HEAVY DUTY WEIGHING

MODULAR BELT SCALES

Design and Installation Guidelines

APPLICATION DATA SHEET 102

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SECTION 1 - INTRODUCTION

A belt scale is utilized to weigh a bulk material during a given period of time, while also indicating momentary flow rates. The two critical data components for belt scales are the material weight per unit length and coveyor belt speed.

Determination of the belt speed across the scale is usually possible with negligible error. The weight of material is usually accomplished by replacing one or more idlers with a weighing unit. This makes it possible to measure the material load per unit length. Difficulties in obtaining accurate weighing with belt scales are mainly caused by the dynamic effects of the conveyor belt. If the belt travels with no vertical misalignment between the idlers in the weighing unit and the adjacent (approach & retreat) stationary idlers, weighing problems are the same as with a platform scale.
Any vertical misalignment between idlers affects load transfer to the weigh idler which, together with belt tension and structural rigidity, may lead to considerable weighing errors.

With electronic (load cell-based) belt scales, load measurement can be made directly under the weigh idlers with no perceptible idler deflection. Displacements caused by varying tension on the belt (the most serious source of error) are then negligible. However, this assumes that the fixed idlers at either side of the scale and the conveyor frame also possess adequate rigidity.

Displacements independent of the load on the belt which arise because of idler misalignment or soiled idlers, principally cause zero point errors. These errors are eliminated in most electronic scales by the 'automatic-zero' setting function. This function is typically invoked as soon as the scale runs empty.

Therefore, it is technically possible to eliminate any error caused by the presence of the conveyor belt itself. However, the scale must also be located at a suitable point within the conveyor, and the installation must be carried out in the proper manner. The following sections provide the necessary guidelines to successfully plan a belt scale installation.

SECTION 2 - SELECTION OF A SCALE TYPE

The detection of material load with a belt scale is very similar to the performance of a static scale under load. In both instances, absolute accuracy depends on calibration. Static scales are typically calibrated with known static weights. Belt scales must be calibrated with a known quantity of material passing across the subject conveyor.

Typical belt scale faults which adversely affect weighing accuracy are due to misalignment of idlers through the weigh span, usually in conjunction with belt tensioning effects. The National Institute of Standards and Technology (NIST) Handbook 44, section 2.21, guidelines must be followed for legal approval of belt scales. Handbook 44 provides detailed instructions on conveyor design and scale location. The subject conveyor must be sufficiently rigid and the conveyor rollers well centered and aligned. Belt tension in the scale area must be virtually constant.

Given that Handbook 44's requirements are fulfilled, one other factor can reduce weighing errors due to the mechanical conditions: the length of the scale weigh span. The longer the weigh span, the less negative impact the mechanical influnences will have on the belt scale's accuracy.

The length of the scale span can be increased by changing the idler spacing of the scale or by using more than one set of weigh idlers in the conveyor. Scale designs employing varying numbers of weigh idlers are described in the following sections. In all cases, scale calibration errors are assumed to be negligible. In practice, this means that tests must be made using a known quantity of material.

SINGLE WEIGH IDLER

Merrick's Model 475 belt scale is modular with at least one weigh idler comprising the complete weighing unit. The scale is easily installed in existing conveyors and offers extremely simple and accurate alignment of the weighing area. The principle is shown in **Figure 1**.

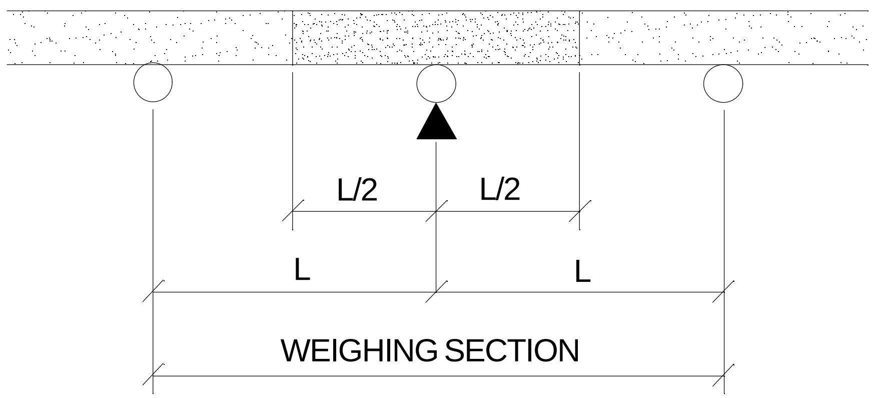

Figure 1 - Belt Scale with Single Weighing Unit

Weighing errors from the belt are mainly caused by variations in belt tension, therefore the scale should be installed in conveyor locations that minimize tension effects. Belt tension should be as low as possible, without incurring belt slippage (see Section 3).

Idler spacing (L) should be increased for greatest accuracy. However, the weigh span length will be limited by cantenary effects, increased belt wear, and material spillage. Adjacent idlers and the conveyor frame itself must also be satisfactorily rigid (see Section 3). These measures are usually not costly and offer simple weighing unit installation. If these mechanical conditions cannot be satisfied, errors will be considerably greater. However, they can be reduced by the incorporation of additional weighing units.

DUAL WEIGH IDLERS

To achieve better accuracy than that attainable with a single weigh idler (or if a scale must be installed in a conveyor with considerable variations in belt tension), simply install an additional weighing unit in the conveyor, as shown in **Figure 2**.

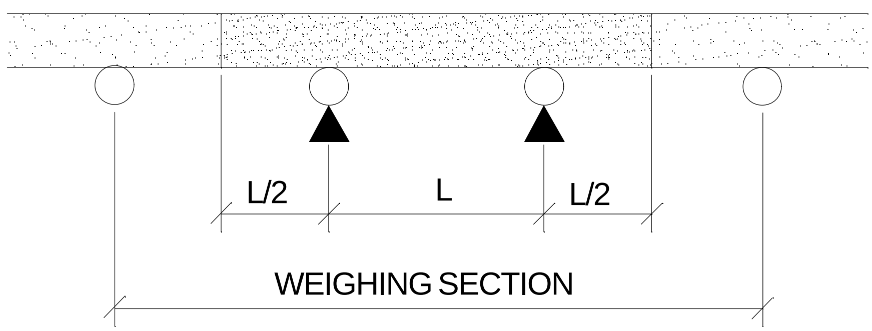

Figure 2 - Belt Scale with Dual Weighing Units

With:

(1) favorable mechanical conditions,
(2) maximized idler spacings (L),
(3) rigid conveyor framework in the weighing area, and
(4) minimized variations in belt tension,

the 2-idler configuration permits accuracies of up to 0.25% of test load.

TRIPLE WEIGH IDLERS

The introduction of a third weighing unit **(Figure 3)** reduces the impact of mechanical sources of error to less than one-third of the value obtainable with only one weigh idler. With (1) favorable mechanical conditions, (2) maximum idler spacings (L), (3) rigid conveyor framework in the weighing area, and (4) minimized variations in belt tension,

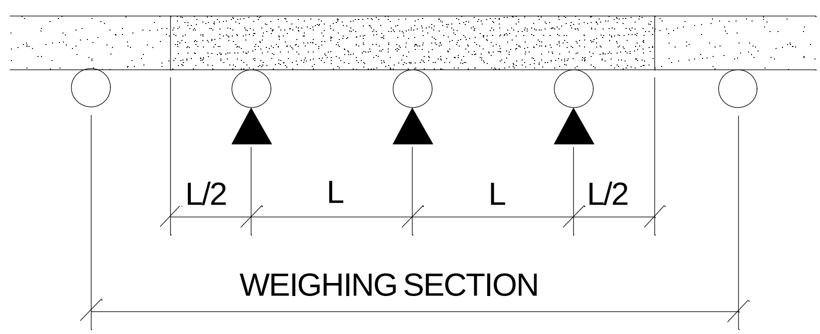

Figure 3 - Belt Scale with Triple Weighing Units

this configuration satisfies legal-for-trade requirements according to Handbook 44. Handbook 44 requires an acceptance tolerance of +/-0.25% of test load for conveyed quantities between 35% to 98 % of the rated capacity. This standard also requires repeatability between material tests of 0.25% (1/400).

The choice of weighing unit quantity depends upon: (1) accuracy requirements, (2) scale location constraints with a subject conveyor, and (3) the conveyor's structural rigidity throughout the weighing area. The following section provides the various considerations necessary in optimally chosing a scale location on a conveyor.

SECTION 3 - LOCATION OF THE BELT SCALE

The most important factor in assuring accurate weighing results is the application of the belt scale to the conveyor. Although other factors must be considered in continuous weighing applications, the majority of problems encountered after an installation are traced to improper applications.

The key to successfully applying the scale to the conveyor is to avoid locating the scale in any area of the conveyor where it is subjected to excessive belt tension and/or lifting of the conveyor belt. Always remember that the conveyor belt is an integral part of the scale and, as such, must remain in contact with the weigh module at all times.

The following application guidelines should be followed to assure the best accuracy.

A. BELT TENSION CONSIDERATIONS:
(See **Figure 4**)

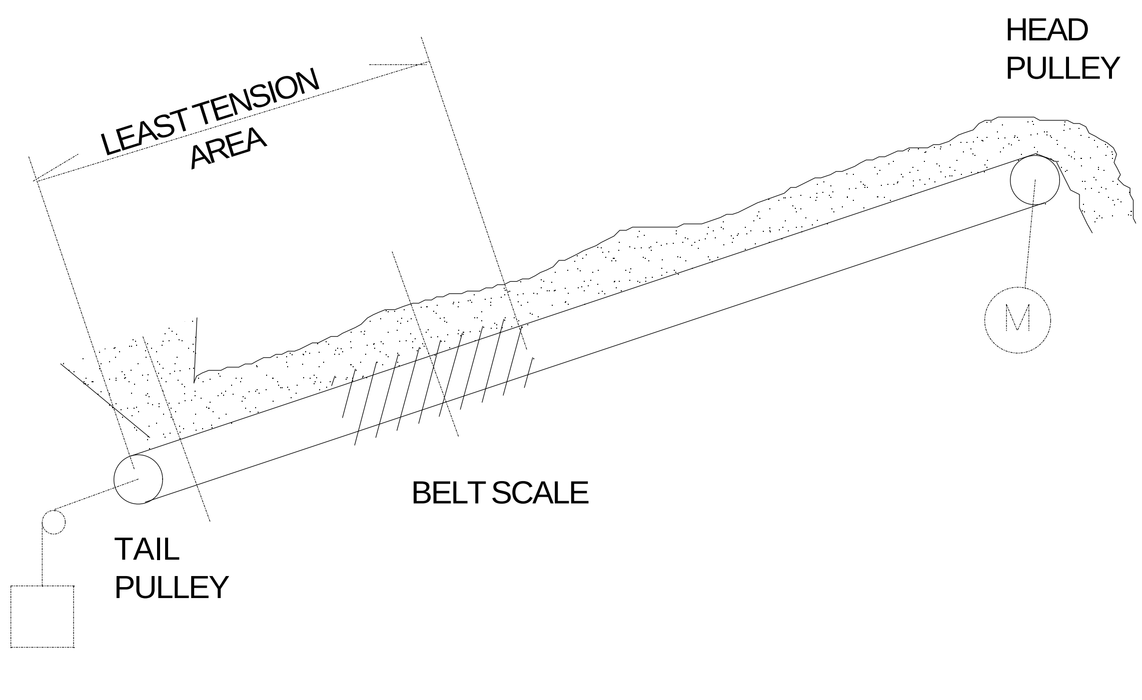

Figure 4 - Belt Tension Considerations

The belt scale should be installed near the conveyor tail pulley to minimize the effects of the belt tension. The tail end of a conveyor has the lowest amount of belt tension and, even more importantly, the lowest amount of tension variations.

B. MATERIAL TRANSITION
(See **Figure 5**)

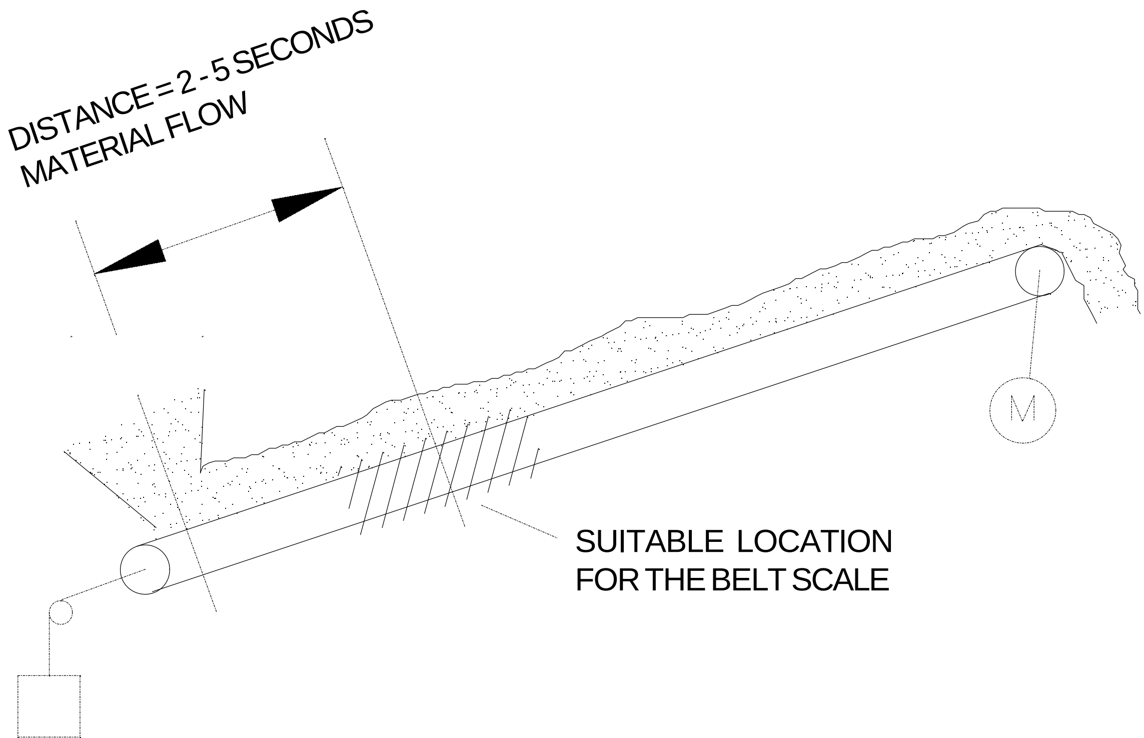

Figure 5 - Material Transition

The conveyed material requires settling time at the infeed before approaching the belt scale weigh span in order to achieve accurate weight measurement. The distance from the end of the infeed skirt-boards or loading point to the first weigh idler is minimally a distance conveyed by the belt in 2 to 5 seconds.

C. BELT TRANSITION

The belt undergoes a transition at the discharge. Therefore, if the intended belt scale location is near the head pulley, there must be a minimum number of idlers between the belt scale and the head pulley. The minimum number of idlers is dependent on the idler troughing angle. Gradual transition is preferred to prevent a lifting effect of the belt over the scale area. (See **Figures 6** & **6A**)

	Type of idler	No. of idlers
Fig. 6	Flat Idler......................................	2
	20 degree Troughed....................	2
Fig. 6A	35 degree Troughed....................	3 (1-35^0, 2-20^0)

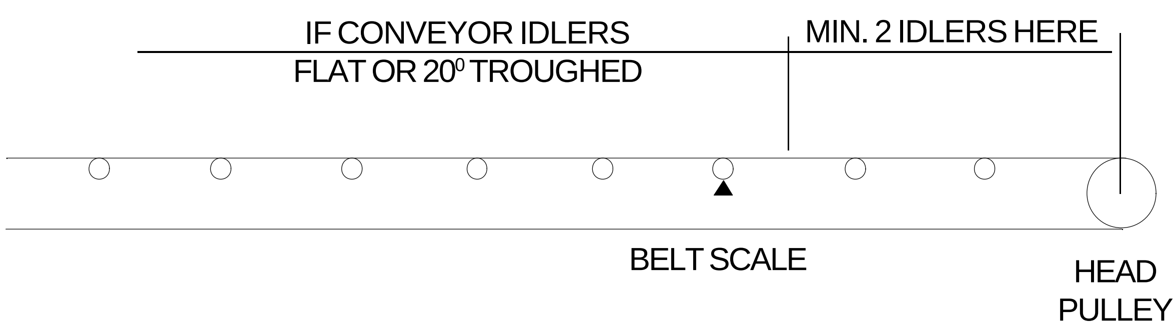

FIGURE 6

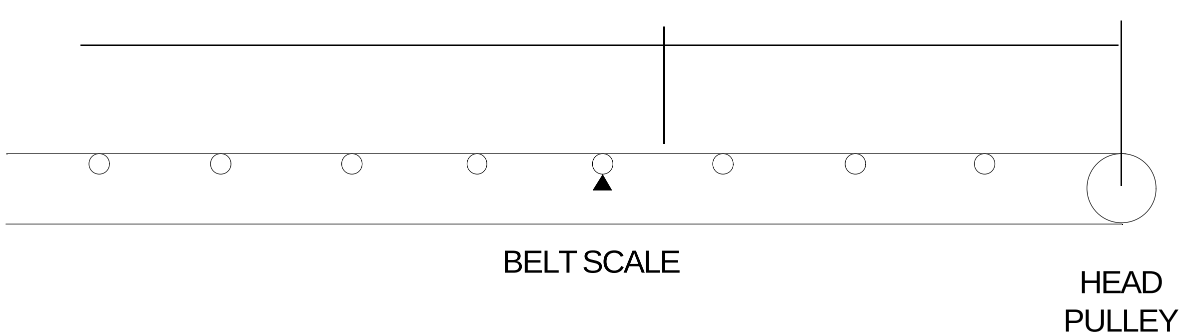

FIGURE 6A

D. TAKE-UPS

If the conveyor is longer than 75 feet, a gravity take-up must be provided to maintain a uniform belt tension. The device shall be of the counter-weighted type with either vertical or horizontal travel. The take-up must not introduce excessive belt tension and should be designed to allow the addition or removal of counter weights.

E. RIGID CONSTRUCTION

The conveyor structure (particularly in the area of the scale) must be rigid enough to resist deflection under maximum load. Conveyor stringers at the scale and for not less than 20 feet before and beyond the scale shall be continuous or securely joined and of sufficient size (and so supported) as to eliminate relative deflection between the scale and adjacent idlers when under load. The conveyor stringers should be so designed that the deflection between any two adjacent idlers within the weigh area does not exceed 0.025 inch under load.

F. FRAME WEAKNESS

Weakness in the conveyor frame (see **Figure 7**) is reduced by reinforcing the frame supporting the scale span or by installing additional support legs (**Figure 7b**) to equalize conveyor deflection at the weigh idlers. Angled braces (**Figure 7c**) or supports installed under each idler (**Figure 7d**) provide the most stable weighing section. Angled braces are usually the simplest solution for tubular frames.

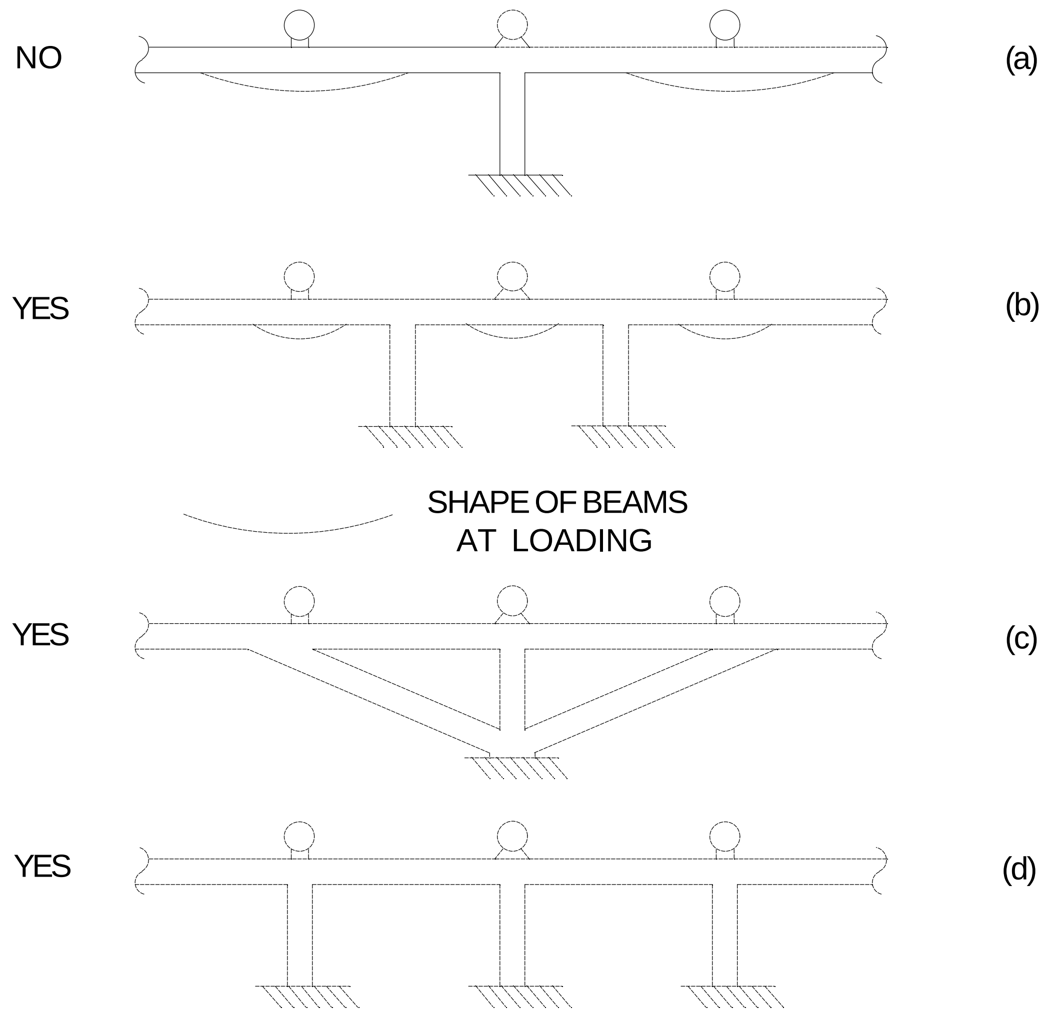

FIGURE 7 - REINFORCEMENT OF CONVEYOR FRAMES

G. IDLER WEAKNESS

Weaknesses in idlers are usually considerable for troughed belt conveyors. Since the load is imposed at the middle of the idlers (see **Figure 8**), the idler beams usually deflect 0.04 inches (1 mm) or more. This leads to considerable weighing error. Reinforcement of the idlers adjacent to the scale span (2 approach and 2 retreat) with additional welded beams can minimize weighing errors caused by idler deflection.

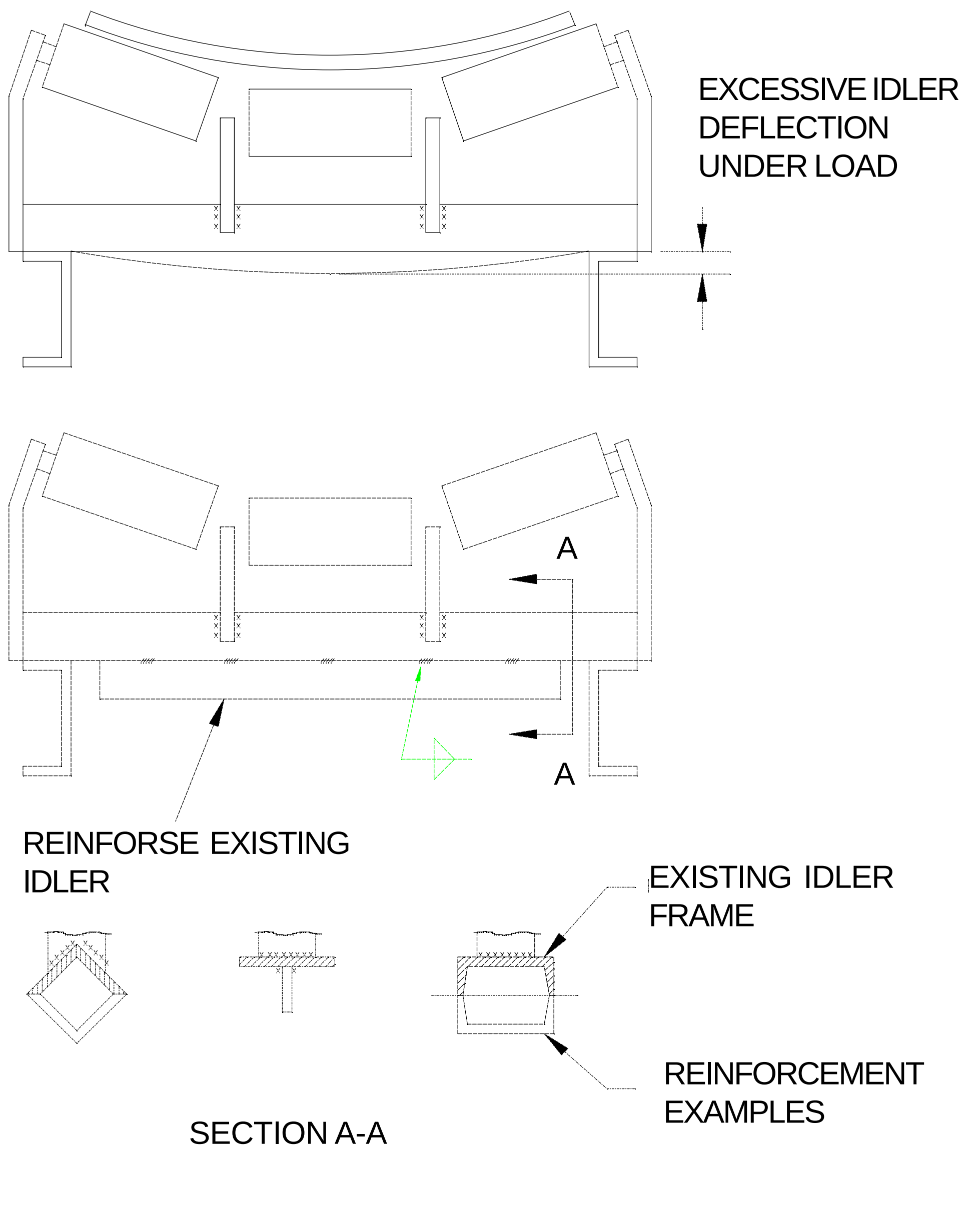

FIGURE 8 - IDLER REINFORCEMENT

Rope conveyors are not acceptable unless a rigid section is provided for the belt scale as shown in **Figure 9**.

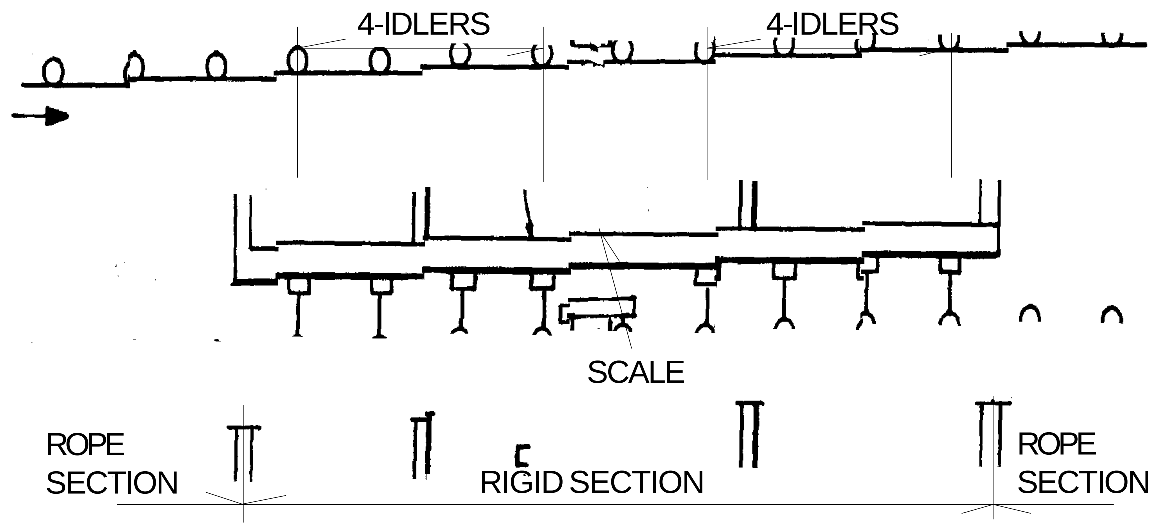

FIGURE 9

H. RIGID IDLERS

Always use rigid 3-roll in-line type idlers on the belt scale and at least two idlers either side. Do not use offset center roll or garland-type idlers.

I. WIND BREAK

(See **Figure 10**)
If the location of the belt scale is to be subjected to high winds (above 5 mph) the conveyor belt must be shielded by use of a wind break. The wind break must extend to 40 ft. either side of the scale location and 4 ft. above and below the belt line. (The length of the wind break may be reduced on short conveyors less than 80 ft. in length.)

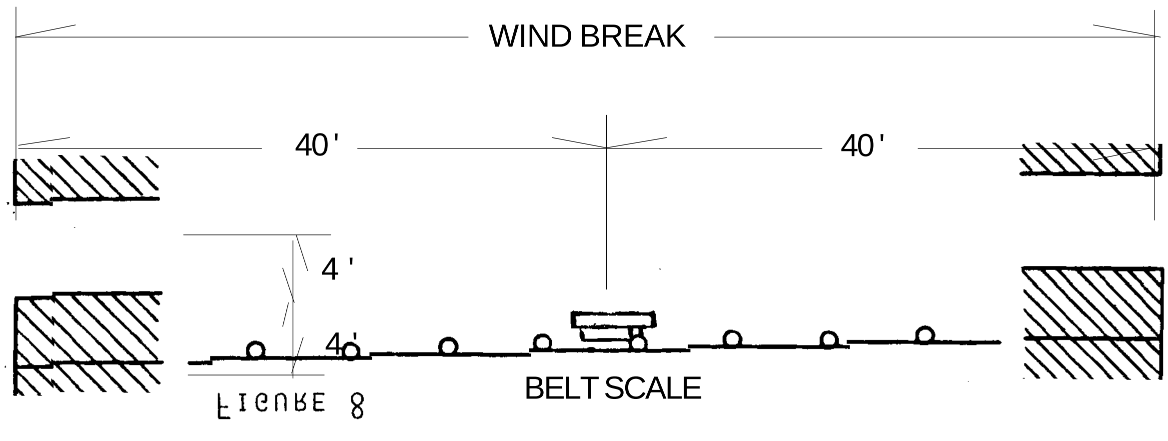

FIGURE 10

J. FIXED INCLINATION

If the conveyor is inclined, the inclination must be fixed at one specific angle. Portable conveyors are not recommended.

K. STEEP INCLINES

The conveyor inclination must not exceed the material angle of slide to prevent roll back and reweighing of the material.

L. CONCAVE AND CONVEX CURVES
(See **Figures 11** & **11A**)

If the conveyor is designed with a concave curve (**Figure 11**), the belt scale must be located 40 ft. from the point of tangency as curves induce inherent mis-alignment. Concave curves require special attention, since the belt tends to lift when running empty. As a rule, errors can be avoided if there is a sufficiently long, straight conveyor section between the scale and the curve. The preferred scale location is shown below the curve in '**SECTION A**'.

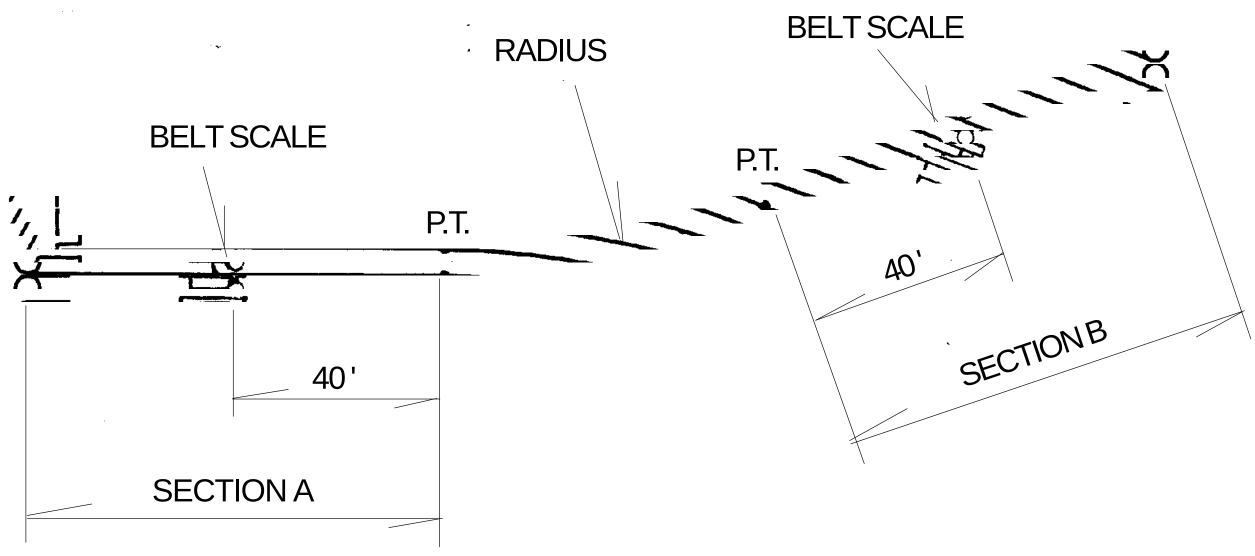

FIGURE 11

If the conveyor is designed with a convex curve (**Figure 11A**), the belt scale should be located in '**SECTION A**'.

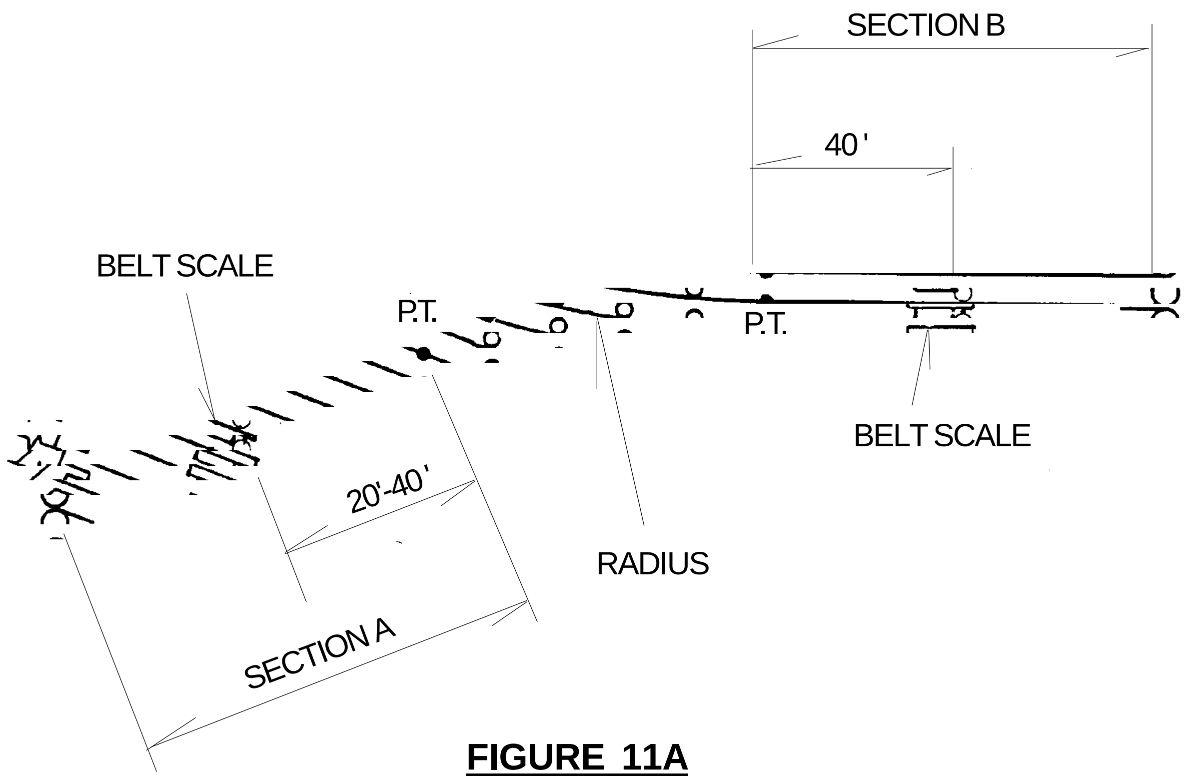

FIGURE 11A

Note: If '**SECTION A**' (**<u>Figures 11</u>** & **<u>11A</u>**) is not long enough to satisfy a proper installation, alternate '**SECTION B**' should be considered, providing material tests can be run to establish a necessary correction factor to compensate for the inherent scale location error.

M. TRAINING IDLERS

If training idlers are used, they must not be located within 60 feet from the centerline of the weigh span of the belt scale.

N. STICKY MATERIALS

Belt scrapers or belt cleaners are recommended for materials that tend to stick to the belt and would tend to affect the zero of the belt scale.

O. NON-UNIFORM LOADING

The conveyor loading mechanism shall be designed to provide uniform belt loading over the belt scale through the full range of the scale operation. If the loading is not uniform, a series of diagonally placed plows should be used to eliminate hills and valleys in the material. Sufficient impact idlers shall be provided in the conveyor under each loading point to prevent deflection of the belt during the time material is being loaded.

P. MULTIPLE FEED POINTS

Wherever possible; avoid installing the belt scale on conveyors with multiple infeeds unless all feed points will be used at the same time.

Q. REVERSIBLE CONVEYORS

Avoid trying to weigh accurately in both directions on reversible conveyors. The use of two scales is a better solution.

R. TRIPPERS

If the conveyor is provided with a tripper, the belt scale must be located at a point 40 feet from the point of tangency of the belt with the tripper fully retracted (toward the tail pulley). See **Figure 12**.

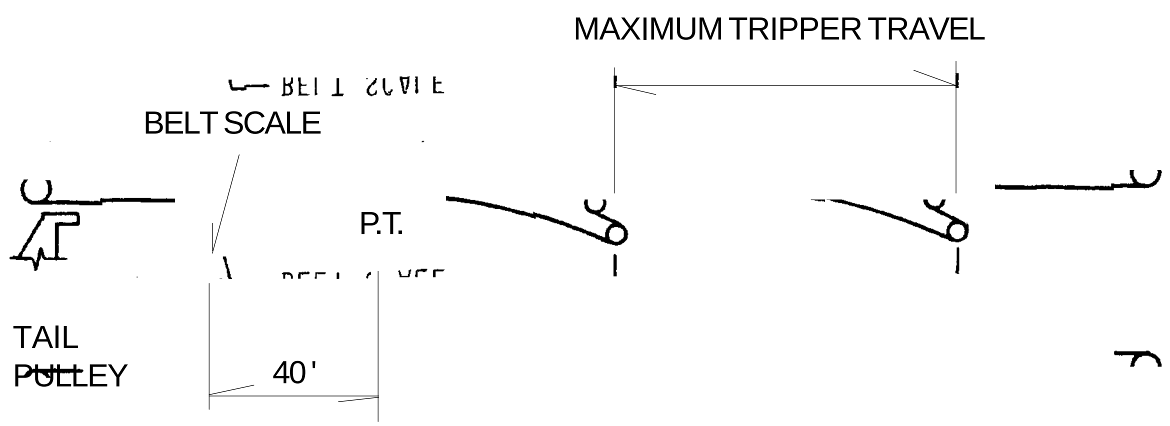

FIGURE 12

SECTION 4 - DETERMINING NUMBER OF WEIGHING IDLERS

The general rule is that control scales require a minimum of one suspended idler whereas an inventory scale (or one that is to be used for a high degree of accuracy) requires at least two or three suspended idlers. There are two overruling factors; (1) belt speed, and (2) weight per foot of material on the belt.

1. BELT SPEED

The material must not travel across the weigh span in less than 0.4 seconds.**
If the travel is less than 0.4 seconds, either the number of idlers suspended or the idler spacing will have to be increased to permit a longer time interval across the weigh span. The other alternative would be to slow the belt speed down, which may affect the maximum capacity of the belt conveyor system. (See **Figure 13)**

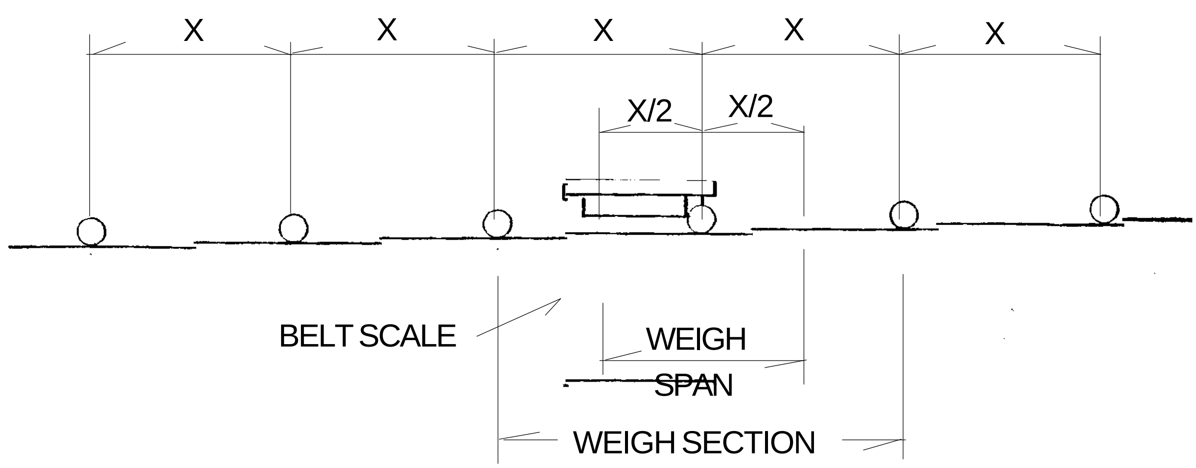

FIGURE 13

Weigh span = idler spacing (feet) X # of weigh units.

Speed in feet/second (FPS) = belt speed / 60 seconds

Weigh span / FPS = must be greater than 0.4 seconds*

** 1.0 seconds for certified scales

EXAMPLE:

Conveyor belt speed = 500 FPM
Idler spacing = 3'-0"
Therefore, for a single weigh unit: 3'-0" / 8.3 = 0.36 seconds

The example does not satisfy the design requirements; therefore, one of the following three factors will have to be reviewed.

a. Increase the idler spacing.
b. Add a second weigh unit.
c. Slow down the belt speed, which may affect the maximum capacity of the belt conveyor system.

2. WEIGHT PER FOOT

All scale designs are limited to a minimum weight that may be sensed accurately. The minimum load is calculated as follows:

EXAMPLE:

300 TPH conveyor running at 150 feet per minute.

LB/FT belt load on conveyor = $\frac{300 * 2000 \text{ (short tons)}}{150 * 60}$

= 66.66 LB/FT belt load

The weight on the load cell = 66.66 * the idler spacing in feet
= 66.66 * 3
= **199.98 pound**s

The minimum load on a model 475 modular belt scale is 10.00 pounds.