BS EN 16974:2016

BSI Standards Publication

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

bsi.

National foreword

This British Standard is the UK implementation of EN 16974:2016.

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2016

ISBN 978 0 580 92799 7

ICS 53.040.20

Compliance with a British Standard cannot confer immunity from legal obligations.

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

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16974

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

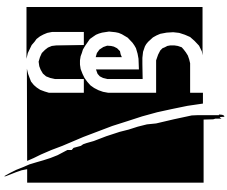
Fördergurte - Gurtbreitenbezogener Eindrückrollwiderstand - Anforderungen, Prüfung

This European Standard was approved by CEN on 13 July 2016.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 16974:2016 E

Contents

Page

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.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2017, and conflicting national standards shall be withdrawn at the latest by March 2017.

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

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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

Symbol	Meaning	Unit
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

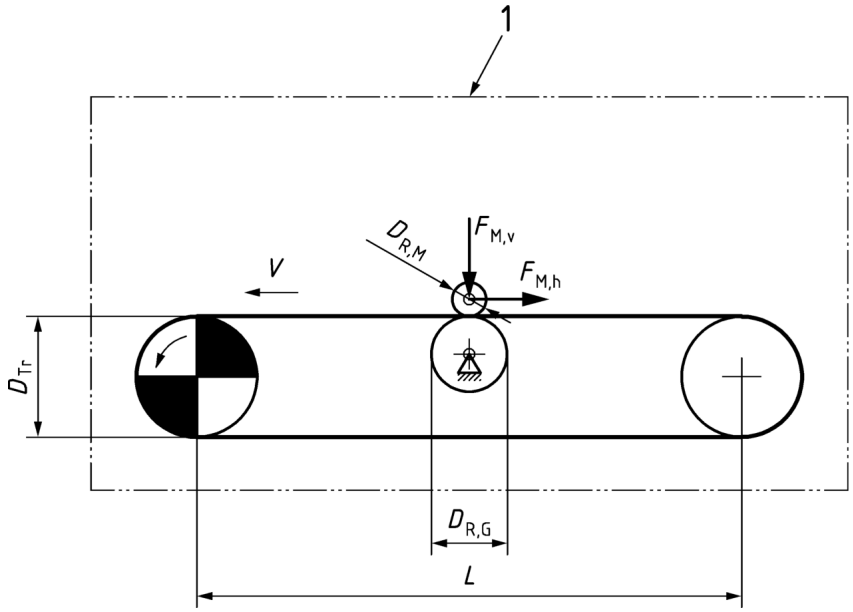
5 Test rig

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.

$$D_{\mathrm{R,G}} \geq 1{,}5 \times D_{\mathrm{R,M}} \tag{1}$$

The diameters $D_{R,G}$ and $D_{\mathrm{R,M}}$ 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 FM,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:

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

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.

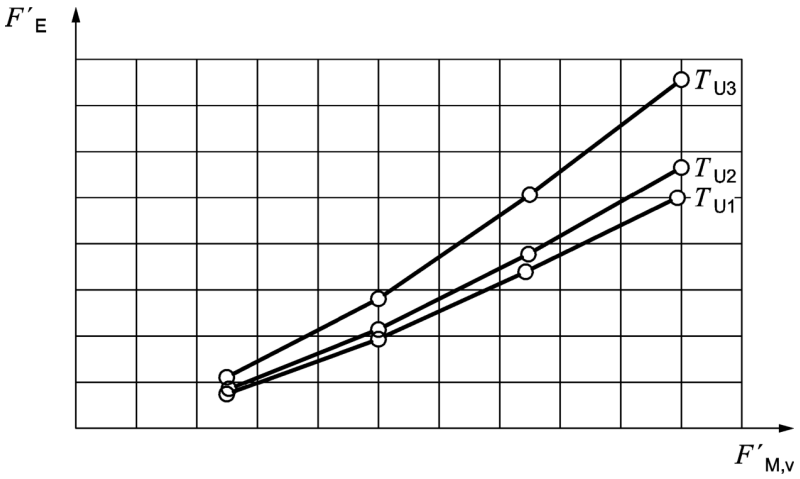


Figure 2 — Example for the variation of the width related indentation rolling resistance F'_E depending on the width related vertical force $F'_{M,v}$ under consideration of the ambient temperature T_U

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.

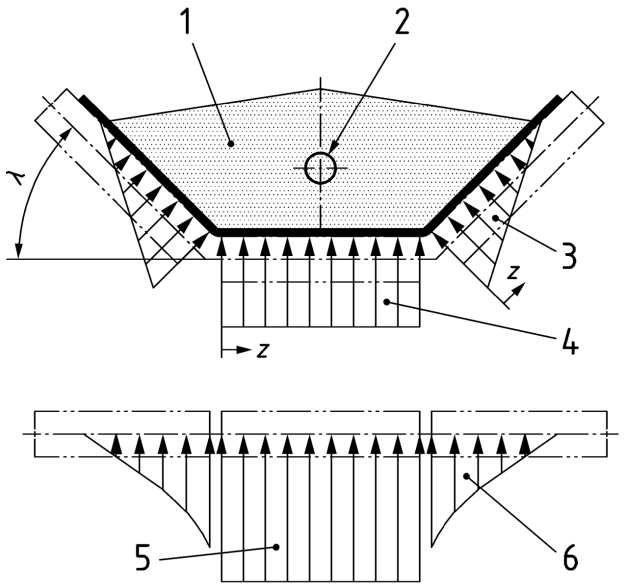
Annex A
(informative)

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:

$$F_{\mathrm{n}} = \int_{0}^{b_{\mathrm{R}}} q(z) \times dz \tag{A.1}$$

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

$$q_{\mathrm{m}}(z) = \frac{F_{n,m}}{b_{\mathrm{R,m}}} \tag{A.2}$$

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

$$q_{s}(z) = \frac{2 \times F_{n,s}}{b^{2}{}_{R,s}} \times (b_{R,s} - z) \tag{A.3}$$

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

$$F'_{E} = c_{\mathrm{a}} \times (F'_{M,v})^{c_{\mathrm{b}}} \tag{A.4}$$

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 $F'_{\mathrm{M,v}}$.

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 $q(\mathrm{z}) = F'_{\mathrm{M,v}}$:

$$F_{\mathrm{E}} = \int_{0}^{b_{\mathrm{R}}} c_{\mathrm{a}} \times q(z)^{c_{\mathrm{b}}} \times dz \tag{A.5}$$

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.

$$F_{\mathrm{E,ges}} = F_{\mathrm{E,m}} + 2 \times F_{\mathrm{E,s}} \tag{A.6}$$

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 $F_{\mathrm{E,\,ges}}$:

$$F_{\mathrm{E,ges}} = c_{\mathrm{a}} \times \left(\frac{F_{\mathrm{n,m}}}{b_{\mathrm{R,m}}} \right)^{c_{\mathrm{b}}} \times b_{\mathrm{R,m}} + 2 \times \frac{c_{\mathrm{a}} \times b_{\mathrm{R,s}}}{c_{\mathrm{b}} + 1} \times \left(\frac{2 \times F_{\mathrm{n,s}}}{b_{\mathrm{R,s}}} \right)^{c_{\mathrm{b}}} \tag{A.7}$$

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*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Copyright in BSI publications

All the content in BSI publications, including British Standards, is the property of and copyrighted by BSI or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use.

Save for the provisions below, you may not transfer, share or disseminate any portion of the standard to any other person. You may not adapt, distribute, commercially exploit, or publicly display the standard or any portion thereof in any manner whatsoever without BSI's prior written consent.

Storing and using standards

Standards purchased in soft copy format:

- A British Standard purchased in soft copy format is licensed to a sole named user for personal or internal company use only.
- The standard may be stored on more than 1 device provided that it is accessible by the sole named user only and that only 1 copy is accessed at any one time.
- A single paper copy may be printed for personal or internal company use only.

Standards purchased in hard copy format:

- A British Standard purchased in hard copy format is for personal or internal company use only.
- It may not be further reproduced – in any format – to create an additional copy. This includes scanning of the document.

If you need more than 1 copy of the document, or if you wish to share the document on an internal network, you can save money by choosing a subscription product (see 'Subscriptions').

Reproducing extracts

For permission to reproduce content from BSI publications contact the BSI Copyright & Licensing team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email subscriptions@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Useful Contacts

Customer Services
Tel: +44 345 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 345 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.