EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 60276

September 2019

ICS 01.040.29; 29.100.20

Supersedes EN 60276:1996 and all of its amendments and corrigenda (if any)

English Version

Carbon brushes, brush holders, commutators and slip-rings - Definitions and nomenclature (IEC 60276:2018)

Balais de charbon, porte-balais, collecteurs et bagues - Définitions et nomenclature (IEC 60276:2018)

Definitionen und Benennungen für Kohlebürsten, Bürstenhalter, Kommutatoren und Schleifringe (IEC 60276:2018)

This European Standard was approved by CENELEC on 2018-06-12. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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

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

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN IEC 60276:2019 E

European foreword

The text of document 2/1898/FDIS, future edition 2 of IEC 60276, prepared by IEC/TC 2 "Rotating machinery" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60276:2019.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2020-03-20
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2022-09-20

This document supersedes EN 60276:1996 and all of its amendments and corrigenda (if any).

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

Endorsement notice

The text of the International Standard IEC 60276:2018 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60136	-	Dimensions of brushes and brush-holders for electrical machinery	-	-
IEC 60773	-	Test methods and apparatus for measurement of the operational characteristics of brushes	-	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

CARBON BRUSHES, BRUSH HOLDERS, COMMUTATORS AND SLIP-RINGS – DEFINITIONS AND NOMENCLATURE

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60276 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition, issued in 1968 and its Amendment 1, issued in 1987. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– Some nomenclature has been deleted or added, whereas remaining definitions have been detailed and clarified, to reflect the technical evolution since 1987.
– Additional definitions have been included to address the request for reviewing this standard, in particular nomenclature of commutator/slip-rings markings, brush markings and commutation sparks codes.

The text of this standard is based on the following documents:

FDIS	Report on voting
2/1898/FDIS	2/1901/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

CARBON BRUSHES, BRUSH HOLDERS, COMMUTATORS AND SLIP-RINGS – DEFINITIONS AND NOMENCLATURE

1 Scope

This document applies to carbon brushes for electrical machinery. For the present, it applies only to carbon brushes for commutators and slip-rings in rotating machines.

Terms and definitions are relative to the brush construction (references 100's to 500's and parts of 900's) and to the markings when operating on a rotating machine (references 600's to 800's).

By extension, terms and definitions may be relevant for any kind of sliding electrical contacts for electrical machinery.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60136, *Dimensions of brushes and brush-holders for electrical machinery*

IEC 60773, *Test methods and apparatus for measurement of the operational characteristics of brushes*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE Brushes are classified according to the class of grade used, as follows.

3.1
grade
brush material used for the brush body, defined by its composition and its physical properties

3.2
carbon
consists of various forms of amorphous carbon, generally made of a mixture of carbonaceous powders agglomerated with a binder, moulded and baked at suitable temperature to carbonize the binder

Note 1 to entry: Also named hard carbon (or plain carbon).

Note 2 to entry: The material can contain additives and can be impregnated with oils, wax or resin. This material contains principally carbon, because it is not graphitized during baking operation.

3.3
carbon-graphite
carbographitic
CG
consists of a mixture of powdered amorphous carbon and graphite, agglomerated with a binder (pitch or resin), moulded and baked at suitable temperature to carbonize the binder

3.4
electrographite
electrographitic
EG
consists of various forms of amorphous carbon (hard carbon or carbon-graphite) converted during manufacture into artificial / synthetic graphite

3.5
natural-graphite
NG
carbon-graphite grade consisting principally of natural graphite

Note 1 to entry: Sometimes also called soft graphite.

3.6
resin-bonded
bakelite-graphite
BG
consists of powdered carbon and/or graphite bonded with a resin (artificial, synthetic or natural) and polymerized at suitable temperature

3.7
metal-graphite
metallographitic
MG
consists of a mixture of powdered metals and graphite pressed and baked at suitable temperature

Note 1 to entry: Baking is named sintering when a reducing atmosphere is used during baking.

3.8
metal-impregnated
M
consists of carbon, carbon-graphite or electrographite which contains a metal which has been added by an impregnation process.

Metal can be added by:

– melting the metal and impregnating under pressure, or

– impregnating with a metal precursor and decomposition of this precursor during a further baking operation, or

– deposition in vapour phase.

Note 1 to entry: The second and third processes are also called metallization.

4 Symbols and abbreviated terms

4.1 Symbols

a axial dimension of brush (mm)

c chamfer dimension (mm)

I current per brush (A)

r radial dimension of brush (mm)

R radius (mm)

t tangential dimension of brush (mm)

U voltage (V)

α contact bevel angle (°)

β top bevel angle (°)

4.2 Subscripts

A anodic

C cathodic

B brush

T top of the brush

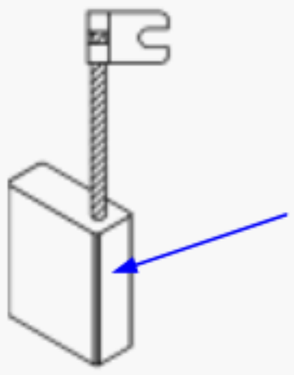
c contact

5 Nomenclature

NOTE The definition corresponds to the part highlighted in blue / grey colour or pointed out by an arrow on the corresponding figure (when applicable).

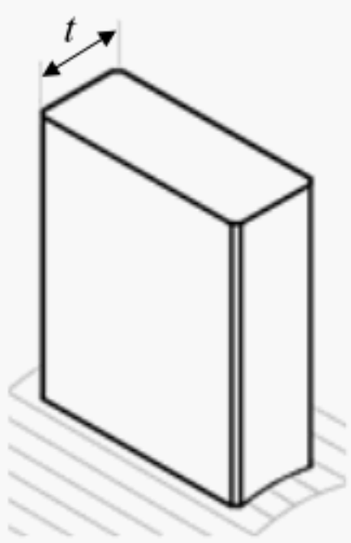
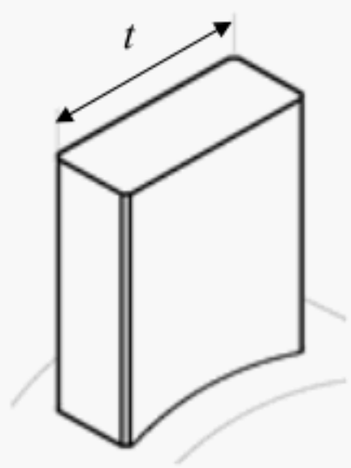
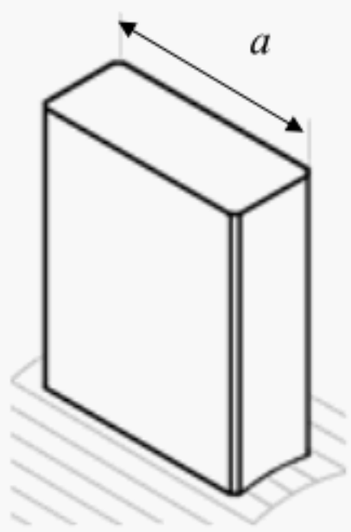
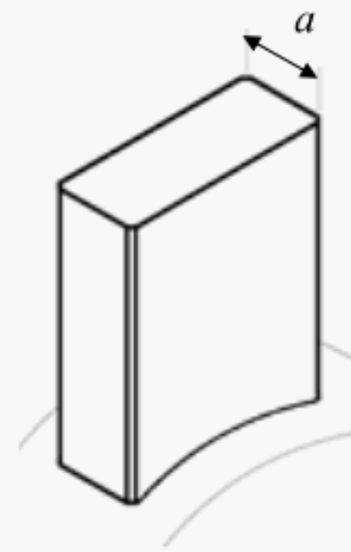
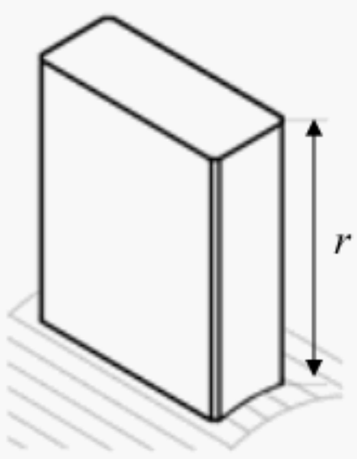
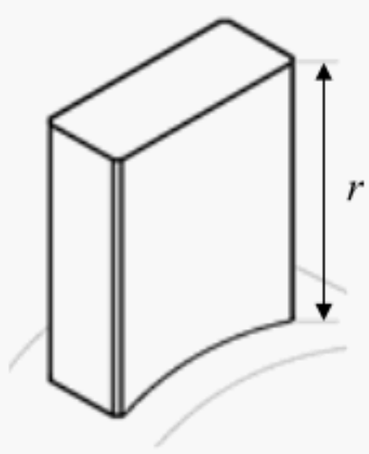
5.1 Brushes

5.1.1 101: Body / block

101		Brush body / block

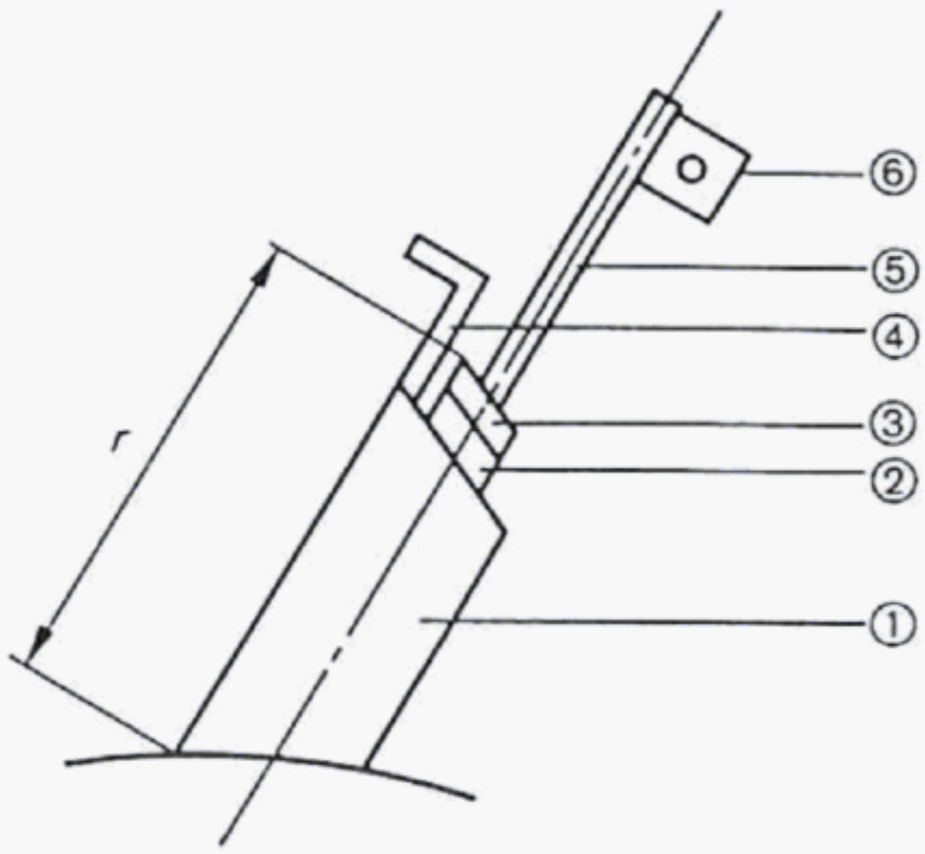
5.1.2 102 to 104: Definitions of t, a and r

References a) and b) below correspond respectively to commutator (DC Motor) and slip-ring (synchronous or asynchronous machine).

102	a)  	b)  	Tangential dimension t is the brush dimension in the tangential direction defined by the distance between two planes parallel to the centre line (see 105), the planes comprising the faces of the brush (see 121).
103	a)  	b)  	Axial dimension a is the brush dimension in the axial direction defined by the distance between two planes parallel to the centre line (see 105), the planes comprising the sides of the brush (see 118).
104	a)  	b)  	Radial dimension r is the brush dimension in the radial direction defined by the distance between two planes normal to the brush centre line (see 105), passing over the extremities of the brush elements, or parts of elements, which take part in the pressure application (see Figure 1). r is the longest dimension parallel to the centre line.

Recommended dimensions for t, a and r, as well as tolerances, are given in IEC 60136.

The pressure systems fitted on brushes are excluded from r. With reference to Figure 1 only the elements marked 1, 2 and 3 take part in the pressure application. The possible litigious cases which could not be justified by the definition of r shall be dealt with by agreement.



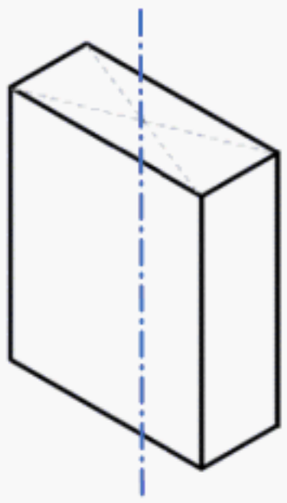
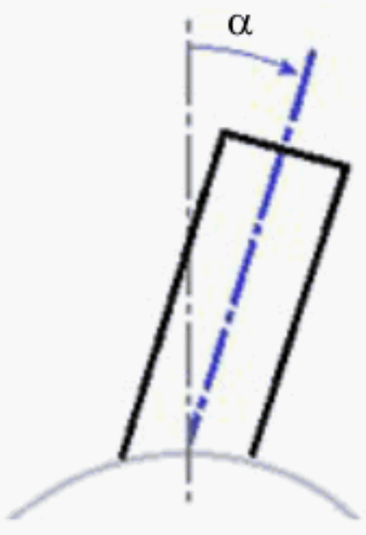
Key

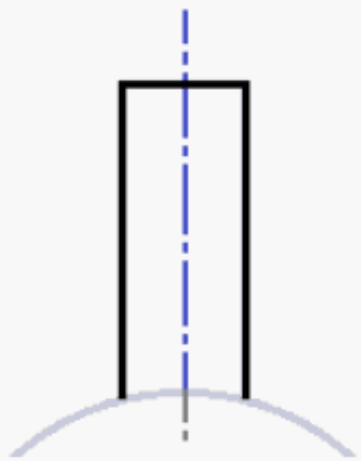
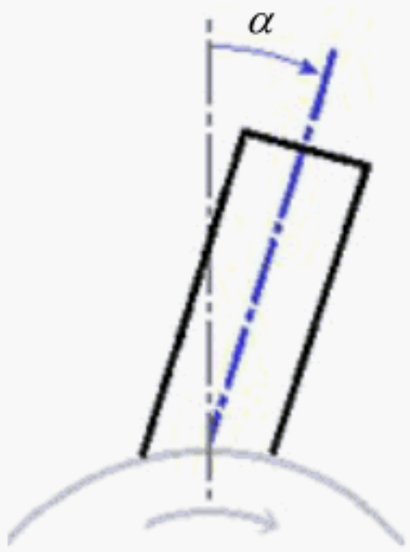
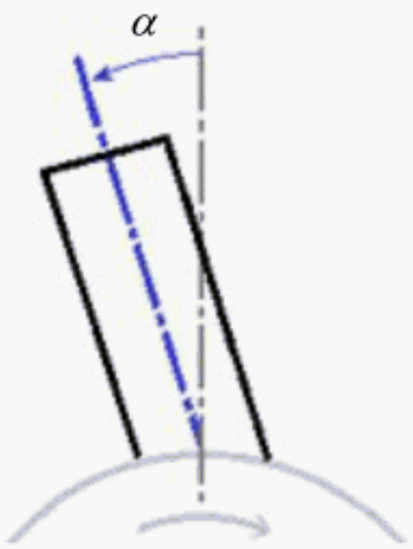
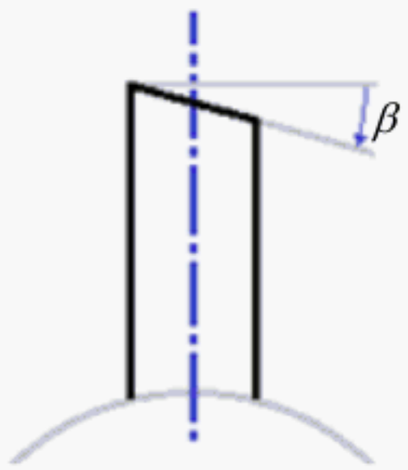
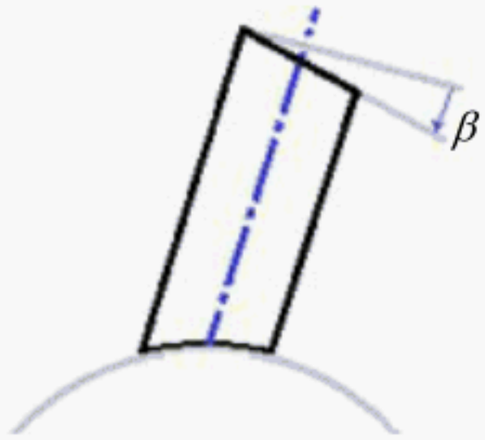
1 brush material (body)
2 soft top pad
3 hard top pad
4 metal retainer
5 brush flexible
6 brush terminal

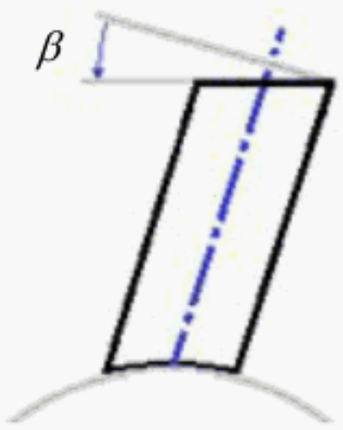
Figure 1 – Elements of the brush for definition of *r* dimension

5.1.3 105 to 112: Angles

NOTE 1 Figures 106 to 112 are cross-section view of the carbon brush.

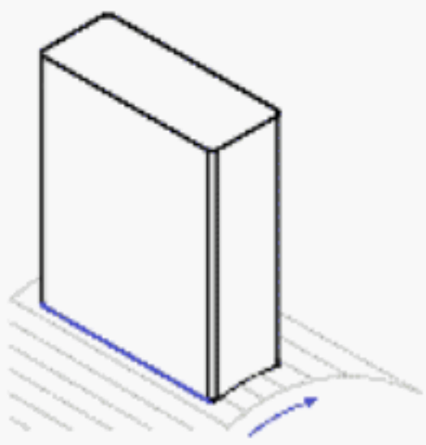
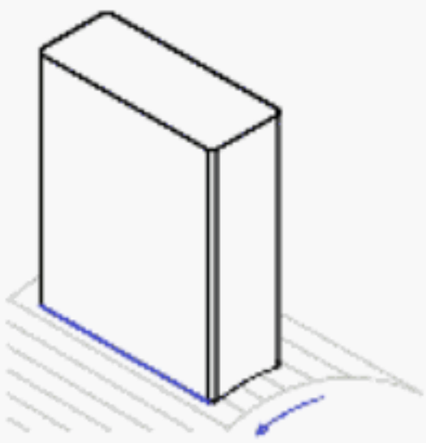
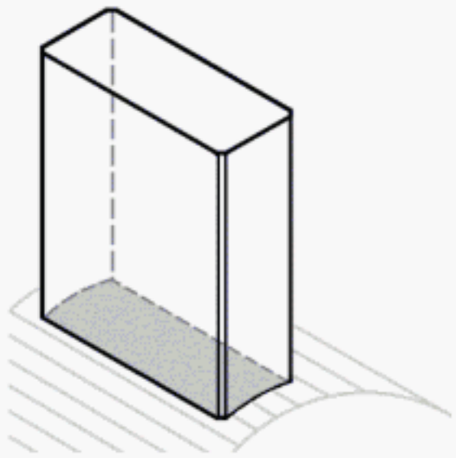
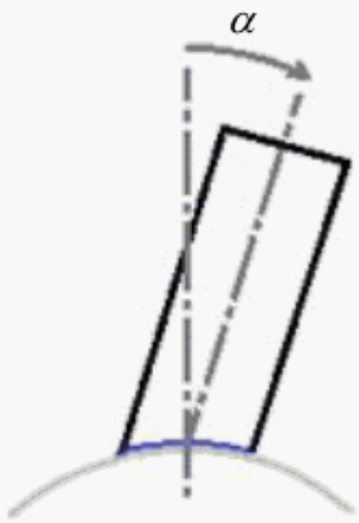
105		Centre line
106		Contact bevel angle α Angle between the center line of the brush and the radial axis of the commutator/ring.

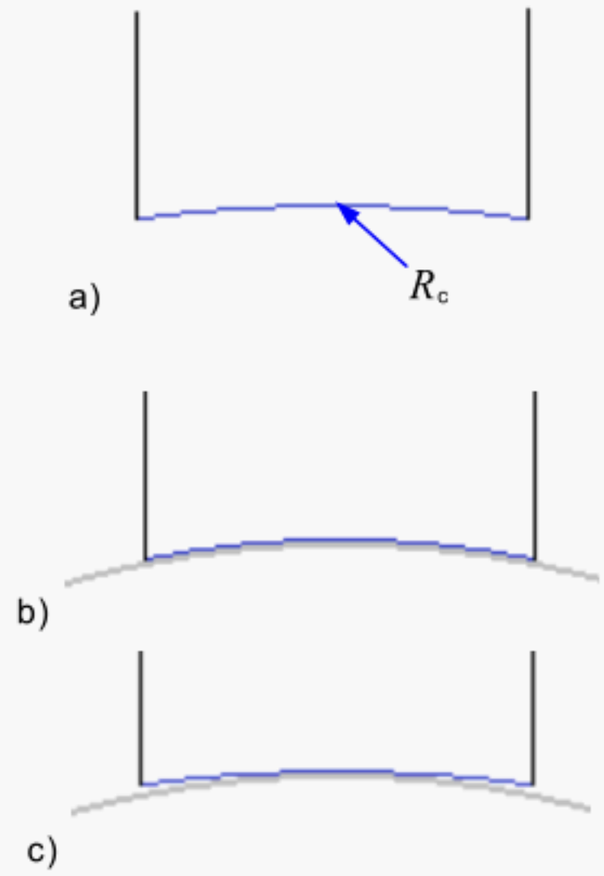
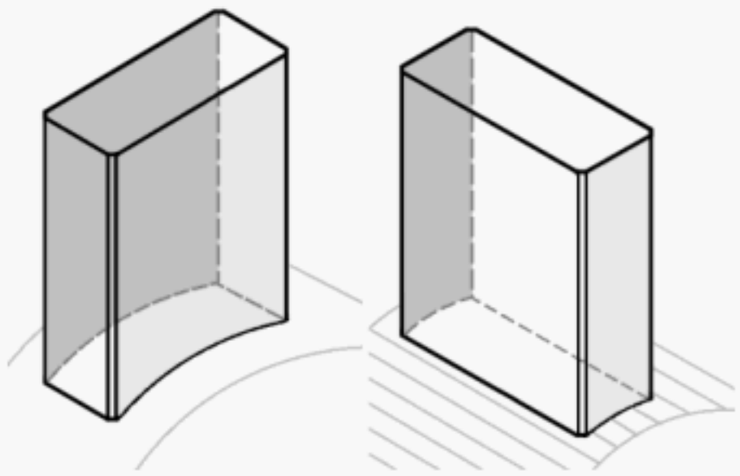
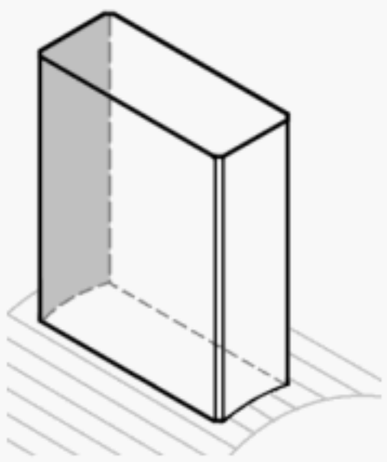
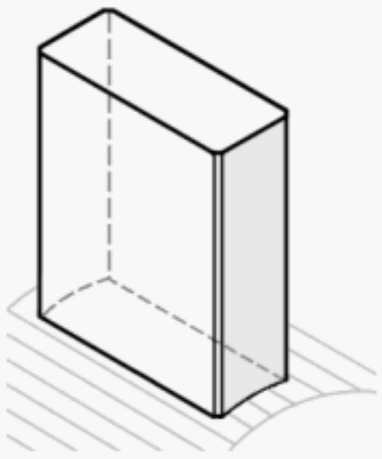
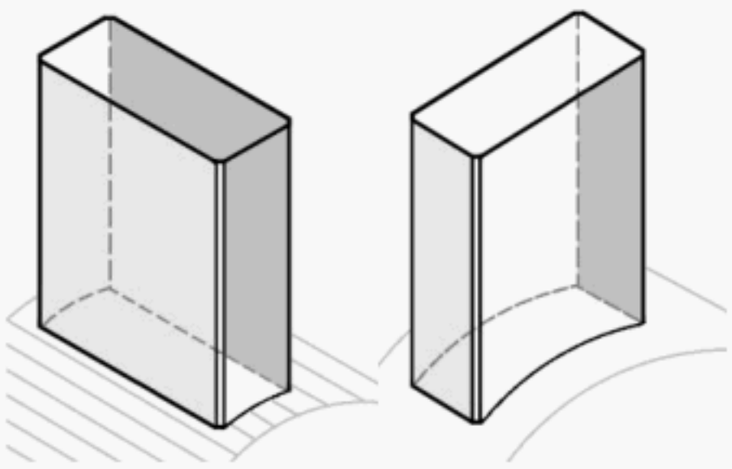
107		Radial brush when α is equal to zero
108		Reaction brush when α is positive (in the same direction as the rotation)
109		Trailing brush when α is negative (in the opposite direction of the rotation)
110		Top bevel angle β
111		Positive top bevel angle

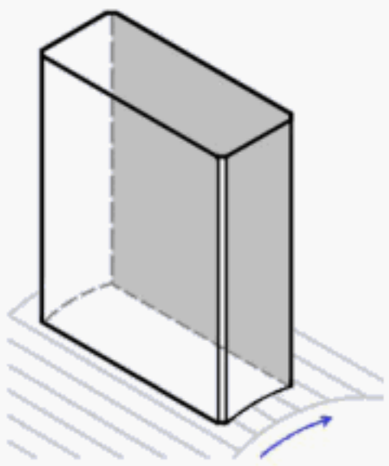
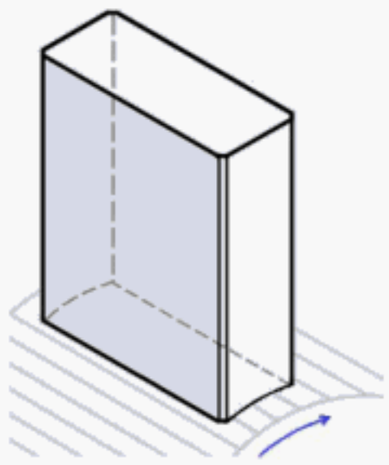
112		Negative top bevel angle

NOTE 2 IEC 60136 gives some recommendations for values of α and β angles.

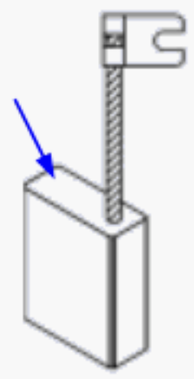
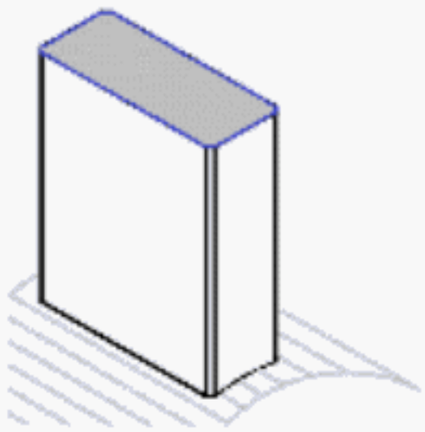
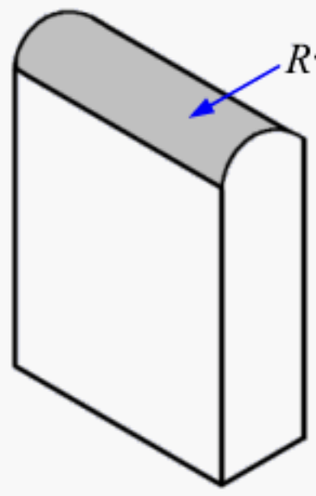
5.1.4 113 to 123: Edges and faces

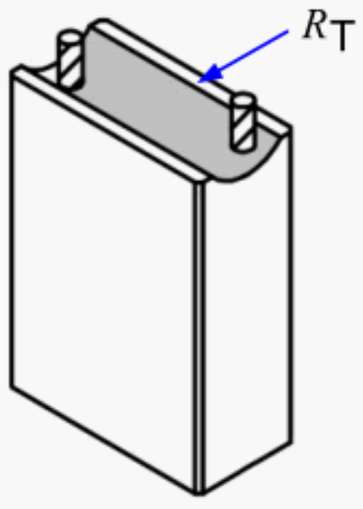
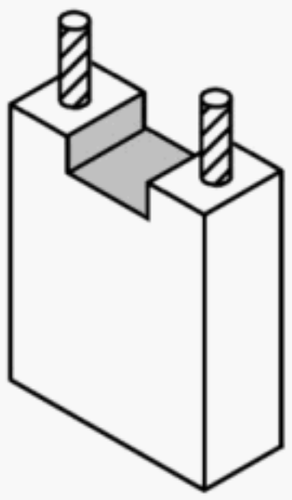
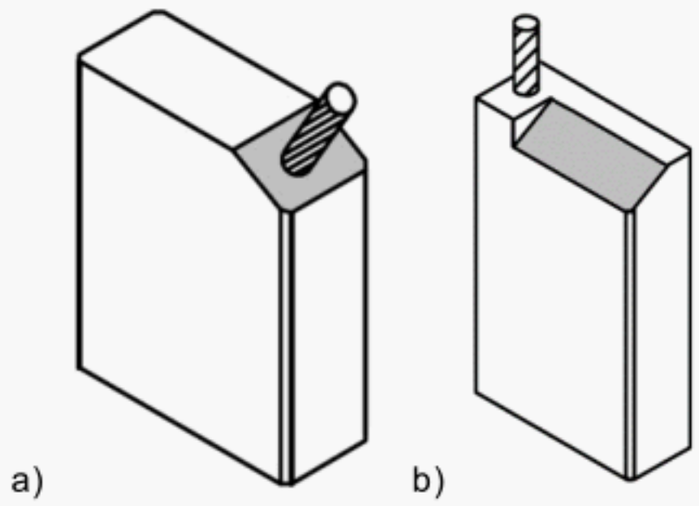
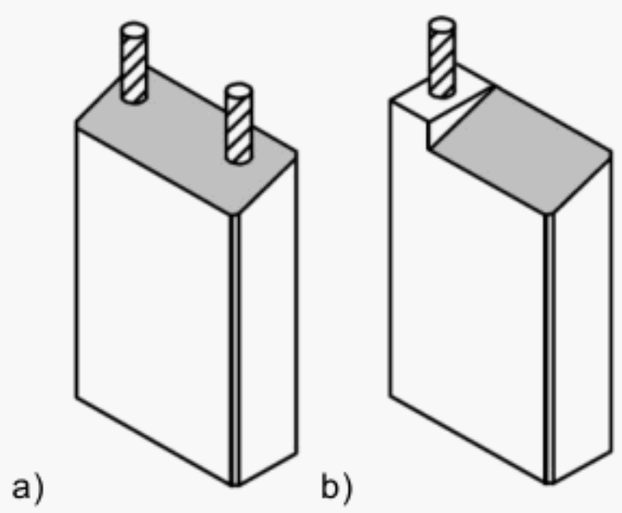
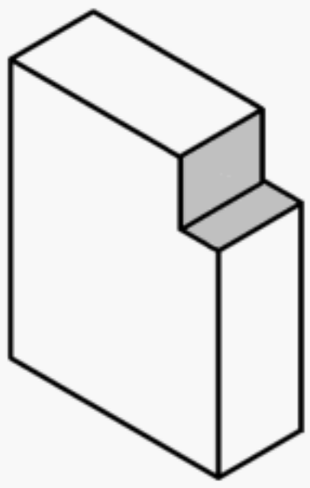
113		Entering edge (leading edge)
114		Leaving edge (trailing edge)
115		Contact surface (contact face)
116		Bevelled contact surface (bevelled contact face)

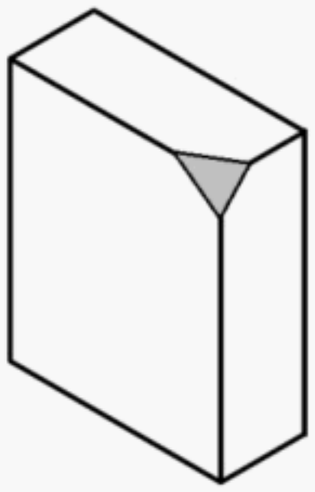
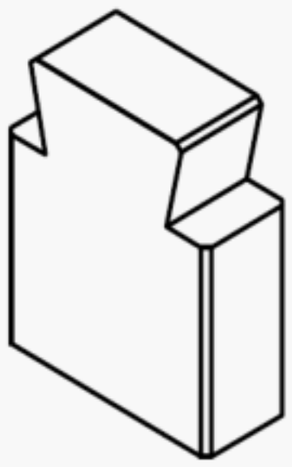
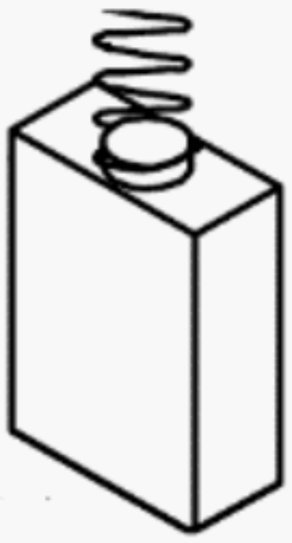
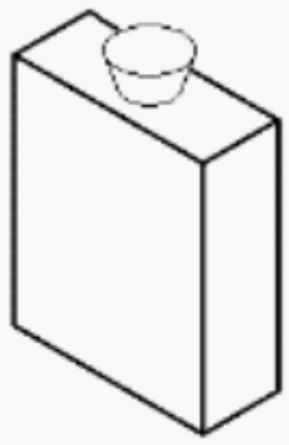
117		Radiused contact surface (concave contact face) Figure a) Brush with a radius R_c Figures b) and c) are relative to fitted/bedded brushes Figure b) When the radius is equal to the radius of the commutator/slip-ring – after fitting (machining operation), the brush 117 is named fitted brush, – after bedding (machine operating at the specified conditions of speed and current density during a certain time), the brush 117 is named bedded brush. Figure a) when the radius R_c is machined with a dimension slightly superior to the radius of the commutator/slip-ring the brush 117 is named pre-fitted brush.
118		Sides
119		Inner side, i.e. winding side (for commutator) NOTE Winding side is at the rear part of the commutator on the figure.
120		Outer side, i.e. non-winding side (for commutator) NOTE Winding side is at the rear part of the commutator on the figure).
121		Faces

122		Front face (front)
123		Back face (back)

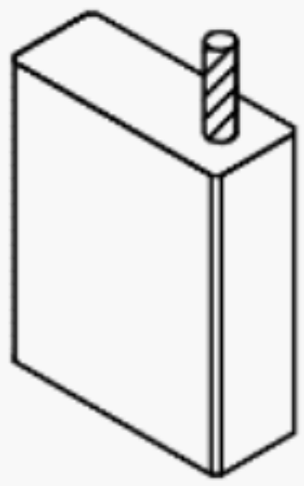
5.1.5 124 to 136: Brush top

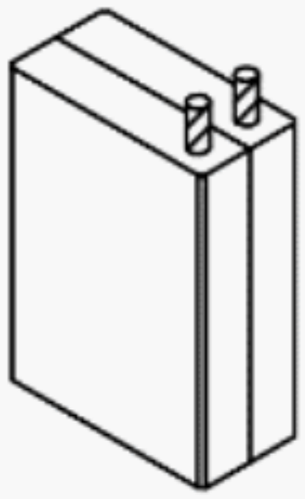
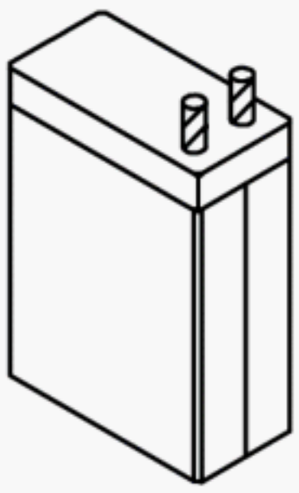
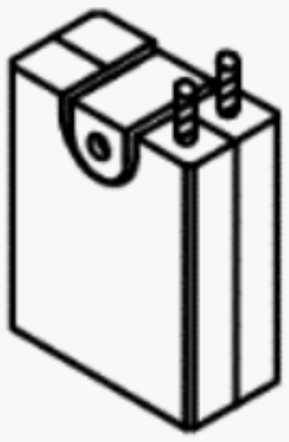
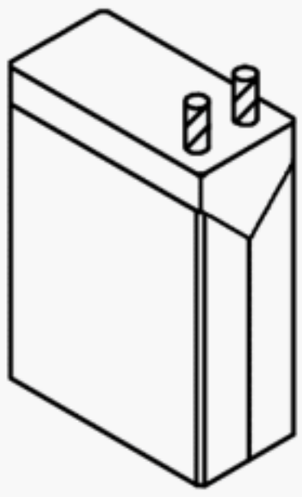
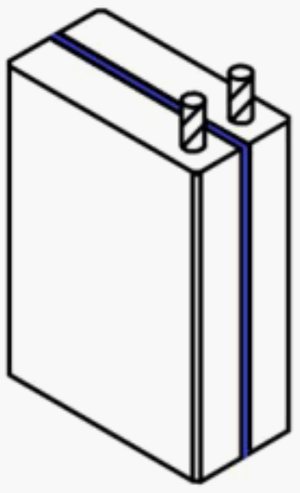
124		Top
125		Top surface
126		Rounded top (convex top) – radius R_T

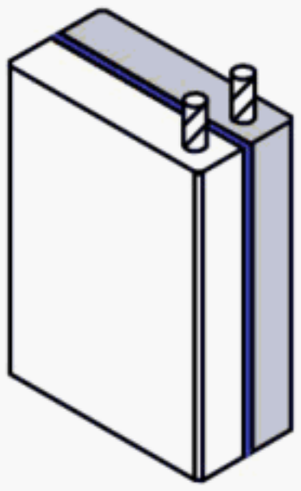
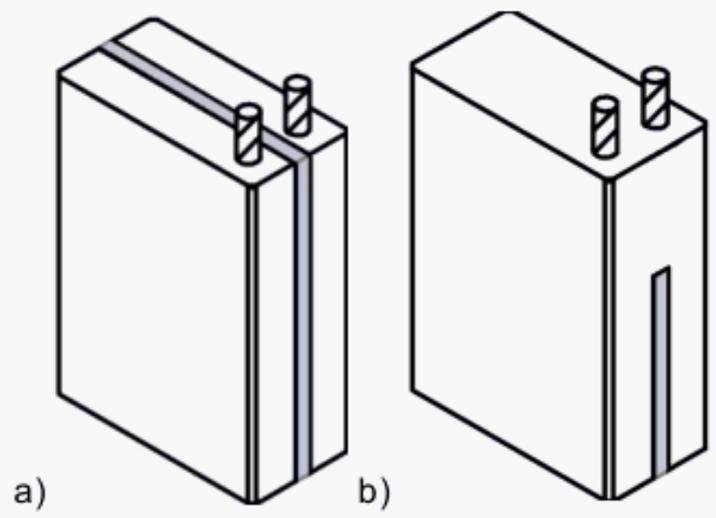
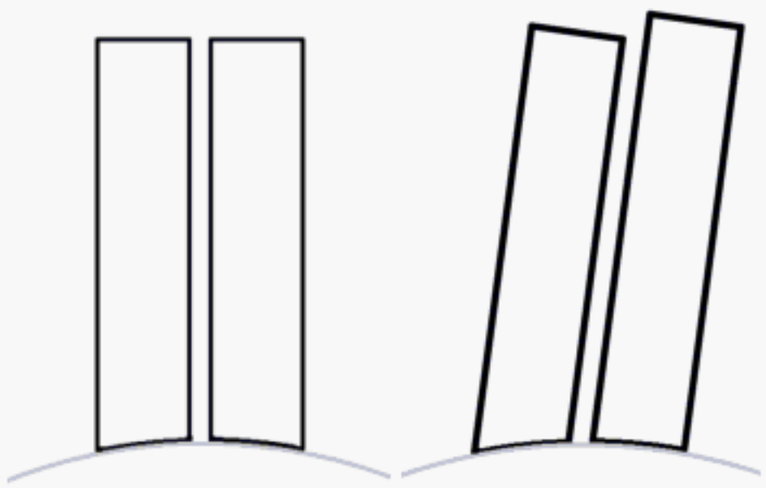
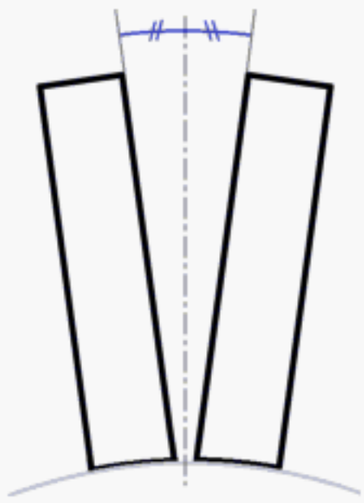
127		Grooved top – radius R_T
128		Slotted top
129		a) Bevelled edge b) Partly bevelled edge
130		a) Bevelled top b) Partly bevelled top
131		Shoulder

132		Bevelled corner
133	134 to 136	Headed brush
134		Dovetailed top (double angle shoulder)
135		Cylindrical head
136		Conical head

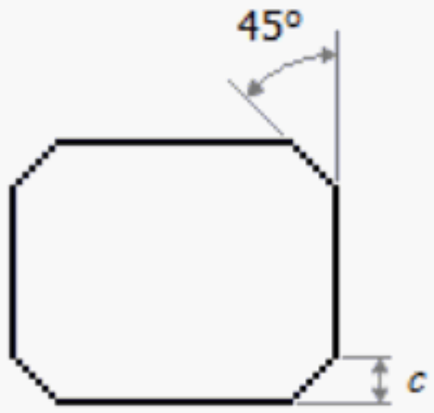
5.1.6 137 to 146: Monobloc, divided or double brushes

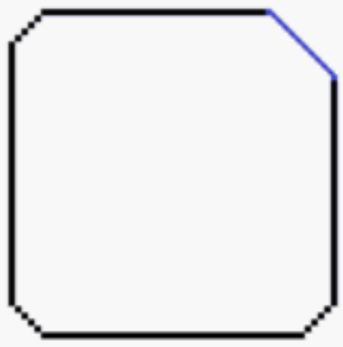
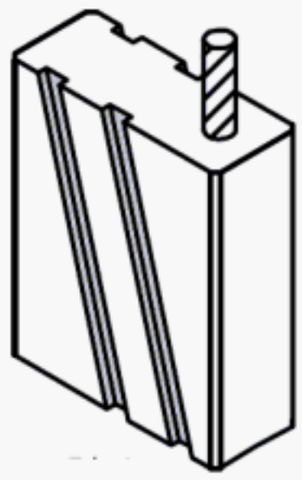
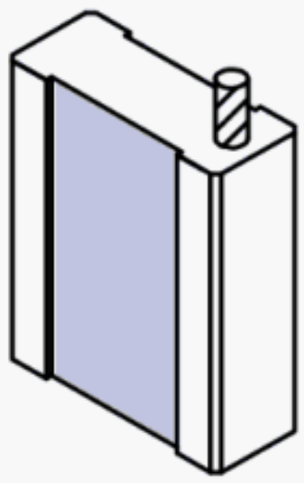
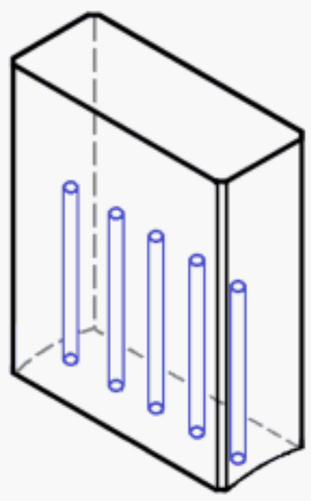
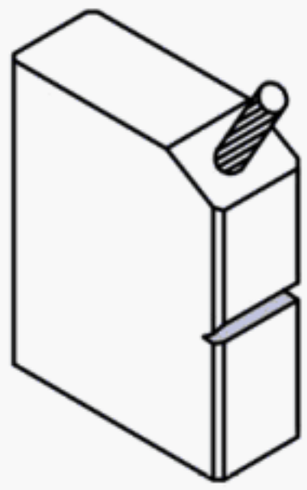
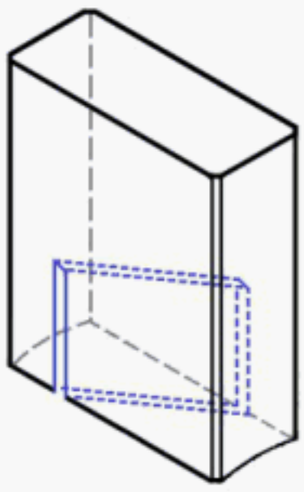
137		Solid/monobloc brush

138		Split/divided brush (2 wafers) NOTE Both wafers have the same grade. Triple split brush (3 wafers) may also be possible.
139		Split brush with plate separated top
140		Split brush with clip NOTE See 5.2 for tops.
141		Split brush with wedge top NOTE Generally wafers are joined by a bonded insulated top.
142		Sandwich brush (sandwich brush laminated), where wafers are made of the same grade NOTE Generally wafers are joined by an adhesive.

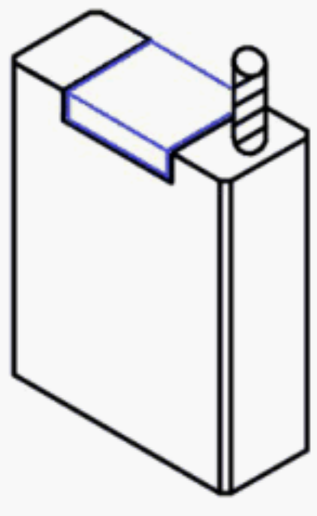
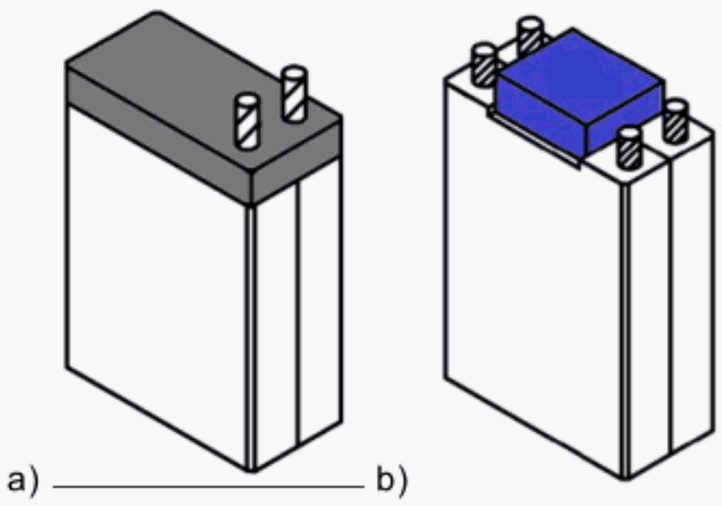
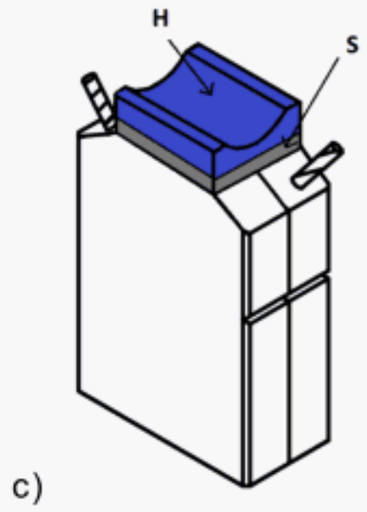
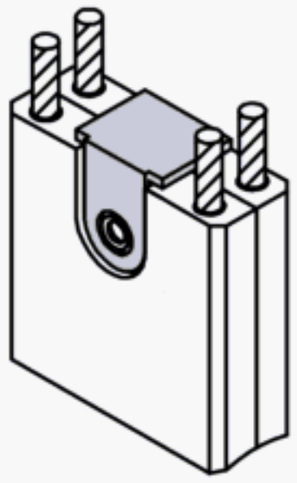
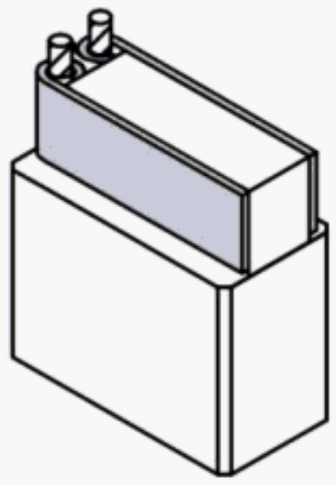
143		Dual grade sandwich (laminated) NOTE Generally wafers are joined by an adhesive.
144		Brush with insert a) insulator sheet NOTE Generally wafers are joined by an adhesive. b) second grade insertion
145		Tandem/double brush
146		V-tandem brush

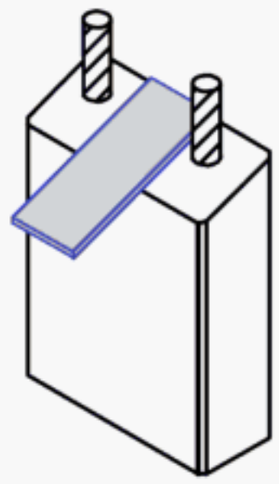
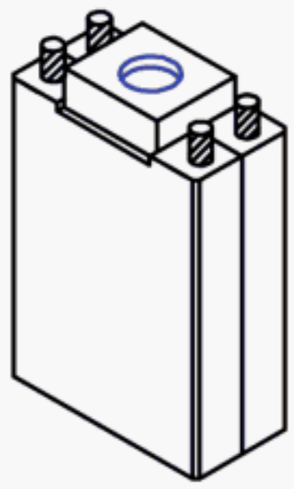
5.1.7 147 to 153: Other configurations

147		Chamfer NOTE referred values of c are given in IEC 60136.

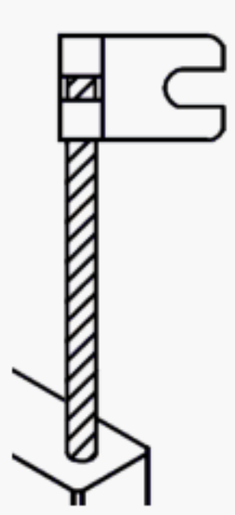
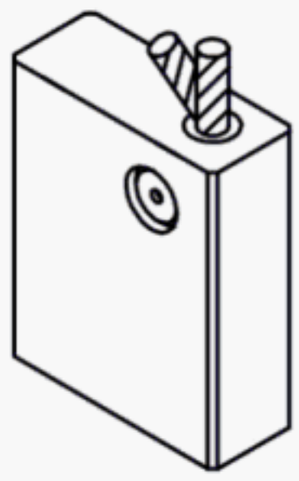
148		Non-reversing chamfer NOTE Typically used for a square brush.
149		Dust grooves
150		Dust slot
151		Cored brush
152		Wear indicator
153		Contact face with saw cut

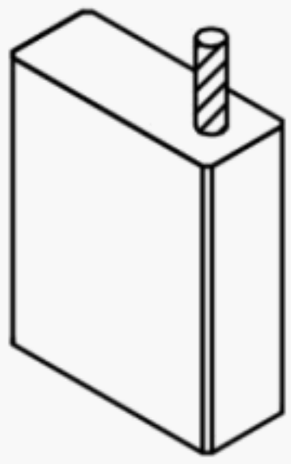
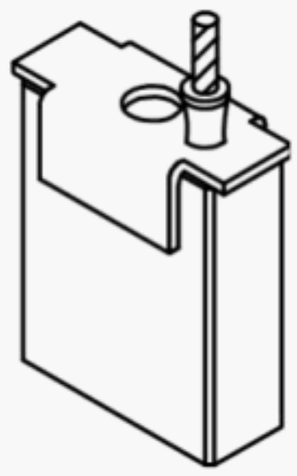
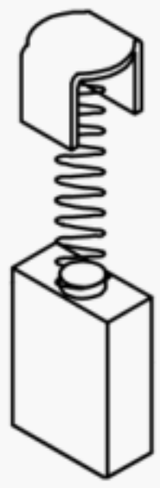
5.2 Tops (references No. 201 and following)

201		Top insert
202	  c)	Insulated top a) shock absorber (rubber) b) hard (plastic/composite) c) mixed: shock absorber S + hard top H NOTE Insulated top can be independent or glued.
203		Riveted metal top (metal clip)
204		Soldered metal top

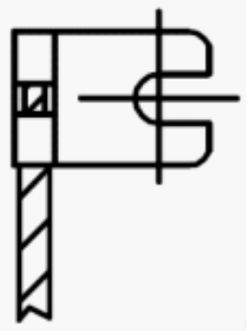
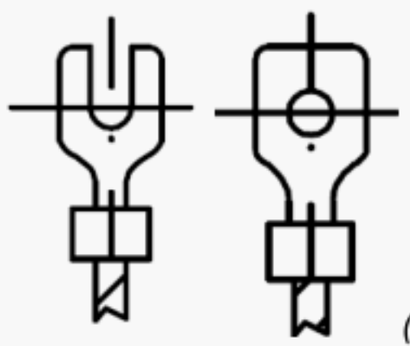
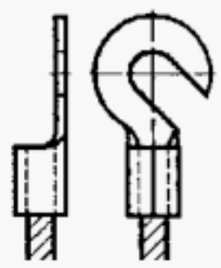
205		Cantilever top
206		Top with a guiding hole

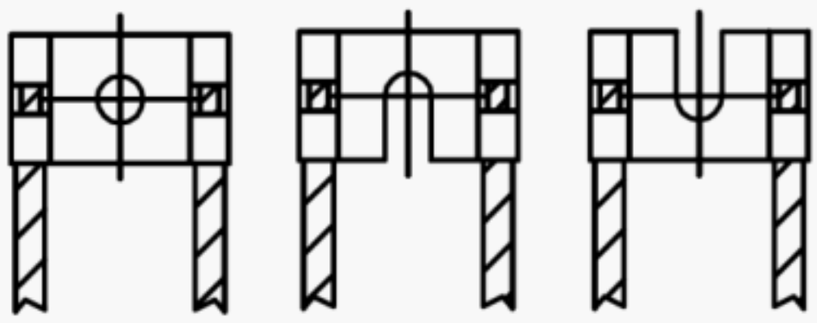
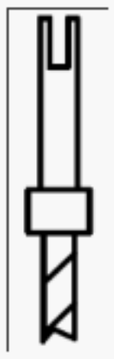
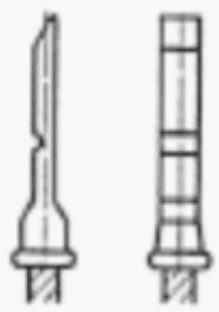
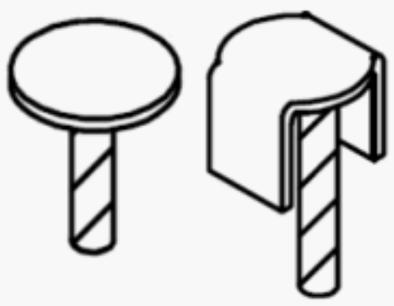
5.3 Flexibles (shunts) and other electrical connections (references No. 301 and following)

301		Flexible (shunt) NOTE Flexible is made of conductive material, such as copper, tinned copper. IEC 60136 gives definitions of cables: material, composition, dimensions (length and section).
302		Insulated flexible
303		Riveted connection

304		Tamped connection
305		Soldered connection (on a metal top)
306		Spring connexion: Electrical connection with pressure system

5.4 Terminals (references No. 401 and following)

401	 *(example)*	Flag terminal
402	 *(example)*	Axial terminal example: Spade terminal
403		Hook terminal

404		Double shoe terminal
405		Pin terminal
406		Flat pin terminal
407		Pin terminal (soldered on shunt)

NOTE 1 IEC 60136 gives some recommendations for dimensions of terminals.

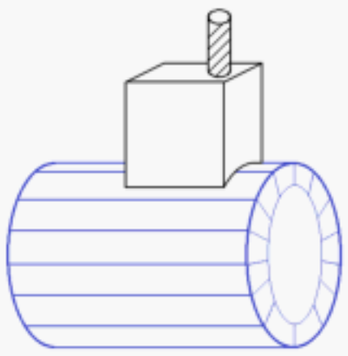
NOTE 2 Items number 403, 405 and 406 are rarely used.

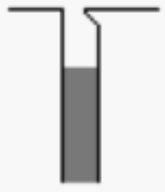
NOTE 3 Open slots are usually preferred compared to closed holes, because they are easier to mount. Nevertheless, closed holes are favoured when high vibrations can occur.

5.5 Commutators and slip-ring (references No. 501 and following)

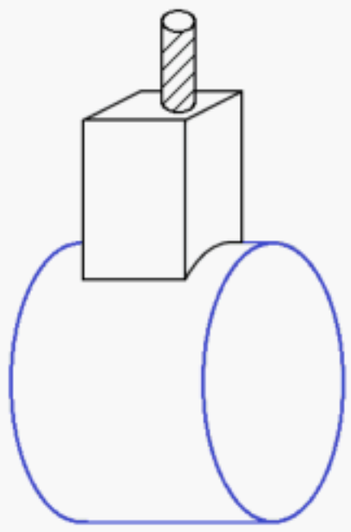
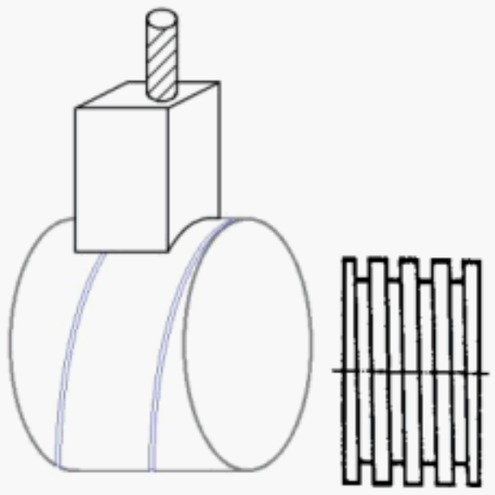
NOTE 502 to 512 and 515 are crossed-section definitions.

5.5.1 501 to 512: Commutators

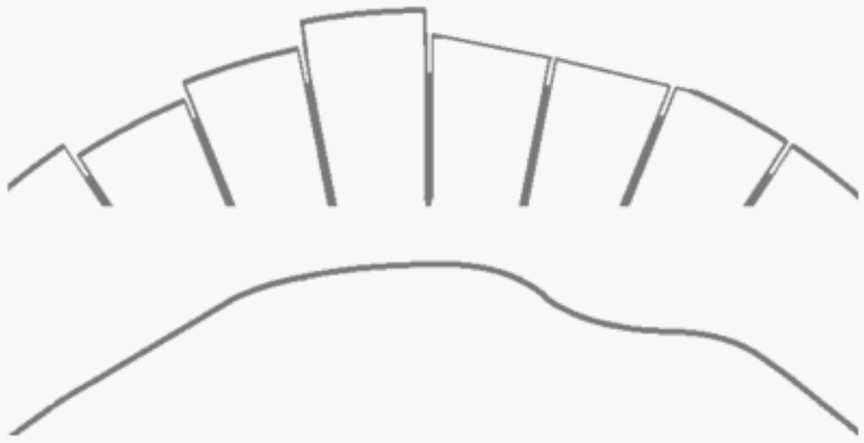
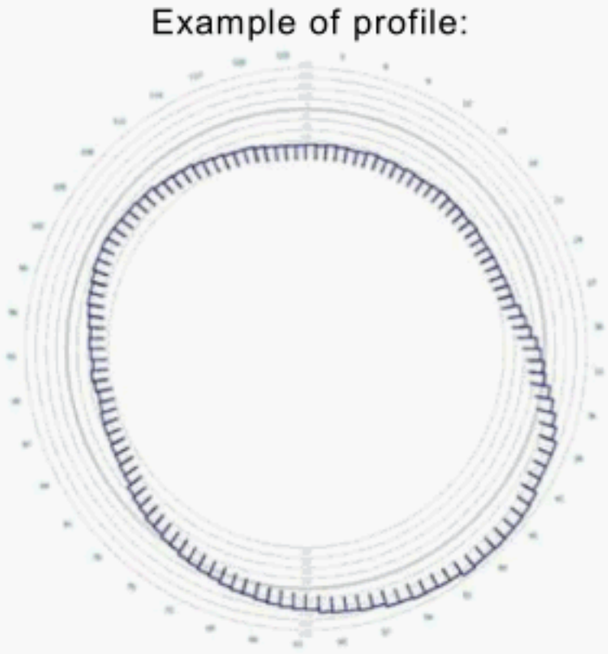
501		Cylindrical commutator (DC machine)
502		Insulator (mica or moulded resin)

503		Recessed or under cut insulator
504		Flush insulator
505		Worn down to the micas / insulator
506		High mica (sticking out insulator)
507		Flat (flat spot)
508		High bar
509		Low bar
510		Chamfered bars
511		Burs at bars edge
512		Copper drag

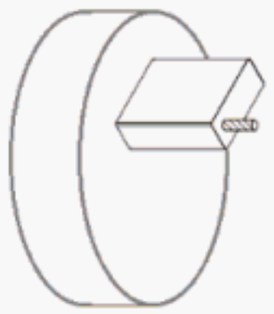
5.5.2 513 to 514: Slip-rings

513		Slip-ring (collector ring)
514		Helically grooved slip-ring

5.5.3 515: Profile

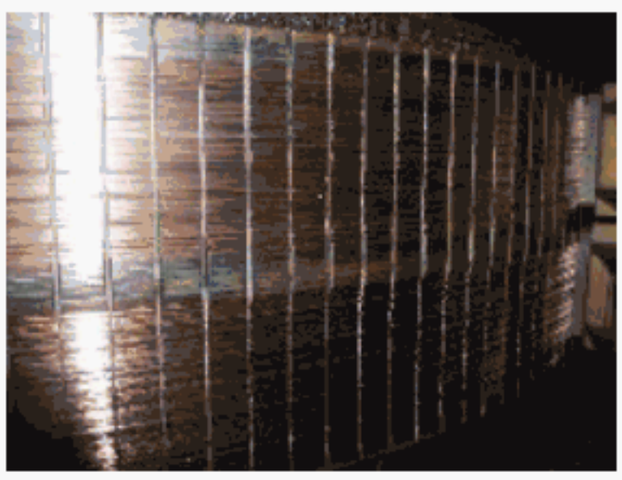
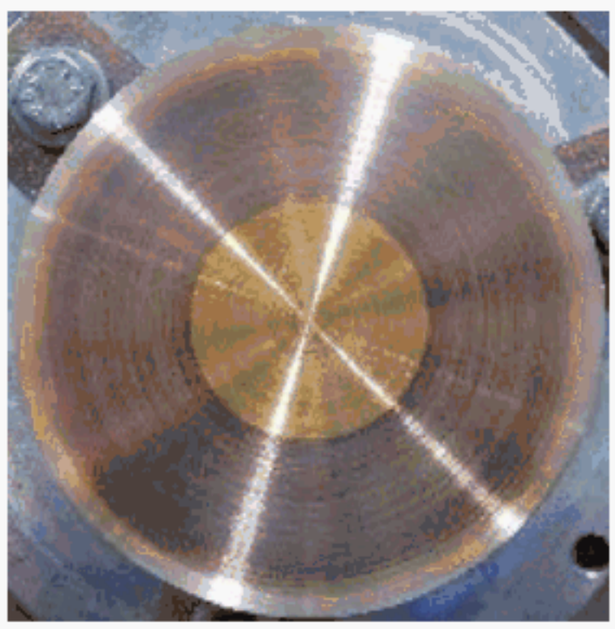
515	 Example of profile: 	Rough commutator or slip-ring
NOTE The run-out (or runout) is a measurement of radial displacement of the commutator/slip-ring surface while it is turned.		

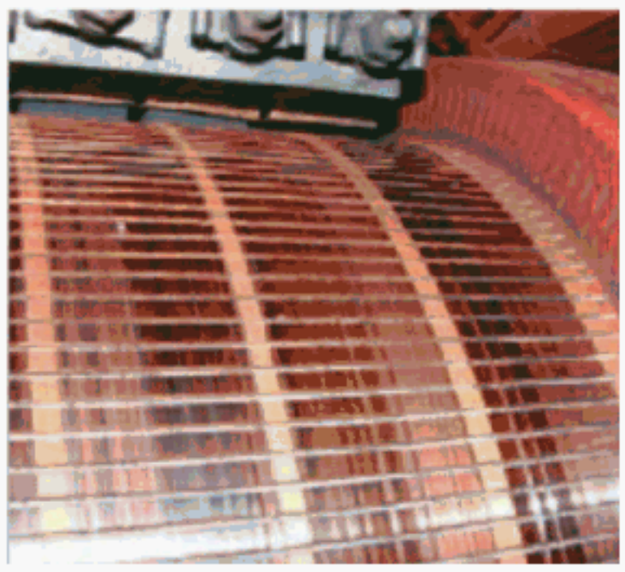
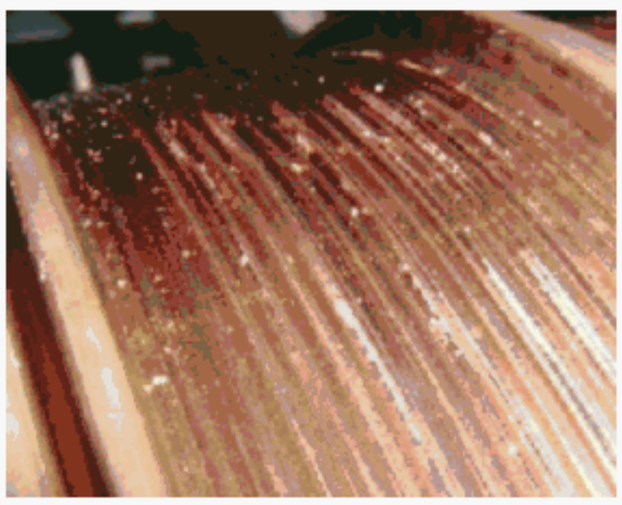
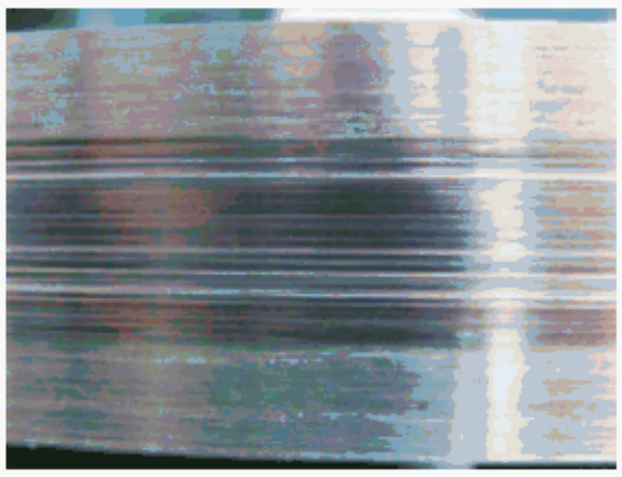
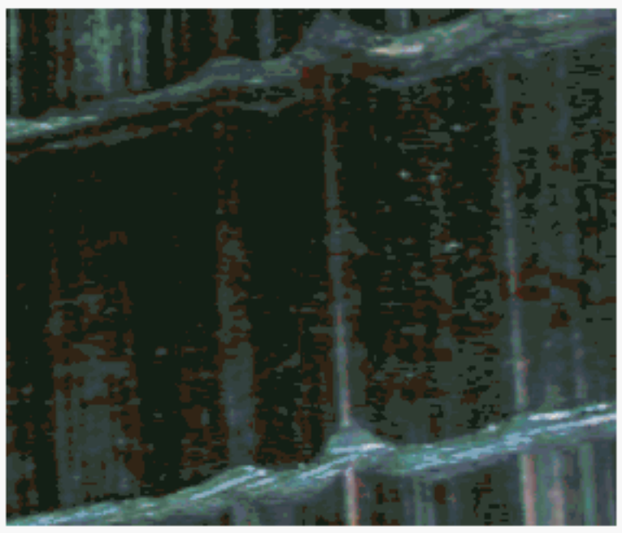
5.5.4 516: Flat contact

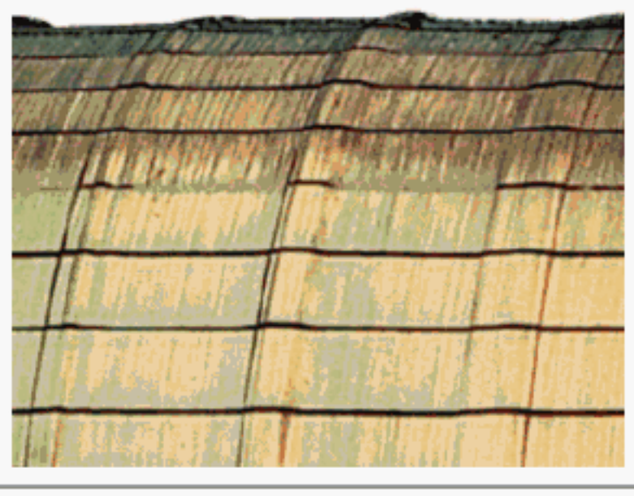
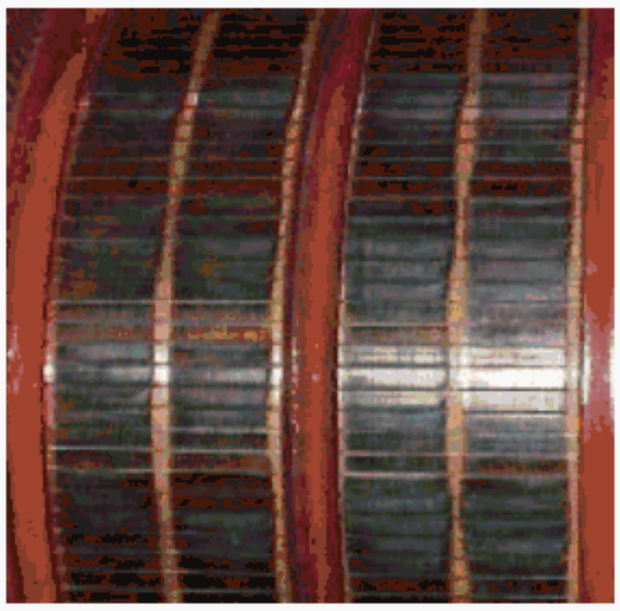
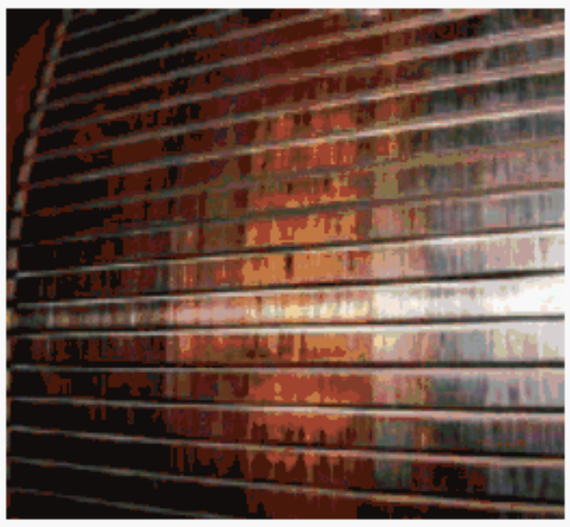
516		Flat disk or commutator Example: shaft earthing for traction (railways)

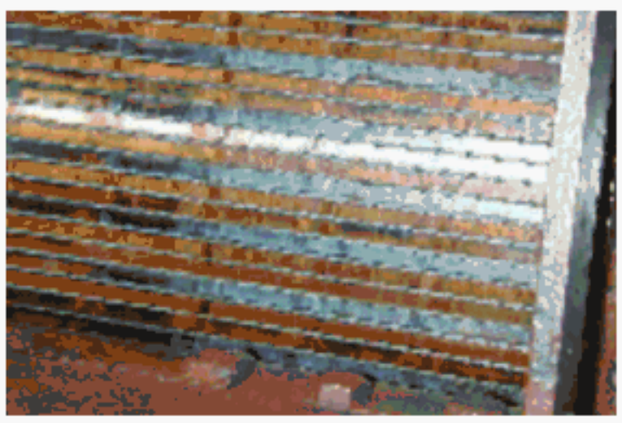
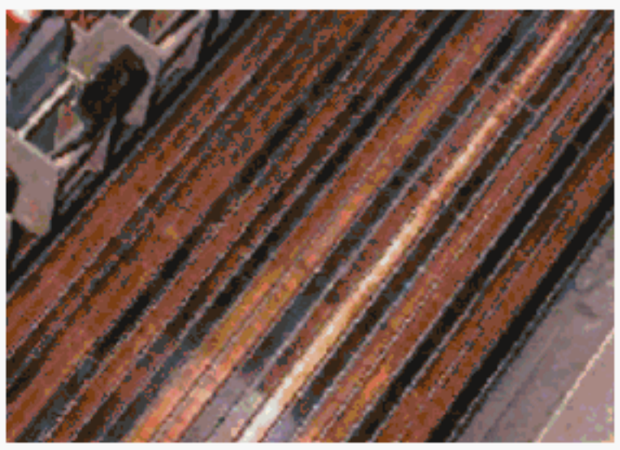
5.6 Commutator and slip-rings markings (references No. 601 and following)

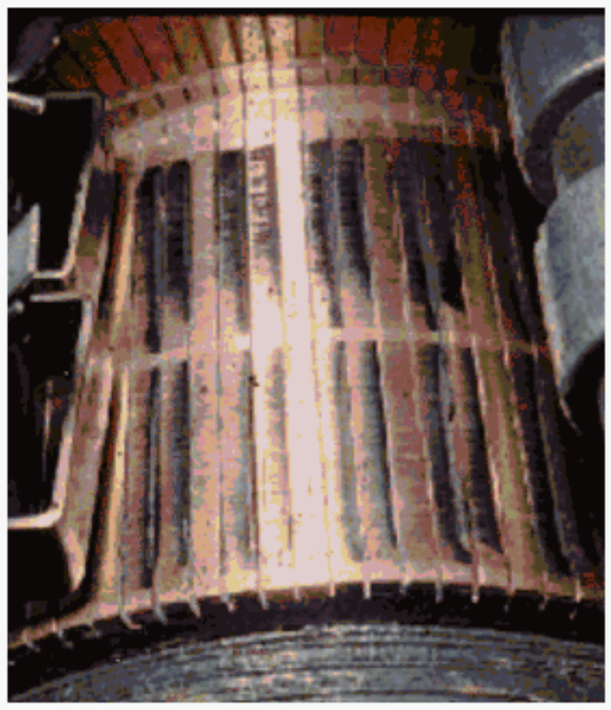
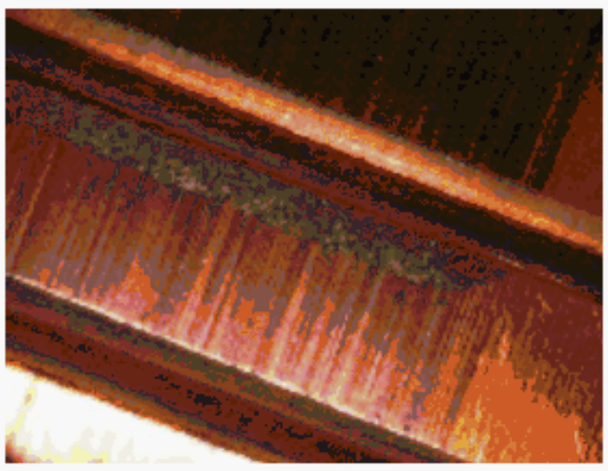
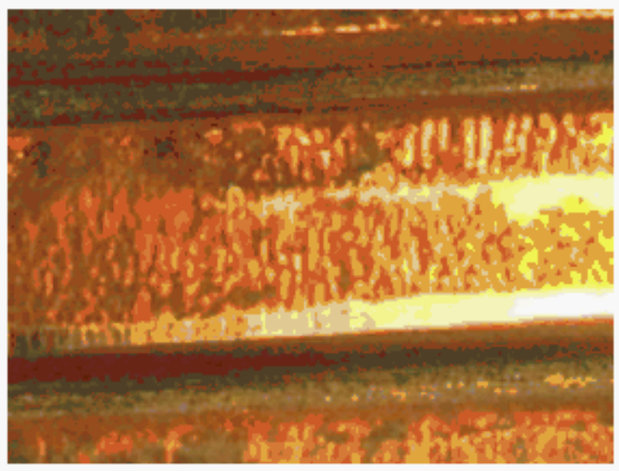
Definitions below apply to surface of commutators or slip-rings.

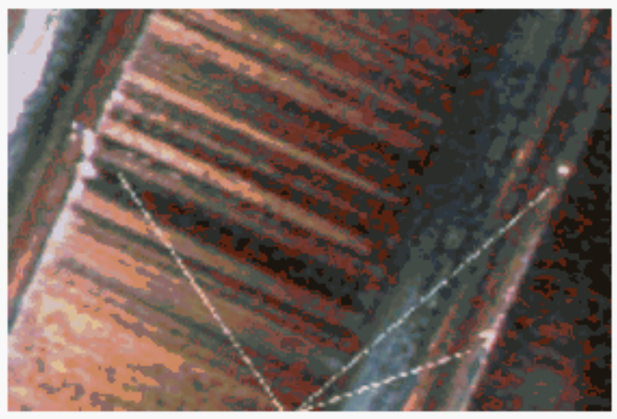
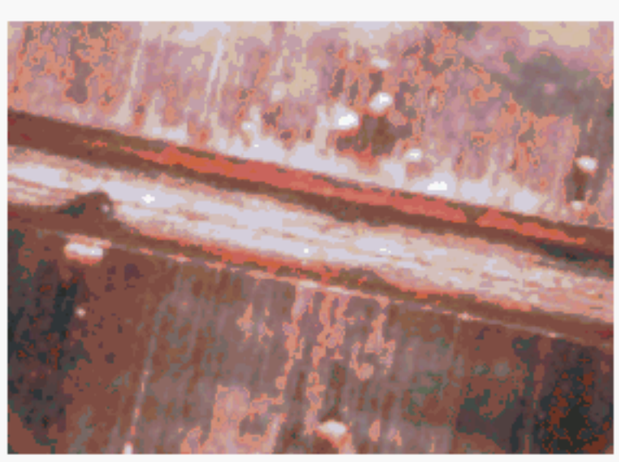
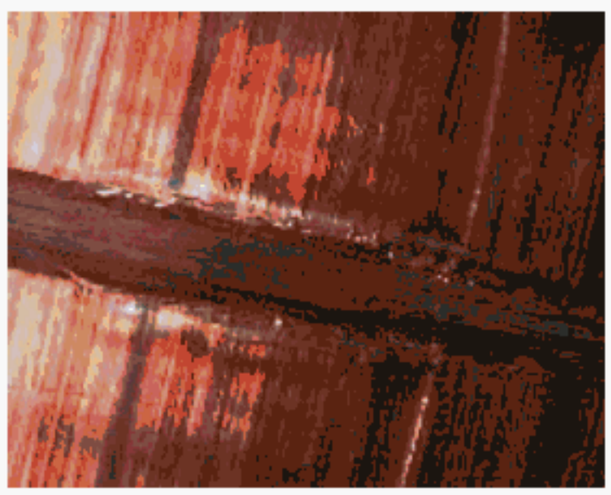
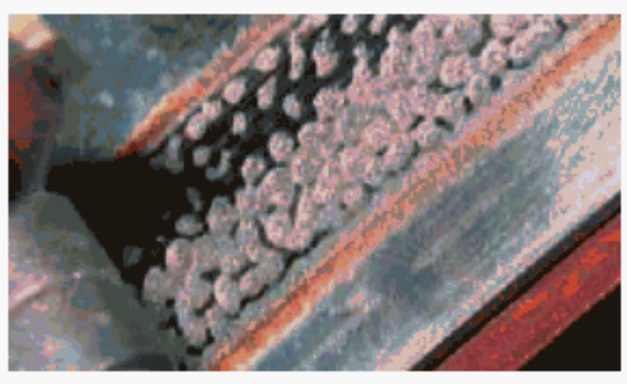
601		Skin / patina: uniform film – light brown to dark brown
602	a)  b) 	Lining (streaking) a) on commutator b) on flat disk

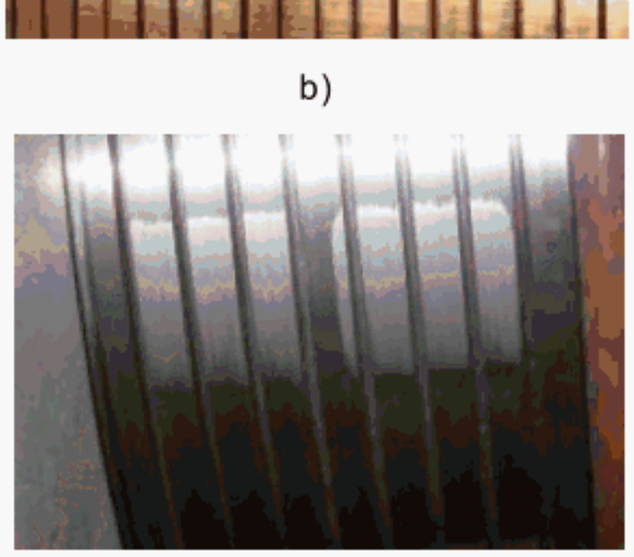
603		Banding
604	 	Ribbing
605	 	Threading

606		Grooving (non-uniform wear of commutator)
607		Ridging
608		Waved track – Hourglass shape film
609		Non-conductive or patchy film (thick patina over all surface or over limited area)

610	a)  b) 	Patina surface discoloration Examples: a) uniform discoloration of bars in tangential direction b) local discoloration (due to local overheat)
611		Screw / helical thread
612	a)  b) 	Marking a) regular bar marking b) irregular bar marking

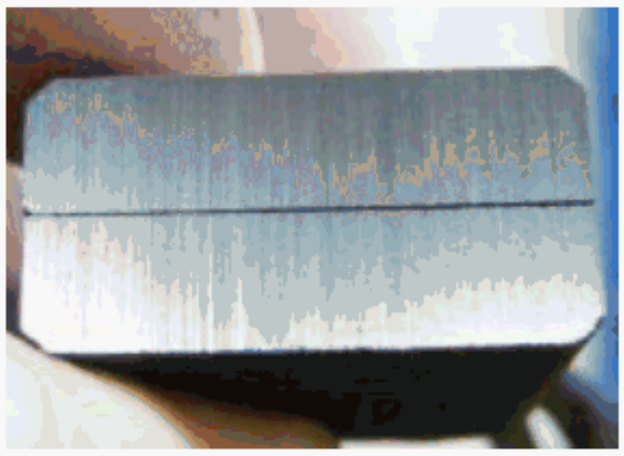
613		Copper dragging
614		Burning
615	a)  b)  c) 	Bar burn: Roughen surface by arc a) at exit edge of bar b) whole surface of one bar c) pole pitch bar burning

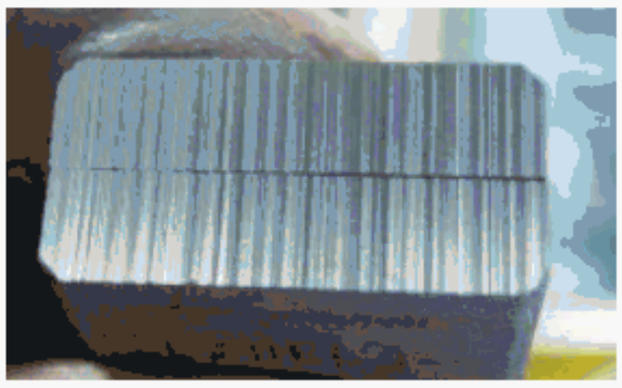
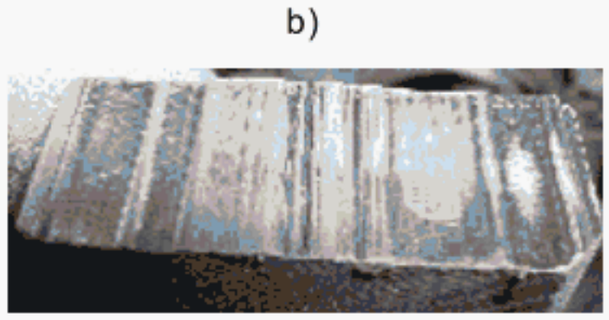
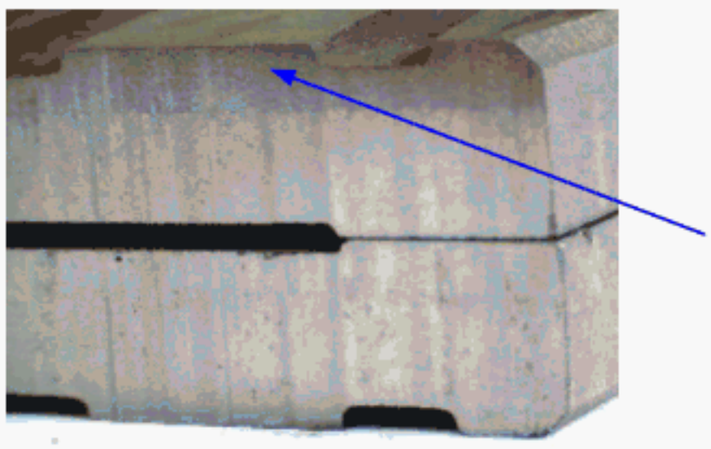
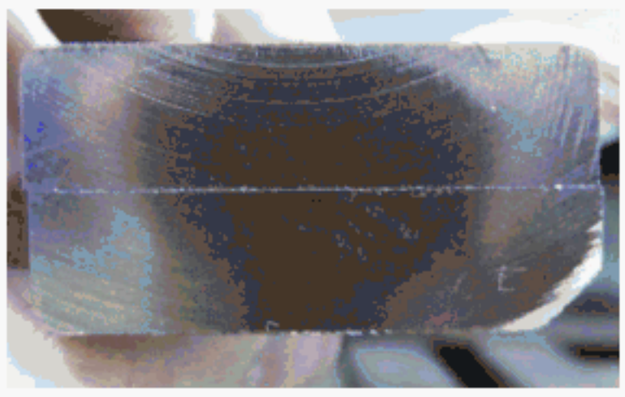
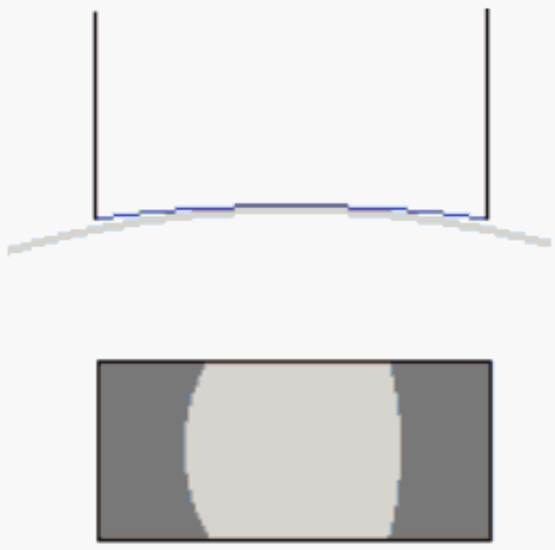
616	a)  b) 	Arc spot a) at bar edge NOTE This step may evolve to a fracture at bar edge. b) on bar surface
617		Bar to bar arc spot
618		Pitting: strong spark marks

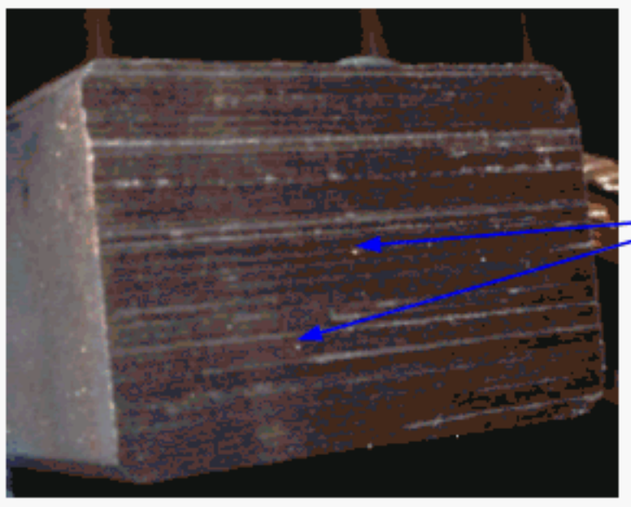
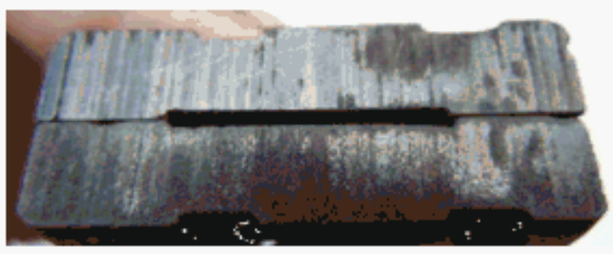
619	a)  b) 	Ghost mark a) on commutator b) on slip-ring
620		Glazing: brilliant surface, without roughness (mirror-like)

5.7 Brush markings (references No. 701 and following)

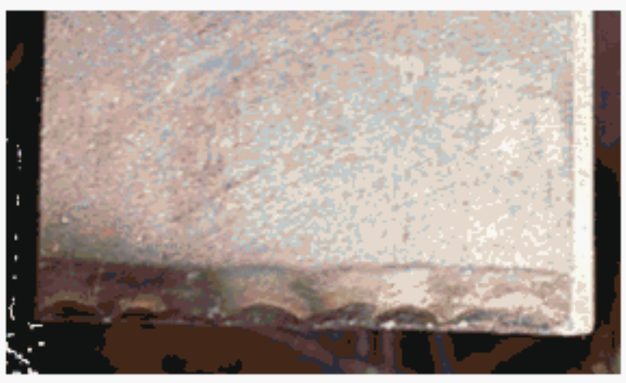
5.7.1 701 to 710: Sliding surface markings

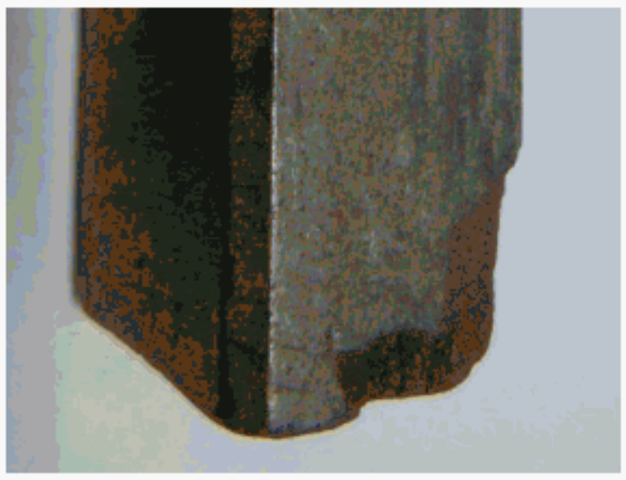
701		Shining (normal running conditions)

702	a)  b) 	Circumferential lining (streaking) / streaks a) Light b) Heavy
703		Matt zone
704		Glossy surface (like a mirror)
705		Dual contact surface
706		Limited contact area: one shining zone (contact area) and two mat zone (no contact areas) NOTE Frequently observed when brush is not fully bedded.

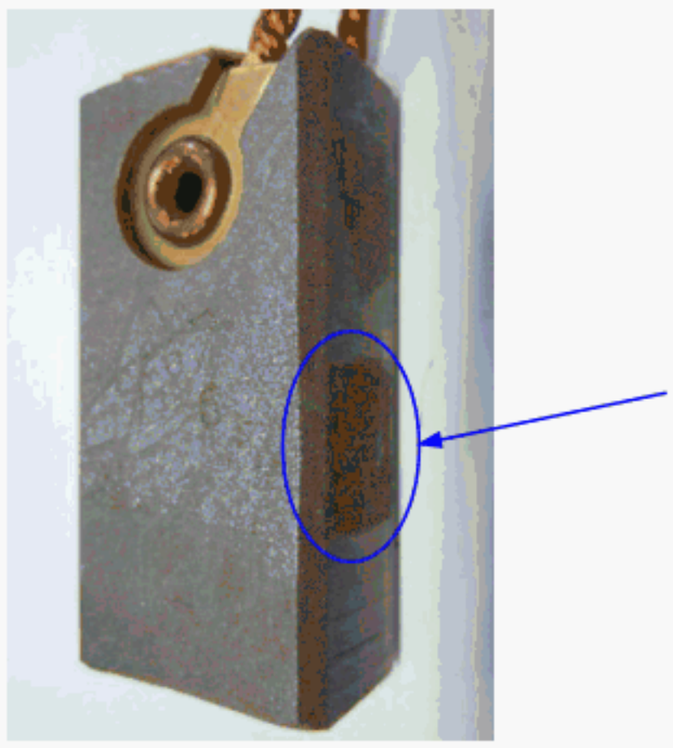
707		Burnt zone (erosion)
708		Copper picking: transfer of copper from the sliding surface of commutator / slip-ring
709		Holes (removal of grains from the surface)
710		Pollution

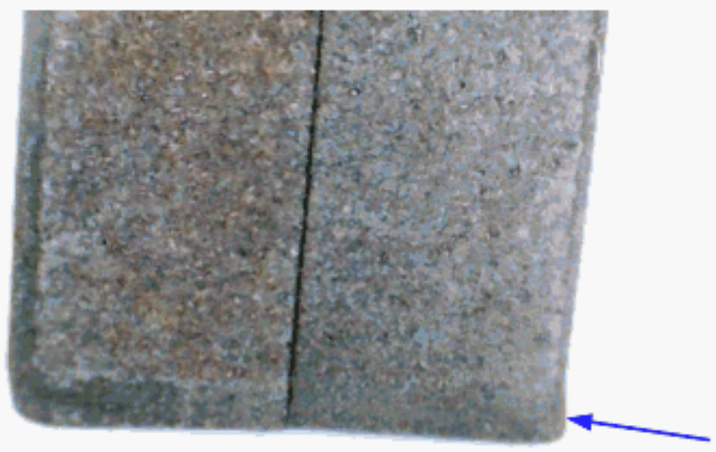
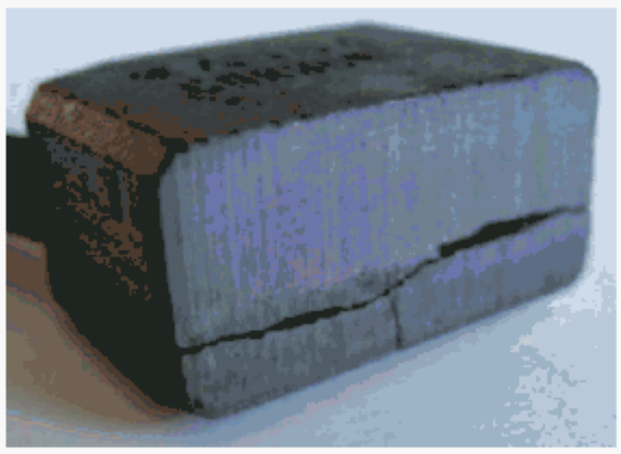
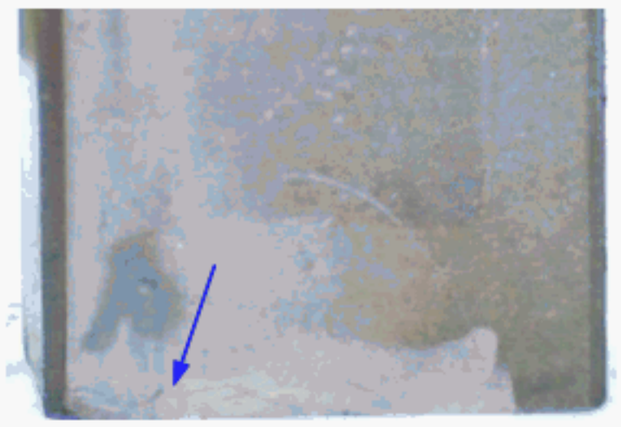
5.7.2 711 to 716: Edge/corner markings

711		Traces of sparking on the edge
712		Traces of glowing close to the edge
713		Chipping (mechanical origin)

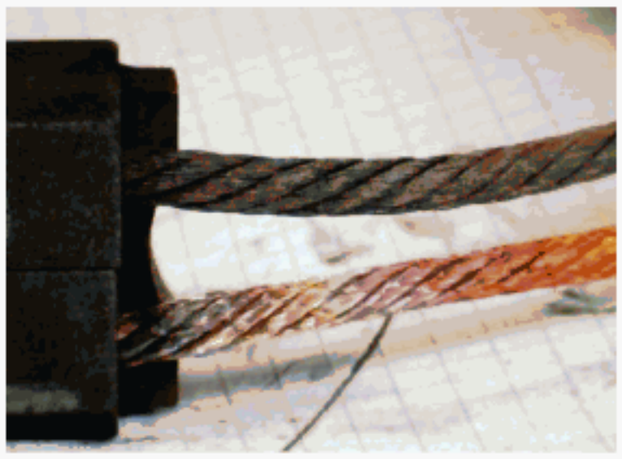
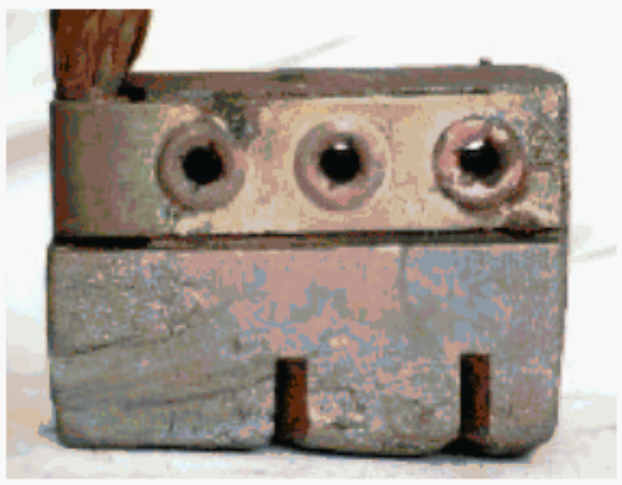
714		Tipping at contact surface corner
715		Tipping at side edge
716		Elephant foot at surface edge

5.7.3 717 to 721: Side markings

717		Side wear zone

718		Erosion of brush face (current passing through brush holder)
719	 a)  b)	Cross-section side wear: a) Elephant nose cross-section wear (external side) b) V-shape cross-section wear (between wafers)
720		Mechanical crack
721		Thermal crack and discoloration

5.7.4 722 to 727: Connection markings

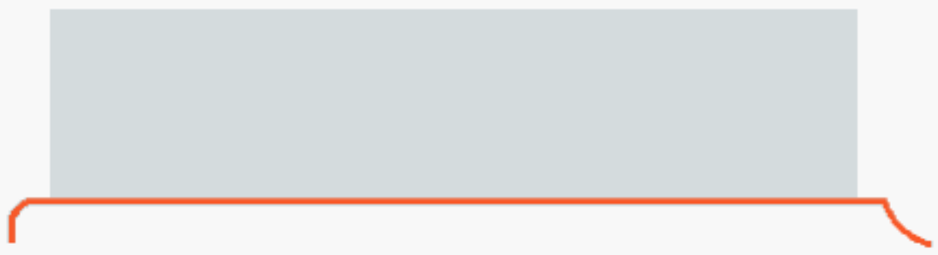
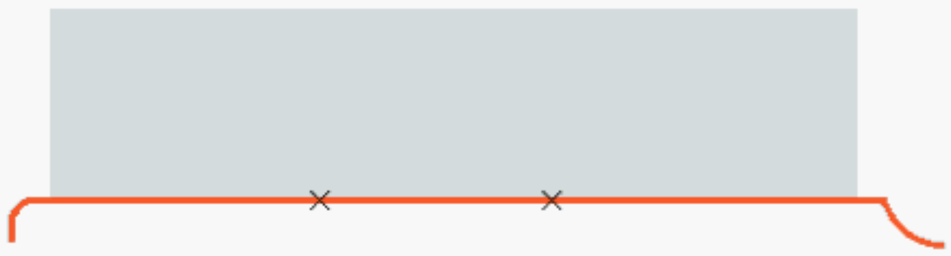
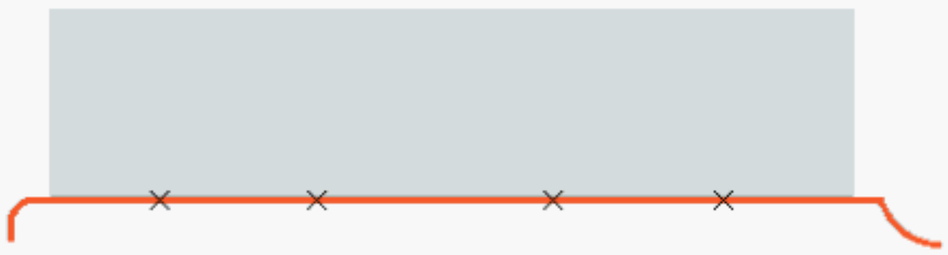
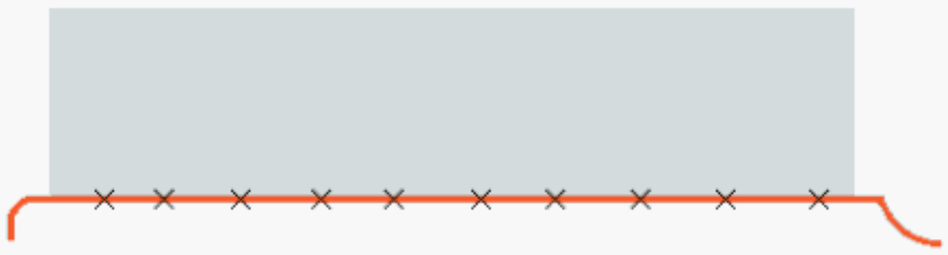
722		Fringed cable/ shunt
723		Cable/ shunt broken
724		Pulled up / torned out cable / shunt
725		Colored cable/shunt
726		Colored rivet and discoloration of brush grade around rivet area

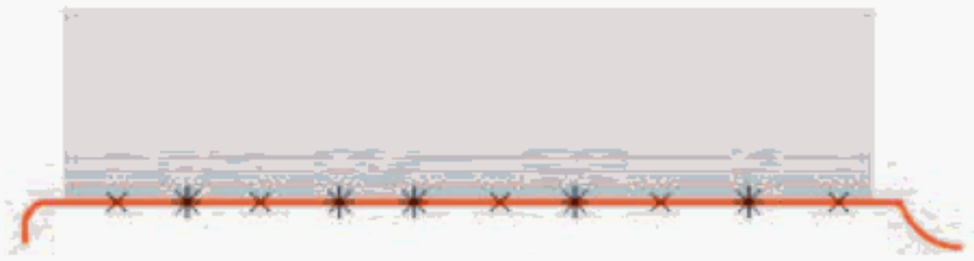
727		Cut cable sleeve

5.8 Spark evaluation (references No. 801 and following)

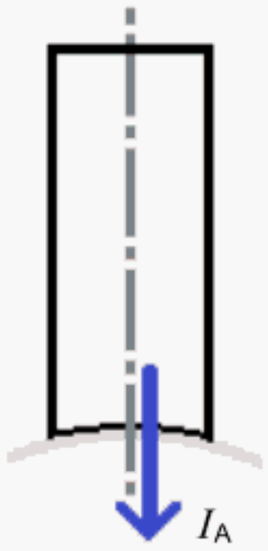
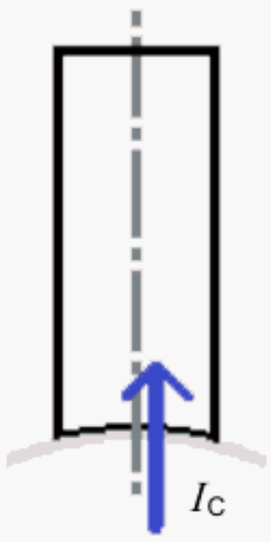
Spark codes definitions herein do not only concern commutators machines, but also slip-ring application, as it is a criterion of injury for the machine. In figures below, sparks are seen from a tangential brush view. Annex A gives a guidance on spark evaluation.

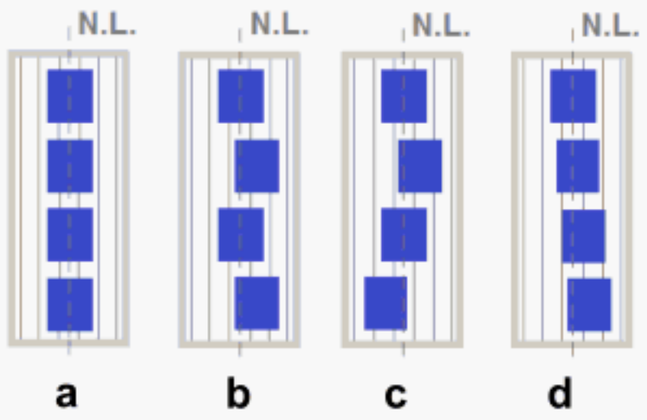
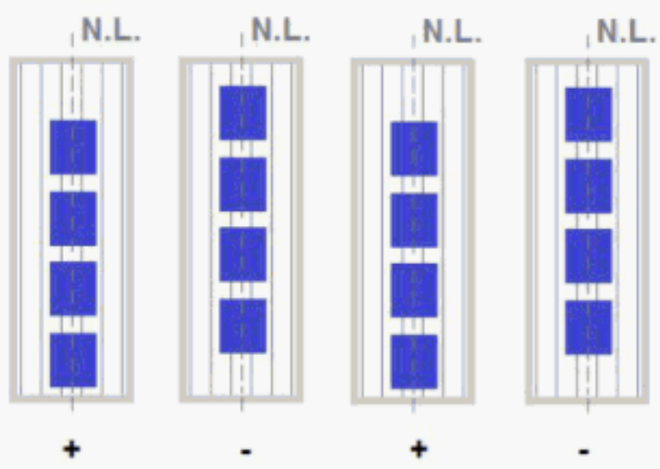
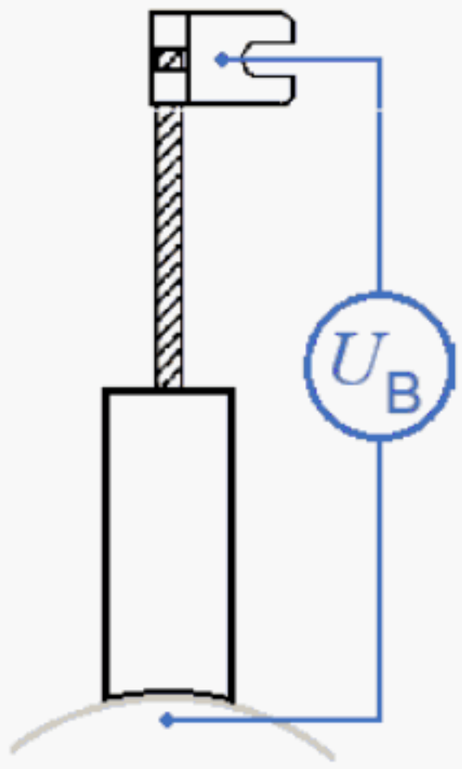
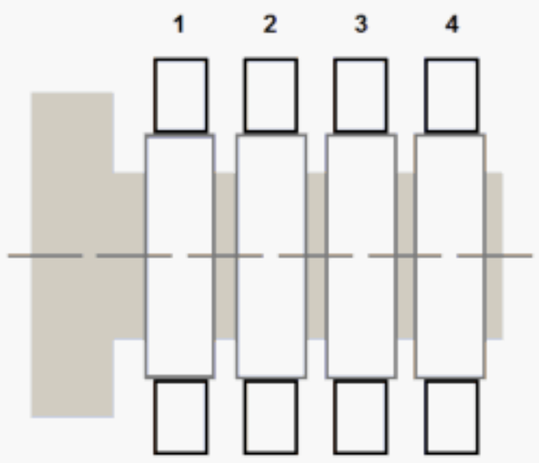
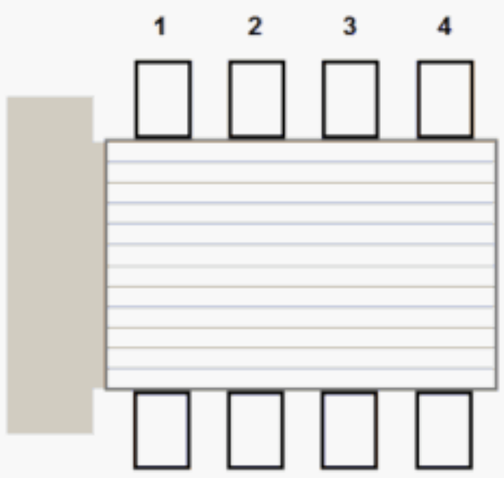
NOTE Subclause 5.9 is inspired from the withdrawn standard IEC 60638: *Criteria for assessing and coding of the commutation of rotating electrical machines for traction*.

N°	Spark figures	Spark code	Description
801		1	No spark
802		2	Intermittent beads
803		3	Several beads
804		4	Numerous beads
805		5	Intermittent shootings

N°	Spark figures	Spark code	Description
806		6	Several shootings
807		7	Numerous streamers
808		8	Heavy and continuous streamers

5.9 Miscellaneous (references No. 901 and following)

901		Anodic brush The current I_A flows from the fixed part to the rotating part through the brush.
902		Cathodic brush The current I_C flows from the rotating part to the fixed part through the brush.

903		Circumferential (tangential) stagger where N.L. is the neutral line of the DC machine NOTE When deemed necessary by the OEM, it is imperative that it is done correctly. Type b) is generally preferred. Examples: a) no stagger b) to d) different stagger positions
904		Axial stagger where N.L. is the neutral line of the DC machine NOTE Equal number of positive and negative brushes per track shall be maintained.
905		Total single brush voltage drop «U_B» NOTE IEC 60773 gives methods for measuring brush voltage drop.
906		Numbering of slip-rings: track 1 is the closest to the power part of the rotor.
907		Numbering of brush tracks: track 1 is the closest to the armature winding.

Annex A
(informative)

Spark codes

A.1 Criteria for assessment of sparking

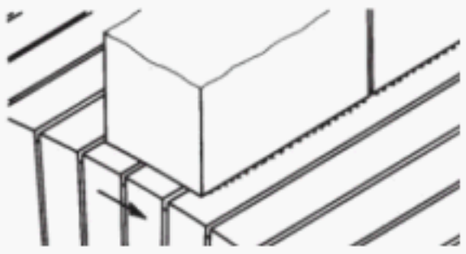
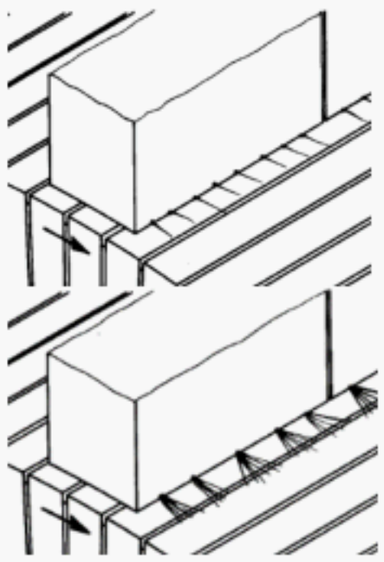
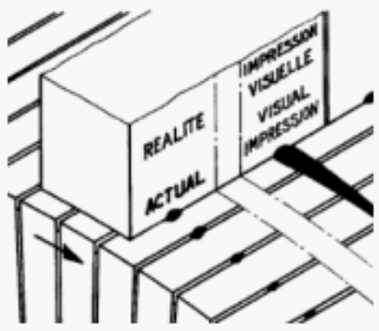
Sparks records shall be done during runs in steady-state conditions. Observations shall be made in the normal condition of lighting in the room.

Sparking is checked on all brush arms which can be directly observed. Only the arm exhibiting the worst commutation shall be recorded.

The basic criteria for observation of sparks are, see Table A.1:

– size of ordinary sparks (and proportion of the edge on which they appear);
– shooting sparks;
– streamers.

Table A.1 – Additional definitions of spark

810		Ordinary sparks	Sparks of all sizes localized at the edge of brushes.
811		Shooting sparks	Incandescent particles flying out from the leaving edge (almost straight luminous lines)
813		Streamers	Small arcs occurring between consecutive segments and blowing out at a certain distance from the leaving edge. NOTE The eyes perceives them in the form of continuous luminous lines lying on the commutator.

NOTE Figures from IEC 60638:1979 (withdrawn).

Experts consider spark code as a criterion of injury for the machine.

For commutators, spark code are injurious when:

– spark code over 5 when continuous, and
  spark code over 6 when transient.

For slip-rings (in particular steel and stainless steel):

– spark code strictly over 2, even when transient.

A.2 Complementary observations

Spark level N can be correlated to a relative light energy E_r. A polynomial function can be assessed:

$$E_r = k \times (N-1)^2$$

where k is a constant.

Sparks may also be described by their colour and sound (when possible). Observations below are indicative, see Table A.2.

Table A.2 – Relationship between energy, colour, sound and spark code

N°	Spark code	Energy coefficient (N-1)²	Colour	Sound
801	1	0	No	No
802	2	1	Red	No sound
803	3	4	Orange	No sound
804	4	9	Orange-Yellow	Almost no sound
805	5	16	Yellow-White	Slight cracking sound
806	6	25	White	Cracking sound
807	7	36	White-Blue	Loud cracking sound
808	8	49	Blue – sometimes green	Loud cracking sound

A.3 Relation between spark code and Westinghouse scale

Users usually quote sparks with the Westinghouse scale. Table A.3 shows the correspondence with Westinghouse code:

Table A.3 – Relationship between spark code and Westinghouse scale

Spark code	1	2	3	4	5	6	7	8
Westinghouse code	1	1 ¼	1 ½	1 ¾	2	2 ¼	2 ½	3