Conveyors

Department of Mining, Dressing and Transport Machines AGH

Belt Conveyors for Bulk Materials
Calculations by CEMA 5\textsuperscript{th} Edition

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consultations: Mondays 11.00 - 12.00
Nomenclature of components of a typical belt conveyor

- Feed chute
- Loading skirts
- Troughed conveyor belt
- Tail pulley
- Closely spaced idlers at loading point*
- Troughing carrying idlers**
- Return idlers**
- Head pulley and drive
- Discharge chute
- Vertical gravity take-up

*Impact idlers, if required
**Training idlers, as required
**TYPICAL BELT CONVEYOR TRAVEL PATHS**

Figure 2.2 Horizontal belt.

Figure 2.3 Horizontal and ascending path, when space will permit vertical curve and belt strength will permit one belt.

Figure 2.4 Ascending and horizontal path, when belt tensions will permit one belt and space will permit vertical curve.

Figure 2.5 Possible horizontal and ascending path, when space will not permit a vertical curve or when the conveyor belt strength requires two belts.

Figure 2.6 Ascending and horizontal path, when advisable to use two conveyor belts.

Figure 2.7 Possible horizontal and ascending path, when space will not permit vertical curve but belt strength will permit only one belt.

Figure 2.8 Compound path with declines, horizontal portions, vertical curves, and incline.

Figure 2.9 Loading can be accomplished, as shown, on minor inclines or declines.
Design Considerations

- Characteristics and Conveyability of Bulk Materials
- Capacities, Belt Widths, and Speeds
- Belt Conveyor Idlers
- Belt Tension, Power, and Drive Engineering
- Belt Selection
- Pulleys and Shafts
- Vertical Curves
- Steep Angle Conveying
- Belt Takeups, Cleaners, and Accessories
- Conveyor Loading and Discharge
- Conveyor Motor Drives and Controls
- Operation, Maintenance, and Safety
Characteristics and Conveyability of Bulk Materials

- The **angle of repose** of a material is the acute angle which the surface of a normal, freely formed pile makes to the horizontal.

- 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. This angle usually is 5 degrees to 15 degrees less than the angle of repose, though in some materials it may be as much as 20 degrees less.
# Flowability—angle of surcharge—angle of repose

<table>
<thead>
<tr>
<th>Flow</th>
<th>Very free flowing 1*</th>
<th>Free flowing 2*</th>
<th>Average flowing 3*</th>
<th>Sluggish 4*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angle of Surcharge</strong></td>
<td>5°</td>
<td>10°</td>
<td>20°</td>
<td>25°</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="5° diagram" /></td>
<td><img src="image" alt="10° diagram" /></td>
<td><img src="image" alt="20° diagram" /></td>
<td><img src="image" alt="25° diagram" /></td>
</tr>
<tr>
<td><strong>Angle of Repose</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-19°</td>
<td>20-25°</td>
<td>30-34°</td>
<td>35-39°</td>
<td>40° - up</td>
</tr>
<tr>
<td><strong>Material Characteristics</strong></td>
<td>Uniform size, very small rounded particles, either very wet or very dry, such as dry silica sand, cement, wet concrete, etc.</td>
<td>Rounded, dry polished particles, of medium weight, such as whole grain and beans.</td>
<td>Irregular, granular or lumpy materials of medium weight, such as anthracite coal, cottonseed meal, clay, etc.</td>
<td>Typical common materials such as bituminous coal, stone, most ores, etc.</td>
</tr>
</tbody>
</table>
### Characteristics of Bulk Solid Materials - CEMA

<table>
<thead>
<tr>
<th>Material Characteristics</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td></td>
</tr>
<tr>
<td>Very fine—100 mesh and under</td>
<td>A</td>
</tr>
<tr>
<td>Fine—1/8 inch and under</td>
<td>B</td>
</tr>
<tr>
<td>Granular—Under 1/2 inch</td>
<td>C</td>
</tr>
<tr>
<td>Lumpy—containing lumps over 1/2' inch</td>
<td>D</td>
</tr>
<tr>
<td>Irregular—stringy, interlocking, mats together</td>
<td>E</td>
</tr>
<tr>
<td><strong>Flowability</strong></td>
<td></td>
</tr>
<tr>
<td>Very free flowing—angle of repose less than 19°</td>
<td>1</td>
</tr>
<tr>
<td>Free-flowing—angle of repose 20° to 29°</td>
<td>2</td>
</tr>
<tr>
<td>Average flowing—angle of repose 30° to 39°</td>
<td>3</td>
</tr>
<tr>
<td>Sluggish—angle of repose 40° and over</td>
<td>4</td>
</tr>
<tr>
<td><strong>Abrasiveness</strong></td>
<td></td>
</tr>
<tr>
<td>Nonabrasive</td>
<td>5</td>
</tr>
<tr>
<td>Abrasive</td>
<td>6</td>
</tr>
<tr>
<td>Very abrasive</td>
<td>7</td>
</tr>
<tr>
<td>Very sharp—cuts or gouges belt covers</td>
<td>8</td>
</tr>
<tr>
<td><strong>Miscellaneous Characteristics</strong> (Sometimes more than one of these characteristics may apply)</td>
<td></td>
</tr>
<tr>
<td>Very dusty</td>
<td>L</td>
</tr>
<tr>
<td>Aerates and develops fluid characteristics</td>
<td>M</td>
</tr>
<tr>
<td>Contains explosive dust</td>
<td>N</td>
</tr>
<tr>
<td>Contaminable, affecting use or saleability</td>
<td>P</td>
</tr>
<tr>
<td>Degradable, affecting use or saleability</td>
<td>0</td>
</tr>
<tr>
<td>Gives off harmful fumes or dust</td>
<td>R</td>
</tr>
<tr>
<td>Highly corrosive</td>
<td>S</td>
</tr>
<tr>
<td>Mildly corrosive</td>
<td>T</td>
</tr>
<tr>
<td>Hygroscopic</td>
<td>U</td>
</tr>
<tr>
<td>Interlocks or mats</td>
<td>V</td>
</tr>
<tr>
<td>Oils or chemical present—may affect rubber products</td>
<td>W</td>
</tr>
<tr>
<td>Packs under pressure</td>
<td>X</td>
</tr>
<tr>
<td>Very light and fluffy—may be wind-swept</td>
<td>Y</td>
</tr>
<tr>
<td>Elevated temperature</td>
<td>Z</td>
</tr>
</tbody>
</table>

Example: A very fine material that is free-flowing, abrasive, and contains explosive dust would be designated: **Class A26N.**
<table>
<thead>
<tr>
<th>Material</th>
<th>Average weight (lbs/cu ft)</th>
<th>Angle of repose (degrees)</th>
<th>Recommended maximum inclination (degrees)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashes, fly</td>
<td>40-45</td>
<td>42</td>
<td>20-25</td>
<td>A37</td>
</tr>
<tr>
<td>Cement, Portland</td>
<td>72-99</td>
<td>30-44</td>
<td>20-23</td>
<td>A36M</td>
</tr>
<tr>
<td>Coal, anthracite, river, or culm, ⅛ inch and under</td>
<td>60</td>
<td>35</td>
<td>18</td>
<td>B35TY</td>
</tr>
<tr>
<td>Coal, lignite</td>
<td>40-45</td>
<td>38</td>
<td>22</td>
<td>D36T</td>
</tr>
<tr>
<td>Copper ore</td>
<td>120-150</td>
<td>30-44</td>
<td>20</td>
<td>*D37</td>
</tr>
<tr>
<td>Dolomite, lumpy</td>
<td>80-100</td>
<td>30-44</td>
<td>22</td>
<td>D36</td>
</tr>
<tr>
<td>Gravel, dry, sharp</td>
<td>90-100</td>
<td>30-44</td>
<td>15-17</td>
<td>D37</td>
</tr>
<tr>
<td>Lignite, air-dried</td>
<td>45-55</td>
<td>30-44</td>
<td>*D35</td>
<td></td>
</tr>
<tr>
<td>Rock, soft, excavated with shovel</td>
<td>100-110</td>
<td>30-44</td>
<td>22</td>
<td>D36</td>
</tr>
<tr>
<td>Salt, common dry, fine</td>
<td>70-80</td>
<td>25</td>
<td>11</td>
<td>D26TUW</td>
</tr>
<tr>
<td>Sandstone, broken</td>
<td>85-90</td>
<td>30-44</td>
<td>D37</td>
<td></td>
</tr>
<tr>
<td>Wood chips</td>
<td>10-30</td>
<td>45</td>
<td>27</td>
<td>E45WY</td>
</tr>
<tr>
<td>Coal, anthracite, river, or culm, 1/8 inch and under</td>
<td>60</td>
<td>35</td>
<td>18</td>
<td>B35TY</td>
</tr>
<tr>
<td>Coal, anthracite, sized</td>
<td>55-60</td>
<td>27</td>
<td>16</td>
<td>C26</td>
</tr>
<tr>
<td>Coal, bituminous, mined 50 mesh and under</td>
<td>50-54</td>
<td>45</td>
<td>24</td>
<td>B45T</td>
</tr>
<tr>
<td>Coal, bituminous, mined and sized</td>
<td>45-55</td>
<td>35</td>
<td>16</td>
<td>D35T</td>
</tr>
<tr>
<td>Coal, bituminous, mined, run of mine</td>
<td>45-55</td>
<td>38</td>
<td>18</td>
<td>D35T</td>
</tr>
<tr>
<td>*Coal, bituminous, mined, slack, 1/2 inch and under</td>
<td>43-50</td>
<td>40</td>
<td>22</td>
<td>C35T</td>
</tr>
<tr>
<td>Coal, bituminous, stripping, not cleaned</td>
<td>50-60</td>
<td>40</td>
<td>22</td>
<td>D36T</td>
</tr>
<tr>
<td>Coal, lignite</td>
<td>40-45</td>
<td>38</td>
<td>22</td>
<td>D36T</td>
</tr>
</tbody>
</table>
Belt Widths

- The belt widths are as follows: 18, 24, 30, 36, 42, 48, 54, 60, 72, 84, and 96 inches.

- The width of the narrower belts may be governed by the size of lumps to be handled. Belts must be wide enough so that any combination of prevailing lumps and finer material does not load the lumps too close to the edge of the conveyor belt.

Figure 4.1 Belt width necessary for a given lump size. Fines: no greater than 1/10 maximum lump size.
## Recommended maximum belt speeds

<table>
<thead>
<tr>
<th>Material Being Conveyed</th>
<th>Belt Speeds (fpm)</th>
<th>Belt Width (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain or other free-flowing, nonabrasive material</td>
<td>500</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>24-30</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>36-42</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>48-96</td>
</tr>
<tr>
<td>Coal, damp clay, soft ores, overburden and earth, fine-crushed stone</td>
<td>400</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>24-36</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>42-60</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>72-95</td>
</tr>
<tr>
<td>Heavy, hard, sharp-edged ore, coarse-crushed stone</td>
<td>350</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>24-36</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>Over 36</td>
</tr>
<tr>
<td>Foundry sand, prepared or damp; shake-out sand with small cores, with or without small castings (not hot enough to harm belting)</td>
<td>350</td>
<td>Any width</td>
</tr>
<tr>
<td>Prepared foundry sand and similar damp (or dry abrasive) materials discharged from belt by rubber-edged plows</td>
<td>200</td>
<td>Any width</td>
</tr>
<tr>
<td>Nonabrasive materials discharged from belt by means of plows</td>
<td>200, except for wood pulp, where 300 to 400 is preferable</td>
<td>Any width</td>
</tr>
<tr>
<td>Feeder belts, flat or troughed, for feeding fine, nonabrasive, or mildly abrasive materials from hoppers and bins</td>
<td>50 to 100</td>
<td>Any width</td>
</tr>
</tbody>
</table>

1 m/s = 196.85 ft/min  
1 ft = 0.3048 m
Example: Belt Conveyor Parameters

- Coal, anthracite, sized
- Capacity: 1000 tph
- Length: 1000 m → 3300 feet
- Lift: 115 feet

- Belt speed: 600 fpm
- Belt width: 42 inches
Area of load cross section

\[ \alpha = \text{angle of surcharge, degrees} \]
\[ \beta = \text{angle of idler roll, degrees} \]
\[ A_s = \text{area of surcharge, square inches} \]
\[ A_b = \text{base trapezoidal area, square inches} \]
\[ l = \text{length, one edge of trapezoidal area, inches} \]
\[ l_1 = \text{length, other edge of trapezoidal area, inches} \]
\[ j = \text{height of trapezoidal area, inches} \]
\[ m = \text{slant length trapezoid, inches} \]
\[ r = \text{radius of surcharge arc, inches} \]
\[ f = \text{horizontal projection of slant side of trapezoid, inches} \]
\[ c = \text{edge distance, edge of material to edge of belt, inches} \]
\[ b = \text{width of belt, inches} \]

Standard edge distance \[ c = 0.055b + 0.9, \text{ inches} \]
Belt Conveyor Capacity Table

1. Determine the surcharge angle of the material.
   - The surcharge angle, on the average, will be 5 degrees to 15 degrees less than the angle of repose.
     
     \( \text{ex. } 27^\circ - 12^\circ = 15^\circ \) 

2. Determine the density of the material in pounds per cubic foot (lb/ft\(^3\)).

3. Choose the idler shape.

4. Select a suitable conveyor belt speed.

5. Convert the desired tonnage per hour (tph) to be conveyed to the equivalent in cubic feet per hour (ft\(^3\)/hr).
   \[ \text{ft}^3/\text{hr} = \frac{\text{tph} \times 2000}{\text{material density}} \]
   
   \( \text{ex. } 1000 \text{ tph} \times 2000 \div 60 = 33333 \text{ ft}^3/\text{hr} \)

6. Convert the desired capacity in cubic feet per hour to the equivalent capacity at a belt speed of 100 fpm.
   \[
   \text{Capacity (equivalent)} = (\text{ft}^3/\text{hr}) \times \left(\frac{100}{\text{actual belt speed (fpm)}}\right)
   \]
   
   \( \text{ex. } \text{Capacity (equiv)} = 33333 \times (100 / 600 \text{ fpm}) = 5555 \text{ ft}^3/\text{hr} \)

7. Find the appropriate belt width

8. Selected belt speed may require revision
### Belt Conveyor Capacity Table

Table 4-3. 35-degree troughed belt—three equal rolls standard edge distance = 0.055b + 0.9 inch.

<table>
<thead>
<tr>
<th>Belt Width (Inches)</th>
<th>( A_t ) - Cross Section of Load (ft(^2))</th>
<th>Capacity at 100 FPM (ft(^3)/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surcharge Angle</td>
<td>0°</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>.144</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>.278</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>.455</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>.676</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>.940</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>1.248</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>1.599</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>1.994</td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>2.913</td>
</tr>
<tr>
<td>96</td>
<td></td>
<td>5.274</td>
</tr>
</tbody>
</table>

1 lb = 0.4536 kg
1 ft\(^3\) = 0.028 m\(^3\)
1 ft\(^2\) = 0.093 m\(^2\)
# Idler Spacing

Factors to consider when selecting idler spacing are **belt weight**, **material weight**, **idler load rating**, **belt sag**, **idler life**, **belt rating**, **belt tension**, and **radius in vertical curves**

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Troughing Idler Spacing</th>
<th>Weight of Material Handled, lbs/cu ft</th>
<th>Return Idlers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>18</td>
<td>5.5</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>24</td>
<td>5.0</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>30</td>
<td>5.0</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>36</td>
<td>5.0</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>42</td>
<td>4.5</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>48</td>
<td>4.5</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>54</td>
<td>4.5</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>60</td>
<td>4.0</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>72</td>
<td>4.0</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>84</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td>96</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* Spacing indicated in feet. Spacing may be limited by load rating of idler. See idler load ratings in Tables 5-7—5-11.
Example: Belt Conveyor Parameters

- Belt speed: 600 fpm
- Belt width: 42 inches
- Trough Angle: 35°
- \( \frac{5555 \text{ [ft}^3\text{/hr}]}{7524 \text{ [ft}^3\text{/hr}]} = 74\% \)
- Idler spacing: 4.5 feet
The Selection of Idlers

Idler life is determined by a combination of many factors, such as seals, bearings, shell thickness, belt speed, lump size/material density, maintenance, environment, temperature, and the proper CEMA series of idler to handle the maximum calculated idler load.

Table 5-1. Idler classification.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Former Series Number</th>
<th>Roll Diameter (inches)</th>
<th>Belt Width (inches)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>II</td>
<td>4&quot;</td>
<td>18&quot; through 48&quot;</td>
<td>Light Duty</td>
</tr>
<tr>
<td>B5</td>
<td>II</td>
<td>5&quot;</td>
<td>18&quot; through 48&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>C4</td>
<td>III</td>
<td>4&quot;</td>
<td>18&quot; through 60&quot;</td>
<td>Medium Duty</td>
</tr>
<tr>
<td>C5</td>
<td>III</td>
<td>5&quot;</td>
<td>18&quot; through 60&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>C6</td>
<td>IV</td>
<td>6&quot;</td>
<td>24&quot; through 60&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>D5</td>
<td>None</td>
<td>5&quot;</td>
<td>24&quot; through 72&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>D6</td>
<td>None</td>
<td>6&quot;</td>
<td>24&quot; through 72&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>E6</td>
<td>V</td>
<td>6&quot;</td>
<td>36&quot; through 96&quot;</td>
<td>Heavy Duty</td>
</tr>
<tr>
<td>E7</td>
<td>VI</td>
<td>7&quot;</td>
<td>36&quot; through 96&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

CEMA B load rating based on minimum $L_{10}$ of 30,000 hours at 500 rpm
CEMA C load rating based on minimum $L_{10}$ of 30,000 hours at 500 rpm
CEMA D load rating based on minimum $L_{10}$ of 60,000 hours at 500 rpm
CEMA E load rating based on minimum $L_{10}$ of 60,000 hours at 500 rpm
Step No. 1 Troughing Idler Series Selection

Calculated Idler Load (lbs) = \( CIL = ((WB + (WM \times K1)) \times SI) + IML \)

Where:

- \( WB \) = Belt weight (lbs/ft) use actual or estimate from Table 5-5
- \( WM \) = Material weight (lbs/ft) = \( \frac{Q \times 2000}{(60 \times Vee)} \)
- \( Q \) = Quantity of material conveyed (tons per hour)
- \( Vee \) = Design belt speed (fpm)
- \( SI \) = Spacing of idlers (ft)
- \( KI \) = Lump adjustment factor (see Table 5-6)
- \( IML \) = Idler misalignment load (lbs) due to idler height deviation and belt tension = \( \frac{D \times T}{(6 \times SI)} \)

Where:

- \( D \) = Misalignment (in.)
- \( T \) = Belt tension (lbs)
- \( SI \) = Idler spacing (ft)
Step No. 1 Troughing Idler Series Selection

- \( WB = \text{Belt weight (lbs/ft)} \)

### Table 5-5. WB-Estimated average belt weight, multiple- and reduced-ply belts, lbs/ft.

<table>
<thead>
<tr>
<th>Belt Width (inches ( b ))</th>
<th>Material Carried, lbs/cu ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30-74</td>
</tr>
<tr>
<td>18</td>
<td>3.5</td>
</tr>
<tr>
<td>24</td>
<td>4.5</td>
</tr>
<tr>
<td>30</td>
<td>6.0</td>
</tr>
<tr>
<td>36</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>42</strong></td>
<td><strong>11.0</strong></td>
</tr>
<tr>
<td>48</td>
<td>14.0</td>
</tr>
<tr>
<td>54</td>
<td>16.0</td>
</tr>
<tr>
<td>60</td>
<td>18.0</td>
</tr>
<tr>
<td>72</td>
<td>21.0</td>
</tr>
<tr>
<td>84</td>
<td>25.0</td>
</tr>
<tr>
<td>96</td>
<td>30.0</td>
</tr>
</tbody>
</table>

1. Steel cable belts increase the above value by 50%.
Step No. 1 Troughing Idler Series Selection

- \( K_l = \text{Lump adjustment factor} \)

<table>
<thead>
<tr>
<th>Maximum Lump Size (inches)</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
<th>150</th>
<th>175</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>8</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>12</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>14</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>16</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>18</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Idler Series Selection

Calculated Idler Load (lbs) = \( CIL = (11 + (55 \times 1.0)) \times 4.5 + 0 = 297 \text{ lbs} \)

Where:
- \( WB = 11 \text{ lbs/ft} \)
- \( WM = \frac{1000 \times 2000}{60 \times 600} = 55 \text{ lbs/ft} \)
- \( Q = 1000 \text{ tons per hour} \)
- \( Vee = 600 \text{ fpm} \)
- \( SI = 4.5 \text{ ft} \)
- \( Kl = 1.0 \)
- \( IML = 0 \)

Calculated Return Idler Load (lbs) = \( CILR = (11 \times 10) + 0 = 110 \text{ lbs} \)

- \( SI = 10.0 \text{ ft} \)
### Load ratings for CEMA idlers, lbs

Notes:
1. Troughing idler load ratings (Tables 5.7–5.10) are for three equal length rolls.
2. Load ratings also apply for impact rolls.
3. Troughing idler load ratings are based on a load distribution of 70% on center roll and 15% on each end roll for all trough angles.
4. Unequal length rolls or picking idlers are not covered by this standard.

#### Table 5-7. Load ratings for CEMA B idlers, lbs (rigid frame).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th>20°</th>
<th>35°</th>
<th>45°</th>
<th>Single Roll Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td></td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>220</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>190</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>165</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>410</td>
<td>410</td>
<td>396</td>
<td>155</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>390</td>
<td>363</td>
<td>351</td>
<td>140</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>380</td>
<td>353</td>
<td>342</td>
<td>130</td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 30,000 hours at 500 rpm.

#### Table 5-8. Load ratings for CEMA C idlers, lbs (rigid frame).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th>20°</th>
<th>35°</th>
<th>45°</th>
<th>Single Roll Return</th>
<th>Two Roll “Vee” Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td></td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>475</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>325</td>
<td>500</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>900</td>
<td>900</td>
<td>900</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>900</td>
<td>837</td>
<td>810</td>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>850</td>
<td>791</td>
<td>765</td>
<td>150</td>
<td>500</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>800</td>
<td>744</td>
<td>720</td>
<td>125</td>
<td>500</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>750</td>
<td>698</td>
<td>675</td>
<td>*</td>
<td>500</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>700</td>
<td>650</td>
<td>630</td>
<td>*</td>
<td>500</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td>700</td>
<td>650</td>
<td>630</td>
<td>*</td>
<td>500</td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 30,000 hours at 500 rpm.

*Use CEMA D return idler

#### Table 5-9. Load ratings for CEMA D idlers, lbs (rigid frame).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th>20°</th>
<th>35°</th>
<th>45°</th>
<th>Single Roll Return</th>
<th>Two Roll “Vee” Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td></td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>600</td>
<td>850</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>600</td>
<td>850</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>600</td>
<td>850</td>
</tr>
<tr>
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<td></td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>425</td>
<td>850</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>1200</td>
<td>1116</td>
<td>1080</td>
<td>375</td>
<td>850</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>1150</td>
<td>1070</td>
<td>1035</td>
<td>280</td>
<td>850</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td>1200</td>
<td>1116</td>
<td>1080</td>
<td>215</td>
<td>850</td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>1050</td>
<td>977</td>
<td>945</td>
<td>155</td>
<td>850</td>
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<tr>
<td>78</td>
<td></td>
<td>800</td>
<td>744</td>
<td>720</td>
<td>125</td>
<td>850</td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 60,000 hours at 500 rpm.

#### Table 5-10. Load ratings for CEMA E idlers, lbs (rigid frame and catenary where applicable).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th>20°</th>
<th>35°</th>
<th>45°</th>
<th>Single Roll Return</th>
<th>Two Roll “Vee” Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
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<tr>
<td>66</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>700</td>
<td>1300</td>
</tr>
<tr>
<td>78</td>
<td></td>
<td>1800</td>
<td>1800</td>
<td>1800</td>
<td>625</td>
<td>1300</td>
</tr>
<tr>
<td>84</td>
<td></td>
<td>1800</td>
<td>1674</td>
<td>1620</td>
<td>550</td>
<td>1300</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>1800</td>
<td>1674</td>
<td>1620</td>
<td>475</td>
<td>1300</td>
</tr>
<tr>
<td>96</td>
<td></td>
<td>1750</td>
<td>1628</td>
<td>1575</td>
<td>400</td>
<td>1300</td>
</tr>
<tr>
<td>102</td>
<td></td>
<td>1750</td>
<td>1628</td>
<td>1575</td>
<td>250</td>
<td>1300</td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 60,000 hours at 500 rpm.
K2 = Effect of load on predicted bearing L10 life

Table 5-7. Load ratings for CEMA B idlers, lbs (rigid frame).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°</td>
<td>35°</td>
<td>45°</td>
<td>Single Roll Return</td>
</tr>
<tr>
<td>18</td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>220</td>
</tr>
<tr>
<td>24</td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>190</td>
</tr>
<tr>
<td>30</td>
<td>410</td>
<td>410</td>
<td>410</td>
<td>165</td>
</tr>
<tr>
<td>36</td>
<td>410</td>
<td>410</td>
<td>396</td>
<td>155</td>
</tr>
<tr>
<td>42</td>
<td>390</td>
<td>363</td>
<td>351</td>
<td>140</td>
</tr>
<tr>
<td>48</td>
<td>380</td>
<td>353</td>
<td>342</td>
<td>130</td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 30,000 hours at 500 rpm.

$L_{10}$ (CORRECTED) = $L_{10}$ (RATING) $\times$ K2 $\times$ K3A $\times$ K3B (IF APPLICABLE)

![Graph showing K2 factor against CIL (Calculated Idler Load) to Idler Load Rating]

$\frac{297}{363} = 0.82 \rightarrow K2 = 2.0$

Bearing $L10 = (30,000 \times 2.0) = 60,000$ hours
K3A = Effect of belt speed on predicted bearing L10 life

\[
\text{rpm} = \frac{\text{Belt Speed (fpm)} \times 12}{\text{Roll Diameter (in)} \times \pi}
\]

= \frac{600 \times 12}{4 \times 3.14} = 573 \text{ rpm} \Rightarrow K3A = 0.9

K3B = Effect of roll diameter on predicted bearing L10 life

Bearing L10 = (60,000 \times 0.9 \times 1.0) = 54,000 \text{ hours}

4 inches \Rightarrow K3B = 1.0
**K4 = Environmental, maintenance, and other special conditions**

- **K4A** = Effect of maintenance on potential idler life.
  
  *FAIR → K4A = 0.5*

- **K4B** = Effect of environmental conditions on potential idler life.
  
  *Dusty, Wet → K4B = 0.6*

  
  \[
  \text{1 deg } F = 0.5556 \text{ C} \\
  \text{C} = \frac{5}{9} (F - 32) \\
  \text{F} = \frac{9}{5} \times \text{C} + 32
  \]

  - **K4C** = Effect of operating temperature on potential idler life.
  
  \[
  9/5 \times 26°C + 32 = 79°F \rightarrow K4C = 1.0
  \]

  \[\text{Bearing L10} = (54,000 \times 0.5 \times 0.6 \times 1.0) = 16,200 \text{ hours}\]
CEMA C Idlers

Table 5-8. Load ratings for CEMA C idlers, lbs (rigid frame).

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>Trough Angle</th>
<th>Single Roll Return</th>
<th>Two Roll “Vee” Return</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°</td>
<td>35°</td>
<td>45°</td>
</tr>
<tr>
<td>18</td>
<td>900</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>24</td>
<td>900</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>30</td>
<td>900</td>
<td>900</td>
<td>837</td>
</tr>
<tr>
<td>36</td>
<td>900</td>
<td>900</td>
<td>810</td>
</tr>
<tr>
<td><strong>42</strong></td>
<td><strong>850</strong></td>
<td><strong>791</strong></td>
<td><strong>765</strong></td>
</tr>
<tr>
<td><strong>48</strong></td>
<td><strong>800</strong></td>
<td><strong>744</strong></td>
<td><strong>720</strong></td>
</tr>
<tr>
<td>54</td>
<td>750</td>
<td>698</td>
<td>675</td>
</tr>
<tr>
<td>60</td>
<td>700</td>
<td>650</td>
<td>630</td>
</tr>
<tr>
<td>66</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Ratings based on minimum $L_{10}$ of 30,000 hours at 500 rpm.

*B Use CFMA D return idler

\[
= \frac{297}{791} = 0.4 \rightarrow K_2 = 10.0
\]

*Bearing $L_{10} = (30,000 \times 10.0 \times 0.9 \times 0.5 \times 0.6) = 81,000$ hours
### Table 5-11. Average weight (lbs) of troughing idler rotating parts—steel rolls.

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>CEMA Idler Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B4</td>
</tr>
<tr>
<td>18</td>
<td>15.0</td>
</tr>
<tr>
<td>24</td>
<td>18.3</td>
</tr>
<tr>
<td>30</td>
<td>21.8</td>
</tr>
<tr>
<td>36</td>
<td>25.3</td>
</tr>
<tr>
<td>42</td>
<td>30.8</td>
</tr>
<tr>
<td>48</td>
<td>32.9</td>
</tr>
<tr>
<td>54</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5-12. Average weight (lbs) of return idler rotating parts—steel rolls.

<table>
<thead>
<tr>
<th>Belt Width (inches)</th>
<th>CEMA Idler Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B4</td>
</tr>
<tr>
<td>18</td>
<td>13.1</td>
</tr>
<tr>
<td>24</td>
<td>16.3</td>
</tr>
<tr>
<td>30</td>
<td>19.5</td>
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<tr>
<td>36</td>
<td>22.7</td>
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<tr>
<td>42</td>
<td>26.0</td>
</tr>
<tr>
<td>48</td>
<td>27.4</td>
</tr>
<tr>
<td>54</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>
Basic Power Requirements

- The horsepower, \( hp \), required at the drive of a belt conveyor, is derived from the pounds of the effective tension, \( T_e \), required at the drive pulley to propel or restrain the loaded conveyor at the design velocity of the belt \( V \), in fpm:

\[
hp = \frac{T_e \times V}{33,000}
\]

- \( T_e \) is the final summarization of the belt tensions produced by forces such as:
  1. The gravitational load to lift or lower the material being transported.
  2. The frictional resistance of the conveyor components, drive, and all accessories while operating at design capacity.
  3. The frictional resistance of the material as it is being conveyed.
  4. The force required to accelerate the material continuously as it is fed onto the conveyor by a chute or a feeder.
Effective tension, $T_e$

$$T_e = L K_t (K_x + K_y W_b + 0.015 W_b) + W_m (L K_y \pm H) + T_p + T_{am} + T_{ac}$$

Where:

- $L$ = length of conveyor, ft
- $K_t$ = ambient temperature correction factor
- $K_x$ = factor used to calculate the frictional resistance of the idlers and the sliding resistance between the belt and idler rolls, lbs per ft
- $K_y$ = carrying run factor used to calculate the combination of the resistance of the belt and the resistance of the load to flexure as the belt and load move over the idlers. For return run use constant 0.015.
- $W_b$ = weight of belt in pounds per foot of belt length.
- $W_m = \text{weight of material, lbs per foot of belt length}$
- $H$ = vertical distance that material is lifted or lowered, ft
- $T_p$ = tension resulting from resistance of belt to flexure around pulleys and the resistance of pulleys to rotation on their bearings, total for all pulleys, lbs
- $T_{am} = \text{tension resulting from the force to accelerate the material continuously as it is fed onto the belts, lbs}$
- $T_{ac} = \text{total of the tensions from conveyor accessories, lbs}$

$$W_m = \frac{Q \times 2,000}{60 \times V} = \frac{33.33 \times Q}{V}$$
$K_t$ — Ambient Temperature Correction Factor

79 °F $\rightarrow K_t = 1.0$
**Kₙ — Idler Friction Factor, lbs/ft**

- The frictional resistance of idler rolls to rotation and sliding resistance between the belt and the idler rolls.

- Values of $K_x$ can be calculated from the equation:

\[
K_x = 0.00068(W_b + W_m) + \frac{A_i}{S_i}, \text{ lbs tension per foot of belt length}
\]

\[
A_i = \begin{cases} 
1.5 & \text{for 6" diameter idler rolls, CEMA C6, D6} \\
1.8 & \text{for 5" diameter idler rolls, CEMA B5, C5, D5} \\
2.3 & \text{for 4" diameter idler rolls, CEMA B4, C4} \\
2.4 & \text{for 7" diameter idler rolls, CEMA E7} \\
2.8 & \text{for 6" diameter idler rolls, CEMA E6}
\end{cases}
\]

For regenerative declined conveyors, $A_i = 0$.

\[
W_b = 11 \text{ lbs/ft} \\
W_m = \frac{(1000 \times 2000)}{(60 \times 600)} = 55 \text{ lbs/ft} \\
S_i = 4.5 \text{ ft} \\
CEMA \ B4
\]

\[
K_x = 0.00068(11 + 55) + 2.3/4.5 = 0.0449 + 0.51 = 0.555 \text{ lbs/ft}
\]
**K_y — Factor for Calculating the Force of Belt and Load Flexure over the Idlers**

- Resistance of the belt to flexure as it moves over idlers
- Resistance of the load to flexure as it rides the belt over the idlers

Table 6-2 gives values of $K_y$ for carrying idlers as they vary with differences in the weight/ft of the conveyor belt, $W_b$; load, $W_m$; idler spacing, $S_i$; and the percent of slope or angle that the conveyor makes with the horizontal.

<table>
<thead>
<tr>
<th>Conveyor Length (ft)</th>
<th>$W_b + W_m$ (lbs/ft)</th>
<th>0</th>
<th>2</th>
<th>3.5</th>
<th>5</th>
<th>7</th>
<th>12</th>
<th>24</th>
<th>33</th>
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<tbody>
<tr>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>50</td>
<td>0.024</td>
<td>0.022</td>
<td>0.019</td>
<td>0.017</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>75</td>
<td>0.023</td>
<td>0.019</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>100</td>
<td>0.022</td>
<td>0.017</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>150</td>
<td>0.022</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>200</td>
<td>0.019</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>250</td>
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<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
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</tr>
<tr>
<td>300</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
<td>0.018</td>
</tr>
</tbody>
</table>

$W_b + W_m = 66$ lbs/ft  
$S_i = 4.5$ ft  
Length: 3300 feet  
Height: 115 feet  
Slope: 2 degrees

$K_y = 0.020$
<table>
<thead>
<tr>
<th>Conveyor Length (ft)</th>
<th>W_{g} + W_{m} (lbs/ft)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>24</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
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<td>0.035</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>150</td>
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<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
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<tr>
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<td>0.031</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
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<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
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<td>0.031</td>
</tr>
<tr>
<td></td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
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<td>0.035</td>
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<td>0.031</td>
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<td>0.031</td>
<td>0.031</td>
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<tr>
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<td>0.031</td>
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</tr>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
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<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
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</tr>
<tr>
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</tr>
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</tr>
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<td>0.031</td>
<td>0.031</td>
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<td>0.034</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
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<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
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<td>0.035</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
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<td>0.035</td>
<td>0.034</td>
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<td>0.031</td>
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<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
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<tr>
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<td>0.035</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
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<tr>
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<td>0.031</td>
<td>0.031</td>
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<tr>
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<td>0.034</td>
<td>0.034</td>
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<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
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<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>0.035</td>
<td>0.034</td>
<td>0.034</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Idler spacing: The above values of \( K_y \) are based on the following idler spacing (for other spacing, see Table 6-3).
Corrected factor $K_y$

Table 6-3. Corrected factor $K_y$ values when other than tabular carrying idler spacings are used.

<table>
<thead>
<tr>
<th>$W_{b} + W_{m}$ (lbs/ft)</th>
<th>$S_p$ (ft)</th>
<th>Reference Values of $K_y$ for Interpolation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.016</td>
<td>0.018</td>
</tr>
<tr>
<td>Less than 50</td>
<td>3.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0174</td>
</tr>
<tr>
<td>50 to 99</td>
<td>3.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>0.0175</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0184</td>
</tr>
<tr>
<td>100 to 140</td>
<td>3.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
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</tr>
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<td>0.0188</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0201</td>
</tr>
<tr>
<td>150 to 199</td>
<td>3.0</td>
<td>0.0160</td>
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<td>0.0172</td>
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</tr>
<tr>
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<td>4.5</td>
<td>0.0209</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0225</td>
</tr>
<tr>
<td>200 to 249</td>
<td>3.0</td>
<td>0.0160</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>0.0177</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>0.0192</td>
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<tr>
<td></td>
<td>4.5</td>
<td>0.0216</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.0227</td>
</tr>
</tbody>
</table>

→ $K_y = 0.0214$
After estimating the average belt tension and selecting an idler spacing, refer to Table 6-4 to obtain values for A and B for use in the following equation:

\[ W_b + W_m = 66 \text{ lbs/ft} \]

\[ S_i = 4.5 \text{ ft} \]

\[ K_y = 0.04036 \]

\[ K_y = 0.01261 \]
\( T_p = \) total of the belt tensions required to rotate each of the pulleys on the conveyor

Table 6-5. Belt tension to rotate pulleys.

<table>
<thead>
<tr>
<th>Location of Pulleys</th>
<th>Degrees Wrap of Belt</th>
<th>Pounds of Tension at Belt Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tight side</td>
<td>150° to 240°</td>
<td>200 lbs/pulley</td>
</tr>
<tr>
<td>Slack side</td>
<td>150° to 240°</td>
<td>150 lbs/pulley</td>
</tr>
<tr>
<td>All other pulleys</td>
<td>less than 150°</td>
<td>100 lbs/pulley</td>
</tr>
</tbody>
</table>

Note: Double the above values for pulley shafts that are not operating in antifriction bearings.

\( 2 \times 200 = 400 \text{ lbs} \\
3 \times 150 = 450 \text{ lbs} \\

\( T_p = 950 \text{ lbs} \)
Pulleys

1-2

Carrying Side of Belt

Tail Pulley

Head Pulley

Primary Drive Pulley

Secondary Drive Pulley

Wrap

T₁

T₂

T₃
$T_{am}$ — force to accelerate the material continuously as it is fed onto the belt

$$T_{am} = \frac{Q \times 2000}{3600 \times 32.2} \times \frac{V - V_0}{60}$$

Where:

- $Q =$ Capacity of loading point, tph
- $g =$ 32.2 ft/sec$^2$
- $V =$ design belt speed, fpm
- $V_0 =$ initial velocity of material as it is fed onto belt, fpm

$$T_{am} = 2.8755 \times 10^{-4} \times Q \times (V - V_0)$$
$$= 2.8755 \times 10^{-4} \times 1000 \times (600 - 0) = 172.53 \text{ lbs}$$

To use this chart:

Enter chart at belt velocity and read $T_{am}$ per 1,000 tph.

Again enter chart at material velocity in direction of belt travel and read $T_{am}$ per 1,000 tph. This may be positive, zero, or negative.

Subtract the second $T_{am}$ reading from the first $T_{am}$ reading and convert the difference from 1,000 tph to the value for the actual tonnage. This will be the $T_{am}$ desired, lbs.
**$T_{ac}$ — resistance generated by conveyor accessories**

Conveyor accessories such as trippers, stackers, plows, belt cleaning equipment, and skirtboards usually add to the effective tension, $T_e$

- $T_{tr}$ — from trippers and stackers
- $T_{pl}$ — from frictional resistance of plows
- $T_{bc}$ — from belt-cleaning devices
- $T_{sb}$ — from skirtboard friction

$T_{sb} = L_b (C_s h_s^2 + 6)$

$L_b = \text{skirtboard length, ft one skirtboard} = 10 \text{ ft}$

$h_s = \text{depth of the material touching the skirtboard, in} = 10 \text{ in}$

$T_{tr} = 0 \text{ lbs}$

$T_{pl} = 0 \text{ lbs}$

$T_{bc} = 0 \text{ lbs}$

$T_{sb} = 113.8 \text{ lbs}$
Resistance Calculations

\[ T_e \text{ equals the total of the following:} \]

\[ T_x \text{, idler friction} = L \times K_x \times K_t \]
\[ + Tyc \text{, belt flexure, carrying idlers} = L \times K_y \times W_b \times K_t \]
\[ + Tyr \text{, belt flexure, return idlers} = L \times 0.015 \times W_b \times K_t \]

Subtotal (A) \[ LK_t(K_x + K_yW_b + 0.015W_b) \]
\[ = 3300 \times 0.555 \times 1.0 = 1831.5 \text{ lbs} \]
\[ + Tyc \text{, belt flexure, carrying idlers} = 3300 \times 0.0214 \times 11 \times 1.0 = 776.8 \text{ lbs} \]
\[ + Tyr \text{, belt flexure, return idlers} = 3300 \times 0.015 \times 11 \times 1.0 = 544.5 \text{ lbs} \]

Subtotal (A) \[ 3152.8 \text{ lbs} \]

\[ + Tym \text{, material flexure} = L \times K_y \times W_m \]
\[ + T_m \text{, lift or lower} = H \times W_m \]

Subtotal (B) \[ W_m(LK_y \pm H) \]
\[ = 3300 \times 0.0214 \times 55.0 = 3884.1 \text{ lbs} \]
\[ + Tym \text{, material flexure} = 115 \times 55 = 6325 \text{ lbs} \]

Subtotal (B) \[ 10209.1 \text{ lbs} \]

\[ T_p \text{, pulley resistance} \]
\[ = 950 \text{ lbs} \]

\[ T_{am} \text{, accelerated material} \]
\[ = 172.5 \text{ lbs} \]

\[ T_{ac} \text{, accessories} = (T_{tr} + T_{pl} + T_{bc} + T_{sb}) \]
\[ = 113.8 \text{ lbs} \]

Subtotal (C) \[ 1236.3 \text{ lbs} \]

\[ Te = \Sigma \text{ Subtotals (A), (B), and (C)} \]
\[ = 14598.2 \text{ lbs} \]

CEMA Horsepower Formula
\[ hp = \frac{T_e \times V}{30,000} \]
\[ = 265.4 \text{ hp} \]

If drive efficiency = .94, horsepower at motor shaft = \[ \frac{265.4}{.94} = 282.3 \text{ hp.} \]
Wrap Factor, $C_w$

$T_e = T_1 - T_2$ = effective belt tension, lbs
$T_1$ = tight-side tension at pulley, lbs
$T_2$ = slack-side tension at pulley, lbs
$e$ = base of naperian logarithms = 2.718

$f$ = coefficient of friction between pulley surface and belt surface (0.25 rubber surfaced belt driving bare steel or cast iron pulley; 0.35 rubber surfaced belt driving rubber lagged pulley surface). Values apply to normal running calculations

$\theta$ = wrap of belt around the pulley, radians (one degree = 0.0174 radians)

$C_w$ = wrap factor

\[
\frac{T_2}{T_e} = \frac{1}{e^{f\theta} - 1}
\]

$C_w = 0.08$

<table>
<thead>
<tr>
<th>Type of Pulley Drive</th>
<th>$\theta$ Wrap</th>
<th>$\theta$ Wrap</th>
<th>Automatic Takeup</th>
<th>Manual Takeup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$T_1$</td>
<td>$T_2$</td>
<td>$T_1$</td>
</tr>
<tr>
<td>Single, no snub</td>
<td>180$^\circ$</td>
<td>0.84</td>
<td>0.50</td>
<td>1.2</td>
</tr>
<tr>
<td>Single with snub</td>
<td>200$^\circ$</td>
<td>0.72</td>
<td>0.42</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>210$^\circ$</td>
<td>0.66</td>
<td>0.38</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>220$^\circ$</td>
<td>0.62</td>
<td>0.35</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>240$^\circ$</td>
<td>0.54</td>
<td>0.30</td>
<td>0.8</td>
</tr>
<tr>
<td>Dual*</td>
<td>380$^\circ$</td>
<td>0.23</td>
<td>0.11</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>420$^\circ$</td>
<td>0.18</td>
<td>0.08</td>
<td>—</td>
</tr>
</tbody>
</table>
Tension Relationships and Belt Sag Between Idlers

\[
\text{Sag, ft} = \frac{WS_i^2}{8T}
\]

\[\Rightarrow \]

For 3 percent sag, \[ T_0 = 4.2S_i(W_b + W_m) \]

For 2 percent sag, \[ T_0 = 6.25S_i(W_b + W_m) \]

For 1\frac{1}{2} \text{ percent sag, } \[ T_0 = 8.4S_i(W_b + W_m) \]

\[\Rightarrow T_0 = 1856.2 \text{ lbs}\]

where:
- \( W = \text{weight, } (W_b + W_m), \text{ lbs/ft of belt and material} \)
- \( S_i = \text{idler spacing, ft} \)
- \( T = \text{tension in belt, lbs} \)

Table 6-10. Recommended belt sag percentages for various full load conditions.

<table>
<thead>
<tr>
<th>Idler Troughing Angle</th>
<th>Material</th>
<th>All Fines</th>
<th>One-half the Maximum Lump Size*</th>
<th>Maximum Lump Size*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°</td>
<td>All Fines</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>35°</td>
<td>All Fines</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>45°</td>
<td>All Fines</td>
<td>3%</td>
<td>2%</td>
<td>1\frac{1}{2}%</td>
</tr>
</tbody>
</table>
Maximum and Minimum Belt Tensions

Slack Side Tension, \( T_2 \)
- \( T_2 = T_e C_w \)
  - or
- \( T_2 = T_0 \pm T_b \pm T_{yr} \)

Use the larger value of \( T_2 \)

Tension, \( T_b \). The weight of the carrying and/or return run belt for a sloped conveyor is carried on the pulley at the top of the slope. This must be considered in calculating the \( T_2 \) tension, as indicated above.
- \( T_b = H \times W_b \)
  - where:
    - \( W_b = \) weight of belt, lbs/ft
    - \( H = \) net change in elevation, ft

Return Belt Friction Tension, \( T_{yr} \). The return belt friction is the belt tension resulting from the empty belt moving over the return run idlers:
- \( T_{yr} = 0.015 \times L \times W_b \times K_t \)
  - where:
    - \( L = \) length, ft, of conveyor to center of terminal pulleys
    - \( K_t = \) temperature correction factor

\[
T_t = T_0 \quad \text{or} \quad T_t = T_2 - T_b + T_{yr}
\]
\[
T_t = T_{\text{min}}
\]
\[
T_1 = T_2 + T_e = T_{\text{max}}
\]

\[
T_2 = 1167.8 \text{ lbs}
\]
\[
T_2 = 1856.2 + 1256 - 544.5 = 2567.7 \text{ lbs}
\]
\[
T_b = 115 \times 11 = 1265 \text{ lbs}
\]
\[
T_{yr} = 544.5 \text{ lbs}
\]
\[
T_{\text{min}} = 1856.2 \text{ lbs}
\]
\[
T_{\text{max}} = 17165.9 \text{ lbs}
\]
Belt stress = \( \frac{T1}{\text{Belt width}} = \frac{17166}{42} = 409 \text{ lbs per inch of width (PIW)} \)

Convert from PIW to EP:

\[
\frac{(409 \text{ PIW} \times 10 \text{ SF})}{5.71} = 716 \text{ N/mm}
\]
Bibliography

- Continuous handling equipment – Nomenclature, ISO 2148-1974
- Belt Conveyors for Bulk Materials, Calculations by CEMA 5th Edition
- Kulinowski, Kasza: Wykłady „Conveyors”, www.kmg.agh.edu.pl
- www.conveyorbeltguide.com
- IDLER CATALOG, Superior Industries, LLC

\[
\begin{align*}
\text{Pound-force, lbf} & \times 4.4482 = \text{N} \\
\text{Mass, lbs} & \times 0.4536 = \text{kg} \\
\text{Length, ft} & \times 0.3048 = \text{m} \\
\text{Velocity, fpm} & \times 0.0051 = \text{m/sec} \\
\text{Mass per length, lbs/ft} & \times 1.4882 = \text{kg/m} \\
\text{Acceleration, ft/sec}^2 & \times 0.3048 = \text{m/sec}^2 \\
\text{Area, ft}^2 & \times 0.0929 = \text{m}^2 \\
\text{Volume, ft}^3 & \times 0.0283 = \text{m}^3 \\
\text{Horsepower, hp (US)} & \times 745.7 = \text{W (Watts)} \\
\end{align*}
\]

\[ g - \text{Acceleration due to gravity, } 32.2 \text{ ft/sec}^2 \]
Questions?

Thank you