Technical Article
Technical Article Content Pulled from the NIBA Belt Line Newsletter

NIBA–The Belting Association
6737 W. Washington St. #1300
Milwaukee, WI 53214
Ph: 414-389-8606
www.niba.org

How to Design Take-up Travel for a Fabric Conveyor Belt

Contributed by Mitesh Kadakia
Goodyear EPD (Veyance Technologies Incorporated)
Member, NIBA Education/Technical Committee
Beltline Reprint December 2009

This article covers the important aspects of fabric conveyor belt elongation and how to design the conveyor system take-up so that adequate take-up travel length is allocated.

The purpose of take-up devices in belt conveyors is to establish and maintain a predetermined level of tension in the belt. Maintaining correct take-up tension will lessen the chance of drive slippage and/or excessive belt sag.

Drive slippage can result in excessive pulley cover wear, take-up counterweight bounce, and possible belt breakage if the take-up counterweight bounces high enough.

Excessive belt sag occurs when the belt tension is low and the belt drops (sags) between the idlers more than normal. Optimal belt sag is 1.0% - 2.0% of the center-to-center distance between the carrying side idlers during running conditions. Too little sag will create tracking problems due to the lack of frictional contact between the belt and the idler cans. Too much sag creates excessive friction between the belt and the idler cans, which, in turn, creates a higher horsepower requirement for the drive motor and accelerated wear of the pulley covers.

In order to maintain optimal conveyor belt tension, it is important to allow adequate take-up travel length in the conveyor system design. Insufficient take-up travel length will cause the take-up counterweight to bottom out as it naturally elongates. In order to move the counterweight up to its correct operational position, the belt would have to be shortened and re-spliced**. Re-splicing creates downtime and unscheduled maintenance costs for the customer.** It is critical to understand how much take-up travel length is required and how much belt elongation must be accommodated. This is why elongation is considered Goodyear's Seventh Design Criteria.

There are two types of elongation: **permanent** and **elastic**:

1. **Permanent elongation** means that the belt will not contract to its pre-elongation length and that this condition will last the life of the belt. Permanent elongation is typically experienced in the first 30-60 days of use. How quickly the permanent elongation occurs depends on how many hours a day the belt is loaded at the system's maximum operating tension.

2. **Elastic elongation** is a condition of expansion and contraction. An example of elastic elongation can be seen when simply stretching and then releasing a common rubber band. Elastic elongation is made up of two components. The first component is the elastic elongation that is observed when the counterweight (CW) is engaged after splicing. The elongation from this component appears to be permanent because the counterweight is always engaged. If the counterweight is raised at a later date to make a belt or splice

repair, the belt will contract in length. The second elastic elongation component is observed in the movement of the take-up counterweight when accelerating or loading.

What is take-up travel?
Take-up travel is the maximum length available for the take-up carriage to travel before bottoming out. It is the distance from the end of the take-up carriage or counterweight to the ground. It is NOT the distance from the take-up pulley to the ground.

The same principles also apply to horizontal take-up devices. The take-up travel for a hydraulic or screw take-up is simply the stroke of the hydraulic arm or the screw worm gear. There are occasionally variations of this concept such as double take-ups.

Recommended take-up position when splicing:
Note: There are many long center to center systems (2000+ ft) where less than 10% of initial take-up length should be left after splicing.

Ideal design for available take-up travel:
Take-up travel should be designed at 2 % of the belt center to center length. For example, if the c-c distance is 1000 ft, the recommendation for available take-up travel should be 20 ft minimum.

How to calculate the take-up travel requirement based on the permanent and elastic elongation characteristics of the belt:
Permanent elongation is a function of the maximum system tension that the belt experiences on a given system. If two identical systems are running at 1000 TPH and 2000 TPH respectively, the permanent elongation of 2000 TPH will be higher than 1000 TPH. This is because the maximum tension of 2000 TPH will be higher than the 1000 TPH system. Higher the belt tension, higher the permanent elongation for one specific belt construction. All belt manufacturers publish the permanent elongation values and are based on maximum tension being 100 % of the belt rated tension. This value can be used for calculation but it will be the worst case. For more precise calculation, contact belt manufacturer for the tension vs elongation equation.

Elastic elongation due to the take-up engagement (Ecw) is a function of the belt carcass elastic modulus and the sum of the weights of the counterweight and take-up pulley. **The higher the modulus of the belt carcass, the lower the elastic elongation.** This can be calculated by the following formula:

Ecw = Percent elastic elongation due to take-up engagement

Ecw = [Counterweight (lbs) / (2 * width of the belt * modulus of the belt carcass from brochure) * 100

Take-up movement due to Ecw = (center to center distance) * Ecw / 100

Elastic elongation due to startup and loading is a function of the tension differential (stop to start and unloaded to loaded) and the elastic modulus of the belt carcass. Soft start motor couplings decrease the startup tension spike dramatically because the acceleration time is increased. The severity of the spike during loading is dictated by the differential in tension between loaded and unloaded conditions. As the belt accelerates or is loaded (after being empty), the belt will elongate **temporarily**. When the startup is complete or the belt becomes empty again, the take-up will move back to its original position.

Because, elastic elongation is dependent on the system parameters and belt modulus, there is no easy formula. For shorter c-c and soft start systems, 0.5 % of c-c length can be used and 0.75 % for longer c-c and hard start systems. Contact belt manufacturers for more detail information if more precise calculations are needed.

Total Elongation = Permanent Elongation + Elastic Elongation due to CW + Elastic Elongation due to start up / loading:

Two examples are shown here:

1. On a 1000 ft center-to-center distance system at the XYZ power plant, the available take-up travel is 10 ft.

Belt specification = 500 piw 4 ply 42" wide belt

Maximum tension given = 450 piw (lbs per inch)

Calculated value

Permanent elongation = 9 ft

Elastic elongation due to counter weight engagement = 1 ft

Elastic elongation due to the start up = 2 ft

The total elongation calculated = 11 ft

The recommendation is to use a mechanical splice initially and then vulcanize splice after counterweight has moved at least 6 ft down. **Note: The belt removal will be 12 ft of belt because of the belt loop at the counterweight.**

2. On a 800 ft center-to-center distance system at the XYZ quarry, the available take-up travel is 10 ft.

Belt specification = 800 piw 4 ply 48" wide belt

Maximum tension given = 200 piw (lbs per inch)

Belt spec chosen due to impact requirement based on primary crusher belt

Calculated value
Permanent elongation = 3 ft

Elastic elongation due to counter weight engagement = 0.5 ft

Elastic elongation due to the start up = 0.5 ft

The total elongation calculated = 4 ft

The recommendation is to use vulcanized splice as the original splice as re-splicing will not be needed if there was not any slack left in the system and the take-up unit is minimum 7 ft from the ground when spliced (90/10 Rule).

Slack in the system at the time of the splicing:
It is not uncommon to see a take-up carriage move more than a few feet when the counterweight is released. If the counterweight moves more than the calculated elastic component due to counterweight, then it is the slack in the system that was not taken out at the time of the splicing. This is often interpreted as belt elongation but **this is NOT belt elongation.** Slack is caused by the belt splicer not adequately tensioning the belt prior to splicing. It is hard to take all the slack out when the system length is quite long (for system > 2000 ft c-c as a guideline). It is very critical to record how much the take-up unit has moved or traveled with respect to time, especially right after being spliced, and how much belt has been removed with respect to time. It is important to save belt samples removed for lab testing.

Take-up travel vs the amount of the belt:
There is sometimes confusion between the take-up travel vs the total amount of the belt. Often the amount of the take-up travel is confused as the total amount of the belt in the take-up. The total amount of the belt in the take-up is two times the take-up travel. If there was 12 ft removed from a 800 ft c-c system, then the % elongation is not 12 ft divided by 800 ft. It is 6 ft divided by 800 ft.

To select the proper belt based on a given take-up travel or to design proper take-up travel, consult your belt manufacturer.