PDHonline Course M344 (2 PDH)

Belt Conveyor for Bulk Materials - Practical Calculations

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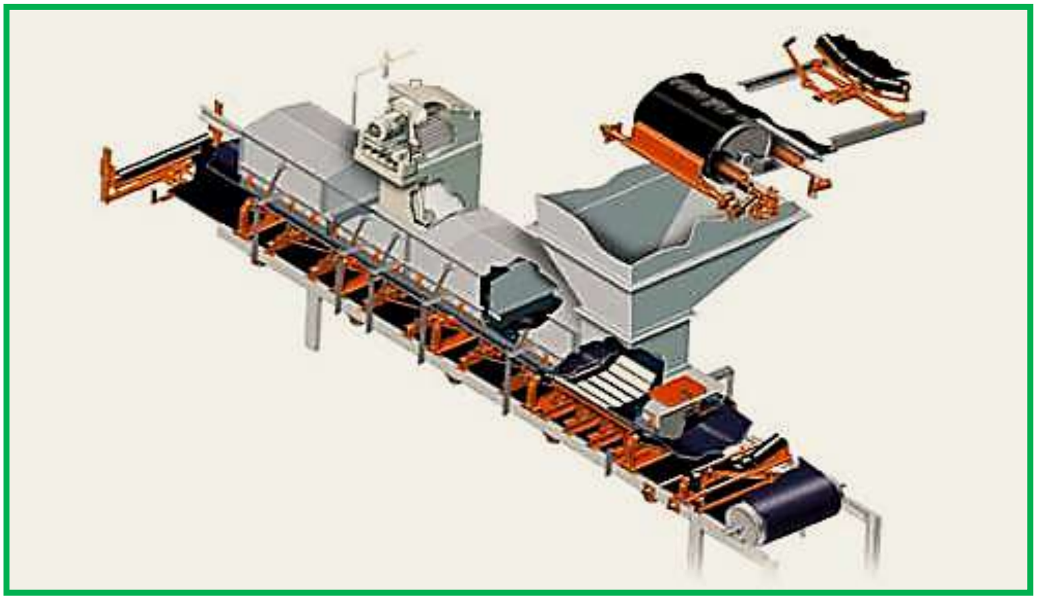
OBS.: This is a didactic and professional handbook. It´s highly recommended downloading and printing the course content for your study, before answering the quiz questions.

BELT CONVEYORS FOR BULK MATERIALS



1. INTRODUCTION:

Belt conveyors consist of two powered pulleys with a continuous loop of belting material used to convey products. Belt conveyors are the most economical powered conveyor and are typically used for conveying products over long distances, at high speeds, or for incline/decline applications. This is done with endless procession of hooks, gears, buckets, and a wide rubber belt. The belt is then supported by a series of rollers along the path.

Belt conveyors are an excellent choice for an inexpensive and simple method of moving products from one point to another. Because of the simplicity of the flat, moving belt, they can be used to move a variety of product sizes, shapes and weights effectively for long lengths with a single drive. Belt Conveyors are also a great option to move products through elevations. Incline Belt Conveyors from low to high and Decline Belt Conveyors from high to low.

This manual is short, with quick and easy reading paragraphs, very practical for calculations of belt, chain conveyors and mechanical miscellaneous, in the metric and imperial system. The main function, however, is to give more informative methods for both experienced professionals and beginners interested in knowing the dynamics of Material Handling.

Material handling equipment is mechanical equipment used for the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal.

Material handling equipment include belt conveyors of several models and patterns, horizontal, vertical, inclined, declined, with chains or rollers, tube type, etc. Works in warehousing & distribution; manufacturing; order fulfillment; aerospace; government military & agency; automotive; parcel Handling; appliances; cabinetry & furniture; food & beverage.

Note: In recent years, CEMA (Conveyor Equipment Manufacturers Association) and many member companies have developed computer programs capable of engineering analysis of the most complex and extensive process for belt and other material conveyor types. These programs are more comprehensive and include more extensive analysis and calculations, not included in this short manual.

2. BELT CHARACTERISTICS:

There are a great range of belt conveyors specially manufactured to perform any carrying application and to surpass since a simple unit loading to tough conveying industrial conditions. See below some of the belt characteristics and special applications.

a. Standard Rubber Belts:

- Standard belts incorporate covers suitable for the handling of most abrasive materials having a blend of natural and synthetic rubber.

b. Cut Resistant Belts:

- Cut resistant belts have a high content of natural rubber, recommended for belts operating under extremely difficult conditions where cutting and gouging of covers may occur.

c. Heat Resistant Belts:

- Heat Resistant belts incorporate covers with styrene butadiene, recommended for belts handling materials with temperatures up to 1200° C.

d. Super Heat Resistant Belts:

- Super Heat Resistant belts have Chlorobutyl covers, recommended for belts handling materials with temperatures of up to 1700°C.

e. Fire Resistant Belts:

- Fire resistant belts are manufactured with covers containing neoprene with multi-ply carcass constructions to meet the maximum standards of safety in underground mines.

f. Wood Handling Belts:

- These belts were especially developed non-staining for the timber industry compounded to provide resistance to oil and resin.

g. Concentrator Belts:

- Concentrator belts are uniquely applied at gold mine concentrators.

h. PVC Solid Woven Belts:

- PVC solid woven belts also known as “Vinyplast” are manufactured with polyester and nylon with cotton soaked in armor of PVC and PVC coatings, developed to withstand the impact, tear and abrasion as the requirements to meet the most stringent flame-resistant standards.

i. Food Quality Belts:

- Food quality belts are manufactured from non-toxic materials resistant to oils, fats and staining to meet the hygiene requirements of the food processing industry.

j. Nitrile Covered PVC Belts:

- Nitrile covered PVC belts were developed for application in mines where the danger of fire exists and also have properties of flame retardant, oil, abrasion and heat resistance.

k. Steel cord Belts:

- Steel cord belts are generally manufactured for application in long distances conveyors stiffened with a steel wire inserted within a high quality rubber in order to get exceptional traction load and material high impact.

l. Fire Resistant Steel cord Belts:

- Fire resistant steel cords belts were developed with properties of self-extinguishing fire to offer advantages in free maintenance operations and long life for conveyors situated in fiery mines.

m. Oil Resistant Belts:

- Oil resistant belts are manufactured to provide easily washable linings in nitrile, neoprene or synthetic rubber in all layers, allowing ease application in handling of materials containing vegetable oils and minerals.

n. Chevron Standard Belts:

- Chevron standard belts are manufactured with steel tyre cords in a 'V shape at intervals over the belt length. These belts are generally recommended for standard belting where difficult conditions are applied i.e. slag transportation.

o. Corrugated Sidewall Belts:

- Corrugated sidewall belts are the most effective ways of elevating materials in a confined space, and less space requirements, no transfer point, low maintenance and big capacity, commonly used in cement plants, coal-fired power plants, ports, and chemical industry.

3. BELT CONVEYORS - BASIC CALCULATIONS:

1. Mass of the Load per Unit Length:

Load per unit length. Given the production capacity **Qt = tph**, the **weight of the load** per unit length **(kg/m) – (lbs per ft)** is calculated by:

$$Wm = \frac{2000.\,Qt}{60 \times v} \quad \text{or} \quad Wm = \frac{33.333.\,Qt}{v} = (\text{lb/ft})$$

$$Q = 0.278.\frac{Qt}{v} \quad \text{or} \quad Q = \frac{Qt}{3.600 \times v} = \quad (\text{Kg/m})$$

2. Belt Tensions:

In order to find the maximum tension is necessary to calculate the effective tension, that is, the force required to move the conveyor and the load at a constant speed. The calculation of the total tension is based on a constant speed of the belt including the necessary basic conditions to overcome the frictional resistance and tension forces. In a basic way the effective tension is composed of:

- The tension to move with an empty belt, **Tx;**
- The tension of move the load horizontally, **Ty;**
- The tension to increase or decrease the load, **Tz;**
- The tension to overcome the resistance of accessories, **Tus;**
- The tension to overcome the resistance of scrapers, **Tuc.**

a. The total tension is:

$$T_e = T_x + T_y + T_z + Tus + Tuc =$$

b. The tension to move the empty belt is:

$$T_x = G \times f_x \times L_c =$$

c. The tension to move the load horizontally is:

$$T_y = Q\,(Wm) \times f_y \times L_C =$$

d. The tension to lift the load is:

$$T_z = Q\,(Wm) \times H =$$

e. The tension needed to overcome the resistance of the skirtboards, **Tus:**

$$T_{us} = \frac{f_s \times Q\,(Wm) \times L_s}{v \times b}\,(\text{Kg}) \text{ or } T_{us} = f_s.\,L_s.\,h_s^2\,(\text{lb}) =$$

f. The tension to overcome the resistance of scrapers, **Tuc**:

$$T_{uc} = A \times \rho \times f_c =$$

g. Moving trippers require additional pulleys in the system and therefore add a new tension**, Tut**

$$T_{ut} = 0.01.\frac{(d_o \times T_1)}{D_t}$$

3. Belt Length Correction, L_c:

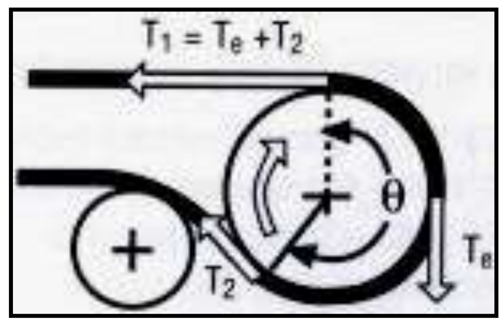
Short belt conveyors require relatively more power to overcome the resistance to friction than long ones and therefore an adjustment is made to calculate the effective tension.

$$L_C = L + 70 \text{ m (metric)}$$
$$L_C = L + 230 \text{ ft (imperial)}$$

Therefore, the belt length correction is:

$$C = \frac{L_c}{L}$$

All conveyors require an additional belt tension in order to allow the pulley to drive forward an effective tension without slipping. In a case of a simple horizontal conveyor **T1** is the sum of the effective tension **Te** and the slack side, the tension **T2**.



$$T_1 = T_e + T_2 =$$

For the inclined conveyor, additional tensions are induced due to the mass of the belt on the slope.

$$T_1 = T_e + T_2 + T_h =$$

Minimum tension to prevent slipping, Tm:

The relations between T_1 and T_2 are:

$$\frac{T_1}{T_2} = e^{\theta} =$$

So:

$$T_2 = \frac{1.\,T_e}{e^{\theta} - 1} =$$

The fundamental equation is given by:

(The Euler's equation): $T1 \leq T2.e^{\mu\alpha} =$

where:

T1 and T2 = tight side and slack side tensions at the driving pulley;
α = wrap angle of the belt in radiation;
e = natural logarithmic (Naperian) base, 2.718;
μ = Friction factor.

Considering the **factor K** to prevent slipping, $\mathbf{T_m}$, is:

$\mathbf{T_m = k \times T_e =}$

The minimum tension to prevent belt sag between two rolls, $\mathbf{T_s}$ is**:**

$\mathbf{T_s = S_f \times (B + Q) \times I_d =}$

The slope tension, $\mathbf{T_h}$ is**:**

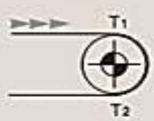
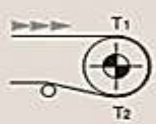
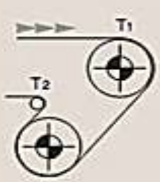
$\mathbf{T_h = B \times H =}$

Table 1: Coefficient of friction (between driving pulley and belt of pulley lag):

Operating conditions	Smooth bare steel pulley	Rubber lagging with herring bone grooves	Polyurethane lagging with Herring bone grooves	Ceramic lagging with Herring bone grooves	PVC belt
Dry	0.35 to 0.4	0.4 to 0.45	0.35 to 0.4	0.4 to 0.45	0.25 to 0.35
Clean wet (Water)	0.1	0.35	0.35	0.35 to 0.4	0.15 to 0.3
Wet and dirty (Clay)	0.05 to 0.1	0.25 to 0.3	0.2	0.35	Less than 0.25

Table 2: Wrap factor k:

Wrap factor K

drive arrangement	Angle of wrap α	tension unit or counterweight pulley unlagged	lagged	screw tension unit pulley unlagged	lagged
	180°	0.84	0.50	1.2	0.8
	200°	0.72	0.42	1.00	0.75
	210°	0.66	0.38	0.95	0.70
	220°	0.62	0.35	0.90	0.65
	240°	0.54	0.30	0.80	0.60
	380°	0.23	0.11	-	-
	420°	0.18	0.08	-	-

The final driving power **P** is calculated with the following formulas:

$\mathbf{P = \frac{T_e \times v}{75} =}$ **(metric) and** $\mathbf{P = \frac{T_e \times v}{33{,}000} =}$ **(imperial)**

Table 3 – Symbols:

Symbol	Description	Unit	Symbol	Description	Unit
A	Contact area of scraper	m^2 - ft^2	**S_f**	Sag factor	**(See Table)**
B	Belt mass per unit length	kg/m - lb/ft **(See Table)**	**T**	Unit tension	kg/m – lb/ft
b	Width between skirt plates	m - ft	**T_1**	Maximum belt tension across full belt width	kg - lbs
B_c	Edge Distance	mm - in	**T_2**	Slack side tension	kg - lbs
C	Length correction coefficient		**T_e**	Effective tension	kg - lbs
D	Material Density	kg/m^3- lb/ft^3	**T_h**	Slope tension	kg - lbs
D_t	Diameter of pulley	mm - in	**T_m**	Minimum tension to prevent slipping	kg - lbs
d_o	Diameter of pulley bearings	mm - in	**T_s**	Minimum tension to limit sag	kg - lbs
f_c	Friction coefficient for scrapers	**(See Table)**	**T_u**	Tension to overcome resistance of accessories	kg - lbs
f_s	Friction coefficient for skirtboards	**(See Table)**	**T_{uc}**	Tension to overcome resistance of scrapers	kg - lbs
f_x	Friction coefficient for empty belt	**(See Table)**	**T_{us}**	Tension to overcome resistance of skirtboards	kg - lbs
f_y	Friction coefficient for loaded belt	**(See Table)**	**T_x**	Tension to move the empty belt	kg - lbs
G	Mass of moving parts –	kg/m – lb/ft **(See Table)**	**T_y**	Tension to move the load horizontally	kg – lbs
H	Change in elevation along conveyor length	m - ft	**T_z**	Tension to lift (or lower) the load	kg - lbs
h_s	depth of the material touching the skirt board	in	**Wm**	Mass of load per unit length	kg/m - lb/ft
I_d	Idler spacing (carry idlers)	m - ft	**W**	Belt width	mm - in
k	Drive factor	**(See Table)**	**Wb**	Belt mass per unit length	kg/m - lb/ft
L	Horizontal length of conveyor	m - ft	**θ**	Angle of wrap on the drive radians	radians
L_c	Corrected length of conveyor	m - ft	**ρ**	Pressure of scraper on the belt	kg/m^2 – lb/ft^2
L_s	Length of skirt board	m - ft	**τ**	Belt capacity in ton per hour	t/hr - tph
P	Absorbed power	kW - HP	**β**	Trough angle	degree
Q	Mass of load per unit length	kg/m – lb/ft	**α**	Material surcharge angle	degree
Qt	Belt Capacity	tph	**v**	Belt Speed	m/s - fpm

Table 4 – Material Characteristics:

Material	Type	Suggested Grade	Bulk Density (t/m³)	Bulk Density (lb/ft³)	Angle of Surcharge (degrees)	Max. Conveyor Slope (degrees
Aluminium sulphate	NA	N	0,90	56	20	17
Ammonium sulphate,	MA	N	0,80	50	10	10
Asbestos ore or rock	VA	N/M	1,30	81	20	18
Ashes, coal, dry	MA	N	0,60	37	25	23
Ashes, coal, wet	MA	N	0,75	47	25	25
Ashes, gas producer,	MA	N	1,20	75	30	28
Bark, wood,	NA	N	0,24	15	30	27
Bauxite, ground, dry	VA	N/M	1,10	68	20	18
Bauxite, mine run	VA	N/M	1,36	85	20	17
Brick	VA	N/M	1,76	110	30	27
Calcium carbide	MA	N	1,20	75	20	18
Carbon black, pelletized	MA	N	0,35	22	5	5
Cement, Portland	NA	N/PHR	1,50	94	25	20
Cement clinker	MA	N/DHR	1,36	85	25	18
Chalk, lumpy	MA	N	1,30	81	10	15
Chalk, 100 mesh and under	MA	N	1,10	68	25	28
Charcoal	MA	N	0,35	22	25	22
Clay, calcined	MA	N	1,44	90	25	22
Clay, fines	MA	N	1,76	110	20	22
Coal, anthracite, sized	NA	N/PVC	0,90	56	10	16
Coal, bituminous, sized	NA	N/PVC	0,80	50	20	16
Coke, petroleum, calcined	VA	N/M	0,64	40	20	20
Concrete wet	VA	N/M	2,20	137	24	18
Copper ore	VA	N/M	2,17	135	20	20
Copper sulphate	VA	N/M	1,30	81	20	17
Dolomite	VA	N/M	1,60	100	18	20
Earth, as dug, dry	VA	N/M	1,20	75	20	20
Earth, wet, with clay	MA	N	1,70	106	30	23
Feldspar	VA	N/M	1,44	90	25	17
Foundry sand, old sand cores	VA	M/PHR	1,36	85	25	20
Granite, broken, 75mm lumps	VA	N/M	1,44	90	10	18
Graphite,	NA	N	0,65	40	10	15
Gravel, pebbles	VA	N/M	1,52	95	10	12
Gypsum, dust	MA	N	1,50	94	20	20

Iron ore, coarse crushed	VA	N/M	3,00	187	20	18
Iron ore, crushed fine	VA	N/M	3,50	218	20	18
Kaolin clay, 75mm and under	MA	N	1,00	62	20	19
Lead ores	MA	N	3,80	237	10	15
Lime, hydrated	NA	N	0,60	37	25	21
Lime, pebble	MA	N	0,90	56	10	17
Limestone, agricultural 3mm and under	MA	N	1,10	68	10	20
Magnesium sulphate	MA	N	1,10	68	10	15
Manganese ore	VA	N/M	2,15	134	25	20
Mica, ground	MA	N	0,22	14	20	23
Phosphate, ground fertilizer	MA	N/OR/PVC	0,80	50	20	18
Phosphate rock, broken, dry	VA	N/M	2,00	125	20	18
Phosphate rock, pulverized	VA	N/M	2,10	131	25	18
Phosphate, triple super	MA	N/OR/PVC	0,80	50	20	18
Pyrites, pellets	VA	N/M	2,00	125	10	15
Potash ore	MA	N	1,30	81	10	15
Quartz	HA/S	N/M	1,36	85	10	15
Rock, crushed	HA/S	N/M	2,15	134	20	18
Rubber, pellets	MA	N	0,80	50	20	22
Sand, bank, dry	VA	N/M	1,60	100	20	18
Sand, foundry, prepared	VA	N/M	1,36	85	30	24
Sawdust	NA	N/OR/PVC/W	0,20	12	25	22
Sinter	VA	N/M/PHR	1,80	112	10	15
Slag, blast furnace, crushed	VA	M/PHR/DHR	1,36	85	10	10
Sodium phosphate	MA	N	0,90	56	10	16
Sugar, granulated	NA	GF	0,83	52	10	15
Sugar, raw, cane	MA	N	0,96	60	20	22
Talc, powdered	NA	N	0,90	56	10	12
Titanium ore	VA	N/M	2,40	150	10	18
Vermiculite, ore	MA	N	1,20	75	20	20
Woodchips	NA	OR/W	0,32	20	30	27
Zinc ore, crushed	HA/S	M	2,60	162	25	22

Obs.: Consider point where is the comma. Example 0,20 consider 0.20.

Table 5: Standard Trough Angle and Surcharge Angle Characteristics:

Belt Cover Types:

N - NH Polyisoprene

M - Higher natural rubber content

OR - Oil resistant

GF - Grey Food

PHR - Heat Resistant

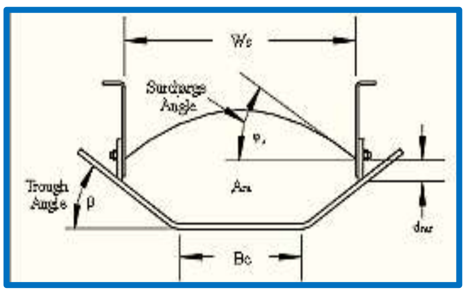
SPHR - Super heat resistant

W - Wood master

DHR - Delta Hete heat resistant

PVC – Polyvinylchloride

FR - Fire resistant



Typical Flowability:

Std. Trough Angle	Surcharge or Repose Angle	Material Characteristics
5°	0° - 19°	Uniform size
10°	20° - 29°	Round, dry, medium weight
20°	30° - 34°	Granular lumpy (Coal, Clay)
25°	35° - 39°	Coal, stone, ores
30°	40° - 45°	Irregular (wood chips)

Material abrasiveness:

HA/S - Highly abrasive/sharp
MA - Mildly abrasive
NA - Non-abrasive
VA - Very abrasive

4. CEMA BELT TENSION THEORY:

The CEMA procedure can be applied to any conventional troughed conveyor belt. However it is advised that this analysis must be verified by a competent and experienced conveyor designer. The general factors and terms can be used by the **following formula**:

$$Q = \frac{2000 \times Qt}{V\ (m/s)} = (Kg/m) \qquad \text{or} \qquad Wm = \frac{33.333 \times Qt}{v\ (fpm)} = (lb/ft)$$

Wb = **Belt mass** measured in **kg/m, (lb/ft)**;
Q/Wm = Material mass on the belt also measured in **kg/m, (lb/ft);**
Qt = Capacity of conveyor in tons/hour **(t/h)**.

Obs: The metric formula gives difference in lb/ft direct conversion.

The tension or force required to move the load horizontally over the conveyor length, will depend on the length of the conveyor, the rate of loading and the calculation/selection of the factors listed above.

a. Tension required to carry the load horizontally **(T_{hor}):**

$$T_{hor} = L.Kt\,[Kx + Ky\,(Wb + Wm)] + (0.015.Wb) =$$

Where:

L = Conveyor length, (m, ft).

Kt Factor: Normally this factor is **set at 1.0**; however a note of caution is required at extreme low temperatures (below freezing) because the lubrication selection of the idler bearing becomes critical and has resulted in failure of some installations.

Table 6: **Kx Factor**: Idler resistance and the belt sliding resistance over the idler.

$$Kx = 0.00068(Wb + Wm) + \frac{Ai}{Si} = \text{lb/ft (belt length)} =$$
Ai =1.5 for 6" diameter idler rolls, CEMA C6, D6;
Ai =1.8 for 5" diameter idler rolls, CEMA B5, C5, D5;
Ai =2.3 for 4" diameter idler rolls, CEMA B4, C4;
Ai =2.4 for 7" diameter idler rolls, CEMA E7;
Ai =2.8 for 6" diameter idler rolls, CEMA E6.

Ky Factor: Is considered to vary between **0.016 and 0.035.** The normal selection is **0.022**. For the return belt use a **Ky factor** of **0.015** throughout. **Ky factor** is a function of belt tension, material characteristic and load shape.

b. Tension required to lift or lower the load **(T_{lift}):**

The tension or force necessary to **raise** or **lower** the load through the vertical distance required. This component can be positive or negative according to whether the load is raised or lowered.

T_{lift} = **+-H x Wm** =

Where:

+-H = Top height or down height of belt conveyor (vertical distance), (m) (ft);
Wm = Mass of load per unit length, (Kg/m) (lb/ft).

CEMA empirical factors. Some of these factors include: Idler roller friction **(Kx)** belt and load flexure resistance **(Ky)** and skirtboard friction **(Tsb).**

c. Required HP:

To determine the required HP, first calculate **the belt tension or belt effective pull** at specified belt speed. **Belt tension (Te),** required to overcome gravity, friction, momentum and conveyor components. Calculate the using the following formula:

$$Te = L.Kt\,(Kx + Ky.Wb + 0.015Wb) + Wm\,(L.Ky \pm H) + T_x + T_y + T_z + T_{us} =$$

The final formula components indicated above are:

T_X = Tension to **move the empty belt**
T_y = Tension to **move the load horizontally**
T_z = Tension to **lift the load**
T_{us} = Tension to **overcome friction**

Calculate the **power required** to drive the belt using:

$$HP = \frac{Te\ (lb) \times v\ (fpm)}{33{,}000} = \text{(imperial) or} \quad CV = \frac{Te\ (Kg) \times v\ (m/s)}{75} = \text{(metric)}$$

Table 7: Sag Factor:

Percentage Sag	Sag Factor S_f
3%	4.2
2%	6.3
1,5%	8.4

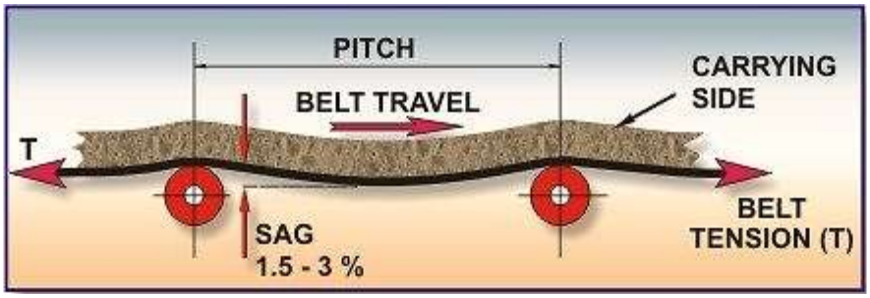


Table 8: Recommended Sag Percent:

Trough Angle (degree)	Fine Material	Lumps up to max lump size	Max Lump Size
20	3%	3%	3%
35	3%	2%	2%
45	3%	2%	1,5%

Table 9: Friction Factors:

Symbol	Description	Value of the friction factor		
		Normal operating conditions. Horizontal length up to 250 m (820 ft)	Normal operating conditions. Horizontal length more than 250 m (820 ft)	Very well aligned structure. No tilted idlers. Horizontal length more than 500 m (1640 ft)
f_C	Friction coefficient for scrapers	0.600	0.600	0.600
f_S	Friction coefficient for skirtboards	0.650	0.650	0.650
f_X	Friction coefficient for empty belt	0.022	0.020	0.020
f_Y	Friction coefficient for loaded belt	0.027	0.022	0.020

Table 10: Estimated Belt Mass - B (Wb) – (kg/m) (lb/ft):

Belt Width (mm)	Belt Width (in)	Operating Conditions		
		Light Duty kg/m (lb/ft)	Medium Duty kg/m (lb/ft)	Heavy Duty kg/m (lb/ft)
500	20	4.1 (2.75)	6.2 (4.16)	10.3 (6.92)
600	24	5.0 (3.36)	7.4 (4.97)	12.3 (8.26)
750	30	6.2 (4.16)	9.3 (6.25)	15.5 (10.41)
900	36	7.4 (4.97)	11.1 (7.46)	18.5 (12.43)
1050	42	8.6 (5.78)	13.0 (8.73)	21.6 (14.51)
1200	48	9.8 (6.58)	14.8 (9.94)	24.7 (16.60)
1350	54	11.0 (7.39)	16.7 (11.22)	27.8 (18.68)
1500	60	12.3 (8.26)	18.6 (12.50)	30.9 (20.76)
1650	66	13.5 (9.07)	20.5 (13.77)	33.9 (22.78)
1800	72	14.7 (9,88)	22.3 (14.98)	37.0 (24.86)

Table 11: Mass of Moving Parts - G:

Belt Width (mm)	Belt Width (in)	Mass of Moving Parts (kg/m) (lb/ft)			
		Light Duty 4" Idlers **Light Belt**	Medium Duty 5" Idlers **Moderate Belt**	Heavy Duty 6" Idlers **Heavy Belt**	Extra Heavy Duty 6" Idlers **Steel Cord Belt**
450	18	23 (15.4)	25 (16.8)	33 (22.2)	
600	20	29 (19.5)	36 (24.2)	45 (30.2)	49 (33.0)
750	24	37 (25.0)	46 (31.0)	57 (38.3)	63 (42.3)
900	30	45 (30.0)	55 (37.0)	70 (47.0)	79 (53.0)
1050	36	52 (35.0)	64 (43.0)	82 (55.0)	94 (63.2)
1200	42	63 (42.3)	71 (47.7)	95 (63.8)	110 (74.0)
1350	48	70 (47.0)	82 (55.0)	107 (72.0)	127 (85.3)
1500	54		91 (61.2)	121 (81.3)	143 (96.0)
1650	60		100 (67.2)	132 (88.7)	160 (107.5)
1800	66			144 (96.7)	178 (119.6)
2100	72			168 (112.8)	205 (137.7)
2200	84			177 (119.0)	219 (147.2)

Table 12: Drive Factor, k:

Angle of Belt Wrap at Drive (Degrees)	Type of Drive	Screw Take-up		Gravity or Automatic Winch Take-up	
		Bare Pulley	Lagged Pulley	Bare Pulley	Lagged Pulley
150	Plain	1.5	1.0	1.08	0.670
160	Plain	1.4	0.9	0.99	0.600
170	Plain	1.3	0.9	0.91	0.550
180	Plain	1.2	0.8	0.84	0.500
190	Snubbed	1.1	0.7	0.77	0.450
200	Snubbed	1.0	0.7	0.72	0.420
210	Snubbed	1.0	0.7	0.67	0.380
220	Snubbed	0.9	0.6	0.62	0.350
230	Snubbed	0.9	0.6	0.58	0.320
240	Snubbed	0.8	0.6	0.54	0.300
340	Dual	0.5	0.4	0.29	0.143
360	Dual	0.5	0.4	0.26	0.125
380	Dual	0.5	0.3	0.23	0.108
400	Dual	0.5	0.3	0.21	0.095
420	Dual	0.4	0.3	0.19	0.084
440	Dual			0.17	0.074

Table 13: Belt Carcass Thickness (mm) (in):

Textile Reinforced Rubber Belting No. of Plies				Solid Woven PVC Belting	Steel cord Reinforced Rubber Belting
2	3	4	5		
2.0 (0.08)					
2.6 (0.104)					
2.7 (0.108)	3.2 (0.128)				
2.8 (0.112)	3.5 (0.14)				
3.0 (0.12)	3.8 (0.152)	5.0 (0.2)		4.9 (0.196)	
4.0 (0.16)	4.2 (0.168)	5.2 (0.208)	5.9 (0.236)	5.9 (0.236)	3.2 (0.128)
4.3 (0.172)	5.2 (0.208)	5.8 (0.232)	6.6 (0.264)	6.2 (0.248)	3.2 (0.128)
5.0 (0.2)	6.0 (0.24)	6.9 (0.276)	7.2 (0.288)	6.9 (0.276)	3.7 (0.148)
5.7 (0.228)	6.5 (0.25)	7.6 (0.304)	8.5 (0.34)	7.4 (0.296)	3.7 (0.148)
	8.4 (0.336)	9.6 (0.384)	10.0 (0.4)	8.4 (0.336)	3.7 (0.148)
	9.5 (0.38)	10.5 (0,.)	11.0 (0.44)	9.9 (0.396)	5.4 (0.216)
		12.0 (0.48)	13.0 (0.52)	12.4 (0.496)	5.4 (0.216)

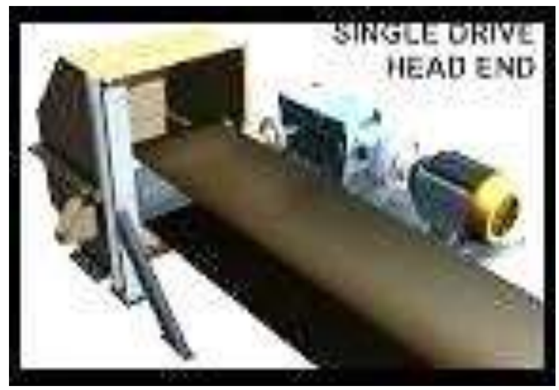
Notes:

1. The values given in the table are estimated values for use in the calculation of maximum belt operating tension necessary to make the correct belt selection.

2. When the belt specification has to be determined more accurately, the mass should be checked from manufacturers' recommendation tables.

Example: Calculate the **belt tension and driving power** of a simple conveyor, **step by step**:

Belt width =	900 mm (36 in)
Conveyor Length =	250 m (~820 ft)
Lift Length =	20 m (~65 ft)
Skirtboard Length =	3 m (~10 ft)
Skirt plates Width =	0,970 m (~3.2 ft)
Material Depth =	90 mm (~3.5 in)
Capacity =	400 t/hr (tph)
Speed =	1.4 m/s (~275 fpm)
Material Conveyed=	Coal
Driving Pulley =	210 degree wrap (lagged)
Take-up =	Gravity
Idler Spacing =	1.2 m (~4 ft)
Idler Roll Diameter =	127 mm (5 in)



Metric System

Calculate the load **(kg/m):**

$$Q = 0.278.\frac{Qt}{v}$$

$$= \frac{0,278 \times 400}{1,4}$$

$Q = 79.4$ kg/m

Correct length:

$$L_C = L + 70 \text{ m}$$

$= 250 + 70$

$L_C = 320$ m

$$C = \frac{L_C}{L}$$

$= \frac{320}{250} =$ **$C = 1.28$**

Convert	***To***	***Multiply by***
m	**ft**	**3,281**
cm²	in²	0.155
m²	**ft²**	**10.7639**
m³	ft³	35.3148
m/s	**ft/min**	**196,85**
kg	**lb**	**2,205**
N	lbf	0.2248
kN/m	lbf/in	5.71
kg/cm	lb/in	5.6
kg/m	**lb/ft**	**0,672**
kg/cm²	lb/in²	14.2
kg/m³	**lb/ft³**	**0.0624**
kW	**HP**	**1.3405**
Watts	*HP*	0.00134

US System

Calculate the load **(lb/ft):**

$$Wm = 33.333.\frac{Qt}{v}$$

$$= \frac{33.333 \times 400}{275}$$

$Wm = 48.5$ lb/ft

Correct length:

$$L_C = L + 230 \text{ ft}$$

$= 820 + 230$

$L_C = 1050$ ft

$$C = \frac{L_C}{L}$$

$= \frac{1050}{820} =$ **$C = 1.28$**

Now, to calculate the **belt tensions**, as defined below, the estimated values of the moving parts **mass** are in **Table 11**. For a 900 mm (36 inches) width belt, the **mass** of moving parts from **Table 11** is **55 kg/m** (~37 lb/ft)**.** The friction values for **f_X - f_Y** and **f_s** are considered in **Table 9.**

a. Tension to move the **empty belt:**

$T_X = G \times f_X \times L_C =$
$= 55 \times 0.022 \times 320$
$= 37 \times 0.022 \times 1050$

T_x = 387 Kg
T_x = 854 lb

b. Tension to move the **load horizontally**:

$T_y = Q\ (Wm) \times f_Y \times L_C =$
$= 79.4 \times 0.027 \times 320$
$= 48.5 \times 0.027 \times 1050$

T_y = 686 Kg
T_y = 1375 lb

c. Tension to **lift the load**:

$T_Z = Q\ (Wm) \times H =$
$= 79.4 \times 20$
$= 48.5 \times 65$

T_z = 1588 Kg
T_z = 3120 lb

Obs: The metric formula **(Q)** gives difference in lb/ft **(Wm)** considering a direct conversion.

d. Tension to **overcome friction**:

$$T_{us} = \frac{f_s \times Q \times L_s}{v \times b} = (Kg)$$

$$T_{us} = \frac{0.650 \times 79.4 \times 3}{1.4 \times 0.970} =$$

T_{us} = 114 Kg
T_{us} = 252 lb (considered a direct conversion Kg to lb)

e. **The effective tension** is:

No scrapers were indicated, then the tension **(Tuc)** to overcome the resistance of scrapers is **zero**.

$T_e = T_x + T_y + T_z + Tus + Tuc =$
$= 387 + 686 + 1588 + 114 + 0 =$
$= 854 + 1375 + 3120 + 252 + 0 =$

Te = 2775 Kg
Te = 5601 lb [= **6125 lb**] – (difference considering direct conversion).

Other **load tensions** to be considered are**:**

a. Slack side tension: The drive factor **for 210 degree wrap** and lagged pulley, to prevent slip, with a gravity take-up, as given in **Table 12, is 0.38**.

$T_m = k \times T_e =$
= 0.38 x 2775
= 0.38 x 5601

Tm = 1054 Kg
Tm = 2128 lb [= 2326 lb] – (considering direct conversion).

b. Load tension, average:

$T_S = S_f (B + Qt) \times l_d =$

S_f = Considering a **2%,** sag indicated in Table 7 **is 6.3.**
B = Belt mass a 900 mm (36 in) in Table 10 **is 11.1 kg/m (7,46 lb/ft)**.
l_d = Idler spacing (carry idlers).

= 6.3 x (11.1 + 79.4) x 1.2 =
= 6.3 x (7.46 + 48.5) x 3.9 =

Ts = 684 Kg
Ts = 1375 lb [= 1509 lb] – (considering direct conversion).

c. Tension to lift the empty belt, considering:

- **H** = Lift length is 20 m (65 ft),
- **B** = 11.1 (Kg/m) (7.46 lb/ft)

$T_h = B \times H$
=11.1 x 20 =
=7.46 x 65 =

T_h = 222 Kg
T_h = 485 lb [= **490 lb**] - (considering direct conversion).

d. Effective tension, **T_1**: considering **T_e, T_m and T_h.**

$T_1 = T_e + T_m + T_h =$
= 2775 + 1054 + 222
= 5428 + 2062 + 485

T_1 = 4051 Kg
T_1 = 7975 lb [= **8942 lb**] - (considering direct conversion).

Then the **effective tension,** is:

Te = 2775 Kg (5601 lb) and **T_1 = 4051 Kg (7975 lb).**

To calculate the **HP driving power**, always consider the higher load:

$$P_{CV} = \frac{T_e \times v}{75} \text{ (metric)} \quad – \quad P_{HP} = \frac{T_e \times v}{33{,}000} \text{ (imperial)}$$

$$\mathbf{P_{CV}} = \frac{4051 \times 1.4}{75} = \mathbf{\sim 75\ CV}$$

$$\mathbf{P_{CV} = 75 / 1.34\ (kW\ Factor) = \sim 100\ kW}$$

$$\mathbf{P_{HP}} = \frac{7975 \times 275}{33{,}000} = \mathbf{\sim 66\ HP}$$ (Use next **standard motor power** = **75 HP).**

Belt tension, **T,** in **kg/m or lb/ft** of the belt:

$$\mathbf{T} = \frac{\mathbf{T_1}}{\mathbf{W}}$$ considering **W = belt width 36"**

$$= \frac{4051}{900\ mm} = \frac{4051}{0.90\ m}$$

$$= \frac{7975}{36\ in} = \frac{7975}{3\ ft}$$

T = 4500 Kg/m
T = 2658 lb/ft [= **3024 lb/ft**] - (considering direct conversion).

5. TROUGHED BELT CONVEYOR CAPACITIES:

The capacity of a troughed belt is a function of the, cross sectional area of the load that can be carried, no spillage; the belt speed and the bulk material density. To optimize the loading, the **transversal area** should be designed to ensure the most advantageous initial load as follows:

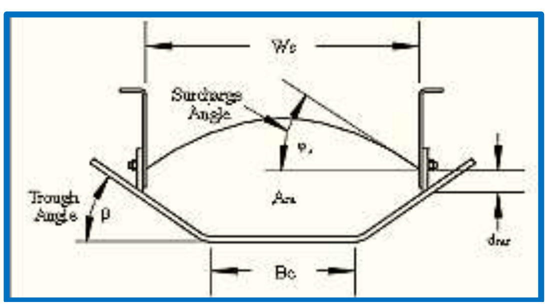
Load Capacity **(metric)** - $\mathbf{Qt = 3.6A_t \times \delta \times v\ (t/h) =}$

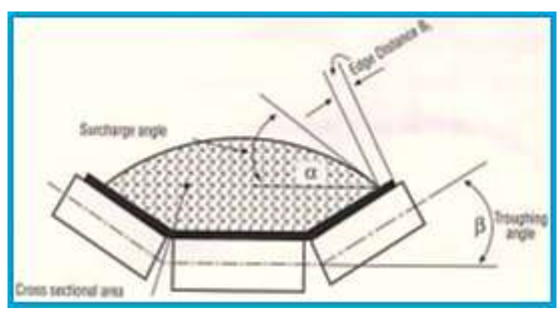
Load Capacity **(imperial)** – $\mathbf{Qt} = \dfrac{\mathbf{A_t \times \delta \times v}}{\mathbf{33.333}}\ \mathbf{(tph) =}$

Where:

Qt = Conveyor Capacity – t/h – (tph)
At = Cross sectional area - m^2 - (ft^2)
δ = Bulk density of the material - kg/m^3 - (lb/ft^3)
v = Conveyor speed - m/s – fpm

Standard Edge Distance = **0.055b + 0.9 Inch** - (b = belt width)





Obs.: The following tables are orientative and indicated for three equal rolls, troughed belts at **20° and 35**°, bulk density of **62.4 lb/ft³ (1000 Kg/m³)**, according to CEMA Standards.

Table 14: 20° Troughed Belt - Three Equal Rolls

Belt Width		A-Cross-Section of Load (m^2)						A-Cross Section of Load (ft^2)					
		Surcharge Angle						Surcharge angle					
mm	(in)	0°	10°	15°	20°	25°	30°	0°	10°	15°	20°	25°	30°
450	(18)	0.008	0.012	0.014	0.016	0.017	0.019	0.089	0.128	0.147	0.167	0.188	0.209
600	(24)	0.016	0.023	**0.026**	0.030	0.033	0.037	0.173	0.246	**0.283**	0.320	0.359	0.399
750	(30)	0.026	0.037	0.043	0.048	0.054	0.060	0.284	0.402	0.462	0.522	0.585	0.649
900	(36)	0.039	0.055	0.064	0.072	0.080	0.089	0.423	0.596	0.684	0.774	0.866	0.960
1,050	(42)	0.055	0.077	0.088	0.100	0.112	0.124	0.588	0.828	0.950	1.074	1.201	1.332
1,200	(48)	0.073	0.102	0.117	0.132	0.148	0.164	0.781	1.099	1.260	1.424	1.592	1.765
1,350	(54)	0.093	0.131	0.150	0.169	0.189	0.210	1.002	1.407	1.613	1.822	2.037	2.258
1,500	(60)	0.116	0.163	0.187	0.211	0.236	0.261	1.249	1.753	2.009	2.270	2.537	2.812
1,800	(72)	0.170	0.238	0.272	0.308	0.344	0.381	1.826	2.560	2.933	3.312	3.701	4.102
2,100	(84)	0.233	0.327	0.374	0.423	0.472	0.524	2.513	3.519	4.030	4.551	5.085	5.635
2,400	(96)	0.307	0.430	0.493	0.556	0.621	0.689	3.308	4.631	5.302	5.986	6.687	7.411

Table 15: 35° Troughed Belt - Three Equal Rolls

Belt Width		A-Cross-Section of Load (m^2)						A-Cross Section of Load (ft^2)					
		Surcharge Angle						Surcharge angle					
mm	(in)	0°	10°	15°	20°	25°	30°	0°	10°	15°	20°	25°	30°
450	(18)	0.013	0.016	0.018	0.020	0.021	0.023	0.144	0.177	0.194	0.212	0.230	0.248
600	(24)	0.026	0.032	0.035	0.038	0.041	0.044	0.278	0.341	0.373	0.406	0.440	0.474
750	(30)	0.042	0.052	0.057	0.062	0.067	0.072	0.455	0.557	0.609	0.662	0.716	0.772
900	(36)	0.063	0.077	0.084	**0.091**	0.098	0.106	0.676	0.826	0.903	**0.980**	1.060	1.142
1,050	(42)	0.087	0.107	0.117	0.126	0.137	0.147	0.940	1.148	1.254	1.361	1.471	1.585
1,200	(48)	0.116	0.141	0.154	0.168	0.181	0.195	1.248	1.523	1.662	1.804	1.949	2.099
1,350	(54)	0.149	0.181	0.198	0.215	0.232	0.250	1.599	1.950	2.128	2.309	2.494	2.686
1,500	(60)	0.185	0.226	0.246	0.267	0.289	0.311	1.994	2.429	2.651	2.876	3.107	3.345
1,800	(72)	0.271	0.330	0.359	0.390	0.421	0.453	2.913	3.547	3.869	4.197	4.532	4.879
2,100	(84)	0.372	0.453	0.494	0.536	0.578	0.623	4.007	4.876	5.317	5.766	6.226	6.701
2,400	(96)	0.490	0.596	0.650	0.705	0.761	0.819	5.274	6.415	6.994	7.584	8.189	8.812

Table 16: Factors **"K"** for conveyors **inclined or declined**:

Belt Slope	**5°**	**10°**	**15°**	**17,5°**	**20°**
Cos φ	0.996	0.985	0.954	0.940	0.906

Table 17: CEMA Standard **Edge Distance**:

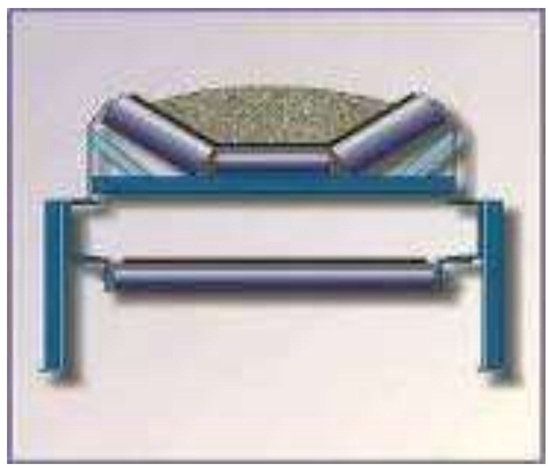
Belt Width (in)	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**72**	**84**	**96**
Edge Distance (in)	1.89	2.22	2.55	2.88	3.22	1.89	2,22	2.55	2.88	3.22	6.18

Table 18: CEMA Standard **Skirtboard Width**, **Ws**:

Belt Width (in)	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**72**	**84**	**96**
Skirtboard Width (in)	12	16	20	24	28	32	36	40	48	56	64

Practical Examples:

1. Calculate the capacity of a **24 inches** belt conveyor with the following data:



Belt conveyor speed, **v** = 1.2 m/s;
Bulk density, **δ** = 1200 Kg/m³;
Conveyor slope, **φ** = 10°;
Rolls - troughed angle, **α** = 15°;
Surcharge angle, **β =** 20°

Qt = At x v x 3.6 x φ x K

Qt = 0.026 (table) x 1,2 x 3.6 x 1200 x 0.954 **= 130 t/h**

$$Qt = \frac{A_t \times \delta \times v \times K}{33.333} =$$

$$Qt = \frac{0.283 \text{ (table)} \times 75 \times 240 \times 0.954}{33.333} = \boxed{145 \text{ tph}}$$

2. Calculate the capacity of a **36 inches belt conveyor** with the following data:

Qt = Belt conveyor capacity - tph (loaded with 100% e 78% – see table;
At = Cross section area - m² (ft²);
V = Belt speed = 1.0 m/s (200 fpm);
δ = Bulk density = 1750 kg/m³ (110 lb/ft³);
β = Rolls - troughed angle = 35°;
α = Surcharge angle (phosphate rock) = 20°.
K= Slope correction = 15° = 0.954;

3. Capacity calculations according to loading capacity (metric and US systems):

Qt = 0.091 (table) x 1.0 x 3.6 x 1750 x 0.954 **= 547 t/h = 100 % capacity (metric);**

Qt = 0.071 (table) x 1.0 x 3.6 x 1750 x 0.954 **= 427 t/h = 78% capacity (metric);**

Table 19: Example of Capacity for a 36" Width Conveyor Belt:

Belt Width 36" (900 mm)	Rolls - Troughed Angle β	Cross Sectional Area (m^2) (ft^2)	Belt Speed 1,0 m/s (200 fpm) Capacity t/h
	35° (100%)	0,091 (0,980)	547 (617)
	35° (78%)	0,071 (0,764)	427 (481)

$$Qt = \frac{0.980 \text{ (table)} \times 110 \times 200 \times 0.954}{33.333} = 617 \text{ tph}$$ **= 100 % capacity (US);**

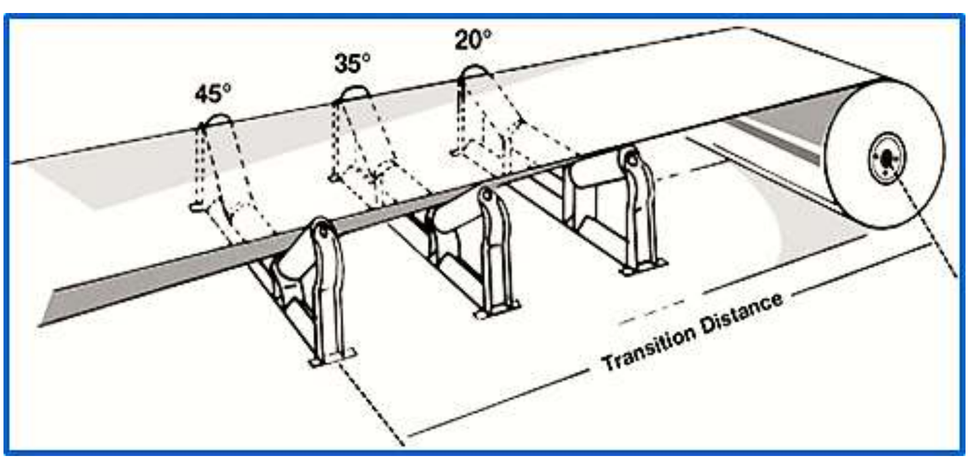
$$Qt = \frac{0.764 \text{ (table)} \times 110 \times 200 \times 0.954}{33.333} = 481 \text{ tph}$$ **= 78 % capacity (US).**

Obs.: There is a difference when conversion of capacity in tph between **metric and imperial** calculations using the formula. We recommend CEMA procedures when someone needs calculation with imperial formulas. Anyway, for common and practical conditions a good procedure is taking the average capacity between the metric and imperial final capacity calculations, as showed above.

6. BELT CARRYING IDLERS OR BELT TROUGHED ROLLERS:

Troughed belt conveyor is defined when the belt forms a trough on the carrying side while running over **idler rollers** which are either in set of **2 rolls, 3 rolls or 5 rolls**. The **standard trough angles** are commonly: **15°, 20°, 25°, 30°, 35°, 40° and 45°**. Return idlers are usually straight roller type.

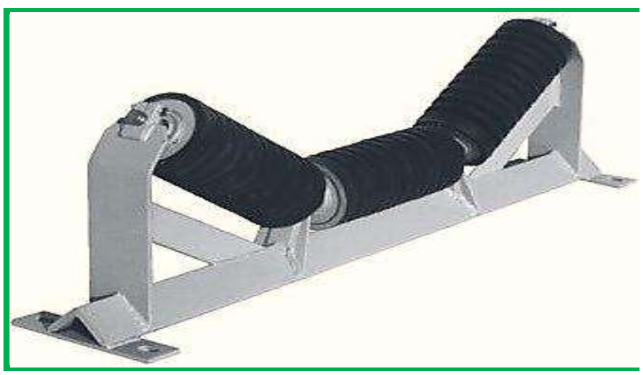
Transverse flexibility or rigidity of the belt is another significant consideration. It is important that the belt trough properly. The empty conveyor belt must make sufficient contact with the center roll in order to track properly. Troughed belt conveyors are used for higher capacity, higher speed requirements, and for handling bulk material of large lump size. It is suitable for inclined or declined type conveyors.



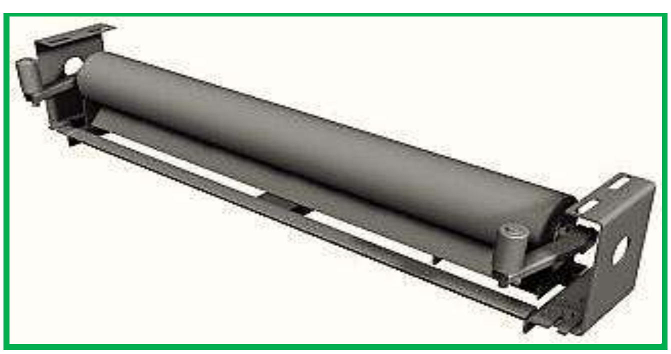
The transition distance is defined as the distance from the **center line** of the first fully **troughed idler** roll to the **center line** of either the head or **tail pulley**. The distance from the pulley to the top of the wing idler is certainly greater than the distance from the pulley to the center roll of the troughing set. If the transition distance is too short, the edge of the belt can be over stretched. This will adversely affect the load support and belt life.

a. Three in Line Idler Rolls: The most commonly used type of carrying idlers used, consist of three in line idler rolls of equal length. The three roll troughing idlers form the belt into the best troughed shape to carry a maximum load cross section.

b. Impact Idlers: Are another type of carrying idlers used at the loading points, where the lump size and the weight of the material mass seriously damage the belt, if the belt are too much rigidly supported. Such idlers are called as impact idlers.



c. Return Idlers: Are used for supporting the belt in return side, positioned between brackets attached directly to the conveyor frame, designated as Return idlers: The return idlers which carry the weight of the empty belt in the return side or the lower side of the conveyor are mostly single roller straight idler. The main dimensions of the idler are the diameter and length.



d. Special Impact Idlers: The most frequently used type of special **impact idlers** consist of a three roll assembly, each roll being made of spaced resilient discs. These idlers are also known as cushion idlers.

e. Idlers Common Diameters: The most common diameters of carrying and return idlers are the following: **Roll Diameters**: **2 ½", 3", 3 ½", 4", 4 ¼", 4 ½", 5", 5 ¼", 5 ½", 6".**

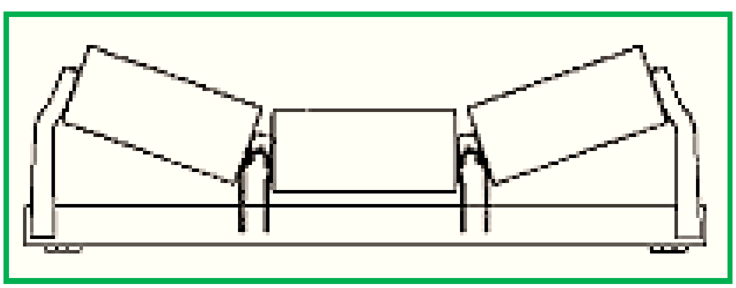
f. Idler Spacing: The spacing of idlers on the loaded run of the conveyor, carrying bulk material, depends on the belt width, the specific weight of the bulk material, the type of the idler. The spacing of the idlers in the loading zone of the belt is about half the normal spacing of idlers in the carrying side.

A set of **self-aligning idler** or training idler should be provided at the carrying side and return side at an interval of **15.0 m (50.0 ft)** on the carrying run and 30 m (100.0 ft) at the return run. It consists of an ordinary troughed three roller idler mounted on swivel frame which is free to swivel within a limit about a vertical pivot.

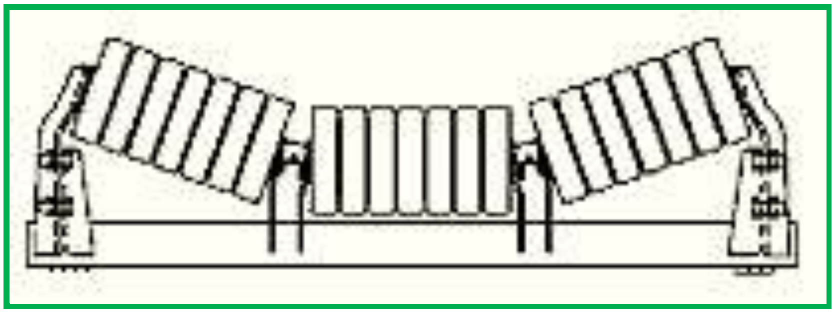
g. Application Example: Belt speed of about **5 m/s**, (16.4 ft/s), temperature of about **20°C** (68°F), and **108** mm (4 ¼") to **159** mm (6 ¼") diameter carrying idlers with ball bearing and labyrinth grease seals, the **idler spacing** is **1.0 to 1.5 m** (3.0 ft to 5.0 ft) for upper carrying side and **3.0 m** (10.0 ft) for the return side.

7. CEMA TROUGHED IDLERS:

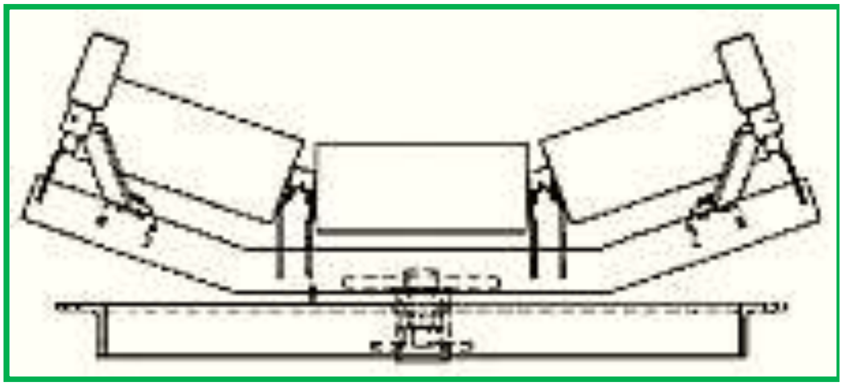
a. Troughed Belt Idlers: For general carrying service is available with roll inclinations of 20°, 35°, and 45°. The common models are: E4601S, E4601W, E4701S, E4701W, E4602S, E4602W, E4702S, E4702W, E4628S, E4628W, E4728S and E4728W.



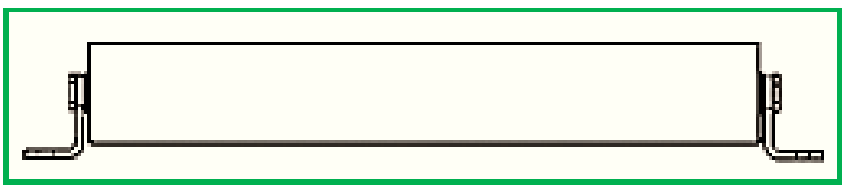
b. Rubber Cushion Idlers: Protect the belt by absorbing impacts at loading and transfer points. Design features include removable end brackets on 35° and 45° idlers. **Models**: E4604S, E4704S, E4623S, E4723S, E4630S, E4730S



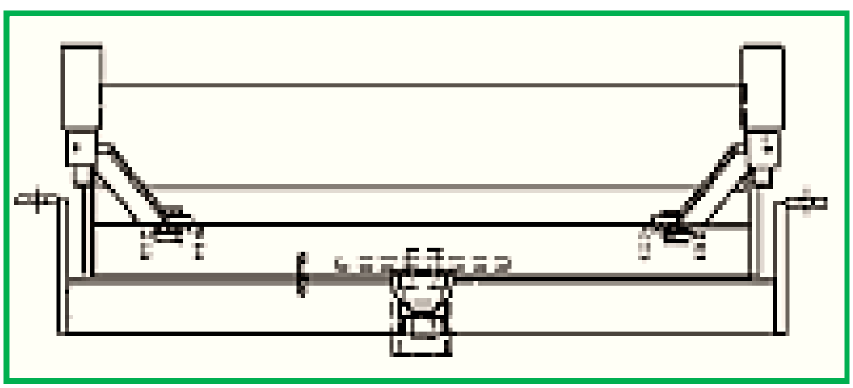
c. Training Idlers: Automatically train belts and protect belt edges from damage caused by misalignment. Positive action type for belts operating in one direction; actuating shoe type for two directional operations (reversing). **Models**: E4607S, E4707S, E4608S, E4708S E4632S, E4732S, E4637S, E4737S.



d. Flat Belt Idlers: Are used for handling bulk materials such as prepared foundry sand and underlined cotton seed where it is desirable to plow off material at one or more intermediate points along the conveyor. Also used for pulpwood logs, packages, picking and sorting conveyors. **Models**: E4613S, E4713S.



e. Flat Belt Training Idlers: automatically train belts and protect belt edges from damage caused by misalignment. Available in the positive action type for belts operating in one direction. **Models**: E4614S, E4714S.



f. CEMA Part Number Guide:

CEMA Main Types:

E = Troughing Idler Equal Length Rolls;
EI = Rubber Cushion Troughing Idler;
EA = Self-Aligner;
RET = Return Idler;
F LT = Flat Carrier Idler.

g. CEMA Classification:

Idler Specifications				
Specs	Bearing Size	Diameter	Thickness	Belt Width
CEMA B	17 mm	4", 5"	11, 9 Ga	18"- 48"
CEMA C	20 mm	4", 5", 6"	11, 9, 7 Ga	18"- 60"
CEMA D	25 mm	5", 6"	9, 7 Ga	24"- 72"
CEMA E	40 mm	6", 7"	1/4"	36"- 96"
CEMA F	50 mm	7", 8"	1/2" or 3/4"	42"- 120"

h. Coefficient of Friction: This coefficient of friction has a basic value of **0.02** for normally aligned belt conveyors and the same has a basic value of **0.012** for downhill conveyor requiring a brake motor. The coefficient of friction of **0.02** is only applicable to installations using **70% to 110%** of the nominal capacity, equipped with three roll carrying idlers for the upper side of the belt, a **30° side troughing** angle.

Under **favorable** conditions, such as properly aligned installations with properly lubricated ball bearings, the value of the coefficient of friction may be as low as **0.016**. For **unfavorable** conditions, such as poorly aligned belt conveyors with old bearings **"f"** may be as high as **0.03**.

8. STANDARD BELT CONVEYOR PULLEYS:

Diameters of **standard pulleys** are: 200 mm (8"), 250 mm (10"), 315 mm (12"), 400 mm (16"), 500 mm (20"), 630 mm (25"), 800 mm (32"), 1000 mm (40"), 1250 mm (50"), 1400 mm (56") and 1600 mm (64"). The pulleys may be **straight faced** or **crowned**. The crown serves to keep the belt centered. The height of the crown is usually 0.5% of the pulley width, but not less than **3 mm** (1/8"). The pulley diameter **Dp** depends on the number of plies of belt and may be also be determined from the formula:

Dp > K.i = (mm) (inches)

Where:

K = A factor depending on the number of plies (125 to 150);
i = Number of plies.

The drive pulley may be **lagged** by a rubber coating whenever necessary, to increase the coefficient of friction. The **lagging thickness** shall vary between **6 mm** (1/4”) to **12 mm** (1/2”). The hardness of rubber lagging of the pulley shall be less than that of the cover rubber of the running belt.

a. Pulley Types: Pulleys are manufactured in a wide range of sizes, consisting of a continuous rim and two end discs fitted with hubs. In most of the conveyor pulleys intermediate stiffening discs are welded inside the rim. Below are shown typical welded pulleys or conveyor pulleys:

 **Steel drum-pulley**	 **Spun end curve crown pulley**
 **Spiral drum conveyor pulley**	 **Welded steel pulley with diamond grooved lagging**
 **Welded steel pulley with grooved Lagging**	 **Spiral Wing Conveyor pulley**

Obs.: Other pulleys are self-cleaning wing types are used as tail, take-up, or snub pulley where material tends to build up on the pulley face. Magnetic types of pulleys are used to remove tramp iron from the material being conveyed.

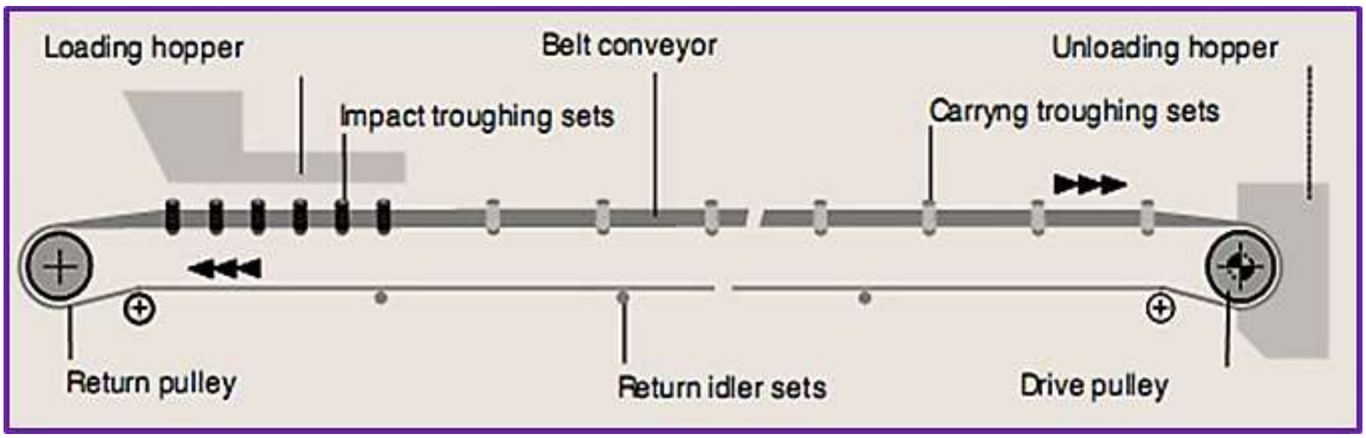
9. BELT CONVEYORS ACCESSORIES:

The function of a belt conveyor is to continuously transport bulk materials of a mixed or homogeneous sort, a variable distance of some metres to tens of kilometers. One of the principal components of the conveyor is the elastomer belt which has a double function; to contain the conveyed material and to transmit the force necessary to move the load.

The belt conveyor is designed to transport material in a continuous movement on the upper part of the belt. The belt surfaces, upper on the carrying strand and lower on the return strand, touch a series of rollers that are mounted from the conveyor structure in a group known as a troughing set. At either end of the conveyor the belt wraps around a pulley, one of which is coupled to a drive unit to transmit the motion.

Based on the load large belt conveyors are able to show cost add savings of up to 40 - 60 % with respect to truck or lorry transport. The electrical and mechanical components of the conveyor such as rollers, drums bearings, motors etc., are produced according to the highest standards.

The principal components of the conveyor, rollers and belt, need very little maintenance providing the design and the installation has been correctly performed. The elastomer belt needs only occasional or superficial repair and as the rollers are sealed for life they need no lubrication.



The high quality and advanced technology may reduce even further, or substitute, the need for ordinary maintenance. Drum lagging has a life of at least two years. The utilization of adequate accessories to clean the belt at the feed and discharge points yields corresponding improvements to increase the life of the installation with minor maintenance.

The image above illustrates the basic components of a typical belt conveyor. In practice, according to the variety of uses, it is possible to have many other diverse combinations of load and unload areas, elevations, and other accessories.

a. Drive Head: May be of traditional design or with motorized drum unit, as described below:

- **Traditional Drive Group**: Consists of a drive drum of a diameter appropriately sized to the load on the belt, and an idler drum at the opposing end. The power is supplied by a direct coupled motor gearbox or by a direct or parallel shaft drive driving the drive drum through a suitably sized couple.

- **Motorized Drum**: In this arrangement the motor, gearbox and bearings form a complete designed unit inside and protected by the drum shell which directly powers the belt. Today motorized drums are produced in **diameters up to 800 mm (32")** with **power in the order of 130 kW,** with a drive efficiency may reach **97 %**.

b. Drive Pulley: The shell face of the conventional drive pulley or the motorized drum may be left as normal finish or clad in rubber of a thickness calculated knowing the power to be transmitted. The cladding may be grooved as herringbone design; or horizontal grooves to the direction of travel; or diamond grooves; all designed to increase the coefficient of friction and to facilitate the release of water from the drum surface. The drum diameter is dimensioned according to the class and type of belt and to the designed pressures on its surface.

c. Return Pulleys: The shell face does not necessarily need to be clad except in certain cases, and the diameter is normally less than that designed for the drive pulley.

d. Deflection or Snubbing Pulleys: Are used to increase the angle of wrap of the belt and overall for all the necessary changes in belt direction in the areas of counterweight tensioner, mobile unloaders, etc.

e. Rollers: Support the belt and are guaranteed to rotate freely and easily under load. They are the most important components and represent a considerable value of the whole cost. The correct sizing of the roller is fundamental to the guarantee of the plant efficiency and economy in use.

f. Upper Trough Idlers and Return Idlers: The carrying rollers are in general positioned in brackets welded to a cross member or frame. The angle of the side roller varies from 20 to 45° . It is also possible to arrive at angles of up to 60° using the “garland” suspension design. The return roller set may be designed incorporating one single width roller or two rollers operating in a “V” formation at angles of 10°. Depending on various types of material being conveyed the upper carrying sets may be designed symmetrically or not, to suit.

g. Tension Units: The force necessary to maintain the belt contact to the drive pulley is provided by tension units. Usually there are two types of take up arrangements. These are; fixed take up device that may be adjusted periodically by manual operation and automatic take up device (constant load type).

- **Manual Screw Take-up:** The most common is the screw take-up. The take-up pulley rotates in two bearing blocks, which may slide on stationery guide ways, with help of two screws. The tension is created by the two screws which are tightened and periodically adjusted with a spanner.

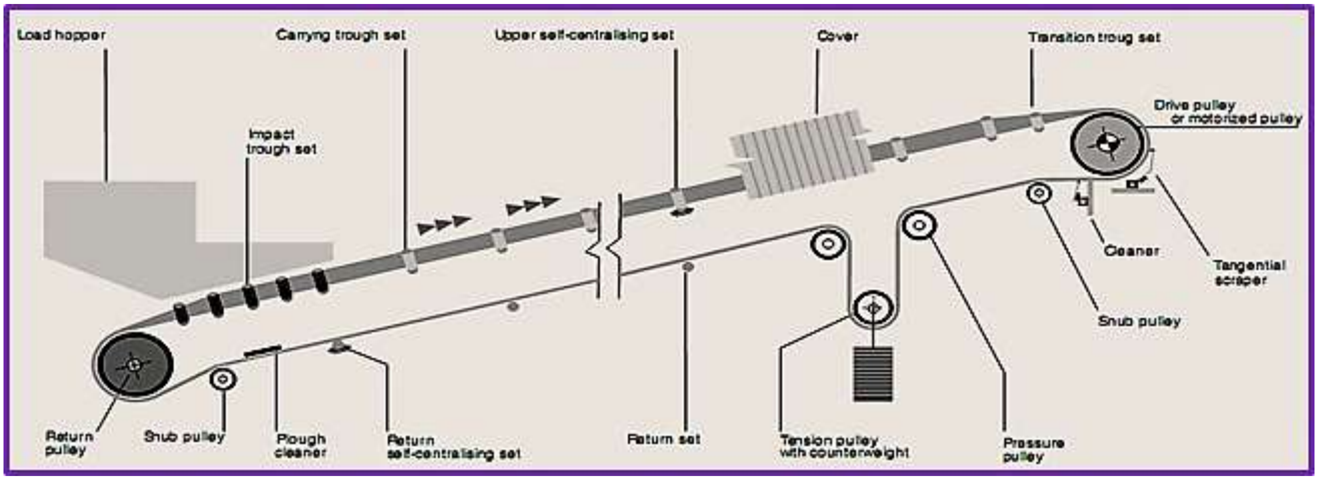
- **Counterweight:** The designed movement of the counterweight tension unit is derived from the elasticity of the belt during its various phases of operation as a conveyor. The minimum movement of a tension unit must not be less than **2%** of the distance between the centers of the conveyor using textile woven belts, or **0.5%** of the conveyor using steel corded belts.

- **Hydraulic, Pneumatic and Electrical Take-up Devices**: Are also used in automatic take up arrangement the take up pulley is mounted on slides or on a trolley which is pulled backwards by means of a steel rope and deflecting pulleys.

h. Hopper: The hopper is designed to allow easy loading and sliding of the material in a way to absorb the shocks of the load and avoids blockage and damage to the belt. The hopper slide should relate to the way the material falls and its trajectory and is designed according to the speed of the conveyor. Lump size and the specific gravity of the charge and its physical properties such as humidity, corrosiveness etc. are all very relevant to the design.

i. Cleaning Devices: The system of cleaning the belt today must be considered with particular attention to reduce the need for frequent maintenance especially when the belt is conveying wet or sticky materials. Efficient cleaning allows the conveyor to obtain maximum productivity.

j. Conveyor Covers: Covers over the conveyor are of fundamental importance when it is necessary to protect the conveyed material from the atmosphere and to guarantee efficient plant function.



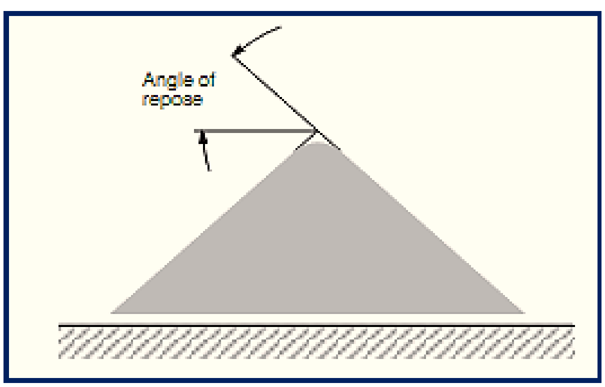
10. BASIC DESIGN CRITERIA:

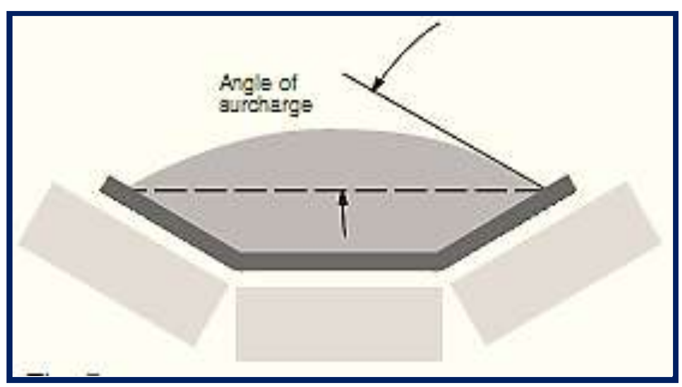
The choice of the optimum conveyor system and its project design and rationalization depends on full knowledge of the construction characteristics and the forces involved that apply themselves to all the system components. The principal factors that influence the sizing of a belt conveyor are : the required load volume, the type of transported material and its characteristics such as grain or lump size, and chemical / physical properties.

The route and height profile of the conveyor is also relevant. In the following illustrations you may follow the criteria used for the calculation of the belt speed and width, the type and arrangement of troughing sets, the type of rollers to be used and finally the determination of the drum sizes.

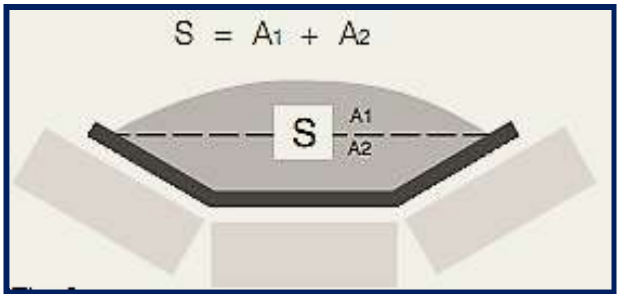
a. Conveyed Material: The correct project design of the belt conveyor must begin with an evaluation of the characteristics of the conveyed material and in particular the angle of repose and the angle of surcharge. The angle of repose of a material, also known as the “angle of natural friction” is the angle at which the material, when heaped freely onto a horizontal surface takes up to the horizontal plane.

The angle of surcharge is the angle measured with respect to the horizontal plane, of the surface of the material being conveyed by a moving belt. This angle is normally between **5° and 15°** (for a few materials up to **20°**) and is much less than the angle of repose.





b. Conveyed Material Area: The conveyed material settles into a configuration as shown in sectional diagram. The area of the section **“S”** may be calculated geometrically adding the area of a circle **A1** to that of the trapezoid **A2**.

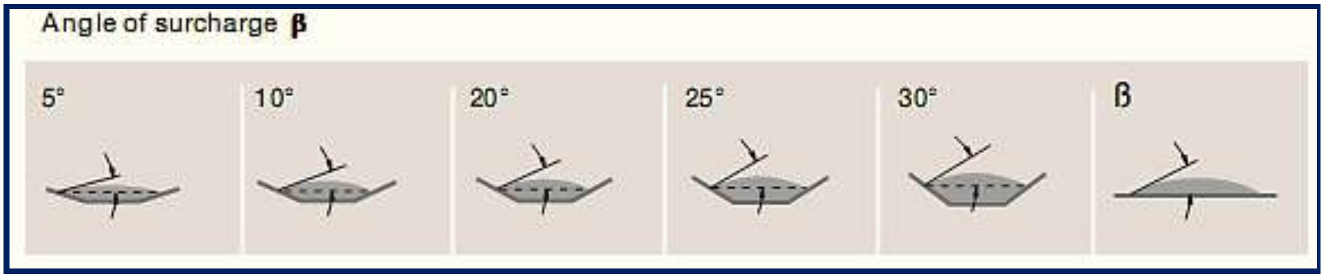


$$S = \frac{I_{VT}}{3600} \quad [m^2]$$

(1 m² = 10.76 ft²)

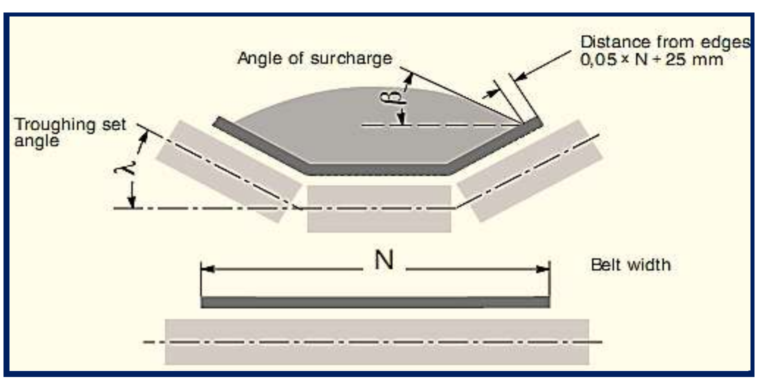
Where :

Ivt = Conveyed Volume at a conveyor speed of 1 m/s), (m²):



Belt Angle of Repose (°):				
0 -19	**20 - 29**	**30 - 34**	**35 - 39**	**40 and more**
Uniform dimensions, round particles, very small size. Very humid or very dry such as dry sand, silica, cement and wet limestone dust etc.	Partly rounded particles, dry and smooth. Average weight as for example cereal, grain and beans.	Irregular material, granular particles of average weight as for example anthracite coal, clay etc.	General everyday material as for example bituminous coal and the majority of minerals.	Irregular viscous fibrous material which tends to get worse in handling, as for example wood shavings, sugar cane by product, foundry sand, etc.

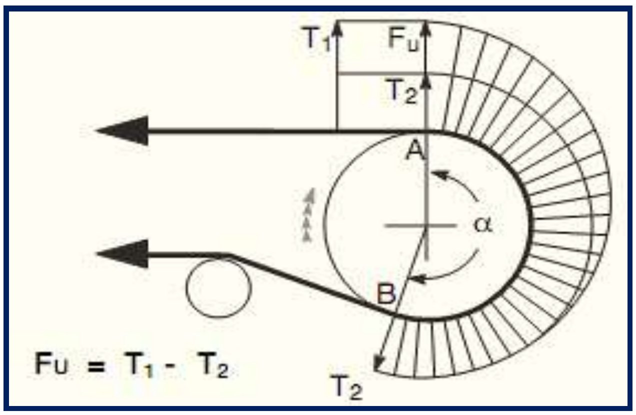
c. Belt Width: Given, the optimum belt speed, the determination of the belt width is largely a function of the quantity of conveyed material which is indicated by the project data. In the following section, the conveyor capacity may be expressed as loaded volume **Ivt** **(**m³/h)(ft³/h), per v = **1 m/s** (**3.28 ft/s**). The inclination of the side rollers (from **20°** **to 45°**) defines the angle of the troughing set.



Troughing sets at **35°/40°/45°** are used in special cases, where because of this onerous position the belts must be able to adapt to such an accentuated trough. In practice the choice and design of a troughing set is that which meets the required loaded volume, using a belt of minimum width and therefore the most economic. All things being equal the width of the belt at the greatest angle corresponds to an increase in the loaded volume IVT.

The design of the loaded troughing set is decided also as a function of the capacity of the belt acting as a trough. In the past the inclination of the side rollers of a troughing set has been always **20°**. Today the improvements in the structure and materials in the manufacture of conveyor belts allows the use of troughing sets with side rollers inclined at **30°/35°**. It may be observed however that the belt width must be sufficient to accept and contain the loading of material onto the belt whether it is of mixed large lump size or fine material.

d. Belt Tensions: Te, T1 and T2. The total tangential force Fu at the pulley circumference corresponds to the differences between tensions T1 (tight side) and T2 (output side). From these is derived the necessary torque to begin to move the belt and transmit power.



The relationship between T1 and T2 may be expressed :

$$\frac{T_1}{T_2} \leq e^{fa}$$

Where:

fa = Coefficient of friction between belt and drum, due angle of wrap;
e = Natural logarithmic base, 2.718.

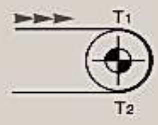
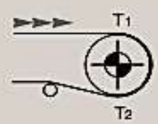
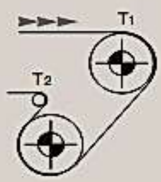
The sign (=) defines the limiting condition of belt adherence. If the ratio **T1/T2 > e**^{fa} the belt will slide on the drive pulley and the movement cannot be transmitted.

$$T_1 = F_U + T_2$$

The value **Cw**, which defines the wrap factor, is a function of the angle of wrap of the belt on the drive pulley (may be 420° when there are double pulleys) and the value of the coefficient of friction **fa** between the belt and pulley. Thus the calculation of the minimum belt tension values is able to be made to the limit of adherence of the belt on the pulley so that the position of a tensioner may be positioned downstream of the drive pulley.

A belt tensioning device may be used as necessary to increase the adherence of the belt to the drive pulley. This will be used to maintain an adequate tension in all working conditions. On the following pages various types of belt tensioning devices commonly used are described. The table below gives the value of the wrap factor **Cw** in relation to the angle of wrap, the system of tensioning and the use of the pulley in a lagged or unlagged condition.

Wrap factor **Cw**

drive arrangement	Angle of wrap α	tension unit or counterweight pulley unlagged	tension unit or counterweight pulley lagged	screw tension unit pulley unlagged	screw tension unit pulley lagged
	180°	0.84	0.50	1.2	0.8
	200°	0.72	0.42	1.00	0.75
	210°	0.66	0.38	0.95	0.70
	220°	0.62	0.35	0.90	0.65
	240°	0.54	0.30	0.80	0.60
	380°	0.23	0.11	-	-
	420°	0.18	0.08	-	-

Given the values **T1** and **T2**, we may analyze the belt tensions in other areas that are critical to the conveyor. These are:

- Tension **T3** relative to the slack section of the return pulley;
- Tension **T_0** minimum at tail end, in the material loading area;
- Tension **Tg** of the belt at the point of connection to the tension unit device;
- Tension **Tmax** is the maximum belt tension.

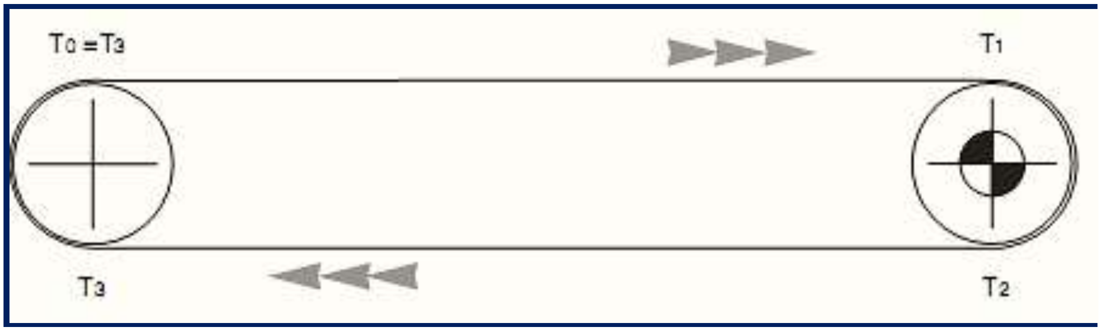
The tension **T3** that is generated at the belt slack side of the tail pulley is given from the algebraic sum of the tensions **T2** and the tangential forces **Fr** relative to a single return section of the belt.

Tension T3 already defined,

$$T_1 = Fu + T_2 \quad \text{and} \quad T_2 = Fu \times Cw$$

Therefore the tension T3 is given by :

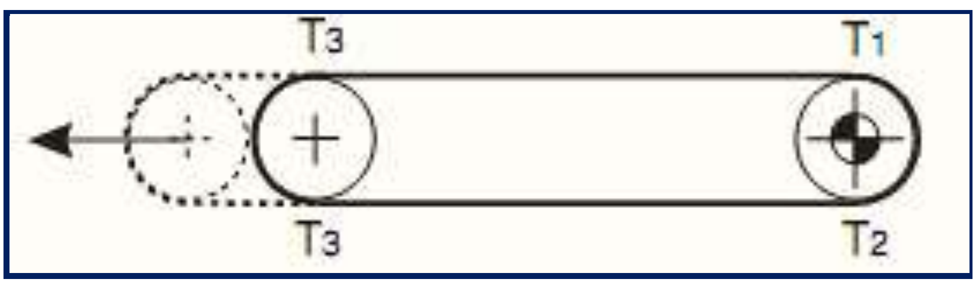
$$T_3 = T_2 + (Fr_1 + Fr_2 + Fr_3 \ldots)$$



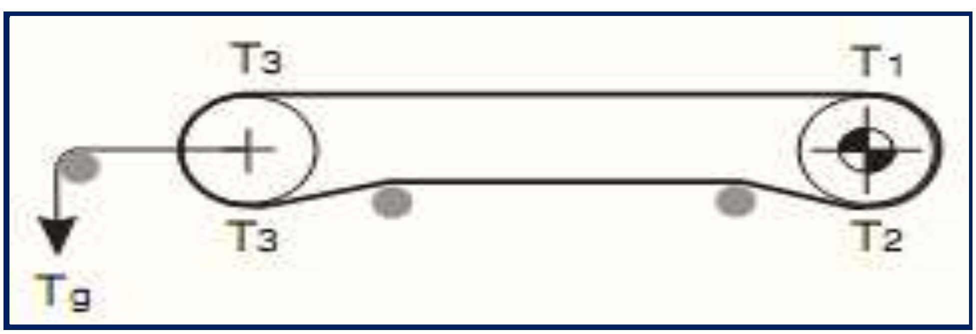
e. Tension T_0: The minimum necessary tension **T3** at the slack side of the return pulley, besides the belt adhesion to the driving pulley so as to transmit the movement must also guarantee a deflection not superseding **2%** of the length of pitch between consecutive troughing sets. Furthermore the tensions must avoid material spillage from the belt and excessive passive resistance caused by the dynamics of material as the belt travels over the troughing sets the minimum tension T_0 necessary to maintain a deflection of **2%,** as defined before:

f. Tension Tg and Tensioning Devices: Tension devices used generally on belt conveyors are screw type or counterweight. The screw type tension unit is positioned at the tail end and is normally **applied to conveyors** where the centers not more than **30 / 40 m (98 ft / 131 ft)**. Where conveyors are of larger centers the counterweight tension unit is used or winch style unit where space is at a premium. The tension unit minimum movement required is determined as a function of the type of belt installed, that is :

- The stretch of a belt with **textile core** needs a minimum **2%** of the conveyor centers;
- The stretch of a **belt with metal or steel core** needs a minimum of **0.3/0.5%** of the conveyor centers. Typical tension by screw device: In this arrangement the tension is regulated normally with the occasional periodic check of the tensioning screw.

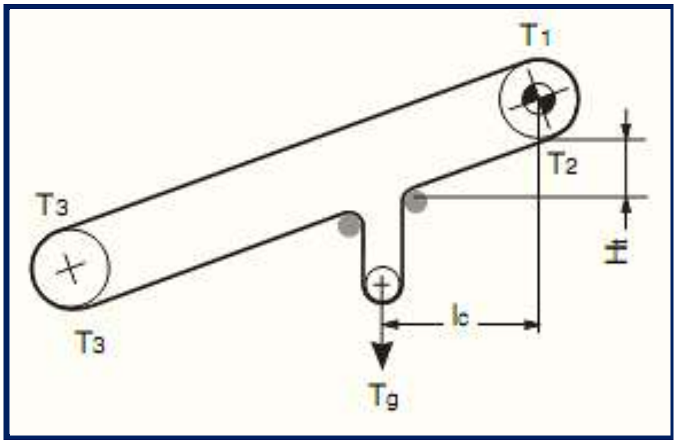


In this arrangement the conveyor is tensioned using a counterweight.



$$T_g = 2(T_3)$$

Also in this arrangement the conveyor is tensioned using a counterweight.



$$Tg = 2T_2 + 2\,[(Ic \times Cq \times Ct \times f)\,(q_b + q_{RU}) \pm (Ht \times q_b)]$$

Where:

Ic = Distance from centre of drive pulley to the counterweight point;
Ht = Belt height change from the point where the counterweight applies to the point where the belt exits from the slack side of the pulley, (m) (ft).

g. Correct Dimensioning Verification: The belt is adequately dimensioned when the essential tension **T3** (for the correct deflection of the belt) is less than the calculated tension $\mathbf{T_0}$ the tension **T** has to be:

T2 = Fu x Cw and is calculated as:
T2 = T3 ± Fr (where T3 = T_0)

h. Maximum tension (Tmax): This is the belt tension at the point where the conveyor is under the greatest stress. Normally it is coincidental in value with tension **T1**. Along the length of a conveyor with variable height change and in particular where conditions are variable and extreme, **Tmax** may be found in different sections of the belt.

$$Tu_{max} = \frac{Tmax}{B} = (kg/m)\ (lb/ft)$$

Where:

Tmax = Tension at the highest stress point of the belt (kg) (lb);
B = Belt width (m) (ft);

i. Roller Diameter in Relation to Speed: The formula below gives the existing relationship between maximum belt speed, roller diameter and the relative r.p.m. The correct choice of diameter must take into consideration the belt width. From the belt speed and roller diameter we are able to determine the revolutions per minute of the roller using the formula:

$$n = \frac{v \times 1000 \times 60}{D \times \pi}\ [r.p.m]$$

Where:

D = roller diameter [mm] (in);
v = belt speed [m/s] (ft/s).

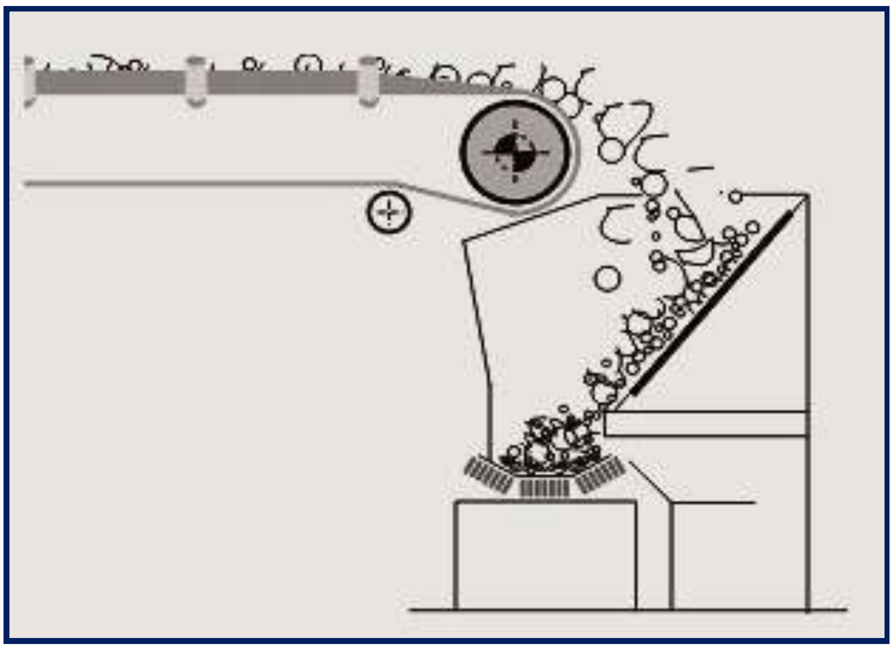
j. Driving Power: Considering the total tangential force (Fu) at the periphery of the drive pulley, the belt speed (v) and the efficiency (η) of the reduction gear, the minimum necessary driving power (P) is:

$$P = \frac{Fu \times v}{100 \times \eta} \text{ [kW]}$$

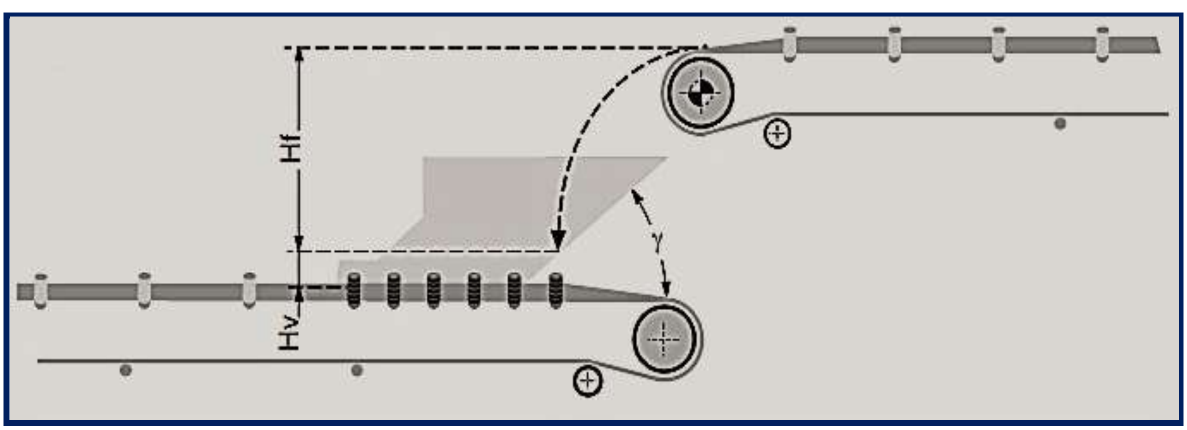
(1 kW = 1.34 HP)

11. LOADING OF BELT AND IMPACT ROLLERS:

The feed system of material falling or dropping onto a belt conveyor must be constructed to minimize or eliminate impact damage to the belt material and surface. This is of particular importance when the material falls from a considerable height and consists of large lumps with sharp edges. The rollers supporting or carrying the belt in the loading zone are normally installed as impact design (with rubber rings), mounted onto troughing set frames set close to each other.



The height the material falls, must be reduced to the minimum possible, compatible with the requirements of the plant design. In the choice of impact rollers is important to follow two significant design aspects; constant loading with uniform fine material and loading with material consisting of large lumps.



a. Constant Loading with Uniform Fine Material: Impact rollers must be designed not only to carry the load of material arriving on the belt but also the impact load from falling material. For loose, homogenous fine material the impact force **(pi)**, given the corrected fall height, is calculated according to the following formula:

$$pi \cong Iv \times \frac{\sqrt{Hc}}{8} \quad [Kg]$$

The definition of the correct load fall height **Hc** may be given by the following formula :

$$Hc = Hf + Hv \times sen^2\gamma$$

Where:

pi = Impact force;
Iv = Flow of material in t/hr (the belt load capacity;
Hf= Fall height from the upper face of the loading belt to the contact point of material in the hopper;
Hv = Height from the contact point of material contained in the hopper to the belt face of the lower belt;
γ = Hopper inclination angle.

The force acting **(pic)** on the central roller, is obtained with the factor Fp, and the side roller angle λ:

$$pic \cong Fp \times pi$$

where:

$Fp = 0.65$ per $\lambda = 30°$
$Fp = 0.67$ per $\lambda = 35°$
$Fp = 0.72$ per $\lambda = 45°$

Example: Calculate the impact force **(pi)** and the central roller load **(pic)** on a transition belt conveyor, given that the loading of the material is:

Iv = 1800 t/h,
Hc = 1.5m
λ = 30°

$$pi = 1800 \times \frac{\sqrt{1.5}}{8} = 275 \text{ Kg}$$

The load on the central roller is:

$$pic = Fp \times pi = 0.65 \times 275 = 179 \text{ Kg}$$

b. Belt Cleaners: Efficient systems of belt cleaning result from a reduction in belt maintenance time and increased production, proportional to the quantity of material recovered in the process and a large increase in the life of moving parts. There are a variety of devices used for belt cleaning. The majority of these may be divided into two groups; static and dynamic.

- The static systems may be applied along all positions on the dirty side of the belt, acting directly on the belt using a segmented blade.

- The dynamic systems use driving electric motors and more costly in terms of capital cost, installation and commissioning.

- The belt cleaners consist of pulleys or motorized pulleys fixed with special plastic or rubber materials or brushes, in direct contact with the belt.


Static belt cleaners


Dynamic belt cleaners

c. Examples of Special Belt Conveyors: The overland conveyor shown below, given as an example, was designed with horizontal and vertical curves to handle bulk materials on both the upper and lower belt strands at the same time. The conveyor reliably handles different materials simultaneously between the cement plant and the harbor.

Material Conveyed:

- Cement clinker on the upper belt from the plant to the harbor;
- Coal, gypsum and slag on the lower belt from the harbor to the plant;
- Capacity: 850 t/h on the upper belt and 575 t/h on the lower belt;
- Conveying speed: 2,70 m/s;
- Drive capacity: 6 x 132 kW;
- Center distance: 4196 m Belt width: 1000 mm;
- Curve radii: 1500/1700/2000 m;
- No. of horizontal curves: 6;
- No. of vertical curves: 18;

The installation of the conveyor shown below, guarantees a continuous flow of raw material from the primary preparation plant in the quarry and the cement operations. The layout design had many considerations to take into account, including mountains and valleys, rugged terrain and crossing of a road and river. Due to the topography of the conveyor route, this installation featured the integration of horizontal curves into vertical curves.

12. BELT CONVEYOR COVERS:

Commonly fabricated in a robust construction of **aluminum** or **galvanized steel**, which efficiently protects the material being carried from being down off the conveyor.

Application:

- Protection of belting, material and idlers from wind, rain and snow.
- Covers manufactured out of 22 GA. (0.034"), generally smooth galvanized steel.
- Bands manufactured out of 12 GA. (.108") generally galvanized steel (up to 36") and 10 GA. (0.138") 42" and larger.
- 4'-0" Long sections are standard.

Models:

- Full style (180º belt coverage).
- 3/4 Style (135º belt coverage).
- A-60 Style (larger vertical sides).
- A-63 Style (larger vertical sides and radius for CEMA E Idlers).
- A-1-Full Aluminum Hoods.

Sizes:

Belt Widths:

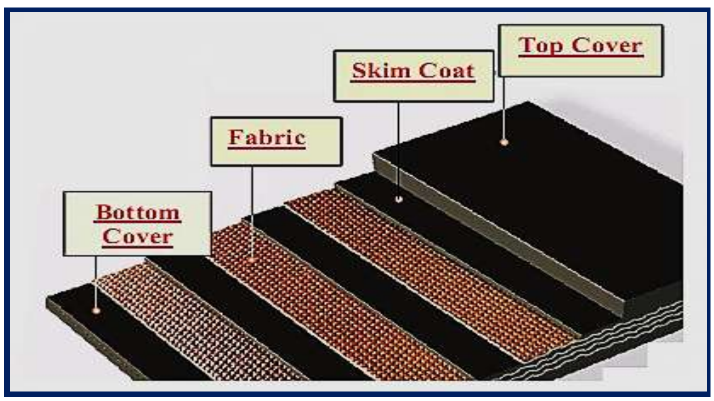
- 18" to 72"
- 18" to 60"
- 36" to 96"

On inclined not covered conveyors the rain can cause bigger problems because the material gets washed away. The sides must be opened easily, to permit inspection or roller replacement, simplifying maintenance. Sheet **galvanized steel metal** or **aluminum** covers can be the perfect solution to protect the material from rain and wind and to protect the environment from noise and dust.

Besides metal covers, there is a possibility of covering the conveyors with **PVC** and **rubber** covers. Commonly the sheet metal covers are made of **galvanized steel** with maximum thickness of **0,75 mm**, self-standing, safe and very easy to assembly and disassembly. They do not require any maintenance and can be mounted on any conveyor with belt width from **400 to 1800** mm.

13. BELT FABRICATION TYPES:

Belts are fabricated to be applicable to all types of industry, especially in areas where aggregate or bulk materials are carried, from light duty to the heaviest of service conditions.



a. Conveyor Belt Types: The conveyor belts are supplied with **2 to 6 plies**. This makes it possible to provide the ideal construction for every application, available in all cover qualities.

Rubber Belts - for general purposes:

RMA-1 DIN-X, M BS-M24 AS-M JIS-S	These cover rubber grades have the characteristics to provide the highest abrasion resistance & cut-and-gouge resistance as well as ozone resistant. These cover rubbers are used for heavy impact, large sized lumps, and sharp material		
RUBBER GRADE	TENSILE STRENGTH Min (Mpa.N/mm²)	ELONGATION Min (%)	ABRASION LOSS Max (mm³)
DIN-X	25	450	120
DIN-M(RMA-1)	25	450	150
AS-M	24	450	125

RMA-2 DIN-Y, N BS-N17 AS-N JIS-G	These cover rubber grades are widely used for general purpose with resistance to abrasion, ozone, cutting and gouging and suitable for handling crushed rock, limestone, coal, slag, etc.		
RUBBER GRADE	TENSILE STRENGTH Min (Mpa.N/mm^2)	ELONGATION Min (%)	ABRASION LOSS Max (mm^3)
DIN-Y	20	400	150
DIN-N(RMA-2)	20	400	200
AS-N	17	400	200

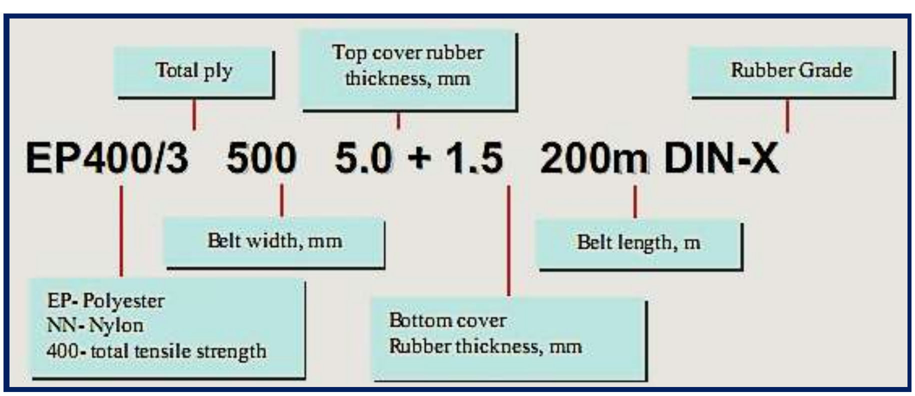
b. Application and Operation Conditions: Suitable for wide ranges of operating conditions. The bulk handling conveyor belt is widely utilized in the industrial fields of mining, engineering works, cement, quarry and aggregate industries. Depending on the cover rubber selection, the belts are suitable for both conveyor and elevator services.

Nylon/Polyester Belt:

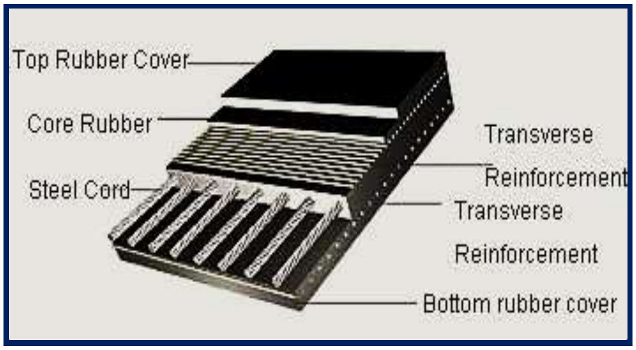
ITEM	GRADE	NN100	NN120	NN150	NN200	NN250	NN300	NN350	NN400	NN500
Min Tensile Strength	Kg/cm-ply	100	120	150	200	250	300	350	400	500
	Lb/in-ply	560	672	840	1'120	1'400	1'680	1'960	2'240	2'800
Working Tension Rating (Vulcanized)	Kg/cm-ply	8.4	10.0	12.5	16.7	20.8	25.0	29.2	33.3	41.7
	Lb/in-ply	46.7	56.0	70.0	93.3	116.7	140.0	163.3	186.7	233.3
Approx. Gouge per Ply with skim coat	Mm	0.70	0.85	0.90	1.15	1.20	1.35	1.60	1.70	2.10
	inch	0.028	0.034	0.035	0.045	0.047	0.053	0.063	0.067	0.083

c. Belt Manufacturing Features: Exceptional shock & impact resistance to the carrying surface. Excellent through ability and flexibility. Good resistance to dew and water. The main belting product purposes are; Abrasion resistant; Heat resistant; Oil and fat resistant; Fire resistant; Multi-ply belts; Impact, rip and tear resistant; Steel reinforced; Monoply solid woven; Closed conveyor; Profiled belts; Slider belts; Aramid reinforced; Elevator belts.

Standard Designation:



d. Steel Cord Belts: The main features are, high tensile strength, shock resistant, long-life, good troughable, and flexing resistant, suitable for conveying in long-distant, high-speed and large quantity conveying, used in cement plants, coal-fired power plants, ports, and chemical industry.



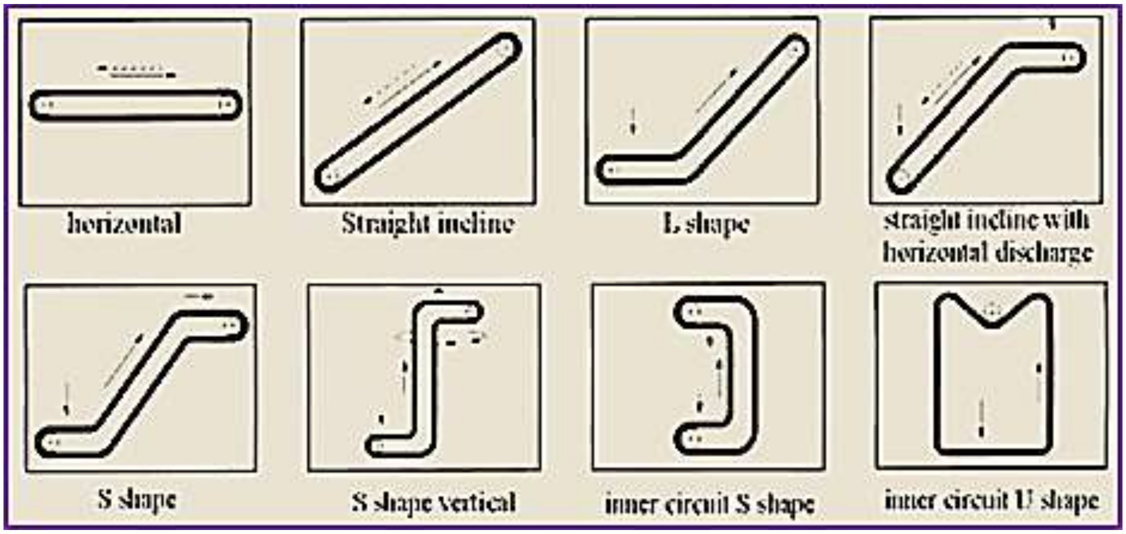
e. Operational Types: Conventional, fire-resistant, cold-resistant, abrasion-resistant, heat-resistant, acid & alkali-resistant and oil-resistant.

Steel cord belt standard and major data

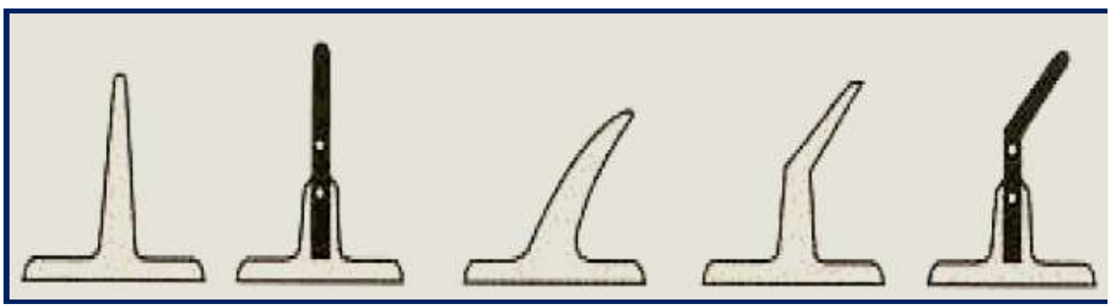
Type	Standard and main technical data
Conventional	GB9770
Fire-retardant	HG2539 II type MT147
Conventional flame retardant	HG2539 I type
Heat-resistant	HG2297
Abrasion-resistant	shore abrasion 90 mm^3
Heat abrasion-resistant	resistant 125C^o, shore abrasion 150mm^3
Acid/alkali/oil /resistant	HG4-846
Cold-resistant	fragility temperature -40C^o

f. Corrugated Flex Belts: Corrugated sidewall conveyor belts are types with the most effective ways of elevating materials in a confined space achieved by: single belt operation, wide range material can be handled, less space requirement, no transfer point, low maintenance and big capacity.

g. Corrugated Belt Applications: Used in cement plants, coal-fired power plants, ports, and chemical industry. Types**:** Four parts: top cover rubber; bottom cover rubber; reinforced core; cross-rigid. Thickness of top cover rubber: **3 – 6 mm**; Thickness of bottom cover rubber: **1.5 - 4.5 mm**.



h. Cleat Types - T, TS, C, TC and TCS: The cleat is made of enforced fabrics; solid, anti-shock to avoiding distortion **"TS and TCS"** cleat are normally use d for abrasion condition. The cleat type **"T" and "TS"** are normally used up to 40° inclination; the **"C, TC and TCS"** are normally used from 40° to 90°. Sidewall, cleat and base belt are joined through double hot vulcanization method. Cleat and sidewall are joined through bolt to prevent leakage of material.



14. INTERNATIONAL ISO STANDARDS:

ISO 1049:1975:

Continuous mechanical handling equipment for loose bulk materials - Vibrating conveyors and feeders with rectangular or trapezoidal trough;

ISO 1050:1975:

Continuous mechanical handling equipment for loose bulk materials - Screw conveyors;

ISO 1535:1975:

Continuous mechanical handling equipment for loose bulk materials - Troughed belt conveyors (other than portable conveyors) - Belts;

ISO 1536:1975:

Continuous mechanical handling equipment for loose bulk materials - Troughed belt conveyors (other than portable conveyors) - Belt pulleys;

ISO 1537:1975:

Continuous mechanical handling equipment for loose bulk materials - Troughed belt conveyors (other than portable conveyors) – Idlers;

ISO 1807:1975:

Continuous mechanical handling equipment for loose bulk materials - Oscillating conveyors and shaking or reciprocating feeders with rectangular or trapezoidal trough;

ISO 1815:1975:

Continuous mechanical handling equipment for loose bulk materials - Vibrating feeders and conveyors with tubular trough;

ISO 1816:1975:

Continuous mechanical handling equipment for loose bulk materials and unit loads - Belt conveyors – Basic characteristics of motorized driving pulleys;

ISO 2109:1975:

Continuous mechanical handling equipment - Light duty belt conveyors for loose bulk materials;

ISO 2139:1975:

Continuous mechanical handling equipment for loose bulk materials - Oscillating conveyors and shaking or reciprocating feeders with tubular trough;

ISO 2140:1975:

Continuous mechanical handling equipment for loose bulk materials - Apron conveyors;

ISO 2406:1974:

Continuous mechanical handling equipment – Mobile and portable conveyors - Constructional specifications;

ISO 4123:1979:

Belt conveyors - Impact rings for carrying idlers and discs for return idlers - Main dimensions;

ISO 5048:1989:

Continuous mechanical handling equipment – Belt conveyors with carrying idlers - Calculation of operating power and tensile forces;

ISO 7119:1981:

Continuous mechanical handling equipment for loose bulk materials - Screw conveyors - Design rules for drive power;

ISO 7189:1983:

Continuous mechanical handling equipment – Apron conveyors – Design;

ISO 1120:2002:

Conveyor belts - Determination of strength of Mechanical fastenings - Static test method;

ISO 14890:2003:

Conveyor belts - Specification for rubber or plastics covered conveyor belts of textile construction for general use;

ISO 16851:2004:

Textile conveyor belts - Determination of the net length of an endless (spliced) conveyor belt;

ISO 21180:2005:

Light conveyor belts - Determination of the maximum tensile strength;

ISO 21182:2005:

Light conveyor belts - Determination of the coefficient of friction;

ISO 3684:1990:

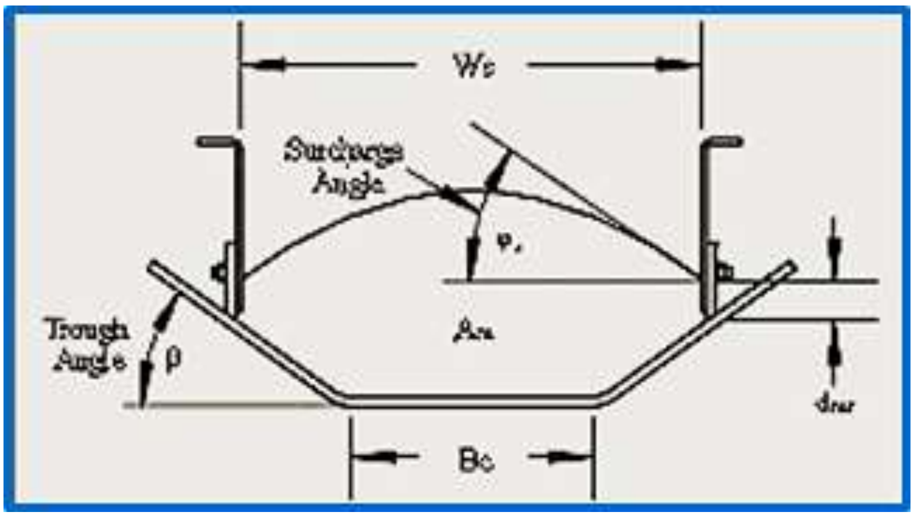
Conveyor belts - Determination of minimum pulley diameters;

15. EASY SPREADSHEET CALCULATION TABLE: (Copy and paste to an excel spreadsheet).

PRACTICAL SPREADSHEET FOR BELT CONVEYORS USING THE FORMULA: - Qt = At x v x 3,6 x ϕ x K1 x K2							
Procedure: In red columns, give the desired speed (m/s), material density (kg/m3), conveyor belt inclination factor (see table below), accommodation angle factor (surcharge angle - see table below):							
EXAMPLE: Belt 24"; Load Idlers at 20°; v = 1,0; δ = 1200; Belt Conveyor Inclination 15°; Surcharge Angle = 15°							
Belt Width (Inches) (mm)	Trough Angle	At -Load Cross Area (m²)	Speed (m/s)	Material Density	Belt Inclination Factor	Accommodation Angle Factor	Capacity (t/h)
			v	δ	K1	K2	Qt =
(24") 600	20	0,033	**1**	**1000**	**0,954**	**0,7**	**79,3**
	25	0,037	**1**	**1000**	**0,954**	**0,7**	**89,0**
	30	0,038	**1,5**	**1200**	**0,954**	**0,7**	**164,4**
	35	0,04	**1,5**	**1500**	**0,954**	**0,7**	**216,4**
(30") 750	20	0,054					0,0
	25	0,06					0,0
	30	0,062					0,0
	35	0,065					0,0
(36") 900	20	0,08					0,0
	25	0,09					0,0
	30	0,092					0,0
	35	0,096					0,0
(42") 1050	20	0,111					0,0
	25	0,124					0,0
	30	0,128					0,0
	35	0,134					0,0
(48") 1200	20	0,147					0,0
	25	0,165					0,0
	30	0,17					0,0
	35	0,178					0,0
(54") 1350	20	0,189					0,0
	25	0,211					0,0
	30	0,217					0,0
	35	0,227					0,0
(60") 1500	20	0,235					0,0
	25	0,263					0,0
	30	0,271					0,0
	35	0,283					0,0
(72") 1800	20	0,343					0,0
	25	0,384					0,0
	30	0,395					0,0
	35	0,413					0,0

BELT INCLINATION ANGLE	0°	5°	10°	15°	17,5°	20°
COSINE FACTOR K1	1.00	0.996	0.985	0.954	0.940	0.906

SURCHARGE ANGLE	LOAD IDLERS ANGLE (TROUGH ANGLE) – FACTOR K2			
	20°	25°	30°	35°
10°	0.61	0.70	0.77	0.84
15°	0.70	0.78	0.86	0.92
20°	0.79	0.87	0.94	1.00
25°	0.88	0.96	1.03	1.08



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