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Conveyor belts — Indentation rolling resistance related to belt width — Requirements and testing

Courroies transporteuses — Résistance au roulement par suite d'enfoncement relative à la largeur de courroie — Exigences et essais

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This document was prepared by TechnicalCommittee ISO/TC 41, *Pulleys and belts (includingveebelts)*, Subcommittee SC 3, *Conveyor belts*.

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Introduction

The indentation rolling resistance is caused by the energy loss connected to the deformation of the conveyor belt due to its contact with the idler. Apart from the technological properties of the conveyor belt, the magnitude of the indentation rolling resistance depends on the following factors:

— design of the conveyor belt, especially the pulley side cover plate thickness;

— vertical load;

— idler diameter;

— ambient temperature;

— belt speed.

The width-related indentation rolling resistance is measured in a test rig with an idler which exerts an evenly distributed vertical force on the belt. An indentation rolling resistance to be used for the design of belt conveyors for an idler station with more than one idler can only be calculated considering the vertical forces and their distribution between belt and idler (refer to Annex A).

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Conveyor belts — Indentation rolling resistance related to belt width — Requirements and testing

1 Scope

This document defines a method for the determination of the width-related indentation rolling resistance of conveyor belts. The goal is to be a full-scale test and simulation on finished belt constructions which are reproducible and relevant for the practical use. The test results can be used for a comparison of conveyor belts and for design of belt conveyors with steel cord and fabric conveyor belts.

This document is not suitable or valid for light conveyor belts described in ISO 21183-1.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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4 Symbols and units

Table 1 shows the symbols and units used in this document.

Table 1 — Symbols and units

Symbol	Meaning	Unit
B	Belt width	mm
b_K	Width of the rubber edge of the belt	mm
b_R	Length of the contact line between belt and idler shell	mm
c_a	Factor in the approximation equation for the width related indentation rolling resistance	-
c_b	Exponent in the approximation equation for the width related indentation rolling resistance	-
$D_{R,M}$	Diameter of measuring idler	mm
$D_{R,G}$	Diameter of the opposing idler	mm
D_S	Steel cord diameter	mm
D_{Tr}	Pulley diameter	mm
F_E	Indentation rolling resistance acting on one idler	N
$F_{E,ges}$	Total indentation rolling resistance acting on an idler station with three idlers	N
F'_E	Indentation rolling resistance related to belt width	N/mm

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Table 1 *(continued)*

Symbol	Meaning	Unit
$F_{M,h}$	Horizontal force acting on the measuring idler turning clockwise ($F_{M,h,r}$) or anti-clockwise ($F_{M,h,l}$)	N
$F_{M,v}$	Vertical force on the measuring idler corresponding to the load	N
$F'_{M,v}$	Vertical force related to the belt width	N/mm
F_n	Normal force acting on an idler	N
F_R	Idler rolling resistance	N
L	Distance axis-to-axis	mm
n_S	Number of steel cords	-
q	Length related load acting on the idler	N/mm
s_1	Cover plate thickness, carrying side	mm
s_2	Cover plate thickness, pulley side	mm
T_U	Ambient temperature	°C
t	Cord pitch	mm
v	Belt speed	m/s
z	Coordinate of length	mm
λ	Idler trough angle	°

Table 2 described the used indices in this document.

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Table 2 — Indices

Index	Meaning
m	Middle idler
s	Side idler

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5 Test rig

The testing apparatus is a test rig with a rotating belt sample, constructed with a drive pulley and a tensioning pulley. Both pulleys have a minimum diameter of 800 mm (Figure 1). The distance axis-to-axis has a minimum value of 3 500 mm. For high strength conveyor belts and large splice lengths differing pulley diameters and distances axis-to-axis shall be agreed upon with the operator of the test rig. The belt speed is adjustable and is constantly monitored with appropriate sensors. The complete test rig is placed in an isolated climate chamber, so that the ambient temperature can be adjusted with suitable heating and cooling devices. There is a special measuring arrangement with which an idler can be pressed on to the belt with a defined force. As counter support an idler is installed. This idler has a minimum diameter $D_{R,G}$ of 400 mm and the diameter shall be larger than the diameter $D_{R,M}$ of the measuring idler by a minimum factor of 1,5 as Formula (1).

$$D_{R,G} \geq 1{,}5 \times D_{R,M} \quad (1)$$

The diameters $D_{R,G}$ and $D_{R,M}$ shall be chosen corresponding to the parameters of the belt conveyor and to be agreed upon with the operator of the test rig.

The test rig shall be constructed in a way that it is possible to install the test belt as an endless belt. Figure 1 shows a schematic picture of the test rig.

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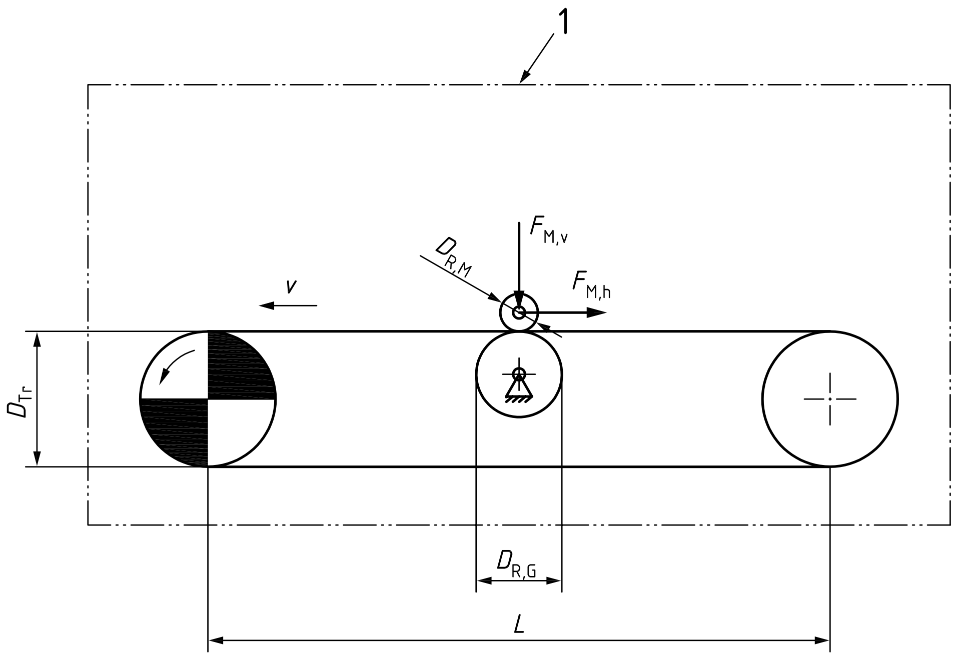

Key

1 temperature isolating chamber

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Figure 1 — Schematic picture one example of the test rig

For the measurement of the indentation rolling resistance idlers with varying diameters and shell lengths are used. These are installed in an adjustable frame. The shell length of the idler shall be at least 10 % longer than the width of the test belt. The frame shall be in a statically simply fixed position. It shall be avoided that the position is over-determined and that resulting forces are created. These can distort the measurement results. All suspension points shall be equipped with suitable force sensors in order to determine all suspending forces unambiguously. The perpendicular alignment of the measuring idler to the belt can be checked with the help of a force sensor which records the forces that act in axial direction upon this idler, if the alignment is not correct.

In order to determine the width-related indentation rolling resistance, the forces are measured which act upon the left and the right side of the idler – and therefore, upon the frame – with suitable force sensors. To calculate the indentation rolling resistance from these values, the part of the horizontal force caused by the idler rolling resistance shall be known and shall be subtracted from the measured horizontal force $F_{M,h.}$ The idler rolling resistance can either be measured simultaneously with suitable sensors, or it can be measured separately. In the latter case the test parameters of the measurement of indentation rolling resistance need to be taken into consideration.

6 Preparation of test samples

The endless length of the test belts depends on the distance axis-to-axis of the test rig L and the pulley diameter D_{Tr} and deviations from the values stated in Clause 5 shall be agreed with the operator of the test rig. The width of the test belt shall be a minimum of 350 mm. For steel-cord belts the width of the rubber belt edge shall be chosen as Formula (2):

$$b_K = \frac{1}{2} \times (t - D_S) \tag{2}$$

In fabric belts rubber edges shall be avoided, so that the belt width is equal to the width of the tension carrier.

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The test belts shall be joined with a splice of minimized length, which can differ from the standard splice layout. The horizontal force measured in the splice area can differ from the force measured in the belt. Therefore, it is not taken into consideration for the calculation of the indentation rolling resistance.

7 Procedure

The cover plate to be measured shall be in contact with the measuring idler.

Prior to each measurement the test rig shall be operated in constant test conditions long enough, so that the idler running resistance and the measured horizontal forces reach a steady state. The complete test rig shall be brought to the desired temperature over a sufficiently long time, so that in the complete cross section of the test belt the temperature equals the surrounding temperature in the climate chamber of the test rig.

In order to cancel the influence of zero drift errors when measuring the horizontal forces acting on the measuring idler, the belt running direction shall be alternated several times during the measurement. The value of the difference between the measured horizontal force of the belt running to the left $F_{\mathrm{M,h,l}}$ and the belt running to the right $F_{\mathrm{M,h,r}}$ is taken into account for the calculation of the indentation rolling resistance.

The measurements shall be performed with a test idler of which the diameter $D_{\mathrm{R,M}}$ equals the diameter of the idlers in the conveyor. The vertical forces used in the measurements shall be chosen according to the normal forces between belt and idler station in the real life conveyor.

The different temperatures T_{U} set in the climate chamber of the test rig shall be chosen corresponding to the temperatures to be expected at the real life conveyor.

In order to gain accurate results it is important to achieve an introduction free from superpositions of the vertical force $F_{\mathrm{M,v}}$ – which is a magnitude larger than the measured horizontal forces. A possible influence on the horizontal force from the vertical force shall be taken into consideration.

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8 Calculation and expression of results

The width-related indentation rolling resistance F'_{E} is calculated, by Formula (3), from the absolute value of the difference between the horizontal force measured for the belt running to the left $F_{\mathrm{M,h,l}}$ and running to the right $F_{\mathrm{M,h,r}}$, considering their different algebraic signs. Furthermore, the rolling resistance F_{R} of the used measuring idler shall be subtracted.

$$F'_{\mathrm{E}} = \frac{|F_{\mathrm{M,h,l}} - F_{\mathrm{M,h,r}}| - 2 \times F_{\mathrm{R}}}{2 \times B} \tag{3}$$

When showing the width related indentation rolling resistance as variation of the vertical force $F_{\mathrm{M,v}}$ it is recommended to also relate the vertical force to the belt width as Formula (4).

$$F'_{\mathrm{M,v}} = \frac{F_{\mathrm{M,v}}}{B} \tag{4}$$

Figure 2 shows an example for the relation between the width related indentation rolling resistance F'_{E} and the width related vertical force $F'_{\mathrm{M,v}}$, considering the ambient temperature T_{U} as parameter.

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