Construction and Maintenance of Belt Conveyors for Coal and Bulk Material Handling Plants

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The information contained in this booklet represents a significant collection of technical information on construction, design considerations and maintenance of belt conveyors for coal and bulk material handling plants. This information will help to achieve increased reliability at a decreased cost. Assemblage of this information will provide a single point of reference that might otherwise be time consuming to obtain. Most of the information given in this booklet is mainly derived from literature on the subject from sources as per the reference list given at the end of this booklet. For more information, please refer them. All information contained in this booklet has been assembled with great care. However, the information is given for guidance purposes only. The ultimate responsibility for its use and any subsequent liability rests with the end user. Please view the disclaimer uploaded on http://www.practicalmaintenance.net.

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Note: Since only part of the content is edited, some of the content may not be up to date.

Content

Need for Bulk Material Handling Plants with Conveyors

Our present civilization requires producing innumerable items for comfort of people in a very large quantity. These items are produced from raw materials from planet earth with appropriate processes. For example, we need huge quantity of cement, which is made from mined materials. We need steel to make simple items like pins to steamers, which requires movement of huge quantity of iron ore. Similarly, generation of electric power on mega scale require movement of huge quantity of coal from mine to thermal power station.

Above examples require installation of a bulk material handling plant at source of the raw material plants and the processing plants. They have become the backbone of such plants as production gets severely affected if the plant is not available.

A bulk material handling plant consists of numerous equipments which works in a coordinated manner to achieve ultimate functional need. The belt conveyors are very important equipment in such plant to ensure flow of material through various equipments of the plant like wagon tipplers, crushers, stacker/reclaimer, vibrating screens, trippers etc. In view of this, information about construction, design considerations and maintenance of belt conveyors for coal and bulk materials is given in the following chapters.

Characteristics of Bulk Materials

Basic classification of material is made on the basis of forms. They are gases, liquids, semi liquids and solids. Solids are further classified into two main groups: Unit load and Bulk Material. The successful design of a conveyor belt for bulk material handling begins with an accurate appraisal of the characteristics of the material to be transported. The behavior of bulk materials greatly depends on the moisture content and particle size distribution of the material. Wide variations in material behavior and bulk density with moisture and particle size can lead to unexpected tonnage or capacity issues, excessive spillage or material buildup, and equipment or system malfunction and failure. In view of this, information about characteristics of bulk materials is given in this article.

Unit Load and Bulk Material

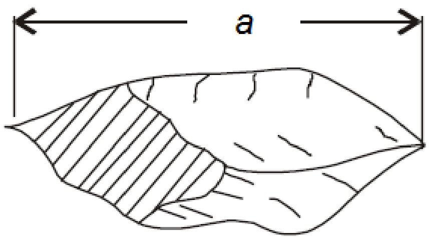
Unit loads are formed solids of various sizes, shapes and weights. Some of these are counted by number of pieces like machine parts and fabricated items. Tared goods like containers, bags, packaged items etc. and materials which are handled en-masse like forest products (logs), structural, etc. are other examples of unit loads. Unit loads have been classified by Bureau of Indian Standards' (BIS) specification number IS 8005.

Bulk materials are those which are powdery, granular or lumpy in nature and are stored in heaps. Example of bulk materials are: minerals (ores, coal, etc.), earthly materials (gravel, sand, clay, etc.), processed materials (cement, salt, chemicals, etc.) and agricultural products (grain, sugar, flour, etc.).

Characteristics of Bulk Materials

Major characteristics of bulk materials, so far as their handling is concerned, are: lump size, bulk weight (density), moisture content, flowability (mobility of its particles), angles of repose, abrasiveness, corrosivity, etc.

Lump Size



Size of a Particle

Lump size of a material is determined by the distribution of particle sizes. As shown in above figure, the largest diagonal size '*a*' of a particle in mm is called the particle size. The materials may be distinguished as sized (classified) or unsized (non-classified) as follows:

Sized (classified) are the materials for which the ratio between the size of the largest lump/particle, a_{max} and smallest lump, a_{min} is less than or equal to 2.5.

Unsized (non-classified) are the materials for which ratio a_{max} / a_{min} is greater than 2.5.

Average lump size of a sized material = (maximum particle size + minimum particle size) / 2

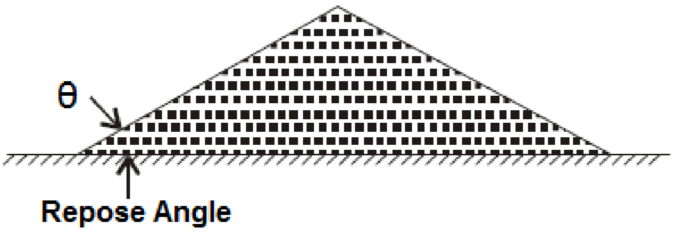
Hence, average lump size of sized bulk material = (a_{max} + a_{min}) / 2

Sized materials are adequately defined by the values a_{max} and a_{min}. Unsized materials, however, require, in most cases, a complete sieve analysis in which the ratio of the lump size shall not exceed 2.5.

Bulk Density

Bulk weight or bulk density of a lumpy material is the weight of the material per unit volume in bulk. Because of empty spaces between the particles in bulk materials, bulk density is always less than density of a particle of the same material.

Repose Angle

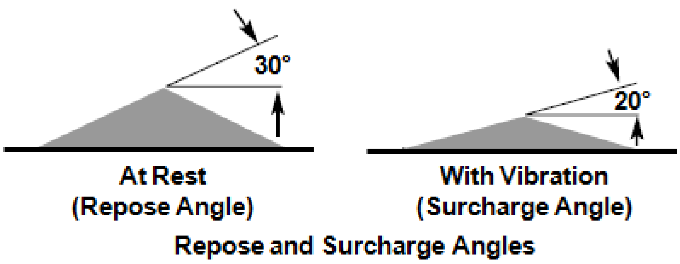


As shown in above figure, when bulk material is dropped on the horizontal surface (ground), it forms a conical heap with certain inclination (angle) with the horizontal surface. The angle of repose (θ) of a material is the natural angle formed by gravity discharge of the material and measured from a horizontal base.

Repose angle dependent on flowability of the material. The higher value of repose angle signifies less flowability of the material. The repose angle for liquid is zero.

The repose angle of a material is an important parameter because it decides the shape and volume of material in stockpiles and storages. It may be noted that the repose angle of a material is susceptible to variation in moisture content.

Surcharge Angle



Repose and Surcharge Angles

However, if the material is dropped on the horizontal surface which is in vibrating condition or is having internal agitation, the material tends to settle/spread and will have lesser inclination with the horizontal surface. This reduced inclination is known as surcharge angle.

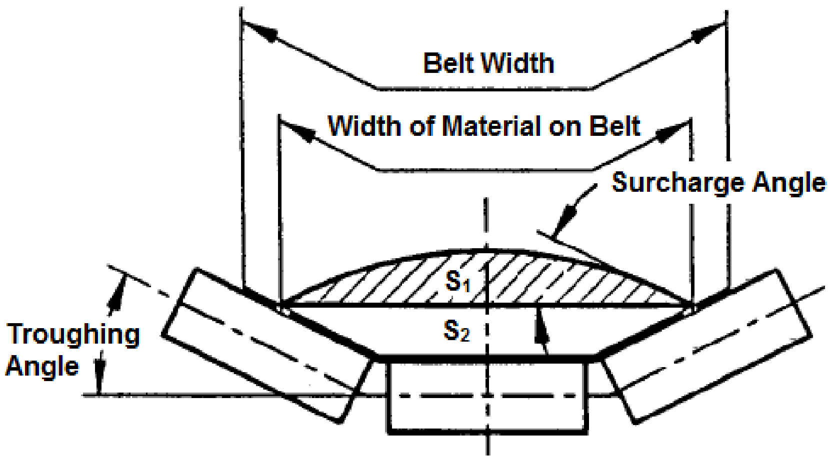
During belt conveying, the material is lying on moving belt. Since the belt sags down between two idlers and rises up when passing on an idler, material particles on the belt is made to move up and down along the belt as it travels forward. This creates presence of vertically fluctuating inertial forces in the body of the bulk material. The belt also opens out slightly between two idlers and closes when passing on the idler. Thus material particles are also oscillating horizontally. This phenomenon results in internal agitation to the material on belt and therefore the material's external faces assume inclination at surcharge angle. The angle of surcharge of a material is the angle to the horizontal which the surface of the material assumes while the material is at rest on a moving conveyor belt. Thus belt's ability to accommodate material is governed by surcharge angle instead of repose angle. In general, the surcharge angle is 5 to 15 degrees less as compared to repose angle. However, in some materials it may be as much as 20 degrees less.

Abrasivity

The property of particles of bulk materials to wear away the surface they come in contact with when in motion is called abrasivity. The abrasiveness of the material affects the wear of belt and other components of conveyor / material handling equipment (like hoppers, chutes, skirtboards, buckets, chain links, etc.) coming in contact with the material. At loading point, the incoming material's velocity is different than the belt velocity. Material takes some time to acquire belt velocity resulting in momentary sliding of the material on belt and causes belt wear. Due to this, for lesser wear, the conveyor handling more abrasive material should have lesser belt speed whereas less abrasive material can be conveyed at higher speed. The agitated condition of material on a belt also causes wear on the belt surface continuously from loading point to discharge point.

Conveyor Capacity

Belt conveyor is required to convey certain quantity of material per hour. As shown in the figure given below, the material is accommodated on the belt forming certain cross-section of the material [S = S_1 (Upper Section) + S_2 (Lower Section)]. This cross-section multiplied by belt velocity provides volume of material being transported in unit time. Thus belt conveyor's ability to transport material is volumetric in nature.



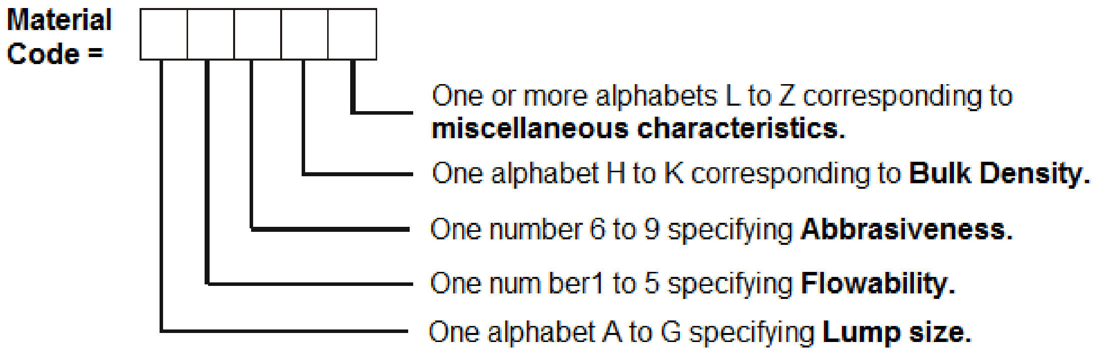
S = Total Cross Sectional Area of Material = $S_1 + S_2$

Cross Sectional Area Occupied by Material

The transported volume is converted into tonees (1 metric tonee = 1000 kg) by multiplying it with the 'Bulk Density' of the material, in the condition as it is on the belt.

Material Classification and Codification System as per IS 8730

Classification and codification of bulk materials (being handled by continuous material handling equipment) based on lump size, flowability, abrasiveness, bulk density and various other characteristics have been specified by the Bureau of Indian standards (BIS) specification number IS 8730. Following figure shows the alphanumeric codification system as per this specification (IS 8730: 1997, Reaffirmed 2002).



Alphanumeric Codification System as per IS:8730

In this material code, if any of the above characteristics is not known, corresponding number or alphabet is dropped from the material code.

The following table shows the descriptions and limits of the different classes of material characteristics.

Classification of Bulk Materials as per IS 8730			
Material Characteristics	**Description of characteristics with Typical Examples**	**Limits of Characteristics**	**Class**
1. Lump size	Dusty material (cement)	“a_{max}” upto 0.05 mm	A
	Powdered material (fine sand)	“a_{max}” upto 0.05 to 0.50 mm	B
	Granular material (grain)	“a_{max}” upto 0.5 to 10 mm	C
	Small sized lumpy (crushed, iron ore)	“a_{max}” upto 10 to 60 mm	D
	Medium sized lumpy (chipped wood)	“a_{max}” upto 60 to 200 mm	E
	Large lump materials	“a_{max}” upto 200 to 500 mm	F
	Especially large lump size (boulder)	“a_{max}” over 500 mm	G
2. Flowability	Very free flowing (cement, dry sand)	Angle of repose: 0°- 20°	1
	Free flowing (whole grains)	Angle of repose: 20°- 30°	2
	Average flowing (anthracite coal, clay)	Angle of repose: 30°- 35°	3
	Average flowing (bituminous coal, ores, stone)	Angle of repose: 35°- 40°	4
	Sluggish (wood chips, bagasse, tempered foundry sand)	Angle of repose: > 40°	5
3. Abrasiveness	Non-abrasive (grains)	-	6
	Abrasive (alumina)	-	7
	Very abrasive (ore, slag)	-	8
	Very sharp (metal scraps)	Cuts belting of conveyors.	9
4. Bulk density	Light (saw, dust, peat, coke)	Up to 0.6 t/m^3	H
	Medium (wheat, coal, slag)	0.6 to 1.6 t/m^3	I
	Heavy (iron ore)	1.6 to 2.0 t/m^3	J
	Very heavy	2.0 to 4.0 t/m^3	K
5. Miscellaneous characteristics	Please refer the following table.	Note: Sometimes more than one of these characteristics may apply.	L to Z

Miscellaneous Characteristics of Bulk Materials as per IS 8730	
Miscellaneous Characteristics	**Class**
Aerates and develops fluid (or dual operating) characteristics	L
Contains explosive (or external) dust	M
Sticky	N
Contaminable affecting use or saleability	P
Degradable, affecting use or saleability	Q
Gives off harmful fumes or dust	R
Highly corrosive	S
Mildly corrosive	T
Hygroscopic	U
Oils or chemicals present. May affect rubber products.	W
Packs under pressure	X
Very light and fluffy (or very high flowability and dusty). May be wind swept	Y
Elevated temperature	Z

BIS specification number IS 8730:1997 lists 486 different bulk materials with their bulk densities, flowability properties and codes.

Material characteristics and codes as per IS 8730:1997 for some common materials are given in the following table.

Material Characteristics and Codes as per IS 8730:1997				
Material	**Average Bulk Density, kg/m^3**	**Angle of Repose, Degrees**	**Recommended Maximum Inclination, Degrees***	**Material Code**
Alumina	800-1040	22	10-12	B27M
Ashes, fly	640-720	42	20-25	A58
Bauxite, mine run	1280-1440	31	17	B38
Cement, Portland	1500	39	20-23	A27M
Cement, Clinker	1200-1520	30-40	18-20	D38
Clay, dry, lumpy	960-1200	35	18-20	D37
Coal, anthracite, sized	960	27	16	C27
Coal, bituminous, mined, classified	960	35	16	D36QT
Copper ore	1920-2400	-	18-20	D28
Earth as excavated dry	1120-1280	35	20	B37
Iron ore	1600-3200	35	18-20	D37
Iron ore, crushed	2160-2400	-	20-22	C27
Iron ore, pellets	2500-2880	20	12	D28 & D28Z
Lignite, air dried	720-880	-	-	D26
Lignite, raw, heavy	900-960	38	22	D37T
Limestone	1360-1440	30-45	-	-
Limestone, crushed	1360-1440	38	20	A26M
Limestone, dust	1360-1520	38-45	18	A57M
Rock, crushed	2000-2320	-	-	D27
Salt, common dry, coarse	720-800	30-45	18-22	C27TU
Salt, common dry, fine	1120-1280	25	11	D27TUW
Sand, bank, dry	1440-1760	35	16-18	C37
Sand, foundry, prepared	1440	39	22	D38
Sand, foundry, shakeout	1440	39	22	D38
Sand, silica, dry	1440-1600	30-35	10-15	B28
Sulphur, crushed	880-960	30-45	16	C36MS
Sulphur, powdered	880-960	30-45	21	B36MW
Urea, prills	700	23-27	13	C26SU

* The angle of inclination is for conventional belt conveyors which allow free rollback of material.

Note:
In the preparation of IS 8730, considerable assistance has been derived from IS0 3435: 1977 'Continuous mechanical handling equipment - Classification and symbolization of bulk materials'.

Material Classification and Code System as per ANSI / CEMA Standard No. 550 - 2003 - R2015, Classification and Definitions of Bulk Materials

CEMA is the Conveyor Equipment Manufacturers Association (5672 Strand Ct., Suite 2 • Naples, Florida 34110, USA. Phone: 239-514-3441, Internet: www.cemanet.org) and is an industry group dedicated to the advancement of the conveyor industry.

Brief information on ANSI / CEMA Standard No. 550 - 2003 - R2015 is given in this section.

ANSI / CEMA Standard No. 550 - 2003 - R2015 is a system for classification of materials according to their individual handling characteristics.

CEMA's material code system consists of actual bulk density, loose and code designations for size, flowability, abrasiveness and miscellaneous properties or hazards as shown in the following table.

Material Classification and Code System as per ANSI / CEMA - 550 - 2003 - R2015		
Major Class	**Material Characteristic Included**	**Code Designation**
Density	Bulk Density, Loose	Actual Lbs/Cu Ft
Size	Very Fine - No. 200 Sieve (.0029") And Under	A_{200}
	Very Fine - No. 100 Sieve (.0059") And Under	A_{100}
	Very Fine - No. 40 Sieve (.016") And Under	A_{40}
	Fine - No. 6 Sieve (.132") And Under	B_6
	Granular - 1/2" And Under	C ½
	Granular - 3" And Under	D_3
	Granular - 7" And Under	D_7
	Lumpy - 16" And Under	D_{16}
	Lumpy - Over 16" To Be Specified, X=Actual Maximum Size	D_X
	Irregular - Stringy, Fibrous, Cylindrical, Slabs, Etc.	E
Flowability	Very Free Flowing - Flow Function >10	1
	Free Flowing - Flow Function >4 But <10	2
	Average Flowing - Flow Function >2 But <4	3
	Sluggish - Flow Function < 2	4
Abrasiveness	Mildly Abrasive - Index 1 - 17	5
	Moderately Abrasive - Index 18 - 67	6
	Extremely Abrasive - Index 68 - 416	7
Miscellaneous Properties or Hazards (More than one may apply)	Builds Up and Hardens	F
	Generates Static Electricity	G
	Decomposes - Deteriorates in Storage	H
	Flammability	J
	Becomes Plastic or Tends to Soften	K
	Very Dusty	L
	Aerates and Becomes Fluid	M
	Contains Explosive Dust	N
	Stickiness-Adhesion	O
	Contaminable, Affecting Use	P
	Degradable, Affecting Use	Q
	Gives Off Harmful or Toxic Gas or Fumes	R

	Highly Corrosive	S
	Mildly Corrosive	T
	Hygroscopic	U
	Interlocks, Mats or Agglomerates	V
	Oils Present (May Affect Rubber)	W
	Packs under Pressure	X
	Very Light and Fluffy - May be Wind Swept	Y
	Elevated Temperature	Z

More information on flowability (Flow Function) and abrasiveness (Abrasive - Index) please see ANSI / CEMA Standard No. 550 - 2003 - R2015.

It can be seen that CEMA's material code system (classification method) is more precise as compared to IS 8730.

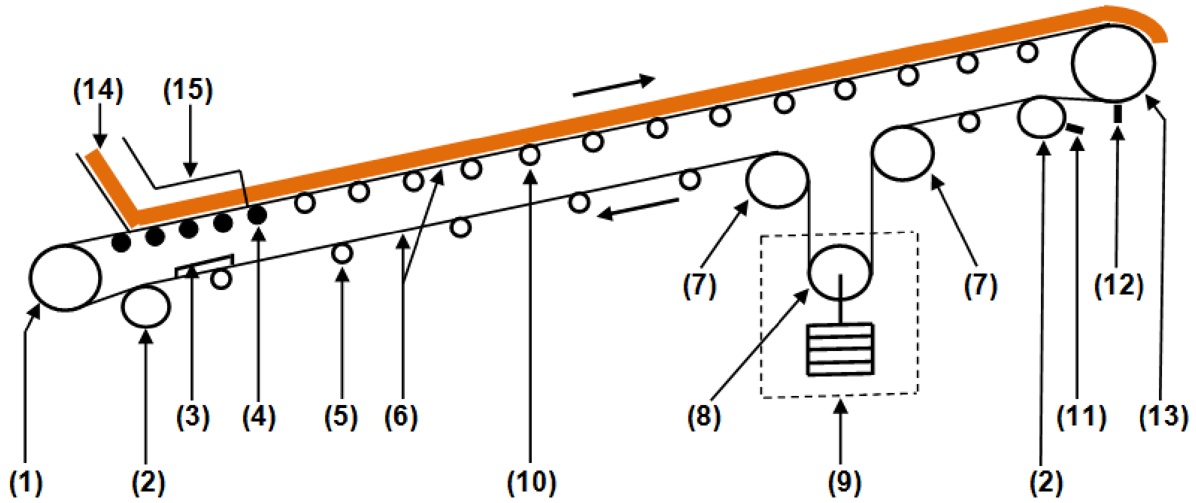
ANSI / CEMA Standard No. 550 - 2003 - R2015 classifies over 500 bulk materials.

For example, following table gives CEMA's material code for some common materials.

Material Description	**Loose Bulk Density (lbf/ft^3)**	**CEMA Material Code**	**Angle of Repose (degrees)**	**Max. Allowable Angle of Conveyor Inclination (degrees)**
Cement, Clinker	75-95	$85D_336$	30-40	18-20
Coal, Bituminous, Mined	45-55	$50D_X35$	38	15
Coal, Lignite	37-45	$41D_335TN$	38	15
Copper, Ore	120-150	$125D_X36$	30-44	20
Earth, Wet, Containing Clay	100-110	$105D_{16}46OV$	45	23
Gravel, Pebbles	90-100	$95D_327$	30	12

Mechanical Components in a Belt Conveyor

The following figure schematically shows the mechanical components of a typical belt conveyor.



Mechanical Components of a Typical Belt Conveyor

(1) Tail pulley
(2) Snub pulley (at head-end and tail-end)
(3) Internal belt cleaner (internal belt scraper)
(4) Impact idlers ((impact rollers)
(5) Return idlers (return rollers)
(6) Belt (continuous loop of carrying run & return run)
(7) Bend pulleys
(8) Takeup pulley
(9) Takeup unit
(10) Carrying idlers (carrying rollers)
(11) Pulley cleaner (pulley scraper)
(12) External belt cleaner (external belt scraper)
(13) Head pulley (normally this is discharge pulley and also drive pulley)
(14) Feed chute
(15) Skirt-board

Working of a Belt Conveyor

The rear end of a belt conveyor is known as tail-end and its forward end is known as head-end. The material is fed onto a belt conveyor at tail-end. The material fed onto the belt conveyor rests on its upper run and travels forward with the belt. The material on reaching the head pulley drops down automatically due to gravity and discharge velocity, while turning round the head pulley. Thus material is conveyed from the tail-end to the head-end in a continuous manner.

The point where material is put on the belt is known as feed point or loading point. The conveyor can have more than one feed point or moving feed point.

The point where material is getting discharged from the belt is known as discharge point. Generally, this point is head-end of the conveyor. However, it can also be created at intermediate point by specialized means (for example, tripper).

It is very important to note that belt conveyor simply conveys whatever quantity of material is put on the belt at the feed point. If the incoming material quantity is less, it operates at partial load. However, if the incoming material quantity is excessive, it will lead to spillage and even breakdown. Therefore, the quantity of material being fed to conveyor should not exceed the design capacity.

Methods of Feeding / Loading Belt Conveyor

The equipment which puts regulated quantity of material on the belt is known as a feeder. Generally, a conveyor receives the feed by a belt feeder, a vibrating feeder or an equipment/machine.

Sometime, a belt feeder, a vibrating feeder or a small belt conveyor starting from outlet of a hopper and conveying fine granular material have regulating gate at feed point. This ensures reasonably controlled conveying.

A belt feeder is similar to a belt conveyor but its working is different from belt conveyor. The design procedure of a belt conveyor is applicable to a belt feeder with appropriate difference.

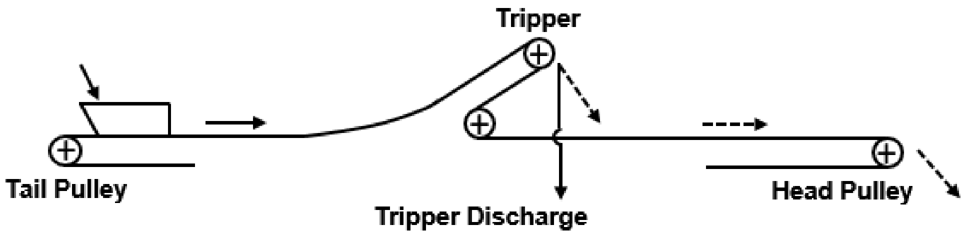
Equipment like crusher, screen etc. discharges at a controlled rate and become a feeder for the outgoing conveyor. These are generally at fixed location.

A travelling machine such as bucket wheel reclaimer, paddle feeder etc. also feed the material at controlled rate onto a conveyor.

Methods of Discharge from Belt Conveyor

Head pulley discharge is the most widely used method for discharging material from a belt conveyor.

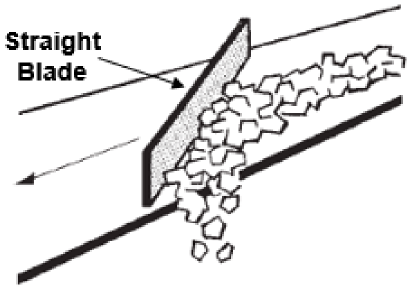
A reversible belt conveyor discharges at both the ends i.e. at head end while running in the forward direction, and alternatively at tail end while running in the reverse direction.



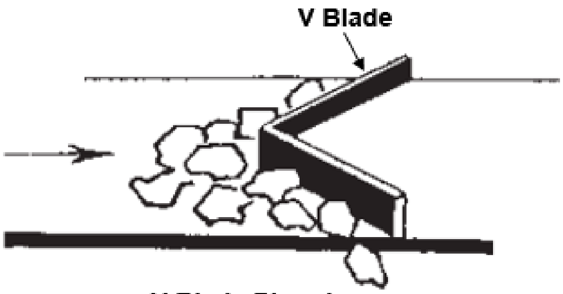
Trippers are devices used to discharge bulk materials from a belt conveyor at points upstream from the head pulley. As shown in above figure, trippers consist of a frame supporting two idling pulleys, one above and forward of the other. The conveyor belt passes over and around the upper pulley and around and under the lower pulley. The belt usually inclines to the upper pulley and may run horizontal or it may then incline again from the lower pulley. By this construction material is discharged to a chute as the belt wraps around the upper pulley. The chute can be arranged to catch and divert the discharged material in any desired direction. The material can be discharged on one / both sides of the conveyor or it can be fed back onto the conveyor for discharge at head end. However, full quantity of material flows to any one of the above paths.

Trippers can be stationary (fixed) or movable (travelling). Stationary trippers are used where the discharge of material is to occur at a specific location. More than one stationary tripper may be used on a belt conveyor. Movable tripper is a machine with wheels running on rails, which are installed along conveyor length. The tripper moves along conveyor length (horizontal), while maintaining continuous mechanical connection with the belt conveyor. It can be moved by an electric motor mounted on the tripper. Many times, more than one movable trippers are used on a long belt conveyor to save time in moving the tripper over a very long distance.

Ploughs are used to discharge/divert free flowing materials from flat belt conveyors. Like tripper, plough may be fixed or travelling.



Straight Blade Plough



V Blade Plough

Plough Types

As shown in above figure, for single discharge, plough is having a straight blade and installed at an angle to the belt. However, when it is desired to discharge the material to both the sides simultaneously, the blade is constructed in the 'V' form, the angle being determined by the speed of the belt.

Plough on Troughed Belt Conveyor

As shown in above figure, for troughed belt conveyors, a flat steel plate or straight idler roller/s of a span more than the belt width may be used under the troughed belt to flatten it at the discharge location. For more information on plough for troughed belt conveyors, please view website of H & B Mining (www.handbmining.com.au).

Ploughs are used in places where it is inconvenient or impossible to install a tripper. Ploughs are cheaper than trippers and takes up less head room. However, plows make the belt to wear faster and therefore they are used for less abrasive materials and slower speed belts.

Several ploughs can be incorporated along one belt conveyor and can be arranged to discharge material to either or both sides of the belt simultaneously. When not in use the blades can be raised to clear the material on the belt.

Specification for Troughed Belt Conveyors

Indian Standards **IS 4776 gives specification for troughed belt conveyors**. It has two parts as under.

Part I: Troughed Belt Conveyors for Surface Installation
Part II: Troughed Belt Conveyors for Underground Installation

Part I covers the requirements for troughed belt conveyors using rubber and canvas belts conforming to IS: 1891 'Specification for rubber conveyor and elevator belting' for handling loose bulk materials within the range of belt widths from 300 mm to 2000 mm. If other types of conveyor belting are used, requirements in the standard which relate to belt tensions and takeup allowances may not be applicable.

Part II covers the requirement for sectional type electrically driven troughed belt conveyors commonly used underground in coal mines, metal mines and non-metallic mines for handling loose bulk materials using fire resistance conveyor belting, conforming to IS: 3181 'Specification for fire resistant conveyor belting for underground use in coal mines', within the belt width from 500 to 1600 mm.

Information on conveyor belts and various components of a conveyor is given in the following chapters.

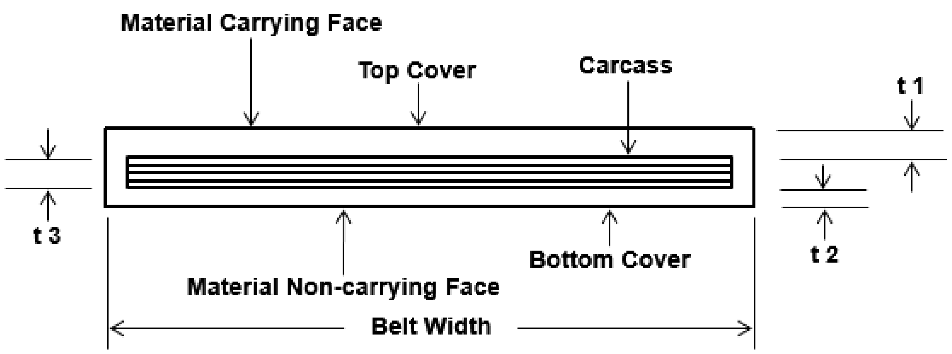
Belts

The conveyor belt is the most important element of a belt conveyor installation. Often the belt is the costliest item in a conveyor. Therefore, the selection of the conveyor belt must be made with great care. It should be capable of doing the following tasks:

- Transport the load.
- Absorb the impact energy at the loading point.
- Withstand temperature and chemical effects (heat, oil, acidity, etc.).
- Meet safety requirements (flame resistant, antistatic etc.).

As it is in contact with the material, it wears due to impact, abrasion, etc. Important information about belts is given in this chapter.

Belt Construction



Belt Cross-Section (At right-angle to belt length)

As illustrated in above figure, the conveyor belt primarily consists of top cover, carcass and bottom cover. The material non-carrying face of the conveyor is also called pulley surface or the running side of the conveyor.

Top (carrying side/surface) cover thickness = t1
Bottom (non-carrying / running side / pulley surface) cover thickness = t2
Carcass thickness = t3
Belt's total thickness = t = t1 + t2 +t3

The belt's carcass thickness is the distance between the highest points of the upper layer of fabric and the lowest points of the lower layer of fabric.

The standard belt widths in mm are 300, 400, 500, 600, 650, 800, 1000, 1200, 1400, 1500, 1600, 1800, 2000, 2200, 2400, 2600, 2800, 3000 and 3200.

Carcass

In a sense, the carcass is the conveyor belt since it must:

- Provide the tensile strength necessary to move the loaded belt.
- Absorb the impact of the impinging material being loaded onto the conveyor belt.
- Provide longitudinal and transverse stiffness to belt for supporting the material as the belt is moving on spaced idlers.
- Provide adequate strength for holding fastener.

Most of conveyor belts carcass is made of one or more plies of woven textile fabric. A fabric is a planar textile structure produced by interlacing yarns, fibers, or filaments. However, for high tension application, carcass of single-layered, steel cord/cable is also used. Ultra-high tension conveyors will require the use of steel cord belts and, more recently, Aramid carcass.

Textile Fabric Belts

A fiber is a unit of matter having a length at least 100 times its diameter and which can be spun into a yarn. **Filament fibers** refer to fibers of long continuous lengths, while **staple fibers** refer to those of shorter lengths, which are about a few inches (3/4” to 2 1/2”) long. Most natural fibers, such as cotton and wool, are staple fibers. Synthetic fibers, such as nylon and polyester, are considered filament fibers. The natural fiber silk is also a filament fiber, but when filament fibers are cut short, they are considered staple fibers.

Yarn is “a generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric”

Yarns made from short, staple fibers are called **spun yarns**. Whereas yarns made from continuous filament fibers are called **filament yarns**. However, the yarn processing methods for spun yarns are very different from those of filament yarns. Filament yarns are stronger than the same-size spun yarns of the same synthetic material.

Textile fabrics belts are the most commonly used belts for conveyors and elevators. As the name indicates, these belts have carcass made of textile fabric.

In textile fabric belts, carcass is composed of single special ply or more number of plies. The 'Ply' is the fabric (fabric body) which is designed to take loads. The ply is formed by weaving (usually at right angles) of warp yarns (threads), which run lengthwise, and weft (filling) yarns, which run crosswise. The tensile strength of warps is more because the same is required to withstand the main tension occurring in the belt.

Loom - Weaving Machine

The manufacture of a textile fabric requires the use of an apparatus called a “loom,” or weaving machine. This mechanical device weaves the fabric by interlacing a series of parallel yarns in the longitudinal (or warp) direction with a series of parallel yarns in the transverse (or weft/filling) direction. Warp yarns are delivered to the loom in the form of a “sheet.” The weft yarns, on the other hand, are normally delivered one at a time, either by a “shuttle” (as was typical of earlier loom designs), or by a yarn gripping device called a “rapier” (as with the more modern looms available today).

In short, the loom provides the means to interlace the warp and weft yarns, bringing them together at the designed frequency and style, required in the woven fabric.

After weaving, for most rubber based belting (Natural, SBR, NBR, CR, EPDM, etc.), the textile fabric is dip-treated with Rescorcinol-Formaldehyde-Latex (RFL) coating to provide adequate adhesion with rubber compounds. For thermoplastic type belt, the treatment can involve acrylics, polyurethane, PVC or other treatment for the respective textile reinforcements.

The yarns of required size and strength are used to make a ply, which appears similar to cloth / mat, but is very strong, tough and flexible to suit tension rating of carcass / belt.

The textile fabric carcass is made from cotton, cellulose (viscose), rayon (viscose), nylon (polyamide), polyester, fiber glass and aramid.

Fabric strengths ranging from 63 N/mm up to and including 630 N/mm are generally available. The standardized strength sequence is: 63, 80, 100, 125, 160, 200, 250, 315, 400, 500 and 630 N/mm.

Properties of common textile yarns (for carcass) are as under.

Type of yarn	Cotton	Cellulose Staple Fibre	Super Strong Rayon	Polyamide (Nylon)	Polyester
Breaking length* (km)	12 to 15	22	51 to 54	80 to 81	75
Elongation at break (%)	12	19 to 20	11.5 to 12	17 to 18	12 to 13
Change of tensile strength due to moisture (%)	+8	-20 to -25	-20 to -25	-10	0
Density (g/cm^3)	1.50 to 1.54	1.50 to 1.52	1.50 to 1.52	1.14	1.38

* Vertically freely suspended self-supporting length, under gravity

International nomenclature for various carcass materials is as under.

Cotton - B (C is also used in India)
Viscose - Z (In DIN standard, R is used for Rayon)
Polyamide (Nylon) - P (N is also used in India)
Polyester - E
Aramid - D
Steel - St

Carcass is made with combination of above materials also. Some of the popular versions are as under.

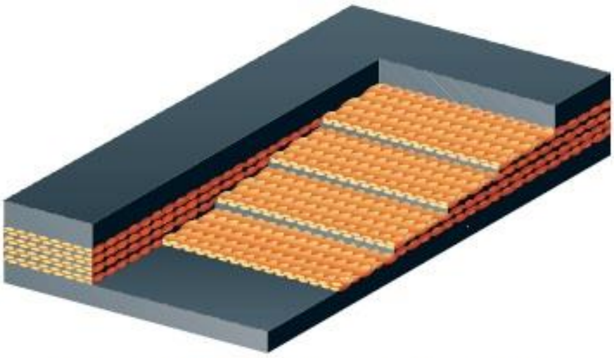
- Cotton fabric (warp cotton, weft cotton)
- Cotton nylon (warp cotton, weft nylon)
- Cellulose fabric (warp cellulose, weft cellulose)
- Rayon nylon (warp rayon, weft nylon)
- Nylon nylon (warp polyamide, weft polyamide). Polyamide is commonly called as nylon.
- Polyester (warp polyester, weft polyester)
- Polyester polyamide (warp polyester, weft polyamide i.e. nylon)

In polyester polyamide (EP) belts, the low-elongation polyester fibres are used in the warp (lengthwise yarns) whereas the more elastic polyamide (nylon) fibres are used in the weft (crosswise yarns). This combines the best properties of both textiles, offering high strength but low stretch conveyor belt with excellent impact resistance, troughability, load support, and fastener holding ability.

In textile fabric belts, many times carcass composed of single special ply (mono-ply) is used as they have certain advantages. Some of them have superior ability for metal fasteners and some are economical. However, tensile strength range is less for such belts compared to multi-ply belts.

A belt with two or more plies (layers of fabric) is called a multi-ply (poly-ply) belt. Textile fabric multi-ply conventional belts are extensively used for general conveying applications.

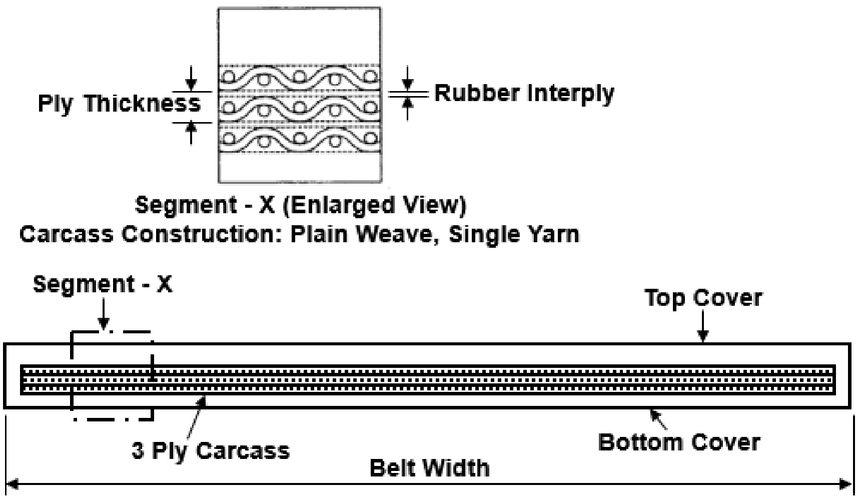
A typical **multi-ply carcass** can consist of between two to six plies in the required tensile strength. For elevator belting, three to six plies may be necessary due to the risk of tearing at the bucket holding bolts.



Textile Fabric Multi-Ply Conventional Belts

Above figure shows a textile fabric multi-ply conventional (without constructional feature) belt. In this type of belts, the plies are overlaid and combined to form carcass of required strength.

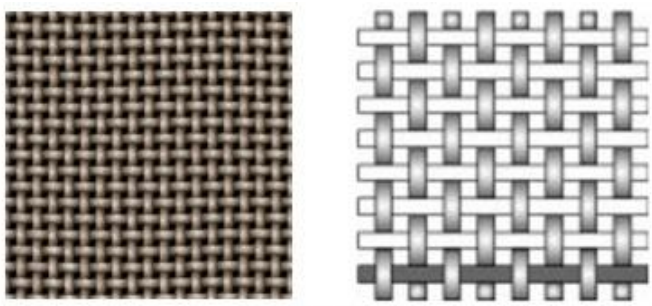
Step splice method is applicable for splicing (jointing) of multiply belts with more than two plies.



Multi-Ply Belt Cross-Section (At right-angle to belt length)

As shown in above figure, typical belt manufacturing process involves application of thin rubber - interplay (also called skim) coating - to fabric ply so that rubber spreads very effectively through interstices of the fabric. Rubber interplay is an important contributor to internal belt adhesions, impact resistance, and plays a significant role in determining belt “load support” and “troughability.” Improper or marginal rubber interplay can adversely affect belt performance in general and can lead to ply separation and/or failure at idler junction. Subsequently, these plies are sandwich between top cover and bottom cover to form full cross section of the belt. Thereafter the full cross section of the belt is subjected to hot vulcanizing process which creates bond between ply to ply and ply to cover.

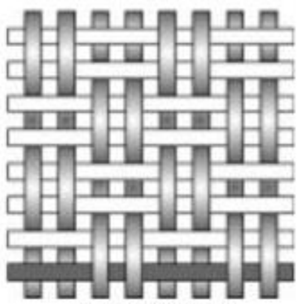
Various types of carcass weaves/styles are used depending on the type and/or duty expected of a belt.



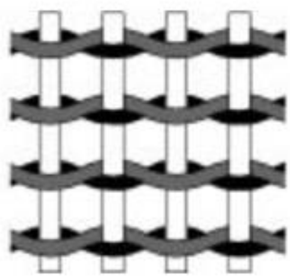
Plain Weave

The plain weave is the most common and least complicated fabric pattern used for flat belts. In plain weave, the warp yarns (lengthwise yarns) and the weft/fill yarns (crosswise yarns) pass over and under each other. This means that both members are crimped (Essentially, each assumes a sine-wave-like configuration). In this weave, the high level of fibre crimp imparts relatively low mechanical properties compared with the other weave styles. With large fibres this weave style gives excessive crimp and therefore it is used for lower-tension plied belts.

Twill Weave



Basket Weave



Leno Weave

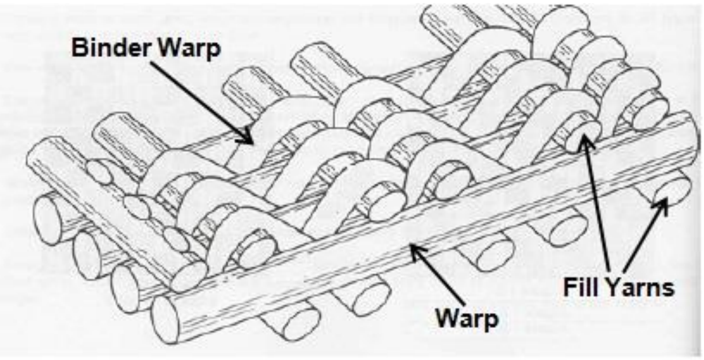
Common Weave Constructions

Twill weave and basket/oxford weave are used to achieve enhanced physical properties, beyond that which the plain weave can provide.

As shown in above figure, in a twill weave, warp fibres alternately weave over and under two or more weft fibres in a regular repeated manner. A basket weave is fundamentally the same as plain weave except that two or more warp fibres alternately interlace with two or more weft fibres. As crimp is reduced in these weaves, the fabric has higher mechanical properties.

Basket/Oxford weave is also called crow’s foot as this weave appears like a bird’s foot.

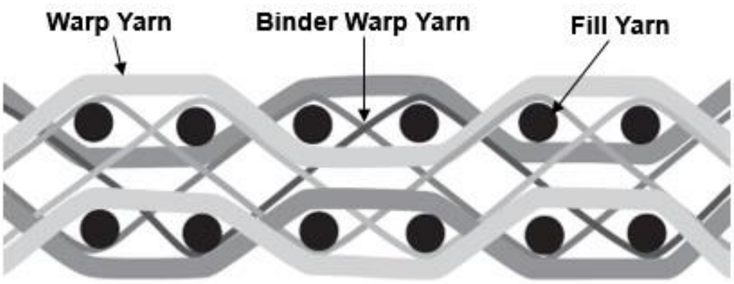
Leno weave has an open mesh and is usually used as a breaker fabric.



Straight Warp Fabric

In the straight warp fabric design, tension-bearing warp yarns are straight, that is, without crimp. Fill yarns are then laid transversely and alternately, above and below the main tension yarns. Because these yarns are not getting crimped, much thicker yarns are used in this weave than yarns in the conventional weave fabrics. Further, the warp yarns and fill yarns are locked together by means of another series of lengthwise yarns, known as the binder warp system. The binder warp system locks the tension and fill cords tightly together, creating a belt which is unusually tough and which has exceptional tear and impact resistance, as well as good mechanical fastener holding strength.

The straight tension-bearing warp yarns eliminate “geometric/construction stretch” and results in a conveyor belt construction with a minimum stretch property. The straight fill yarns provide a “beam" effect for better load support and transverse rigidity.



Solid Woven Fabric

As shown in above figure, solid woven fabric consists of multiple layers of warp and fill yarns interwoven (held together) with binder warp yarn. Solid woven fabric is generally used in single-ply (uni-ply or mono-ply) belts.

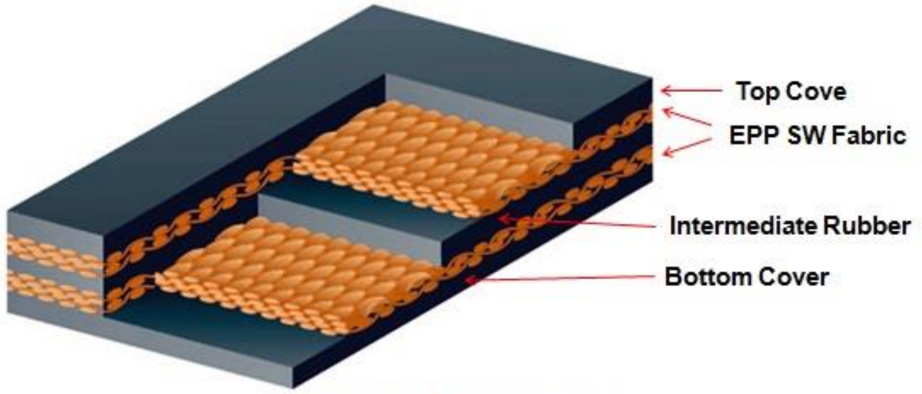

Solid Woven Carcass

As shown in above figure, in a solid woven carcass depending on tensile strength and duty, filament and staple yarns in polyester, polyamide or aramid are held together in a highly complex composite fabric construction in which many layers of warp and filling yarns are interwoven. Many times, the composite fabric is impregnated and covered with poly-vinyl chloride resins. The resultant solid woven PVC product/belt is primarily used for following two applications.

- Underground mining for flame retardency and excellent mechanical fastener holding.
- As elevator belting at grain terminals for its inherent oil resistance and excellent mechanical fastener holding.

PVC conveyor belt consist of PVC impregnated solid woven carcass and PVC covers. PVC conveyor belts are ideally suited for rough usage below ground and they meet the strictest safety regulations for fire-protection.

Many times EP belts are made with solid woven carcass to withstand tough conditions like extreme impact and high pulling forces. They are used to convey materials like stone, logs, and rocks. These belts are made with a single-ply carcass and double-ply carcass.



CON-BITEX® by ContiTech

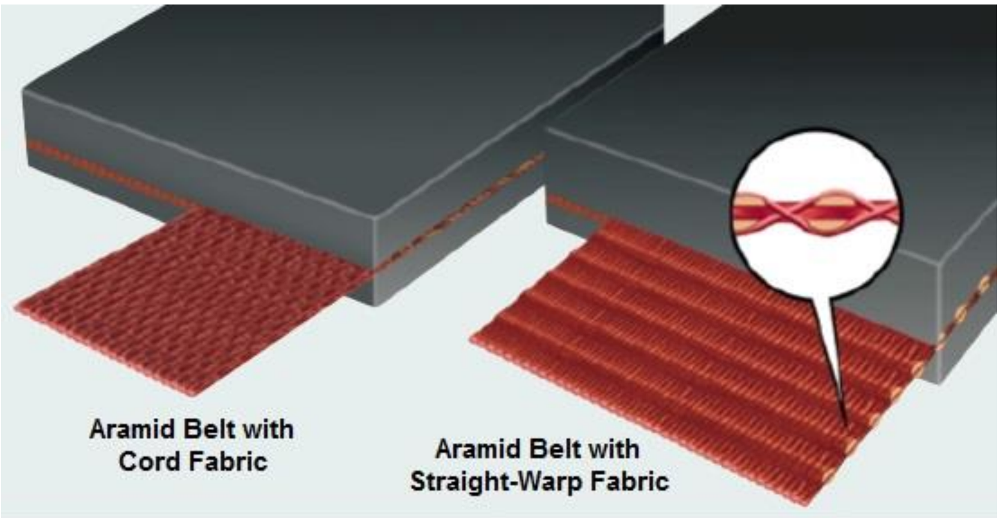
Above figure shows construction of CON-BITEX ® EPP textile conveyor belts by ContiTech with double-ply carcass. In its EPP solid woven fabric, straight polyester (E) warp threads lie in the direction of belt travel, polyamide (P) weft threads in the transverse direction and both of them are joined together by an additional binder yarn made of polyamide (P). CON-MONTEX® by ContiTech is having a single-ply carcass of EPP. Resistance and absorption of impact energy with EPP 630/1 is comparable to a 4-ply belt with a strength rating of EP 1600/4.

The finger splice method is recommended for splicing EPP conveyor belts.

Aramid Conveyor Belts

Aramid conveyor belts are made from aramid fibers. Aramid is as light as other synthetic fibers like polyester or polyamide, but as strong as steel. It has low elongation, no creep and excellent resistance against heat and chemicals. It does not corrode or rot.

As there is only one fabric ply in these belts, the carcass is light and flexible with optimum strength utilization. These belts are fatigue resistant throughout their lifetime. As shown in following figure, different fabric designs are available.



Aramid Conveyor Belts

The cord fabric consists of straight aramid cords in longitudinal direction. The straight-warp fabric contains additional transverse polyamide cords that protect the aramid cords from both sides. If increased impact resistance is required, additional polyamide breaker plies can be provided in the cover.

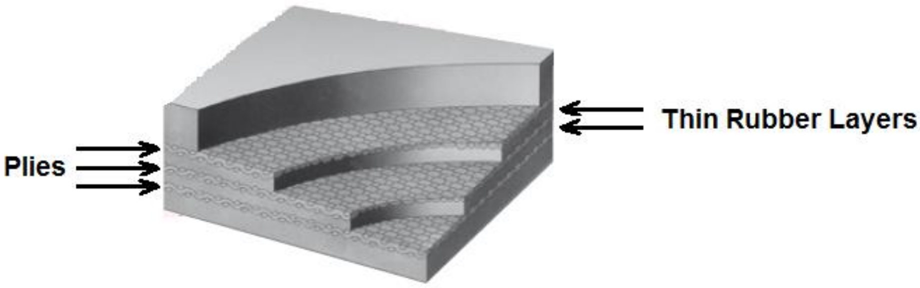
Depending on carcass thickness, these belts can be spliced with overlap or finger splice. Cold splicing is possible in emergencies.

Constructional Features

Textile fabric conventional belts can have various constructional features such as skim-coated plies, breaker ply, transverse cord protection, moulded edge construction and cut edge construction.

Breakers are woven fabrics primarily of nylon and/or polyester. The "Leno" weave is most often utilized because of its open nature. Many times cords are also incorporated. Placement of the breakers is generally above the carcass in the top cover (or below if applied to the bottom cover). Because of the open nature of their weave, these fabrics tend to dissipate impact energy and help to prevent puncture of the belt carcass from sharp materials through the cover. Cover adhesion may also be increased by adding breakers.

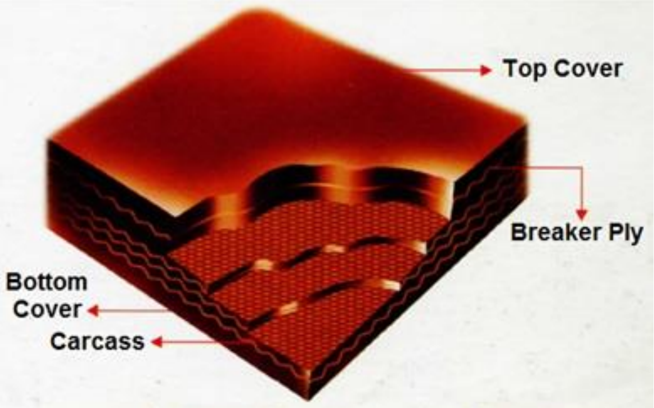
<u>Skim-coated Plies:</u>



Skim Coated Plies

In skim-coated plies, a thin additional layer of rubber is applied between plies. This extra rubber layer between plies improves the belt’s ability to withstand impact by diffusing the impact forces. This results in more durable bond between plies and is used for handling heavy / lumpy materials.

Breaker Ply:

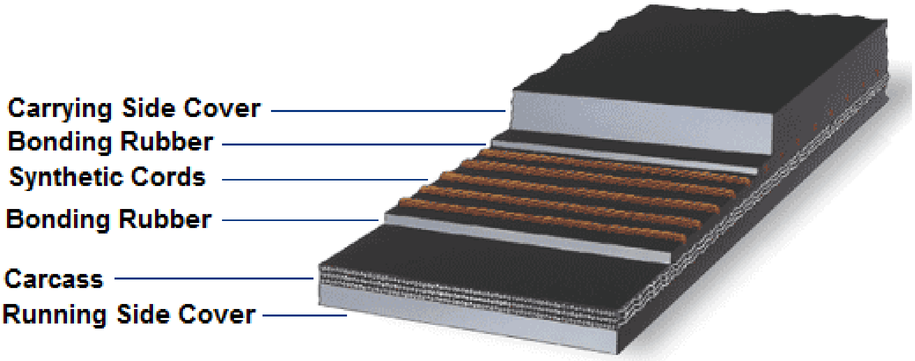


Conveyor Belt with Breaker Ply

As shown in above figure, in this construction a breaker ply is provided within the top cover to improve the impact resistance of a belt for handling very lumpy material. Breaker ply is a woven fabric primarily of nylon and/or polyester. The "Leno" weave is most often utilized because of its open nature. Because of the open nature of the weave, the fabric tends to dissipate impact energy and help to prevent puncture of the belt carcass from sharp materials through the cover. It also prevents the progress of rubber cut.

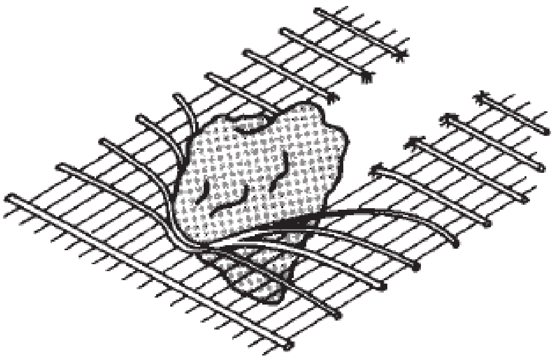
Because cover adhesion increases due to addition of breaker ply, sometimes it is provided in the bottom cover also for improving its adhesion to the carcass. This improves the belt life when high tractive pull is to be transmitted from drive pulley to carcass.

Transverse Cord Protection:



Conveyor Belt with Transverse Cords

As shown in above figure, the impact resistance of a conveyor belt can be improved by providing transverse cords in the carrying side cover (top cover). In conveyor belts with transverse cord protection, synthetic cords (of nylon or equal elastic material), approximately 1.5 to 3.0 mm in diameter are placed in transverse direction at regular interval/spacing. As the transverse cords are placed widthwise, they do not affect minimum pulley diameter. They are also having minimum effect on troughability due to elasticity of nylon and spaced pattern.



Steel Breaker Ply

Slitting open of conveyor belts is a relatively frequent cause of damage which leads to prolonged interruptions and incurs great costs. In most cases it originates from sharp edged pieces of material being trapped in the transfer chute. To avoid such damage, as shown in above figure, many times steel breaker ply (or cords) is embedded in the cover rubber.

Moulded Edge Construction

In the moulded edge construction, the carcass terminates slightly before belt edge and the belt edges are moulded/made from rubber. This construction was very common during the use of cotton fabric as carcass material because cotton fabric is susceptible to moisture spread by capillary with consequent weakening due to biotic effect. Moulded edge is also necessary if the carcass is to be shielded from the environmental condition. However, these belts are costly because moulding of the edge involves additional step in manufacture.

Cut Edge Construction

In the cut edge construction, the belt edges are trimmed after manufacture. Very wide belt can be readily cut into smaller widths for effecting immediate supply.

Carcass Designation

Formerly, the plies were made from cotton yarns, which served the industry for a very long time. The current practice is to use plies woven from N/N (nylon / nylon) or EP (polyester polyamide) yarns. The carcass formed from such plies is stronger and is found to be more suitable for most of the conveyor application.

The carcass designation for general range of popularly used N/N or EP fabric multi-ply conveyor belts is as under.

315/2, 315/3; 400/2, 400/3, 400/4; 500/3, 500/4, 500/5; 630/3. 630/4. 630/5; 800/3, 800/4, 800/5; 1000/3, 1000/4, 1000/5; 1250/4, 1250/5, 1250/6; 1400/4, 1400/5. 1400/6; 1600/4, 1600/5; 2000/5, 2000/6.

Above carcass designations as per **European practice** means following data about itself.

Example: In carcass 1250/4,

/4: This means; carcass is composed of 4 number of plies.
1250/: This means, total breaking strength of carcass (i.e. total of all 4 plies together) is 1250 N per mm of belt width (Breaking tensile force is acting along the length of belt / conveying direction).

As per Indian Standard, carcass 1250/4 means as under.

/4: This means; carcass is composed of 4 number of plies.
1250/: This means, total breaking strength of carcass (i.e. total of all 4 plies together) is 1250 kN per meter (kN/m) of belt width.

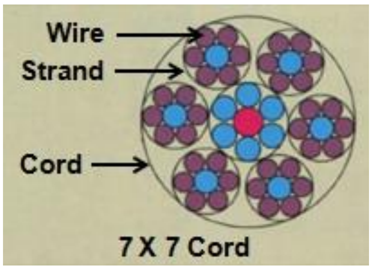
Pounds per Inch of Width (PIW)

English system of measurement is still prevalent in the United States. There, belt tension is rated in pounds / inch of width (PIW). It may be noted that in this method the carcass is rated by the manufacturer in terms of permissible <u>maximum recommended operating tension</u> (It may be noted that: Recommended Operating Tension = Total Breaking Strength ÷ Safety Factor). The following equations may be used for the unit's conversion.

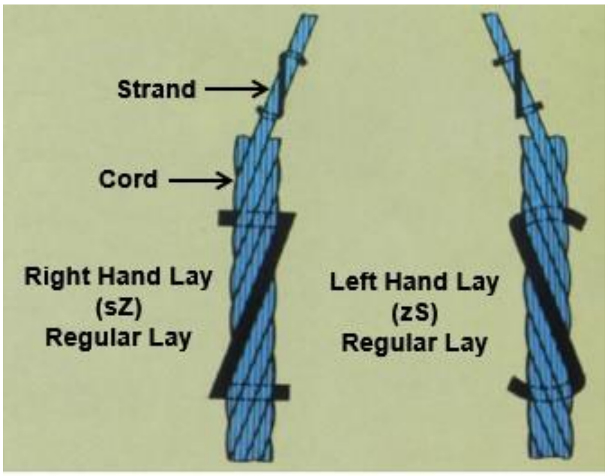
1 Newton per millimeter = 1kN/m = 5.714 pounds / inch of width.

Steel Cord Belts

Steel cord belts have carcass of steel cords (sometimes these are also mentioned as steel wire ropes or steel cable).

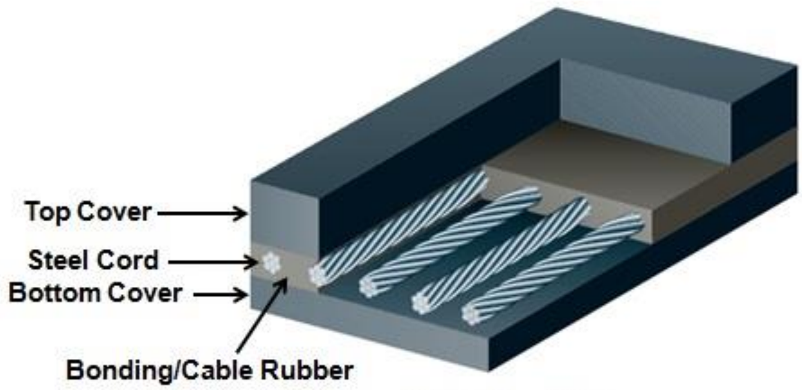


Steel wires (say seven or suitable number) are twisted together to form one strand. Than the strands (say seven or suitable number) are twisted together to form the cord. Subsequently such cords are utilized to make a steel cord belt. Steel cords are also galvanized for protection against corrosion during long service life of a belt. Above figure shows cross section of a 7x7 (7 strands of 7 wires) steel cord.



Lay of Steel Cords

As shown in above figure, wires are twisted round a core to form a strand. Strands are helically laid to form the cord [Right Hand Lay, Regular (Ordinary) Lay or Left Hand Lay, Regular (Ordinary) Lay]. In a cord, the direction of twist for the strand (S or Z) is opposite to the direction of twist for the cord.

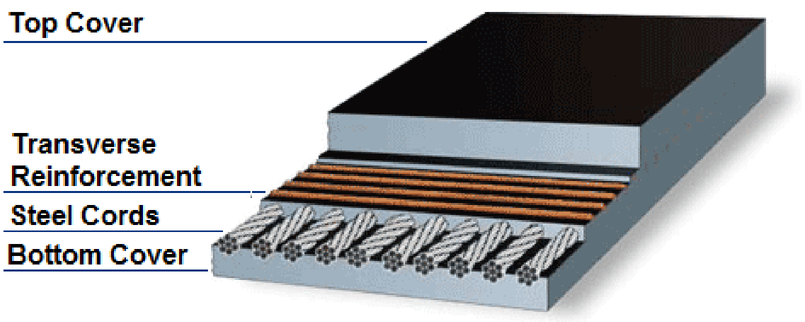


Cross-Section of Steel Cord Belt

Above figure shows typical cross section of a steel cord belt. In a steel cord belt, the steel cords are spaced parallel in a single layer and are completely encased (embedded) in elastomeric compound. Secondly, the cords in a belt occur as S and Z alternatively. This arrangement eliminates accumulation of residual torsion and also minimizes possibility of belt mistracking. These belts are made with molded edge construction.

Utmost care is necessary during manufacturing for equal 'tensile status' of all the cords. This is required so that tensile force acting on belt during operation is equally shared by all cords. This is essential to prevent belt failure due to over stressing of some cords at the expense of relatively loose cords. This is also essential for straight running of belt during operation.

Steel cord belts are also available with transverse-reinforcement in top and bottom cover. This consists of textile cords at regular pitch laid at right angle to steel cords. Such textile cords resist lengthwise cutting/slitting of belt and also improves belt's ability to withstand material impacts. The textile cords have good stretchable characteristics for least effect on troughablity of belt. The following figure shows a steel cord belt with transverse reinforcement in top cover.



Steel Cord Belt with Transverse Reinforcement in Top Cover

Steel cord belts have very high breaking strength up to 8000 N/mm compared to up to 2000 N/mm for textile fabric belts. Therefore, steel cord belts are needed when belts have to withstand very high tensions, beyond the range of textile fabrics. Belt conveyors of very long lengths or belt conveyors with great level difference between head and tail end will have such very high tension requirement.

Since steel cord belts have very low stretch compared to the textile fabric belts, the required movement of takeup pulley to absorb belt stretch during operation is very low. As a result of this, the provision of takeup pulley movement for steel cord belts is only about 0.3% of the conveyor length as compared to 2 to 2.5% of conveyor length for the textile fabric belts.

Steel cord belts are easier to trough as carcass does not create bending resistance to troughing due to absence of weft members. Bending resistance is only by rubber, which is less due to its stretchability.

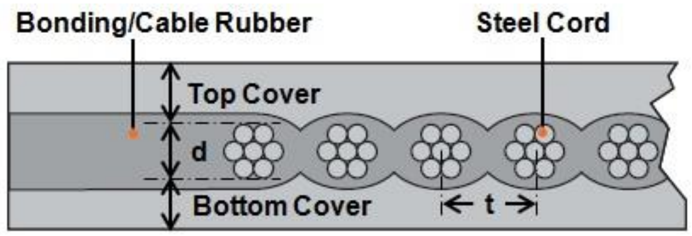
Steel cord belts have smaller pulley diameters compared to fabric belt of equal strength which results into less cost for pulleys.

The general range of steel cord belt is:

St 400, St 500, St 630, St 800, St 1000, St 1120, St 1250, St 1400, St 1600, St 1800, St 2000, St 2250, St 2500, St 2800, St 3150, St 3500, St 4000, St 4500, St 5000, St 5400, St 6300, St 7100, St 8000 and St 8500.

In foregoing notation, as an example in St 1600, the 'St' implies steel cord belt and it has breaking strength of 1600 N per mm width of belt.

Dimensions Requirements as per DIN 22131, Part 1



Steel Cord Belt Dimensions Requirements

As per DIN 22131, Part 1 belt types ranging from St 500 to St 8000 are technically possible. Particular details may be agreed upon request. The cord diameter (d), cord division/pitch (t) and minimum cover thickness for the most current belt types shall be as per the following table.

Belt Type	Min. Breaking Load N/mm	Cord Diameter d max. mm	Cord Division t ± 1.5 mm	Min. Cover Thickness mm
St 1000	1000	4.1	12	4
St 1250	1250	4.9	14	4
St 1600	1600	5.6	15	4
St 2000	2000	5.6	12	4
St 2500	2500	7.2	15	5
St 3150	3150	8.1	15	5.5
St 3500	3500	8.6	15	6
St 4000	4000	8.9	15	6.5
St 4500	4500	9.7	16	7
St 5000	5000	10.9	17	7.5
St 5400	5400	11.3	17	8

Important technical data (guide values) for steel cord belts manufactured by ContiTech, Germany are given in the following table. These data are for STAHLCORD® to DIN 22129, DIN 22131 and in special versions (Series R 20).

Belt Type	Cord Diameter mm	Min. Drive Pulley Diameter mm	Min. Cover Thickness mm
St 500	2.9	500	3
St 630	2.9	500	3
St 800	3.6	630	3
St 1000	4.0	630	3
St 1120	4.0	630	3
St 1250	4.8	630	3
St 1400	4.0	630	3
St 1600	5.5	800	4
St 1800	5.5	800	4
St 2000	5.5	800	4
St 2250	5.5	800	4
St 2500	7.1	1000	5
St 2800	7.1	1000	5
St 3150	7.9	1250	5.5
St 3500	8.4	1250	5.5
St 4000	8.9	1250	6.5
St 4500	9.6	1400	7
St 5000	10.7	1600	7.5
St 5400	11.2	1600	8
St 6300	12.3	1800	8.5
St 7100	13.1	1800	9

Note: For more information, please contact ContiTech, Germany.

Carcass Material Selection

Following table gives general information on material composition and selection for carcass material.

Common Name	Material Composition	General Information
Cotton	Natural Cellulose	Cotton is the only natural fiber used to great extent for belting. As it absorbs high amount of moisture, it is susceptible to mildew (a form of fungus) attack..
Nylon	Polyamide	It has high strength and high elongation. It has good resistance to abrasion, fatigue and impact. While moisture absorption is not as high as cotton, it will absorb up to 10% of its own weight in moisture. It has high resistance to mildew.
Polyester	Polyester	It has high strength and low elongation. It has good resistance to abrasion and fatigue. As moisture absorption is extremely low, it has excellent resistance to mildew.
Fiber Glass	Fiber Glass	It is used in high temperature applications.
Kevlar*	Aramid	It has very high strength and very low elongation. It does not melt but does decompose at high temperatures.
Nomex*	Aramid	It has very high strength and high elongation. However its high temperature properties are excellent.
Steel Cord	Steel	It has very high strength and very low elongation. Very good troughing characteristics. Good fatigue and abrasion resistance.

* Kevlar and Nomex are registered trademarks of DuPont.

Evaluation of characteristics for various carcass materials is given in the following table.

Characteristics	Carcass Material				
	Nylon (P)	Polyester (E)	Polyester Nylon (EP)	Aramide (D)	Steel Cord (St)
Tensile Strength	Very Good	Very Good	Very Good	Excellent	Excellent
Adhesion	Very Good	Very Good	Very Good	Very Good	Excellent
Elongation	Moderate	Very Good	Very Good	Excellent	Excellent
Resistance to Moisture	Good	Very Good	Very Good	Very Good	Good
Impact Resistance	Good	Good	Good	Good	Excellent

Belt Stretch/Elongation

During operation, the conveyor belt gets stretched. Some of this stretch is temporary which is due to changes in the belt tensions caused by starting or braking conditions or caused by change in thermal conditions. However, belt stretch caused by elongation in the fibers and fabrics used in the belt construction due to straightening of fabric and creep elongation of fiber material is permanent. A conveyor belt can have following types of stretches.

Elastic Stretch

This is that part of a belt's stretch which occurs during changes in belt tension. Changes in belt tension occurs during starting acceleration, braking deceleration and belt loading. This stretch is almost entirely recovered when the applied pull or stress is removed.

Constructional Stretch

This is generally due to the type of fabric weave. In a conventionally woven fabric, the warp strands which are crimped tend to straighten out as the load is applied. This results in belt growth, a portion of which is non-recoverable.

Permanent Length Change

This includes changes in length caused by elongation in the basic fiber structure due to creep elongation. It also includes the portions of the elastic stretch and constructional stretch which are non-recoverable.

Takeup systems allow the conveyor to compensate for these changes in overall belt length without having to cut sections out of the belt.

Elongation Properties of Belt Carcass (at 10% of breaking strength)

Normally, belts operate below 10% of breaking strength. Therefore, the elongation properties measured at 10% of breaking strength provide reference values. In view of this, the elongation properties of various carcass materials measured at 10% of breaking strength are given in the following table.

Carcass	Elastic elongation (%)	Permanent elongation (%)	Total elongation (%)
Cotton	1.5 to 2.0	0.2 to 0.4	1.7 to 2.4
EP (up to 200)	0.6 to 0.9	0.5 to 0.8	1.1 to 1.6
EP (above 250)	0.9 to 1.2	0.8 to 1.6	1.6 to 2.8
Steel cord	0.1 to 0.3	-	0.1 to 0.3
Nylon	Approximately 2.5	2.0	4.5

Since the elongation values for NN belt are more compared to EP belts, NN belts need longer take-up stroke.

Troughability, Load support and Number of Plies

Tensile strength is not the only consideration necessary in the design of a conveyor belt carcass. Transverse flexibility or rigidity of the belt is another significant consideration.

Case A
Stiff Belt - Improper Troughing

Case B
Flexible Belt - Proper Troughing

Proper and Improper Troughing

It is important that the belt trough properly. The empty conveyor belt must make sufficient contact with the center roll in order to track properly.

As shown in above figure, the belt in case A is too stiff to contact the center rolls, and therefore, will wander from side to side with the possibility of causing considerable damage to the belt edges and the structure. The belt in case B shows sufficient contact with the center roll and is the condition we should strive for.

As a general rule, the belt troughability is adequate if minimum 35 to 40% of belt width is in touch with idlers, even while being empty. In this condition, it should also touch the central roller.

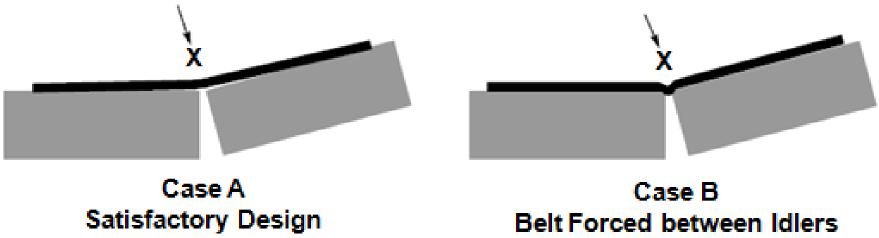
In view of above, a belt should be checked for the maximum number of plies beyond which transverse flexibility is reduced and the troughing efficiency is affected. Transverse flexibility varies with the belt width and trough angle. For flexibility, generally belt with stronger fabric and lesser number of plies is selected. Troughability also increases with increase in belt width. The checking may be carried out from manufacturers' recommendatory tables providing maximum number of plies for adequate troughing or minimum width for adequate troughing for various types/constructions.

This design consideration is referred to as maximum ply design or, in other words, the maximum number of plies beyond which troughability will not be adequate.

Flexing of Troughed Belt

Most conveyor belts operate over troughed idlers. The troughing angle of these idlers usually varies from 20 degrees to 45 degrees and beyond.

As shown in above figure, this trough angle affects the belt by creating a line along which the belt is constantly flexed. The greater the trough angle, the greater the flexing action. When the belt is fully loaded, the portion of the load (X) directly over the idler junction gap forces the belt to flex to a shorter radius. The heavier the load, the smaller the radius through which the belt must flex. The forces will also try to push the belt down into the idler junction gap.



Need for Sufficient Transverse Rigidity

As shown in above figure, in case A, the belt design is satisfactory in that it does bridge the angle properly under full load. Whereas in case B, the weight of the load has forced the belt tightly into the gap between idlers and premature failure can occur.

Consequently, a belt must be designed with sufficient transverse rigidity to “bridge” the idler junction gap with a satisfactory radius and flex life so that for a given idler angle and load weight, premature belt failure will not occur. This design can be checked from manufacturers' recommendatory tables providing either minimum number of plies for adequate load support or maximum width for adequate load support for various types/constructions.

This design consideration is referred to as <u>minimum ply design</u> or, in other words, the minimum number of plies to support the load properly over the idler junction angle.

From above, it is apparent that there are two extremes of transverse/lateral belt flexibility/rigidity to be considered in making a belt selection and these are generally referred to as <u>minimum and maximum ply design</u>.

Covers

The carcass needs protection against material abrasion, impact, wear and chemical corrosive action so that it does not weaken.

This is done by incorporating rubber layer on top of carcass (material carrying side) as well as on bottom side of carcass (non-carrying side or running side). The rubber layer on carrying side is known as ‘Top Cover'. The rubber layer on bottom side is known as 'Bottom Cover'.

Protection to the carcass from wear and impact is provided by covers as under:

- The material being loaded onto belt rubs with belt for short time till material velocity matches with belt velocity. The top cover bears this abrasive action / wear.

- The material being loaded is falling onto belt. The material with its sharp edges tends to cut/gouge belt. The top cover withstands such actions and protects the carcass.

- Material resting on the belt has invisible minute to and fro movement every time the belt passes on an idler. Top cover withstands the wear arising from this movement.

- The carrying side belt moves on carrying side idlers keeping belt bottom cover in contact with idlers. Similarly, the return side belt moves on return side idlers keeping top cover in contact with idlers. There is a slight but continuous wearing effect on belt, as it moves on idlers. The wearing effect also arises due to material contamination, stuck idlers and misalignment of idlers.

The covers are basically made from two materials, rubber and PVC. In general, the cover's material is rubber, unless mentioned otherwise. The rubbers of various characteristics, which are popularly known as grades, are used to suit application and standards being followed. In case of PVC, frictional coefficient of covers with respect to material and drive pulley is comparatively low. Since PVC is prone to deterioration by sunlight, it is mainly used for underground application.

The wear resistance quality of a conveyor belt is one of the major factors that determine its life expectancy and ultimately its cost-effectiveness. Selection of the type and quality of outer cover will largely determine the effectiveness and operational lifetime of conveyor belts.

General purpose covers/belts serve a broad range of industrial applications including mining, ore processing, lumber, paper/pulp and agriculture, to name a few. By and large, these belts will have covers of natural rubber, SBR, polybutadiene, and acrylonitrile or blends thereof. These cover compounds are further defined by Grade N or N-17 and M or M-24 as per Indian Standard and as either RMA Grade I or RMA Grade II as per The Rubber Manufacturers Association of USA and belting industry (Now ARPM, The Association for Rubber Products Manufacturers, Inc. USA, Internet: www.arpminc.org).

Special purpose covers/belts are those that require special characteristics and properties. Conveyor applications and systems that operate outside the normal parameters covered under general purposes will include high temperatures (above 175°F/80°C), low temperatures, (below 40°F/5°C), fire/flame resistance, oil exposure, food ("FDA") processing, and chemical resistance.

The widely used cover grades are as under.

Grade-M or M-24, as per IS: 1891 and **RMA Grade I** will consist of natural or synthetic rubber or blends which will be characterized by high cut, gouge, and tear resistance and having very good to excellent abrasion resistance. These covers are recommended for service involving sharp and abrasive materials, and for severe impact loading conditions.

Grade-N or N-17, as per IS: 1891 and **RMA Grade II** will consist of elastomeric composition similar to that of Grade-M or M-24 and RMA Grade I with good to excellent abrasion resistance in applications involving the conveyance of abrasive materials, but may not provide the degree of cut and gouge resistance of Grade-M or M-24 and RMA Grade I covers. This is ideal for general class of materials, which are not very lumpy or sharp edged.

Generally, most general purpose (Grade M and Grade N) belts will resist stiffening/hardening down to -40°F/°C. However, in case of most general purpose belts, when there are prolonged periods of downtime during which the belts are exposed to -40°F/°C for several days or weeks, starting may be difficult or harmful due to their stiffening. When these conditions are expected, belts can be selected which are having low temperature plasticizers or blends incorporated in them to keep them flexible.

Grade-HR (Heat resistant) belts are manufactured to handle hot materials. The cover compounds consisting of butyl or EPDM can resist the degrading effects of high temperatures up to approximately 400°F/200°C. Neoprene (polychloroprene) and Hypalon (chloro-sulfonated polyethylene) based compounds also exhibit good heat aging properties. Belting with silicone or Viton (fluorocarbon polymers) covers will withstand very high temperatures, up to approximately 700°F.

In case of cotton, degradation of strength will start from 120°C. Polyester and nylon fibers/textiles will melt at temperatures above 500°F/260°C. However, loss of dimensional stability and softening will occur well before this temperature is reached. In view of this, glass fiber carcasses are often recommended where operating temperatures exceed 400°F/200°C.

On the rubber portions (cover) of the belt, elevated temperature increases the rate of oxidation and continue the original vulcanization so that in most cases the compound becomes hard and brittle, flakes off, and exposes the carcass, which burns or abrades away. Depending on composition of cover compound and carcass, various sub-grades of HR belts are available to suit different temperatures.

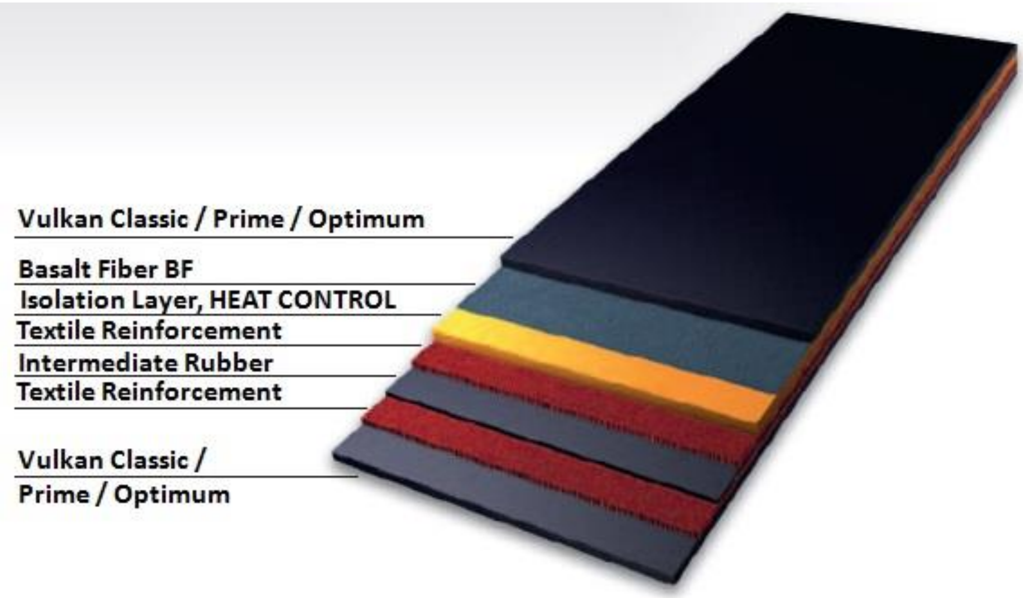
If a material is fine, it can have a more harmful effect on a belt than a lumpy material at a given temperature because fine material will make better contact with the belt surface and facilitates conduction of heat into the belt cover and carcass. Thus, the belt more nearly reaches the temperature of the material conveyed. Lumpy material, by its nature, creates voids between it and the belt, allowing some cooling of the belt and the material.

The belt speed influences the heating up and cooling down periods of the belt. Due to this, loaded belt is never stopped. If stopped, it can destroy a belt in a very short time.

As the belt cover offers a certain amount of thermal insulation to the carcass, belt covers for hot application are 1/8 to 1/4 in. thicker than normal application. For conveyors open to air, each 1/8 in. of top cover provides approximately 40°F of carcass protection.

Modular System

While transporting hot materials, thermal decomposition of the rubber layers and melting of the carcass can result in a failure of the belt. With the modular system conveyor belts can be assembled from different components depending on the type of application.



Conveyor Belt with Modular System

As shown in above figure, the right combination of materials provides a long life even with higher temperatures. By using the isolation layer, HEAT CONTROL, a reduction of the temperature transfer towards the carcass up to 40°C can be achieved. The high melting point of glass or basalt fiber (GF/BF) protects the belt while transporting glowing material.

As the isolation layer is independent of the cover grades, it can be used for flame-retardant, oil- and chemical resistant grade also.

Following table gives, cover properties and quality characteristics for Contiflex® VULKAN Textile Conveyor Belts with heat-resistant covers.

Description	Material Temperature* °C	Cold Flexibility °C	Tensile Strength MPa	Elongation at Break %	Abrasion mm^3	Oil Resistance Volume Swelling %	Basic Polymer	Special Characteristics
VULKAN CLASSIC	100-200	-40	≥ 20	> 400	< 130	-	SBR	Grade "Y" acc. to DIN 22102, bondable
VULKAN PRIME	150-500	-50	≥ 10	> 400	< 150	-	EPM	Resistant to acids and lye
VULKAN OPTIMUM	200-600	-40	≥ 20	> 450	< 120	-	EPDM	Resistant to acids and lye
VULKAN TG	80-300	-30	≥ 20	> 600	< 180	< 3	NBR	Resistant to oil
VULKAN GS	50-180	-20	≥ 16	> 500	< 230	< 3	NBR	Fire-retardant acc. to EN 20340, resistant to oil
VULKAN TV	100-400	-15	≥ 10	> 300	< 300	< 15	EVA	Halogen-free, low-fuming, temperature-resistant, fire-retardant
VULKAN GKT	50-220	-25	≥ 18	> 450	< 150	< 35	CR	Self-extinguishing, resistant to oil, UV and ozone

*The maximum temperatures are influenced by the form of the material, the time influence and the construction of the installation. In closed systems (e.g. elevator belt, pipe conveyor) the permissible temperature drops accordingly. Temperatures of the conveyed materials can be higher, depending on the size of the material pieces and on the operating conditions.

Modular system conveyor belts are manufactured by ContiTech AG. For complete and latest information please view their website, www.contitech.de/cbg-ms.

Note: In case an application is beyond the temperature scope of rubber belts, pan type or steel mesh type (Magaldi Superbelt) conveyors may be used.

Grade-FR (Fire / flame resistant) belts reduce the occurrence and spread of fire hazard. Currently, belt and belt compounds using SBR, nitrite, polychloroprene (neoprene) and PVC are routinely utilized to make FR grade belts. Cover compounds are designed to meet specific national or international standards. These standards typically define laboratory tests which either demonstrate that the belt is able to self-extinguish after being set on fire (Bunsen burner or gallery tests), or which establish that the belt will not initiate a fire from the heat generated when the belt is stalled against a rotating steel drum, (drum friction test). The latter simulates a potential mine condition where a belt is stalled against a rotating drive pulley.

PVC impregnated solid woven carcass belting is designed to meet underground mining regulations and specifications. PVC conveyor belts consist of PVC impregnated solid woven carcass and PVC covers. Since polychloroprene rubber (CR) is highly fire resistant by nature, only a little amount or no addition of fire retardants is necessary. In case of a fire, endothermic processes are initiated due to the high content of halogens (chlorides, bromides) in it which withdraw energy and extinguish the fire. PVC shows a similar behavior. PVG belts consist of a PVC impregnated solid woven carcass and chloroprene rubber covers. In general, practice shows that the operating life of PVG belts is two to three times that of PVC belts. Multi-ply EP / PP textile carcass belts or steel cord belts with FR grade covers are used for above the ground application.

Oil-resistant grade of rubber cover is used to handle oily materials. Normal quality cover tends to swell even if the load to be conveyed has only the smallest percentage of oil or fats and the rubber tends to soften. Belt covers designed to resist swelling and degradation in oily environments will often incorporate Nitrile based polymer, polyvinyl chloride (PVC), or urethane. The type of oil encountered as well as the temperatures in which the belt must operate is of prime importance. Highly aromatic and asphaltene-based materials, as well as exposure to diesel fuel, are best handled with a Nitrile or urethane based compound. PVC belting will resist light oil (e. g., mineral and napthenic oils) degradation at lower temperatures. Neoprene/polychloroprene compounds will also resist low aromatic oils and fuels satisfactorily.

Hygienic grade of rubber cover is used to handle foodstuff. Food processing entails belt exposure to both vegetable oil and animal fats. In such environments, PVC and nitrite-based belt constructions predominate. Both have good resistance to swelling and degradation under these conditions. To convey food stuffs, the cover quality must comply with National and International regulations.

Chemical resistant grade of rubber cover is used to protect against chemical effect. Conveyor belting manufacturers should be consulted when systems are being operated in specific chemical environments. The condition in which the conveyor belt is operating should be clearly defined. Consideration of the chemical concentration and temperature, as well as the possible presence of incidental processing chemicals or oils should also be taken into account.

Belts having special characteristics such as FR or oil resistant etc. often have lesser resistance to wear / impact, and therefore, these should be used where needed. Generally, they wear faster and also cost more compared to usual grade - M or N.

Cover Materials Characteristics and Areas of Application

Natural Rubber (NR)

Because of its special properties, natural rubber is a good basic material for belt cover rubbers. Important information on it is as under.

<u>Technical Characteristics</u>

- Very good tensile strength and elongation
- High heat resistance and elasticity
- High tearing and shear strength
- Good abrasion resistance characteristics

<u>Temperature Stability</u>

Generally, stable within the temperature range of −30°C to +80°C. With special rubber compounding a widening of this range may be achieved from −40°C to +100°C.

<u>Chemical Stability</u>

Resistant to water, alcohol, acetone, dilute acids and alkalis. However, limited resistance to concentrated acids and alkalis where compounding and service temperatures are major consideration.

<u>Special Characteristics</u>

With special compounding natural rubber based mixes can be made antistatic and flame resistant. By adding antiozonants a substantial protection against harsh temperature effects, sunlight and ambient weather conditions can be achieved.

Scope

In all applications where high physical properties are called for and the chemical and temperature demands are not excessive.

Synthetic Rubber (SBR)

SBR is a synthetic polymerization product consisting of styrene and butadiene whose characteristics are similar to natural rubber. Tensile strength and cut resistance are good. Abrasion, heat and ozone resistances are better than natural rubber.

Nitrile Rubber (NBR)

NBR is a copolymer of butadiene and acrylonitrile. It is not resistant to Ketones, esters aromatics and hydrocarbons. The physical property values are slightly lower than those of natural rubber. The operating temperature range can be controlled between −40°C to +120°C. NBR is relatively abrasion resistant, resistant to ageing and is used for oil and fat resistant belt covers.

Butyl Rubber (IIR)

Butyl rubber is a polymerization product of Isobutylene and Isoprene. It has a very good ozone and temperature resistance.

In addition to a very good resistance to ageing, depending on compounding, it is able to withstand temperatures of −30°C to +150°C.

It has a limited resistance to acids and alkalis, animal and vegetable fats. Butyl rubber is used mainly for heat resistant conveyor belting.

Ethylene Propylene Rubber (EPDM)

EPDM is temperature resistant similar to Butyl but with a considerably higher resistance to wear and tear. Additionally, EPDM has a better ozone resistance than all other basic polymers.

Chloroprene Rubber (CR) / Commonly Called as Neoprene

CR is a Synthetic polymerization product of Chlorobutadiene. The mechanical properties are similar to natural rubber but significantly better in respect of ozone and oil resistance. The chlorine in Chloroprene gives the product a high degree of flame resistance.

The working temperature range is −30°C to +80°C.

The resistance to animal and vegetable oils and fats is superior to natural rubber as is the ageing resistance.

Nitrile Chloroprene Rubber (NCR)

The use of Nitrile in Chloroprene rubber enhances the dynamic properties. For cover rubber which requires a high oil and fat resistance whether it be animal, vegetable or mineral and also requiring superior mechanical properties. NCR is better than CR.

Silicone Rubber (VMQ, FVMQ)

Silicone rubber has outstanding resistance to high heat, excellent flexibility at low temperatures, very good electrical insulation and excellent resistance to weather, ozone, sunlight, and oxidation.

The working temperature range is −101°C to +260°C.

However, it has poor resistance to abrasion, tear and cut growth; low tensile strength; inferior resistance to oil, gasoline, and solvents; poor resistance to alkalis and acids.

Note

In the foregoing, basic materials are main ingredients of cover rubber components. They provide the principal characteristics of each quality but can be affected by the addition of other compounding ingredients to achieve higher requirements of standards and regulations.

Generally, hardness of cover rubber is specified to be 60 ± 5 deg. Shore, Scale A.

Belt Cover Thickness

The top cover and bottom cover protect the carcass against weakening during service life of belt. The top cover is thicker compared to the bottom cover because operational strain and wear is much more in the top cover.

As a general rule, 80% of conveyor belt surface wear occurs on the top cover of the belt with approximately 20% of wear on the bottom cover. Wear on the top cover is primarily caused by the abrasive action of the materials being carried, especially at the loading point where the belt is also exposed to impact by the bulk material and the material is accelerated by the belt surface.

Short belts (below 50 metres) usually wear at a faster rate because they pass the loading and discharge points more frequently compared to long belts. For this reason, the selection of the correct type of cover quality and the thickness of shorter length belts is very important.

Wear on the bottom cover of the belt is mainly caused by the friction contact with the pulley surface and idlers. The rate and uniformity of this type of wear can be adversely affected by many other factors such as misaligned or worn pulley and idlers set at incorrect angles.

Unclean environment, where there is a buildup of waste material can cause added wear on both the top and bottom covers of a belt. Belt cleaning systems, especially such as scrapers, can also cause wear to the top cover surface.

In an effort to extend operational lifetime, many conveyor belt users resort to fitting belts with increasingly thicker covers. However, covers that are too thick can potentially cause other problems. It is recommended that the difference in thickness between the top cover and the bottom cover should not exceed a ratio of more than 3 to 1. If the difference in the thicknesses between the covers is too great, the natural shrinkage of the rubber after being vulcanized can lead to harmful tensions in the belt.

As the cover thickness decision is mainly on the basis of empirical data and experience, it is advisable to be marginally liberal in selection of cover thickness, which results into more life for belt (carcass as well as covers) at comparatively less increase in total price.

Recommendations for selection of cover thicknesses by Phoenix Conveyor Belt Systems GMBH, Germany and Fenner Dunlop, Australia are as under.

Recommendations by Phoenix Conveyor Belt Systems GMBH, Germany

Guide values for top and bottom cover thicknesses/gauges for textile carcass and steel cord conveyor belts for different uses (in mm) are as under.

Textile Carcass Belts			
Use	Material Handled	Top Side	Bottom Side
Mobile belt conveyors	Fine bulk material, light bulk material	2	1
Loading and unloading plants and coal handling plants	Coal, potassium, gravel, sand, fine ore	2 to 4	2
Loading and unloading plants, gravel pits, quarries	Lump coal, rocks, rough gravel, ore, overburden	4 to 8	2 to 3
Excavators and spreaders, crushers	Coarse lumps of rock, ore, overburden	8 to 16	3 to 4

Steel Cord Belts			
Use	Material Handled	Top Side	Bottom Side
Loading and unloading plants and coal handling plants	Coal, potassium, gravel, sand, fine ore	4 to 8	4 to 6
Loading and unloading plants, coal mines, quarries	Lump coal, rocks, rough gravel, ore, overburden	6 to 12	4 to 8
Excavators and spreaders, crushers	Rocks in lumps, ore, coal, overburden	10 to 20	6 to 10

Recommendations by Fenner Dunlop, Australia

Previous experience will always be the best guide to the optimum selection of both the type and thickness of belt cover, however if this information is not available as will be the case for new installations, the following steps should be followed.

Calculate the time cycle of the conveyor = $(2 \times L) \div S$

Where,
L = conveyor centers (m)
S = belt speed (m/s)

Use following tables to select appropriate top cover thickness based on time cycle, type of material and lump size.

For difficult applications such as belt feeders, or impact belts, heavier covers may be required.

Time Cycle (Seconds) Cycle time for complete belt revolution	Lightly Abrasive Materials					Moderately Abrasive Materials				
	Lump Size (mm)					Lump Size (mm)				
	10	50	125	200	300	10	50	125	200	300
15 Seconds	1-2	3-5	6-7	8-10	10-12	1-2	4-5	7-10	9-12	11-15
30 Seconds	1-2	3-4	5-6	6-8	8-10	1-2	3-4	5-8	7-10	9-12
60 Seconds	1-2	2-3	4-5	5-6	7-8	1-2	3-4	5-6	6-8	7-10
120 Seconds	1-2	2-3	3-4	5-6	6-7	1-2	2-3	4-6	5-7	6-9
180 Seconds and over	1-2	1-2	3-4	4-5	5-6	1-2	2-3	4-5	5-6	6-8
Typical Materials	Wood chips, bituminous coal, grains, round river gravel, etc.					Basalt, sand, arthracite coal, crushed gravel, etc.				

Time Cycle (Seconds) Cycle time for complete belt revolution	Heavily Abrasive Materials Lump Size (mm)					Extremely Abrasive Materials Lump Size (mm)				
	10	50	125	200	300	10	50	125	200	300
15 Seconds	2-4	4-7	7-10	10-15	12-19	3-6	4-10	8-15	10-19	13-23
30 Seconds	2-3	3-6	6-10	8-12	10-15	2-5	4-8	6-12	8-15	10-18
60 Seconds	1-3	3-5	5-8	6-10	8-13	2-4	3-6	5-10	7-13	9-15
120 Seconds	1-2	2-4	4-7	6-9	7-11	2-4	3-6	5-7	6-11	8-13
180 Seconds and over	1-2	2-4	4-6	5-8	6-10	2-3	2-5	4-8	5-10	7-12
Typical Materials	Lime stone, ores, phosphate, slag, cement clinker, etc.					Glass cullet, granite, quartz ores, etc.				

As a guide, pulley (bottom) side cover should generally be not less than 1/4 of carry side cover for covers up to 9 mm and about 1/3 of carry cover thickness for covers heavier than 9 mm. Operating conditions can dictate that heavier pulley side covers are required.

For long centre, long time cycle conveyors, pulley side cover can be up to 1/2 of carry side cover.

Important Note

When installing the belt, make sure that the carrying side (top cover) is up. Conveyor belts are generally brand marked on the carrying side cover along one edge of the belt. However, branding may be on the non-carrying side (bottom cover) also. As per CEMA, if cleaning of the conveyor belt is a critical issue or the belt is very long then the brand should be placed on the bottom cover to prevent fines from accumulating in the brand and subsequently falling from the belt. In view of this, confirm the carrying side by checking cover thickness. It is recommended to install the conveyor belt in such a way that the branding on the belt comes along the same edge of the conveyor along its entire length.

Belt Widths and Maximum Belt Speeds

Belt width, belt speed and conveyor capacity are inter-dependent.

Belt Widths

Certain minimum belt width is necessary in relation to lump size. If the belt width is not adequate, it will affect belt and idler life. It can also result in jamming at loading point.

It is recommended that maximum lump size for various belt widths be as given below.

- For a 20° surcharge, with 10 percent lumps and 90 percent fines, the recommended maximum lump size is one-third of the belt width (*b*/3).
- With all lumps and no fines, the recommended maximum lump size is one-fifth of the belt width (*b*/5).
- For a 30° surcharge, with 10 percent lumps and 90 percent fines, the recommended maximum lump size is one-sixth of the belt width (*b*/6).
- With all lumps and no fines, the recommended maximum lump size is one-tenth of the belt width (*b*/10).

<u>Fenner Dunlop, Australia</u>

Recommendations by Fenner Dunlop, Australia on maximum lump size for various belt widths are given in the following table.

Belt Width (mm)	If Uniform Lumps (mm)	If Mixed with Approximately 80% Fines (mm)
400	75	125
450	100	150
500	100	175
600	125	200
650	125	250
750	150	300
800	150	300
900	175	325
1000	200	375
1050	200	375
1200	300	450
1350	300	500
1400	300	600
1500	350	600
1600	375	600
1800	450	600
2000	450	600
2200	475	650

Maximum Belt Speeds

High speed requires narrower belt widths and lower belt tension. However, wear and tear is greater.

Recommendations by Fenner Dunlop, Australia on typical belt speeds in general use (meters per second) are given in the following table.

Belt Width (mm)	Grain or Free Flowing Material	Run-of-mine, Crushed Coal and Earth	Hard Ores and Stone
400	2.0	1.5	-
450	2.5	2.25	1.75
500	3.0	2.25	1.75
600	3.0	2.5	2.25
650	3.25	2.75	2.50
750	3.5	3.0 - 3.5	2.75
800	3.75	3.0 - 3.5	2.75
900	4.0	3.0 - 3.5	3.0
1000	4.0	3.0 - 3.5	3.0
1050	4.0	3.0 - 3.5	3.0
1200	4.0	3.25 - 4.0	3.0 - 3.5
1350	4.5	3.25 - 4.0	3.0 - 3.5
1400	4.5	3.25 - 4.0	3.0 - 3.5
1500	4.5	3.25 - 4.0	3.0 - 3.5
1600	5.0	3.75 - 4.25	3.25 - 4.0
1800	5.0	3.75 - 4.25	3.25 - 4.0
2000	-	3.75 - 4.25	3.25 - 4.0
2200	-	3.75 - 4.25	-

NOTE: There is a worldwide tendency to use increased belt speeds wherever possible. For example, brown coal is handled at speeds over 7.5 m/s and in Australia, iron ore at speeds over 5 m/s. Such higher speeds and those shown under run-of-mine coal, crushed coal and earth in the above table demand special attention to the design and maintenance of loading, transfer and discharge points.

Safety Factor

Operating tension in a belt is sum of the longitudinal tensile forces occurring in the belt. The belt carcass has certain breaking strength. The belt type / carcass is selected such that (breaking strength of carcass) ÷ (operating tension) results into certain minimum safety factor.

Traditionally, the conveyor industry has used safety factors around 10:1 for fabric belts and around 6.7:1 for steel cord belts, however, higher and lower factors are common. It is intended to cover not only the imprecisely determinable losses of strength in the splice but also the increased belt tensions that may occur on starting and stopping, together with all additional strains. This calculation is therefore reasonably reliable only for conventional belt conveyors with standard start-up and braking properties.

Minimum safety factors required at a belt joint for different operating conditions are as under (as per ContiTech, Germany and DIN).

Operating Condition	Continuous (S)	Temporary (S_t)
Favourable (minimum load cycle strain & bending strain)	6.7	4.5
Normal	8.0	5.4
Unfavourable (high load cycle strain & bending strain)	9.5	6.4

S: Safety factor during steady state i.e. continuous operation

S_t: Safety factor during temporary load condition (Example: starting / stopping)

These values are applicable to fabric belts as well as steel cord belts.

The maximum tension during steady speed implies continuously occurring load. Therefore, the safety factor in relation to continuous load is more. The belt tensions during starting / stopping phase are temporary/momentary occurrence, and hence, the safety factor with respect to these temporary tensions is less.

Operating conditions (favourable, normal and unfavourable) are with respect to the weakening effect to carcass / joint by the combined effect of bending strain and loading strain.

The weakening effect due to bending strain is related to pulley diameter and frequency of bending strain. The weakening effect due to loading strain depends upon lump size, lump density, lump sharpness, fall height, feed point layout and loading frequency.

Operating condition (favourable, normal and unfavourable) has to be decided by designer as it is not possible to define them in mathematical terms. Following typical interpretation will help a designer to choose appropriate operating condition.

Favourable condition can occur for long distance conveyor where bending strain and loading strain are happening after long interval of time (as frequency is less for longer conveyors). Low frequency of load cycles can be assumed if the conveyor belt is being designed for a relatively short operating period. It can also occur if pulley is one step bigger because bending strain is less for bigger pulley.

Unfavourable condition can occur for short distance conveyor. It can also occur in conveyors with “allowable weaker” carcass with maximum size lumps.

Normal condition occurs in conveyors where neither favourable nor unfavourable conditions occur.

As per IS 11592: 2000 (Reaffirmed 2010), the factor of safety may vary from 9 to 12.5 in case of textile belts and 7 to 10 in case of steel cord belts depending upon the application, type of belt joint, type of take-up device and type of starting for conveyors. For general guidance a factor of safety of 10 is normally used for textile belts with vulcanized joints and on a conveyor with gravity take-up and 7 for steel cord belting.

Belt Life

Generally, if operated and maintained properly, belt replacement on average is every five years for hard rock applications and up to 15 years for non-abrasive applications.

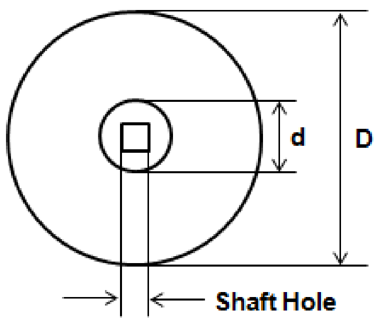
Belt Storage

If belts are to be stored for long periods or in extreme climates, some protection from direct sunlight and extreme temperature is recommended.

Belts should ideally be stored indoors in a temperature range of 0°C to 25°C. If proper warehousing is not possible, belts should at least be covered with black polythene and suitably fastened against wind damage.

The belt roll, if resting on the belt face, should be rolled a bit every six weeks to distribute the permanent deformation on the belt caused on the regions lying under the belt weight. Belt rolls found telescoped should be immediately opened and properly re-rolled. Conveyor belts weighing over 1500 kg should be supported off the ground on 'A' frames.

Wooden drums of the belts should be examined once in three months to ensure that wood is not failing due to white ants and similar insects. Spraying of insecticide over the drums will prevent this type of damage.



$$L = \frac{D^2 - d^2}{1.27\,t}$$

L = Belt Length (m)
D = Roll Diameter (m)
d = Core Diameter (m)
t = Belt Thickness (m)

Belt Length Calculation

Formula given in above figure can be used to calculate the belt length.

Belt Standards

The belt and cover grades are manufactured in accordance with standards. These standards provide the modalities for testing of various properties to meet the contractual needs between supplier and purchaser. Information about various Indian and German (DIN) standards is given in this chapter.

In India, IS 1891: Conveyor and Elevator Textile Belting - Specification is widely followed. It has five parts as under.

Part 1: General purpose belting
Part 2: Heat resistant belting
Part 3: Oil resistant belting
Part 4: Hygienic belting
Part 5: Fire resistant belting

The requirements for conveyor belting for underground use in coal-mines have been covered in IS 3181: Conveyor belts - Fire resistant conveyor belting for underground mines and such other hazardous applications.

For fire-performance and antistatic requirements for conveyor belting, Canadian standard CAN/CSA-M422-M87 is also specified by some users.

Some user specifies ISO 340: Conveyor belts - Laboratory scale flammability characteristics - Requirements and test method for flame retardation test.

IS 4240 is the standard for glossary of conveyors terms and definitions.

IS 1891 (Part 1): 1994, Reaffirmed - 2006

IS 1891 (Part 1) covers the requirements of rubber/plastics conveyor and elevator textile belting for general use on flat or troughed idlers. Important information given in the standard is as under.

IS 3400: Methods of test for vulcanized rubbers (Part 1, Part 3, Part 4 and Part 9) and IS 5996: Cotton belting ducks are necessary adjuncts to this standard.

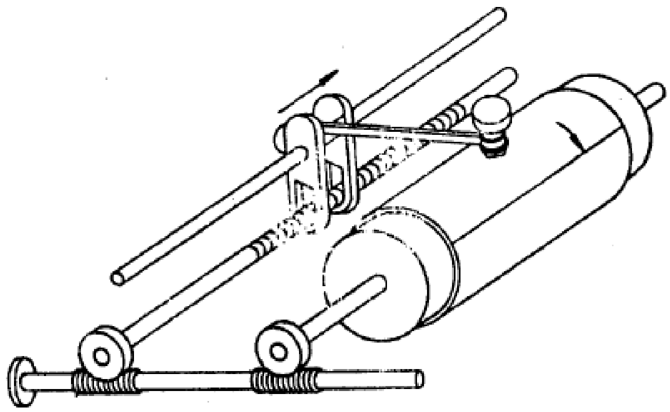
Grades of Rubber Cover

Physical properties of various grades are as under.

Grade	Minimum Tensile Strength, MPa	Minimum Elongation at Break (%)	Maximum Abrasion Loss, mm^3
M-24	24.0	450	150
N-17	17.0	400	200
N-17 (Synthetic)	17.0	400	150

Method of Determining Abrasion Loss

The method of determining the abrasion loss of rubber cover is given in Annex D of the standard. Brief information about the test is as under.

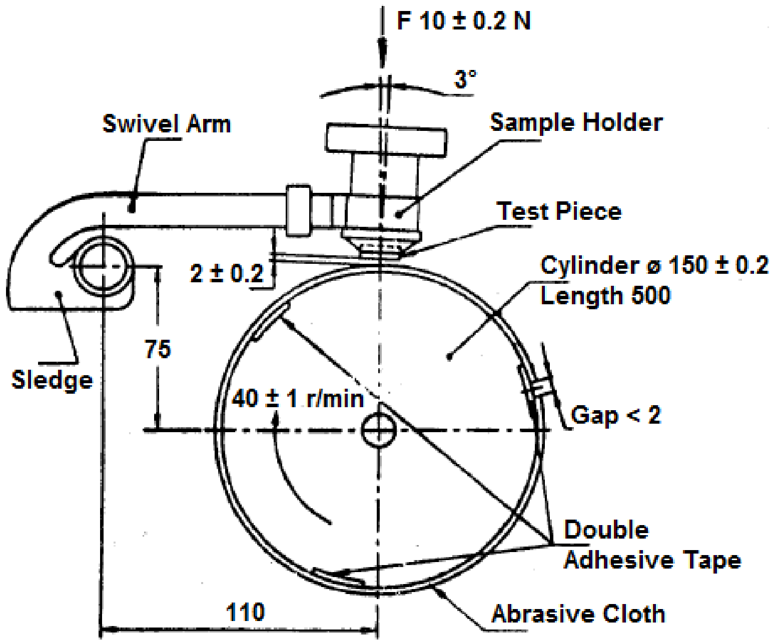


Test Apparatus - Abrasion Loss (Schematic Illustration)

To determine abrasion loss, a cylindrical standardized test piece is passed over an emery-cloth at a constant load of 10 N and at a constant speed of 0.32 m/s for 40 m (in special cases 20 m). The loss in weight (in mg) of the test piece is accurately determined to the nearest mg and the volume loss is calculated by using the density which is determined according to IS 3400 (Part 9): 1978.

As shown in above figure, the test apparatus consists of a laterally movable test piece holder and a rotatable cylinder to which the emery-cloth is fixed tight by three evenly spaced strips of double sided adhesive tape extended along the complete length of the cylinder.

The following figure shows drawing of abrasion loss test apparatus.



Note: All dimensions in millimeters.

Drawing of Abrasion Loss Test Apparatus

As shown in above figure, the cylinder shall have a diameter of 150 ± 0.2 mm and a length of about 500 mm. It shall be rotated at a frequency of 40 ± 1 rev per min, the direction of rotation being as indicated in above figures.

The test piece holder is mounted on swivel arm which has at the other end a sledge with a spindle to be moved laterally at 4.20 ± 0.04 mm per revolution of the cylinder. For more information on the test, please see the standard.

Full Thickness Breaking Strength

Full thickness breaking strength of finished belting shall be not less than the values given in the following table.

Type	Longitudinal Direction kN/m Width (Min)	Transverse Direction kN/m Width (Min)
160	160	63
180	180	71
200	200	80
224	224	90
250	250	100
280	280	112
315	315	125
355	355	140
400	400	160
450	450	Not specified
500	500	Not specified
560	560	Not specified
630	630	Not specified
800	800	Not specified
1000	1000	Not specified
1250	1250	Not specified
1400	1400	Not specified
1600	1600	Not specified
1800	1800	Not specified

Recommended Maximum Working Tension

The value of recommended maximum working tension (allowable working tension) for different type of belts is as under.

Belt Type (Carcass)	Recommended Maximum Working Tension, kN/m	
	Mechanical Joints	Spliced (Vulcanized) Joints
160	16	16
180	18	18
200	20	20
224	22	22.4
250	24	25
280	26	28
315	31	31.5
355	35	35.5
400	40	40
450	45	45
500	50	50
560	55	56
630	63	70
800	80	90
1000	Mechanical fasteners not recommended.	110
1250		140
1400		155
1600		180
1800		200

Elongation at Reference Load

Reference load is defined as being one tenth of the specified full thickness breaking strength of the belt in the longitudinal direction.

Note: This definition does not necessarily imply that a 10:1 factor should be in design calculations.

<u>The elongation of the finished belting in the longitudinal direction at the reference load</u> (when tested by the method described in Annex F of the standard) <u>shall not be greater than 4 percent</u>.

The elongation of the finished belting in the longitudinal direction at the load corresponding to the maximum breaking strength (when tested by the method described in Annex F), shall be not less than 10 percent.

Adhesion

The adhesion between cover and the carcass and between the adjacent plies shall be such that (when tested in the manner described in Annex G of the standard) the force required to cause their separation shall be as given in the following table.

Sr. No.	Test	Force, Min (kN/m Width)		
		Cotton or Cotton/Synthetic	100 percent Polyamide	100 percent Synthetic
1	Adhesion between adjacent plies	3.00	5.25	4.50
2	Adhesion between cover and carcass:			
	Covers up to and including 1.00 mm thick	No test	No test	No test
	Covers over 1.00 mm up to and including 1.50 mm thick	2.20	3.15	3.15
	Covers over 1.5 mm thick	2.60	4.50	3.50

Ageing

In case of rubber cover after ageing for 72 h at 70°C ± 1°C in accordance with the requirements of IS 3400 (Part 4): 1987, the tensile strength and elongation at break shall not vary from the original unaged values by more than the amounts specified below:

Property	Change Percent, Max
Tensile strength	+ 10, − 20
Elongation	+ 10, − 25

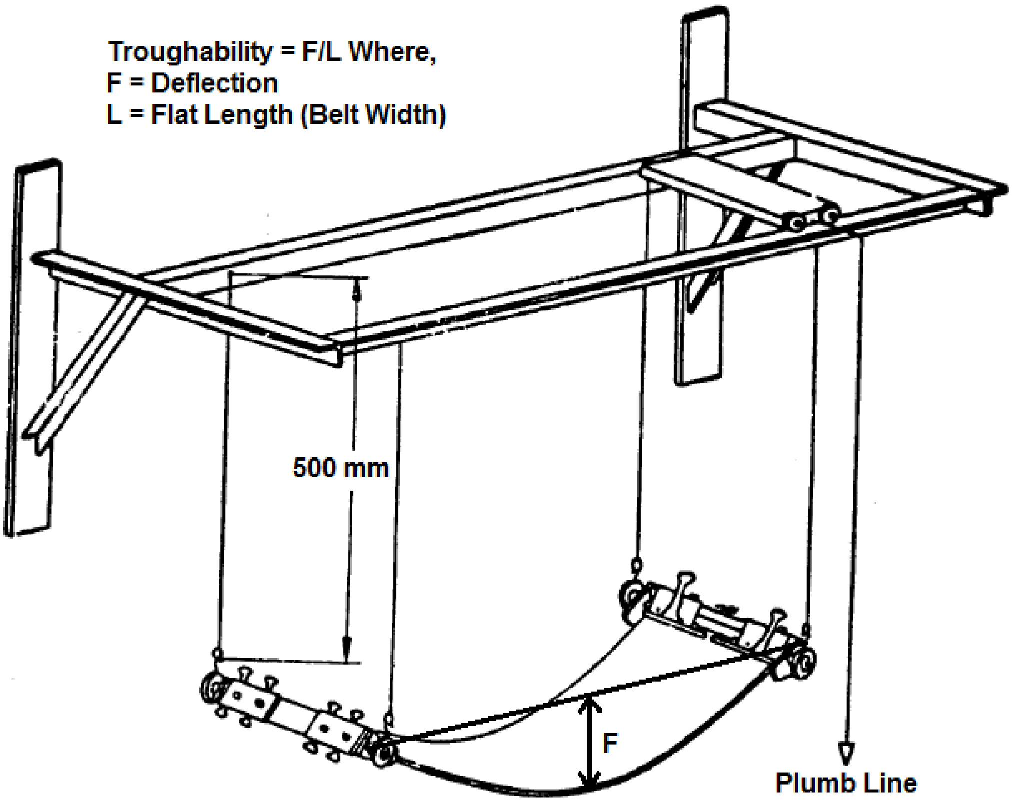
Troughability

An appropriate amount of troughability is necessary to provide good belt tracking. This depends mainly on the transverse stiffness of a belt and its own weight.

If agreed to between the purchaser and the manufacturer, the conveyor belting shall be tested for troughability. This will be a type test only.

Following figure shows the set up to measure troughability (Annex H, IS 1891, Part 1).

Troughability is expressed as the ratio F/L.



Apparatus for Measuring Troughability

The troughability, when determined in accordance with the method described in Annex H of the standard shall be as given in the following table.

Trough Angle Up to and Including	Troughability, Minimum
20	0.05
25	0.07
30	0.09
35	0.11
45	0.17
55	0.23

As shown in the following figure, exceeding the maximum trough angle of a particular belt can cause the belt to permanently deform into a cupped position.


Cupped Belt

This cupping can make a belt difficult to seal, difficult to clean, and almost impossible to track. As the belt cupping increases, the surface contact between the rolling components and the belt is reduced, diminishing the ability of the rolling component to steer the belt in the desired direction. The conveyor may not operate at design speed because cupping will also reduce the friction between the drive pulley and the belt.

Designation

Belting complying with the requirements of this standard shall be designated by IS No., grade of the cover, the type of belting defined by the full thickness breaking strength and number of plies.

Example:

A conveyor belt with cover grade M24 and Type 200 having 4 plies shall be designated as:
Conveyer Belt IS 1891 (Part 1) M.24 - 200/4

IS 1891 (Part 2): 1993, Reaffirmed - 2008

This standard (Part 2) covers the requirements of conveyor and elevator textile betting for use on flat or troughed idlers for conveying hot materials which are classified as follows:

Grade	Resistance to Temperature, °C (Maximum)	
	Lump / Predominance of Lumps	Fines (Powdered Materials) / Predominance of Fines
Grade T-1	125	100
Grade T-2	150	125

Tensile Strength and Elongation

Tensile strength and elongation at break of rubber cover when tested as described in Annex B of IS 1891 (Part 1): 1994 shall be as specified in the following table.

Property	Grade	
	Grade T-1	Grade T-2
Tensile strength (MPa), Minimum	12.5	12.5
Elongation at break (%), Minimum	350	350

Adhesion

The adhesion between the cover and the carcass and between the adjacent plies shall be such that when tested in the manner described in Annex G of IS 1891 (Part 1) 1994, the force required to cause the separation shall be as given in the following table.

Sl. No.	Test	Force, Minimum kN/m Width	
		For Cotton or Cotton Polyamide Plies	For Synthetic Plies
1	Adhesion between adjacent plies	3.00	4.50
2	Adhesion between cover and carcass		
	(a) Cover up to and including 1.00 mm thick	No Test	No Test
	(b) Cover over 1.00 mm and up to and including 1.50 mm thick.	2.20	3.00
	(c) Cover over 1.50 mm thick.	2.50	3.50
Note: No individual value obtained at the time of measurement shall be below the value specified by more than 0.80 kN/m width.			

Heat Resistance

Rubber Cover

After exposure to a temperature of 100 ± 2°C for 72 h in the case of Grade T-1 and 125 ± 2 °C for 72 h in the case of Grade T-2, the test being carried out as described in IS 3400 (Part 4):1987, the tensile strength and elongation at break of the rubbers covers shall not vary from the original unaged values by more than the amounts specified below:

Property	Grade T-1	Grade T-2
Tensile strength (%)	−25	−35
Elongation at break (%)	−40	−50

Adhesion

After exposure of the belt pieces prepared according to G-1 of IS 1891 (Part 1): 1994 to a temperature of 70 ± 1°C for 72 h in case of Grade T-1 and 100 ± 2°C for 72 h in case of Grade T-2, the test being carried out as described in IS 3400 (Part 4): 1987, the values for adhesion between covers and the carcass and between the adjacent plies shall not vary from the original unaged values by more than − 50 %.

Abrasion Resistance

The abrasion loss in case of rubber cover when tested as per method given in Annex D of IS 1891 (Part 1): 1994 [see also IS 3400 (Part 3): 1987] shall not exceed 250 mm^3 for both grades T-1 and T-2.

IS 1891 (Part 3): 1988, (Amended 2005)

IS 1891 (Part 3) covers the requirements of rubberized textile oil-resistant conveyor belting for general use in environments where oil-resistance is required. This standard does not cover PVC oil-resistant belting. Important information given in the standard is as under.

When tested as described in Appendix C of IS: 1891 (Part 1) - 1994, the breaking strength and elongation at break of the rubber cover shall be as following:

Breaking Strength: 12.0 MPa, Minimum
Elongation at Break: 250%, Minimum

After ageing for 168 hours at 70 ± 1°C in a manner described in IS: 3400 (Part 4), the tensile strength and elongation at break of the rubber used for cover shall not vary from the values before ageing by more than 35%.

Volume Swelling: The cover of the belting when tested in accordance with IS: 3400 (Part 6) shall comply with the following.

Test Liquid	Test Temperature °C	Duration of Test h	Change in Volume % Max.	Remarks
1) 70% by volume iso-octane, 30% by volume toluene	27 ± 1	70 ± 2	75	Test simulates condition where contacting liquid is petroleum fuel, for example, high speed diesel, petrol, kerosine, etc.
2) Petroleum oil having following properties: Aniline point 69-70° Celsius Kinematic viscosity at 37-8 Celsius 31.9 to 34.1 mm^2/s (cSt) Flash point 163° Celsius	27 ± 1	70 ± 2	75	Test simulates condition where contacting liquid is petroleum oil type, such as lubricating oil.

Note: In case of liquids of ambiguous condition, it is preferred to make the test on actual service liquid coming in contact with the belt, and the actual swell in volume in this case should also not exceed 75%.

IS 1891 (Part 4): 1978, Reaffirmed - 2006

This standard covers requirement for rubberized canvas hygienic conveyor belting intended for handling foodstuff and other products which require hygienic handling.

Rubber Cover: All the compounding ingredients used in the rubber compound from which the rubber covers are made should be free from harmful ingredients liable to extraction by contact with the foodstuffs and other materials being handled or which may cause the development of undesirable odor (smell), taste or discoloration.

When tasted as described in Appendix C of IS: 1891 (Part 1), the tensile strength and elongation at break of rubber shall be as follows.

Tensile Strength: 10 MN/m^2, Minimum
Elongation at Break: 350%, Minimum

IS 1891 (Part 5): 1993

IS 1891 (Part 5) covers the requirements of fire resistant antistatic rubber and/or PVC conveyor and elevator textile reinforced belting for use in surface installations where fire hazards exist. Important information given in the standard is as under.

The full thickness breaking strength shall be according to IS 1891 (Part 1). The rubber used in the top and bottom cover of the belting shall be of fire resistant, antistatic (FRAS) grade. The minimum tensile strength of rubber cover shall be 17 MPa and minimum elongation at break of rubber cover shall be 350%. However, if plastics or rubber/plastic mix material is used for the cover, the value of tensile strength and elongation at break shall be as agreed to between manufacturer and purchaser.

Following tests are performed for fire resistance.

Drum Friction Test

When samples are tested in accordance with Annex A of the standard, the belt shall show no sign of flame, spark or glow. The drum temperature shall not exceed 325°C and the belting shall part within the 3 h test period.

Flame Test

When samples are tested in accordance with Annex B of the standard, the average duration of the flame shall not exceed 40 seconds and the average duration of glow shall not exceed 120 seconds.

Electrical Surface Resistance Test (Anti-static Test)

The purpose of this test is to ensure that the belt surface is sufficiently conductive to prevent the buildup of static electric charge that can ignite gases and dust in the atmosphere.

When samples are tested in accordance with Annex C of the standard, the electrical resistance shall not exceed 300 mega ohms.

For information on test apparatus and test procedure, please see the specification.

IS 3181: 1992 (Amended 2005)

This standard covers the requirements for fire resistant conveyor belting made from fire resistant compounds and textile reinforcements for use in underground mines and such other hazardous applications where risk of fire is involved.

The belting shall be of solid woven construction or shall consist of plies of woven fabric and shall be impregnated with a fire resistant compound and have fire resistant covers, the whole being fused or vulcanized together in accordance with the best manufacturing practice.

<u>The edges of the belting shall be completely sealed by fire resistant compound</u>.

Belting complying with the requirements of this specification shall be designated by belt type according to its physical properties as given in the following table.

Designation and Properties of Finished Belting

Belt Type	Designation	Breaking Strength Min.		Elongation at Break Min.		Tear Strength Min. kN
		Longitudinal kN/m	Transverse kN/m	Longitudinal Percent	Transverse Percent	
1	2700	470	235	17	18	1.00
2	3000	525	265	17	18	1.00
3	3500	610	265	17	18	1.09
4	4000	700	352	17	18	1.09
5	5000	875	352	15	18	1.18
6	6500	1140	352	Not specified		1.54
8	8000	1400	352	Not specified		1.54

The mean belt thickness and the derived carcass thickness shall not be less than given below.

Belt Type	Belt Thickness, mm	Carcass Thickness, mm
1	Not specified	Not specified
2	Not specified	Not specified
3	7.5	5.9
4	8.0	6.4
5	8.5	6.9
6 and above	9.0	7.4

For checking fire resistance, following tests are carried out.

Drum Friction Test

The belting shall be tested as per method described in Annex F and there shall not be any visible sign of flame or glow on any part of any one of the test pieces of belting either during each test or after each test piece breaks. The temperature of the surface of the drum during each test shall not exceed 325°C.

Spirit Burner Flame Test

When tested as per method described in Annex G, the belt shall comply with the following:

For the six test pieces with the outer covers intact, the average time for all visible flame or glow to disappear after withdrawal of the burner shall not exceed 3 seconds. No individual test piece shall flame or glow for more than 10 seconds.

For the six test pieces with outer covers removed, the average time for all visible flame or glow to disappear after the withdrawal of the burner shall not exceed 5 seconds. No individual test piece shall flame or glow for more than 15 seconds.

Propane Burner Test

The belting shall be tested as per the method described in Annex H and shall be self-extinguishing, after the propane flame has been removed, all combustion shall cease and a minimum of 250 mm long full width portion on each test piece shall remain undamaged at the completion of the test.

Test Certificate

The following figure shows a typical conveyor belt test certificate.

SEMPERTRANS NIRLON LIMITED

Regd. Off.: 21 / 1, M.I.D.C., Dhatav, Tal. - Roha, Dist. Raigad
Ph. : 02194 - 263579, 263578, Fax : 91-2194-263672
Marketing Off. : Pahadi Village, Goregaon (East), Mumbai - 400 063
Phone : 26850234 / 0235 / 0236 Fax : 91-22-26850035

CONVEYOR BELT TEST CERTIFICATE

Certificate No. : **270009**
Coustomer :
Customers Order No. : **5100024374 DT.24.08.04**

Date : **05.01.05**
Belt No. : **050009**
I. P. O. No. : **4-1-558**
No. of Belts : **ONE**

(1) BELT DIMESIONS :

	Width (mm)	Fabric Rating	No. of Ply	Cover Thickness (mm) Top	Cover Thickness (mm) Bottom	Cover Grade	Length (Mtrs)
Specified :	1000	400/4	4	3.0	2.0	M24	300
Observed :	1002	400/4	4	3.0	2.0	M24	300

(1) A : Additional Feature : 1) Edge : **CUT EDGE**

(2) Physical Prop. : As Per **IS-1891(PART-1)1994 GRADE-M24 AND P.O.SPECIFICATION**

(2) A : Full Thickness Breaking Strength & Elongation :

	Breaking Strength (kN/m) Warp	Breaking Strength (kN/m) Weft	Warp Elongation (%) Ref. Load : 400 N/CM	Warp Elongation (%) Break
Specified : specified	400(MIN)	160(MIN)	3.0(MAX)	10.0(MIN)
Observed : observed	458	177	1.0	16.0

(2) B : Cover Properties And Adhesion :

		Before Ageing Observed	Specified (MIN)	% Change After Ageing 72 Hrs @70° C Observed	Specified
Top Cover	a) Tensile (Mpa) :	25.9	24.0	-3.3	+10,-20
	b) % Elon. @ Break :	605	450	-8.5	+10,-25
	c) Hardness (SHA) :	66	65+5	-	-
Bottom Cover	a) Tensile (Mpa) :	25.8	24.0	-3.7	+10,-20
	b) % Elon. @ Break :	615	450	-9.0	+10,-25
	c) Hardness (SHA) :	66	65+5	-	-
Adhesion (KN/M)	a) Top Cover to Ply :	8.4	4.5	0.0	0
	b) Bot. Cover to Ply :	6.3	4.5	0.0	0
	c) Ply to Ply :	9.3	5.3	0.0	0

(3) Additional Tests :

	Observed	Specified
1) Abrasion Loss (mm3)	114	175(MAX)
0	0	0
0	0	0
2) Troughability	0.4	0.05(~~max~~) min

For Sempertrans Nirlon Ltd.

(V.J.SURYAWANSHI DY.MANAGER(Tech)
Authorised Signatory

Cover Properties as per International Standards

Information about code letters for covers as per DIN / ISO and properties requirement as per DIN, ISO and RMA standards is given in this section.

Code Letters for Cover Types as per DIN (German)

Code letters as per DIN 22102 and DIN 22131 for cover types with standard grades and cover types with special properties are given in the following table.

Properties	Code Letter as per DIN Standard
Standard cover grades	W, X, Y and Z
With antistatic covers	E
With antistatic covers and flame resistant with covers	K
Flame resistant with and without covers and with antistatic covers	S
Heat resistant	T
Cold resistant	R
Oil and grease resistant	G
For foodstuffs	A
For chemical products	C
Safety specifications with regard to fire-engineering properties for surface use	vt
Safety specifications with regard to fire engineering and electrical properties for underground use in German coal mining	V

As per DIN 22102 or DIN 22131; W, X, Y, Z and K are standard cover grades. As per ISO 10247; D, H and L are standard cover grades. There are only minor deviations in mechanical properties as per DIN and ISO.

Mechanical Properties as per DIN and ISO

Mechanical properties of standard covers according to DIN 22102, DIN 22131 and ISO 10247 are summarized in the following table.

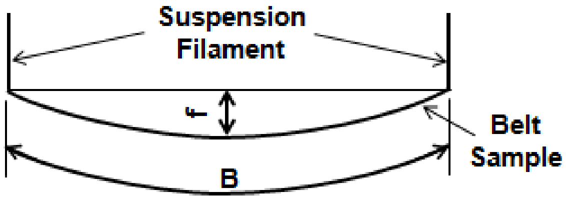
Cover Types		Tensile Strength N/mm^2 min.	Elongation at Break % min.	Abrasion mm^3 max.
DIN 22102 DIN 22131	ISO 10247			
W	(D)	18 (18)	400 (400)	90 (100)
X	(H)	25 (24)	450 (450)	120 (120)
Y	-	20	400	150
Z	(L)	15 (15)	350 (350)	250 (200)
K*	-	20	400	200

* For flame resistant conveyor belts according to DIN 22103 with antistatic covers according to DIN 22104.

Note: In steel cord conveyor belts (DIN 22131), there is no cover of Z type.

Troughability as per DIN

As shown in the following figure, troughability is given by the ratio, Deflection f / Belt Width B.



Troughability Measurement

The minimum values of f / B with 3 idler rollers of the same dimensions as specified in ISO 703 Conveyor belts - Transverse flexibility (troughability) - Test method, DIN 22107 for conveyor belts with textile plies (DIN 22102) and steel cord conveyor belts (DIN 22131) are given in the following table.

Inclination of Side Idler Rollers	f / B min.
20°	0.08
25°	0.10
30°	0.12
35°	0.14
40°	0.16
45°	0.18
50°	0.20
55°	0.23
60°	0.26

Various DIN standards for the cover materials are:

22100: Synthetic materials for use in underground mines
22102: Conveyor belts with textile plies
22103: Fire resistant conveyor belts
22104: Antistatic conveyor belts
22109: Conveyor belts with textile plies for coal mining
22118: Conveyor belts with textile plies for use in coal mining; fire testing
22129: Steel cord conveyor belts for underground coal mining
22131: Steel cord conveyor belts

Mechanical Properties as per RMA, USA (Now ARPM, USA)

When covers are tested in accordance with ASTM D412 for the tensile strength and elongation at break and with ISO 4649 Part B for volume loss (mm^3) shall comply with the following table.

RMA Grade	Minimum Tensile Strength (psi)	Minimum Tensile Strength (MPa)	Minimum Elongation at Break (%)	Maximum Volume Loss (mm^3)
I	2500	17	400	125 mm^3
II	2000	14	400	175 mm^3

General Purpose Rubber Cover and Ply Adhesion shall comply with the following table.

Adhesion between Adjacent Plies		Adhesion between Cover & Ply			
30 lbs/in	5 kN/m	1/32” (0.8 mm) ≤ Cover Thickness ≤ 1/16” (1.6 mm)		Covers greater than 1/16” (1.6 mm)	
		16 lbs/in	3 kN/m	30 lbs/in	5 kN/m

Important properties of most widely used Continental cover materials (guide values) are given in the following table.

Code Letter to DIN	**Continental Quality Designation**	**Density in kg/dm³**	**Admissible Temperature in °C***				**Resistance to Oil and Grease**	**Polymer**	**Suitability**
			Sustained Load		**Peak Load**				
			min.	**max.**	**min.**	**max.**			
X	ATRB	1.09	−50	+60	−55	+70	no	NR	general conveying (peak requirements)
Y	Conti extra	1.13	−30	+60	−35	+70	no	NR/SBR	general conveying
**	Conti-clean (dirt repellent)	1.12	−50	+60	−55	+70	no	BR/NR	cases of heavy soiling (with high moisture content)
Y,K	FH (flame resistance)	1.24	−30	+60	−35	+70	no	NR/BR	lignite excavating equipment, open cast
S, K	FW (non-inflammable)	1.38	-	+60	-	+70	no	SBR	underground and surface
V	V (self-extinguishing)	1.42 1.60	-	+100	-	+110	to some degree	CR	underground mining (most stringent safety regulations)
S, T	VULKAN® spezial (non-inflammable)	1.39	−30	+110	−30	+130	to some degree	CR	hot materials with glowing embers
T	VULKAN®-T 130	1.13	−30	+110	−40	+130	no	SBR	hot materials
T	VULKAN® extra-T150	1.13	−30	+130	−40	+150	no	SBR	hot materials
T, C	VULKAN® super – T 180	1.05	−30	+180	−40	+200	no	EPM	hot materials, also resistant to acid and alkali
G	TDAX	1.17	−10	+70	−20	+90	yes	NBR	oily or greasy materials
G	TBBX	1.13	−50	+60	−50	+70	yes	NBR	oil sand handling
A	TDLX	1.21	−10	+120	−15	+140	yes	NBR	foodstuffs (in oily, greasy or extreme temperature conditions)
C	TOWN	1.0	−40	+60	−45	+70	no	NR	materials with acid content
E	TBBN (conductive)	1.25	−30	+60	−35	+70	no	NR	materials with explosion hazard
V	PVC (self-extinguishing)	1.35	−5	+50	−5	+60	yes	PVC	underground mining

* The temperature specifications refer to the conveyor belt. The carrying capacity also depends on the nature of the temperature effect (see WdK guidelines, No. 339).
** Conti-clean is a special quality with good operative properties.

For more information on cover materials and data, contact ContiTech (www.contitech.de).

Splicing

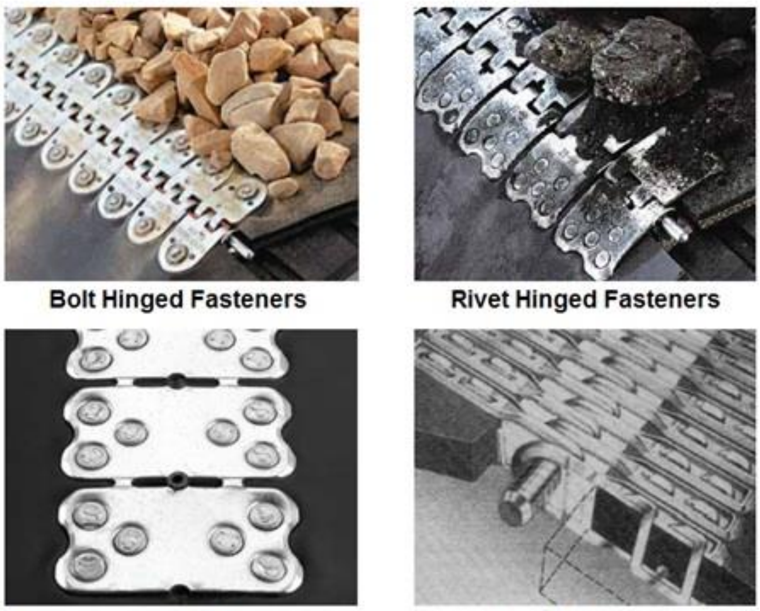
Conveyor belting is shipped on a roll, and so before use, the two ends of a belt must be spliced (joined together) to provide a continuous loop. The two methods for joining the ends of the belt together are: mechanical splicing, the process of joining belt ends by mechanical fasteners and vulcanized splicing, the process of joining belt ends through heat and/or chemicals. The vulcanized splice method provides a stronger connection and longer service life. However, in many cases a mechanical splice is acceptable, and in certain cases it may be preferred. Information about both the methods of splicing is given in this chapter.

Mechanical Splicing

Mechanical fasteners are available in two types, hinged and solid plate, and with a variety of attachment methods including rivets, bolts, and staples. They are fabricated from a variety of metals to resist corrosion and wear and match application conditions.

Hinged fasteners are available in three methods of attachment: staple, bolt, or rivet. They are usually supplied in continuous strips to fit standard belt widths. These strip assemblies ensure proper spacing and alignment. The chief advantage of hinged fasteners is that by removing the linking pin they are separable. This way the belt can be shortened, extended or removed/opened to allow maintenance on conveyor components. They are also ideal for belt conveyors with smaller pulley diameters.

Solid plate fasteners make a strong, durable joint with no gap for fines. Solid plate fasteners are effective in the most rugged conveying applications in mines and quarries. The plate segments are installed from one belt end to the other using staples, rivets, or bolts. However, they are not suitable for small pulleys where they may be too large to bend around the pulley, causing components of the splice to pull out or break.

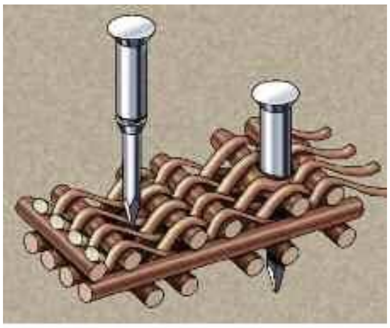


Bolt Hinged Fasteners | Rivet Hinged Fasteners

Rivet Solid Plate Fasteners | Staple Fasteners

Types of Mechanical Fasteners for Heavy Duty Application

Above figure shows some commonly used mechanical fasteners to make heavy duty joints.



Rivet Solid Plate Fastener

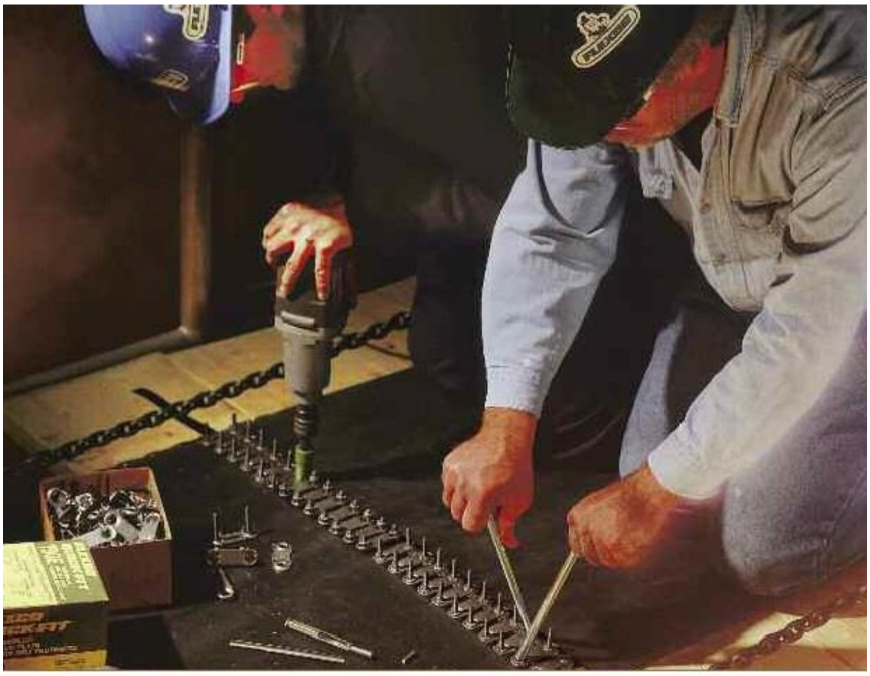
Rivet fastener systems are recommended for the most demanding high-tension applications. As shown in above figure, in rivet solid plate fastener systems, the staggered, multi-point attachments penetrate between carcass fibers without severing them. They are ideal for use with straight-warp belting.

Bolt Solid Plate Fastener

Above figure shows the most commonly used mechanical fastener called bolt solid plate fastener. Bolt solid plate fasteners use bolts to compress the top and bottom plates distributing splice tension evenly across the entire width of each fastener plate. For added strength and pull-out resistance, specially-formed teeth penetrate deep into the belt carcass but without damaging the carcass fibres. Installation can be carried out faster if bolt ends are piloted. A piloted bolt automatically aligns the bolt and nut threads. Bolt solid plate fasteners are available in various sizes to accommodate belts of different thickness. Following table may be used to select bolt solid plate fasteners manufactured by Flexco.

Fastener Size	Belt Thickness Range, mm	For Belts with Mechanical Fastener Ratings up to, kN/m	Minimum Pulley Diameter, mm
1	5 - 11	30	300
140, 140VP	5 - 11	40	360
190, 190VP	8 - 14	65	460
1-1/2	11 - 17	50	460
2.2VP	14 - 21	75	760
2	8 - 32	123	510
2-1/4	14 - 30	105	920
2-1/2	19 - 25	75	1070
3	24 & over	100	1220

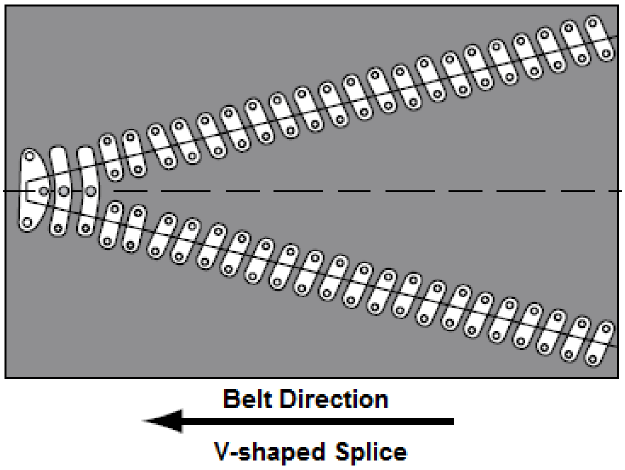
In VP, Vulcanized Plate fasteners, top plates are covered with rubber. They provide increased impact protection and reduce exposure to wear, resulting in longer splice life.



Application of Mechanical Fasteners

Above figure shows application of bolt solid plate fasteners for making a mechanical splice. Specially designed templates, punches and boring tools may be used to accurately punch holes into the belt and do the job faster. As shown in above figure, after tighten the nuts, excess bolt ends are broken off using two bolt breakers and bolt ends are peened or ground to finish the job. For detail installation instructions, please view Flexco's website.

Although the bolt solid plate fastener can be used for a conventional 90˚ splice, these fasteners with a 45° splice will accommodate smaller pulleys if smaller pulley diameters are present (up to 25% smaller size than recommended for 90˚ splices).



Belt Direction

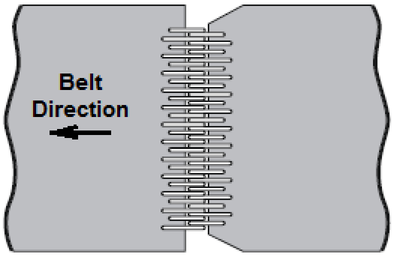
V-shaped Splice

As shown in above figure the bolt solid plate fasteners can also be installed in a V-shaped pattern for joining thick, high-tension belts designed for vulcanization.

It is a common but incorrect practice to stock only one size of mechanical fastener in the maintenance supply room (store). Most fasteners are available in a range of sizes. In all cases, the manufacturer's recommendations should be checked to ensure that the fastener size is matched to the pulley sizes and belt thickness. If the belt is to be skived in order to countersink the fastener down to the surface of the belt, this skived thickness should be considered when thinking about fastener size.

Where belt ends are joined with mechanical fasteners, the first requirement of a good joint is that the belt ends be cut square. Failure to do so will cause some portion of the belt adjacent to the joint to run to one side at all points along the conveyor.

To protect the corners of the belt, it is often useful to notch or chamfer the corners of the belts at the splice.

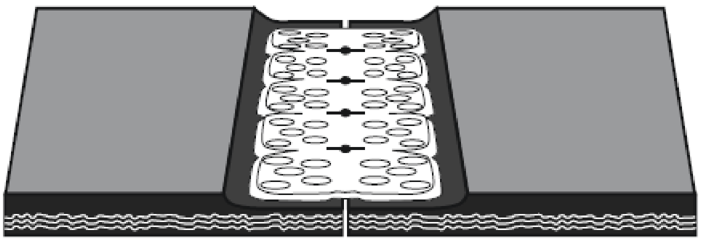


Belt Notching

As shown in above figure, on uni-direction (one-direction) belt, it is only necessary to notch the trailing end of the belt. The notch is cut in the belt from the first fastener on each end of the splice out to the belt edge at a 60° angle. The notch will help prevent the hang-up of the corners of the belt at the splice on the conveyor structure.

Plate type fasteners sometimes conflict with aggressive belt cleaning system cleaners, especially where hardened metal blades are used. Hence many operators prefer to use nonmetallic (i.e., urethane) belt cleaner blades on belts with mechanical splices for fear of wearing or catching the splice and ripping it out.

However, development of a new tool for skiving helps make mechanical fasteners more scraper-friendly.


Application of Mechanical Fasteners after Skiving


Belt Skiver

As shown in above figure, using a belt skiver, one can easily remove a uniform strip of cover material to leave a smooth flat-bottomed trough with a rounded corner so that both the top and bottom splice pieces can be recessed into the belt surface. Skiving the belt also reduces noise in operations, as clips are now recessed and do not "click clack" against the idlers.

However, metal fasteners are not suitable to transport hot materials as they absorb the heat and transmit it to the belt plies, causing deterioration of the carcass.

For more information on mechanical fasteners, please view Flexco's website.

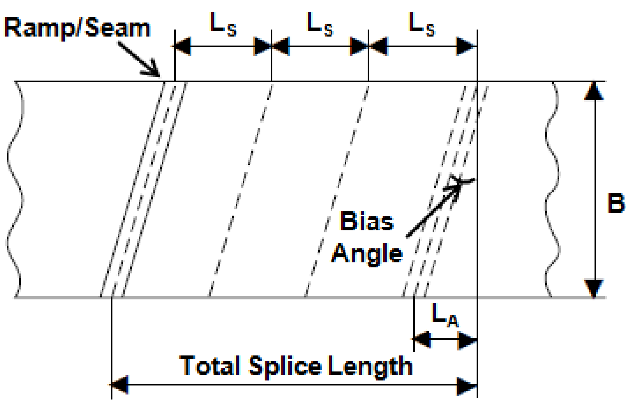
Oriental Rubber Industries Ltd., Pune (www.orientalrubber.com) are distributor for Flexco's products in India.

MATO Corporation USA (www.mato-usa.com) also manufactures mechanical fasteners.

Vulcanized Splicing of Textile Conveyor Belt

Wherever practicable, a hot vulcanized splice is preferred for making a conveyor belt endless as against cold vulcanization and metal fasteners.

The basis for creating a splice is strong adhesion between the textile layers and the surrounding rubber. At the connecting interface, the layers of the two belt ends are overlapped as prescribed. For a hot vulcanized splice, the ends are embedded in a rubber cement and vulcanized. For cold vulcanized splices, the function of the rubber cement is assumed by an adhesive or bonding agent that cures at room temperature. The tension is transferred via the surrounding rubber from the plies of one belt section to the plies of the other belt section. The length of the step is important. The length depends on the type of fabric and belt.



Stepped Splice

Various types of splices are: the straight joint (90° across the belt), the diagonal splice (with a bias angle), the Chevron splice and the zig-zag splice.

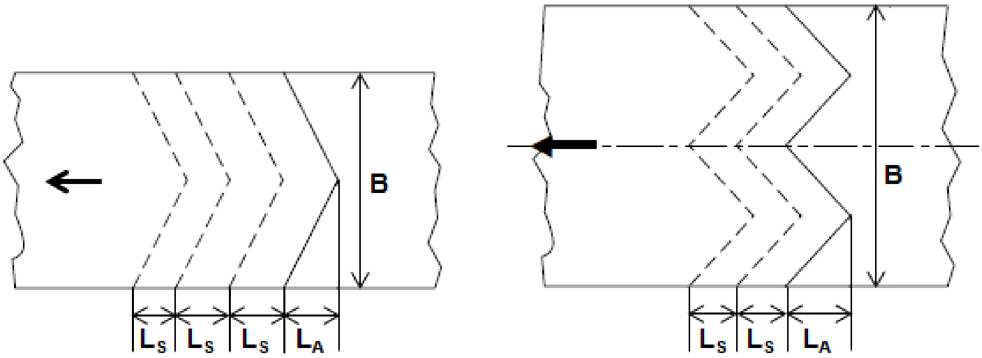
Type of a splice is chosen depending on the application. Above figure shows the most commonly used stepped diagonal splice method. In above figure,

B = Belt Width
L_A = Bias Length
L_S = Step Length

In general, for multi ply belts:

Number of Steps (z) = Number of Plies - 1
$\therefore$ Total Splice Length =Splice Length + Bias Length = $z \times L_S + L_A$

Fabric joints are generally cut at an angle/bias. The angled joint prevents the joint from being stressed over the entire width of the belt when it bends around pulleys. The greater the angle, the less the stress on the joint but makes the splice longer. An angle of 16° 40' has proven to be a satisfactory standard. It is also easy to construct as it results in a bias length (L_A) equal to 0.3 x Belt Width.



Chevron and Zig-Zag Splices

Above figure shows Chevron and zig-zag splices. In Chevron splices, generally bias length (L_A) is kept between 0.25 B and 0.5 B and step length (L_S) between 200 and 300 mm. In a zig-zag splice, bias length (L_A) is about 0.25 B and step length (L_S) is about 150 mm. Chevron type of splice is used for belts having short centre to centre distances while zig-zag type of splice is used for reversible conveyor belts and weigher belts. These types of splices are also used for small pulley diameters.

In general, the splices have the same thickness and flexural strength as the conveyor belt. If a thick spot cannot be avoided (for example: one ply belt with overlap), it may not exceed 3 mm. If scrapers are used to clean the belt, the splice can be damaged if it is more than 3 mm thicker than the rest.

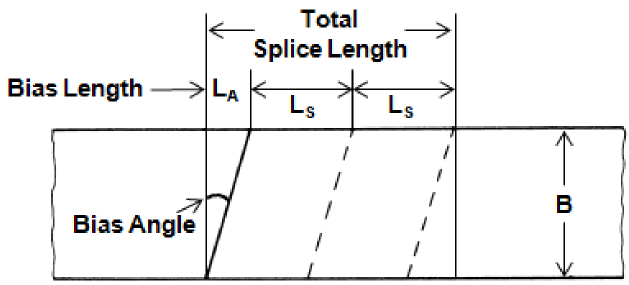
For solid woven carcass and high tension fabric belts with heavy gauge fabrics, a so-called **finger splice** is used instead of a standard stepped ply splice. In the finger splice, mating triangular fingers are cut into the carcass of the belt ends to be joined. The fingers improve the flexibility of the splice by breaking up the joint line into many small sections. A splice fabric is used over the fingered section to help distribute the tension transfer from one belt end to the other.

Typically, the materials used for a vulcanization (both hot and cold) are available in kit form. Kits from the belt manufacturer are sometimes preferred, particularly for high heat resistant, oil resistant and other special grade conveyor belts. Although there are generic kits and they are available in the market for the most common belt grades.

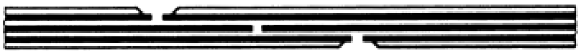
Hot Vulcanization of Textile Conveyor Belt

Step splice is applicable for multiply (with more than two plies) belts. Whereas for single (one) ply belts overlap splices can be made and for two ply belts an additional ply may be inserted in the splice area.

Splicing of Conveyor Belts with More than Two Plies



3 Ply Belt, 2 Steps



Splicing of 3 Ply Belt

As shown in above figure, for conveyor belts with more than two plies, splicing is generally carried out by stepped diagonal method. The figure shows splicing of a 3 ply belt.

Selection of Step Length (DIN 22102 - Part 3)				
Belt Rating	**Breaking Strength of One Ply (N/mm)**	**Step Length (mm)**	**Splice Length (mm)**	**Number of Steps**
315/3	80-100	150	300	2
400/3	125-160	200	400	2
500/3			400	2
630/4			600	3
800/4	200-250	250	750	3
1000/5			1000	4
1250/5			1000	4
1600/5	315-400	300	1200	4
2000/5			1200	4
2500/5	500-630	350	1400	4
3150/5			1400	4

The step length depends on the type of fabric and belt. The step length may be selected as per above table (as per DIN 22102 - Part 3).

If the belt rating cannot be found in the table, the necessary splicing length can be calculated in the following way:

Calculate the breaking strength of one ply. For this value the necessary step length can be taken from the table. If this length is multiplied with the possible number of steps (Number of plies -1) and bias length is added, it gives the splice length.

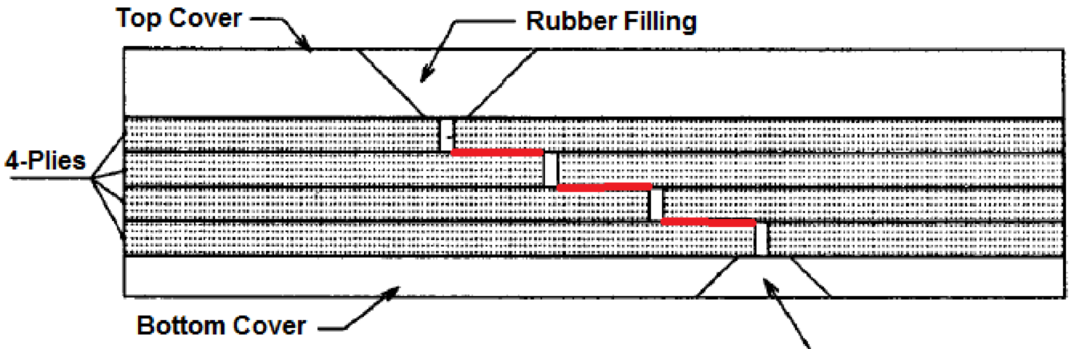
Example: One ply of a 1000/3 has a breaking strength of approximately 333 N/mm (1000 ÷ 3 = 333.3). The step length for this value is 300 mm, therefore the splice length in mm is 300 mm × (3 - 1) + Bias Length in mm = 600 + Bias Length in mm.

Generally, width of top/bottom cover channel also called seam (where cover rubber is filled in) is about 30 to 50 mm.

Joint Efficiency

Due to spicing, belt's tensile strength reduces. This reduction in the belt's strength is referred as joint efficiency.

The joint efficiency results in strength loss by one ply because the top ply does not get loaded after the joint. This is illustrated by an example of a 4 ply belt in the following figure. It can be seen that due to splicing, only three plies are getting loaded though there are four plies in the belt.



Joint Efficiency

The joint efficiency for different ply belt can be calculated as under.

For 3 ply, joint efficiency = 2 ÷ (2 + 1) = 0.66 [34% loss in belt strength]
For 4 ply, joint efficiency = 3 ÷ (3 + 1) = 0.75 [25% loss in belt strength]
For 5 ply, joint efficiency = 4 ÷ (4 + 1) = 0.80 [20% loss in belt strength]

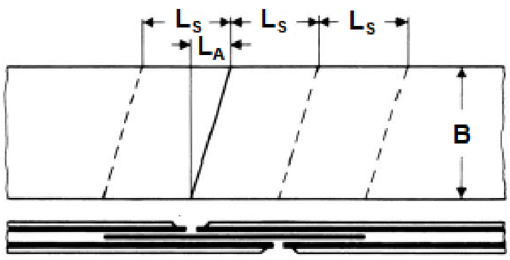
In general,

Joint efficiency = Z ÷ (Z + 1), where z = Number of steps

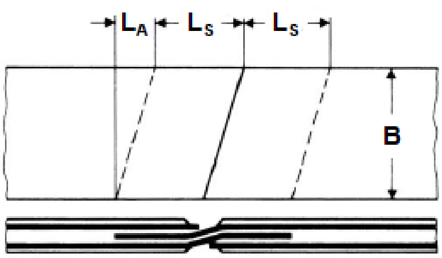
As explained above, a fabric belt's splice commonly has less strength than the belt. However, failure to achieve 100 % joint efficiency in the belt's splice does not create a source of belt failure and is no reason for concern. The durability of a fabric belt's splice is not primarily dependent upon its tensile or pullout strength. Excessive bending stresses may cause the splice to open up and result in a failure even under moderate belt tension.

As joint efficiency of 0.5 (that is 50% loss in belt strength) calculated for a belt with two plies is usually not justifiable, other options have been found in belt construction and splice design as explained in the following section.

Splicing of Conveyor Belts with Two Plies



Splice with Additional Fabric



Interlaced Splice

Splicing of Conveyor Belts with Two Plies

As shown in above figure, there are two options for making splice on conveyor belts with two plies without loss in belt strength.

Option 1: Splice with additional fabric (1 to 2 mm thick)
Option 2: Interlaced Splice

The step length may be selected as per following table

Belt Type	Minimum Step Length, L_S, mm
200/2	180
250/2	180
315/2	180
400/2	200
500/2	200
630/2	250
800/2	250

Splicing of Conveyor Belts with Single Ply

DIN 22102, Part 3 provides for two options for making splices on conveyor belts with single ply.

Option 1: Overlapping splices for belt types ≤ 500/1
Option 2: Finger splices for belt types ≥ 630/1

Overlapping Splice

Overlapping splices are easy to make. However, as they are thick, they can be ignored in practice. Finger splices are very costly to make and require manual skills. However, they are not thick to the detriment of the cover thickness at the splice area.

Vulcanizing Materials

For vulcanized splicing, following vulcanizing materials are used. These materials are perishable (i.e. they have a shelf life in storage). Therefore, before their use, the date of their expiry should be checked.

Vulcanizing (Conveyor Belting) Solution

It is also called cement. The vulcanizing solution is applied by brush over the fabric plies/carcass after cleaning them to replace the frictioning/dipping solution removed from them during the stripping (Note: Apply the cement solution sparingly. It only serves to improve the adhesiveness while assembling and actually can harm the bond after vulcanization).

Tie Gum

It is also called insulation compound or intermediate rubber plate. It is uncured rubber. It is available in 0.3 to 0.8 mm thickness. The tie gum is applied over (on) the conveyor vulcanizing solution as a skim coat to improve adhesion between plies.

Fabric

It is uncured, rubber calendered to fabric. It is used in finger splicing. Many times a breaker fabric is also used below cover rubber compound/fill-in. They enhance pulley flex dynamics and provide some tensile strength.

Cover Rubber Compound/Fill-in

This compound (uncured rubber) is required to replace cover rubber and is used to build up the face and back cover channels (seams) in splices and also for replacing damaged portions of the cover. Cover compound is available in 1.6 mm thickness interleaved. Any thickness of cover rubber can be built up by using the requisite number of layers of this compound.

Release Paper (or cloth)

It (silicone paper) is used for good flow of the rubber to avoid the creation of wrinkles while pressing and allow release of the splice from sticking to the platens.

Solvent

Trichloroethylene is an incombustible solvent. It is used for cleaning.

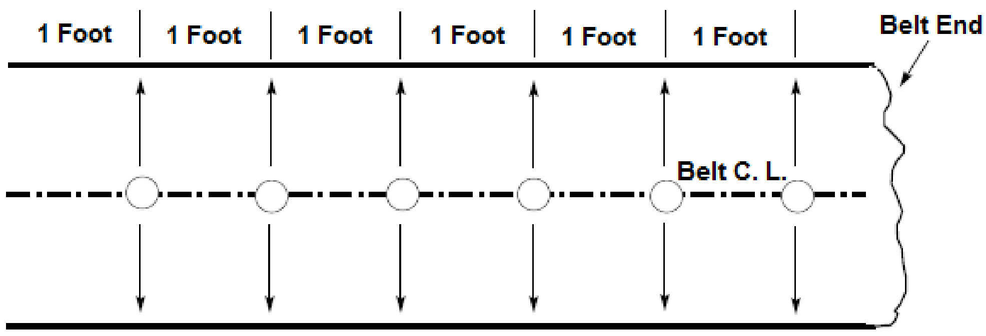
Judging Usability of Rubber Materials

To judge the usability of tie gum and cover rubber compound (fill-in), cut a strip of approximately 20 mm wide, from each material at room temperature and dip in solvent (trichloroethylene or toluene) for approximately ten seconds. After removing each strip from the solvent allow to dry naturally for about one minute before grasping it by hand. If the rubber is sticky, the material is usable. If the rubber is not sticky, the material is not usable.

Splicing Instructions

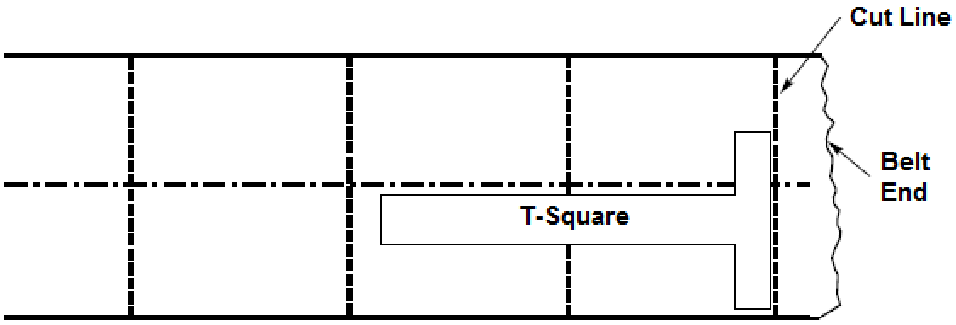
Accurate squaring of the belt ends prior to splicing is essential to distribute stress evenly throughout the splice which is required for true running of a belt.

To properly square the belt ends, use the **center line method** as under.



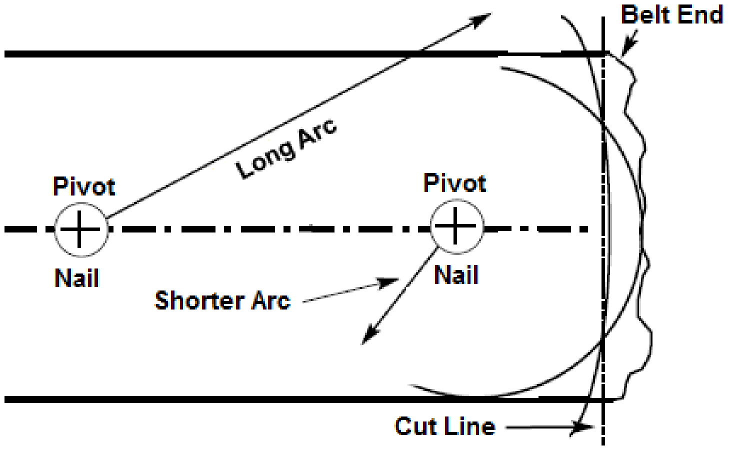
To establish the belt center line, start near the belt end as shown in above figure. Measure the belt width at seven points approximately 1 foot apart. Divide each measurement in two and mark these center points as shown.

Using these seven “center points,” draw a line to form the belt’s center line. Next, using a carpenter square or “T” square, draw a “cut line” across the width of the belt near the belt end as shown in the following figure. Repeat this for the other belt end. Using this “cut line” as the guide, cut off the end of the belt with a sharp knife. Make sure that the cut is clean and vertical.



Marking of Cut Line and Other Right Angle Guide Lines

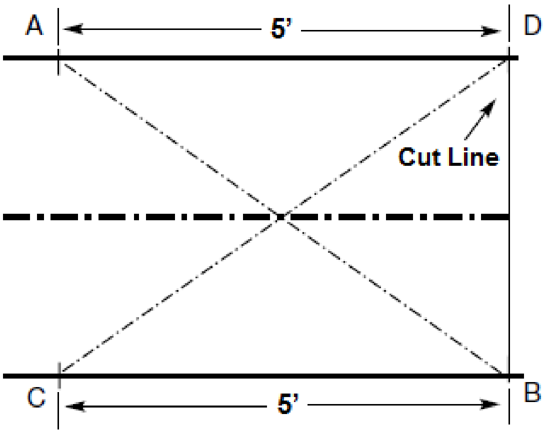
An alternative method of squaring belt ends is called the "**double intersecting arc**" method.



Joining of the points where the arcs intersect gives the right angle cut line.

Alternative Arc Method of Squaring Ends

First establish the center line as indicated previously. Once that center line has been established, pick a point on the center line and approximately 2 or 3 times the belt width from the belt end. An arc (long) is now struck as shown in above figure. A second shorter arc is now struck as shown. The pivot point in this case is on the center line and is close to the belt end. The arc length is slightly less than one-half of the belt width. Now draw a line through the two points of these arcs intersection. This is the "cut line." This line is perpendicular to the center line of the belt.



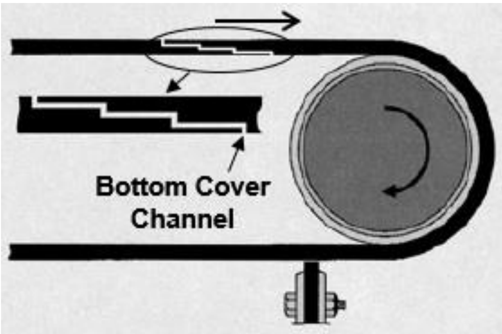
Proving Accuracy of Squared-Cut End

It is always a good idea to double-check the accuracy of the squared and cut end. Measure 5 feet along each edge from the end of the belt, then utilizing a tape measure, check the two diagonals. They should be equal and further, should intersect on the belt center line.

After squaring the belt ends, they are aligned and fixed with crossbars or C-clamps to the ends of the worktable.

The **Laser Belt Square** makes the process of squaring a belt for splicing fast, easy and accurate in a fraction of the time of conventional squaring method (for information on Laser Belt Square, please view FLEXCO's website.

Now the belt ends are prepared in a series of steps, the number of steps being one less than the number of plies. After roughening the rubber interfaces and carefully removing the coarse dust, the belt ends are ready for applying vulcanizing solution. Prepare the ends such that joint/step direction is as per the following recommendation.

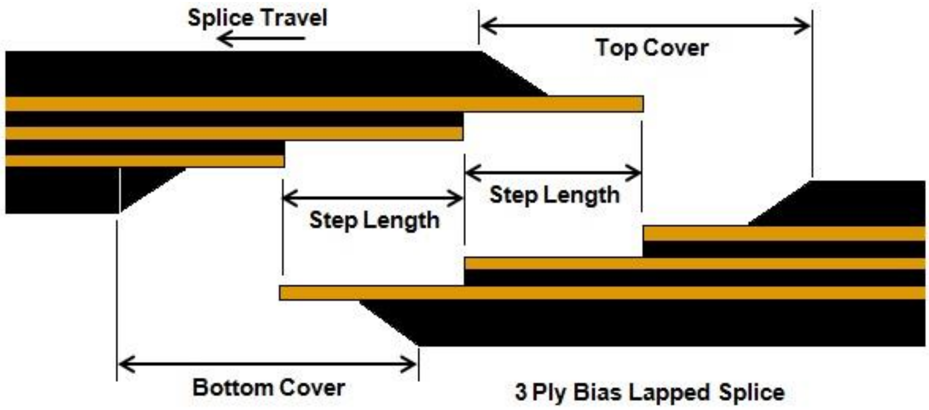


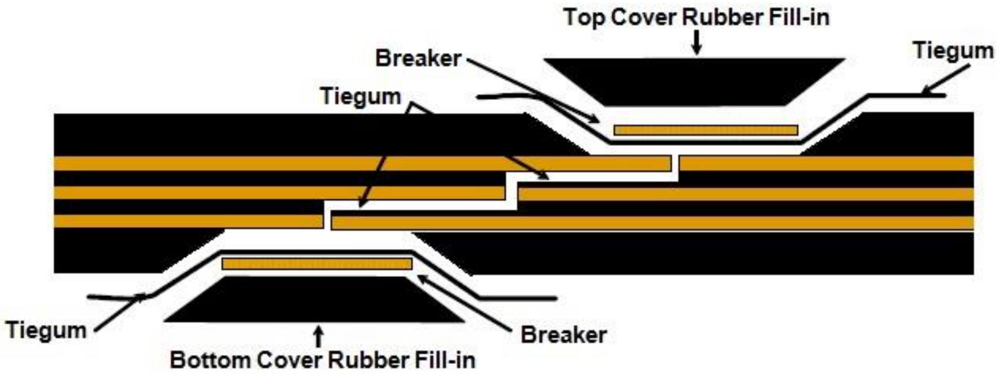
Scrapper Running with Joint/Step

As shown in above figure, if the scrapers are working hard, the splice should be made in such a way that the scraper is not scraping against, but moving with the joint/step. That is, the cover compound built on the back (bottom) cover channel leads the one on the face (top) cover. However, in the case of belts running on slider plates, this has to be reversed.

Now a thin layer of vulcanizing solution is applied on the prepared surfaces. After all the solvent has evaporated (trapped solvent can cause bubbles during vulcanization), 0.3 mm to 0.8 mm thick intermediate rubber plate is placed on the belt and the rubber plate is pressed onto the fabric steps with a hand roller. Cover rubber compound strips are also placed in the steps/grooves for the bottom cover channel.

Now both belt ends can be joined. This operation requires a great deal of care since the belt ends must remain aligned and the fabric steps must abut precisely. After joining, the two belt ends are pressed thoroughly by rolling, starting from the middle. Finally, the top cover channel groove is filled by placing the cover rubber compound strip in it.





Vulcanizing Fabric Belt Splice

Above figure shows detail of a typical 3 ply fabric belt with vulcanizing compounds. As shown in above figure, sometimes breaker (fabric) is also used below cover rubber.

The splice is now ready for vulcanization. Vulcanization is carried out with portable vulcanizer (vulcanization equipment). The heating plates of the vulcanizer should extend over the splice area in the lengthwise direction of the belt by approximately 100 mm. To ensure sufficient vulcanization of the edges and to hold the side shims in place, the plates should extend at least 50 mm over the side, that is:

Width of the heating surface = belt width + 100 mm

It may sometimes be necessary to cure the full splice length in more than one charge. In such cases care should be taken to see to it that the channels are vulcanized always in one single cure. Also ensure that the first and the last charge at the ends of the splice are at least 75 mm inside the platens of the vulcanizer and that an adequate overlap of 75 mm exists between two consecutive charges.

Note: When belts are installed for underground coal mines, make sure that only permissible fire-proof heating plates are used.

Vulcanizing Pressure, Temperature and Time

For hot splicing of textile conveyor belts, Phoenix Conveyor Belt India (P) Limited recommends following values of vulcanizing pressure, temperature and time.

Vulcanizing pressure = approximately 10.0 bar (kg/cm^2).

Vulcanizing temperature should be controlled within 150°C ± 5°C.

Vulcanizing time should be as per the following table.
(Usually preheating time = 40 to 60 minutes)

Belt Thickness (mm)	Holding Time, minutes
Up to 10	25
Over 10 up to 12	30
Over 12 up to 15	36
Over 15 up to 17	42
Over 17 up to 20	48
Over 20 up to 22	53
Over 22 up to 25	60
Over 25 up to 30	70

Apply pressure gradually and switch on the heating plates. Apply full pressure when the platen temperature reaches 100°C.

Switch off the heating plate when the temperature reaches 150°C. If the temperature drops down to 148°C, switch it once again (instead of manual operation, a self-regulating heating system may be used). Curing time starts as soon as the temperature reaches 147°C.

Check the hydraulic pressure continuously during the curing period.

When the conveyor belt is installed in the open air, strong temperature fluctuations e.g. caused by a side wind are to be prevented by setting up a weather-protection tent or a tarpaulin shelter.

After the heating time has expired, it is recommended that the splice be cooled under pressure to about 70°C. Then the vulcanization equipment can be disassembled. Opening the tent or blowing compressed air onto the heating device can shorten the cooling time.

Splicing Precautions

1. Ensure that the belt is not wet.

2. Great care should be taken in the use of the ply cutting knife in order not to cut deeper than intended.

3. The buffing operation should be done carefully, so that the fabric ply and the rubber impregnation between the plies are not damaged, since it would reduce the strength of the splice considerably.

4. Blisters are sometimes formed while curing the splice. It could occur due to lack of sufficient time for the conveyor belting solution to dry or due to foreign matter/moisture. Blisters should be cut open and the area carefully examined to determine the cause of blisters. Any evidence that has caused the blisters must be removed. The area should be cleaned with Naphtha and when dry, two coats of conveyor belting solution should be applied, allowing each coat to dry thoroughly. If only the cover is blistered, this part of the cover must be removed and replaced with cover compound by building up the required thickness. If the blister is in the carcass, this area must be cut open longitudinally and dried thoroughly. After roughening up the surface with emery cloth, two coats of conveyor belting solution should be applied, allowing each coat to dry thoroughly. The opening must then be closed and the belt cured at recommended temperature and pressure.

5. The edge bars (moulding irons) should be placed at both edges of the splice, which must be approximately 1-2 mm thinner than the belt. Ensure proper contact between the belt

and the edge bar by carpenter's clamp or through wedges. The edges of the belt along the splice sometimes become porous. This happens when the edge bars are not fitted tightly or if the pressure is insufficient during curing. In such cases the area of porosity must be removed carefully and replaced with new compound. In case the channel is found to be porous, the channel rubber must be removed and repaired.

It is recommended that if more than one pair of platens is used, a metal sheet should be placed between the platen and the conveyor belt.

Cold Vulcanization of Textile Conveyor Belt

When it is not possible to carry out hot vulcanization, one shall carry out cold vulcanization. However, in carrying out cold vulcanization, care shall be taken to use high quality adhesive or bonding agent. Adhesive supplied by **REMA TIP TOP** are excellent for such jobs. For more information on their products, please view their website: www.rema-tiptop.com.

For procurement of Rema Tip Top products in India, one may contact TTGA PVT. LTD. (www.ttga.in).

However, in case of following conditions, cold vulcanization is NOT recommended.

- Ambient temperature below 10°C, and no belt surface heating assistance is available
- Relative atmospheric humidity above 70 %, again in the absence of heat assistance
- Dampness in the fabric plies
- Butyl / EPDM conveyor belts (high temperature resistant belts)
- Nitrile oil resistant conveyor belts

The preparations for hot vulcanization and cold vulcanization (including step length) are similar till belt ends are made ready for application of vulcanizing solution (that is, squaring of the belt ends, selection of step length, preparing steps, roughening the rubber interfaces and carefully removing the coarse dust). From this point onwards, proceed as under.

Coat the complete splice area with the activated cold vulcanization solution. Number of coats to be applied depends on strength of the fabric. Use the following table for drying time.

Generally, the cold vulcanization solution is activated by mixing 5% of hardener in it. The mixing time is roughly 5 minutes. Once ready for use, the solution is generally useful for 2 hours.

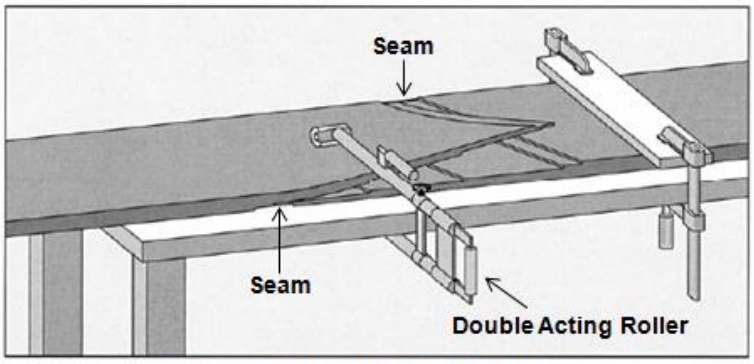
Number of Coats	Drying Time of the Coats at Room Temperature
If it is necessary to coat the splice surface two times	
1st coat	minimum 30 min., maximum 24 hours
2nd coat	Back of hand test*, maximum 20 min.
If it is necessary to coat the splice surface three times	
1st coat	minimum 30 min., maximum 24 hours
2nd coat	minimum 30 min., maximum 24 hours
3rd coat	Back of hand test*, maximum 20 min.

* Dried up until it reaches a “tack free state” (it varies between 15 and 20 minutes).

Note: Fabric with coarse surface structure requires three coats.

If the final coat (depending on number of coats requirement, 2nd or 3rd coat) is over dried, one more coat shall be applied.

After application of cold vulcanization solution, the belt ends are laid carefully together in proper alignment and full contact is achieved with hand roller, pressure rollers, or hammering in a prescribed pattern. The bond can often be improved by simply putting weights on the belt during the cure interval. Cure time is as fast as one hour, although better results can be achieved if the belt can be left for at least six hours.



Fitting Together Prepared Surfaces

As shown in above figure, it is recommended to provide seam (cover channel) at both ends of the splice in cold vulcanization. They should be filled by cover strips.

For fitting together, the prepared surfaces, rolling down them with a double acting roller is recommended. Double acting roller will get the needed pressure into the splice which is absolute necessary for getting the adhesion between the plies. The surfaces should be rolled down from the centre to the edges (in this case, there will not be any air between the upper and the lower part of the conveyer belt). The initial pressure should not be high (pressure screw tightened lightly). The second, third and last exposures should be with higher pressure.

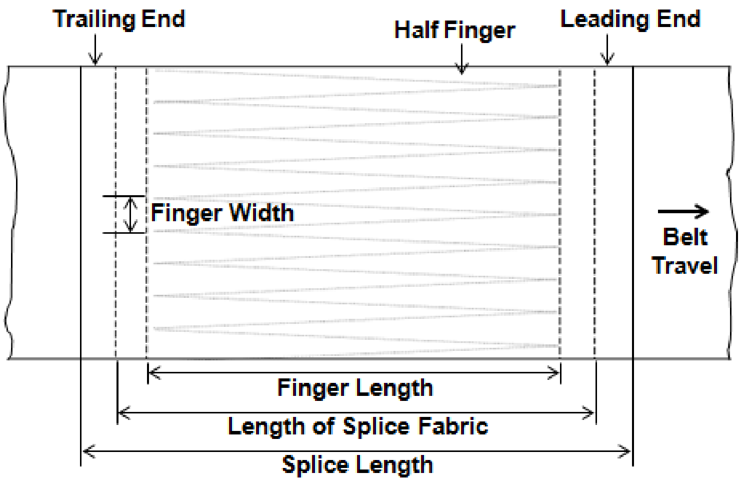
Double Acting Roller

Above figure shows construction of a typical double acting roller.

Note:
Belts subjected to light load and with relatively low tension can be tensioned and put into operation after minimum 2 hours. Heavy duty belts with high tension should be allowed to stand without load for minimum 6 hours.

Finger Splicing

A finger splice is used for very strong conveyor belts with one or two plies. It only performs well if it is completed very carefully.



Joint Dimensions for Finger Splicing

Recommended joint dimensions for finger splicing by ContiTech are as under.

Belt Type	Finger Length (L_{fin}) mm	Finger Width (W) mm	Length of Splice Fabric (L_{fab}) mm	Splice Length (L_s) mm
630/1	800	60	1100	1300
800/1	1000	60	1300	1500
1000/1	1250	60	1500	1700
1200/1	1500	60	1800	2000
1600/1	2000	70	2300	2500
2000/1	2400	70	2700	2900
2500/1	3000	70	3300	3500
3150/1	3800	70	4100	4300
4000/1	4200	70	4500	4700

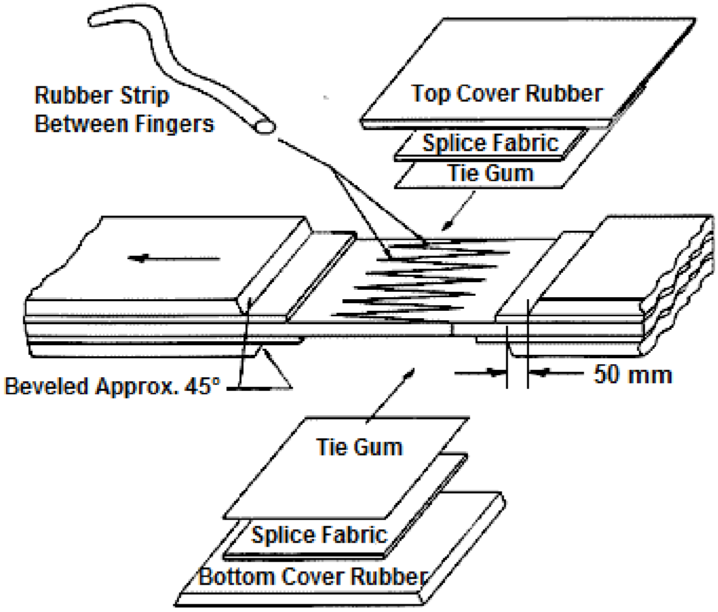
In general, the following rules apply:

Finger Length (L_{fin}) = 1.2 x Minimum Breaking Strength of Belt (N / mm of belt width)
Length of Splice Fabric (L_{fab}) = Finger Length (L_{fin}) + 300 mm
Splice Length (L_s) = Finger Length (L_{fin}) + 500 mm

As shown in above figure, make sure that on leading end of the belt the finger width at the edges is W/2 (half finger). The width of the fingers between them approximates the desired width W. All fingers on the trailing end of belt should have full width. If many splices of this kind are to be made, it is recommendable to prepare a template to draw the finger pattern.

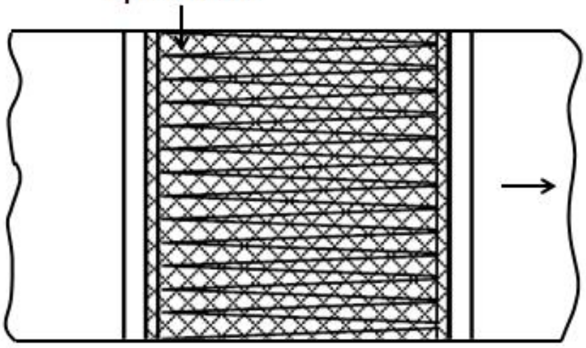
It is important to cut fingers accurately to ensure a high joint strength. It is also critical that the cut is perpendicular to the belt surface. Finger cutting is best done with a rotating, motor-driven circular knife. A keyhole saw may also be used.

To ensure a small gap between each finger, many times one end of the splice is pulled back (for amount of pull back, please follow manufacturers recommendation) before assembling the two ends. As shown in the following figure, to prevent the hinging effect that may occur with the cover rubbers being in the same vertical alignment, many times length of top cover removed is longer (100 mm to provide offset of 50mm) as compared to bottom cover.



Finger Splicing

Above figure shows construction detail of a typical finger splice. As shown in the figure, in a finger splice, splice fabric is used to transfer the tensile strength.



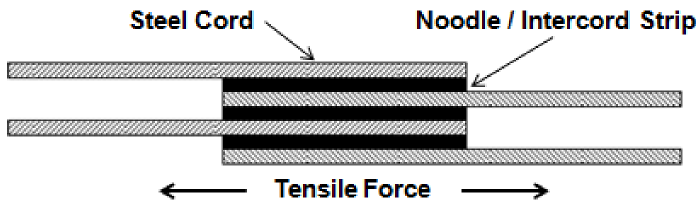
Splice Fabric with Bias

As shown in above figure, some manufacturers recommend using the splice fabric with the bias i.e. the warp and weft yarns of the splice fabric run at 45° to those in the belt. Follow manufacturer's recommendation.

Vulcanized Splicing of Steel Cord Conveyor Belt

In splicing a steel cord conveyor belt, all rubber is removed from both belt ends either by hand cutting or a cable stripping machine. This separating process leaves the cords embedded in a thin layer of the special core rubber. The corresponding cables of the two belt ends are then laid together (beginning with the middle cords) following a prescribed cord laying pattern. A special unvulcanized rubber compound (called noodle or intercord strip) is filled between the cables. The noodle height would be based on the cord diameter. Noodle is also filled in the gaps between the cords (e.g. in the cord transition zone and the gaps between the cord tails). Thus cured splice is held together by way of this special noodle rubber material.

Generally oblique joints (bias = 0.3 x belt width) are made, but perpendicular joints are also permissible.



Steel Cord Splice Working

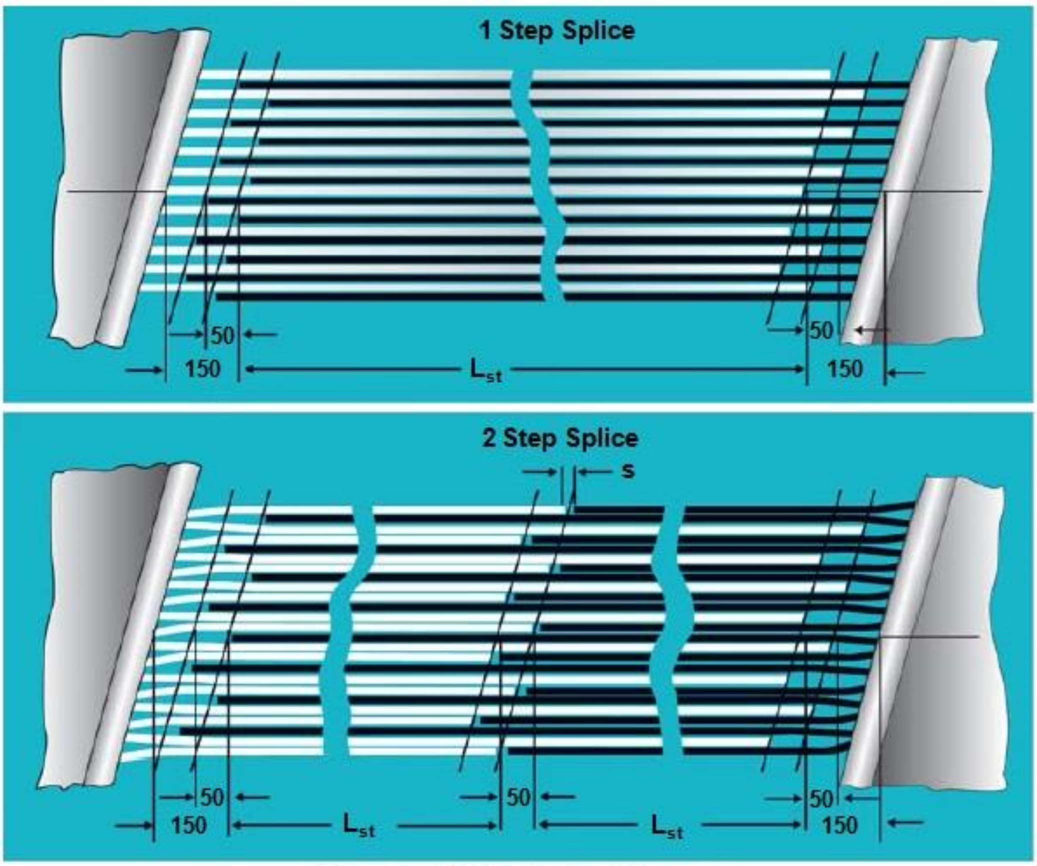
As shown in above figure, the strength of the joint evolves from the pull out force between the steel cord and noodle rubber in the splice. Hence, the gap between two parallel cords coming from the opposite end should be sufficient to achieve a good pull out force.

In order to provide the pullout strength required when splicing the cords of one belt end into the other, the thickness of noodle rubber between the mating cords must be a minimum of 1.9 mm. Where the belt construction (i.e., cord diameter and pitch) permits this without modification, the splice is termed a one-step splice.

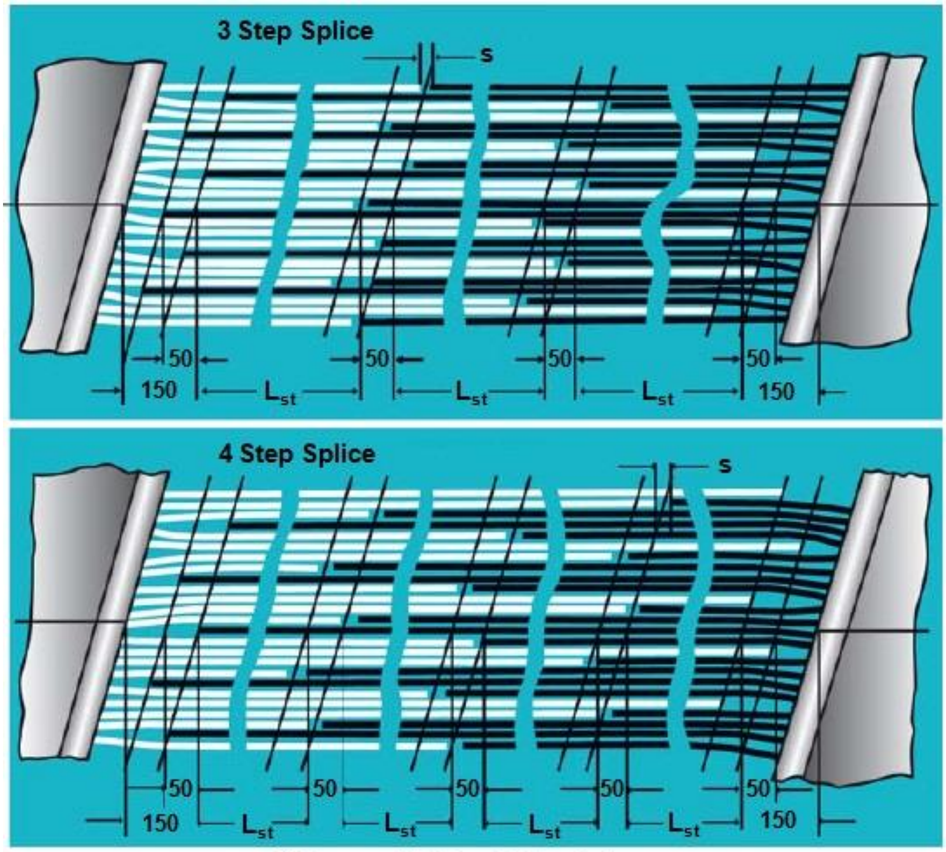
However, if the distance between cords in the belt does not permit the interlayer of opposing cords with the minimum thickness of noodle rubber, then opposing cords must be cut off and butted together in a prescribed pattern to allow for the necessary thickness of rubber. When these cords are cut and butted in the splice length, it is termed a multistep splice.

In view of above, the splice geometry and length of splice are dependent on the cord breaking strength, cord pull out strength, cord diameter, number of cords etc.

Different splice schemes as per DIN 22131, Part IV are shown in the following figures. In the following figures, s = a small gap between the cord tails.



1 Step and 2 Step Splice Schemes



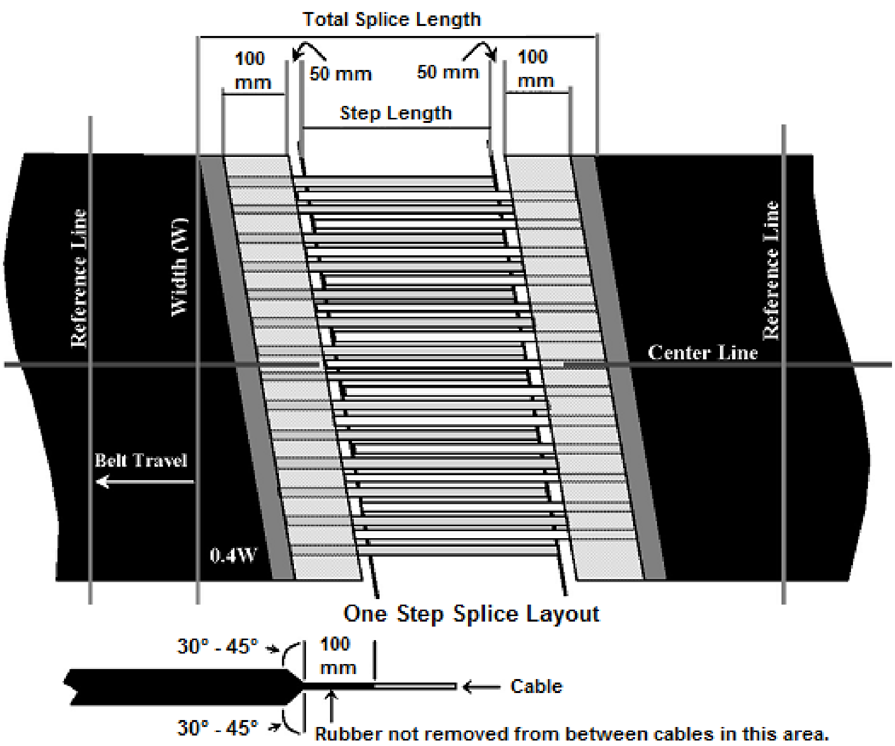
3 Step and 4 Step Splice Schemes

Splice dimensions for general purpose belts as per DIN 22131, Part IV, are given in the following table.

Splice Dimensions (DIN 22131, Part IV)				
Belt Rating	**Number of Steps**	**Minimum Step Lengths (L_{st}) mm**	**Additional Belt Length for Overlap mm**	**Min. Thickness of Intermediate Rubber in mm**
Up to St 1000	1	300	600 + 0.3 B	1.9
St 1250	1	350	650 + 0.3 B	2.1
St 1600	1	450	750 + 0.3 B	1.9
St 2000	2	400	1150 + 0.3 B	2.4
St 2500	2	500	1350 + 0.3 B	2.5
St 3150	2	650	1650 + 0.3 B	1.9
St 3500	3	650	2350 + 0.3 B	2.6
St 4000	3	750	2650 + 0.3 B	2.3
St 4500	3	800	2800 + 0.3 B	2.3
St 5000	4	900	4050 + 0.3 B	2.7
St 5400	4	1000	4450 + 0.3 B	2.3

Note: B = Belt Width

Please consult belt manufacturer for belt construction other than DIN and special grade belts.



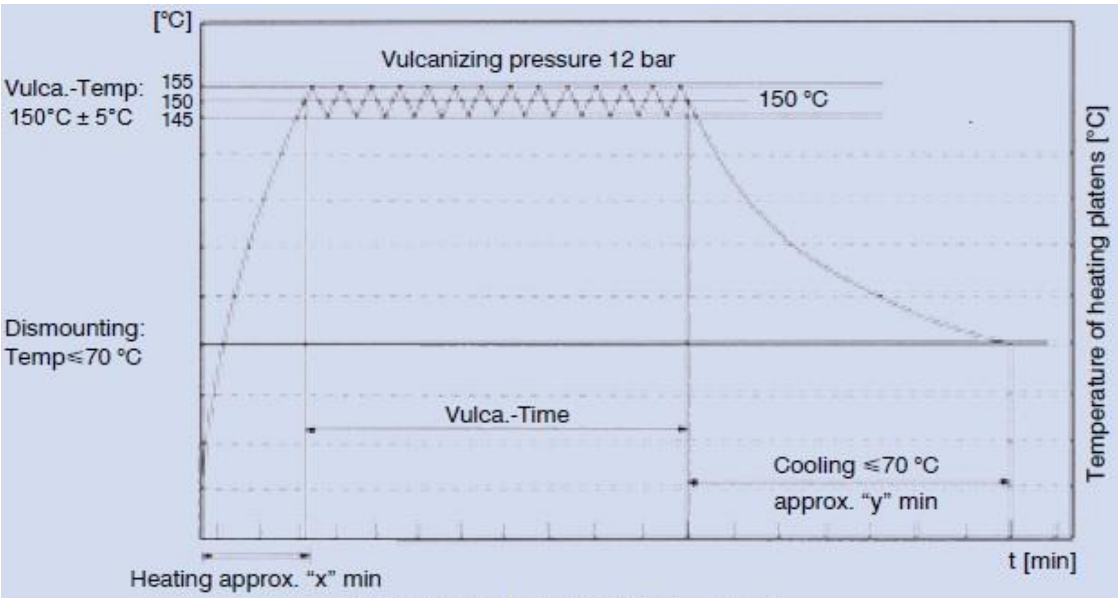
One Step Splicing of Steel Cord Belt

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

Generally, USA manufacturers recommend oblique joints with bias equal to 0.4 x belt width. Above figure shows preparation of one step splice with bias equal to 0.4 x belt width.

Curing conditions recommended by Phoenix Conveyor Belt India (P) Limited are as under.

Curing temperature: 150°C ± 5°C



Controlling Vulcanizing Temperature

Curing time: as per the following table.

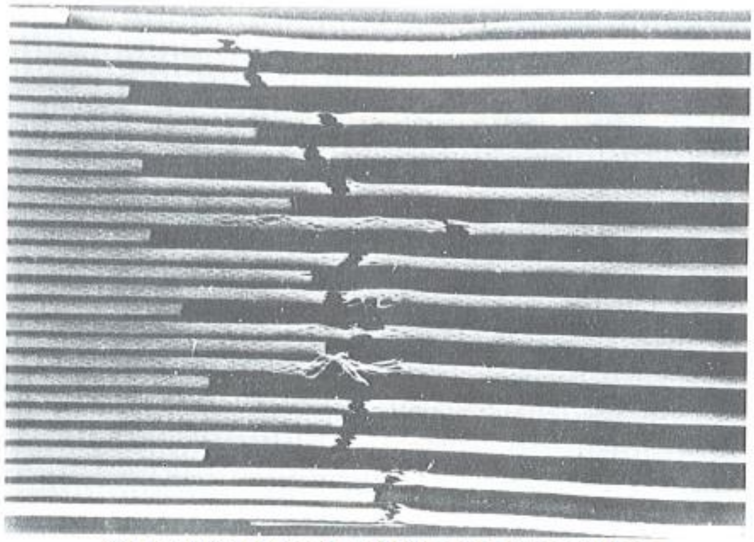
Belt Thickness, mm	Holding Time, minutes
Up to 24	60
26	65
28	70
30	75
32	80
34	85

Hydraulic pressure: around 12 bar.

Post cure cooling: cool down the splice to at least 70°C before releasing the hydraulic pressure.

Splice Strength of Steel Cord Conveyor Belt

As we have seen earlier, the joint efficiency of a textile fabric belt (tensile strength) depends upon the number of plies in the belt. Because, in any splice, one ply of carcass is lost with respect to its tensile strength. As a result, its efficiency is always less than 100%.



X-ray of Steel Cord Belt Pulled to Destruction

However, for a steel cord belt, the tensile strength (joint efficiency) of the splice theoretically equals or exceeds that of the belt because of the pattern of overlapping and dispersal of cord/cable ends. Above figure shows an X-ray picture of a steel cord belt pulled to destruction. It can be seen that the failure has occurred out of the splice area.

Some of the advantages and disadvantages of vulcanized versus mechanically fastened splices are as under.

Advantages and Disadvantages of Vulcanized Splice

Advantages of vulcanized splice are as under.

- It has the highest practical strength.
- Correctly carried out on the appropriate conveyor equipment and properly used, a vulcanized splice can last for years. However, with the exception of steel cord belts, a vulcanized splice normally will not last for the life of the belt.
- Because a vulcanized splice is smooth and continuous, conveyed material cannot seep through it. Also, a vulcanized splice does not damage or interfere with belt cleaners, as can be with mechanically fastened splices.

Disadvantages of vulcanized splice are as under.

- Cost to carry out a vulcanized splice is many times more than that of a mechanically fastened splice.
- To insure sufficient takeup travel for accommodating both elastic and permanent variation in belt length, longer takeup travel must be provided to store belt for making replacement splice when required in future.
- Replacing or renewing a vulcanized splice can be time consuming and costly, especially in emergency repair situations.
- As quality of vulcanized splice is affected by splice operator's errors, only trained and experienced splicer should be used. Quality of vulcanized splice is also affected by quality and age of splicing materials. As splicing materials have limited shelf lives (which can be extended with refrigerated storage), over-age materials should not be used.
- Vulcanizing can be more difficult and less reliable on older, worn belts.

Advantages and Disadvantages of Mechanically Fastened Splice

Advantages of mechanically fastened splice are as under.

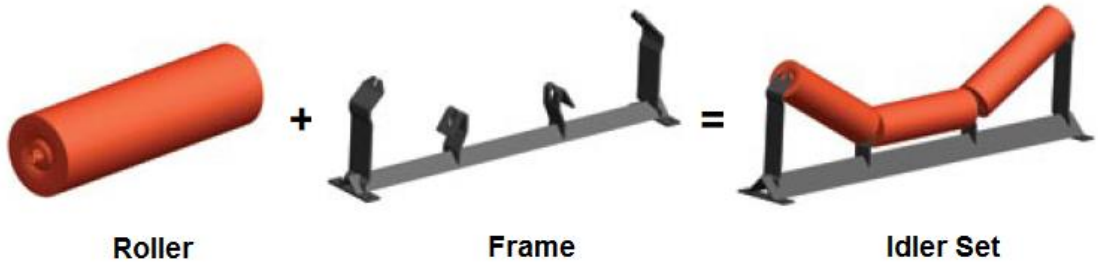
- A mechanically fastened splice can be completed by experienced personnel in a very short time as compared to time required to complete a vulcanized splice.
- The cost of labor and fasteners for a mechanically fastened splice will be a fraction of the cost of a vulcanized splice.
- Usually, only hand tools are required.

Disadvantages of mechanically fastened splice are as under.

- Exposure of cut belt ends to the moisture and conveyed materials / environment may have a harmful effect on the belt carcass fabric.
- Mechanical fasteners cannot be applied to produce as smooth a surface at the splice as that of a vulcanized splice. Belt cleaners sometimes catch on the fasteners with resultant damage to the splice, cleaner, or belt.
- It is very difficult to produce a mechanically fastened splice (without application of a tape if feasible) that can be considered leak-proof in conveying fine materials.
- In hot service, fasteners absorb heat and transmit it directly into the belt carcass. This may cause local carcass degradation and early splice failure.

Idlers

A conveyor belt need supports between head pulley and tail pulley which are located quite apart. As the belt is in motion, these supports have to be in the form of rollers to avoid sliding of the belt on supports. Hence rollers, called idlers are necessary for belt conveyors. Because the belt movement imparts rotary-motion to rollers at matching peripheral speed, it moves on supporting rollers without sliding.



'Idler set' (or idler) generally means complete unit comprising of roller/s along with its mounting frame or mounting linkage (in case of garland idlers).

Information about idler's functions, construction detail, types and design considerations is given in this chapter.

Idler's Functions

Idlers perform following functions.

- To support belt along with material on carrying run with minimum resistance to belt motion.
- To support belt on return run with minimum resistance to belt motion.
- To form the belt trough profile for accommodating material on carrying run.
- The carrying belt changes its shape from flat to trough at tail pulley and trough to flat at head pulley. The transition idlers gradually change the belt profile at these locations with minimum strain to the belt.
- The belt alignment in major length of conveyor is maintained by idlers as a result of aligning action and by friction grip with the idlers, once the belt is laid in position.

The idlers impart self-aligning action to belt by following means.

- The conveyors are often equipped with pivoted self-aligning type idlers in carrying and return run which perform to keep the belt at conveyor center line.
- The fixed frame type idlers are often provided with forward tilt of side rollers, which has self aligning action on belt.

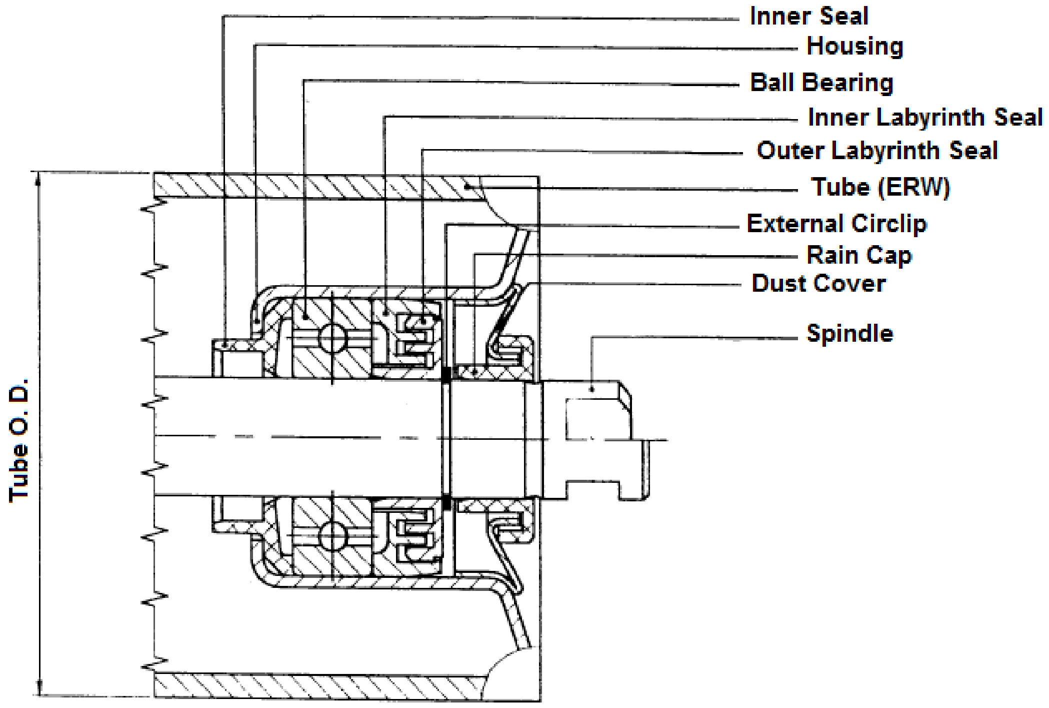
Construction Detail of Rollers/Rolls

Generally, impact idlers, carrying idlers, self-aligning carrying idlers, return idlers and self aligning return idlers are used in a conveyor. They use rollers. Information on rollers and their construction is given in this section.

Rollers are very important components of a conveyor as they are in contact with belt and affect the performance of a conveyor to a large extent.

When these rollers are mounted on a steel frame, they make **fixed frame type idler set**. The rollers with mounting linkage make a **garland type idler set**. The roller generally has dead shaft (i.e. shaft remains standstill during rotation of roller). The shaft is called spindle.

The typical construction of a roller/roll end is shown in the following figure.



Construction of Roll End

Tube

The tube/shell (periphery) is generally made from steel tube of ERW quality. The ERW implies electric resistance welded steel tube. The tube is of normal steel but with good dimensional features such as close tolerances for diameter, thickness, ovality, eccentricity and straightness. In India, designer generally uses tubes as per IS 9295.

Bearings

The rolls are fitted with antifriction bearings for connection between rotating shell and stationary spindle. The antifriction bearings could be of taper roller type or single row deep groove type. Generally, the bearings are single row seize-resistant ball bearings with C3 clearance. The minimum design rated life for the bearings shall be 25000 hours. The present trend is to use deep groove ball bearings which are lubricated for life. However, if a customer wants, re-greasing arrangement is provided.

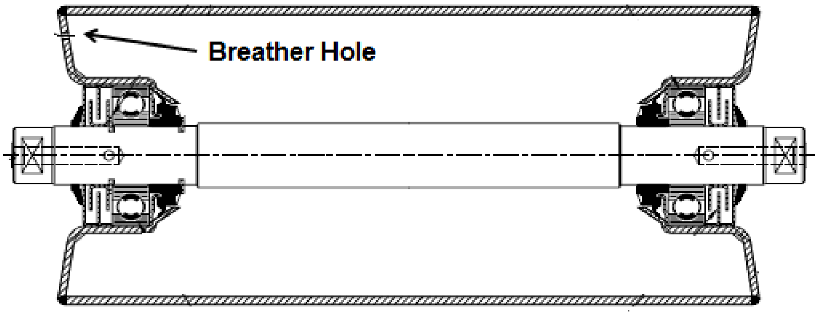
Spindle

Spindles are generally made from bright bars (as per IS 9550), conforming to C 45 or C 35 or EN 8 (C 40 Carbon Steel is having 0 35% - 0.45% C) material.

Sealing

The bearing assembly is sealed on inner side as well as on outer side by proper design of sealing system to retain grease, and to prevent intrusion of dust and water into bearings. The sealing is often in the form of multiple barriers (labyrinth) to achieve the functional requirement. The sealing arrangement and their materials vary with various manufacturers. Nylon, oil-resistant neoprene rubber, zinc aluminum alloy, spring-steel etc. are widely used materials for seals.

Breather Hole



Roller with a Breather Hole

The greatest cause of a roller's bearing failure is lubricant contamination by grit and moisture. Pressure variations within normal rollers cause gritty and moist air to flow through the seal assemblies and into the bearings. This results in contamination, oxidation and emulsification of the bearing lubricant.

To overcome the problem, as shown in above figure, sometimes a breather hole is provided to prevent cyclic pumping of air through the bearing and seal assembly.

Types of Rollers

The three common types of rollers are:

Plain Roller

Plain Roller - This is the most common type of roller used for general applications. The roller can be supplied with a steel, aluminium or plastic shell.

Impact Roller

Impact Roller - This roller is used where there is heavy impact from lumps of material. Rubber impact disks cushion the roller and conveyor from the impact.

Disc Roller

Disc Roller - Disc roller is used on the return side of the conveyor. Rubber or polyurethane discs break up the contact between the belt and the roller and encourage any product that is adhered to the belt to break off and fall away.

Types of Idler Sets

Idler sets supporting the loaded run of the conveyor belt are called **carrying idlers** whereas idler sets supporting the empty return run of the conveyor belt are called **return idlers**. Generally idler means an idler set.

There are two types of idler sets. They are fixed frame and garland type. Information about these idler sets (commonly called idlers) is given in the following sections.

Fixed Frame Type Idlers

The fixed frame type idlers have rolls mounted on steel frame. Such idlers are very widely used for all normal conveyors.

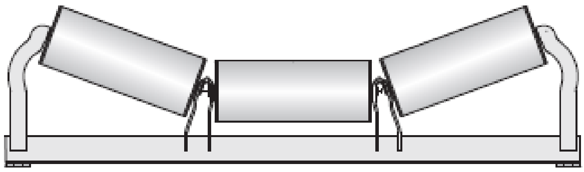
In general, the fixed frame idlers are installed in a plane right angle to belt motion, keeping its base horizontal.

There are various types of fixed frame idlers in accordance with the specific function (load carrying, impact resistance, belt training, etc.) they are required to perform. The idler's type or name is synonymous with their function. Various types of most commonly used fixed frame idlers are as under.

Carrying idlers are of two general configurations. One is used for troughed belts whereas the other configuration is used for supporting flat belts.

Due to the increased cross sectional fill depth, troughed belts can carry far greater tonnages than flat belts of the same width and speed.

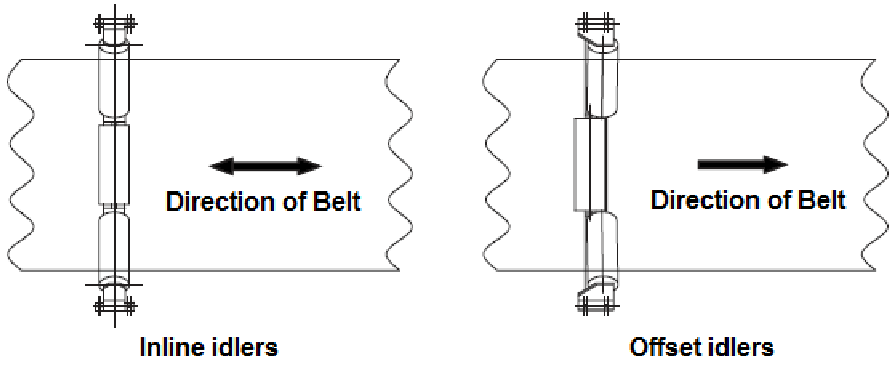
Trough Carrying Idler



Trough Carrying Idler

These are used for supporting the belt run on carrying side. The idler set comprises of 2, 3 or 5 rolls and the supporting frame. They usually consist of three rolls as shown in above figure. The center roller is horizontal and the two outer rollers are inclined upward.

As shown in the following figure, the three rolls troughing idlers are made as either inline or offset center roll design.



Inline Vs Offset Idlers

Inline idlers are generally used on long conveyors and where thick belts are used.

Offset idlers have slightly overlapping rollers for light duty belts that are susceptible to pinching. They are commonly known as a grain idler as they are used in grain industry where thin belts are used. They also have a self-training property and hence they must be installed in the correct orientation (unidirectional belt, as shown in above figure).

Trough carrying idlers are made with different troughing angles. However, 35 degree troughing idlers are the most widely used type. For different loading capacity, they are fitted with different size of bearings.

In view of above, the full name for reasonably describing this type of idler should include information on roller size, number of rollers, troughing angle and bearing size, for example, “1200 mm belt trough carrying idler set with 139.7mm 0D x 4.5 mm Thick, 3 equal inline roll, 35° troughing and bearing 6205”.

Two roll trough carrying idlers, commonly called V-trough carrying idlers are generally used for lesser belt widths and for conveying materials of limited lump sizes. Such idlers are less costly.

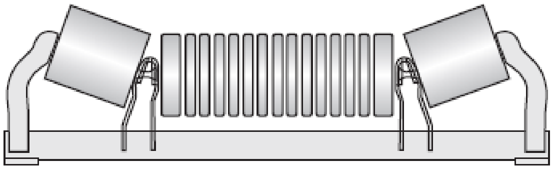
Flat Carrying Idler

Flat Carrying Idler

As shown in above figure, this type of idler generally consists of a single horizontal roll positioned between brackets which attach directly to the conveyor frame.

These idlers are used for supporting flat belt carrying run. Material is sometimes carried on flat belt when capacity is low or material is to be discharged at intermediate points by simple means such as plows or the process demands such conveyance.

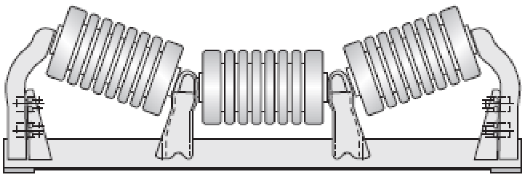
Picking and Feeder Idler



Picking and Feeder Idler

Above figure shows picking and feeder idler. These idlers use a long (extended) center roll and short side rolls inclined at 20 degrees to allow maximum product dispersal for inspection and sorting or where a shallow bed of material is required to minimize degradation. Standard design features rubber cushion center roll and steel end rolls. However, they are also available with all steel or all rubber cushion rolls.

Trough Impact Idler



Trough Impact Idler

The impact idlers, sometimes referred to as “cushion idlers” are used to support carrying belt under loading/feeding-zone. The impact idlers are inevitable for handling lumpy and heavy materials to absorb impact of falling material and to protect belt from undue damage and wear. They should be located under the loading point of the belt such that major impact force strikes the belt between the supporting idlers rather than over any one of them. In impact idlers, individual narrow rubber discs are force-fitted on tubular roll and held in position by end-rings. Each disc is made of a resilient material such as a soft (40 to 50 Deg. Shore-A) natural rubber, grooved and relieved to allow the rubber to move under impact. The resilient discs help absorb energy from impact loads, which could save the belt from impact damage. The discs are sacrificed in favor of reducing the risk of belt damage.

The impact idlers generally imply 3 roll trough impact idler set. The impact idler’s troughing angle, roll length and roll quantity is normally same as for other troughing idlers in a conveyor.

Impact idlers are available for V-trough carrying idlers and flat carrying idler also.

Self Aligning Carrying Idler (S. A. Carrying Idler)

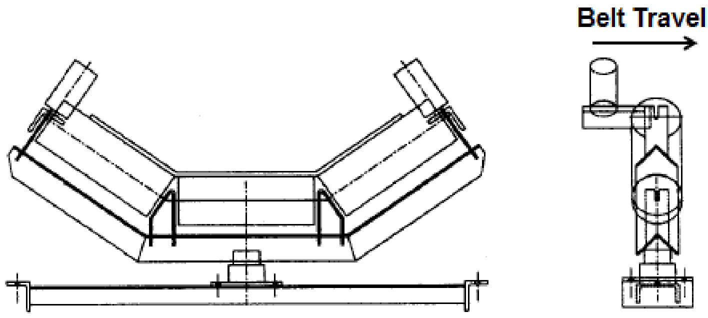
Normal carrying idlers are the primary devices that control the belt alignment. No self aligning (S. A.) carrying idlers are needed for well designed, precisely assembled and maintained belt conveyors. There are transient conditions, however, that may cause conveyor belts to become misaligned. For this reason, conveyor manufacturers also furnish S. A. carrying idlers to help control belt alignment in difficult situations.

The S. A. carrying idlers are provided under carrying belt run at an interval of 15 to 21 m spacing in place of standard carrying idler. Normal practice is to have such idler every 12th to

16th pitch of standard carrying idlers. The idler applies aligning force on carrying belt run whenever it deviates from conveyor centre line.

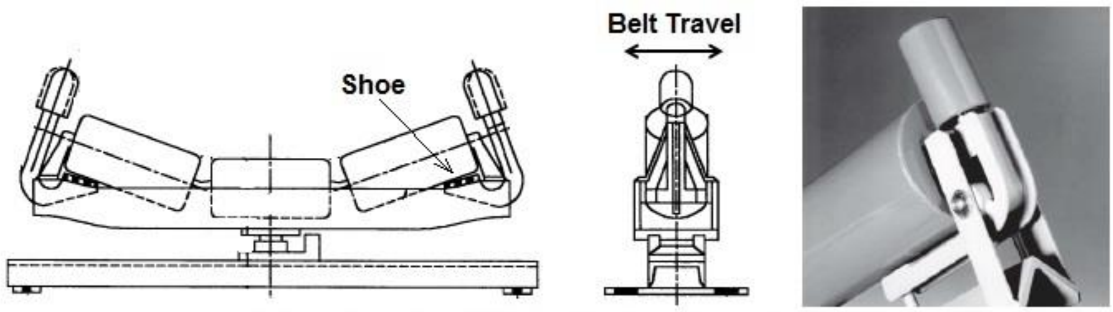
These idlers would have 3-roll, 2-roll or single roll exactly matching to normal carrying idlers. The idler set is having above roll/s mounted on swiveling frame, which is centrally pivoted on stationary frame. Usually a vertical guide roller is provided at each end of the swiveling frame, which tries to push the misaligned belt towards conveyor centre line. The swiveling movement is restricted within permissible limits (about 10°) by stoppers.

There are two types of S. A. carrying idlers with vertical guide rollers. Positive action type is used for belts operating in uni-direction (one direction) and actuating shoe (brake) type is used for bi-direction (two direction) operations (reversing type conveyors).



Positive Action Type 3-Roller S. A. Carrying Idler

Above figure shows positive action type 3-Roller S. A. carrying idler. In this type of idler, swinging about the center pivot is accomplished with the pressure of the off-center belt against the vertical guide roller fitted on fixed arm attached to the idler frame.



Actuating Shoe Type 3-Roller S. A. Carrying Idler

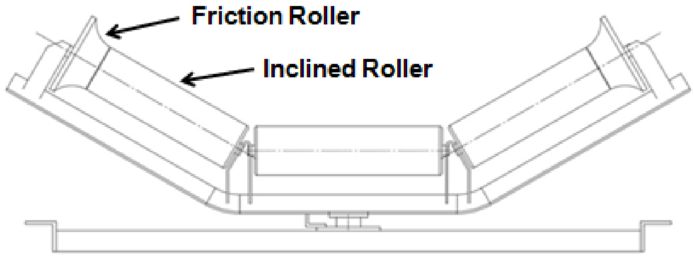
Above figure shows actuating shoe (brake) type 3-Roller S. A. carrying idler. In this type of idler, swinging about the center pivot is accomplished with the pressure of the off-center belt against the vertical guide roller fitted on L-shape hinged lever. The L-shape hinged lever in turn activates the shoe. The activated shoe retards speed of the side idler roller resulting in the idler swinging about its center pivot.

Effectiveness of self aligning idlers depends on the belt tension. In general, the greater the belt tensions, the less effective the self aligning idlers.

Upper Friction Self Aligning Idler

In an upper friction self aligning idler, a friction roller with a curvature (curved conical frustum) is provided at each end of the two inclined rollers as shown in the following figure.

Due to its symmetrical construction, this type of idlers can be used for bi-direction (two direction) operations (reversing type conveyors).

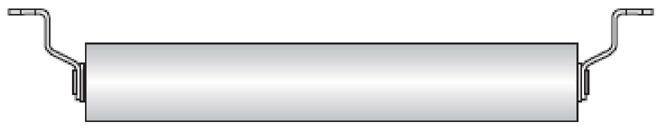


Upper Friction Self Aligning Idler

It may be noted that in this type of idlers, rotation of friction roller and inclined roller are independent of each other. Like in self aligning carrying idlers, in these idlers also the rollers are mounted on the swiveling frame, which is centrally pivoted on a stationary frame.

This type of idler is commonly found in Chinese designed conveyors.

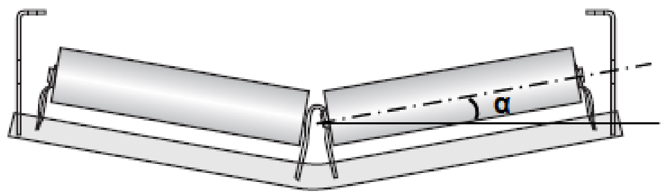
Flat Return Idler (Single roll return idler)



Flat Return Idler

Flat return idler usually has single roll to support the return run of the belt conveyor. The idler consists of single roll and 2 brackets to install the roll below conveyor stringers.

V-Type Return Idler (Two-Roll V-type Return Idler)



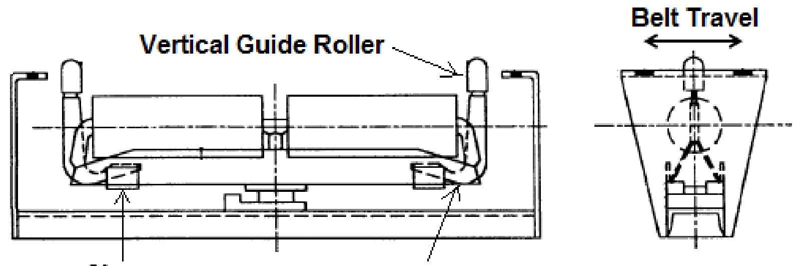
V-Type Return Idler

Instead of single roll return idlers, as shown in above figure, many times two-roll V-type return idlers are used for better training and higher load ratings (use of heavy, high-tension fabric and steel cord belts). The troughing angle (α) is generally 10°, but 15° is also used. The trough shape gives self-aligning action to the belt.

A decrease in wear life of the roll shell may occur with V-type return idlers. This happens because most of the belt weight is contacting the roll about one-fourth of the roll length from the centerline of the idler.

Self Aligning Return Idler (S. A. Return Idler)

These idlers are provided under return belt run at an interval of 21 to 30 m, in place of usual return idler. General practice is to use such idler at every 7th to 10th pitch of standard idler. The idler applies aligning force on return belt run whenever it deviates from conveyor centre line.



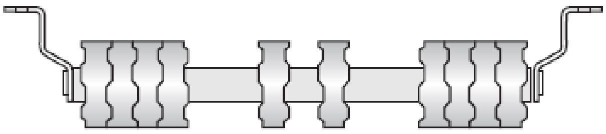
Actuating Shoe Type S. A. Return Idler

Like S. A. carrying idlers, there are two types of S. A. return idlers with vertical guide rollers. Positive action type is used for belts operating in one direction and actuating shoe (brake) type is used for two direction operations (reversing type conveyors). Above figure shows actuating shoe (brake) type S.A. return idler. Upper friction type self aligning idlers are also used on return side (usually in Chinese design). S. A. return idlers on return belt are usually more effective than the S. A. carrying idlers on carrying run due to lower belt tension on the return run.

Self-Cleaning Return Idlers

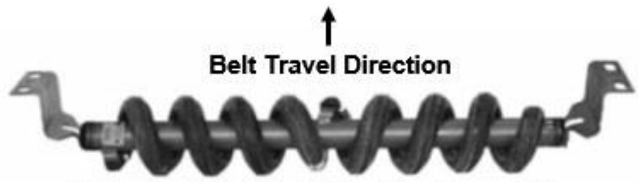
An important factor to be considered with return idler applications is the adherence of material to the carrying surface of the belt. Such material may be abrasive and wear the shell of the return idler rolls. If the material is sticky, it will adhere to the return idler rolls also. A large buildup of this material may cause misalignment of the return run of the belt.

Several types of return idler rolls are available to overcome these problems. When sticky material is a problem, rubber or urethane disc, or rubber coated helically shaped, self-cleaning return idlers can be used. Disc and helical rolls reduce the tendency for material build up. The following figure shows construction of a typical return idler with rubber discs.



Return Idler with Rubber Discs

The rubber disc type return idlers are having many discs at each end of the roll to provide better belt support.



Helical or Spiral Self Cleaning Return Idler

Above figure shows construction of a typical helical or spiral self-cleaning return idler. In case of this type of idlers, the correct direction of rotation is important and is clearly marked on each idler. As shown in above figure, the "V" formed by right-hand and left-hand spirals should point in the direction of belt rotation/travel.

On short conveyors, the complete return run may require self-cleaning idlers. However, on long return belt runs, it is necessary to use these idlers only up to the point where the material on the belt surface no longer will adhere to and build up on normal return idler rolls. Beyond this point, standard return idlers can be used.

Sometimes the conveyor handling normal material has first two/three return idlers of rubber discs' type. This results into localized separation of adhering material particles instead of their separation along a longer length of conveyor which is difficult to clean.

Beater Bar Return Roll

Beater bar return roll, shown in above figure is another design to defeat sticky material buildup on the return side of the belt. The rods create beating motion to keep belt clean and free of any carryback material. The bars allow gaps for material to escape. It is recommended to install the beater bar in the first return roll location from the head pulley.

This design is also applicable with cleated belts where belt cleaners are not effective.

Garland Idlers

Conveyor with Garland Idlers for Transporting Coal from Opencast Coal Mine

This type of idler has 2 or 3 or 5 rolls which are linked in series and suspended at ends from the conveyor stringers (or wire rope supported conveyor systems). The idler so suspended looks like garland/catenary and therefore the idler is known as garland or catenary or suspended idler. Usually they consist of a three (3) roll configuration for carrying, two (2) roll configuration for returns and five (5) roll for impact idlers.

The flexibility of the garland idler, in both longitudinal and transverse directions, gives this type of idler the ability to adapt to load conditions.

The garland idlers are used instead of fixed frame idlers for certain application based on following characteristics.

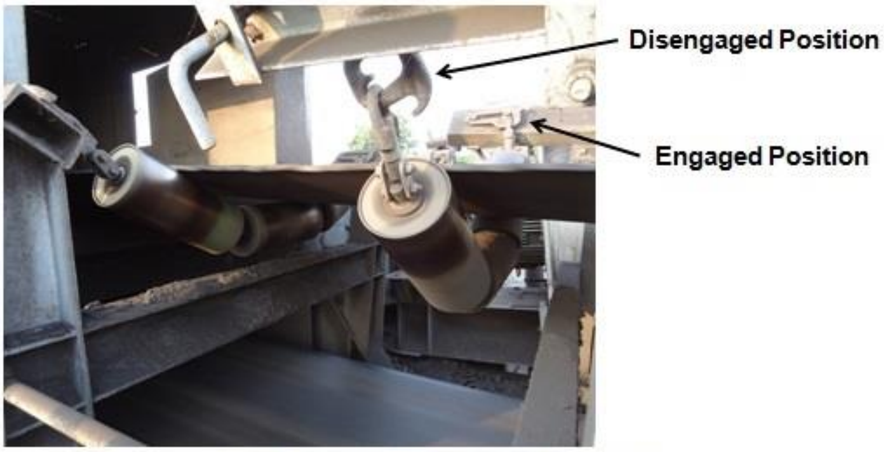
- These idlers are highly tolerant to distortion and misalignment of conveyor frame.
- These idlers are lighter compared to fixed frame idlers due to absence of steel frame.
- If any idler is observed defective during conveyer operation, same can be deactivated instantly without disturbing or stopping the running conveyor.
- 5-roll garland idlers at feeding zone provide much better protection to belt against material impact.
- The garland idler hangs under gravity, hence its plane of installation is always vertical. This implies that the belt motion and thereby the conveying direction has to be nearly horizontal to suit vertical plane of idlers. Thus garland idlers are primarily suitable for horizontal conveying.

Garland Idler (Suspended Idler Set)

Suspension Devices

As shown in above figure, garland idlers usually consist of rolls connected together by links and are suspended by means of various devices such as hooks, suspension plate or chains.

Quick release suspensions allow the idler to be lowered away from belt contact in the case of roll failure.



Quick Release Suspension Positions

Above figure shows a three roll garland idler with quick release suspensions. To show how a quick release suspension allows the idler to be lowered away from belt contact, one suspension is shown in the engaged position while the other suspension is shown in the disengaged position. Because the disengagement results in making the idler length longer, it gets lowered away from belt contact.

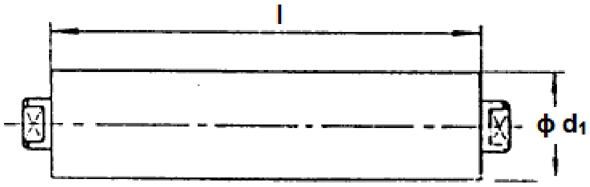
It is recommended that the maximum troughing angle for 2 rolls garlands should not exceed 30°, for 3 rolls garlands 45° and for 5 rolls garlands 60°.

IS 8598 - 1987 (Reaffirmed 1998)

IS 8598 covers the requirements for carrying and return idlers and idler sets up to and including three idlers for belt conveyors.

Requirement of various dimensions - idler diameters, idler lengths, mounting dimensions for idler sets, edge clearance and spindle end detail are specified in the specification.

Idler Dimensions



Idler Dimensions

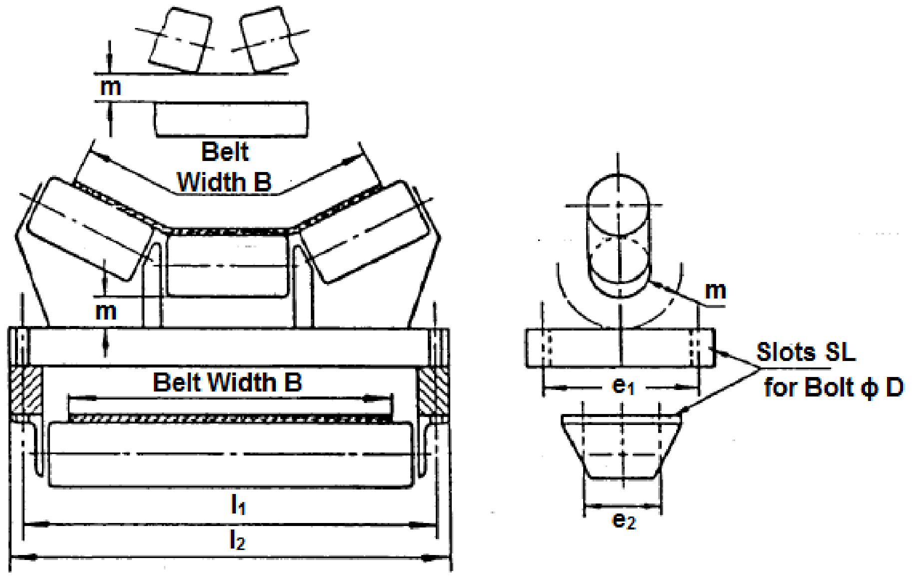
The idler diameters, d_1 in millimeters, of carrying and return idlers shall be selected from the following:

Carrying and Return Idlers													Carrying Idlers Only
63.5	76.1	88.9	101.6	108	114.3	127	133	139.7	152.4	159	168.3	193.7	219.1

The standard idler lengths (l) of carrying and return idlers in millimeters are: 100, 150, 160, 190, 200, 235, 250, 290, 315, 350, 380, 400, 415, 465, 500, 530, 550, 600, 625, 670, 700, 710, 750, 800, 850, 900, 950, 1000, 1050, 1100, 1120, 1150, 1200, 1250, 1400, 1500, 1600, 1700, 1800, 2000 and 2200.

Idlers length and diameter combinations are given in Table 1 of the standard. There are four types of spindle ends (A, B, C and D). For their detail, please see the standard.

Mounting Dimensions for Idler Sets

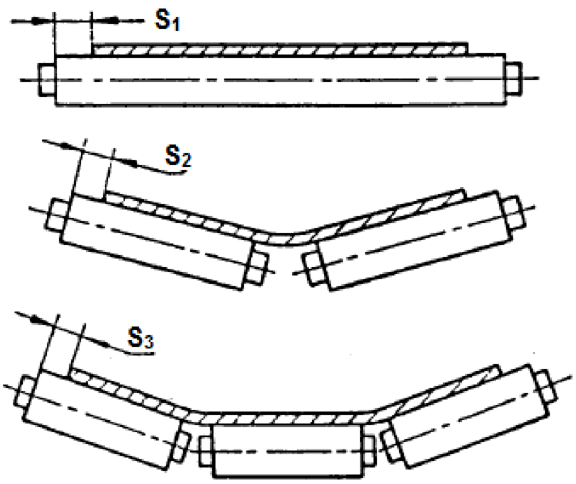


Mounting Dimensions for Idler Sets

Mounting dimensions for idler sets depends on belt width. Standard mounting dimensions are shown in above figure (for numerical value of dimensions, please see the standard).

Edge Clearance

Edge clearance shall be as given in the following table (all dimensions are in mm).

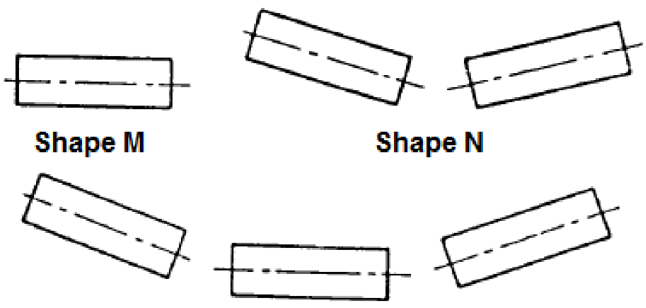


Edge Clearance

Belt Width B	Edge Clearance		
	S_1	S_2	S_3
400	50	40	35
500	50	40	40
650	50	55	50
800	75	65	70
1000	75	75	70
1200	100	100	100
1400	100	100	100
1600	100	100	100
1800	100	100	100
2000	100	100	100

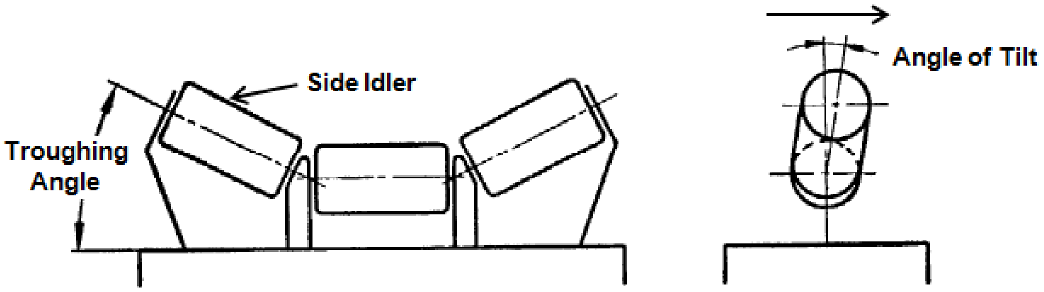
Shape of Idler Set

As per the specification, idler sets in terms of shape shall be designated as M, N and P as shown in the figure given below.



Shape of Idler Set

Other important requirements of IS 8598 are as given below.



Troughing Angle and Angle of Tilt for Side Idlers

Troughing angle is angle of the axis of side idlers from the horizontal.

The troughing angle shall be 15°, 20°, 25°, 30°, 35°, 40° or 50° for all standard widths of belts.

The troughing angle of 15° is applicable for 2-roll belt conveyors (idler sets of N shape) only.

The value of troughing angle of rollers of return idlers shall be selected out of 0°, 10° and 15° for all standard widths of belts.

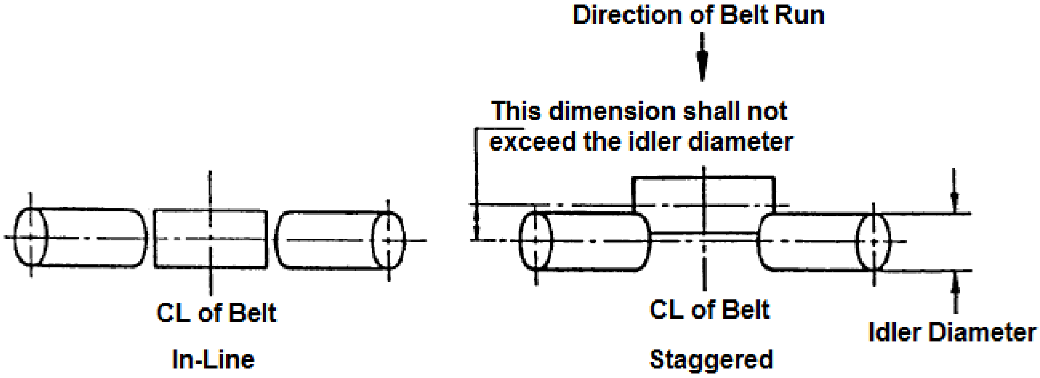
As shown in above figure, idler sets are often made with forward tilt of side idlers/rollers. The forward tilt of side idlers helps in belt tracking/alignment but accelerates wearing action due to extra friction between the belt and side idlers.

Angle of tilt of side idlers shall be chosen as a function of the troughing angle and the belt speed, and shall be as small as practicable and in any case shall not be more than 3°.

Note 1: The angle of tilt of side idlers shall be in the direction of the belt run for the uni-directional conveyors and it shall be zero degree for bi-directional (reversible) conveyors.

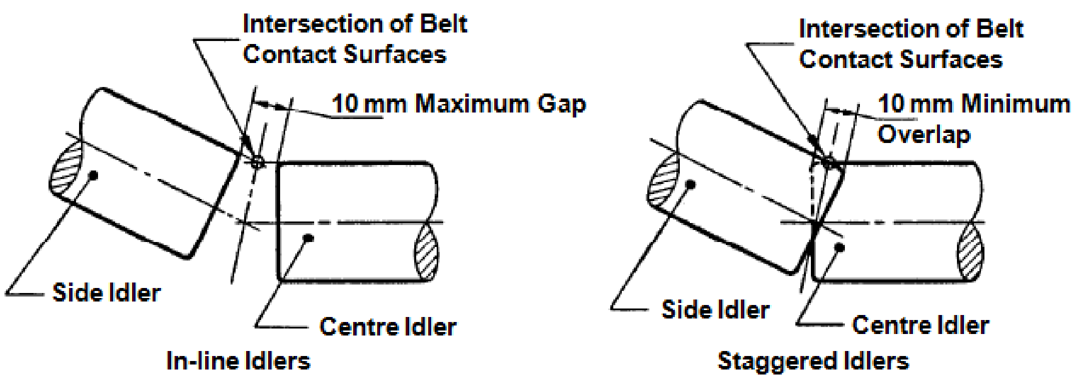
Note 2: It is not required to provide angle of tilt unless specifically desired by the purchaser.

Troughed carrying idler sets built up from three idlers may be arranged with the idlers in-line or staggered as shown in the following figure.



Plan Views of In-Line and Staggered Carrying Idler Sets

When staggered, the displacement of the axis of the centre idler from the adjacent axis of the side idlers shall not exceed the diameter of the idlers.



Arrangement of Idler Sets Viewed in Vertical Plane

As shown in above figure, in case of in-line idler sets, the gap between the adjacent ends of the centre and side idlers/rollers shall not be greater than 10 mm.

However, for staggered (offset) idlers the overlap shall be minimum 10 mm as shown in above figure. Since staggered idlers are having self training property, they must be installed in the correct orientation (as per the arrow showing direction of belt run).

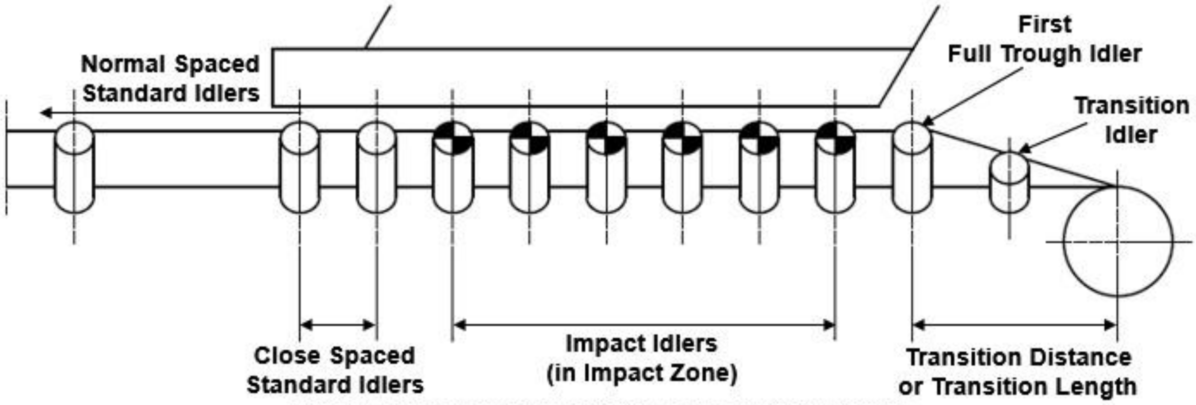
The idler outside diameter, measured by a dial test indicator at any point along its length when rotated on its own beatings, shall not exceed the total indicator reading (TIR) of 1.6 mm for idler lengths below 1350 mm and 2 mm for idler lengths of 1350 mm and above.

High roll run out can contribute to the tendency for the belt to flap between idlers.

Unless the purchaser specifies a longer minimum rated life, the minimum design rated life for the idler bearings shall be 25000 hours for bearings lubricated for life as well as intermittently lubricated bearings.

Steel tubes used in the manufacture of idlers and idler sets shall conform to IS 9295.

Transition Idlers



Typical Idlers Arrangement for Loading at Tail Pulley

The distance between a terminal pulley and the adjacent first fully troughed idler set at either the head or tail end of a conveyor is known as the transition distance or transition length. In this transition length, the belt changes its profile from a flat to a fully troughed or vice versa respectively. This changing of the belt's profile is commonly called transition. Transition can occur in other areas of the conveyor also, such as a tripper head. During transition, tension at the edges/sides of the belt is greater than at the center. If the transition distance is too short, it will result in excess tensions in the conveyor belt edges which can cause the following problems:

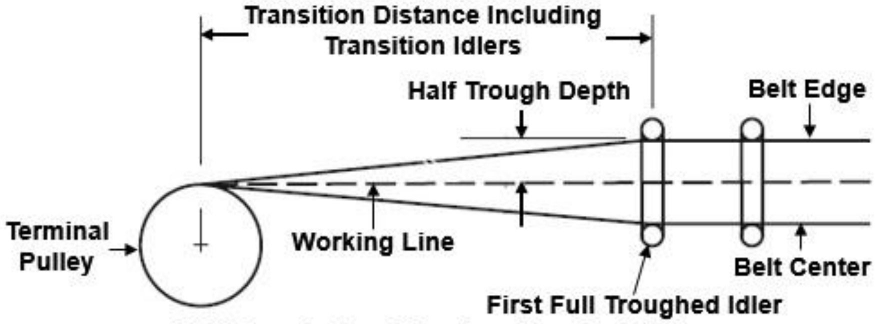
- Splice failure - at belt edges.
- Premature roller failure due to high loads on the inclined/wing rollers.
- Excessive and accelerated pulley lagging wear.
- If the belt edge stress exceeds the elastic limit of the carcass, the belt edge will be stretched permanently and will cause difficulty in belt training.
- An excessive difference between edge and center tensions can overcome the belt's lateral stiffness. This can force the belt down into the trough, so it buckles through the center, or catches in the idler junctions where the rollers of the idler join.

These tensions can be kept within safe limits by maintaining the proper transition distance, thus, minimizing the stretch (and stress) induced in the belt. Proper transition distance is especially very important when deeply troughed idlers are used.

Depending on the transition distance, one or more transition idlers should be used to support the belt between the terminal pulley and the first fully troughed idler.

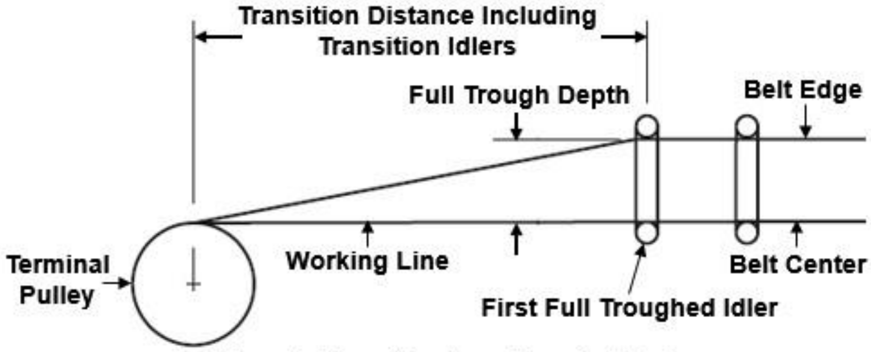
It is recommended to install several transition idlers supporting the belt to work up gradually from a flat profile to a fully troughed profile. Transition idlers are similar to 3-roll / 2-roll trough carrying idlers but with troughing angle less than standard trough carrying idlers. A good practice is to place a 20° troughing idler as a transition idler forward of a 35° troughing idler, and both a 20° and a 35° idler in front of a 45° troughing idler.

The two transition arrangements are half trough transition from terminal pulley and full trough transition from terminal pulley.



Half Trough Transition from Terminal Pulley

Above figure shows half trough transition arrangement from a terminal pulley. In this arrangement the terminal pulley is elevated, so that its top is in line with the mid-point of the wing idler. This arrangement will shorten the transition distance required as compared with full trough transition arrangement from a terminal pulley, but allow the belt to rise off the idlers. If unloaded belt gets lifted up at loading pulley (generally tail pulley) into the skirts, belt can get damaged (cut).



Full Trough Transition from Terminal Pulley

Above figure shows full trough transition arrangement from a terminal pulley. In this arrangement the terminal pulley top is in line with the top of the center roller of the troughed idler set. The transition distance required will be longer in this arrangement as compared with half trough transition arrangement from a terminal pulley, but the belt is more likely to remain down on the idlers. In view of this, it is recommended to use the full trough transition arrangement.

The distance required for transition varies with the amount of troughing required, the belt thickness, the construction of the belt and the rated tension of the belt.

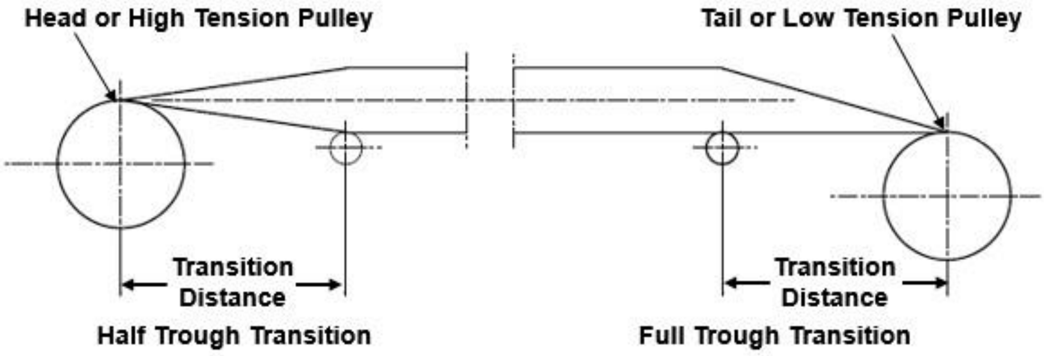
It is recommended that transition distances are obtained directly from the belt manufacture or from an appropriate standard such as ISO 5293 Conveyor belts - Determination of minimum transition distance on three idler rollers or publication such as Belt Conveyors for Bulk Materials by CEMA, USA.

Alternatively, the following tables can be used as a guide.

Transition Distance = Transition Factor × Belt Width (BW)

Half Trough Transition - Recommended Minimum Transition Factor			
Idler Trough Angle	**% Rated Belt Tension**	**Transition Factor**	
		Fabric Belts	**Steel Cord Belts**
30°	> 90%	1.4	3.2
	60% to 90%	1.1	2.4
	< 60%	0.8	1.6
35°	> 90%	1.6	3.4
	60% to 90%	1.3	2.6
	< 60%	1.0	1.8
45°	> 90%	2.0	4.0
	60% to 90%	1.6	3.2
	< 60%	1.3	2.3

Full Trough Transition - Recommended Minimum Transition Factor			
Idler Trough Angle	**% Rated Belt Tension**	**Transition Factor**	
		Fabric Belts	**Steel Cord Belts**
30°	> 90%	3.0	6.6
	60% to 90%	2.2	5.0
	< 60%	1.6	3.4
35°	> 90%	3.2	6.8
	60% to 90%	2.4	5.2
	< 60%	1.8	3.6
45°	> 90%	4.0	8.0
	60% to 90%	3.2	6.4
	< 60%	2.4	4.4



Common Transition Practice

As shown in above figure, it is a common transition practice to locate the head or discharge pulleys at half of the trough depth (half trough transition) to minimize the stresses induced in the belt and on the wing rollers. In the case of tail pulleys, the full trough depth (full trough transition) is often used to avoid an unloaded belt from being lifted up into the skirts which can result in mechanical damage.

Roller Selection

Table given below provides the general recommendations for selection of roller outer diameter and thickness. Thicker rollers are to be used for handling very abrasive material. Thicker rollers are also recommended if the bulk density of the material is more than 1400 kg/m^3, particularly for belts widths of more than 1200 mm.

Sr. No.	Belt Speed, m/s	Belt Width, mm	Shall O. D. x Thickness, mm (Nominal)
1	Up to 1.60	Up to 500	76.1 x 3.65, 76.1 x 4.50
2	Up to 1.85	Up to 1000	88.9 x 4.05, 88.9 x 4.85
3	Up to 2.35	Up to 1600	108/114.3 x 4.50, 108/114.3 x 4.85
4	Up to 3.00	Up to 1600	133/139.7 x 4.50, 133/139.7 x 4.85
5	Up to 3.60	Up to 1600	152.4/159 x 4.50, 152.4/159 x 4.85
		Up to 2000	152.4/159 x 4.85, 152.4/159 x 5.40
		Up to 2400	152.4/159 x 5.40, 152.4/159 x 6.30
6	Up to 4.20	Up to 1600	159/165.1 x 4.50, 159/165.1 x 4.85
		Up to 1800	159/165.1 x 4.85, 159/165.1 x 5.40
		Up to 2400	159/165.1 x 5.40, 159/165.1 x 6.30
7	Up to 4.75	Up to 1800	165.1/168.3 x 4.85, 165.1/168.3 x 5.40
		Up to 2400	165.1/168.3 x 5.40, 165.1/168.3 x 6.30
8	Up to 5.60	Up to 1800	193.7 x 4.85, 193.7 x 5.40
		Up to 2400	193.7 x 5.40, 193.7 x 6.30

To increase shell wear life, it is recommended to use thicker metal shells. Generally thicker shell is required for the return idlers because they contact the dirty side of the belt resulting in abrasive wear of the shell.

Idler life depends on many factors such as seals, bearings, shell thickness, belt speed, lump size/material density, maintenance, environment, temperature, and load on the idler. Though bearing life is generally used as an indicator of idler life, it must be remembered that the effect of other variables (e.g., seals selection and quality) may be more important in determining idler life than the bearings.

Bearing life is based on the number of revolutions of the bearing. Hence for a given belt speed, using larger diameter rolls will increase idler bearing life. In addition, the wear life of the shell will also increase. ContiTech, Germany recommends that idler rpm (revolutions per minute) should not be exceeded 600-700.

Shell material for Idlers is usually ERW steel tubing. For most belt conveyor applications, this material provides sufficient idler life most economically. However, for severe abrasive or corrosive conditions, covered idler rolls are available in a variety of materials. Some of the generically available lining materials are: rubber lagging, neoprene lagging, polyethylene sleeves, carboxylated nitrile, urethane and ceramic.

If shell life of steel roll idlers is less due to abrasion, material buildup, or corrosion; rolls made from high molecular weight polyethylene may be used.

As idler life depends on load on them, load on the idler should be calculated to select the proper class (series) of idlers.

For more information on idler load, load calculation, etc. please see Belt Conveyors for Bulk Materials published by CEMA, USA.

Idler Misalignment Load (IML)

As shown in above figure, when an idler is higher than the adjacent idlers, a component of belt tension, called idler misalignment load (IML) gets added to the normal load on that idler. This additional load will result in premature failure of that idler. In view of this, care should be taken during installation of idlers.

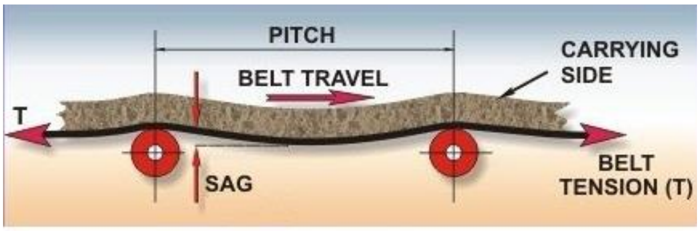
Idler Selection as per IS 11592: 2000

In IS 11592: 2000, three methods are given for idler selection as Annex B, Annex C and Annex D.

As per Annex C, idlers are classified in four series based on type of bearing, idler shaft diameter and roll diameter as shown in the following table. Using the table, type of idler can be selected based on belt width and application.

Series	Bearing Type	Shaft Dia. at Bearing (mm)	Roll Dia. (mm)	Belt Width (mm)	Application Range
Light	Deep groove ball bearing	20	63.5, 76.1, 88.9, 101.6	300-800	For intermittent operation, relatively low capacities and for lightweight materials of limited lump size.
Medium	Deep groove ball bearing	20	88.9, 101.6, 108, 114.3, 120, 127, 133, 139.7	400-1200	For intermittent operation, medium capacities and for moderate weight, semi-abrasive materials containing lumps larger and heavier than those handled by light duty series idlers, or for continuous operation when handling light weight, fine materials.
Heavy duty	Roller / taper roller / ball	25	101.6, 108, 114.3, 120, 127, 133, 139.7, 152.4	500-1600	For continuous operation, high capacities and for heavier weight, abrasive materials where the size of lump is limited by belt width.
Extra heavy duty	Roller / taper roller / ball	25 - 30	139.7, 152.4, 219.1	800-2000	For continuous operation, highest capacities and for the heaviest and coarsest materials.

Pitch of Idler Sets



Belt Sag

The pitch of idler sets along the length of the conveyor depends upon number of factors.

Belt sag is the vertical deflection of a belt from a straight line between idlers. Increased idler spacing increases the belt sag and hence the power loss due to friction is greater. But very low belt sag means higher belt tensions and therefore, cost of the belt is high. If the belt is allowed to sag at loading zone, fines and small pieces of material will work their way out, dropping onto the floor as spillage or becoming airborne as a cloud of dust.

The practical upper limit of belt sag is 2 percent of the idler spacing after which the force required to pull the load increases steeply. As per IS 11592: 2000 (Reaffirmed 2010), for all practical cases, the belt sag shall be limited to 0.5 to 2.0 percent of the idler spacing.

As per the standard (IS 11592) in normal circumstances, conveyors arranged with the pitch as indicated in the following table may be found to be suitable.

Belt Width, mm	**Troughed Belt Carrying Idler Sets Pitch, mm for Material Bulk Density, t/m^3**		**Flat Belt Carrying Idler Set Pitch, mm**	**Trough and Flat Return Idler Sets Pitch, mm**
	0.40 to 1.20	**1.20 to 2.80**		
300, 400, 500, 650	1500	1200	1000	3000
800, 1000	1200	1000	1000	3000
1200, 1400, 1600, 1800, 2000	1000	1000	750	3000

As per the standard, a set of self aligning idler shall be provided at drive end (approaching pulley) and return end of conveyor and at an interval of 15 m on the carrying run wherever feasible and 30 m at the return run. In case of short conveyors, at least one set of self aligning idlers shall be provided at the carrying and return run. In case of steel cord belting, the distance of self aligning idlers on carrying run may be reduced to 10 m.

On long centre, heavily loaded, high tension conveyor systems, it is possible to use graduated idler spacing. The sag will vary inversely with the tension in the belt. Since the tension varies along the length of the belt the spacing can be graduated, being smallest at the zone of low tension and increasing as the belt tension increases. Savings can thus be made on both the carrying and return run.

If impact idlers are used at loading zones, their ratings are no higher than standard idler ratings, however they are spaced closely to reduce the belt sag. Fenner Dunlop Conveyor Belting Australia recommends impact idlers spacing to be approximately 1/4 to 1/2 of the carrying idler spacing.

Sandvik Mining and Construction suggests the following idler spacing.

Suggested Idler Spacing (m), Trough Idler							
Belt Width (mm)	**Material Bulk Density (Kg/m^3)**						**Return Idler**
	500	**800**	**1200**	**1600**	**2400**	**3200**	
350	1.7	1.5	1.5	1.5	1.4	1.4	3.0
400	1.7	1.5	1.5	1.5	1.4	1.4	3.0
450	1.7	1.5	1.5	1.5	1.4	1.4	3.0
500	1.7	1.5	1.4	1.4	1.2	1.2	3.0
600	1.5	1.4	1.4	1.4	1.2	1.2	3.0
650	1.5	1.4	1.4	1.4	1.2	1.2	3.0
750	1.5	1.4	1.4	1.2	1.2	1.2	3.0
800	1.5	1.4	1.4	1.2	1.2	1.2	3.0
900	1.5	1.4	1.2	1.2	1.0	1.0	3.0
1,000	1.4	1.4	1.2	1.0	1.0	1.0	3.0
1,050	1.4	1.4	1.2	1.0	1.0	1.0	3.0
1,200	1.4	1.2	1.2	1.0	1.0	0.9	3.0

1,350	1.4	1.2	1.2	1.0	0.9	0.9	3.0
1,400	1.4	1.2	1.0	1.0	0.9	0.9	3.0
1,500	1.2	1.2	1.0	0.9	0.9	0.9	3.0
1,600	1.2	1.2	1.0	0.9	0.9	0.8	3.0
1,800	1.2	1.0	1.0	0.9	0.9	0.8	3.0
2,000	1.2	1.0	1.0	0.9	0.9	0.8	3.0
2,200	1.0	1.0	1.0	0.8	0.8	0.6	3.0
2,400	1.0	1.0	0.9	0.8	0.8	0.6	3.0
2,500	1.0	1.0	0.9	0.6	0.6	0.6	3.0

Belt Scale Idlers

A belt conveyor scale is a device that measures the rate at which bulk material is conveyed and delivered on a moving conveyor belt. Further, it can compute the total mass of material conveyed over a given period.

The weight on the conveyor belt is measured by sensing the force on one or more conveyor idlers. The motion of the material is measured by sensing travel of the belt with a device that produces an output representing a fixed distance of belt travel. Because the measured force represents weight per unit length (for example, kg/m), it can be multiplied by the belt travel to acquire total weight (for example, kg/m x m = kg). This function can be accomplished with an electromechanical or electronic integrator.

In addition to displaying total weight passed over the belt conveyor scale, most modern integrators also display instantaneous rate (that is, kg/hour) and provide transmitted outputs for remote monitoring and control requirements.

The frequency of calibration varies depending on the application and site conditions. In general, it is recommended to calibration it twice in a year. The accuracy of the belt scale can be checked by live load test. In a live load test, belt is run with the material (that is, material is run over the belt scale) and accurately collected. The quantity of collected material should be greater than 10% of the maximum feed rate in one hour or one complete revolution of the belt.

Conveyors that include belt scales require idlers with weigh/scale quality (balanced and machined) in the weigh idler zone in order to attain proper weighing accuracy. Weigh idler zone is the section of the conveyor fitted with weigh quality idlers. The weigh idler zone includes the idlers mounted on the belt weigher (weighed idlers) and the weigh idlers preceding (lead-in weigh idlers) and following (lead-out idler) the weighed idlers.

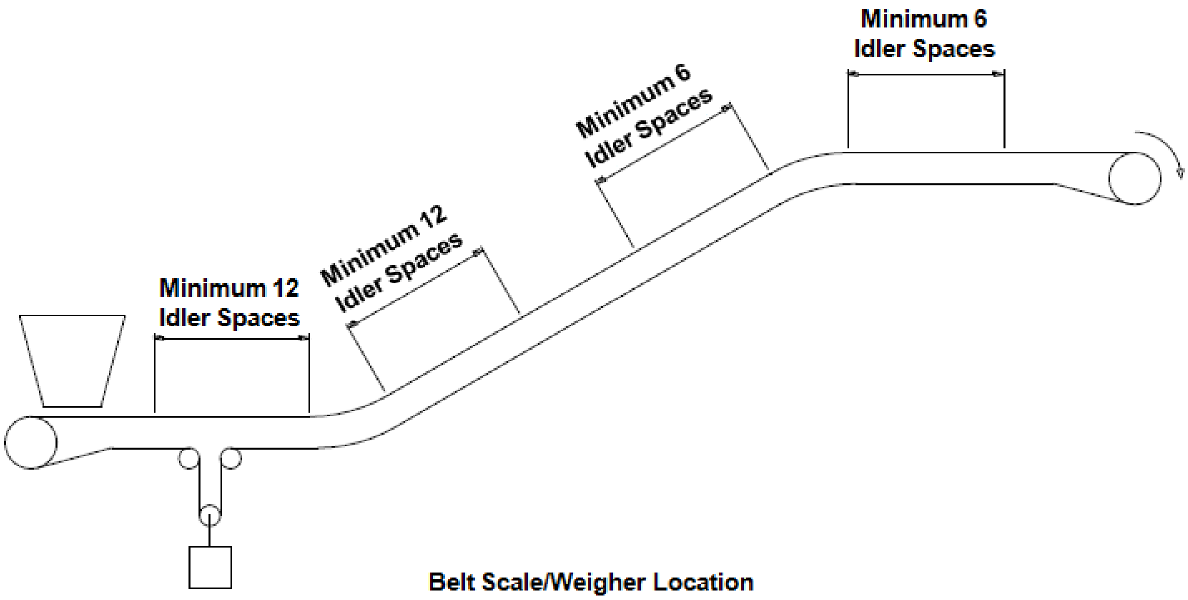
It is recommended that the weigh idlers within the weigh idler zone must be raised by 3-10 mm.

Kinder & Co. Pty Ltd (www.kinder.com.au) recommends that the roller be balanced to 0.01 Nm and roller shell machined to 0.13 mm total indicator run-out (T.I.R). They also recommend that three lead-in and three lead-out idler frames be fitted with weigh quality rollers, however, when the belt speed is two meters per second or less, two frames can be used without adversely affecting accuracy.

For dimensional tolerances for scale quality idlers/rolls as per CEMA specifications, please see CEMA Standard No. 502, Bulk Material Belt Conveyor Troughing and Return Idlers.

Belt tension greatly affects the accuracy of the belt weigher. Generally, the belt tension is lower near the tail of the conveyor and a maximum at the head of the conveyor. In view of this, try to install the weigher as close to the tail as possible.

Conveyor stringers must be continuous members (welded, not bolted) in the weigh idler zone. It is recommended that conveyor belt scales shall be located at least 10 feet from the load zone of the conveyor to prevent the dynamics of loading from interfering with the output and to allow ample space for skirting and dust control.



Belt Scale/Weigher Location

It is also recommended that the belt scale/weigher must not be mounted in the curve of a conveyor. As shown in above figure, a belt scale must be at least 12 idler spaces from the end of a concave curve and 6 idler spaces from a convex curve.

Proper alignment of all components and the control of contaminants are essential. As belt conveyor scales from different manufacturers vary in characteristics, instructions, accuracy and dimensions, basic application information and installation requirements relative to idler spacing and position must be obtained from the specific scale manufacturer.

Idler Life

As per Sandvik, their idlers will provide years of trouble free performance - often in excess of 15 years' service in the most demanding applications. 15 years of idler life is achievable if the idlers are designed [minimum bearing life (L_{10}) of 60,000 hours at 500 rpm] for it. In view of this, 15 years of idler life should be a GOAL of all maintenance engineers.

Long Term Storage of Idlers

Long term storage is defined as any storage in excess of six months. Idlers that are to stored long term prior to being placed into service must be stored in a covered area. In the event that idlers must be stored outdoors, each skid of idlers should be covered securely with a tarpaulin. The maximum ambient temperature should be 105°F and the minimum ambient temperature should be 30°F. Each idler roll should be rotated several revolutions (5 to 6) every six (6) months in order to maintain proper lubrication of the roller or ball bearings.

Caution

Although one stuck idler roll may not appear important, maintenance personnel should realize that under a high-speed belt handling abrasive material, its shell could soon wear through, presenting a knife edge which could severely damage an expensive belt. Well-trained personnel would be able to detect impending failure in such a case, and correct the malfunction before any damage could occur.

Pulleys

Pulleys are necessary in conveyor to change the direction of belt in a vertical plane, and to form endless loop for continuous operation. In addition, the drive pulley also transmits the motive power to the belt. The pulleys can be broadly classified as drive-pulley and non-drive pulley. The drive-pulley supports the belt at bend and also transmits power to it. The non-drive pulley only supports the belt at bend. Generally, conveyor's head pulley functions as drive pulley and pulleys at tail, take-up, bend and snub location are non-drive pulleys. The head pulley can be also a non-drive pulley, if the drive is not provided with it.

The basic construction of drive and non-drive pulley is same except for following differences.

- The drive pulley has to transmit torque from shaft to rim. Therefore, the pulley connection with shaft should be suitable for torque transmission. The non-drive pulley does not transmit torque.

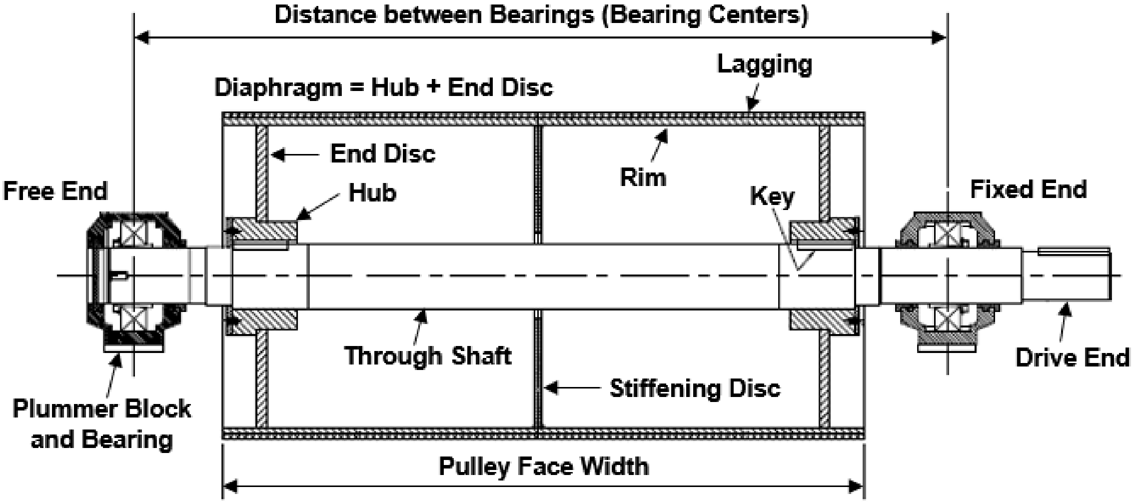
- The drive pulley has live shaft. Whereas non-drive pulley can have live (rotating) shaft or dead (stationary) shaft.

Present day conveyors use drum type welded steel construction pulleys. It derives this name because pulley's main body is having a drum shape. It is constructed by welding of steel rim, end discs and hubs. Hub and end disc assembly is commonly called a **diaphragm**.

Standard/Conventional Pulleys (Pulleys with Plate Diaphragms)

These pulleys are the most widely used pulleys for general conveying application. This type of pulley is economical, easy to make and suits well for textile fabric belts of lower tension ratings.

The pulley consists of a rim, 2 end disc, 2 hubs, 2 external bearing units and through steel shaft. The outer face of pulley's rim is often provided with rubber lagging. In most wide faced conveyor pulleys, intermediate stiffening disc/s is welded inside the rim.



Standard / Conventional Drive Pulley

Above figure shows construction of a standard/conventional drive pulley with cylindrical hubs. Depending on application/requirement, the hubs are either press fit (interference fit with keyway) or clearance fit with keyway and set screws.

The typical manufacturing sequence involves first welding of the hubs with end discs, then mounting these hub-end discs (diaphragms) on shaft and subsequent welding of diaphragms to rim. Later on the rim's outer diameter is machined on shaft centers.

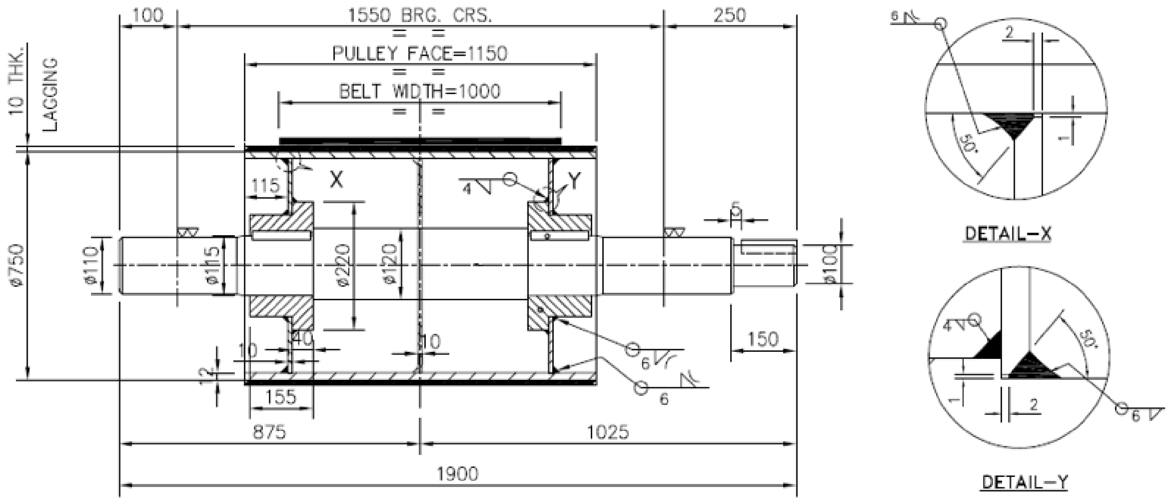
Above method ensures the following.

- Hubs bore and rim outer diameter being concentric with shaft.
- Diaphragms are at right angle to shaft and rim.

The shaft size between two cylindrical bore hubs should be slightly less (by 1 or 2 mm) than hub bore if removal of shaft is needed at later stage.

The drive pulley is keyed onto shaft at both the hubs. The non-drive pulley is mounted on shaft by keyed connection or shrink-fit by thermal expansion and contraction. It is difficult to remove shaft when mounting is by shrink-fit, but the advantage is stronger shaft due to absence of key weakening (smaller diameter of shaft for same load).

The pulley is supported by 2 plummer blocks, one on each side of the pulley. The plummer block is equipped with self-aligning ball bearing or self-aligning double row spherical roller bearing. For heavier sizes, the bearing will usually have taper bore and adapter sleeve for ease of fitting / removal of the bearing. The bearing mounting (within plummer block zone) on one side is 'fixed', and on other side is 'floating'. This enables pulley assembly to avoid axial stress due to axial expansions / contraction and inaccuracy of shaft length between the bearings. The bearings are sized for a life of 25000 to 50000 hours depending upon application.



The pulley rim is rolled from 14 mm thick plate and machined to 12 mm after welding of diaphragms to the rim.

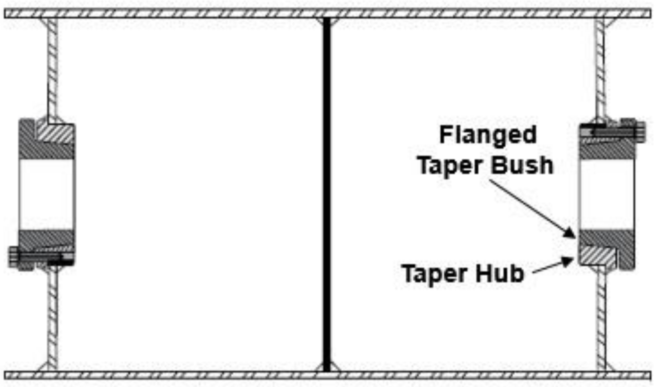
Drawing of a Typical Standard/Conventional Pulley

Above figure shows drawing of a typical standard/conventional pulley. The detail in it gives information on fit up for welding.

Hub and Bushing (Compression Style Hub) Systems

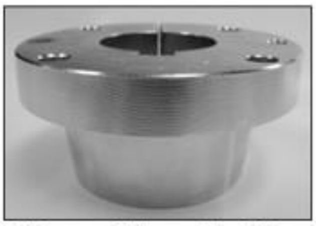
Although some conveyor pulleys are manufactured with cylindrical bores (as shown in the previous section), taper hub and bushing (compression hub and bushing) systems are more common. These systems consist of a hub and a bushing with tapered mating surfaces that cause the hub to expand and the bushing to contract onto the shaft when the screws are tightened.

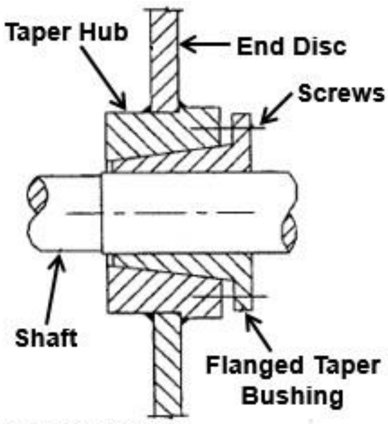
Flanged Taper Bushing System



Pulley with Flanged Taper Bushing System

Above figure shows construction of a typical pulley with flanged taper bushing system.


Flanged Taper Bushing



Flanged Taper Bushing System

As shown in above figure, in a flanged taper bushing system, flanged taper bushings are installed by inserting cap screws through the flanged taper bushing and engaging them into threaded holes in the taper hubs. These systems are available in various series.

Generally, the flanged systems have a normal taper (in the order of 2 inches per foot on the diameter, for XT® series) or shallow tapers (approximately 3/4 inch per foot on the diameter, for QD® series). The advantage of the normal taper is that it reduces pulley end disc stress caused by the installation of the second bushing. The less the amount of axial movement required to develop the expansion forces, the lower the stress induced in the end discs when installing the bushing on the other end. The advantage of a shallow taper is that they can develop higher expansion/contraction forces.

QD® series bushings are originally designed for single hub applications such as sheaves and sprockets. The XT® series bushings are designed specifically for pulley applications with two hubs.

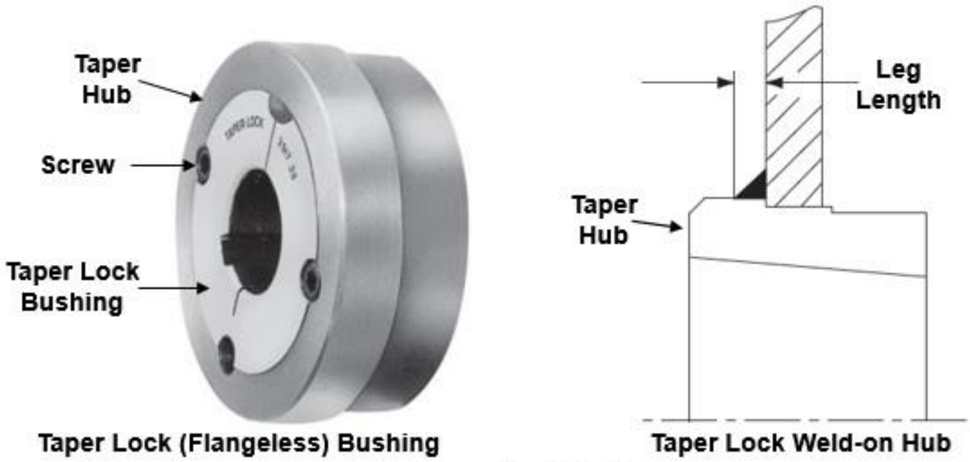
XT® is a registered trademark of Van Gorp Corp.
QD® is a registered trademark of Emerson Electric Corp

Follow the bushing manufacturer's instructions for installation of the bushings.

Note: Completely tighten the screws on one bushing before proceeding to tighten the screws on other one.

Taper Lock (Flangeless Bushing) System

As shown in the following figure, a Taper Lock® system (flangeless taper bushing system) comprises of a taper bushing (1-11/16” taper per foot) and screws. The taper bushing is installed in a taper hub/pulley. Taper-Lock® is a registered trademark of Reliance Electric Company.

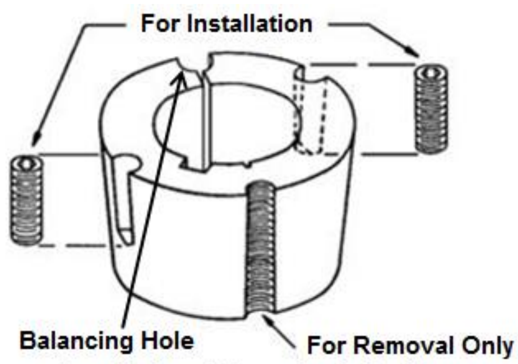


Taper Lock System

In case of Taper Lock weld-on hub system, the taper hubs are welded on to the end discs. The weld leg length should be only sufficient for required strength. Excess weld should not be done to prevent distortion due to more heat input.

Taper lock bushings are installed with screws that engage in threaded half holes in the mating hub and non-threaded half holes in the bushing. Tightening the screws causes the hub and bushing to move axially relative to one another. The hub expands and the bushing contracts on the shaft. The radial force develops enough friction to allow the hub and the bushing system to keep the pulley locked securely to the shaft axially and usually with the aid of a key, to transmit torque from the shaft to drive pulley. Keys are generally not required on non-drive pulleys. Since there is no flange, the taper lock system requires less axial space than flanged bushing.

Following procedure may be followed for the installation of a taper lock bushing.



Installation of Taper Lock Bushing

Ensure that there is no oil or lubricant between the taper on the outside of the bushing and the taper bore of the hub, to which the bushing is being installed.

Place the bushing into the hub and match half holes to make complete holes. It is important to note that the holes need to be matched, not the threads. Each hole will be threaded on one side only. Threads are provided on the bushing for its removal.

Oil threads, the point of the set screws or threads, then place the screws loosely into the holes that are threaded on the hub side. Ensure that the bushing is free in the hub.

Insert the correctly sized key into the shaft keyway, ensuring the key is a press fit into the shaft keyway. Insert the shaft in the bushing and locate it in the desired position. Ensure that there is an air gap between the top of the key and the keyway slot in the bushing. This will prevent cracking of the bushing.

Screws should be tightened gradually and alternately to required torque. Lightly tap against the bushing using a hammer and block or sleeve (this will ensure that the bushing is seated squarely into the hub). Screws will now turn a little more. Repeat this hammering and screw tightening once or twice to achieve maximum grip on the shaft.

Fill the holes that are not used with grease or silicone sealant to prevent them from filling with dirt and/or rust.

After drive has been running under normal conditions for a short time, stop and check tightness of screws.

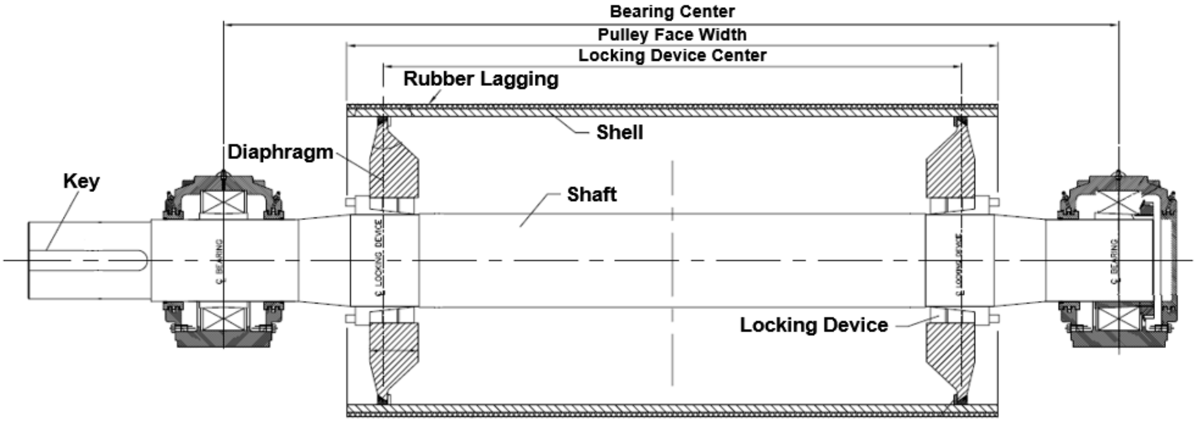
As shown in above figure, many times bushings are having even number of holes, i.e. a forth, balance hole. This design is to dynamically balance the bushing for high speed applications.

It may be noted that both the above systems (Flanged Bushing System and Taper Lock System) use split tapered bushings.

Advantages of Hub and Bushing System

- The tapered bushings are very quick and simple to install and dismount.
- The clamping force of the bushing on the shaft improves concentricity.

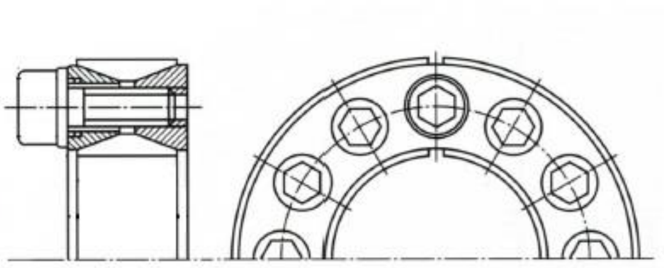
Keyless Locking Assemblies (Devices)



Pulley with Keyless Locking Assemblies (Devices)

Keyless locking assemblies (devices) are also used to connect shafts to pulleys. Above figure shows construction of a typical pulley with keyless locking assemblies. These are not to be confused with shallow taper type hub and bushing systems that do not require keys to lock non-drive pulleys and some small-bore drive pulleys to the shaft. These assemblies use many more screws than the other systems. They develop very high expansion/contraction forces and therefore do not utilize keys to lock the pulley to the shaft.

Keyless locking assemblies are available in many types/designs to suit numerous applications. Bikon (www.bikon.com), Ringfeder (www.ringfeder.com) and Ringspann (www.ringspann.com) of Germany are leading suppliers of keyless locking assemblies.



Keyless Locking Assembly (Double Taper Type)

Above figure shows construction of a keyless locking assembly (device). Typically, in a keyless locking assembly, tightening the screws slide the cones (taper rings) towards each other, forcing the inner ring against the shaft and the outer ring against the end disc or hub respectively. Thus, it creates strong friction grip on shaft and hub to transmit forces. Due to the very high expansion/contraction forces, keyless locking assemblies require special design considerations to handle the resulting stresses in the shaft and end disc/hub.

This type of mounting arrangement permits easy removal / refitting of pulley on shaft. Since there is no keyway on the shaft, there is no shaft weakening and stress concentration.

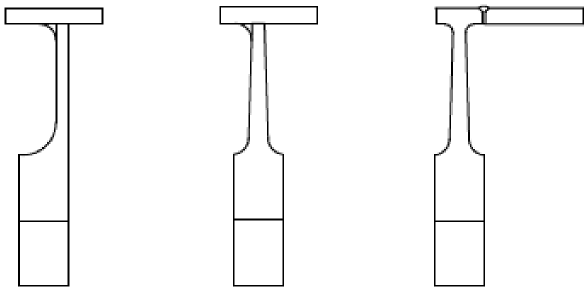
Mine Duty Pulleys

A mine duty pulley is one in which material thicknesses have been increased for a rigid, conservative design compared to standard pulleys. Mine duty pulleys were originally specified and used for underground mining operations where the abusive environment and high cost of installation demanded a more conservative design.

Mine Duty Pulleys may be considered in a conveyor application requiring heavier construction and more conservative design to give greater service life where abrasion is a factor, or the conveyor is to be operated for longer running hours.

Engineered pulleys / Turbo Diaphragms Type Pulleys

Steeply inclined or long conveyors have high tractive pull. Such conveyors are equipped with fabric belt of high tension rating or steel cord belt. These belts impose sever loading on pulleys. The standard/conventional pulleys have certain weak areas (load resisting area from hub to end disc and welded joint at end disc’s outer diameter and rim) where stress/tension concentrates beyond the capacities of these pulleys. Since these areas are prone to failure, standard pulleys are not suitable for such applications. Such conveyors also demand manufacturing tolerances beyond the tolerances of standard pulleys. Hence for heavy duty applications, welded steel custom-made engineered pulleys / turbo diaphragm type pulleys are used in which stresses are evenly distributed.



End Disc/Hub Configurations for Engineered Pulleys

Above figure shows some common end disc/hub configurations (diaphragms) for engineered pulleys. These diaphragms are usually made of high quality cast steels and machined all over. The diaphragms are thicker at inner radius and gradually taper in thickness towards outer radius. Since these diaphragms are not having a weld joint between hub and end disc, the stresses are evenly distributed. Since the disc/hub configuration looks like single stage turbine wheel, they are called turbo-diaphragm.

Special manufacturing specifications often include accurately machined surfaces, stress relieving, special welding controls, and non-destructive testing. It is recommended use shaft deflection limit of 0.0015 in./in. (i.e. 5 minutes) for engineered pulleys used in critical applications.

In engineered pulley, generally keyless locking assemblies (devices) are used to connect shaft to the pulley.

Materials of Construction

The typical materials of construction for pulleys are as under.

Rim, diaphragms and hubs: Mild Steel (up to 0.30% C)
Shaft for standard pulleys: Mild Steel, Steel C-40, C-45 or EN 8 (steel C-40 is Carbon Steel having 0.35 - 0.45% C)
Shafts for engineered pulleys: En 9, steel C- 55 (having 0.50 - 0.60% C), En 19 (1 per cent chromium - Molybdenum steel; 0.35 - 0.45% C, 0.9 - 1.5% Cr, 0.20 - 0.40% Mo), etc.

It may be noted that high strength shafting is of value in cases where it permits the shaft ends to be turned down so that smaller diameter, high capacity antifriction bearings can be used. It is also sometimes of value on drive shafts to withstand the added torsional stresses. It may be noted that while the use of high strength steel increases the strength of the shaft, its use does not decrease deflection.

Runout Tolerance

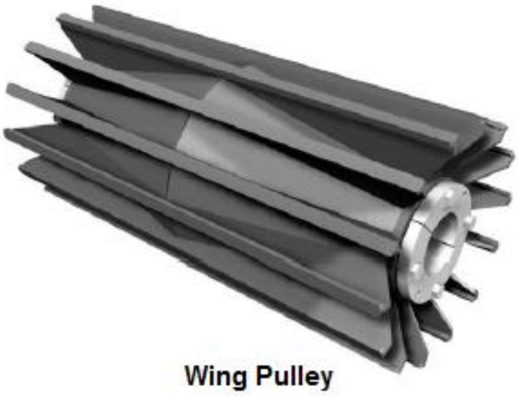
Runout tolerance on diameter is measured at the midpoint of the bare pulley face. Permissible runout tolerance depends on the pulley diameter. For common applications, recommended runouts are as under.

Permissible Runout Tolerances for Common Applications	
Diameter (inches)	Maximum Total Indicator Reading (inches)
8 thru 24	0.125
30 thru 48	0.188
54 thru 60	0.250

When the lagging is not machined, the runout tolerance over lagging is specified by the individual pulley manufacturers.

Engineered pulleys to be used with steel cable or high modulus belts are usually machined with a straight face and have permissible maximum total indicator runout reading to be 0.030 inches (0.76 mm) for both lagged (over/under lagging) and unlagged pulleys.

Wing Pulley



Wing Pulley

As shown in above figure, sometimes instead of standard pulley, self-cleaning wing pulley is used at the tail, take-up or snub locations where material tends to build up on the pulley face. Inclined valley-shaped recess prevents fine or granular material from being caught between the pulley and the return belt. The material gathers in the valley-shaped recesses and falls out of the open ends as the pulley revolves. Such pulley prevents damage to the belt and pulley as debris does not stick to its surface. The most significant drawback of wing pulleys is the oscillating action they introduce to the belt path. The wings introduce a pulsating motion that make noise and destabilizes the belt path which adversely affects the belt sealing system.

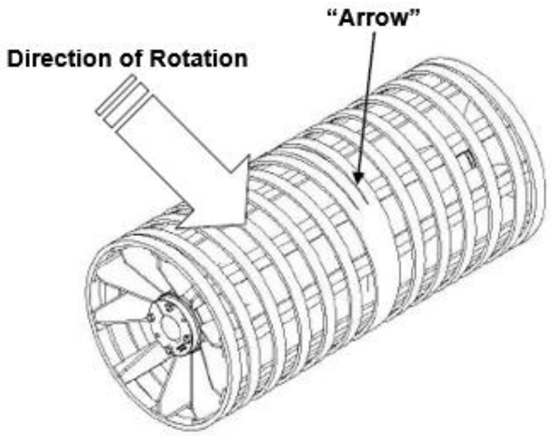
It is recommended to consider use of wing pulleys when the material is granular and free flowing. They should be used at belt speeds under 450 ft/min only. The use of wing pulleys should be limited because they will shorten the life of the belt and the mechanical belt splice.

Spiral Pulleys

Spirals can be added to drum pulleys and wing pulleys. It is more common to have a spiral wing pulley than a spiral drum pulley.

Spiral Wing Pulley

As shown in above figure wrapping a band of steel in a spiral around the wing pulley allows the pulley to achieve continuous contact with the conveyor belt which eliminates excessive noise and pulsating motion without sacrificing the self-cleaning action.



Installation of Spiral Wing Pulley

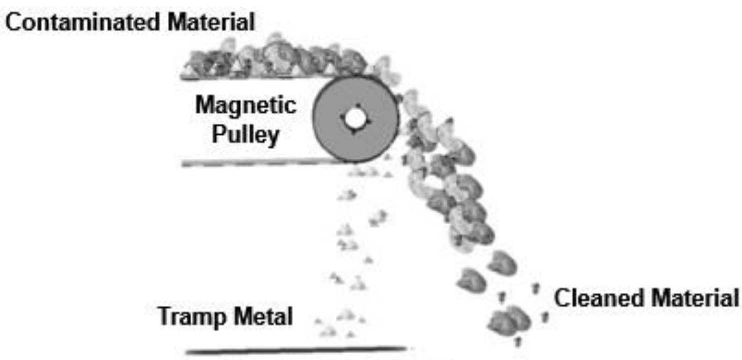
For installation of a spiral wing pulley, locate the "arrow" (as shown in above figure) formed by the steel bands as the spiral in each direction in the center of the pulley.

Install the spiral wing pulley so that the "arrow" points in the direction of rotation to maximizes the cleaning action by the spirals.

Spiral Drum Pulley

When the tensions are too high to use a spiral wing pulley and you still need the cleaning action that a spiral wing pulley provides, spirals can be added to drum pulleys to move the material from the center of the pulley to the edges. The spirals on the drum pulleys are much thicker than the one used on wing pulleys to create an area for the material to travel through.

Magnetic Pulleys



Magnetic Pulley

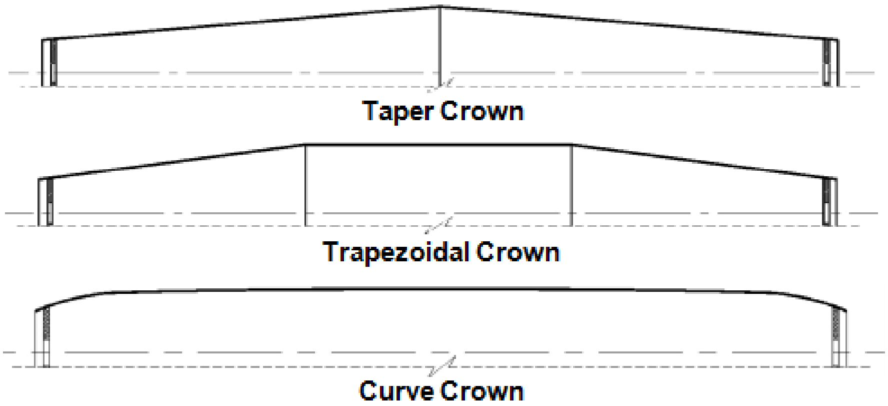
Magnetic pulleys are a type of magnetic separator. As shown in above figure, magnetic pulleys are widely used in the recycling industry to separate steel from aluminum. These pulleys also provide maximum, continuous protection against tramp iron contamination in the processing of materials such as chemicals, plastics, grains, food products, ceramic and coal.

Self-cleaning action separates both large and fine metal particles from non-ferrous material. Easy to install these pulleys provide permanent magnetic strength while requiring no maintenance. Pulleys are constructed with either radial or axial poles.

Pulley Crowning

The pulley crowning means the pulley diameter at center of face width is slightly bigger than pulley diameter at ends. The conventional value of crowning is in the range of 5 mm to 10 mm, per metre of total face width. Pulley crowning helps to reduce belt misalignment in certain situation. The crowned pulley operates from the basic principle of tracking that the belt moves to the part of the component it touches first. In the case of crowned pulley, the belt first touches the higher middle area of the pulley and so is directed into the center. The crowning is created during machining of rim face and subsequently on rubber.

Note: All profiles are exaggerated for illustration purpose.



Common Crown Profiles

Above figure shows common crown profiles.

Taper Crown

Face of the conveyor pulley is tapered with the high point located at the center and tapering toward each end. Provides belt tracking capability, but the peak at the center causes wear and stretching at the center of the belt, decreasing belt life.

Trapezoidal Crown

Face of the pulley is flat in the center and tapers towards the ends forming a trapezoidal shape. Provides enhanced belt tracking capability as compared to taper crown while providing an even wear surface, lengthening belt life.

Curve Crown

Curve crown pulleys have a long, flat surface in the center of the pulley with the ends curved to a smaller diameter. Except on short pulleys, the curved surface extends approximately 200 mm from the edge. Provides enhanced belt tracking as compared to trapezoidal crown, an even wear surface, and lengthened belt life.

Crowned pulleys are most effective on conveyors with short, low-tension belts. With higher tension, steel cable belts, and troughed conveyors, little steering effect is obtained from the crown of the pulley. Crowns are most effective where there is a long unsupported span-four times belt width or greater-approaching the pulley (for example - in a tripper).

It may be noted that, present trend is to have no crowning on pulleys.

It is recommended that crowned pulleys should never be used on conveyors using steel-cord belt.

Dead Shaft Pulleys

In a dead shaft conveyor pulley, shaft is not rotating. The construction typically uses a drum or wing pulley designed to accept bearings for shaft attachment, rather than the typical hub and bushing connection.

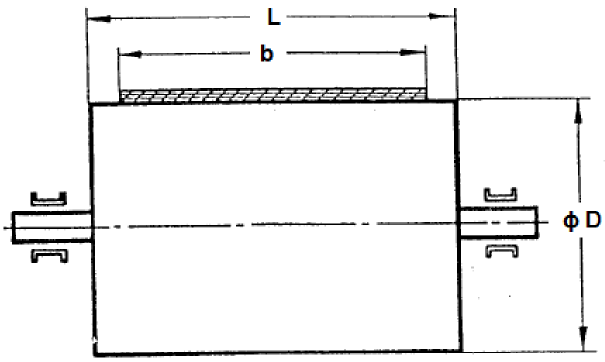
Since stationary stress limits can be higher than fatigue stress limits, dead shaft designs may be safely designed with smaller diameter shafts.

It may be noted that the dead shaft conveyor pulley is not suitable for pulley locations requiring torque transmission due to the non-rotating shaft.

IS 8531: 1986 (Reaffirmed 1998)

IS 8531 covers the requirements of pulleys for belt conveyors. Important requirements as per the specification are as under.

Dimensions



Pulley Face Width

The basic diameter, D, of the pulley shall be one of the following.

200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1400 and 1600 mm.

Pulleys shall be manufactured such that belts shall have minimum edge clearance of 50 mm up to belt widths (b) of 650 mm; 75 mm for belt widths of 800 and 1000 mm; and 100 mm for belt widths exceeding 1000 mm. These edge clearances shall be applicable to conveyor belt speeds not greater than 3 m/s. For conveyor belt speeds greater than 3 m/s, the edge clearances shall be as agreed to between the purchaser and the manufacturer.

Thus, for conveyor belt speeds up to 3 m/s, pulley face width (L) for various belt widths (b), shall be as per following table.

Belt Width, b	300	400	500	650	800	1000	1250	1400	1600	1800	2000
Pulley Face Width, L	400	500	600	750	950	1150	1400	1600	1800	2000	2200

Material

The pulley may be made from material as per IS: 1239 (Part 1) - 1979 and IS: 3601 - 1966 for steel tubes. Alternatively, pulleys may be manufactured from Grade FG 200 of IS: 210 - 1978 'Specification for grey iron castings' or from mild steel conforming to IS: 226-1975 'Specification for structural steel (standard quality)' or conforming to IS: 2062 - 1980 'Specification for structural steel (fusion welding quality)'.

Balancing

Pulleys shall be statically balanced.

Diameter Tolerance

When determining the basic diameter of a pulley, it shall he measured at the centre and shall not include the thickness of any pulley lagging. The diameter of pulley shall be maintained within the tolerance given below.

Pulley Diameter (D) mm	Pulley Face Width (L) mm	
	Up to and Including 650	Above 650
Up to and Including 630	+6 −3	+12 −3
Above 630	+12 −3	+15 −3

Note: The out of roundness shall be ± 0.5 percent prior to lagging if any.

Lagging

The lagging, where provided, shall be as follows.

- For plain rubber lagged pulley, the lagging thickness shall be 6 mm minimum up to 500 mm diameter pulleys and 10 mm minimum for over 500 mm diameter pulleys.

- For grooved rubber lagged pulleys, the depth of the groove shall be 6 mm minimum with 3 mm minimum thickness of material under the bottom of the groove.

The hardness of rubber lagging of the pulley shall be less than that of the cover rubber of the running belt. The value of hardness in shore number shall be as agreed to between the purchaser and the manufacturer.

Designation

A pulley of basic diameter of 400 mm and of face width 600 mm with crowning (C) shall be designated as, 'Belt Pulley 400 × 600 C IS: 8531' and a pulley of basic diameter of 400 mm and face width of 600 mm with rubber lagging (R), shall be designated as, 'Belt Pulley 400 × 600 R IS: 8531'.

ANSI/CEMA Specifications for Welded Steel Conveyor Pulleys

For information on welded steel conveyor pulleys as per ANSI/CEMA specifications, please see ANSI/CEMA Standard B105.1, Specifications for Welded Steel Conveyor Pulleys with Compression Type Hubs. The standard gives recommended load ratings, dimensional information, and criteria for selection of welded steel conveyor pulleys.

Pulley Lagging

Lagging is a term used to describe the variety of elastomers used to coat the contact surface of a conveyor pulley. Generally, pulleys are provided with rubber lagging. Lagging is used on driving pulleys to increase the coefficient of friction between the belt and pulley. The increase in the coefficient of friction permits transmission of higher tractive pull by the belt with reduction in belt tensions and consequent economy (lower belt cost).

Lagging is also used to reduce abrasive wear on the pulley face and to effect a self-cleaning action on the surface of the pulley. Abrasive wear and material buildup can substantially decrease pulley life. Hence, drive pulleys should always be lagged. Non-driving pulleys, especially on the carrying side of the belt (bend pulley), should be lagged whenever abrasive or buildup conditions exist.

The rubber lagging is generally applied to the rim face by hot vulcanizing process. However, replacement of worn out lagging at site is generally carried by cold vulcanizing method. In general, the drive pulley can have rubber lagging thickness from 6 mm to 20 mm in accordance with duty. Similarly, non-drive pulley can have rubber lagging thickness of 6 mm to 15 mm. Standard application uses rubber of natural quality, hardness 60° shore A, ultimate strength 15 to 17 N/mm^2 and minimum elongation of 400% at break. With high tension belts, lagging of 70° shore A hardness is sometimes used.

As per IS 11592 (Indian Standard on Selection and Design of Belt Conveyors - Code of Practice), the lagging thickness shall vary between 6 to 12 mm and the durometer hardness on head pulley shall be 55° to 65° Shore A scale. The durometer hardness on the snub and bend pulley shall be 35° to 45° Shore A scale. Softer rubber is recommended because it tends to resist the material build up on pulley face and allow solid objects to get embedded in the rubber rather than damage the belt.

Lagging Grooves

Drive pulleys which operate in wet and damp condition commonly incorporate grooves in specific pattern and direction to shed water and slurry materials that can build up at the lagging interface and lower lagging efficiency.

Common groove shapes used include diamond, herringbone and chevron patterns. Following figure shows the common groove patterns.

Common Groove Patterns

In a chevron pattern, the grooves meet at the center of the pulley face, while in the herringbone pattern the grooves are offset by one-half the groove spacing. In the herringbone and chevron patterns, the apex points in the direction of belt travel to allow easy escape of material trapped between belt and pulley. Hence, herringbone and chevron patterns are used for uni-directional conveyor. In chevron pattern, the groove lines are continuously extending from one end to other end of the pulley. This makes it slightly weaker as compared to herringbone pattern but is marginally better in cleaning. The diamond patterned is the most commonly used pattern. This pattern is used for conveyor operating in both directions.

The grooves are inclined at approximately 60° to belt line. They are usually spaced on 30 to 60 mm centers. Groove spacing is the dimension measured at right angle to grooves; and is the dimension of un-grooved rubber. Generally, the dimensions of the grooves are 6 mm wide by 6 mm deep with a 3 mm minimum thickness of material under the bottom of the rubber. Diamond pattern is available in different sizes. Two common sizes are 86x50x(6/8/10) mm and 35x18x6 mm.

Many suppliers are supplying rubber lagging sheets with a special bonding layer. This bonding layer facilitates cold bonding of the lagging sheet with pulley resulting in a stronger bonding.

Ceramic Lagging

In applications where belt slip or high wear are a concern, ceramic lagging may be used. Ceramic lagging commonly consists of a series of tiles embedded in a rubber substrate forming a bar profile. The tiles may be smooth or have raised surfaces on each tile. Those with raised surfaces tend to have better drive characteristics under wet, sloppy conditions. Due to the raised surface on the tile and the nature of ceramic, this type of lagging exhibits a superior coefficient of friction and greater wear resistance than rubber lagging. Depending upon application conditions, dimpled ceramic lagging can provide approximately 2 times higher traction than rubber lagging.

Ceramic lagging also incorporates grooves, which are configured based upon the ceramic tile layout.

For Rema Tip Top lagging materials in India: You may contact TTGA Pvt. Ltd. (www.ttga.in)

Oriental Rubber (www.orientalrubber.com) and TEGA Industries (www.orientalrubber.com) are India based reputed suppliers of lagging materials.

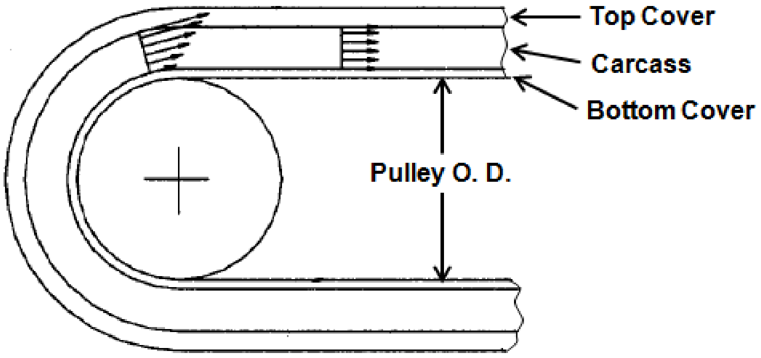
Friction Coefficient

The friction coefficient μ between driving pulley and rubber belting for different conditions (DIN 22101) is as given in the following table.

Operating Conditions	Friction coefficient μ between driving pulley and rubber belting			
	Sooth Bare Rim Steel Pulley	Rubber Lagging, herringbone	Polyurethane Lagging, herringbone	Ceramic Lagging, herringbone
Operation in dry conditions	0.35 to 0.40	0.40 to 0.45	0.35 to 0.40	0.40 to 0.45
Operation in clean and wet conditions (water)	0.1	0.35	0.35	0.35 to 0.40
Operation in wet and dirty conditions (clay or loam)	0.05 to 0.10	0.25 to 0.30	0.2	0.35

Effect of Pulley Diameter on Belt

The belt carcass is much stiffer as compared to rubber covers and hence carcass determines the pulley diameter. Belt carcass construction and tension in it decides the pulley diameter. The stiffer carcass in a belt needs pulley of bigger diameter. Further, when belt is passing on pulley, the carcass portion on outer radius stretches whereas carcass portion on inner radius contracts. Due to this, the stress (tension) distribution across the belt thickness changes as shown in the figure given below (Note: for easy of understanding, belt carcass thickness is highly exaggerated in the figure).



Stress Distribution across the Belt Thickness

It can be seen that the stress in the outer portion of the carcass is higher when it is passing on pulley, although average stress in carcass is same. The belt under higher tension will have less room for putting additional bending stress and therefore it will need bigger pulley. The belt with lower tension has more room for putting additional bending stress and permits use of smaller diameter pulley. Thus, the same conveyor has different diameter of pulleys at head, tail, take-up, bend and snub due to different values of belt tension at these locations.

In view of above, belt should have adequate fatigue resistance against repeated flexure by pulley. The smaller the pulley diameter and the thicker the belt fabric, the carcass fatigue will become more violent. Hence, the smaller (compared to design requirement) diameter pulleys will result into ply separation, weakening of carcass, weakening of joint and thereby premature failure of belt.

Minimum Pulley Diameter

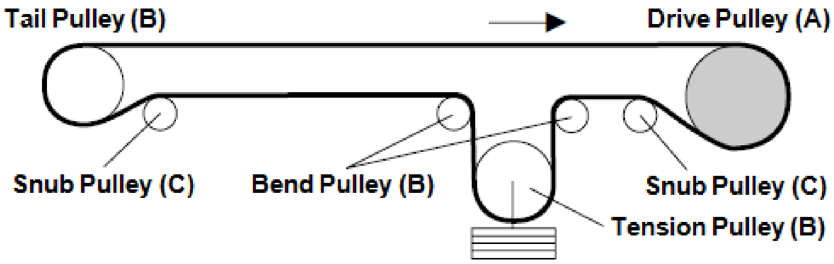
Minimum pulley diameter for textile fabric belts (as per ISO 3684: Determination of minimum pulley diameters) is as under.

Carcass Thickness (mm)				**Recommended Minimum Pulley Diameter, mm**								
Material of warp in carcass				Percentage of the maximum allowable working tension								
Nylon*		Polyester**		over 60% to 100%			over 30% to 60%			up to 30%		
				Type of pulley			Type of pulley			Type of pulley		
from	to	from	to	A	B	C	A	B	C	A	B	C
-	1.1	-	0.9	100								
1.2	1.3	1.0	1.1	125	100		100					
1.4	1.7	1.2	1.4	160	125	100	125	100		100	100	
1.8	2.2	1.5	1.8	200	160	125	160	125	100	125	125	100
2.3	2.7	1.9	2.3	250	200	160	200	160	125	160	160	125
2.8	3.5	2.4	2.9	315	250	200	250	200	160	200	200	160
3.6	4.4	3.0	3.7	400	315	250	315	250	200	250	250	200
4.5	5.5	3.8	4.6	500	400	315	400	315	250	315	315	250
5.6	7.0	4.7	5.8	630	500	400	500	400	315	400	400	315
7.1	8.8	5.9	7.4	800	630	500	630	500	400	500	500	400

8.9	11.1	7.5	9.2	1000	800	630	800	630	500	630	630	500
11.2	13.8	9.3	11.5	1250	1000	800	1000	800	630	800	800	630
13.9	15.5	11.6	12.9	1400	1250	1000	1250	1000	800	1000	1000	800
15.6	17.7	13.0	14.8	1600	1250	1000	1250	1000	800	1000	1000	800
17.8	20.0	14.9	16.6	1800	1400	1250	1400	1250	1000	1250	1250	1000
		16.7	18.5	2000	1600	1250	1600	1250	1000	1250	1250	1000

* This data is applicable to popular nylon-nylon belt (i.e.warp of nylon and weft of nylon).
** This data is applicable to EP belt (i.e. warp of polyester and weft of nylon).
Note: For information on cotton and cotton-polyester carcass, please refer the ISO 3684.

Information on type of pulley for above table is as under.



Type of Pulley

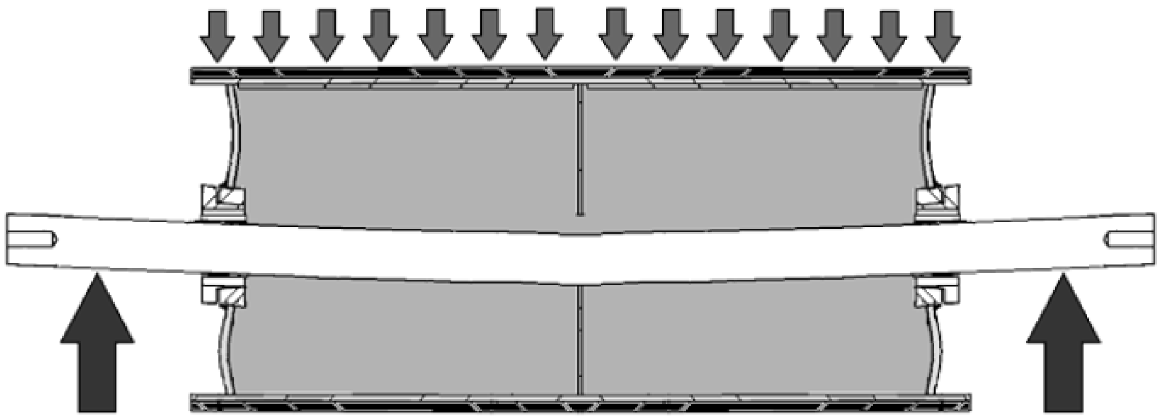
Type of Pulley	Application	Examples
A	Pulleys in the areas of high belt stress.	Drive Pulley, Tripper Pulley
B	Pulleys in areas of low belt stress	Tail Pulley, Bend Pulley, Tension Pulley
C	Pulleys with an angle of wrap ≤ 30	Snub Pulley

Design Considerations

Information on selection of shaft size and taper hub and bushing systems is given in this section.

Shaft Deflection

The single largest contributor to premature failure of conveyor pulleys is end disk fatigue caused by excessive shaft deflection. Shaft deflection is the bending or flexing of a shaft caused by the sum of the loads on the pulley. The sources of these loads include belt tension, product load and the weight of the pulley itself. Excessive shaft deflection occurs as a result of an undersized shaft. Following figure illustrates the concept of shaft deflection.

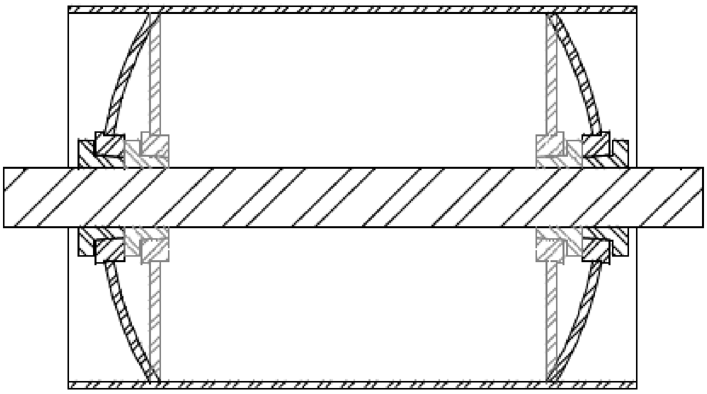

Excessive Shaft Deflection due to Undersized Shaft (Exaggerated for Effect)

Excessive shaft deflection occurs when shaft diameter is improperly sized for the demands of an application. Although it may appear as a potential solution, selecting a shaft material with greater strength characteristics will have virtually no effect to shaft deflection. The modulus of elasticity, which is a physical property of a substance which describes its tendency to deform elastically when a force is applied to it, remains virtually the same across all grades of steel, and because of this, the only proper way to increase the stiffness of a steel conveyor pulley shaft is to increase its diameter.

In view of above, it is recommended that shafts (for standard pulleys) be designed with a maximum bending stress of 8000 psi or a maximum free shaft deflection slope at the hub of 0.0023 inches per inch.

The distance between the center of each bearing support and the center of each hub connection will impact the degree to which the shaft deflects. This deflection should be accounted for when selecting a shaft diameter. A greater distance between the bearing centers, without increase in hub centers will require a larger diameter shaft to accommodate the same load.

Style of Hub Connection



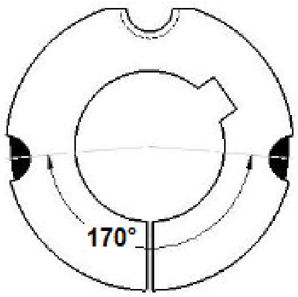
End Disk Pre-Stress (Exaggerated)

The act of installing a hub and bushing (compression type hub) in a two hub application leads to pre-stressing of end disks. As the bolts are tightened, the bushing is drawn into the hub causing it to compress onto the shaft. At a certain point the shaft will no longer be able to move within the bushing. Further tightening of the bolts will draw the hub outward instead of drawing the bushing inward (assuming the bushing on the opposite side has already been fastened in place). This will cause the end disks to bow outward or pre-stress on the shaft and end disks. The shallower the hub taper, the greater the amount of pre-stressing. Ideally, this pre-stress would be primarily absorbed by the end disks, as depicted in above figure. However, if the end disk is built to be more rigid than the shaft, the pre-stressing will not be absorbed by the shaft in place of the end disk, causing the shaft to deflect.

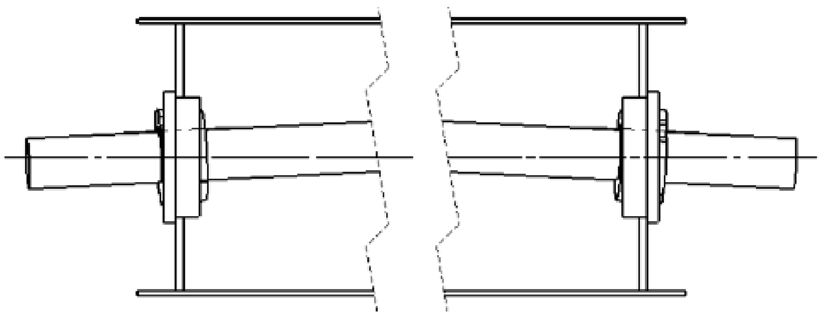
Compression hubs and taper flanged bushings with steep taper angle (XT series hubs) were specifically designed for use in conveyor pulleys with two hub connection points. The steep taper angle (2” taper per foot) minimizes end disk pre-stressing that can occur during the installation of the bushings. This design feature reduces the likelihood of pulley failure as a result of end disk fatigue. The reduced clamping pressure caused by the steep taper angle is compensated by use of adequately sized bolts used to install the bushing in the hub.

Compression hubs and taper flanged bushings with shallow taper angle (QD series hubs) were originally designed for use in power transmission products generally utilizing one hub connection point such as sprockets and sheaves. The shallow taper angle (3/4” taper per foot) is ideal for torque transmission, but can pre-stress the end disk when bushings are installed; increasing the probability of end disk fatigue in products designed with two hub connection points. The uneven bolt spacing on the hubs can also lead to non-uniform draw up, which increases the risk of bolt breakage, bushing breakage, or bending shafts upon installation.

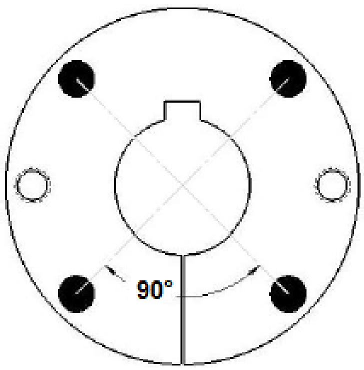
Taper Lock hubs and bushings were designed for use in power transmission products utilizing one hub connection point such as sprockets and sheaves. Taper Lock systems have a moderate taper angle (1-11/16” taper per foot) which minimizes end disk deflection in the products with two hub connection points. Taper Lock systems are also sought for aesthetic reasons due to the clean look of their flush bushing arrangement. However, of all compression hub and bushing systems, Taper Lock has the weakest ability to grip the mating shaft. Additionally, Taper Lock systems used in two hub configurations increase the likelihood of shaft misalignment and measurable maximum circular runout.



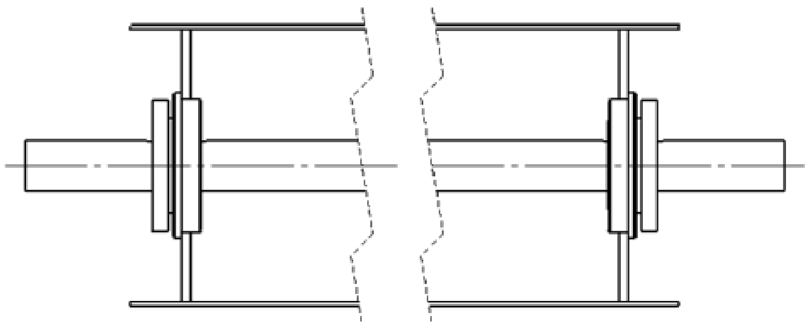
Typical Taper Lock Bushing



Typical Taper Lock Pulley Assembly



Typical Flanged Bushing



Typical Flanged Pulley Assembly

Comparison between Assembly of Flanged Systems and Taper Lock Systems

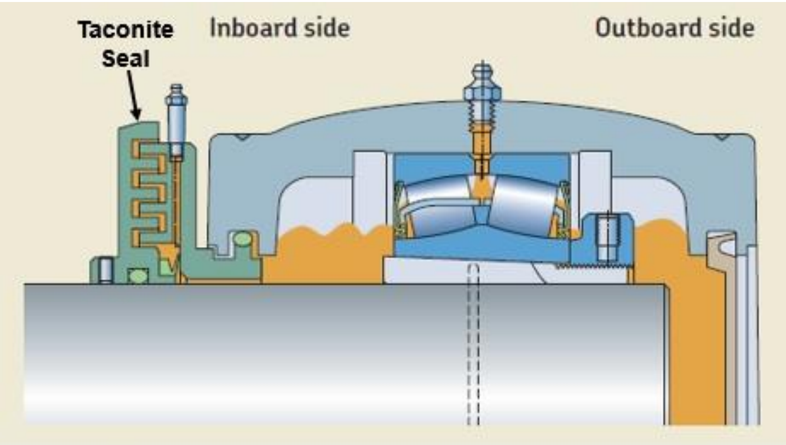
When installing bushings and a shaft into a pulley with compression style hubs, the desired result is to locate the bushing face such that it is fixed on a plane parallel to the hub face. Since three points define a plane, having three or more retaining bolts in the hub/bushing assembly is ideal for maintaining this alignment. Compression style systems which utilize a minimum of three equal spaced screws (for example, flanged bushing systems, XT series hubs uses a minimum of 4 screws) will generally keep the bushings in acceptable alignment with the mating hubs by allowing even pressure to be applied all the way around the circumference of the bushing. The parallel alignment of the hub and bushing faces will keep the shaft extension perpendicular to the hub face and help to maintain its concentricity with the pulley. Maintaining shaft alignment when using hub and bushing systems with only two retaining bolts (such as Taper Lock system with two screws) can prove to be difficult. The two screws utilized in these designs are located 170° apart (as opposed to 180°) which causes additional pre-stress on the shaft by creating a moment arm around the centerline of the shaft. The moment arm makes the shaft more likely to bend toward the 170° side of the angle which is already weakened by the split in the bushing being located on this side.

Since maintaining shaft alignment with Taper Lock systems is difficult, the runout measured on the final pulley assembly is typically greater. Considering this, a pulley manufactured with flanged taper bushing system will have a more desirable maximum circular runout than a similar pulley manufactured with Taper Lock bushings.

These reasons are why taper flanged bushings are preferred and Taper Lock type hubs and bushings are not recommended for use in two hub pulley configurations.

Note: Content given in this section (Design Considerations) is reproduced based on information by Pro Cal Inc. (www.pcimfg.com).

SKF Taconite Seal for Pulley Bearings



SKF Taconite Seal Fitted to Inboard Side of a Housing

A new SKF Taconite Seal for bearings in split housings protects pulley bearings against contaminated or wet operating conditions. Benefits of this multi-stage labyrinth cartridge seal include exclusion of contaminants and improved prevention of water ingress (even during high-pressure washing) resulting in maximized bearing and seal service life leading to optimized performance and uptime.

Above figure shows SKF Taconite Seal fitted to inboard side of a housing. For more information on SKF Taconite Seal, view SKF Taconite Seal installation (www.skf.com).

Cooper Split Bearings

Use of Cooper split bearings may be considered for pulley bearings due to relative ease of fitting, maintenance and replacement of them over traditional spherical roller bearings. If cost is a constrain, they may be considered for drive pulleys. For more information on Cooper Bearings USA (part of the KAYDON Group), view their website, www.CooperBearings.com.

Belt Takeups

The purpose of takeup devices in belt conveyors is to establish and preferably to maintain a predetermined tension in the belt (for no slip between belt and the drive pulley) at some critical point. Often the critical point lies immediately following the drive since it is necessary to maintain tension at that point to prevent slippage on the drive pulleys. In some cases, however, the critical point may not be near the drive but at some convenient location.

“Takeup” devices derive their name from the fact that they take up changes in belt length. In taking up length, they maintain tension, which is their primary purpose. Information on various types of takeup arrangements is given in this chapter.

Need

All properly designed belt conveyor requires the use of some form of takeup device for the following.

- To insure adequate amount of slack side tension at the drive pulley to prevent belt slip.
- To permanently insure adequate belt tension at the loading point and at any other point of the conveyor to keep the troughed belt in shape (to avoid material spillage) and limit belt sag between carrying idlers.
- To compensate for operating belt length variation due to physical factors (instantaneous tensions, permanent elongation, outside temperature, temperature of conveyed material, etc.).
- To allow belt storage for making replacement splices without having to add an extra piece of belt.

If the designed tension is more than the necessary (over designed), it will result in costlier belt, pulleys and structure. However, if the tension applied is more than the designed, it will damage belt, pulleys, etc.

Types of Takeup

Constructionally four types of takeup are used. They are: screw takeup, vertical gravity takeup, horizontal gravity takeup and winch takeup. Functionally, these takeup devices can be grouped in two types: Manual takeup devices (also called fixed takeup devices) and automatic takeup devices (also called floating takeup pulley type devices).

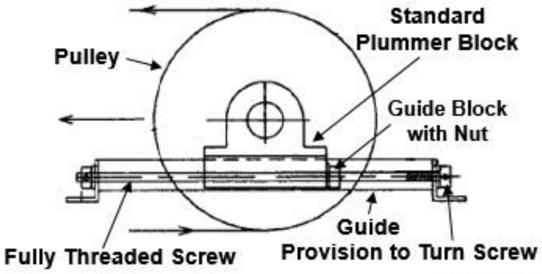
Manual/Fixed Takeup Devices

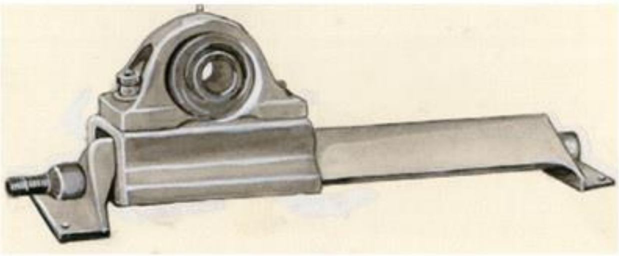
Manual/fixed takeup devices are used where automatic takeup devices are not practical because of space limitations, for cost considerations, or in the case of relatively short, light-duty belt conveyors, where takeup considerations are not critical.

They are called fixed takeup devices because the takeup pulley does not shift during conveyor operation. This means belt length remains constant whether the conveyor is running at steady speed, starting or braking.

In this device, the takeup arrangement is generally installed with the tail pulley, which also acts as the takeup pulley and the pulley remains fixed between successive periodic adjustments. The device can be also installed on return run, using bend pulleys. Takeup devices of this type are generally screw type and winch type.

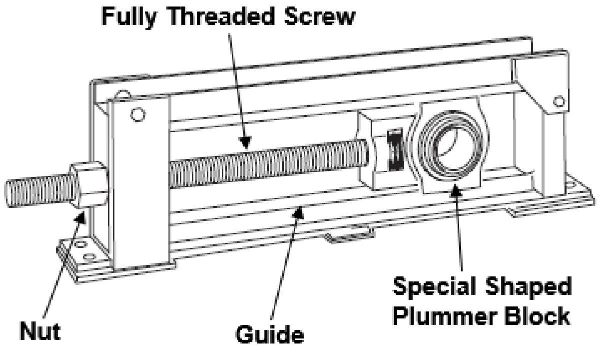
Screw Type Takeups

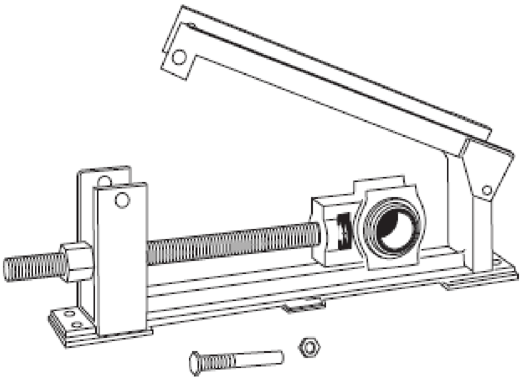




Non-extendable Screw Takeup

Above figure shows non-extendable screw type takeup. In this type of takeup, the screw remains at same location. The take up pulley plummer block is mounted on the guide block and turning of the screw shifts the guide block. This type of arrangement permits the use of standard plummer block for pulley support.





Extendable Screw Takeup

Above figure shows extendable/shifting screw type takeup device. In this type, turning of the nut shifts the screw which in turn moves the plummer block. Since in this arrangement the screw and pulley center line are in the same plane, the belt force is transferred to screw without tilting movement. Thus this is a better design than non-extendable screw type. However, this type of arrangement requires a special shaped plummer block.

Tail Pulley with Extendable Screw Type Takeup

It is recommended to install extendable screw type takeups as shown in above figure (screw turning arrangement towards head pulley) to prevent obstruction by the screw extension.

Screw type takeup devices give no indication of the tension they establish and are adjusted by trial methods until slippage is avoided. Hence belt tightening depends on judgment of the maintenance personnel. For adjustment of belt tension, both side screws are operated alternatively in short step movement or simultaneously. As they are unable to compensate for any length changes in the belt between adjustments, there is a wide variation in the belt tension. Manual screw type takeups also require a careful operator to observe when additional takeup (readjustment) is required.

As the applied tension is not fully determinable in this device, it generally leads to excessive tensioning of the belt (when tension is insufficient, belt slips and quickly deteriorates). This excessive tensioning is unavoidable and shall be taken into account when determining the size of the belt and designing the mechanical components. For this reason, these devices are used only in case of short conveyors of up to 60 m lengths and under light duty cycle condition.

Winch Takeup

In winch takeup device, the tension is adjusted by means of a winch which does not automatically compensate for belt length variations. A tension indicator may be included between winch and pulley. This device also requires careful checking of tension and leads to excessive belt tension in order to avoid too frequent take-ups (readjustments). They may be used for long conveyors and under heavy duty conditions provided that these conveyors are equipped with belts having very low elongation coefficient under the effect of load and over a long period, for example, steel cord belts.

Automatic Takeup Devices

In automatic takeup devices, takeup pulley is mounted on slides or on a trolley and travels freely while a constant tension is automatically maintained to ensure normal conveyor operation in all cases. In these devices, because pulley shifts down / up / sides in relation to belt stretch / shrinkage due to variation in tension, temperature, etc., they are also called floating takeup pulley type devices. Since they automatically compensate for belt stretch under varying operating conditions, they provide the lowest tension around the belt path.

All types of automatic takeup devices include a system for adjusting belt tension. These systems either act passively as with gravity or actively with controlled power provided by hydraulic, electric, or pneumatic means. The most common type is the gravity takeup that utilizes a heavy gravity weight (called counter weight) hanging from a takeup pulley carriage. In this device the takeup force remains constant in all operating conditions once the counter weight is set initially during installation stage.

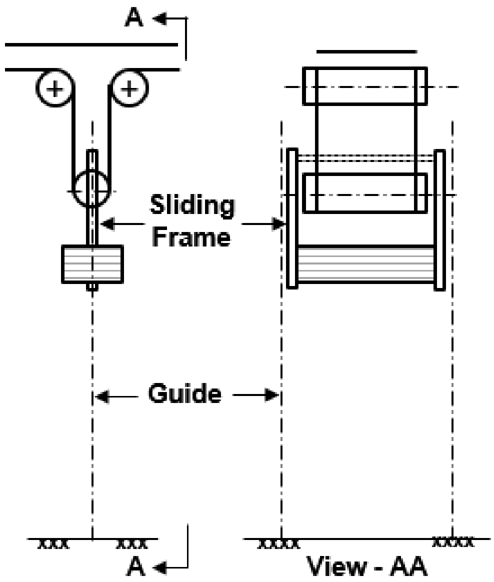
Automatic takeup devices may be located at any point along the return run or at the tail pulley. Takeup devices along the return run use a vertical or a horizontal festoon (U-Loop) in the belt.

Automatic takeup device, usually preferred for long center conveyors has following features:

- It is self-adjusting and automatic.
- Greater takeup movement is possible.
- It is suitable for horizontal or vertical installation.
- It can be located at drive end (preferred for low tensions).

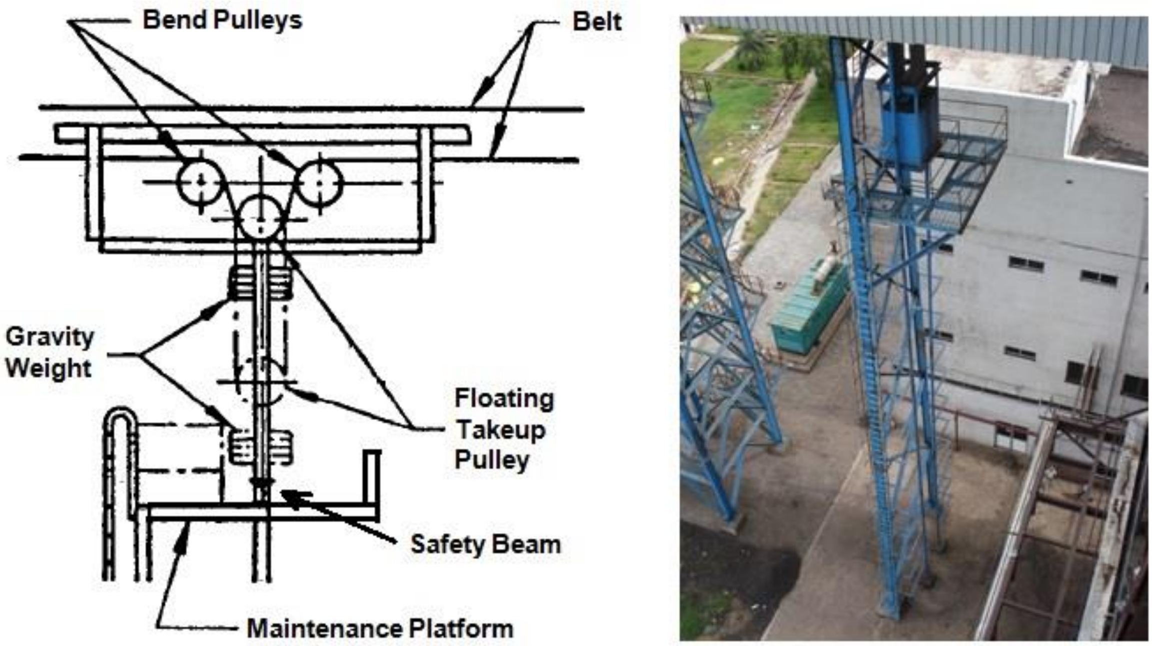
Vertical Gravity Takeup (VGTU) Devices

The vertical gravity takeup device needs to be installed below the elevated portion of the conveyor. In a vertical gravity takeup (VGTU) device, weights necessary to provide proper tension at that point are hung from the takeup pulley of the takeup arrangement using a vertical festoon. As the takeup pulley moves vertically up / down, the arrangement is commonly called Vertical Gravity Takeup (**VGTU**).



Standard Vertical Gravity Takeup

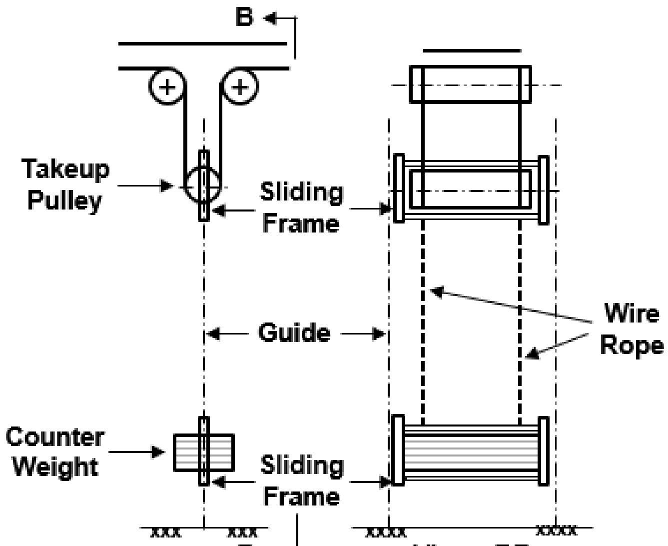
As shown in above figure, in a standard vertical gravity takeup device, the takeup pulley is mounted on a sliding frame. The sliding frame also supports the counter weight assembly. The takeup pulley, counter weight and frame forms the single sliding/moving unit. The sliding unit hangs from the belt for vertical free movement along the guides.



Vertical Gravity Takeup for High Heights

As shown in above figure, in installations where floating takeup pulley is located at high height/elevation, it is very important to install maintenance platform and safety beam. If maintenance platform and safety beam are not installed, in case of belt failure, takeup pulley assembly will fall on ground and may get damaged.

Guarding of any automatic takeup is extremely important due to the unpredictable nature of movement and the forces and speeds that often develop. For safety, wire mesh protection guard of approximately 1.8-meter height should be provided at the footing of guides to prevent entry of any person / animal under the sliding unit. In the photograph of VGTU installation shown in above figure, wire mesh protection guard is not there. It is an example of bad design / erection.



Typical VGTU Installation with Counter Weight at Lower Level

When the takeup pulley is to be installed at very high elevation and it is also required to have very heavy counter weight, it is better to separate sliding frame for takeup pulley and counter weight. In such cases, as shown in above figure, the counter weight frame should be connected with takeup pulley frame by wire ropes to transmit the takeup force.

Takeup Pulley

Counter Weight

Typical VGTU Installation with Separate Sliding Frames for Takeup Pulley and Counter Weight

Above figure shows typical vertical gravity takeup (VGTU) installation with separate sliding frames for the takeup pulley and counter weight (Note: For better clarity in above figure, snap shots of only takeup pulleys and counter weights are shown - it shows two takeup pulleys and two counter weights because there are two conveyors).

The splicing/rejoining of belt require slackening of belt. This is possible by lifting the takeup pulley with hoist. Hence a structural member with provision to attach hoist is provided at upper ends of guides.

Horizontal Gravity Takeup (HGTU) Devices

This is also a gravity operated takeup device wherein takeup pulley moves horizontally, and hence it is known as horizontal gravity takeup device.

If one decides to have gravity takeup for conveyor, the horizontal gravity takeup will be needed instead of vertical gravity takeup, in following two situations.

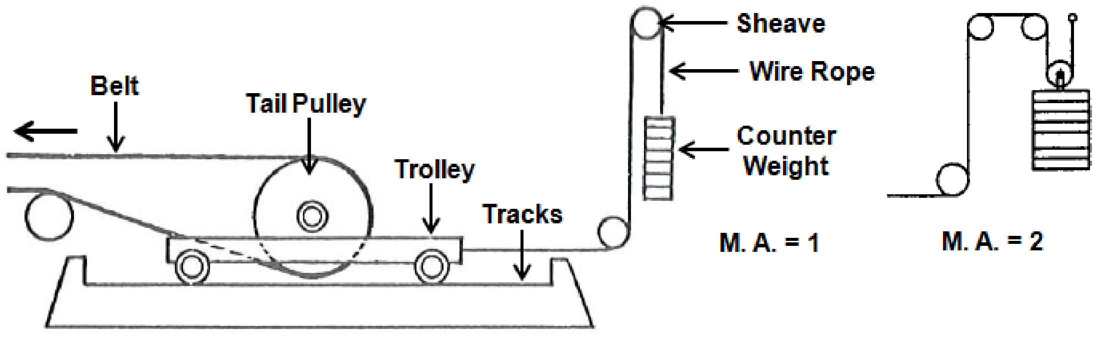
1. The conveyor does not have necessary headroom to install vertical gravity takeup between ground and conveyor.

2. The conveyor is very long and is equipped with fabric belt which results into a long takeup stroke.

The horizontal gravity takeup device can be placed at two locations: at tail end and at intermediate point.

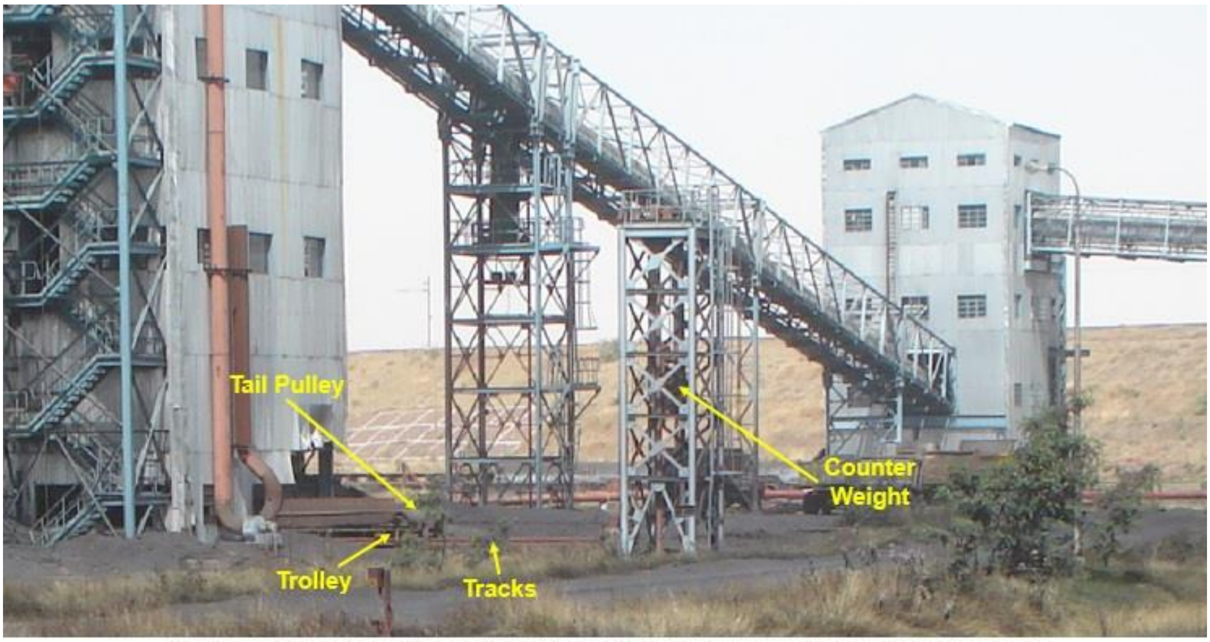
The takeup location at tail end is economical because it does not require extra pulleys and extra length of belt. However, if the conveyor is very long (say above 450 m) it will have delayed response to drive, due to large inertia of the return run. This can cause very small momentary slippage between belt and drive pulley, resulting in faster wear of belt and drive pulley periphery.

The takeup location at intermediate point can be chosen closer to drive, resulting in quicker response to the needs of drive. This will be due to less inertia of moving mass between takeup and drive. Such arrangement of takeup at intermediate point is known as “horizontal gravity festoon/loop takeup". The device at intermediate point is expensive due to need for additional pulleys, additional belt, structural, etc.



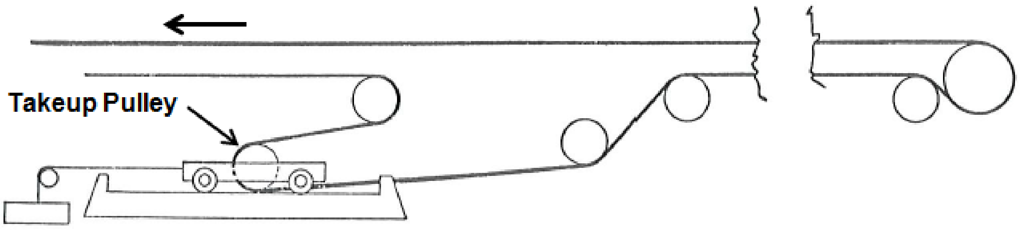
Horizontal Gravity Takeup Arrangement at Tail Pulley

Above figure shows the horizontal gravity takeup arrangement with the takeup at tail pulley. In this takeup device, takeup is provided by mounting the tail pulley on a trolley/carriage that runs on tracks (horizontal guide frame) parallel to the centerline of the belt. A system of wire rope (cable) and sheaves to a suspended weight at any convenient location keeps this trolley pulled back and establishes belt tension. The rope can be arranged in usual loops for mechanical advantage (M. A.) to reduce vertical travel of counter weight. The wire rope system with mechanical advantage reduces tower height and also size of sheaves/rope, but increases the counter weight quantity in multiples. Generally, one opts for mechanical advantage of 2 for long travel stroke.



Typical Installation with Horizontal Gravity Takeup Arrangement at Tail Pulley

Above figure shows photograph of a typical installation with horizontal gravity takeup arrangement at tail pulley



Horizontal Gravity Takeup Arrangement at Intermediate Point

Above figure shows horizontal gravity takeup arrangement with the takeup at an intermediate point. This type of takeup device consists of a takeup pulley assembly, a trolley to support the pulley assembly and allow for horizontal motion, a takeup weight, and a wire rope and sheave system to connect the weight to the trolley. The suspended weight at any convenient location keeps this trolley pulled back and establishes belt tension.

The following figure shows photograph of a typical installation with horizontal gravity takeup at intermediate point. As it is not possible to show construction detail of the takeup pulley, trolley/carriage and tracks in the figure, the construction detail is shown in the next figure.

Typical Installation with Horizontal Gravity Takeup at Intermediate Point

The following figure shows typical construction detail of a takeup pulley on a trolley/carriage and tracks (horizontal guide frame).


Takeup Pulley on a Trolley and Tracks

Following two figures show detail of wire ropes and sheaves to transmit counter weight force to the trolley. It may be noted that the lubrication of the sheave bearings and the rope is important to maintain friction at low levels.

Detail of Wire Ropes and Sheaves - 1 of 2

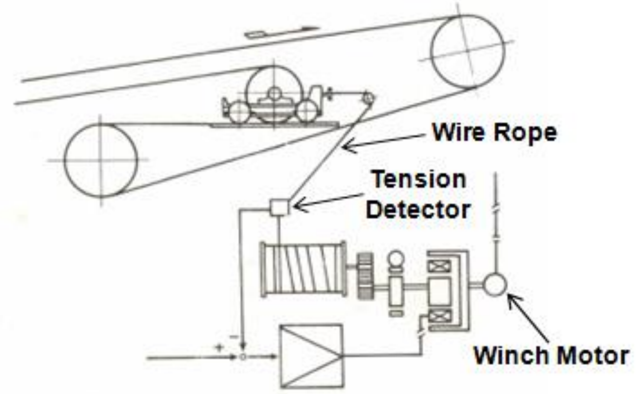
Detail of Wire Ropes and Sheaves - 2 of 2

If two parallel lines of ropes are used to create total take-up force, it is necessary that both the lines should share equal tension. The unequal sharing of tension will not allow proper functioning of take-up device. Equal tension in both the lines can be achieved by use of an equalizing beam.

Automatic Winch Takeup

Winch takeup device can also be used as automatic takeup arrangement when automatic tension regulation (ATR, by employing load cells, electronic sensing devices etc.) is provided to signal for the winch motor to run in one direction or reverse for specific number of turns or to stop as governed by predetermined values of belt tensions for any particular installation.

This is highly recommended for long centers high capacity belt conveyors since it fetches less space (horizontal/vertical) and also do not unnecessarily put the belt always in heavy tension as imparted by the constant counter weights necessary for operation at maximum design load in a gravity takeup device. The heavy tension in gravity takeup arrangement continues to exist in the belt even when it is not running.



Automatic Winch Takeup Arrangement with ATR

Above figure shows schematic diagram of an automatic winch takeup arrangement with automatic tension regulation (ATR). The following figure shows photograph of a takeup utilizing winch powered by an electric motor.

Winch Powered By Electric Motor

It may be noted that in above takeup system, number of sheaves are used for mechanical advantage (M. A.).

Selection of Takeup Location

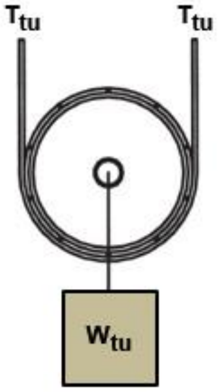
The choice of takeup and its location has to be decided depending on the configuration and length of the conveyor and available space. Since acceleration and braking of conveyors have certain effects on the takeup, they also should to be taken into account while deciding the location of takeup.

Following table shows preferred takeup locations as per IS 11592

Conveyor Geometry	Preferred Takeup Location
Horizontal head drive	Following drive on return side of belt
Incline, head drive	Following drive on return side of belt
Decline, tail drive	At or near head
Decline then horizontal portion, tail drive	At or near head
Combination of incline and decline, head drive	Following head or low point in return run
Combination of incline and decline, tail drive	Following head or point in return run

Takeup Weight

After having decided the location of takeup, the belt tension at that location and the take up weight can be calculated as follows:



Conventional Vertical Gravity Takeup

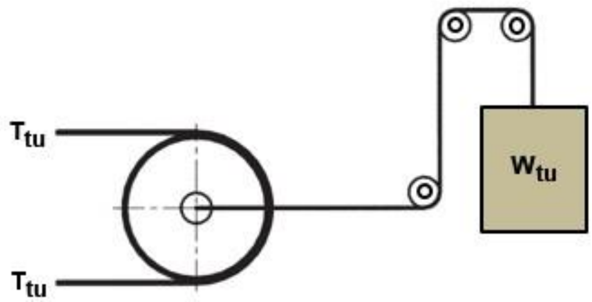
The belt tension produced by a vertical gravity takeup is a function of the "takeup weight." It should be noted that this weight consists of the weight of all elements supported by the belt. The weight includes the takeup pulley assembly, the framework, and the takeup weight proper. The equation for the belt tensions produced by a vertical takeup is simply:

$T_{tu} = W / 2$

Where,

T_{tu} = belt tension at takeup
W = total hanging weight including the pulley, bearings and structure as well as the weight itself (W_{tu}).

The conveyor belt tensions produced by a vertical gravity takeup are well understood and easily calculated. The belt tensions produced by horizontal gravity takeup are more complex and require extra steps (friction force of takeup carriage rope, sheave, mechanical advantage ratio, if any, etc.) in design and calculation. A simple version is shown in the following figure.



Horizontal Gravity Takeup

Recommended Takeup Movement

Gravity takeup system movement or travel is determined by following factors.

- The conveyor center-to-center distance
- The construction of the conveyor belt
- Environmental conditions (for example, maximum and minimum temperatures)
- Amount of belt storage required

The values for takeup travel/movement, in lengthwise direction, listed in the following table are generally suitable for most conveyor applications.

Type of Takeup and Belt Carcass Material in the Lengthwise Direction	Percent of Rated Tension		
	100%	75%	50% or less
Manual Takeup			
Polyester	2.00%	1.75%	1.50%
Nylon	3.00%	3.00%	2.50%
Fiberglass	1.00%	0.75%	0.50%
Automatic Takeup			
Polyester	1.75%	1.50%	1.25%
Nylon	3.00%	2.50%	2.00%
Fiberglass	1.00%	0.75%	0.50%
Steel Cable	0.40%	0.30%	0.20%

A reduction or increase in these values will depend upon factors which include environmental and operating conditions as well as belt selection.

The takeup should also provide sufficient movement to accommodate acceleration or deceleration surges without having the takeup will strike against its stops.

Horizontal and Vertical Curves

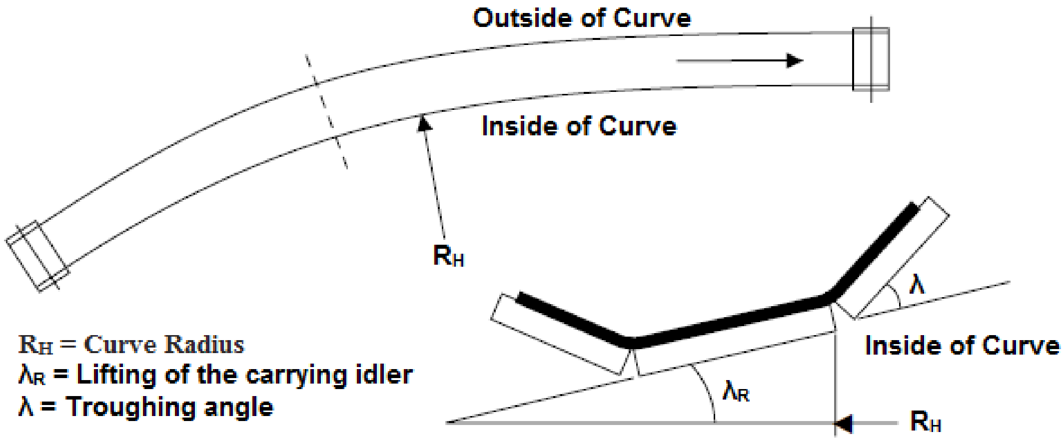
In general, the belt conveyor will connect the feeding point with the discharge point of the material handled in the straightest possible line. The path can also, however, be adapted within certain limits to the given situation for optimum routing by horizontal and vertical curves. In view of this, information on horizontal and vertical curves is given in this chapter.

Horizontal Curves

Belt conveyor systems provide the means of transporting materials via the shortest distance between the required loading and unloading points.

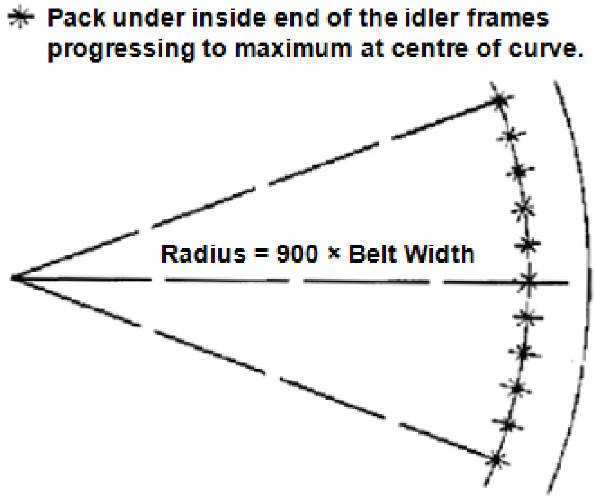
Belt Conveyor with Horizontal Curve

As a conveyor's total length increases, the probability that transfer stations/points will be required to avoid some obstacle in its straight line path also increases. However, now technology has advanced substantially in the design and application of horizontally curved belt conveyors. Hence within limits, horizontal curves eliminate the constraints of the straight line conveyor and reduce the installation and operating cost of the conveyor due to elimination of transfer stations.



Unconstrained Equilibrium in Horizontally Curved Conveyors

As shown in above picture, horizontally curved conveyors use conventional troughed conveyor belts and standard components. However, the tendency of belt tension to pull the belt toward the center of the radius must be protected by tilting the idlers. In these conveyors the loaded and empty belt passes through the carry and return runs of the horizontal curve in unconstrained equilibrium due to lifting of the carrying idlers on the inside of the curve by angle λ_R (approximately 5° to 15°) depending on curve radius and belt tension.



Plan of Typical Horizontal Curve

As shown in above figure, for tilting the carrying idlers, starting at the beginning of the curve, packing should be provided under the end of the idler frames at the inside of the curve. The thickness of this packing should be progressive from say 1 mm at the beginning of the curve to about 75 mm at the centre of the curve, then progressively decreasing to 1 mm again at the end of the curve. This reverse camber effect assists in preventing the belt climbing the idlers towards the centre of the curve. In addition to the reverse camber, forward tilting of the carrying idlers in the direction of belt travel will be also helpful for true running of the belt.

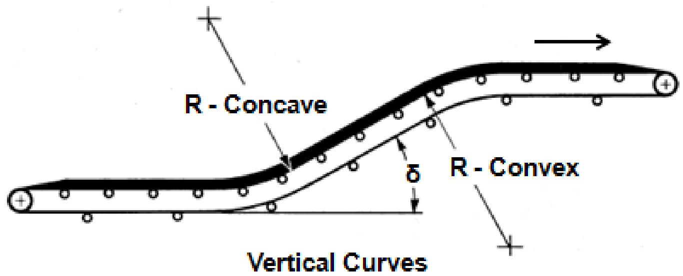
For horizontal curves, the largest possible radius should always be used. However, it is recommended that the minimum allowable radius is 900 x belt width.

It is also recommended that idlers in the transition area are somewhat wider than usual.

Horizontally curved conveyors enhance the reliability, availability and environmental advantages of the standard belt conveyor by eliminating the infrastructure and dust control requirements at transfer stations.

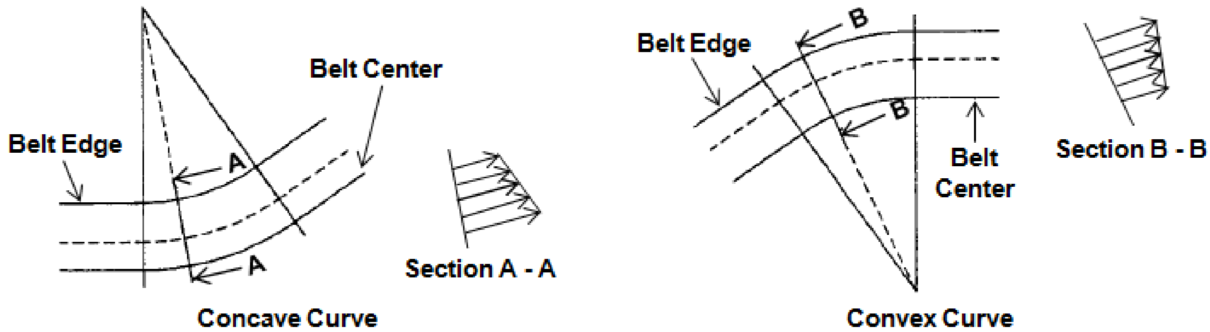
Vertical Curves

Vertical curves are frequently provided for transfer of material to an adjoining belt conveyor. A conveyor will also change inclination at certain points due to layout requirement, for example, with underpasses and overpasses. Both concave and convex curves may arise due to these requirements.



Vertical Curves

As shown in above figure, a conveyor belt is said to pass through a concave vertical curve when the center of curvature lies above the belt. In a concave vertical curve, the belt path goes from horizontal to incline. A conveyor belt is said to pass through a convex vertical curve when the center of curvature lies below the belt. In a convex vertical curve, the belt path goes from incline to horizontal or less inclined.



Stress Redistribution at Curves

A conveyor's curvature results into stretching of belt/carcass on outer radius and contraction of belt/carcass on inner radius. As shown in above figure, this results into redistribution of stress/tension within the belt. The tension redistribution will cause extra tension/mm at outer radius and reduction of tension/mm at inner radius, although total tension remains the same. The presence of extra tension/mm reduces the safety factor in affected portion of the belt. Therefore, the conveyor radius needs to be chosen such that the increased tension/mm does not cross the permitted bare minimum safety factor of the belt, to prevent permanent elongation of the belt and thereby its damage. However, as the belt cannot withstand compression, the reduction in tension at inner radius should not result in to zero or negative tension because the belt portion under negative tension will buckle.

Hence for proper functioning of a conveyor, gradual change in the direction is required. This gradual change in the direction requires selection of adequate radius at the transition point. If adequate radius is not provided, it will result into unreliable performance and reduction in the belt life.

Concave Curves

In case of concave curves, the gravity forces of the belt and the load (if present) tend to hold the belt down on the idlers while the tension in the belt tends to lift it off the idlers. At start-up or load change there may be a risk of the belt lifting off the carrying idlers in this region. This can lead to a reduction in pre-tension. Hence the minimum radius shall be such that the belt will not lift off the carrying or return idlers even under worst condition (when the belt is fully loaded up to the start of the curve and empty thereafter). Any lifting of the belt should be also avoided to prevent spilling/discharge of material from the belt. Smaller radii are permissible if lifting in unloaded state is accepted. However, the empty belt may be held from rising too far by the use of one or more hold down pulleys, installed high enough to clear load when the belt is on the carriers. Use of a heavier belt (increased belt weight) will also help to hold the belt down on the idlers.

The radius of the concave curve is proportional to the belt tension but inversely proportional to the mass of belt per metre. For practical purposes, IS 11592 recommends minimum radius of 45 metres for the concave curves.

With a concave vertical curve, buckling of the belt edges and overstressing of the centre of the belt can occur. Hence the belt design for minimum radius should be checked to avoid them.

Convex Curves

In case of convex curves, the gravity forces of belt and of load (if present), and the belt tension itself, press the belt onto the idlers. As the belt tends to press more at convex curvature, the belt lift-up is not the issue at convex curvature. Contrary the troughing idlers on a convex curve are more heavily loaded by radial pressures from the belt than those idlers not on the curve, and this is taken care by reduced pitch of idlers, if necessary.

When a conveyor belt passes around the convex curve, the stress across the belt is redistributed such that the belt edges, being on a larger radius, are more highly stressed than the belt center where the radius of curvature is less. Due to this, in a convex curve, overstressing of the belt edges and buckling of the centre of the belt can occur. Hence in convex curves, the minimum radius (belt design) should be checked to avoid them.

As per IS 11592, the minimum radius of the convex curves shall not be less than 12 times the width of belt for practical purposes where troughing idlers of 30° troughing angle or less are used.

Minimum radii for convex curves in meters recommended by Dunlop for 3 roll carrying idlers are given in the following table.

Belt Width (mm)	**Trough Angle for Textile Belts**			**Trough Angle for Steel Cord Belts**	
	20°	30°	45°	30°	45°
500	6.5	9.3	13.5	30.0	-
650	8.5	12.5	17.5	40.0	-
800	10.5	15.0	21.0	48.5	68.5
1000	13.0	19.5	27.0	62.0	88.0
1200	16.0	23.0	32.0	74.5	104.0
1400	18.5	27.0	38.0	87.0	123.0
1600	21.0	31.0	44.0	100.0	141.0
1800	24.0	35.0	50.0	113.0	160.0
2000	26.5	39.0	55.0	125.0	177.0
2200	30.0	44.0	62.0	140.0	198.0

The chances of belt fold-up are more for thin belt and deep trough idlers. Belt design should be checked to prevent the buckling in such cases.

As per Metso Minerals (Internet: www.metsominerals.com), for textile conveyor belts, standard values for minimum curve radii in mm should be as per the following table.

Troughing Angle in Degree	20	25	30	35	40	45
Concave Curve Radii in mm	14×B	17×B	21×B	24×B	27×B	30×B
Convex Curve Radii in mm	20×B	30×B	40×B	45×B	50×B	55×B

B = Belt width in mm

Idler Spacing on Curves (Convex or Concave)

As per IS 11592, following points shall be taken into consideration:

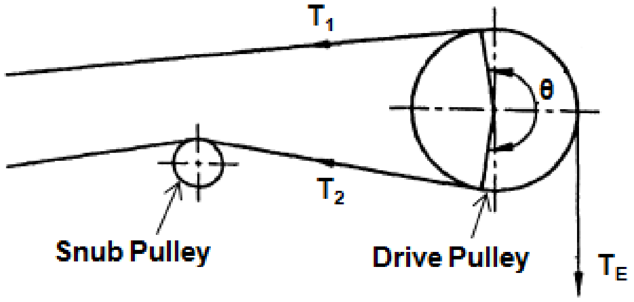
- The spacing of the idlers on concave curves shall be normal spacing, and for convex curves, it shall be 40 to 50 percent of the normal spacing of the idlers or if the spacing is variable, the spacing on that part of the length of conveyor.

- The number of idler spacing shall not be less than three for any type of curves.

Conveyor Drive Selection

Information about selection of a drive type for a conveyor is given in this chapter.

In belt conveyor, the driving force / tractive pull to draw the belt with load is transmitted to the belt by friction between the belt and the driving pulley.



Tensile Forces Exerted on a Belt

Above figure shows tensile forces exerted on a belt where,

T_1 = Tension in a belt, at entry side of drive pulley (just prior to reaching the pulley)
T_2 = Tension in a belt, at leaving side of drive pulley (immediately after leaving the pulley)
T_E = Driving force / tractive pull (effective tension) applied on the drive pulley
θ = Angle of wrap in radian
μ = Coefficient of friction between belt and drive pulley surface
e = The base of Naperian logarithms

At any time or during any dynamic condition of operation for positive power, following rule (Euler's law of friction drive) applies for no slip between belt and the drive pulley:

$T_E = T_1 - T_2$
$T_1/T_2 \leq e^{\mu\theta}$

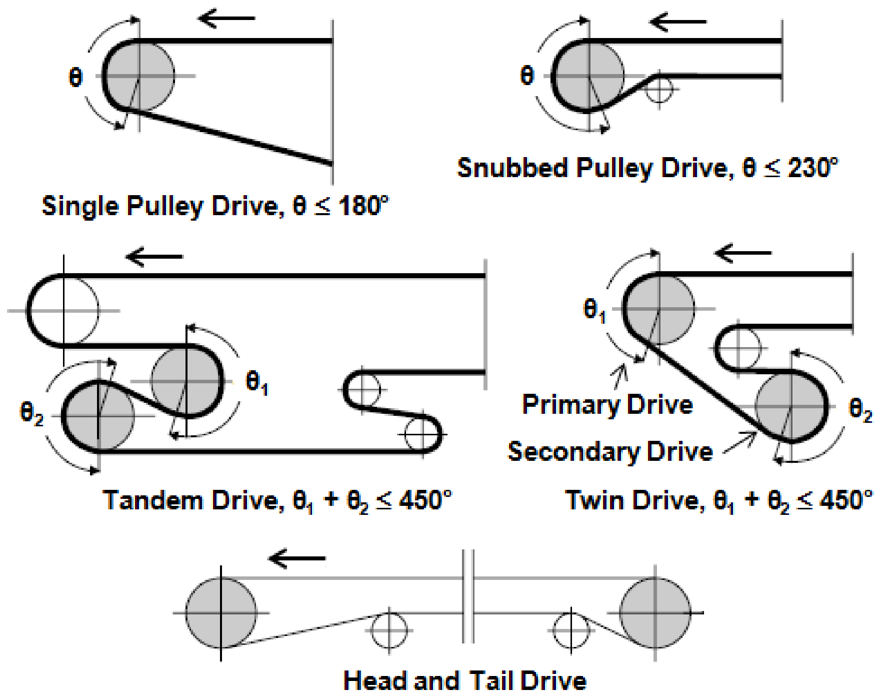
Above basic relation between T_1 and T_2 also results into following additional formulae for T_2:

$$T_2 \geq \left(\frac{1}{e^{\mu\theta} - 1} \right) T_E \qquad \therefore\ T_2 \geq C\, T_E \qquad \text{Where } C = \left(\frac{1}{e^{\mu\theta} - 1} \right)$$

Hence, to reduce the maximum tension (T_1) in the belt to reduce cost of a conveyor belt, selection of the drive shall be carried out for the optimum value of T_2 by selecting optimum values of μ and θ.

The coefficient of friction (μ) between belt and drive pulley surface depends upon material of belt cover, material of pulley surface and operating condition (dry condition, clean and wet condition or wet and dirty condition). Hence, the drive pulleys may be lagged, wherever necessary, to increase the coefficient of friction between the belt and the drive pulley.

The selection of angle of wrap (θ) for a drive may be carried out as under.



Drive Arrangements

Above figure shows various types of drive arrangements.

Single, Unsnubbed, Bare/Lagged Pulley Drive

The simplest drive arrangement consists of one steel pulley connected to the source of power, having belt wrapped around it with an arc ≤ 180°. This can be used for low capacity, short centre conveyors handling nonabrasive material. The pulley may be lagged to increase the coefficient of friction and avoid pulley wear for abrasive materials.

Snubbed, Bare/Lagged Pulley Drive

The ratio of maximum belt tension (T_1) to effective belt tension (T_E) for the drive is decreased by snubbing the belt at drive pulley which may be bare or lagged. The arc of contact is increased from 180° to 230° by providing snub pulley. In majority of normal medium to large capacity belt conveyors, handling mild abrasive to fairly abrasive materials, 210° snub pulley drive with head pulley lagged with hard rubber is adopted.

Tandem Drive

Where the belt tensile forces are very high and it is necessary to increase the angle of arc of contact, tandem drives are used.

The tandem pulleys are both driven and share the load resulting in a lower effective tension for a given power transmitted. The tandem drive with arc of contact from 300° to 440° or more can function with one or two motors. The location of such drive is usually determined by the physical requirements of the plant and its accessibility.

Twin Drive

A twin drive consists of two pulleys of identical overall diameters each being independently driven.

The driving motors shall be of the same type and have the same torque/speed characteristics, as also shall be of the case with fluid couplings, when these are fitted.

In practice, the two drives will not share equally, there being a small difference in power due to the contraction of the belt in drive head causing the secondary pulley to revolve at a lower speed than the primary pulley. The difference in speed will be a function of the belt tensions related to the stretch characteristics of the belt and is normally well within the slip characteristics of either the electric motors or fluid couplings (when these are fitted).

With this type of drive, the distance between the two drive pulleys is not fixed as in the case of geared tandem drive and the extent of separation is not critical, although practical considerations such as mounting and housing usually make it convenient to have the two drive units reasonably close together. The scope of having a greater length of belt between the two drive pulleys, than is possible with geared tandem drive, makes for greater flexibility in absorbing the effect of belt contraction or creep. Also the greater flexibility of layout of dual drives normally makes it possible to reeve the belt in such a way that the non-carrying or clean side of the belt is in contact with both drive pulleys, thus eliminating the likelihood of difficulty due to material built-up on the face of the pulleys. In twin drive, drive units should be arranged such that both drive pulleys drive on the clear side of the belt.

Head and Tail Drive

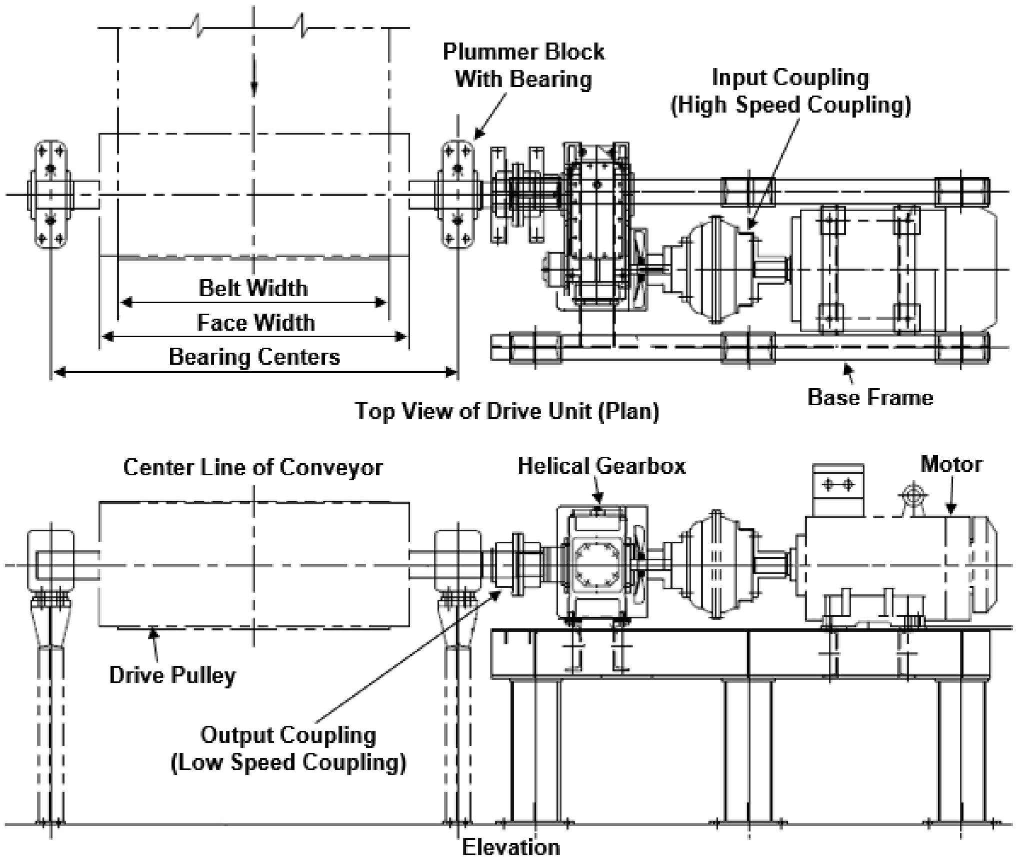
Drives at the head and the tail may be used for relatively long installations, reversible drives or where high return side resistance can occur.

Drive Units and Gearboxes

Conveyor includes one or more number of drive units to provide mechanical power for operating the conveyor. The drive unit gives running torque to drive pulley which results into tractive pull for belt.

The drive unit for a conveyor will generally comprise of electric motor, speed reduction gearbox, couplings, holdback, brake, safety guards and a common fabricated and machined base frame for supporting above components in a single assembly. Brief information about drive unit and gearboxes is given in this chapter.

Following figure shows typical drive unit with helical gearbox.



Drive Unit with Helical Gearbox

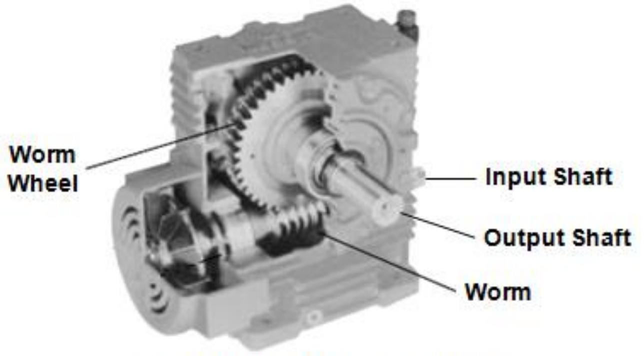
Gearboxes

The drive unit for belt conveyor always needs speed reduction gearbox because the drive pulley rpm is much less compared to motor rpm. Normally the gearboxes are of helical type. The gears are case hardened and ground. The lubrication of the gear pairs is by bath immersion whereas the antifriction bearings are splash lubricated. The gearbox casing is split at the axle centre so that all components are easily accessible when the top half of the casing is removed. Lifting lugs, breather and oil level gauge are provided. Various types of gearboxes used for conveyor drives are as under.

Foot Mounted Worm Gearbox

This is an economical gearbox used for general purpose small kW conveyors. The characteristic features of such gearboxes are as under.

- The input shaft and output shaft are at right angle to each other, which needs minimum space for installation.
- The mechanical efficiency of transmission is low, in the range of 80% to 90%.
- The worm and worm wheel has self-locking feature i.e. motion can be transmitted from input shaft to output shaft, but not in reverse direction. The self-locking is partial for low ratio but 100% for higher ratios. This prevents roll back of incline conveyor. Hence, it eliminates need for hold back, or reduces its size.



Foot Mounted Worm Gearbox

Above figure shows parts of a foot mounted worm gearbox. Generally, the materials of construction for the parts are as under.

Worm: casehardening alloy steel
Worm wheel: phosphor-bronze PB2-C as per British Standard B.S. 1400
Gear case: C. I. grade FG 220 and FG 250 (for heavy duty) as per Indian Standard IS 210.

Generally large worm wheels are made of centrifugally cast phosphor-bronze rim, shrink fitted and brazed to C.I. centers. Where the duties demand, rims are welded to steel centers.

In view of low mechanical efficiency of transmission, present trend is to use planetary gearboxes instead of worm gearboxes.

Hollow Output Shaft Worm Gearbox


Hollow Output Shaft Worm Gearbox

As shown in above figure, this type of gearbox has hollow output shaft to suit mounting on the end of the drive pulley shaft. Hence it does not require output coupling.

It also has self-locking feature which is common for worm gear unit.

Horizontal Foot Mounted Geared Motor

As shown in the following figure, in such type of drive, motor and gear box forms a single compact unit. It eliminates need for an input coupling.

Horizontal Foot Mounted Worm Geared Motor

Though above figure shows a worm geared motor, helical geared motors are also available. A helical geared motor will be more efficient as compared to worm geared motor.

Since the drive does not permit use of fluid coupling because input coupling is absent, such units are used for small to medium kW drives.

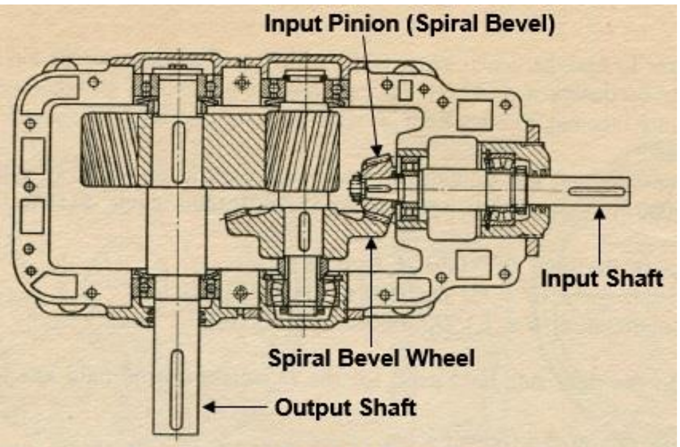
Parallel Shaft Helical Gearbox

Parallel Shaft Helical Gearbox

Above figure shows construction of a typical foot mounted parallel shaft helical gearbox. The parallel shaft helical gearboxes are the first choice for heavy duty high kW conveyors. These gearboxes are widely used for big size drives. Their characteristics features are as under.

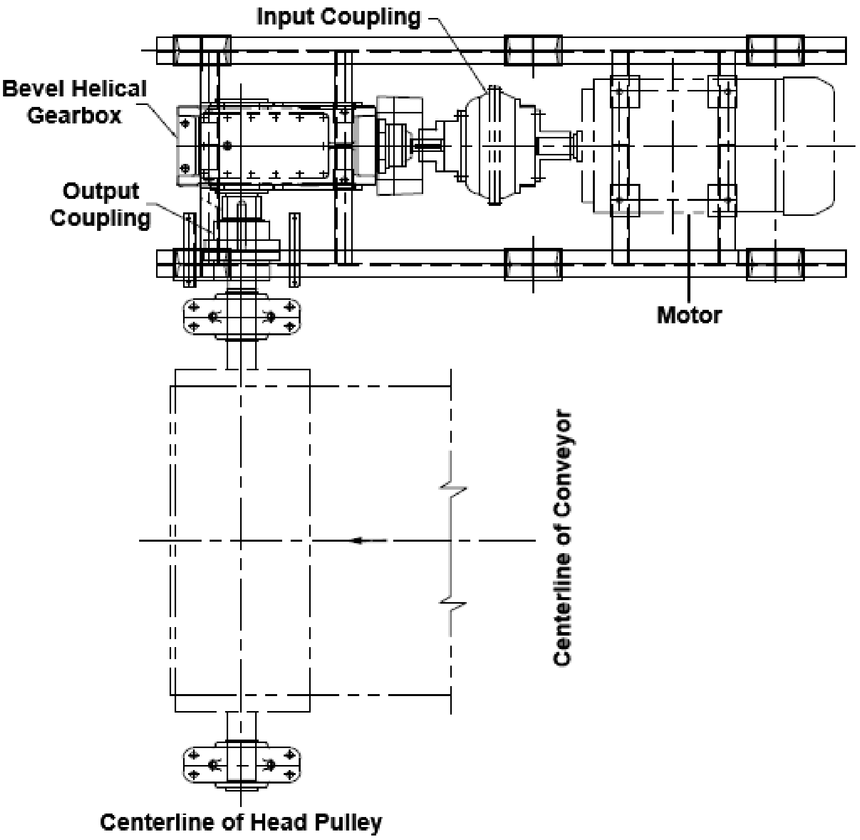
- It has high efficiency for mechanical power transmission (about 99% for single reduction helical drive and 98% for double reduction helical drive).
- It allows easy mounting of internal hold back.
- The horizontal split type casing enables access to all Internals by removing only the top casing, without disturbing the drive installation.

Bevel Helical Gearbox (Foot Mounted)



Bevel Helical Gearbox (Foot Mounted)

Above figure shows cross sectional view of a bevel helical gearbox. Bevel helical gearbox, also known as right angel shaft helical gearbox, is used in place of parallel shaft helical gearbox where space is restricted and compact arrangement is needed as shown in the following figure.



Use of Bevel Helical Gearbox for Compact Arrangement

In such gearboxes the first pair of gearing is bevel type and all other subsequent gearing pairs are of helical type.

However, the efficiency for mechanical power transmission is slightly low as compared to helical gear box (about 98 % for single reduction bevel drive and 97.5 % for double reduction bevel helical drive).

Capacity

The actual gear drive capacity is determined by either the lowest rated mechanical component or by its thermal rating. Thermal rating is defined as the maximum power that can be continuously transmitted through the gear drive while not exceeding a specified sump temperature. Gear drives rated to American Gear Manufacturers Association (AGMA) standards allow a maximum of 200°F sump temperature.

Reducer/gearbox selection is made based on an "equivalent power rating" which is calculated by multiplying the prime mover rated power by a service factor. The speed reducer must have a mechanical rating capacity equal to or higher than the equivalent power rating and a thermal rating (without service factor) higher than the application power. Typical service factors are provided in the following table.

Typical Service Factors for Speed Reducers in Conveyor Applications			
Loading	**0 to 3 hrs./day**	**3 to 10 hrs./day**	**More than 10 hrs./day**
Uniform	1	1	1.25
Heavy Duty	1	1.25	1.5
Severe	1.5	1.75	2

Gearbox Life

It has been said that a gear wears out until it wears in after which it never wears out. That is, after a gear has worn in during initial start-up period, it will have an indefinite life, provided it is properly lubricated with a clean lubricant of the proper viscosity and film strength (by periodically changing lubricant), and operating within its rated capacity. However, the fast wearing items like radial shaft seals (oil seals) and bearings will need early replacement.

Note:
For information on maintenance of gearboxes, please see the booklet titled "fundamentals, selection, installation and maintenance of gearboxes (gear drives) - Part 2" uploaded at www.practicalmaintenance.net.

Couplings

The coupling between motor and gearbox input side is called input coupling or high speed coupling (because it is located at input side of gearbox and is rotating at higher speed compare to other coupling). The coupling between gearbox and drive pulley is called out put coupling or slow speed coupling. The term high speed coupling or slow speed coupling is for identification purpose only and the term itself does not signify any difference in type of coupling

The input coupling can be of flexible type or fluid type. Generally flexible coupling of pin and bush type or resilient grid type is provided for drive power up to 30 kW. Fluid coupling is provided for drive power above 30 kW. The output coupling is always flexible type (mostly gear type). The input coupling may also have Integral brake drum when the conveyor is provided with brake. The brake is always located at input side of gearbox, because its higher speed enables to absorb kinetic energy of conveyor with smaller force, and thereby smaller brake.

A flexible coupling is necessary because it is not practical to achieve and maintain 100% alignment of shafts to be connected. Minor misalignment can creep in during installation, operation and maintenance or due to settlement / deformation of supporting structures. The fluid coupling, when used as high speed coupling, is also having in-built flexible coupling to compensate for misalignments.

Conveyor Belt Cleaners

Many bulk materials conveyed on belts are somewhat sticky. Hence, some of this material will adhere to the conveying surface of the belt and not discharge with the rest of the load at the unloading point. The residual material is carried back on the return run. As the material gets dry or gets dislodged by the vibration of the return rollers, it falls off the belt, at various points along the belt line to cause housekeeping and maintenance problems. Considerable expense will be required in a never-ending cleanup of this carryback. The carryback also leads to excessive wear, buildup on return idlers resulting in misalignment of the belt, and possible damage to the belt by forcing the belt against some part of the supporting structure. In addition, accumulation of material on the ground or clouds of dust in the air can present a health and safety hazard. Therefore, it is desirable to clean the belt.

A conveyor belt cleaner is any accessory used to remove material adhering to the carrying side of a conveyor belt after the normal point of material discharge. Information about various types of conveyor belt cleaners is given in this article.

Note: For damp and sticky materials, belts with anti-stick coating (e.g. ContiClean® A-H) and simple cleaning method may be considered instead of costly cleaning systems.

Design Considerations and Recommendations

Each conveyor discharge point should be designed to readily accommodate at least one conveyor belt cleaner and be designed to accommodate, with minor modifications, additional cleaners in the future.

The foremost requirement of cleaner design is that it must minimize the risk of damage to the belt, splice or cleaner itself. It would defeat the purpose if a cleaner that is installed to enhance conveyor performance damages the belt.

It is important that cleaners be installed out of the flow of the main material body and that the cleaned materials cannot adhere to the blades and structure. Cleaners should be located at or near a point where the belt is supported by a pulley, pressure roller or other device to prevent the belt from being forced up by the cleaning action (resulting in less effective cleaning).

The conveyor discharge chute should be designed so that the carryback cleaned from the cleaners will fall by gravity onto the receiving belt or chute. If such design is not possible, a mechanical method to ensure flow of cleaned carryback onto the receiving belt or chute should be included in the design.

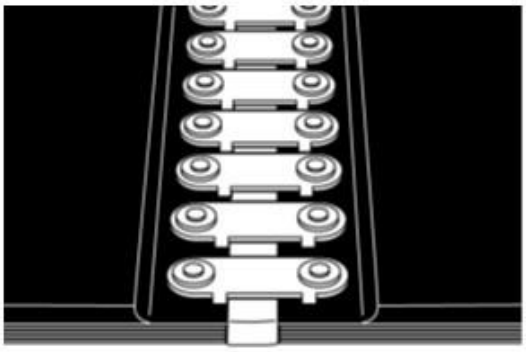
The mounting of belt cleaners is often made difficult or less than ideal because the basic spacing and support requirements have not been considered in sizing of the chute or conveyor structure. Because there are a wide variety of belt cleaner designs available it is recommended that the belt cleaner manufacturer is consulted during the design of a system so that adequate structural support is provided.

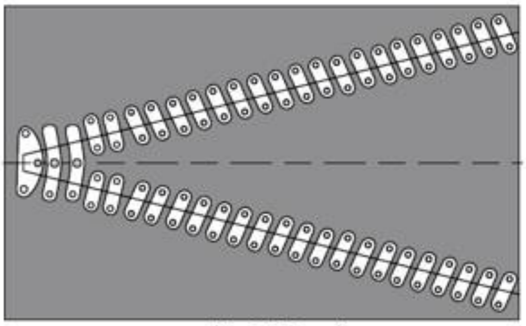
Blade cleaners are passive systems. To function, they require no drive mechanism. However, they require an energy source - a counter weight, spring, compressed air reservoir or twisted rubber band to hold the cleaning edge against the belt. The blade element that directly contacts the belt is subject to abrasive wear and must be readjusted or replaced at installation-specific time intervals to maintain cleaning performance as per manufacturer's instructions.

All tensioning systems should be designed to allow the cleaning edge to relieve itself away from the belt if obstructed.

The conveyor discharge chute and access platforms should be designed to allow for convenient installation and service of the belt cleaners.

The use of vulcanized or recessed mechanical splices on the belt improves cleaning. Improperly installed or worn splices can catch on the cleaners and cause them to jump and vibrate or "chatter".


Recessed Mechanical Splice



V-shaped Mechanical Splice

Cleaner Friendly Mechanical Splices

As shown in above figure, if mechanical splices are used, they should be recessed as per the supplier’s recommendations. In addition, the belt cleaner mount should incorporate some relief mechanism that allows the blades to be pushed momentarily away from the belt and then return to cleaning position. Diagonal or V-shaped mechanical splices can increase the life of the mechanical splice and improve the performance of the belt cleaner since the blade will not contact the splice all at one time.

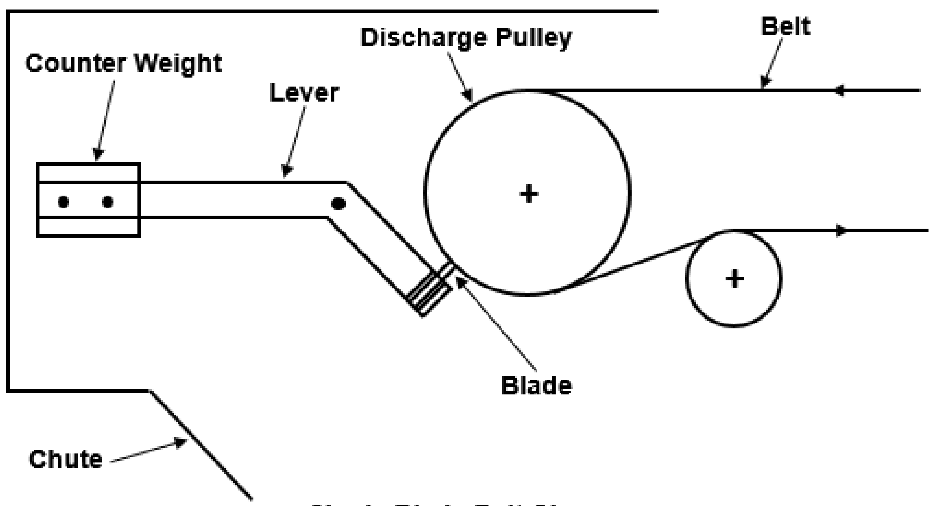
Typically, cleaners are made with blades that are not the full width of the belt. The difference in width does not affect cleaning performance because the full width of the belt is not typically used to carry material.

Selecting a belt cleaner for a particular application requires the assessment of a number of factors. These factors including belt condition, belt splices, belt speed, bulk material, ambient temperature, material size, and moisture content. To reduce the cost of production, there is a trend in industry to use lower cost materials with higher contents of fines. As the quality of the bulk material deteriorates, the problems of belt cleaning increase and therefore the need for more attention to belt cleaning. In view of this, it is important to design the belt cleaning systems for the problems created by the "worst" material conditions instead of the "ideal" or even "normal" operating conditions. If the belt cleaning system is designed for the "worst" material conditions, the cleaning system will be better able to cope with changes in the material without becoming totally ineffective.

Belt cleaners of various types are available to suit the material being conveyed and users' preferences. Information on them is given in the following sections.

Conventional Belt Cleaner

Typically, these are some form of scraper or wiper device mounted at or near the discharge pulley to remove the residual fines that adhere to the belt as it passes around the head pulley.



Single Blade Belt Cleaner

Above figure shows construction of a single blade belt cleaner (scraper).

The cleaner has single blade, generally of rubber, which is pressed against belt by counter weight and lever assembly. The blade scraps off the material particles from belt surface. The material being removed by scraper merges with the main material flow into the chute.

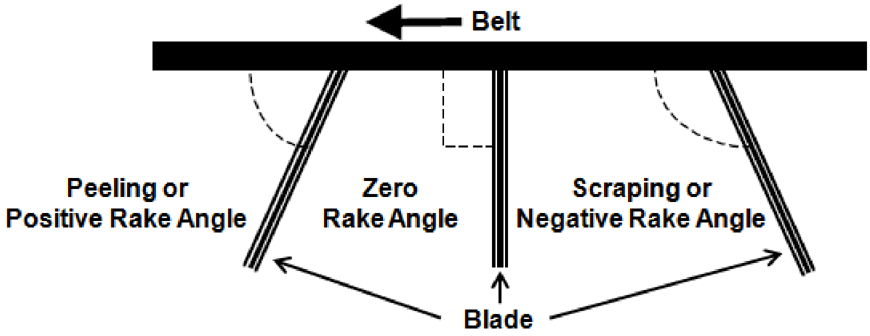
However, conventional external belt cleaners are generally ineffective, at least over the long term.

Engineered Belt Cleaners

Engineered belt cleaners are designed to be more effective, provide longer service life and reduce maintenance requirements by incorporating the use of advanced materials such as plastics, ceramics and tungsten carbide, and improvements in the tensioning devices to hold the cleaning edge against the belt. Information on working of engineered belt cleaners is given in this section.

Peeling vs. Scraping

The angle of attack of the cleaning blades against the belt is called belt cleaning angle. Following figure shows various cleaning angles.



Belt Cleaning Angles

Generally speaking, there are two alternatives: peeling blades and scraping blades. With peeling, the blades are opposed to the direction of belt travel whereas in scraping, the blades are inclined in the direction of travel, typically at an angle of 3 to 15 degrees from the vertical. Each design has its advocates.

Metal blades in a peeling position are quickly honed to razor sharpness by the moving belt and can do expensive damage if they are knocked out of alignment. Peeling blades are also subject to high-frequency vibration that causes the blades to “chatter,” repeatedly jabbing the sharpened edges into the belt cover.

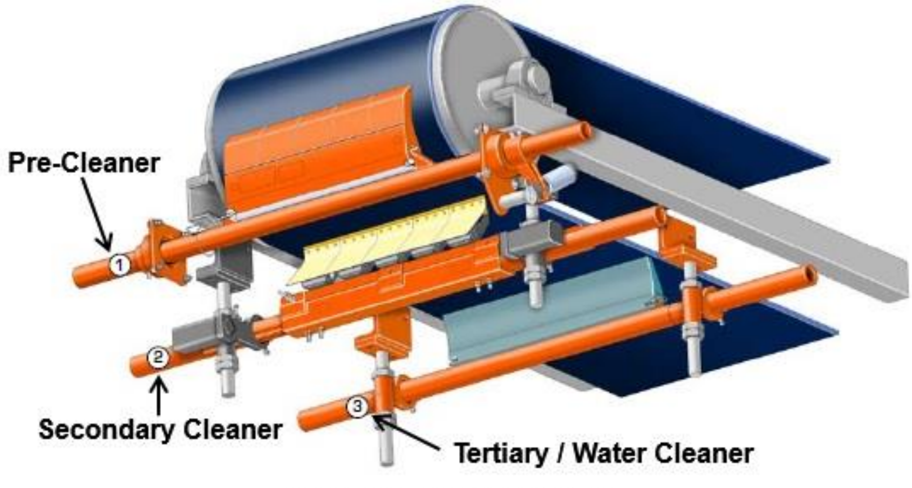
Scraping blades allow material to build up on the inclined cleaning edge, which can pull the blade away from effective cleaning contact. With a scraping blade, the upstream edges of the cleaning blade will not bite into the belt surface, even if held against the belt with excess pressure.

A general opinion is that the peeling angle is acceptable for primary cleaners, which are applied at very low pressures against the belt due to their position and their construction. However, it is advisable to use blades in a scraping position in secondary cleaners, where higher blade-to-belt cleaning pressures and metal blades present more risk to the belt, splice, and cleaner itself.

Systems Approach to Belt Cleaning

Since more than one “pass” (more than one time cleaning) at the belt must be made to effectively remove carryback material, engineered belt cleaners follow systems approach to belt cleaning - multiple cleaning systems.

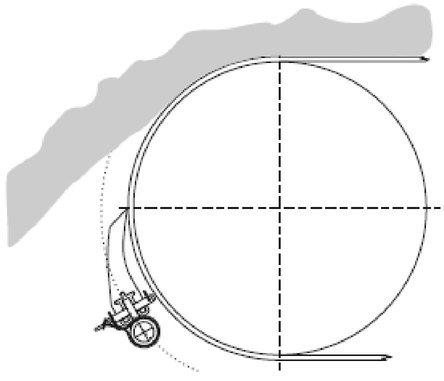
The phrase multiple cleaning systems could refer to any combination, ranging from the commonly seen pre-cleaner and secondary cleaner system to more sophisticated systems that include a pre-cleaner and one or several secondary cleaners, and/or a tertiary cleaner of yet another type. These could possibly be combined with a belt “wash box,” incorporating sprayed water and wipers for “squeegee” belt drying.



Multiple Cleaning System

Above figure shows a multiple cleaning system consisting of three types of belt cleaners.

A **pre-cleaner**, sometimes called the primary cleaner is used for removing the heavy residue of materials adhering to the belt surface, leaving behind only a thin skim of fines. This controls the amount of carryback that reaches the secondary cleaner(s), protecting them from being overloaded by a flood of material.



Location of Pre-Cleaner

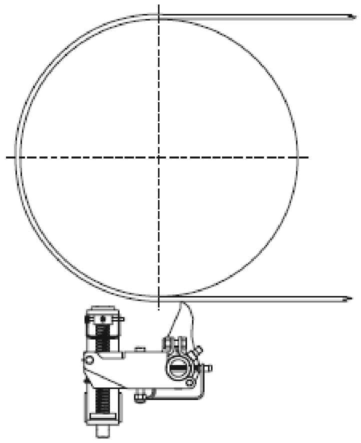
As shown in above figure, the pre-cleaner, is generally installed on the face of the head pulley just below the trajectory of the material discharging from the belt. This position allows the material removed from the belt to fall in the discharge chute with the main cargo as it leaves the belt.

This places the pre-cleaner blade in a peeling position, inclined against the movement of the belt and pulley at an angle between 30 to 45 degrees. Use of this low angle of attack, in combination with elastomer pre-cleaner blades applied with light pressure against the belt, results in low wear rates for both the blade and the belt surface.

To minimize the risk to belt, splice, and cleaner from even a lightly tensioned blade in a peeling position, pre-cleaners should always use resilient urethane or rubber blades (rather than metal) and be only lightly tensioned (about 2 psi) against the belt.

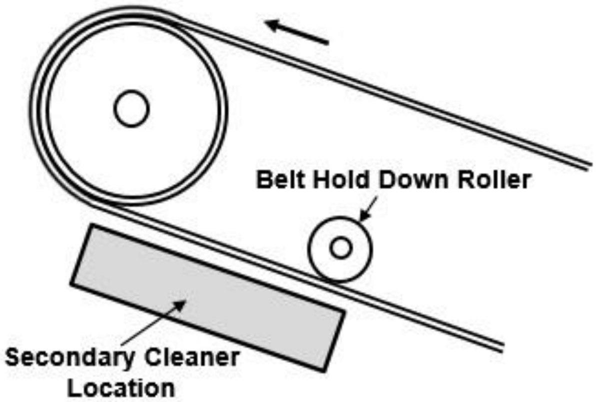
Due to low blade-to-belt pressure, the tensioning system will be able to relieve/bounce the blade away from the belt when a splice or obstruction moves past the cleaning edge to reduce the risk of damage.

Secondary cleaners are designed to remove the remainder of material, the sticky fines that have passed under the blade of the pre-cleaner.



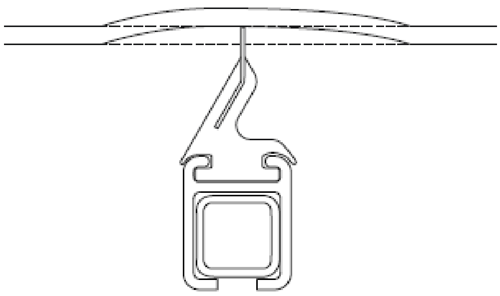
Best Location for Secondary Cleaner

The positioning of the secondary cleaner(s) is important. As shown in above figure, it is best to place the secondary cleaner blades in contact with the belt while the belt is still against the head pulley. This allows the secondary cleaner (or the initial secondary cleaner, if more than one are used) to scrape against a firm surface for more effective material removal.



Second Location for Secondary Cleaner

As shown in above figure, the second most practical location for secondary cleaners is the space between where the belt leaves the head pulley and where it contacts the first snub pulley, bend pulley or return idler.


Cleaner Location which can alter Belt's Line of Travel

As shown in above figure, if a secondary cleaner is installed in a position where its pressure against the belt changes the belt's line of travel, cleaning performance will be ineffective. In this case, increasing the applied pressure will only serve to change the line more and wear components faster, without improving cleaning performance.

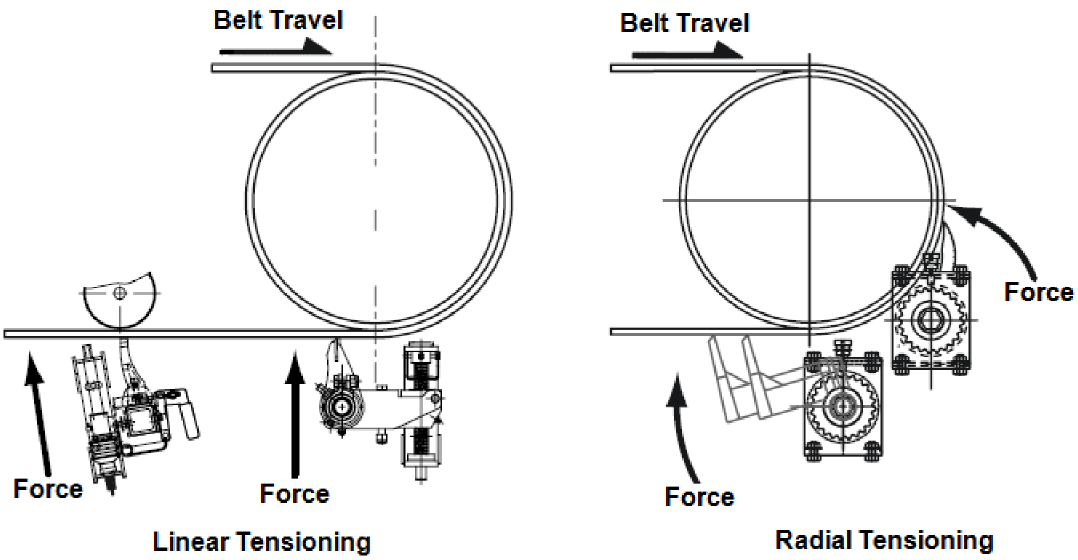
The blades for cleaners used in the secondary location are often made of a hard material such as tool steel or tungsten carbide. Some designers prefer to avoid the application of a metal blade against the belt, so urethane or rubber is also used.

The angle of the blade against the belt in a secondary cleaning location is an important consideration. A scraping or perpendicular angle is often used for metal bladed cleaner at secondary location because metal blades in the peeling position are quickly honed to extreme sharpness. Testing has indicated that an angle of 7 to 15 degrees in the direction of belt travel (scraping) maintains cleaning efficiency while allowing easier splice passage. Rubber and urethane bladed cleaners used in the secondary location are usually positioned perpendicular to the belt.

Because this cleaner must be as efficient as possible, the blade must mate evenly with the belt. The moving belt does not present a consistent and uniform surface. There are peaks and valleys that the cleaner must adjust to instantly. Narrow, independent blades that are individually suspended have the best potential to remain in precise contact as the belt surface passes across the cleaning edge. Research indicates that a design using multiple blades approximately six to eight inches (150 to 200 mm) wide is well suited for effective cleaning.

In some cases, it is desirable to clean the belt in a position other than the primary or secondary location. This is often the case with wash boxes and specialty cleaners at other locations (called tertiary location). Many times only **water cleaner** made of soft urethane blade is used for squeegeeing the belt for effective removal of residual material and moisture from the grooves and cuts in cover, drying the belt.

Linear or Radial Adjustment



Ways to Adjust Belt Cleaners

As shown in above figure, there are two ways for belt cleaner adjustment/tensioning. The linear-adjusted cleaners are pushed up (in a line) against the belt whereas the radially adjusted cleaners are installed with a mainframe as an axis and rotated into position.

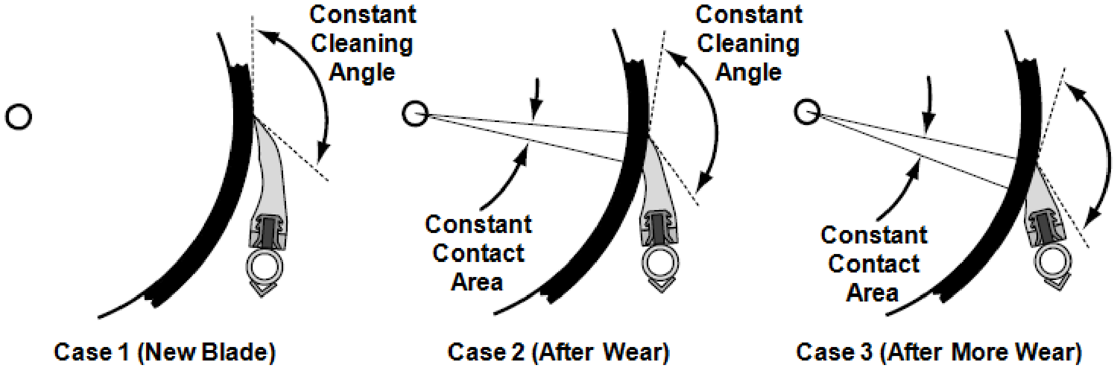
Radially-adjusted cleaners have several practical advantages over the linear design. They are easier to install, can be adjusted from one side of the belt, and can more readily rotate away from the belt to absorb the shock inherent in belt motion and splice passage.

However, linear-adjusted cleaners have one advantage. The cleaning angle (the angle at which the blade sits against the belt) remains constant. The blade remains positioned at the same cleaning angle, regardless of the state of blade wear. Without prejudice to which type of cleaner is the best choice, it is obvious that a radially-adjusted cleaner can work at maximum efficiency for only a portion of its blade life.

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

To overcome the problem with changing blade angle, one design in radially-adjusted belt cleaners incorporates a curved blade. This design is termed “CARP”, for Constant Angle Radial Pressure.

As shown in the following figure, designs incorporating CARP technology feature a curved blade designed so that as the blade wears, the blade maintains the same angle against the belt. In addition to maintaining cleaner efficiency, this design also eliminates such problems as vibration or “chatter” stemming from incorrect cleaning angles and the over tensioning of worn cleaner blades.



Constant Angle Blade Design

A new cleaner blade has a small contact area on the belt. Blades are usually designed with a “point” to allow them to “wear in” quickly to achieve a good fit to the belt, regardless of the head pulley diameter. Typically, as cleaner blades wear, the surface area of the blade touching the belt increases. This causes cleaner efficiency to decline because of the relative reduction in blade-to-belt pressure. Therefore, the system’s tensioner requires adjustment (retensioning) to provide the additional pressure per square inch of belt contact area for consistent cleaning performance. It would be better to design cleaners that do not suffer from this gradual increase of blade-to-belt area. The CARP principle cited above has also proved capable of minimizing the change in area throughout a blade’s wear life. It can be seen in above figure that after initial wear, contact area remains constant in case 2 (after wear) and case 3 (after more wear).

Optimal Cleaning Pressure

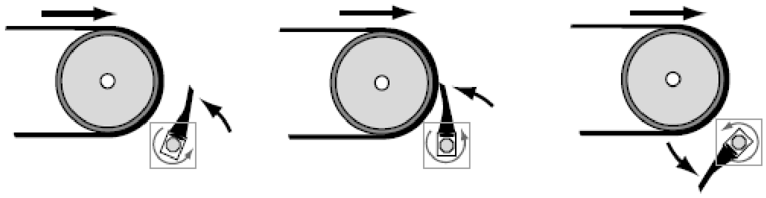
A key factor in the performance of any cleaning system is the ability to sustain the force required to keep the cleaning edge against the belt. Blade-to-belt pressure must be controlled to achieve optimal cleaning with a minimal rate of blade wear. Many people have the misconception that the harder you tension the cleaner against the belt, the better it will clean. Research has demonstrated - this is not true.

In a study, it was found that the amount of both carryback and blade wear decrease with increasing blade pressure until an optimum blade pressure is reached. The study established this optimum blade-to-belt pressure to be 11 to 14 psi (76 to 97 kPa) of blade-to-belt contact. Increasing pressure beyond the 11 to 14 psi (76 to 97 kPa) range raises blade-to-belt friction, thus shortening blade life, increasing belt wear, and increasing power consumption without providing any improvement in cleaning performance.

Tensioning Systems

Blade-to-belt cleaning pressure is maintained by some form of tensioning device. The choice for a given installation depends on conveyor and cleaner specifications and plant preferences.

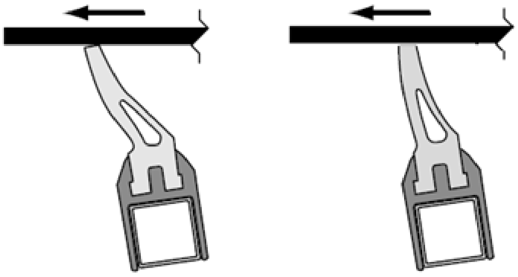
All tensioning systems should be designed to allow the cleaning edge to relieve itself away from the belt (temporary self-relieving) to allow passage of mechanical splices and other obstructions.



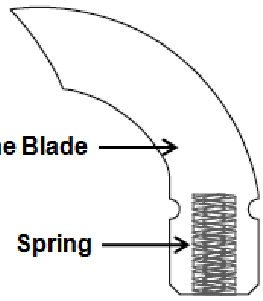
Self-Relieving of Tensioner

As shown in above figure, to minimize the risk of damage or injury, tensioners should self-relieve, automatically uncoupling if the blades "pull through." by obstructions or holes in the belt.

As shown in the following figure, many times flexed urethane blades use the resilience of the urethane to supply cleaning pressure.


Flexed Urethane Blade Tensioner

When installed, these blades are deflected by being forced against the belt. As the blade wears, it "stands taller" to maintain cleaning pressure. Because the blade itself supplies both cleaning pressure and shock-absorbing capacity, the cleaner does not need a conventional tensioner. Instead, the blade assembly is forced against the belt, and the mainframe is locked into position.



Spring Molded Urethane Blade

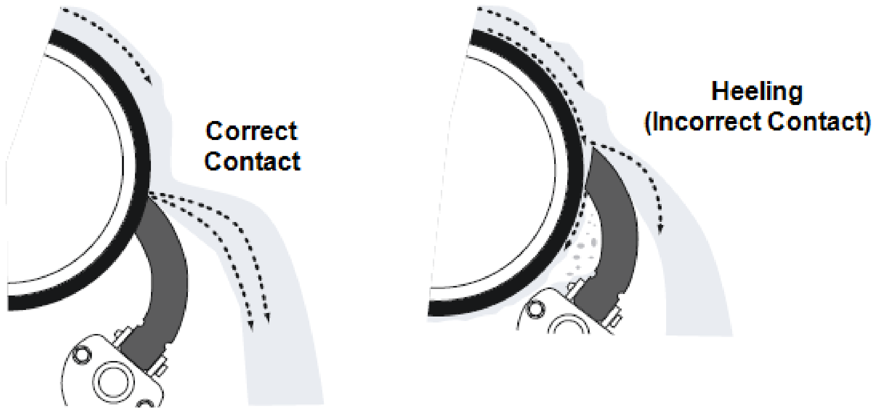
As shown in above figure, many times a spring is molded inside the urethane blade which allows the cleaner to maintain cleaning pressure over the entire life of the blade and virtually eliminate the need to retension the cleaner to maintain cleaning performance.

Testing indicates that a cleaning edge composed of narrow, independently-suspended blades will stay against the belt's surface a higher percentage of the time than a single "slab" blade. A single blade must be constructed to resist the forces of its total surface contact. A multiple-blade design with individual spring or elastomer support will keep each blade in proper cleaning tension against the belt, yet allow each individual blade to yield to a lower pressure than the tensioning device's total applied force. In other words, narrow blades can match up better against the belt, follow changes in surface contour, bounce away from the belt for splice passage, and return more easily than a single, continuous blade. This means a proper multiple blade design is more efficient and safer for the cleaner, the belt, and the operator.

Cleaner Installation

Regardless of the make of a belt cleaner the critical factor in cleaner installation is that the center of the cleaner mainframe must be installed at the correct distance from the face of the pulley. Maintaining the proper dimension places the blades at the correct angle of attack against the belt for best cleaning, proper blade wear, and longest life.

Hence it is recommended to follow manufacturer's installation or operator's manual for belt cleaner installation instructions.



Heeling Due to Installing Pre-Cleaner Too Closely

Many problems can occur when a pre-cleaner blade is mounted too close to a belt. As shown in above figure, if the pre-cleaner blade has a flat or curved contact surface, a cleaner mounted too close will cause the heel of the blade to contact the belt first. This "heeling" creates a gap along the leading edge of the blade. Material will collect in this gap to the extent that the accumulation will force the blade away from the belt. Once the blade is forced away from the belt, large amounts of material will pass between the belt and the blade. This greatly decreases cleaning efficiency. The passage of this amount of material will also cause the blade to wear much faster.

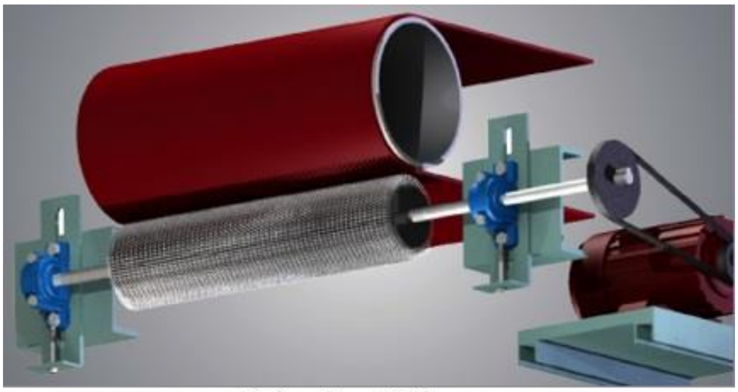
A cleaner will not clean sufficiently, if its blade is not centered on the belt (cleaner width is usually smaller than belt width).

Note:

Strips of belting should not be used for belt cleaning because there may be embedded fines of abrasive material caught in the belt carcass, which can cause excessive wear of the moving belt.

Rotary Brush Cleaners

Rotary brush cleaners are used to solve the carryback problem in belts handling hot materials like Clinker, Coke, Alumina and other fine powdery substances which are susceptible to thermal cracks, resulting in fine powder getting stuck between the cracks, and falling throughout the length of the conveyor.



Rotary Brush Cleaner

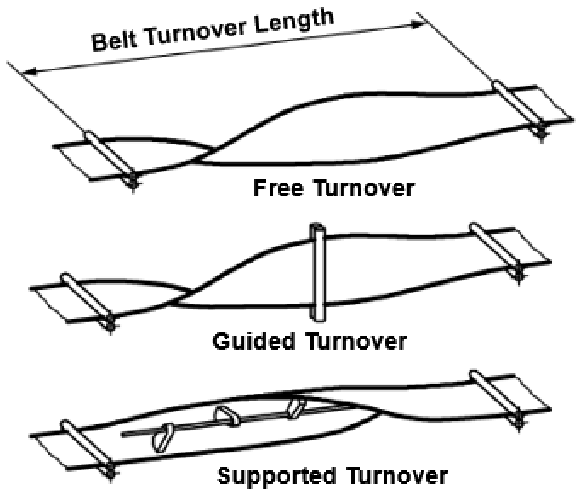
These cleaners could be free-wheeling (turned by the motion of the belt) or driven by an electric motor as shown in above figure. Generally, they consist of a special brush arrangement designed for fitment below the head pulley on the return side to enable the brushed off material to fall into the discharge chute. In case of cleaner driven by an electric motor, it consists of a motorized power driven shaft supported on anti-friction bearing blocks, to which nylon or polypropylene brush rolls are mounted. The direction of rotation is opposite to that of the return belt travel.

The V-belt drive ensures that right peripheral speed of the rotary cleaner can be achieved to get maximum cleaning efficiency.

In India, such cleaners are manufactured by Kaveri Ultra Polymers P Limited. For more information, view their website, www.kaveri.in.

Belt Turnovers

One method of solving belt cleaning problems on the return side run is the use of belt turnover. In this method, the belt is twisted 180° after it passes the discharge point. This brings the clean surface of the belt into contact with the return idlers. The belt is turned back again 180° before it enters the tail section to return the carrying side of the belt to the up position at the loading point.



Turnover Arrangements

Above figure shows different types of turnover arrangements used based on belt width and belt type.

Guided Turnover Arrangement

Free turnover is used with textile belts up to a width of 1200 mm and a thickness of 10 mm. At the entry and exit points of the turnover lengths, the belt is fed through a pair of rollers. Guided turnover is used with textile and steel cord belts up to 1600 mm wide. In guided turnover, to support the belt in the turnover length, a pair of vertical rollers is used. As shown in above figure, sometimes many pairs of vertical rollers are also used. Supported turnover is used with textile and steel cord belts up to 2400 mm wide. In supported turnover, the belt is fed over support rollers which run on a lengthwise axis.

Following table gives the standard values for the dimensioning of turnover lengths as per DIN 22101:2011-12.

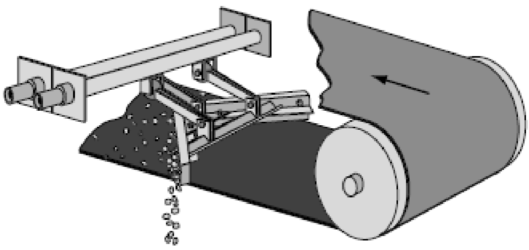
Type of Belt Turnover	**Maximum Belt Width, mm**	**Minimum Turnover Length for Conveyor Belts with**		
		Cotton Plies	EP Plies	Steel Cord Plies
Free turnover	1200	8 *B*	10 *B*	-
Guided turnover	1600	10 *B*	12.5 *B*	22 *B*
Supported turnover	2400	-	10 *B*	15 *B*

B = Belt width

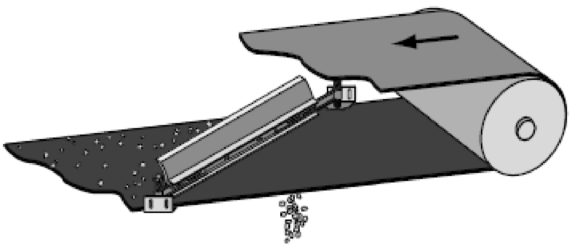
The standard values provided in above table will be sufficient if the return strand is subjected to low belt tensions. If this is not the case, a more precise calculation is to be carried out.

Tail Protection Plows

Even though a belt conveyor is carefully designed, spillage from the carrying side of the belt may occasionally occur at the loading point and elsewhere along the belt. This fugitive material can fall on the return run of the belt, ultimately getting trapped between the belt and the tail pulley causing possible damage to the belt or misalignment of the belt. Two devices used to prevent this problem are deck plates and tail protection plows.



V-Plow



Diagonal Plow

Tail Protection Plows

A tail protection plow (or return belt scraper) is installed on the upper side of the return belt just before it enters the tail pulley. It removes any material spilled onto the return run. It thus prevents this spilled material from becoming trapped between the belt and the tail pulley.

A belt plow is generally composed of a stationary scraper of an elastomeric compound that contacts the inner surface of a conveyor belt to deflect particles from the belt that otherwise would become trapped between a pulley and the belt. As shown in above figure, these units can be V (at 45° to 60° angle) shaped to deflect material to each side of the belt or diagonal (at 45° to 60° angle) shaped to deflect material to one side of the belt.

In most cases, the plow rides on the belt, tensioned against the belt either by a tensioning device or simply by its own weight. It is free to float up and down with any fluctuations in belt travel. The plow also should be tied with a safety cable to prevent it being carried into the pulley should it become dismounted.

On belt conveyors that travel only in one direction, the plow can be a V-plow. The point of the "V" should direct toward the head pulley so that any loose material carried on the belt’s inside surface is deflected off the conveyor by the wings of the plow.

In case the conveyor has two directions of movement (either reversing conveyor or accidental rollback), the return belt scraper should be a diagonal plow to provide protection regardless of the direction of belt movement. Diagonal plows are installed across the belt at an angle of 45° to the direction of travel.

If the conveyor is truly bi-directional, so that either pulley can serve as a discharge pulley, diagonal plows should be installed at each end.

Curved Blade Diagonal Plow

As shown in above figure, a new diagonal plow design (by Martin Engineering, USA) features a curved blade. The curved face prevents cohesive material from climbing the blade.

For more information on belt cleaners, please see Belt Conveyors for Bulk Materials published by CEMA, USA. Many companies are manufacturing engineered belt cleaners. For more information on them, please view websites of following companies.

Martin Engineering, USA (www.martin-eng.com)
Flexco, USA (www.flexco.com)
Hosch Equipment (India) Pvt. Limited (www.hoschonline.com)

Acknowledgement

Most of the figures and some text of this chapter is reproduced from third edition of Foundations™ by Martin Engineering, USA (www.martin-eng.com). However, for up to date information, you are requested to refer to the latest edition of Foundations™ by them.

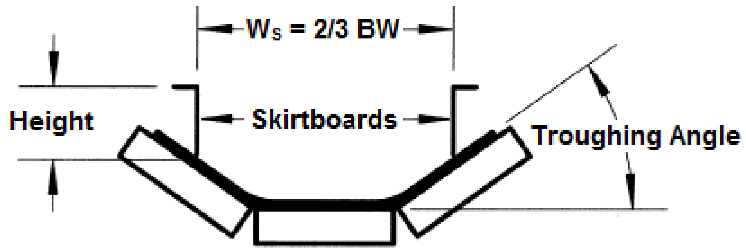
Skirtboards

Skirtboards are provided to retain the material as it settles on the belt after it leaves the loading chute and to settle any dust particles back onto the belt until it reaches the belt speed. The skirtboards usually are an extension of the sides of the lower chute and extend roughly parallel to one another for some distance along the conveyor belt. The skirtboards normally are made of steel with high resistance to abrasion. Wear liners are often installed on the interior of the skirtboard as a sacrificial surface.

The lower edges of the skirtboards are positioned some distance above the belt. The gap between the skirtboard bottom edge and the belt surface is sealed by a flexible elastomer sealing strip installed on the exterior of the skirtboards.

Information on skirtboards and skirtboards sealing system is given in this chapter.

Skirtboards



Skirtboard Width and Height

As shown in above figure, generally the maximum distance between skirtboards is two-thirds the width of a troughed belt.

The height of skirtboards must be sufficient to contain the material volume as it is loaded on the belt.

Usually, when the loading is in the direction of the troughed belt travel the skirtboard length is a function of the difference between the velocity of the loading material, at the moment the material reaches the belt, and the belt speed. For the installation where this difference is small, the length of the skirtboard can safely be 0.6 m for each 0.5 m/s of belt speed, with a minimum length of 1.0 m. This distance refers to the length of skirtboard beyond the impact zone. Otherwise, it should be long enough to allow the load to settle into the profile it is to maintain for the rest of its conveyor journey. The need for a dust suppression or collection system may require an increase in the length and height of skirtboard for use to establish a plenum.

Skirtboards are generally covered to minimize dusting. For covering, the top edges of the skirtboards can be externally flanged and the cover fastened to these flanges.

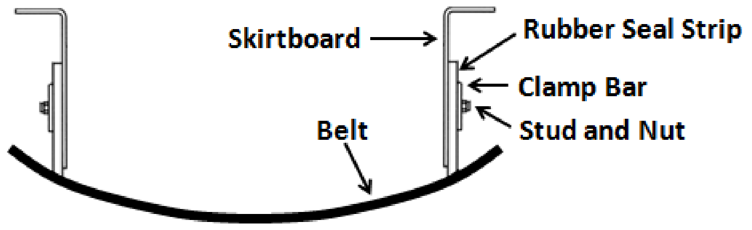
To minimize fugitive material, gap between the skirtboards and the belt should be as small as possible, consistent with safe operation of the belt. Larger clearance can be used, but this necessitates thicker rubber-edging strips, particularly for long skirtboards.

To avoid the entrapment of material lumps between skirtboards and belt, the skirtboards should be installed such that they taper outwards in the direction of belt travel (horizontally) as well as taper upwards providing increased clearance from the belt (vertically). The gradual widening of the skirtboards, 12 to 25 mm over the entire length of the transfer point, provides a relief mechanism for any material that could become entrapped and risk gouging or abrading the moving belt. Rather than being pinched between the skirtboard or lining and the belt, the lumps of material are pulled free by belt motion. These openings should form a straight line, without jagged (saw-toothed) pattern, which could capture material in it.

Skirtboard Sealing

To prevent the leakage of fines through the gap between the lower edge of the skirtboards and the moving belt, it is common practice to provide a flexible sealing strip (called skirt rubber) on the outside of the skirtboard. These strips, generally an elastomer such as rubber is connected to the skirtboards in such a manner that they can be adjusted to take care of their wearing. Generally, hardness of the sealing strip is 50° to 60°, Shore A. Numbers of sealing systems/arrangements are available. Information on various types of sealing systems is given in this section.

Vertical Sealing/Skirting



Vertical Sealing

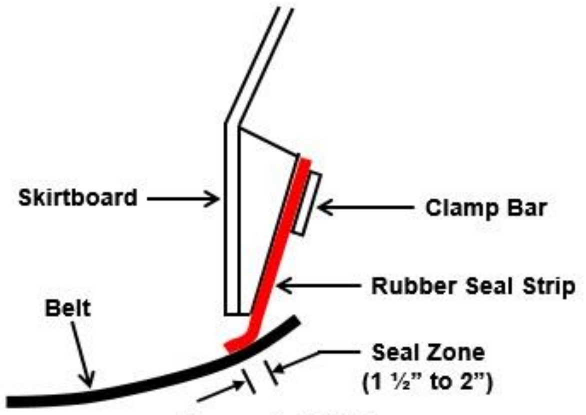
As shown in above figure, a vertical sealing/skirting arrangement generally consists of long strips of an elastomer held against the lower edge of the skirtboard by an arrangement of clamps. However, in this design, readjustment of long sealing strips is difficult.

SPILL-EX Skirt Sealing System

To overcome difficulty of adjusting long sealing strips, many manufacturers are offering a system where sealing is carried out by segmented type rubber blocks (number of small blocks). Above figure shows the SPILL-EX skirt sealing system developed by Tega Industries.

For more information on the system, please view their website, www.tegaindustries.com.

Tangential Skirting

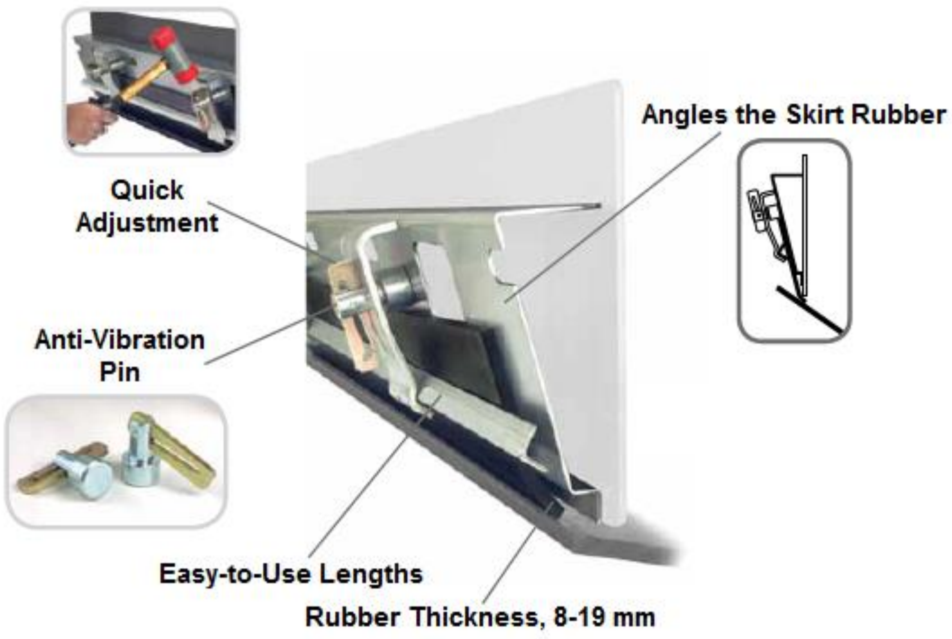


Tangential Skirting

As shown in above figure, sealing strips can be installed at an angle also. This arrangement is known as tangential skirting. Since the seal strip is installed at an angle, it turns back under the skirtboard. A seal strip installed at an angle provides a better seal between idlers as the belt flexes under load. However, care must be exercised in design to combine good sealing with minimizing friction and belt cover wear (sealing zone between 1 ½” to 2”).

To minimize friction and belt cover wear, pressure between sealing surfaces can be reduced by reducing the hardness of skirt rubber. One leading Indian material handling equipment manufacturer recommends hardness of 35°, Shore A.

Many manufacturers are offering sealing systems to convert vertical sealing/skirting arrangement to tangential skirting.



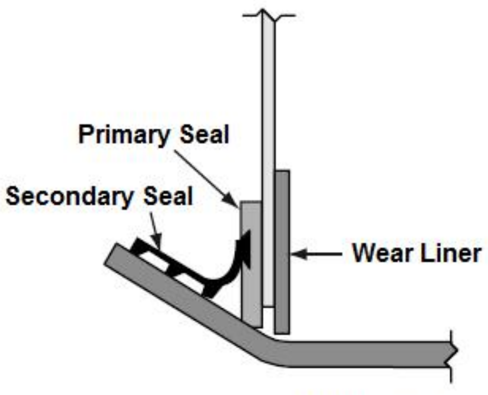
Flex-SEAL Skirting System

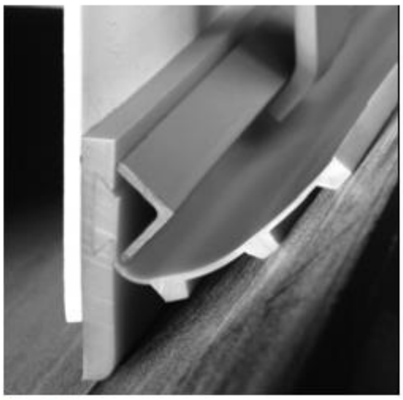
Above figure shows one such arrangement, Flex-SEAL™ skirting system by Flexco. For more information on their system, please view their website, www.flexco.com.

Please note the use of anti-vibration pins which makes seal adjustment easy.

Engineered Skirting

To enhance sealing performance, many companies are offering engineered skirting/sealing strips.





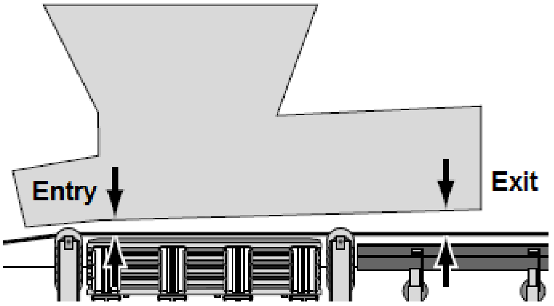
Multiple-Barrier Sealing System

Above figure shows engineered skirting system called multiple-barrier sealing system by Martin Engineering. To improve performance, instead of relying on a single strip, this sealing system uses two layers. It incorporates wear liner, a primary sealing strip and a secondary strip. The secondary sealing strip is joined to the back of the primary with a dovetail and lies on the belt's outer edge like an apron.

The primary strip is pushed gently down to the belt to contain most particles, and the secondary strip lies on the belt's outer edge to contain any fines that pushes under the wear liner and primary strip. This secondary strip contains a channel to capture the fines, eventually redirecting the particles into the main body of material.

For more information on engineered skirting system, please view website of Martin Engineering, USA (www.martin-eng.com).

Skirtboard Construction



Distance between Belt and Skirtboard

As noted earlier and shown in above figure, the skirtboard should open gradually, both horizontally and vertically, from the loading point (entry) in the direction of belt travel to permit entrapped material to free itself.

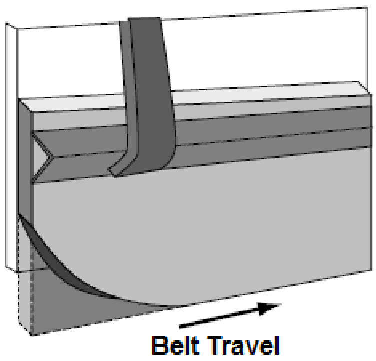
The gap between the belt and the skirtboard should be as small as possible. The closer the skirtboard and belt are together, the easier it is to maintain a seal between them. The lower edges of the skirt plates should be positioned 1/4 inch (6 mm) to 3/8 inch (10 mm) above the belt at the belt's entry into the loading zone (belt tail). This dimension should be uniformly increased in the direction of belt travel to 3/4 inch (19 mm) to 1 inch (25 mm) at the exit of load zone. This close clearance cannot be accomplished unless the belt travel is stabilized within a plus-or-minus tolerance of 1/16 inch (1.5 mm) at the entry (belt tail) end of the chute.

With the skirtboard positioned close to the belt, it is critical to the safety of the belt that the belt be prevented from rising up off the idlers during conveyor start up. Hold-down rollers can be installed to keep the belt on the idlers.

The thickness of the skirtboard must be sufficient to withstand side pressures that may occur when the chute becomes plugged or the belt rolls backward. Except in very light applications, the minimum thickness of mild steel used for skirtboard construction should be 1/4 inch (6 mm). On belts moving at over 750 fpm (3.7 m/sec) or 54 inches (1300 mm) or more wide, the minimum thickness should be 3/8 inch (10 mm). For applications over 1000 fpm (5 m/sec) or 72 inches (1800 mm) wide, the minimum thickness should be 1/2 inch (12 mm).

Skirtboard should be supported at regular intervals with structural steel. The most common support design is an angle frame installed on approximately the same centers as the carrying idlers.

Sealing strip (skirt rubber) must form a continuous unit along the sides of the steel skirtboard. If simple, end-to-end butt joints are employed to splice lengths of sealing strip together, material will eventually push between the adjoining surfaces and leak out. An interlocking or overlapping joint is best to prevent this spillage.



Rounding the Sealing Strip

As shown in above figure, if belt is mechanically spliced, sealing strip may be rounded at entry to reduce the chance of a mechanical belt fastener catch the strip to rip it or pull it off the chute.

Hardness of Skirt Board Sealing Strip

There are many theories on the hardness required for skirt board sealing strip. In general, the hardness of the sealing strip should be sufficient to allow it to perform its designed mechanical function. More important than hardness is the selection of a sealing strip that is sacrificial and wears before wearing the belt.

Maintenance of the Sealing System

As the conveyor runs, the heat generated by the friction of the belt against the skirting seal combines with the wearing action of the fines to erode the sealing strip. To counter this wear, the sealing strip must be adjusted down against the belt frequently.

Skirtboard sealing strips should be adjusted so that the sealing strip just touches the belt surface. Forcing the sealing strip hard against the belt cover will lead to extra wear in both the belt and the sealing strip because of the additional heat generated from the increased friction.

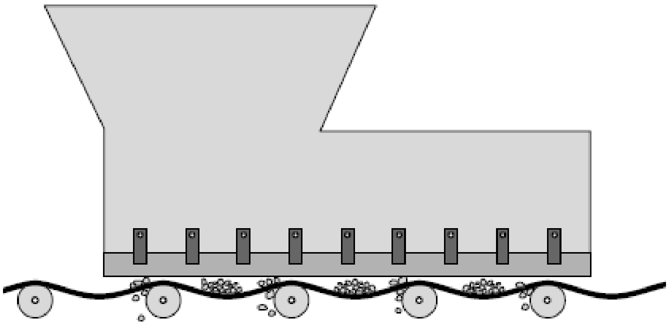
Forcing the sealing strip hard against the belt cover will also require additional power to move the belt. On conveyors with lengthy skirtboards, excessive pressure of the rubber sealing strip may overload the motor driving the conveyor particularly at conveyor start.

Strips of used conveyor belting should never be used for a skirt board sealing strip as the belt carcass may have picked up abrasive fines, which can damage the cover of the moving belt.

Impact Cradle/Bed

Proper belt support is very important for an effective, minimum spillage at loading / transfer point. In view of this, information on impact cradle/bed and slider bed is given in this chapter.

Impact Cradle/Bed and Slider Bed



Material Leaks Due to Belt Sag between Impact Idlers

As shown in above figure, if rubber-cushioned impact idlers are used for absorbing impact in the belt's loading zone, no matter how closely they are spaced, the rounded shape of the idler allows the conveyor belt to oscillate or sag away from the ideal flat profile. This sag allows and encourages the release of fugitive material.

Impact Cradle

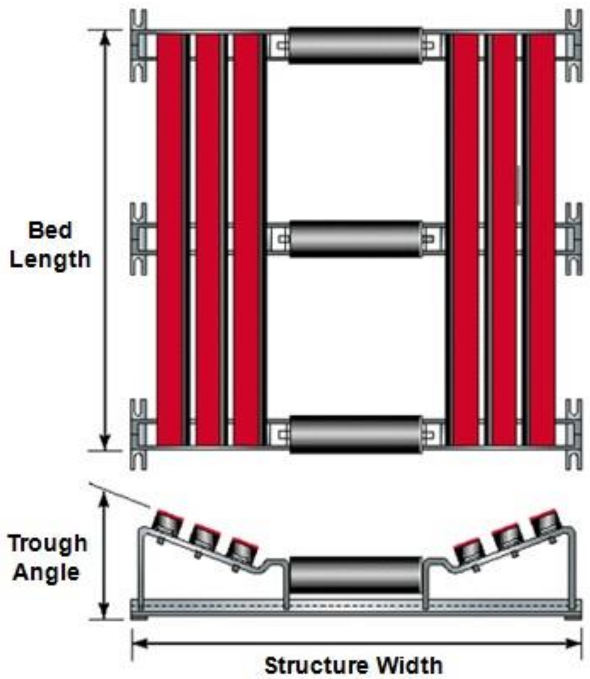
As shown in above figure, the solution for the problem is the use of impact cradle/bed composed of impact-absorbing bars in the loading zone. Impact cradles are typically composed of a number of energy-absorbing bars held in a steel framework.

Slider beds may be used for light-duty impact. Slider beds are similar in design to impact beds but do not have the built in ability to absorb impact. The slider bed is for belt edge support to facilitate sealing of the belt at the skirtboard by eliminating belt sag.

Cradles with Bars and Rollers

Manufacturers offer a wide variety of hybrid designs, combination of impact and edge sealing systems for specific applications.

Hybrid designs are popular as a way of combining the low power requirements of rollers and the flat sealing surface of the impact bar. A number of hybrid designs are available, which use bars for a continuous seal at the belt edge, but incorporate rollers under the center of the belt.



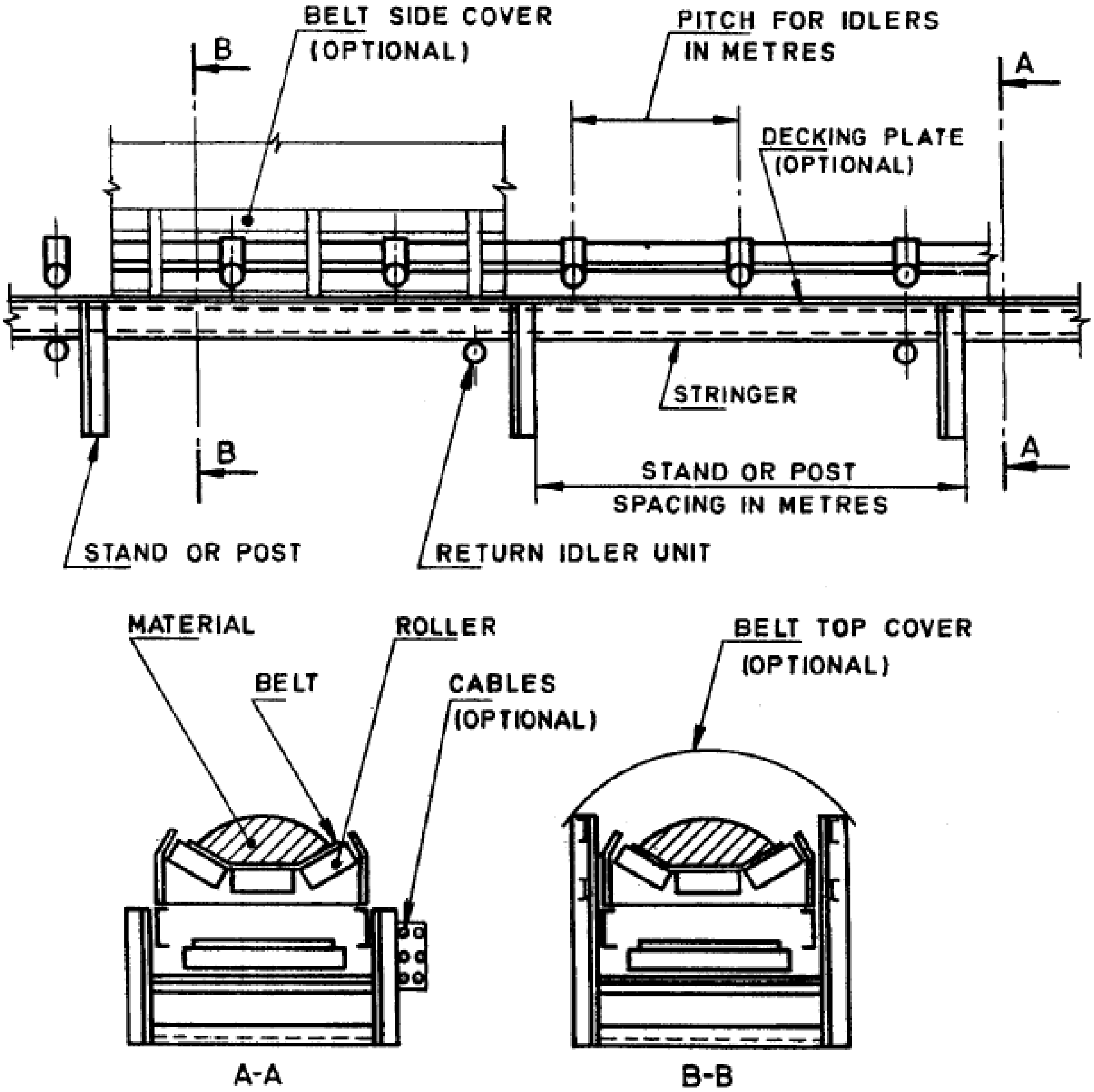
Edge Seal System

As an example, Fenner Dunlop offers edge seal system to tackle the potential mess and hazard associated with skirt leakage at loading/impact points in a conveyor system.

As shown in above figure, the edge seal system is designed to be used in conjunction with the impact system. It creates a flat surface after the impact zone and under the skirting. This prevents leakage caused by belt sag between idlers even under heavy load. For more information on the system, please view their website, www.fennerdunlopamericas.com.

Conveyor Structure Components

Following figure shows general layout of intermediate portion of conveyor structure for the purpose of identification of various components/parts.



General Layout of Intermediate Portion of Conveyor Structure

Stringer and Stand/Post

Stringer is a longitudinal supporting member between the head and tail terminal. It is provided on each side of a conveyor. Stringers are used to support the carrying idlers, return idlers, deck plates and conveyor switches.

Standard steel channel sections are often used as stringers. Sawn or glued-laminated timbers have also been used for stringer sections, and the use of timber may be advantageous when handling certain corrosive bulk materials such as salt.

The vertical members called stand or post are provided at regular interval to support the stringers.

Deck Plates

Deck plates are 1.5 to 3.0 mm thick flat, bent or curved metal sheets. They are installed between the belt's carrying and return runs. These plates act as a shield to deflect any fugitive material. This construction, common to many well-designed belt conveyors, protects the return run of the belt, both from any spilled material and from the weather.

Belt Top Covers (Hoods)

Belt top cover (hood) is a weather protection device. Conveyor covers are basically provided to cover the carrying side of the belt, thereby protecting the belt directly from rain water and wind forces. Weather protection shall be installed whenever the wind speed is frequently in excess of the speed that will create fugitive material or push the empty belt out of alignment.

These covers are usually semicircular in shape and are made of flat or corrugated sheets, commonly either of galvanized iron or aluminum. They are fastened to the stringers and are situated over the belt. The arrangement and fastening of the covers should permit convenient access to permit servicing the belt and idlers. The belt covers frequently are hinged at one side.

Belt Side Covers

Where protection is needed from wind alone, it is provided by installing suitably reinforced metal sheets called belt side covers on the windward side of the conveyor stringers.

Chutes

A conveyor receives material at its loading point(s). This material can come from various sources like other conveyors, storage hoppers, process vessels, etc. While the source of the material may be different, it is all fed to the receiving conveyor through a feeding device called the chute. Number of problems can occur on a conveyor if the loading chute is not designed properly. In view of this, information about chutes is given in this chapter.

Functions of the Chute

Chutes should be designed to perform the following functions.

- To hold the material received in it and direct the flow of the material.
- To discharge the material centrally in the direction of travel of the receiving conveyor at a speed similar to receiving belt's speed.
- To ensure that the material does not block inside the chute but flows continuously.
- To minimize impact on the receiving belt and product degradation.
- Collect and return the material scraped by the belt cleaners to the main material flow.
- To minimize the generation and release of dust.

Information about various design considerations for a chute to fulfil its functions is given in the following sections.

Loading the Belt

The benefits of discharging the material centrally on the receiving belt by a chute in such a manner that the material velocity in the direction of belt travel is, as nearly as possible, equal to the velocity of the receiving belt itself are:

- Belt's cover wear is minimized due to small or absence of relative velocity.
- There is a saving in power consumption because the material is not required to be accelerated again to the belt's velocity.
- Potential for conveyor tracking problems caused due off-center loading is minimized which often result in spillage and subsequent clean-up costs. In extreme situations it also results in belt edge damage due to belt rubbing with conveyor structure.
- Reduces direct contact with skirting and associated wear problems.

It is recommended that the placement of material on the belt should not be done while the belt is in the transition zone (area where belt is not in a fully troughed condition).

Chute Construction

Material of Construction

Chutes are generally fabricated from steel plates, typically mild steel or stainless steel, depending on the material that is to move through it.

Mostly chutes are manufactured from mild steel plates. Being ductile, it offers ease of fabrication and forming into complex shapes with good structural strength at a moderate price. However, mild steel has inherent tendency for rusting and corrosion and is also very prone to build-up of damp fines in areas outside the mainstream flow. Steep chute angles are required to counter this situation. However, due to a Brinell hardness of approximately 150, mild steel is only moderately resistant to impact and abrasive wear.

The selection of plate thickness is dependent on the structural strength requirements and the margin for wear if the chute is not to be fitted with a replaceable liner system (usually plate thickness is 16 mm without liner and 10 mm with liner).

Chute Size

Generally, it is recommended that:

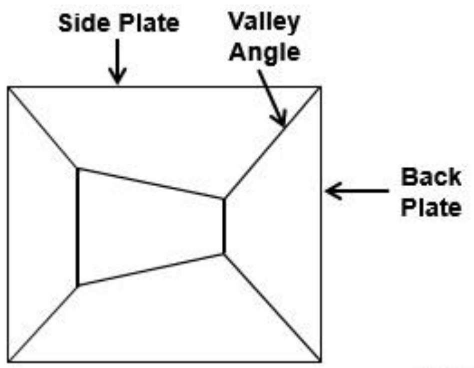
- The width of the chute bottom should be no greater than two-thirds the width of the receiving belt.

- The inside width of the loading chute should be at least two and a half times the largest dimension of uniformly sized lumps, when they represent a considerable percentage of the material flow. Where lumps and fines are mixed, the inside width of the chute may be as small as two times maximum lump size.

Above proportions are essential for proper loading of the belt by preventing interlocking and jamming of lumps in the chute.

Valley Angles

When designing a transfer chute, the selection of "valley angle" is very important. As shown in the following figure, valley angle is the angle formed by the line of intersection between the back plate and side plate to horizontal. This angle is less than the angle formed by either the back plate or side plate to horizontal. The valley angle must be steep enough to ensure that the material flows freely.



$$\cot \alpha = \sqrt{\cot^2(\beta) + \cot^2(\gamma)}$$

Where:
α = Valley Angle (to horizontal)
β = Back Plate Angle (to horizontal)
γ = Side Plate Angle (to horizontal)

Valley Angle

In general, it is recommended that for handling coal, minimum valley angle should be 60°.

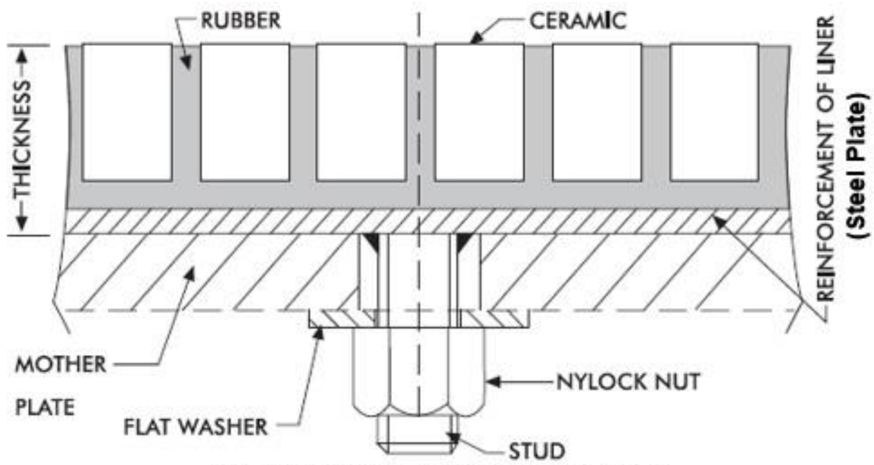
Wear Liners

The continual bombardment of material against the sides of the chute is the main source of wear in a transfer chute. Therefore, transfer chutes should be lined on flow surfaces with a material providing good abrasive wear resistance so that this liner, not the chute itself, is the sacrificial element. Sometimes liners are also installed for the specific purpose of reducing wall friction and adhesion. The type of liner material must be compatible with the bulk material being handled. Depending on cost of lining material as well as ease of attaching it to the chute walls, most of times their selection is some sort of compromise. Commonly used lining materials are ceramic, high carbon steel, abrasion resistant low alloy steels, chromium carbide overlay, stainless steel and Ultra High Molecular Weight (UHMW) Polyethylene.

Ceramic Liners

High alumina ceramic is a material with aluminum oxide of 85% to 92%. Its hardness is 9.0 Moh. Ceramic liners are widely used to resist abrasion in chutes and hoppers where a measure of impact resistance is an added requirement. Ceramic liners are particularly suitable for handling coal.

Ceramic liners are available as ceramic tiles of various shapes and composite ceramic products. Fixing of ceramic tiles is usually carried out by epoxy.



Composite Ceramic Products Fixing

Composite ceramic products are made by alumina ceramic rods or hexagonal ceramic tiles bounded within a resilient rubber matrix. The extremely hard ceramic elements provide resistance to wear, while the elastic properties of rubber effectively dampen the impact forces. Composite ceramic products are generally steel backed. As shown in above figure, composite ceramic products can be conventionally fixed to the mother plate by stud welded at the back of the steel plates.

Composite ceramic products are sold by trade names [for examples: Elastocer by Tega Industries Limited, India (www.tegaindustries.com), LUDOLINER™ by FLSmidth (www.flsmidth.com), etc.].

High Carbon Steel

High carbon steel plate is available in a range of qualities (0.30% C to 0.50% C) offering improved hardness from 150 HB to 250 HB and hence better wear resistance than mild steel (up to 150 HB). However, the material is slightly more difficult to form and fabricate than mild steel. TISCRAL (0.42 to 0.50% C and 0.20 to 0.40% Cr) is the trade name for high carbon steel plates sold by Tata Steel Limited, India.

It may be noted that SAILHARD (0.23% C and 0.65% Cr having BHN 200) is the trade name for the low carbon steel plates sold by Steel Authority of India Limited (SAIL).

Abrasion Resistant Plates

Abrasion resistant low alloy steels offer resistance to both impact and abrasive wear. These are mostly of low Nickel/Chromium/Molybdenum composition with hardness in the range 300 to 500 HB. These steels are more difficult to fabricate and form into the more complex chutes compared with mild steel. Many times these plated are installed using countersunk bolts or welded studs.

Many companies are selling these plates under different trade/brand names. SSAB is a leading producer of high strength steels. They are marketing wear plates under the trademark Hardox. It may be noted that Hardox has exceptional weldability. Any conventional welding method can be used for welding these steels to any type of weldable steel. For more information on Hardox, please view their website: www.hardox.com.

Chromium Carbide Overlay (Clad Plates)

For protection against material having very high levels of abrasion, chromium carbide overlay (clad plates) are used. As chromium carbide is very brittle, it is overlaid onto a backing plate for installation. Generally, the hard facing is between 53 and 65 Rockwell “C”, and some overlay materials “work harden” to 75 Rockwell “C”. The backing plate can be of mild steel or stainless steel depending on application requirements. However, due to high brittleness, this material is not suited for high impact applications.

Corrosion Resistant Stainless Steel (12% Chromium)

Corrosion resistant stainless steel plates are used for handling damp bulk materials where corrosion resistance is an essential feature in maintaining satisfactory flow. These plates are corrosion resistant / martensitic stainless steel containing 12% chromium based on compositions.

Hardness of these plates range from 200 HB to 400 HB. The increased hardness available in some brands giving increased abrasion resistance but they are more difficult to form and fabricate. These steels offer good flow, low friction properties with resistance to corrosion and impact and abrasion resistance largely depending on the hardness. Fixing is usually by holes through the lining with bolts or welding to the chute backing.

For many materials including coal, Stainless Steel Grade 409 M is acceptable low cost lining material.

Stainless Steel

Austenitic Stainless steel (17% - 18% Cr) is available in a number of grades to suit the different requirements. Grade 304 is available in sheet form and is suitable for most bulk material handling applications outside the chemical, food and pharmaceutical industries. Grade 316 stainless steel is available in similar sheet form and is an acceptable material for most food and pharmaceutical applications. For chute work, a “polished” surface finish is usually adopted. Stainless steel offers a low wall friction in handling many of the more difficult materials and avoids problems from rusting and corrosion. The grades 304 and 316 can be easily formed and fabricated into chute.

Due to high cost, their use is mostly limited to applications where thin linings are required to meet low-slip requirements and where its improved abrasion resistance as compared to mild steel is of benefit.

Proprietary composite lining sheets are available comprising stainless steel sheeting with a bonded rubber backing offering the low-slip properties of stainless steel with improved impact resistance due to the cushioning offered by the rubber backing at impact areas. These plates can be fixed by rubber adhesives onto the backing chute work or by countersunk bolts.

Rubber/Synthetic Rubber

Due to its resilience, rubber is also used as a liner material to cushion or absorb the impact. Since the ability to absorb the impact depends on the thickness of rubber at the impact point, the thickness of rubber at the impact point is important. The direction of the impacting material is also important. On a plain rubber surface, best resistance to impact damage is obtained when the impact angle is 90°. It is recommended to avoid approach angles of 30° to 45°. Hardness of 60° Shore A is appropriate for most applications.

The method of fixing the rubber lining in the impact area must be secured properly. To prevent failure of the rubber lining at its fixing bolts due to movement and stretching of the rubber lining leading to its bulging away, it is recommended to use rubber lining with a metal or fabric stiffening layer in it.

UHMW Polyethylene

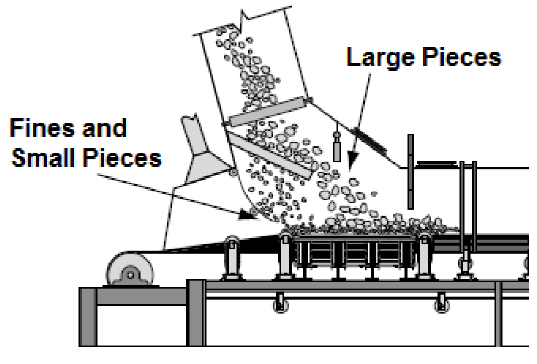
Ultra High Molecular Weight Polyethylene (UHMW) is common as a chute and hopper lining material for lighter applications. It is a tough material of relatively low cost, which can be easily cut and shaped. UHMW has good resistance to sliding abrasion and a low coefficient of friction and has particularly good non-stick properties, which greatly assist in the handling of damp and sticky materials. Coefficient of friction for UHMW liners is only 0.16 as compared to 0.373 for stainless steel liners. It does not absorb moisture.

However, this material cannot handle impact and wears rapidly under impact conditions. It is not suited to handling highly abrasive materials. However, by the use of additives such as glass fibers or beads it is possible to improve the abrasion resistance. It will not operate at temperatures in excess of 100º C. At high temperature it will soften and melt.

Note:
If non-steel linings are installed, it is important to consider the different expansion rates between linings and the steel surfaces to which they are attached. If there are large temperature changes, gaps must be left between adjacent pieces. Typically, expansion joint of 1/8 inch (3 mm) is allowed at every two to three feet (600 to 900 mm).

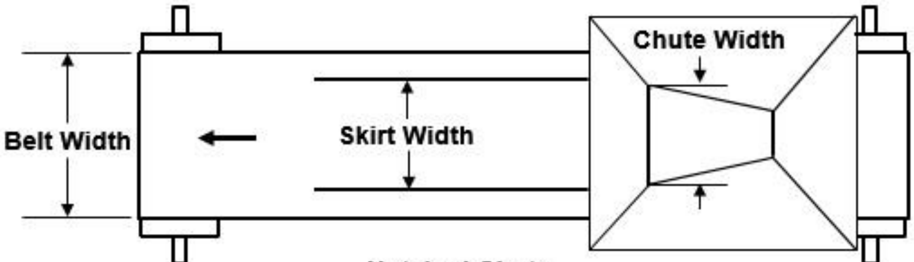
Impact Reduction

If the material consists of a mixture of fines and lumps, the loading chute can be designed such that it first deposits the fines on the belt, and then deposits the lumps. This allows formation of the fines layer first to cushion the impact of the lumps. This can be accomplished by incorporating a grizzly bar/screen, or a notched/wedge shaped loading opening in the chute.



Installation of Grizzly Bars for Impact Reduction

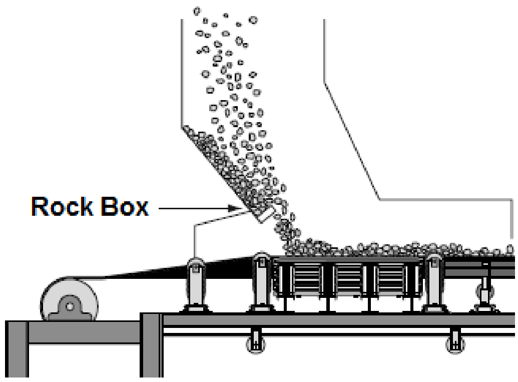
As shown in above figure, fines first pass through grizzly bars to form a protective bed of material on the belt to cushion the impact of larger lumps which are unable to pass through the bars but slide down the incline and land on the belt later.



Notched Chute

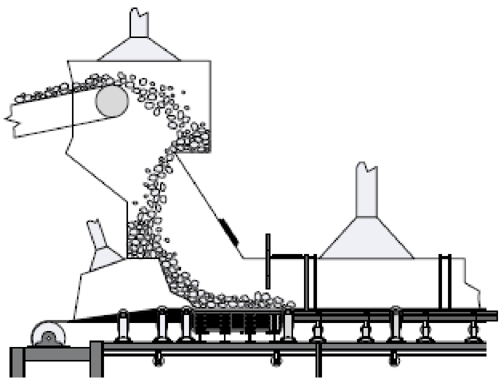
Above figure shows notched or wedge shaped chute which serve a similar purpose by letting a layer of fines pass onto the belt in advance of any larger lumps of material.

Another method to minimize wear by unloading material on material itself is to fabricate the chute bottom such that it forms a box in which some of the material is retained. The material forms an angle in the box approximately equal to the angle of repose. Subsequent material moving through the chute flows over this retained material, wearing the material rather than the chute walls. Impact force is also dissipated as material bounces off the retained material. This arrangement is commonly called a "stone box" or "rock box" and is most often seen in gravel, rock, and ore handling.



Chute with a Rock Box

Above figure shows chute with a rock box.



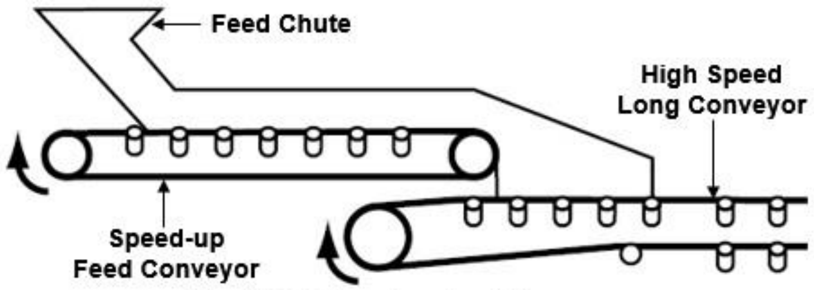
Chute with Multiple Rock Boxes

Above figure shows chute with multiple rock boxes. Multiple rock boxes are used to form a rock ladder to break up longer material drops. Usually the rock boxes are arranged in such a manner that material discharged from a belt conveyor never has a free drop of more than 5 to 6 feet.

Caution
A chute with a rock box should not be used for combustible materials, such as dusty coal.

When a slow moving load hits a fast moving belt, there is a slipping action that causes substantial abrasion of the receiving belt's cover. By loading material at or near belt speed, this slip is reduced and belt life is improved.

As shown in the following figure, the use of a short "sacrificial" or “speed-up” feed belt running in the same direction and speed as the main conveyor is one method of absorbing the impact and wear.



Sacrificial Speed-up Feed Conveyor

The length of this speed-up conveyor should be sufficient to bring the speed of the material very close to the speed of the long belt conveyor. The cover of the speedup belt should be thick enough to take care of the wear caused by the acceleration of the material leaving the loading chute. If the impact of the material leaving the loading chute is high, the speed-up conveyor should be flat. It should run on flat, impact absorbing idlers or an impact absorbing slider bed. This flat belt can be made of the required plies and thickness of cover to meet the impact, without consideration of belt troughing capabilities.

If the impact condition is not severe, a lighter-bodied belt can be used, with a cover thick enough to withstand the wear. This lighter belt can be carried on troughing idlers.

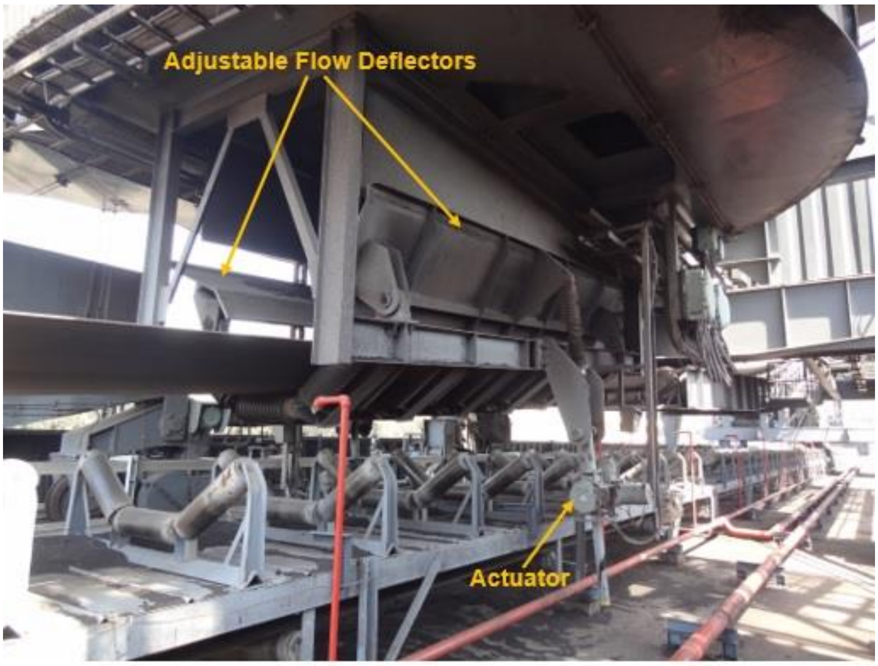
Flat or troughed, speed-up conveyor belts must be considered consumable and therefore must be replaced relatively frequently.

Centralizing the Load

Off-center loading, placing the material predominantly on one side of the belt, is a problem at many transfer points. It is most commonly seen on transfer points that must change the direction of material movement.

Generally, to ensure that the material takes a central and symmetrical profile on the receiving conveyor to minimize potential for conveyor tracking problems, deflectors are provided inside the chute.

It is common practice during the initial start-up of a new conveyor system to install deflectors within the chute to center the load. All too often, however, no permanent record is kept of the position or size of these deflectors. As they wear, problems begin to show. Meanwhile the project has been accepted, the contract has been closed, and the people who designed the deflectors and made them work at start-up are nowhere to be found. This creates another period of trial and error for the design and positioning of replacement deflectors, a period with increased spillage and higher risk of component damage. It is important to keep detailed dimensional information on deflectors, so they can be duplicated when replacement is required.



Adjustable Flow Deflectors at Exit of a Reclaimer Chute

As shown in above figure (showing a yard conveyor below a stacker cum reclaimer), sometimes adjustable flow deflectors are installed at exit of the chute to reduce the problem of off-center loading. They turn material toward the center of the belt, away from the belt edges to minimize potential for conveyor tracking problems.

Bridging and Ratholing

There are two fundamental bulk material flow problems that are responsible for most applications of flow aid devices in the industry are bridging (also known as arching) and ratholing.

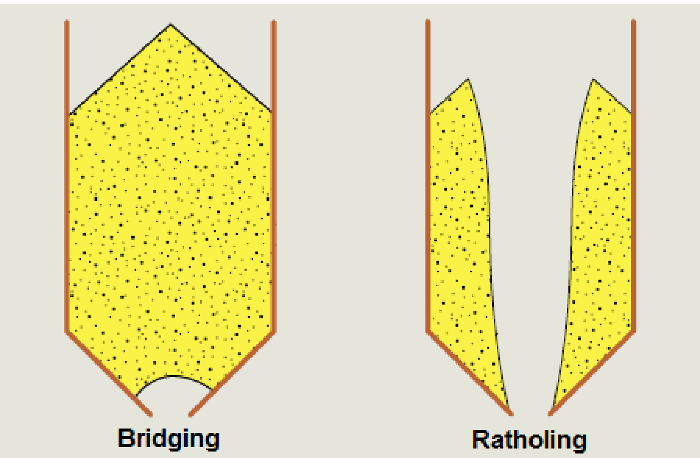


Illustration of Bridging and Ratholing

As shown in above figure, bridging of material occurs when the cohesive strength of the bulk material is sufficient to form a bridge of material capable of supporting the column of material above it. Due to bridging, discharge is prevented and a no flow condition results. Ratholing occurs when the sliding friction between the material and the vessel wall slows the flow of material in the outer perimeter of the vessel. As a result, the innermost material is able to flow through the central flow channel, while the outer material is restricted. Vibration, when applied properly, reduces the cohesive strength of the bulk materials and reduces sliding friction, thus eliminating these two major bulk material flow problems.

When an external vibrator is applied, the energy is transmitted through the vessel wall and the bulk material. The pattern and distance through which energy is transmitted is referred to as the “area of influence” of the vibrator.

Based on a variety of factors including bulk density, particle size, moisture content, temperature, vessel size and shape, and material of construction, vibrators are sized for the application and their areas of influence are determined. The vibrators are then located on the vessel so that the areas of influence overlap, and they are controlled through a sequence to facilitate the optimum flow pattern and minimize utility consumption.

Use of Flow Aid Devices on Chutes

Despite the best intentions of designers, there are occasions where there will be material buildup in transfer chutes. Materials with high-moisture content can adhere to walls or even freeze in the winter operations. Continuous operation can serve to compress the cover/overlay material harder and more firmly onto the wall and in some cases, the chute will be completely blocked.

The old solution for breaking loose blockages and removing accumulations from vessels was to hammer on the outside of the chute. However, this action worsens the problem as the bumps and ridges left in the wall by the hammer blows leads to additional material accumulations. A better solution is use of a flow aid device. Information on various flow aid devices is as under.

Vibrators

Installation of a vibrator can maintain flow through transfer chutes. These devices supply energy that reduces the friction of the walls and the material to keep the material sliding to the chute discharge.

Most commonly, a single vibrator is applied on the wall that features the shallowest angle or is the most buildup-prone area. Both air and electric vibrators have been used, depending on the available sources of power.

Electric Vibrators

There are two types of electric vibrators - magnetic vibrators and the unbalanced motors. Magnetic vibrators are spring/mass systems that pass a linear, aligned vibration to the working device. In unbalanced motors, weights are eccentrically attached at the ends of the running shaft. The so-called eccentric weights (flyweights) generates vibration due to the centrifugal force of these eccentric weights.

Friedrich Schwingtechnik GmbH (www.friedrich-schwingtechnik.de) is a reputed manufacturer of unbalanced motors. OMB vibrator Motors, Italia (www.ombvibrators.com) also is a reputed brand. DPH Engineering Pvt. Ltd., Mumbai (www.dphengg.com) is a distributor of OMB make vibrator motors in India.

For information on construction and working of electric vibrators, please see the booklet titled "construction, working and maintenance of vibrators and vibrating screens" uploaded at www.practicalmaintenance.net.

Air Vibrators

Pneumatic (air) vibrators incorporates a piston and bore. During operation, compressed air is alternately directed from one end of the piston to the other through a series of internal ports. The piston is the only moving part, which makes the pneumatic piston vibrators a reliable, low maintenance device.

The forces generated by pneumatic piston vibrators are linear, so they may be directed and concentrated in the problem area.

They are available in three distinct types of operation - Impacting, Air Cushioned and Timed Impact.

Impacting units deliver a high-energy impulse with each stroke of the piston. The impacting model is the most effective of the three in eliminating difficult flow problems.

The air cushioned units trap a cushion of air at the base of the piston, eliminating the impact. Although the air cushioned models are quieter, a larger size is normally required.

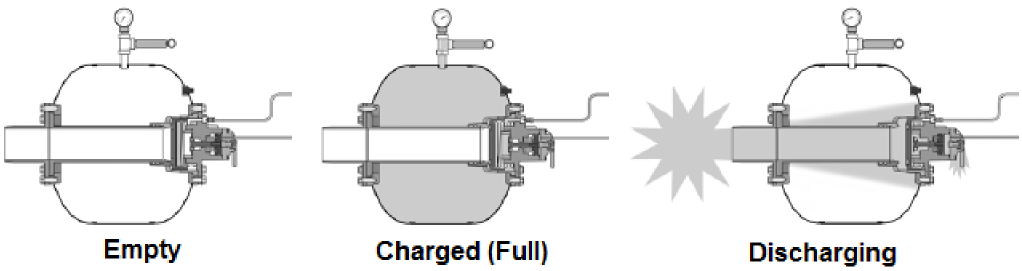
Timed impact models deliver a single high-energy impulse triggered by the output of a timer or other controlling device. Timed impact units are particularly effective in applications where dry materials adhere to vessel walls.

For more information on air vibrators, please view website of National Air Vibrator Co., USA (www.navco.us).

Air Cannons

Another solution to overcome chute buildups is the use of air cannons.

Air Cannon is a pneumatic bulk material-moving system that quickly releases compressed air into storage vessels, transfer chutes or feed pipes to maintain material flow. Air cannon system consists of one or more air cannons mounted on a transfer chute, storage vessel or process vessel.



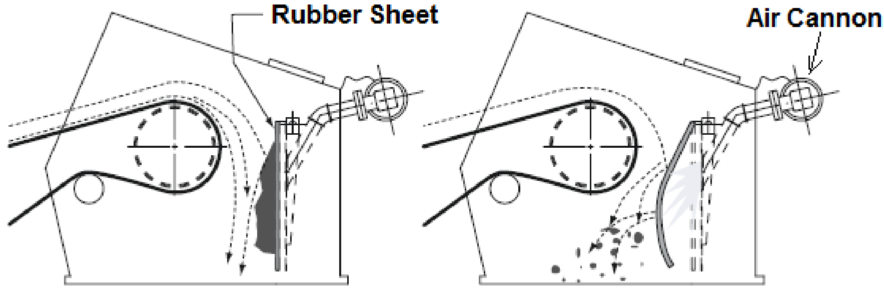
Charging and Discharging of Air Cannon

As shown in above figure, air cannon is called charged when it's tank is filled with compressed air or nitrogen between 10 psi and 125 psi operating pressure (made up to 150 psi). When the tank pressure equals the charging line pressure, airflow is static and the air cannon is ready to be discharged. By activating the solenoid valve, a positive pressure signal is sent to the air cannon's exhaust valve causing it to actuate and release the pressure held by the piston. The piston is instantly forced back by the air pressure stored in the tank. The blast of air is then directed through the discharge pipe or nozzle into the storage or process vessel.

Two installation techniques are used for its application.

One involves using flat nozzles to release the “blast” from the cannon directly into the material. Specially designed flat nozzles are installed into the chute wall where buildups are found.

The number of air cannons required depends on the size and shape of the chute. Air cannons are installed at several heights around the vessel, and the discharge firing cycle works from top to bottom of the installation.



Discharge of Air Cannon into Rubber Blanket

As shown in above figure, in the second installation technique, the air cannon discharge into the back of a flexible lining/blanket on the chute wall. The blanket is secured only at the top. Operation of the air cannon gives the blanket a periodic “kick” to break loose the material.

Typically, one air cannon can keep 15 to 20 square feet (1.5 to 2 square meters) of chute wall free of material. Air cannons with a volume of 1.75 cubic feet (50 liters) of air and a 4 inch (100 mm) discharge show the best results.

Regardless of technique used, the firing cycle for the air cannon installation must be adjusted for the specific conditions of material, chute and climate. After satisfactory results are obtained, the cannons can be put on an automatic timer, so their discharge cycle continues removing material without attention or intervention from plant personnel.

It is critical that the steel chute and support structure are sound, as the discharge of one or more air cannons into this vessel can create potentially damaging vibrations.

For more information on air cannons, please view website of Martin Engineering, USA (www.martin-eng.com).

Application Problem and Solutions

In case material contains some very sticky material (e.g. fine clay in coal), flow aid devices do not give satisfactory results. In such cases, it is recommended (by field engineers) to periodically wash the chutes to clear them of the material built up using high pressure water jets. However, material conveying operation should be stopped during the cleaning operation to prevent addition of water to the conveyed material.

However, for conveying the material without interruption (periodic washing), chute profile may be analyzed using modeling and dynamic analysis techniques (Discrete Element Methods) and modified based on the results if possible (available space may be a problem).

Discrete Element Methods (DEM)

In conventional designing of chutes, engineers need to rely on rule of thumb engineering and past experience leading to design by trial-and-error. However, computer simulations, the Discrete Element Method (DEM) helps in designing more efficient and reliable chutes.

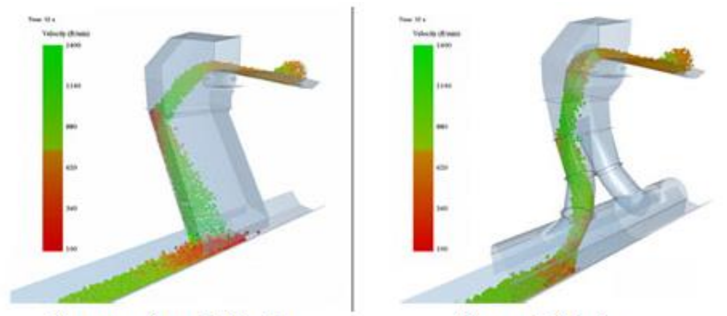
The Discrete Element Method (DEM) is a numerical analysis model for the mechanical analysis of a system of interacting particles or bodies. In the DEM, particle movements are integrated with time, using the equation of motion. The results from a DEM model provide a detailed evolution of the particles motion, interaction forces and stresses over the duration of the analysis.

Model execution usually generates extreme amounts of data. However, data is of no value unless it is turned into knowledge. To better understand and use all this data, scientific visualization, Computer Aided Design (CAD) is used. This visual representation of the data allows the designer to see the material flow inside the chute.

Many software applications which integrate the Discrete Element Method (DEM) and Computer Aided Design (CAD) are now available in the market.

The greatest benefit that can be derived from the use of these models is the feeling an experienced engineer can develop by visualizing performance prior to building. From this feel, the designer can arrange the components in order to eliminate unwanted behavior such as:

- Plugging
- Belt and chute wear and abrasion
- Material degradation
- Dust
- Off center loading / spillage



Conventional Chute **Curved Chute**

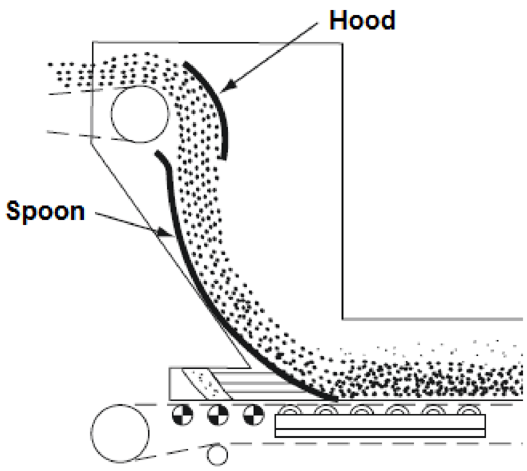
Result of DEM Analysis for Conventional and Curved Chute

For an example, above figure shows results of analysis obtained by DEM for a conventional and curved chute.

"Hood and Spoon" Chutes

This computer modeling of flow (DEM) is very useful in the development of "hood and spoon" chutes.

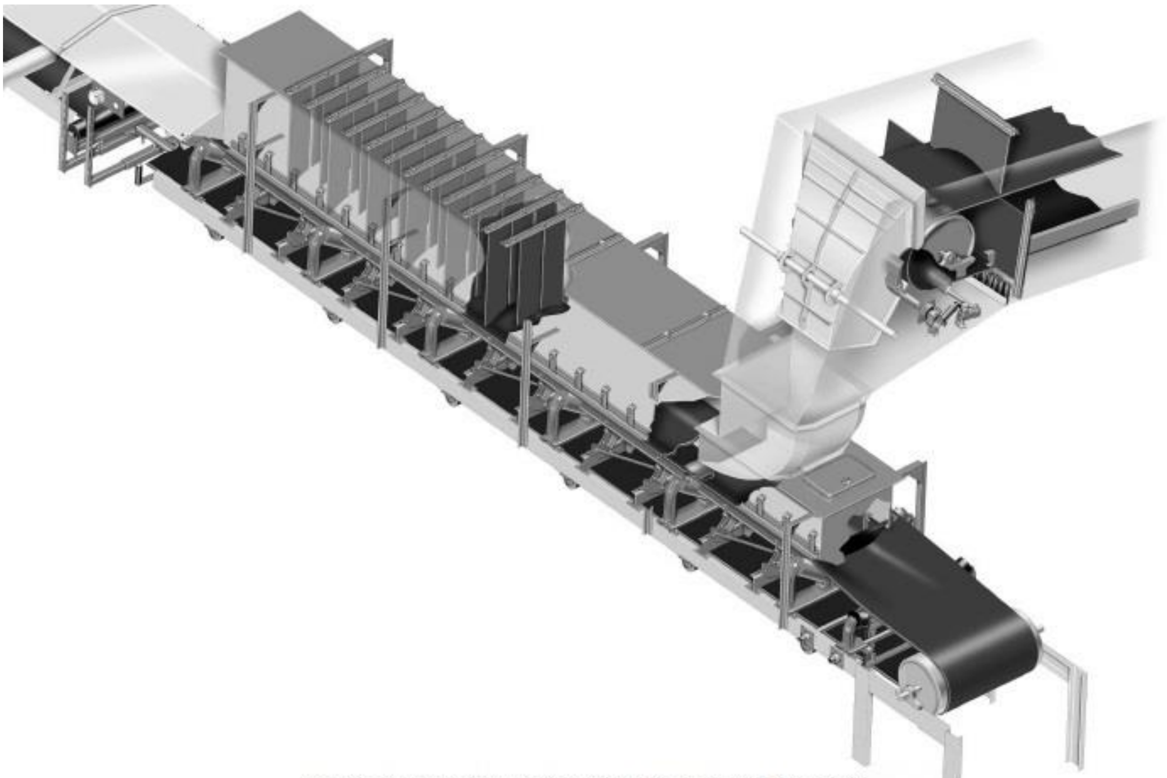
Each "hood and spoon" chute must be properly designed to match the material characteristics, flow requirements, and conveyor specifications. Properly designed system will control the movement of material to prevent dust and fugitive material and reduce belt damage.



Hood and Spoon Chute

As shown in above figure, "hood" serves to receive and deflect the material downward. Rather than letting the material stream expand and pull in air, it keeps the stream (and the individual material particles) close together. There is less air captured that will be released when the material lands on the belt. With this reduction in the air carried with the material stream, there is less air (and airborne dust) expelled when the material lands on the receiving conveyor.

The "spoon" forms a curved loading chute so that material flows evenly onto the receiving belt. The spoon is designed to lay the material on the belt at the proper direction and speed with minimum impact.



Typical Transfer point with "Hood and Spoon"

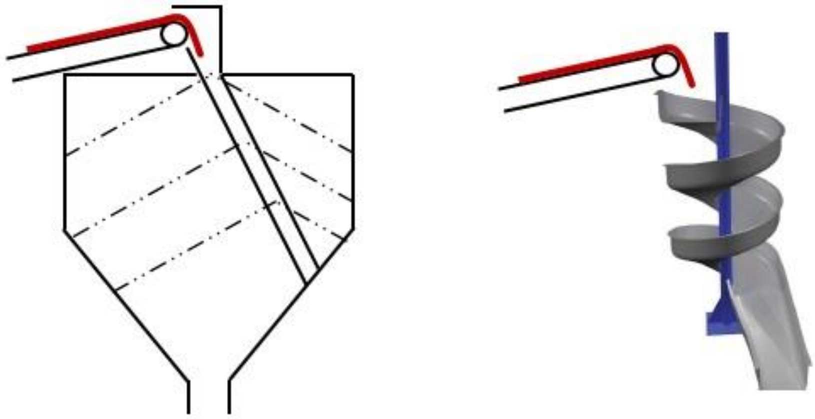
Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

Above figure shows typical transfer point with “Hood and Spoon”. It can be seen that the arrangement loads material at center of the receiving belt in proper direction and speed with minimum impact.

For new transfer chute system, it is recommended that the modeling and dynamic analysis techniques (DEM) should be used so as to reduce impact of the material on the receiving belt. By controlling the flow of material, impact idlers or slider beds are often not required and load zones can utilize the standard idler spacing as specified on the rest of the belt. These design methods mean that all the associated problems of belt wear, spillage, dust generation and product degradation are substantially reduced.

Lowering Chutes

Lowering chutes are used for directing materials to storage where dusting and degradation are objectionable.



Bin Lowering Chute Spiral Lowering Chute

Lowering Chutes

Bin Lowering Chutes

As shown in above figure, a bin lowering chute consist of a straight, declined, channel chute. It runs from the belt conveyor discharge point down into the bin and is secured to the sloping side of the bin near the bin bottom. The slope of the chute to the horizontal must be 10° to 15° greater than the angle of repose of the material. If so, material slides down the chute quietly with minimum dusting. When the material meets with the bin side or the surface of the material in the bin, it leaves the chute and spreads out conically.

Spiral Lowering Chutes

Above figure shows typical spiral lowering chute used to prevent breakage of fragile or soft material. It also prevents dusting.

Telescopic Chutes

Telescopic chutes are used to minimize the height of material fall into stockpiles to minimize dusting. The telescopic sections are usually cable-connected in such a manner that a winch can successively lift the sections of the chute. As shown in the following figure, the lower end of the chute is always kept just clear of the top of the stockpile to reduce dust generation.

Telescopic Chute

Dust Suppression System and Dust Collection System

The dust arises at material transfer points, crushing, screening etc. The arising of the dust at such location is natural, and is not objectionable. The only requirement is that the dust so formed should not come into the surrounding external air. The three primary root causes for fugitive dust emission at transfer points of a conveyor are spillage, carryback and airborne dust. Dust emission due to spillage can be reduced through the use of well-designed skirt board and its sealing system. Dust emission due to carryback can be reduced through the use of engineered belt cleaners. Dust emission due to airborne dust can be reduced through designing an engineered transfer system, the addition of a dust suppression system, and/or the use of an effective dust collection/extraction system. As information on skirt board and its sealing system and engineered belt cleaners to reduce dust emission is already covered in previous chapters, information about designing an engineered transfer system, dust suppression system and the use of an effective dust collection/extraction system to reduce airborne dust emission is given in this chapter.

Reasons for Controlling Dust Emission

Following are the main reasons for controlling the dust emission.

Health

The small particulate matter affects humans as it is inhaled, forcing the heart and lungs to work harder to provide oxygen to the body. This can lead to a decreased breathing ability and damage to the heart.

Reduced Operating Efficiency

Frequently the fugitive material is not recyclable which reduces the operating efficiency and increases the cost of production.

Increased Conveyor Maintenance Costs

Excessive spillage leads to premature belt, idler and pulley failure leading to increase in downtime and maintenance costs. The clean-up cost also increases.

Reduced Plant Safety

There is a higher risk of explosions when combustible material is allowed to build up on and around conveyors. Poor visibility due to emission may lead to an accident.

Basics of Dust Control

The conditions that determine whether fine materials become airborne are air velocity, particle size and cohesion of the bulk material.

The relationship of these characteristics can be summarized as under.

$$\text{Airborne Property} \propto \frac{\text{Air Velocity}}{\text{Particle Size} \times \text{Cohesiveness}}$$

If air velocity is increased, but particle size and cohesiveness remain constant, then dust will increase. If air velocity remains constant and particle size and/or cohesiveness are increased, the amount of airborne dust will be reduced.

When one or more of these parameters is a given, the ability to control dust depends on altering one or both of the other characteristics. For example, when the size of coal particles being transported cannot be changed, the air velocity or cohesive force of the particles must be altered to minimize dust emission.

Sources of Air

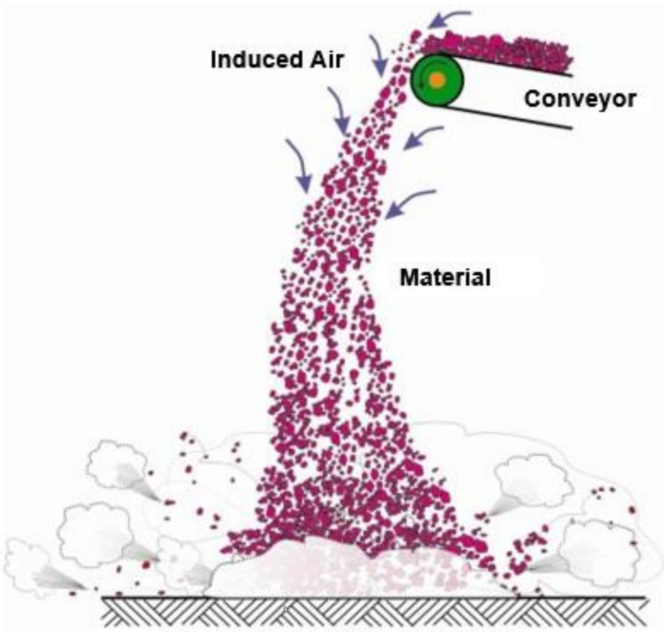
There are three sources for air movement in a given transfer point: Displaced Air, Induced Air and Generated Air.

Displaced Air

When a certain volume of material enters a chute the same volume of air is pushed out. The amount of displaced air is therefore equal to the volume of material introduced into the chute. However, one cannot reduce this amount.

Induced Air

Induced air is the air dragged by the moving product along the material trajectory after leaving the head pulley.



Demonstration of Air Induction

Air induction is based on the concept that material falling through air imparts momentum to the surrounding air. Due to this energy transfer, a stream of air always travels with the falling material. Above figure demonstrates air induction as material falls from a conveyor.

Generally, the induced air is the major portion of air responsible for the dust emission.

Generated Air

This is the air generated by the action of equipment that feed the conveyor load zone, such as crushers, hammer mills, wood chippers etc.

Control of Air Velocity (Designing of Engineered Transfer System)

A complete system to control dust by controlling velocity of the air at a conveyor transfer point consists of the following three design parameters.

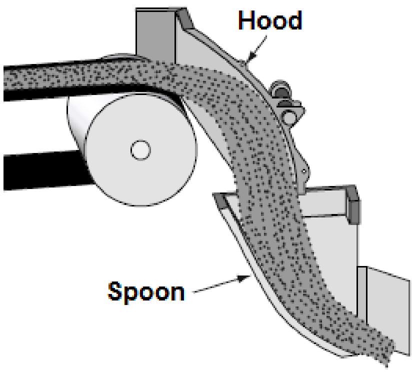
1. To limit the air coming into the enclosure.
2. To reduce the creation of dust inside the enclosure.
3. To lower air velocities within the enclosure, allowing suspended dust to fall back on the conveyor belt.

When material is conveyed, it contains a certain amount of entrapped air. In a conventional conveyor discharge, the material falls freely. During fall, the particles separate and each of them drags air. The total amount of induced air depends on the degree of size and separation of particles, as well as on the speed of falling material. When the material lands and becomes "compacted" most of this air is released, causing an increase of air pressure (positive pressure) in the load zone and surroundings. The main reason for dust emission is the positive pressure inside the chute, which tends to drive out the airborne particles.

Hence, to reduce the dust emission, the amount of induced air should be minimized. It may be noted that more the induced air, more the velocity of the air (because passage area remains constant).

Because the amount of induced air depends on open area at upstream end of the transfer point where air is induced into the system by action of falling material, to minimize the induced air, the size of the open area should be minimized. For this, rubber curtain may be installed at the belt's entrance to the enclosure. It is also important to keep inspection doors and other openings closed/sealed while the belt is in operation.

Keeping the material in a consolidated body will also reduce the amount of induced air. For this, a "hood and spoon" design may be used to confine the stream of moving material as shown in the following figure.



Hood and Spoon Type Chute

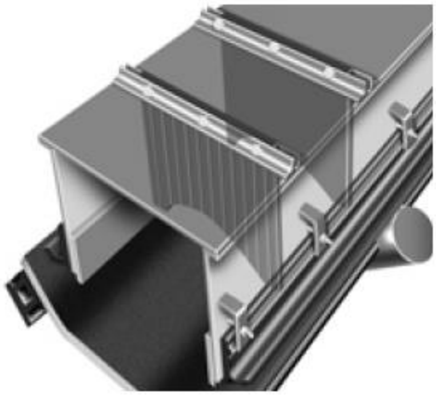
The hood minimizes the expansion (particles separate) of the material body, deflecting the stream downward. The spoon provides a curved loading chute that provides a smooth line of descent so the material slides down to the receptacle - whether that is a vessel or the loading zone of another conveyor.

This system also mitigates splash when material hits the receiving conveyor. Therefore, there is less dust and high velocity air escaping.

In some cases, either the hood or spoon is used, but not both. The hood can be used to minimizes the expansion of the material body and direct the stream downward for center loading.

Dust Curtain at Exit of Transfer Point

Because dust curtains slow air movement, allowing dust particles to drop out of the air, dust curtains are installed at exit of the transfer point as shown in above figure.



Curtains Installed Inside Skirtboard

As shown in above figure, rather than placing the curtains at the end of the covered skirtboard, it is better to install them inside the covered skirtboard. When the curtain is at the end of the steel enclosure, any material particles hit by the curtain can be displaced from the belt. By placing the curtains so the final curtain is one belt width from the end of the enclosure, any material that contacts the curtains still has room to settle into a stable profile within the confines of the enclosed area.

As shown in above figure, these curtains with slits at intervals across its width should be of rubber having shore A hardness of 60 to 70 degree and extend to roughly one inch (25 mm) below the top of the pile of conveyed product.

Dust Suppression System (Cohesiveness Control)

Dust Suppression is wetting of the fines by the application of water with or without chemicals. Wetting of the fines can be carried out either to the stream of the material to prevent fines from being carried off into the air (prevention of fines), or to the air above the material, to return airborne fines to the material bed (suppression of fines).

By wetting the fines, either as they lay in the material stream or as they are being lifted into the air above, the weight of each dust particle is increased so it is less likely to become airborne. The moisture also increases the cohesive force of the material body itself, creating larger, heavier groups of particles, and making it more difficult for air movement to carry off fines.

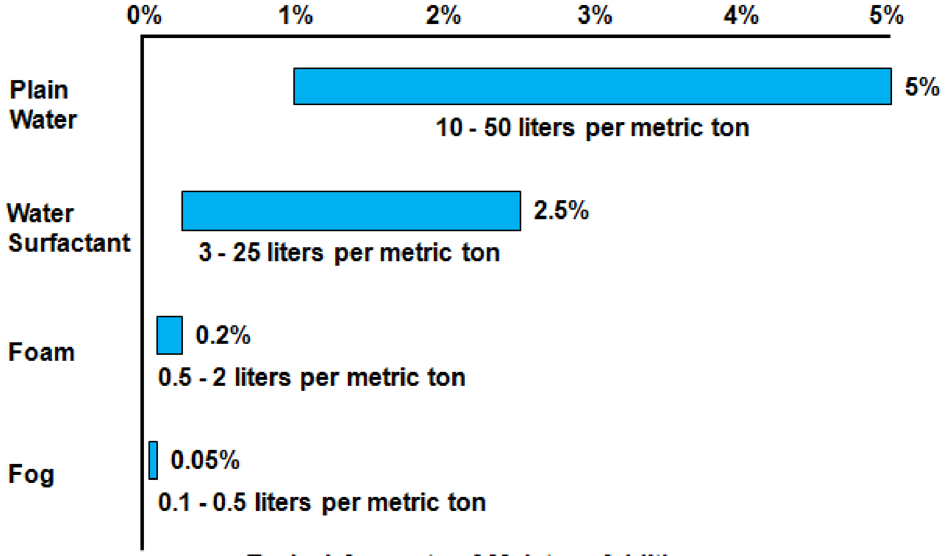
Generally, most operations require both prevention and suppression of fines to effectively control dust emission.

Spray nozzles are used for wetting of the fines. The keys to effective wet spray dust control are proper application of moisture, careful nozzle location, controlling droplet size, choosing the best spray pattern and spray nozzle type, and proper maintenance of equipment.

Various systems available in the market for wetting of the fines are as under.

- Plain water spray
- Water surfactant spray
- Foam spray
- Fog spray

The addition of water by these systems result in increased content of moisture in the material. The following chart compares the amounts of moisture addition for the type of coal being handled.



Typical Amounts of Moisture Addition

Plain Water and Fog Systems

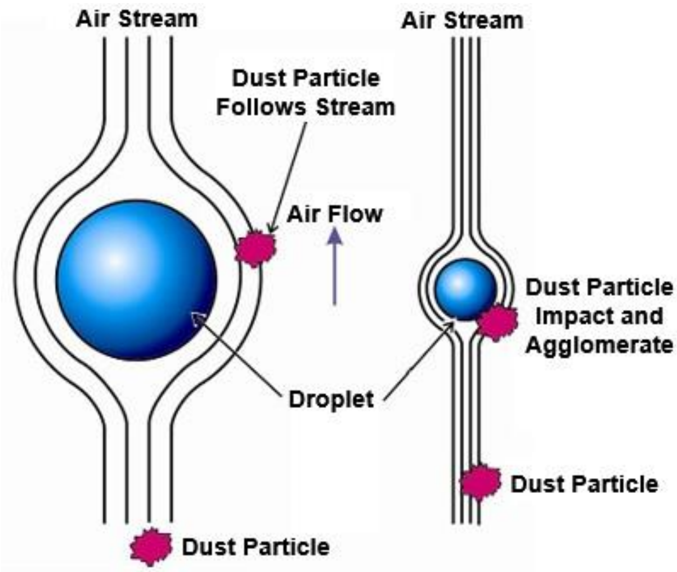
Plain water systems are typically the least expensive and easiest to design and implement. However, following points should be considered in designing / selecting the system.

Addition of too much moisture can cause material to stick together, complicating the flow characteristics of the material being conveyed resulting in operation and maintenance problems.

In applications like coal-fired power plants and cement plants, there is a thermal penalty because water added to the material going into the thermal process must be "burned off" by the process. This will reduce the process efficiency and increase fuel costs. As per one estimate, 850 KWH of energy would be required to evaporate 1000 Kgs (1.0 CuM) of water.

Hence, when applying water to conveyor systems, a good axiom is “less is more”.

When using sprays, one of the primary considerations is the droplet size. If the droplet diameter is much greater than the diameter of the dust particle, the dust particle simply follows the air stream lines around the droplet. If the water droplet is of a size comparable to that of the dust particle, contact occurs as the dust particle follows the stream lines and collides with the droplet as shown in the following figure. Hence, for optimal agglomeration, the particle and water droplet sizes should be roughly equivalent. The probability of impaction also increases as the size of the water spray droplets decreases, because as the size of the droplets decreases, the number of droplets increases. Droplets that are too small evaporate too quickly and release the captured dust particles.



Effect of Droplet Size On Dust Particle Impingement

Following are particle/droplet size for common precipitation:

Thin fog: 2 to 10 μm
Thick fog: 10 to 50 μm
Mist: 50 to 100 μm
Light rain: 100 to 500 μm
Moderate rain: 500 to 1000 μm
Intense rain: 1000 to 2000 μm
Heavy rain: 2000 to 5000 μm

Particle diameter for some materials in microns are:

Ground limestone: 10 to 1000 μm
Fly ash: 10 to 200 μm
Coal dust: 1 to 100 μm
Cement dust: 3 to 100 μm
Carbon black: 0.01 to 0.3 μm
Pulverized coal: 3 to 500 μm

Standard hydraulic nozzles and atomizing nozzles are used for wetting of the fines.

Standard hydraulic nozzles produce drops between 200 and 1200 μm. However, for dust prevention, it is recommended that standard hydraulic nozzles which produces droplet sizes above 100 μm (preferably 200 to 500 μm) should be used.

For dust prevention systems, nozzles should be located upstream of the transfer point where dust emissions, in most cases, are being created. The nozzles should be located at an optimum target distance from the material - far enough to provide the coverage required but close enough so that air currents do not carry the droplets away from their intended target.

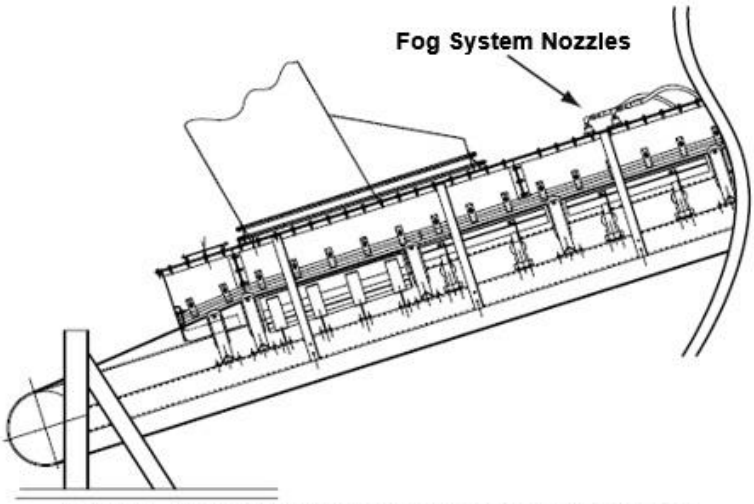
For suppression of airborne dust, atomizing nozzles which produce extremely small water droplets (drops between 1 and 200 μm) are used because to knock down existing dust in the air, the water droplets should be in similar size ranges to the dust particles. The intent is to have the droplets collide and attach themselves (agglomerate) to the dust particles, causing them to fall back to the material body from the air. As atomizing nozzles produce extremely small water droplets, like fog, these systems are called **Fog Systems**. Capturing airborne dust with water sprays is most effective in areas with little air turbulence. Hence, depending on the environment, enclosure may be required.

Atomization shears the water into very small particles, reducing surface tension. For a fog system, atomization is achieved by pumping water through nozzles at high pressure (single-fluid atomization) or by using a combination of compressed air and water pumped at lower pressure (two-fluid atomization) to produce extremely small drops (fog).

In a single-fluid atomization, also called hydraulic or airless atomization, hydraulic fine spray nozzles are used to generate the fog. Under this method, water is forced under high pressure through a small orifice that shatters the water droplets into microscopic (relatively small- to medium-sized) particles. The energy created by the high-pressure pump is used to atomize the water droplets, rather than increase water velocity, thereby minimizing displaced air. Hydraulic fine spray nozzles are preferred in most areas because by eliminating the requirement of compressed air, the installation is simple and operating costs are lower.

In two-fluid atomization, fog is produced from water and compressed air by passing them together through a two fluid nozzle. In this method atomization is achieved at lower pressures than the single-fluid atomization method because the compressed air breaks the liquid into small droplets. This method produces very small droplets. When the fog generated by this method has droplet size between1 to 10 μm, it does not wet the product. In such cases, the system is often called **"Dry Fog" System**.

In most cases, air atomizing nozzles are effective in locations where dust particles are extremely small and the nozzles can be located in close proximity to the dust source, although some applications will require large capacity air atomizing nozzles to throw their sprays long distances to reach the dust.



Typical Location of Fog System Nozzles on Conveyors

As shown in above figure, location of fog system nozzles on a conveyor is generally near the end of the transfer point. This allows the material load to settle, and any pick-ups for active or passive dust collection systems to remove dust-laden air without risk of blinding the filtration media with moistened dust particles.

Fog generation nozzles should be installed to cover the full width of the conveyor's skirted area. It is recommended that skirtboard height be at least 24 inches (600 mm) to allow the cone of nozzle output to reach optimum coverage.

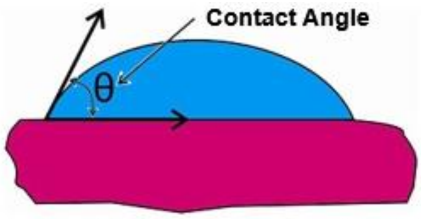
The nozzle spray pattern should be designed so that all emissions of material are forced to pass through the blanket/curtain of fog without putting the fog spray directly onto the main body of the material. The spray is directed above the material, rather than at the material.

It may be noted that fog systems supply extremely small water droplets that maximize the capture potential of the water while minimizing the amount of water added to the product.

Surfactant System

The effectiveness of any wetting system is related to the relationship size of the particle versus size of the droplet. When the droplet is too big, the efficiency of the system is very low. Often, the minerals being handled repel water and it is sometimes difficult using water only systems to allow the water to become absorbed into the finer fraction of the product. Hence, when water alone is not efficient, surfactants are used for wetting the fines. In a surfactant system, surfactant is added to water because they lower the surface tension of the water solution, which has the following effects:

- Reduced droplet diameter
- An increase in the number of droplets for a given volume of water; and
- A decrease in the contact angle (θ), defined as the angle at which a liquid meets a solid surface as shown in the following figure.



Contact Angle Between Liquid and Solid Surface

As a result, use of surfactant increases the rate at which the droplets are able to wet or coat dust particles and less moisture is used to produce the same effects as compared to typical water application.

The water pressure can also be reduced. The nozzles are also larger in diameter. Generally, the water consumption is from 0.75 - 7 gallons per ton. The water to surfactant relationship is 1:5000. Water pressure ranges from 175 up to 220 psi and nozzle diameter from 1/32" to 1/16". However, because this system produces large droplets, the efficiency is not ideal when the particles are less than 100 microns in diameter.

Despite the effectiveness of surfactants, it must be noted that they are not often used in the metal/nonmetal industry due to following.

- Surfactants are significantly more expensive than a typical water application.
- They can alter the properties of the mineral or material being processed.
- They can damage some equipment such as conveyor belts and seals.
- Surfactant systems require more upkeep and maintenance than typical water systems.
- Surfactants have limited usefulness in the metal/nonmetal mining industry, as opposed to in the coal industry (coal usually requires the use of surfactants), since ore or stone are much easier to wet than is coal due to its hydrophobic nature.

Hydrophobic refers to the property of a substance to repel water. In actuality, it isn't that the substance is repelled by water so much as its lack of attraction to it. In general, materials adverse/unfavorable to combine with water are called hydrophobic materials.

Foam System

Foam dust suppression works effectively by reducing the surface tension or "static charge" of individual dust particles and increasing the molecular attraction between fugitive dust particles and the material mass. Mixing of foaming surfactant, water and compressed air in proper proportions generates the foam. Application of foam dust suppression into transfer points can increase immediate and midterm dust suppression through several transfer points and stack out operations (residual effect). Foaming surfactants with residual agents (binders) can increase the dust suppression effect over longer storage or transportation periods, such as stockpiling or shipping. However, using foam in dust suppression is not easy because of the difficulty in reaching all of the particles in the material mass.

Use of Binders

Sometimes binders are also used. Binders agglomerate particles together after the moisture evaporates. Because they eliminate the need for re-application, they give best efficiency in multiple transfer points. However, binders can cause clogging and build-up on nozzles, conveyors and other equipment. Water-soluble binders can cause environmental problems should run-off occur.

Spray System Automation

Ideally, the spray system should be automated so that sprays are only activated when material is actually being processed. For dust knockdown, or suppression, a delay timer may be incorporated into some applications to allow the spray system to operate for a short time period after a dust-producing event.

Belt Loading Monitor

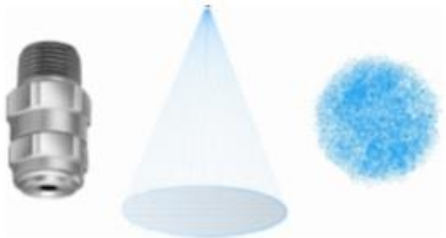
For automation of a spray system, a belt loading monitor also may be used. As shown in above figure, belt loading monitor is a simple and robust device to detect loading of material on the belt conveyor. It consists of a roller assembly which is to be installed below the belt. Due to loading on the belt, the roller makes contact with the belt. The belt pushes the roller down and operates the limit switch contact. The contacts are used in control circuit for interlocking purpose.

Nozzle Types and Spray Patterns

Generally, the process of generating drops is called atomization. The process of atomization begins by forcing liquid through a nozzle. The energy of the liquid (pressure for hydraulic nozzles or liquid and air pressure for two-fluid nozzles) along with the geometry of the nozzle causes the liquid to emerge as small ligaments. These ligaments then break up further into very small “pieces”, which are usually called drops, droplets or liquid particles.

Spray nozzles are categorized by the type of atomization method used and by the spray patterns they produce. The standard hydraulic nozzles produce full cone, hollow cone or flat fan patterns. Hydraulically atomizing nozzles, hydraulic fine spray nozzles (simply called fine spray nozzles) are typically used to produce hollow cone spray pattern. Air atomizing nozzles (which utilize compressed air) are typically used to produce round or flat fan spray patterns.

Hydraulic Full Cone Nozzles



Hydraulic Full Cone Nozzle

As shown in above figure, hydraulic full cone nozzles produce a solid cone-shaped spray pattern with a round impact area that provides high velocity over a distance. They produce medium to large droplet sizes over a wide range of pressures and flows. They are normally used when the sprays need to be located further away from the dust source. They are widely used for dust prevention.

Hydraulic Hollow Cone Nozzles

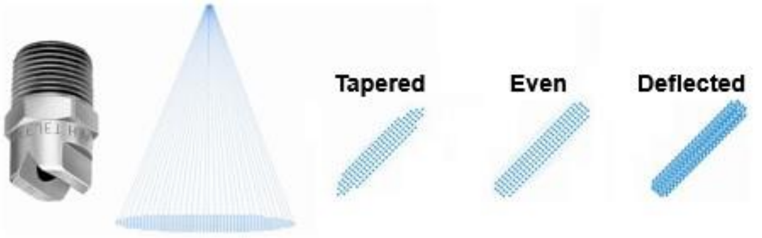
Whirl Chamber Right Angle Design **Spiral Nozzle Design**

Hydraulic Hollow Cone Nozzles

Hydraulic hollow cone nozzles produce a circular ring spray pattern and typically produce smaller drops than other hydraulic nozzle types of the same flow rate. They also have larger orifices which results in reduced nozzle clogging. Hollow cone nozzles are normally useful for operations where airborne dust is widely dispersed and are available in two different designs: whirl chamber and spiral sprays (as shown in above figure). In most whirl chambers, the spray pattern is at a right angle to the liquid inlet; however, in-line designs are also available. Both produce a more uniform pattern with smaller droplets. Spiral sprays are used when greater water flow is needed, resulting in less clogging due to the large orifices. There is also less pattern uniformity and larger droplets are created. They are most widely used for dust prevention.

Hydraulic Flat Fan Nozzles

Hydraulic flat fan nozzles produce relatively large droplets over a wide range of flows and spray angles and are normally located in narrow enclosed spaces.



Hydraulic Flat Fan Nozzle and Spray Patterns

These nozzles are useful for dust prevention systems. As shown in above figure, flat fan nozzles are available in three different designs: tapered, even, and deflected.

Tapered-edge flat spray nozzles are designed for use on a spray manifold or header. These nozzles provide uniform, overall coverage across the impact area as a result of overlapping distributions.

Even flat spray nozzles produce a thin rectangular pattern and provide uniform coverage. In manifold set-ups, the nozzles are positioned for edge-to-edge pattern contact. The nozzles are used primarily in high impact applications.


Deflected Type Flat Spray Nozzle

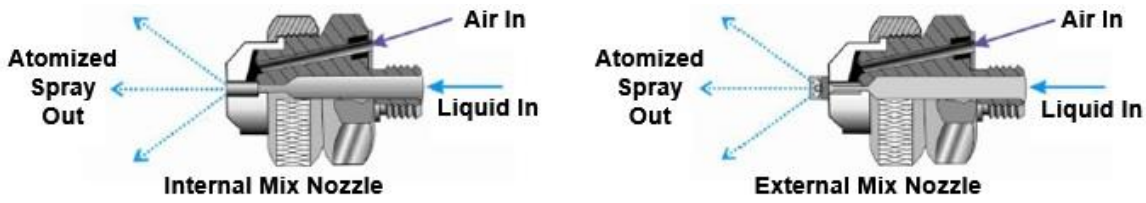
Deflected (tongue) type flat spray nozzles produce a relatively even flat spray pattern of medium-sized drops. As shown in above figure, the spray pattern is formed by liquid flowing over the deflector surface from a round orifice.

Hydraulic Fine Spray Nozzles


Hydraulic Fine Spray Nozzle

Above figure shows typical hydraulic fine spray nozzle used to produce hollow cone spray pattern. Hydraulic fine spray nozzles produce very small droplet and are commonly used to capture small dust particles in enclosed areas to minimize drift. They are widely used for airborne dust suppression and operations requiring a light fog.

Air Atomizing Nozzles



Typical Air Atomizing Nozzle

Above figure shows two styles of air atomizing nozzles known as internal mix and external mix. Internal mix nozzles use an air cap that mixes the liquid and air streams internally to produce a completely atomized spray and external mix nozzles use an air cap that mixes the liquid and air streams outside of the nozzle. In an internal mix nozzle, liquid and air streams are not independent (air pressure acts against the liquid pressure) and a change in air flow will affect the liquid flow. With an external mix nozzle, the liquid pressure is unaffected by the atomization air pressure.

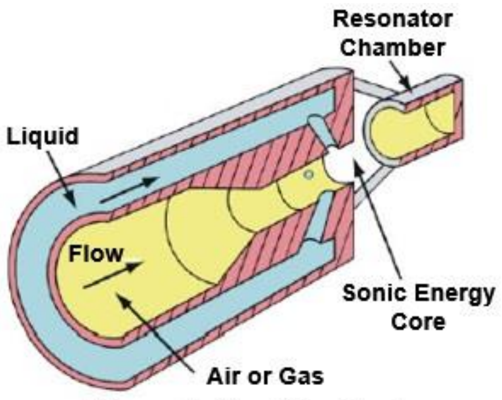
Obtaining finer atomization is accomplished by increasing the air pressure and/or lowering the liquid pressure, resulting in a high ratio of air flow rate to liquid flow rate.

Internal mixing should be preferred when water without solid matter are to be atomized. External mixing is particularly suited for atomizing viscous liquids which are prone to impurities and therefore tend to cause clogging of the nozzle. Low liquid pressures are used with this type of nozzle due to its design.

Internal mix nozzles can produce either round or flat spray patterns and external mix nozzles produce flat spray patterns.

Ultrasonic Atomizing Nozzles

For dust suppression, some companies are using special ultrasonic atomizing nozzles to produce dry fog (water droplets of size 10 microns or less). In these nozzles, atomization of the liquid is carried out be sonic energy as explained below.

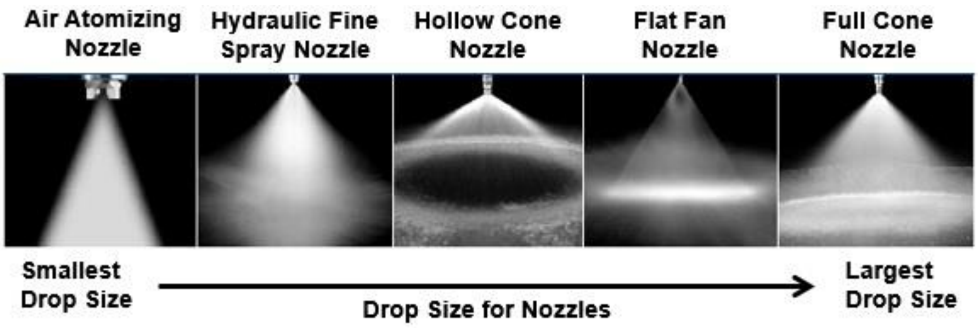


Ultrasonic Atomizing Nozzle

As shown in above figure, in an ultrasonic atomizing nozzle, compressed air passes through the nozzle's inner bore and is accelerated beyond the speed of sound through a convergent / divergent section creating shock waves and passing them into a resonator chamber/cavity where they are reflected back to complement and amplify the primary shock waves. The result is an intense field of sonic energy focused between the nozzle body and the resonator chamber. Any liquid capable of being pumped into the shock wave zone is vigorously sheared into very fine droplets by the sonic energy field. Air bypassing the resonator carries the atomized droplets downstream in a soft plume shaped spray.

Ultrasonic atomizing nozzles operate at very low liquid pressures and have large orifices. The large orifices and low pressures virtually eliminate orifice wear and prevent deterioration of the quality of atomization while greatly extending nozzle life.

Air and ultrasonic atomizing nozzles produce very small drops and are commonly used to capture small dust particles in enclosed areas to minimize drift. They are widely used for airborne dust suppression.



Above figure shows relative drop size for various types of nozzles. It can be seen that air atomizing nozzles produce the smallest drop sizes followed by hydraulic fine spray, hollow cone, flat fan and full cone nozzles.

Many factors affect drop size:

- Higher pressures yield smaller drops and lower pressures yield larger drops.
- Lower flow nozzles produce the smallest drops and higher flow nozzles produce the largest drops.
- Increases in surface tension increase drop size.

Drop velocity is dependent on drop size. Small drops may have a higher initial velocity, but velocity diminishes quickly. Larger drops retain velocity longer and travel further.

Operating conditions will determine which nozzle type and spray pattern will offer the best performance. Following table lists some common dust control application areas and the type of spray nozzle typically used for that application.

Typical Applications by Spray Nozzle Type					
Spray Nozzle Type	Air Atomizing	Hydraulic Fine Spray	Hydraulic Full Cone	Hydraulic Hollow Cone	Hydraulic Flat Fan
Typical Liquid Pressures, psi	10 - 60	30 - 1000	10 - 300	5 - 100	10 - 500
Typical Air Pressures, psi	10 - 70	Not Applicable			
Airborne Dust Suppression					
Jaw crushers	●	●		●	
Loading terminals	●	●			
Primary dump hoppers	●	●			
Transfer points	●	●			
Dust Prevention					
Stackers, reclaimers		●	●		
Stockpiles		●			●
Transfer points		●	●	●	
Transport areas/roads				●	

Spray Nozzles Maintenance

Spray nozzles are designed for long-lasting and trouble-free performance. However, like all components, spray nozzles do wear over time. Nozzle wear causes streaks and heavier flows in the spry pattern. Spray performance can suffer and costs can rise. How quickly wear occurs is dependent on a variety of application-specific factors. Other factors that can negatively impact spray nozzle performance are plugging, corrosion and scale build-up.

To prevent plugging/clogging, use proper water clarification devices and strainers. Also be sure to specify nozzles with adequate free passage.

To prevent corrosion, specify nozzles in the appropriate materials for the solutions being sprayed.

To control build-up of scales, control hardness level of the water. Remove build-up inside the nozzle or on the exterior on a regular basis.

Nozzle Corrosion and Build-Up

Above figure shows nozzle corrosion and build-up on a nozzle.

Maintenance Tips

Examine spray patterns and watch for changes in spray angles, distribution and heavy edges.

As wear may be hard to detect, go beyond visually inspecting nozzles. Periodically check the flow rate and spray pressure at a system level. Flow rate can be checked by reading the flow meter or collecting the spray in a container.

Soak nozzles in mild solvent to loosen debris for easier removal with proper equipment.

Cleaning tools should be significantly softer than the material of the nozzles - toothbrush or toothpick. Never clean the orifice with metal objects.

For more information on nozzles, please visit website: www.spray.com of Spraying Systems Co.

Fog Cannons

A fog cannon may be used when vast open spaces require dust suppression. In a fog cannon, hydraulic spray nozzles are mounted circumferentially around the outlet of a large fan assisted barrel. The nozzles spray together with the high flow of air from the fan throws the droplets many metres towards the source of the dust activity. The droplets scatter in a plume of relatively soft spray and can capture fugitive dust before it becomes airborne.

As standard hydraulic spray nozzles are not effective for airborne dusty suppression, single-fluid atomizing nozzles may be used for such application. Many companies are making systems using single-fluid atomizing nozzles.

Nevis Airborne Dust Suppression System

Above figure shows Nevis airborne dust suppression system (commonly called fog cannons). To generate fog, water is pumped at approximately 20 Kg/Cm^2 through single-fluid atomizing nozzles in their system. Throw range of Nevis (Now Mist Cannon) 25 is 25 meters and Nevis 50 is 50 meters. For more information on Nevis airborne dust suppression system, please contact Excel Combine (www.excelnevis.com).

Wagon Tippler with Plain Water Spray Nozzles for Dust Suppression

Above figure shows installation of a plain water spray system for airborne dusty dust suppression at a wagon tippler.

In general it is found that such system is not effective. In such cases, one fog cannon may be installed on one side of the wagon tippler hopper.

Sprinklers and Rain Guns

Sprinkler

Sprinkler is a device for applying water similar to rainfall. Sprinklers are mainly used where wetting is required over a wide area such as roadways and open yards for dust prevention. They are limited by the throw achievable and rely on good water pressure.

Rain Guns are high performance sprinklers designed for applications where relatively high flows and extended radius of throw are desired.

Rain Bird International, Inc. (www.rainbird.com) is a reputed manufacturer of sprinklers and rain guns.

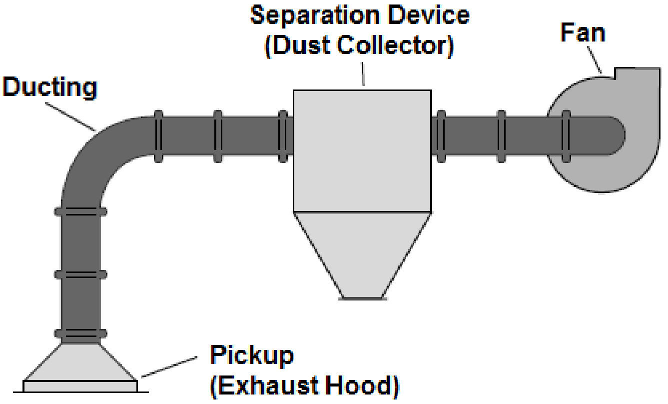
Advantage of Dust Suppression Systems

One advantage of dust suppression is that the material does not have to be handled again. The suppressed dust returns to the main body of conveyed material without requiring additional material handling equipment.

Dust Collection System

This is also known as dust separation system or dust extraction system. This is a dry way to control dust emission at transfer points. It basically consists of passing the dust carrying air from the load zone through some form of filtration or separation system.

There are both active and passive dust collection systems. A passive system merely allows the air to move through the filtration system. An active system, like a vacuum cleaner, pulls in the air through a filtration medium to remove the solids.



Dust Collection System

As shown in above figure, typical active mechanical dust collection system consists of four major components:

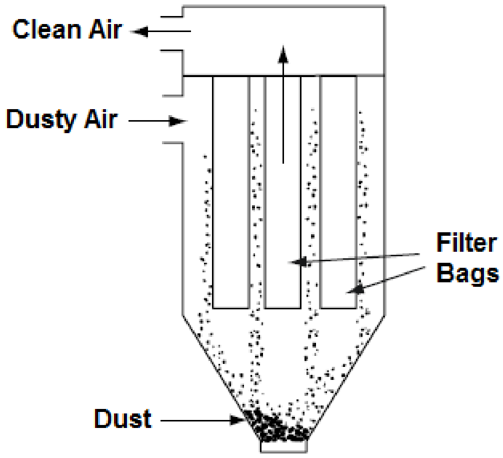
- Exhaust hoods (or pickups) to capture dust at the source(s).
- Ductwork to transport the captured air/dust mixture to a collector.
- A collector, filter or separation device to remove the dust from the air.
- A fan and motor to provide the necessary exhaust volume and energy.

In this method, the dust generation zone is enclosed all around. The ducting connection is taken from this zone to dust extraction unit to exhaust fan and stack (exhaust duct). The fan sucks the air from dust generation zone and emits it outside. This creates negative pressure, which creates outside airflow in to dust generating zone instead of dust laden air leaking out at open connections.

The dust extraction unit separate outs the dust and relatively clean air flows through fan to atmosphere. The dust so separated is fed back onto conveyor, when it is feasible, or else into a hopper. The dust so collected in the hopper is periodically removed by trucks, and is put back into the conveying system at suitable location. Dust extraction unit can be of cyclonic type, bag house type, combination of cyclone-bag house, etc. The purpose of dust extraction is not to separate dust, but to maintain negative pressure in dust generating zone. The dust separating process is the consequence of need to maintain negative pressure in the dust generation zone.

Bag House Type Dust Collectors

Perhaps the most common dust separation technology is the use of fabric collectors, which are placed in structures commonly called bag houses, shown in the following figure.



Bag House Type Dust Collector

In this system, dust-laden air enters an enclosure and passes through bags of filter fabric. The dust gets trapped in the media and if the media were left un-cleaned, air movement would be blocked. Because of this, a cleaning mechanism is provided. Today the industry uses a counter flow of compressed air to automatically clean the "bags".

The bag house collection system works at efficiency of 99% or better in removing respirable dust emissions.

However, for efficient working, there should be an adequate area of filtration media relative to the dust type that is handled. The selection of the correct filtration area (and hence the filtration velocity) is most critical as the efficiency of the separation and filtration process depends on it.

For many dust applications the filter material employed is good quality natural cotton, with a weight of around 250 g/square meter (0.05 lbs/ft^2) and a filtration velocity in the order of 1.5 m/min (5 fpm). However, if there is evidence of moisture or corrosive chemical in the dust stream then it is recommended to use woven polyester which can offer filtration efficiency equivalent to that of a natural fabric but greater resistance to chemical attack. For high temperature applications a special kind of fabric will have to be considered.

The following table gives media alternates.

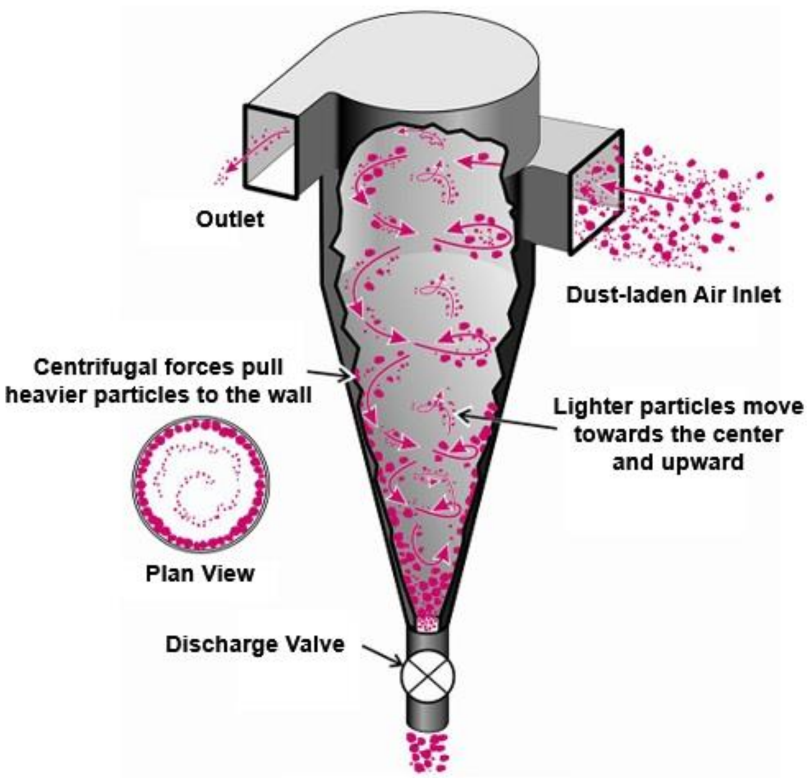
Fiber Type	Acid Resistance	Alkali Resistance	Abrasion Resistance	Will Support Combustion
Woven Cotton	Poor	Poor	Poor	Yes
Woven Polyester	Good	Good	Very Good	No
Polypropylene	Excellent	Excellent	Very Good	Yes
Gortex	Good	Moderate	Very Good	No

Explosion Protection

By its nature a dust collector contains clouds of fine particles in suspension. If these particles are of material known to be combustible, then explosion may occur. A wide range of dust is capable of producing an explosion. These include carbonaceous materials, plastics, fertilizers, pharmaceuticals, fuel, chemicals, foodstuffs and certain metals.

There are several ways to prevent the risk of an explosion. The most common method is to use an explosion relief panel (a panel designed to explode instead of the bag house).

Cyclone Type Dust Collectors



Typical Cyclone Type Dust Collector

Cyclone type dust collectors, commonly called cyclones are a dust collection device that separates particulate from the air by centrifugal force. As shown in above figure, the cyclone works by forcing the incoming airstream to spin in a vortex. As the airstream is forced to change direction, the inertia of the particulates causes them to continue in the original direction and to be separated from the airstream. Although, the cyclone is simple in appearance and operation, the interactions inside a cyclone are complex. A simple way to explain the action taking place inside a cyclone is that there are two vortices that are created during its operation. The main vortex spirals downward and carries the coarser particles. An inner vortex, created near the bottom of the cyclone, spirals upward and carries finer dust particles.

Cyclones are cost-effective and low-maintenance devices, and they can handle high temperatures. However, cyclones do not provide efficient collection of fine or respirable particles. Hence they are often used as pre-cleaners to reduce the workload on more efficient dust collection systems.

For more information on dust collection system, please see the booklet titled “Working, Design Considerations and Maintenance of Bag Type Fabric Filters” uploaded at www.practicalmaintenance.net.

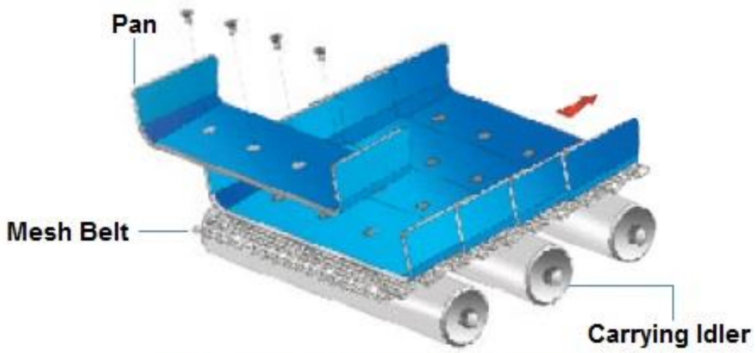
Magaldi Superbelt

It is hard for conventional conveyors to withstand very high temperatures, heavy loads and abrasiveness or sharp edges of several bulk materials. Conventional conveyors often cause production losses, due to unforeseen failures, require excessive maintenance and are noisy and dusty.

During the last 40 years, many successful installations worldwide have confirmed that the Magaldi Superbelt® conveyor (in its different configurations) is the dependable and eco-friendly solution for such problems.

The Magaldi Group supplies to different industrial fields a wide range of equipment based on the Magaldi Superbelt® technology.

Magaldi Superbelt®



Construction of Magaldi Superbelt

As shown in above figure, the Magaldi Superbelt® is made up of a steel mesh belt, which carries partially overlapping steel pans that form a virtually sealed belt conveyor.

The patented method of connecting the pans to the belt leaves all elements free to thermally expand in any direction, without permanent deformation. As a result, the Magaldi Superbelt® withstands temperatures higher than any other known competitive conveyor. The Magaldi Superbelt® is the ideal conveying system for processes regarding cement clinker, lime, magnesium oxide, lead, zinc and manganese sinter, foundry sand, pellets, chips and many other bulk materials.

Superbelt N

The Magaldi Superbelt® "N type" conveyor is used for horizontal or inclined (up to 28°) transportation of bulk materials. It is generally used in place of rubber belt conveyors, drag chain conveyors and vibrating conveyors.

Superbelt E

The Magaldi Superbelt® "E type" conveyor is provided with cross cleats for conveying bulk materials up to 55° inclinations. It is used in place of corrugated side walls rubber belt conveyors, bucket elevators and deep pan conveyors.

Replacement of Rubber Belt Conveyors

It is not uncommon to see in industrial plants, rubber belts damaged by hot or sharp materials, apron leaking material through the gaps between the pans or with chains weakened by temperature over 350 °C.

These are the typical circumstances that can be easily solved using the Magaldi Superbelt®.

It is very easy to fit the carrying idlers and return rollers on existing frames of rubber belts or apron conveyors because the design of a Superbelt belt is very similar to traditional conveyors.

Often it is possible to reuse also head and tail drums, bearings and pillow blocks, motors and gearboxes, take up units.

Main applications of the Magaldi Superbelt® Conveyors include:

- Handling systems for hot clinker and all abrasive, sharp and heavy materials.
- Hoppers and silos loading and unloading.
- Transfer and cooling of both bulk and lumpy materials.

For more information, please view website of Magaldi (www.magaldi.com).

Belt Training / Tracking

For trouble-free running of a belt conveyor, correct installation/alignment of stringers, pulleys and idlers is very important. Incorrect installation/alignment of these components will result in belt misalignment. Belt misalignment can be defined as deviation of belt centerline from conveyor center-line, more precisely the idlers center line. A belt that does not run in alignment can cause material spillage and damage the belt. This misalignment can be corrected by belt training / tracking. Training the belt is a process of adjusting idlers, pulleys and the method of loading in a manner that will correct any tendency of the belt to run off to one side or the other.

Information about stringer alignment, pulley alignment, idler alignment, common causes for belt mistracking, basic belt behavior and procedure for belt training is given in this chapter.

Stringer Alignment

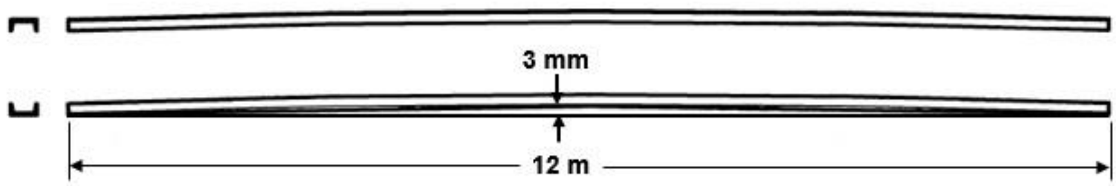
Conveyor stringers must be installed parallel, straight, square and level to allow proper belt training. During installation, dimensional checks shall be made to insure that the following tolerances in the idler carrying members are not exceeded.

Parallel

Tolerance for Parallel Dimension

As shown in above figure, maximum tolerance of ± 3 mm shall be allowed for the back to back dimension in channel or angle stringers. Similarly, ± 3 mm shall be allowed between webs of I-beams, wide flange beams or tees.

Straightness



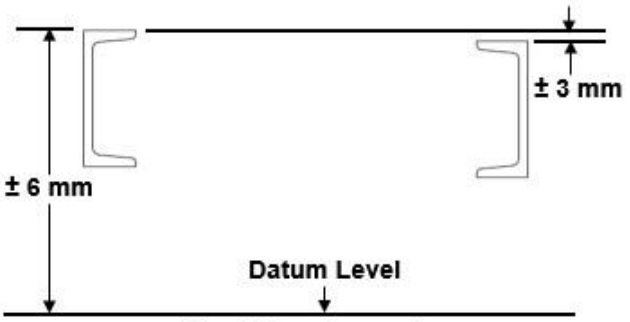
Allowable Lateral Offset

As shown in above figure, the maximum allowable sideway offset in conveyor stringers shall be 3 mm in 12 m of length.

Squareness

A check on squareness can be made by comparing diagonal measurements between two carrying idler sets which are at a distance of approximately four times the distance between two consecutive idler sets. To assure conveyor frame squareness, these diagonals must be within 3 mm. Similarly, the return idlers also should be installed level and parallel to the head and tail pulleys.

Level



Level Requirements

As shown in above figure, the two idler support members shall be leveled within 3 mm regardless of belt width. In addition, the elevation of stringer above support structure shall be held within ± 6 mm.

Pulley Alignment

All belt conveyor pulleys should be leveled and their shaft centerline should be perpendicular to the centerline of the belt.

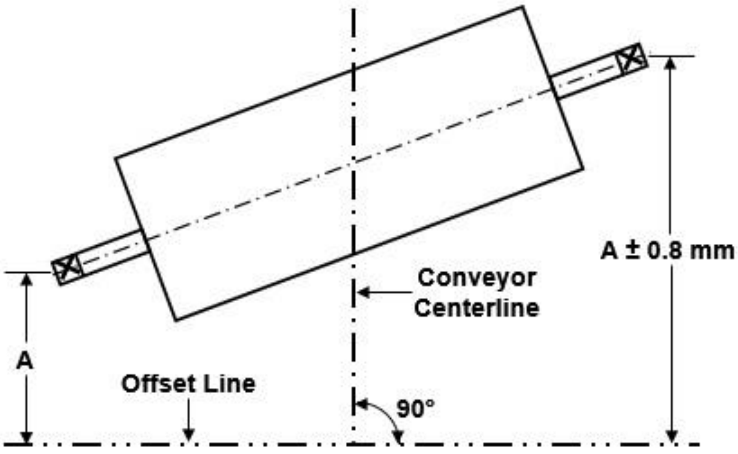
Due to manufacturing tolerances of pulley, it is recommended that alignment measurements should be taken on the pulley shaft and not on pulley.

Pulleys should be alignment to following tolerances.

Shaft Elevations

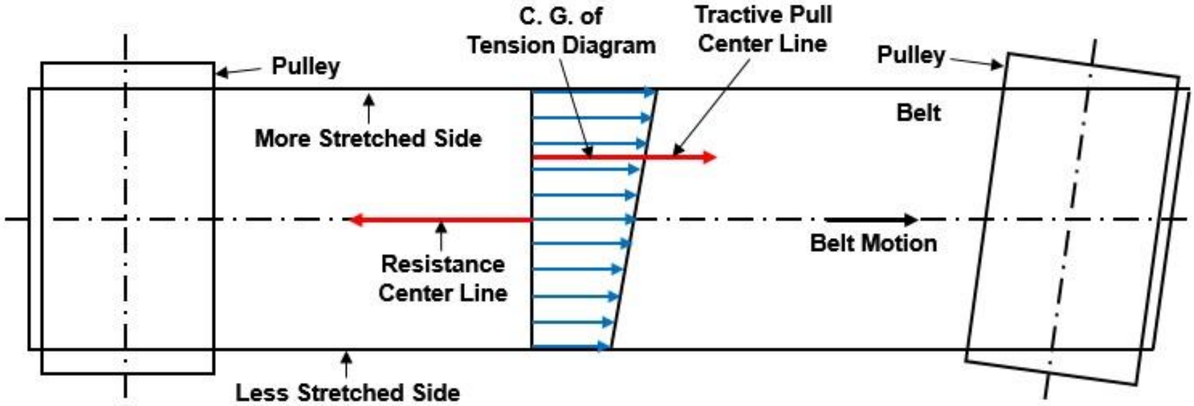
The shaft elevations of the pulley at the bearings should be within ± 0.8 mm.

Shaft Alignment with Conveyor Centerline



Shaft Alignment with Conveyor Centerline

As shown in above figure, measuring from a line constructed perpendicular to the conveyor centerline (Offset line), the pulley shaft centerline should not deviate greater than ± 0.8 mm at the bearings.

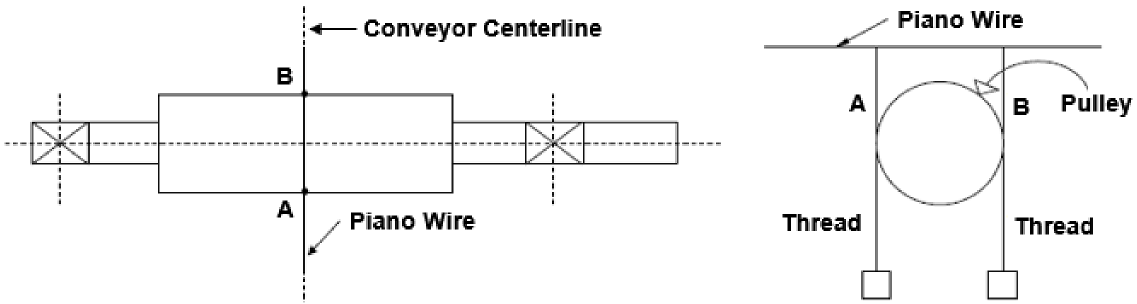


Misaligned Center Line of Pulleys

All pulleys centerlines should be at right angle to conveyor centerline. If this is not the case, as shown in above figure, the tractive pull centerline will not be at belt centerline (which is generally also the resistance centre line), leading to misaligned running. Belts naturally want to “walk away” from a higher tension. If tension is increased on one edge, it will walk the other way.

The belt carcass should be uniform in strength across belt width and it should also be under uniform tensile status across width. Any of these faults during belt manufacture will result into tractive pull being not at belt center line (resistance centre line). Such fault in some portion of the belt will appear as moving misalignment.

Checking perpendicularity of a pulley with the conveyor centerline (whether the pulley’s centerline is at right angle to the conveyor centerline or not) can be carried out as under.



Setup to Check Perpendicularity of Pulley with Conveyor Centerline

Tie piano wire along the axis of conveyor centerline over the pulley as shown in above figure.

Hang two threads coated with color (chalk powder) at A and B from piano wire as shown in the figure so that they touch to the pulley.

Now manually rotate the pulley for one revolution (360 degree). While rotating, ensure that the color threads form two circular impressions (circle A and circle B for the treads hung at A and at B respectively) on the pulley.

If the circle A and circle B are coinciding, then the pulley is at right angle to the center line of the conveyor.

If the circle A and circle B are apart from each other, then the pulley is not at right angle to the center line of the conveyor and needs to be re aligned.

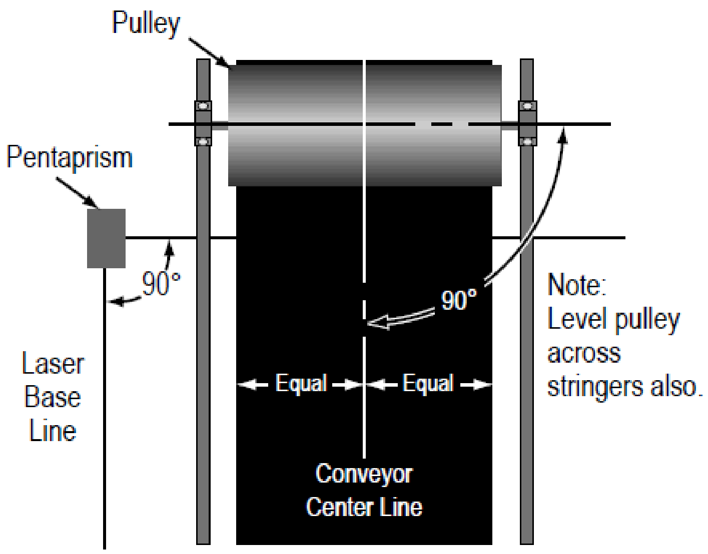
Idler Alignment

Idlers are bolted to the supporting structure. The structure should be horizontal (side to side), square and at the conveyor centerline.

Idlers shall be set from a previously squared and leveled head or tail pulley (it is recommended to start setting the idlers from the discharge pulley). It is also recommended to use laser alignment techniques to establish a datum line. Alternately, a tight wire on the conveyor centerline or offset to it, stretched to form a true centerline reference may be used. This line should be at least 100 feet long and referenced to the squared starting pulley.

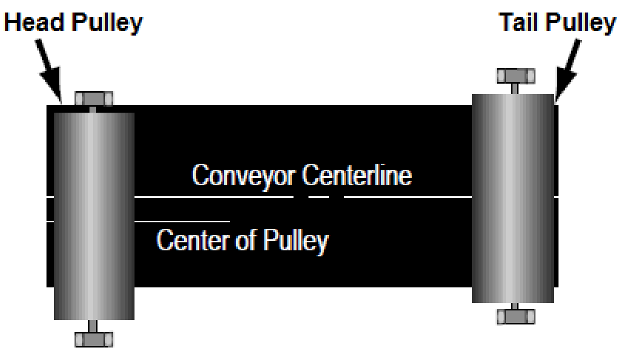
Idlers shall be installed at design spacing and square to the line. After a span of about 50 feet has been filled with idlers, the 100-foot line shall be relocated so that there is a 50-foot overlap on the first position. Repositioning of the laser or tight wire should continue until the entire conveyor length is filled with idlers.

Laser Alignment Technique



Verification of Pulley Perpendicularity Using Laser

As shown in above figure, to check the alignment of the conveyor and its components, a low-power laser tube is used to “shoot” a baseline along a conveyor. Next, a pentaprism is used to bend the laser beam 90° to check the squareness of the installation of the head pulley, tail pulley, snub pulley and bend pulleys. After this, idlers are installed as explained above.



Head Pulley Not on Conveyor Centerline

As shown in above figure, mistracking will occur if the head pulley is not located on the conveyor centerline.

Common Causes for Belt Mistracking

The most common causes for mistracking can be split into various groups as under.

Faults with Belt

- The splice is not square to the belt.
- Different types or thicknesses of belt have been spliced together.
- The belt is bowed or cupped.
- Belt's troughability is unsuitable.
- Defects or damage in the carcass (may show as belt camber).
- Degradation of the belt from exposure to the elements or chemicals.

Faults with Conveyor Structure

- The structure was not accurately aligned during its construction.
- Idlers and pulleys are not aligned in all three axes (please note that excessive play/clearance or uneven counterweight distribution in a gravity take-up system will allow the take-up pulley to become inclined/unleveled).
- Material buildup has altered the profile of idlers or pulleys.
- Idler rolls have seized or been removed.
- The conveyor is subjected to lateral winds.
- The conveyor is subjected to rain or sun on one side.
- The gravity take-up is misaligned.
- The structure has been damaged or settled on one side through ground subsidence.
- The structure has warped due to a conveyor fire.

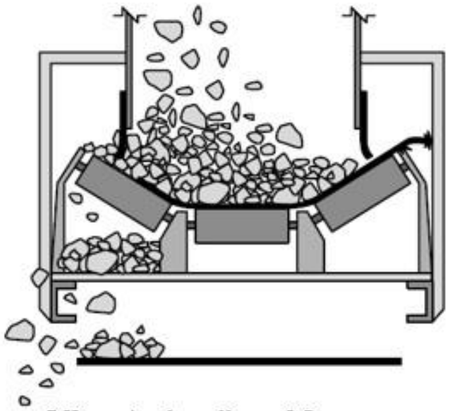
Faults with Material Loading

- The load is not centered.
- The load is segregated, with larger lumps on one side of the belt.

Understanding the basic patterns of belt behavior and undertaking a set of procedures to carefully align the conveyor structure and components in most cases prevent belt wander.

When the belt continues to run off consistently over a fixed length of conveyor, the cause is probably in the alignment or leveling of the conveyor structures, idlers, or pulleys in that area.

If one or more segments of the belt run off at all points along the conveyor, the cause is more likely the belt itself, a splice, or the method of loading.



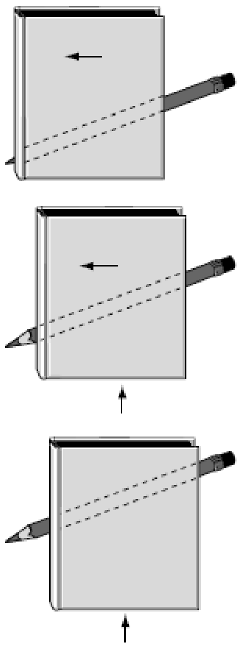
Off-center Loading of Conveyor

As shown in above figure, when the belt is loaded off-center, the center of gravity of the load tends to find the center of the troughing idlers, thus leading the belt off on its lightly loaded edge.

Many times a belt wanders when it is reversed. This happens because the tension areas in the belt change location in relation to the drive pulley and loading area(s).

Basic Belt Behaviors

Basic belt behaviors serve as the guidelines for belt training. Basic belt behaviors are as under.



Note: Book moves toward the side it contacts first.

Belt Behavior

The belt moves toward the end of a roller that it contacts first. If an idler set is installed at an angle across the stringers, the belt will move toward the side it touches first. If one end of the idler is higher than the other, the belt will climb to the high side, because as it lays over the top of the idler, it contacts the higher end first.

As shown in above figure, this can be demonstrated very simply by laying a round pencil on a flat surface, like a table. If a book is laid across the pencil and gently pushed in a direction away from the experimenter, the book will shift to the left or right depending upon which end of the pencil (idler) the book (belt) contacts first.

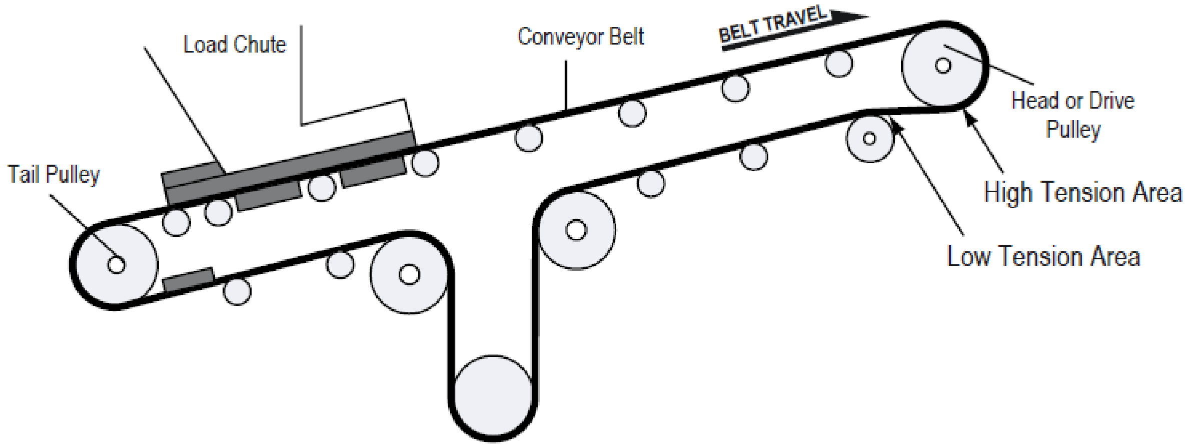
This basic rule is true for both flat idlers and troughed idler sets. In addition, troughed idlers exert a powerful tracking force. With their troughed configuration, a portion of each belt edge is held aloft at a more-or-less vertical angle. A gravitational force is exerted on that raised portion. If the belt is not centered in the set, the force on the one edge will be greater than the other, pulling the belt into the center of the troughed idler set. This gravitational tracking force is so pronounced that bulk conveyors usually depend upon it as their major tracking influence.

However, in case of a pulley, the behavior depends on two factors. Pulleys with their axis at other than 90 degrees to the belt path will lead the belt in the direction of the edge of the belt that first contacts the misaligned pulley (like in case of an idler). But when pulleys are not in level, the belt tends to run to the low side. When combination of the two occurs, the one having the stronger influence will become evident in the belt behavior.

While training, keep in mind that the belt at any given point is more affected by the idlers and other components upstream (the points it has already passed) than the components downstream (which it has not yet reached). This means where mistracking is visible, the cause is at a point the belt has already passed. Corrective measures should be applied some distance before the point where the belt shows visible mistracking.

Belt Training Procedure

The key to knowing where to start the training procedure is to determine the regions of high and low belt tension. That is because adjustments in low-tension areas of the belt have the highest impact on the path of the belt. In high tension areas, there is too much pressure on the belt for the relatively minor idler movements to have significant impact on the belt path.



Regions of High and Low Belt Tension

As shown in above figure, belt tension is highest at the drive pulley and lowest immediately after the drive pulley. By identifying and starting in the low tension areas, the training process can have the greatest impact with the least amount of changes.

Starting from the low tension areas, move around the conveyor, making adjustment to center the belt path. Start immediately after the drive pulley, whether that is at the discharge, center, or tail of the conveyor.

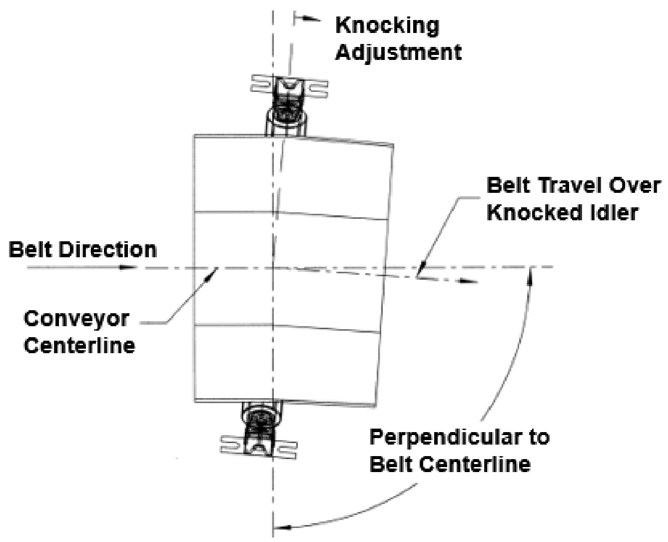
Adjust the first idler set before the place where the belt is visibly off-track by knocking the idler (based on basic belt behaviors guidelines). Then, restart the conveyor and check for belt misalignment. Run the belt to evaluate its effect, but wait for at least two or three complete belt revolutions before making further adjustments, as the effects of idler movement are not always immediately apparent. If the belt is still off-track, adjust the idler immediately before the previously adjusted idler set, making slight adjustments rather than major ones. It is best to shift only one idler at a time, as shifting additional idlers may cause over-correction. If the check shows the belt's path has been over-corrected, it should be restored by moving back the same idler rather than shifting additional idlers.

First track the belt empty, all the way around the conveyor, making especially sure that the belt is centered into the loading zone first, and the discharge area secondly. Please note that as you correct in one area, you may be creating additional problems to "undo" in a later area.

Continue this procedure until the belt tracks up the center of the idlers at this point on the conveyor. Repeat this procedure at other points along the belt, if necessary, until the return side runs true. Then follow with the carrying side of the belt, moving in the direction of belt travel from load zone to discharge point.

After training is completed, run the belt loaded to check the results. If the belt runs true when empty and mistracks when loaded, the problem probably comes with off-center loading. Correct the off-center loading by some suitable method. One method to center the loading is to install baffle/deflector/diverter plates.

Knocking Idlers



Correcting Belt Alignment

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

Training the belt with the troughing idlers is carried out by shifting the idler axis with respect to the path of the belt, commonly known as knocking idlers. This method is effective when the full belt runs to one side along a fixed length of the conveyor. As shown in above figure, misaligned running of the belt can be corrected by knocking ahead (in the direction of belt travel) the end of the idler to which the belt runs.

Shifting idlers in this manner should be spread over a length of conveyor preceding the region of trouble. In no event shall any idler be shifted more than 1/4 inch in any direction from its squared position.

Training a belt by shifting the position of one or more idlers is the same as steering a bike with its handlebars. When you pull one end of the handlebars (or the idler) toward you, the bike (or belt) turns in that direction. This is because the belt will steer to the side of the idler it touches first.

This handlebar principle of steering is a sound one, but only if the belt makes good contact with all three troughing rollers. So before training a belt, it should be checked to be sure it is troughing well at all points along the carrying strand, even when unloaded. If the belt does not “sit down” in the trough, there may be a problem with its compatibility with the structure. In this case, the belt is likely too thick and therefore not suitable for the given trough, and so that belt may never track correctly.

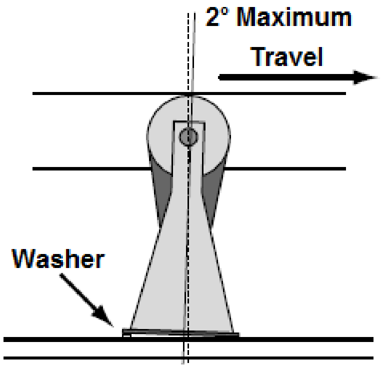
A belt might be made to run straight with half the idlers knocked one way and half the other, but this would increase rolling friction between the belt and idlers. The extra friction will result in increased belt cover wear and increased power consumption. For this reason, all idlers must be initially squared with the path of the belt and minimum shifting should be used for training.

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

In case of reversible belts, idler knocking may have adverse effects. Therefore, it is advised to avoid knocking on reversible belts. Instead, use extreme care in initial alignment.

Tilting Idlers

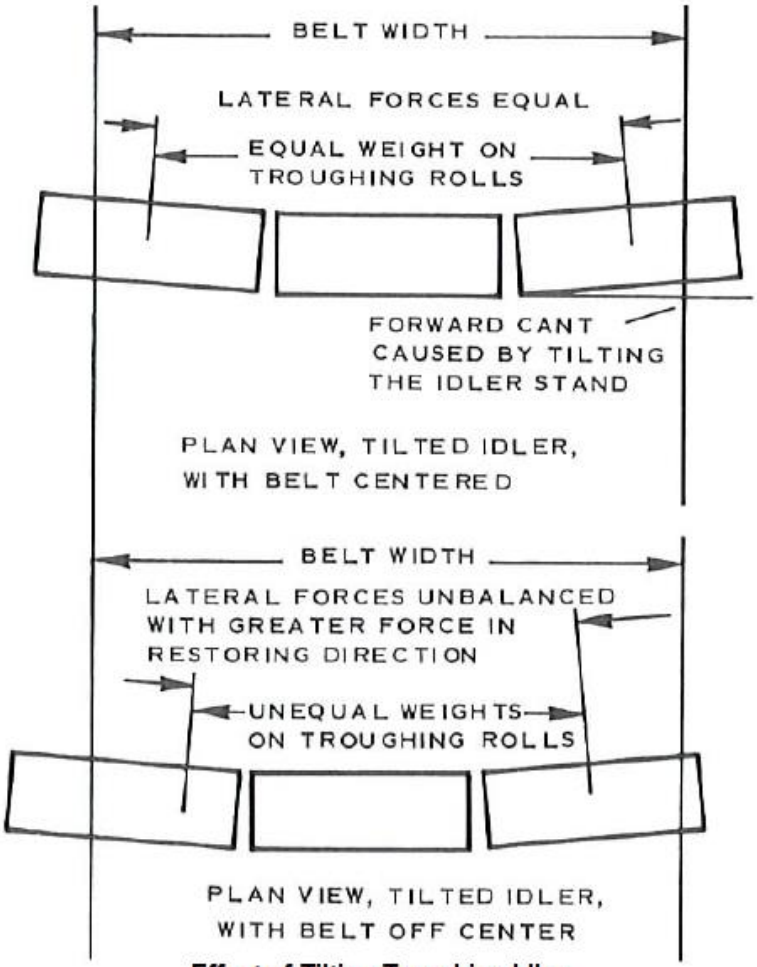
On the carrying/top run, an automatic centering effect is obtained from the regular troughing idlers by tilting them forward in the direction of belt travel. A tilt of no more than two degrees off vertical on every troughing roll produces a strong self-aligning effect.



Tilting Idlers

As shown in above figure, the simplest way to accomplish this is by inserting a shim, which can be a steel washer, underneath the rear leg of the idler frame.

However, too much tilt can reduce the area of contact between belt and roller leading to excessive wear on the bottom cover of the belt. It is best, therefore, not to move the uppermost point of the roller more than two degrees, generally 1/8 to 3/16 of an inch (3 to 5 mm) higher.



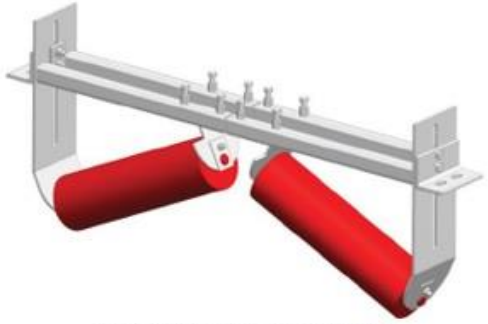
Effect of Tilting Troughing Idler

As shown in above figure, the strong self-aligning effect occurs because a tilt forward on a troughing idler throws the outer end of the inclined roll ahead of the inner end. When the belt tends to run to one side, an increasing portion of its weight rests on that roll, which is so canted (slanted) that it tends to return the belt to the center.

Many times idlers are manufactured with a tilt in the forward direction so that once they are installed they provide self-aligning effect (without shimming underneath the rear leg of the idler frame). However, to avoid incorrect installation of such idlers (installing them in a reverse direction so that they tilt backwards instead of forward), due to lake of knowledge or mistake in identifying the direction of forward tilt, the idlers should be marked with an arrow showing the running direction of the belt on them.

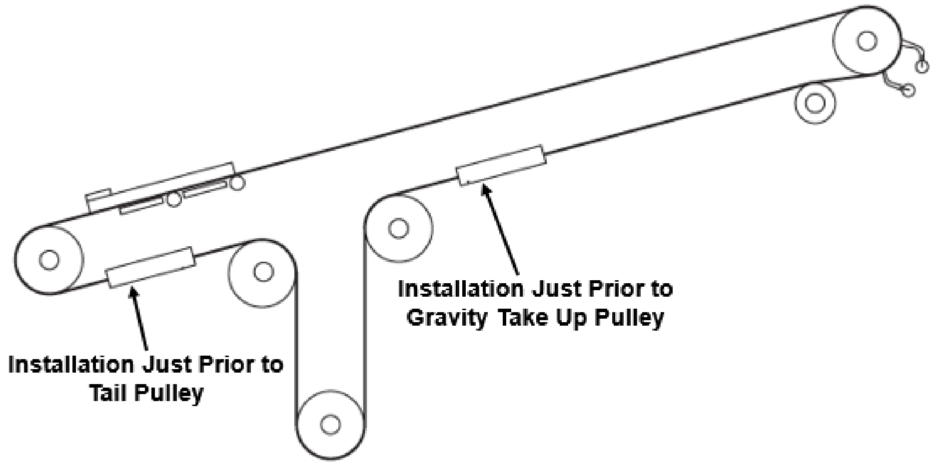
This method has an advantage over “knocking” idlers, because it will correct erratic belts that track to either side.

Inverted Vee Return Idlers



Inverted Vee Return Idler

Inverted Vee return idlers are installed on the return strand of a conveyor belt. They consistently train the belt by continuously funneling the belt into the correct path. They are generally used on high tension conveyor belts.



Application of Inverted Vee Return Idlers

As shown in above figure, inverted Vee return idler is installed just prior to tail pulley to ensure that the belt is centralized for loading of product onto the centre of the belt and just prior to the bend pulley of gravity take up to ensure that the belt enters the gravity take up system squarely.

Typical Installation with Inverted Vee Return Idler

Above figure shows typical installation with inverted Vee return idler just prior to tail pulley.

Application of Inverted Vee Return Idler Before the Bend Pulley

Above figure shows application of inverted Vee return idler just before the bend pulley of gravity take up system.

The inverted Vee return idlers are also best suited to short centered or reversing conveyor applications.

In general, the inverted Vee return idlers can be installed just prior to a known area of mistracking on the return strand of a conveyor.

Vertical Edge Guides


Vertical Edge Guide

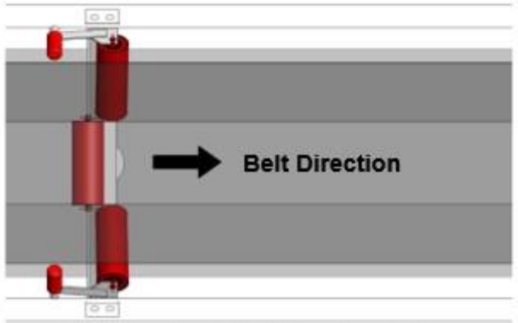
The vertical edge guides are installed in a position approximately perpendicular to the belt's path to keep the belt edge away from the conveyor structure. These side guides do not train the belt. They perform a damage control function, allowing the belt to strike a rolling surface rather than the fixed, structural steel. Vertical edge guides should be installed so that they do not touch the belt edge when it is running normally. If they contact the belt continually, even though they are free to roll, they can wear off the belt edge and cause ply separation. They too get worn out and if not replaced in time, damaged (cut) guide may severely damage the belt.

It may be noted that training the conveyor is making permanent adjustments to the structure, the loading equipment, and the rolling components to get the conveyor to run straight. Tracking is a dynamic process that will readjust the belt while it is running. Tracking uses various devices that will note when and how far the belt is off and then, self-aligning to steer the belt back to the correct path.

Conventional Belt Tracking Idlers

Like idlers with forward tilt, offset idlers are a great start for training belt 'true'. Because the belt moves towards that roller which it contacts first, bringing the centre roller forward by using an offset frame greatly assists the training process.

However, conventional swiveling type self aligning idlers are generally used on carrying and return side of a conveyor belt for tracking it in addition to training it by offset/tilted idlers.



Conventional Belt Tracking Idler

When using a conventional belt tracking idler like the one shown in above figure, the correct orientation and engagement is vital in the performance of the belt tracker.

As per one leading manufacturer of idlers, when installed on low to moderate tensioned conveyor belts, the tracking idlers should be installed between 12mm and 19mm above the standard idler profile. This will enable proper traction between the pivoted rollers and conveyor belt.

For high tension conveyor belt tracking idler installations, please consult your equipment supplier for more defined/calculated engagement figures.

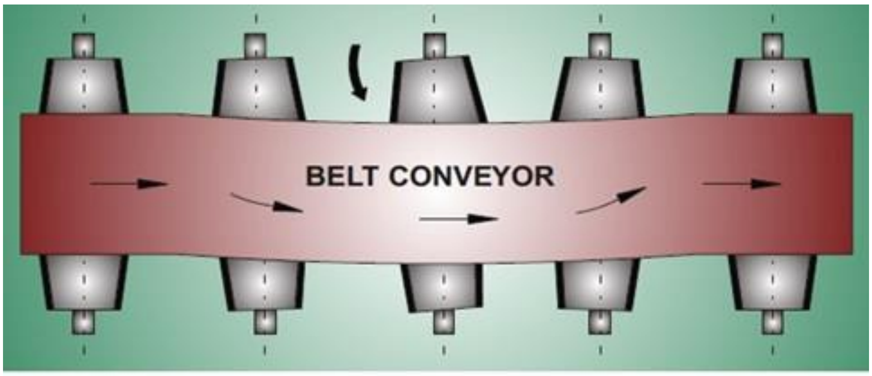
State of the Art Belt Tracking System

Many times conventional swiveling type self aligning idlers are ineffective due to various reasons (mainly jamming of the pivot). In such cases, Tru-Trac trackers may be used.

Tru-Trac Rollers (Pty) Ltd. has developed state of the art belt tracking system for belt conveyors. They are offering flat return tracker and trough tracker to track return side and load carrying side of conveyor belts. It is one of the best belt training systems available.

Construction of Flat Return Tracker

As shown in above figure, the flat return tracker is essentially made up of two parts: an inner, stationary drum, attached to a pin that allows it to pivot laterally, on exactly the same plane as the belt; and an outer drum, that rotates around the inner assembly. The outer drum is tapered towards either end (similar to a crown pulley), creating a slightly smaller diameter on the outside edges than in the middle.



Training of Belt by Tilted Roller

As the belt begins to drift off centre it comes into contact with the tapered edge. Because of the smaller diameter involved, there is a change in forces, causing the tracker to pivot (tilt) forwards around the pin described above. With this change in orientation of the tracker, the belt is steered back towards the centre as shown in above figure.

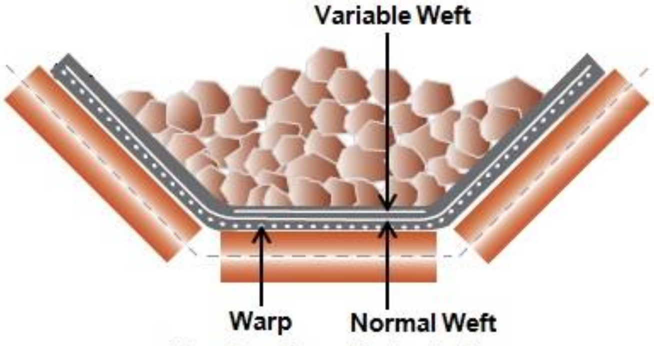
Tru-Trac Trough Tracker

As in the case of flat return tracker, Tru-Trac trough tracker also applies principles of tracking in the horizontal plane. However, in trough tracker wing rollers are incorporated into the design to activate their standard central pivot system. As the belt moves off-center the belt slides up the wing roll and thus causes the Tru-Trac trough tracker to pivot on its internal pivot and steer the belt back to centre with minimum force.

For more information on Tru-Trac trackers, please view their catalogue. (The catalogue may be down loaded from their website, www.tru-trac.com).

Autostable

The patented construction principle of the AUTOSTABLE belt by Sempertrans ensures instantaneous self-centering. This self-centering effect is achieved without the use of additional accessories or modification of the installation.



Construction of Autostable

Above figure shows construction of Autostable. As shown in the figure, its originality lies in the incorporation of a double metal stiffening layer. In these belts, one narrower layer (variable weft), having width roughly equal to the length of center roller is centered on the center line of the belt, creating a “beam effect” in the central part.

The difference in flexibility between this central area and the side areas, which are more flexible in comparison, favors the self-centering of the belt. As the rigid central part cannot adapt to the angle formed by the idler rollers, the belt tends to return to its natural trough, thus favoring its stability along its whole length.

This type of belts can be used to prevent tracking problems in reversible conveyers and installations with poorly centered load.

For more information on Autostable, please view their website, www.sempertrans.com.

Siban (www.siban.com) also supplies self-aligning Beltsiflex® belt for continuous self-alignment.

Camber

Camber

If unbalanced warp tensions exist in a conveyor belt, the belt will usually assume a crescent or banana shape when laid flat upon a horizontal surface. This deviation from a straight line is generally defined as camber.

To measure belt camber, it is recommended that the belt be unrolled on a flat surface like the warehouse floor, a flat horizontal driveway, etc. Next, one end of that belt should be grasped (and one end only) and the belt dragged in a straight line for approximately 3 to 6 meters. If the belt is too heavy for a man to move, then one end should be clamped to a forklift and the same procedure performed. At this point, the belt should lie flat. Unequal and unresolved warp tensions in the belt will cause it to assume a crescent or banana shape.

Camber is measured by drawing a taut line along one edge of the belt and measuring maximum deviation from that taut line to the belt at the point of maximum deviation. Compute % camber as follows:

$$\%\ \text{Camber} = \frac{\text{Maximum Deviation (centimeter)}}{\text{Length of taut line (centimeter)}} \times 100$$

The maximum allowable belt camber as per the Australian Standard 1332 is 0.5% of the test piece length. It is recommended that if the percent camber exceeds 0.5%, the belt manufacturer be contacted. In lightweight, unit/package handling, 0.25% is the maximum.

Camber can be instilled into a belt during the slitting operation if one of the slitting knives is dull. A dull slitting knife will tear the fill/weft yarns (crosswise yarns) rather than cut them. (While the belt is in roll form, the side of the belt that had gone through the dull knife will exhibit a "fuzzy" appearance due to the torn fill yarns.) Usually this type of camber will be less than 0.25% and can be pulled out handily when the belt is properly tensioned.

The fill/weft yarns in the belt carcass will usually lie along the perpendicular to the belt center line. Any deviation from this perpendicular line by the fill/weft yarn is generally defined as "skew".

A skewed pick in a plain weave or twill weave is cause for concern since it is generally indicative of unbalanced warp tensions and will usually go hand-in-hand with a significant camber.

Safety Regulations

Many areas around the world have implemented safety regulations to address problems due to belt mistracking. In the U.S.A., for example, for underground coal mines, MSHA (Mine Safety and Health Administration, Department of Labor) has enacted code 30CFR 75.1731, specifically citing that “conveyor belts must be properly aligned to prevent the moving belt from rubbing against the structure or components.” Failure to comply with these regulations may lead to fines and/or work stoppages.

Check List

For training a belt, following points may be used as a check list.

- Are head and tail pulley shafts parallel to each other?
- Are all pulleys leveled and perpendicular to the frame?
- Are all idlers perpendicular to the frame to which they are bolted?
- Are training idlers installed properly and pointed in the correct direction?
- Does the gravity take-up have the proper amount of weight?
- Are all conveyor pulleys and belt idlers free from material build up?
- Are lagging materials on conveyor pulleys worn or damaged?
- Check the conveyor structure to make sure it is straight. A laser alignment system is the best way to determine the structure's straightness.
- To avoid potential hazards, train a conveyor belt when it is empty. After training is complete, run the belt with a full load and recheck training.
- When working on the system, start just after the drive pulley (usually the head pulley) and work toward the tail pulley on the return side of the belt (bottom side). Locate the maximum point of off-tracking and back up to the fourth, fifth or sixth idler before that point to begin making adjustments.
- Keep in mind that a conveyor belt will always move toward the part of an idler or pulley it touches first.
- Make small adjustments to one idler at a time and check for improvement before making another adjustment. The adjustment may not be immediately apparent, so permit the belt to run for several minutes and at least three full belt revolutions after each idler adjustment to determine if additional tracking is required.

- After adjustment, if the belt has overcorrected, it should be restored by moving back the same idler, and not by shifting additional idlers.
- If above measures do not correct the problems, look for off-center loading of the belt, bent or damaged structures (leveling of the structure), the belt not being joined squarely or defective conveyor belting (carcass).
- A normal troughing idler can be used as a tilt idler by shimming under the idler bracket feet.

Note

After the belt is run in, an electrician should take readings on voltage, amperes, or wattage. This information can be used for future comparison and a quick trouble check (Higher readings in the future may indicate excessive drag due to belt misalignment or frozen belt idler rolls).

References:

Foundations™ by Martin Engineering, USA (www.martin-eng.com).

Belt Conveyors for Bulk Materials published by CEMA, USA.

Steep Angle Conveying

For various bulk materials, maximum inclination angle limits that conventional troughed conveyors with smooth top cover belts can safely convey generally range from 10° to 20° depending on the bulk material. Beyond the recommended maximum angles of incline, the material will tend to slide down the belt. To overcome the problem of material sliding down the belt, for steeper inclinations up to 90°, steep angle conveying belts are used. Information on various types of steep angle conveying belts is given in this chapter.

Steep Angle Conveying Belts

To overcome the problem of material sliding down the belt, for steeper inclinations up to 90°, profiled belts (belts with cleats) or elevator belts are used. Following table shows maximum attainable gradient for different type of belts.

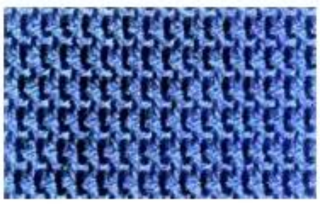
Belt Type	Max. Gradient
Conventional Belts	10° - 20°
Rough Top Belts	up to 35°
Molded Cleat Belts	up to 45°
Pocket Belts	up to 90°
Elevator Belts	up to 90°

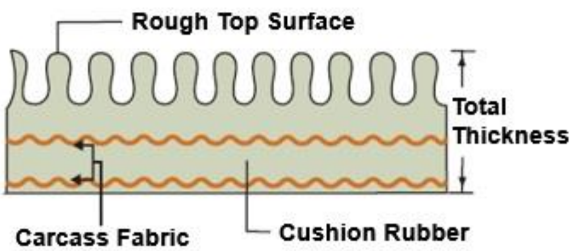
A family of belt conveyors known as "Pipe" or "Tube" Conveyors, "Fold" Belts, "Suspended" Belts and Sandwich Belts totally enclose the material. They are best known for their ability to negotiate tight horizontal, vertical and even compound curves in difficult overland topographies or congested plant process areas and their environmental friendliness. They also allow material to be conveyed up increased angles of incline. Generally, totally enclosed belts allow for a minimum 50% increase in the attainable angle of incline over conventional conveyors.

Information on various types of belts used for steep angle conveying is given in the following sections except "Pipe" or "Tube" Conveyors. Information on pipe conveyor is given in next chapter.

Rough Top Belts

Simply making the belt's top cover irregular increase its ability to carry materials up slightly greater inclines than conventional conveyors with smooth top covers. Belts with a rough textured top cover are called Rough Top or Grip Top belts.





Rough Top Belt

As shown in above figure, rough top belts have a rough textured top cover. It prevents material from sliding on the belt. They are ideal for transporting a wide variety of products from packaging (parcels, sacks, etc.) to lumber yards.

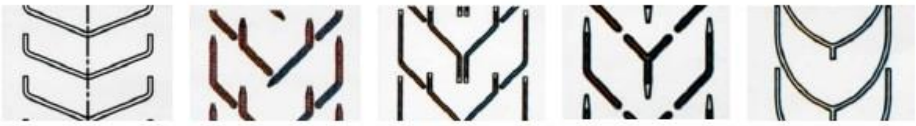
Molded Cleat Belts

Belts with patterns (commonly called cleats) molded on their top cover are commonly called **Chevron** belts. Cleats prevent sliding down (roll back) of the conveyed material. Molded cleats come in a large variety of patterns. The height of the cleat depends upon the lump size of the material to be conveyed and the angle of incline.

Patterns are available from shallow cleats having approximately 6 mm height to deep cleats having 50 mm height.

Chevron Belt

Above figure shows an installation with a chevron belt. Shallow cleats provide a maximum 5° increase in the allowable angle of incline over those for smooth top cover belts. Deep molded cleats can provide greater inclination angles than shallow cleats. Chevron belts may be moulded with different shape and size of profiles/cleats. For illustration, some common profiles are shown in the following figure.



Common Chevron Profiles

Cleat arrangements are usually designed to allow the efficient draining of wet materials. The design should also allow troughing of the belt with standard idlers and have minimum problems when the cleats contact the return idlers.

However, as the cleats will wear more rapidly than a standard smooth top cover, the belt may lose its inclined conveying capabilities.

Because the molded cleat belts can't be cleaned by belts cleaners used to clean standard belt conveyors, use of belt beater, air blast, water spray, or a wash box belt cleaner may be required.

In view of above, use of molded cleat belts is generally restricted to short conveyors where few or no return idlers are needed and either the material does not stick to the surface or where the carry back is acceptable.

For information on maximum allowable incline (degrees) with molded cleat belts please see Belt Conveyors for Bulk Materials published by CEMA.

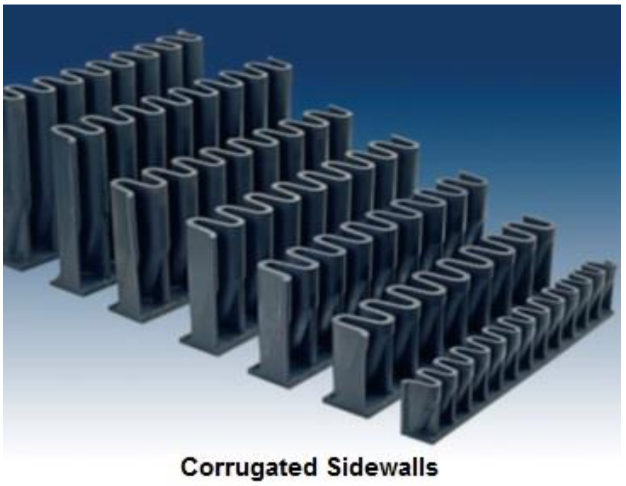
Pocket Belts

Pocket Belt

Above figure shows a typical pocket belt for incline conveying. As shown in the figure, for making a pocket belt, flexible corrugated sidewalls are bonded to the edges of the base belt, along with transverse cleats spanning between the sidewalls. These additions form rectangular prisms commonly called pockets for the material to ride in for very steep incline conveying, up to a gradient of 90° (vertical plane). The addition of sidewalls and cleats also increase the load carrying capacity of these belts over normal belt conveyors and belt conveyors with molded cleats (Chevron belts) for steep incline conveying.

Most pocket belts use a cross-stabilized fabric carcass or steel cord type base belt. The cross-stabilized reinforcement is obtained with either a fabric or woven steel above and/or below the normal longitudinal (warp) tensile carcass. This is to prevent bowing at the deflection wheels and sagging at the return supports.

As shown in the following figure, sidewalls are manufactured in a wide range of heights from 35 mm up to 600 mm. Short sidewalls are made of 100% rubber whereas taller sidewalls for heavier duty application are made of fabric reinforced rubber. Fabric reinforced rubber sidewalls are recommended for heights above 140 mm. Their corrugated design allows them to negotiate the bending around pulleys and deflection wheels, where the top edges of the sidewalls must expand or contract as per requirement. It may be noted that pulleys and/or deflection wheel diameters that are too small in diameter will drastically reduce the bending fatigue life of the sidewalls.



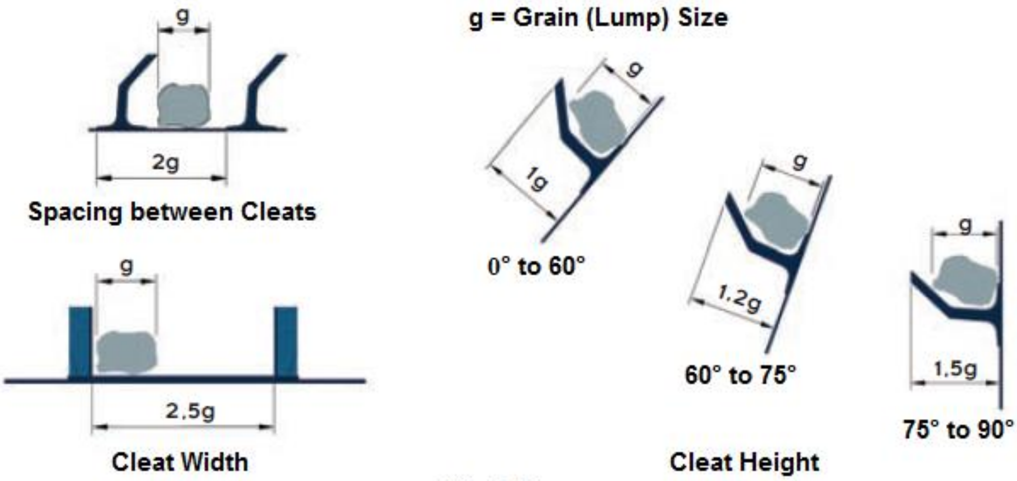
Corrugated Sidewalls

As shown in the following figure, cleats are also manufactured in a wide range of designs. They range from 20 mm height made of 100% rubber for light duty application, up to 580 mm height for extremely heavy duty application. Cleats for heavy duty applications are fabric reinforced, reinforce with rubber stiffeners across their width and that have U-bolts vulcanized in the ends, for fastening to the sidewalls.

Cleat Designs

It is recommended that the height of the side wall must be more between 10 and 20 mm than the height of the selected cleat.

Cleat and sidewall height, cleat spacing and the belt width, are sized on the capacity and lump size to be handled. Siban Peosa (Internet: www.siban.com) recommends the following.

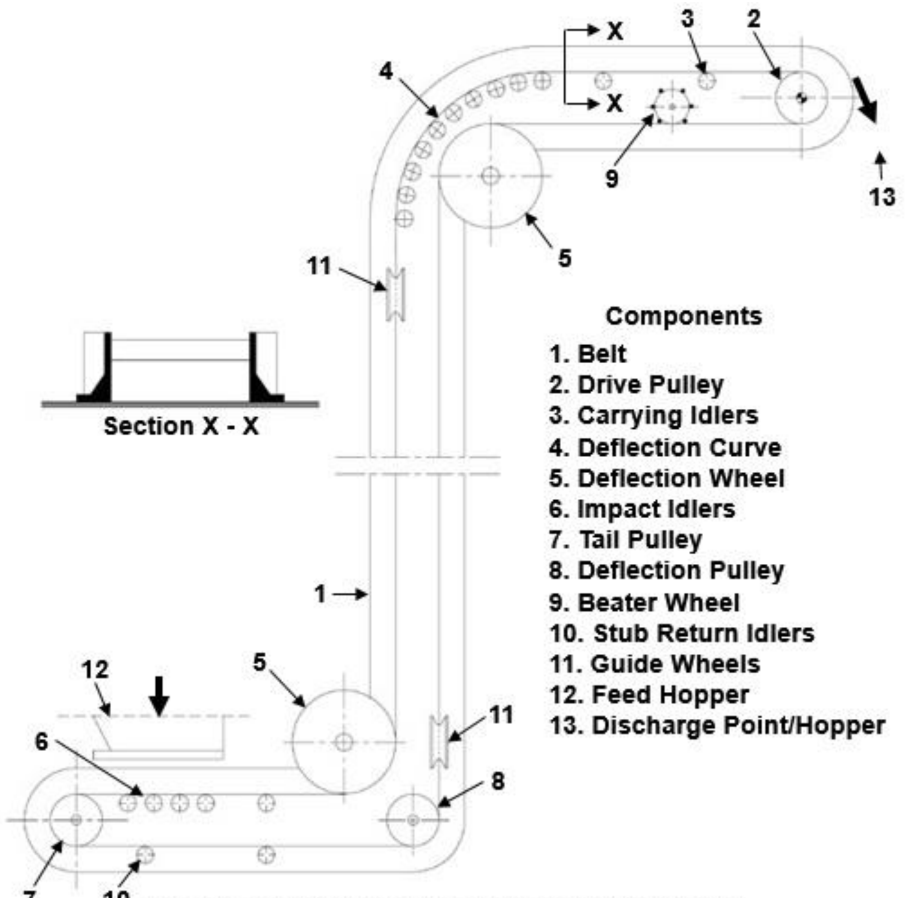


Cleat Size

As shown in above figure, the minimum distance between cleats must be twice the maximum grain (lump) size. The width of cleats must be at least 2.5 times the maximum grain size. The minimum cleat height depends on grain size (g) and the angle of inclination of the belt. The height shall be as per the following table.

Angle of Inclination of Belt in Degree	Cleat Height
0 to 60	(0.75 to 1.0) × grain size (g)
60 to 75	(1.0 to 1.2) × grain size (g)
75 to 90	1.5 × grain size (g)

The following figure shows the mechanical components required in a typical pocket belt for vertical elevating system.



Typical Pocket Belt for Vertical Elevating System

Because a pocket belt is capable of turning through any angle up to a vertical line and back to the horizontal, from the feed hopper up to the discharge point, it eliminates the need for multi drives and prevents product degradation and spillage at transfer points.

Conventional idlers are used along the carrying side. On the return side, conventional idlers are used for light belts whereas stub idlers are used for heavy belts, or where return side space is limited, and where build-up on conventional idlers could occur.

As shown in the following figure, if stub idlers are used on the return belt they are canted / slanted at 3° or 5° depending on the belts flexibility. The 3° is used with steel cord belts and the 5° with fabric carcass belts. Canting of the idlers assist belt tracking. It is important that only stub idlers with rounded dome end caps are used and are slot mounted for adjustment.

Stub Idlers Supporting Return Side of Pocket Belt

Where the upper and/or lower horizontal runs are short enough, no support is required and the belt is allowed to free sag up to 4%.

It may be noted that for conveying material at more than 70° of inclination, no carrying or return support (idlers) is required in the inclined portion of the belt.

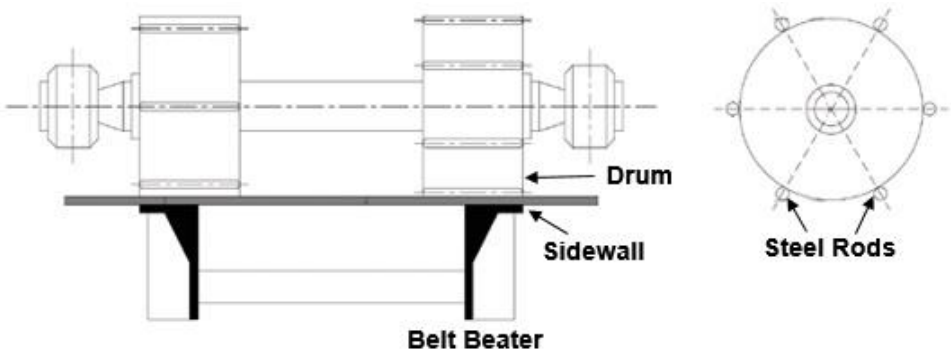
In the majority of cases the discharge pulley is also the drive pulley. For most applications the pulley face is crowned and rubber lagged. However, on some large belts, due to the type of tensile and cross-stabilizing members, it is not advisable to crown the pulley as damage may result to the base belt.

The tail pulley is also the tensioning (take-up) pulley. Tension is normally being applied via screw adjusters. However, on high capacity systems, horizontal gravity or hydraulic take-ups are used to apply tension in the belt. Normally it is preferred that the pulley face is crowned and can be rubber lagged.

Note:
Crowning the pulleys should not be done in the case of belts with textile tension plies and steel cable cross stabilizing plies and with steel cord tension and steel cord cross-stabilized belts because crowning the pulleys may cause damage to the belt.

The guiding wheels are used with cross-stabilized belt constructions to guide the belt. To prevent damage to the belt and maximum belt life, the belt need to be checked for straight running regularly.

Normally larger diameter pulleys are required with pocket belt systems to prevent the sidewalls from being over stressed. Minimum pulley diameter is based on the bending fatigue limit of the sidewalls or that required for the base belt whichever is the largest.

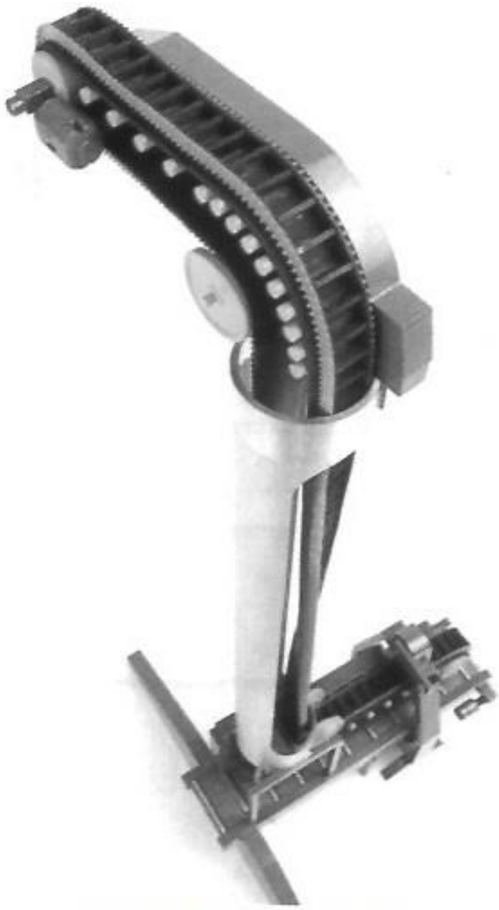


As the belt is more difficult to clean than standard conveyor belts, belt beaters, air knives, water spray or a wash trough must be used. Often a self-driven belt beater that raps the belt and twists it slightly laterally is used.

When installing a belt beater, it is very important to ensure that the drum rods are off-set as shown in above figure. The beater drums should be positioned such that the outer face of a drum is directly above the outer edge of the sidewall.

A small belt conveyor or a mechanical chain and scraper arrangement may be required to be installed below the belt beater or a cleaning device to convey the material knocked out by them.

To add to their versatility, as shown in the following figure, pocket belts can be twisted about their vertical axis. Depending on height, this can be up to 90°.



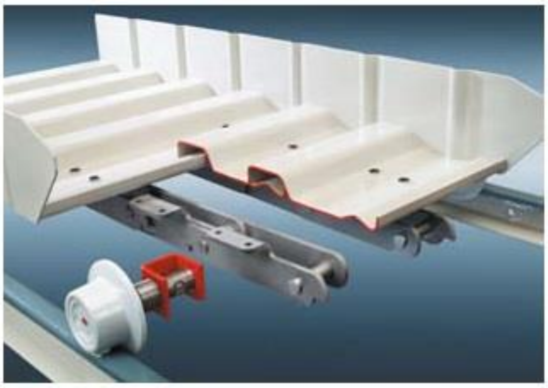
Pocket Belt twisted to 90°

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

For more information on pocket belts, please refer the following:

- Technical Manual for S-Wall™ Sidewall Conveyor Belting published by PHOENIX Conveyor Belt Systems GmbH (www.phoenix-conveyorbelts.com).
- Beltsiflex® belts technologies published by Siban Peosa (www.siban.com)
- Belt Conveyors for Bulk Materials published by CEMA, USA.

Pan Conveyors



Typical Pan Conveyor and Construction Detail

A pan conveyor is used for abrasive or high temperature applications. Like in apron feeders, in a pan conveyor, the metallic pans are driven by a chain attached to them. Above figure shows construction detail of a typical deep drawn pan conveyor. Deep drawn pan conveyors are used for inclination up to 30°. Aumund (www.aumund.com) are one of the reputed suppliers of pan conveyors.

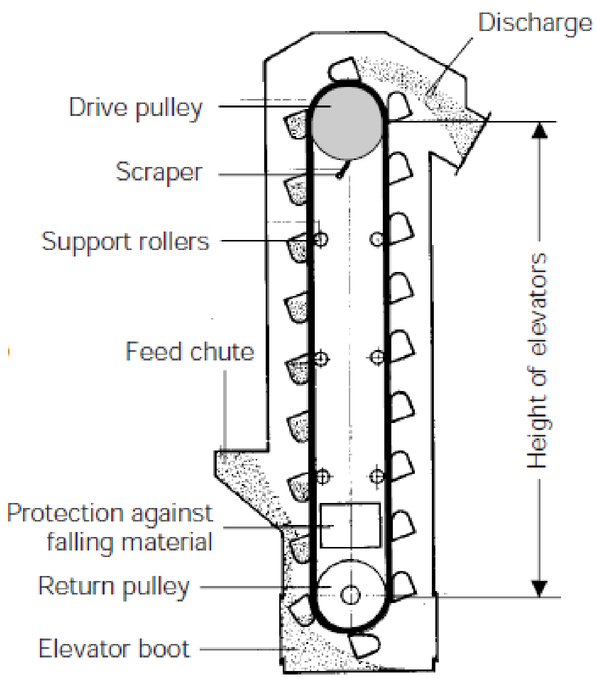
Deep Drawn Pan Conveyor with Baffles

Deep drawn pan conveyors with baffles can be used for conveying at inclination angles up to 45°. A pan conveyor with buckets can be used for conveying at inclination angles up to 60°. Above figure shows deep drawn pan conveyor with baffles to convey hot clinkers at steep angle in a cement plant.

Bucket Elevators

With bucket elevators bulk materials can be conveyed either vertically or sloping upwards. Bucket elevators with belts are used for handling bulk materials such as grains, cereals, sand, gravel, cement, coal, caustic soda, salts, fertilizer and many other free flowing or abrasive materials. However, chains are normally used for wet material, hard and splintery lumps, hot materials or those materials which tend to pack between bucket and belt. With belts it is possible to run elevator at higher speeds as compared to bucket elevators with chains, resulting in higher capacity. They also run with low noise levels and low vibrations. To know materials which can be handled using bucket elevator with belt, please see IS 7167-1974. The standard recommends type of elevator (chain and/or belt) for many common bulk materials.

Following figure shows construction / parts of a typical bucket elevator.



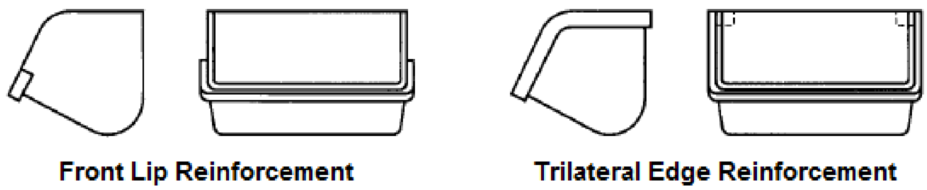
Bucket Elevator

Bucket Types

The type of bucket is determined by the material and the method of discharge (gravitational or centrifugal emptying). Following figure shows shape of buckets as per DIN specifications.

Shape of Buckets as per DIN Specifications

Because the bucket attachments and bucket brim are subject to arduous duty, as shown in following figure, plate steel buckets may be strengthened with welded edge reinforcement.



Bucket Reinforcement

Following table suggests type/shape of bucket for different applications.

DIN Specification	Application
DIN 15231	Flat bucket for light loads such as flour, semolina, grain.
DIN 15232	Flat rounded bucket for light granulated loads such as grain.
DIN 15233	Medium deep bucket for sticky loads such as cane sugar.
DIN 15234	Deep buckets with a flat back wall for heavy pulverized loads or coarse ground loads such as sand, cement, coal.
DIN 15235	Deep buckets with curved back wall for light flowing or rolling loads such as fly ash and potatoes.

Bucket Speed

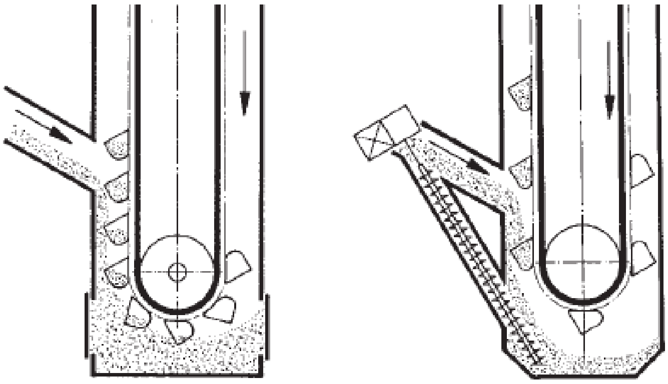
For centrifugal discharge, **high speeds** (V = 1.05 to 4.2 m/s), flat, flat rounded or medium deep buckets are used according to the type of material.

For gravitational discharge, **low speeds** (v = 0.42 to 1.05 m/s), deep buckets are used.

The following speeds are recommended depending upon the function of the bucket elevator, the type of loading and discharge.

Type of Bucket Elevator	V (m/s)
Loading direct or by scoop action, gravitational discharge, slow moving for heavy materials such as ballast and earth.	Up to 1 m/s
Loading direct or by scoop action, centrifugal discharge for normal material such as sand and fertilizer.	1 - 2 m/s
Loading direct or by scoop action, As a rule, centrifugal discharge, very fast running, only with free flowing or light easily scooped material such as grain	2 - 4 m/s and more

Loading



Scoop Loading Direct Loading

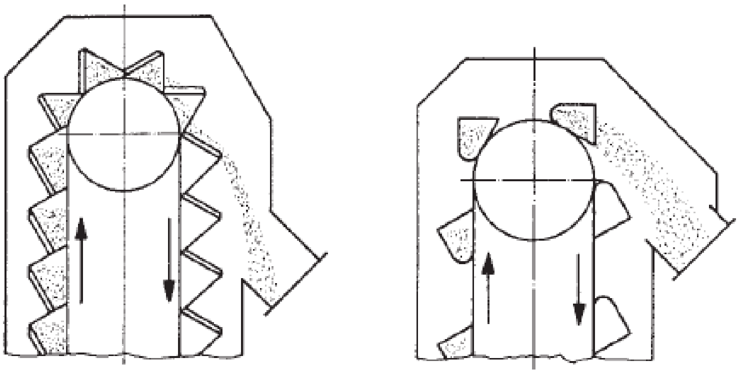
Loading Bucket Elevator

As shown in above figure, the loading i.e., the filling of the bucket can be done either directly or by dredging action. Scoop loading (dredging action) is only possible with free flowing materials and is to be recommended. For materials, those are not freely flowing, direct loading is recommended. However, because the bucket attachments and bucket brim are subject to arduous duty if materials are not freely flowing, the base area (boot) has to be kept clean to avoid danger of buckets being torn off.

Discharging

As shown in the following figure, the discharging of bucket contents can be done by gravitational or centrifugal means. It depends on the speed and the pulley diameter.

Centrifugal discharging is used with high speeds and light flowing loads or coarse granulated, hard materials. The centrifugal discharge only applies when speeds are > 1.2 m/s. Gravitational discharging is used with low speeds and heavy loads with large lumps or light dusty materials.

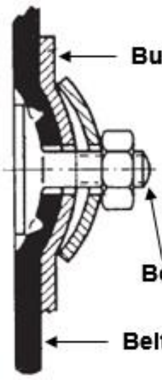

Gravitational Discharge Centrifugal Discharge
Discharging Bucket Elevator

Bucket Pitch

The bucket pitch depends on the speed, the bucket geometry, the type of loading and discharge. With gravitational discharge, the bucket pitch can be small. In gravitational discharge, the material runs over the back of the preceding bucket. However, with the centrifugal discharge, the pitch has to be greater.

Bucket Attachment

The bucket made of steel, plastic or rubber may be bolted to the belt. The principal factor to consider is the resistance the belt carcass has to bolt pull through. Hence, as shown in the following figure, large head bolts are used to prevent them from pulling through the belt.




Elevator Bolt as per DIN 15237
(with standard nut)

Bucket Attachment

Above figure shows most commonly used method of attaching buckets to the belt and elevator bolt as per DIN 15237 with standard nut. DIN 15237 is widely used specification for elevator bolts. In addition to elevator bolts with standard nuts, bolts with nyloc nuts (locknuts), and bolts with an allen key head variety are also available. As per IS 6832 - Reaffirmed 2005 (IS 6832 is based on DIN 15237-1980), the bolts shall conform to the property class 4.6 of IS: 1367 (Part 3).


No.1 or No. 1 Norway

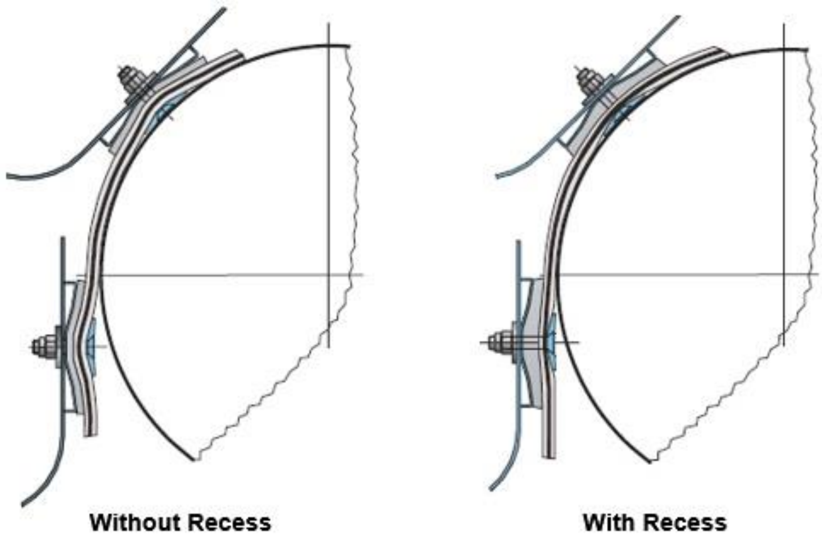

No. 3 or Eclipse or Reliance


Fanged

Elevator Bolts

As shown in above figure, No. 1 or No. 1 Norway elevator bolts (flat countersunk head bolt with square neck under the head); No. 3 or an Eclipse or a Reliance bolts (flat countersunk head bolt with six-pointed radial star beneath the head - it may also have a machined slot on the top of the head) or fanged bolts (flat countersunk head bolt with sharp teeth instead of square neck under the head) are used in USA. As No. 3 bolt has smaller diameter head, it has limited uses in industry.

Often to prevent dirt penetration and thereby reduce wear, soft rubber pads or leather washers are fitted between belt and buckets. They also absorb shock when the buckets pass over the pulleys.



Bucket Mounting Without Recess and With Recess

As shown in above figure, for belts with high traction forces, many times the contact side of the belt is recessed to ensure that the belt is guided without deflections in the bucket mounting area. In this way, tension peaks due to additional strains is avoided.

When two lines of buckets are used on the same belt they should be staggered with respect to each other.

After the unit has been run-in, the bolts should be re-tightened. The bolt threads may be prick-punched to prevent loosening of the nuts.

Splicing

It is important to note that many belts will be furnished with thicker covers on the bucket side, and thinner covers on the pulley side. Before splicing, insure that the belt is installed correctly.

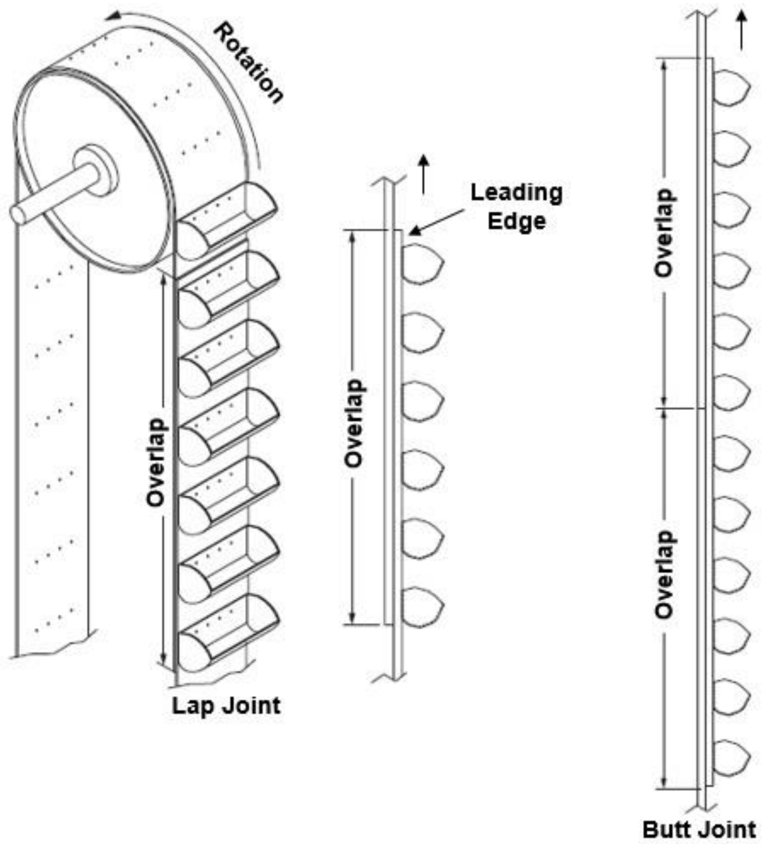
Elevator belts can be spliced (made endless) by the following methods.

- Hot vulcanized splice
- Lap joint
- Butt joint
- Angle joint (Using belt clamps)

When splicing new synthetic belts, it is recommended that the belt is hanged with the buckets installed/attached for 24 hours if possible before splicing. This will remove almost all of the initial stretch and will require less adjustment during the break-in period.

CAUTION: In splicing operations, make sure belt and/or head pulley is secured so that any imbalance cannot result in belt running away over head pulley and dropping into boot.

Though hot vulcanized splice can be used, space limitations usually make them impractical.



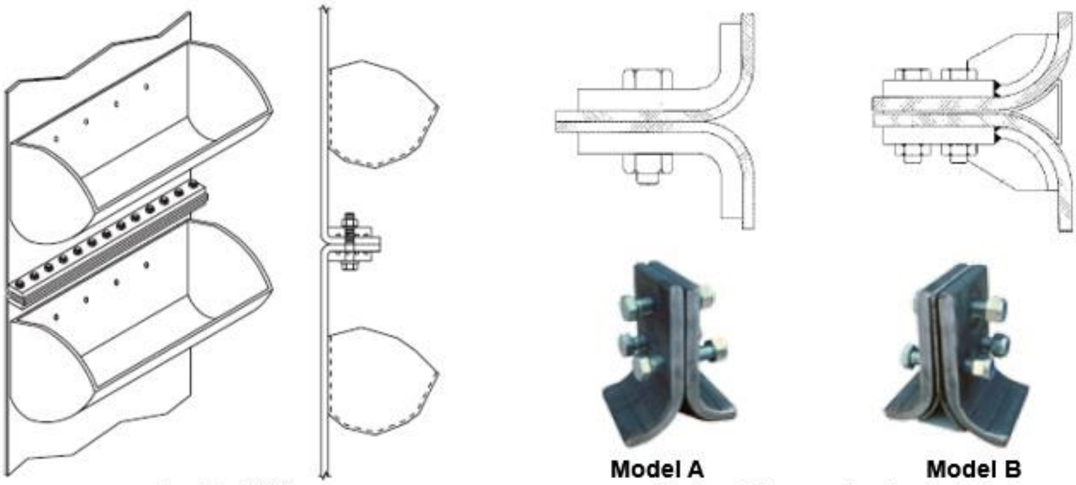
Elevator Bets Splicing - Lap Joint and Butt Joint

The most commonly used splice for elevator belts is the lap joint/splice. Lap joints may be used for thin belts. In a lap joint, the ends of the belt are overlapped and fastened together by the use of buckets and bucket bolts in the lap area as shown in above figure. The belt ends overlap three to six times bucket spacing. Follow manufacturer's recommendation for length of overlap and bolts tightening. The belt ends should be overlapped such that the leading edge of the belt is on the outside. The proper direction for the lap is also shown in above figure. If the belt is installed with the leading edge of the belt butting into the pulley, premature wear can occur to the pulley lagging. On heavy (thick) belting the inside strand end should be tapered for smoother pulley passage.

Butt joint is used for heavier belts. It is also preferred on fast moving elevators for instance if the velocity is greater than 3 m/s. In a butt joint, the ends of the belt are butted together and then a rider strap of the same belting material is used on the bucket side. Like in the lap joint, buckets are bolted though both layers of the belts. The lap belt end and rider strap overlap three to six times bucket spacing as shown in above figure. Butt joint produces a smooth continuous surface on the pulley face of the belt.

Shorter projection buckets are used at butt joint in case of extra thick belts.

Angle joint, shown in the following figure is the simplest and most cost effective but cannot be used in all cases. The pulley diameter and the bending zone of the belt around the angle, have to be taken into consideration.



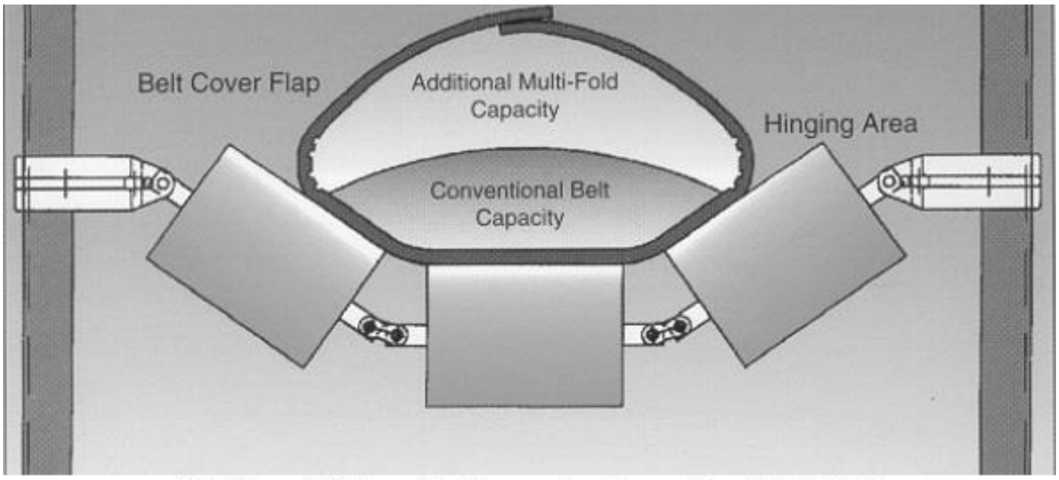
Model A　　Model B

Angle Joint　　Typical Clamps for Angle Joints

Elevator Bets Splicing -Angle Joint (Using belt clamps)

Belt clamps are used to make an angle joint. Belt clamps are available in two models. Model A clamps are suitable for light to average applications. Model B clamps are having a wedge-shaped adaptor to guide the belt over the pulley for more demanding applications.

Fold Belts



Additional Volumetric Conveying Capacity of Fold Belt

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

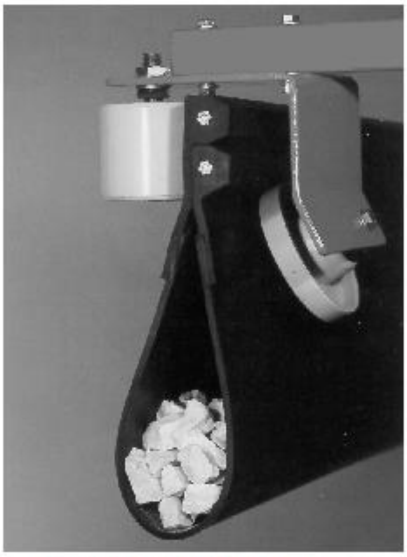
Fold belt utilizes a proprietary belt that has integral flaps on top that fold over the material. For folding the flaps, they incorporate a longitudinal hinging area on both sides of center of the belt, approximately 1/4 of the belt width in from each edge. The flaps overlap each other in the middle and totally enclose the material. However, the belt is fully open at the drive, head, take-up, tail and any bend pulleys. Loading and unloading of material is carried out when the belt is fully open. The belt is generally in the folded position for the return run in order to minimize material spillage and return idler build-up generated by any carry back. Angles of incline or decline up to 45° are possible with fold belts. However, it is necessary to maintain standard incline/decline angles through the tail, discharge, and load transition areas to prevent sliding back of the material because the flaps are not enclosing the material in these locations.

Above figure shows additional volumetric conveying capacity a fold belt can give as compared to capacity of a conventional belt.

Fold belts are sold under trade name Multi-Fold™ Conveyor System by Imperial Technologies Inc. (www.imperial-technologies.com).

For more information on fold belts, please see Belt Conveyors for Bulk Materials published by CEMA, USA.

Suspended Belts



Suspended Belt Conveyor

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

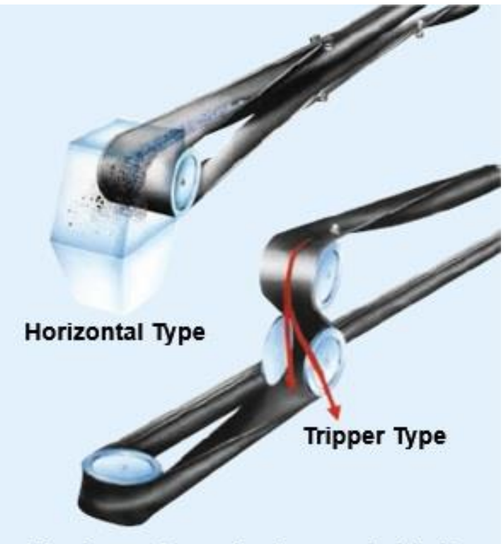
In a suspended belt conveyor, the belt is folded in half and suspended from rollers. The teardrop shaped pouch formed by it fully encloses the material. The main belt has no fabric reinforcement. It is simply a flexible, wear resistant rubber across the full width. A profile having a single steel cable in it is vulcanized to both the edges of the main belt to handle the belt tension. It thus separates the carrying and tensile/power functions into two distinct design elements. These types of belt conveyors are very appropriate for conveying at angles of incline/decline that are greater than conventional conveyors, and typically in the 25° to 35° range.

The carrying and return runs can be arranged over top of each other, side by side, or the carrying and return strands can take entirely separate routes. In all cases the belts are suspended by their profiles.

Because the belt always wants to hang vertically, there is no misalignment.

To load the belt, either at the tail end or anywhere required along the carrying or return run, the belt is opened into a 'U' shape with sufficient room for a loading chute. Deflection rollers are used to spread the top edges open. The belt is closed immediately after the loading chute.

As shown in the following figure, there are two types of discharge arrangements: tripper type discharge arrangement and horizontal type discharge arrangement. The preferred type of discharge arrangement is the tripper type discharge arrangement.



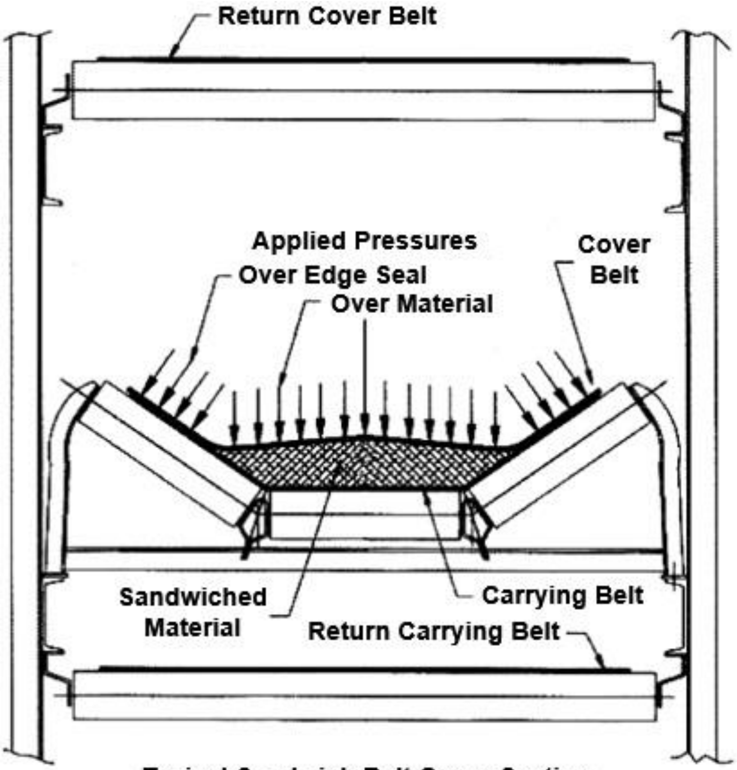
Discharge Types for Suspended Belts

Belt cleaners are generally not used with suspended belts. Centrifugal force and the belts flexibility make it almost self-cleaning. As any carry back is contained within the enclosed return run, no spillage or build-up on components results.

Suspended Belts are sold under trade name SICON® conveyor belt by ContiTech AG (www.contitech.de).

For more information on suspended belts, please see Belt Conveyors for Bulk Materials published by CEMA, USA.

Sandwich Belts

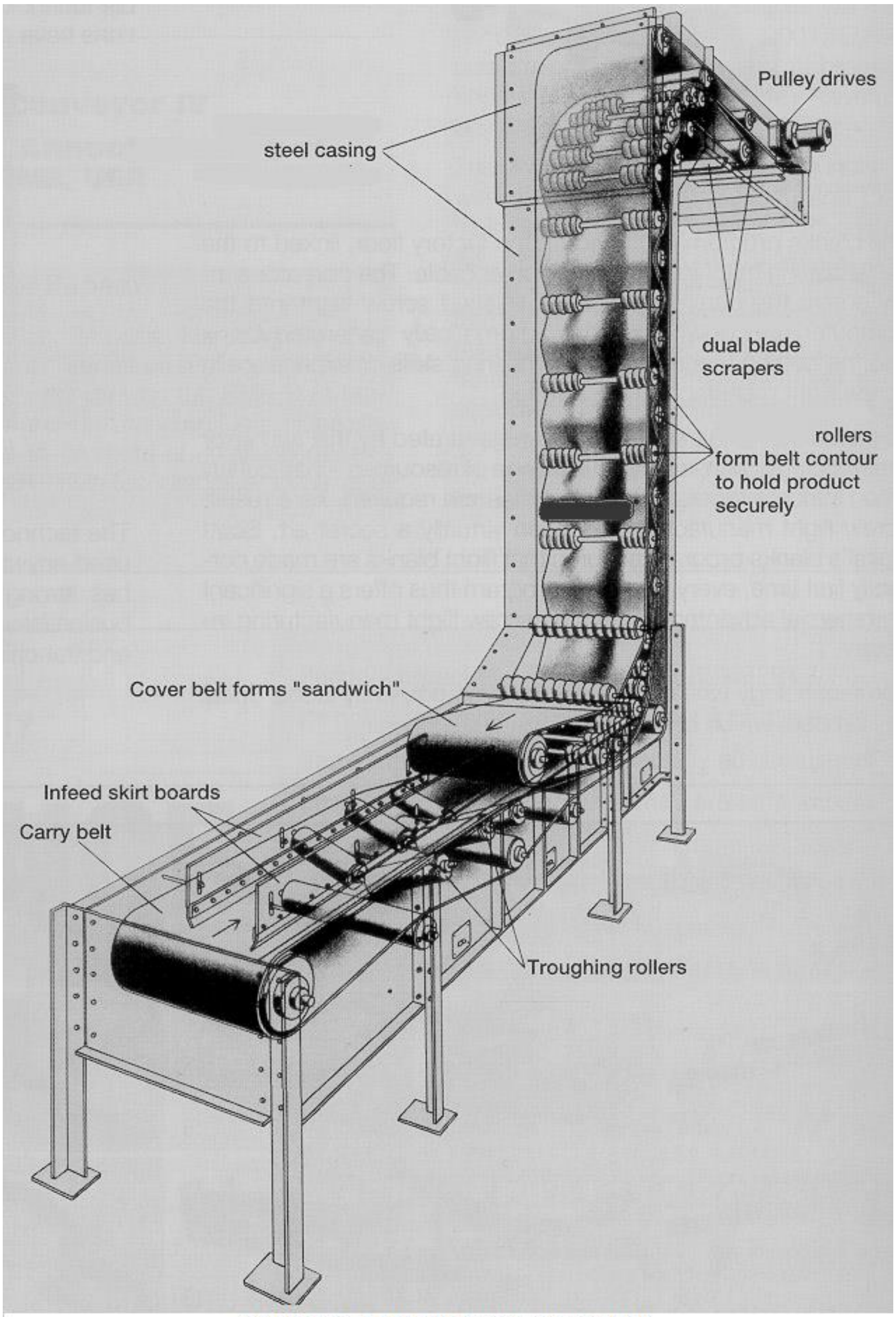


Typical Sandwich Belt Cross Section

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

Above figure shows a typical cross section of a sandwich belt. As shown in the figure, a sandwich belt totally encloses the material between two relatively standard conveyor belts. In a sandwich belt system, pressure is applied via the cover belt to secure the material. This insures that the material will not slide, roll back, or leak out the sides even when conveyed vertically. Various methods of supplying the required pressure are commercially available.

A sandwich belt can be located locally anywhere along a belt conveyor where it is needed to assist in elevating the material, up a steep incline, or down a steep decline. However, very fine, dry bulk materials such as cement cannot be elevated effectively using this method. The following figure shows a totally encased light duty sandwich belt.



Totally Encased Light Duty Sandwich Belt
Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

For more information on sandwich belts, please see Belt Conveyors for Bulk Materials published by CEMA, USA.

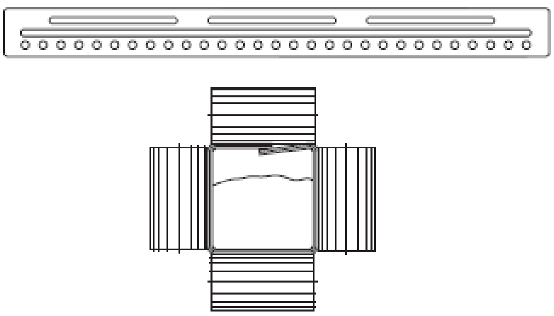
Square Belts

Square Belt

Combining the technical characteristics of the Autostable belt for its construction and of the pipe conveyor for its use, Sempertrans® has developed the square belt.

It is developed to provide an optimum solution to problems of handling bulk products without pollution of the outside environment while at the same time protecting the product conveyed, and offers a unique advantage compared to a conventional pipe conveyor by preventing twisting of the belt, particularly in curved conveyors.

At the loading and tipping points, the square conveyor is opened and closed in the form of a standard trough to pass flat over the pulleys like a conventional conveyor belt. In such belts, the materials can be conveyed on both strands of the belt.



Construction of Square Belt

Above figure shows construction of square a belt. As shown in the figure, the square belt uses three stiffeners with two flexible edges to form a square section which contains the material to be conveyed. This construction is protected by a patent. The carrier strand and the return strand are supported and guided identically by four rollers, two vertical and two horizontal.

For more information on square belts, please contact Sempertrans (www.sempertrans.com).

Pipe Conveyor

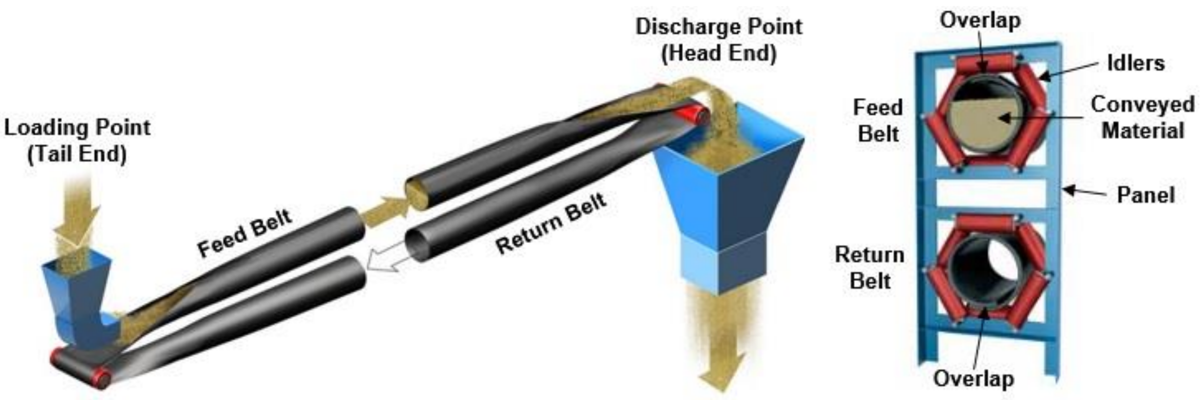
A "Pipe" or "Tube" conveyor totally enclose the material. They are best known for their ability to negotiate tight horizontal, vertical and even compound curves in difficult overland topographies or congested plant process areas and their environmental friendliness. They also, allow material to be conveyed up increased angle of incline.

Pipe Conveyor

Despite all the advantages a disadvantage of the conventional troughed belt conveyor is the occurrence of dust because of product becoming airborne, and spillage of product at the return side of the conveyor due to inadequate cleaning of the belt at the head section. The growing need for reduction of spillage and dust has led to increased demand for the pipe conveyor.

Pipe conveyors find their application in virtually every industry for the transport of bulk solids. In view of this, brief information on pipe conveyor is given in this chapter.

Construction of Pipe Conveyor



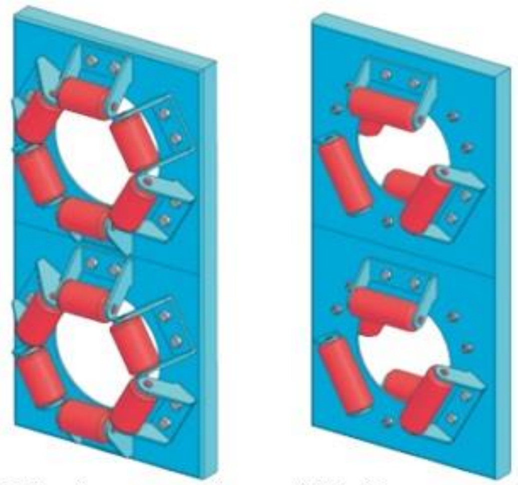
Construction of Pipe Conveyor

As shown in above figure, pipe conveyor utilize a flat belt and has regular trough profile at tail end and head end. However, the belt is bent into pipe (circular) shape with a slight overlap after material has been loaded onto the belt. Thus, material is conveyed in enclosed belt for most of the conveyor length. The belt is made to open out from pipe shape to usual trough profile, prior to reaching head pulley, where material gets discharged like usual conveyor. The belt on return run is also kept in pipe shape.

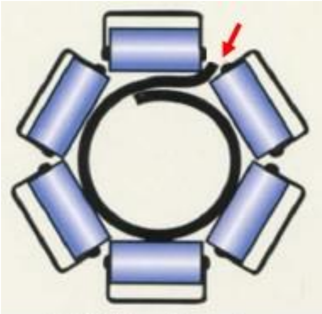
The pipe is formed with the dirty top cover on the inside, on both carrying and return runs. The overlap (at 12 O'clock position) provides an effective seal along the carrying run to protect the environment from the material and/or vice versa. Along the return run, the overlap (at 6 O'clock position) again provides an effective seal and prevents any carryback from contaminating the environment. Thus environmental or housekeeping problems are confined to the head and tail ends of the pipe conveyor only.

Formation of Pipe Shape

As shown in above figure, the pipe shape is formed by gradually increasing the troughing angle until the position is reached where finger shaped stub idlers will direct the belt into an overlap resulting in nearly pipe-shaped belt. From this moment on the belt is kept in the circular form by idlers positioned in a hexagonal configuration.


Inline Arrangement Offset Arrangement
Hexagonal Arrangement of Idler Rolls

Pipe conveyors use either an inline hexagonal arrangement of idler rolls attached to a support panel or an offset arrangement where rolls are alternately placed on either side of the support panel as shown in above figure.

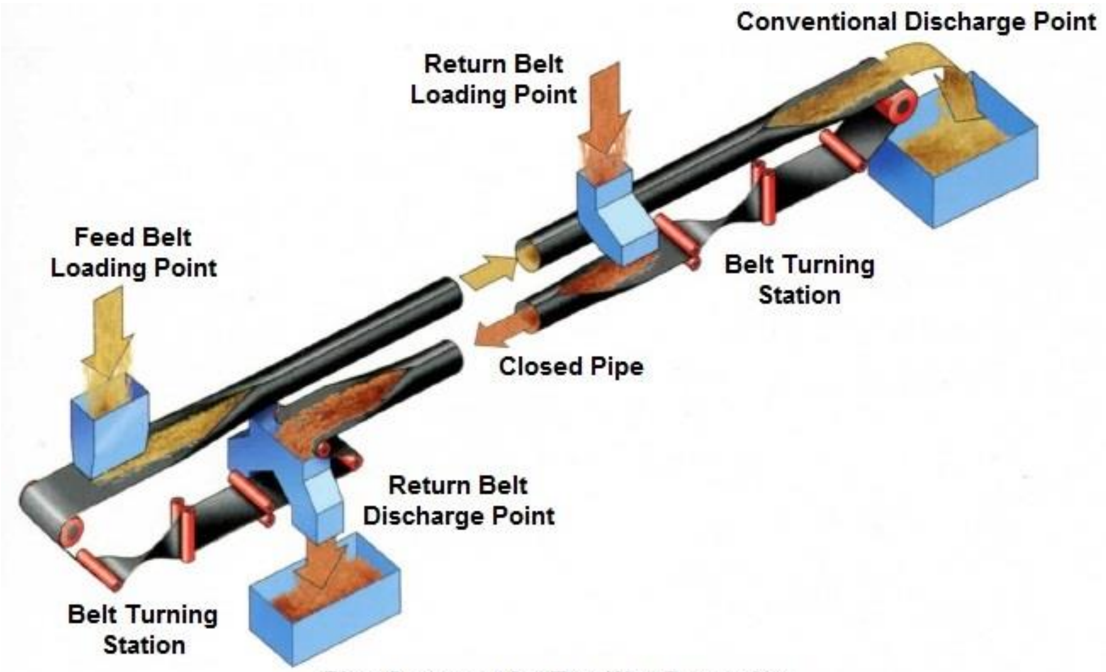


Belt Edge Trapping

In the inline arrangement, rolls are mounted with small gaps (3 to 6 mm or at least less than the belt thickness) to avoid the belt edge to be trapped between two rolls as shown in above figure. With inline designs, many times, a special roll length must be used to get the proper hexagon dimensions.

A major advantage of the offset design is that it has effectively zero roll gap because the adjacent but alternating rolls are slightly overlapping. The offset design also allows use of 'standard' idler rolls because roll length is not a significant factor which is the case with inline designs. The arrangement also allows larger rolls and brackets. If required, the offset design also provides space for fitting the grease fittings and lines required for re-greasable type taper roller bearing design rollers.

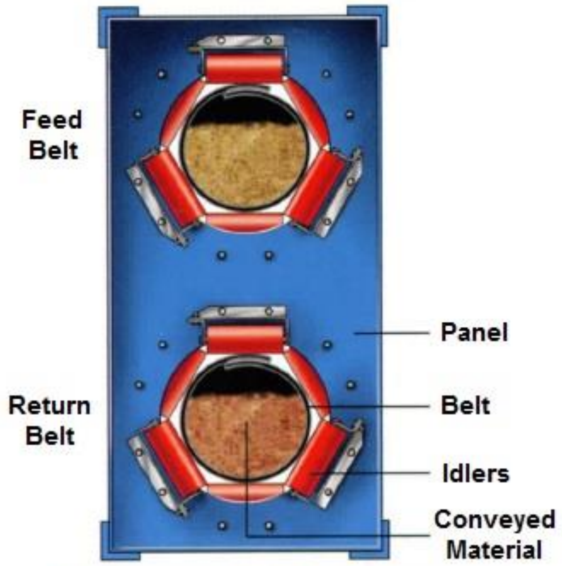
The belt at take-up is in flat form. Hence, the take-up should be kept close to head-end or tail-end, to avoid addition transformation from pipe shape to flat shape and again to pipe shape.



Pipe Conveyor for Two Way Conveying

As shown in above figure, the basic design feature of the pipe conveyor enables usage of the return side for conveying materials in the opposite direction also.

For two way conveying, a belt turnover is used so that the material is loaded onto the other side of the belt and this also insures that the overlap is in the 12 o'clock position for optimum sealing. It may be noted that in two way conveying, the belt overlap is in the 12 o'clock position for both the runs as shown in the following figure.



Belt Overlaps for Two Way Conveying

Advantages

A reasonably long pipe conveyor has the following advantages over conventional conveyors.

- Horizontal and vertical curves enable transportation of material over long distance in a single flight thereby eliminating elaborate and costly transfer point/towers.
- Power to lift the material at each of the transfer point is also saved by use of single pipe conveyor as against multiple flights.
- Increased friction due to larger contact between material and belt allows increased angles of inclination. Generally, it allows for a minimum 50% increase in the attainable angle of incline over conventional conveyors.
- Since the material is completely enclosed, external environmental conditions such as rain, wind, temperature and dust have no negative influences except from heavy wind and rain.
- Clean and spillage free material transport protects the environment and keeps maintenance costs on a low level.
- Compact design with low space requirement and minimized foundation needs.
- Eliminates belt edge damage that occurs with conventional conveyors when they misalign.
- Material can be transported in the upper and lower strands in both directions at the same time even with different kinds of material.

However, it may be noted that because any high temperature material is fully enclosed by the belt, heat resistant pipe conveyor belts do not allow as high a material temperature as with conventional conveyors. The ambient air cannot circulate and cool the material being conveyed or the return run of belt as is the case with conventional belt conveyors.

Belt Construction

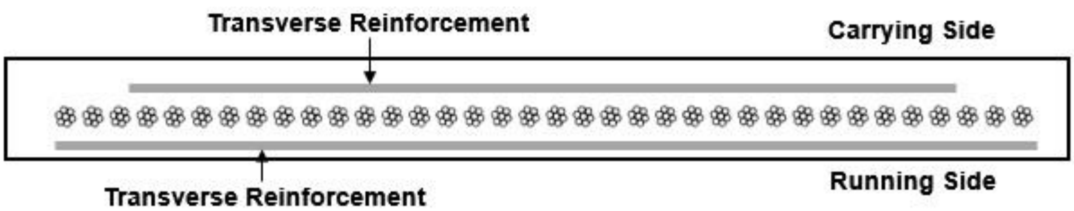
The pipe conveyor uses textile or steel cord construction rubber belt, which has external appearance similar to a conventional belt. However, internally they have a special carcass construction because it must have the required qualities that allow it to close and open properly at the head and tail ends, maintain the pipe shape particularly in tight curves, and maintain a good seal in the overlap zone while it is between idler panels.

The belt for a pipe conveyor must have just required transverse flexibility and rigidity, and the longitudinal flexibility. The belt requires to have a higher transverse rigidity than a belt used with conventional conveyor because the belt will have to unfold on its own at the transitions. A high transverse rigidity is also required for maintaining good belt training. However, it should not have too high a transverse rigidity because transverse rigidity increases the power consumption. The longitudinal flexibility is required to allow tight curves without overstressing the belt.

Although there is a need for just the right amount of transverse rigidity in the belt, the belt edges in the overlap zone must still be flexible to seal adequately. This can be achieved in many ways. One way is to construct the belt so that the edges have little reinforcement in the overlap zone, and the middle portion of the belt to have a higher than normal transverse rigidity. In the smaller pipe diameters this is achieved by increasing the skim rubber thickness between the plies in the middle portion of the belt and leaving the belt edges of normal construction for the flexibility. For larger pipe diameters, other methods are followed such as increasing the number of plies. Following figure shows typical textile belt construction for a pipe conveyor.

Typical Textile Belt Construction for Pipe Conveyor

One method to obtain the required transverse rigidity in a steel cord belt is to install transverse reinforcement above and/or below the steel cords. The topside transverse reinforcement is usually made from 100% synthetic fabrics and does not extend the full width of the belt to increase the flexibility of the overlap zone. The bottom transverse reinforcement is usually made from relatively stiff steel cord weft members with synthetic fabric in the warp direction. The bottom transverse reinforcement normally spans the full width of the belt and in addition are located a distance from the steel cords to increase the transverse rigidity of the belt. Following figure shows typical steel cord belt construction for a pipe conveyor.



Typical Steel Cord Belt Construction for Pipe Conveyor

Pipe Conveyor Capacities

It may be note that with pipe conveyors, certain parameters are normally referred to in terms of the nominal diameter "d" of the pipe, much like the belt width "BW" in conventional belt conveyors. This pipe conveyor nomenclature shall be followed in this chapter where applicable.

Most suppliers will build pipe conveyor from 150 mm to 900 mm nominal diameter with increments of 50 mm in diameter. The amount of overlap is usually 75 to 100 mm for small pipes and up to 250 to 300 mm for the largest diameters.

The allowable capacity of a pipe conveyor can be calculated by assuming roughly 75% of the cross-sectional area of the actual pipe I.D. to occupy the material. This is increased to approximately 80-85% where there are no lumps and good feed control, down to 60% or lower when the material is very lumpy or feed control is poor. Also, tight curves reduce the cross-sectional area that should be utilized.

As pipe conveyors are very susceptible to severe damage from overfilling. It is highly recommended that these conveyors be loaded via a feeder and not directly from a bin or hopper gate. In addition, an overfill condition sensor should be used at the loading zone to shut down the conveyor in the event of such a condition.

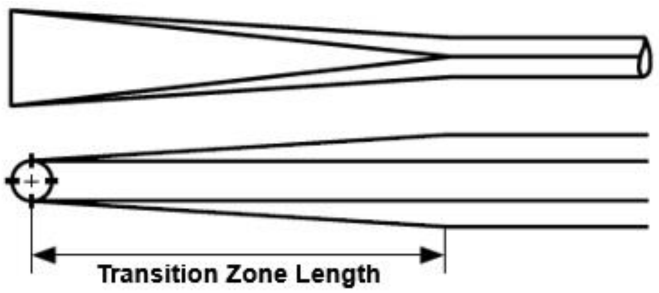
Normally, recommended lump size is typically 25% to 33% of the pipe diameter when conveying at the 75% cross-section. The maximum lump size (50 mm to 350 mm) depends heavily on the percentage of lumps. Hence, if the material has a high percentage of lumps then the lower value (25%) should be used and if it is just an occasional lump, then the higher value (33%) applies.

To make up for their smaller allowable cross-sectional areas, pipe conveyors are often designed to run at higher belt speeds than typically used for conventional conveyors. Recommended maximum conveyor speed (depending on idler diameter) is 2.3 to 6.5 m/s.

Pipe Conveyor Applications

Pipe conveyors are best known for their ability to negotiate tight vertical, horizontal and compound curves, much tighter curves than conventional conveyors. The incline in the vertical plane depends on the material being handled and is probably 30° maximum. The present limit for horizontal curve angle is 90°.

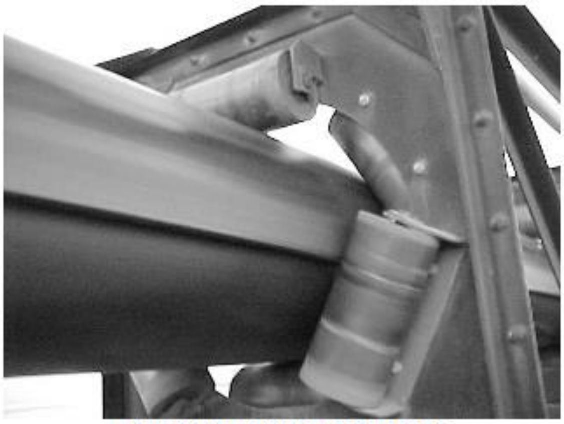
Recommended minimum curve radius for horizontal and vertical curves are: outer diameter x 300 for fabric belts and outer diameter x 600 for steel cord belts. It may be noted that too small a curve radius is one of the most common reasons for premature belt failure.



Recommended minimum transition zone lengths are: outer diameter x 30 for fabric belts and outer diameter x 60 for steel cord belts

Many times the pipe conveyor wants to assume a smaller diameter on the return run of pipe than the carrying run. One of the major reasons for it is that all the belt weight bears on the flexible overlap zone. Some designers for this reason utilize a smaller hexagonal arrangement of rolls in the return run. The resulting extra overlap allows for better return run sealing.

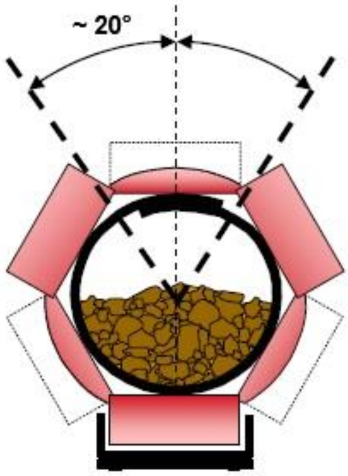
Belt Alignment



Misaligned Pipe Conveyor

Graphic Source: CEMA's Belt Conveyor for Bulk Materials, 6th ed., 2nd printing, 2014

Conventional conveyors have the operational problem of misalignment of the belt laterally which often causes severe damage to the belt edge as it contacts nearby steel work. Pipe conveyors do not have this type of problem because the belt is constrained 360° in the vertical plane by the hexagonal arrangement of idlers at each panel. However, belt misalignment with pipe conveyors is of a torsional nature as shown in above figure where it is clearly seen that the carrying belt has twisted (misaligned) so the overlap is between the 3 and 4 o'clock positions. A twist of the overlap in the carrying run from its normal 12 o'clock position or in the return run from its 6 o'clock position is termed as belt misalignment.



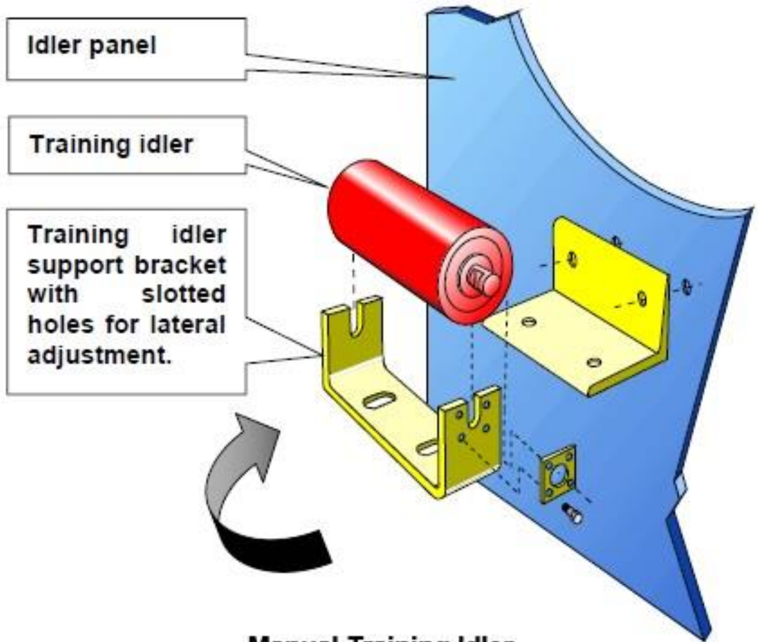
Acceptable Alignment

As shown in above figure, for acceptable/correct alignment, the overlap is permitted to lie approximately 20 degrees on either side of the top-centre position.

The carrying run, when loaded with material runs well aligned since the center of gravity of the belt and material load is well below the centerline of the pipe. This makes the belt stable and it runs true. The carrying run, running unloaded is probably the most problematic situation. The center of gravity is now above the centerline of the belt due to the overlap at the top. This situation is inherently unstable and the belt wants to twist. Twisting by itself is not a problem when the belt is empty since there is no material to leak out. It is just at the head that problems arise. The overlap has to be maintained at the 12 o'clock position for the belt to unfold onto the head pulley properly. This is where all the training efforts should be concentrated, getting the belt overlap to stay at 12 o'clock when empty. The return run does not usually pose a training problem as the center of gravity, due to the belt overlap being at the 6 o'clock position, is below the belt's centerline.

Conventional trough conveyors are provided with self-aligning/training idlers to keep the belt automatically trained. However, this option is not available to pipe conveyors. They are generally aligned using manual training idlers.

Manual training idlers are located along the carrying and return side of a pipe conveyor at specific interval (approximately 20 m) in the pipe section of the pipe conveyor. The training idlers are placed in the direction of maximum belt load, (usually the bottom idlers of each set of six idlers), and are mounted on a bracket which has slotted adjustment holes as shown in the following figure.



Manual Training Idler

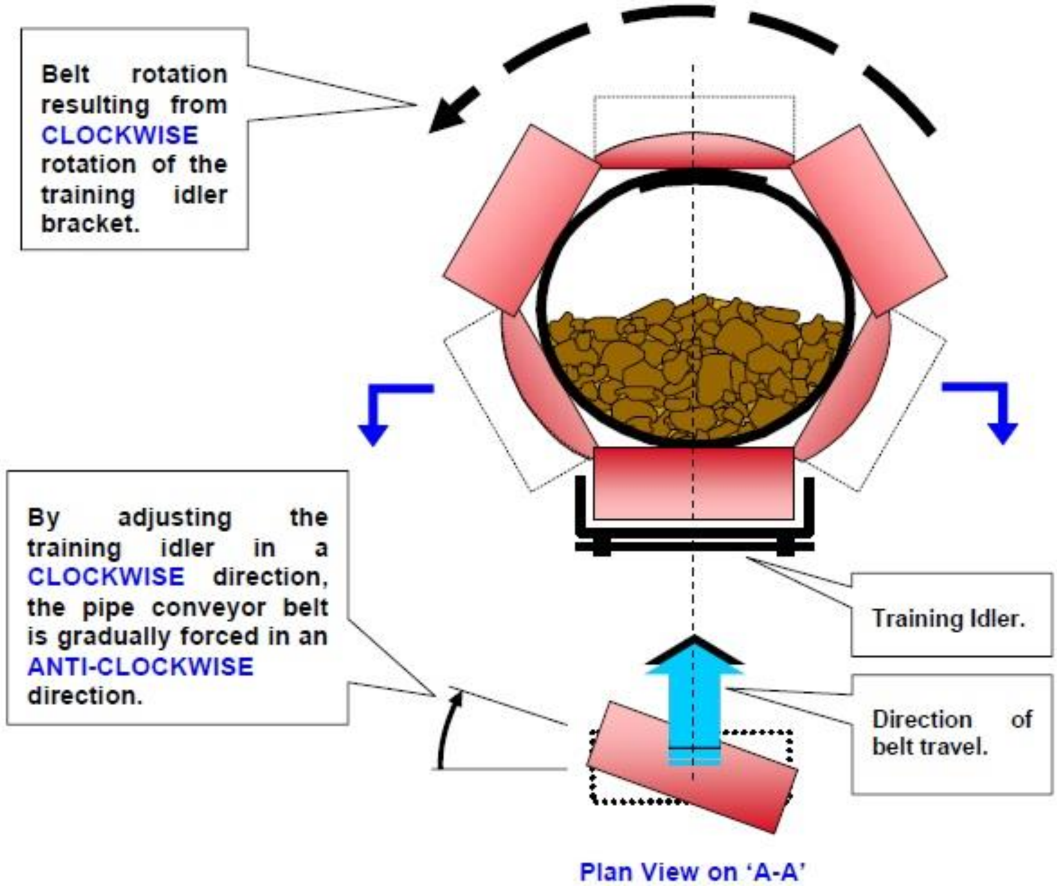
Where the conveyor negotiates a vertical curve, the training idlers may be at the top of the idler panel.

To train a belt, first identify where the belt begins to misalign / rotate, for adjusting the training idlers there. Then establish whether the belt is required to rotate either clockwise or anti-clockwise for the overlap to be at the top (carrying side) or bottom (return side) of the idler set.

The bolts on the adjusting idler bracket must then be loosened slightly, to enable the bracket to be turned.

Now, the idler bracket must be turned in the correct direction. Following figure shows the effects of turning the training bracket and idler. After turning the idler bracket in the correct direction, tighten the bolts on the adjusting idler bracket.

Care must be taken to prevent excessive adjustment of the training idlers. Adjustments must be made to one or two adjacent idlers only, followed by observation to allow the adjustment to take effect before further adjustments are made. After any adjustment is made, the belt should be allowed to make at least one full cycle, before further adjustment is made.



Effect of Turning the Training Idler

FLSmidth (KOCH Pipe Conveyor®) is the leading international pipe conveying systems supplier (www.flsmidth.com).

For more information on pipe conveyors, please see Belt Conveyors for Bulk Materials published by CEMA, USA.

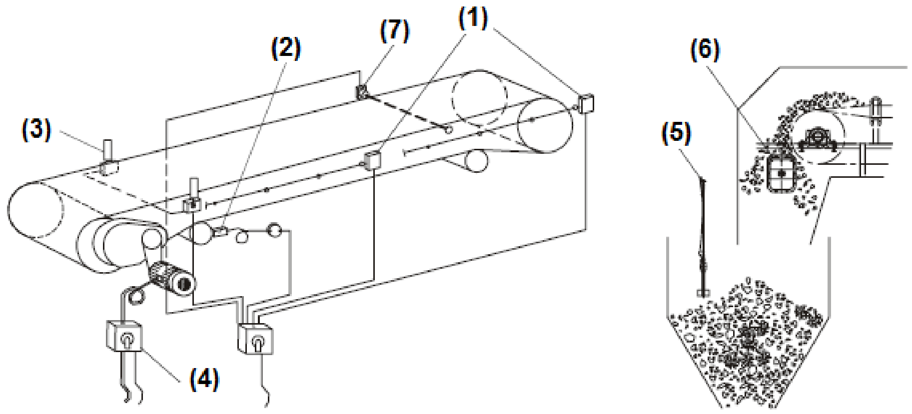
Maintenance

Man-carrying Travelling Maintenance Trolley

To carry out maintenance of elevated overland conveyor, usually a man-carrying travelling maintenance trolley is installed on the triangular gantry as shown in above figure.

Safety

With proper safety precautions, belt conveyors can be operated safely. In safety, two types of devices need to be considered. Devices that protect the belt / equipment and devices for safety of operating personnel and others near the conveyor. Some devices protect both people and belts. Information about various safety devices is given in this chapter.



(1) Pull Cord Switch
(2) Rotation Detector
(3) Belt Misalignment Switch
(4) Safety Switch
(5) Level Limit Switch
(6) Blockage Detector
(7) Belt Tearing Detector

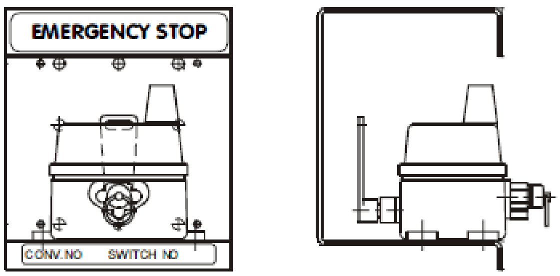
Safety Devices for Belt Conveyors

Above figure shows various electrical safety devices generally used on belt conveyors.

Safety Switch

The safety switch prevents the conveyor from being started. During the work at the conveyor, the switch is turned to the off position. Additionally, the turning of the switch to the operating position can be prevented with a separate lock.

Pull Cord Switch



Pull Cord Switch

Pull cord switch also known as **Rope Operated Emergency Switch** is used as a safety switch to stop the conveyor belt in case of an emergency by pulling the rope. Pull cord switch is mounted on the walkway side of the conveyor belt, preferably at about every 30 meters. When the rope is pulled from any side, the switch gets operated. Unless and until the handle is reset manually to normal position, the switch remains in operated condition. NC contacts of all pull cord switches are wired in series and further connected to PLC. When any switch along the belt operates, the contact opens and conveyor is stopped.

Speed Control / Rotation Detector (Zero Speed Switch)

Speed control / rotation detector, also called zero speed switch can sound an alarm or shut down a system when belt speed deviates too far from the preset range. These may be used to check slippage, to prevent overloading of a belt that is suddenly not moving as fast as required, or to prevent over speed (overloading a downhill conveyor results in over speed).

When the belt starts to slip on a pulley that cannot rotate properly, there is a significant amount of heat built up in a very short period of time. This can damage pulley lagging, the belt or even start a fire. When a belt breaks, some pulleys may continue to rotate while others stop. While there is little time to react to a broken belt there are other actions that can be taken, such as shutting down supply belts to minimize the material spillage. Zero speed switch is useful in such cases.

Commonly electronic speed monitor is used to monitor speed of conveyors and other industrial machinery. This device actuates relay contacts at preset speed. Using these contacts desired control action such as zero speed protection / under speed protection / over speed protection can be achieved.

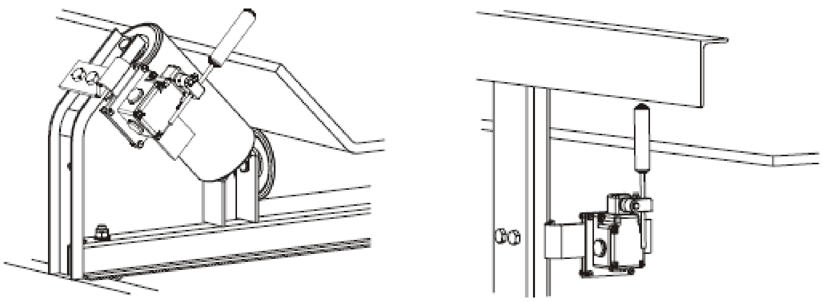
The basic principle of speed monitor is comparison of pulses received from sensor with standard pulses. The unit consists of two parts, sensor probe and control unit. The sensor is to be installed with its sensing face in close proximity of rotating object. On this object, flags are to be fixed. The sensor produces strong electromagnetic waves, which get disturbed by the flags, giving rise to corresponding pulses. These pulses are fed to the control unit where they are compared with standard pulses to sense the speed.

Traditionally they are installed on the end of the tail pulley. However, they are also available for installing on the return idler support. Placing them near the drive-end will reduce the cabling on long belt conveyors.

Belt Slip

Belt slip is the loss in traction of the drive pulley(s) to the belt cover. Constant speed belts normally consist of a rotation detector (belt slip switch) with a set point that trips the conveyor drive when the belt speed is below 80 percent of full speed. The rotation detector is bypassed during starting and stopping. For variable speed conveyors, the rotation detector consists of a speed sensor that measures belt speed and compares with the speed reference sent to the drive system. When the belt speed is below 80 percent of the intended speed, the drive is tripped. This type of rotation detector is active during starting, running, and stopping.

Belt Misalignment Switch (Belt Sway Switch)



Carrying (Upper) Belt　　　　Return Belt

Belt Misalignment Switch

A common cause of severe belt damage is extreme lateral movement, which brings the belt to bear against the structure and possibly folds it upward. Therefore, belt misalignment switch, also known as belt sway or wander switch is provided. The purpose of the belt misalignment switch is to give a warning or/and stop the belt conveyor when the belt has moved too much sideways during the operation the conveyor.

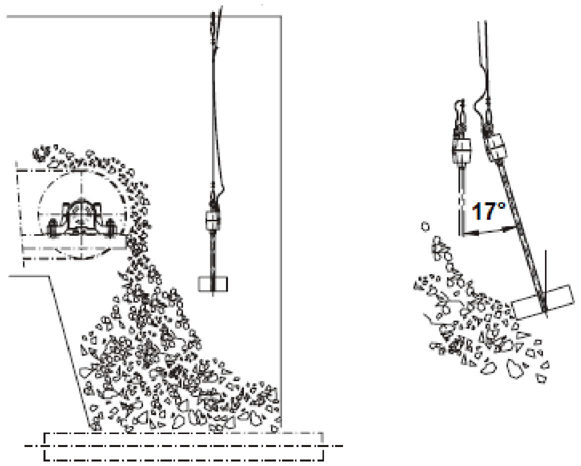
The switch (in pair / both sides of conveyor) is normally used at about 50 m interval along the carrying (upper) belt, but in unstable conditions in long conveyors, it can also be used with the return belt. In case of short conveyors, minimum 2 pairs of switches are provided.

These switches should be installed at any point where the belt enters an enclosure or where a mistracking belt is within reach of structural steel or obstructions. Most commonly, they are installed at the discharge (head pulley) and at the loading zones (tail pulley) of the conveyor, but can be distributed along the conveyor at intervals.

A small clearance is allowed between contact roller of the switch and the belt edge to allow the normal running of the belt with acceptable swaying. When swaying exceeds normal limit, the belt edge pushes the contact roller, which drives the switch and operates the contacts to give a warning or/and stop command.

Level Limit Switch

When conveyors discharge into bins or hoppers, bin level sensors provide protection to the belt. These can consist of simple hanging tilt switches or analog measurement devices such as ultrasonic, radar, or laser devices.

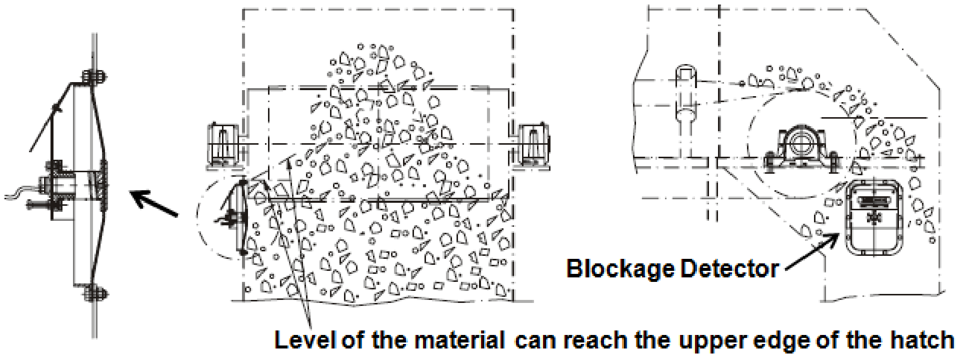


Conveyor Chute with Level Limit Switch

Above figure shows a typical conveyor chute with a level limit switch installed in it. The sturdy metal box of the switch contains a ball-operated micro-switch. The switch is opened when the sensor rod reaches an indication of 17° informing of a blockage or a level limit.

Blockage Detector

A blockage detector is also known as a plugged chute switch. If material “bridges” in the chute, the material will buildup in the hopper. If this buildup goes too high, it may endanger the discharging belt above. Typically controlled by a paddle or an electric eye, plugged chute switches stop the feeder conveyor, halting the flow of material into the chute.



Conveyor Discharge with Blockage Detector

Above figure shows a conveyor discharge with a blockage detector. The rubber plate of the blockage detector is equipped with a spring loaded metal plate. The inductive sensor in the blockage detector operates when the material presses the metal plate against the sensor.

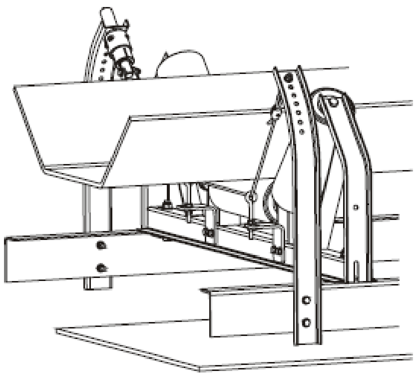
Belt Tearing/Rip Detector

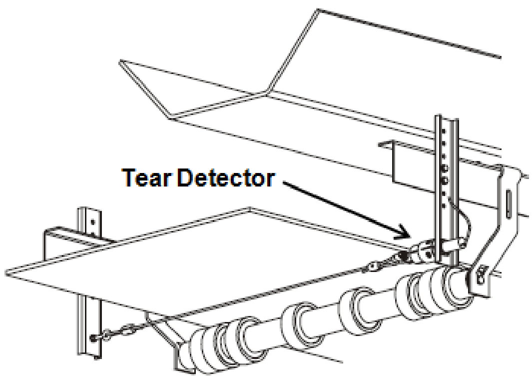
Large metallic objects in the load or belt stuck against the chute work can tear a belt lengthwise. If not detected, this slit can ruin the full length of a belt. With the help of a belt tearing/rip detector, large belt damages can be efficiently prevented.

A belt tear or rip detector is a conveyor accessory consisting a switch or sensor which is designed to detect belt damage like tears, rips and punctures. There are a wide variety of rip and tear detectors available. Some are stand-alone accessories and some are an integral part of the belt, depending upon the applications. Their working varies from simple trip wire devices to sophisticated electronic systems.

Following is Recommended:

- A rip detector shall be placed on every conveyor where there is the possibility of the bulk material (large pieces) or tramp metal penetrating the belt and creating a tear in the belt.
- The rip detector is best positioned on the carrying run of the belt immediately after the point where the bulk material is loaded on the belt.
- On conveyors where the possibility of a rip happening at multiple locations and for a wide variety of reasons the use of a specialized belt with a built in rip detection system should be considered (for example: PHOENOCARE® Sensor Guard by PHOENIX CBS GmbH).


Carrying Belt Detector

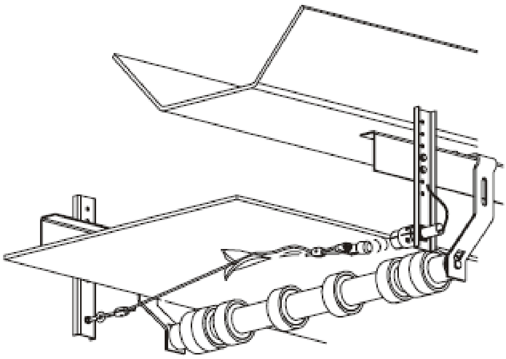


Return Belt Detector

Trip Wire Type Tear Detector

Above figure shows trip wire type tear detectors for installation at carrying side and return side of belt.

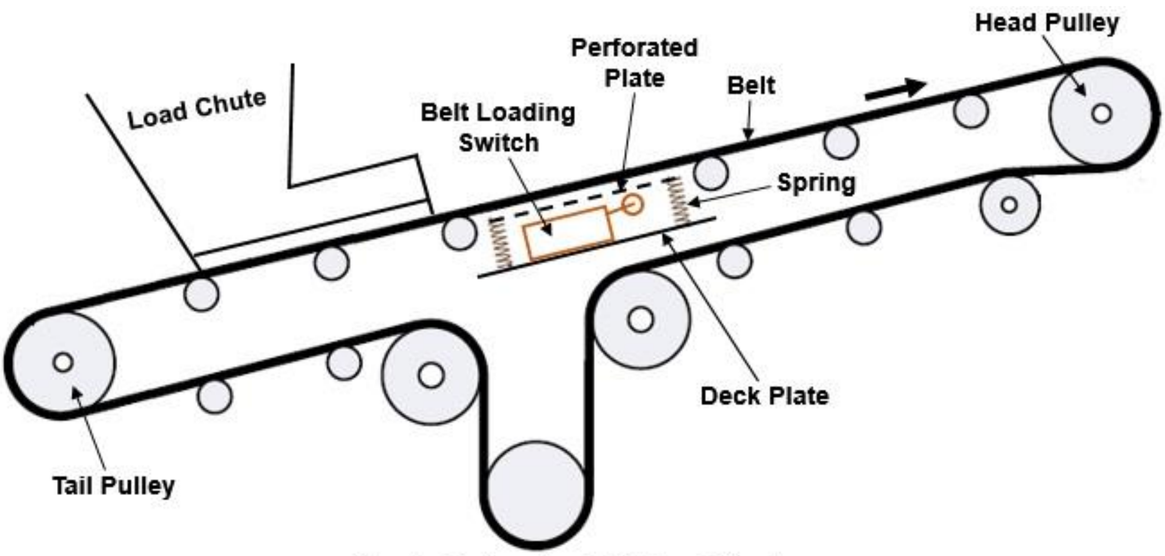
In such detectors, one end of the cable is permanently mounted to a support bracket and the other end is connected to a spring loaded ball located detector unit. As shown in the following figure, the switch gets actuated when an object or broken belt surface sweeps away the cable pulling spring loaded ball out of detector unit.



Damaged Belt Pulls Ball Out of Detector Unit

Simple System for Belt Tear Detection

In India, some companies are using a simple system to detect belt tear / ripping. Its design is done by them. Its construction and working is as under.



Simple System for Belt Tear Detection

As shown in above figure, the rip detection system is installed below the carrying run of the belt immediately after the material loading point of the conveyor. The system consists of a belt loading switch (or sail / paddle switch) installed on the deck plate of the conveyor. A perforated plate (generally, a large piece of a cable tray) supported on springs is installed below the belt with a small gap between the perforated plate and the belt loading switch roller. The stiffness of the springs will depend on bulk density of the material and number of springs used in the system.

In case of belt tearing/ripping (damage), a large quantity of the conveyed material falls on the perforated plate and moves it down due to the weight of the material (as it is supported on springs). This downward movement of the perforated plate pushes roller of the belt loading switch down and operates the limit switch contact. The contact is used in the control circuit to stop the conveyor immediately.

It may be noted that a perforated plate is used to prevent built up of fines on it during normal operation which may move it down and trip the conveyor even though the belt is healthy. In view of this, the perforated plate should be cleaned periodically to prevent false tripping of the conveyor.

Magnetic Devices

Stray metal objects of all types - ranging from bucket loader teeth to steel plate that has fallen from chute linings - can create a problem for operation. If it is carried with the load on the belt, this “tramp iron” can wedge itself into a position where it can gouge or rip the belt. Magnetic head pulleys, which hold the iron on the pulley past the material discharge point and then drop it into a separate pile or chute are commonly used to safeguard the belt.

Another system uses a magnet suspended above the belt to pull the iron out of the load. There are two methods of construction for magnetic separators - use of permanent magnets and use of electric powered magnets or electro-magnets.

Separators using permanent magnets are usually considerably less expensive on initial cost, lighter weight, smaller in size and have no operating costs, as the magnet requires no electrical hook-up to energize the magnets. Electrical powered magnetic separators typically are more powerful, producing stronger and deeper penetrating magnetic fields. This allows them to work through deeper burdens of conveyed material and on faster belt speeds.

Suspended Magnet

As shown in above figure, the suspended magnet is a magnet box that can be suspended from a frame over the conveyor. Ferrous metals are attracted to the faceplate of the suspended magnet as the material is conveyed in the normal path. The suspended magnet can be either permanent or electric and is available in a wide range of magnetic strengths to fit a specific application. It is not self-cleaning so any ferrous metals picked out of the conveyed material have to be physically removed from the magnet face.

As shown in the following figure, the cross belt separator is suspended above, but angled across or perpendicular to the belt conveyor, hence the name cross belt separator. The cross belt separator can be either permanent or electric and is available in a wide range of magnetic strengths to fit specific applications (1000 gauss strength for heavy class conveyors). It is a continuous, self-cleaning solution. Tramp ferrous metal in the conveyed material is attracted up to the magnet and attaches to the separator belt. The cleated separator belt pulls the ferrous metal and discharge it off to the side of the conveyor. The cleats also prevent round metal fragments from rolling and staying in the magnetic field.

Cross Belt Magnetic Separator

However, this arrangement of suspension, across the belt conveyor is less effective for tramp iron deeply buried in the material. To overcome the problem, as shown in the following figure many times magnets are suspended in line with the belt over the discharged trajectory of material. This type of arrangement is commonly called in-line magnetic separator.

In-line Magnetic Separator

Since the material and tramp iron are under free fall suspension condition in this type of arrangement, the material offers list resistance to movement of tramp iron towards magnet. Also, tramp iron velocity along belt helps it to be carried in right direction for discharge. Therefore, this arrangement is more effective for removal of tramp irons.

The magnet suspended above the belt also protect machinery such as crushers, grinders and pulverizers from ferrous tramp metal that may be mixed in with the conveyed material. Removing the tramp metal prevents costly repairs and downtime.

Metal Detectors

A metal detector is a device that sense changes in the electromagnetic fields caused by the presence of conductive materials.

Metal detectors are available in a wide range of sensitivities and configurations for any conveyor design requirement. Metal detectors are capable of detecting ferrous and nonferrous metals.

It is recommended that metal detector should be installed in a location on the conveyor such that it is convenient for removing the tramp metal from the cargo.

Belt Overload Protection

The belt conveyor system is protected from overload by the motor overload of the electric drive motors(s). Motor current can be also used as an indication of over loading. A belt loading "sail or paddle" switch can be used to sense a belt overload at a specific point. Complex belts are sometimes protected from overload by belt weigh scales that measure the belt loading at a point.

Fire Detection and Prevention Systems

Conveyor idlers can occasionally jam or lock due to lack of lubrication, material buildup, or mechanical breakdown. Once locked, the idler's bearings can overheat to a point where they can ignite flammable materials (like coal fines) that have accumulated around the roller. Similarly, friction from belt slippage can lead to overheating and fire. These fires can then quickly spread to flammable material on the belt and the belt itself.

Many plants install complete conveyor fire protection systems including both fire detection sensors and a water spray system to extinguish any fire discovered. Smoke sensors, carbon monoxide sensors and fire detection systems based on infrared, ultraviolet, or fiber optic principles are available. For more information, view an article on spontaneous combustion in coal on this website.

While these systems are not cheap, the costs for installing and maintaining these systems are substantially lower than what it would cost to repair or replace equipment damaged by fire or explosion.

Lighting

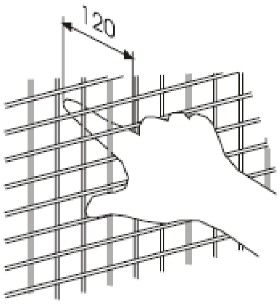
Good lighting contributes to a safe working environment. Recommended illumination is as under.

Conveyors - 40 to 100 Lux depending on operation and maintenance requirement.
Control Room - 300 Lux.

Safety Net / Guarding

Belt conveyors and their transfer points can be dangerous. By their very nature, they feature many "pinch" points. In view of this, area around rotating parts of an equipment and conveyor pulleys should be guarded by safety net. The safety net (guards) may be hot galvanized welded wire net, 30x30x3 mm in size.

As shown in the following figure, safety distance for the safety net is 120 mm with 27 x 27 mm mesh.



Safety Distance

Whilst any equipment is running, all guards must remain properly fitted in their place. Following completion of any work, and before restarting the equipment, ensure that all guards are correctly refitted.

Caution:
No one should ever be allowed to remove adhering or lodged material from a conveyor pulleys or idlers unless the conveyor has been stopped.

Closed-Circuit Television

Video cameras can be installed to observe the points where it is most likely for damage to occur and transmit images back to a central control room. An operator stationed in the control room can observe the monitors, watching for dangerous or damaging conditions.

Pre-Start Alarm

Pre-start alarm is a conveyor accessory which provides an audible or visual device used to alert personnel working on (or near) a conveyor that it is about to start.

It is recommended to install alarms along the conveyor in sufficient number so that the alarm is audible or visible from all locations along the conveyor.

Pre-start alarms are required by OSHA regulations on most conveyors. They are commonly a horn, siren, buzzer, strobe or a flashing light.

Work Safely

Electricity can kill! Isolate all equipment from electrical power supplies before carrying out any maintenance work. A "Permit to Work" system is recommended.

In case of pipe work; isolate, de-pressurize and drain the pipe line to prevent danger from sudden leakage.

Never work alone. Use a lifting harness, safety line and respirator as required. Wear safety helmet and protective footwear. Use ear protection, goggles and/or gloves if the work being carried out is noisy or hazardous to eyes and/or hands. If dust fumes or vapours present a hazard to the respiratory system, the appropriate mask and filter must be worn.

Take care when removing worn parts, they may have sharp edges.

Check for fire or explosion risk before welding or using electrical hand tools.

Clean up any fluid spillage immediately, using appropriate precautions if the fluid being handled is of a hazardous nature. Take required action to remove the cause of the spillage.

Follow all other health and safety regulations, procedures and local requirements.

Lifting Operations

Make sure that all lifting equipment is in serviceable condition and suitable for the task.

Only use approved safe methods of handling heavy equipment.

When eyebolts are fitted to individual parts of the system for lifting purposes, do not attempt to use them to lift the whole assembly. Unless otherwise stated in the detailed instructions in the manual eyebolts are only provided to lift the loosened single part during assembly or dismantling.

Do not pass under suspended loads.

Safety Stickers

Safety awareness can be created by display of safety stickers and warning posters in prominent areas (at pinch points, service access doors, and other hazardous areas on conveyor equipment). CEMA has designed safety posters for various applications as a service to the Industry. Following figure shows the safety poster for bulk conveyor. For more information, please view CEMA’s website, www.cemanet.org.


Bulk Handling Conveyors
SAFETY
Is In Your Hands
Do Not Climb, Sit, Stand, Walk, Ride, or Touch the Conveyor at Any Time
Do Not Perform Maintenance on Conveyor Until Electrical, Air, Hydraulic and Gravity Energy Sources Have Been Locked Out and Blocked
Operate Equipment Only With All Approved Covers and Guards in Place
Lock Out All Power and Block Gravity Loads Before Servicing
Ensure That All Personnel Are Clear of Equipment Before Starting
Allow Only Authorized Personnel and Trained Personnel To Operate or Maintain Conveyors and Accessories
Keep Clothing, Body Parts, and Hair Away from Conveyors
Clean Up Spillage Around Tail Pulleys, Idlers, and Load Points Only When the Power Is Locked Out and Guards Are In Place
Do Not Modify or Misuse Conveyor Controls
Ensure That ALL Controls and Pull Cords are Visible and Accessible
WARNING
TRASH
Do Not Modify or Remove Controls, Guards, Interlocks, Warnings or other Safety Items without Manufacturer's Approval
Report All Unsafe Conditions
POST IN PROMINENT AREA

Trouble Shooting

Most operational problems are created by abuses of the system or attempts to cure the symptoms. Information on belt conveyor problems/symptoms, probable causes and probable solutions is given in this chapter for trouble shooting and to eliminate the root causes for the problems.

The common problems encountered with conveyor belting and the means to overcome them are listed below.

Problem: Belt runs off at tail pulley	
Probable Causes	Probable Solutions
Counterweight too light	Recalculate weight required and adjust counterweight or screw takeup accordingly.
Idlers or pulley out-of-square with center line of conveyor	Realign.
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Side loading	Load in the direction of belt travel, in center of conveyor.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.

Problem: Entire belt runs off at all points of the line	
Probable Causes	Probable Solutions
Side loading	Load in the direction of belt travel, in center of conveyor.
Idlers or pulleys out-of-square with center line of conveyor	Realign.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Belt strained on one side	Allow time for new belt to "break in."
Self aligning (guide) idler sets are stuck (jammed)	Make the self aligning idler sets movable and ensure that they remain movable or replace them.

Problem: One belt section runs off at all points on the line	
Probable Causes	Probable Solutions
Belt improperly spliced	Remove the existing splice and make new splice.
Edge worn or broken	Repair belt edge. Remove badly worn or out-of-square section and splice in a new piece.
Belt bowed	Avoid telescoping belt rolls or storing them in damp locations. A new belt should straighten out when "broken in" or it must be replaced.

Problem: Belt runs off at head pulley	
Probable Causes	Probable Solutions
Idlers or pulley out-of-square with center line of conveyor	Realign.
Pulley lagging worn	Replace worn pulley lagging.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.

Problem: Belt runs to one side throughout entire length at specific idlers	
Probable Causes	Probable Solutions
Idlers or pulleys out-of-square with center line of conveyor	Realign.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Conveyor structure not level	Level the conveyor structure.

Problem: Belt slip	
Probable Causes	Probable Solutions
Insufficient traction between belt and pulley	Increase wrap with snub pulleys. Lag drive pulley. In wet conditions, use grooved lagging.
Counterweight too light	Recalculate weight required and adjust counterweight or screw takeup accordingly.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Pulley lagging worn	Replace worn pulley lagging. Use grooved lagging for wet conditions.
Overloading	Decrease the load

Problem: Belt Slip on starting	
Probable Causes	Probable Solutions
Insufficient traction between belt and pulley	Increase wrap with snub pulleys. Lag drive pulley. In wet conditions, use grooved lagging.
Counterweight too light	Recalculate weight required and adjust counterweight or screw takeup accordingly.
Pulley lagging worn	Replace worn pulley lagging. Use grooved lagging for wet conditions.
Drive under belted/designed	Recalculate maximum belt tensions and select correct belt.
Improper initial position of counter weight carriage leading to it getting stuck in its guide and causing apparent excessive belt stretch	Identify and remove the cause responsible for the counter weight carriage getting stuck in its guide.
Insufficient counter weight travel	Maintain recommended minimum travel distances.

Problem: Excessive belt stretch	
Probable Causes	Probable Solutions
Excessive tension	Recalculate and adjust tension. Use vulcanized splice within recommended limits.
Drive under belted/designed	Recalculate maximum belt tensions and select correct belt.
Material build-up (on pulleys and idlers)	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Counterweight too heavy	Recalculate weight required and adjust counterweight accordingly. Reduce takeup tension to point of slip, then tighten slightly.
Differential speed wrong on dual pulleys	Make necessary adjustment.

Problem: Belt breaks at or behind fasteners or fasteners tear loose	
Probable Causes	Probable Solutions
Belt improperly spliced or wrong fasteners (for example - fastener plates too long for pulley diameter)	Use correct fasteners. Fasteners too tight or too loose. Retighten fasteners after running for a short while. If improperly spliced, remove belt splice and make new splice.
Pulleys too small	Use large-diameter pulleys.
Excessive tension	Recalculate and adjust tension.
Material between belt and pulley	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Drive under belted/designed	Recalculate maximum belt tensions and select correct belt.
Tension too high for fasteners	Use vulcanized splice.

Problem: Vulcanized splice separation	
Probable Causes	Probable Solutions
Excessive tension	Recalculate and adjust tension. Select correct belt.
Pulleys too small	Use large-diameter pulleys.
Material between belt and pulley	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Belt improperly spliced	Use of old or wrong splicing material. Rubber solution not evaporated sufficiently. Ambient conditions during splicing too humid.
Differential speed wrong on dual pulleys	Make necessary adjustment.
Improper transition between troughed belt and terminal pulleys	Adjust transition in accordance with belt manufacturer's recommendation or CEMA Standard.

Problem: Excessive belt top cover wear including rips, gouges, ruptures and tears	
Probable Causes	Probable Solutions
Excessive impact of material on belt	Use correctly designed chutes and baffles. Install impact idlers. Where possible, load fines first. Where material is trapped under skirts, adjust skirtboards to minimum clearance or install cushioning idlers to hold belt against skirts.
Relative loading velocity too high or too low	Adjust chutes or correct belt speed.
Improper loading	Feed should be in direction of belt travel and at belt speed, centered on the belt. Control flow with feeders and chutes.
Damage by abrasives, acid, chemicals, heat, mildew, oil	Use belt designed for specific condition. For abrasive materials working into cuts and between plies, make spot repairs with cold patch or with permanent repair patch. Seal metal fasteners or replace with vulcanized step splice. Enclose belt line for protection against rain, snow, or sun. Don't over-lubricate items.
Belt rubbing over heap of spilled/leaked material below the conveyor	Prevent spillage/leakage of material. Improve housekeeping.
Rubber of poor quality	Procure belt from reputed supplier.
Breaker strip missing or inadequate	Install belt with proper breaker strip.
High sag between idlers causing movement of material on belt as the belt passes over idlers.	Increase tension if unnecessarily low. Reduce idler spacing.
Scraper is hardly pressed on belt.	Position the scraper correctly. Do not use old belt as scrapper.
Skirt boards improperly adjusted or of wrong material	Adjust skirt board supports to adequate gap between metal and belt with the gap increasing in direction of belt travel. Use skirt board rubber (not old belt).
Jam/frozen/sticking idlers	Free idlers. Lubricate.

Problem: Excessive belt bottom cover wear	
Probable Causes	Probable Solutions
Material build-up	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Insufficient traction between belt and drive pulley leading to belt slippage	Increase wrap with snub pulleys. Lag drive pulley. In wet conditions, use grooved lagging.
Pulley lagging worn	Replace worn pulley lagging. Use grooved lagging for wet conditions. Tighten loose and protruding lagging holding bolts.
Excessive tilt of side idlers	Forward tilt of side idlers should be less than 3°.

Problem: Excessive belt edge wear, broken edges	
Probable Causes	Probable Solutions
Side loading	Load in direction of belt travel, in center of conveyor.
Damage by acid, chemicals, heat, mildew, oil	Use belt designed for specific condition. Enclose belt line for protection against rain, snow, or sun.
Belt bowed	Avoid telescoping belt rolls or storing them in damp locations. A new belt should straighten out when "broken in" or it must be replaced.
Belt rubbing with conveyor frame/structure	Install self aligning (training) idlers on carry and return run.
Belt misalignment	Please see training recommendations.

Problem: Belt cover swells in spots or streaks	
Probable Causes	Probable Solutions
Damage by abrasives, acid, chemicals, heat, mildew, oil	Spilled oil or grease. Don't over-lubricate items. Use belt designed for specific condition. For abrasive materials working into cuts and between plies, make spot repairs with cold patch or with permanent repair patch. Seal metal fasteners or replace with vulcanized step splice. Enclose belt line for protection against rain, snow, or sun.

Problem: Belt hardens or cracks	
Probable Causes	Probable Solutions
Damage by heat, chemicals, abrasives, exposure to ozone and UV-light.	Material or ambient temperature too hot. Use belt designed for specific condition. Belt cracks due to extreme influence of ozone and/or UV-light. Enclose belt line for protection against rain, snow, or sun.
Pulleys too small	Use large-diameter pulleys.
Improper storage or handling	Refer to the manufacturer for storage and handling tips.

Problem: Belt top cover softens	
Probable Causes	Probable Solutions
Material contains oil or grease	Use oil and grease resistant cover.
Lubricant has come in contact with belt surface	Don't over-lubricate items. Check grease seals. Clean belt.

Problem: Longitudinal grooving or cracking of belt top cover	
Probable Causes	Probable Solutions
Skirts improperly placed or not maintained	Install skirtboards so that they do not rub against the belt.
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Excessive impact of material on belt	Use correctly designed chutes and baffles. Install impact idlers. Where possible, load fines first. Where material is trapped under skirts, adjust skirtboards to minimum clearance or install cushioning idlers to hold belt against skirts.

Problem: Longitudinal grooving or cracking of belt bottom cover	
Probable Causes	Probable Solutions
Jam/frozen/sticking idlers	Free idlers. Lubricate.
Material build-up	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Pulley lagging worn	Replace worn pulley lagging. Use grooved lagging for wet conditions. Tighten loose and protruding bolts.

Problem: Belt Fabric decay, carcass cracks, ruptures, gouges, etc.	
Probable Causes	Probable Solutions
Excessive impact of material on belt	Use correctly designed chutes and baffles. Install impact idlers. Where possible, load fines first. Where material is trapped under skirts, adjust skirtboards to minimum clearance or install cushioning idlers to hold belt against skirts.
Material between belt and pulley	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.
Breaker strip missing or inadequate	Install belt with proper breaker strip.
Drive under belted/designed	Recalculate maximum belt tensions and select correct belt.
Damage by abrasives, acid, chemicals, heat, mildew, oil	Use belt designed for specific condition. For abrasive materials working into cuts and between plies, make spot repairs with cold patch or with permanent repair patch. Seal metal fasteners or replace with vulcanized step splice. Enclose belt line for protection against rain, snow, or sun. Don't over-lubricate items.
Radius of convex vertical curve too small	Increase radius by vertical realignment of idlers to prevent excessive edge tension.

Problem: Belt Ply separation	
Probable Causes	Probable Solutions
Excessive tension	Recalculate and adjust tension.
Pulleys too small	Use large-diameter pulleys.
Edge worn or broken	Repair belt edge. Remove badly worn or out-of-square section and splice in a new piece.
Damage by abrasives, acid, chemicals, heat, mildew, oil	Use belt designed for specific condition. For abrasive materials working into cuts and between plies, make spot repairs with cold patch or with permanent repair patch. Seal metal fasteners or replace with vulcanized step splice. Enclose belt line for protection against rain, snow, or sun. Don't over-lubricate items.
Belt speed too fast	Reduce belt speed.
Too many reverse bends.	Use more flexible belt.

Problem: Build up on Bend Pulleys and return idlers	
Probable Causes	Probable Solutions
Insufficient number of belt cleaners	Install additional belt cleaners or maintain existing cleaners more frequently.
Bulk material properties have changed	If a permanent change in bulk materials, redesign chutes, belt cleaners and re-evaluate conveyor speed, tension and belt type.

Problem: Spillage of fines and small particles in loading area	
Probable Causes	Probable Solutions
Skirts improperly placed or not maintained	Install skirtboards so that they do not rub against the belt.
Wear liners missing, worn or improperly installed	Replace wear liners so the bottom edge is lined up and gradually relieving in direction of belt travel.
Improper loading	Feed should be in direction of belt travel and at belt speed, centered on the belt.
Excessive belt sag	Recalculate take up tension. Install belt support systems or reduce idler spacing.

Problem: Spillage of larger particles and lumps along conveyor	
Probable Causes	Probable Solutions
Idlers or pulleys out-of-square with center line of conveyor	Realign. Install limit switches for greater safety.
Belt overloaded	Operate belt feed system at design capacity or less.

Problem: Severe pulley cover wear	
Probable Causes	Probable Solutions
Slippage on drive pulley	Increase tension through screw take-up or add counter weight. Increase arc of contact.
Material between belt and pulley, material build-up	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.

Problem: Plugged Chutes	
Probable Causes	Probable Solutions
Bulk material properties have changed	If a permanent change in bulk materials, redesign chutes, belt cleaners and re-evaluate conveyor speed, tension and belt type.
Belt rolls back after shut down	Install or repair belt holdback or brake.

Problem: Belt edges lift off idlers	
Probable Causes	Probable Solutions
Bottom cover too thin or carcass thickness too low	Install belt with thicker carcass or bottom cover.
Belt tension too high	Modify/redesign conveyor to achieve a reduction of belt tension.

Problem: Crosswise cracks of carcass or textile plies, while covers are intact	
Probable Causes	Probable Solutions
Low pulley diameters causes extreme flexing of belt carcass	Increase pulley diameter, install more flexible belt
Material trapped between belt and tail pulley	Remove accumulation. Install internal scraper (cleaning device) and inverted "V" decking. Use skirt-boards properly.

Problem: Reverse troughing of belt	
Probable Causes	Probable Solutions
Material being carried contains some oil	Use oil resistant belt.

Problem: Longitudinal cut through whole belt	
Probable Causes	Probable Solutions
Jam of material or tramp iron	Improve loading situation, install magnetic separator, install rip detection system
Defective idlers has fallen from its support and belt dragged over steel edge	Replace and fix idler on the support
Rupture of pulley rim	Replace pulley

Problem: Carcass fatigue at idler junction	
Probable Causes	Probable Solutions
Improper transition between troughed belt and terminal pulleys.	Increase transition length; use transition idlers; correct installation of transition idlers (many times are they are installed such that they are not touching/supporting the belt at all)
Severe convex vertical curve	Increase curve radius; decrease idler spacing in curve area; lower any elevated idlers in the curve area
Excess gap between idler rolls	Replace belt with heavier belt; replace with idlers having smaller gap.
Insufficient transverse stiffness	Replace the belt with adequate stiffness.

Maintenance Tools and Recommendations

Work can be carried out faster and safer with right tools. Following tools may be used for the same.

- Conveyor belt lifter
- Belt skiver
- Belt Clamps and Smart Belt Clamps
- Laser belt square
- Belt cutter
- Hydraulic nut splitter
- Gearless pulling and lifting machine (Tirfor also called Hook Chuck or Cumalong)
- Induction heater (to heat bearings before installation)
- Coupling / Bearing puller
- Plasma cutting machine (cutting of stainless steel plates for liners)

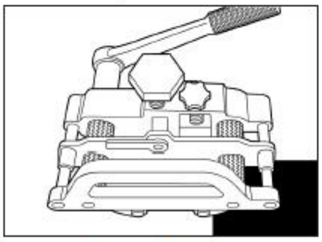

Belt Clamp


Smart Belt Clamp


Conveyor Belt Lifter


Belt Cutter


Laser Belt Square


Belt Skiver

Maintenance Tools

Above figure shows state of the art maintenance tools manufactured by Flexible Steel Lacing Company, USA (www.flexco.com).

Important Instructions

Machined spare parts should be stored in a dry place. Periodically check their condition and reapply anti corrosive compound as per manufacturers recommendation.

During dismantling, mark components to avoid mistakes during reassembly.

Too much grease in a bearing may increase its temperature excessively!

In case of welding work, ensure proper earthing to prevent damage to bearings.

Special care must be taken when carrying out welding work near conveyor belts and other rubber parts. Cover the conveyor belt to protect it from flying sparks, scale or spatters.

In case welding or flame-cutting work is carried out in a combustible area (for example near coal), inspect the area immediately after work is finished. Carry out an inspection again after one hour and then inspect it at an intervals of two hours for at least 12 hours to safeguard against fire.

Recommendations

A "walking inspection" of a bulk material handling system is a good means by which well-trained maintenance personnel can often detect potential problems from any unusual sounds made by such components as idlers, pulleys, shafts, bearings, drives, belts, and belt splices.

Make certain to read the owner/operator manuals issued by the supplier of any piece of equipment for specific instructions on service requirements, procedures, and timetables.

It may be a good idea to keep a maintenance “bone yard” where items removed from service can be stored and cannibalized for necessary replacement parts as needed. However, parts taken from used equipment needs to be thoroughly cleaned and inspected before re-use.

For long life of a conveyor, take care of its **LIC** - acronym which stands for **L**ubrication, **I**llumination and **C**leanliness (Note: Because LIC is very famous in India, I have chosen it here - it stands for Life Insurance Corporation of India.).

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To buy the book, you may write/communicate to him. His contact detail is as under.
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Telephone: +91 (020) 25882916, Email: parimul@pn2.vsnl.net.in.

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Useful Websites

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www.conveyorbelt.com
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