



BSI Standards Publication

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

**National foreword**

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The UK participation in its preparation was entrusted to Technical Committee PRI/67, Conveyor belts.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2016

ISBN 978 0 580 92799 7

ICS 53.040.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2016.

**Amendments/corrigenda issued since publication**

Date	Text affected
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EUROPEAN STANDARD

**EN 16974**

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2016

ICS 53.040.20

English Version

## Conveyor belts - Indentation rolling resistance related to belt width - Requirements, testing

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

Fördergurte - Gurtbreitenbezogener  
Eindruckrollwiderstand - Anforderungen, Prüfung

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## European foreword

This document (EN 16974:2016) has been prepared by Technical Committee CEN/TC 188 “Conveyor belts”, the secretariat of which is held by SNV.

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## 1 Scope

This European Standard defines a method for the determination of the width related indentation rolling resistance of conveyor belts. The goal is that the method easily and quickly delivers values which are reproducible and relevant for the practical use. The test results enable a comparing evaluation and the design of belt conveyors with steelcord and fabric conveyor belts.

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

## 2 Normative references

Not applicable.

## 3 General information

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).

## 4 Symbols and units

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

**Table 1 — Symbols and units**

<b>Symbol</b>	<b>Meaning</b>	<b>Unit</b>
$B$	Belt width	mm
$D_{R,M}$	Diameter of measuring idler	mm
$D_{R,G}$	Diameter of the opposing idler	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
$F_{M,h}$	Horizontal force acting on the measuring idler turning clockwise (FM,h,r) or anti-clockwise (FM,h,le)	N
$F_{M,v}$	The 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
$T_U$	Ambient temperature	°C
$b_K$	Width of the rubber edge of the belt	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	-
$b_R$	Length of the contact line between belt and idler shell	mm
$d$	Steelcord diameter	mm
$q$	Length related load acting on the idler	N/mm
$n_s$	Number of steelcords	-
$s_1$	Cover plate thickness, carrying side	mm
$s_2$	Cover plate thickness, pulley side	mm
$t$	Cord pitch	mm
$v$	Belt speed	m/s
$z$	Coordinate of length	mm

Table 2 described the used indices in this standard.

**Table 2 — Indices**

Index	Meaning
m	Middle idler
s	Side idler

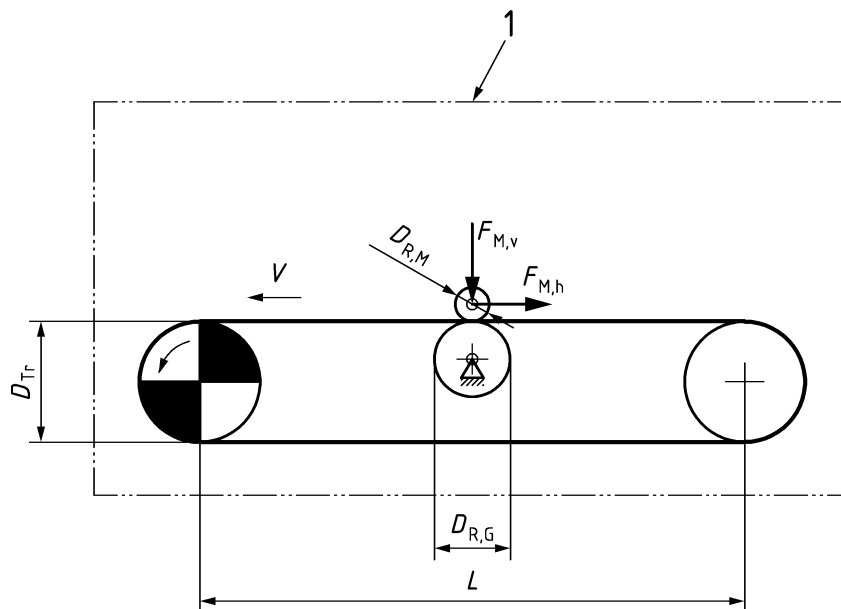
## 5 Test rig

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. In the top run there is a special measuring arrangement with which an idler can be pressed down 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 of the measuring idler by a minimum factor of 1,5.

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

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.



### Key

1 temperature isolating chamber

**Figure 1 — Schematic picture 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 could 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 the 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 cause 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 this 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 follows:

$$b_k = \frac{1}{2} \times (t - d) \quad (2)$$

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

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  $F_{M,h,l}$  and the belt running to the right  $F_{M,h,r}$  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  $D_{R,M}$  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  $F_{M,v}$  – 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.

## 8 Calculation and expression of results

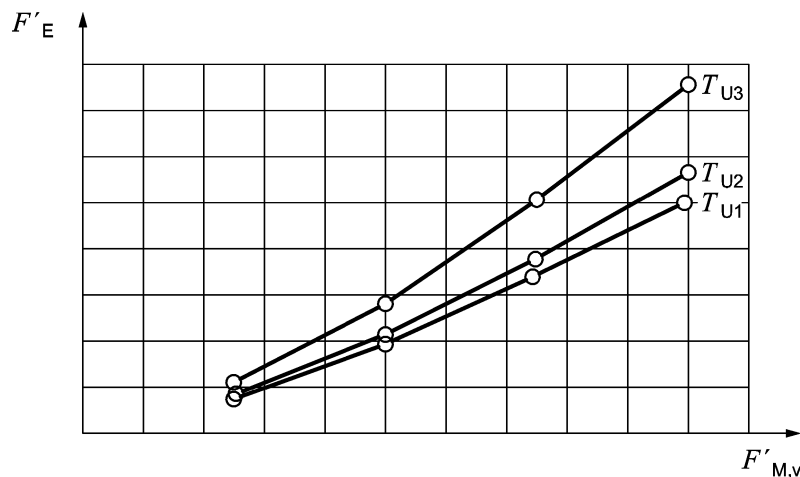
The width related indentation rolling resistance  $F'_E$  is calculated from the absolute value of the difference between the horizontal force measured for the belt running to the left  $F_{M,h,l}$  and running to the right  $F_{M,h,r}$ , considering their different algebraic signs. Furthermore the rolling resistance  $F_R$  of the used measuring idler shall be subtracted.

$$F'_E = \frac{|F_{M,h,l} - F_{M,h,r}| - 2 \times F_R}{2 \times B} \quad (3)$$

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

$$F'_{M,v} = \frac{F_{M,v}}{B} \quad (4)$$

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



**Figure 2 — Example for the variation of the width related indentation rolling resistance  $F'_E$  depending on the width related vertical force  $F'_{M,v}$  under consideration of the ambient temperature  $T_U$**

## 9 Test report

The test report shall contain the following information:

- a) belt manufacturer;
- b) for steelcord conveyor belts:
  - 1) belt type;
  - 2) width related nominal breaking force of the belt in N/mm;
  - 3) belt width  $B$  in mm;

- 4) number of breakers;
  - 5) steelcord diameter  $d$  in mm;
  - 6) cord pitch  $t$  in mm;
  - 7) thickness of the cover plate including protective layers and transverse reinforcements (carrying side  $s_1$  and pulley side  $s_2$  in mm);
  - 8) type and position of protective layers and transverse reinforcements;
  - 9) additional notes (e.g. according to DIN 22129-2 or EN ISO 15236-3);
- c) for fabric conveyor belts:
- 1) belt type;
  - 2) width related nominal breaking force of the belt in N/mm;
  - 3) belt width  $B$  in mm;
  - 4) number of plies;
  - 5) thickness of the cover plate including protective layers and transverse reinforcements (carrying side  $s_1$  and pulley side  $s_2$  in mm);
  - 6) type and position of protective layers and transverse reinforcements;
  - 7) additional notes (e.g. according to DIN 22102-1 or DIN 22109-5);
- d) test conditions:
- 1) type and diameter of the measuring idler  $D_{R,M}$  respectively the support idler  $D_{R,G}$  in mm;
  - 2) width related vertical force  $F'_{M,v}$  in N/mm;
  - 3) belt speed  $v$  in m/s;
  - 4) ambient temperature in the climate chamber  $T_U$  in °C;
- e) test result:
- 1) width related indentation rolling resistance  $F'_E$  in N/mm, for example as variation of the ambient temperature  $T_U$  in °C and the width related vertical force  $F'_{M,v}$  in N/mm.

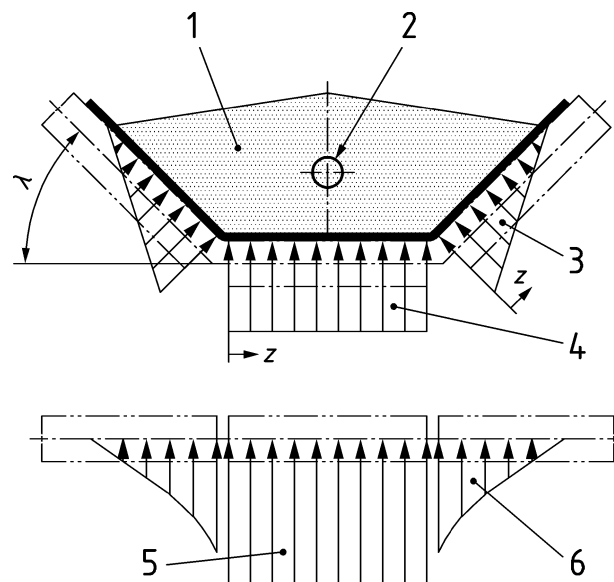
## Annex A (informative)

### Conversion of the measured width related indentation rolling resistance to a 3-part idler station

At the moment reliable knowledge about the conversion of the measured width related indentation rolling resistance to a 3-part idler station only exists for steel cord conveyor belts. For fabric belts such knowledge does not exist.

Regardless of the application of the results of the measurements, for a conversion to the indentation rolling resistance of a complete idler station it is necessary to know the normal forces acting on each idler.

Figure A.1 shows an idealized distribution of the normal forces and the resulting indentation rolling resistance for a 3-part idler station. Here the 3 idlers have the same length and the conveyor is running horizontally and straight.



#### Key

- 1 bulk material
- 2 belt running direction
- 3 width related load on the side idler  $q_s(z)$
- 4 width related load on the middle idler  $q_m(z)$
- 5 width related indentation rolling resistance of the middle idler  $F_{E,m}$
- 6 width related indentation rolling resistance of the side idler  $F_{E,s}$

**Figure A.1 — Idealized distribution of the normal forces along the idler shells and the resulting indentation rolling resistance for a 3-part idler station with idlers of the same length**

The normal force acting on each idler  $F_n$  – considering the length of the contact line between belt and idler  $b_R$  – is calculated as follows:

$$F_n = \int_0^{b_R} q(z) \times dz \quad (\text{A.1})$$

Through solving the integral and considering a constant normal load on the middle idler it follows:

$$q_m(z) = \frac{F_{n,m}}{b_{R,m}} \quad (\text{A.2})$$

Similarly it follows for the linearly increasing or decreasing load on the side idlers:

$$q_s(z) = \frac{2 \times F_{n,s}}{b_{R,s}^2} \times (b_{R,s} - z) \quad (\text{A.3})$$

The measured relationship between the width related indentation rolling resistance and the width related vertical force can generally be described by the following approximation:

$$F'_E = c_a \times (F'_{M,v})^{c_b} \quad (\text{A.4})$$

Here the values of the factor  $c_a$  and the exponent  $c_b$  vary depending on the graph of the width related indentation rolling resistance and the units used for  $F'_E$  and  $F'_{M,v}$ .

The indentation rolling resistance  $F_E$  acting on an idler is calculated as integral of  $F'_E$  as function of the position over the length of contact  $b_R$  under consideration of  $q(z) = F'_{M,v}$ :

$$F_E = \int_0^{b_R} c_a \times q(z)^{c_b} \times dz \quad (\text{A.5})$$

The indentation rolling resistance acting on a 3-part idler station is calculated as the sum of the indentation rolling resistances of the side idlers and the middle idler.

$$F_{E,ges} = F_{E,m} + 2 \times F_{E,s} \quad (\text{A.6})$$

Combining Formulae (A.2) and (A.3) with Formula (A.5) and solving the integral makes possible the calculation of the indentation rolling resistance acting on the side and middle idlers. According to Formula (A.7) the sum of these is  $F_{E,ges}$ :

$$F_{E,ges} = c_a \times \left( \frac{F_{n,m}}{b_{R,m}} \right)^{c_b} \times b_{R,m} + 2 \times \frac{c_a \times b_{R,s}}{c_b + 1} \times \left( \frac{2 \times F_{n,s}}{b_{R,s}} \right)^{c_b} \quad (\text{A.7})$$

Therefore with the knowledge of the geometric conditions, the acting forces and their distribution and the indentation rolling resistance measured in the test rig it is possible to calculate the indentation rolling resistance per idler station.

## Bibliography

- [1] EN ISO 15236-3, *Steel cord conveyor belts - Part 3: Special safety requirements for belts for use in underground installations (ISO 15236-3)*
- [2] EN ISO 21183-1, *Light conveyor belts - Part 1: Principal characteristics and applications (ISO 21183-1)*
- [3] DIN 22101, *Continuous conveyors — Belt conveyors for loose bulk materials — Basis for calculation and dimensioning*
- [4] DIN 22102-1, *Conveyor belts with textile plies for bulk goods — Part 1: Dimensions, specifications, marking*
- [5] DIN 22129-2, *Steelcord conveyor belts for underground coalmining; marking*
- [6] DIN 22109-5, *Conveyor belts with textile plies for coalmining; branding*



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