizzly screens, metal detectors, and video monitors. Regardless of the effectiveness of the precautions, the belt is still vulnerable.

G. Belt-cleaner damage

Conveyor belts often have a paradoxical relationship with belt cleaners. Cleaning systems are required to remove carryback, which reduces fugitive material along the conveyor and so preserves the

Figure 4.19

Tramp iron, ranging from packing-crate strapping to the teeth from loader buckets, can become wedged in the conveyor structure and damage the belt.

Figure 4.20

Impacts from belt-cleaner blade "chatter" can put nicks in the cover of the belt.

Figure 4.21

Bending the belt around too small a pulley can cause cracks in the top cover perpendicular to belt travel.

life of the belt; however, belt cleaners can also have negative effects. Like any foreign object, cleaners can damage a belt, particularly when the cleaning system is poorly applied or poorly maintained. Damage can come from too much pressure or out-of-alignment installation. Chattering cleaner blades can remove pieces from the belt surface (**Figure 4.20**).

Any damage on the surface of the belt or on the cleaning edge of the belt cleaner can create additional vibration, expanding the movement and perpetuating the cycle.

H. Top-cover cracking

Short random cracks in the top cover running perpendicular to the direction of belt travel may be caused by a mismatch between the belt and the pulley diameters (**Figure 4.21**).

Each belt, depending on the manufacturer, number of ply, reinforcing materials, and thickness, will require a different minimum-bend radius. This type of damage occurs if the belt is not matched to all pulley diameters of the structure. Bending a belt in too small of a radius will cause stress on the top cover. This undue stress on the top cover will cause the rubber to crack, exposing the reinforcing materials of the belt, which can lead to damage to the belt's internal carcass.

Figure 4.22

Carrying hot material may lead to cracks in the belt's top cover.

Figure 4.23

Junction-joint failure can be seen as a "W" or "M" shape in the belt as it passes over a return roller.

Any change from the original belt specifications should also be done in conjunction with a rerun of the belt-specification program which includes a study of the conveyor's pulley diameters and tension required to drive the belt.

Installing a thicker belt on an existing system to improve life by preventing other types of belt damage, such as impact, may dramatically shorten the life of the new belt if the diameters of the conveyor pulleys are smaller than recommended by the manufacturer. It is important to always check with the belt manufacturer to ensure this design parameter is met.

I. Heat damage

Conveying hot materials may also cause the top cover to crack or the plies to separate. The cracks from heat damage may run either parallel or perpendicular (or both) to the direction of belt travel (**Figure 4.22**). If the conveyed material is hotter than the belt can handle, holes may be burned through the belt. Using high-temperature belting may reduce this heat cracking and increase belt-life. The only true solution is to cool the material prior to conveying it or to use some other method of moving the material, at least until it is cooled sufficiently.

J. Junction-joint failure

As the belt moves along the conveying system, going from flat to troughed at the terminal pulleys, the outer one-third of the belt is required to travel farther than the center one-third of the belt.

Thus, the outer one-third of the belt must stretch more than the inner one-third. If this stretching takes place in too short of a distance, the belt can become damaged at the point where the outer wing rolls meet the center flat roll. This damage is termed junction-joint failure.

Junction-joint failure appears as small stretch marks running the entire length of the belt in the areas which pass over the points where the wing rollers and the flat rollers meet. (These stretch marks run parallel to the belt, approximately one-third of the belt width in from each edge). In early stages, it can be seen as a "W" or "M" shape in the belt as it passes over a return roller (**Figure 4.23**). This type of belt damage may be so severe as to actually tear the belt into three separate pieces.

Junction-joint failure is caused by too large a gap between idler rollers and enough tension or load to force the belt to deform into the gap. A transition distance that is too short and/or an idler-junction gap of more than 10 millimeters (0.4 in.) or twice the belt thickness may cause junction-joint failure. Belt thickness, reinforcing materials, materials of construction, and trough angles all determine the transition distance of a specific belt. When designing a new system, contemplating a change in belt specifications, or increasing trough angles, it is important to check with the belting manufacturer to ensure that proper transition distances are maintained at both the head and tail pulleys.

K. Belt cupping

A cupped belt happens when the belt has a permanent curvature across its face, perpendicular to the line of travel (**Figure 4.24**).

Belt cupping can be caused by heat, by transition distances not matched to the belt, or by too severe a trough angle for the type of belt being used. Another cause of cupping is over-tensioning the belt. The presence of chemicals such as deicers or dust surfactants can also cause a belt to cup up or down, depending on whether the chemical shrinks or swells the elastomer in the belt's top cover. Aspect ratios that are too great (where the top cover is too thick for the bottom cover) can also cause a belt to cup.

Cupped belts are extremely difficult to track, as the frictional area, the surface where the belt contacts the rollers, is drastically reduced.

L. Belt camber

Camber is a longitudinal curve in the belt when the belt is viewed from the top. The Rubber Manufacturers Association defines camber as the convex edge of the belt; the concave side of the belt is called the bow (**Figure 4.25**). If a belt is composed of more than one section,

Figure 4.24

A cupped belt will not lie down on the idlers.

Figure 4.25

Viewed from the top, camber is a longitudinal curve in the belting.

it may have more than one camber or even conflicting cambers.

This type of damage can be created during manufacture or from improper storing, splicing, or tensioning of the belt (**Figure 4.26**). Proper storage and handling are essential from the time of manufacture to the time of installation.

These curves in the belt produce tracking problems that are often confused with a crooked splice. Camber and bow will produce a slow side to side movement; a crooked splice produces a more rapid "jump" in the belt's tracking. However, a crooked splice has a short area of influence, whereas the curve of a camber or bow is from one end of a belt section to the other.

Figure 4.26

Belt camber can be created during manufacture or by improper storing, splicing, or tensioning of the belt.

Figure 4.27

Specialized adhesives can be used to repair a damaged belt.

BELT REPAIR

Repair of Conveyor Belting

For most operations, conveyor belt-life is measured in years. To achieve the lowest operating cost, inspection of the belt should be a scheduled maintenance procedure. Any belt damage noted during these inspections should be repaired promptly to prevent small problems from becoming big trouble. Damage to a belt can permit the entrance of moisture or foreign materials into the belting, and thus promote premature failure of the belt. To preserve the belt, it is important to make prompt and effective repairs of any damage.

Vulcanized repairs can be made during scheduled maintenance outages when sufficient conveyor downtime is available to allow the long time required to make a vulcanized joint. In nearly all cases, a vulcanized repair requires removal of a complete section of belt and then either re-splicing the remainder or adding an additional piece of belting, often called a "saddle."

Fortunately, many forms of damage lend themselves to relatively simple methods of repair. Repairable forms of damage include:

A. Grooves in which the top cover is worn away by abrasion from material or a foreign object

B. Longitudinal rips in which the belt is slit by a fixed object, such as a metal bar becoming wedged into the conveyor structure

C. Profile rips in which a small tear in the belt edge extends inward

D. Edge gouges in which blunt objects tear chunks of rubber out of the belt edge, generally caused by the mistracking of the belt into the conveyor's structure

Repairs can be made with self-curing, adhesive-like repair materials to keep moisture or foreign material out of the carcass. Mechanical fasteners are another method for repairing damaged belting to restore service without significant downtime and extend the service-life of expensive belts.

Belt Repair Using Adhesives

Adhesives provide a cost-effective means to repair conveyor belting with a high quality bond. Use of adhesive compounds will save downtime and money in maintenance budgets without requiring heavy vulcanizing equipment or creating obstructions with repair hardware in the belt (**Figure 4.27**). Adhesive repair compounds offer simple solutions for belt maintenance that are durable, reliable, and easy to use. There are a number of products available to do this. They include solvent-based contact cements, heat-activated thermoplastics, and two-component urethane elastomers.

All of these systems require some degree of surface preparation, ranging from a simple solvent wipe to extensive grinding or sandblasting. Some may need an application of a primer to improve adhesion.

Most commonly used for standard cold-vulcanized splices, solvent cements are also used for bonding repair strips and patches over damaged areas.

Thermoplastic compounds are “hot melts” that are heated to a liquid state and then harden as they cool, forming a bond. As they cool quickly from their application temperature of 120 to 150 degrees Celsius (250° to 300° F), the repair must be performed quickly, before the adhesive returns to the hardened (non-adhesive) condition. Problems encountered with thermoplastic adhesives include the possibility of shrinkage as the adhesive cools and the risk that high-temperature operations or cargo may cause a softening of the adhesive, leading in turn to failure of the repair.

Urethane products are typically two-component systems that the user can mix and then spread like cake frosting directly onto the area to be repaired. They typically achieve operating strength in a short period, one to two hours, but will continue to cure for eight to twelve hours until full cure strength is reached.

All adhesive systems offer fairly simple applications, assuming the instructions are followed. Of course, it is critical that the adhesive manufacturer’s instructions be followed carefully as to surface preparation, component mixing, pot life, application technique, and cure time. The length of time for an operating cure and full cure may provide the basis for selecting any particular product.

It is important to get the profile of the repaired area down to match the profile of the original belt in order to preserve the repair and avoid more damage to the belt.

It is also important to identify and resolve the cause of the problem, removing the obstruction or correcting the mistracking that led to the belt damage in the first place. Otherwise, the resumption of operations after repair merely initiates a waiting period until the damage recurs and the repair must be made again.

Mechanical Fasteners for Belt Repair

Because of their comparative ease of installation, mechanical splices are often used in emergency repair situations when a new piece of belting must be added to an old belt or when a belt must be patched or a rip closed (**Figure 4.28**). In these cases, the mechanical fasteners are used as a “band-aid” to cover damage and close a

Figure 4.28

Damaged belts can be repaired using mechanical fasteners.

hole, allowing the conveyor to begin running again.

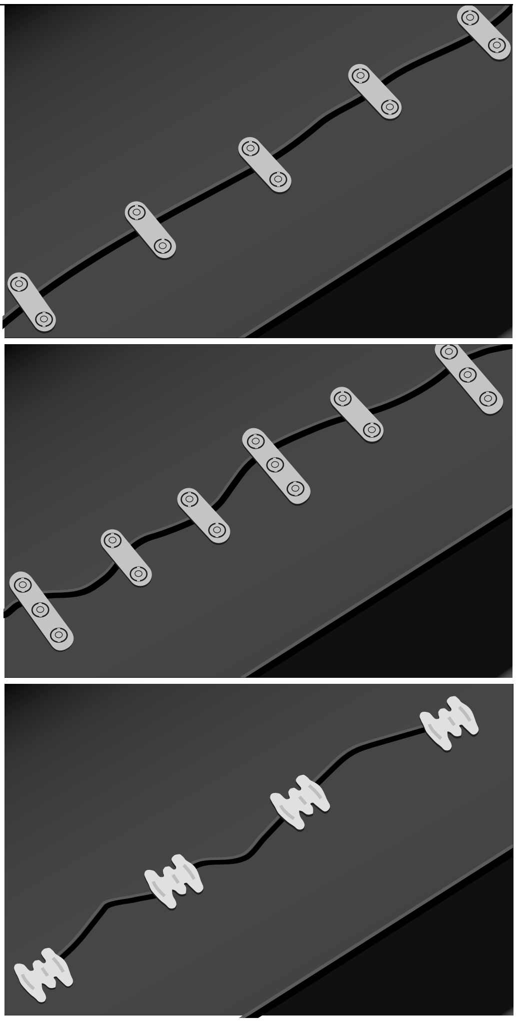
Mechanical splices can be used effectively for belt repair, providing care is used to properly install and recess the fasteners. Of course, the problem with all temporary repairs is that too quickly the "temporary" part becomes forgotten. The system is running; the plant personnel have moved on, at least mentally, to solving other problems. It must be remembered that these repairs are only temporary stopgaps and are not designed for permanence. It is always important to solve the root cause of the problem in order to prevent recurrence.

Figure 4.29

Claw-type fasteners can be hammered in place for a fast repair of a ripped belt.

Figure 4.30

Damaged belting can be repaired with rip-repair fasteners installed in a pattern that alternates two- and three-bolt fasteners.



Recovery from belt damage does not have to involve lengthy downtime. Mechanical rip repair fasteners offer an inexpensive and fast repair. They can be installed with simple tools and without discarding any belting. As soon as the fasteners are in place, the belt can be returned to service without waiting for any "cure" time. They can be installed from the top side of the belt, without removing the belt from the conveyor.

One-piece, hammer-on "claw" style fasteners can provide temporary rip repair where the speed of repair and return to operation is critical (**Figure 4.29**). These rip-repair fasteners can also be used to fortify gouges and soft, damaged spots in the belting to prevent these spots from becoming rips. For repair of jagged ("zig-zag") rips, splice suppliers recommend alternating two- and three-bolt fasteners (**Figure 4.30**) along the repair. The larger (two-bolt) side of the three-bolt fasteners should be placed on the "weaker" flap side of the rip to provide greater strength. For straight rips, standard two-bolt mechanical fasteners are acceptable.

PRESERVING THE LIFE OF THE BELT

Rip-Detection Systems

Increasing numbers of operations are acting to preserve the life of their belting by installing rip-detection systems. In the event of a rip in the belt, these systems sound an alarm and/or automatically shut down a conveyor.

These systems are designed for the situation in which a belt-length rip—arising from a piece of tramp iron or a wedged lump of material that slits the belting into two independent, or nearly independent, pieces—would require the entire replacement of a costly belt. Without a rip-detection system, a belt rip may continue for hundreds or thousands of feet.

Rip-detection systems are most commonly seen on very expensive, production-critical conveyors. In these circumstances, the operation would be shut down for the time required to acquire and install a new belt or make a repair to a belt-length rip.

The rip-detection systems are particularly valuable on long conveyors, where the 60 meter (200 ft) length typically damaged before the conveyor can be shut down is an insignificant loss compared to the value of the length of belting saved by the automatic shutdown.

Although there are differences in operating principles for the various rip-detection systems, each system basically embeds a sensor or signaling agent at places in the conveyor belt. As the belt moves, these indicators pass over the detection points—typically installed at the places where it is likely for a conveyor rip to occur: the loading zone and discharge. When the rip in the belt causes the signal to be interrupted, the alarm is sounded and the belt stopped.

These systems will minimize belt damage and allow the plant to reduce the amount of belting it needs to keep in inventory.

Monitoring of Conveyor Belting

As operating plants push to extend production periods, windows of opportunity for maintenance continue to shrink. Conveyor supply and support companies can now help to accommodate this situation by providing tools that give a better understanding of the condition of conveyor belting.

In addition to the rip-detection systems mentioned above, there are services which will provide a comprehensive monitoring of the condition of a belt. Factors analyzed include the condition of the carcass; the condition and wear of the top cover, including its thickness and its estimated remaining life; and the condition of the splice(s).

Early detection, mapping, and monitoring of damaged areas and of splice strength allow planners to schedule maintenance windows in advance and extend the service-life of the conveyor systems under their control.

BELTING IS THE KEY

In Closing...

The conveyor system is a key to the efficiency of an entire operation; the belting is the key to a conveyor's productivity. Consequently, preservation of the capabilities and life of the belt is essential. Considering the size of the initial investment in conveyor belting, the importance of preserving a belt through regular inspection and repair activities cannot be overstated. The relatively minor costs for careful inspection and belt repair and the somewhat more significant expense of a conveyor outage to allow that repair to be made will be paid back many times over by an extended belt-life.

Looking Ahead...

This chapter, The Belt, was the second chapter regarding basics of conveyors in the section Foundations of Safe Bulk-Materials Handling. The next chapter, Splicing the Belt, concludes this section, describing various types of belt splices and their impact on fugitive materials.

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

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