BRITISH STANDARD

BS EN 13236:2001
Incorporating Amendment No. 1

Safety requirements for superabrasives

The European Standard EN 13236:2001, with the incorporation of amendment A1:2005, has the status of a British Standard

ICS 25.100.70

British Standards

National foreword

This British Standard is the official English language version of EN 13236:2001, including amendment A1:2005.

The start and finish of text introduced or altered by CEN amendment is indicated in the text by tags [A1⟩ ⟨A1]. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1⟩ ⟨A1].

The UK participation in its preparation was entrusted to Technical Committee MTE/13, Grinding wheels, abrasive tools, paper and cloths and powders, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 15 June 2001

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 83 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments
15691	March 2006	See national foreword

ISBN 0 580 37681 8

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13236

January 2001

+ A1

March 2005

ICS 25.100.70

English version

Safety requirements for superabrasives
(includes amendment A1:2005)

Prescriptions de sécurité pour les produits superabrasifs
(inclut l'amendement A1:2005)

Sicherheitsanforderungen für Schleifwerkzeuge mit Diamant oder Bornitrid
(enthält Änderung A1:2005)

This European Standard was approved by CEN on 5 January 2001. Amendment A1 was approved by CEN on 17 February 2005.

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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 Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Ref. No. EN 13236:2001 + A1:2005 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 143 "Machine tools – Safety" 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 July 2001, and conflicting national standards shall be withdrawn at the latest by July 2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This document (EN 13236:2001/A1:2005) has been prepared by Technical Committee CEN/TC 143 "Machine tools – Safety", the secretariat of which is held by SNV.

This Amendment to the European Standard EN 13236:2001 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2005, and conflicting national standards shall be withdrawn at the latest by August 2005.

This document can be applied only in conjunction with EN 13236:2001 *Safety requirements for superabrasives*. Except for the following amendments the content of EN 13236:2001 remains untouched.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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

0 Introduction

This standard has been prepared to be a European standard to provide one means of conforming with the Essential Safety Requirements of the Machinery Directive and associated EFTA regulations.

This standard is addressed to designers, manufacturers and suppliers of the grinding tools described in the scope. In addition, it helps designers, manufacturers and suppliers of grinding machines in the selection of grinding tools, in order to reduce the risks and achieve conformity of the respective machinery with the Essential Safety Requirements of the Machinery Directive.

The extent to which hazards are covered is indicated in the scope of this standard.

1 Scope

This standard is applicable to superabrasives which are manufactured or repaired after the date of issue of the standard. It specifies requirements and/or measures for the removal or reduction of hazards resulting from the design and application of the grinding tools.

This standard contains also procedures and tests for verification of the compliance with the requirements as well as safety information for use which is to be made available to the user by the manufacturer.

The hazards taken into consideration are listed in clause 4 of this standard.

This standard applies to grinding wheels, cutting-off wheels, wires, mounted points and other grinding tools with diamond or cubic boron nitride as abrasive. It does not apply to bonded abrasive products, coated abrasive products, rotating dressing tools, truers nor any non-rotating superabrasive tool.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references subsequent amendments to, or revisions of, any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

prEN 13218 : 1998
Machine tools – Safety – Stationary grinding machines

ISO 286-1
ISO system of limits and fits – Part 1: Bases of tolerances, deviations and fits

ISO 286-2
ISO system of limits and fits – Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts

ISO 565
Test sieves – Metal wire cloth, perforated metal plate and electroformed sheet – Nominal sizes of openings

ISO 2768-1 : 1989
General tolerances; tolerances for linear and angular dimensions without individual tolerance indications

3 Definitions and symbols

For the purpose of this standard the following definitions apply:

3.1 Material

3.1.1 Abrasives

Diamond, natural or synthetic and cubic boron nitride. Symbols shown in table 1.

Table 1: Abrasives

Symbols	Designation
D	diamond
B	cubic boron nitride (CBN)

3.1.2 Bond

Table 2: Type of bond

B	Resinoid and other thermosetting organic bonds
G	Electroplated, single layer and multilayer metal bonds
M	Metal bond
V	Vitrified bond

3.1.3 Additives for bonds

Fillers such as diamond, CBN, silicon carbide, aluminium oxide, graphite, carbides and poreforming agents.

3.1.4 Grain size

Code number for the size of the abrasive grain. There is a differentiation between macro and micro grains, see tables F.1 and F.2.

3.1.5 Concentration

Code number for the volumetric content of abrasive in the section, the concentration 100 corresponding to 25 % diamond or cubic boron nitride volume content.

3.2 Grinding machine

3.2.1 Stationary grinding machine

Machine fixed in position during operation and capable of a combination of one or more types of operations, examples see prEN 13218 : 1998.

3.2.2 Mobile grinding machine

Machine which is manually guided (but not hand-held) during grinding, e.g. joint grinding machine.

3.2.3 Hand-held grinding machine

Machine including those with flexible drive held in the hand during operation.

3.2.4 Stationary cutting-off (Sawing) machine

Machine specifically designed for cutting-off applications. Included are as well mobile cutting-off machines held in position during cutting-off.

3.2.5 Mobile cutting-off (Sawing) machine

Machine which is manually guided (but not handheld) during cutting-off, e.g. joint cutting machine.

3.2.6 Hand-held cutting-off (Sawing) machine

Machine held in the hand during operation.

3.2.7 Grinding and cutting-off (Sawing) machine with totally enclosed working area

Stationary machine for mechanically guided grinding or cutting-off with operating areas which are protected in such a way by separating guards that machining processes including loading and unloading of workpieces can be carried out inside them and persons are protected against hazards generated by bursting of an abrasive product.

3.3 Type of application

Type of guidance of grinding tool and workpiece during grinding and cutting-off, see table 3.

3.3.1 Mechanically guided grinding

The movements of the grinding tool and/or the workpiece are guided by mechanical means.

3.3.2 Manually guided grinding

The movements of the grinding tool and/or the workpiece are guided by the hands of the operator.

3.3.3 Hand-held grinding

The grinding machine is entirely guided by the hands of the operator.

3.4 Method of operation

3.4.1 Peripheral grinding

Grinding with the periphery of the wheel with no or limited side loads.

3.4.2 Face grinding

Grinding with the face of the wheel.

3.4.3 Cutting-off

Cutting-off or slotting with the periphery of the cutting-off wheel.

Table 3: Grinding method, type of machine, type of application

Grinding method	Type of machine	Type of application	Grinding tool	Workpiece	Examples for application / machines
Grinding	Stationary grinding machines	Mechanically guided grinding	Fixed	Mechanically guided	Surface grinding, centerless grinding, creep feed grinding, bevel grinding on glass (glass bevelling machines)
			Mechanically guided	Fixed	Profile grinding of stone and concrete
			Mechanically guided	Mechanically guided	Internal grinding, external, plunge and traverse grinding, jig grinding, decorative stone milling and polishing, pencil edging of glass (automotive glass)
	Stationary and mobile grinding machines	Manually guided grinding	Manually guided	Fixed	Roughing and polishing of stone floors (carriage/floor grinding machines)
			Fixed	Manually guided	Tool grinding (bench grinding machines) decorative glass grinding
	Hand-held grinding machines	Hand-held grinding	Manually guided	Fixed	Stone and concrete milling and polishing (angle, straight grinders)
Cutting-off	Stationary cutting-off machines	Mechanically guided cutting-off	Fixed	Mechanically guided	Cutting-off of bricks and tiles (table saw)
			Mechanically guided	Fixed	Cutting-off of stone and concrete (bridge-type saw, floor and wall saws, wire saw)
			Mechanically guided	Mechanically guided	Cutting-off of semi-conductors
	Stationary and mobile cutting-off machines	Manually guided cutting-off	Manually guided	Fixed	Cutting-off of stone and concrete (table saw, floor saw)
			Fixed	Manually guided	Cutting-off of bricks (table saw)
	Hand-held cutting-off machines	Hand-held cutting- off	Manually guided	Fixed	Cutting-off of stone and concrete (angle grinding machine, hand-held cutting-off machine)

3.5 Dimensional abbreviations for superabrasive products

Table 4: Dimensional abbreviations

Dimensions in mm

Symbol	Designation	
	Abrasive product	Mounted point
D	Outside diameter	Outside diameter
E	Thickness of a wheel, dish wheel and a recessed or relieved wheel, thickness of a blank	
H	Bore diameter	
J	Smallest diameter of tapered cup, dish or tapered wheel	
K	Internal diameter of recess on tapered cup or dish wheel	
L_o		Overhang length of spindle
L_1		Overall length
L_2	Length of segment	Spindle length
L_3		Clamping length
L_4		Reduced length of spindle
L_v	Length of bond interface between segment and core	
R	Radius	Radius
S_d		Spindle diameter
S_1		Diameter of reduced spindle
T	Overall thickness	Overall Thickness
T_1	Reduced hub thickness	
T_D	Outside diameter tolerance limits	Outside diameter tolerance limits
T_H	Bore diameter tolerance limits	
T_T	Thickness tolerance limits	Thickness tolerance limits
U	Thickness of superabrasive section (if less than T or T_1)	
U_1	Reduced thickness of superabrasive section	
W	Rim width	
X	Depth of superabrasive section	Depth of superabrasive section
X_1	Unsupported depth section	
Z	Number of segments	

3.6 Speeds, test speed factor and safety factors

Table 5: Speeds and safety factors

Symbol	Designation	Definition	Unit
n	Speed of rotation	Revolutions per unit of time (rpm)	min^{-1} or $\frac{1}{\text{min}}$
n_{ab}	Deflection speed of mounted points	Speed in rpm at which the spindle of mounted points is deflecting under centrifugal force	min^{-1} or $\frac{1}{\text{min}}$
n_{max}	Maximum speed of rotation	Revolutions per unit of time (rpm) of the new superabrasive at maximum operating speed	min^{-1} or $\frac{1}{\text{min}}$
v	Peripheral speed	Speed at the periphery of the superabrasive	m/s
v_s	Maximum operating speed	The maximum permissible peripheral speed of a rotating superabrasive	m/s
v_{pr}	Safety test speed	Peripheral speed at which the superabrasives are tested by the manufacturer	m/s
f_{pr}	Test speed factor	The ratio of the safety test speed, divided by the maximum peripheral operating speed	–
v_{br}	Bursting speed	The peripheral speed at which the superabrasive breaks under rotational stress	m/s
$v_{br\ min}$	Minimum bursting speed	Peripheral speed, which the superabrasive shall at least reach without bursting under rotational stress	m/s
S	Safety factor	The bursting speed, divided by the maximum peripheral operating speed, all squared. The formula for S is: $S = \left(\frac{v_{br}}{v_S}\right)^2$	–
S_{ab}	Safety factor of spindle deflection for mounted points	The formula is: $S_{ab} = \frac{n_{ab}}{n_{max}}$	–

3.7 Other abbreviations

Table 6: Other abbreviations

Symbol	Designation	Unit
R_e	Yield point	N/mm²
M_b	Bending moment	Nm
E	Modulus of elasticity	N/mm²
F	Force	N
F_A	Shearing force	N
L_f	Lever arm	mm
e	Distance between centre of gravity and geometrical centre of wheel	mm
k_m	Reducing factor for the shaft mass	–
σ_b	Bending strength	N/mm²
ϱ	Density	g/cm^3
ϱ_S	Density of shaft material	g/cm^3
ϱ_G	Density of plated bond	g/cm^3
ϱ_V	Density of vitrified bond	g/cm^3
ϱ_{Vt}	Density of vitrified or other wheel core	g/cm^3
ϱ_B	Density of resinoid bond	g/cm^3
ϱ_M	Density of metal bond	g/cm^3
▼	Grinding face of superabrasive, i.e. that part that actually grinds the workpiece, see annex E.	–

3.8 Other definitions

3.8.1 Labels

Labels contain essential information on the superabrasives to which they belong.

3.8.2 Blotters

Blotters are placed between the superabrasive and flanges.

4 List of hazards

Table 7: List of hazards

Hazard designation	Hazardous situation (Examples)	Relevant clauses in this standard
Ejection of parts	1. Breakage of superabrasive caused by:	
	– improper design, manufacturing defect	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 and Annex C
	– insufficient strength	6
	– wrong selection	7 and Annex A
	– improper handling and storage	7
	– improper use (mounting and grinding process)	7, Annex A and Annex B
	2. Loosening of grinding particles	7
Vibration	Unbalance caused by:	
	– manufacturing defects	5.1.4, 6
	– improper use, mounting	7

5 Requirements

Superabrasives are subject to high stresses during the grinding and cutting operation. They shall therefore have specified safety factors and minimum bursting speeds, as a function of machine type, type of application and maximum peripheral operating speed and comply with the additional requirements laid down in this clause.

5.1 Requirements for superabrasive grinding wheels

5.1.1 General

Shapes and dimensions, see Annex E.

5.1.2 Bore tolerances

The tolerance class for bores on superabrasive wheels is H 7, as per ISO 286-2.

If high temperatures can be expected when using vitrified cores, nominal diameter and bore tolerances may be adopted by the manufacturer to this application.

5.1.3 Maximum permissible plastic deformation

In superabrasives with a metal core, centrifugal forces may induce a permanent increase in outside diameter. At the minimum bursting speed, according to table 8, this permanent increase in diameter in relation to the original outside diameter, shall not exceed IT 11, according to ISO 286-1.

5.1.4 Maximum unbalance

Standard on requirements for maximum unbalance in preparation.

5.1.5 Maximum operating speeds

Superabrasives shall be manufactured for maximum operating speeds conforming to the following sequence:

5 – 6 – 8 – 10 – 12 – 16 – 20 – 25 – 32 – 35 – 40 – 45 – 50 – 63 – 80 – 100 – 125 – 140 – 160 – 180 – 200 – 225 – 250 – 280 – 320 – 360 – 400 – 450 – 500 in m/s.

Conversion table for speeds of rotation and peripheral speeds as a function of external diameter *D* of the grinding wheel see Annex D

5.1.6 Safety factors

The safety factors against breakage caused by centrifugal forces shall be as specified in table 8.

Table 8: Maximum operating speeds, safety factors and minimum bursting speeds for superabrasive grinding wheels

Type of machine	Type of application	Maximum operating speed v_s in m/s	Safety factor S	Minimum bursting speed $v_{br\ min}$ in m/s
Stationary grinding machines	Mechanically guided grinding	< 40	3,00	–
		40	3,00	70
		50	3,00	87
		63	3,00	109
		80	3,00	139
	Mechanically guided grinding with totally enclosed working area	< 80	1,75	–
		80	1,75	106
		100	1,75	132
		125	1,75	165
		140	1,75	185
		160	1,75	212
		180	1,75	238
		200	1,75	265
		225[1)]	1,75[1)]	298
		250[1)]	1,75[1)]	331
		280[1)]	1,75[1)]	370
		320[1)]	1,75[1)]	423
		360[1)]	1,75[1)]	476
		400[1)]	1,75[1)]	529
		450[1)]	1,75[1)]	595
		500[1)]	1,75[1)]	661
Stationary and mobile grinding machines	Manually guided grinding	< 50	3,00	–
		50	3,00	87
		63	3,00	109
		80	3,50	150
Hand-held grinding machines	Hand-held grinding	< 50	3,00	–
		50	3,00	87
		63	3,50	118
		80	3,50	150

1) These safety factors are provisional. Wheels running at these speeds are currently under development.

5.1.7 Standard operating speeds

Where no operating speed has been specified by the user, the manufacturer shall design, test and mark the wheel according to table 9 below.

Table 9: Standard operating speeds for superabrasive grinding wheels

Core	Abrasive section	Method of operation	Maximum operating speed v_s in m/s according to bond type				
			Vitrified V	Resinoid B	Metal M with abrasives and fillers ≤ 45 % by volume	Metal M with abrasives and fillers > 45 % by volume	Electro-plated G
Metal	Manufactured on core, e.g. sintered or electroplated	Peripheral grinding	–	80	80	63	125
		Face grinding	–	63	63	50	100
	Connected to core, e.g. cemented, screwed, clamped, brazed or welded	Peripheral grinding	63	63	63	50	–
		Face grinding	50	50	50	40	–
Resinoid	Manufactured on core, e.g. pressed	Peripheral grinding	–	80	–	–	–
		Face grinding	–	63	–	–	–
	Connected to core, e.g. cemented, screwed, clamped	Peripheral grinding	63	63	63	50	63
		Face grinding	50	50	50	40	50
Vitrified	Manufactured on core, e.g. pressed	Peripheral grinding	50	–	–		–
		Face grinding	40	–	–		–
	Connected to core, e.g. cemented, screwed, clamped	Peripheral grinding	50	50	50		–
		Face grinding	40	40	40		–

5.1.8 Special operating speeds

On specific request by the user, superabrasive grinding wheels may be designed, tested and marked with a maximum operating speed not higher than the special operating speeds as specified in table 10.

For totally-enclosed machines only, the speeds given in table 10 may be exceeded provided that the required safety factor has been met (see table 8).

Table 10: Special operating speeds for superabrasive grinding wheels

<table>
<tr><th rowspan="3">Core</th><th rowspan="3">Abrasive section</th><th rowspan="3">Method of operation</th><th colspan="5">Maximum operating speed v_s in m/s according to bond type</th></tr>
<tr><th rowspan="2">Vitrified V</th><th rowspan="2">Resinoid B</th><th colspan="2">Metal M</th><th rowspan="2">Electro-plated G</th></tr>
<tr><th>with abrasives and fillers ≤ 45 % by volume</th><th>with abrasives and fillers > 45 % by volume</th></tr>
<tr><td rowspan="4">Metal</td><td rowspan="2">Manufactured on core, e.g. sintered or electroplated</td><td>Peripheral grinding</td><td>–</td><td>100</td><td>100</td><td>80</td><td>140</td></tr>
<tr><td>Face grinding</td><td>–</td><td>80</td><td>80</td><td>63</td><td>125</td></tr>
<tr><td rowspan="2">Connected to core, e.g. cemented, screwed, clamped, brazed or welded</td><td>Peripheral grinding</td><td>125</td><td>80</td><td>80</td><td>63</td><td>–</td></tr>
<tr><td>Face grinding</td><td>80</td><td>63</td><td>63</td><td>50</td><td>–</td></tr>
<tr><td rowspan="4">Resinoid</td><td rowspan="2">Manufactured on core, e.g. pressed</td><td>Peripheral grinding</td><td>–</td><td>100</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Face grinding</td><td>–</td><td>80</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td rowspan="2">Connected to core, e.g. cemented, screwed, clamped</td><td>Peripheral grinding</td><td>80</td><td>80</td><td>80</td><td>63</td><td>80</td></tr>
<tr><td>Face grinding</td><td>63</td><td>63</td><td>63</td><td>50</td><td>63</td></tr>
<tr><td rowspan="4">Vitrified</td><td rowspan="2">Manufactured on core, e.g. pressed</td><td>Peripheral grinding</td><td>63</td><td>–</td><td colspan="2">–</td><td>–</td></tr>
<tr><td>Face grinding</td><td>50</td><td>–</td><td colspan="2">–</td><td>–</td></tr>
<tr><td rowspan="2">Connected to core, e.g. cemented screwed, clamped</td><td>Peripheral grinding</td><td>63</td><td>63</td><td colspan="2">63</td><td>–</td></tr>
<tr><td>Face grinding</td><td>50</td><td>50</td><td colspan="2">50</td><td>–</td></tr>
</table>

5.2 Requirements for cutting-off wheels (saws)

5.2.1 General

Standard shapes and dimensions for cutting-off wheels, see Annex E.

5.2.2 Bore tolerances

Tolerance class for bores for cutting-off wheels with outside diameter D ≤ 230 mm for hand held cutting-off machines, H9 as per ISO 286-2, for all other cutting-off wheels, H7.

5.2.3 Maximum permissible plastic deformation

For superabrasive cutting-off wheels with a metal blank, centrifugal forces may induce a permanent increase in outside diameter in relation to the original outside diameter. At the minimum bursting speed, according to table 11, this shall not exceed IT 11, according to ISO 286-1.

5.2.4 Maximum operating speed

See 5.1.5

5.2.5 Safety factors

The safety factors against breakage caused by centrifugal forces shall be as specified in table 11.

Table 11: Maximum operating speeds, safety factors and minimum bursting speeds for cutting-off wheels

Type of machine	Type of application	Maximum operating speed v_s in m/s	Safety factor S	Minimum bursting speed $v_{br\ min}$ in m/s
Stationary cutting-off machines	Mechanically guided cutting-off	< 63	2,00	–
		63	2,00	90
		80	2,00	113
		100	2,00	141
	Mechanically guided cutting-off with totally enclosed working area	< 125	1,75	–
		125	1,75	165
		140	1,75	185
		160	1,75	212
		180	1,75	238
		200	1,75	265
Stationary and mobile cutting-off machines	Manually guided cutting-off	< 80	3,50	–
		80	3,50	150
		100	3,50	188
Hand-held cutting-off machines	Hand-held cutting-off	< 80	3,50	–
		80	3,50	150
		100	3,50	188

5.2.6 Standard operating speeds

Where no operating speed has been specified by the user, the manufacturer shall design, test and mark the cutting-off wheels according to table 12 below.

Table 12: Standard operating speed for cutting-off wheels (saws)

Core		Cutting rim (Abrasive section)	Type of application	Method of operation	Maximum operating speed v_s in m/s for bond type		
					Resinoid B	Metal M	Electro-plated G
Metal	Metal blank, e.g. cast, rolled, forged	continuous	Mechanically and manually guided cutting-off	Wet cutting-off	63	80	80
				Dry cutting-off	–	80	80
		segmented	Mechanically and manually guided cutting-off	Wet cutting-off	–	40[1)]	50[1)]
						80	80
				Dry cutting-off	–	63	80
		continuous or segmented	Hand-held cutting-off	Wet and dry cutting-off	–	63[2)]	80
	Sintered	continuous	Mechanically and manually guided cutting-off	Wet cutting-off	–	63	–
Resinoid		continuous	Mechanically and manually guided cutting-off	Wet and dry cutting-off	63	–	–

1) For difficult to cut materials including granite, diorite, quartzite, reinforced concrete.

2) On cutting-off wheels with metal bond for hand-held cutting-off the connection between rim and blank shall be welded or sintered.

5.2.7 Special operating speeds

On specific request by the user, cutting-off wheels may be designed, tested and marked with a maximum operating speed not higher than the special operating speeds as specified in table 13.

For totally-enclosed machines only, the speeds given in table 13 may be exceeded provided that the required safety factor has been met (see table 11).

Table 13: Special operating speeds for cutting-off wheels (saws)

Core		Cutting rim (Abrasive section)	Type of application	Method of operation	Maximum operating speed v_s in m/s for bond type		
					Resinoid B	Metal M	Electro-plated G
Metal	Metal blank, e.g. cast, rolled, forged	continuous	Mechanically and manually guided cutting-off	Wet cutting-off	80	100	100
				Dry cutting-off	–	100	100
		segmented	Mechanically and manually guided cutting-off	Wet cutting-off	–	50[1)]	63[1)]
						100	100
				Dry cutting-off	–	80	100
		continuous or segmented	Hand-held cutting-off	Wet and dry cutting-off	–	80[2)]	100
	Sintered	continuous	Mechanically and manually guided cutting-off	Wet cutting-off	–	80	–
Resinoid		continuous	Mechanically and manually guided cutting-off	Wet and dry cutting-off	80	–	–

1) For difficult to cut materials including granite, diorite, quartzite and reinforced concrete.

2) On cutting-off wheels with metal bond for hand-held cutting-off the connection between rim and blank shall be welded or sintered.

5.2.8 Requirements for the metal blank

5.2.8.1 Requirements for the metal blank of cutting-off wheels for dry cutting-off

5.2.8.1.1 Dimensions

Metal blanks used for cutting-off wheels for dry cutting-off of asphalt, concrete, natural and synthetic stone shall have a minimum thickness as a function of external diameter as specified in table 14.

Table 14: Dimensions of blanks for dry cutting-off

Type of machine	Diameter of the blank D in mm		Minimum blank thickness E in mm
	more than	up to and including	
Hand-held cutting-off machines	–	115	≥ 0,7
	115	200	≥ 0,9
	200	230	≥ 1,2
Hand-held and stationary cutting-off machines	230	300	≥ 1,2
	300	400	≥ 1,6
Stationary and mobile cutting-off machines	400	500	≥ 2,0
	500	600	≥ 2,5
	600	700	≥ 3,0
	700	900	≥ 3,5
	900	1 200	≥ 4,7
	1 200	1 600	≥ 5,5

5.2.8.1.2 Material and hardness of blanks for laser welded cutting-off wheels

[A1⟩ The material used for the blank shall be steel which shall have the necessary properties enabling it to produce adequate joint strength when welding it to the segments. For example, alloyed cold worked steels having a maximum carbon content of 0,27 % are suitable.

Blanks shall be hardened and tempered: – hardness 36 (±3) HRC; or

Blanks may be strain-hardened:
- minimum hardness 20 HRC for a diameter ≤ 230 mm;
- minimum hardness 24 HRC for a diameter > 230 mm. ⟨A1]

5.2.8.1.3 Material and hardness of blanks for sintered cutting-off wheels

Tool steels, grade to the choice of the manufacturer.

[A1⟩ *Text deleted* ⟨A1]

5.2.8.1.4 Surface finish of the entire slot area

Cutting-off wheels shall be manufactured in such a way that the surface finish in the area of the slots does not cause crack formation. The following values for the surface finish as a function of the manufacturing process shall not be exceeded:

– for machining or non-cutting operations (milling, grinding, notching) R_z ≤ 20 µm

– for thermal cutting (e.g. laser beam cutting) R_z ≤ 50 µm

5.2.8.1.5 Other requirements

Blanks shall be free from visible defects.

5.2.8.2 Requirements for the metal blank of cutting-off wheels for wet cutting-off

5.2.8.2.1 Dimensions

Metal blanks used for cutting-off wheels for wet cutting-off of asphalt, concrete, natural and synthetic stone shall have a minimum thickness as a function of the external diameter as specified in table 15.

Table 15: Dimensions of blanks for wet cutting-off

Machine type	Diameter of the blank D in mm		Minimum blank thickness E in mm	
	more than	up to and including	Cutting of natural and synthetic stone	Cutting of asphalt and concrete
Stationary cutting-off machine	–	300	≥ 1,2	≥ 1,6
	300	400	≥ 1,6	≥ 2,2
	400	500	≥ 2,0	≥ 2,5
	500	600	≥ 2,5	≥ 2,8
	600	700	≥ 3,0	≥ 3,0
	700	900	≥ 3,5	
	900	1 200	≥ 4,7	≥ 3,4
	1 200	1 600	≥ 5,5	
	1 600	2 000	≥ 6,5	≥ 3,5
	2 000	3 500	≥ 8,0	–
	3 500	5 000	≥ 9,0	
Hand-held cutting-off machine	–	230	≥ 0,006 D	
	230	400	> 0,005 D	

5.2.8.2.2 Material

Tool steels, grade to the choice of the manufacturer.

8.2.8.2.3 Surface finish of the entire slot area

See 5.2.8.1.4

5.2.8.2.4 Other requirements

See 5.2.8.1.5

5.2.9 Requirements for the connection of the superabrasive section to the metal blank

5.2.9.1 Connection of segments to the metal blank

The segments for hand-held dry cutting-off wheels shall be connected to the metal blank by welding or sintering, except for $D \leq 400$ mm and $E \geq 4$ mm.

5.2.9.2 Minimum bending strength for segmented cutting-off wheels

For segmented cutting-off wheels and saws the strength of the welded, sintered or brazed joint between the metal blank and the segment shall be designed to conform to the following minimum bending strength values:

- $\sigma_b \geq 600$ N/mm^2 for cutting-off wheels used on hand-held cutting-off machines.
- $\sigma_b \geq 450$ N/mm^2 for cutting-off wheels used on stationary and mobile cutting-off machines.

5.2.9.3 Minimum bending moments for cutting-off wheels with continuous cutting rim in metal bond

For cutting-off wheels with continuous rim, the connection between the metal bond and the blank shall be designed to be capable of withstanding the following bending moment:

$$M_b \geq F \times D/2$$

Where :

F = 125 N

D = outside diameter of the cutting-off wheel in m (metres)

5.3 Requirements for diamond wire

5.3.1 General

Wires with diamond or materials with comparable properties are used on stationary wire sawing machines for sawing (cutting-off) of natural stone, industrial ceramics, concrete and other materials used in structural and civil engineering. Diamond wires shall not be used on hand-held machines.

5.3.2 Requirements

5.3.2.1 Requirements for the support cable

Support cables for diamond wire are subject to frequent breakage due to mechanical stresses or wire fatigue, depending on their construction, type of application and their operating conditions. Therefore, a cable shall be selected which has proven fatigue resistance, e.g. preferably a multi-strand cable made of fine multiple wires, for example: 6 × 7 on a 19 wire core.

Support cables shall have the following minimum values:

Table 16: Requirements for support cables

Wire diameter in mm		Tensile force
Nominal	Range	in kN
4	3,9 to 4,1	10
5	4,8 to 5,0	17

5.3.2.2 Requirements for spring mounted diamond wire

For diamond wires where the abrasive beads are held by means of springs, press rings and spacer rings, the following limit deviations shall be observed:

a) for the new diamond wire:

– bore of the abrasive bead by 0,4 mm greater than the wire diameter
– longitudinal movement of the abrasive beads on the support wire ≤ 8 mm

b) for the used diamond wire:

– bore of the abrasive beads by 0,6 mm greater than the wire diameter.
– longitudinal movement of the abrasive beads on the support cable ≤ 10 mm.

After mounting on the support cable, the support cable and the press rings shall not show any sign of breakage. The press rings shall be capable of withstanding $^{1}/_{12}$ the load capacity of the support cable without moving.

The springs ends shall be close-coiled and ground at each end.

5.3.2.3 Requirements for plastic mounted diamond wires

All abrasive beads shall be mounted on the support cable by means of plastic or vulcanized rubber.

5.3.2.4 Requirements for wire couplings

The wire couplings shall be capable of withstanding at least 25 % of load capacity force of the support cables.

5.3.3 Maximum operating speeds

The maximum operating speed for plastic mounted diamond wires shall not exceed v_s = 50 m/s.

The maximum operating speed for spring-mounted diamond wires shall not exceed v_s = 40 m/s.

5.4 Requirements for mounted points

5.4.1 General

Shapes, dimensions and speed of rotation, see Annex C.

5.4.2 Spindle diameter tolerance limits

The tolerance class for spindle diameters for mounted points is h9 as per ISO 286-2.

5.4.3 Maximum operating speeds

See clause 5.1.5.

5.4.4 Safety factors

The safety factors against breakage caused by centrifugal forces and against bending of the spindle shall correspond to the values specified in table 17.

For all other safety requirements for mounted points, see Annex C.

Table 17: Maximum operating speeds, safety factors and minimum bursting speeds for mounted points

Type of machine	Type of application	Maximum operating speed v_s in m/s	Safety factor S	Minimum bursting speed $v_{br\ min}$ in m/s	Safety factor of spindle deflection S_{ab}
Stationary grinding machines	Mechanically or manually guided grinding	< 50	3	–	1,3
		50		87	
		63		109	

5.5 Requirements for other superabrasives

5.5.1 General

Shapes and dimensions, see Annex E.

5.5.2 Bore diameter tolerance limits

The tolerance class for bores for other superabrasives is H9, as per ISO 286-2.

5.5.3 Maximum operating speeds

See 5.1.5

5.5.4 Safety factors

The safety factors against breakage caused by centrifugal forces shall correspond to the values specified in table 18.

Table 18: Maximum operating speeds, safety factors and minimum bursting speeds for other superabrasives

Machine type	Type of application	Maximum operating speed v_s m/s	Safety factor S	Minimum bursting speed $v_{br\ min}$ m/s
Stationary machines	Mechanically guided grinding	< 63	3,0	–
		63	3,0	109
		80	3,0	139
	Manually guided grinding	80	3,5	150
Hand-held machines	Hand-held grinding	< 40	3,0	–
		40	3,0	70
		50	3,0	87
		63	3,5	118
		80	3,5	150

5.5.5 Standard operating speeds

Where no operating speed has been specified by the user, the manufacturer shall design, test and mark the other superabrasives according to table 19 below.

Table 19: Standard operating speeds for other superabrasives

Abrasive product	Type of application	Maximum operating speed v_s in m/s for bond types		
		Resinoid B	Metal M	Electroplated G
Dish grinding wheel	Hand-held grinding	63	63	63
Shaft mounted tools	Mechanically guided grinding	50	50	50
Profile grinding wheels[1)]	Mechanically guided grinding	–	40	40
	Hand-held grinding	–	80	80
Drills and hollow drills	Mechanically guided grinding	–	12	12
	Hand-held grinding	–	10	10

[1)] Including cutting-off wheels with D < 400 mm and thickness of metal blank $E \geq 4$ mm.

5.5.6 Special operating speeds

On specific demand by the user, other superabrasives may be designed, tested and marked with a maximum operating speed not higher than the special operating speeds as specified in table 20.

Table 20: Special operating speeds for other superabrasives

Abrasive product	Type of application	Maximum peripheral operating speed v_s in m/s for bond types		
		Resinoid B	Metal M	Electroplated G
Dish grinding wheel	Hand-held grinding	80	80	80
Shaft mounted tools	Mechanically guided grinding	63	63	63
Profile grinding wheels[1)]	Mechanically guided grinding	–	50	50
	Hand-held grinding	–	80	80
Drills and hollow drills	Mechanically guided grinding	–	16	16
	Hand-held grinding	–	16	16

[1)] Including cutting-off wheels with D < 400 mm and thickness of metal blank $E \geq 4$ mm.

5.5.7 Requirements for the connection of the superabrasive section to the core for dish wheels

For segmented dish grinding wheels used for hand held grinding, the strength of the connection between abrasive section and core shall be designed so that the minimum shearing force of the abrasive section is F_A = 6 400 N.

5.6 Marking

Superabrasives shall be marked in accordance with Annex A.

The marking shall be indelible and legible. Whenever possible it shall appear on the superabrasive.

5.7 Blotters

Blotters shall be supplied by the manufacturer, supplier or importer when there is a need for this for a safe mounting and use of the superabrasive. Requirements for blotters, see Annex B.

6 Inspection and testing by the manufacturer

Superabrasives shall only be delivered once they have been tested successfully according to this standard.

The inspection of superabrasives by the manufacturer has the purpose of showing manufacturing defects affecting product safety. It shall be carried out as part of the manufacturing process before delivery of the products.

6.1 Test methods for grinding wheels

To verify conformity with the requirements according to 5.1, the following test methods are applied:

– safety speed test according to 6.1.1

– bursting speed test according to 6.1.2

– visual inspection test, according to 6.1.3

– ring test, according to 6.1.4

– bore diameter tolerance inspection according to 6.1.5

– unbalance test according to 6.1.6

6.1.1 Safety Speed Test

In the safety speed test the superabrasive grinding wheel is mounted on a suitable testing machine and is stressed up to the specified safety test speed as described in table 21.

Table 21: Safety test speeds

Type of abrasive product	For Safety factor 1,75[1)]			For Safety factor 3 or 3,5[1)]		
	Maximum operating speed v_s in m/s	Test speed factor f_{pr}	Safety test speed v_{pr} in m/s	Maximum operating speed v_s in m/s	Test speed factor f_{pr}	Safety test speed v_{pr} in m/s
Grinding wheels	< 80	1,1	–	< 40	1,3	–
	80		88	40	1,3	52
	100		110	50	1,3	65
	125		138	63	1,2	76
	140		154	80	1,1	88
	160		176	–	–	–
	180		198			
	200		220			
	225		248			
	250		275			
	280		308			
	320		352			
	360		396			
	400		440			
	450		495			
	500		550			

1) See table 8

6.1.2 Bursting speed test

The wheels are tested by means of a centrifugal speed test. The wheel is mounted on a spindle in a suitable test rig and is subjected to centrifugal force with steadily increasing speed of rotation up to the minimum bursting speed according to table 8. The wheel passes the bursting speed test if it survives the minimum bursting speed without breaking. In addition, for metal core wheels only, the permanent increase in diameter shall be tested after execution of the centrifugal speed test.

All wheels subjected to the bursting test shall be destroyed.

6.1.3 Visual inspection

In the visual inspection test any visible defect of a wheel is identified. Where applicable the visual inspection is complemented by the ring test (see 6.1.4).

Visual inspection shall be carried out by trained and competent persons. Damaged superabrasive grinding wheels shall be destroyed.

6.1.4 Ring Test

The ring test shall be performed on all vitrified-bonded grinding wheels with vitrified cores and an outside diameter of D > 80 mm, with the exception of cemented or nut inserted wheels.

In the ring test, the superabrasive grinding wheel is tapped with a non-metallic object. An undamaged superabrasive produces a clear tone, a damaged superabrasive a dull or rattling tone.

The ring test shall be carried out by trained and competent persons. Damaged superabrasive wheels shall be destroyed.

6.1.5 Bore diameter tolerance inspection

The bore diameter shall be checked with a "go, no-go" plug gauge or equivalent device.

6.1.6 Unbalance test

Standard on methods for unbalance tests is in preparation.

6.1.7 Scope of inspection and testing

Table 22: Scope of inspection and testing

Superabrasive grinding wheel					Maximum operating speed v_s in m/s	Scope of testing		
Designation			Bond of abrasive section	Dimensions in mm		Safety speed test 1) see 6.1.1	Bursting speed test 1) see 6.1.2	Visual inspection see 6.1.3
Grinding wheels, cylinder wheels and segmented wheels, cemented and/or screwed	Metal or resinoid core	for peripheral grinding	M, B	$D \leq 600$	≤ 63	–	–	100 %
					> 63	5 % or 0,1 %		
				$D > 600$	≤ 50	–	–	100 %
					> 50	10 % or 0,1 %		
		for face grinding		$D \leq 600$	≤ 50	–	–	100 %
					> 50	5 % or 0,1 %		
				$D > 600$	≤ 40	–	–	100 %
					> 40	10 % or 0,1 %		
		for peripheral grinding	V	$D \leq 600$	≤ 63	–	–	100 %
					> 63	100 %	–	
				$D > 600$	≤ 50	–	–	100 %
					> 50	100 %	–	
		for face grinding		$D \leq 600$	≤ 50	–	–	100 %
					> 50	100 %	–	
				$D > 600$	≤ 40	–	–	100 %
					> 40	100 %	–	
	Vitrified core	for peripheral and face grinding	M, B, V	$D \leq 150$	≤ 40	–	–	100 %
				$150 < D \leq 400$		10 %	–	
				$D > 400$		100 %	–	
				all	> 40	100 %	–	

(continued)

Table 22 (concluded)

Superabrasive grinding wheel					Maximum operating speed v_s in m/s	Scope of testing		
Designation			Bond of abrasive section	Dimensions in mm		Safety speed test[1)] see 6.1.1	Bursting speed test[1)] see 6.1.2	Visual inspection see 6.1.3
Grinding wheel directly on core	Metal core	for peripheral grinding	G	All	≤ 125	–	–	100 %
					> 125	5 % or 0,1 %		
		for face grinding		All	≤ 100	–	–	100 %
					> 100	5 % or 0,1 %		
		for peripheral grinding	M, with filler > 45 % by volume	$D \leq 600$	≤ 63	–	–	100 %
					> 63	100 %	–	
		for face grinding		$D \leq 600$	≤ 50	–	–	100 %
					> 50	100 %	–	
		for peripheral grinding	M, with filler ≤ 45 % by volume	All	≤ 80	–	–	100 %
					> 80	5 % or 0,1 %		
		for face grinding		$D \leq 600$	≤ 63	–	–	100 %
					> 63	5 % or 0,1 %		
	Resinoid core	for peripheral grinding	B	All	≤ 80	–	–	100 %
					> 80	100 %	–	
				$D \leq 600$	≤ 63	–	–	
		for face grinding			= 80	5% or 0,1 %		100 %
					> 80	100 %	–	
	Vitrified core	for peripheral and face grinding	V	$D \leq 80$	≤ 125	–	–	100 %
				$80 < D \leq 150$	≤ 50	–	–	100 %
					> 50	10 % or 0,1 %		
				$150 < D \leq 400$	≤ 80	10 % or 0,1 %		100 %
					> 80	100 %	–	
				$D > 400$	≤ 50	10 % or 0,1 %		100 %
					> 50	100 %	–	

[1)] As a % of the production rate at least 1 piece per batch. It is the manufacturer's choice to either apply the safety speed test or the bursting speed test, where indicated in the table.

For wheels made with composite cores, e.g. metal/vitrified or metal/resin, select the sampling rate for the weaker material.

6.2 Test methods for cutting-off wheels (saws)

To verify conformity with the requirements according to 5.2 the following test methods are applied:

– safety speed test, according to 6.2.1

– bursting speed test, according to 6.2.2

– visual inspection test, according to 6.2.3

– bending test, according to 6.2.4

– bore hole tolerance inspection according to 6.2.5

6.2.1 Safety Speed Test

In the safety speed test the superabrasive cutting-off wheel is mounted on a suitable testing machine and is stressed up to the specified test speed, as described in table 23.

Table 23: Safety test speeds

Abrasive product	Maximum operating speed v_s in m/s	Test speed factor f_{pr}	Safety test speed v_{pr} in m/s
Cutting-off wheels	80	1,1	88
	100		110
	125		138
	140		154
	160		176
	180		198
	200		220

6.2.2 Bursting test speed

See 6.1.2

6.2.3 Visual inspection

In the visual inspection test any visible defects of the cutting-off wheel are identified.

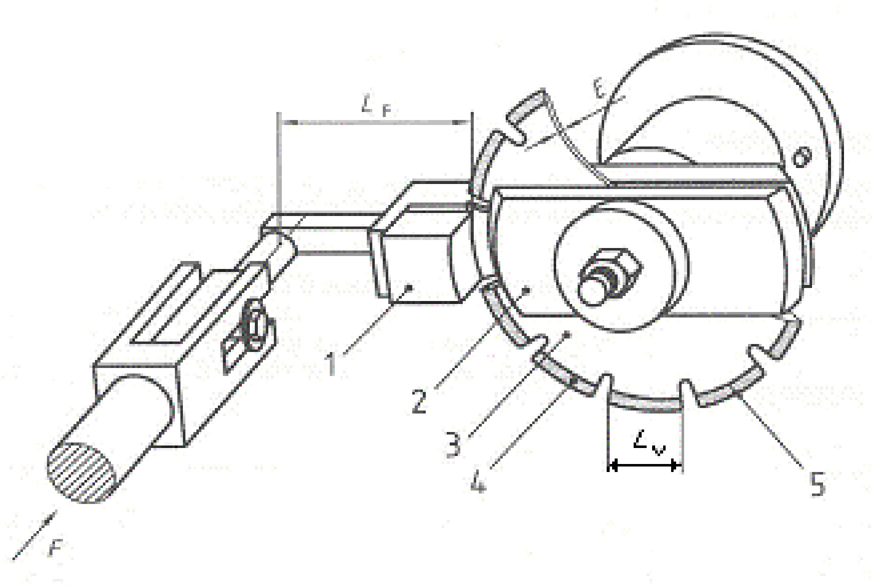
Visual inspection shall be carried out by trained and competent persons.

6.2.4 Bending tests

6.2.4.1 Non destructive bending test

[A1⟩ In bending test the cutting-off wheel is held in the area of the blank in such a way to guarantee that the required minimum bending strength is applied. The distance between the outer edge of the holding device of the blank and the blank/segment interface is approximately 2 mm. The segment to be tested is held up to the depth corresponding to the depth X of the segment by either a clamping piece or a device fitted with a gauged slot corresponding to the width T of the segment with a maximum limit deviation of + 0,5 mm. The clamping piece and the device with the gauged slot have approximately the same length as the segment and a profile similar to the periphery of the blank (figure 1). ⟨A1]

[A1⟩



1 Clamping piece
2 Clamping plate
3 Core
4 Segment
5 Blank/segment interface

Figure 1: Example of a bending test device for segmented cutting-off wheels

Load is applied to the clamping piece or the device fitted with a gauged slot at a distance L_F from the blank/segment interface. The force, F, applied is measured and recorded. ⟨A1]

The bending moment acting on the bond interface is calculated from the force F and the distance L_F as:

$$M_b = \frac{F \times L_F}{10^3} \text{ [Nm]} \quad (1)$$

The bending stress at the bond interface is calculated from the bending moment M_b, the length of bond interface L_v and the blank thickness E as:

$$\sigma_b = \frac{6 \times M_b}{L_v \times E^2} \quad \text{[N/mm}^2\text{]} \quad (2)$$

The bending moment is increased until the bending stress at the bond interface reaches the following values:

– for mechanically guided cutting-off (wet): σ_b = 150 N/mm^2.

– for mechanically guided cutting-off (dry): σ_b = 225 N/mm^2.

– for hand-held cutting-off (wet or dry): σ_b = 225 N/mm^2.

For cutting-off wheels with single-side welding, the bending force is applied to the welded side.

For cutting-off wheels welded on both sides or sintered, the bending force is applied to either side.

The test requirement is verified if no visible damage is seen after the application of the minimum bending stress.

6.2.4.2 Destructive bending test

6.2.4.2.1 Segmented cutting-off wheels

The test is carried out as described in 6.2.4.1. However, the force applied is increased until rupture of the abrasive segment or bond interface occurs. The maximum bending moment M_{bmax} according to the formula (1) is calculated from the maximum force F_{max}. From this the bending strength is calculated as:

$$\sigma_{bB} = \frac{6 \times M_{bmax}}{L_v \times E^2} \quad [\mathrm{N/mm^2}] \qquad (3)$$

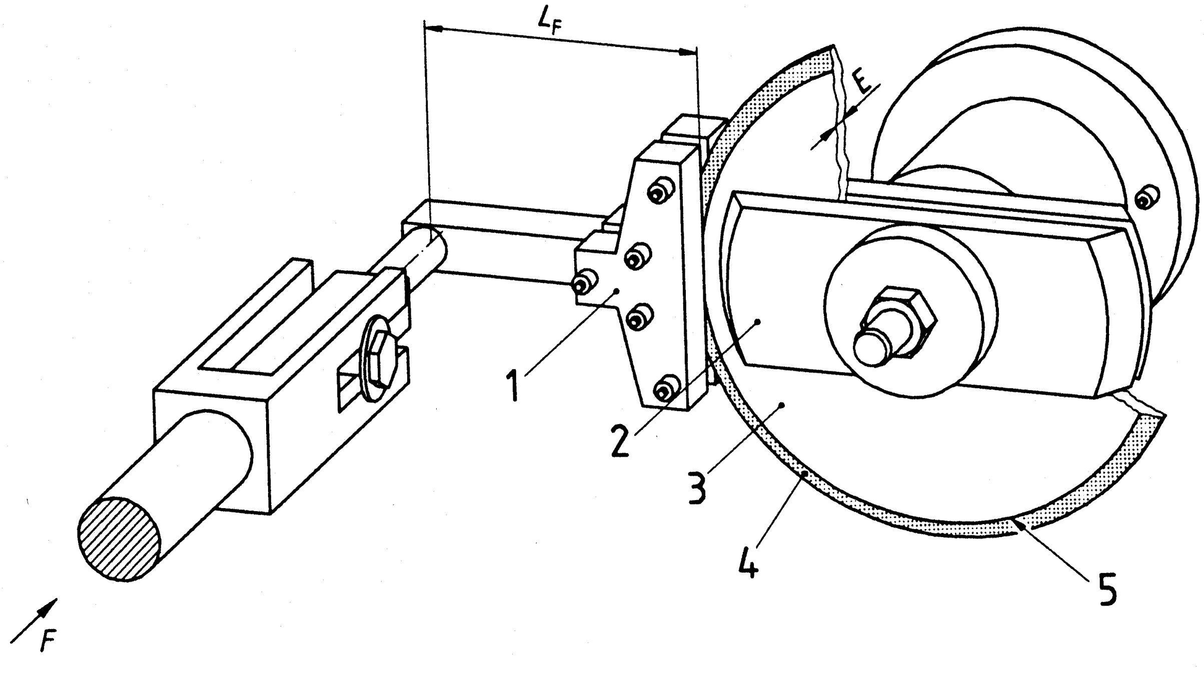
If the rupture does not occur at the bond interface but within the abrasive section, the dimensions L_V and E shall be replaced in the calculation of the bending strength by the length of segment L_2 and the thickness of the abrasive section T.

Sufficient bending strength is verified if the minimum values according to 5.2.9.2 are reached.

6.2.4.2.2 Cutting-off wheels with continuous rim

The test is carried out as described in 6.2.4.1. However, the application of the force is done by means of a clamping piece with a straight front edge by means of which a section of the abrasive rim up to a depth of the abrasive section X (figure 2) is grasped. The force applied is increased until rupture of the abrasive section occurs. The bending moment is calculated from the maximum force F_{max} according to formula (1).

Sufficient strength is verified if the bending moment reaches the minimum values according to 5.2.9.3.



1 Clamping piece
2 Clamping plate
3 Core
4 Segment
5 Bond interface

Figure 2: Example of a bending test device for cutting-off wheels with continuous rim

6.2.5 Bore diameter tolerance inspection

The bore diameter shall be tested with a "go, no-go" plug gauge or equivalent device.

6.2.6 Scope of inspection and testing

Table 24: Scope of inspection and testing

Cutting-off wheels				Maximum operating speed v_s in m/s	Scope of testing				
Designation		Bond of abrasive section	Dimensions in mm		Safety speed test[1] see 6.2.1	Bursting speed test[1] see 6.2.2	Visual inspection see 6.2.3	Bending test [2] see 6.2.4.1	Bending test [2] see 6.2.4.2
Cutting-off wheels with core of	Metal, continuous rim	G	All	≤ 80	–	–	100 %	–	–
				> 80	5 % or 0,1 %				
		M	All	≤ 80	–	–	100 %	–	–
				> 80	5 % or 0,1 %				0,1 %[3]
		B	All	≤ 63	–	–	100 %	–	–
				> 63	10 % or 0,1 %				
	Metal, segmented rim	G	All	≤ 80	–	–	100 %	–	–
				> 80	5 % or 0,1 %				
		M, brazed welded or sintered	All	≤ 63	–	–	100 %	100 % of the segments for all cutting-off wheels	or 0,1 %[4]
				> 63	–	–	100 %		
	Sintered metal	M	All	≤ 63	–	–	100 %	–	–
	Resinoid bond	B	All	≤ 63	–	–	100 %	–	–

[1] In % of the production rate, at least 1 piece per batch. It is the manufacturer's choice to either apply the safety speed test or the bursting speed test, where indicated in the table.

For cutting-off wheels and saws made with composite cores, e.g. metal/vitrified or metal/resinoid, select the sampling rate for the weaker material.

[2] Equivalent test methods are all agreed statistical test methods (SPC)

[3] 0,1 % for all cutting-off wheels of a production rate at least one piece per batch.

[4] In % of all applied segments of a production rate, at least three segments per batch

6.3 Test methods for diamond wires

To verify conformity with the requirements according to 5.3, the following test methods are applied:

– visual inspection test according to 6.3.1

– support cable resistance test according to 6.3.2

– wire couplings test according to 6.3.3

– abrasive beads test according to 6.3.4

– press ring resistance test according to 6.3.5

6.3.1 Visual inspection

In the visual inspection any visible defects of the diamond wire are identified. The visual inspection test shall be carried out by trained and competent persons.

6.3.2 Support cable resistance test

Support cables are tested to their tensile strength to the values set out in 5.3.2.1. This testing procedure may be substituted by adequate product certification by the supplier of the cable and test certificate.

6.3.3 Wire couplings test

Couplings mounted by the diamond wires manufacturer before delivery shall be tested to the values given in 5.3.2.4.

6.3.4 Abrasive beads test

In the case of diamond wires with springs, the dimensions of the bore and the external diameter of the support cables shall be tested according to the requirements in 5.3.2.2. Longitudinal movement and radial clearance shall be in accordance with 5.3.2.2.

In the case of diamond wires with plastic moulding, the diamond wires shall be tested for loose abrasive beads.

6.3.5 Press rings test

The press rings mounted by the diamond wire manufacturer shall be tested according to the values given in 5.3.2.2.

6.3.6 Scope of testing

The testing is carried out as follows:

– Visual inspection	All
– Wire resistance test	two tests per supplied unit, or by adequate product certification with a test certificate by the supplier of the support cable.
– Coupling test	At the manufacturer's discretion
– Press rings test	At the manufacturer's discretion

6.4 Test methods for mounted points

To verify conformity with the requirements according to 5.6 the following test methods are applied:

– bursting speed test according to 6.4.1

– resistance to spindle deflection test according to 6.4.2

– visual inspection according to 6.4.3

– spindle diameter test according to 6.4.4

6.4.1 Bursting speed test

Mounted points are tested by means of a centrifugal speed test. The mounted point is clamped in a suitable test rig and is subjected to centrifugal force with steadily increasing speed of rotation up to the minimum bursting speed as specified in table 17. The overhang spindle length is L_0 = 0.

The mounted point passes the bursting speed test if it survives the minimum bursting speed without breaking.

All mounted points subjected to the bursting speed test shall be destroyed.

6.4.2 Resistance to spindle deflection test

For testing of resistance to spindle deflection of mounted points with maximum operating speeds up to v_s = 50 m/s the parameters given in table C.2 are decisive and the dimensional sizes and speeds given in tables C.3 to C.10 shall be observed.

6.4.3 Visual inspection

In the visual inspection, any visible defects of the mounted points are identified. Visual inspection shall be carried out by trained and competent persons.

6.4.4 Spindle diameter test

The spindle diameter is checked by means of a slip gauge or equivalent device.

6.5 Test methods for other superabrasives

To verify conformity with the requirements according to 5.5 the following test methods are applied.

– safety speed test, according to 6.5.1

– bursting speed test, according to 6.5.2

– visual inspection according to 6.5.3

– ring test (where applicable), according to 6.5.4

– inspection of bore diameter tolerance or spindle diameter test according to 6.5.5

– shearing test according to 6.5.6

6.5.1 Safety Speed Test

In the safety speed test the superabrasive is mounted on a suitable testing machine and is loaded up to the safety test speed, see table 25.

Table 25: Safety test speeds

Type of abrasive product	Maximum operating speed v_s in m/s	Test speed factor f_{pr}	Safety test speed v_{pr} in m/s
Other superabrasives	16	1,3	21
	20		26
	25		33
	32		42
	35		46
	40		52
	50		65
	63	1,2	76
	80	1,1	88

6.5.2 Bursting speed test

See 6.1.2

6.5.3 Visual inspection

In the visual inspection any visible defects are identified.

Visual inspection shall be carried out by trained and competent persons.

6.5.4 Ring test

See 6.1.4

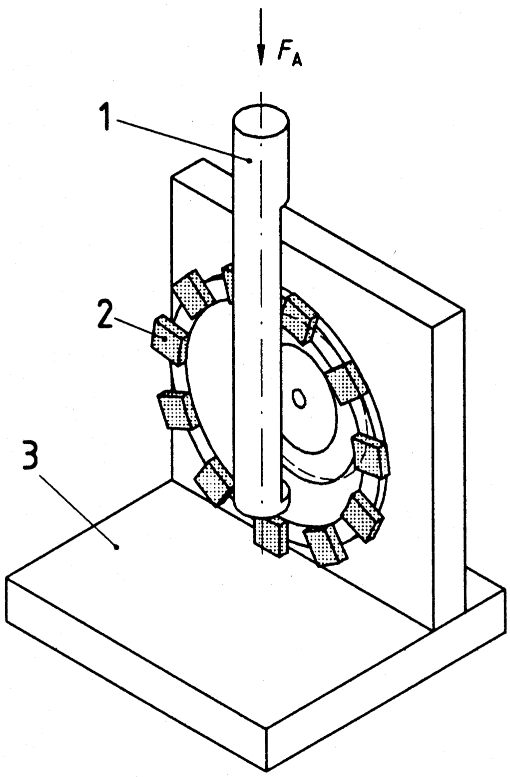
6.5.5 Bore tolerance and spindle diameter

The bore tolerance shall be checked with a "go, no-go" plug gauge or equivalent device.

The spindle diameter shall be checked with a slip gauge or equivalent device.

6.5.6 Testing of shearing strength of segmented dish wheels

The dish wheel is mounted on a console, see figure 3. A shearing force is applied to the segment to be tested by means of a hardened pressure stamp. The size and profile of the pressure stamp at the point of contact corresponds to the abrasive segment. Force is applied to the segment until the segment is sheared off. The force F_A necessary for shearing-off the segment is measured.



1 Pressure stamp
2 Abrasive segment
3 Console

Figure 3: Example of a shearing force test device

Sufficient strength is verified if the shearing force reaches the minimum value according to 5.5.7.

6.5.7 Scope of inspection and testing

Table 26: Scope of inspection and testing

Other superabrasives		Maximum operating speed v_s in m/s	Scope of testing		
Designation	Dimensions in mm		Safety speed test according to 6.5.1 [1)]	Bursting speed test according to 6.5.2 [1)]	Visual inspection according to 6.5.3
Dish grinding wheel	$D \leq 80$	≤ 63	–	–	100 %
	$D > 80$	≤ 63	–	–	
		> 63	5 % or 0,1 %		100 %
Shaft mounted tools	All	≤ 63	–	–	100 %
		> 63	5 % or 0,1 %		
Profile grinding wheels	All	≤ 80	–	–	100 %
Drills and hollow drills	All	All	–	–	100 %

1) As a % of the production rate, at least one piece per batch. It is the manufacturer's choice to either apply the safety speed test or the bursting speed test as indicated in the table.

7 Information for use

The manufacturer, supplier or importer of superabrasives shall bring information on the safe application of superabrasives to the notice of the user.

These information for use shall contain safety recommendations for the correct use of superabrasives as follows:

a) General
Superabrasives are breakable and shall therefore be handled with utmost care! The use of damaged or improperly mounted or used superabrasives is dangerous and can cause serious injuries.

b) Delivery, handling and storage
Superabrasives shall be handled and transported with care. Superabrasives shall be stored in such a manner that they are not subjected to mechanical damages and harmful environmental influences.

c) Selection of superabrasives
Information on the label or the superabrasive as well as restrictions of use, safety indications or any other instruction shall be followed. In case of doubt concerning the selection of superabrasives, the user shall request information from the manufacturer or supplier.

d) Visual inspection and ring test
Superabrasives shall be subjected to a visual inspection as received before mounting. In addition, a ring test shall be executed for superabrasives with vitrified core and abrasive section and D > 80 mm. Damaged superabrasives shall not be used.

e) Mounting, before starting and information for grinding
The mounting of superabrasives shall be carried out according to the instructions provided by both, the superabrasive and the machine manufacturer. Special attention shall be drawn to the fact that mounting of superabrasives is to be carried out by a qualified trained person. Each time after mounting, the superabrasive shall be test run for a reasonable time – the specified maximum operating speed of the superabrasive shall not be exceeded.

f) Further information:
The following instructions shall be observed, supplementary to the information of the grinding machine:

- Observance of the user's information of grinding machine manufacturer.
- Before starting, safety devices shall be mounted to the machine.
- No grinding operations without protection by safety devices.
- Use of personal protective equipment according to the type of machine and type of application, e.g. eye and face protection, ear protection, respiratory protective devices, protective footwear, protective gloves and other protective clothing.
- Only grinding operations for which the superabrasive is suitable shall be carried out (taking into account restrictions of use, safety indications or other information).
- In the case of cutting-off with hand-held grinding machines, the superabrasive shall be placed in the cutting gap in a straight position. Jamming of the hand-held grinding machine shall be prevented.
- Before placing the hand-held grinding machine on the workbench or on the floor it shall be turned off and it shall be ensured that the abrasive product has stopped.

Safety recommendations intended as information for use shall be brought to the notice of the user by the manufacturer, distributor or importer and may be provided:

- as periodical information
- in the course of training arrangements
- or as guidance for practical use.

Annex A (normative)

Marking

A.1 Marking

A.1.1 Content of the marking

Superabrasives shall be marked with the specifications according to table A.1

Table A.1

Specifications / Designation of the superabrasive		1	2	3	4	5	6	7	8
		Manu-facturer, Supplier, Importer	Order No dispatch No	Maximum operating speed in m/s	Maximum speed of rotation in min^{-1}	Colour code	Direction of rotation and run	Restrictions of use	Manu-facturer's declaration of conformity
Grinding wheels	without vitrified core	x	x	x	x	–	–	x	x
	with vitrified core	x	x	x	x	x	–	x	x
Cutting-off wheels		x	x	x	x	–	x	x	x
Mounted points		x	x	–	x	–	–	x	x
Diamond wires		x	x	–	–	–	x	–	x
Other superabrasives		x	x	x	x	–	–	x	x

To column 1

Instead of writing the manufacturer or supplier or importer it is also allowed to write their registered trademark.

To column 2

Product order number, number of dispatch or similar shall be marked to allow product traceability.

To column 3

Maximum operating speed in m/s.

To column 4

Maximum speed of rotation in min^{-1} or rpm. For segments, the indication of the speed of rotation may be omitted.

To column 5

Colour code stripes and design of colour codes for abrasive products, see table A.2.

To column 6

Cutting-off wheels shall be marked with the direction of rotation. Diamond wires shall be marked with the direction of run.

To column 7

Superabrasives, for which specific methods of operation, grinding machines and types of application are to be used, shall be marked with the appropriate restrictions of use according to tables A.3 and A.4.

To column 8

All superabrasives complying with and tested in accordance with this standard shall be marked.

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A.1.2 Colour codes

Table A.2: Colour code and design of colour codes

Maximum operating speed in m/s	Colour code stripe[1]		
	Number and colour	Width of colour code stripe	Width of gap
50	1 × blue	5 mm to 20 mm	–
63	1 × yellow		
80	1 × red		
100	1 × green		
125	1 × blue 1 × yellow	5 mm to 20 mm each	at least 2 mm and no more than width of one colour code stripe
140	1 × blue 1 × red		
160	1 × blue 1 × green		
180	1 × yellow 1 × red		
200	1 × yellow 1 × green		
225	1 × red 1 × green		
250	2 × blue		
280	2 × yellow		
320	2 × red		
360	2 × green		

[1] Colour codes stripes shall be straight and even in width. The basic colour of the label shall clearly differ from the specified colour of the stripe and shall not alter the colour of the stripe.

A.1.3 Restrictions of use

A.1.3.1 Restrictions of use for grinding wheels, mounted points and other superabrasives

Grinding wheels, mounted points and other superabrasives which are not intended for all uses shall be clearly marked with the relevant restrictions of use according to Table A.3.

Table A.3: Restrictions of use (RE) for grinding wheels, mounted points and other superabrasives

Short sign	Label	Application
RE 1	Not permitted for hand-held and manually guided grinding	These superabrasives shall only be used for mechanically guided grinding. NOTE: This restriction only applies to superabrasives manufactured not for use on hand-held or manually guided grinding machines but capable of being mounted on such machines.
RE 4	Only permitted for totally enclosed working area	These superabrasives shall only be used on stationary machines with "Totally-enclosed working area". See 3.2.7

A.1.3.2 Restrictions of use for cutting-off wheels

Cutting-off wheels, which are not intended for all uses shall be clearly marked with the relevant restrictions of use (see Table A.4 below).

Table A.4: Restrictions of use for cutting-off wheels

Short sign	Designation	Application
RE 2	Not permitted for hand-held cutting-off	These cutting-off wheels shall not be used on hand-held cutting-off machines. NOTE: This restriction only applies to wheels manufactured not for use on hand-held machines but capable of being mounted on such machines.
RE 4	Only permitted for totally enclosed working area	These wheels shall only be used on stationary cutting-off machines with "Totally-enclosed working area". See 3.2.7
RE 10	Not permitted for dry cutting-off	These wheels shall only be used for wet cutting-off.
RE 11	Not permitted for hand-held and manually guided cutting-off	These cutting-off wheels shall only be used on stationary cutting-off machines on which both the abrasive product and the workpiece are mechanically guided

A.1.4 Additional inscriptions

Additional inscriptions on the superabrasive such as type number, order number and manufacturer's product name is permitted provided legibility of the other specifications is not impaired.

A.1.5 Multiple or gang mounted wheels

The mounting of several wheels to the same spindle is only permissible if the wheels and the grinding machine are designated as appropriate for the purpose by the wheel and machine manufacturers.

Wheels to be multiple or gang mounted with spacers between each wheel shall be marked in a manner to assure they are correctly mounted on the machine spindle. Additionally each wheel shall be identified as being part of that set for precision grinding. The spacers shall have the same locating areas and recesses as the external flanges.

For wheels with vitrified cores, blotters shall be inserted between spacers and wheels.

Blotters used for multiple or gang mounted wheels shall be resistant to coolants.

A.2 Execution of the marking

The marking of superabrasives shall be indelible and legible. It can be inscribed on a blotter or label or stencilled, printed, stamped or engraved on the product or on an integrated foil.

Restrictions of use shall be part of the marking. They shall be given in full length according to Tables A.3 and A.4. They may as well be given in the form of a short sign RE, if the full text of the restriction of use is given on the rear of the label or on a label added to the smallest packaging unit.

A.2.1 Superabrasives having an outside diameter D > 80 mm

Where it is not possible to give the specified information on a blotter, label or integrated foil fixed to the superabrasive, the actual product shall be marked with at least the maximum speed of rotation and the colour code if necessary, provided the surface and shape of the superabrasive are appropriate for this purpose.

A.2.2 Superabrasives having an outside diameter $D \leq$ 80 mm (small abrasive products)

The marking is carried out on a label added to each superabrasive so that it accompanies the superabrasive up to its final point of use.

If several identical superabrasives are delivered in one packaging unit, the marking of the contents by application of the characteristics to the smallest size pack is sufficient if at least one label for 25 identical superabrasives to each packaging unit is added.

If more than 1 000 identical superabrasives are delivered in one packaging unit to a user, the marking of the contents by application of the data to the packaging unit is sufficient, if at least one label for 100 identical superabrasives is added to each packaging unit.

If several identical small superabrasives with outside diameter 50 mm < $D \leq 80$ mm are delivered to a reseller, each superabrasive shall be accompanied by a label.

If several superabrasives of different materials, shapes or dimensions (e.g. sets of abrasive products in self-service packs) are packed together, the marking of each individual superabrasive on the packaging unit is sufficient.

A.2.3 Superabrasive segments

For superabrasive segments, the marking of the characteristics on the smallest size pack is sufficient, the inscription of the permissible speed of rotation being omitted.

A.2.4 Colour code stripes

The colour code stripe shall appear on the superabrasives itself and/or the label in such a way that it extends through the centres of the superabrasive or the label.

The colour code stripe on the label is not necessary, if the label is cemented to the superabrasive and the colour code stripe extends across the entire diameter of the superabrasive.

The colour code stripe on the superabrasive is not necessary for small superabrasives having diameters of $D \leq 80$ mm.

A.3 Design of the marking

Examples for labels see types A to C.

Type A

Manufacturer/Supplier/Importer/Trade mark	
Order №, dispatch №	
Maximum operating speed	m/s
Maximum operating speed	min^{-1}/rpm
Other inscriptions[1)]	
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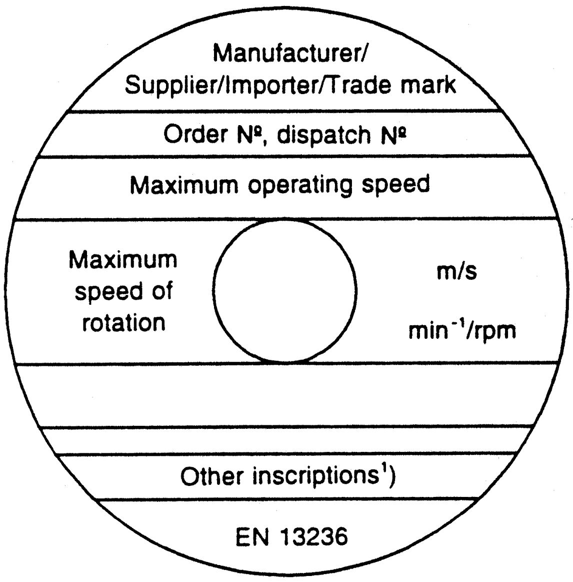
Minimum dimensions (height x width)
52 mm × 74 mm (Format A 8)

Type B



Diameter of label at least 20 mm
larger than minimum diameter of flanges

1) For example, restrictions of use

Type C

Manufacturer/Supplier/Importer/Trade mark		
Additional inscriptions[1)]		
Order Nº, dispatch Nº		
Maximum speed of rotation for overhang length L_o		
5 mm	10 mm	15 mm
min^{-1}/rpm	min^{-1}/rpm	min^{-1}/rpm
20 mm	25 mm	30 mm
min^{-1}/rpm	min^{-1}/rpm	min^{-1}/rpm
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Type C (rearside)

Safety indication The mounted wheel described overleaf shall not be speed higher those shown. The minimum length L_3 of the spindle within in the collet shall be 10 mm.

Minimum dimensions (height x width) 52 mm x 74 mm (Format A 8)

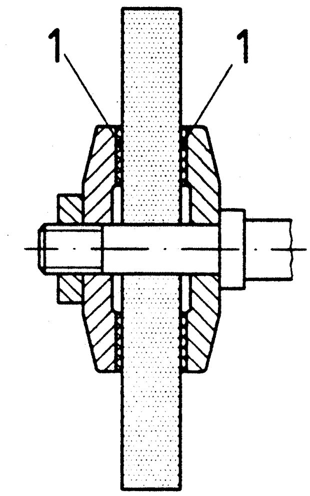
[1)] For example, restrictions of use

Annex B (normative)

Blotters

B.1 Blotters

This Annex includes the requirements for blotters used on superabrasives with vitrified cores provided they are mounted by means of flanges (see figure B.1).



Key
1 Blotters

Figure B.1: Grinding wheel with flanges and flexible blotters

The purpose of blotters is:

a) to compensate for slight irregularities of the surface of the flange and the abrasive product,
b) to increase the coefficient of friction between the abrasive product and the flange,
c) to distribute equally the clamping force over the entire flange clamping area of the abrasive product,
d) to reduce wear of the flanges.

B.2 Requirements

A label shall not be used as blotter. If, however, the use of a blotter is mandatory, it can additionally serve as a label.

B.2.1 Shape and dimensions

The outside diameter of the blotter shall be at least 20 mm greater than the outside diameter of the clamping flanges.

The internal diameter of the blotter shall at least cover the annular contact surface of the clamping flange (minimum covering).

NOTE: Diameter and minimum covering of the clamping flanges according to, e.g. ISO 666.

The thickness of a single blotter shall be 0,2 mm minimum, 1 mm maximum.

B.2.2 Material

Blotters shall be made from a soft or compressible material, e.g. soft cardboard, plastic or rubber.

B.3 Supply of blotters with superabrasives

Blotters are supplied with superabrasives by the manufacturer, supplier or importer on delivery.

Blotters are:

– either fixed permanently to the product
– supplied loosely with the product.

Generally, two blotters of equal material and dimensions are supplied.

Annex C (normative)

Mounted points

C.1 Mounted points

C.1.1 Scope

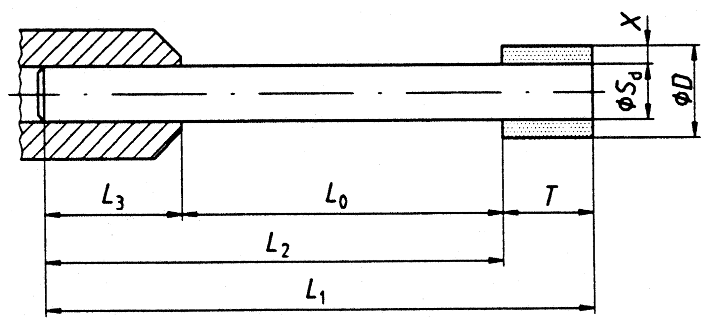
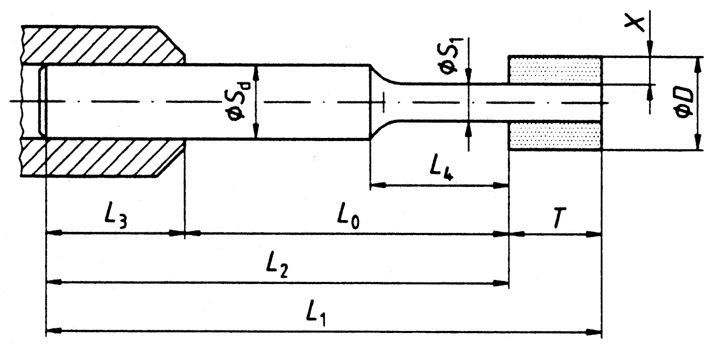
This annex only applies to cylindrical mounted points with maximum peripheral operating speeds up to v_s = 50 m/s.

It does not apply to mounted points with hollow spindles.

C.2 Dimensions and designation

Dimensions and designations according to specifications in Tables C.3 to C.10.
General tolerances according to ISO 2768-1.

Table C.1: Designation of mounted points

Designation	Figure	Short sign
Mounted point, cylindrical shape, plain spindle		ZYN
Mounted point, cylindrical shape, reduced spindle		ZYA

C.3 Maximum speeds of rotation

Mounted points shall have a safety factor against spindle deflection of S_{ab} = 1,3. The parameters determining the resistance to spindle deflection are the unsupported overhang of the mounted point, spindle and abrasive geometry, their material properties and the peripheral operating speed or speed of rotation.

To meet the requirement, the maximum speeds of rotation for mounted points shall be specified as a function of these parameters according to tables C.3 to C.10. The maximum speeds of rotation are calculated according to the calculation model in clause C.4 and based on the parameters according to table C.2.

C.3.1 Characteristics

The calculation of the maximum speeds of rotation of the mounted points is based on the values according to table C.2:

Table C.2: Characteristics for the calculation of maximum speeds of rotation

Modulus of elasticity of the spindle material	E = 210 000 N/mm^2
Yield point of the spindle material	R_e = 600 N/mm^2
Mass eccentricity	e = 0,05 mm
Reducing factor for the spindle mass	k_m = 0,257
Width factor[1)]	k_T = 0,5 to 1,0
Specific density of the spindle material	ϱ_s = 7,85 g/cm^3
Density of the electro-plated bond[2)]	ϱ_G = 7,85 g/cm^3
Density of the verified bond	ϱ_V = 3,6 g/cm^3
Density of the verified core	ϱ_{TV} = 3,6 g/cm^3
Density of the resin bond	ϱ_B = 4,5 g/cm^3
Density of the sintered metal bond	ϱ_M = 8,6 g/cm^3

1) For mounted points with plain and reduced spindles and for all mounted points with electro-plated bond k_T = 1,0

2) For mounted points with electro-plated bond, the density of the bond corresponds to the density of the spindle material due to the small depth of section X.

Table C.3: Mounted points, cylindrical shape, plain spindles (ZYN) vitrified pond (V)

D mm	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm										
						min.	5	10	15	20	25	30	35	40	50	60	70
8	10	2	3	60	50	10	119 366	87 581	63 394	48 181	37 973	30 773	25 493	21 498	–	–	–
				80	70										15 938	12 324	–
10	10	2	3	60	50	10	95 493	70 277	51 210	39 166	31 051	25 305	21 074	17 861	–		–
				80	70										13 364	10 421	–
			6	60	50		95 493	95 493	95 493	95 493	95 493	86 712	70 932	59 087	–	–	–
				80	70										42 818	32 446	–
12	10	2	6	60	50	10	79 577	79 577	79 577	79 577	79 577	75 933	62 591	52 496	–	–	–
				80	70										38 486	29 443	–
			8	60	50	15	79 577	79 577	79 577	79 577	79 577	79 577	79 577	–	–	–	–
				80	70									79 577	59 851	–	–
				100	90											45 181	35 297
12	10	3	6	60	50	10	79 577	79 577	79 577	79 577	79 577	75 933	62 591	52 496	–	–	–
				80	70										38 486	29 443	–
			8	60	50	15	79 577	79 577	79 577	79 577	79 577	79 577	79 577	–	–	–	–
				80	70									79 577	59 851	–	–
				100	90											45 181	35 297
15	10	2	6	60	50	10	63 662	63 662	63 662	63 662	63 662	63 515	52 759	44 562	–	–	–
				80	70										33 079	25 578	–
			8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									63 622	53 018	–	–
				100	90											40 497	31 946
15	10	3	6	60	50	10	63 662	63 662	63 662	63 662	63 662	63 515	52 759	44 562	–	–	–
				80	70										33 079	25 578	–
			8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									63 622	53 018	–	–
				100	90											40 497	31 946
18	10	2	8	60	50	15	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									53 052	47 173	–	–
				100	90											36 364	28 911
18	10	3	8	60	50	15	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									53 052	47 173	–	–
				100	90											36 364	28 911

Table C.4: Mounted points, cylindrical shape, reduced spindles (ZYA) vitrified bond (V)

D mm	T mm	X mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
									10	15	20	25	30	35	40	45	50	55	60	65	70
3	6	0,9	3	1,2	60	54	8	10	75 464	63 009	54 126	47 079	41 162	36 065	31 639	–	–	–	–	–	–
					80	74										27 797	24 472	21606	19 140	–	–
4	6	1,2	3	1,6	60	54	8	10	100 709	85 833	72 750	61 298	51 515	43 354	36 650	–	–	–	–	–	–
					80	74										31 183	26 730	23 091	20 101	–	–
			6		60	54			90 616	68 925	57 545	50 130	44 703	40 426	36 880	–	–	–	–	–	–
					80	74										33 831	31 143	28 734	26 550	–	–
5	6	1,5	3	2,0	60	54	8	10	122 685	101 398	82 229	66 353	53 810	44 085	36 558	–	–	–	–	–	–
					80	74										30 662	26 024	22 336	19 363	–	–
			6		60	54			116 881	94 256	80 341	70 353	62 497	55 952	50 306	–	–	–	–	–	–
					80	74										45 337	40 919	36 975	33 451	–	–
6	8	1,8	6	2,4	60	52	12	10	–	75 471	65 966	58 748	52 873	47 868	43 480	–	–	–	–	–	–
					80	72										39 563	36 037	32 849	29 966	–	–
7	8	2,1	6	2,8	60	52	12	10	–	88 629	78 667	70 327	63 054	56 576	50 761	–	–	–	–	–	–
					80	72										45 541	40 871	36 713	33 026	–	–
8	10	2,4	6	3,2	60	50	15	10	–	71 598	65 150	59 307	53 919	48 929	44 322	–	–	–	–	–	–
					80	70										40 098	36 256	32 789	29 680	–	–
			8		60	50		15	–	71 598	63 184	56 840	51 739	47 447	–	–	–	–	–	–	–
					80	70									43 715	40 395	37 394	34 655	–	–	–
					100	90													32 138	29 820	27 682
	15				60	45			–	46 285	42 260	38 974	36 187	–	–	–	–	–	–	–	–
					80	65								33 754	31 581	29 608	27 795	–	–	–	–
					100	85												26 112	24 543	23 073	21 695
9	10	2,7	6	3,6	60	50	15	15		79 958	72 732	65 806	59 236	53 108	47 494	–	–	–	–	–	–
					80	70										42 431	37 923	33 942	30 448	–	–
			8		60	50				79 958	71 822	65 197	59 543	54 562	–	–	–	–	–	–	–
					80	70									50 082	46 003	42 269	38 842	–	–	–
					100	90													35 701	32 825	30 200
	15				60	45				51 795	47 889	44 492	41 458	–	–	–	–	–	–	–	–
					80	65								38 693	36 138	33 757	–	–	–	–	–
					100	85											31 528	29 437	27 477	25 643	23 929
10	10	3,0	8	4,0	60	50	15	15		88 201	80 049	72 950	66 579	60 764	–	–	–	–	–	–	–
					80	70									55 421	50 509	46 007	41 901	–	–	–
					100	90													38 175	34 807	31 776
	15				60	45				57 248	53 290	49 654	46 259	–	–	–	–	–	–	–	–
					80	65								43 059	40 035	37 177	34 486	31 963	29 609	–	–
					100	85														27 425	25 406

Table C.5: Mounted points, cylindrical shape plain spindles (ZYN) electroplated (G)

D	T	S_d	L_1	L_2	L_3	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
mm	mm	mm	mm	mm	mm min.	5	10	15	20	25	30	35	40	50	60	70	80	90
3,5	5	3	50	45	10	272 837	272 837	191 382	129 697	93 371	70 302	54 786	–	–	–	–	–	–
			75	70									43 868	29 919	21 689	–	–	–
4	5	3	50	45	10	238 732	238 732	167 857	115 860	84 571	64 368	50 598	–	–	–	–	–	–
			75	70									40 804	28 137	20 562	–	–	–
4,5	5	3	50	45	10	212 207	212 207	149 449	104 513	77 088	59 174	46 845	–	–	–	–	–	–
			75	70									38 004	26 457	19 476	–	–	–
	6	4	50	44		212 207	212 207	212 207	160 527	117 073	88 974	–	–	–	–	–	–	–
			75	69								69 821	56 209	38 633	–	–	–	–
5	5	3	50	45	10	190 986	190 986	134 662	95 083	70 695	54 634	43 501	–	–	–	–	–	–
			75	70									35 468	24 895	18 445	–	–	–
	6	4	50	44		190 986	190 986	190 986	145 619	107 488	82 460	–	–	–	–	–	–	
			75	69								65 198	52 812	36 646	–	–	–	–
5,5	6	4	50	44	10	173 624	173 624	173 624	133 167	99 221	76 697	–	–	–	–	–	–	–
			75	69								61 023	49 691	34 770	–	–	–	–
6	6	4	50	44	10	159 155	159 155	159 155	122 626	92 045	71 591	–	–	–	–	–	–	–
			75	69								57 260	46 836	33 013	–	–	–	–
7	8	6	60	52	10	136 419	136 419	136 419	136 419	136 419	112 479	90 006	73 596	–	–	–	–	–
			80	72										51 776	38 360	–	–	–
8	8	6	60	52	10	119 366	119 366	119 366	119 366	119 366	100 069	80 856	66 660	–	–	–	–	–
			80	72										47 517	35 560	–	–	–
9	8	6	60	52	10	106 103	106 103	106 103	106 103	106 103	89 999	73 243	60 762	–	–	–	–	–
			80	72										43 765	33 025	–	–	–
	10	8	60	50	15	106 103	106 103	106 103	106 103	106 103	106 103	106 103	–	–	–	–	–	–
			80	70									90 797	64 744	–	–	–	–
			100	90											48 430	37 562	–	–
10	8	6	60	52	10	95 493	95 493	95 493	95 493	95 493	81 696	66 845	55 723	–	–	–	–	–
			80	72										40 469	30 747	–	–	–
	10	8	60	50	15	95 493	95 493	95 493	95 493	95 493	95 493	95 493	–	–	–	–	–	–
			80	70									83 182	60 004	–	–	–	–
			100	90											45 284	35 369	–	–

(continued)

Table C.5 (concluded)

D mm	T mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
						5	10	15	20	25	30	35	40	50	60	70	80	90
12	8	6	60	52	10	79 577	79 577	79 577	79 577	79 577	68 859	56 761	47 639	–	–	–	–	–
			80	72										35 016	26 879	–	–	–
	10	8	60	50	15	79 577	79 577	79 577	79 577	79 577	79 577	79 577	–	–	–	–	–	–
			80	70									71 013	52 095	–	–	–	–
			100	90											39 852	31 477	–	–
		10	60	50		79 577	79 577	79 577	79 577	79 577	79 577	79 577	–	–	–	–	–	–
			80	70									79 577	76 761	–	–	–	–
			100	90											57 836	45 104	–	–
15	10	8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–	–	–
			80	70									57 996	43 213	–	–	–	–
			100	90											33 501	26 768	–	–
		10	60	50		63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–	–	–
			80	70									63 662	63 662	–	–	–	–
			100	90											49 562	39 191	–	–
		12	80	70	20	63 662	63 662	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
			120	110											63 662	52 637	42 304	34 730
18	10	10	60	50	15	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–	–	–
			80	70									53 052	53 052	–	–	–	–
			100	90											43 061	34 380	–	–
		12	80	70	20	53 052	53 052	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
			120	110											53 052	46 845	38 004	31 450
20	10	10	60	50	15	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–	–	–
			80	70									47 746	47 746	–	–	–	–
			100	90											39 505	31 691	–	–
		12	80	70	20	47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–
			120	110											47 746	43 501	35 468	29 479
22	10	12	80	70	20	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	–	–	–	–
			120	110											43 046	40 527	33 181	27 681
25	10	12	80	70	20	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	–	–	–	–
			120	110											38 197	36 667	30 171	25 284

Table C.6: Mounted points, cylindrical shape reduced spindles (ZYA) electroplated (G)

D	T	S_d	S_1	L_1	L_2	L_4	L_3	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
mm	mm	mm	mm min.	mm	mm	mm	mm min.	5	10	15	20	25	30	35	40	45	50	55	60	65
0,5	2	3	0,32	40	38	4	10	62 057	27 254	20 259	16 821	14 672	–	–	–	–	–	–	–	–
				55	53								13 156	12 004	11 083	–	–	–	–	–
0,6	2	3	0,42	40	38	4	10	100 543	45 297	33 721	27 960	24 308	–	–	–	–	–	–	–	–
				55	53								21 686	19 649	17 978	–	–	–	–	–
0,7	2	3	0,52	40	38	4	10	144 750	66 991	49 904	41 239	35 624	–	–	–	–	–	–	–	–
				55	53								31 485	28 180	25 401	–	–	–	–	–
0,8	2	3	0,50	40	38	6	10	–	50 948	35 116	28 353	24 327	–	–	–	–	–	–	–	–
				55	53								21 539	19 425	17 722	–	–	–	–	–
	4			40	36			–	36 109	25 436	20 703	17 858	–	–	–	–	–	–	–	–
				55	51								15 890	14 408	13 226	–	–	–	–	–
0,9	2	3	0,60	40	38	6	10	–	70 938	49 208	39 698	33 922	–	–	–	–	–	–	–	–
				55	53								29 832	26 659	24 044	–	–	–	–	–
	4			40	36			–	50 239	35 733	29 123	25 079	–	–	–	–	–	–	–	–
				55	51								22 230	20 044	18 265	–	–	–	–	–
1,0	2	3	0,70	40	38	6	10	–	93 246	65 059	52 352	44 436	–	–	–	–	–	–	–	–
				55	53								38 686	34 123	30 306	–	–	–	–	–
	4			40	36			–	65 990	47 364	38 609	33 130	–	–	–	–	–	–	–	–
				55	51								29 184	26 089	23 522	–	–	–	–	–
1,1	4	3	0,80	40	36	9	10	–	81 610	49 294	38 315	32 192	–	–	–	–	–	–	–	–
				55	51								28 056	24 949	22 450	–	–	–	–	–
1,2	4	3	0,90	40	36	9	10	–	96 898	60 471	47 205	39 580	–	–	–	–	–	–	–	–
				55	51								34 305	30 260	26 958	–	–	–	–	–
1,3	4	3	1,00	40	36	9	10	–	112 424	72 240	56 563	47 249	–	–	–	–	–	–	–	–
				55	51								40646	35 493	31 247	–	–	–	–	–
1,4	4	3	1,10	40	36	9	10	–	128 072	84 437	66 210	55 002	–	–	–	–	–	–	–	–
				55	51								46 872	40 450	35 152	–	–	–	–	–
1,5	4	3	1,20	40	36	9	10	–	143 750	96 896	75 958	62 637	–	–	–	–	–	–	–	–
				55	51								52 791	44 975	38 567	–	–	–	–	–
1,6	4	3	1,24	40	36	10	10	–	144 166	95 380	74 467	61 387	–	–	–	–	–	–	–	–
				55	51								51 804	44 223	38 008	–	–	–	–	–
1,7	4	3	1,34	40	36	10	10	–	157 725	107 029	83 580	68 385	–	–	–	–	–	–	–	–
				55	51								57 074	48 120	40 850	–	–	–	–	–

(continued)

Table C.6 (concluded)

D mm	T mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
								5	10	15	20	25	30	35	40	45	50	55	60	65
1,8	4	3	1,44	40	36	10	10	–	171 228	118 609	92 457	74 970	–	–	–	–	–	–	–	–
				55	51								61 829	51 484	43 201	–	–	–	–	–
1,9	4	3	1,54	40	36	10	10	–	184 664	129 998	100 951	81 021	–	–	–	–	–	–	–	–
				55	51								66 003	54 305	45 090	–	–	–	–	–
2,0	4	3	1,64	40	36	10	10	–	198 023	141 081	108 934	86 453	–	–	–	–	–	–	–	–
				55	51								69 571	56 607	46 567	–	–	–	–	–
2,2	4	3	1,84	40	36	14	10	–	–	138 000	105 841	84 192	–	–	–	–	–	–	–	–
				55	51								68 098	55 707	46 042	–	–	–	–	–
2,4	4	3	2,04	40	36	14	10	–	–	154 590	118 089	92 326	–	–	–	–	–	–	–	–
				55	51								73 226	58 856	47 953	–	–	–	–	–
2,6	4	3	2,24	40	36	14	10	–	–	170 546	128 443	98 374	–	–	–	–	–	–	–	–
				55	51								76 577	60 658	48 882	–	–	–	–	–
2,8	4	3	2,44	40	36	14	10	–	–	185 749	136 715	102 431	–	–	–	–	–	–	–	–
				55	51								78 396	61 234	48 934	–	–	–	–	–
3,0	4	3	2,64	40	36	19	10	–	–	–	131 368	99 316	–	–	–	–	–	–	–	–
				55	51								76 502	60 013	48 106	–	–	–	–	–
3,5	5	6	3,14	60	55	19	10	–	–	–	141 873	110 523	91 560	78 040	67 535	58 978	–	–	–	–
				80	75												51 823	45 755	40 566	36 108
4,0	5	6	3,65	60	55	19	10	–	–	–	167 323	133 177	110 045	92 606	78 771	67 520	–	–	–	–
				80	75												58 258	50 577	44 173	38 807
4,5	5	6	4,14	60	55			–	–	–	190 190	152 186	124 447	103 043	86 142	72 651	–	–	–	–
				80	75												61 801	53 016	45 851	39 961
5,0	5	6	4,64	60	55	19	10	–	–	–	190 986	168 599	135 464	110 124	90 577	75 380	–	–	–	–
				80	75												63 375	53 855	46 251	40 101
5,5	5	6	5,14	60	55			–	–	–	173 624	173 624	142 637	113 729	92 018	75 727	–	–	–	–
				80	75												63 266	53 565	45 887	39 719
6,0	6	6	5,64	60	54			–	–	–	159 155	159 155	136 633	107 922	87 150	–	–	–	–	–
				80	74											71 719	59 981	50 865	43 656	–

Table C.7: Mounted points, cylindrical shape, plain spindles (ZYN), metal bond (M)

D mm	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 5	10	15	20	25	30	35	40	50	60	70
4	6	0,5	3	60	54	10	238 732	222 041	145 722	102 588	76 012	58 535	46 447	37 746	–	–	–
				80	74										26 338	19 417	–
5	6	1,0	3	60	54	10	190 986	169 671	114 298	82 207	62 011	48 484	38 977	32 037	–	–	–
				80	74										22 778	17 044	–
6	6	1,5	3	60	54	10	159 155	138 142	94 262	68 568	52 245	41 217	33 404	27 657	–	–	–
				80	74										19 916	15 062	–
8	6	1,0	6	60	54	10	119 366	119 366	119 366	119 366	119 366	113 855	90 885	74 172	–	–	–
				80	74										52 043	38 493	–
	10			60	50		119 366	119 366	119 366	119 366	107 219	85 859	70 279	58 576	–	–	–
				80	70										49 568	42 487	–
10	6	2,0	6	60	54	10	95 493	95 493	95 493	95 493	95 493	94 304	76 266	62 954	–	–	–
				80	74										45 009	33 789	–
	10			60	50		95 493	95 493	95 493	95 493	84 098	68 248	56 533	47 627	–	–	–
				80	70										35 192	27 103	–
12	6	2,0	6	60	54	10	79 577	79 577	79 577	79 577	79 577	79 577	65 848	54 736	–	–	–
				80	74										39 613	30 044	–
	10			60	50		79 577	79 577	79 577	79 577	69 980	57 171	47 653	40 379	–	–	–
				80	70										30 150	23 435	–
	6	3,0		60	54	10	79 577	79 577	79 577	79 577	79 577	79 577	65 361	54 348	–	–	–
				80	74										39 353	29 861	–
	10			60	50		79 577	79 577	79 577	79 577	69 356	56 677	47 253	40 050	–	–	–
				80	70										29 917	23 263	–
15	6	2,0	6	60	54	10	63 662	63 662	63 662	63 662	63 662	63 662	54 391	45 512	–	–	–
				80	74										33 332	25 546	–
	10			60	50		63 662	63 662	63 662	63 662	55 980	45 986	38 530	32 812	–	–	–
				80	70										24 728	19 384	–
		2,0	8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									56 846	42 410	–	–
				100	90											32 914	–
	15			60	45		63 662	63 662	63 662	63 662	63 662	57 757	–	–	–	–	–
				80	65								49 152	42 382	–	–	–
				100	85										32 534	25 827	–

(continued)

Table C.7 (continued)

D	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 5	10	15	20	25	30	35	40	50	60	70
15	6	3,0	6	60	54	10	63 662	63 662	63 662	63 662	63 662	63 662	53 999	45 193	–	–	–
				80	74										33 111	25 386	
	10			60	50		63 662	63 662	63 662	63 662	55 523	45 618	38 228	32 559	–	–	–
				80	70										24 544	19 245	–
			8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									56 422	42 112	–	–
				100	90											32 697	26 160
	15			60	45		63 662	63 662	63 662	63 662	63 662	57 262	–	–	–	–	–
				80	65								48 741	42 036	32 280	–	–
				100	85											25 634	20 891
18	10	2,0	8	60	50	15	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									48 042	36 158	–	–
				100	90											28 285	22 785
	15			60	45		53 052	53 052	53 052	53 052	53 052	47 803	–	–	–	–	–
				80	65								40 837	35 343	–	–	–
				100	85										27 319	21 827	17 889
	10	3,0		60	50		53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									47 709	35 918	–	–
				100	90											28 106	22 646
	15			60	45		53 052	53 052	53 052	53 052	53 052	47 438	–	–	–	–	–
				80	65								40 531	35 081	–	–	–
				100	85										27 124	21 676	17 768
20	10	2,0	8	60	50	15	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–
				80	70									43 518	32 884	–	–
				100	90											25 819	20 869
	15			60	45		47 746	47 746	47 746	47 746	47 746	42 909	–	–	–	–	–
				80	65								36 717	31 827	24 676	–	–
				100	85											19 772	16 248
	10		10	60	50		47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–
				80	70									47 746	47 746	–	–
				100	90											38 950	31 268
	15			60	45		47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–	–
				80	65								47 746	47 746	–	–	–
				100	85										47 746	38 950	31 268

(continued)

Table C.7 (concluded)

D mm	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 5	10	15	20	25	30	35	40	50	60	70
20	10	3,0	8	60	50	15								–	–	–	–
				80	70		47 746	47 746	47 746	47 746	47 746	47 746	47 746	43 233	32 676	–	–
				100	90											25 662	20 746
	15			60	45								–	–	–	–	–
				80	65		47 746	47 746	47 746	47 746	47 746	42 604	36 459	31 607	24 510	–	–
				100	85											19 642	16 144
	10		10	60	50									–	–	–	–
				80	70		47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–
				100	90											38 726	31 097
	15			60	45								–	–	–	–	–
				80	65		47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	37 891	–	–
				100	85											30 201	24 689
22	10	2,0	10	60	50	15							–	–	–	–	–
				80	70		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	–	–
				100	90											35 960	28 974
	15			60	45								–	–	–	–	–
				80	65		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	34 805	–	–
				100	85											27 825	22 809
22	10	3,0	10	60	50	15								–	–	–	–
				80	70		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	–	–
				100	90											35 760	28 819
	15			60	45								–	–	–	–	–
				80	65		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	34 585	–	–
				100	85											27 655	22 675
25	10	2,0	10	60	50	15								–	–	–	–
				80	70		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	–	–
				100	90											32 197	26 052
	15			60	45								–	–	–	–	–
				80	65		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	30 756	–	–
				100	85											24 676	20 296
25	10	3,0	10	60	50	15								–	–	–	–
				80	70		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	–	–
				100	90											32 028	25 920
	15			60	45								–	–	–	–	–
				80	65		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	30 578	–	–
				100	85											24 537	20 185

Table C.8: Mounted points, cylindrical shape, reduced spindles (ZYA), metal bond (M)

D mm	T mm	X mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
									10	15	20	25	30	35	40	45	50	55	60	65	70
3	6	0,9	3	1,2	60	54	8	10	54 126	48 539	43 650	39 199	35 092	31 311	27 868	–	–	–	–	–	–
					80	74										24 773	22 025	19 605	17 490	–	–
4	6	1,0	3	2,0	60	54	8	10	108 665	91 105	74 720	60 846	49 717	40 990	34 175	–	–	–	–	–	–
					80	74										28 797	24 540	21 137	18 381	–	–
			6		60	54			105 275	87 739	76 080	67 326	60 235	54 205	48 924	–	–	–	–	–	–
					80	74										44 225	40 013	36 229	32 831	–	–
		1,2	3	1,6	60	54			71 022	63 566	55 886	48 450	41 660	35 724	30 677	–	–	–	–	–	–
					80	74										26 451	22 935	20 011	17 572	–	–
			6		60	54			67 656	56 986	49 960	44 794	40 712	37 318	34 389	–	–	–	–	–	–
					80	74										31 794	29 452	27 313	25 345	–	–
5	6	1,0	6	3,0	60	54	8	10	189 039	159 602	135 924	115 883	98 749	84 201	71 978	–	–	–	–	–	–
					80	74										61 789	53 329	46 306	40 463	–	–
		1,5	3	2,0	60	54			85 792	73 403	61 237	50 596	41 864	34 894	29 374	–	–	–	–	–	–
					80	74										24 963	21 435	18 589	16 266	–	–
			6		60	54			85 130	74 842	66 995	60 556	55 002	50 060	45 584	–	–	–	–	–	–
					80	74										41 497	37 762	34 355	31 261	–	–
6	8	1,0	6	4,0	60	52	12	10	–	149 112	127 498	108 361	91 869	77 982	66 461	–	–	–	–	–	–
					80	72										56 971	49 164	42 727	37 388	–	–
		1,5		3,0	60	52			–	84 705	76 678	69 304	62 457	56 117	50 302	–	–	–	–	–	–
					80	72										45 031	40 305	36 106	32 399	–	–
7	8	1,0	6	5,0	60	52	12	10	–	136 419	136 419	123 650	99 971	81 869	68 035	–	–	–	–	–	–
					80	72										57 306	48 857	42 106	36 639	–	–
		2,0		3,0	60	52			–	72 454	66 759	61 194	55 785	50 602	45 724	–	–	–	–	–	–
					80	72										41 216	37 111	33 418	30 125	–	–
8	10	1,5	6	5,0	60	50	15	10	–	119 366	104 575	88 077	74 240	62 822	53 490	–	–	–	–	–	–
					80	70										45 967	39 854	34 841	30 692	–	–
			8		60	50		15	–	119 366	110 583	98 732	87 806		–	–	–	–	–	–	–
					80	70								77 870	68 967	61 096	54 204	48 207	–	–	–
					100	90													43 009	38 506	34 604
	15				60	45			–	80 986	74 407	68 063	62 007	–	–	–	–	–	–	–	–
					80	65								56 307	51 019	46 177	41 792	–	–	–	–
					100	85												37 851	34 332	31 198	28 415

(continued)

Table C.8 (concluded)

D mm	T mm	X mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 10	15	20	25	30	35	40	45	50	55	60	65	70
8	10	2,0	6	4,0	60	50	15	10	–	77 711	70 771	63 759	56 982	50 671	44 962	–	–	–	–	–	–
					80	70										39 899	35 466	31 614	28 278	–	–
			8		60	50		15							–	–	–	–	–	–	–
					80	70			–	77 711	71 695	66 167	60 997	56 125					–	–	–
					100	90									51 537	47 238	43 238	39 545	36 160	33 078	30 283
	15				60	45								–	–	–	–	–	–	–	–
					80	65			–	50 193	47 301	44 525	41 837					–	–	–	–
					100	85								39 230	36 705	34 274	31 948	29 738	27 655	25 703	23 886
9	10	2,0	6	5,0	60	50	15	10	–	106 103	91 941	78 041	66 236	56 394	–	–	–	–	–	–	–
					80	70									48 283	41 699	36 317	31 879	–	–	–
			8		60	50		15							–	–	–	–	–	–	–
					80	70			–	106 103	97 822	88 396	79 394	70 992					–	–	–
					100	90									63 318	56 429	50 325	44 963	40 277	36 190	32 628
	15				60	45									–	–	–	–	–	–	–
					80	65			–	70 089	65 133	60 162	55 272	50 559				–	–	–	–
					100	85									46 107	41 971	38 179	34 738	31 638	28 859	26 374
10	10	2,0	8	6,0	60	50	15	15							–	–	–	–	–	–	–
					80	70			–	95 493	95 493	95 493	92 364	79 998					–	–	–
					100	90									69 420	60 476	52 932	46 525	41 148	36 608	32 752
	15				60	45									–	–	–	–	–	–	–
					80	65			–	91 200	82 233	73 529	65 413	58 068					–	–	–
					100	85									51 555	45 854	40 900	36 608	32 865	29 623	26 812

Table C.9: Mounted points, cylindrical shape, plain spindles (ZYN), resinoid bond (B)

D mm	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 5	10	15	20	25	30	35	40	50	60	70
4	6	0,5	3	60	54	10	238 732	238 732	166 273	115 177	84 268	64 238	50 550	40 795	–	–	–
				80	74										28 156	20 586	
5	6	1,0	3	60	54	10	190 986	190 986	139 235	98 489	73 258	56 594	45 028	36 676	–	–	–
				80	74										25 687	18 990	–
6	6	1,0	3	60	54	10	159 155	159 155	112 265	80 845	61 049	47 777	38 441	31 620	–	–	–
				80	74										22 511	16 861	–
8	6	1,0	6	60	54	10	119 366	119 366	119 366	119 366	119 366	119 366	98 911	80 165	–	–	–
				80	74										55 635	40 812	–
	10			60	50		119 366	119 366	119 366	119 366	119 366	96 973	78 685	65 088	–	–	–
				80	70										46 627	35 014	–
10	6	2,0	6	60	54	10	95 493	95 493	95 493	95 493	95 493	95 493	88 105	72 071	–	–	–
				80	74										50 756	37 648	–
	10			60	50		95 493	95 493	95 493	95 493	95 493	82 282	67 528	56 413	–	–	–
				80	70										41 079	31 251	–
12	6	2,0	6	60	54	10	79 577	79 577	79 577	79 577	79 577	79 577	75 217	62 134	–	–	–
				80	74										44 480	33 427	–
	10			60	50		79 577	79 577	79 577	79 577	79 577	67 085	55 609	46 879	–	–	–
				80	70										34 679	26 734	–
	6	3,0		60	54		79 577	79 577	79 577	79 577	79 577	79 577	78 727	64 869	–	–	–
				80	74										46 237	34 626	–
	10			60	50		79 577	79 577	79 577	79 577	79 577	71 021	58 730	49 400	–	–	–
				80	70										36 400	27 967	–
15	6	2,0	6	60	54	10	63 662	63 662	63 662	63 662	63 662	63 662	61 086	50 925	–	–	–
				80	74										37 045	28 222	–
	10			60	50		63 662	63 662	63 662	63 662	63 662	52 413	43 790	37 188	–	–	–
				80	70										27 882	21 753	–
			8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									63 662	47 459	–	–
				100	90											36 569	29 063
	15			60	45		63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–	–
				80	65								56 404	48 453	36 939	–	–
				100	85											29 142	23 608

(continued)

Table C.9 (continued)

D mm	T mm	X mm	S_d mm	L_1 mm	L_2 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 5	10	15	20	25	30	35	40	50	60	70
15	6	3,0	6	60	54	10	63 662	63 662	63 662	63 662	63 662	63 662	63 662	53 070	–	–	–
				80	74										38 495	29 254	–
	10			60	50		63 662	63 662	63 662	63 662	63 662	55 065	45 946	38 972	–	–	–
				80	70										29 153	22 698	–
			8	60	50	15	63 662	63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–
				80	70									63 662	49 460	–	–
				100	90											37 995	30 117
	15			60	45		63 662	63 662	63 662	63 662	63 662	63 662	–	–	–	–	–
				80	65								59 440	50 975	38 740	–	–
				100	85											30 479	24 631
15	10	2,0	8	60	50	15	53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									53 052	39 936	–	–
				100	90											31 096	24 943
	15			60	45		53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–	–
				80	65								45 784	39 540	30 442	–	–
				100	85											24 232	19 790
	10	3,0		60	50		53 052	53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–
				80	70									53 052	41 478	–	–
				100	90											32 232	25 807
	15			60	45		53 052	53 052	53 052	53 052	53 052	53 052	–	–	–	–	–
				80	65								47 871	41 302	31 741	–	–
				100	85											25 224	20 570
20	10	2,0	8	60	50	15	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–
				80	70									47 746	36 046	–	–
				100	90											28 201	22 720
	15			60	45		47 746	47 746	47 746	47 746	47 746	47 631	–	–	–	–	–
				80	65								40 693	35 220	27 227	–	–
				100	85											21 756	17 832
	10		10	60	50		47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–
				80	70									47 746	47 746	–	–
				100	90											42 306	33 812
	15			60	45		47 746	47 746	47 746	47 746	47 746	47 746	–	–	–	–	–
				80	65								47 746	47 746	42 045	–	–
				100	85											33 366	27 165

(continued)

Table C.9 (concluded)

D	T	X	S_d	L_1	L_2	L_3	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm										
mm	mm	mm	mm	mm	mm	mm min.	5	10	15	20	25	30	35	40	50	60	70
20	10	3,0	8	60	50	15								–	–	–	–
				80	70		47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	37 350	–	–
				100	90											29 176	23 472
	15			60	45								–	–	–	–	–
				80	65		47 746	47 746	47 746	47 746	47 746	47 746	42 374	36 649	28 295	–	–
				100	85											22 582	18 488
	10		10	60	50									–	–	–	–
				80	70		47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	–	–
				100	90											43 663	34 831
	15			60	45								–	–	–	–	–
				80	65		47 746	47 746	47 746	47 746	47 746	47 746	47 746	47 746	43 674	–	–
				100	85											34 594	28 118
22	10	2,0	10	60	50	15								–	–	–	–
				80	70		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	–	–
				100	90											38 873	31 210
	15			60	45								–	–	–	–	–
				80	65		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	38 058	–	–
				100	85											30 329	24 789
22	10	3,0	10	60	50	15								–	–	–	–
				80	70		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	–	–
				100	90											40 064	32 116
	15			60	45								–	–	–	–	–
				80	65		43 406	43 406	43 406	43 406	43 406	43 406	43 406	43 406	39 420	–	–
				100	85											31 371	25 608
25	10	2,0	10	60	50	15								–	–	–	–
				80	70		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	–	–
				100	90											34 579	27 906
	15			60	45								–	–	–	–	–
				80	65		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	33 300	–	–
				100	85											26 659	21 882
25	10	3,0	10	60	50	15								–	–	–	–
				80	70		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	–	–
				100	90											35 561	28 666
	15			60	45								–	–	–	–	–
				80	65		38 197	38 197	38 197	38 197	38 197	38 197	38 197	38 197	34 368	–	–
				100	85											27 487	22 541

Table C.10: Mounted points, cylindrical shape, reduced spindles (ZYA), resinoid bond (B)

D mm	T mm	X mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm: 10	15	20	25	30	35	40	45	50	55	60	65	70
3	6	0,9	3	1,2	60	54	8	10	69 769	59 450	51 683	45 309	39 836	35 049	30 847	–	–	–	–	–	–
					80	74										27 171	23 971	21 201	18 808	–	–
4	6	1,0	3	2,0	60	54	8	10	138 467	112 444	89 999	71 888	57 828	47 065	38 815	–	–	–	–	–	–
					80	74										32 404	27 394	23 431	20 251	–	–
			6		60	54			129 236	100 509	84 225	73 029	64 456	57 444	51 473	–	–	–	–	–	–
					80	74										46 268	41 672	37 592	33 962	–	–
5	6	1,0	3	3,0	60	54	8	10	190 986	139 235	98 489	73 258	56 594	45 028	36 676	–	–	–	–	–	–
					80	74										30 451	25 687	21 960	18 990	–	–
			6		60	54			190 986	184 027	152 130	127 203	106 916	90 244	76 539	–	–	–	–	–	–
					80	74										65 294	56 067	48 478	42 209	–	–
		1,5	3	2,0	60	54			112 555	94 005	76 861	62 431	50 905	41 894	34 875	–	–	–	–	–	–
					80	74										29 347	24 980	21 494	18 674	–	–
			6		60	54			108 553	89 646	77 349	68 238	60 921	54 738	49 348	–	–	–	–	–	–
					80	74										44 567	40 292	36 459	33 023	–	–
6	8	1,0	6	4,0	60	52	12	10	–	159 155	147 424	122 788	102 525	85 995	72 591	–	–	–	–	–	–
					80	72										61 738	52 929	45 742	39 835	–	–
		1,5		3,0	60	52			–	106 144	92 719	81 665	72 168	63 851	56 528	–	–	–	–	–	–
					80	72										50 090	44 450	39 530	35 250	–	–
7	8	1,0	6	5,0	60	52	12	10	–	136 419	136 419	136 419	111 661	90 507	74 576	–	–	–	–	–	–
					80	72										62 366	52 845	45 302	39 238	–	–
		2,0		3,0	60	52			–	93 046	83 122	74 385	66 518	59 394	52 968	–	–	–	–	–	–
					80	72										47 216	42 109	37 606	33 654	–	–
8	10	1,5	6	5,0	60	50	15	10	–	119 366	119 366	105 225	87 512	73 204	61 710	–	–	–	–	–	–
					80	70										52 568	45 225	39 264	34 375	–	–
			8		60	50		15	–	119 366	119 366	115 616	100 991	88 293	77 296	67 816	–	52 709	–	–	–
					80	70											59 678		–	–	–
					100	90													46 742	41 630	37 238
	15				60	45			–	101 752	91 148	81 709	73 220	–	–	–	–	–	–	–	–
					80	65								65 580	58 734	52 632	47 223	–	–	–	–
					100	85												42 448	38 244	34 548	31 298

(continued)

Table C.10 (concluded)

D mm	T mm	X mm	S_d mm	S_1 mm min.	L_1 mm	L_2 mm	L_4 mm	L_3 mm min.	Maximum speeds of rotation n_{max} in min^{-1} for overhang length L_o in mm												
									10	15	20	25	30	35	40	45	50	55	60	65	70
8	10	2,0	6	4,0	60	50	15	10	–	100 223	89 266	78 940	69 442	60 917	53 417	–	–	–	–	–	–
					80	70										46 912	41 319	36 530	32 435	–	–
			8		60	50		15	–	100 223	89 109	80 010	72 206	65 324	–	–	–	–	–	–	–
					80	70									59 160	53 604	48 590	44 071	–	–	–
					100	90													40 009	36 368	33 111
	15				60	45			–	65 472	59 984	55 196	50 904	–	–	–	–	–	–	–	–
					80	65								46 989	43 383	40 047	36 958	–	–	–	–
					100	85												34 101	31 466	29 044	26 822
9	10	2,0	6	5,0	60	50	15	10	–	106 103	106 103	95 880	80 346	67 643	57 338	–	–	–	–	–	–
					80	70										49 078	42 401	36 950	32 457	–	–
			8		60	50		15	–	106 103	106 103	106 103	93 992	82 816	–	–	–	–	–	–	–
					80	70									72 955	64 338	56 862	50 404	–	–	–
					100	90													44 839	40 044	35 906
	15				60	45			–	90 049	81 869	74 248	67 158	–	–	–	–	–	–	–	–
					80	65								60 615	54 636	49 228	44 376	–	–	–	–
					100	85												40 052	36 214	32 817	29 814
10	10	2,0	8	6,0	60	50	15	15	–	95 493	95 493	95 493	95 493	93 311	–	–	–	–	–	–	–
					80	70									80 094	69 118	59 997	52 351	–	–	–
					100	90													46 000	40 688	36 212
	15				60	45			–	95 493	95 493	90 212	79 217	–	–	–	–	–	–	–	–
					80	65								69 522	61 102	53 856	47 648	–	–	–	–
					100	85												42 337	37 756	33 825	30 445

C.4 Calculation of the maximum speeds of rotation

C.4.1 Validity of the calculation model

The calculation model for the determination of the maximum speeds of rotation of mounted points is based on mathematical relations connecting the physical relationships between the geometric dimensions and material properties of a mounted point and a rotational stress in such a way that the real processes are described with sufficient precision. The calculation model represents the real processes which, however, are not identical with the actual procedure. The quality of the calculation model is determined by a desirable high congruence between the actual procedure and its representation in a model. By means of experimental tests, this congruence has been proven for points as are described in the preceding tables in their constructional shapes and geometric dimensions. In order to prove the validity of the calculation model beyond this scope, it will be necessary to carry out further practical tests. The calculation model is not suited to describe the influence of notch effect processes at reduced parts of spindles and run-out tolerances of the wheel spindle and the chuck on the maximum speeds of rotation.

C.4.2 Calculation model

C.4.2.1 Mounted points with plain and reduced spindles

The maximum speeds of rotation are calculated with the derived relation (1):

a) for plain spindles ZYN

b) for reduced spindles ZYA

$$n_{max} = \frac{30}{\pi \cdot s_{ab}} \cdot \sqrt{\frac{3 \cdot E \cdot I^*}{C_e \cdot m^* \cdot L_k^3}} \quad [\text{min}^{-1}] \tag{1}$$

with

a) plain spindles ZYN:

$$\frac{I^*}{L_k^3} = \frac{I}{L^3} \tag{2}$$

b) reduced spindles ZYA:

$$\frac{I^*}{L_k^3} = \frac{I_S}{\frac{I_S}{I_{S1}}\left(T + L_4\right)^3 + L^3 - \left(T + L_4\right)^3} \tag{3}$$

$$I_S = \frac{\pi \cdot S^4}{64} \tag{4}$$

b) reduced spindles ZYA:

$$I_{S1} = \frac{\pi \cdot S_1^4}{64} \tag{5}$$

$$C_e = 1 + \frac{e}{w_{ab}} \tag{6}$$

and

a) plain spindles ZYN:

$$w_{ab} = \frac{2 \cdot \sigma_{zul} \cdot L^2}{3 \cdot E \cdot S} \tag{7}$$

b) reduced spindles ZYA:

$$w_{ab} = \frac{F_{zul}}{3 \cdot E} \cdot \left[\frac{(L_4 + T)^3}{I_{S1}} + \frac{L^3 - (L_4 + T)^3}{I_S}\right] \tag{8}$$

F_{zul} is the maximum force just permitted without exceeding the permissible bending. It is determined by a separate calculation of the reduced part of the spindle and the non-reduced part of the spindle according to formula (9).

$$F_{zul} = \min \begin{cases} \dfrac{2 \cdot \sigma_{zul} \cdot I_{s1}}{S_1 \cdot (L_4 + T)} \\[2ex] \dfrac{2 \cdot \sigma_{zul} \cdot I_s}{S_d \cdot L} \end{cases} \tag{9}$$

σ_{zul} corresponds to the yield point R_e of the spindle material. The protruding length L of the mounted point is calculated by:

$$L = L_0 + T \tag{10}$$

The reduced mass m^* is calculated by the relations specified below. The mounted point can be divided into partial volumes (figure C.1). The reduced mass is then determined by a summation of the partial volumes combined by multiplication with the corresponding specific density of the material used for the shaft, the abrasive product and the abrasive section:

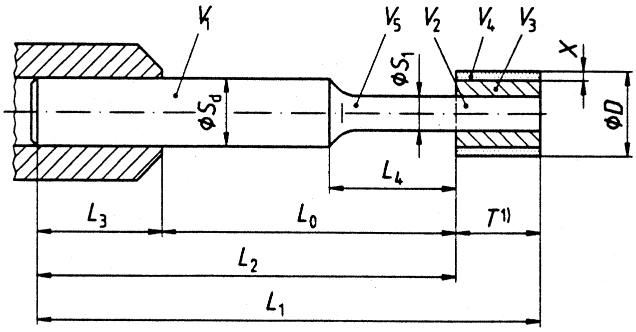


Figure C.1: Volume division for mounted points with reduced spindle (ZYA)

$$m^* = k_m \cdot \varrho_s \cdot (V_1 + V_2) + \varrho_T \cdot V_3 + \varrho_{Sk} \cdot V_4 \qquad (11)$$

Reduced mass for the non-reduced spindle and

$$m^* = k_m \cdot \varrho_s \cdot (V_1 + V_2 + V_5) + \varrho_T \cdot V_3 + \varrho_{Sk} \cdot V_4 \qquad (12)$$

reduced mass for the reduced spindle.

The following relations apply:

$$V_1 = \frac{\pi}{4} \cdot S_d^2 \cdot L_0 \qquad (13)$$

$$V_1 = \frac{\pi}{4} \cdot S_d^2 \cdot (L_0 - L_4) \qquad (14)$$

$$V_2 = \frac{\pi}{4} \cdot S_d^2 \cdot T \qquad (15)$$

$$V_2 = \frac{\pi}{4} \cdot S_1^2 \cdot T \qquad (16)$$

$$V_3 = \frac{\pi}{4} \cdot \left[(D - 2\,X)^2 - S^2\right] \cdot T \qquad (17)$$

$$V_3 = \frac{\pi}{4} \cdot \left[(D - 2\,X)^2 - S_1^2\right] \cdot T \qquad (18)$$

$$V_4 = \frac{\pi}{4} \cdot \left[D^2 - (D - 2\,X)^2\right] \cdot T \qquad (19)$$

$$V_5 = \frac{\pi}{4} \cdot S_1^2 \cdot L_4 \qquad (20)$$

With the quantity k_m, a reduction factor is introduced by means of which the mass of the spindle is only partially added to the mass of the abrasive product. As a function of the structure of the abrasive product and the type of bond, the following conditions apply to the relations (11) and (12) for the calculation of the reduced masses.

Bond G: the depth of the abrasive section X, here single layer, is neglected in the calculation of the mass (X = 0, V_4 = 0), the abrasive product is made of steel ($\varrho_T = \varrho_S$)

Bond V: the volume of the section (V_4) and the volume of the support (V_3) are made of ceramics ($\varrho_{Sk} = \varrho_T$)

Bond B, M: the volume of the support (V_3) is made of steel ($\varrho_T = \varrho_S$)

By means of the relations described above, the maximum speed of rotation of a mounted point can be calculated for a given unsupported overhang length L_0 with the relation (1), since all other quantities are specific material constants, are given by the geometric dimensions or were or may be empirically determined, as the mass eccentricity.

Table C.11: Designation of the calculation quantities

C_e	–	Factor
I_s, I_{s1}	mm^4	Geometrical moment of inertia
L	mm	Protruding length of the mounted point ($L = L_0 + T$)
L_k	mm	Coefficient of length
m*	g	Reduced mass of the mounted point
V_1	mm^3	Spindle volume (non-reduced part)
V_2	mm^3	Spindle volume within the abrasive product
V_3	mm^3	Support volume
V_4	mm^3	Abrasive section volume
V_5	mm^3	Volume of reduced spindle
w_{ab}	mm	Permissible bending of spindle
ϱ_{Sk}	g/cm^3	Abrasive section density
ϱ_T	g/cm^3	Support density

Annex D (informative)

Speed conversion table for speed of rotation and peripheral speed

Diameter of superabrasive in mm	Maximum operating speed v_s in m/s														
	5	**6**	**8**	**10**	**12**	**16**	**20**	**25**	**32**	**35**	**40**	**45**	**50**	**63**	**80**
6	16000	19100	25500	31900	38200	51000	64000	80000	102000	112000	128000	143240	160000	201000	
8	12000	14400	19100	24000	29000	38200	48000	60000	76500	84000	95500	107430	120000	150500	191000
10	9600	11500	15300	19100	23000	30600	38200	48000	61200	67000	76500	86000	95500	120500	153000
13	7400	8850	11800	14700	17700	23550	29500	35600	47100	51500	58800	66500	73500	92600	118000
16	6000	7200	9550	11950	14350	19100	23900	29850	38200	41800	47800	54000	59700	75200	95500
20	4800	5750	7650	9550	11500	15300	19100	23900	30600	33500	38200	43000	47800	60200	76500
25	3850	4600	6150	7650	9200	12300	15300	19100	24500	26800	30600	34400	38200	48200	61200
32	3000	3600	4800	6000	7200	9550	11950	14950	19100	20900	23900	26900	30000	37600	48000
40	2400	2900	3850	4800	5750	7650	9550	11950	15300	16750	19100	21500	23900	30100	38200
50	1950	2300	3100	3850	4600	6150	7650	9550	12250	13400	15300	17200	19100	24100	30600
63	1550	1850	2450	3050	3650	4850	6100	7600	9750	10650	12150	13650	15200	19100	24300
80	1200	1450	1950	2400	2900	3850	4800	6000	7650	8400	9550	10750	12000	15100	19100
100	960	1150	1550	1950	2300	3100	3850	4800	6150	6700	7650	8600	9550	12100	15300
115	830	1000	1350	1700	2000	2700	3350	4200	5350	5850	6650	7500	8350	10500	13300
125	770	920	1250	1550	1850	2450	3100	3850	4900	5350	6150	6900	7650	9650	12250
150	640	770	1050	1300	1550	2050	2550	3200	4100	4500	5100	5750	6400	8050	10200
180	530	640	850	1100	1300	1700	2150	2700	3400	3750	4250	4800	5350	6700	8500
200	480	580	765	955	1150	1550	1950	2400	3100	3350	3850	4300	4800	6050	7650
230	420	500	665	830	1000	1350	1700	2100	2700	2950	3350	3750	4200	5250	6650
250	380	460	615	765	920	1250	1550	1950	2450	2700	3100	3450	3850	4850	6150
300	320	380	510	640	765	1050	1300	1600	2050	2250	2550	2870	3200	4050	5100
350/ 356	280	330	440	550	655	875	1100	1400	1750	1950	2200	2450	2750	3450	4400
400/ 406	240	290	385	480	575	765	960	1200	1550	1700	1950	2150	2400	3050	3850
450/ 457	210	255	340	425	510	680	850	1100	1400	1500	1700	1950	2150	2700	3400
500/ 508	190	230	310	385	460	615	765	960	1250	1350	1550	1750	1950	2450	3100
600/ 610	160	190	255	320	385	510	640	800	1050	1150	1300	1450	1600	2050	2550
750/ 762	130	155	205	255	310	410	510	640	820	895	1050	1150	1300	1650	2050
800/ 813	120	145	195	240	290	385	480	600	765	840	960	1075	1200	1550	1950
900/ 914	110	130	170	215	255	340	425	535	680	750	850	955	1100	1350	1700
1000/ 1015	100	115	155	195	230	310	385	480	615	670	765	860	960	1250	1550
1060/ 1067	95	110	150	185	220	295	365	455	585	640	730	820	910	1150	1500
1120	90	105	140	175	210	280	350	435	560	610	695	780	870	1100	1400
1220	85	95	130	160	195	255	320	400	510	560	640	720	800	1050	1300
1500	65	75	105	130	155	205	255	320	410	450	510	757	640	805	1050
1800	55	65	85	110	130	170	220	265	340	375	425	475	535	670	850

Diameter of superabrasive in mm	Maximum operating speed v_s in m/s												
	100	**125**	**140**	**160**	**180**	**225**	**250**	**280**	**320**	**360**	**400**	**450**	**500**
6													
8													
10	191000												
13	147000	184000	206000										
16	120000	150000	168000	191000									
20	95500	120000	134000	153000	172000								
25	76500	95500	107000	123000	138000	172000	191000						
32	60000	75000	84000	95500	107500	135000	150000	168000	191000				
40	47800	59700	67000	76500	86000	107500	120000	134000	153000	172000	191000		
50	38200	47750	53500	61200	68800	86000	95500	107000	123000	138000	153000	172000	191000
63	30350	37900	42500	48500	54600	68250	75800	84900	97000	110000	121500	136500	152000
80	23900	29850	33500	38200	43000	53750	59700	66900	76500	86000	95500	107500	120000
100	19100	23900	26800	30600	34400	43000	47750	53500	61200	69000	76500	86000	95500
115	16650	20800	23250	26600	30000	37400	41550	46500	53200	60000	66500	75000	83000
125	15300	19100	21400	24500	27500	34400	38200	42800	48900	55000	61200	68800	76500
150	12750	16000	17850	20400	23000	28650	31850	36700	40800	45900	51000	57500	63700
180	10650	13300	14900	17000	19100	23900	26550	29700	34000	38200	42500	48000	53100
200	9550	11950	13400	15300	17200	21500	23900	26750	30600	34400	38200	43000	47800
230	8350	10400	11650	13300	14950	18700	20800	23250	26600	29900	33300	37400	41600
250	7650	9550	10700	12250	13800	17200	19100	21400	24500	27500	30600	34400	38200
300	6400	8000	8950	10200	11500	14350	15950	17850	20400	23000	25500	28650	31900
350/ 356	5500	6850	7650	8750	9850	12300	13650	15300	17500	19650	21900	24600	27300
400/ 406	4800	6000	6700	7650	8600	10750	11950	13400	15300	17200	19100	21500	23900
450/ 457	4250	5350	5950	6800	7650	9550	10650	11900	13600	15300	17000	19100	21250
500/ 508	3850	4800	5350	6150	6900	8600	9550	10700	12250	13800	15300	17200	19100
600/ 610	3200	4000	4500	5100	5750	7200	8000	8950	10200	11500	12750	14350	15950
750/ 762	2550	3200	3600	4100	4600	5750	6400	7150	8150	9200	10200	11500	12750
800/ 813	2400	3000	3350	3850	4300	5400	6000	6700	7650	8600	9550	10750	11950
900/ 914	2150	2700	3000	3400	3850	4800	5350	5950	6800	7650	8500	9550	10650
1000/ 1015	1950	2400	2700	3100	3450	4300	4800	5350	6150	6900	7650	8600	9550
1060/ 1067	1850	2300	2550	2950	3300	4100	4550	5100	5850	6550	7300	8200	9100
1120	1750	2200	2450	2800	3150	3960	4350	4900	5600	6250	6950	7850	8700
1220	1600	2000	2250	2550	2900	3600	4000	4500	5100	5750	6400	7200	8000
1500	1300	1600	1800	2050	2300	2900	3200	3600	4100	4600	5100	5750	6400
1800	1100	1350	1500	1700	1950	2400	2650	3000	3400	3850	4250	4800	5350

Annex E (informative)

Shapes and dimensions of grinding wheels and cutting-off wheels

E.1 Shapes and dimensions of grinding wheels and cutting-off wheels

E.1.1 Structure of the designation

E.1.1.1 Principle core shapes, see table E.1.

E.1.1.2 The first position in the system for the determination of the standard types of superabrasive wheels specifies the core shape, on which the diamond or CBN abrasive section is mounted.

E.1.1.3 The symbol is defined irrespective of the location of the superabrasive section or the end use of the wheel.

E.1.1.4 The presence of a recess in the core to accommodate the superabrasive section does not affect the determination of the symbol.

E.1.1.5 A recess or bevel shall not affect the determination of the symbol.

E.1.1.6 The designation is realized by means of numbers and shall comply with the recommendations for the determination of other superabrasive wheel types.

E.1.1.7 For superabrasive section see table E.2.

E.1.1.8 The second position in the system for the determination of the standard types of superabrasive wheels specifies the shape of the superabrasive cross-section.

E.1.1.9 The location of the superabrasive section on the core does not affect the designation of the cross section.

E.1.1.10 The axis of the superabrasive section may be in any direction. The superabrasive section is defined by four surfaces: outside surface, inside surface and two side surfaces.

E.1.1.11 The designation is realized by means of letters and shall comply with the recommendations for the designation of active wheel surfaces of other wheels.

Designation of a superabrasive wheel

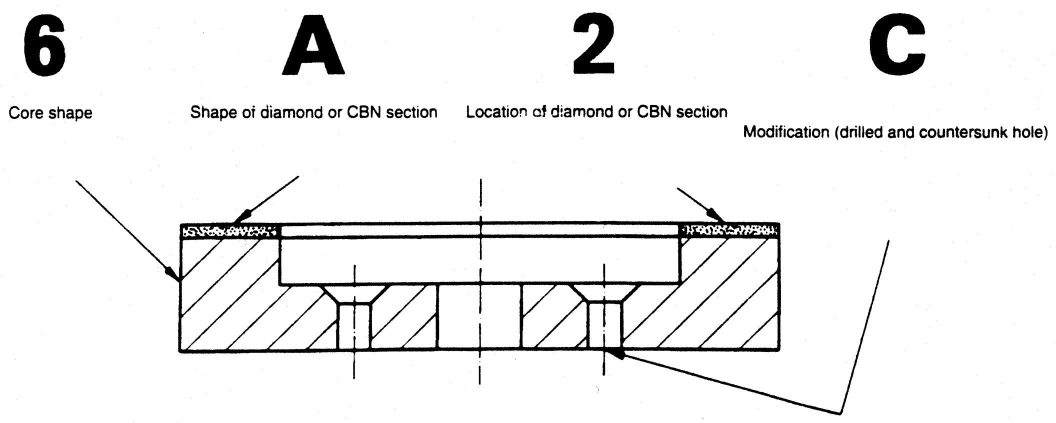


Figure E.1

Table E.1: Core shapes and designations

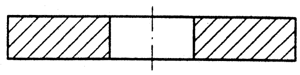
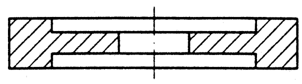
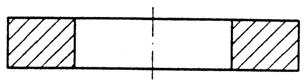
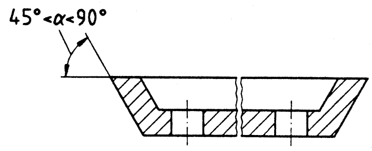
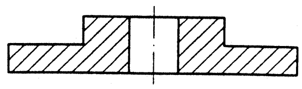
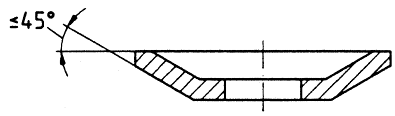
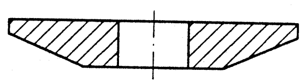
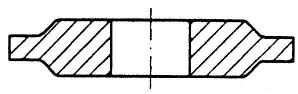
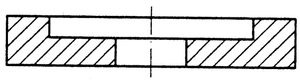
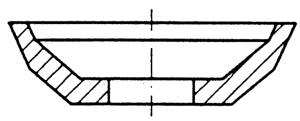
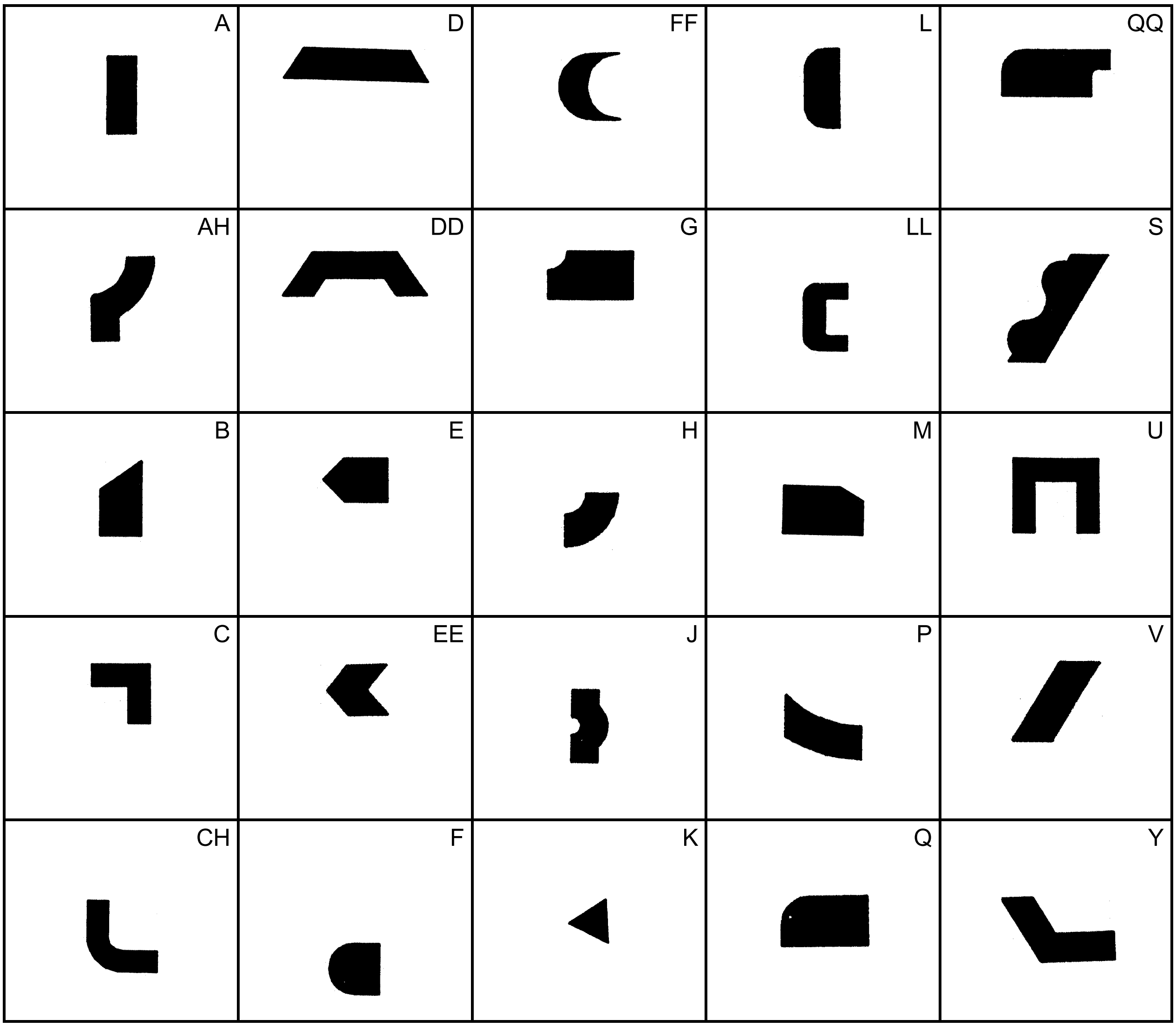
1 	9 
2 	11 
3 	12 
4 	14 
6 	15 

Table E.2: Shape of the superabrasive section and its designation



E.1.2 Location of the superabrasive section, see table E.3

E.1.2.1 The third position in the system for the determination of standard types of superabrasive wheels describes the location of the superabrasive section on the core. A general rule for the location of the superabrasive section on the core is that the outer points of an angular or convex cross section (section) will correspond to the outside diameter.

E.1.2.2 The designation is realized by means of numbers.

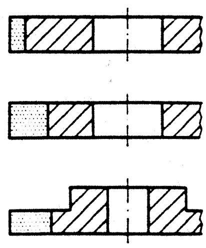
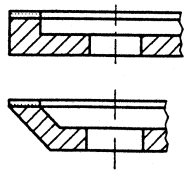
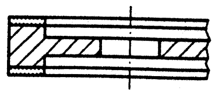
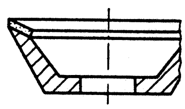
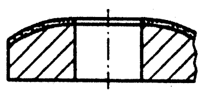
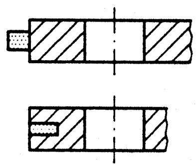
E.1.3 Modifications, see table E.4.

The fourth position in the system for the determination of the standard types of superabrasive wheels describes the modifications. The designation is realized by means of letters.

This fourth position is only added if necessary.

Modifications from standard wheel types are permitted within the specified designations.

Table E.3: Location and designation

Number of location	Definition	Shape
1 – periphery	The superabrasive section is placed on the periphery of the core and extends the full thickness of the wheel. The axial length of this section may be greater than, equal to, or less than the depth of diamond or CBN, measured radially. One or more hubs are not added to the wheel thickness for the purpose of this description.	
2 – one side	The superabrasive section is placed on the side of the wheel and the length of the superabrasive section extends from the periphery towards the centre. It may or may not include the entire side and shall be greater than the diamond or CBN depth measured axially	
3 – both sides	The superabrasive sections are placed on both sides of the wheel and extend from the periphery towards the centre. They may or may not include the entire sides, and the radial length of the superabrasive section exceeds the axial diamond or CBN depth	
4 – inside bevel or arc	This designation applies to the general wheel types 2, 6, 11, 12 and 15, and locates the superabrasive section on the side wall. This wall has an angle or arc extending from a higher point at the wheel periphery to a lower point towards the wheel centre.	
5 – outside bevel or arc	This designation applies to the general wheel types 2, 6, 11, and 15 and locates the superabrasive section on the side wall. This wall has an angle or arc extending from a lower point at the wheel periphery to a higher point toward the wheel centre	
6 – Part of periphery	The superabrasive section is placed on the periphery of the core but does not extend the full thickness of the wheel and does not reach to either side.	

(continued)

Table E.3 (concluded)

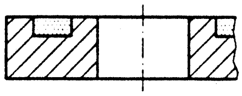
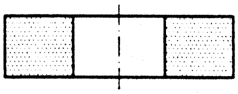
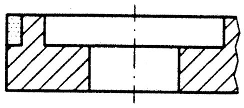
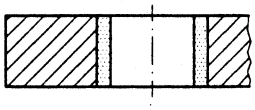
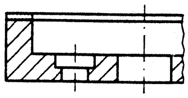
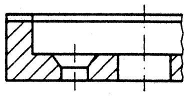
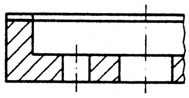
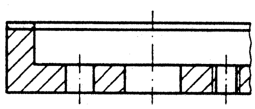
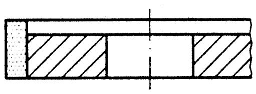
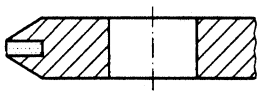
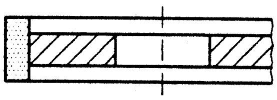
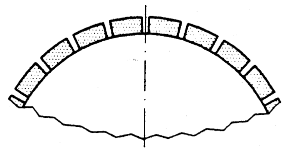
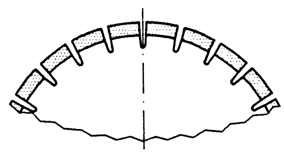
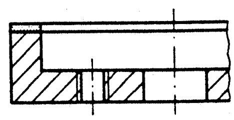
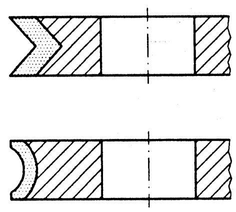
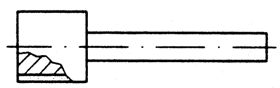
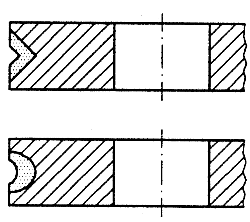
Number of location	Definition	Shape
7 – Part of side	The superabrasive section is placed on the side of the core and does not extend to the wheel periphery. It may or may not extend to the centre.	
8 – throughout	No core, superabrasive wheel consists of solid superabrasive section.	
9 – corner	This designates a location which would commonly be considered to be on the periphery except that the superabrasive section is on one corner but does not extend to the other corner.	
10 – annular	This designates a location of the superabrasive section on the inner annular of the wheel	

Table E.4: Modifications and designation

Symbol	Designation	Shape
B – drill and counterbore	Holes drilled and counterbored in core	
C – drill and countersink	Holes drilled and countersunk in core	
H – plain hole	Straight holes drilled in core	
M – holes plain and threaded	Mixed holes, some plain, some threaded, in the core	
P – relieved one side	Relief on one side of the wheel, thickness of core less than wheel thickness	
Q – superabrasive inserted	Three surfaces of the superabrasive section are partially or wholly enclosed by the core	
R – relieved two sides	Relief on both sides of the superabrasive wheel. The thickness of the core is less than the wheel thickness	

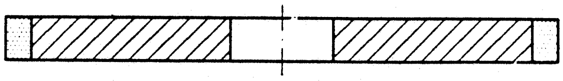
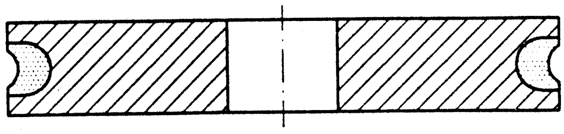
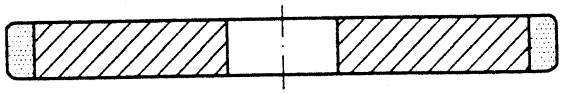
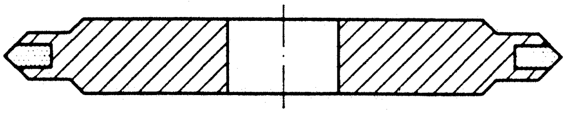
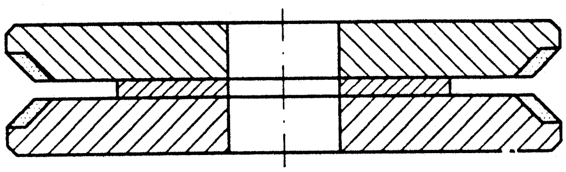
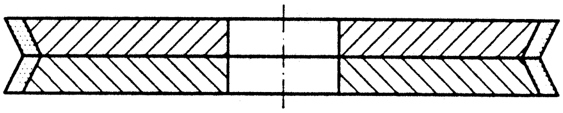
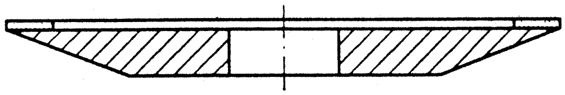
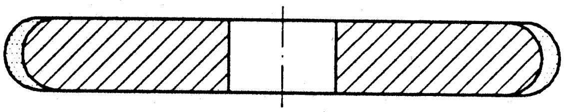
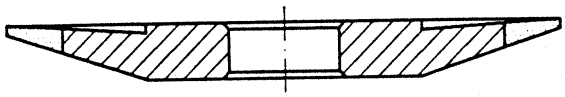
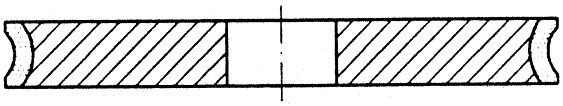
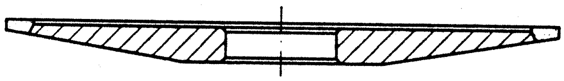
(continued)

Table E.4 (concluded)

Symbol	Designation	Shape
S – segmented diamond sections	The superabrasive wheel has a section which is interrupted by grooves and applied to a core with solid rim (Clearance between segments has no bearing on definition)	
SS – segmented and slotted	Superabrasive wheel, having segments mounted on solid and slotted core rim.	
T – threaded holes	Threaded holes in core	
V – superabrasive inverted	The superabrasive cross-section is considered inverted if it is mounted on the core so that the interior point of any angle or the concave side of any arc is exposed Exception: superabrasive section AH is placed on the core with the concave side of the arc exposed	
W – on shaft	Superabrasive section core and mounting shaft cannot be dismounted	
Y – superabrasive inserted and inverted	See definitions for Q and V	

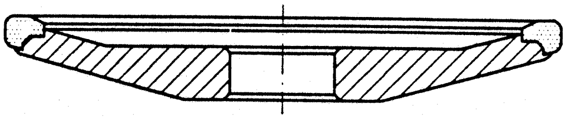
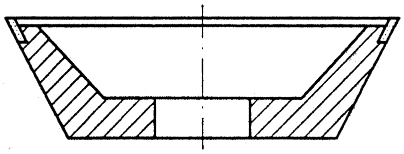
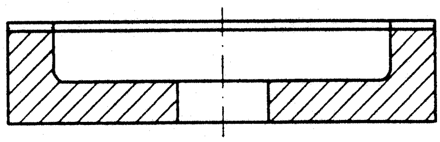
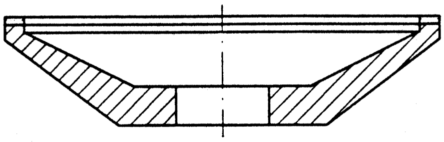
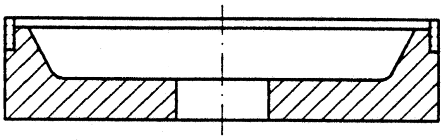
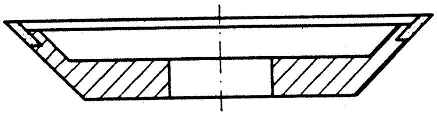
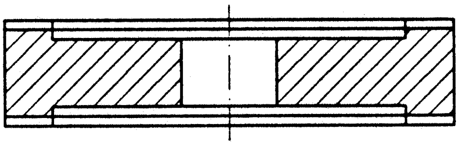
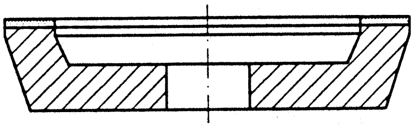
E.2 Examples for wheel shapes and designations

Table E.5: Types, designations and nominal dimensions for grinding wheels

Type 1A1 	Type 1FF6Y 
Type 1E6Q 	Type 1L1 
Type 14E6Q 	Type 1V9 
Type 1EE1V 	Type 4A2 
Type 1FF1 	Type 4BT9 
Type 1FF1V 	Type 4ET9 

(continued)

Table E.5 (continued)

Type 4C2 	Type 11V9 
Type 6A2 	Type 12A2 
Type 6A9 	Type 12V9 
Type 9A3 	Type 14A1 
Type 11A2 	Type 14EE1 

(continued)

Table E.5 (concluded)

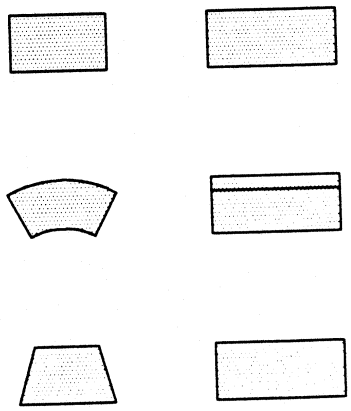
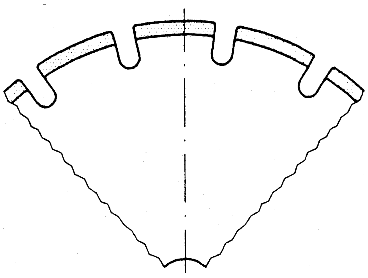
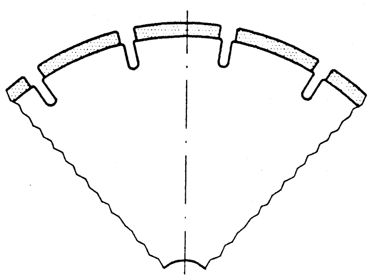
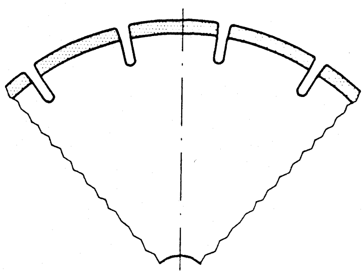
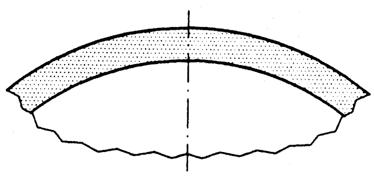
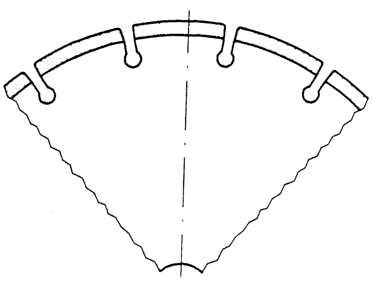
Type 31 Superabrasive segment Examples 	

Table E.6: Types, designations and nominal dimensions for cutting-off wheels

Type 1A1 C1 wide spacing, wide slots 	Type 1A1 C4 wide spacing, narrow slots 
Type 1A1 C2 narrow spacing, narrow slots 	Type 1A1 R continuous cutting rim 
Type 1A1 C3 narrow spacing, narrow slots, punched at the rear 	–

Annex F (informative)

Grain sizes and concentration for diamond and cubic boron nitride

F.1 Grain sizes and concentration for diamond and cubic boron nitride

Table F.1: Macro grains for diamond and cubic boron nitride

Grain size denomination	Nominal mesh aperture acc. to ISO 565 in µm	Mesh size Grain size range
46	45/38	325/400
54	53/45	270/250
64	63/53	230/270
76	75/63	200/230
91	90/75	170/200
107	106/90	140/170
126	125/ 106	120/140
151	150/ 125	100/120
181	180/ 150	80/100
213	212/ 180	70/80
251	250/ 180	60/70
252	250/ 212	60/80
301	300/ 250	50/60
302	300/ 312	50/70
356	355/ 300	45/50
357	355/ 250	45/60
358	355/ 212	45/70
420	425/ 355	40/45
427	425/ 300	40/50
501	500/ 425	35/40
502	500/ 355	35/45
601	600/ 500	30/35
602	600/ 425	30/40
711	710/ 600	25/30
712	710/ 500	25/35
851	850/ 710	20/25
852	850/ 600	20/30
1001	1000/850	18/20
1002	1000/710	18/25
1181	1180/1000	16/18
1182	1180/850	16/20

Table F.2: Micro grains for diamond or cubic boron nitride

Grain size denomination	Median size permissible range in µm	Max. standard deviation in µm	Max. grain size in µm
0 to 0,5	0,25 to 0,30	0,15	0,75
0,5 to 1	0,65 to 0,85	0,25	1,5
0,5 to 2	1,10 to 1,35	0,4	3
1 to 2,5	1,60 to 1,90	0,6	4
1 to 3	1,80 to 2,20	0,7	5
2 to 3	2,25 to 2,75	0,5	5
2 to 4	2,70 to 3,30	0,9	7
2 to 5	3,15 to 3,85	1,1	8
3 to 6	3,60 to 4,40	1,2	10
3 to 7	4,50 to 5,50	1,4	12
4 to 8	5,40 to 6,60	1,7	15
5 to 10	6,75 to 9,25	1,9	18
6 to 12	8,10 to 9,90	2,0	20
8 to 12	9,00 to 11,00	2,2	22
8 to 15	10,00 to 13,00	2,6	26
10 to 15	11,25 to 13,75	3,0	26
10 to 18	12,50 to 15,50	3,3	28
10 to 20	13,50 to 16,50	3,5	32
10 to 22	14,40 to 17,60	3,8	35
12 to 22	15,30 to 18,70	4,0	35
15 to 20	15,75 to 19,25	4,0	32
15 to 25	18,00 to 22,00	4,5	38
15 to 30	20,25 to 24,75	5,0	42
20 to 30	22,50 to 27,50	5,5	42
22 to 36	26,10 to 31,90	6,5	54
25 to 37	27,90 to 34,10	6,0	56
35 to 45	36,00 to 44,00	7,0	60
30 to 50	36,00 to 44,00	8,0	66
40 to 60	45,00 to 55,00	9,0	80
50 to 70	54,00 to 66,00	12,0	90
54 to 80	60,30 to 73,70	13,0	100
42 to 84	56,70 to 69,30	14,0	105
60 to 100	72,00 to 88,00	15,0	120

Table F.3: Concentration

Abrasive	Concentration[1)]	Volume in %	Grain content in carat[2)]/cm³
D	200	50	8,8
	175	43,75	7,7
	150	37,5	6,6
	125	31,25	5,5
	100	25	4,4
	75	18,75	3,3
	50	12,5	2,2
	25	6,25	1,1
B	200	50	8,7
	175	43,75	7,61
	150	37,5	6,53
	125	31,25	5,44
	100	25	4,35
	75	18,75	3,26
	50	12,5	2,18
	25	6,25	1,09

1) Code number for the volumetric content of abrasive in the superabrasive section, the concentration 100 corresponding to 25 % diamond or cubic boron nitride volume content. Smaller or greater concentrations are a fraction or a multiple of the concentration 100.

2) 1 carat ≙ 0,2 g.

Bibliography

ISO 666 : 1996
Machines Tools – Mounting of plain grinding wheels by means of hub flanges

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