Maximizing Conveyor Belt Performance

Industry Standards vs Real World Applications

Presented By

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Seminar Purpose

This seminar will focus on industry standards versus real world application of conveyor performance. The goal is to educate and improve participants knowledge of conveyor belt operation.

• Belt Construction & Selection
• Operational Forces
• Transition Distances
• Understanding Tension (Rated Versus Operating)
• Quick Tension Calculations
• Splices (Mechanical & Vulcanized)
• Trouble Shooting (tracking, training and belt wear characteristics)
Conveyor Belt Construction & Selection
Selecting the Proper Conveyor Belt

• Determine the following:
  – Maximum working tension the belt will perform under
  – Minimum pulley diameters
  – Troughability
  – Load support or transverse stiffness
  – Transition distance
  – Impact requirements
  – Compound requirements
Conveyor Belt Construction

• Three Main Components

  – Carcass, strength member
  – Skims, the rubber between the fabric plies
  – Belt covers
Skims & Covers

- Skims are important contributors to internal belt adhesions, impact resistance, and play a significant role in determining belt load support and troughability. Marginal gauge skims can lead to ply separation and/or idler junction failure.

- Covers are used to protect the carcass from impact, abrasion and, if possible, to improve the belt rolling resistance. Gauges and compounds come in many varieties, and are selected to be compatible with the conditions in which they are going to be working.
The Carcass

• In general most conveyor belt fabrics produced today utilizes polyester warps (lengthwise yarns) and nylon fills (widthwise yarns).

• This combines the best properties of both textiles offering high strength, low stretch conveyor belt with excellent impact resistance, troughability and load support.
The Carcass

- Polyester
- Nylon
- Fiberglass
- Aramid
The Carcass – Side View

Top Cover

Warp

Rubber Skim

Fill Yarns

Bottom Cover
Nylon

- High strength, high elongation, good fatigue resistance, toughness, and impact resistance.

- While moisture absorption not as high as cotton, it will absorb up to 10% of its own weight in moisture.

- Thus poor dimensional stability.

- At one time, nylon represented 40% of the raw material input into belt manufacturing. Today, it is something less than 20%.
Polyester

- High strength, good fatigue resistance, low elongation in warp and good throughability in weft.
- Extremely low moisture absorption.
- Thus good dimensional stability.
- Polyester usage in the manufacture of belting has grown from 0% in 1960 to something in the range of 80-85% today.
The Carcass
Polyester vs. Nylon

- Higher adhesions with polyester
- Polyester absorbs 0.4% water when saturated
- Nylon absorbs 10.0% water when saturated

Water breaks down adhesions and greatly reduces the fabric’s integrity and strength
Carcass Design - Plain Weave

- Conventional plied belting
  - Traditional weave (Warp/Fill over and under)
Carcass Design – Special Weave

• MANY versions of the “plain” weave are in service today.
  – Common variations of this weave that are used in conveyor belting are... square (or “basket”) weave, oxford weave, twill weave, and the crows-foot weave

“Twill” Weave … one of many variations of the “Plain” Weave
Straight Warp Carcass Design

- Straight Warp Weave - (Reduced Ply)
  - Utilizes three yarns, straight warp, fill and binder
    - Warp & Fill lay perpendicular & binder locks them together
      - Three to five times rip/tear rating vs. plain weave
RFL
Resorcinol Formaldehyde Latex

- The large use of synthetic fabrics in conveyor belts require the use of a special adhesive dip for rubber to fabric adhesion.
- A common mistake in vulcanized splicing is the removal of this RFL coating by buffing or lightly napping the fabric not only reduces the adhesion of the splice it also reduces its strength.
- NOTE: If the conveyor belt fabric strips clean or has a damaged treatment a fabric primer should be applied.
Buffing The Fabric Plies

• The warp thread absorbs all the tensile forces.
• Damage to this thread by cutting or buffing jeopardizes the splice.
Fabric Damage from Buffing
Scandura Splice School Royalon Peel Test Results

Using Scandura Splice Materials

Samples of Spliced Belt Cut 1" Wide (Buffed & Non-Buffed Fabric)

T-Peel Tested at 10 inches per min.

Buffing vs. Adhesions
Specifying Belt

BELT TENSION RATING

A belt’s rated tension is a measurement of the force (tension) required to move the conveyed product.

Rated tension is affected by...

- The weight of the material being conveyed
- The speed the material is being conveyed
- The angle of incline or decline in the conveyor system
- Resistance from idlers, cleaners, skirt board, etc.
Specifying Belt

• Each belt is rated as to its strength (the amount of pulling force that it will withstand).
• The tension the belt is able to withstand is known as the rated working tension.
• This rating is determined by the type of reinforcement used in the carcass of the belt. For instance, a 3/330 may have 3 plies rated at 110 # PIW each, which would produce a belt with a PIW rating of 330#

Standard fabric PIW working tensions are:
• 110# - 125# - 150# - 200# - 250# - 300# - 500#
Strength Relationships

BOTH are determined through a carcass “stress-strain” test

PIW Rating vs. Break Strength
Conveyor Belt
Operational Forces
Typical Conveyor Configuration
Tensions Around the Conveyor

Pulling the Belt
Tensions Around the Conveyor

Pushing the Belt
Tensions Around the Conveyor
Tensions Around the Conveyor
Conveyor Belt Tensions
Rated vs Operating
Maximum Operating Tension Considerations

- Belt width / length
- Speed (FPM)
- Capacity (TPH)
- Lift or incline/decline of the conveyor structure
- Counter-weight arrangement
- Motor (HP)
- Drive configuration
Tension Calculations Using the Full-Motor Method

• This simple tension format is based on assuming that 100% of the motor’s nameplate horsepower will be delivered directly into the belt.

• In general that doesn’t happen. Actual belt tension as calculated by a detailed long method will generally give a lesser value.

• Can be used as a quick field guide to estimate max tension.
Tension Calculations Using the Full-Motor Method

PIW = \frac{33,000 (1+C_w) \text{ HP}}{S \times W}

- Where:
  - \text{PIW} = \text{lbs/in width} \text{ (max operating tension)}
  - \text{S} = \text{belt speed} \text{ (ft/min)}
  - \text{W} = \text{belt width} \text{ (inches)}
  - \text{HP} = \text{motor horsepower} \text{ (nameplate)}

\text{C_w} = \text{drive “wrap factor”}

<table>
<thead>
<tr>
<th>Wrap Angle</th>
<th>Automatic TU</th>
<th>Manual TU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bare</td>
<td>Lagged</td>
</tr>
<tr>
<td>180°</td>
<td>0.84</td>
<td>0.50</td>
</tr>
<tr>
<td>210°</td>
<td>0.66</td>
<td>0.38</td>
</tr>
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</table>
Minimum Pulley Diameter’s

- Pulley sizes where the belt has over 6” of wrap on the pulley.
- Pulley sizes are based on operational belt tension.
- Undersized pulley’s can cause:
  - Ply separation
  - Belt splice separation
  - Premature flex fatigue
## NIBA - Minimum Pulley Diameter’s

<table>
<thead>
<tr>
<th>Number of Plies</th>
<th>80 to 100%</th>
<th>60 to 80%</th>
<th>40 to 60%</th>
<th>Under 40%</th>
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<td>24</td>
<td>20</td>
<td>14</td>
<td>12</td>
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<td>30</td>
<td>24</td>
<td>18</td>
<td>16</td>
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<td>4</td>
<td>36</td>
<td>30</td>
<td>24</td>
<td>20</td>
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<td>5</td>
<td>42</td>
<td>36</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>48</td>
<td>42</td>
<td>36</td>
<td>30</td>
</tr>
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</table>
Undersized Pulley – Ply Buckling

- The carcass must adequately “flex” over each pulley without buckling.
- The carcass must have acceptable elongation characteristics.
Undersized Pulley – Ply Buckling

- Improper pulley flexing could overstress the fatigue limit of the carcass (ply separation, transverse ply fractures, splice failures, etc.)
Conveyor Belt
Transition Distance
Conveyor Transition Zone

Edge of the belt is under more tension in the transition area.

A little known contributor of splice failures!!

The distance from flat to full trough.
Transition Distance

Transition distance is defined as the length from the center line of the first fully troughed idler roll to the center of either the head or tail pulley.
Types of Transitions

2 basic profiles used – Full & Half

Affects head, tail, tripper, and all booster/drive pulleys

Full Trough

Half Trough

$L_1$
Short Transition Distance

• The edge could be over tensioned and may force the center of the belt to buckle up.
• Splice failure and belt delamination will occur.
Note- Missing Idler Cans and Center Buckle
**Transition Length Increase**

**Full Trough**

- **Tension**
- **Compression**

- **Belt width**
- **L₁**
Full Trough

Transition Length Increase

Compression

Tension

Belt width

$L_i$
Transition Length Increase

L₁

Tension

Belt width

Compression

Full Trough
Half Trough → pulley raise 3.5”

Transition Length Increase
Half Trough
→ pulley raise 3.5”

Transition Length Increase
Half Trough
→ pulley raise 3.5”

Transition Length Increase

compression

belt width

tension
Lagged Pulley – Short Half Trough Transition Wear
## Full Trough Transition Table

<table>
<thead>
<tr>
<th>Idler Angle</th>
<th>% Rated</th>
<th>Belt Tension</th>
<th>Fabric Belt</th>
<th>Steel Cord Belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°</td>
<td>Over 90</td>
<td>1.6</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 to 90</td>
<td>1.2</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 60</td>
<td>2.4</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>35°</td>
<td>Over 90</td>
<td>3.2</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 to 90</td>
<td>2.4</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 60</td>
<td>1.8</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>45°</td>
<td>Over 90</td>
<td>4.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 to 90</td>
<td>3.2</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 60</td>
<td>2.4</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>
### ½ Trough Transition Table

<table>
<thead>
<tr>
<th>Idler Angle</th>
<th>% Rated</th>
<th>Belt Width x Factor = Transition Length (inch)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fabric Belt</td>
</tr>
<tr>
<td></td>
<td>Belt Tension</td>
<td></td>
</tr>
<tr>
<td>20°</td>
<td>Over 90</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>60 to 90</td>
<td>0.8</td>
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<tr>
<td></td>
<td>Less than 60</td>
<td>0.6</td>
</tr>
<tr>
<td>35°</td>
<td>Over 90</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>60 to 90</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Less than 60</td>
<td>1.0</td>
</tr>
<tr>
<td>45°</td>
<td>Over 90</td>
<td>2.0</td>
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<tr>
<td></td>
<td>60 to 90</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Less than 60</td>
<td>1.3</td>
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### Tail Transition

**Belt Tension vs Belt width**

<table>
<thead>
<tr>
<th>Length</th>
<th>75.6  in</th>
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<tbody>
<tr>
<td>Belt width</td>
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<tr>
<td>Trough angle</td>
<td>35     Deg</td>
</tr>
<tr>
<td>Pulley Height (h)</td>
<td>0.0     in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>384.9  plw</td>
</tr>
<tr>
<td>Maximum Tension</td>
<td>570.7  plw</td>
</tr>
<tr>
<td>Maximum Percent</td>
<td>86.5   %</td>
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<tr>
<td>Minimum Tension</td>
<td>323.7  plw</td>
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<tr>
<td>Minimum Percent</td>
<td>49.0   %</td>
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</tbody>
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*Acceptable: Yes*

### Head Transition

**Belt Tension vs Belt width**

<table>
<thead>
<tr>
<th>Length</th>
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<tr>
<td>Trough angle</td>
<td>35     Deg</td>
</tr>
<tr>
<td>Pulley Height (h)</td>
<td>3.8    in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>381.3  plw</td>
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<tr>
<td>Maximum Tension</td>
<td>466.4  plw</td>
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<tr>
<td>Maximum Percent</td>
<td>70.7   %</td>
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<td>Minimum Tension</td>
<td>266.7  plw</td>
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<tr>
<td>Minimum Percent</td>
<td>40.4   %</td>
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*Acceptable: Yes*
Tail Transition

Belt Tension vs Belt width

Length ..........(L) ..........65.0 in
Belt width ..........42 in
Trough angle ...........35 Deg
Pulley Height (h) ..........0.0 in
Running Tension ..........384.9 plw
Maximum Tension ..........636.6 plw
Maximum Percent ..........96.4 %
Minimum Tension ..........302.0 plw
Minimum Percent ..........45.8 %
Acceptable ..........Yes

Head Transition

Belt Tension vs Belt width

Length ..........(L) ..........32.0 in
Belt width ..........42 in
Trough angle ...........35 Deg
Pulley Height (h) ..........3.8 in
Running Tension ..........381.3 plw
Maximum Tension ..........528.1 plw
Maximum Percent ..........80.0 %
Minimum Tension ..........183.7 plw
Minimum Percent ..........27.8 %
Acceptable ..........Yes
### Tail Transition

**Belt Tension vs Belt width**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Length</td>
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<tr>
<td>Belt width</td>
<td>42 in</td>
</tr>
<tr>
<td>Trough angle</td>
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<tr>
<td>Pulley Height (h)</td>
<td>0.0 in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>384.9 piw</td>
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<tr>
<td>Maximum Tension</td>
<td>737.0 piw</td>
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<tr>
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<td>Minimum Tension</td>
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<td>Minimum Percent</td>
<td>40.8 %</td>
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<td>Acceptable</td>
<td>Yes</td>
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### Head Transition

**Belt Tension vs Belt width**

<table>
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<th>Parameter</th>
<th>Value</th>
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<tbody>
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<td>Length</td>
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<tr>
<td>Belt width</td>
<td>42 in</td>
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<tr>
<td>Trough angle</td>
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<tr>
<td>Pulley Height (h)</td>
<td>3.8 in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>381.3 piw</td>
</tr>
<tr>
<td>Maximum Tension</td>
<td>692.9 piw</td>
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<td>Maximum Percent</td>
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<tr>
<td>Minimum Tension</td>
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<td>Minimum Percent</td>
<td>-5.6 %</td>
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<td>Acceptable</td>
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### Tail Transition

**Belt Tension vs Belt width**

<table>
<thead>
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<th>Length (L)</th>
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<tr>
<td>Belt width</td>
<td>42     in</td>
</tr>
<tr>
<td>Trough angle</td>
<td>35 Deg</td>
</tr>
<tr>
<td>Pulley Height (h)</td>
<td>0.0    in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>384.9  piw</td>
</tr>
<tr>
<td>Maximum Tension</td>
<td>912.5  piw</td>
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<tr>
<td>Maximum Percent</td>
<td>138.3  %</td>
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<tr>
<td>Minimum Tension</td>
<td>211.5  piw</td>
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<tr>
<td>Minimum Percent</td>
<td>32.0   %</td>
</tr>
<tr>
<td>Acceptable</td>
<td>No</td>
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### Head Transition

**Belt Tension vs Belt width**

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<th>Length (L)</th>
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<tbody>
<tr>
<td>Belt width</td>
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<tr>
<td>Trough angle</td>
<td>35 Deg</td>
</tr>
<tr>
<td>Pulley Height (h)</td>
<td>3.8    in</td>
</tr>
<tr>
<td>Running Tension</td>
<td>381.3  piw</td>
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<tr>
<td>Maximum Tension</td>
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<tr>
<td>Maximum Percent</td>
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<tr>
<td>Minimum Tension</td>
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<tr>
<td>Minimum Percent</td>
<td>-156.4 %</td>
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<tr>
<td>Acceptable</td>
<td>No</td>
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Conveyor Belt Splices

Mechanical & Vulcanized
Conveyor Belt Splices

• The Mechanical Splice is a common jointing method for low to mid tension types of fabric belts.

• The Hot Vulcanized Splice is the type in general use for mid & high tension heavy duty fabric belts and all steel cable belts.

• Any of these methods use materials that have to be tested to perfectly match the belt type for optimum splice service life. Expert and meticulous workmanship is necessary to ensure splice strength and life when using any of these methods.
Mechanical Splice Introduction

• Mechanical Belt Fasteners (MBF’s) offer economical, reliable and long lasting belt splices.
• The majority of fabric belts manufactured today are compatible with and designed for MBF’s.
• Advances in design of the fasteners and in the application and belt preparation tools have increased the performance of mechanical splices in many heavy duty belting applications.
MECHANICAL FASTENER SELECTION

• Know the physical demands on the fastener and the environment in which it must operate.

• Determine maximum operating tension, minimum pulley size, speed of belt, type and thickness of belting, maximum temperature, presence of corrosives, type of belt cleaners, use of metal detectors, concerns about sparking, need for hinged or non-hinged joint, etc.
Fastener Selection

• Measure belt thickness.
• If countersinking fasteners, measure after skiving.
• Textured surfaces should be removed before measuring.
• Extreme wear in the splice area must be measured.
Fastener Selection

- Measure the diameter of the smallest pulley in your drive.
- Only consider pulleys over which the belt makes a 90° wrap.
- For tail or take-up wing type pulleys add 25% to the pulley diameter.
Hinged or Solid Plate?

- Use solid plate whenever possible.
- Prevents sifting of fines and liquids, reducing clean-up.
- No moving parts provides a longer splice life.
Hinged or Solid Plate?

• Hinged fasteners are preferred on portable conveyors and on conveyors with smaller pulley diameters.
• Use hinged fasteners when belts need to be installed in tight spaces.
Fastener Selection

• Match fastener material to operating environment.

• Special fastener materials are available for many types of applications.
  – Wet
  – Corrosive
  – Heat over 250°F (121°C)
  – Food Industry
  – Non-Sparking
  – Non-magnetic
Vulcanized Splice Introduction

- Vulcanized belt splices provide a method of joining the ends of conveyor belts without interrupting the continuity of the belt.
- The underlying principle is to establish flexible adhesion between the components of the two belt ends being joined in the splice.
- The goal is to develop this flexible adhesion in the splice area equivalent or greater to that of the breaking strength of the fabric in the original belt.
TYPES OF VULCANIZED SPLICES

• STEPPED SPLICE
• FINGER SPLICE
• STEEL CABLE BELT SPLICE
STEPPED SPLICE

BEVELED CUT COVER
SEAMS APPROX. 45°

TIE GUM
TIE GUM

TOP COVER GUM
REINFORCING FABRIC OR BREAKER
TIE GUM

CEMENT
SOLVENT

BOTTOM COVER GUM
REINFORCING FABRIC OR BREAKER
TIE GUM
FINGER SPLICE

Lay out the splice so that no two seams occur at the same longitudinal location.

Illustration shows cut edge, but aramid belts always have rubber edges.
STEEL CABLE BELT SPLICE

OVERLAP SPLICE

DIRECTION OF BELT TRAVEL

REFERENCE LINES

SPLICE ANGLE

BOTTOM COVER SEAM

TOP COVER SEAM

BUTT - OVERLAP SPLICE

DIRECTION OF BELT TRAVEL

OTHER CABLE PATTERNS COMMONLY USED INVOLVE A GREATER PROPORTION OF BUTTED CABLES WHERE CABLE SPACING IS RELATIVELY CLOSE.

CABLE RUBBER STRIPS BETWEEN CABLES

COVER RUBBER
Fabric Belt Splice Construction

• Fabric belt splice’s use two basic designs to prevent any buckling stress on the joint, that could force it open.
  
  • Bias Step Splice
  
  • Finger Splice
Fabric Belt Step Splices

• The Bias Step Splice eliminates one ply from the transmission of tensile forces in the splice area.
• The lower the number of plies in the belt the greater the loss of strength as a percentage of the overall belt strength.
3 Ply Belt Splice - Side View

• A 3-ply belt using a 2-step splice and has a decrease in break strength of 33%.
• A 2 ply belt would have a 50% loss.
Rubber to Fabric Adhesion

- In the conveyor belt industry stringent requirements are set for the bond between the skim rubber and the load carriers (plies).

40 lbs (18 kg) T-peel adhesion per inch of width gives more than 700 lbs (300 kg) of shearing force per square inch.
• A splice should only be as long as to reach its maximum static efficiency of the nominal belt strength.
• Each inch the splice length gets longer, the unloaded length of the splice step increases.
• Each inch the unloaded length of the splice increases, the greater chance of shorting the lifetime of the splice.
Splicing Theory (Perceived)

- Rubber
- Textile

States:
- Unloaded
- Loaded
Splicing Theory (Real)

Real relationship of the loaded splicing step

Loading in the splice step

Elongation

Loading of transfer rubber layer

Elongation
Splice Shear Value (288,000 lbs)

36” 3-ply 330 PIW Belt

8” Step

8” Step

576 sq inches in PT

300 lbs per sq in of shear

700 lbs per sq in of shear
Splice Curing

When curing Splices they should be cured in one heat. Many failures are from the multi curing process.
Finger Splice

• Finger Splice is stronger since there is no removal of any of the plies as you would in a step splice. All plies are in power transmission.
• Dynamic fatigue improvement with more than ten times better flex life than a step splice.
• The Finger Splice has proven to be a solution for problem and high tension belts.
Finger Splice

Direction of Belt Travel

Center Line

Direction of Travel
The vulcanizer platens should be 6 to 8 inches longer than the splice length (each end) to prevent this buckling.

A vulcanizer with even surface pressure (100 PSI) and flexible platens should be used for splicing.
Steel Cord Belt Splice

- Steel cord belting is most commonly used on long conveyors because of its very low permanent stretch and low elastic elongation.
- Steel Cord Belt Splices are much like the Finger Splice in the assembly process. They are well known for long life when done correctly.
Steel Cord Splice Assembly

- Cover Stock
- Cable Gum
- Noodle
Steel Cord splices require a Vulcanizer capable of 200 psi curing pressure and sized to cure the splice in one heat. The platen should extend past the splice at each end 8-10".
Questions?