Conveyors

An Introduction to Conveyor Fundamentals

Summary

Pure and simple, conveyors transport material. From the perspective of economy, conveyors perform the redundant tasks historically done by animals, people, handcarts, wagons, and trucks. From conveying integrated circuits only a few inches, to millions of tons of dirt over many miles, conveyor systems are the backbone of global product handling. This article examines the types of conveyors, conveyor components, and relevant terminology. While there are many types of conveyor systems in use throughout the world, this rudimentary knowledge of the fundamentals gives you an advantage when specifying, or changing your current systems.

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Introduction

Pure and simple, conveyors transport material. From the perspective of economy, conveyors perform the redundant tasks historically done by animals, people, handcarts, wagons, and trucks. From conveying integrated circuits only a few inches, to millions of tons of dirt over many miles, conveyor systems are the backbone of global product handling. This article examines the types of conveyors, conveyor components, and relevant terminology.

Advantages to Conveyors

History shows us that conveyors have been in use since the late 18th century, when they hauled bulk agricultural goods. These conveyors freed resources to conduct other, more skilled tasks.

There are many advantages for conveyor usage over other forms of material transportation:

- Operates in all weather conditions
- High tonnage per hour
- Low cost to tonnage ratio
- Mobility
- Length easily shortened
- Length easily extended
- Adaptable to terrain requirements
- Low degradation of material during transport
- Capable of multiple gathering points
- Capable of multiple discharge points
- Meets environmental requirements
- Safety

Leather, canvas, and non-reinforced rubber were used as the conveying surface until World War II. During the War years, rubber and cotton became rationed items, thus forcing manufacturers to develop other materials for use in conveyor systems. Synthetic material was used in place of rubber and cotton, and quickly became the inspiration for future developments.

Conveyor Profiles

There are many different types of conveyor systems, and each possesses a profile fitting the application. Accordingly, each profile may have its advantages and disadvantages; however, the application dictates the profile.

Straight Incline

A "straight" conveyor profile does not include a concave or convex assent or descent. Figure 1 illustrates the straight conveyor profile.

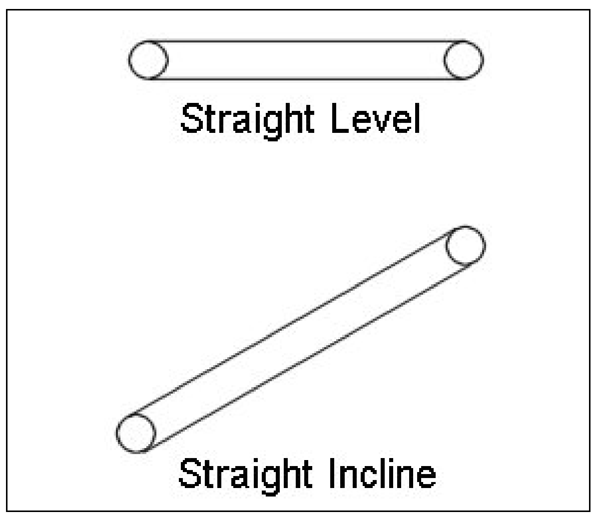

Figure 1. Conveyor Profile, Straight Level and Straight Incline.

Although both profiles are straight, the possibility of an elevation change is not precluded, as found in a "straight incline." In most cases, there will be a combination of straight and incline. Which leads to the next two types of profiles.

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Convex Curve

A “convex curve” profile uses one or more convex shaped curves. The convex curve forces the conveyor belt over the transition, thus ensuring solid seating to the idlers even when the belt does not contain material.

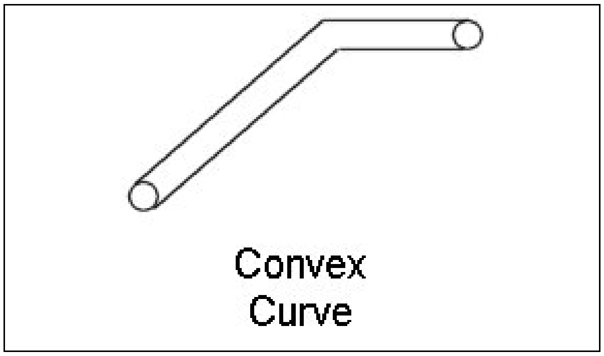

Figure 2. Conveyor Profile, Convex Curve.

Concave

The “concave curve” profile uses one or more concave shaped curves (Figure 3). The concave curve tracks in the idlers well when loaded, but can lift off the conveyor when empty and proper tensioning precautions have not been made.

Conveyor belts only track well when they are in contact with all rollers of each idler. Consequently, conveyor belts on concave profile systems tend to track poorly. Design considerations should include plans for appropriate tensioning, and starting practices.

Types of Conveyors

Light Duty

A light duty conveyor system consists of a carrying surface (usually a light weight conveyor belt), a support structure, and a drive pulley. Although not always required, many lightweight conveyor systems have an end pulley, take-up pulley, or a combination end / take-up pulley. Components differ by conveyor type. Listed are various types of common systems, all of which are designated by their carrying support type.

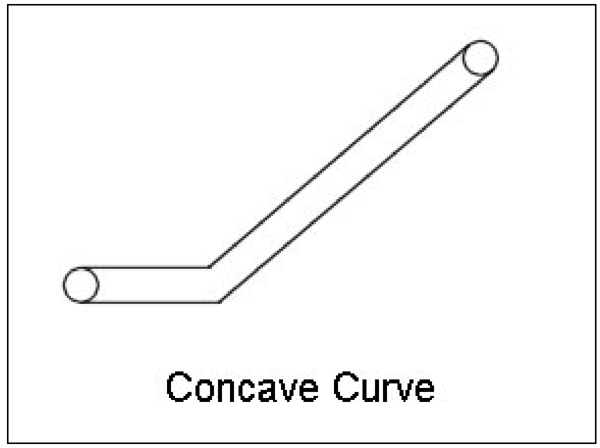

Figure 3. Conveyor Profile, Concave Curve.

Slider Bed conveyors consist of a flat bed (constructed of steel, although other materials may be used) to support the conveying surface, and a drive pulley (Figure 4).

Very popular in lightly loaded conveying applications, the slider bed generates a high coefficient of friction. Advantages of a slider bed are cost and easy construction, coupled with full belt load support. In the case of food applications where the system has tendency to get wet, suction between the belt and bed may stall the conveyor.

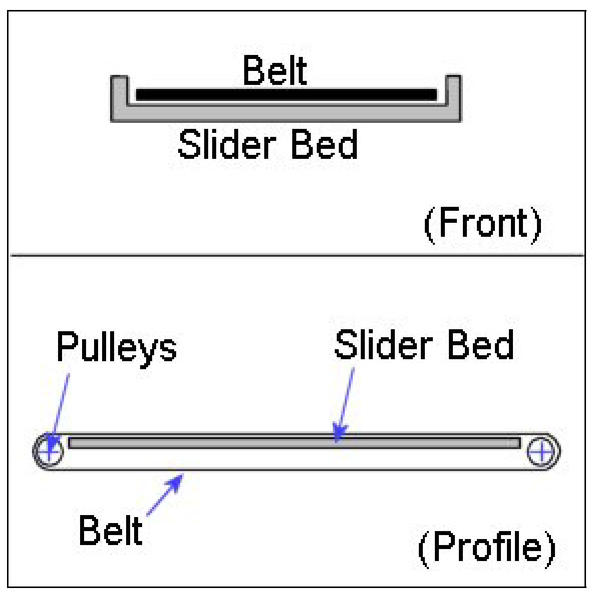

Figure 4. Slider Bed Conveyor.

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Slider Bar conveyors consist of a group of parallel bars (usually constructed of steel, although other materials may be used) to support the conveying surface, and a drive pulley (Figure 5).

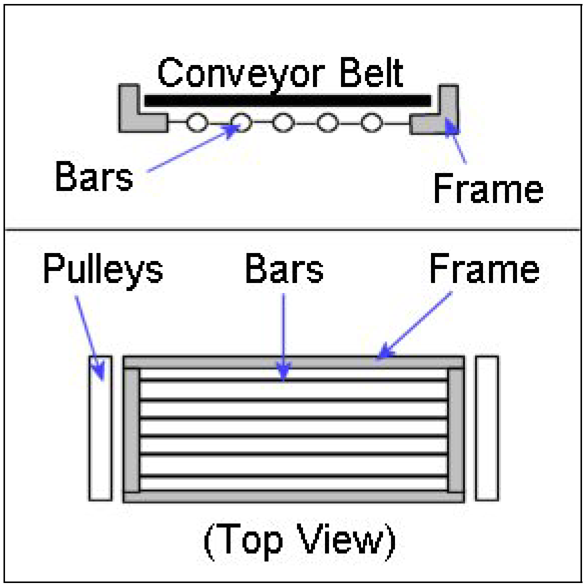

Figure 5. Slider Bar Conveyor.

Like the slider bed, the slider bar conveyor is designed for light loads. Inexpensive and easy to construct, the slider bar conveyor has a much lower coefficient of friction, and is ideal for wet applications.

Roller Bed conveyors consist of multiple shaft supported "free rolling" canisters (usually constructed of steel, although other materials may be used) aligned perpendicular to the conveying surface, and one drive pulley (Figure 6).

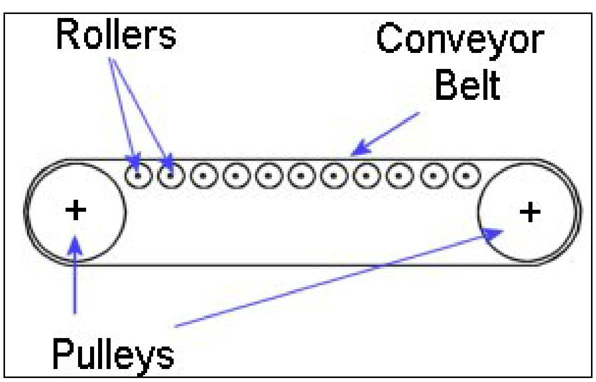

Figure 6. Roller Bed Conveyor.

More expensive to build and operate, the roller bed conveyor has a very low coefficient of friction.

Roller bed conveyors can generate high decibel ratings when combined with hundreds or thousands of other rollers in an indoor environment. The noise comes from the low precision, non-caged, rolling element bearings. The hollow rollers accentuate this noise.

There is also a roller conveyor (non-powered), where material is physically pushed along by hand. The design is similar to Figure 6, yet has no driver pulleys and no conveyor belt.

Live Roller conveyors are identical to the roller conveyor; however, the difference is that instead of using a drive pulley to move the conveying surface, each roller is powered to rotate, thus moving the material. Roller rotation is generated either by a conveyor belt (Figure 7) riding underneath the rollers, or by each roller being driven by its own drive belt.

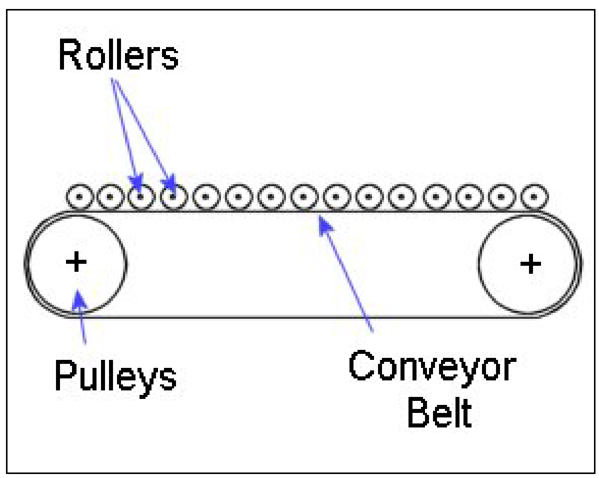

Figure 7. Live Roller Conveyor.

Live roller conveyors are relatively expensive as compared to a slide bed or slider bar system. Maintenance costs are higher as well, but live roller systems tend to be quieter and overall longevity is greater. This is due to the conveyor belt's driven style design. With this

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design, the rollers only rotate when a product is passed along the top. In doing so, the weight of the box, or bag, pushes down the spring loaded roller, which in turn makes contact with the moving conveyor belt below. When the box or bag has passed, the spring-loaded roller disengages the belt and stops rolling. In effect, less maintenance is required, thus lowering operation costs. In addition, decibel ratings decrease because fewer rollers are rotating.

Heavy Duty

A heavy-duty conveyor system consists of a carrying surface (usually a multiplied heavy duty conveyor belt), a support structure, and a drive pulley. Unlike most lightweight conveyor systems, heavy duty systems need an end and take-up pulley. Heavy duty systems are easily recognized by their heavy construction and idler belt support units.

Figure 8. Heavy-Duty Conveyor (typical) [1].

Bucket Elevators

Bucket elevator systems move material vertically (or at high inclines), by using a bucket affixed to a conveyor belt, cable, or chain. Bucket elevators are highly specialized and components vary by application.

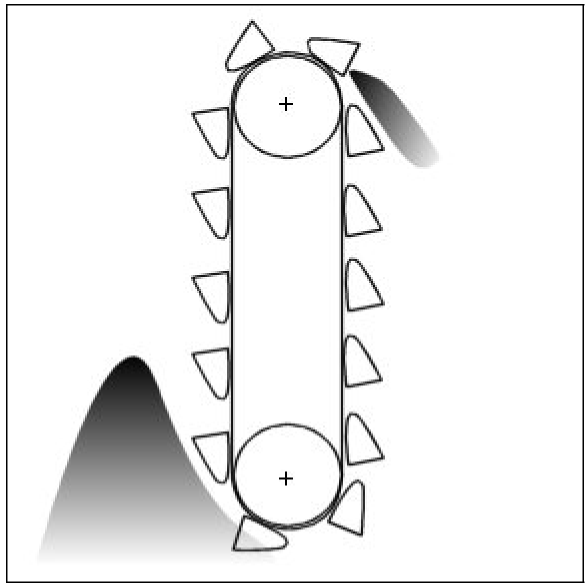

Figure 9. Bucket Elevator (typical).

Folding belt conveyor systems fall into the heavy-duty category. The folding belt system is identical to a conventional system, with the exception of belt construction. In a folding system, the belt has the capability to fold over the material being conveyed, thus encapsulating the material (Figure 10).

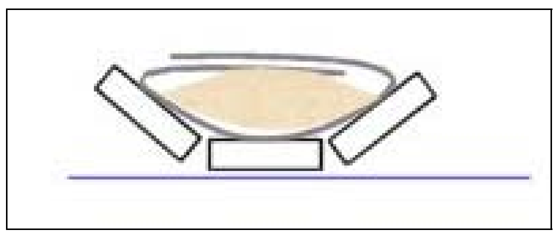

Figure 10. Folding Belt

Folding belts are very expensive, and are usually used in applications where terrain is severe or potential loss of material is high.

Tabletop Conveyors

The term "tabletop conveyors" refers mainly to the type of conveying surface (Figure 11). The construction of a tabletop type conveyor consists of the carrying surface (usually some type of interlocking chain), drive pulley sprockets, and support idler sprockets.

A tabletop belt is similar to a conventional roller chain. Made from many different types

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of materials, the tabletop belt consists of multiple flat links interconnected with pins. This type of construction makes codifications and repairs much more economical than that of a conventional conveyor belt. It also allows the user to change belt widths with little effort, or major equipment redesign. Similar to the wire belt, the tabletop belt is good in applications where liquid drainage is required.

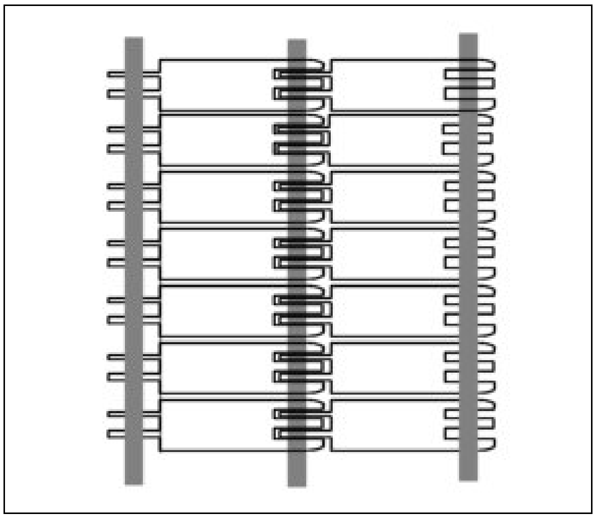

Figure 11. Table Top Belt (Typical Link).

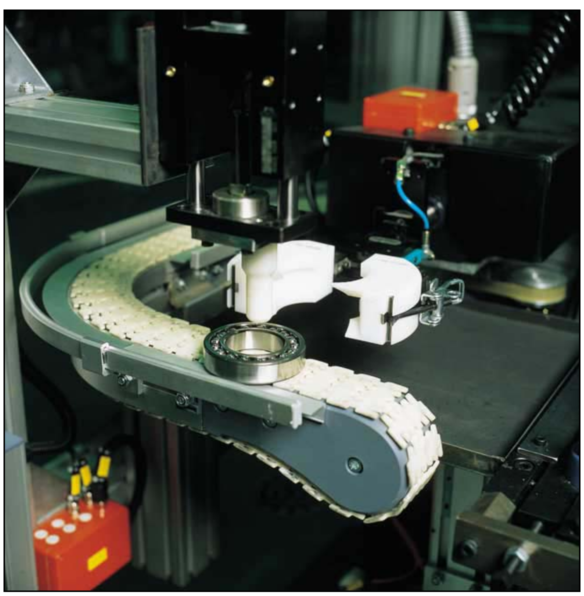

Figure 12. FlexLink - example of a tabletop conveyor - used in the SKF production channels.

Wire Belts

A wire belt conveyor system also refers to the conveying surface. Light to heavy gauge wire is interlinked to form the carrying surface, called a wire belt. System construction consists of the wire belt, support surface, a drive pulley, tail pulley, and a take-up mechanism.

Wire belts are used in rugged applications where polymers will not work, or where the cost of special materials becomes cost prohibitive. Construction consists of links and pins. The wire links are assembled side by side, aligned and held in place by the links.

Because the wire belt is made of steel, it is capable of withstanding heat and cold, as well as water and chemicals. They are also advantageous when drainage is required.

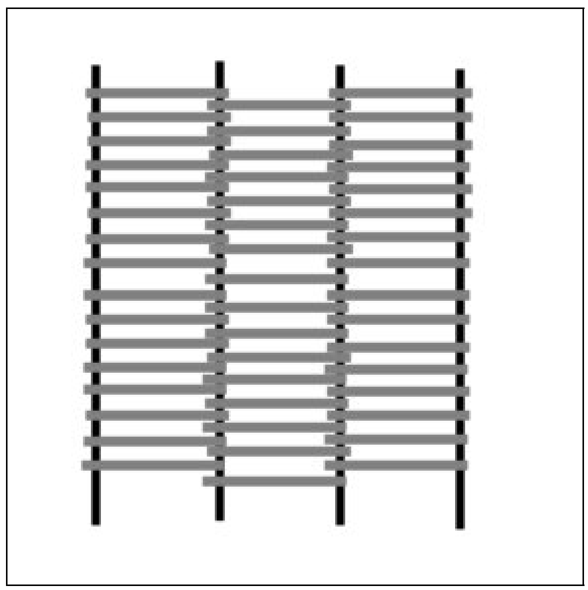

Figure 13. Wire Belt.

Conveyor Idlers and Motors

Carrying Idlers

Carrying Idlers are free rotating units designed to support the conveying surface, usually a conveyor belt. Idlers are constructed of three main components: frame, rollers (or cans), and rolling element bearings.

Assembled, carrying idlers are designed to trough the carrying surface. Figure 14

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illustrates how a conveyor belt rides in the idler trough.

Idler rollers are generally available in diameters ranging from four to seven inches. Situating the outer cans at predefined angles to the center roller forms the idler trough. Generally, idlers come standard in three degrees of trough: 20°, 35°, and 45°.

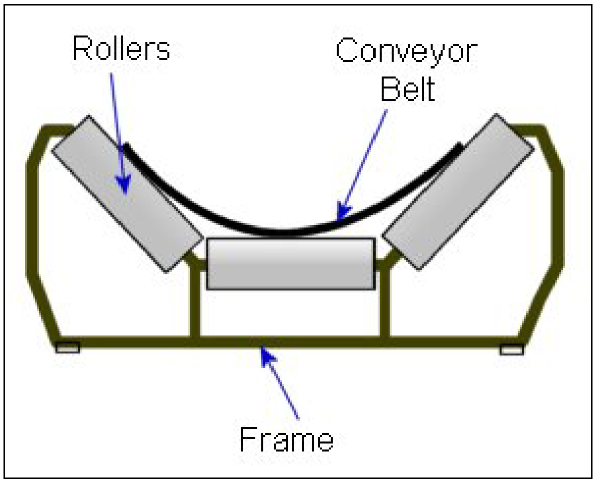

Figure 14.Carrying Idler (typical).

The trough allows the loaded material to be transferred with the least amount of spillage.

Depending upon the application requirements, most idlers are spaced three to four feet apart on center. This allows ample load support to the conveyor belt.

It is important that the belt makes contact with all rollers to ensure proper belt tracking and training, as well as load support.

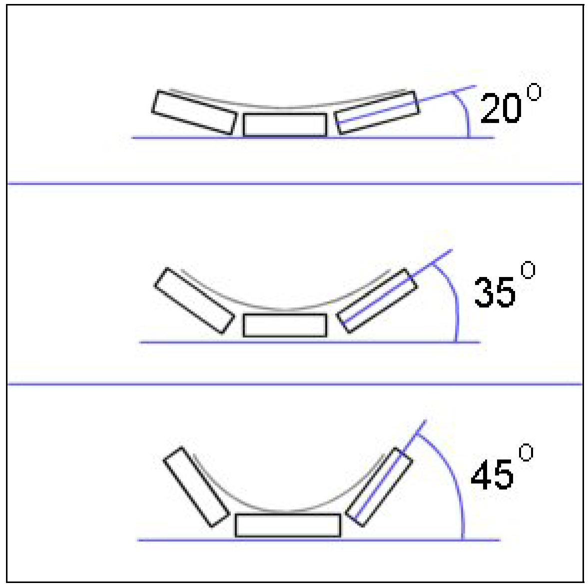

Figure 15. Idlers (20, 35, 45 Degrees).

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Rolling element bearings allow the idler roller's free rotation. As can be seen in Figure 16, the bearing is situated in a recess, protected by a seal from contamination.

Many rollers fail due to the rolling element bearing ceasing to function, thereby causing the roller to freeze. A frozen idler can cause belt tracking problems and belt damage.

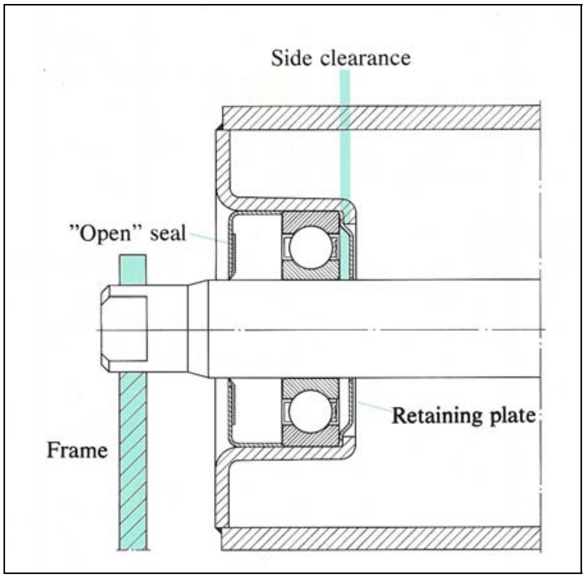

Figure 16. Idler Cut-A-Way [1].

Return Idlers

Return Idlers are positioned below the conveyor system structure and provide a surface for carrying the conveyor belt in the opposite direction of the carrying side of travel (Figure 17).

Like the carrying idler, the return idler consists of three components: frame (idler supports), roller (or "can"), and rolling elements bearings.

Depending upon the application requirements, most return idlers are spaced 10 feet apart on center.

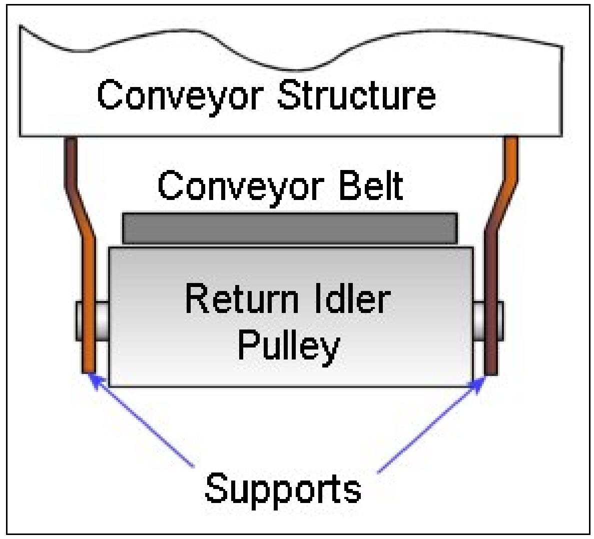

Figure 17. Return Idler

Impact Idlers

Impact Idlers are specially designed to absorb the energy produced upon impact of the product being conveyed, to the conveyor's carrying surface.

Identical to traditional troughed idlers, impact idlers rollers are engineered to absorb the impact by coating the rollers in rubber, or affixing semi-pneumatic impact rings.

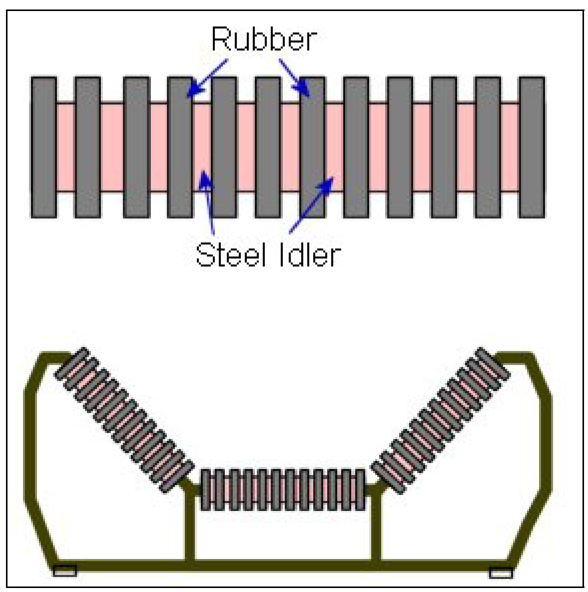

Figure 18. Impact Idler.

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Training Rollers

Training Rollers are used to keep the conveyor belt centered on the conveyor system (Figure 19).

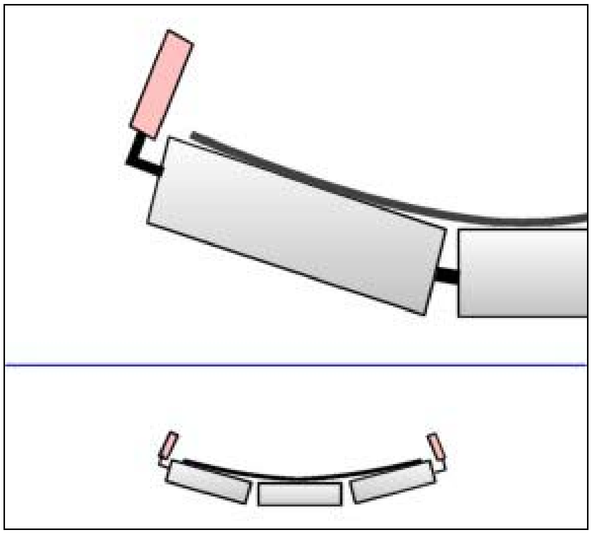

Figure 19. Training Roller (Typical).

Training rollers are affixed to the frame of the carrying or return idlers. The perpendicular positioning of the training roller to the belt keeps the belt from tracking off the carrying idler.

Motors

One most essential part of the conveyor system is the prime mover. While steam and internal combustion engines are used as prime movers, the electric motor, by far, is the most commonly used with conveyor systems [2].

Electric motors range from fractional (1/4 hp) for very light conveyor applications, to very heavy-duty application high horsepower motors (5000 hp).

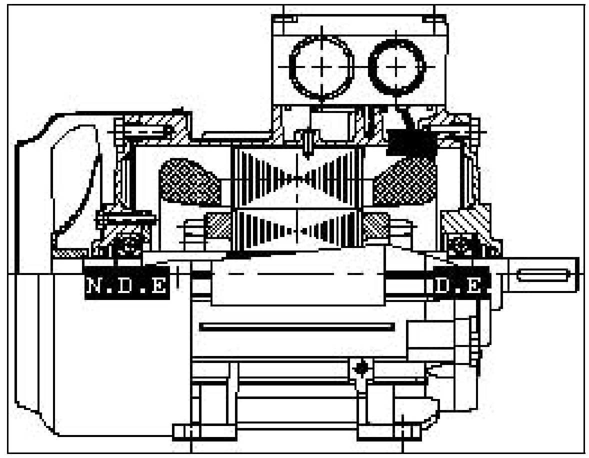

Figure 20. Electric Motor (typical) [2].

Conveyor Belts

Plied

Plied conveyor belts consist of covers, one or more fabric plies / carcasses, and skim coats (Figure 21).

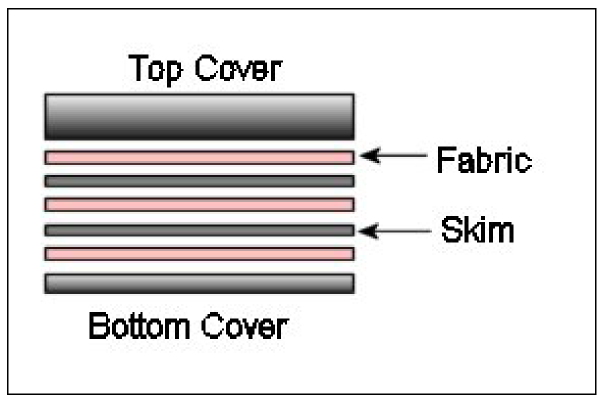

Figure 21. Plied Belt Cross Section.

The cover is constructed of rubber or other polymers, and is designed to protect the fabric plies / carcasses against potential damage from the material being conveyed and other unforeseen hazards. In many cases, there is a bottom cover that comes in contact with the pulleys and idlers. The inclusion of a cover is designed to protect the carcass against possible wear that could eventually damage the belt's integrity.

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The fabric plies or carcass is the load-carrying member of the belt components. The plies provide strength against impact, a medium for fastener holding, and protect against rips and tears. There are three types of materials used in the construction of the plies: polyester, nylon, and steel.

Polyester provides the best resistance against stretch. In addition, polyester plies tend not to shrink, and trough well on the carrying idlers. Unfortunately, belts made from all polyester are relatively inflexible and are more likely to experience rips, tears, and punctures. For this reason, polyester belts are poor at supporting mechanical fasteners in rugged applications, and should be a consideration for vulcanization.

Nylon fibers have an excellent memory, thus making them an excellent carcass for harsh applications. Nylon carcasses are more likely to stretch than polyester belts, but technology has advanced to the point where the percentage variations are negligible.

The nylon carcass holds up well to high impacts, and is excellent at withstanding the pressures of trapped material between the belt and pulleys. Not only does the nylon carcass trough well, but it has superior mechanical fastener retention.

In higher pounds per an inch of width (PIW) rated belts, a combination of polyester and nylon are used. In this type of carcass construction, the polyester is used as the warp cord, while the nylon is used as the weft or fill. Accordingly, the polyester allows for a higher tension longitudinally, while the nylon provides greater fastener retention and trapped material pliability.

There are two basic types of **steel** belts: the steel mesh carcass, and the steel cable belt. While the steel mesh carcass is rare, the steel cable belt is very popular in long overland systems where a very heavy-duty conveying surface is needed.

Between the plies is the skim coat. The skim is rubber or another polymer, which provides load support, adhesion between the fabric plies, and helps absorb impact.

Heavy belts are rated according to fabric weight and cover thickness. For example, a three ply 330 PIW, ¼ x 1 belt is broken down as follows:

- Three ply 330 PIW tell us that there are three separate plies/carcasses, of 110 PIW (pounds per inch of width) each.
- The ¼ x 1 tells us that the top cover polymer is ¼” thick and the bottom cover is 1/16” thick.

Because there are many different belt selections for most applications, please consult your belt supplier for specific nomenclature and belting recommendations.

Lightweight

Lightweight conveyor belts come in many types and styles. Lightweight belting can be plied or have an integral woven fabric.

Like the heavy-duty plied belts, a plied lightweight belt is rated by each ply fabric’s PIW. Similarly, a woven carcass belt’s load carrying capacity is also measured in PIW (Figure 22).

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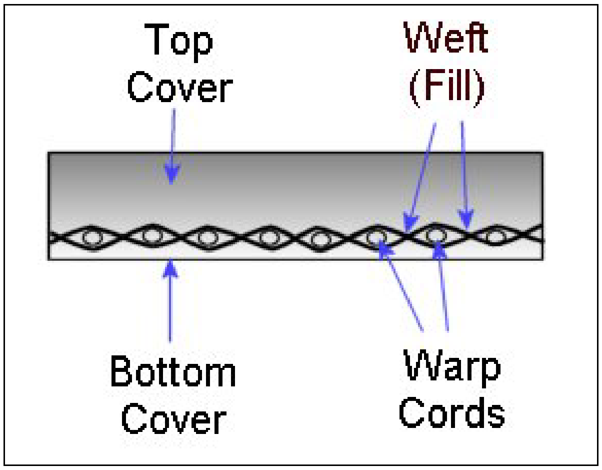

Figure 22. Light Weight Belt Cross-Section (typical).

Lightweight belt applications range from food processing, distribution center, and airport luggage handling, to postal and high-tech parts movement.

In most cases, a lightweight belt is selected for its profile and polymer qualities over its load carrying capacity. Top cover profiles such as "roughtops," "pebbletops," and "meatcleats" are just a few of the hundreds of examples of what is available. Lightweight belting manufacturers design their profiles to meet a large cross-section of applications. Therefore, it is sometimes difficult to find a perfect match for the application, but the probability of finding a suitable substitute is high.

Polymer material is the other consideration in lightweight belting selections. Application parameters strongly dictate which polymer to use in a conveyor system. Again, manufacturers purposely manufacture specific profiles with application relevant polymers. These combinations are a result of years of application experience.

Rubber Compounds

Every conveyor belt manufacturer touts their rubber compound as superior compared to other brands. The Rubber Manufacturer's Association (RMA) has classified compounds into different types and grades so that consumers are able to ensure they are getting the right rubber for their application. Specific RMA text concerning rubber types and grades can be found at http://www.rma.org/.

Grade I (RMA 1): "Superior resistance to abrasion cutting, gouging, and tearing caused by the impact of large material. Recommended for transporting large, heavy lump ores, quartz, trap rock, granite, glass bullet, scrap, ballast and similar heavy-duty applications" [4].

Grade II (RMA II): "Excellent for continuous abrasion and good resistance to cutting and gouging, recommended for conveying sand and gravel, limestone, crushed rock, slag, coke, coal, cement rock, potash, trona, salt and other abrasives" [4].

In addition to the RMA standards, each belting manufacturer makes available specialty compounds to meet specific application demands. These requirements range from oil resistance to heat and fire resistance.

SOR (Super Oil Resistant): "Highly resists mineral oil and most other oils that cause swelling and sponginess. Recommended for handling animal or vegetable fats, oily metals, etc." [4].

MOR (Moderate Oil Resistant): "Recommended for specialized service such as waste disposal sewage, sludge, and oil treated materials" [4].

Fire Resistant (MSHA): "Meets U.S.A. Mine Safety and Health Administration requirements. Designed for service in coal, potash, salt and other underground mining where fire resistant belts are mandatory" [4].

SCORF (Static Conductive Oil & Fire Resistant): "Specially compounded for the oily effect or grains. This is static conductive and flame resistant; meets MSHA requirements" [4].

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Other Conveyor Components

Gearboxes

Gearboxes, or speed reducers, are necessary in a conveyor application to reduce the prime mover output RPM to a speed more suitable for the conveyor application [3].

Pulleys

Drum Pulleys are used as point of angle change for the conveying surface. Used as a head, tail, take-up, or snub, the drum pulley is usually larger in diameter than an idler roller (ranging from 10" to 42" in diameter in normal applications).

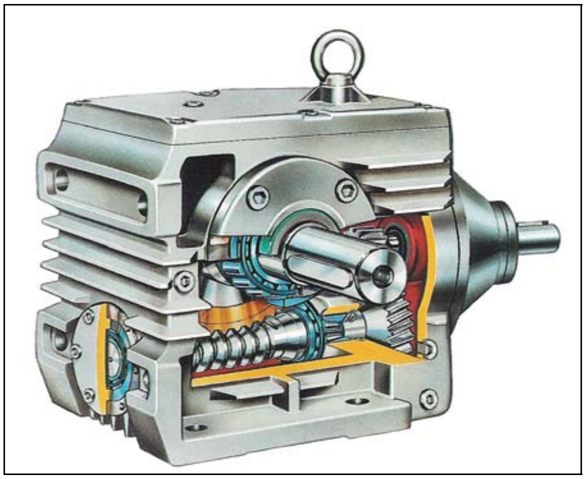

Figure 23. Right Angle Worm Speed Reducer.

Due to the fact that a minimum bend radius limits conveyor belts, pulley diameter becomes a factor when upgrading or replacing existing belt.

Winged Pulleys are used as point of angle change for the conveying surface. Similar to the drum pulley, winged pulleys can be used as a head, tail, or take-up. Also like the drum pulley, the winged pulley is usually larger in diameter than an idler roller (ranging from 10" to 42" in diameter in normal applications).

The differentiating characteristic of the winged pulley is the construction. The carrying surface is not smooth like a drum pulley. Instead, the winged pulley, in profile view appears to have spokes emanating from the hub center forming gaps on the carrying surface (Figure 24). These gaps allow trapped material (between the pulley and the belt) to escape at the end of the pulley.

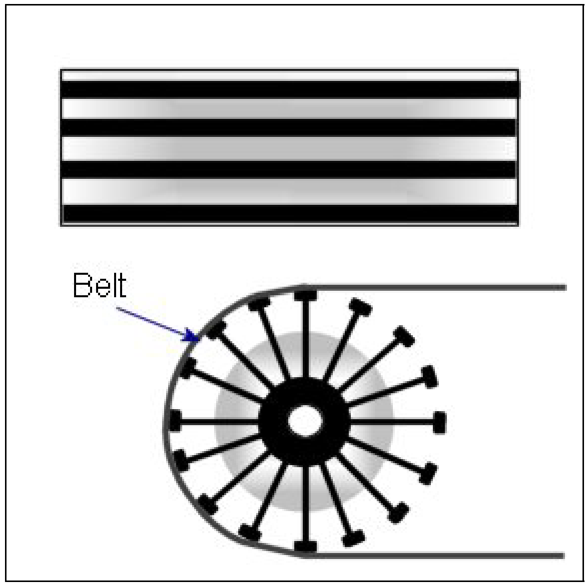

Figure 24. Winged Pulley.

Material, such as rocks, when caught between the pulley face and the conveyor belt can produce belt punctures. Apart from large rocks, material buildup on a drum pulley can cause abrasive wear to the bottom cover of the belt, and poor belt tracking.

Lagged Pulleys are used as point of angle change for the conveying surface. The lagged pulley is nothing more than a drum pulley with a layer of rubber or ceramic tiles are bonded to its surface. This rubber surface provides a higher coefficient of friction between the conveyor belt and the pulley, reducing slippage on startup, heavily loaded applications, and where wet or slippery conditions are of concern.

Also like the drum pulley, the lagged pulley is usually larger in diameter than an idler roller (ranging from 10" to 42" in diameter in normal applications).

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Take-ups

Conveyor belts stretch over time due to many different factors: drive location, moisture, loaded starts, frequency of starts, braking, etc. In addition, belts experience periods of momentary elongation, such as when a conveyor system starts. As the initial load is accelerated to speed, the belt eventually returns to its initial length. Belting manufacturers know this and provide stretch and elongation factors to be calculated into the conveyor operation.

By providing elongation factors as a percentage, the conveyor engineer can anticipate how much the belt will grow over time. To compensate for this belt growth, the extra belt must be either removed, or the conveyor travel distance must be able to compensate. As an example, if a belt is calculated to stretch 2%, then a 1000' belt will stretch twenty feet over its useful life. As a result, the belt becomes loose, slips on the drive pulley, and not track on the conveyor system properly.

Take-up pulleys remove this slack from the conveyor belt. There are many types of conveyor belt take-up pulleys, but the two most popular are screw and gravity.

Screw take-ups are most commonly located at the mid section or the tail of the conveyor system, and use a screw mechanism on each side of the take-pulley to reduce belt slack.

Gravity take-ups are usually located toward the head / drive pulley. The gravity pulley is attached to a weight, as determined by the belt manufacturer, and rides in a vertical motion to compensate for overall belt stretch as well as periodic temporary elongation during start-up.

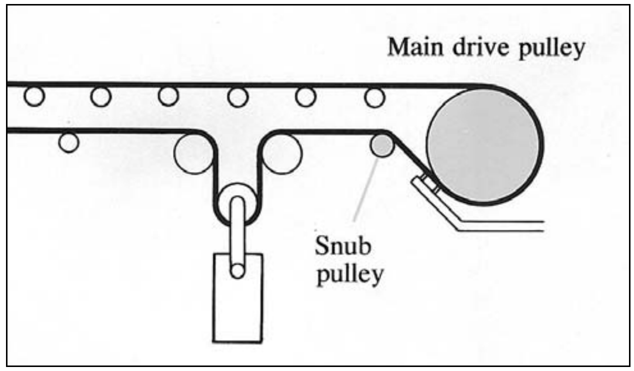

Figure 25. Gravity Take-Up Configuration .

The gravity take-up is also useful in preventing serious damage to a system during a jam.

Tripper Arrangements

As application demands vary, some conveyors must have the capability to change where the load is discharged without physically moving the entire conveyor structure. Obvious examples of changing discharge location are seen in the sand and gravel industry where the same conveyor systems are used to build multiple piles of material. To do this, a tripper is used.

A tripper conveyor has the ability to discharge material at any point before that material gets to the head pulley.

It can also discharge the material to the left or right side of the conveyor structure as well as back onto the conveyor itself.

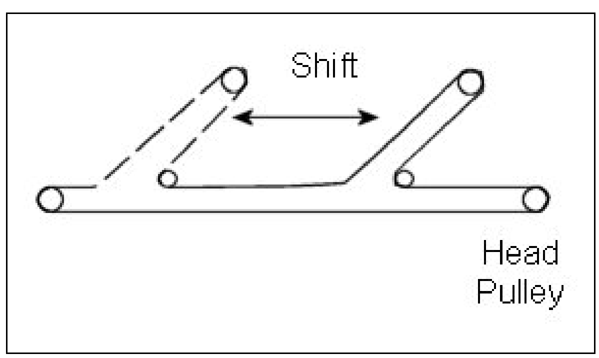

Figure 26. Tripper Configuration.

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Back-stops

Mounted usually within the speed reducer of a conveyor drive system, the backstop prevents the conveyor from reversing direction during a power outage under a loaded condition. In some instances, the backstop prevents a conveyor belt from coming off the conveyor system should the belt itself break [5].

Emergency Stops / Cords

Emergency stops / cords are cables that run the length of the conveyor system, and are designed to stop the conveyor from running when pulled during an emergency.

Belt Cleaners

"Carry-back," the portion of material left on the conveyor belt after material has been offloaded or discharged, has always been a problem in conveyor operation. Carry-back is messy, as it accumulates along the return run and requires manpower to remove it. Carry-back tends to wear return idlers and pulleys. More importantly, carry-back falling off conveyors can draw fines from the EPA.

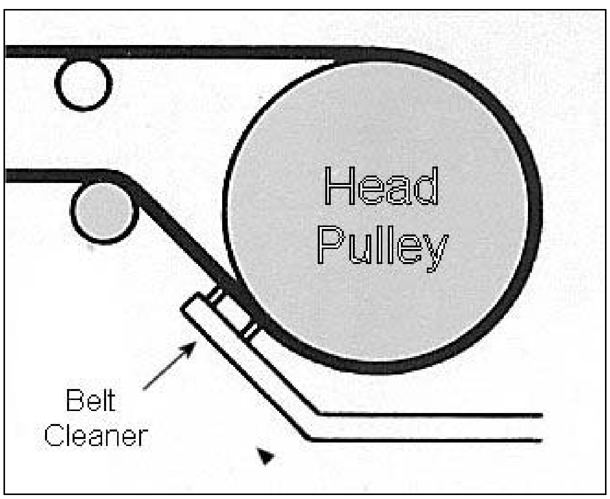

Figure 27. Belt Cleaner.

There are two types of belt cleaners: brush and blade. Yet, while there are many styles of each type, the objective is the same: keep material from sticking to the belt on the return run.

V-Guides

V-guides may be used to keep a conveyor belt centered on a system. A v-guide is a polymer extrusion in the shape of a v, welded or chemically bonded to the bottom cover of a conveyor belt. This v-guide rides, firmly seated, in a specially cut groove in the pulleys and rollers, thus keeping the entire belt centered.

Skirtboard

During the conveyor loading process, a hopper fills the conveyor belt. If not properly handled, not all the material will make its way directly to the belt. Depending upon the angle and slope of the hopper, material can end up everywhere but where it belongs. The skirtboard is a rubber strip, clamped into place at the point where the hopper comes into contact with the belt. The skirtboard, in essence, seals the loading area.

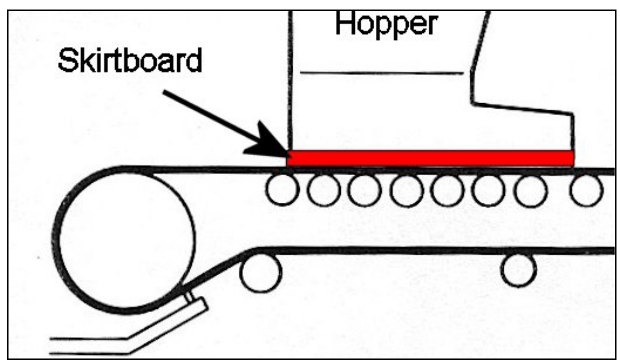

Figure 28. Skirtboard.

While many use old pieces of conveyor belting as skirtboard, most belting manufacturers advise against it. Fabric plies and rubber durometer of an old belt skirtboard can cause damage to the conveyor belt itself. Check with your local supplier for the skirtboards suitable for your application.

Belt Training

Moving or adjusting idlers and pulleys to achieve proper, central running of the conveyor belt through the system, trains a conveyor belt.

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It takes time for new conveyor belts to run-in properly. Run-in is the point at which the conveyor belt follows the system without running significantly to either side. When a conveyor belt consistently runs to the side of a system, either at one point or throughout the entire run, chances are that there is either a change in the alignment of the structure (or its components), or a change in the material loading. This kind of operating condition can result in material spillage or even damage to the belt itself.

While many at first believe that a poorly tracking system is the product of a belt defect or belt-slitting problem, be assured that this (while possible) is highly unlikely. Experience indicates that structural or application changes are the cause of the problem. There is also the possibility of an improperly aligned splice. Check with your conveyor belt supplier for specific training assistance.

Dimensions

Figure 29 provides rudimentary reference points of a conveyor system.

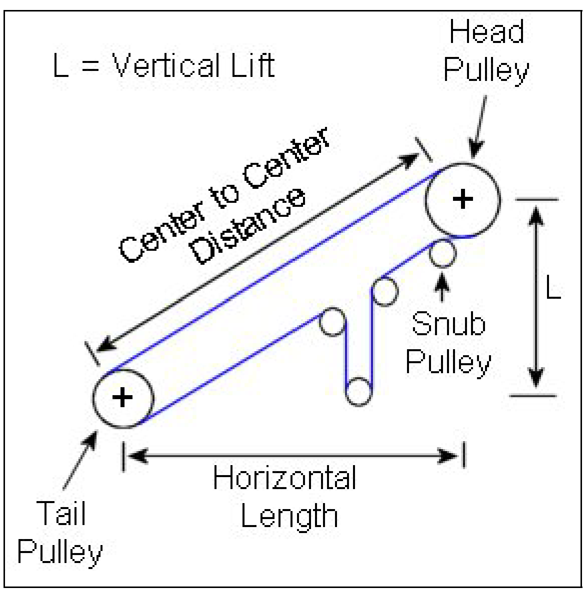

Figure 29. Reference Points.

All conveyor belting manufacturers have specialized programs for calculating proper belt sizes, based upon application and system features. Likewise, conveyor manufacturers have software to make conveyor design simple.

Conclusion

As can be seen, the conveyor system is nothing more than a few basic components. The optimum objective is to synchronize these components into one harmonious material moving instrument. This is sometimes very difficult to do, considering the potential size, material being conveyed, and the environment in which the system is expected to operate.

In heavy-duty conveying systems, most of the individual components (motors, gearboxes, and conveyor belts) can be very expensive. Normally, should one component fail, the odds that it will damage another component is high. A proactive preventative maintenance program will pay for itself over time should it keep the operator from replacing one of these expensive components. Obviously, preventative maintenance must be weighted against the potential loss of not only components, but to lost production.

Terminology

CEMA **–** Conveyor Equipment Manufacturers Association **-** http://www.cemanet.org/

EMR – Canadian Energy, Mines and Resources

MSHA – U.S.A. Mine Safety, and Health Administration.

Maximum Tension –Refers to the maximum amount of tension the belt can experience before failure. Factors affecting maximum tension are: return side friction, carrying side empty friction, friction due to load, total force friction, incline load tension, effective tension, slack side tension, belt slope, and minimum tension.

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OSHA – U.S.A. Occupational Safety and Health Administration.

Polymer Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule. [1]

Transition Distance – The distance between the head or tail pulley, to the closest idler.

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[3] Specification Development for Conveyor Drive Systems, FALK, Falk_opr009EV, http://www.aptitudeXchange.com

[4] U.S.R. Conveyor Belting

[5] Failure Analysis of Back Stops, FALK, Falk_opr009H4, see http://www.aptitudeXchange.com

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