IS 11592 (2000): Selection and Design of Belt Conveyors - Code of Practice [MED 6: Mechanical Engineering]

भारतीय मानक

पट्टा वाहकों का चयन और डिजाइन — रीति संहिता

(पहला पुनरीक्षण)

Indian Standard

SELECTION AND DESIGN OF BELT CONVEYORS — CODE OF PRACTICE

(First Revision)

ICS 53.040.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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TO
IS 11592 : 2000 SELECTION AND DESIGN OF BELT CONVEYORS — CODE OF PRACTICE

(First Revision)

[*Page* 20, *clause* **8.5.4.5**, *Equation* (34)] — Substitute the following for the existing:

$$T_{max} = T_1 = T_E \left\{ \frac{\xi}{\varepsilon^{\mu\varphi} - 1} + 1 \right\} \qquad ...(34)$$

(MED 06)

Reprography Unit, BIS, New Delhi, India

Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, ME 06

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee had been approved by the Mechanical Engineering Divisional Council.

Belt conveyors play an important role in the key sectors of the economy such as mines, steel plants, thermal power stations etc. Accordingly, the design of the belt conveyors has to take care of various parameters. This standard has been prepared to help the engineers and technocrats and industry for making use of uniform practice for selection and design of belt conveyors in India.

This standard was first published in 1985 and has been revised to bring it in line with ISO 5048 which has since been revised. In addition, the reference of Indian standards referred in the standard is also being up-dated. Further the errors noted during the implementation of the standards are also being corrected.

This standard has basically covered the conveyor system using belts from 300 mm to 2 000 mm belt widths conforming to IS 1891 (Part 1) : 1994 'Conveyor and elevator textile belting : Part 1 General purpose belting *(fourth revision)'.* At present belts of width upto 3 000 mm are also being used in Indian industries. This standard can be made applicable to belts of all widths subject to availability of technical data.

In the preparation of this standard assistance has been derived from the following:

ISO 5048 : 1989	Continuous mechanical handling equipment — Belt conveyors with carrying idlers — Calculations of operating power and tensile forces
ISO 5049 (Part 1) : 1994	Mobile equipment for continuous handling of bulk materials — Part 1 : Rules for design of steel structures
ISO 5293 : 1981	Conveyor belts — Formula for transition distance on three equal length idler rolls
ISO/TR 10357 : 1989	Conveyor belts — Formula for transition distance on three equal length idler rollers (new method)
DIN 22101 : 1979	Continuous mechanical handling equipment; belt conveyors for bulk materials: bases for calculation and design
BS 2890 : 1973	Troughed belt conveyors
BS 5934 : 1980	Method for calculation of operating power and tensile forces in belt conveyors with carrying idlers on continuous mechanical handling equipment

For the purpose of deciding whether a particular requirement of this standard is compiled with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values *(revised)'.* The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

SELECTION AND DESIGN OF BELT CONVEYORS — CODE OF PRACTICE
(*First Revision*)

1 SCOPE

1.1 This standard provides guidance for selection and design practices to be adopted for belt conveyors.

1.2 This standard applies to stationary and shiftable and/or extendable conveyors handling loose bulk material and such material, which behave as solids. For guidance, classification and properties of such material are covered in IS 8730.

1.3 This standard covers the conveyors with belt widths ranging from 300 mm to 2 000 mm as currently in vogue in conformity with relevant Indian Standards but excluding special purpose conveyors.

NOTES

1 Conveyors, not covered under this scope and special purpose conveyors, for example, feeders, package conveyors, etc, will be covered in a separate standard.

2 This standard also covers the conveyors using steel cord belting.

3 Special requirements for conveyors for use in underground coal mines are also covered by this standard.

4 This standard does not include certain data on steel cord conveyors and conveyors for underground mines where relevant Indian Standards are available.

1.4 Attention is drawn to the many varied factors which influence the driving force on the drive pulley and which make it extremely difficult to redirect the power requirement exactly. This Indian Standard is intended to give a simple method of conveyor design calculation. Consequently it is limited in terms of precision but is sufficient in the majority of cases. Many factors are not taken into account in the formulae but details are provided on their nature and their effect. In simple cases, which are the most frequent, it is possible to progress easily from the calculation of power requirements to those of the necessary and the real tensions in the belt, which are critical in the selection of the belt and in the design of the mechanical equipment. However, certain conveyors present more complicated problems, for example those with multiple drives, or with an undulating profile in vertical elevation. For these calculations, which are not covered in this Indian Standard, it is advisable to consult a competent expert.

1.5 The recommendations given in this standard shall be applied both to individual conveyor, as well as conveyor systems consisting of more than one conveyor. Care shall however be taken to apply clauses pertaining to system requirements.

1.6 This code covers the belt running on idler rollers only and not on slides/beds.

1.7 This standard applies for only smooth surfaced belt.

1.8 This standard excludes the installations using horizontal curves

2 REFERENCES

2.1 The Indian Standards listed in Annex A contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY, SYMBOLS AND UNITS

3.1 For the purpose of this standard, the terms and definitions given in IS 4240 shall apply.

3.2 Symbols and Units

Symbols and their units used in this standard for calculations are summarized in Table 1.

4 TYPE OF CONVEYORS

4.1 The conveyors are troughed and flat, both horizontal and/or inclined or declined with or without curvatures in vertical plane.

4.2 Troughed conveyor is that in which the belt forms a trough on the carrying side while resting/running over idler rolls which are either in set of 5-rolls/3-rolls or 2-rools. The troughing angle adopted shall conform to IS 8598 and shall be selected from the following values: 15°, 20°, 25°, 30°, 35°, 40°, 45°.

NOTE — The troughed angle of 15° is applicable for 2-roll belt conveyors only.

4.2.1 For return idlers, the troughing angle of 0°, 10°, or 15°, shall preferably be adopted.

4.3 Flat belt conveyor is that in which the belt runs flat on the carrying side, over an idler or a set of idlers.

Table 1 Symbols and Units

(*Clauses* 3.2, 8.5.1.3, 8.11.3.1 *and* 8.11.3.2.)

SI No.	Symbols	Description	Unit
(1)	(2)	(3)	(4)
1.	A	Cross-sectional area of load on belt	m^2
2.	A_1	Area of contact between belt and belt cleaner	m^2
3.	B	Belt width	m^2
4.	B_1	Bearing life factor	—
5.	C	Conveyor capacity	t/h
6.	C_1	Coefficient depending upon trough angle	—
7.	D	Pulley diameter	m
8.	E	Belt modulus	kN/m
9.	E_b	Belt specific modulus	—
10.	F_n	Force available for acceleration of the total equivalent mass	N
11.	F_b	Bracking force	N
12.	F_d	Force required for deceleration	N
13.	F_{ad}	Additional force required for deceleration	N
14.	F_{eq}	Equivalent force on each idler bearing	N
15.	F_{eqm}	Modified equivalent force on each idler bearing	N
16.	F_1	Total vertical force on central idler roll	N
17.	GD^2 ($4wk^2$)	Moment of inertia of drive system	$N.ms^2$
18.	H	Lift of conveyor between loading end and discharge end	m
19.	H_1	Height of material on belt ai discharge pulley	m
20.	K	Slope factor	—
21.	K_2	Scraping factor	N/m
22.	K_1	Application factor for idler	—
23.	K_L	Lump factor	—
24.	K_S	Service factor	—
25.	K	Speed factor	—
26.	L	Conveyor length (distance between centres)	m
27.	L_1	Length of installation equipped with tilted idler	m
28.	m_{eu}	Total equivalent mass	kg
29.	N_1	Rated motor speed	rev/min
30.	N_2	Drive pulley speed	rev/min
31.	N_B	Normal strength of belt	N/m
32.	P_A	Absorbed power	kW
33.	P_{op}	Operating power requirement on drive pulley	kW
34.	P_M	Motor output power (shaft)	kW
35.	P_{Mi}	Installed motor output power	kW
36.	Q	Volumetric conveyor capacity	m^3/s
37.	R_e	Radius (minimum) of curve	m
38.	R_b	Pulley bearing resistance not to be calculated for drive pulley	N
39.	R_i	Resistance due to idler tilting	N
40.	R	Main resistances	N
41.	R_r	Resistance due to friction at discharge plough	N
42.	R_s	Secondary resistances	N
43.	R_v	Vectorial sum of the two belt tensions acting on the pulley and of the forces due to the mass of the revolving parts of the pulley	N
44.	R_w	Wrap resistance between belt and pulley	N
45.	R_s	Inertial and frictional resistance at the loading point and in the acceleration area between the handled material and the belt	N
46.	R_{be}	Frictional resistance due to the belt cleaners	N
47.	R_{sh}	Resistance due to friction between handled material and skirt plates	N
48.	R_{SL}	Slope resistance	N

Table 1 *(Continued)*

SI No.	Symbols	Description	Unit
(1)	(2)	(3)	(4)
49.	R_{sp}	Special resistance	N
50.	R_{sks}	Frictional resistance between handled material and the skirt plate in acceleration area	N
51.	R_{sp1}	Special main resistances	N
52.	R_{sp2}	Special secondary resistances	N
53.	S	Maximum allowable belt sag	–
54.	S_F	Safety factor	—
55.	T_E	Peripheral force on the drive pulleys	N
56.	T_s	Tension at the curve for both starting and running condition	kN/m
57.	T_m	Maximum recommended belt tension	kN/m
58.	T_m	Average belt tension at the pulley	N/m
59.	T_{min}	Minimum belt tension to limit belt sag	N/m
60.	T_1	Maximum belt tension under normal operating conditions	N/m
61.	T_{max}	Maximum operating belt tension	N/m
62.	$T_{E\,max}$	Maximum peripheral force	N/m
63.	$T_{2\,min}$	Minimum slack side tension	N/m
64.	T_{SB}	Belt tension in starting/braking condition	N/m
65.	$T_{C\,max}$	Tension at the curve when belt is partially loaded up to beginning of curve	N/m
66.	$T_{t\,max}$	Maximum belt tension when belt is partially loaded up to beginning of curve	N/m
67.	T	Induced belt edge stress in transitions	N/mm
68.	V	Belt speed	m/s
69.	V_o	Handled material conveying speed component in the direction of belt motion	m/s
70.	V_{LF}	Load factor	—
71.	X, Y	Cordinates of curves	m
72.	Z	Distance between working point and tangent point on curves	m
73.	b	Width of material on belt	m
74.	b_1	Interskirt plate width	m
75.	d	Shaft diameter inside bearing	m
76.	e	Base for natural logarithm (a constant)	2.718 Appr
77.	f	Aritificial friction coefficient	—
78.	g	Acceleration due to gravity	9.806 m/s^2
79.	h_1,h_2	Ordinates for trajectory of material	m
80.	l	Angle of tilt of the idler axis with respect to a plane perpendicular to the longitudinal axis of the belt	degree
81.	l_1, l_2	Distances from point of separation to the points situated on the tangent line from which ordinates are to be drawn	m
82.	l_e	Acceleration length at loading area	m
83.	l_{sk}	Length of installation equipped with skirt plates excluding *(see* SI No. 82)	m
84.	m_B	Mass of belt per metre	kg/m
85.	m_c	Mass of revolving idler parts along the carrying side of the conveyor per metre	kg/m
86.	m_d	Mass of material that can be safely discharged on the next chute or hopper	kg
87.	m_G	Mass of handled material on conveyor per metre	kg/m
88.	m_i	Equivalent mass for drive system per metre length of conveyor	kg/m
89.	m_p	Mass of revolving parts of pulleys per metre length of conveyor	kg/m
90.	m_r	Mass of revolving idler parts along the return side of the conveyor per metre	kg/m
91.	n_t	Number of trippers	—
92.	P	Pressure between belt cleaner and belt	N/m^2

Table 1 *(Concluded)*

Sl No.	Symbols	Description	Unit
(1)	(2)	(3)	(4)
93	*PC*	Pitch of carrier idler or idler spacing on carrying side of the conveyor	m
94	P_t	Pitch of return idler or idler spacing on return side of conveyor	m
95	P_1	Ratio of starting motor torque and full load torque	—
96	r_p	Radius of discharge pulley +0 025m (this 0 025 m represents the approximate thickness of belt)	m
97	t	Belt thickness	m
98	t_s	Time taken to accelerate the load	s
99	t_d	Deceleration time	s
100	t_d	Reduced deceleration time	s
101	t_m	Time required by motor to accelerate the conveyor	s
102	t_i	Length of the centre idler	m
103	t_{max}	Maximum permissible stopping time or maximum permissible coasting time	s
104	x	Transition distance	m
105	y	Vertical distance the belt edge rises or lowers during transition	m
106	α	Numerical coefficient, being a function of conveyor length	—
107	β	Factor for extra power for trippers	—
108	δ	Slope angle of the conveyor from horizontal line in the moving direction	degree
109	$\eta_1\eta_2$	Power transmission efficiencies for positive and regenerative power respectively	—
110.	η	Drive efficiency	—
111.	θ	Angle from vertical at which material will leave the belt	degree
112	τ	Troughing angle of return idlers	degree
113	λ	Angle between side axis of the troughed carrying idlers and horizontal troughing angle	degree
114	μ	Coefficient of friction between drive pulley and belt	—
115	μ_6	Coefficient of friction between carrying idlers and bell	—
116	μ_1	Coefficient of friction between material and belt	—
117	μ_2	Coefficient of friction between material and skirt plates	—
118	μ_3	Coefficient of friction between belt and belt cleaner	—
119	ξ	Acceleration coefficient	—
120	ρ	Bulk density of material	t/m^3
121	ø	Angle of wrap	radian
122	ψ	Surcharge angle	degree
123	B	Belt width	m
124	θ	Surcharge angle	degree
125	b	Edge margin, that is unusable width of the belt	m
126	S	Total cross-sectional area of the material S_1 = Upper section S_2 = Lower section	

5 SELECTION

Table 2 lists the features of troughed and flat belt conveyors and shall help in selecting the type of belt conveyor.

6 LAYOUT

6.1 For a single conveyor the centre-to-centre distance between head and tail pulley and lift of conveyors is fixed to suit feed and discharge requirements. However, points mentioned in **6.3** shall be considered here also to the extent applicable.

6.2 For system layout, the following data is required to proceed further:

a) Site plan with suitable contour drawings;
b) Over/under surface interferences, namely, existing and proposed roads, drains, rails, rivers, transmission lines, buildings, structures, etc;
c) Grade deviations;
d) Material flow diagram and flow rates;
e) Details of receiving point(s), discharge/distribution point(s);
f) Material characteristics including size analysis;
g) Climatic data and site condition; and
h) Specific requirement for tensioning arrangement, if any.

Table 2 Features of Belt Conveyors
(Clause 5)

Troughed Belt Conveyors	Flat Belt Conveyors
Higher capacity requirements	Lower capacity requirements
High speed requirements	Low speed requirements
Large lump size of material with or without intermediate discharge with trippers	Relatively higher angle of repose of conveyed material, limited lumps size of conveyed material, intermediate discharge with ploughs, distributor plates
With or without vertical curvature	Without vertical curvature
Suitable for inclination or declination in accordance with IS 8730	Maximum inclination allowed is 6°. Declination undesirable

6.2.1 In case of shiftable conveyors, in addition to data covered in **6.2**, the following data is also required:

a) Layout of working face;
b) Difference in levels between the head and tail ends;
c) Whether future extensions are required or not. If so, the proposed level of the head end or tail end to be altered;
d) Type of shifting;
e) Location of discharge conveyors in case of pivot operation;
f) Type of tripper/transfer feeder movement (whether crawler mounted or rail mounted); and
g) Maximum allowable ground pressure.

6.2.2 For layout of system of conveyors and/or individual conveyor in underground (mining) installations, points such as compact drive head, flame proof motors, fire retarding belting and safety precautions against fire in all other equipment especially fluid coupling and other electrical items shall be duly taken care off.

6.3 Based on the above data, the conveyor system is laid out, taking following points into consideration:

a) Keeping allowable inclination within permissible limit *(see* IS 8730);
b) Keeping conveyor lengths (including allowance for belt elongation) within reasonable limits so as not to exceed the likely RMBT (recommended maximum belt tension) for selected type of conveyor belting;
c) Keeping minimum overhead clearances below the conveyors according to the site requirements while crossing road, water ways and railways and maintaining minimum clearances in accordance with the statutory requirements;
d) Keeping all transfer points in line with direction of flow, maintaining a minimum transfer point height and avoiding reversal of direction of flow of material unless absolutely necessary due to site constraints; and
e) Coasting time of a conveyor shall be taken into consideration to avoid build-up of material. In case, it is unavoidable, suitable means of coasting corrections at transfer point shall be considered. Use of surge hopper shall be considered if coasting time can not be corrected.

6.4 Typical layouts of conveyors are shown in Fig. 1A to 1J.

7 CONVEYOR DESIGN PROCEDURE

7.1 Once the configuration and layout of a conveyor is finalized the following design steps are taken for sizing the conveyor.

7.1.1 Wherever multiple choices are specified, the worst condition applicable shall be considered for the design of the conveyor system.

7.2 The known maximum lump size of the material can be found from Table 3 taking into account the classification of material as given in **7.3.1.**

7.3 Size of Material

7.3.1 Material shall be classed as '*sized*' and '*unsized*' based on the material as follows:

a) *Unsized* — 30 percent by mass of all material less than one-sixth maximum lump size.

   50 percent by mass of all material less than one-third maximum lump size.

   75 percent by mass of all material less than one-half maximum lump size.

   90 percent by mass of all material less than two-third maximum lump size.

b) *Sized* — Material not falling within the above grading.

Table 3 Maximum Lumps Sizes in Relation to Belt Width

(Clause 7.2)

All dimensions in millimetres.

Width of Belt According to IS 1891 (Part 1) (Standard Widths Underlined)	Maximum Lump Size	
	Uniform Size	Unsized (Maximum Dimensions)
300	75	100
400	75	100
450	75	125
500	100	150
600	125	200
650	125	230
750	180	300
800	180	330
900	200	380
1 000	260	430
1 050	280	460
1 200	360	530
1 350	380	660
1 400	380	680
1 500	410	750
1 600	410	800
1 800	460	900
2 000	500	1 020

NOTE — The exact determination of maximum lump size also requires consideration of troughing angle, belt speed or abrasiveness and other material characteristics.

7.3.2 *Lump Size*

Lump size indicates the longest single dimension of largest lump. This shall not be confused with crusher setting or screen openings as these limit only one dimension.

7.4 Ascertain speed factor as sum of lump size factor *(see* Table 4), air borne factor *(see* Table 4) and abrasiveness factor *(see* Table 5) and select belt speed *(see* Table 6).

7.5 If the conveyor is inclined/declined, select a safe angle of inclination/declination for the particular material *(also see* IS 8730 and 8.1.2). Determine the angle of surcharge according to the nature of the material *(see* IS 8730).

7.6 From the selected belt speed, angle of inclination/declination and angle of surcharge for the material, determine belt width and troughing angle for the required capacity of the conveyor from Tables 7, 8, 9, 10 and 11.

7.7 Use the larger of the belt width as determined by **7.2** and **7.6** and rework if the belt width requirement from **7.2** is lower than that required by **7.6**.

7.8 Consider the type of supporting idlers and their spacing [*see* **8.8** for selection and IS 4776 (Part 1) for spacing].

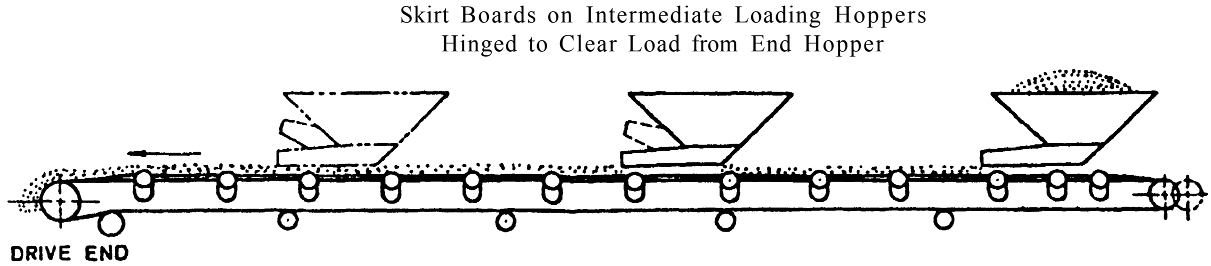


Fig. 1A Horizontal or Inclined Conveyor — Loaded at one end and discharged at other end may also be loaded at intermediate points through fixed or movable spouts

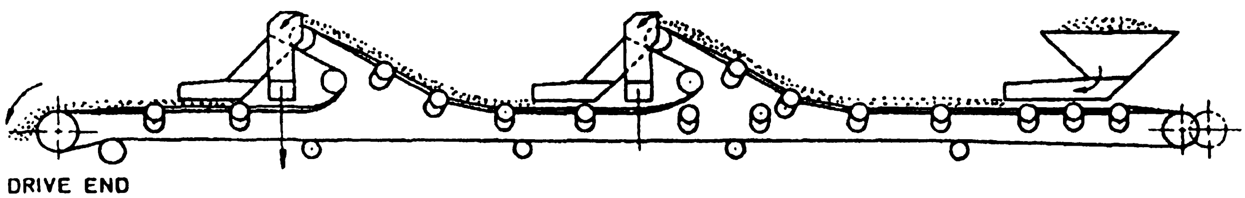


Fig. 1B Horizontal Conveyor — Discharges at intermediate points through fixed trippers or at end

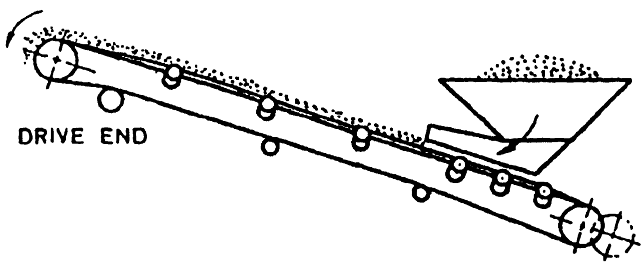


Fig. 1C Inclined Conveyor — will carry up varying slopes which depend upon the nature of material is loaded in usual way and discharges over head pulley

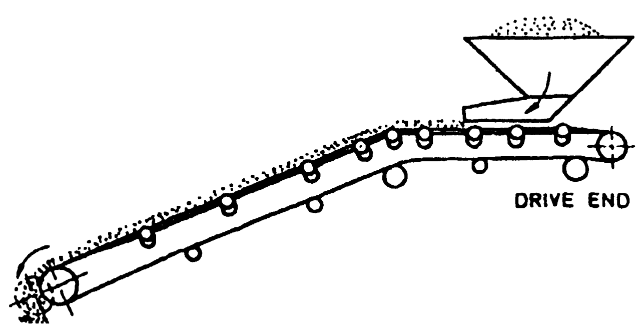


Fig. 1D Inclined or retarding conveyor for lowering material gently down slopes similar to those used in style in Fig. 1C conveyor. May be combined with other arrangements and when in operation the drive acts as a brake

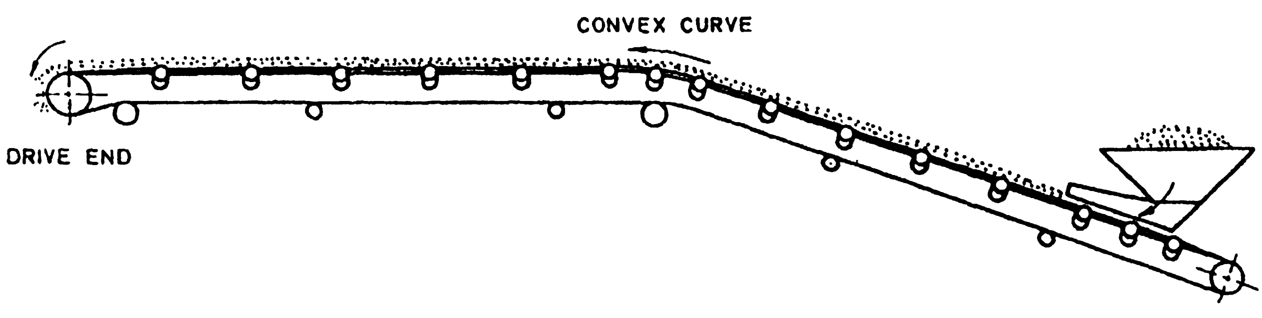


Fig. 1E Combination Inclined and Horizontal Conveyor — The horizontal run can be discharged at head end or at any intermediate point by means of fixed or movable trippers. The bend in carrying run can be made over an idler pulley, but the method shown is preferable

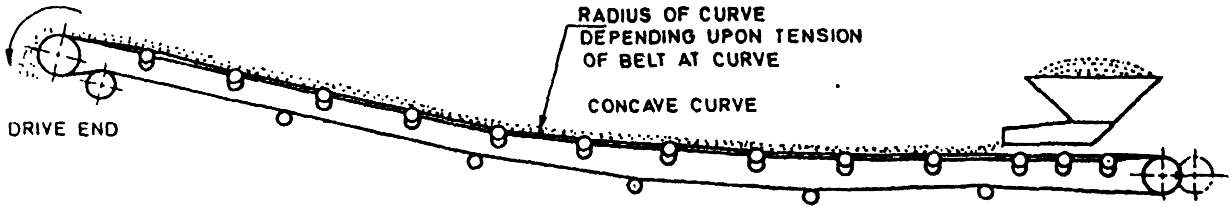


Fig. 1F Simplest method for conveying horizontally and up an incline where belt tension is not excessive. The radius or curved section must be ample to prevent belt, loaded or empty, lifting from carriers, maximum inclines depend upon nature of material handled and method of loading

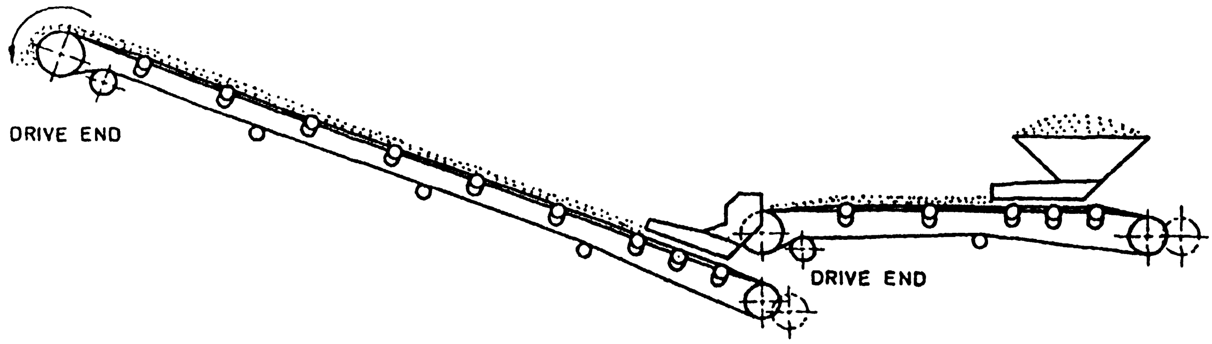


Fig. 1G This arragement combining two conveyor units is often necessary where limited space and high belt tension make the sweeping curve impracticable

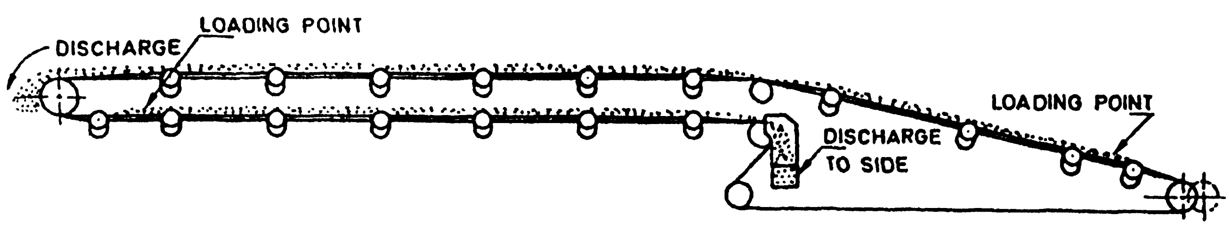
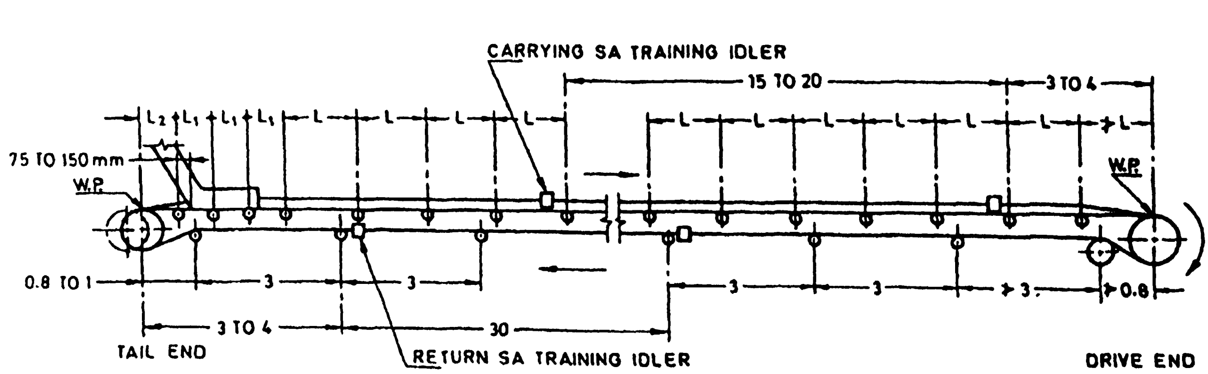


Fig. 1H For conveying on both upper and return belt often used with flat belt for packages



All dimensions in millimetres.

Fig. 1J Idlers spacing for belt conveyor

7.9 Calculate the resistances (tensions) for all conditions including empty belt, loaded belt, lift/drop and other accessories.

7.10 From the tension requirement, determine the absorbed power.

7.11 Select type of drive and determine slack side tensions.

7.12 Find out the minimum recommended belt tensions for limiting belt sag to 0.5 to 2 percent of the distance between adjacent idlers on the carrying side. This sag in no case shall exceed beyond 2 percent.

Table 4 Lump Size Factor

(Clause 7.4)

Material	Lump Size	Lump Size Factor	Air Borne Factor
Fine Grain to Dust	< 10 mm	0	4
Granular	< 25 mm	1	0
Sized and Unsized	Quantity of largest lump is <20 percent of maximum permissible lump size (for the selected belt width)	2	0
Sized	Quantity of largest lump is <60 percent of maximum permissible lump size (for the selected belt width)	3	0
Unsized	Largest lump does not exceed maximum permissible lump size (for the selected belt width)	4	0
Sized	Largest lump does not exceed maximum permissible lump size (for the selected belt width)	4	0

Table 5 Abrasiveness Factor

(Clause 7.4)

Abrasiveness	Type of Material	Abrasiveness Factor
Non Abrasive	Free flowing materials, such as cereal grams, wood, chips, wood pulp, fullers earth, flue dust, soda lime, char, loam sand, ground gravel.	1
Mildly Abrasive	Materials, such as aggregate, run-of-bank sand and gravel, slate, coal, salt, sand stohe.	2
Abrasive	Materials, such as slag, spar, limestone concentrates, pellets.	3
Very Abrasive	Iron ores, taconite, jaspar, heavy minerals, flint rock, glass cullet, granite, traprock, pyrites, sinter, coke.	4

7.13 Calculate slope tension and return side friction tensions.

7.14 Depending upon conveyor configuration, that is inclination/declination regeneration, location of drive, compute the minimum required slack side tension.

Table 6 Maximum Recommended Belt Speeds (m/s)

(Clauses 7.4, 8.1.3, 8.2.2 *and* 8.3.3)

Speed Factor \ Belt Width, mm	Up to 500	600 to 650	750 to 800	950 to 1 050	1 200 to 2 000
1	2.50	3.00	3.50	4.00	4.50
2	2.30	2.75	3.20	3.65	4.12
3-4	2.00	2.38	2.75	3.15	3.55
5-6	1.65	2.00	2.35	2.65	3.00
7-8	1.45	1.75	2.05	2.35	2.62

7.15 Compare slack side tension values obtained from **7.11** and **7.14** and use higher of the two values to calculate maximum operating tension. Also calculate maximum starting tension.

7.16 Multiply maximum operating tension by the minimum safety factor with reference to type of belt, joints and take-up, etc.

7.17 Select a belt having breaking strength in excess of value obtained from **7.16.** Check this result with recommended maximum and minimum and maximum belt width/numbers of plies for troughing and supporting the load.

7.18 Tentatively decide belt specification including cover thickness grade and construction.

7.19 Check adequacy of belt for starting and breaking tension calculated in **7.15.**

7.20 Finalise belt selection.

7.21 Determine drive power considering transmission losses after selecting machinery between drive pulley and source of power. Consideration shall be given here to limiting requirements of starting tensions and corresponding minimum acceleration time requirements.

7.22 Determine the various pulley sizes namely, drive pulley, head pulley, tail pulley, snub pulley, take-up pulley, etc. Due considerations shall be given to recommendations made in IS 1891 (Part 1) while making the selection for pulley sizes.

7.22.1 Basis for selection of pulley sizes for PVC belting *(see* IS 3181) for underground use are as follows:

PVC Belt Type	*Tensile Strength (Minimum)*		*Minimum Pulley Diameters for Satisfactory Flexing*		
	Longitudinal (kN/m Width)	Transverse (kN/m Width)	Drive Pulley mm	Driven Pulley mm	Low Tension Pulley mm
3	580	245	450	350	250
4	700	265	500	400	300
5	875	280	650	550	400
6	1 140	350	800	700	550
8	1 400	350	900	700	550

Table 7 Maximum Section of the Handled Material in m^2 for Triple Roller Troguhed Belts According to Fig. 2 with Equal Length Carrying Idlers

(Clauses 7.6, 8.3.2, 8.4.3, 8.4.3.2 *and* 8.4.5)

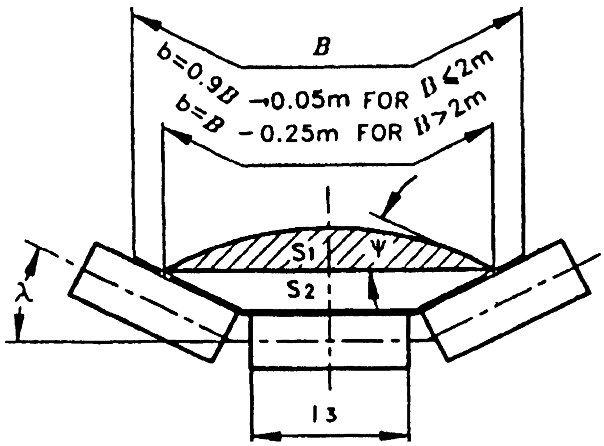


FIG. 2 MAXIMUM SECTION *B* OF HANDLED MATERIAL FOR TRIPLE ROLLER TROUGHED BELT

Belt Width mm	Surcharge Angle	Trough Angle					
		20°	25°	30°	35°	40°	45°
500	0°	0.009 8	0.012 0	0.013 9	0.015 7	0.017 3	0.018 6
	10°	0.014 2	0.016 2	0.018 0	0.019 6	0.021 0	0.022 0
	20°	0.018 7	0.020 6	0.022 2	0.023 6	0.024 7	0.025 6
	30°	0.023 4	0.025 2	0.026 6	0.027 8	0.028 7	0.029 3
650	0°	0.018 4	0.022 4	0.026 0	0.029 4	0.032 2	0.034 7
	10°	0.026 2	0.029 9	0.033 2	0.036 2	0.038 6	0.040 7
	20°	0.034 2	0.037 7	0.040 6	0.043 3	0.045 3	0.046 9
	30°	0.042 7	0.045 9	0.048 4	0.050 7	0.052 3	0.053 4
800	0°	0.027 9	0.034 4	0.040 2	0.045 4	0.050 0	0.054 0
	10°	0.040 5	0.046 6	0.051 8	0.056 4	0.060 3	0.063 6
	20°	0.053 5	0.059 1	0.063 8	0.067 8	0.071	0.073 6
	30°	0.067 1	0.072 2	0.076 3	0.079 8	0.082 2	0.084 0
1 000	0°	0.047 8	0.058 2	0.067 7	0.076 3	0.083 8	0.089 8
	10°	0.067 4	0.077 1	0.085 7	0.093 3	0.099 8	0.105
	20°	0.087 6	0.096 6	0.104	0.111	0.116	0.120
	30°	0.109	0.117	0.134	0.129	0.134	0.136
1 200	0°	0.070 0	0.085 3	0.099 2	0.112	0.123	0.132
	10°	0.098 8	0.113	0.126	0.137	0.146	0.154
	20°	0.129	0.142	0.153	0.163	0.171	0.176
	30°	0.160	0.172	0.182	0.190	0.196	0.200
1 400	0°	0.098 0	0.120	0.139	0.157	0.171	0.184
	10°	0.138	0.158	0.175	0.191	0.204	0.214
	20°	0.179	0.197	0.213	0.220	0.237	0.245
	30°	0.221	0.238	0.253	0.264	0.272	0.277
1 600	0°	0.130	0.159	0.185	0.208	0.228	0.244
	10°	0.182	0.209	0.233	0.253	0.270	0.283
	20°	0.236	0.261	0.282	0.300	0.314	0.324
	30°	0.293	0.315	0.334	0.349	0.360	0.366
1 800	0°	0.167	0.203	0.237	0.266	0.292	0.313
	10°	0.233	0.268	0.298	0.324	0.346	0.363
	20°	0.302	0.334	0.361	0.384	0.401	0.414
	30°	0.374	0.403	0.427	0.446	0.460	0.468
2 000	0°	0.207	0.253	0.294	0.331	0.362	0.388
	10°	0.290	0.332	0.370	0.403	0.429	0.450
	20°	0.376	0.415	0.448	0.476	0.490	0.514
	30°	0.465	0.501	0.530	0.554	0.571	0.581

Table 7 — *Concluded*

Belt Width mm	Surcharge Angle	Trough Angle					
		20°	25°	30°	35°	40°	45°
2 200[1)]	0°	0 257	0 311	0 363	0.408	0 446	0.478
	10°	0 357	0 408	0 455	0 494	0 527	0 552
	20°	0 461	0 508	0 549	0 584	0610	0 629
	30°	0 569	0613	0 649	0.677	0 697	0710
2 400[1)]	0°	0 303	0 368	0 428	0 482	0 528	0 566
	10°	0 423	0 484	0 539	0 586	0 625	0 656
	20°	0 547	0 604	0 653	0 694	0.725	0 748
	30°	0 677	0 729	0.772	0.806	0 830	0 845
2 600[1)]	0°	0 360	0.439	0.510	0.573	0 628	0 672
	10°	0 502	0 575	0 640	0 695	0.741	0.777
	20°	0 648	0.716	0.774	0.822	0 859	0 885
	30°	0 801	0 863	0914	0 953	0 982	0 999
2 800[1)]	0°	0 413	0 505	0.585	0 660	0 721	0 774
	10°	0 578	0 663	0 737	0.803	0 885	0 897
	20°	0 749	0 827	0 894	0 950	0.993	1 025
	30°	0 928	0 998	1.063	1.104	1.137	1.158

NOTE - Suitable adjustment may be made in case of other values of surcharge angle and troughing angle.

[1)]Indicates sizes generally not available in the country and meant for information only.

7.23 Finalized drive power considering transmission losses after selecting machinery between drive pulley and the source of power.

7.24 Finalise the drive element's specification like coupling, belt/chain drive, gear box.

7.25 Determine drive shaft diameter and other terminal shaftings.

7.26 Select proper bearings for the duty conditions and service life.

7.27 Consider location and type of take-up and find out the amount of take-up tension and the take-up movement.

7.28 Calculate coasting time of individual conveyors and correct the coasting times for the conveyor system.

7.29 Consider if hold back and brake are required simultaneously or one will be sufficient. Determine the type and location of hold back/brake.

7.30 Calculate the braking force and torque required.

8 DESIGN ASPECTS

8.1 Characteristics of Material Affecting Conveyor Design

8.1.1 The proper design of a belt conveyor/conveyor system is greatly influenced by the characteristics of the material to be handled. Generally, the material is classified as shown in IS 8730.

8.1.2 Care shall be taken for the inclination of an inclined/declined conveyor, carrying lumps of material, as these are likely to slide down, wherever possible. Actual inclination of the conveyor shall not exceed the maximum allowable value *(see* IS 8730). In case of declination, the angle of declination shall not exceed 12° in any case.

8.1.3 Table 6 shows the maximum recommended belt speeds for different sizes of belts based on speed factor (speed factor = lump size factor + abrasiveness factor). For systems with ploughs and trippers, lower speeds of belt shall be adopted.

8.1.4 *Physical Condition of Material*

Care shall be taken to analyse the physical condition of the material to be conveyed which are classified as follows:

a) Oily or liable to react with rubber products,
b) High temperature,
c) Non-abrasive,
d) Mildly abrasive,
e) Abrasive,
f) Very abrasive,
g) Sharp abrasive,
h) Easily degradable,
j) Mildly corrosive,
k) Highly corrosive,
m) Explosive or creating harmful dust,
n) Very dusty,
p) Inflammable,
q) Hygroscopic, and
r) Sticky.

Table 8 Maximum Section *B* of the Handled Material in m^2 for Two Equal Idler Troughed Belts According to Fig. 3 and for Flat Belts According to Fig. 4

(Clauses 7.6, 8.3.2, 8.4.3, 8.4.3.2 *and* 8.4.5)

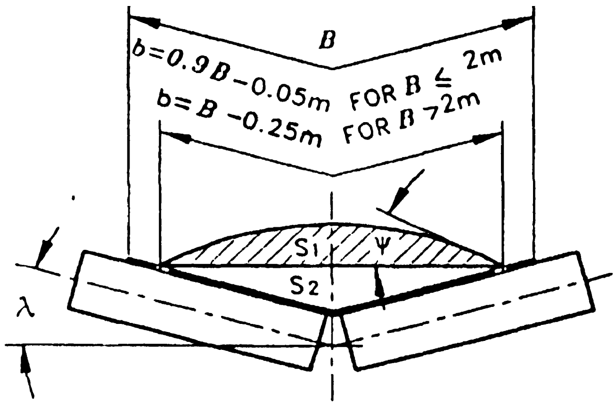


FIG. 3 MAXIMUM SECTION *B* OF HANDLED MATERIAL FOR Two EQUAL IDLER TROUGHED BELT

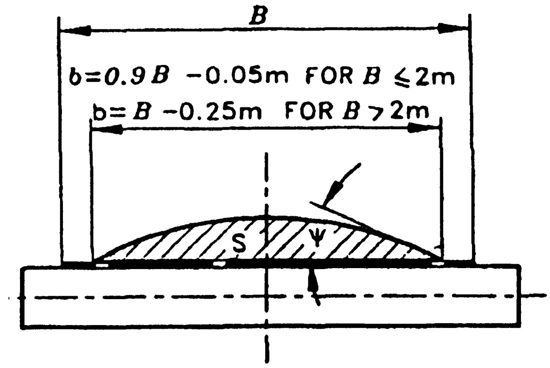


FIG. 4 MAXIMUM SECTION *B* OF HANDLED MATERIAL FOR FLAT BELT

Belt Width mm	Surcharge Angle	Two Idler Troughed Belts Trough Angle			Flat Belt
		15°	20°	25°	
300	0°	—	—	–	—
	10°	—	—	—	0.001 4
	20°	—	—	—	0.002 9
	30°	—	—	—	0.004 4
400	0°	0.005 9	0.007 7	0.009 2	—
	10°	0.008 5	0.010 2	0.011 5	0.002 8
	20°	0.011 2	0.012 7	0.013 8	0.005 7
	30°	0.014 0	0.015 4	0.016 3	0.008 7
500	0°	0.010 0	0.012 9	0.015 4	–
	10°	0.014 3	0.017 0	0.019 2	0.004 7
	20°	0.018 8	0.021 2	0.023 2	0.009 4
	30°	0.023 5	0.025 7	0.027 3	0.014 5
650	0°	0.017 9	0.023 1	0.027 4	–
	10°	0.025 7	0.030 4	0.034 2	0.008 3
	20°	0.033 7	0.038 0	0.041 3	0.016 9
	30°	0.042 1	0.045 9	0.048 6	0.025 9
800	0°	0.027 7	0.036 0	0.042 9	–
	10°	0.039 9	0.047 5	0.053 6	0.013 0
	20°	0.052 4	0.059 4	0.064 7	0.026 5
	30°	0.065 6	0.071 8	0.076 3	0.040 6
1 000	0°	0.044 9	0.057 9	0.069 0	–
	10°	0.064 4	0.076 5	0.086 2	0.021 0
	20°	0.084 6	0.095 6	0.104	0.042 7
	30°	0.106	0.116	0.123	0.065 3
1 200	0°	0.066 3	0.085 1	0.102	–
	10°	0.095 0	0.112	0.127	0.030 8
	20°	0.125	0.140	0.153	0.062 6
	30°	0.156	0.170	0.181	0.095 8
1 400	0°	–	–		
	10°	—	—	—	0.042 5
	20°	—	—	—	0.086 4
	30°	—	—	—	0.132
1 600	0°	–			
	10°	—	—	—	0.056 0
	20°	—	—	—	0.114
	30°	—	—	—	0.175

NOTE - Suitable adjustments may be nude in case of other values of surcharge angle and troughing angle.

Table 9 Slope Factor *K*

(*Clauses* 7.6, 8.3.2, 8.4.4 and *Fig.* 5)

Conveyor Inclination, Degrees	Slope Factor *K*	Conveyor Inclination, Degrees	Slope Factor *K*	Conveyor Inclination, Degrees	Slope Factor *K*
2	1 00			25	0.68
4	0.99	16	0.89	26	0.66
6	0.98	18	0.85	27	0.64
8	0.97	20	0.81	28	0.61
10	0.95	21-22	0.78-0.76	29	0.59
12	0.93	23	0.73	30	0.56
14	0.91	24	0.71		

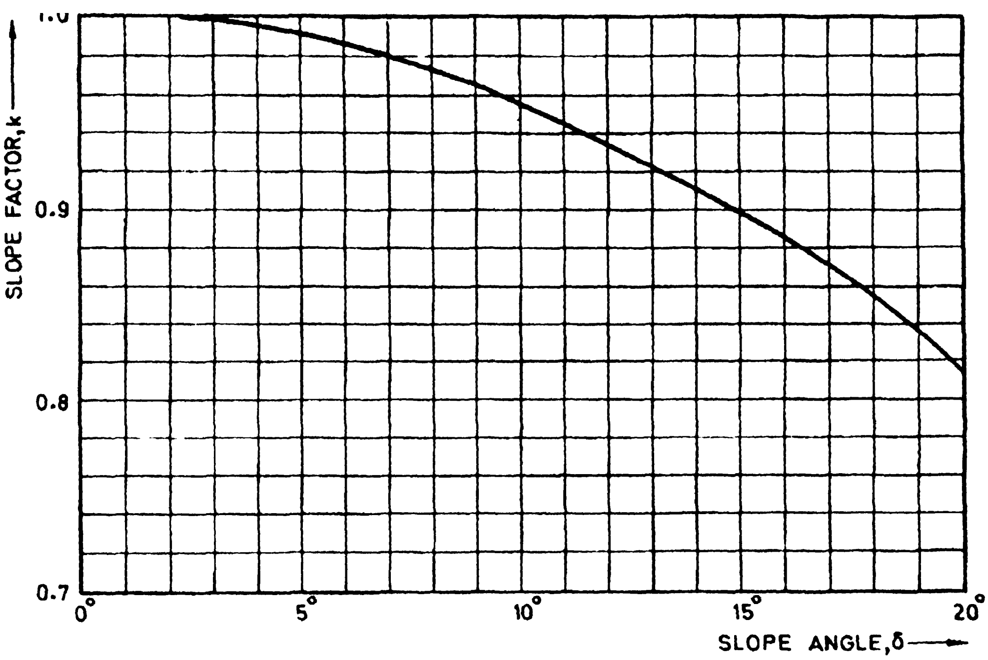


FIG. 5 FACTOR *K* AS A FUNCTION OF 8 FOR ASCENDING CONVEYOR

8.1.4.1 Selection of various components of the conveyor system shall be made taking the relevant physical conditions of material into account.

8.1.5 *Flowability, Abrasion and Other Miscellaneous Characteristics of Materials*

8.1.5.1 Based on size, shape, angle of repose and angle of surcharge, the flowability of bulk materials is given in IS 8730.

8.1.5.2 Due consideration shall be given to abrasion and other miscellaneous characteristics of material in selection of belts. These properties of material are classified in IS 8730.

8.2 Belt Speed

8.2.1 Belt speed depends on the following factors:

a) Capacity required and belt width;
b) Loading and unloading conditions;
c) Size, shapes, flowability and other characteristics of the material conveyed;
d) Belt construction;
e) Inclination of belt conveyor, and
f) Idler construction and diameter.

8.2.2 Belt speed shall be selected from the recommendation given in Table 6. Higher belt speeds may be considered under special design conditions.

Table 10 Maximum Capcity of a Belt Conveyor in tonnes/hour

(Clauses 7.6, 8.3.2, 8.3.3 *and* 8.4.5)

Capacity based on:

Bulk density of material, ρ = 1.0 t/m^3

Belt speed V = 1.0 m/s

Slope factor K = 1.00

Belt Width mm	Surcharge Angle	Triple Equal Roll Roller Troughed Belt, Trough Angle					
		20°	25°	30°	35°	40°	45°
500	0°	35	43	50	56	62	67
	10°	51	58	65	70	75	79
	20°	67	74	80	85	89	92
	30°	84	90	96	100	103	105
650	0°	56	80	93	106	116	125
	10°	94	107	119	130	139	146
	20°	123	135	146	156	163	169
	30°	153	165	174	182	188	192
800	0°	100	123	144	163	180	194
	10°	145	168	186	203	217	229
	20°	192	212	229	244	255	265
	30°	241	260	274	287	296	302
1 000	0°	172	209	243	274	301	323
	10°	242	277	308	336	359	378
	20°	315	348	374	399	417	432
	30°	392	421	446	464	482	489
1 200	0°	252	307	357	403	443	475
	10°	355	407	453	493	525	554
	20°	464	511	551	587	615	633
	30°	576	619	655	684	705	720
1 400	0°	352	432	500	565	615	662
	10°	497	569	630	687	734	770
	20°	644	709	767	792	853	882
	30°	795	857	911	950	979	997
1 600	0°	468	572	666	749	820	878
	10°	655	752	839	911	972	1 019
	20°	849	939	1 015	1 080	1 130	1 166
	30°	1 054	1 134	1 202	1 256	1 296	1 317
1 800	0°	601	731	853	957	1 051	1 127
	10°	839	965	1 073	1 166	1 245	1 307
	20°	1 087	1 202	1 299	1 382	1 443	1 490
	30°	1 346	1 451	1 537	1 605	1 656	1 685
2 000	0°	745	911	1 058	1 191	1 303	1 397
	10°	1 044	1 195	1 332	1 451	1 544	1 620
	20°	1 359	1 494	1 613	1 713	1 793	1 850
	30°	1 674	1 803	1 908	1 994	2 055	2091

NOTE — Suitable adjustments may be made in case of other values of surcharge angle and troughing angle.

Table 11 Maximum Capacity of a Belt Conveyor in tonnes/hours

(Clauses 7.6, 8.3.2, 8.3.3 *and* 8.4.5)

Capacity based on:

Bulk density of material, $\rho = 1.0$ t/m^3

Belt speed V = 1.0 m/s

Slope factor K = 1.00

Belt Width mm	Surcharge Angle	Two Idler Troughed Belts Trough Angle			Flat Belts
		15°	20°	25°	
300	0°	—	—	—	—
	10°	—	—	—	5.0
	20°	—	—	—	10.5
	30°	—	—	—	15.8
400	0°	21	27	33	—
	10°	30	36	41	10.0
	20°	40	45	49	20.5
	30°	50	55	58	31
500	0°	36	46	55	—
	10°	53	61	69	17
	20°	67	76	83	34
	30°	84	92	98	52
650	0°	64	83	98	—
	10°	96	109	123	30
	20°	121	137	148	60
	30°	151	165	175	93
800	0°	99	129	154	—
	10°	143	171	193	47
	20°	188	214	233	95
	30°	236	258	274	146
1 000	0°	161	208	248	—
	10°	232	275	310	75
	20°	304	344	374	154
	30°	381	417	443	235
1 200	0°	238	306	367	—
	10°	342	403	457	111
	20°	450	504	551	225
	30°	561	612	651	345
1 400	0°	—	—	—	—
	10°	—	—	—	153
	20°	—	—	—	311
	30°	—	—	—	475
1 600	0°				
	10°	—	—	—	201
	20°	—	—	—	410
	30°	—	—	—	630

NOTE — Suitable adjustments may be made in case of other values of surcharge angle and troughing angle.

8.2.3 Higher belt speeds may be adopted after taking into consideration the resultant effect arising out of:

a) creation of turbulence at loading points and acceleration in cover wear;
b) encouraging of low density material to become air borne;
c) increase in product size degradation; and
d) reduction in life of chutes and transfer devices.

8.2.3.1 It is important also to check the adequacy of the type of belting, its joining and safety devices for the conveyors.

8.2.4 Extreme care shall be exercised while selecting speed, as lower speed will make the installation costly but on the other hand a higher speed is likely to create problems of spillage, dust generation and loss of fine powdery materials.

8.3 Widths of Belt

8.3.1 The width of belt is predominantly governed by two factors, the lump size of the material conveyed and the capacity requirements of the conveyor.

8.3.2 Tables 7, 8, 9, 10 and 11 give cross-sectional area, slope factor and carrying capacity respectively of belt conveyors.

8.3.3 The width of belt for the capacity requirement can be read off from Tables 10 and 11. This shall, however be checked for minimum belt width from Table 6 for given lump size factor. The greater of the two values shall be adopted.

8.3.4 The standard width of belts in millimetres as specified in IS 1891 (Part I) are as follows:

300, 400, 500, 600, 650, 800, 1 000, 1 200, 1 400, 1 600, 1 800 and 2 000.

8.4 Capacity of Belt Conveyor

8.4.1 The capacity of a belt conveyor is determined primarily by the following three factors:

a) *Cross-section of load on the belt* — The cross-sectional load on the belt will vary with the width of belt, the type of carrying idlers used which determines the amount of troughing given to the belt, and the nature of the material being handled, which determines the quantity of material that can be safely loaded on to a given cross-section;
b) Speed of belt; and
c) Slope factor.

8.4.2 General formula for calculation of the capacity of all types of belt conveyors shall be as follows:

$$C = 3\ 600\ \rho\ A\ V K, Max \quad \text{... (1)}$$

8.4.3 Figures 2 to 4 show the most usual trough sections for which the cross-sectional area. A of the material is given in Tables 7 and 8 which are calculated on a belt width, filled with material, of width b (below 2 000 mm):

$$b = 0.9\ B - 0.05 \quad \text{...(2)}$$

8.4.3.1 For belts of width greater then 2 000 mm,

$$b = B - 0.25 \quad \text{...(3)}$$

8.4.3.2 Tables 7 and 8 indicate cross-sectional area from materials having surcharge angles of 0°, 10°, 20° and 30°. The choice of right surcharge angle depends on the conveyed material and the distance it has to travel. For normally flowing material, surcharge angle of 20° shall generally be chosen as standard value. Easily flowing or almost fluid materials, however attain surcharge angle of less than 20° and may drop down to 0°. Surcharge angle higher than 20° occur only for materials featuring a very high internal friction.

8.4.4 The slope factor, K, in equation (1) takes into account the decrease of the section of the handed material on the belt when a gradient is involved. Table 9 read with Fig. 5 gives values of K, the slope factor, for different inclinations of a conveyor.

8.4.5 Tables 10 and 11 give the belt conveyor capacities for horizontal conveyors, that is, $K = 1.0$ based on the load cross-section as given in Tables 7 and 8 for a material of bulk density of 1.0 t/m, and belt speed of 1.0 m/s. To calculate the capacity of a specific conveyor, the corresponding value given in Table 10 and Table 11 shall be multiplied by the actual bulk density of the material, the belt speed and the slope factor.

8.4.5.1 To take surges and unevenness in loading operations into account, the capacity of belt conveyor calculated according to **8.4.5** shall be generally limited to 90 percent. In case of conveyors with belt widths up to 600 mm, the capacity shall be reduced to 75 percent.

8.5 Driving Force and Power Calculation

8.5.1 *Peripheral Force Required on the Driving Pulley(s).*

8.5.1.1 The required peripheral force, T_E on the driving pulley(s) of a belt conveyor is obtained by adding up all the resistances,

$$T_E = R + R_s\ R_{sp1} + R_{sp2} + R_{SL} \quad \text{...(4)}$$

$$= f\ .\ L\ .\ g.\ [m_c + m_r + (2m_B + m_G)\cos\delta] + R_s + R_{sp1} + R_{sp2} \quad \text{...(5)}$$

$$= \alpha f\ .\ L\ .\ g.\ [m_c + m_r + (2m_B + m_G)\cos\delta] + m_G.H.g + R_{sp1} + R_{sp2} \quad \text{...(6)}$$

where

T_E = driving force on the driving pulleys in N;

R = main resistances in N comprising of:

i) rotational resistance of the carrying and return idlers due to the friction in idler bearings and seals, and

ii) belt advancement resistance, resulting from the impression of the idlers in the belt, the recurrent flexing of the belt and of the material;

R_s = secondary resistances in N comprising of:

i) the inertial and factional resistances due to the acceleration of the material at the loading area,

ii) resistance due to the friction on the side walls of the skirt board at the loading area,

iii) pulley bearing resistance with the exception of the driving pulley bearings, and

iv) the resistance due to wrapping of the belt on the pulleys;

R_{sp1} = special main resistances in N comprising of:

i) drag resistance due to forward tilt of the idler in the direction of movement of the belt, and

ii) resistance due to friction against chute flaps or skirt plates, when these are present over the full length of the belt;

R_{sp2} = special secondary resistance in N comprising of:

i) resistance due to friction with belt and pulley cleaners,

ii) resistance due to friction with the chute flaps or skirt plates, when present over a part of the conveyor length,

iii) resistance due to inverting the return strand to the belt,

iv) resistance due to discharge ploughs, and

v) resistance due to tripers;

R_{SL} = slope resistance in N, that is, the resistance due to lifting or lowering the material on inclined conveyors; and

$$= m_G . H . g \qquad ...(7)$$

NOTE — H is taken as positive for ascending installation and negative for descending installation.

f = artificial coefficient of friction, dimensionless comprising of rolling resistance of the idlers along the carrying and return sides of belt and the belt advancement resistance;

= 0.020, is a basic value for normally aligned belt conveyors; and

= 0.012, is a basic value for down hill conveyors requiring a brake-motor.

NOTES

1 Under favourable conditions such as fixed and properly aligned installations with easily rolling idlers and low internal friction material/may be as low as 0.016 (basic value of 0.020 reduced by 20 percent) and for unfavourable conditions such as poorly aligned belt conveyors with badly rolling idlers and high internal friction material,f may be as high as 0.030 (basic value of 0.020 increased by 50 percent). The basic value 0.020 conforms to majority of cases.

2 The basic value, 0.020 of f is only applicable to installations used at around 70 to 110 percent of their nominal capacity, conveying products with an average internal friction coefficient, equipped with three-roll carrying idlers for the upper side of the belt, a 30° side troughing angle, belt speeds of about 5 m/s, surrounding temperatures of about 20°C and 108 to 159 mm diameter carrying idlers with labyrinth grease seals, together with idler spacing of 1 to 1.5 m for the carrying side of the belt and of around 3 m for the return side of the belt.

3 The value,f, may, increase above the value 0.020 range up to 0.030 in the following cases:

a) for handled materials with a high internal friction coefficients;

b) for troughing angle of over 30°;

c) for belt speeds of over 5 m/s;

d) for carrying idler diameters lower than the above mentioned;

e) for surrounding temperatures of less than 20°C;

f) for a decrease of the belt tension;

g) for flexible carcass belts and those with thick and flexible covers;

h) for poorly aligned installations;

j) when operating conditions are dusty and wet and/or sticky;

k) for idler spacing of markedly more than 1.5 m for the carrying side upper strand of the belt and 3 m for the return side (lower strand) of the belt.

4 The artificial friction coefficient,f, may decrease under the basic value of 0.020 if the conditions stated in Note 3 are reversed.

5 When the installation is running under no-load conditions, the value of f can be either lower or higher than under full-load operating conditions, depending on the mass of the moving parts and on the conveyor belt tension. Downhill conveyors which require to be braked by brake-motor, shall, as a safety measure, be calculated with a value lower by 40 percent than used for the calculation of driven belt conveyors. The result of this is a basic value of f = 0.012.

6 Value of f may increase above the value of 0.030 under certain adverse conditions and/or type installation as for example in case of underground mines.

α[1)] = numerical coefficient, being a function of conveyor length L (*see* Fig. 6)

$$= \frac{\text{Total resistance without slope resistance and without special resistance}}{\text{Main resistance}}$$

11111)For conveyors with centre distances less than 80 m, the value of α is unsure, as indicated by the batched area of Fig. 6. Where the smaller secondary resistances and the greater values are possible especially for short high speed feed conveyors of large capacities.

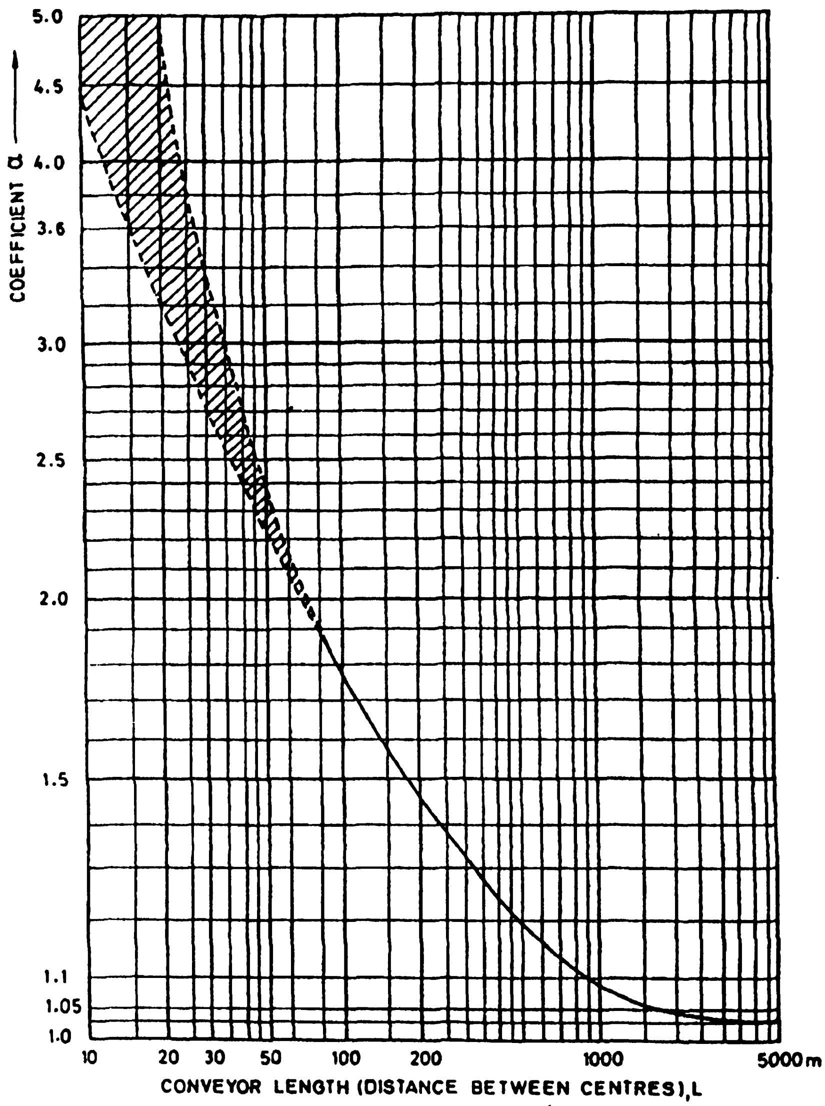


FIG. 6 VALUES OF COEFFICIENT α AS FUNCTION OF CONVEYOR LENGTH L

$$= \frac{R + R_s}{R} \quad ...(8)$$

m_G = mass per metre, of handled material in kg/m

= 1000 rQ/V ...(9)

where

Q = volumetric conveyor capacity in m^3/s;

= AVK; and ...(10)

H = lift of the conveyor between the discharge area in m. In case a belt tripper is used H shall include lift of the tripper also.

8.5.1.2 Equation (6) is generally use for determining the driving force T_E. If the conveyor slope is less than 18°, the factor cos δ in equations (5) and (6) shall be omitted. Equation (5) is applicable for all conveyor lengths. However equation (6) can be used for approximate calculations for conveyors length more than 80 m.

8.5.1.3 *Calculation for secondary resistance,* R_s (for symbols, *see* Table 1)

$$R_s = R_s + R_{sks} + R_w + R_b \quad ...(11)$$

where

R_s = intertial and frictional resistance at the loading point and in the acceleration are between the handled material and the bel in N

= $Q.1000.\rho.(V\text{-}V_0)$ ...(12

R_{sks} = frictional resistance between handles material and the skirt plates in th acceleration area in N

$$= \frac{\mu_2 . Q^2 . 1\,000 \rho . g . l_a}{\left[\frac{(V + V_0)}{2}\right]^2 b_1^2} \quad ...(13)$$

R_w = wrap resistance between belt and pulley, in N (not to be calculated for drive pulleys)

$$9B\left[140 + 0.01 \cdot \frac{T_{av}}{B}\right]\frac{t}{D} \quad ...(14)$$

for *fabric carcass belt*

$$12B\left[200 + 0.01 \cdot \frac{T_{av}}{B}\right]\frac{t}{D} \quad ...(15)$$

for *steel cord belt*

NOTE — The values of wrap resistance R_w shall generally be calculated in accordance with formulae (14) and (15). For guidance, following table gives the values of wrap resistance:

Locution of Pulley	*Degree of Wrap of Belt*	*Wrap Resistance N*
Tight side	150° to 240°	230
Slack side	150° to 240°	175
All other pulleys	—	140

R_b = pulley bearing resistance (not to be calculated for driving pulleys) in N

$$= 0.005\frac{d}{D}R_v \quad ...(16)$$

l_d = acceleration length at loading area m

$$= \frac{V^2 - V_0^2}{2g.\mu_1}, Min \quad ...(17)$$

μ_1 = coefficient of friction between material and belt

= 0.5 to 0.7

μ_2 = coefficient of friction between material and skirt plates

= 0.5 to 0.7

8.5.1.4 *Calculation for special main and secondary resistances.* R_{spl} *and* R_{sp2}

R_{sp} = special resistances in N

$= (R_{spl} + R_{sp2})$ ...(18)

$= (R_l + R_{sk} + R_{bc} + R_p)$ ...(19)

where

R_t = resistance due to idler tilting

$= g\,.C_1\ \mu_0 L_1\ (m_B + m_G) \cos\delta \sin i$ ... (20)

in case of carrying idlers equipped with three equal length rollers.

$= g\ .\ \mu_0 L_1\ (m_B) \cos\tau \cos\delta \sin i$ ... (21)

in case of return idlers equipped with two rollers.

R_{sk} = resistance due to friction between handled material and skirt plates in N

$$= \frac{\mu_2.Q^2.1\,000\rho.g.l_{sk}}{V^2 b_1^2} \quad ...(22)$$

R_{be} = frictional resistance due to belt cleaners in N

$= A_1\ \rho.\mu_3$ ...(23)

NOTE — The frictional resistance due to belt cleaners. R_{bc}, shall be calculated in accordance with formula (23). For guidance, a value between 360 and 530 N/m length of each scraper may be used.

R_p = resistance due to friction at the discharge plough in N

$= B\ .K_a$ ...(24)

C_1 = 0.4 trough factor up to 30° trough

= 0.5 trough factor above 30° and up to 45° trough

μ_0 = coefficient of friction between carrying idlers and belts

= 0.3 to 0.4

μ_2 = coefficient of friction between material and skirt plates

= 0.5 to 0.7

μ_3 = 0.6 to 0.7 between belt and belt cleaner

P = Pressure between belt cleaner and belt

$= 3(10)^4$ to 10^5 N/m²

K_a = scraping factor in N/m

= normally 1 500 N/m

8.5.2 The formulae given in **8.5.1** for the calculation of the peripheral force at the driving pulley are suitable only for uniformly and continuously loaded installations. For belt conveyors running over rough ground with slope changes or only sloping in the down hill direction, for which partial loading of the belt is frequently the case, the computing of the peripheral force shall be carried out for different operating conditions, for example:

a) empty conveyor;
b) fully loaded throughout;
c) loaded on some sections of the conveyor with a rising, level or slightly dropping run where each section requires positive force to move it, and empty on the remaining sections which would be regenerative if loaded; and
d) loaded on regenerative sections and empty on sections with a rising, level or slightly descending run.

8.5.2.1 The highest peripheral force on the driving pulley, whether positive or negative, found in this manner shall be used for the design of the driving system.

8.5.3 *Belt Conveyor Operating Power Requirements*

8.53.1 The power required at the driving pulley(s) of a belt conveyor shall be:

$$P_{DP} = \frac{T_E\ .\ V}{1\,000}\ \text{kW} \quad ...(25)$$

$$P_A = \frac{T_E \cdot V}{1\,000} + \frac{(R_{wd} + R_{bd})\,V}{1\,000}\ \text{kW} \quad \dots (26)$$

after taking drive pulleys loss into acount

where

R_{wd} = Wrap resistance between belt and pulley for drive pulley and is to be calculated as given for R_w, and

R_{bd} = Pulley bearing resistance for drive pulley and is to be calculated as given for R_{bd}.

8.5.3.2 The motor output power (shaft) shall be:

$$P_M = \frac{P_A}{\eta_1} \quad \dots (27)$$

for conveyors requiring positive power

$= P_A \eta_2$ for regenerative conveyors ... (28)

NOTES

1 Efficiency of various transmission elements shall be taken into account while adopting the values of η_1. For guidance, Table 12 may be referred. However where necessary, the actual efficiency may be taken into account.

2 While deciding on the motor power to be adopted, consideration shall be given to the actual likely condition of usage of installation.

3 η_2 = 1.0 to 0.95.

8.5.3.3 *Additional power required due to tripper*

a) If a belt conveyor has n_t number of trippers the power requirement shall be:

$$P_a = \frac{T_E \cdot V}{1\,000}(1 + n_t\beta) + \frac{(R_{wd} + R_{bd})V}{1\,000}\ \text{kW} \quad \dots (29)$$

where

β = factor for extra power for each tripper and shall be taken from Table 13 or Table 14 as the case may be.

b) Table 13 gives the values of factor β for a tripper which is either fixed or separately driven and Table 14 is for belt propelled trippers and is restricted to those lengths and slopes where these are applicable.

c) The lift of the tripper shall be included in the conveyor lift (H).

d) The peripheral force required on the driving pulleys for a belt conveyor with 'n_t' numbers of trippers shall be $T_E(1 + \beta n_t)N$ and further calculations shall be based on this force only.

8.5.4 *Belt Forces*

8.5.4.1 The tensile forces on the belt, being different at different point on belt of the conveyor, depend upon:

a) the path of the conveyor;

b) the number and arrangement of the driving pulleys;

c) the characteristics of the driving and braking systems;

d) the type, location and arrangement of the belt tensioning devices; and

e) the load case of the installation: starting, nominal rating, braking, stopped either at no load or completely or partially loaded.

Table 12 Efficiency for Various Transmission Units

[*Clause* 8.5.3.2 *(Note* 1)]

Type of Drive	Percentage Efficiency
Enclosed gear units —	
Single reduction helical/straight cut	Up to 98
Double reduction helical/straight cut	Up to 96
Triple reduction helical/straight cut	Up to 94
Spiral bevel/helical/worm gear	Use manufacturers' rating
Double reduction	Up to 96
Triple reduction	Up to 94
Chain drives — Totally enclosed and oil lubricated	Up to 98
V- Belt drives	95
Tooth belt drives	95-98
Fluid drives	Use manufacturer's rating

NOTES

1 The percentage given for gear units are based upon well ventilated boxes filled with the manufacturer's recommended lubricants.

2 Multiply together appropriate percentage for each reduction from prime mover to head pulley to obtain overall efficiency of transmission.

8.5.4.2 The tensile forces exerted on the belt shall be such that, at any rating, the peripheral forces applied to all the driving pulleys are transmitted to the belt by friction without slipping and the belt sag between the supporting idlers does not exceed a safe limit.

8.5.43 *Transmission of the peripheral force at the driving pulley(s)*

For the transmission of a peripheral force for T_E from a driving pulley to the belt the minimum tensile force T_{2min} on the return belt shall be calculated from the formula:

$$T_{2\,min} \geq T_{E\,max} \frac{1}{e^{\mu\phi} - 1} \quad \dots (30)$$

$$\geq T_E\, \xi \frac{1}{e^{\mu\phi} - 1} \quad \dots (31)$$

where

$T_{E\,Max}$ = Maximum peripheral force, in N, often occurs when starting up or when braking the completely loaded conveyor. For guidance, with ratio of T_E and $T_{E\,max}$ may be taken from Table 15 depending upon the characteristics of selected drive.

μ = the coefficient of friction between the driving pulley and the belt and can be determined from Table 16.

Table 13 Factor *β* for Extra Power Required for Separately Driven Tripper
[*Clauses* 8.5.3.3 (a) *and* 8.5.3.3 (b)]

Conveyor Length m	Tripper Slope				
	0°	1° - 5°	6° - 10°	11° - 15°	16° - 20°
5	—	—	—	0.27	0.23
10	—	—	0.29	0.24	0.19
15	—	—	0.20	0.17	0.15
20	—	0.21	0.17	0.14	0.12
30	—	0.19	0.11	0.10	0.08
45	—	0.15	0.10	0.08	0.08
60	—	0.11	0.08	0.08	0.08
75	—	0.11	0.08	0.08	0.08
90	0.11	0.10	0.08	0.08	0.08
120	0.09	0.09	0.08	0.08	0.08
150	0.08	0.08	0.08	0.07	0.07
180	0.07	0.07	0.07	0.07	0.07
210	0.07	0.07	0.07	0.07	0.07
250	0.07	0.07	0.07	0.07	0.07
300	0.07	0.07	0.07	0.07	0.07
600	0.07	0.07	0.07	—	0.07
1 000	0.07	0.07	0.07	—	0.06

Table 14 Factor β for Extra Power Required for Belt Propelled Trippers
[*Clauses* 8.5.3.3 (a) *and* 8.5.3.3 (b)]

Conveyor Length m	Tripper Slope				
	0°	1° - 5°	6° - 10°	11° - 15°	16° - 20°
5	—	—	—	0.52	0.44
10	—	—	0.54	0.46	0.35
15	—	—	0.36	0.30	0.25
20	—	0.40	0.30	0.23	0.19
30	—	0.32	0.21	0.17	0.14
45	—	0.27	0.18	0.15	0.13
60	—	0.21	0.15	0.12	0.11
75	—	0.19	0.14	0.11	0.10
90	0.19	0.17	0.12	0.10	0.09
120	0.14	0.13	0.10	—	—
150	0.13	0.12	0.10	—	—
180	0.11	0.10	—	—	—
210	0.11	0.10	—	—	—
250	0.10	—	—	—	—

8.5.4.4 *Minimum tensile force to limit the belt sag*

The minimum tensile force T_{min} which shall be exerted on the belt to limit the amount of belt sag between the two sets of idlers shall be:

$$T_{min} \geq \frac{P_c(m_B + m_G)g}{8S}, \text{ for carrying side} \quad ...(32)$$

$$\geq \frac{P_r m_B \cdot g}{8S}, \text{ for return side} \quad ...(33)$$

where

S = maximum allowable belt sag
= 0.005 to 0.02.

Values lower than these never be reached at any point on the installation. The maximum allowable belt sag $[(S = h/a)_{adm}]$, is generally fixed at between 0.005 and 0.02

8.5.4.5 *Variation of the tensile forces and maximum tensile force on the belt*

The necessary tensile force and its alteration along the conveying length shall he determined for each load case as a function of the number, the arrangement and characteristics of the driving and braking devices, and according to the type and location of the tensioning devices, by suitably adding to or subtracting from the minimum forces exerted on the belt the motion resistances, the forces due to the weight of the belt and the conveyed products, and the peripheral forces applied to oil the driving pulleys. The minimum necessary tensile force is fixed either by the ability of transmitting the peripheral force at a driving pulley or by the limitation of belt sag. This highest value of the necessary tensile force for a given load case is generally maintained with all the other load cases even if they do not require it, as normally it is not reasonable and not practicable to produce different take-up forces with different load cases. The maximum tensile force T_{max}, exerted on the belt which has to be used for the choice and the dimensioning of the belt can not be indicated by a formula which is universally valid. It is only in the simple cases, which, however, occur relative often, that is, in the case of horizontal conveying c with a small gradient, and if there is a single drivin pulley, and if low braking forces for stopping the plan are required, that the maximum tensile force applied to the belt can be calculated, approximately, by using formula (34) *(see* Fig. 7):

Table 15 Values of Drive Coefficient ξ

(*Clause* 8.5.4.3)

Sl No.	Type of Drive	Drive Coefficien $\xi \approx \frac{T_{E\,max}}{T_E}$
i)	Three phase squirrel cage motor with pin bush coupling and direct on line start	1.8. to 2.2
ii)	Three phase squirrel cage motor with fluid coupling and direct on the line start	1.5 to 1.6
iii)	Three phase squirrel cage motor with special fluid coupling with delayed chamber fitting	1.2 to 1.5
IV)	Three phase squirrel cage motor with special fluid coupling with delayed chamber with panel and scoop control	1.2
v)	Three phase squirrel cage motor with flexible coupling and start/delta start, slip-ring motor with slip gear starting control	1.2

$$T_{max} = T_1 = T_E\left(\frac{\xi}{\varepsilon^{\mu\phi} - 1} - 1\right) \quad ...(34)$$

NOTE — The coefficient takes into account the fact thi the peripheral force should be higher when starting the plant up then when at its nominal rating. According to th drive characteristics, the coefficient is between 1.2 and 2

8.6 Belt Specification

8.6.1 A conveyor belt consists of two elements, th carcass and the cover. The carcass is the reinforcin member and may be of either textile reinforcements steel cords and supplies the tensile strength and the body to the belt to hold the shape. In case of texti

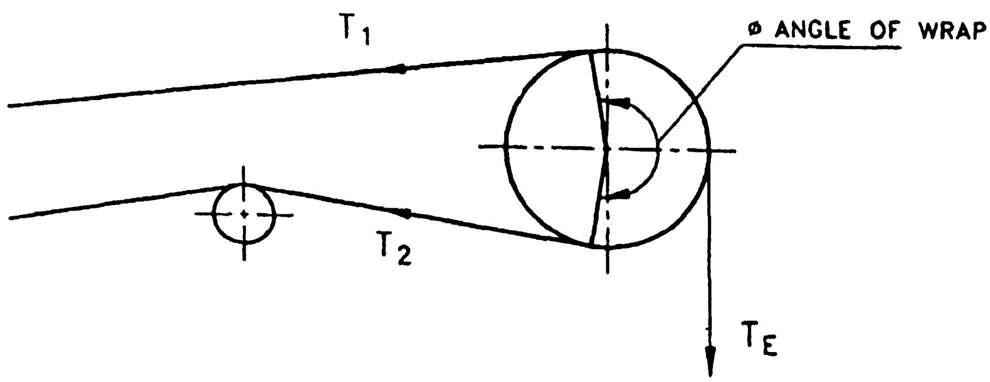


FIG. 7 TENSILE FORCES EXERTED ON BELT

Table 16 Friction Coefficient Between Driving Pulley and Rubber Belting

(Clause 8.5.4.3)

Pulley Leg / Operating Conditions	Smooth Bare Rim Steel Pulley	Rubber Lagging with Herringbone Patterned Grooves	Pulyurethane Lagging with Herringbone Patterned Grooves	Caramic Lagging with Harringbone Patterned Grooves	PVC Belt Type
Dry condition operation	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 condition (water) operation	0.1	0.35	0.35	0.35 to 0.4	0.15 to 0.30
Operation under wet and dirty (clay or loam conditions)	0.5 to 0.1	0.25 to 0.3	0.2	0.35	Less than 0.25
Operation under very wet and dirty condition	0.05	0.25	0.2	0.3	0.15

reinforcement, the carcass is normally build up of plies of textile fabric. The strength of fabric and the number of plies in the carcass of the belt may be varied together to suit the strength requirements. However, the strength of carcass has a practical limit. If the belt is too tough, troughing and training the belt will be very difficult. Therefore, the belt with lesser number of plies with stronger fabric is generally preferred because it is more flexible both in troughing and going round the terminal pulleys. The steel cord belting is used to meet the condition of small elongation and good troughbility in conjunction with higher operating tensile forces. PVC belting is generally selected for underground mining applications where fire hazard exists.

8.6.2 *Selection of Belt Carcass*

8.6.2.1 Tensile forces calculated in accordance with formula (34) *(see* **8.5.4.5)** is then used in selection of belt carcass based on full thickness tensile strength (FTTS) (belt type).

8.6.2.2 *Full thickness tensile strength (FTTS) method*

The value of tensile forces *(see* **8.6.2.1)** multiplied by factor of safety gives the required value of full thickness tensile strength of the required belt. The full thickness tensile strength of belt fixes the 'Type' of belt to be selected. The factor of safety may vary from 9 to 12.5 in case of textile belts and 7 to 10 in case of steel cord belts depending upon the application, type of belt joint, type of take-up device and type of starting for converyors. For general guidance a factor of safety of 10 is normally used for textile belts with vulcanized joints and on a conveyor with gravity take-up and 7 for steel cord belting.

8.6.2.3 After the selection, the selected carcass shall he checked for the following two constraints:

a) Adequate 'body' to support the load of the material carried for the specific width of the belt. This may be checked from manufacturers' recommendatory tables providing either minimum number of plies for adequate load support or maximum width for adequate load support for various types/constructions as also impact loading.
b) Adequate flexibility to trough on the specified angle of idlers. This may be checked from manufacturers' recommendatory tables pro-viding maximum number of plies for adequate troughing or minimum width for adequate troughing for various types/constructions.

8.6.2.4 The selected belting carcass shall be subsequently cross-checked for compatibility with the vertical curves occurring on the conveyor *(see* **8.9**).

8.6.3 *Selection of Cover*

8.6.3.1 The properties needed for the cover of belt include resistance to cutting, gauging, tearing, abrasion, aging, moisture absorption and in some conditions to oils, chemical and heat.

8.6.3.2 The grade and thickness of top cover of belt depend upon a number of conditions, the most important of which are:

a) abrasive qualities of the material being handled.
b) loading cycle, that is, the frequency with which the belt receives the load.
c) lump size of the material.
d) loading and unloading conditions.
e) temperature of the material to be handled.
f) chemical activity of the material.
g) contamination of the material with oils.
h) fire resistant cover needed or not.

8.6.3.3 The back cover thickness of a belt is generally 1.0 to 3.0 mm for textile rubber belts and 0.8 to 1.2 mm for PVC belts. In case of steel cord belts, back cover thickness is minimum 4.0 mm and range up to full thickness of face cover.

8.6.3.4 Care shall be taken for the determination of back cover thickness for belts on tandem drives and other

other special applications, where there is considerable wear and tear in the back side of the belt. In such cases the back cover thickness may be increased to 3 mm and above as may be necessary.

8.6.3.5 The cover grade is determined by characteristics of the material handled. The recommended values of rubber cover grade selection are given in IS 1891 (Part 1).

8.6.4 *Standardization of Belt Constructions*

Where belting specifications are being selected for a number of conveyors in a plant it is worthwhile to consider standardization of carcass and covers for a particular width of belting. This is to be looked into in terms of expected life and inventory. It may be noted here that the adequacy of belting constructions with respect to actual service conditions that exist on each individual installation should be ensured whilst standardizing.

8.7 Pulleys

8.7.1 Based on percentage tensile force (ratio between the working tensile force and maximum allowable tensile force of the selected belt), diameters of pulleys shall be selected from the recommended values given in IS 1891 (Part 1) and shall conform to IS 8S31.

8.7.2 The drive pulleys may be lagged, wherever necessary, to increase the coefficient of friction between the belt and the drive pulley.

8.7.3 The lagging thickness shall vary between 6 to 12 mm and the durometer hardness on head pulley shall be 55 to 65 Shore A scale, whilst on the snub and bend pulley shall be 35 to 45 Shore A scale. The softer rubber tends to resist the build up and allowing of solid objects to get embedded in the rubber rather than damage the belt.

8.7.4 In case of steel cord belting and PVC belting, special consideration shall be made in selection of pulley diameters and lagging, its type, thickness, material and application.

8.8 Idlers

8.8.1 *General Types of Idlers*

8.8.1.1 There are two basic type of belt conveyor idlers:

a) Carrying idlers which support the loaded run of the conveyor belt; and
b) Return idlers which support empty return run of the conveyor belt.

8.8.1.2 *Carrying idlers*

a) General *configurations* — Carrying idlers can have three types of general configurations:
    1) Five/three roll throughing idlers for troughed belts *(see* Fig. 2) consisting of four/two outer rolls, which are inclined upward and a horizontal central roll.
    2) Two roll throughing idlers for troughed belts *(see* Fig. 3) consisting of two identical idler rolls, inclined upward to facilitate the belt to from a trough.
    3) Horizontal carrying idler for supporting flat loaded belts *(see* Fig. 4) consisting of a single horizontal idler roll positioned between brackets which attach directly to the conveyor frame.
b) *Type of carrying idlers*
    1) The most commonly used type to carrying idlers consists of three in line idler rolls of equal length. For a given width of belt, roll inclination and surcharge angle of the material, the three equal length roll troughing idler forms the belt into the best troughed shape to carry a maximum load cross-section.
    2) Troughing idler arrangement having a relatively long horizontal roll and two short upward inclined rolls does not form a given belt into a trough for maximum load cross-section but is useful under certain conditions, for instance where conveyor's load must be spread for manual inspection, picking up or sorting. The inclined end rolls turn up the belt edges to prevent or greatly minimize spillage.
    3) In an offset troughing idler, the inclined rolls (two numbers on both the sides) and the horizontal roll are located in two different vertical planes.
    4) *Catenary type* — Troughing idler consists of a flexible catenary member on which integral small diameter rolls or multiple roll assembly is mounted. The rolls can be moulded either in the flexible member, which rotates as an assembly in fixed bearings at the ends of the catenary member or in the individual rolls which may rotate on bearings supported by the flexible catenary member.
    5) *Garland type* — This type of idlers are suspended from stringers by suitable suspension methods. This type of idlers consist of rolls connected in between with flexible links and can be used for both on carrying and return side.
    6) *Impact cushioned idlers* — Impact type idlers having rolls made of resilient material, are used at loading points where the lump size and the weight of the handled

8.8.3 *Tilting of Idler*

8.8.3.1 Angle of tilt shall be provided on the side rollers if specified by the purchaser.

8.8.3.2 The angle of tilt on side rollers of idlers shall be in the direction of belt run for the unidirectional conveyors and it shall be 'zero' degree for reversible belt conveyor.

8.8.3.3 Angle of tilt on side rollers of idlers shall be as small as possible (generally 2°) and in any case, it shall not be more than 3°.

8.8.4 *Idler Spacing*

8.8.4.1 *Carrying idler spacing*

The following points shall be considered carefully while determining the idler spacing for carrying idlers of a belt conveyor:

a) Increased idler spacing increases the belt sag and hence the power loss due to friction is greater.
b) Very low belt sag means higher belt tensions and therefore, cost of the belt is high.
c) The practical upper limit of belt sag is 2 percent of the idler spacing after which the force required to pull the load increases steeply. However, for all practical cases, the belt sag shall be limited to 0.5 to 2.0 percent of the idler spacing.
d) The belt tensions, especially for a long centre conveyor, very considerably along the length of the conveyor, which means different idler spacings are required to limit the belt sag to a fixed value. Proper care shall be taken to determine the idler spacings for such conveyors. The idler spacings in the carrying side (P_c) and in the return side (P_t) of the belt can be determined from the equations (32) and (33) for graduated idler spacings by deciding a safe maximum allowable belt sag (S); and finding other terms of the equations. For example, in a long centre conveyor, with uniform slope, there can be three sections, the first might be one-tenth of the conveyor length (independent of loading section) with a carrying idler spacing of 100 percent of the average, the secbnd section of three-tenth of conveyor length at 85 percent of average spacing, and the remaining three-fifth of conveyor length at 125 percent of average spacing. The maximum spacing shall be so selected as to ensure that the belt does not loose its troughed shape. If the slope of the conveyor varies, the idler spacing shall be arranged to suit the belt tensions at various points.
e) Idlers at the feed point of the conveyor shall be closely spaced to avoid higher belt sag due to impact of load.
f) To determine the idler spacing towards or at the head, the following factors other than the limiting belt sag shall be considered:
   1) There shall be no side spill of the material as the belt flattens out in going from the last troughing idlers on to the head pulley.
   2) The load shall not change its cross-section between idlers that is the edges of the belt shall not flatten down.
   3) The load on each idler shall not exceed the load rating value.
g) In normal circumstances, conveyors arranged with the pitch as indicated in Table 17 may be found to be suitable.

8.8.4.2 The spacings of carrying as well as return idlers for belt widths of 1 200 or more as given in Table 17 shall be checked for the idler load capacities.

8.8.4.3 A set of self aligning idler shall be provided at drive end and return end of conveyor and at an interval of 15 m on the carrying run wherever feasible and 30 m at the return run. In case or short converyors, at least one set of self-aligning idlers shall be provided at the carrying and return run. In case of steel cord belting, the distance of self-aligning idlers on carrying run may be reduced to 10 m.

8.8.4.4 *Calculation of transition distance*

The distance between the terminal pulley and the adjacent fully troughed idler set at either at the head or tail end of a conveyor, is known as transition distance. This spacing shall not be short so that the edges of the belt are stretched too much as the belt loses its troughed shape and flatterns down the rim of the pulley. The transition distance, therefore, shall be such as to limit the edge tension to a maximum of 130 percent of maximum rated belt tension and prevent buckling of centre portion of belt. In addition, occurrence of zero or negative tensions in the centre of the belts also shall be avoided when the belt tension is low such as occurring at tail end of some conveyors. To minimize this stretch, usually the pin of the terminal pulley is set in line with the tops of the horizontal rolls of the troughing idlers. Alternately the rim of terminal pulley may be set at a line located at one-third of the depth of troughed section of the conveyor. The transition distance shall be calculated from the following formula:

$$x = 0.707y\left(\frac{E}{\Delta T}\right)^{1/2} \qquad \dots (35)$$

Table 17 Recommended Idler Spacing

[*Clauses* 8.8.4.1(g) *and* 8.8.4.2]

All dimensions in millimetres.

<table>
<tr><th>Belt Width</th><th colspan="2">Troughed Belt</th><th>Flat Belt</th><th>Return Idler Sets</th></tr>
<tr><td></td><td colspan="2">Carrying Idler Sets for Materials of Bulk Density (t/m^3)</td><td></td><td>Troughed and Flat Belt</td></tr>
<tr><td></td><td>0.40 to 1.20</td><td>1.20 to 2.80</td><td></td><td></td></tr>
<tr><td colspan="5">Recommended Spacings</td></tr>
<tr><td>300
400
500
650</td><td>1 500</td><td>1 200</td><td rowspan="2">1 000</td><td rowspan="3">3 000</td></tr>
<tr><td>800
1 000</td><td>1 200</td><td>1 000</td></tr>
<tr><td>1 200
1 400
1 600
1 800
2 000</td><td>1 000</td><td>1 000</td><td>750</td></tr>
</table>

where

y $\dfrac{B \sin\lambda}{3}$ when pulley is in line with top centre idler roller ...(36)

$= \dfrac{B \sin\lambda}{4.5}$ when pulley is elevated by one-third of the trough depth above the line of the centre idler roller ...(37)

E = the elastic modulus measured at the maximum rated belt tension (RMBT) in N/mn and is provided by the manufacturer

ΔT = the induced belt edge stress in the transition in N/mm and is selected from Table 18 in relation to the ratio of belt tension at the transition to maximum rated belt tension. An alternative method of calculating ΔT is given in Annex F.

8.8.4.5 *Special consideration for spacing the idlers at head end*

The distance from the head pulley to the nearest troughing idler shall not be more than the spacing of the idler which is considered proper for the load on the belt and tension on the belt.

8.8.4.6 *Special considerations for spacing the idlers at loading point*

The following points shall be considered while deciding the idler spacing at the loading point:

a) The distance between tail pulley and the first fully troughed idler shall be in accordance with **8.8.4.4.**

b) The rim of the tail pulley shall be in accordance with **8.8.4.4** so as to aviod the belt getting damaged due to lifting and rubbing against the loading chute or skirt boards.

c) The first fully troughed idler is generally set about 150 mm behind the end of the loading chute or wherever the material first strikes the belt so that neither the idler is hurt by the impact of the material, nor any damage is done to the belt where it is backed up by the idler.

d) The spacing of first few idlers under the skirt board shall be made closer, generally 0.33 to 0.75 of normal idler spacing to prevent the belt from sagging away from the boards or the rubber guard strip.

e) Rubber covered idlers or alternatively mounting the idler stand on rubber filler blocks shall be considered if the impact of the material is severe at the feed point. Provision of impact shall be considered.

f) When idler spacing is graduated, the idlers just ahead of the loading point shall be set closer than the average spacing so that the belt takes the load of the material away from the skirt boards without abrupt change of load cross-section.

g) In case of a long conveyor having a continuous loading zone for almost entire length of the conveyor, for example, when fed by mobile plough feeder or by mobile reclaimer provision of impact table in the feeding machine is recommended in place of providing continuously closed spaced cushioned idlers for the entire length of the travel. The receiving conveyor shall have normally spaced troughing idlers without any skirt.

8.8.4.7 *Idler spacing on curves (convex or concave)*

Following points shall be taken into consideration:

a) The spacing of the idlers on concave curves shall be normal spacing, and for convex curves, it shall be 40 to 50 percent of the normal spacing of the idlers or if the spacing is variable, the spacing on that part of the length of conveyor.
b) The number of idler spacings shall not be less than three for any type of curves.

Table 18 Induced Belt Edge Stress
(Clause 8.8.4.4)

Ratio of Belt Tension at Transition to Maximum Rated Belt Tension (T_m)	ΔT
1.0	$0.30T_m$
0.9	$0.35T_m$
0.8	$0.45T_m$
0.7	$0.55T_m$
0.6 to 0.3	$0.60T_m$
0.2	$0.40T_m$
0.1	$0.20T_m$
0.05	$0.10T_m$

8.8.5 *Idler Selection*

8.8.5.1 It is extremely important to select proper idlers as they considerably influence the performance of a belt conveyor. The selection of idler is governed by many factors, namely, the type of service, loading, surrounding conditions, the characteristics of the material handled, the belt speed, etc.

8.8.5.2 Typical methods for selection of idler based on a particular service conditions of a belt conveyor are given in Annexes B, C and D for guidance. Any method of selection of idler may be used for arriving at suitable idler sizes.

8.8.5.3 Annex E gives the method for calculation of idler bearing load.

8.9 Curves in Belt Conveyors

8.9.1 There are two kinds of curves in belt conveyors:

a) Convex curves, where the components of belt tension act downwards or against the belt supports; and
b) Concave curves, where components of belt tension act upward tending to lift the belt off its supports.

8.9.2 *Convex Curves*

8.9.2.1 The transition of the belt from inclined to horizontal or less inclined may be done with help of a turning pulley or a group (minimum three sets) of troughed idlers. The belt shall not be bent with the aid of a turning pulley where the belt speed is high enough to cause the load to leave the belt by an appreciable distance (*see* **8.13.3** on discharge trajectories). However, even if the belt speed is not high, the later method shall generally be adopted.

8.9.2.2 The minimum radius of the curves shall not be less than 12 times the width of belt for practical purposes where troughing idlers of 30° troughing angle or less axe used. However, two factors, as follows, shall be considered in design to ensure that the path of the belt follows a satisfactory radius:

a) *Overstress of belt edges*

$$\text{Minimum radius, } R_c = \frac{B.E\sin\lambda}{4.5(T_m - T_c)}\ \text{m} \quad ...(38)$$

b) *Lack of tension at belt centre*

$$\text{Minimum radius, } \frac{B.E\sin\lambda}{9(T_c - 4.5)}\ \text{m} \quad ...(39)$$

NOTES

1 T_e will be checked for all load conditions.

2 Radius to be checked for all load conditions and maximum radius to be adopted.

8.9.2.3 Belt modulus '*E*' required by formulae (38) and (39) is a product of specific modulus for the material of belt carcass and rated tensile strength. For calculation, values of specific modulus, E_s, can be taken from Annex G.

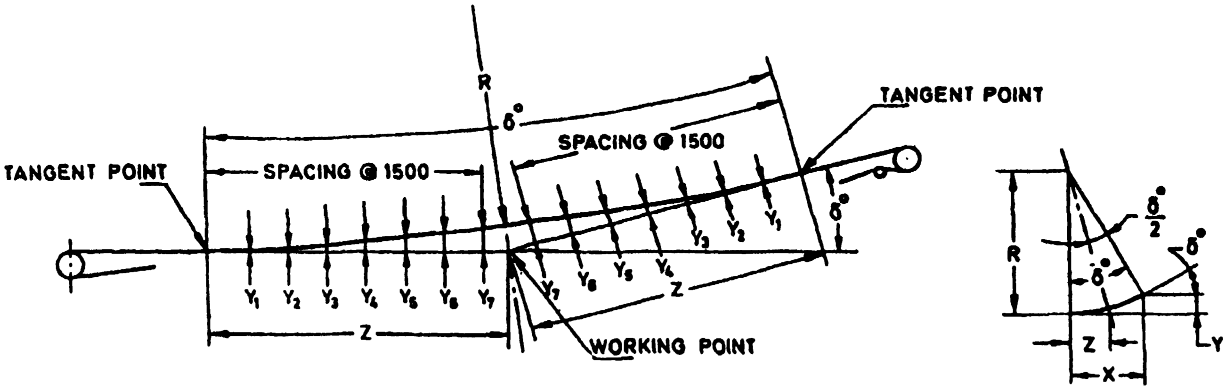
$$E = E_s \times \text{Rated Tensile Strength} \quad ...(40)$$

8.9.2.4 Idler spacing shall be in accordance with **8.8.3.7**.

8.9.3 *Concave Curves*

8.9.3.1 When the belt curves upwards from horizontal to an incline section or from an inclined section of the belt to a more inclined section, the freely sagging belt forms a curve that composes part of a catenary.

8.9.3.2 The minimum radius shall be such that the belt will not lift off the carrying or return idlers even under worst condition when the belt is fully loaded up to the start of the curve and empty thereafter.



All dimensions in millimetres.

FIG. 8 RADIUS OF CURVATURE FOR CONVACE CURVE

8.9.3.3 The radius of the curve is proportional to the belt tension but inversely proportional to the mass of belt per metre.

8.9.3.4 The minimum radius, R_c, of the curve is recommended as 45 metres for practical purposes. However following three factors shall be considered in design to ensure that the path of the belt follows a satisfactory radius:

a) *Lift off*

Minimum radius for empty belt,

$$R_c = \frac{T_c.B.1\,000}{9.8\,m_B} \text{metres} \quad \text{... (41)}$$

Minimum radius for loaded belt,

$$R_c = \frac{T_c.B.1\,000}{9.8\,(m_B + m_G)} \text{ metres} \quad \text{... (42)}$$

Minimum radius for partially loaded belt (loaded up to beginning of curve),

$$R_c = \frac{T_{cmax}\,B.1\,000}{9.8\,m_B} \quad \text{... (43)}$$

where

$T_{Cmax} = T_{lmax} - flg\,[m_C + m_B \cos \delta] - [R_s + R_{spl} + R_{sp2}]$ ...(44)

$[R_s + R_{spl} + R_{sp2}]$ shall be caluclated for distance in which belt is empty and shall exclude the length of cruve.

T_{lmax} shall be worked out from equations (33) and (5) considering the belt is only partially loaded.

b) *Overstress at centre of belt*

$$\text{Minimum radius } R_c \quad \frac{B.E\sin\lambda}{9\,(T_m - T_c)} \text{ metres} \quad \text{... (45)}$$

c) *Lack of tension at belt edge*

$$\text{Minimum radius} \quad R\frac{B.E\sin\lambda}{4.5\,(T_c - 4.5)} \text{ metres} \quad \text{... (46)}$$

8.9.3.5 Belt modulus 'E' required for formulae (45) and (46) can be calculated with the help of equation (40) and Annex G.

8.9.3.6 The empty belt may be held from rising too far by the use of one or more hold-down pulleys set high enough to clear load when the belt is on the carriers.

8.9.3.7 Table 19 read with Fig. 8 gives typical values for ordinates with $\delta = 20°$.

8.10 Drive Selection

8.10.1 *Basis of Selection*

8.10.1.1 The fundamental equation for a belt conveyor drive is given by equation (30) in **8.5.4.3.** For most efficient drive, the ratio of maximum tensile force, T_1, and the minimum tensile force, T_2, that is the slack-side tensile force in the belt, should be as high as possible.

8.10.1.2 Table 20 gives the value of ratios of forces T_1, T_2 minimum and T_E for different arcs of contact on driving pulley(s).

8.10.1.3 For the selection of type of drive, minimum number of pulleys and least flexing of the belt consistent with the lowest practical belt tension is preferred.

8.10.2 *Types and Selection of Drives*

8.10.2.1 *Single, unsnubbed, bare/lagged pulley drive*

The simplest drive arrangement consists of one steel pulley connected to the source of power, having belt wrapped around it on an arc of 180°. This can be used for low capacity, short centre conveyors handling of impact table in the feeding machine is recommended in place of providing continuously closed spaced cushioned idlers for the entire length of the travel. The receiving conveyor shall have normally spaced troughing idlers without any skirt.

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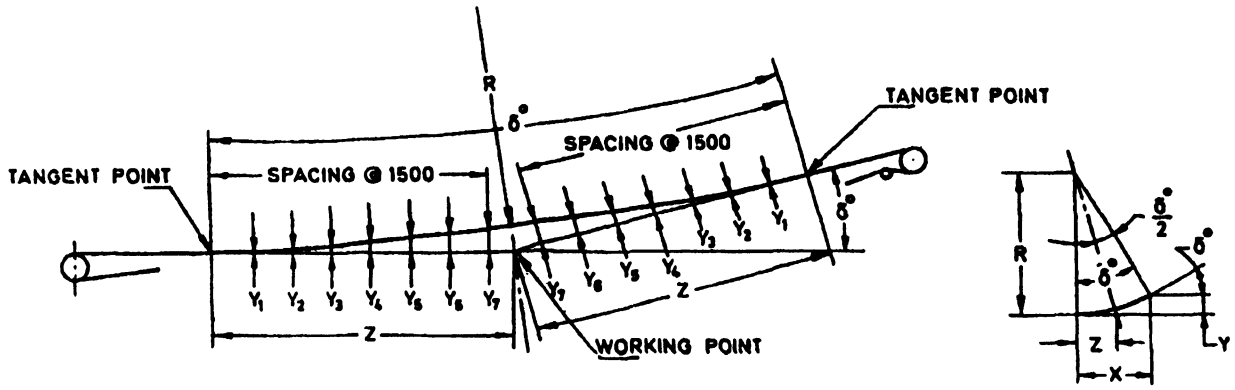

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b) *Overstress at centre of belt*

$$\text{Minimum radius } R = \frac{B.E\sin\lambda}{9\,(T_m - T_c)} \text{ metres} \quad \text{... (45)}$$

c) *Lack of tension at belt edge*

$$\text{Minimum radius } R_c = \frac{B.E\sin\lambda}{4.5\,(T_c - 4.5)} \text{ metres} \quad \text{... (46)}$$

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8.10.1.3 For the selection of type of drive, minimum number of pulleys and least flexing of the belt consistent with the lowest practical belt tension is preferred.

8.10.2 *Types and Selection of Drives*

8.10.2.1 *Single, unsnubbed, bare/lagged pulley drive*

The simplest drive arrangement consists of one steel pulley connected to the source of power, having belt wrapped around it on an arc of 180°. This can be used for low capacity, short centre conveyors handling non-abrasive material. The pulley may be lagged to increase the coefficient of friction and avoid pulley wear for abrasive materials.

8.10.2.2 *Snubbed, bare/lagged pulley drive*

The ratio of maximum belt tension to effective belt tension for the drive is decreased by snubbing the belt at head pulley which may be bare or lagged. The arc of contact is increased from 180° to 210° and can further be increased to 260° by providing snub/drive pulley. In majority of normal medium to large capacity belt conveyors, handling mild abrasive to fairly abrasive materials, 210° snub pulley drive with head pulley lagged with hard rubber is adopted.

8.10.2.3 *Tandem drive*

Where the belt tensile forces are very high and it is necessary to increase the angle of arc of contact, tandem drives are used. The tandem pulleys are both driven and share the load resulting in a lower effective tension for a given power transmitted. The tandem drive with arc of contact from 300° to 440° or more can function with one or two motors. The location of such drive is usually determined by the physical requirements of the plant and its accessibility.

8.10.2.4 *Drive pulleys with twin drive*

For belt conveyors, use of twin drive pulleys can be considered as given in Annex H.

8.10.3 *Drive motors*

8.10.3.1 At the start of the belt, the tension is normal tension plus additional tension to overcome the inertia of the load. This increased starting tension is detrimental to the belt specially for long conveyors and it is necessary to design the drive system to suit the strength of the selected belt. Except in short and low speed conveyor, the belt tension during the start will tend to be as much as the drive capable of exerting and in cases of repeated over-loading, the belt may fail due to fatigue.

8.10.3.2 *Safety factor at starting and braking condition*

Safety factor for the belts when calculated in accordance with the following formula shall not fall below six in case of textile fabric belt and below five in case of steel cord belt when the conveyors are starting up or braking:

$$S_F = \frac{N_B . B}{T_{SB}} \qquad \text{... (47)}$$

8.10.3.3 Belt manufacturers commonly rate conveyor bells so that they are able to withstand the frequent extra loads that occur in starting. Also drive factors, $\frac{1}{e^{\mu\phi} - 1}$ or T_2/T_E allow for some extra tension before slipping would occur between pulley and belt. A correctly designed drive will allow maximum allowable tension force of the belt until the belt has been brought to its running speed. It shall be ensured that the drive system including drive motor, coupling, gear box, pulley and chain drive, etc, does not exert even at the starting condition, any more tensile force than the recommended transient capacity of the belt.

8.10.3.4 The above applies to normal duty conveyors with single or dual drive provided with controlled start of motor (that is fluid coupling, centrifugal hydraulic slip, eddy current, clutch) by use of devices for speed and acceleration control.

8.10.3.5 To avoid these undesirable aspects it is necessary to limit the torque developed during startup, and extend the acceleration period as reasonably long as possible, and this is achieved by acceleration control. The acceleration control can be provided by using a dc motor as the prime mover, but the motor and associated switchgear are both large and expensive. A most effective means of control is to interpose a hydraulic coupling or torque converter between the electric motor and input shaft of the drive unit's reduction gear. This allows the compact, high speed, ac motor to be employed, whilst providing, the desired acceleration control. It is important, however, to ensure that on multi-motor dual drives that all electric motors and hydraulic couplings have the same torque and speed characteristics respectively, and that the speed differential between the drive pulleys is within the slip characteristics of motors and couplings. When selecting hydraulic couplings it shall be remembered that the slip characteristics can be modified by adjusting the volume of oil in the working circuit. Two basic forms are available. In one type the oil filling can only be adjusted with the unit stationary and remains constant thereafter. In the other type the filling may be adjusted during operation so that both the rate of filling and the final quantity can be varied. The first type is very widely adopted for conveyor drives up to approximately 110 kW but it is obvious that the latter type gives a wider range of adjustment and is amenable to external control. It is commonly selected in multi-motor installations where individual powers of 75 kW and larger are used. The rate at which this slack belt is accumulated and, therefore, the rate at which the take-up unit has to be designed to operate is directly proportional to the rate to acceleration, so the longer and more controlled the acceleration the smoother and lower the rate of take-up.

Table 19 Value of Ordinates for Convace Curve

(Clause 8.9.3.7)

Distance from Tangent Point in metres	Radius of Curve (R_e) in metres														
	50	65	80	95	110	125	140	165	180	210	240	270	300	330	360
1.5	0.022	0.017	0.014	0.011	0.010	0.009	0.008	0.006	0.006	0.005	0.004 6	0.004 1	0.003 7	0.003 4	0.003 1
3	0.090	0.069	0.056	0.047	0.040	0.036	0.032	0.027	0.025	0.021	0.018	0.016	0.015	0.013	0.012
4.5	0.202	0.155	0.126	0.106	0.092	0.081	0.092	0.061	0.056	0.048	0.042	0.037	0.033	0.030	0.028
6	0.361	0.277	0.225	0.189	0.163	0.144	0.128	0.109	0.100	0.085	0.075	0.066	0.060	0.054	0.050
7.5	0.565	0.434	0.352	0.296	0.255	0.225	0.201	0.170	0.156	0.133	0.117	0.104	0.093	0.085	0.078
9	0.816	0.626	0.507	0.427	0.363	0.324	0.289	0.245	0.255	0.192	0.168	0.150	0.135	0.122	0.112
10.5		0.853	0.692	0.582	0.502	0.441	0.394	0.334	0.306	0.262	0.229	0.204	0.183	0.167	0.153
12		1.117	0.905	0.760	0.656	0.577	0.515	0.436	0.400	0.343	0.300	0.266	0.240	0.218	0.200
13.5			1.147	0.964	0.831	0.731	0.652	0.553	0.506	0.434	0.379	0.337	0.303	0.276	0.253
15			1.418	1.191	1.027	0.903	0.805	0.683	0.626	0.536	0.469	0.416	0.375	0.341	0.312
16.5				1.443	1.244	1.093	0.957	0.827	0.757	0.649	0.567	0.504	0.454	0.412	0.378
18				1.720	1.482	1.305	1.161	0.984	0.902	0.772	0.675	0.600	0.540	0.491	0.450
19.5					1.742	1.530	1.364	1.156	1.059	0.907	0.793	0.705	0.634	0.576	0.528
21					2.023	1.776	1.589	1.341	1.229	1.052	0.920	0.817	0.735	0.668	0.613
22.5						2.041	1.819	1.541	1.411	1.208	1.057	0.939	0.844	0.767	0.703
24						2.325	2.072	1.754	1.607	1.375	1.203	1.068	0.961	0.873	0.800
25.5							2.341	1.982	1.815	1.553	1.358	1.206	1.085	0.986	0.904
27							2.628	2.224	2.036	1.742	1.523	1.353	1.217	1.106	1.013
28.5								2.480	2.270	1.942	1.698	1.508	1.356	1.232	1.129
30								2.750	2.517	2.153	1.882	1.671	1.503	1.366	1.252
31.5									2.777	2.375	2.076	1.843	1.658	1.506	1.380
33									3.050	2.609	2.279	2.024	1.820	1.654	1.515
34.5										2.853	2.492	2.213	1.990	1.808	1.656
36										3.108	2.715	2.410	2.167	1.969	1.804
37.5										3.375	2.947	2.616	2.352	2.137	1.958
39										3.653	3.189	2.831	2.545	2.312	2.118
40.5											3.441	3.054	2.746	2.494	2.285
42											3.703	3.286	2.954	2.683	2.458
43.5											3.975	3.527	3.170	2.879	2.637
45											4.256	3.776	3.394	3.082	2.823
46.5												4.034	3.625	3.292	3.015
48												4.300	3.864	3.509	3.214
49.5												4.567	4.111	3.733	3.419
51												4.860	4.366	3.964	3.630
52.5													4.629	4.202	3.848
54													4.900	4.448	4.073
55.5													5.178	4.700	4.303
57													5.464	4.960	4.541
58.5														5.226	4.784
60														5.500	5.035
61.5															5.292
63															5.555
64.5															5.825
66															6.101
67.5															6.384

Table 20 Arc of Contact and Ratio of Tensions

(Based on μ = 0.25 for bare pulley and 0.35 for lagged pulley)

(*Clause* 8.10.1.2)

Arc of Contact on Driving Pulley degree	Ratio T_1/T_2		Ratio T_2/T_E		Ratio T_1/T_E		Type of Drive
	Bare pulley	Lagged pulley	Bare pulley	Lagged pulley	Bare pulley	Lagged pulley	
180	2.19	3.00	0.85	0.50	1.85	1.50	Plain
190	2.29	3.19	0.78	0.46	1.78	1.46	Snubbed
200	2.39	3.39	0.72	0.42	1.72	1.42	do
210	2.50	3.61	0.67	0.38	1.67	1.38	do
220	2.61	3.83	0.62	0.35	1.62	1.35	Snubbed
230	2.73	4.13	0.58	0.32	1.58	1.32	do
240	2.85	4.33	0.54	0.30	1.54	1.30	do
360	4 80	9.02	0.26	0.13	1.26	1.13	Tandem
380	5.25	10.19	0.23	0.11	1.23	1.11	do
400	5.72	11.51	0.21	0.09	1.21	1.09	do
420	6.25	13.00	0.19	0.08	1.19	1.08	do
440	6.90	15.29	0.17	0.07	1.17	1.07	Tandem
460	7.67	15.90	0.15	0.063	1.15	1.063	do
480	8.15	19.21	0.14	0.055	1.14	1.055	do
500	8.86	21.21	0.13	0.050	1.13	1.05	Tandem
600	13.71	39.06	0.08	0.030	1.08	1.03	do

8.11 Coasting

8.11.1 *Coasting Time*

It is important to note that the drives of a conveyor system which consists of more than one belt conveyor in which at least one belt feeds on to another, have to be interconnected electrically so that if one conveyor is stopped for any reason, the one feeding on to it must slop. If the physical properties of conveyor are such that it would coast for a longer time than the one on to which it feeds there will be pile up of material at the transfer point. In general, in any conveyor system with more than one conveyors, the length of the deceleration cycle of any successive conveyor calculated in accordance with **8.11.4,** shall be at least equal to or greater than that of the preceding one. Therefore

$$t_{max} \leq \frac{2md}{m_G . V} \quad \text{... (48)}$$

8.11.1.1 For conveyors with belts conforming to IS 1891 (Part 2) carrying hot material, this aspect takes special importance as otherwise belt is liable to be damaged by burning.

8.11.2 *Hold-back and Brakes*

8.11.2.1 Hold-back arrangement and/or brake shall be provided on conveyors which tend to reverse the direction of run when power is off or under very heavy overload.

8.11.2.2 Any conveyor requiring greater power to lift the load than the power required to move the belt and the load horizontally, shall be provided with hold-back or brake arrangement.

8.11.2.3 A regenerative downhill conveyor does not need a hold-back, but it shall be equipped with an automatic brake capable of bringing the fully loaded conveyor to rest within a reasonable time, when power is off.

8.113 *Acceleration Time*

8.11.3.1 *Acceleration time for the load of a conveyor*

The time taken to accelerate the load on any conveyor is given by (for symbols *see* Table 1).

$$t_a = \frac{(m_c + m_r + 2m_B + m_G + m_p) L.V.}{T_E - T_1} \quad \text{...(49)}$$

where

T_E = 1.5 T_m for steel cord belts; and

= 1.6 T_m for tensile fabric belts.

8.11.3.2 *Time taken by the motor to accelerate the conveyor*

The time which the drive motor needs to accelerate the conveyor assuming the components treated as hollow cylinders is given by (for symbols *see* Table 1):

$$t_m = m_{eq} \frac{V}{F_a} \quad \text{... (50)}$$

where

$$m_{eq} = (m_c + m_r + 2m_B + m_G + m_p + m_i).L \text{ kg} \quad \text{...(51)}$$

$$m_l = \frac{(GD)^2}{4L} \cdot \left(\frac{2\pi N}{60V}\right)^2 \quad \text{... (52)}$$

$$F_a = \frac{(\eta p_l \times P_M - P_A) \cdot 1\,000}{V} \quad \text{...(53)}$$

ρ_l = ratio of average starting motor torque and full load motor torque depending upon type of coupling to and starting of motor (*see also* **8.5.4.3**)

NOTE — The GD^2 value in the above equation shall be cumulative value of all the equivalent GD^2 of motor, reducer, drive pulley, coupling and drive pulley in Nm all referred to the motor shaft axis.

$$m_l.L.V^2 = \frac{GD^2}{4}\left(\frac{2\pi N_1}{60}\right)^2 + \frac{GD^2}{4}\cdot\left(\frac{2\pi N_1}{60}\right)^2 + \frac{GD^2}{4}\left(\frac{2\pi N_1}{60}\right)^2 +$$

(For Motor) (for H.S. Coupling) (For Gear Box)

$$\frac{GD^2}{4}\cdot\left(\frac{2\pi N_1}{60}\right)^2 + \frac{GD^2}{4}\cdot\left(\frac{2\pi N_2}{60}\right)^2 \quad \text{...(54)}$$

(For S.S. Coupling) (For Drive Pulley)

8.11.3.3 The allowable time taken for the motor to accelerate the loaded belt has to be greater than or equal to the minimum acceleration time to stay within the maximum allowable belt tension, while starting the conveyor fully loaded that it $t_m \geq t_a$.

8.11.4 *Deceleration Time*

8.11.4.1 By equating the kinetic energy of a conveyor to the power absorbed, the time, t_d in seconds to bring the conveyor to rest from its running speed of V m/s with usual notations is given by:

$$t_d = m_{eq} \frac{V^2}{1\,000 P_A} \quad \text{... (55)}$$

8.11.4.2 The resisting factional retarding force is:

$$F_d = \frac{P_A - 1\,000}{V} \text{ newtons} \quad \text{.. (56)}$$

8.11.4.3 If the deceleration time, t_d, is to be reduced to "t'_d" since the total retarding force is inversely proportional to the deceleration time, additional braking force, F_{ad}, required is:

$$F_{ad} = \frac{P_A.1\,000}{V} \cdot \frac{t_d - t'_d}{t'_d} \text{ newtons} \quad \text{... (57)}$$

8.11.4.4 If the brake is connected to the drive pulley shaft, the drive pulley is required to transmit to the belt a braking force equal to:

$$\frac{P_A.1\,000}{V} \cdot \frac{t_d - t'_d}{t_d} \cdot \frac{m_{eq} - m_l.L}{m_{eq}} \text{ newtons} \quad \text{... (58)}$$

8.11.4.5 The difference in the values of **8.11.4.3** and **8.11.4.4** is the braking force required to decelerate the drive and drive pulley and is not transmitted to the belt.

8.11.5 *Braking or Deceleration Forces*

8.11.5.1 The braking force required for any conveyor is the algebraic sum of inertia force, frictional resistance force, and gravity material load forces, inclined or declined. The frictional resistance forces and gravity forces, if any, are equal to T_E, the effective driving force.

8.11.5.2 The braking force is given:

a) *In case of horizontal, inclined or declined and non-regenerative belt conveyors, by*

$$F_b = m_{eq} \frac{V}{t_{max}} - T_E \text{ newtons} \quad \text{...(59)}$$

b) *In case of regenerative decline belt conveyors by*

$$F_b = m_{eq} \frac{V}{t_{max}} + T_E \text{ newtons} \quad \text{... (60)}$$

8.12 Take-Up

8.12.1 *Functions*

Main functions of take-up are:

a) ensuring adequate tension of the belt leaving the drive pulley so as to aviod any slipping of the belt;
b) permanently ensuring adequate belt tension at the loading point and at any other point of the conveyor to keep the troughed belt in shape and limit belt sag between carrying idlers;
c) compensating for operating belt length variation due to physical factors (instantaneous tensions, permanent elongation, outside temperature, temperature of conveyed material, dampness, etc); and
d) making available, if needed, an adequate extra

length of belt to enable rejoining without having to add an extra piece of belt.

8.12.2 *Types*

8.12.2.1 Two types of take-up generally used are:

a) fixed take-up devices that are adjusted periodically, and

b) automatic take-up devices (constant load type).

8.12.2.2 *Fixed take-up devices*

In this type of take-up devices, the take-up pulley remains fixed between successive periodic adjustments. Take-ups of this type generally used are;

a) *Screw take-up* — In this system the adjustment is manually effected by means of two screws acting upon the pulley bearings and which are tightened simultaneously or successively. The screw is normally of non-extendable type and sliding surfaces are suitably protected against ingress of dirt. In this system, the applied tension is not fully determinable. This generally leads to excessive tension of belt (when tension is insufficient, belt slips and quickly deteriorates). This excessive tension is unavoidable and shall be taken into account when determining the size of the belt, designing the mechanical components and calculating the adjustments. For this reason, these devices are used only in case of short conveyors of up to 60 m lengths and under light duty cycle condition.

b) *Winch take-up* — In this system, the tension is adjusted by means of a mechanical motorized device which does not automatically compensate for belt length variations. A tension indicator may be included between winch and pulley. This system also requires careful checking of tension and leads to excessive belt tension in order to aviod too frequent take-ups. However, it may be used for long conveyors and under heavy duty conditions provided that these conveyors are equipped with belts having very low elongation coefficient under the effect of load and over a long period, for example, steel cord belts which are used almost exclusively.

8.12.2.3 *Automatic take-up*

In this system, take-up pulley is mounted on slides or on a trolley and travels freely while a constant tension is automatically maintained to ensure normal conveyor operation in all cases. The most frequently used type is gravity weight operated take-up device. Hydraulic, pneumatic or electrical take-up devices of various types are also used. All types of automatic take-up devices shall include a system for adjusting belt tension. Automatic take-up has following features:

a) It is self-adjusting and automatic.

b) Greater take-up movement is possible.

c) It is suitable for horizontal or vertical installation.

d) It is preferred for long centre conveyors.

e) It can be located at drive end (preferred for low tensions).

f) In case of underground mines, provision of loop at drive end may be made to cater for take-up and small extension of belt conveyor lengths.

8.12.2.4 *Winch take-up (automatic)*

Winch take-up device can also be used as automatic take-up arrangement when automatic tension regulation (ATR, by employing load ceils, electronic sensing devices etc) is provided to signal for the winch motor to run in one direction or reverse for specific number of turns or to stop as governed by predetermined values of belt tensions for any particular installation. This is highly recommended for long centres high capacity belt conveyors since it fetches less space (horizontal/vertical) and also do not unnecessarily put the belt always in heavy tension as imparted by the constant counter weights necessary for operation at maximum design load in a gravity take-up. The heavy tension is gravity type-up arrangements continues to exist in the belt even when it is not running.

8.12.3 *Selection of Take-Up*

The choice of take-up and their location has to be decided depending on the configuration and length of the conveyor and available space. But acceleration and braking of conveyors have certain effects on the take-up. These have to be taken into account while deciding the location of take-up. For guidance effect of acceleration and braking on counterweight take-up is given in Table 21.

8.12.3.1 Typical take-ups are shown in Fig. 9 to 12.

8.12.4 *Take-Up Weight*

After having decided the location of take-up, the belt tension at this location, the take up weight can be calculated as follows:

Take-up weight mechanical advantage = belt tension at point of take-up - weight of take-up pulley and its frame + friction force of take-up carriage rope, sheave, etc ...(61)

8.12.5 *Take-Up Movement*

8.12.5.1 It consists of two parts:

a) Allowance for belt elongation, and

b) Allowance for contigencies and factor of safety.

Table 21 Effect of Acceleration or Braking on Counter Weight Take-Up
(*Clause* 8.12.3)

Conveyor Geometry	Preferred Take-Up Location	Acceleration Effect	Braking Effect
Horizontal head drive	Following drive on return side of belt	None	Tends to lift counterweight Brakes not usually large enough to cause trouble.
Incline, head drive	Following drive on return side of belt	Little or none	Little or none
Decline, tail drive	At or near head	Tends to lift counterweight if declination is low	None
Decline then horizontal portion, tail drive	At or near head	Critical — lifts counterweight and feeds slack to foot of incline[1)]	None
Combination of incline, and decline, head drive	Following head or low point in return run	Little or none	Critical when stopping with decline loaded — Lifts counterweight and slack runs to foot of decline[1)]
Combination of incline and decline, tail drive	Following head or point in return run	Critical — lifts counterweight and feeds slack to foot of decline	Little or none

[1)]Such take-up problems can be handled by a very heavy single counterweight, a double counterweight, by tail-end brakes, or head and tail driving.

b) Belt jointing system;
c) Belt carcass determining the elastic and permanent stretch values which shall be provided by the manufacturer;
d) Ratio of operating tension to the maximum allowed tension;
e) Starting up system and magnitude of resulting dynamic force on the belt;
f) Position of take-up device;
g) Possibility, when take-up device has reached the end of its adjustment length, of its being brought back to its former position by cutting and rejoining the belt;
h) Weather conditions in which the installation is operated (wide temperature deviations between day and night); and
j) Influence on some types of belts of the physical characteristics of conveyed materials (heat or excessive moisture content) especially if covers are not carefully checked and maintained periodically.

8.12.5.3 Take-up movement may be worked out as follows:

a) Determine the belt elongation according to manufacturers recommendations,
b) Check the operating tensions at critical points through the circuit. Calculate average belt tension throughout the circuit with belt starting when fully loaded.
c) The average tension with conveyor empty and stopped.
d) Determine the load factor.

$$V_{LF} \quad \frac{\text{Value at 8.12.5.3(b)} - \text{Value at 8.12.5.3(c)}}{\text{Belt rating}} \times \text{Total length of belt} \quad \ldots (62)$$

e) *Actual belt elongation* = $V_{LF\times}$ Belt elongation at reference load ...(63)

f) *Allowance for contingency and safety* = 0.300 m + 0.5 percent of belt length in mm ...(64)

g) Belt reserve for splicing. It shall be equal to allowance for one minimum splice length.

8.12.5.4 Where take-up movement worked out is very large, it may be necessary to reduce the take-up movement or make use of combination of gravity and winch take-up or use more than one gravity take-up. In any case, the values of take-up shall be not less than the values specified in Table 1 of IS 4776 (Part 1). These values are applicable to underground installations also using belts conforming to IS 3181 [*see* IS 4776 (Part 2)].

8.13 Conveyor Loading and Discharge

8.13.1 For a successful belt conveyor installation, it is absolutely necessary that the conveyor belt be loaded properly and discharged properly. The requirements of loading and discharge are so important that they need very careful consideration while planning the layout and detailing of the loading/unloading facilities. Besides contributing to a good performance of the conveyor without spillage, a properly designed loading and discharge system would add considerably to the belt conveyor life.

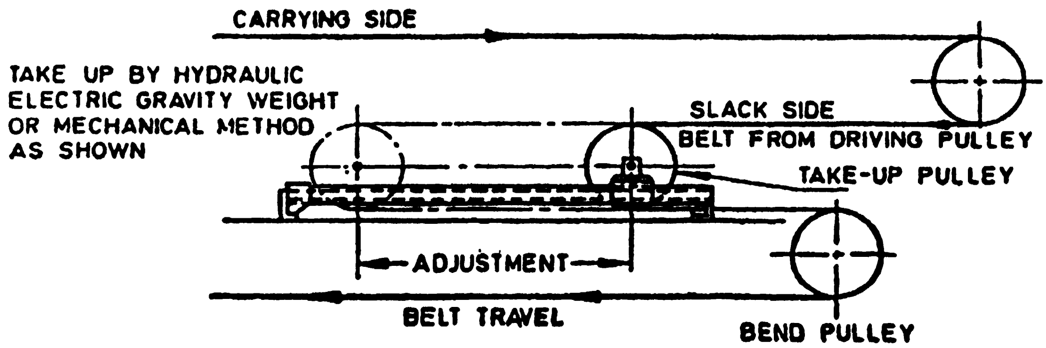


FIG. 9 TYPCIAL LOOP TAKE-UP DEVICE

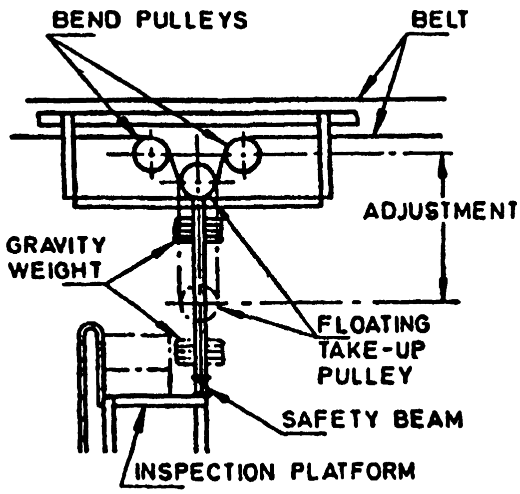


FIG. 10 TYPICAL GRAVITY WEIGHT OPERATED TAKE-UP AT INTERMEDIATE POINT OF CONVEYOR

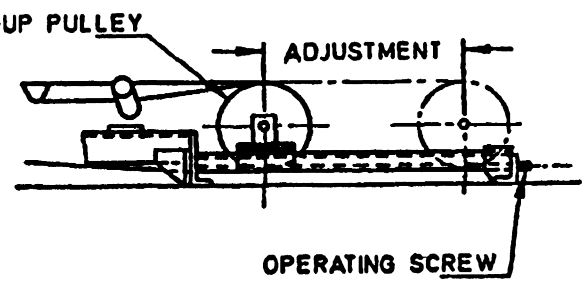


FIG. 11 TYPICAL SCREW OPERATED TAKE-UP AT TAIL END OF CONVEYOR

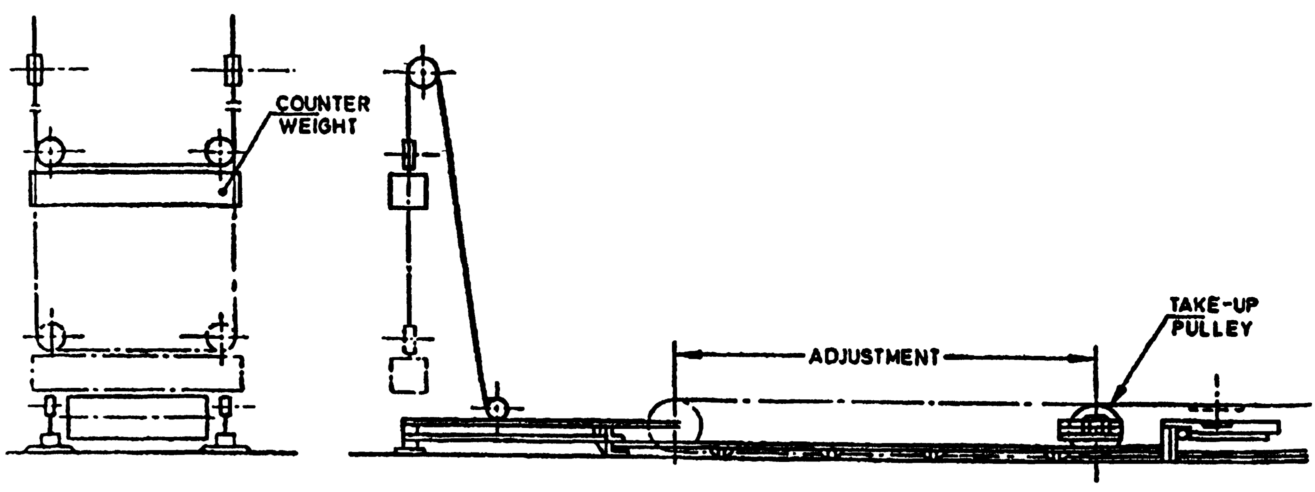


FIG. 12 TYPICAL GRAVITY WEIGHT OPERATED TAKE-UP TAIL END OF CONVEYOR

need very careful consideration while planning the layout and detailing of the loading/unloading facilities. Besides contributing to a good performance of the conveyor without spillage, a properly designed loading and discharge system would add considerably to the belt conveyor life.

8.13.2 *Conveyor Loading*

8.13.2.1 Some of the main considerations for proper loading of the material and transfer of the material on lo the belt conveyor are as follows:

a) Placing of material centrally on the belt.
b) Avoiding too frequent surging of loads.
c) Material velocity being in the direction of belt travel and as close to the velocity of the belt as possible.
d) Loading of the lumps near the centre and riding a cushion of Tines.
e) Keeping the loading in case of transverse transfer as near to 90° as possible.
0 Avoiding horizontal angularity of transfer greater than 90°
g) Providing a suitable skirt plate extending along the sides of the belt serving to confine the load while it is in a state of agitation before it settles down into a quite moving stream.
h) Feeding the sloping conveyors where the size of lump or absence of fines would indicate danger of lumps rolling specially for downhill conveyors.
j) Inclining the loading chute both forwards and outwards.
k) Keeping the width of the chutes generally not greater than two-thirds the width of the receiving belt, inside width being 2.5 to 3 times the largest dimensions of uniformly sized lumps.
m) Providing the back or bottom plates of the chutes in a manner so that the material preferable is guided from the back of the chute to the belt. In case of fines and lumps, it may be necessary to provide a grizzly so that the screened fines may receive the lumps over them.
n) Provision of stone boxes for heavy, abrasive and lumpy material so that the impact is absorbed by the stone boxes where the blow of the abrasive material is taken on the retained material at that point.
p) Keeping the transfer heights to the minimum.
q) Providing minimum angle of slope. Keeping in conformity with the static angle of repose of the material, it should preferably be about 20° to 30° higher than the static angle of repose of the material. The slope shall be fixed based on the properties of the material such as moisture contents, stickiness, flowability etc.
r) Avoiding direct impact of the material on to the roller and the bottom most back portion of the chute being minimum 150 mm away from the idler.

8.13.2.2 *Skirt board*

To retain the material on the belt after it leaves the loading chute and until it reaches belt speed, skirt boards are necessary. These skirt boards are usually an extension of the sides of the loading chute. The length of skirt board is generally between 0.6 m to 1.0 m for every 0.5 m/s speed of belt depending on the loading conditions but in any case not less than 1.6 m in length. The skirt board preferably should terminate above an idler rather than between the idlers. The skirt boards are normally covered with rubber strips of adjustable type both at the back and at the sides being provided with suitable shape for centralising the material on the belt. At times, the skirt boards are provided with rubber screen, that is, rubber flapper to minimize the dusting due to air turbulence.

8.13.3 *Conveyor Discharge*

8.13.3.1 The material can be discharged from the belt conveyor in different ways to achieve the various desired results. The discharge can be accomplished either at the end of the conveyor or at a definite point or points in between which can extend along side the belt conveyor, either on one or both sides, at a point or for a considerable distance. The flexibility of dischrage arrangement of belt conveyor facilities its use in the maximum fill of long bins and the erection of large and various shaped storage piles.

8.13.3.2 The simplest arrangement of discharge from a conveyor belt is by material passing over an end pulley and falling on to a pile or onto the other conveyor through a suitable loading chute. A fork in the discharge chute with a gate or flapper can permit the material to flow either in one or in both directions as desired.

8.13.3.3 If several specific points of discharge are required, the fixed trippers may be provided. Moveable trippers, if provided, can discharge intermittently either on one or both sides of the belt conveyor. Sometimes, ploughs can also be used for discharging the material either on one or both sides at intermediate locations.

8.13.3.4 A carefully designed discharge chute is necessary for successful operation as besides meeting the operational requirements of discharging or apportioning the material in to the various directions. It can also eliminate collection of the material adhering to the belt, avoidance of spilled material and controlling of dusty or dry powdery and fine material.

8.13.3.5 The following are some of the main features for designing a good discharge chute:

a) The upper end of the discharge chute shall enclose the cleaning device and catch material cleaned from the belt if necessary by employing a separate dribble chute.
b) Calculate the trajectory of the material and ensure that material falling from the end of the discharge pulley falls on the back plate of the loading chute.
c) Provision of removable of liners in case of abrasive material.
d) Providing sliding surface at an angle of about 20° to 30° higher than the static angle of repose.
e) Avoiding abrupt changes of direction in the chute to eliminate material build up and plugging.
f) Provision of rock boxes in the discharge chute; where necessary, for abrasive, lumpy and heavy material.
g) Providing cross-sectional area of 4 times, the load cross-section and minimum three lumps.

8.13.4 *Trajectory of Material*

8.13.4.1 The path or the trajectory of the material after it leaves the belt is a parabola when the material is discharged over the head pulley, and is determined by two considerations:

a) *The point* where the material leaves the belt. This is the point at which the centrifugal force on the material acting radially outward is balanced by the gravitational force or its component in the radial direction as the case may be.
b) *The direction* in which the material moves at the instant it leaves the belt.

8.13.4.2 Practical determination of the trajectory is explained in Annex J.

NOTES

1 In drawing the bell running into the pulley, care shall be taken for the actual slope of the centre portion of the belt. Actual slope is often greater than that is assumed for the following reasons:

a) The rim of the head pulley is sometimes set above the line along the rims of the carriers central rolls.

b) There is always some sag in the belt which causes an increase in actual slope.

2 The effect of air resistance being negligible in most of the cases, is not taken into account in determining the trajectory.

3 The trajectory obtained as discussed here locates the bottom of the stream of material.

8.13.5 Typical arrangements of loading and discharge chutes are shown in Fig. 1.

8.14 Structurals

8.14.1 *General*

While designing the structural, due attention shall be given to the provisions laid down in IS 7155 (in eight parts). In addition, the following main points shall also be taken into consideration:

a) The design of the structural members, besides taking care of the surge loading, shall also take into account the likely loads coming on account of any spillages due to failure of protective/coasting devices.
b) A maintenance walkway of 800 mm minimum width along the run of the conveyor in a gallery shall be provided. If specified by the purchaser, and additional walkway on the other side may also be provided. In case of double conveyors, side walkways *(see* Fig. 12) may be provided on two sides of conveyors in addition to the central walkway, if required by purchaser.
c) *Walkwary runner* — Size of the selection shall be adequate to satisfy strength and deflection.
d) *Toe guard* — Toe guard shall be provided around all openings on floor and also on sides of conveyor gallery walkway as a safety measure. The toe guard shall have a minimum depth of 65 mm and a thickness of minimum 6 mm. Gallery walkway supporting angle shall be considered as toe guard provided dimension limitation as shown in Fig. 12 is satisfied.
e) *Hand rail* — Hand rails shall fulfil the following requirements:
   1) Hand rails shall be provided around all openings. It shall also be provided on one side of walkway in conveyor gallery having slope more than 7°.
   2) The hand rails, either single or double (as indicated in Fig. 13) shall be provided. However in case of belt height more than 1 m from floor level, double hand rails, that is, one at top and other at half way height from floor, shall be provided.
   3) The hand railing shall be supported either from conveyor stand/post or from independent support. For conveyor stand/post having more than 3 m spacing, the railing shall have independent supports.
   4) The section for hand railing shall be of galvanized pipe of 32 mm nominal bore unless specifically required by purchaser.
   5) The hand rail post shall be 32 NB (A) galvanized pipe or minimum ISA 65 × 65 × 6 galvanized unless specified otherwise.
f) The walkway along the inclined conveyor shall

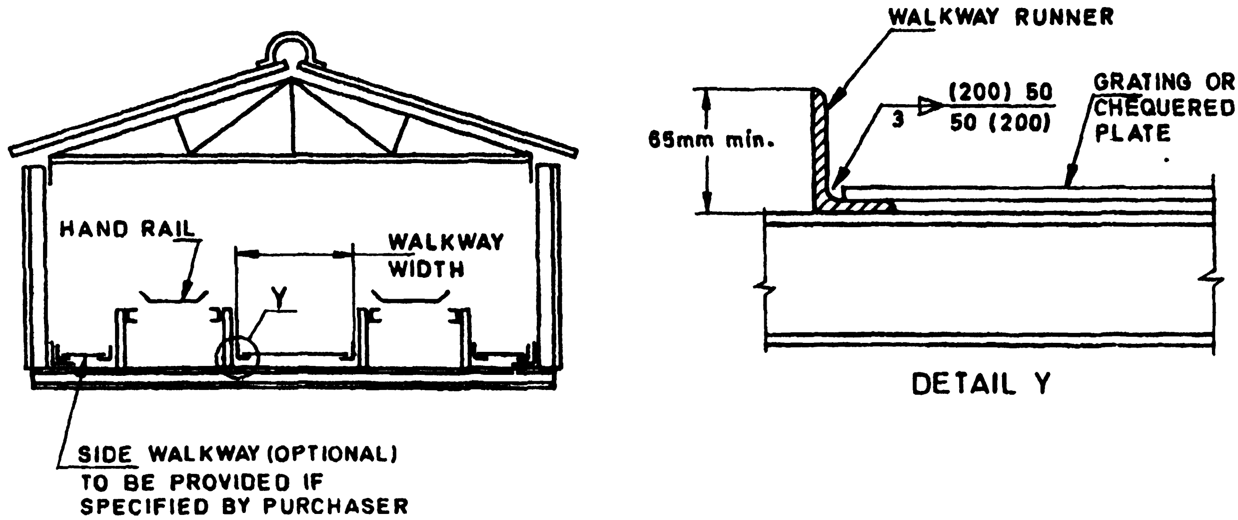


FIG. 13 ARRANGEMENT IN DOUBLE CONVEYORS AND THEIR DESIGN APPROACH

be provided with anti-skid surface and shall be designed for a single moving load of 300 daN or a live load of 250 dapa whichever is larger. Use of gratings or chequered plates or precast concrete slabs with their top surface left unfinished may be considered for providing anti-skid surface. In case of conveyor installations with more than 10° inclination, stepped walkways without any intermediate landings shall be provided. However in case of gratings, provision of gallery seal plates shall be considered in structural design.

g) For corrosive and open atmospheric conditions of working, due consideration shall be given to **3.8.2** to **3.8.4** of IS 800 and **6.3** and **6.4** of IS 6521 (Part 1) in the design of structural components.

h) Supporting of gallery frames on the trestles using roller supports shall be preferred. Suitable precautions shall be taken to protect the roller guides/slotted holes/guides etc, from accumulation of dust or material carried through the conveyor. Such installations shall be regularly inspected for their proper operation.

j) Where conveyor gallery frames have to be connected to junction houses or other buildings, it is desirable that such connections be made so that the gallery frames are free to move in the longitudinal direction.

k) Wherever conveyor has to run in an underground tunnel, a clear walkway space of 1 000 mm shall be provided along the length of conveyor on either side. For conveyors used in underground mines, this clear space shall be not less than 1 m along the length of conveyor on either side from any structure of the conveyor. In case of double conveyors, a central walkway of minimum 1 000 mm width shall be provided ensuring that at least 800 mm is available at drive or head pulley end. In addition, at head or tail end a clear walkway space of not less than 1 m on either side shall be provided.

m) The drive end structure shall be made sufficiently rigid to prevent any vibration and shall be provided with sufficient maintenance space all around, which shall not be less than 800 mm to the nearest obstacle. The design of structure shall be in accordance with **8.14.8.**

n) Transfer houses shall be so designed so as to provide sufficient head room for removal of heaviest parts and lifting of the belt to enable changing of the conveyor belting. Wherever provision has to be left in the transfer tower for keeping a heavy equipment forming a part of the conveyor such as pulley, motor gear box, the structural shall be designed to take care of the concentrated load in addition to the distributed load of 350 dapa.

p) All structural design shall conform to related Indian Standards such as IS 800, IS 875 (in five parts), IS 7155 (in eight parts), etc taking into account the various environmental conditions including earthquake and wind forces.

8.14.2 *Structural Design*

8.14.2.1 Whenever designing the structure for conveyors, the total of following three load groups shall be taken into account:

a) Main loads,
b) Additional loads, and
c) Special loads.

8.14.2.2 The main loads comprise of all the permanent loads which occur when the equipment is used under normal operating conditions as specified by the purchaser. The main components of main loads are:

a) *Dead loads* — These are load forces of all fixed and movable construction parts, always present in operation of mechanical and electrical plants as well as of the support structure.
b) *Useful loads* — The effective load carried on the conveyor is considered which is determined from designed output in m^3/h. The following points are considered while deciding the designed output:
   1) Where the belt load is limited by automatic devices, the load on the conveyor will be assumed to be that which results from the output thus limited.
   2) Where there is no output limiter, the design output is that resulting from the maximum cross-sectional area of material conveyed on the conveyor multiplied by the conveying speed. Unless otherwise specified in the agreement, the cross-sectional area shall be determined assuming a surcharge angle of 20°. Figures 2 to 4 show the maximum sections of product conveyed as a function of surcharge angle and for the trough angle for different conveyor design.
   3) Where the design output resulting from **8.14.2.2** (b) (1) or **8.14.2.2** (b) (2) on upward units is lower than that of downward units, the downward units may have the same output as the upward units.
   4) *Dynamic load factor* — In order to take into account the dynamic loads which could be applied to the conveyor, the load as calculated above together with weight of belt shall be multiplied by factor 1.1. For trippers and other movable equipments, the factor shall be 1.5.
c) *Incrustation* — The degree of incrustation (dirt accumulation) depends on the specific material and the operating conditions prevailing in each given case. For guidance, a load of 10 percent of the theoretical effective load calculated according to **8.14.2.2**(b) shall be taken into account as the load on the conveyor devices due to dirt accumulation. The actual values can deviate to either higher or lower values. For storage yard appliances, the values are generally lower while for reclaimers, they are to be taken as minimum values.
d) *Forces at conveying elements for the useful load* — Belt tensions shall be taken into consideration for the calculation as far as they have an affect on the structure.
e) *Permanent dynamic effects* — Following points shall be considered under this head:
   1) In general the dynamic effect of the falling masses at the transfer points, the rotating parts of machinery etc, shall be considered as acting locally.
   2) The inertia force due to acceleration and braking of moving structural parts, like tripper and shuttle conveyor, shall be taken into account. These can be neglected for appliances working outdoors if the acceleration or deceleration is less than or equal to 0.2 m/s^2.
f) *Inclination of the conveyor* — The effect of inclination of conveyors shall be taken into account for design of structures. The inclinations shall be according to appropriate conveyor layout.
g) *Loads on gang ways, platforms and roof* — Loads on these structures shall be considered as given below:
   1) Live loads, only for the design of cladding roof truss, purlins shall be according to IS 875 (in five parts).
   2) Live loads to be considered for gallery frame work design shall be in accordance with **8.14.1**(f). For the design of gallery walkway, platform, etc, member, the worst combination shall be considered as indicated in **8.14.1**(f).
   3) The platform members shall be suitably designed for live load of 2 500 Pa (uniformly divided load) or 3 000 N whichever is worst.
   4) The stairs shall be designed for a single moving load of 1 000 N and the railings and the guards shall be able to withstand a horizontal load of 300 N.
   5) When higher loads are to be supported temporarily under **8.14.2.2**(g)(1) to **8.14.2.2** (g)(4) above, the sizing of the member shall be done accordingly.
h) White designing the trestles supporting the conveyor gantry, 80 percent of live load considered for walkway under (g) shall be taken.

8.14.2.3 *Additional loads*

These are loads that may occur intermittently during operation or the equipment or when the equipment is not working. Those loads either replace certain main loads or are loaded to the main loads. The main components of additional loads are:

a) *Snow and ice load* — The loads due to snow and ice shall be considered as in case of incrustation load [*see* **8.14.2.2** (c)]. In case, the customer does not prescribe load values due to particular climatic conditions, snow and ice load need not be included.
b) *Temperature load* — Temperature effects need only be considered in special cases, for example, when using materials with very different expansion coefficients within the same component. Alternatively, the temperature effects may be taken care of by providing suitable connection details to permit movements due to thermal effects such as slotted holes etc.
c) *Spillage load* — During the operation of belt conveyor or at the time of repair/replacement of belts, the material on the belt is spilled on to the conveyor structure. The structure shall, therefore, take into account loading due to this effect. A load of 1 kPa may be considered.
d) *Non-permanent dynamic effect* — The main forces due to the acceleration and braking of moving parts such as travelling tripper, paddle feeders etc, occurring less than 2×10^4 times during the life time of the appliances shall be checked as additional load. As additional loads, they may be disregarded if their effect is less than that of the wind forces during the operation. If the main forces are such that they have to be taken into account, the wind effects shall be disregarded.

8.14.2.4 *Special loads*

These comprise the loads which shall not occur during and outside the operation of the equipment but the occurrence of which is not to be excluded. The main components of special loads are:

a) *Clogging of chutes* — The weight of the clogging is to be calculated using a load which is equivalent to the capacity of the chute in question, with due reference to the slope angle. The material normally within the chute may be deducted. The actual bulk weight must be taken for calculation.
b) *Loads due to earthquakes* — As far as the delivery contract contains data concerning the effects due to earthquakes, these loads have to be considered in the calculation as special loads. While calculating load, reference may be made to IS 1893.
c) *Buffer effects* — For equipment like tripper, paddle feeders etc, having speeds below 0.7 m/s, no account shall be taken of buffer effects. For speeds in excess of 0.7 m/s, account must be taken of the reaction on the structure by collision with buffer, when buffering is not made impossible by special devices. It shall be assumed that the buffers are capable of absorbing the kinetic energy of the machine with operating load upto a certain fraction of the rated travelling speed V_T — this fraction is fixed at minimum 0.7 V_T. The resulting loads on the structure shall be calculated in terms of the retardation imparted to the machinery by the buffer in use.
d) *Wind load* — Wind loads on the structure of the conveyor installation shall be calculated taking into consideration the recommendation made in IS 875 (in five parts). The lattice girders supporting the conveyor shall be suitably braced at top and botton chord levels to transmit the wind load to the end portals connected to the trestles.
e) Conveyor installations transporting fine materials like sulphur, fine chemicals, ores, and coal with high percentage of fines, require a continuous hood over the conveyor. This hood is also required where protection from moisture contamination is required and where dust control equipment are provided as essential requirement. Due consideration shall be given to these loads in design of structures for conveyors.
f) Foundation for conveyors structures shall be suitably designed and constructed so that it does not settle. Due consideration shall given to the action of deformation in structures due to settlement of foundation, if settlement can not be avoided.
g) In case of galleries, temperature expansion joints shall be introduced at intervals of approximately 180 m to divide galleries in to blocks. In each block, one four-legged rigid support guaranteeing stability of structure in longitudinal direction shall be provided. This shall also take care of all longitudinal forces foreseen in the given block.
h) Other loads, if any, for the provision of following:
    1) Water pipe line for dust suppression, plant cleaning or fire fighting etc.

2) Dust cxtraction/ventillation ducting.

3) Electric cables and cable racks.

j) In case of conveyors exceeding 2S0 m in length, crossovers shall be provided from ground to ground with cat ladder or from side walkway to otherside walkway and/or central walkway at a spacing not exceeding 180 m.

8.14.2.5 Skid mounting used in open-cast and underground mines, in case of shiftable conveyor is shown in Fig. 14.

8.14.3 *Vibration*

If no resonance is to occur in adjoining structures and buildings, then the amplitude of vibration of the foundation shall not exceed the values specified in Fig. 15. The design of foundations and structures supporting heavy machineries such as crushers, screens and vibrating feeders shall be in accordance with IS 2974 (Part 1) or IS 2974 (Part 3) or IS 2974 (Part 4).

8.14.4 *Design Considerations for Stringer and Stand Supporting Intermediate Portion of Conveyor*

8.14.4.1 Figure 16 gives the general layout of intermediate portion of conveyor for the purpose of identification of loads.

8.14.4.2 *Design of stringer*

The design of stringer shall be carried out considering the stringer as either a simply supported beam or a continuous beam as the case may be. The following loads shall be considered for the design of stringer:

a) A concentrated load consisting of material conveyed considering normal capacity of conveyor, weight of belt and weight of carrying idler unit.

b) A uniformity distributed load consisting of weight of decking plate, belt top cover, belt side cover and weight of stringer itself; and

c) A concentrated load consisting of weight of belt and weight of return idler unit.

8.14.4.3 *Design of stand or post*

Stand/Post shall be designed considering end conditions provided, namely, both ends hinged or one end hinged and other end fixed etc. The load to be considered for the design of stand or post shall include weight of stand unit and weight of cabled in addition to the loads specified in **8.14.4.2**(a), **8.14.4.2**(b) and **8.14.4.2**(c).

8.14.4.4 *Supporting stools*

Typical arrangement is shown in Fig. 17 for supporting stools between conveyor galleries bottom and top of stool.

8.14.5 *Limiting Deflection*

Deflection for various structural members supporting conveyor structure shall not exceed the following limits:

a) Conveyor gantry/bridge	$\frac{\text{Span}}{325}$
b) Trestle supporting gantry/tower in the transverse direction	$\frac{\text{Height}}{1\,000}$
c) Stringer supporting conveyor structural member directly supporting in the tripper	$\frac{\text{Span}}{900}$
d) Member supporting the tripper	$\frac{\text{Span}}{325}$

8.14.6 Camber shall be provided for span greater than 20 m. It shall be either zero or positive to neutralize the deflection due to dead load only.

8.14.7 *Cladding for Galleries/Tower Structure*

In view of the economy in structural members/ foundations, easy availability and ease in working, faster speed, easy repairs, the material shall be either of G I sheets or aluminium sheets. Provision of translusent sheets at intervals shall also be considered for natural lighting inside galleries during daytime.

8.14.8 *Design of Head and Tail Frame*

8.14.8.1 Head and tail frames shall, preferably, be designed as braced portal frame. Following loads shall be considered for the design:

a) Maximum belt tension,

b) Dead load of head or tail pulley together with the belt being supported by head or tail pulley.

c) In order to take into account the dynamic effect, the above loads as calculated in **8.14.8.1**(a) and **8.14.8.1**(b) shall be multiplied by 1.25.

d) Self weight.

e) Additional loads, both live and dead load, from maintenance platform and/or drive unit if supported from frame.

8.14.8.2 In addition, suitable cross-bracing connecting the frames (as shown in Fig. 17) shall be provided to reduce the effect of vibration.

9 ACCESSORIES

9.1 General

The various accessories required for a conveyor could be briefly stated as follows:

a) Drive elements like motors, gear boxes, chain and chain drives, flexible and fluid couplings, clutches and brakes;

b) Trippers both belt driven and motorised, fixed and moving;

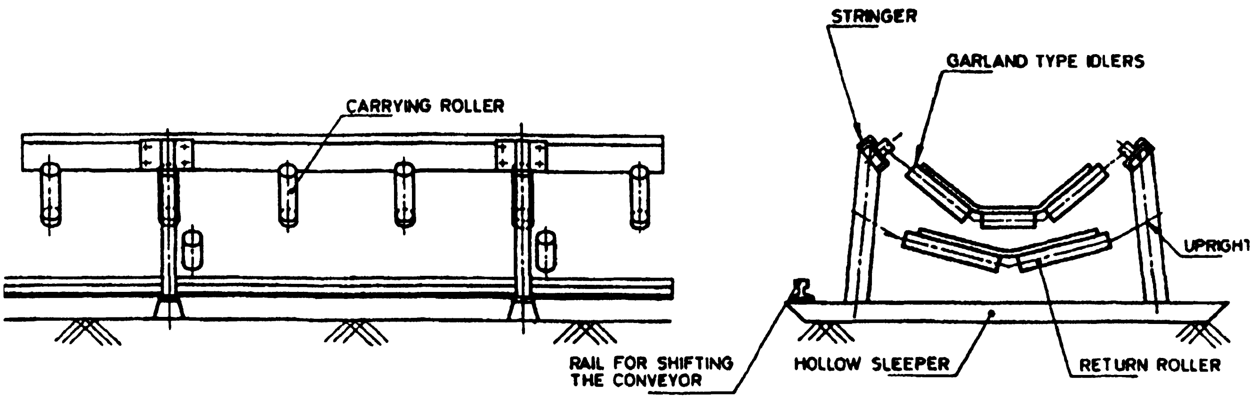
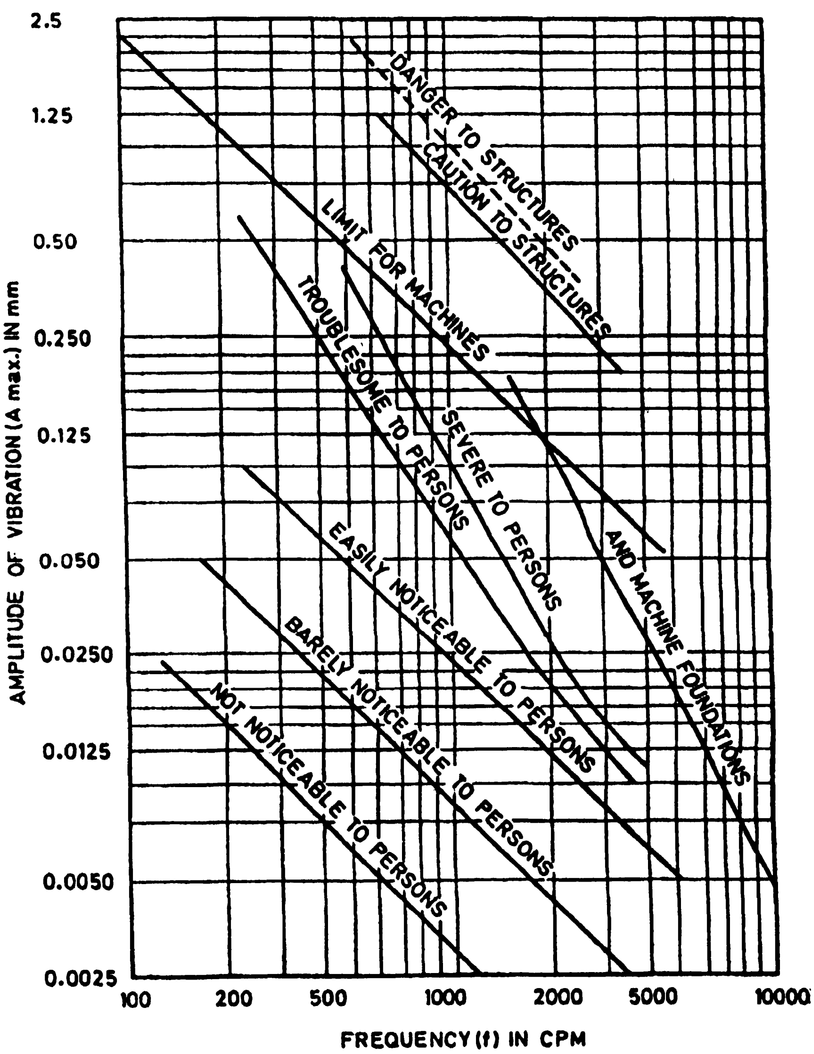


FIG. 14 SHIFTABLE CONVEYOR IN OPEN-CAST MINE

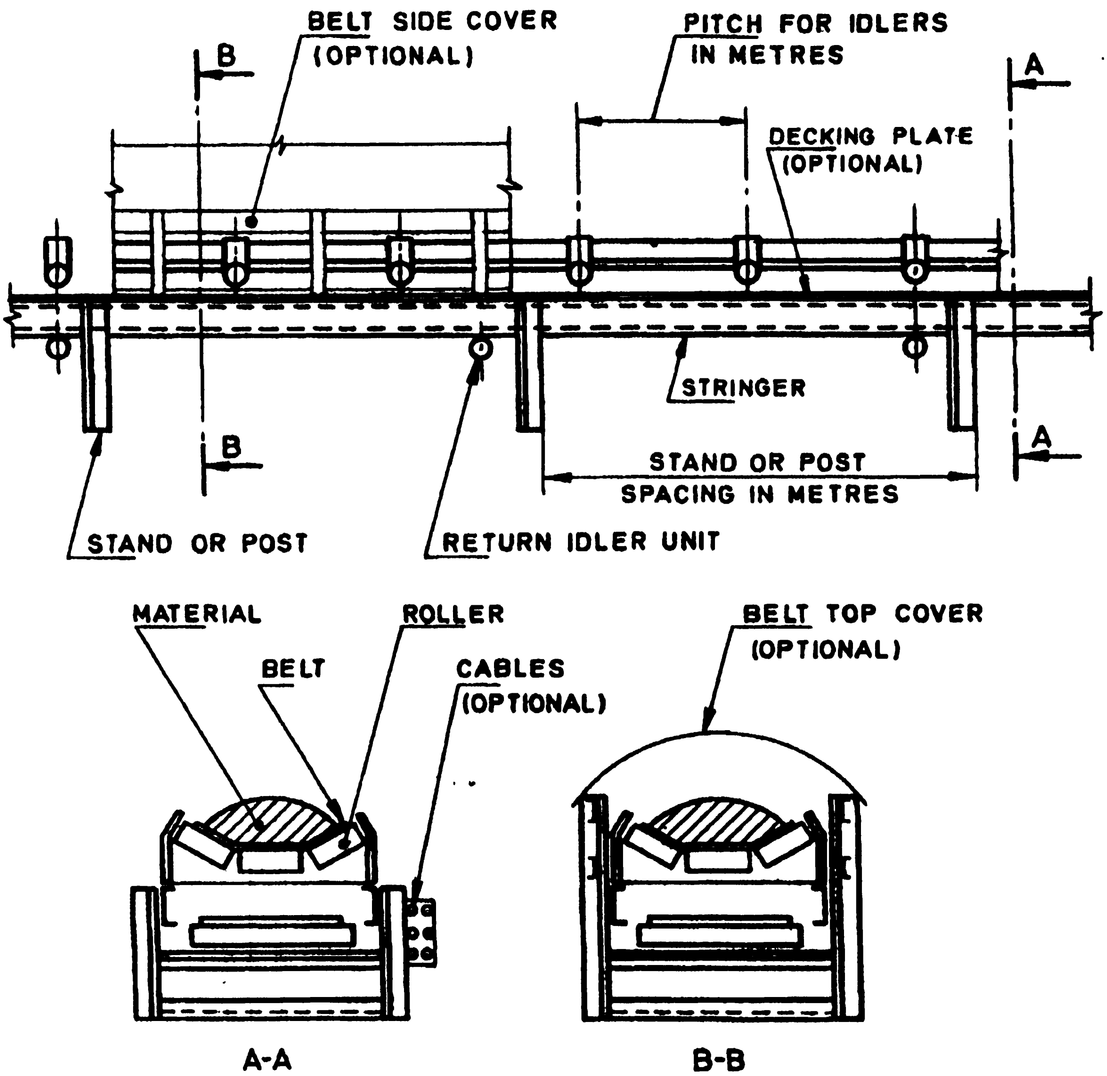


NOTES

1 Resonance in the neighbouring structures will be negligible if the amplitude of vibration is less than 0.20 mm.

2 For foundations of rotary type of machines of low frequency (0 to 300 c/min), it is possible to state that if no resonance is to occur in adjoining buildings and structures, then the amplitudes of vibrations of a foundation shall not exceed 0.30 mm.

FIG. 15 LIMITING AMPTITUDE FOR VERTICAL VIBRATION



NOTE — Belt top cover and belt side cover may be replaced by semi-circular type belt cover in one piece.

FIG. 16 GENERAL LAYOUT FOR INTERMEDIATE-PORTION OF CONVEYOR STRUCTURE

c) Ploughs;
d) Special lowering chute for example, spiral, bin-lowering rock ladders and telescopic chutes;
e) Belt cleaners both internal and external;
f) Hold-backs;
g) Control gears;
h) Protective devices for example, emergency stop switches and cable, overload switches, over load devices, belt slip, chute plugging, take-up movement; belt sway overspeed tripping, etc;
j) Decking plates; and
k) Skirt plates.

9.2 Motor Selection

9.2.1 *General*

9.2.1.1 The motor for belt conveyor drive shall be selected considering various factors such as starting torque, pull-out torque, starting current (for selection of cables considering voltage drop during starting conveyor drive), speed/torque characteristics of load, type of coupling used and following electrical parameters effecting motor design:

a) Rated voltage and frequency;
b) Variation in voltage, frequency and combined voltage and frequency variation;
c) Construction, for example, type of mounting;
d) Class of insulation;
e) Ambient temperature;
f) Speed;
g) Type or enclosure and degree of prtection;
h) Direction of rotation;

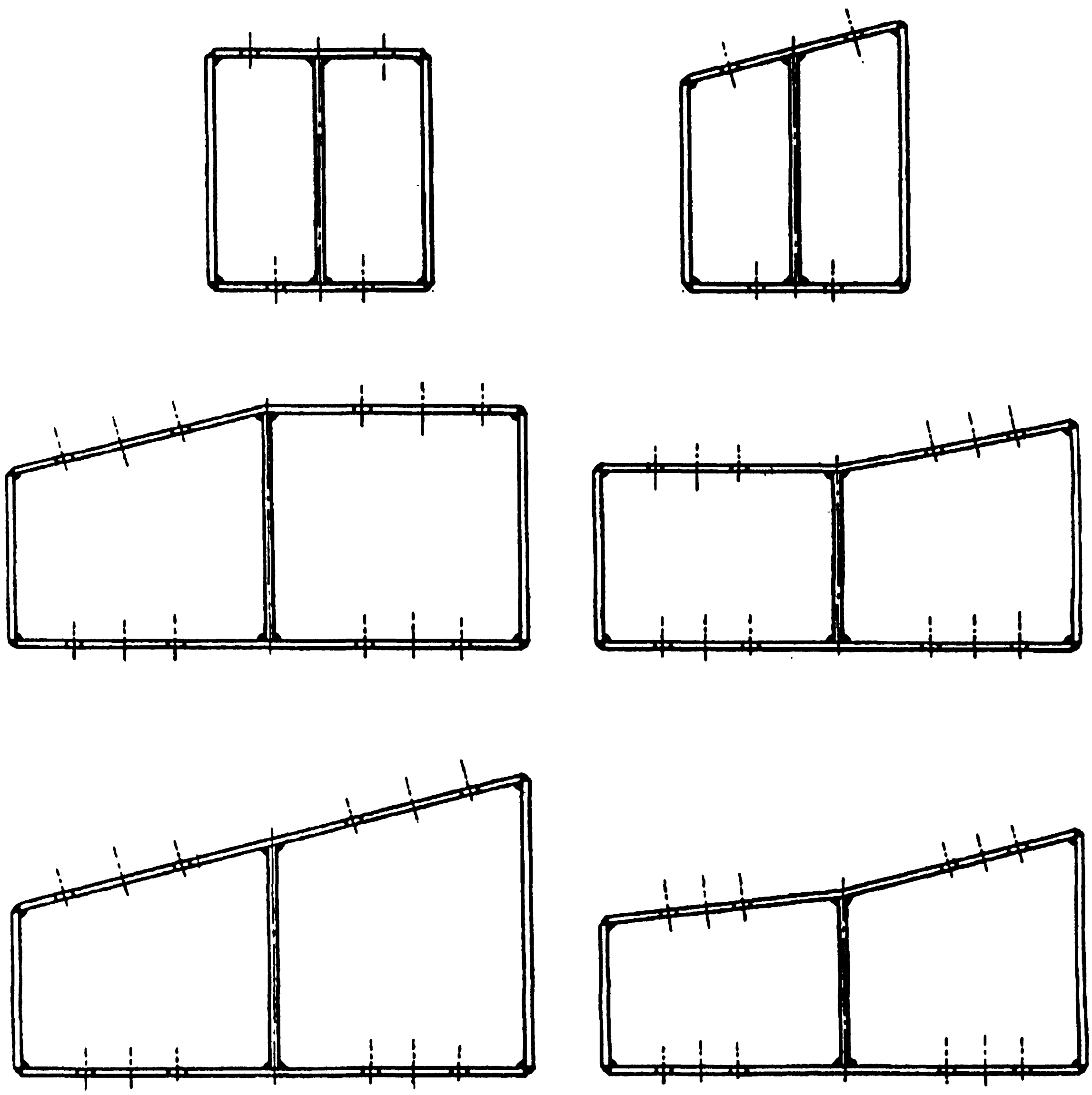


FIG. 17 TYPICAL DETAILS OF HEAD AND TAIL FRAMES

j) Location of terminal box looking from drive end shaft;
k) Short circuit load of terminal box;
m) Number of cables and size of cables for cable terminal box;
n) Type of starting;
p) Vibration limit; and
q) Type of earthing and number of earthing terminals.

9.2.1.2 Motor shall have continuous ratio at least equal to the power required by the conveyor divided by the efficiency of the drive unit.

9.2.1.3 For downhill regenerative conveyors, the motor rating shall be at least equal to the power required multiplied by the drive efficiency of the motor. The motor shall be capable of giving higher torque than required at steady-state of operating condition under worst permissible conditions of voltage and frequency variation. The starting time of the conveyor shall not exceed locked motor withstand time of the motor. In case of low starting torque requirements, where acceleration time is more than thermal withstand time, suitable protection like locked rotor relay and speed monitoring device shall be provided to the drive.

9.2.1.4 In general, squirrel cage three-phase alternating current induction motors are the simplest, most economical and minimum maintenance drive units for conveyors coupled with fluid couplings.

9.2.1.5 Motor acceleration time, t_m, shall be within the thermal characteristics of the motor, that is, the motor shall withstand the starting current for that period. Otherwise the motor shall be specially designed.

9.2.2 *Selection*

9.2.2.1 For conveyors of small capacities up to drive power of 40 kW, squirrel cage induction motor with direct on line start shall be used. Motorised head pulley up to 10 kW can be used.

9.2.2.2 For medium length conveyor of medium capacity up to drive power of 150 kW to ensure torque control of drive, the following type of drives be used:

a) Slip-ring induction motor with resistance starting; or
b) Squirrel cage motor with controlled eddy-current coupling; or
c) ac motors with static power amplifiers; or
d) Squirrel cage motor with scoop controlled fluid coupling or traction type fluid coupling.

9.2.2.3 For long conveyors of heavy capacity, for stabilising the desired value of load torque of driving motor, not only during starting but also during normal operation of the conveyor, the following electric drives are recommended:

a) Squirrel cage motors with controlled electro-magnetic (eddy-current) couplings; or
b) Squirrel cage motors with thyristor frequency converters with sufficient overload capacity; or
c) Squirrel cage motor with scoop controlled fluid coupling or traction type fluid coupling; or
d) Slip-ring motor with resistance start.

9.2.2.4 When high voltage motors are used, the rating for motor is not the criteria for type of starting. Method of starting shall be determined by the system parameters.

9.2.2.5 For selection of motor and its starting methods, consideration shall be given to the type of coupling selected (*see* **9.2.2.3**) and drive requirements.

9.2.2.6 The gearbox shall be selected to suit the drive system (*see* **9.2.2.3** to **9.2.2.5**) and the requirements of **9.3**.

9.3 Speed Reducers

9.3.1 Selection of the type of speed reducers can be determined by preference cost, power limitations, space limitations and drive location.

9.3.2 The gearbox shall be enclosed type running in an oil bath to give quietness of operation and saving of power.

9.3.3 Stepless or in-stage reduction may be accomplished satisfactorily by means of a V-belt drive in portable and very small capacity installations so that additional advantage of changing the speed ratio to meet different capacity requirements of the conveyors are obtained.

9.3.4 For drive motor of power requirements up to 30 kW, worm reducers may also be considered.

9.3.5 For drive motor of above 30 kW, helical gear box shall be preferred.

9.3.6 The gear box shall be rated with the following minimum service factor for electric drives, in accordance with IS 7403.

Duration of Service	*Service Factor*
2 hours per day	0.9
8 hours per day	1.1
12 hours per day	1.25
24 hours per day	1.5

9.3.6.1 The rating of the gearbox shall not be less than the rating of the installed motor.

9.3.7 The selection of gear type, that is, spur, worm and helical, shall be done taking into consideration various aspects such as layout, torque, effeciency, economics, etc.

9.4 Couplings

9.4.1 The use of flexible couplings shall be preferred up to 30 kW and may also be considered for small conveyors requiring less than 50 kW.

9.4.2 Fluid couplings shall preferably be used when conveyor power requirement exceeds 30 kW. For slip-ring induction motors requiring power up to 630 kW, flexible coupling may be used.

9.4.3 The choice between an allowable slip type coupling, for example, fluid coupling, and a solid coupling, for example, pin-bush coupling, shall always be considered for any conveyor requiring higher motor power than 30 kW. Fluid coupling provide following advantages:

a) Smooth acceleration of belt thereby reducing $T_{E\,max}$;
b) Quicker acceleration of motor reducing its heating during its starting; and
c) Reduction in oversizing of cables for motors to compensate terminal voltage drop during starting.

9.5 Ladders and Spiral Chutes

9.5.1 Ladders and spiral chutes are used to lower loads vertically by gravity. They retard the rate at which the loud descends and prevent its landing with an impact.

9.5.2 Ladder chute for bulk material is a vertical square pipe, the inside of which holds alternately spaced shelves. The material being lowered is held up by failing from shelf to shelf. The layer of material covering the shelves protects them against rapid wear.

9.5.3 When a fragile load (such as coke, coal, coal briquettes) has to be lowered from a great height (within a hopper, for instance), special devices like partitions, with rubber diaphragms or spiral chutes may be used to arrest the material degradation.

9.5.4 A bulk or unit load lowered along a spiral chute slides down the spiral surface and reaches the lower level without impact. A spiral chute is a trough which follows a helix secured around a vertical column or suspended rod, sometimes mounted within a vertical pipe of large diameter. The chute may have a rectangular, rounded or oblique-angled cross-section depending on the shape generated. The spiral chutes have the property of automatically keeping the speed of the load within definite limits.

9.6 Ploughs

9.6.1 Ploughs are used to discharge/divert free flowing and non-abrasive materials which can be carried with a little or no troughing, from belt conveyors. Plough can be used on belt troughed with idler rolls inclined at 20°. A flat steel plate or closed pitched one piece idler roller of a span more than the belt width may be used under the troughed belt where it flattens to discharge/direct/divide the material flow.

9.6.2 Ploughs are used in places where it is inconvenient or impossible to install a tripper. Ploughs are cheaper than trippers and takes-up less head room. Fixed trippers are better in performance than ploughs.

9.6.3 The plough may be fixed or travelling. The movable plough can be operated manually or by rope-haulage system.

9.6.4 Several ploughs can be incorporated along one belt conveyor and can be arranged to discharge material to either or both sides of the belt simultaneously. When not in use the blades can be raised to clear the material on the belt.

9.6.5 The blades can be constructed of timber or steel plate, the conveyor belt being flattended by means of movable platform of timber, steel plate or rollers. The single discharge type shall be arranged at an angle to the belt when discharging at one side and when it is desired to discharge the material to both sides simultaneously, the blade can be arranged in 'V' form, the angle being determined by the speed of the belt.

9.6.6 With any construction, a chute or guard shall be provided at each discharge point to prevent scattered material from collecting under the upper run and fouling the idlers or else falling on the return belt.

9.7 Trippers

9.7.1 Trippers are devices used to discharge bulk materials from a belt conveyor at points upstream from the head pulley. Essentially, trippers consist of a frame supporting two idling pulleys, one above and forward of the other. The conveyor belt passes over and around the upper pulley and around and under the lower pulley. The belt usually inclines to the upper pulley and may run horizontal or it may then incline again from the lower pulley. By this construction material is discharged to a chute as the belt wraps around the upper pulley. The chute can be arranged to catch and divert the discharged material in any desired direction (*see* Fig. 18).

9.7.2 Trippers can be stationary (fixed) or movable. Stationary trippers are used where the discharge of material is to occur at a specific location. More than one stationary tripper may be used on a belt conveyor. Trippers shall have dimensions as given in IS 14386.

9.7.3 All trippers absorb a certain amount of power from conveyor belt drive. This is because belt flexes over the tripper pulleys and also the material is to be raised to sufficient height to allow for necessary chute head room.

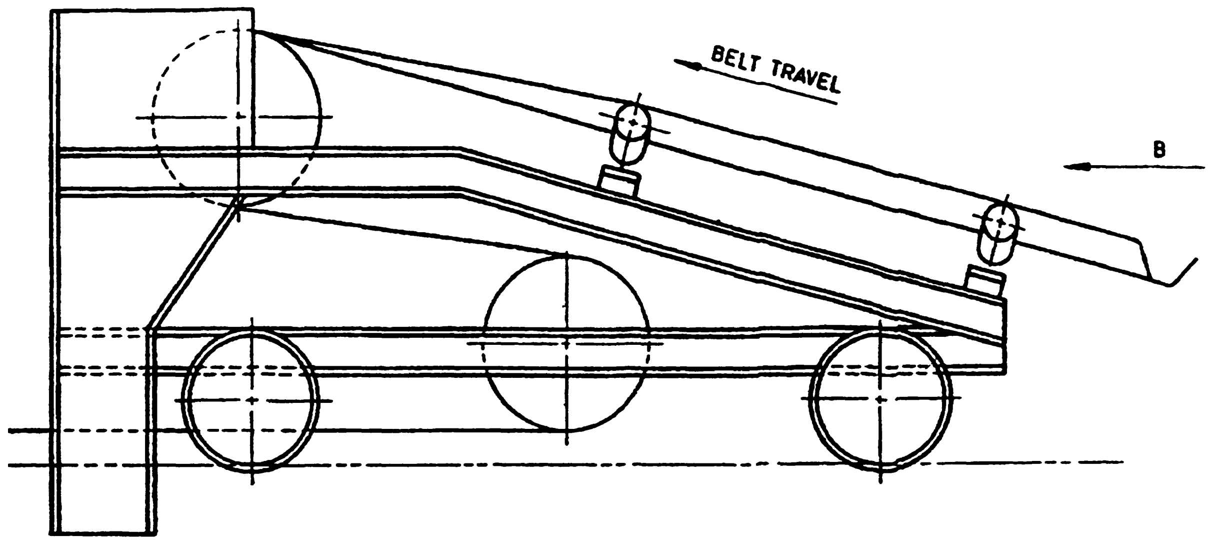
9.7.4 Movable trippers can be moved by a cable and winch by the belt itself, or by an electric motor mounted on the tripper.

9.8 Belt Turner

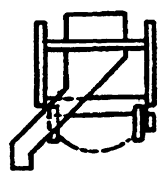
The cleaning of a belt handling wet, sticky, corrosive or freezing materials is always difficult and very rarely is all the material removed before the carrying surface comes in contact with the return idlers. The consequent build up of material on these idlers causes a reduction in the belt life'and the return idler life. This damage can be greatly reduced by the use of turn-over conveyor belt system. The belt at both ends of the return strand is turned, each being in the same direction giving a 360° twist. This results in the carrying surface of the belt never being in contact with any of the carrying or return idlers, the only contact being with the snubbing pulley causing a reverse bend in the belt.

9.9 Belt Cleaner

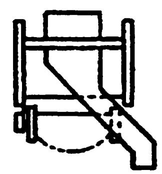
9.9.1 It is necessary to clean the belt when snub pulleys or bend pulleys or tandem drive pulleys make contact with the dirty side of the belt on the return run. This is especially the case when handling materials which are likely to pack on the belt, such as sticky and wet



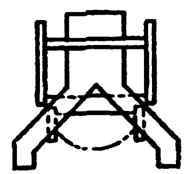
TYPICAL TRAVELLING TRIPPER
The discharge chutes may be as below and are shown in direction arrow '*B*'



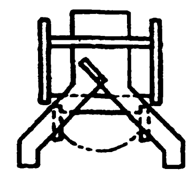
One way chute for one side discharge (left hand)



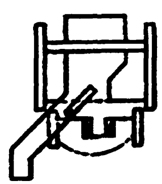
One-way chute for one side discharge (right hand)



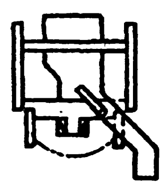
Two-way chute for discharge to both sides simultaneously



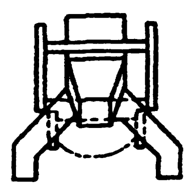
Two-way chute with flap valve for discharge to either side alternatively or to both sides simultaneously



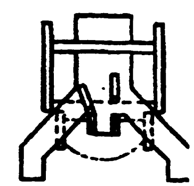
Two-way chute with flap valve for discharge to one side (left side) or alternatively forward



Two-way chute with flap valve for discharge to one side right hand or alternatively forward



Three-way chute with flap valve for discharge to both alternatively forward



Three-way chute with two flap valves for discharge to either sides alternatively, both sides simultaneously or alternatively forward.

FIG. 18 TRIPPERS

materials, or those that are likely to have damp, greasy or oily patches which eventually rot the belt.

9.9.2 There are three main types of external automatic belt cleaners:

a) a rotary brush,
b) the counterweighted wiper, and
c) the spring-loaded wiper.

9.9.2.1 In addition, internal belt cleaners of V-type shall be used near tail pulley to prevent material from getting between the pulley and belt as it wraps round the tail pulley. These V-type plough cleaners shall be adjusted to float on the return belt without exerting undue load on belt surface. These can also be made of adjustable counterweighted type. Their use is recommended even on short conveyor lengths and where full length decking is provided from the feed to the discharge end as a safety measure.

9.9.3 The rotary brush is fitted with a drive pulley and is rotated in opposite direction from it by a short centre roller chain drive. A cantilevered weighted arm is attached to the brush for facing it to the belt, whilst at the same time, preventing jamming and unnecessary wear on the bristles. The speed of the tip of the bristles for brushes 200 to 300 mm in diameter shall generally be:

Dry materials	2.0 to 3.0 m/s
Damp materials	5.0 to 7.5 m/s
Wet and sticky materials	6.0 to 7.5 m/s

9.9.3.1 The brush shall be mounted so that it can be adjusted toward the belt to compensate for wear on the tips of bristles and in such a way that the drive to the brush is not affected.

9.9.4 Because of high speed, brushes are short-lived. The most effective as well as most economic type of belt cleaning apparatus is the spring-loaded type belt wiper. Dry or very wet materials are easiest to remove.

9.9.4.1 When particularly gummy materials with tendency to cling to the belt and solidfy, are encountered, it is recommended to use water spray directed against the return belt about 500 mm ahead of the cleaner. It is also beneficial to have a very fine spray directed against the belt just before it passes under the loading point, as this will tend to keep the material from adhering. Usually a small amount of water will suffice. As the cleaner is specially effective in removing water, there is little danger of objectionable dribble.

9.9.4.2 Where cleaning is of primary importance, two cleaners may be provided so that one can be removed at any time for servicing. In any case, arrange pulleys at the discharge end to allow ample room for cleaning equipment including dribble chute of flume.

9.9.4.3 The blades of the spring type cleaner shall engage the belt only where it is straight, never on a pulley. One cleaner shall generally have at least 300 mm of straight belt, two cleaners not less than 750 mm.

9.9.5 It is sometimes necessary to use steel scrappers on the rims of snub pulleys. Tripper pulleys and deflector pulleys that engage the carrying side of belt, in order to prevent accumulation of material, may hurt the surface of the belt or cause it to run out of line. The blade shall be located so that the scrapings can be disposed of.

10 SAFETY AND STATUTORY REQUIREMENTS

The conveyor shall conform to all the statutory requirements. In addition, the conveyor shall also take into account all the statutory requirements as mentioned in IS 7155 (in eight parts). Any additional safety requirements to the extent specified by the purchaser shall also be taken into account.

11 PAINTING

The complete conveyor system and the conveyor shall be provided with suitable painting both primary and finished to suit the environmental conditions in accordance with requirements of the purchaser.

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
800 : 1984	Code of practice for general construction in steel *(second revision)*
875	Code of practice for design loads (other than earthquake) for buildings and structures:
(Part 1) : 1987	Dead loads—Unit weights of building material and stored materials *(second revision)*
(Part 2) : 1987	Imposed loads *(second revision)*
(Part 3) : 1987	Wind loads *(second revision)*
(Part 4) : 1987	Snow loads *(second revision)*
(Part 5) : 1987	Special loads and load combinations *(second revision)*
1891	Conveyor and elevator textile belting:
(Part 1) : 1994	General purpose belting *(fourth revision)*
(Part 2) : 1993	Heat resistant belting *(third revision)*
(Part 3) : 1988	Oil resistant belting *(second revision)*
(Part 4) : 1978	Hygenic belting *(first revision)*
(Part 5) : 1993	Fire resistant belting for surface application
1893 : 1975	Criteria for earthquake resistant design of structures *(fourth revision)*
2974	Code of practice for design and construction of machine foundations:
(Part 1) : 1982	Foundation for reciprocating type machines *(second revision)*
(Part 3) : 1992	Foundations for rotary type machines (medium and high frequency) *(second revision)*
(Part 4) : 1979	Foundations for rotary type machines of law frequency *(first revision)*
3181 : 1992	Conveyor belt — Fire resistant conveyor belting for underground and such other hazardous applications *(fourth revision)*
4240 : 1984	Glossary of conveyor terms and definitions *(first revision)*
4776	Specification for troughed conveyors:
(Part 1) : 1977	Troughed belt conveyors for surface installation *(first revision)*
(Part 2) : 1977	Troughed belt conveyors for underground installation
6521 (Part 1): 1972	Code of practice for design of tower cranes: Part 1 Static and rail mounted
7155	Code of recommended practice for conveyor safety:
(Part 1) : 1986	General information *(first revision)*
(Part 2) : 1986	General safety requirements *(first revision)*
(Part 3) : 1986	Belt conveyor and feeders *(first revision)*
(Part 4) : 1990	Vibrating conveyor/feeder *(first revision)*
(Part 5) : 1990	Apron conveyor/apron feeder *(first revision)*
(Part 6) : 1990	Selection, training and supervision of operators *(first revision)*
(Part 7) : 1990	Inspection and maintenance *(first revision)*
(Part 8) : 1994	Flight conveyor (scraper conveyor) *(first revision)*
7403 : 1974	Code of practice for selection of standard worm and helical gear boxes
8531 : 1986	Specification for pulleys for belt conveyors *(first revision)*
8598 : 1987	Specification for idlers and idler sets for belt conveyors *(first revision)*
8730 : 1997	Classification and codification of bulk materials for continuous material handling equipment *(first revision)*
14386 : 1996	Belt conveyor — Travelling tripper — Motorised — For belt widths 650 mm to 1 600 mm —Dimensions

ANNEX B

(*Clause* 8.8.5.2)

FIRST METHOD FOR IDLER SELECTION

B-1 IDLER CLASSIFICATION

The idlers are classified into six numbers series as given in Table 22.

B-2 IDLER SELECTION

B-2.1 Select required duty along Y_1, axis of square I (*see* Fig. 19), then move horizontally to meet line representating maintenance condition applicable. From this point move vertically again to meet the curves signifying effect of stoppage on the system. From this point move horizontally to meet Y_2 axis. This will represent reference point *A*.

B-2.2 Select density of material to be handled along the axis Y_4 of square II (*see* Fig. 19) and move horizontally to meet the lines representing required belt width. From this point move vertically up or down to join the lines representing conveyor speed desired.

B-2.3 From this point of intersection proceed horizontally to meet axis Y_3. This will represent reference point *B*. Join point *A* and *B*. The segment of the selection bar through which line *AB* passes, will indicate the series of idler conveyor most suitable for use.

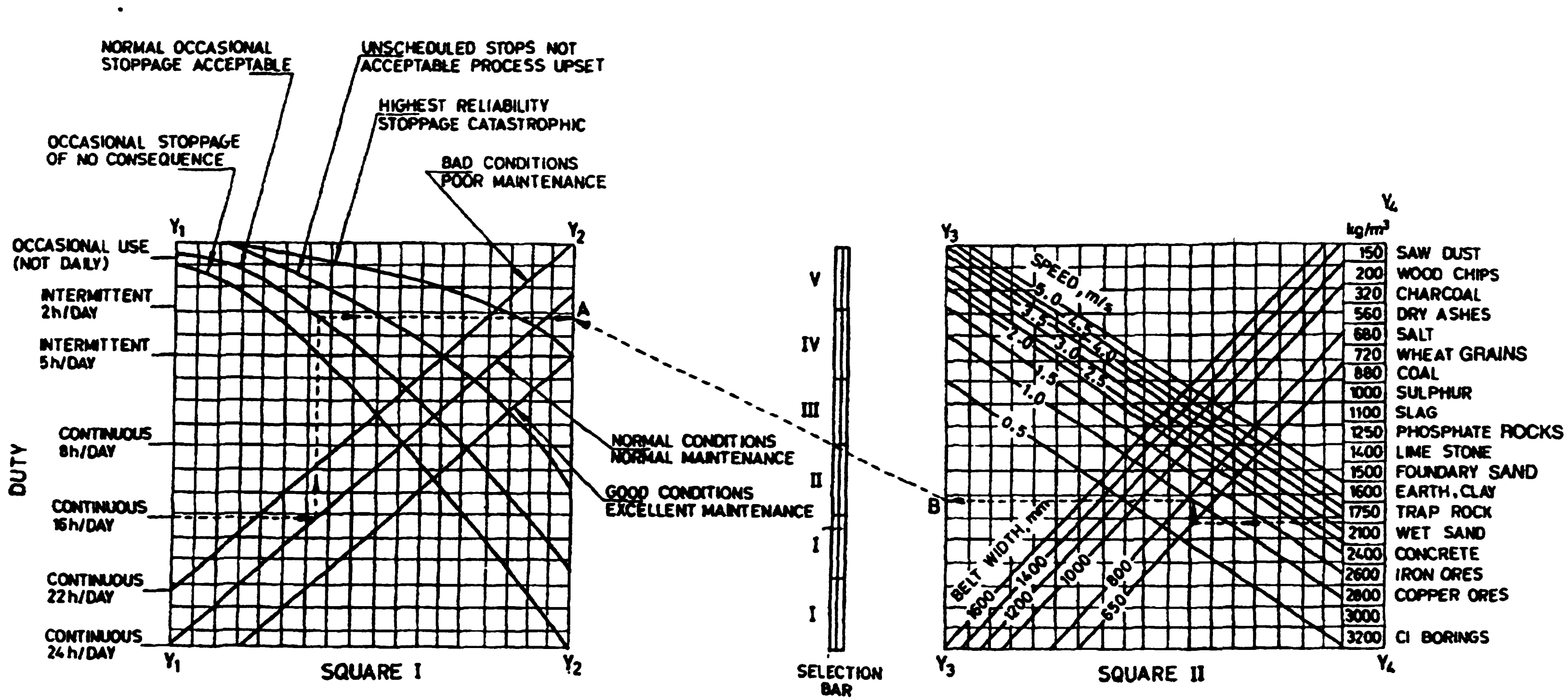
B-2.4 The dotted line drawn on the chart as an example illustrates the selection of suitable idler for following duty:

a) 16 h/day continuous duty;
b) Used under normal conditions and normal maintenance;
c) System accepting occasional stoppage as normal;
d) Conveying trap rock with 1 790 kg/m^3 density;
e) On belt width 650 mm; and
f) Moving at 1.0 m/s speed.

Table 22 Idler Classification

(*Clause* B-1)

Idler Series	Roller Diameter	Bearing Type	Belt Width	Maximum Belt Speed, m/s	Suitable for
I	63.5 to 101.6	Ball	300-800	2.5	Fine material with small lumps—Non-abrasive, intermittent duty.
II	88.9 to 139.7	Ball	400-1 000	4.0	Fine material, small sized lumps, slightly abrasive, continuous duty.
III	101.6 to 139.7	Ball	500-1 200	4.0	Unsizes medium lumps, mixed with fine sized small lumps, moderately abrasive, continuous duty.
IV	127 to 139.7	Ball/roller/taper roller	500-1 400	4.0	Unsized, large lumps, mixed with small sized medium lumps moderately abrasive continuous duty.
V	139.7 to 219.1	Ball/roller/taper roller	800-2 000	5.0	Large size lumps, highly abrasive, critical duty.
VI	168.3 to 219.1	Ball/roller/taper roller	1 600-2 000	4.0	Large capacity conveyor with lumps.



NOTES

1 Select required duty along Y_1 axis of square I, then move horizontally to meet line representing maintenance condition applicable from this point move vertically again to meet the curves signifying effect of stoppage on the system. From this point move horizontally to meet Y_2 axis. This will represent reference point A.

2 Select density of material to be handled along the axis Y_4 of square II and move horizontally to meet the lines representing required boh width. From this point move vertically up or down to joint the lines representing conveyor speed desired.

3 From this point of intersection proceed horizontally to meet axis Y_3. This will represent reference point *B*. Join point *A* and *B*. The segment of the selection bar through line *AB* passes, will indicate the series if idler conveyor most suitable for use.

FIG. 19 SELECTION OF IDLERS

ANNEX C

(Clause 8.8.5.2)

SECOND METHOD OF IDLER SELECTION

C-1 IDLER CLASSIFICATION

Idlers are classified in four series as given in Table 23.

C-2 IDLER SELECTION

Idler spacing for troughed belts and flat belts are selected as shown in Fig. 20 and 21 respectively.

Table 23 Idler Classification

(*Clause* C-1)

Series	Bearing Type	Shaft Dia at Bearing (mm)	Roll Dia (mm)	Belt Width (mm)	Application Range
Light	Deep groove ball bearing	20	63.5, 76.1, 88.9, 101.6	300-800	For intermittent operation, relatively low capacities and for light weight materials of limited lump size.
Medium	Deep groove ball bearing	20	88.9, 101.6, 108, 114.3, 120, 127, 133, 139.7	400-1 200	For intermittent operation, medium capacities and for moderate weight, semi-abrasive materials containing lumps larger and heavier than those handled by light duty series idlers, or for continuous operation when handling light weight, fine materials.
Heavy duty	Roller/taper roller/ball	25	101.6, 108, 114.3, 120, 127, 133, 152.4	500-1 600	For continuous operation, high capacities and for heavier weight, abrasive materials where the size of lump is limited by belt width.
Extra heavy duty	Roller/taper roller/ball	25-30	139.7, 152.4 to 219.1	800-2 000	For continuous operation, highest capacities and for the heaviest and coarsest materials.

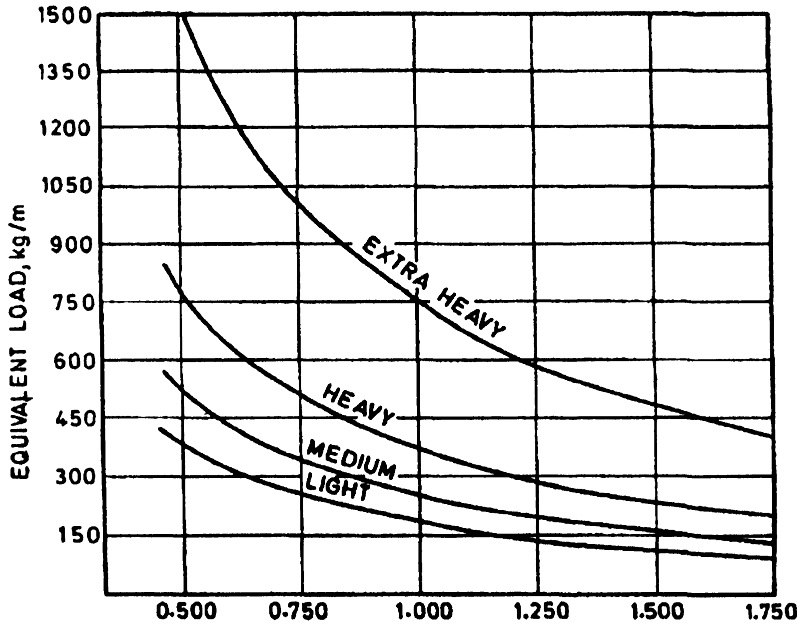


FIG. 20 TROUGHED BELT IDLER SPACING

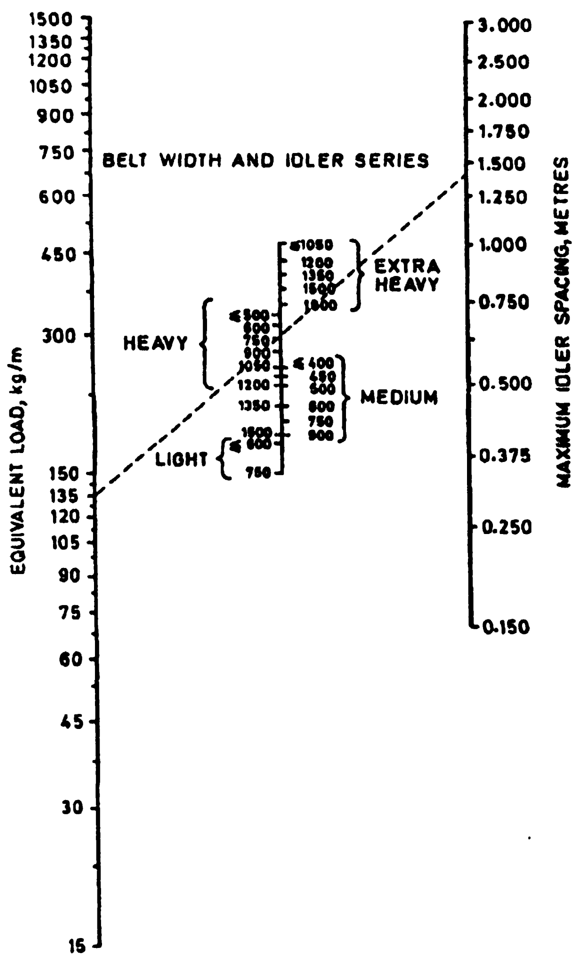


FIG. 21 FLAT BELT IDLER SPACING

ANNEX D

(Clause 8.8.5.2)

THIRD METHOD FOR IDLER SELECTION

D-1 CLASSIFICATION OF IDLERS

The idlers are classified into five series numbers as given in Table 24 based upon roll diameters and bearing sizes. The bearings may be either deep grooved ball or taper roller bearings with shaft diameter as shown in Table 24.

Table 24 Classification-Idler Series Number

(Clause D-1)

All dimensions in millimetres.

Idler Series Number	Roll Dia	Shaft Dia at Bearing	Maximum Belt Width
I	63.5 to 127	17	650
II	101.6 to 127	20	1 200
III	127, 133, 139 7	20 or 22	1 600
IV	139.7, 152.4, 159	25 or 30	1 600
V	152.4, 159	25, 30 or 40	2 000
VI	168.3, 219.1	30 or 40	2 000

D-2 BASIS FOR SELECTION OF IDLERS

D-2.1 This selection of idler series depends on three conditions:

a) Type of service;
b) Charecteristics of material to be handled; and
c) Belt speed.

D-2.2 Type of Service

The severity of conditions under which the idlers will be used, is the prime consideration for the selection of idlers. This includes the hours of operation per day and overall life expected from the installation. In temporary installation such as dam construction or quarrying, life may be a few years while for permanent installations, several decades of life may be expected.

D-2.3 Type of Material Handled

The weight of material on belt effects the load and spacing of idlers and therefore has a direct bearing on idler selection. The material lump size modifies the direct effect of weight by introduction of an impact factor. In case of return idlers, only weight carried by idlers is that of belt itself.

D-2.4 Belt Speed

Belt speed is an important factor in idler service life and thetefore governs its selection. It determines the rotational speed of idler based upon the diameter of the roll. Belt speed also has a direct bearing on wear life of idler roll surface, particularly for the return idlers.

D-3 METHOD FOR SELECTION OF IDLER SERIES

D-3.1 Table 25 gives the service factor *'A'* representing the type of service of conveyor installation, Table 26 and Table 27 give the service factors *'B'* and *'C'* applicable for troughing and return idlers respectively, representing the effect of material handled. The product of service factors *'A'* and *'B'* (*'A'* and *'C'* for return idlers) gives application factor used in the selection of idler series number.

Table 25 Service Factor *'A'*

(Clause D-3.1)

Type of Service		Factor *'A'*
Intermittent operation—(less than 6 hours per day)		6
Return idlers		6
Troughing idlers —	Portable or temporary installations	6
Seasonal operation for stockpiling		12
Conveying materials with bulk density over 1 920 kg/m^3		15
One shift operation—(6 to 9 hours per day)		
Return idlers		9
Troughing idlers —	Classified material up to 1 280 kg/m^3	9
	Classified material up to 1 920 kg/m^3	12
	Classified material over 1 920 kg/m^3	15
Unclassified material, limited by belt widths only		15
Two shift operation—(10 to 16 hours per day)		
Return idlers		12
Troughing idlers —	Classified material up to 1 600 kg/m^3	12
	Classified material over 1 600 kg/m^3	15
Unclassified material, limited by belt width only		15
Continuous operation—(over 16 hours per day)		
All materials		15

Table 26 Service Factor '*B*'
(*Clause* D-3.1)

Maximum Lump Size mm	Bulk Density of Material, kg/m³						
	800	1 200	1 600	2 000	2 400	2 800	3 200
100	24	36	48	60	72	84	96
150	32	48	64	80	96	112	128
200	40	60	80	100	120	140	160
250	48	72	96	120	144	168	192
300	56	84	112	140	168	196	224
350	64	96	128	160	192	224	256
400	72	108	144	180	216	252	288
450	80	120	260	200	240	280	320

D-3.2 Figures 22 and 23 depict the relationship between application factor and belt speed for troughing and return idlers. These curves are used for selection of idler series number for troughing and return idlers respectively.

D-3.3 The application factor *(see* **D-3.1)** when plotted, against the selected bell speed for installation in Fig. 22 and Fig. 23 gives the best suited idler series number for troughing and return idlers respectively of the particular installation.

D-3.4 Example

Type of service	8 h/day one shift
Type of material	Crushed stone, 1 600 kg/m³
Maximum lump size	100 mm
Belt speed	1.75 m/s
Belt width selected	800 mm

Table 27 Service Factor '*C*'
(*Clause* D-3.1)

Belt Width mm	Bulk Density of Material, kg/m³		
	Up to 1 200	1 200 to 2 000	Above 2 000
300	2.3	2.8	2.9
400	2.8	3.5	3.6
500	3.5	4.5	4.6
630	4.6	6.2	6.8
800	6.6	8.0	9.2
1 000	10.2	10.19	13.0
1 200	13.6	14.2	166
1 400	16.1	17.7	20.0
1600	18.0	21.8	22.6
1 800	20.3	24.3	25.7

D-3.4.1 *For Troughing Idler Selection*

From Table 25	Factor A = 12
From Table 26	Factor B = 48
Therefore, troughing idler application factor	$A \times B = 12 \times 48 = 576$

D-3.4.1.1 From Fig. 20, for a belt speed of 1.75 m/s and an application factor of 576 a series II idler is selected.

D-3.4.2 *For Return Idler Selection*

From Table 25	Factor A = 9
From Table 27	Factor C = 8
Application factor for return idlers	$A \times C = 9 \times 8 = 72$

D-3.4.2.1 From Fig. 23 for a belt speed of 1.75 m/s and an application factor of 72, a series II idler is indicated.

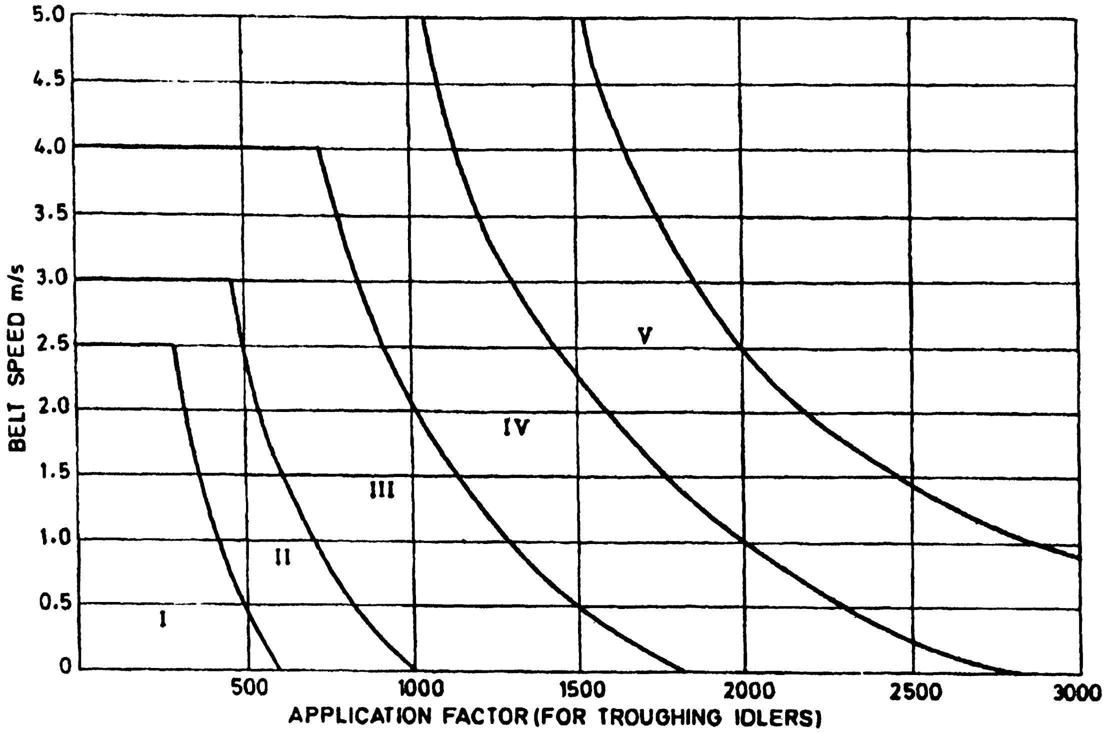


FIG. 22 SELECTION CHART FOR TROUGHING IDLER (FOR BELT WIDTH UP TO 1 500 mm)

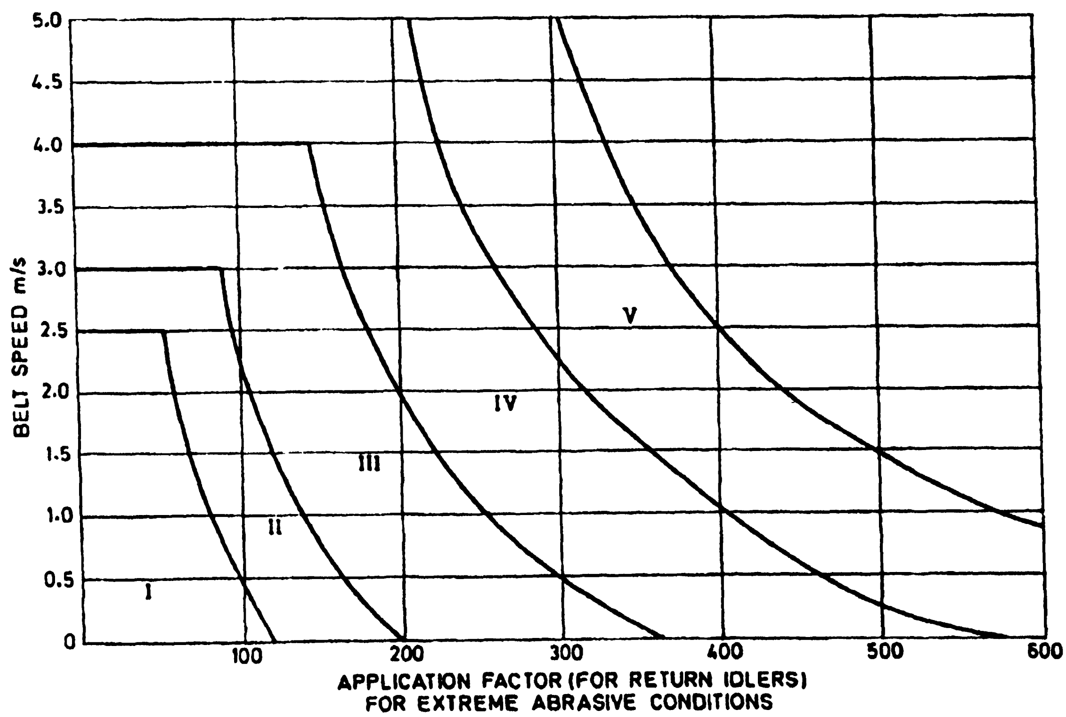


FIG. 23 SELECTION CHART FOR RETURN IDLER (FOR BELT WIDTH THROUGH 1 500 mm)

ANNEX E

(*Clause* 8.8.5.3)

CALCULATIONS FOR EQUIVALENT LOAD ON IDLER BEARINGS FOR THREE EQUAL ROLL TROUGHED IDLER SET

E-1 The load on central idler roll is the summation of loads due to weight of material and weight of belt and is given by (for symbols *see* Table 1)

$$F_l = \left(\frac{2}{3} m_G \cdot g \cdot p_c\right) + \left(\frac{1}{3} m_B \cdot g \cdot p_c\right) \text{newton} \quad \text{...(65)}$$

E-2 The equivalent force on each bearing of the idler is given by:

$$F_{eq} = \frac{1}{2} \cdot F_l \cdot K_i \quad \text{... (66)}$$

where K_l is the application factor for the idlers as given in Table 28.

E-3 The modified equivalent force on each bearing considering the life of bearing is given by:

$$F_{eqm} = \frac{1}{2} \cdot F_l \cdot K_l \cdot B_f \quad \text{... (67)}$$

where B_f is the bearing life factor. The value B_f based on 60 000 working hours at the required belt speed may be obtained from bearing manufacturers.

NOTE — The above is typical method of calculation and there can be other methods as well.

Table 28 Application Factor K_l

(*Clause* E-2)

Type of Factor	Operating Conditions			Service/Speed/Lump Factor
Service factor (K_s)	Hours of operation		Up to 6	0.7
			6 to 10	1.0
			10 to 16	1.3
			16 to 24	1.7
Service factor (K_v)	Belt speed, m/s		Up to 1.0	0.8
			1.0 to 2.0	0.9
			2.0 to 3.0	1.0
			3.0 to 4.0	1.1
			4.0 to 5.0	1.2
Lump factor (K_L)	Maximum lump dimension in mm	Unclassified material	0 to 100	1.0
			100 to 150	1.3
			150 to 200	1.7
			200 to 250	2.0
			250 to 300	2.3
			300 to 350	2.7
			350 to 400	3.0
			400 to 450	3.3
			450 to 500	3.7
			500 to 550	4.0
			550 to 600	4.3
		Classified material	0 to 100	1.3
			100 to 150	1.6
			150 to 200	2.0
			200 to 250	2.3
			250 to 300	2.7

Factor $K_l = K_x . K_v . K_L$

ANNEX F

(Clause 8.8.4.4)

ALTERNATIVE METHOD OF CALCULATION OF INDUCED BELT EDGE TENSION, ΔT

F-1 Induced belt edge tension is the ratio of maximum belt edge tension and the maximum rated belt tension, T_m. The induced belt edge tension may be more than maximum rated belt tension during peak belt loadings in short time non-steady operating condition during starting and stopping the conveyor belt.

F-2 Based on the recommendation of the manufacturer, the maximum belt edge tension under steady operating condition is selected. The value of ΔT is taken from Table 29 (interpolating if necessary) against the ratio of average belt tension at transition to maximum rated bell tension with the assumption that the gap (or overlap) between the rollers (idlers) conforms to IS 8598.

F-3 Value of ΔT given in Table 29 will ensure that:

a) edge tension does not exceed either in steady operating conditions or in the temporary non-steady conditions from the maximum recommended tension of the belt or belt joint in the steady condition by the ratio selected.

b) tension in the belt centre remains adequate and always positive to prevent belt buckling.

F-4 A hgiher value of ΔT may be fixed, if agreed by the belt manufacturer, for the maximum transition distance. If agreed by the manufacturer, the value of maximum belt edge tension may be taken as twice the maximum rated belt tension in case of textile belts and 2.7 times the maximum rated belt tension in case of steel cord belts for belt edge tension in short time non-steady operating condition.

Table 29 Values of ΔT

(*Clauses* F-2 *and* F-3)

Maximum Belt Edge Tension F	$1.3T_m$ 130%	$1.45T_m$ 145%	$1.6T_m$ 160%	$1.8T_m$ 180%	$2T_m$ 200%	$2.3T_m$ 230%	$2.7T_m$ 270%	Criterion
Ratio of Average Belt Tension at Transition to T	ΔT							
$1.5T_m$	—	—	—	0.45 T_m	0.75 T_m	1.2 T_m	1.8 T_m	Maximum belt edge tension F percent
$1.4T_m$	—	—	0.3 T_m	0.6 T_m	0.9 T_m	1.35 T_m	1.95 T_m	
$1.3T_m$	—	0.25T_m	0.45 T_m	0.75 T_m	1.05 T_m	1.5 T_m	2.1 T_m	
$1.2T_m$	0.15 T_m	0.4 T_m	0.6 T_m	0.9 T_m	1.2 T_m	1.65 T_m	2.25 T_m	
$1.1T_m$	0.3 T_m	0.55 T_m	0.75 T_m	1.05 T_m	1.35 T_m	1.8 T_m	2.4 T_m	
$1.0T_m$	0.45 T_m	0.7 T_m	0.9 T_m	1.2 T_m	1.5 T_m	1.95 T_m	2.55 T_m	
$0.9T_m$	0.6 T_m	0.85 T_m	1.05 T_m	1.35 T_m	1.65 T_m	2.1 T_m	2.7 T_m	
$0.8T_m$	0.75 T_m	1 T_m	1.2 T_m	1.5 T_m	1.8 T_m	2.25 T_m	2.4 T_m	No belt centre buckling
$0.7T_m$	0.9 T_m	1.15 T_m	1.35 T_m	1.65 T_m	1.95 T_m	2.1 T_m	2.1 T_m	
$0.6T_m$	1.05 T_m	1.3 T_m	1.5 T_m	1.8 T_m	1.8 T_m	1.8 T_m	1.8 T_m	
$0.5T_m$	1.2 T_m	1.45 T_m	1.5 T_m	1.5 T_m	1.5 T_m	1.5 T_m	1.5 T_m	
$0.4T_m$	1.2 T_m	1.2 T_m	1.2 T_m	1.2 T_m	1.2 T_m	1.2 T_m	1.2 T_m	
$0.3T_m$	0.9 T_m	0.9 T_m	0.9 T_m	0.9 T_m	0.9 T_m	0.9 T_m	0.9 T_m	
$0.2T_m$	0.6 T_m	0.6 T_m	0.6 T_m	0.6 T_m	0.6 T_m	0.6 T_m	0.6 T_m	
$0.1T_m$	0.3 T_m	0.3 T_m	0.3 T_m	0.3 T_m	0.3 T_m	0.3 T_m	0.3 T_m	
$0.05T_m$	0.15 T_m	0.15 T_m	0.15 T_m	0.15 T_m	0.15 T_m	0.15 T_m	0.15 T_m	

ANNEX G

(*Clauses* 8.9.2.3 *and* 8.9.3.5)

SPECIFIC MODULUS FOR BELT MATERIALS

G-1 For the calculation of belt modulus, the values for specific modulus for different types of material of belts are given below:

Carcass Construction (Longitudinal Direction)	*Range*	*Typical Value*
Cotton	7-10	9
Polyamide	5-7	7
Polyester	10-20	16
Nylon/Nylon	6-8	6.5
Rayon	10-14	12
Steel cord	30-50	50

ANNEX H

(*Clause* 8.10.2.4)

SELECTION OF DRIVE PULLEYS WITH TWIN DRIVE

H-1 Drive pulleys with twin drive consists of two pulleys of identical overall diameters each being independently driven.

H-2 The driving motors shall be of the same type and have the same torque/speed characteristics, as also shall be of the case with fluid couplings, when these are fitted.

H-3 In practice, the two drives will not share equally, there being a small difference in power due to the contraction of the belt in drive head causing the secondary pulley to revolve at a lower speed than the primary pulley. The difference in speed will be a function of the belt tensions related to the stretch characteristics of the belt and is normally well within the slip characteristics of either the electric motors or fluid couplings (when these are fitted).

H-4 With this type of drive, the distance between the two drive pulleys is not fixed as in the case of geared tandem drive and the extent of separation is not critical, although practical considerations such as mounting and housing usually make it convenient to have the two drive units reasonably close together. The scope of having a greater length of belt between the two drive pulleys, than is possible with geared tandem drive, makes for greater flexibility in absorbing the effect of belt contraction or creep. Also the greater flexibility of layout of dual drives normally makes it possible to reeve the belt in such a way that the non-carrying or clean side of the belt is in contact with both drive pulleys, thus eliminating the liklihood of difficulty due to material built-up on the face of the pulleys. In dual, drive units should be arranged, so that both drive pulleys drive on the clear side of belt.

ANNEX J

(Clause 8.13.4.2)

DETERMINATION OF TRAJECTORY OF MATERIAL LEAVING THE BELT

J-1 For design of discharge openings and receiving chutes, it is necessary to know the trajectory of material leaving the head pulley in a conveyor system. Trajectory of material is fixed by the angle of separation of material from the belt and the vertical ordinates from the tangent line drawn at the point of separation on head pulley.

J-2 DETERMINATION OF POINT OF SEPARATION

J-2.1 The angle of separation, that is, the angle from vertical at which material will leave the belt as it travels over discharge pulley is calculated from the following formula:

$$\cos\theta = \frac{V^2}{g \cdot r_p} \qquad \text{... (68)}$$

J-2.2 For guidance, a graphical representation for determination of angle of separation is given in Fig. 24.

J-3 DETERMINATION OF ORDINATES

J-3.1 The length of vertical ordinates h_1, h_2, from point at equal intervals placed on tangent line drawn at the point of separation are calculated from the following formula:

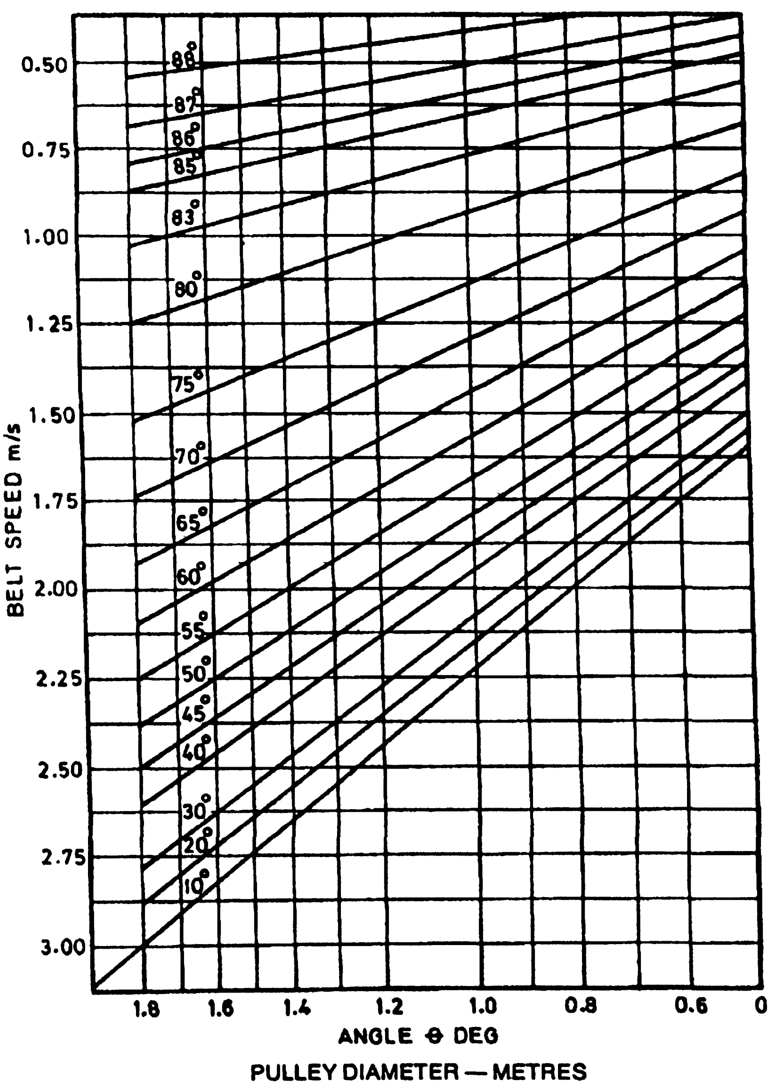


FIG. 24 ANGLE OF SEPARATION FOR BELTS

$$h_1 = \frac{gl_1^2}{2V^2}, h_2 = \frac{gl_2^2}{2V^2} \quad \text{... (69)}$$

J-3.2 For guidance the value of ordinates h_1, h_2, ... in metres with l = 0.50 m per 1.0 m/s of belt speed are given below:

h_1	h_2	h_3	h_4	h_5
0.012	0.049	0.110	0196	0.306
h_6	h_7	h_8	h_9	h_{10}
0.441	0.600	0.784	0.993	1.226
h_{11}	h_{12}	h_{13}	h_{14}	h_{15}
1.483	1.765	2.071	2.402	2.757

J-4 GRAPHICAL REPRESENTATION OF TRAJECTORY OF MATERIAL

J-4.1 The graphical representation of trajectory of material indicates the actual path which will be followed by the material after it leaves the discharge pulley. The trajectory of the material depends upon the configuration of the belt conveyor and is graphically represented in the manner laid down in **J-2.2** and **J-4.3.**

J-4.2 For Ascending and Horizontal Belts

If $\cos \theta < 1$ *(see* **J-2.1)** then the tangent line shall be drawn at the point of separation *(see* Fig. 25). If $\cos \theta = 1$, the tangent line shall be drawn in the direction of belt travel *(see* Fig. 25).

J-4.3 For Descending Belts

If $\cos \theta < 1$ and angle of separation is more than angle of inclination, δ, of the conveyor belt then the tangent line is drawn at the point of separation *(see* Fig. 25). If $\cos \theta \geq 1$ and is less than or equal to angle of inclination, δ, of conveyor belt, the tangent line shall be drawn in the direction of belt travel *(see* Fig. 25).

J-5 For drawing the trajectory of top of the stream of material of height H_1, the radius r_p in formula (68) is replaced by ($r_p + H_1$) and velocity V by :

$$V\frac{(r_p + H_1)}{r_p}$$

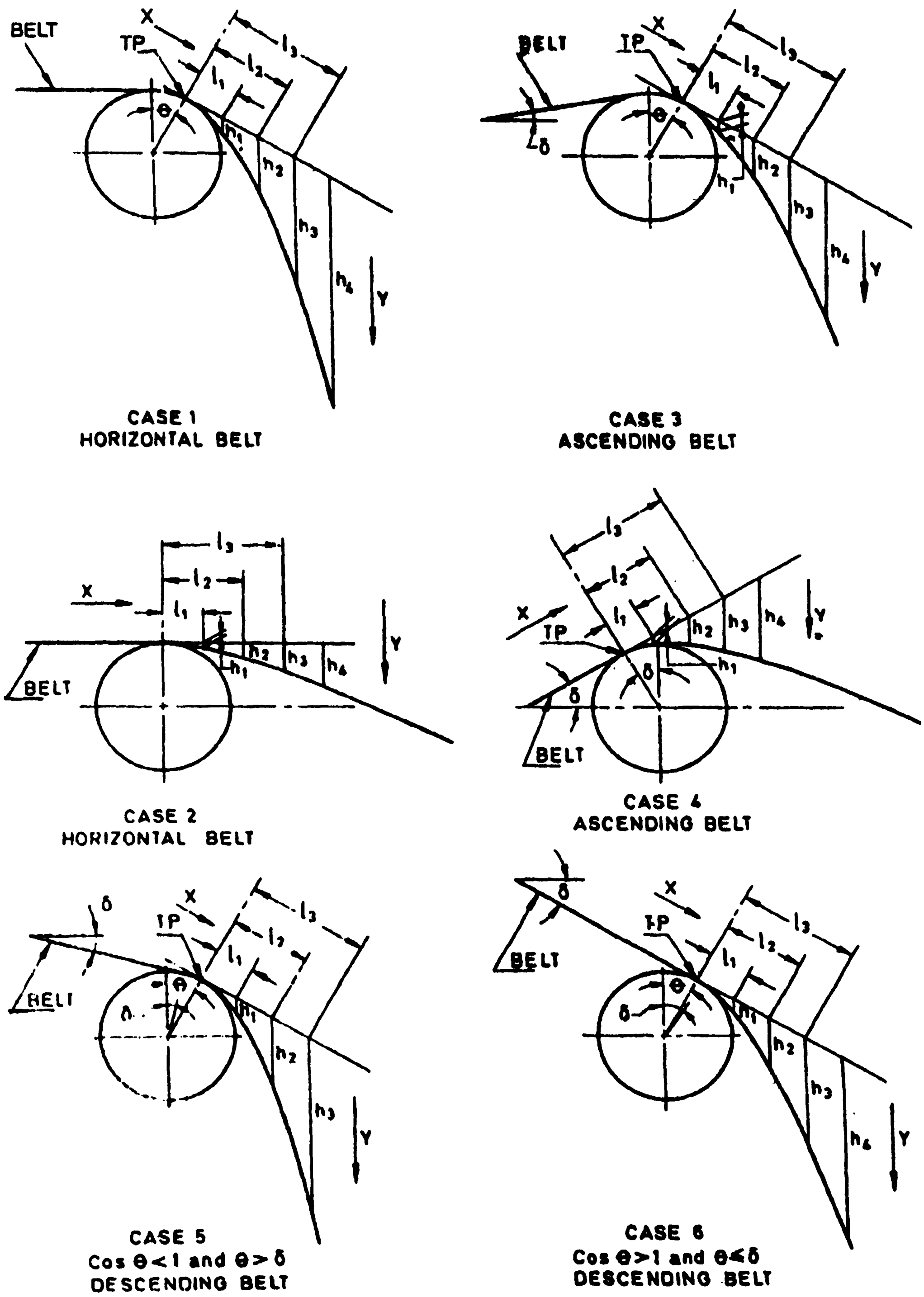


FIG. 25 TRAJECTORY OF MATERIAL

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