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Conveyor belts — Determination of minimum transition distance on three idler rollers

Courroies transporteuses — Détermination de la distance minimale de transition d'auge à trois rouleaux égaux

Reference number
ISO 5293:2004(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5293 was prepared by Technical Committee ISO/TC 41, *Pulleys and belts (including veebelts)*, Subcommittee SC 3, *Conveyor belts*.

This second edition cancels and replaces ISO 5293:1981 and ISO/TR 10357:1989, which have been technically revised.

Conveyor belts — Determination of minimum transition distance on three idler rollers

1 Scope

This International Standard specifies the formula for calculating conveyor belt transition distances and details its application and derivation.

This International Standard is not suitable or valid for light conveyor belts as described in ISO 21183-1[1].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1537, *Continuous mechanical handling equipment for loose bulk materials — Troughed belt conveyors (other than portable conveyors) — Idlers*

ISO 9856, *Conveyor belts — Determination of elastic and permanent elongation and calculation of elastic modulus*

3 Calculation of minimum transition distance

The formula for calculating the transition distance, the derivation of which is given in Annex A, is as follows:

$$L_1 = \frac{h}{\sin\lambda}\left[\frac{M}{\Delta T}(1-\cos\lambda)\right]^{0,5}$$

where

L_1 is the transition distance, expressed in metres;

h is the vertical distance, expressed in metres, the belt edge raises or lowers in the transition (see Figure 1);

λ is the idler trough angle;

M is the elastic modulus, expressed in newtons per millimetre, measured under tension T_R;

T_R is the maximum recommended belt-to-belt joint tension (RMBT), expressed in newtons per millimetre, for a steady-state condition of the conveyor;

ΔT is the induced belt edge stress, expressed in newtons per millimetre, in the transition.

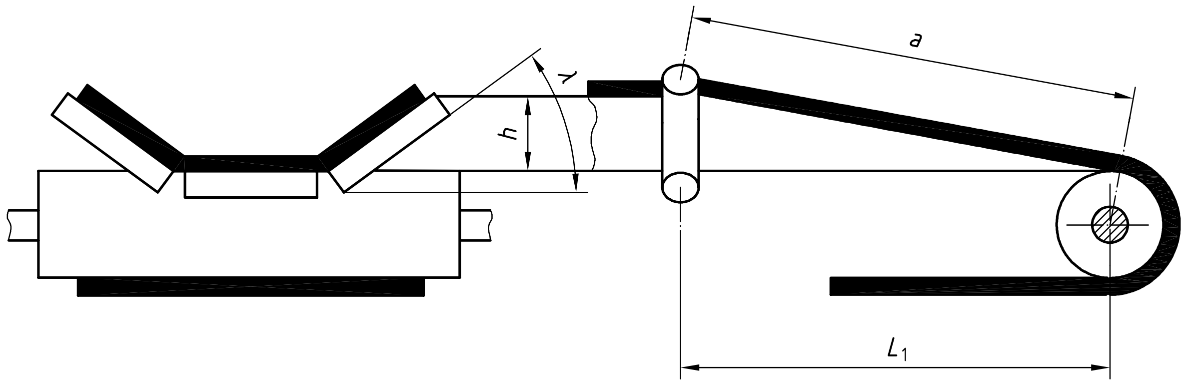


Figure 1 — Transition distance

4 Application of the formula for transition distance

4.1 General

Calculate the transition distance by using appropriate values of M, h and ΔT as described in 4.2 to 4.4, as appropriate.

4.2 Values of elastic modulus, M, of belt

Determine the values in accordance with ISO 9856.

4.3 Values of vertical distance, h, which the belt edge raises or lowers

4.3.1 General

Calculate the values from the idler trough angle λ (see Figure 1) and the position of the terminal pulley with respect to the centre idler roller. Four common situations are described in 4.3.2 and 4.3.3.

4.3.2 Three equal length roller

4.3.2.1 The pulley is on a line with the top centre idler roller (see Figure 2).

$$h = \frac{b \sin \lambda}{3}$$

where

h is the vertical distance, expressed in metres, that the belt edge raises or lowers in the transition (see Figure 1);

b is the width, expressed in metres, of the belt;

λ is the idler trough angle.

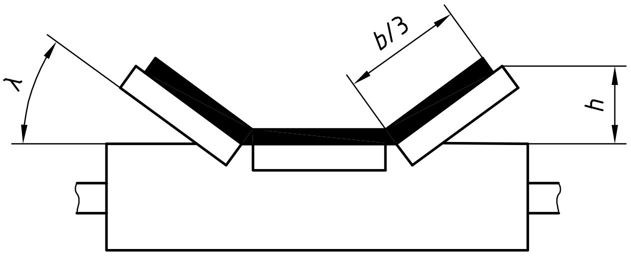


Figure 2 — Pulley on line with top centre idler roller

4.3.2.2 The pulley is elevated by 1/3 of the trough depth above the line of centre idler roller (see Figure 3).

h is then equal to 2/3 full trough depth, i.e.

$$h = \frac{2}{3} \times \frac{b \sin \lambda}{3} = \frac{b \sin \lambda}{4,5}$$

where

- h is the vertical distance, expressed in metres, the belt edge raises or lowers in the transition (see Figure 1);
- b is the width, expressed in metres, of the belt;
- λ is the idler trough angle.

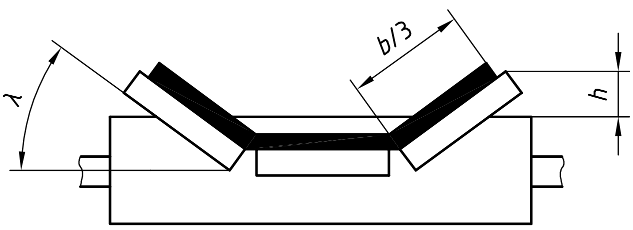


Figure 3 — Pulley elevated by 1/3 of trough depth above line of centre idler roller

4.3.3 Long centre roller

4.3.3.1 The pulley is on a line with the top centre idler roller (see Figure 4).

$$h = b_1 \times \sin \lambda$$

where

- h is the vertical distance, expressed in metres, the belt edge raises or lowers in the transition (see Figure 1);
- b_1 is the amount of belt width, expressed in metres, on one of the outer rollers, i.e. $(b = 2b_1 + b_2)$;
- λ is the idler trough angle.

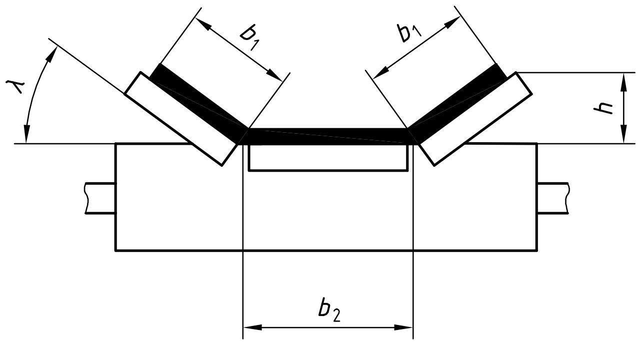


Figure 4 — Pulley on line with top centre idler roller

4.3.3.2 The pulley is elevated by 1/3 of the trough depth above the line of centre idler roller (see Figure 5).

h is then equal to 2/3 full trough depth, i.e.

$$h = \frac{2}{3} \times b_1 \times \sin \lambda$$

where

- h is the vertical distance, expressed in metres, the belt edge raises or lowers in the transition (see Figure 1);
- b_1 is the amount of belt width, expressed in metres, on one of the outer rollers, i.e. $(b = 2b_1 + b_2)$;
- λ is the idler trough angle.

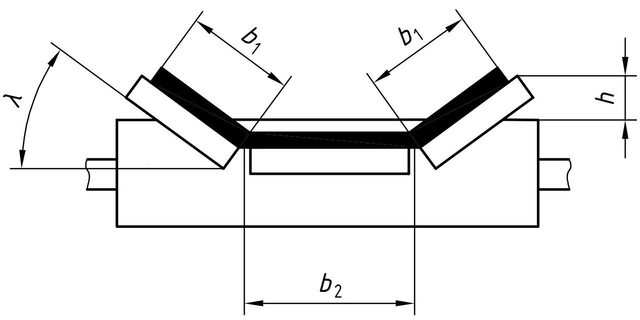


Figure 5 — Pulley elevated by 1/3 of trough depth above line of centre idler roller

4.4 Values of ΔT

4.4.1 Calculate the average belt tension at the transition and express it as a fraction of the maximum recommended belt tension for a steady operating condition, T_R, taking the strength of the belt joints into account. Values of belt tension at transition higher than 1 T_R take into account peak belt loadings which can occur in short-time non-steady operating conditions, for example when starting and stopping the conveyor belt.

In agreement with the belt manufacturer, select a maximum belt edge tension of F % related to the steady operating condition (100 %), provided that the gap (or overlap) between the rollers complies with the requirements of ISO 1537.

4.4.2 The values of ΔT selected (calculated in accordance with Annex B) will

a) prevent edge tension not only in the steady operating conditions but also in the temporary non-steady conditions from exceeding the maximum recommended tension of the belt or the belt joints in the steady conditions by F %;

b) keep the tension in the belt centre adequate and always positive to prevent the centre of the belt from buckling.

NOTE Further information regarding F % is given in Clause B.1.

4.4.3 The additional tensions induced at the troughing transition will normally also be equalized beyond the transition distance. For this reason the actual existing edge stress will be lower. For determining the maximum transition distances a higher value of ΔT can be agreed with the belt manufacturer, if necessary.

4.4.4 Unless otherwise specified by the belt manufacturer, the values below can be allowed for belt edge tensions in short-time non-steady operating conditions:

$F \leqslant 1{,}8T_\mathrm{R}$ or 180 % max. for textile belts; and

$F \leqslant 2{,}0T_\mathrm{R}$ or 200 % max. for steel cord belts.

Annex A
(normative)

Derivation of the formula for transition distance

A.1 The following two assumptions are made to simplify the mathematics and because they only have a minor effect on the calculated transition distance, the effect of the first partially compensated by the effect of the second.

The portion of belt on the inclined troughing roll is assumed to be equal to $b/3$ whereas it is normally slightly less than this.

The belt edge is assumed to make a straight vertical drop through the transition whereas there is actually a slight lateral displacement as well.

A.2 From the stress-strain-modulus relationship

$$\frac{a-L_1}{L_1} M = \Delta T \quad \text{(A.1)}$$

or

$$a = L_1 \left(\frac{\Delta T}{M} + 1\right) \quad \text{(A.2)}$$

where

a is the length of belt edge in transition distance;

L_1, M, h and ΔT are defined in Clause 3.

A.3 Furthermore, by the Pythagorean theorem:

$$a = \left\{L_1^2 + h^2 + \left[\frac{h}{\sin\lambda}(1-\cos\lambda)\right]^2\right\}^{0,5} \quad \text{(A.3)}$$

A.4 Let Equation (A.2) equal Equation (A.3). Square both sides and simplify to the following:

$$\left[L_1\left(\frac{\Delta T}{M}+1\right)\right]^2 = L_1^2 + h^2 + \left[\frac{h}{\sin\lambda}(1-\cos\lambda)\right]^2$$

$$L_1^2\left[\left(\frac{\Delta T}{M}\right)^2 + \frac{2\Delta T}{M}\right] = \left(\frac{h}{\sin\lambda}\right)^2 \times 2(1-\cos\lambda) \quad \text{(A.4)}$$

A.5 $\left(\frac{\Delta T}{M}\right)^2$ in Equation (A.4) is very close to zero.

$$L_1{}^2 = \left(\frac{h}{\sin\lambda}\right)^2 \frac{M}{\Delta T}\left(1-\cos\lambda\right)$$

Therefore

$$L_1 = \frac{h}{\sin\lambda}\left[\frac{M}{\Delta T}\left(1-\cos\lambda\right)\right]^{0,5} \qquad \text{(A.5)}$$

Annex B
(normative)

Derivation of values of ΔT

B.1 Normal and maximum tensions

For normal (steady) operating conditions a maximum recommended belt or belt joint tension T_R is assumed. For this condition the belt edge tension is taken as the 100 % basis.

In the troughing transition, the edge tension will be twice as high during each revolution and higher still during the non-steady conditions (starting and stopping). These belt edge tensions are taken as F %.

NOTE If calculations are based on assumptions of safety factors the following equation applies:

$$F = \frac{S_{sta}}{S}$$

where

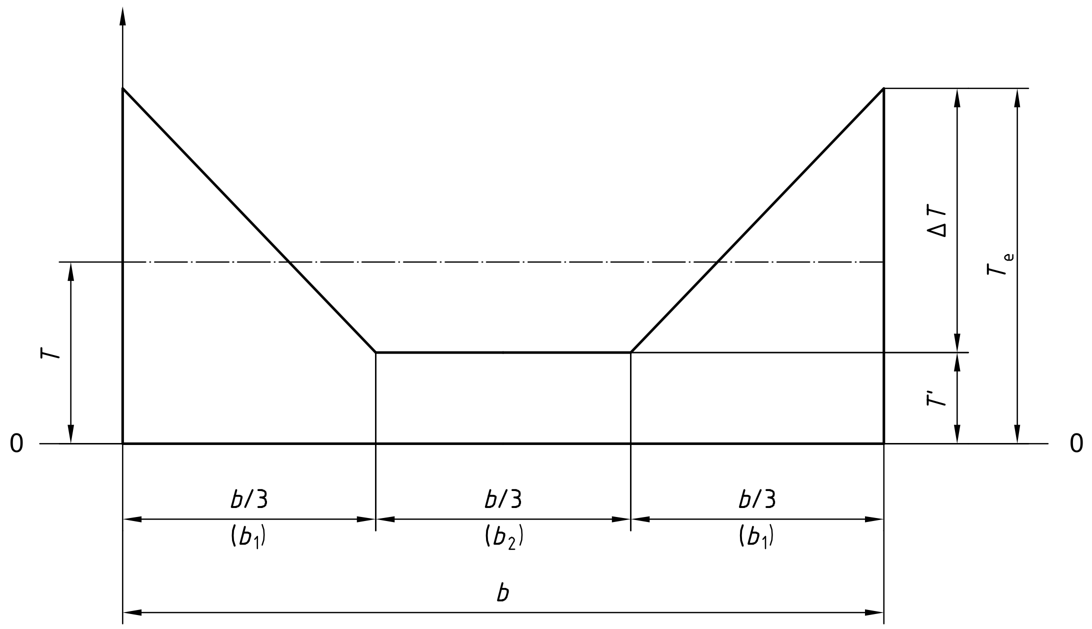
S_{sta} is the safety factor in the steady operating condition (in the case of the belt joint strength, $S_{sta} = 8$);

S is the safety factor corresponding to the maximum permissible edge tension in short-time non-steady operating conditions (e.g. $S > 4$ for textile belts, $S = 3$ for steel cord belts).

B.2 Belt tension distribution

Figure B.1 shows the tension relationship in the troughing transition. The two assumptions made in Clause A.1 apply likewise.

(The diagram should not be mistaken for the geometrical relationship shown in Figure 3.)



where

b is the belt width $(b = 2b_1 + b_2)$;
T is the average belt tension at the transition;
T_e is the maximum edge tension at the transition;
T' is the tension in the trough centre;
ΔT is the induced belt edge stress at the transition.

Figure B.1 — Belt tension relationship in troughing transition

From Figure B.1, it follows that

$$T = T' + \frac{b_1 \times \Delta T}{2b_1 + b_2} \quad \text{(B.1)}$$

B.3 Maximum edge tensions

These are given by:

$$T = C \times T_R$$

where C is the ratio of the average belt tension at the transition to the maximum recommended belt tension (RMBT);

$T' = T_e - \Delta T$ (see Clause B.2)

$T_e = F \times T_R$ (see Clause B.1)

From Equation (B.1), it follows that the tension in the belt edges can be calculated from Equation (B.2):

$$\Delta T = \frac{b}{b_1 + b_2}\left(F - C\right)\, T_R \quad \text{(B.2)}$$

B.4 No belt centre buckling

The tension in the centre of the belt always has to be positive in order to prevent buckling. This means that

$$T' > 0$$

or

$$T > \frac{b_1 \times \Delta T}{2b_1 + b_2} \text{ [see Equation (B.1)]}$$

Taking

$$T = C \times T_R \text{ (see Clause B.3)}$$

it is possible to derive Equation (B.3) for the criterion "no buckling in the belt centre":

$$\Delta T = \frac{b}{b_1} T_R \tag{B.3}$$

B.5 Minimum transition distance

The transition distance has to be sufficient to avoid excessive edge tension as described in Clause B.3 and belt centre buckling as described in Clause B.4.

The minimum transition distance (L_1) is calculated from Equation (A.5) derived in Clause A.5, i.e.

$$L_1 = \frac{h}{\sin\lambda}\left[\frac{M}{\Delta T}(1-\cos\lambda)\right]^{0,5}$$

Perform the calculation twice using values for ΔT calculated from Equation (B.2) in Clause B.3 and Equation (B.3) in Clause B.4.

The larger of the two values obtained for L_1 is the minimum transition distance.

Bibliography

[1] ISO 21183-1, *Light conveyor belts — Part 1: Principal characteristics and applications*[1)]

1) To be published. (Identical to EN 873:1996)

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