Image courtesy of Flexco.

Chapter 25 Blocking the Belt Against Motion

Thanks to Greg Westphall, Director of Engineering, Flexco, for consultation and review of this chapter.

INTRODUCTION

The Risk of Unwanted Belt Motion

As already discussed in this volume, it is standard practice—indeed, it should be required procedure—that prior to performing work on or around belt conveyors, the drive system is de-energized. This includes lockout and tagout of the drive system of the belt conveyor, as well as any related equipment that might feed material into or out of the conveyor. This other equipment includes other conveyors, feeders, crushers, and the gates above gravity-feeding bins. In addition, access should be restricted to any load points that may be serviced by mobile equipment.

However, what is less commonly known is there remains the potential for belt motion—and the resultant risk of injury—even when a conveyor is properly locked out and tagged out. Belt conveyors have harmed and killed workers by moving even when the drive system has been de-energized.

As noted in the *Safety Around Belt Conveyors Guideline* published by the Conveyor Manufacturers Association of South Africa Limited,

> ... It is important to remember the danger presented by residual energy stored within the system and to address this adequately.
>
> Thus it is necessary to isolate the stored energy from the work area or to completely release all stored energy from the system, so that work can be performed in a safe environment.

How a Locked-Out Belt Can Move

In order to operate, the belting on a conveyor is placed under tension, both from the weight of the cargo loaded onto it and from the force of the drive system and the takeup system. These forces combine to create a tension that pulls the belt tight, and thus allows the drive system to move the belt through the structure.

Conveyor belting under tension is like a stretched rubber band. This stretching comes as the belt is placed under considerable tension. The amount of tension is based on factors such as belt geometry, belt material, drive and takeup specifications, and the amount of conveyed material on the incline or decline of the belt.

There are places along the conveyor system where the tensions can be considerably higher than other areas of the system. The position of the drive or braking system, takeup, and incline or decline of the system, loaded portions of the belt, and whether the belt is moving or stopped determines where tensions are high and where they are lower.

These tensions allow the application of energy from the torque of the drive to the belt in the case of inclined conveyors, or from the load and by gravity to the belt for declined conveyors, in order to efficiently move the belt and its cargo. In the case of inclined conveyors, if there is inadequate tension present, there will be no movement or at least no efficient movement. Instead of moving through the conveyor structure, the belt will slip where it contacts the rotating components in the drive or braking system. In the case of declined conveyors, the tension created by the load and gravity is often used to generate power at the tail pulley. If the tension is inadequate at the tail, the belt will slip and the braking effect of the tail pulley via friction will allow the belt to slip.

The Legal Requirement to Block Equipment

As a noun, the term ‘block’ means an obstacle or obstruction, or as a verb, to make unsuitable for passage or progress by obstruction, to prevent normal function. (**Figure 25.1.**)

Many jurisdictions include the requirement that equipment that is undergoing maintenance be blocked to prevent movement. This is not explicitly a conveyor regulation, but rather is included in the requirements for general industrial (or mining) equipment.

For example, in the United States, the Mine Safety and Health Administration (MSHA) requires in *30 CFR 56/57.14105* that:

> Repairs or maintenance of machinery or equipment shall be performed only after the power is off, and the machinery or equipment is blocked against hazardous motion.

This is applicable for both Part 56 (for Surface Metal and Nonmetal Mines) and Part 57 (for Underground Metal and Nonmetal Mines).

Ontario’s *Occupational Health and Safety Act (R.S.O. 1990)* has similar requirements

Figure 25.1.

The phrase ‘blocking the belt’ is used to describe the method of clamping the belt to prevent all movement.

Image courtesy of Flexco.

in Section 75: Maintenance and Repairs of Regulation 851 for Industrial Establishments. It requires that:

> A part of a machine, transmission machinery, device or thing shall be cleaned, oiled, adjusted, repaired, or have maintenance work performed on it only when, (b) any part that has been stopped and that may subsequently move and endanger a worker has been blocked to prevent its movement.

Beltcon Paper Discusses Fatalities from Unwanted Belt Motion

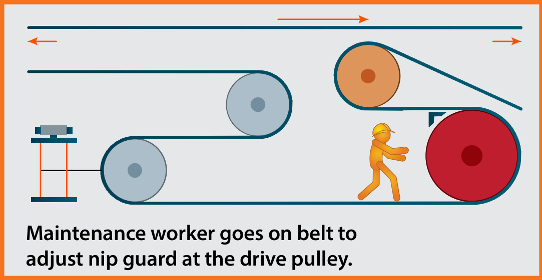
A 2013 paper, *Non-Gravity Take-up Technology*, by Alan Exton included a discussion of the hazards of stored energy and uncontrolled belt movement. The paper was presented as part of the Beltcon 17 Conference in South Africa.

Exton defines stored energy as:

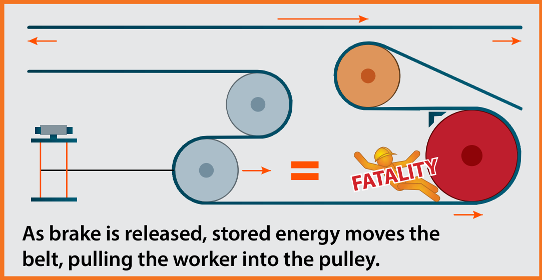
> potential energy derived from the elasticity of the belt, that is stored in a belt strand within a conveyor system and if released, presents itself as an instantaneous danger to human life and equipment.

He then recounts two examples of fatalities resulting from this stored energy.

Example 1: Maintenance Accident (Figure 1.)



Maintenance worker goes on belt to adjust nip guard at the drive pulley.

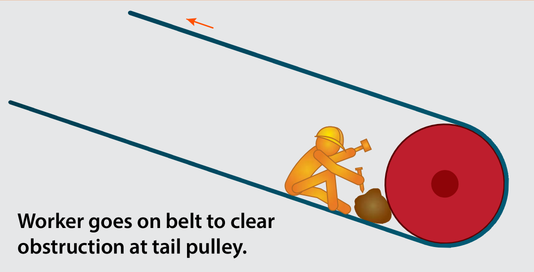


As brake is released, stored energy moves the belt, pulling the worker into the pulley.

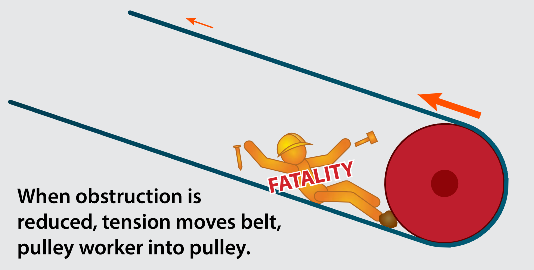
Figure 1.

A worker was installing a nip-point guard on the secondary drive pulley of a conveyor. The necessary risk assessments were completed, and the work was planned so it could be carried out safely. Meanwhile, additional workers were replacing idlers on the same conveyor. When the idler team finished the job, they released the brake on the takeup. Stored energy caused the belt to move forward, pulling the nip guard worker into the pulley. The result: a fatality.

Example 2: Tail Pulley Accident (Figure 2.)



Worker goes on belt to clear obstruction at tail pulley.



When obstruction is reduced, tension moves belt, pulley worker into pulley.

Figure 2.

A large rock is lodged between the tail pulley and the return strand of an inclined conveyor. This resulted in an electrical overload causing the drive to trip. A holdback on the head (drive) pulley prevented the carrying side from rolling back and so releasing the tension on the carrying strand of belt. A worker went between the strands at the tail pulley, intending to reduce the rock in size to allow its removal. Once the rock was sufficiently smaller, the tension on the two strands equalized, and the stored energy was released. The resulting movement of the belt pulled the worker into the pulley. The result: a fatality.

Both fatalities could have been prevented if the belts had been properly blocked.

In Exton's paper, stored energy is a topic that "requires permanent attention. …. A misunderstanding of this potential energy has proven to be LETHAL in our industry."

Assessing the Risk of Uncontrolled Motion

Even when a belt conveyor has been properly locked out and tagged out, there may still be significant amounts of tension or potential energy present in the system. This energy creates a risk of injury to personnel who are working on or around the conveyor.

It is important to note the distinction between *energy* and *power*. These terms are similar in meaning, but they cannot be used synonymously in all instances. The term *power* relates to kinetic energy or the energy of motion. Even when a conveyor has its power supply turned off and locked out, there may still be residual energy present. This energy is captured in the form of potential or stored energy from the pull of the counterweight, from the mass of the cargo on a loaded belt due to gravity, and from the tension stored in sections of a stretched, but not moving, belt.

Which way will the belt move?

In some circumstances it is difficult to predict in which direction a stalled or blocked belt will move when released. The illustration below helps explain the difficulty in judging the movement of a suddenly released belt, and so shows the need for blocking the belt to prevent unwanted movement and provide safety for workers.

The example below was prepared using conveyor design software to assess belt tension and the effects of a blockage. The following example shows an inclined belt where the motor has stalled due to the blockage of rotation at one of the pulleys.

This sequence shows a Belt blocked at the tail pulley. A backstop is installed on the head pulley.

In the illustrations, the thicker the colored fill shown around the belt, the higher the tension in the belt. Tension is typically highest at the head and lowest at the tail due to the gravity load of the bulk material.

Figure 1: Green
The belt shows normal running tensions.

Figure 2: Orange
An obstruction blocks the tail pulley and the drive motor stalls and trips out. Tension (in the orange fill) is locked into the stalled and stretched belt as potential or stored energy. The belt is kept from moving backward from the load on the belt by a backstop.

Figure 3: Red
When the obstruction is removed, the tension in the system drops to a normal stopped level. The tail pulley now rotates clockwise, and the takeup will move up. In the immediate area of the blockage, the belt will also move in a clockwise direction until the stored energy (over-stretching) in the belt is relieved. This creates nip points between the in-running belt and the tail and takeup pulleys.

The amount of movement depends on the length of the belt (recovered stretch) and the actual amount of tension stored in the belt from the stopping of the motor by the obstruction.

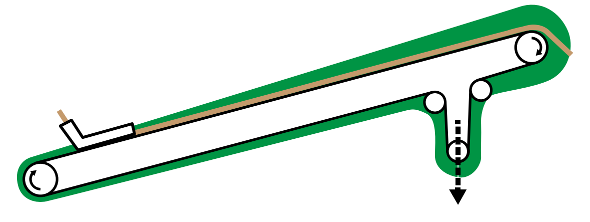


Figure 1.

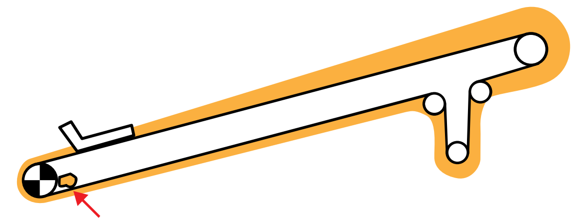


Figure 2.

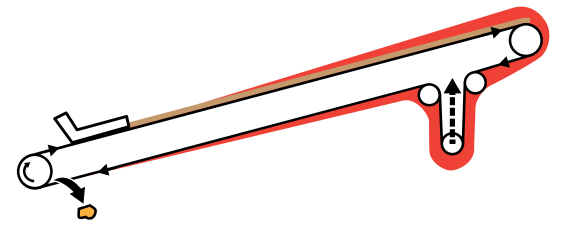


Figure 3.

In the case of a belt that is not endless due to a broken splice or that has been separated on purpose for repairs, there still can be potential energy stored in the hanging or inclined sections of belt.

The essential practices of lockout and tagout must be continued. But in addition, there will be many instances when the belt conveyor must be physically restrained from moving under its own stored energy. (**Figure 25.2.**)

Other Sources of Stored Energy

There are other sources of stored energy associated with a conveyor. Buildups of material in chutes and on structures can contain significant potential energy, and there have been numerous fatal accidents from falling materials while working inside of chutes. Traveling mechanisms such as trippers or stacker-reclaimers can move unexpectedly, causing the belt to move if it is not blocked. Accessories such as samplers or discharge plows can move unexpectedly during belt maintenance. Corroded or worn components or structures can give way from added loads while the belt is stopped but work is in progress.

Thus, it is necessary to isolate the stored energy from the belt and the surrounding work area or to completely release or block all stored energy from the system, so that work can be performed in a safe environment.

Figure 25.2.

To prevent inadvertent movement, the belt should be physically restrained.

Image courtesy of Flexco.

The blockout methodology uses 'brute force' mechanisms to physically prevent the belt from moving. The belt will not move because it is kept from moving by being held in one position.

Blocking the Belt

Despite the availability of various other—sometimes easier but often less successful—techniques, the best way to assure worker safety is to physically restrain the belt from moving. This is called 'blocking' the conveyor belt.

'Blockout' is the phrase to describe the activities that will physically restrain the belt so it cannot move. These procedures are applied in addition to the accepted lockout / tagout procedure which isolates the conveyor from its power supply.

The word 'blockout' is used because it fits well with other phrases such as lockout and tagout.

Some Not-So-Successful Methods

There are other techniques that can be used to reduce belt tension and eliminate the chance for uncontrolled belt motion. These techniques have only mixed results and consequently might not lead to safe conditions.

For example, properly installed brakes and backstops may help prevent this rollback. However, a plant should not rely on the backstops or brakes to prevent a belt from moving on its own. There have been instances when the belt has moved due to the internal tensions created by the belt stretch.

Another technique calls for the lifting of the conveyor's takeup counterweight. (**Figure 25.3.**) In essence, this method reduces the tension on the belt by reducing the pull of the takeup mechanism. But there are still other potential sources of tension on the belting, such as the stretch inherent in the belting itself, the weight of the belt, or the gravitational pull exerted by the weight of the cargo on the belt. While removing the pull of the counterweight may reduce the tension, it does not eliminate the potential for the other stored energy sources. Nor does it necessarily secure the belt against motion. Removing the pull of the counterweight alone is not sufficient to remove all the tension and force in the belt that can injure personnel.

Clamps, Chains, and Come-Alongs

Blocking the belt is performed using belt clamps in combination with chains and ratchet lever hoists (commonly called come-alongs) to physically restrain the belt. The intent is to prevent movement of the belting by securing it to a substantial member of the conveyor structure.

This task amounts to squeezing the belt between two bars that are compressed together. With the belt thus held, the clamps can then be attached (via chains and come-alongs) to the conveyor structure. (**Figure 25.4.**)

It is possible to block a belt using only clamps by wedging the clamps into the conveyor structure. However in that case, the clamp(s) must be wedged firmly into the structure—a process that is harder to both install and remove efficiently and safely, and which poses a greater risk of accidental release.

It is common to block the belt using chocks when working on pulley lagging, removing buildup or material wedged between the belt and pulley. However in this case, the chocks must be wedged firmly into both the in-running nip points and the outgoing nip points. As a result, they may only stop the rotation but not the belt movement at the nip and they are difficult to install and remove safely.

Chocks or wedges can also be used to secure the belt against fixed structural members such as beams or cross braces, but the amount of clamping force is unknown and relying on point contact is an unreliable method.

Clamps

Clamps are used as a method to lock the belt in place by securing the belt—in one or more positions, but usually on both sides of the section of belt being worked upon—to the conveyor structure. If the amount of tension or other forces on the belt are less than the clamping force applied to it and the strength of the framework is great enough to resist the pull against it, the belt cannot move.

Most clamps operate by tightening two engineered cross-belt beams down to the belt, holding the belt securely between the beams. In some lighter-duty applications, an alternative belt clamp can be affixed to the outside edges of the belt. In either case, the clamps must be capable of creating sufficient friction across a large enough clamping area to restrain belt movement.

The *Safety Around Belt Conveyors* guideline published by the Conveyor Manufacturers Association of South Africa Limited notes:

> Where belt clamps are utilised, these must be securely anchored to the structure. This applies to both permanent clamps and temporary belt pulling clamps. Belt clamps must be inspected and tested before attachment to ensure that they are able to withstand the belt

Figure 25.3.

Lifting of the takeup counterweight alone is not sufficient to completely remove the risk of belt movement.

Image courtesy of the United States Mine Rescue Association.

Figure 25.4.

Blocking the belt should be performed by securing the belt between clamps, which in turn are connected to the conveyor structure.

Image courtesy of Flexco.

tensions in the localised area.

The clamp specification of the Conveyor Manufacturers Association of South Africa Limited published as *Clamps for Belt Conveyors (MC01 Rev 01)* lists two types of belt clamps: fixed or belt-restraining clamps, and portable or pulling clamps. The permanent clamps are designed into the conveyor structure and are usually hydraulic shuttle systems with two sets of moving clamps. To move the belt, one clamp is loosened and one clamp engaged. The belt is pulled forward and clamped, festooning a short section of belt. (**Figure 25.5.**) The belt can then be spliced or repaired. The same system can be used to feed new belt onto the conveyor.

Either type can be used for the purposes of blocking a belt, providing it can be securely fixed to the conveyor structure and has sufficient blocking capacity. Consequently, the clamps must be solidly constructed and in sound condition.

Come-Alongs

A come-along is a portable, hand-operated ratchet lever winch used for stretching, lifting, and lowering objects. Also called lever chain hoists, come-alongs are convenient and portable enough to use in almost any situation. They are compact, light, and very easy to rig into position. They are small enough to carry in one hand and often weigh less than 20 pounds [≈9 kg] each.

In a belt-blocking operation, come-alongs can be used to connect, secure, and tighten the belt clamp to the conveyor structure. By using a pair of come-alongs—one on each side of the conveyor—the clamps (and hence the belting) can be secured evenly to the conveyor structure.

Figure 25.5.

To allow the belt to be spliced or repaired, one clamp is loosened and one clamp engaged. The belt is pulled forward and re-clamped, festooning a short section.

Image courtesy of Flexco.

Since the come-along is being used to provide safety to humans, they must be of adequate strength and be inspected to ensure they are fit for the intended use of blocking the belt movement.

Chains and Chain Slings

Chains, straps, or wire-rope cables are commonly used to connect the clamps (which hold the belt) to the conveyor structure. Even though these connecting methods are not being used in a typical lifting situation, they must be of adequate working strength—defined as 1/10th their breaking strength—and inspected to the same standards as wire-rope cables, slings, or chains used for lifting and hoisting.

A chain sling—that is, the combination of chain, hooks, and links that will serve as the connection between the belt clamp and the come-along and/or the conveyor structure—must be manufactured from alloy steel. They come in a variety of lengths and combinations of hooks and components, depending on the application.

Every chain or chain sling is only as strong as its weakest link, so it is very important that every component of the sling meets the standards for rated capacity, which is called the working load limit (WLL). The WLL is determined by the 'grade' of the chain and its components. For overhead lifting, only high-grade alloy steel chains and components may be used. These devices must meet a variety of strict quality standards such as minimum breaking strength, fatigue testing, and heat resistance. All chains and components must be marked by the manufacturer with a grade from which the load rating can be determined.

The most commonly used chains for overhead lifting are rated at Grade 80; however, the industry is moving to the stronger and safer Grade 100 and Grade 120 chains.

Attachments, such as hooks and rings, links, and couplings should have a rated capacity at least equal to that of the alloy-steel chain with which they are used. All chains and components must be marked by the manufacturer with a grade from which the load rating can be determined. It is important to note that a number of factors such as lifting at an angle, wrapping the chain around a load, or extreme temperature substantially reduces the WLL of the sling. These factors must be considered when determining what type of sling is necessary to lift a load.

Chain slings come in a variety of lengths and combinations of hooks and components, depending on the lifting application. (**Figure 25.6.**) The National Association of Chain Manufacturers have specified a variety of chain testing and safety standards, including the American Society of Mechanical Engineers *ASME B30.9* and *ASTM-A906*. Any chain sling used for lifting must have suitable characteristics for the type of load hitch and environment and must be in accordance with *ASME B30.9*, Sections 9-1.5 and 9-1.8.

The use of chain slings or sling components is governed by United States Department of Labor Occupational Safety and Health Administration (OSHA) regulations. In particular, *29 CFR 1910.184* governs the operation and usage of alloy-steel chain slings and sling components. In other areas, consult the local standards-issuing and regulatory bodies.

It should be noted that the come-along, chain, and clamps form a system. All components should have similar capacity ratings. Otherwise, the lowest-rated component becomes the 'weak link' in the system, and prone to failure. Matching the clamp capacity to the come-along capacity prevents tensioning of the clamps beyond their design limitations.

Proper Blocking Procedures

In the preferred method, the clamp spans across the entire width of the conveyor belt. There are two types of clamps, ones that require some movement of the belt to engage the clamps, and a second that does not require movement of the belt for the clamps to engage.

The clamps that require movement of the belt to engage are cam- or scissor-style. These clamps apply more clamping pressure as the tension from the come-along increases. Matching the clamp capacity to the capacity of the come-along is important to prevent overloading the clamp or crushing the belt.

The type that does not require some movement of the belt are the vise-style clamps. With the vise-style clamps, the pulling capacity depends upon the torque applied to the clamp screws. The vice style is often misused when releasing the tension in the belt by keeping the come-along engaged as the vice screws are loosened, allowing the belt to slip through the clamp. The proper procedure is to simultaneously release or play out the come-alongs.

The clamps should be construction of high-grade steel or aluminum components that are rugged and lightweight, making for easy transportation and assembly.

It is critical that the blocking equipment be properly checked prior to use. Inspect the clamps and the rest of the equipment for damage or missing components.

Prior to attaching the clamps, clean off any accumulated material that might interfere with the clamping surface's ability to hold the belt securely. Similarly, make sure the belt is clean

Figure 25.6.

Chains or chin slings are commonly used to secure the belt clamp to the conveyor structure.

Image courtesy of Flexco.

of foreign substances such as oil, water, or cargo material at the point where the clamp(s) will be attached.

Clamps are typically affixed to the belting by tightening screws/bolts, which in turn forces the top bar down toward the bottom bar, pinching the belt between. Some lighter-duty belt clamps are tightened with blows from a hammer.

The belt clamp should be secured to a structural member of the conveyor capable of restraining the expected forces. (**Figure 25.7.**)

Where belt clamps are utilized, they must be securely anchored to the structure. The belt clamps should be sized correctly for the application and should have gripping sides that will hold the belt properly.

When the clamp is butted against the structure to block belt motion, the adjusting screws on the clamp—that create the 'pinching' action that holds the belt—should be no more than 30 millimeters [≈1.18 in.] from the edge of the belt. Clamping farther away from the belt edges creates too much bending on the clamp bars and reduces the strength of the clamp and the whole belt-blocking apparatus.

Figure 25.7.

To prevent belt movement, the belt clamp should be secured to a structural member capable of restraining the expected forces.

Image courtesy of Flexco.

Figure 25.8.

It is preferable to secure the clamps to the conveyor structure rather than an idler frame.

Image courtesy of Flexco.

Keep in mind that the belt may move in either direction based on the conditions present at the time. Consequently, the belt should be clamped on both sides of the work zone so it cannot move in either direction; these conditions can and do change as the work progresses.

Never tie off the clamps to the structure at an angle as this will apply uneven stress to the belt and weaken the blocking action. Make sure the clamp is positioned 90 degrees to the belt's direction of travel. Usually, this is not possible since the structure is always wider than the belt. Minimize the angle between the belt and the structure, as the breaking force applied to the cable for a given load is greater when the angle is greater. By choosing a clamp as close as possible to the width of the structure, the angle can be minimized.

Although, when pulling (stringing) a belt onto a conveyor, it is very common to use one cable in the center, never connect only a single tension or pulling device (come-along) when blocking the belt for maintenance. Always use two come-alongs so that even force can be applied on both sides of the belt.

Belt clamps must be inspected and tested before attachment to ensure that they are able to withstand the belt tensions. They should be inspected prior to each use and periodically returned to the manufacturer for inspection and testing.

An Idler Frame is Not Enough

Belt clamps should be firmly installed to or against the conveyor structure, rather than just rolling components such as idlers. (**Figure 25.8.**)

The use of idlers for the purpose of securing the belt clamps to block belt motion is not recommended, as the idler frame is designed for the loads of a short section of conveyor and has little strength to resist the stored energy. The forces of the belt tension—resulting from forces of the cargo and the pull of the takeup mechanism—can be significant and sufficient to pull the belt free from the relatively insubstantial construction of an idler frame.

It is much better to attach and secure belt clamps to the conveyor structure. This is typically a structural member of the framework engineered to withstand the types of load that the weight of the belt and cargo and tension of the conveyor system will produce.

Engineered Clamps for Safety's Sake

To securely attach a clamp to the belt to prevent movement, it is recommended that engineered equipment be used. The use of homemade devices composed of c-clamps, lumber, and chains can lead to problems and potential dangers. Homemade devices most likely will not be sufficiently strong enough to accomplish the job of controlling the stored energy, because they do not have the engineering design and testing to assure safety.

On the other hand, engineered belt clamps are specially designed to properly secure a belt to allow safe belt conveyor maintenance. Use the engineered systems within the limits of their design capacities to achieve safe and effective performance.

Engineered belt clamps are readily available from several suppliers, including the manufacturers of mechanical belt splices. (**Figure 25.9.**)

Checking for Risks of Movement

A pre-job analysis should be performed prior to assigning employees to work around belt conveyors. This should determine if a blockout procedure is required.

This pre-job analysis should include these questions:

A. Will any work be performed in pinch-point areas?

This includes all pulleys, carrying rolls, return rolls, drive components, and belt cleaners, as well as the sealing systems along the load zone.

B. Will the belt need to be cut?

The weight of the belt alone can make the belt travel forward or backward.

C. Will several crews be working on the conveyor system at the same time?

If so, will the work performed by one crew affect the safety of another crew working someplace else along or around the belt?

D. Is suitable blocking equipment available?

Clamps should be inspected before each use for defects and missing components. Damaged clamps or clamps with missing components should not be used.

E. Are workers trained in the proper application of belt-motion blocking equipment?

Companies should conduct regular training for those employees who work on or around belt conveyors.

Once it is determined there is a risk of belt movement, a blockout procedure should be applied.

BEST PRACTICES

Belt blockout should be used in conjunction with Lockout / Tagout procedures; it is not intended as a replacement for those procedures.

Figure 25.9.

Engineered belt clamps useful for blocking belt motion are available from several manufacturers.

Image courtesy of Flexco.

- Effectively blocking a belt should be done to prevent belt movement in either direction.
- Use only engineered belt clamps within their rated capacity.

Best practices when blocking a belt using belt clamps and come-alongs include:

- Move the section of the belt to be repaired to the lowest tension area of the conveyor if possible.
- Unload material from the belt and raise or release takeup tension.
- Try starting the conveyor from all operator and control room locations capable of starting the conveyor once the conveyor is locked out, tagged out, and blocked out. This is called Testout. (**See Chapter 24 Working Safely Around the Conveyor.**)
- When possible, move the belt to a work area where the tension is typically the lowest. On inclined belts, this is usually around the tail and on declined belts, the discharge.
- Inspect belt clamps before every use for defects and missing components. Damaged clamps or clamps with missing components should not be used.
- Be aware of the consequences if the come-along or clamp fails. The operator should never stand in line with the pulling force of the come-along.
- Mark the belting against a reference point to check for belt slippage.
- Stop pulling if slipping or belt creep is observed in the attachment of the clamp to the belting or to the structure.
- Release the tension when work is complete. It is recommended to release the tension on both come-along chains before loosening the clamping system.
- Contact the clamp manufacturer whenever in doubt about the application or clamp capacity required.

CLOSING THOUGHTS
Blocking Against Unwanted Motion

Even though a belt conveyor is locked out and tagged out, the risk of injury around belt conveyors remains high due to the chance for uncontrolled belt movement. If employees are required to be on the belt or near pinch points on the conveyor, the belt should be physically restrained from moving under its own stored energy. (**Figure 25.10.**)

A program requiring mechanical restraint of the belt using equipment engineered for that purpose and connected to the conveyor structure will protect employees who are required to work on or around belt conveyors. ⚠

Figure 25.10.

If employees are required to be on the belt or near conveyor pinch points, the belt should be physically restrained from moving under its own stored energy.

Image courtesy of Flexco.