TECHNICAL REPORT

ISO TR 10357

First edition
1989-11-01

Conveyor belts — Formula for transition distance on three equal length idler rollers (new method)

Courroies transporteuses — Formule de calcul de la distance de transition d'auge à trois rouleaux égaux (nouvelle méthode)

Reference number
ISO/TR 10357 : 1989 (E)

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.

The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

— type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development requiring wider exposure;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical reports are accepted for publication directly by ISO Council. Technical reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical reports type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10357, which is a technical report of type 2, was prepared by Technical Committee ISO/TC 41, *Pulleys and belts (including veebelts).*

Annexes A and B of this Technical Report are for information only.

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Introduction

The distance between the terminal pulley and the adjacent fully troughed idler set at either the head or tail end of a conveyor is known as the transition distance. Within this distance, the belt changes from a fully troughed to a flat profile, or *vice versa.* It is important that these distances should be sufficient to prevent the tension in the belt edge which will destroy the edges and force the belt towards the idler intersections, becoming excessive. In addition, the occurrence of zero or negative tensions in the centre of the belts must be avoided when the belt tension is low, such as occurs at the tail end of some conveyors. It is recommended that the transition distances be calculated from the formula given in ISO 5293 : 1981, *Conveyor belts — Formula for transition distance on three equal length idler rollers,* taking the appropriate values of the functions from the tables provided and using the manufacturer's value of belt modulus. The level of the top of the terminal pulleys is significant and is normally set in line with the horizontal rollers of the three pulley sets or, alternatively, in line with an imaginary line located at one third of the depth of the troughed section of the conveyor. Calculation methods for each of these configurations are given.

In the instance of ISO work, a method which is an important step forward for the accuracy of calculation and the inclusion of admissible stress exerted on the belt was proposed.

This method requires a good knowledge of the belt stress in non-steady operating conditions, for example when starting and stopping the conveyor belt.

In view of current state of standardization, no standard exists which allows these stresses to be calculated with the expected degree of accuracy.

So it was agreed to prepare a type 2 technical report, rather than revise ISO 5293 : 1981, in order not to exclude the possibility of progress given by this new method.

Since the application of this new method must be tested during a determined time to take into account technological progress, it was agreed that this Technical Report would be issued in the meantime.

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Conveyor belts — Formula for transition distance on three equal length idler rollers (new method)

1 Scope

This Technical Report specifies the formula for calculating conveyor belt transition distances.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1537 : 1975, *Continuous mechanical handling equipment for loose bulk materials — Troughed belt conveyors (other than portable conveyors) — Idlers.*

ISO 9856 : 1989, *Conveyor belts — Determination of elastic modulus.*

3 Formula for calculating transition distance

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

$$L_1 = 0{,}707\, h \left(\frac{M}{\Delta T}\right)^{1/2}$$

where

L_1 is the transition distance, in metres;

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

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

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

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

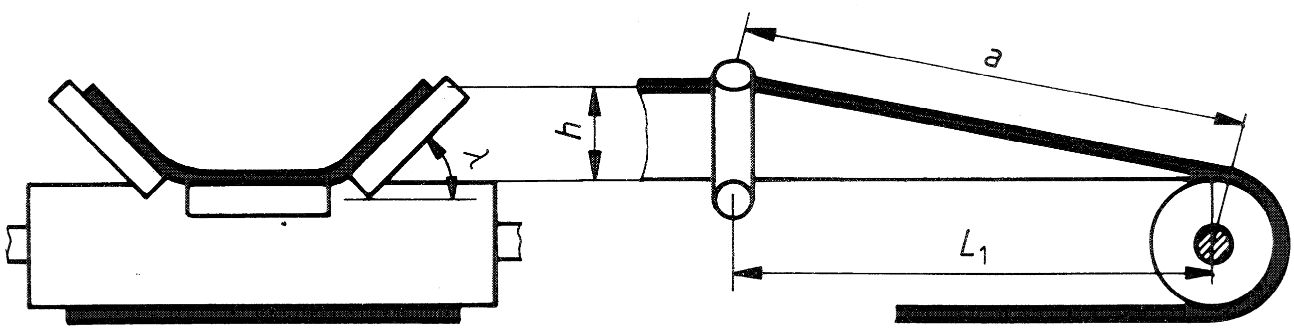


Figure 1

4 Application of the formula for transition distance

Calculate the transition distance by using appropriate values of M, h and ΔT as follows.

4.1 Values of elastic modulus, M, of belt

These are determined in accordance with ISO 9856.

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

This is calculated from the idler trough angle λ (see figure 1) and the position of the terminal pulley with respect to the centre idler roller. Two common situations are as follows.

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

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

where

h is as defined in clause 3;

b is the width of the belt, in metres;

λ is the idler trough angle.

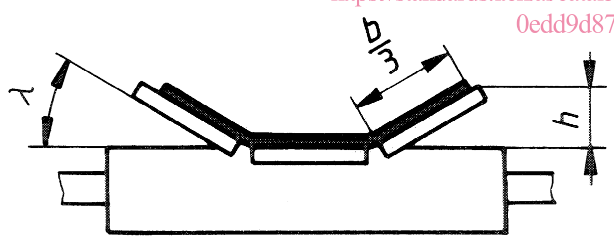


Figure 2

4.2.2 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, b and λ are as defined in 4.2.1.

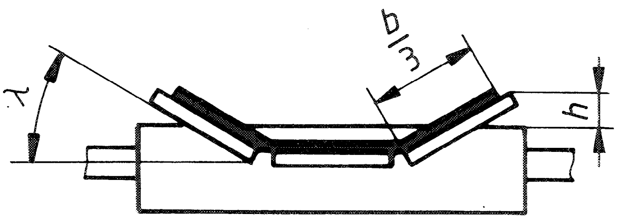


Figure 3

4.3 Values of ΔT

4.3.1 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 %) and take the value ΔT from table 1 (interpolating if necessary), provided that the gap (or overlap) between the rollers complies with the requirements of ISO 1537.

4.3.2 The values of ΔT selected (calculated in accordance with annex B) will

— 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 %;

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

4.3.3 The additional tensions induced at the troughing transition will normally be equalized beyond the transition distance as well. For this reason the actual existing edge stress will be lower. For determining the maximum transition distances a higher value of ΔT can be fixed by agreement with the belt manufaturers, if necessary.

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

$F \leqslant 2\ T_R$ or 200 % max. for textile belts;

$F = 2,7\ T_R$ or 270 % max. for steel cord belts.

Table 1

Maximum belt edge tension F	$1,3\ T_R$ 130 %	$1,45\ T_R$ 145 %	$1,6\ T_R$ 160 %	$1,8\ T_R$ 180 %	$2\ T_R$ 200 %	$2,3\ T_R$ 230 %	$2,7\ T_R$ 270 %	Criterion
Ratio of average belt tension at transition to T_R	ΔT							
$1,5\ T_R$	—	—	—	$0,45\ T_R$	$0,75\ T_R$	$1,2\ T_R$	$1,8\ T_R$	Maximum belt edge tension F %
$1,4\ T_R$	—	—	$0,3\ T_R$	$0,6\ T_R$	$0,9\ T_R$	$1,35\ T_R$	$1,95\ T_R$	
$1,3\ T_R$	—	$0,25\ T_R$	$0,45\ T_R$	$0,75\ T_R$	$1,05\ T_R$	$1,5\ T_R$	$2,1\ T_R$	
$1,2\ T_R$	$0,15\ T_R$	$0,4\ T_R$	$0,6\ T_R$	$0,9\ T_R$	$1,2\ T_R$	$1,65\ T_R$	$2,25\ T_R$	
$1,1\ T_R$	$0,3\ T_R$	$0,55\ T_R$	$0,75\ T_R$	$1,05\ T_R$	$1,35\ T_R$	$1,8\ T_R$	$2,4\ T_R$	
$1,0\ T_R$	$0,45\ T_R$	$0,7\ T_R$	$0,9\ T_R$	$1,2\ T_R$	$1,5\ T_R$	$1,95\ T_R$	$2,55\ T_R$	
$0,9\ T_R$	$0,6\ T_R$	$0,85\ T_R$	$1,05\ T_R$	$1,35\ T_R$	$1,65\ T_R$	$2,1\ T_R$	$2,7\ T_R$	
$0,8\ T_R$	$0,75\ T_R$	$1\ T_R$	$1,2\ T_R$	$1,5\ T_R$	$1,8\ T_R$	$2,25\ T_R$	$2,4\ T_R$	No belt centre buckling
$0,7\ T_R$	$0,9\ T_R$	$1,15\ T_R$	$1,35\ T_R$	$1,65\ T_R$	$1,95\ T_R$	$2,1\ T_R$	$2,1\ T_R$	
$0,6\ T_R$	$1,05\ T_R$	$1,3\ T_R$	$1,5\ T_R$	$1,8\ T_R$	$1,8\ T_R$	$1,8\ T_R$	$1,8\ T_R$	
$0,5\ T_R$	$1,2\ T_R$	$1,45\ T_R$	$1,5\ T_R$	$1,5\ T_R$	$1,5\ T_R$	$1,5\ T_R$	$1,5\ T_R$	
$0,4\ T_R$	$1,2\ T_R$	$1,2\ T_R$	$1,2\ T_R$	$1,2\ T_R$	$1,2\ T_R$	$1,2\ T_R$	$1,2\ T_R$	
$0,3\ T_R$	$0,9\ T_R$	$0,9\ T_R$	$0,9\ T_R$	$0,9\ T_R$	$0,9\ T_R$	$0,9\ T_R$	$0,9\ T_R$	
$0,2\ T_R$	$0,6\ T_R$	$0,6\ T_R$	$0,6\ T_R$	$0,6\ T_R$	$0,6\ T_R$	$0,6\ T_R$	$0,6\ T_R$	
$0,1\ T_R$	$0,3\ T_R$	$0,3\ T_R$	$0,3\ T_R$	$0,3\ T_R$	$0,3\ T_R$	$0,3\ T_R$	$0,3\ T_R$	
$0,05\ T_R$	$0,15\ T_R$	$0,15\ T_R$	$0,15\ T_R$	$0,15\ T_R$	$0,15\ T_R$	$0,15\ T_R$	$0,15\ T_R$	

Annex A
(informative)

Derivation of the formula for transition distance

A.1 Assumptions

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

The portion of belt on the inclined troughing roll is assumed to be $\frac{b}{3}$ whereas in fact it is slightly less.

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.1.1 From the stress-strain-modulus relationship

$$\frac{a - L_1}{L_1} M = \Delta T \qquad \ldots (1)$$

Or:

$$a = L_1 \left(\frac{\Delta T}{M} + 1 \right) \qquad \ldots (2)$$

where

a is the length of belt edge in transition distance;

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

A.1.2 Also, by the Pythagorean theorem:

$$a = (L_1{}^2 + h^2)^{1/2} \qquad \ldots (3)$$

A.1.3 Let equation (2) equal equation (3). Square both sides and simplify to the following:

$$L_1 = \frac{\left(\frac{M}{\Delta T} \right) h}{\left(1 + \frac{2\,M}{\Delta T} \right)^{1/2}} \qquad \ldots (4)$$

A.1.4 Drop the 1 in the equation (4) denominator since it will be very small compared with $\frac{2M}{\Delta T}$

Then simplify to the following formula for transition distance:

$$L_1 = 0{,}707\, h \left(\frac{M}{\Delta T} \right)^{1/2} \qquad \ldots (5)$$

Annex B
(informative)

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:

$$F = S_{sta}/S$$

where

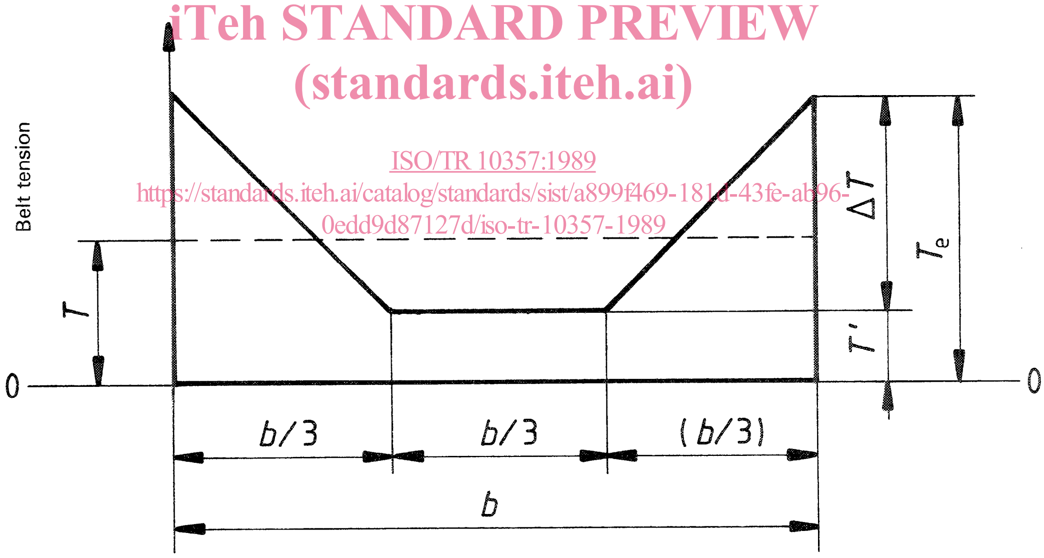
S_{sta} is the safety factor in the steady operating condition (in the case of the belt joint strength $S_{sta} = 8$);

S is the safety factor corresponding to the maximum permissible edge tension in short-time non-steady operating conditions (for example $S \geqslant 4$ 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;
- 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