

Electrical equipment of industrial machines —

Part 1: Specification for general requirements

This European Standard EN 60 204-1 has the status of a
British Standard

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Contents

	Page
Cooperating organizations	Inside front cover
National foreword	ii
Cover page of EN 60 204	1
Brief history	2
Technical text	2
Content of EN 60 204	3
Preface of IEC Publication 204-1 (1981)	7
National appendix W UK Committees responsible	70
National appendix X Cross references to British Standards	71
Publication referred to	74

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Committee and is the English language version of EN 60 204 “*Electrical equipment of industrial machines*” Part 1 “General requirements”, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by that organization from IEC Publication 204-1 (1981) and 204-2 (1984) which have the same title as that of the European Standard. This British Standard supersedes BS 2771:1974 “Specification for electrical equipment of machine tools. General-purpose and mass production machines and their electronic equipment”, which is withdrawn.

Terminology and conventions. Some terminology and certain conventions are not identical with those used in British Standards and in particular attention is drawn to the use of the comma as a decimal marker. This is in accord with European practice but it should be noted that it is current practice in British Standards to use a full point on the baseline as a decimal marker.

Cross-references. Details of other international publications quoted in this standard are given in Appendix F. Where there are British Standards either identical or technically equivalent to these international standards the relationship is given in National appendix X.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 74, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Electrical equipment of industrial machines Part 1. General requirements

[IEC 204-1 (1981 – 2nd edition, modified)]

Équipement électrique des machines
industrielles
Partie 1. Règles générales [CEI 204-1
(1981 – 2ème édition modifiée)]

Elektrische Ausrüstung von
Industriemaschinen
Teil 1. Allgemeine Festlegungen [IEC 204-1
(1981 – 2. Ausgabe, modifiziert)]

This European Standard was ratified by CENELEC on 10th May 1984. CENELEC members are bound to comply with the requirements of the 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 CENELEC General Secretariat 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 CENELEC General Secretariat has the same status as the official versions.

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CENELEC

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

Central Secretariat: rue Bréderode 2, B-1000 Brussels

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Brief history

The CENELEC Questionnaire Procedure performed for finding out whether or not IEC 204-1 (second edition, 1981) could be accepted without textual changes, has shown that a number of CENELEC common modifications became necessary for the acceptance of IEC 204-1 as a European Standard (EN). These modifications, prepared in several meetings of a Preparatory Working Group which was set up by the Technical Board, were submitted to the CENELEC members for vote and acceptance by CENELEC.

Technical text

The text of the International Standard IEC 204-1 (second edition, 1981) was approved by CENELEC on 10 May 1984 as a European Standard with agreed common modifications. For the sake of clarity, these CENELEC common modifications have been incorporated at the appropriate places in the text of IEC 204-1 (1981); they are marked by a vertical line at the left-hand margin. The relevant parts of the original IEC text have been quoted as “INFORMATION” directly after the text of the common modifications.

Appendices designated “normative” are part of the body of the standard. Appendices designated “informative” are given only for information.

NOTE Edition I of this standard has been printed with the following dates:

English version: November 1985; French version: May 1984 (already homologated); German version: November 1985.

All versions are identical.

Contents

	Page		Page
Brief history	2	3.1.4 Marking of replaceable components	13
Technical text	2	3.1.5 Item designations of components, devices, terminals, cables and conductors	13
Preface of IEC Publication 204-1 (1981)	7	3.1.6 Functional identification of actuators	13
1 General	8	3.2 Technical documentation	14
1.1 Scope	8	3.2.1 General	14
1.2 Object	9	3.2.2 List of the different types of documents	14
1.3 Additional user requirements	9	3.2.3 Requirements applicable to all documents	15
1.4 General operating, transportation and storage conditions	9	3.2.4 Requirements applicable to particular documents	15
1.4.1 Ambient air temperature	9	3.2.4.1 Installation drawing	15
1.4.2 Altitude	9	3.2.4.2 Block diagram	15
1.4.3 Atmospheric conditions	10	3.2.4.3 Circuit diagram (U.S.A.: schematic or elementary diagram)	15
1.4.4 Installation and operating conditions	10	3.2.4.4 Description of sequence of operations and/or sequence chart	17
1.4.5 Transportation and storage	10	3.2.4.5 Interconnection diagram	17
2 Definitions	10	3.2.4.6 Parts list	17
2.1 Electronic equipment	10	3.2.4.7 Maintenance instruction	18
2.2 Controlgear assembly	10	3.2.4.8 Location diagram or table	18
2.3 Enclosure	10	3.2.4.9 List of wearing and spare parts	18
2.4 Duct	10	4 General requirements	18
2.5 Conduit	11	4.1 Components and devices	18
2.6 Live part	11	4.2 Supply	18
2.7 Exposed conductive part	11	4.3 Connection to the supply network	19
2.8 Protective conductor	11	5 Protective measures	19
2.9 Protective circuit	11	5.1 Protection against electric shock	19
2.10 Power circuit	11	5.1.1 Protection against electric shock in normal service	20
2.11 Control circuit	11	5.1.1.1 Protection by enclosures	20
2.12 Signalling circuit	11	5.1.1.2 Protection by insulation of live parts	20
2.13 Component	11	5.1.2 Protection against electric shock in case of a fault	20
2.14 Switching device	11	5.1.2.1 Protection by automatic disconnection of supply	21
2.15 Control device	11	5.1.2.2 Protection by use of Class II equipment or by equivalent insulation	24
2.16 Actuator	12	5.1.2.3 Protection by use of "functional extra-low voltage (FELV)"	24
2.17 Marking	12	5.1.2.4 Protection by electrical separation	24
2.18 Item designation	12		
2.19 Servicing level	12		
2.20 Instructed persons	12		
2.21 Skilled persons	12		
3 Warning signs, marking, item designation and technical documentation	12		
3.1 Warning signs, marking and item designation	12		
3.1.1 Warning signs on enclosures	12		
3.1.2 Marking of controlgear assemblies	12		
3.1.3 Marking of control devices	13		

		Page			Page
5.1.3	Protection against electric shock both in normal service and in case of a fault, protection by “machine extra-low voltage (MELV)”	25	7.1.1	Arrangement of electrical devices	36
			7.1.2	Accessibility	37
			7.1.3	Clearances and creepage distances	37
5.1.4	Residual voltages		7.2	Controlgear assemblies	37
5.2	Short-circuit protection	25	7.2.1	Degree of protection	37
5.2.1	General protection	25	7.2.2	Openings	38
5.2.2	Protection of circuits and branches	26	7.2.3	Doors	38
5.2.3	Rating and setting of short-circuit protective devices	26	7.2.4	Arrangement of electrical devices	38
5.2.4	Conductors in front of the devices protecting them	26	7.2.5	Non-electric parts and devices	38
5.3	Overload protection	27	7.2.6	Mounting and handling of controlgear assemblies	39
5.4	Protection against automatic re-start after supply interruption and restoration	27	8	Control devices	39
			8.1	General	39
			8.1.1	Location and mounting	39
			8.1.2	Protection	39
5.5	Voltage drop protection	27	8.1.3	Plug-in control devices	39
5.6	Emergency stopping and supply disconnecting device	27	8.1.4	Position sensors (including proximity sensors)	39
5.7	Protection in case of failure	30	8.1.5	Electro-magnets	40
5.8	Interferences	31	8.1.6	Pressure and temperature sensors	40
6	Control and signalling circuits	31	8.2	Hand-operated control switches and indicator lights	40
6.1	Control and signalling circuit supplies and protection	31	8.2.1	Accessibility of switches	40
6.1.1	Use of transformers	31	8.2.2	Protection	40
6.1.2	Direct connection to the supply	32	8.2.3	Push-buttons	40
6.1.3	Several transformers	32	8.2.4	Indicator lights (signalling lamps)	43
6.1.4	Overcurrent protection	32	8.2.5	Illuminated push-buttons	44
6.2	Control circuit	32	9	Cables and conductors	46
6.2.1	Preferred values of the control voltages	32	9.1	Types of conductors and cables	47
6.2.2	Protection against unintended operation by earth faults	33	9.2	Insulation of cables	47
6.2.3	Connection of coils and contacts and input/output units	33	9.3	Cross-section of conductors	47
6.2.4	Protective interlocks	33	9.3.1	Current-carrying capacity	47
6.2.5	START and STOP functions	34	9.3.2	Voltage drop	48
6.2.6	Cycle start	34	9.3.3	Minimum cross-sections of copper conductors	48
6.2.7	Emergency stop	35	10	Wiring	48
6.2.8	Automatic operation—manual operation	35	10.1	General	48
6.2.9	Control of sequence in automatic operation	36	10.1.1	Connections	48
6.3	Signalling circuit	36	10.1.2	Cable runs	49
7	Mechanical design, arrangement of electrical devices, etc.	36	10.1.3	Connections to movable parts	49
			10.1.4	Conductors of different circuits	49
7.1	Requirements applicable to the whole electrical equipment	36	10.1.5	Cable lugs	49
			10.1.6	Terminals and connection boxes	49
			10.2	Identification of conductors	49

	Page		Page
10.2.1 Identification of the protective conductor (PE) and of the neutral conductor (N)	49	Appendix B (normative) Current-carrying capacity and short-circuit protection of cables insulated with polyvinyl chloride in the electrical equipment of industrial machines	59
10.2.2 Identification of other conductors	50	Appendix C (normative) Comparison of the conductor cross-sectional areas	64
10.3 Wiring inside enclosures	50	Appendix D (informative) Item designation of the electrical equipment of industrial machines	65
10.3.1 Internal ducts	50	Appendix E (informative) Examples of drawings, diagrams, tables and instructions	66
10.3.2 Interconnection terminals and plug-and-socket connectors	50	Appendix F (normative) Other international publications quoted in this standard	66
10.3.3 Test points	50	Appendix G (informative) Original IEC text of Scope of IEC 204-1 (1981)	69
10.4 Wiring outside enclosures	50	Table I — Guide for the selection of the cross-section of copper protective conductors	23
10.4.1 External ducts	50	Table II — Size of the terminal for the external protective conductor	23
10.4.2 Connection to moving elements of the machine	51	Table III — Colours of push-buttons and their meaning	42
10.4.3 Interconnection of devices on the machine	51	Table IV — Colours of indicator lights and their meaning	44
10.4.4 Plug and socket connections	52	Table V — Recommended application of colours for illuminated push-buttons	46
10.4.5 Dismantling for shipment	52	Table VI — Minimum cross-section of cables	48
10.4.6 Spare conductors	52	Table BI — Derating factor	60
11 Electric motors	52	Table BII — Current-carrying capacities	61
11.1 General requirements	52	Table BIII — Maximum permissible total cut-out time of short-circuit protective devices for copper conductors and rated currents of standard fuses	63
11.2 Dimensions	52	Table CI	64
11.3 Characteristics	52	INFORMATION as to original IEC text	
11.4 Type of enclosure	53	The Foreword of IEC Publication 204-1 (1984) is not part this European Standard;	
11.5 Mechanical vibration	53	Appendix D (informative), Appendix E (informative), Appendix F (normative) and Appendix G (informative) are not included in IEC 204-1 (1981)	
11.6 Method of starting	53		
11.7 Mounting	53		
11.8 Nameplates	53		
12 Connection to accessories and local lighting	54		
12.1 Connection to accessories	54		
12.2 Local lighting of the machine	54		
13 Testing	54		
13.1 Insulation tests	55		
13.2 Voltage test	55		
13.3 Continuity of the protective circuit	55		
13.4 Operating tests	55		
13.4.1 Routine test without load on the machine	55		
13.4.2 Operating type test with the loaded machine	56		
14 Inquiry form	56		
Appendix A (normative) Inquiry form for the electrical equipment of industrial machines	57		

INFORMATION as to original IEC text

The Foreword of IEC Publication 204-1 (1981) is not part of this European Standard. It reads:

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

| Preface of IEC Publication 204-1 (1981)

This standard has been prepared by IEC Technical Committee No. 44: Electrical Equipment of Industrial Machines.

It forms Part 1 of the second edition of IEC Publication 204 and supersedes the following publications:

IEC Publication 204-1 (first edition, 1967);

Amendment No. 1 (1967) to IEC
Publication 204-1;

IEC Publication 204-1A (1969), not including Appendix D: Recommended Graphical Symbols for Use on
Diagrams for the Electrical Equipment of Machine Tools (not to be re-published);

IEC Publication 204-1B (1975);

IEC Publication 204-2 (first edition, 1967);

IEC Publication 204-3 (first edition, 1968).

IEC Publication 204-2 (second edition, 1984) contains Part 2 and comprises:

Appendix D: Item designation of the electrical equipment of industrial machines

Appendix E: Examples of drawings, diagrams, table and instructions

NOTE The above-mentioned Appendix D and Appendix E are referred to in this European Standard as Appendix D and Appendix E (both informative), with Notes explaining the harmonization situation.

INFORMATION as to original IEC text

The paragraph before the Note has been editorially updated; the Note is not included in the IEC text.

Following the decisions taken at the meeting held in Washington in 1970 to revise Publications 204-1, 204-2 and 204-3 and to combine Publications 204-1 and 204-2 into a single publication, drafts for the new edition were discussed at the meetings held in Munich in 1973, Santa Margherita in 1976 and in Paris in 1978, where it was further decided to combine the three publications 204-1, 204-2 and 204-3 into one single publication. As a result of this latter meeting, a draft, Document 44(Central Office)48, was submitted to the National Committees under the Six Months' Rule in May 1979. Amendments, Document 44(Central Office)50, were submitted for approval under the Two Months' Procedure in May 1980.

The National Committees of the following countries voted explicitly in favour of publication:

Australia	Italy
Austria	Japan
Belgium	Netherlands
Brazil	Romania
Czechoslovakia	South Africa (Republic of)
Denmark	Sweden
Egypt	Switzerland
Finland	Turkey
France	Union of Soviet
Germany	Socialist Republics
Hungary	United Kingdom
Ireland	United States of America

NOTE Other international publications quoted in this standard are given in Appendix F (normative). Where those publications have been implemented as Harmonization Documents (HD), reference to the relevant HDs has been included.

INFORMATION as to original IEC text

It reads: *Other IEC publications quoted in this standard.*

(The list given under this IEC heading does not include the following publications:

IEC 227-1, IEC 245-1, IEC 364-5-523, ISO 65, ISO 216, ISO 3864, ISO 7000)

1. General

1.1 Scope

INFORMATION as to original IEC text

The text of the Scope, Sub-clause 1.1 of IEC Publication 204-1 (1981), is included in Appendix G (informative) to this European Standard.

This standard is applicable to the electrical and electronic equipment of industrial machines not portable by hand while working, used for carrying out industrial operations on materials or components.

It does not cover all the requirements (for example for guarding, interlocking and control) which may be needed or required (e.g. by other standards or regulations) in order to safeguard personnel from other hazards than electrical, such as those associated with dangerous parts of the machine or the ejection of fragments of the machine or of process materials.

NOTE In this standard the term “electrical” includes both electrical and electronic matters, for example, “electrical equipment” means both the electrical and the electronic equipment.

Requirements which apply only to electronic equipment are printed in **bold type**.

NOTE Additional user requirements are printed in *italic type* (see Sub-clause 1.3).

The equipment covered by this standard commences at the point of connection of the supply to the electrical equipment of the machine (see Sub-clause 4.3.3). This standard applies to equipment which operate from a.c. supplies with nominal voltages up to and including 1 000 V a.c. between lines and nominal frequencies up to and including 200 Hz. For frequencies greater than 200 Hz special requirements may apply.

For electrical equipment which operates from a.c. supplies with nominal voltages higher than 1 000 V between lines, this standard applies to the circuits having a voltage not exceeding 1 000 V.

NOTE For equipment which operates from d.c. supplies with nominal voltages not exceeding 1 500 V d.c., this standard can be used as a guide.

This standard specifically includes, but is not limited to, the electrical equipment of machines for:

- metalworking;
- woodworking;
- plastic moulding and extruding;
- manufacturing of products from plastic material;
- textile and clothing industries;
- manufacturing of products from leather;
- manufacturing of products from rubber;
- manufacturing of products from paper and its derivatives;
- printing;
- food and allied industries;
- packaging.

Also included is the electrical equipment of automatic machines for assembling, material handling (for example conveyors) and inspection, if associated with the machines listed above.

NOTE Automatic machines for assembling may include welding equipment, for which reference should be made to the standards dealing with electrical and electronic equipment for welding, cutting and related techniques.

Additional and special requirements according to the relevant standards, regulations or recognized practice, have also to be complied with for the electrical and electronic equipment of machines which:

- are used in open air;
- use or produce explosive material, for example paint or sawdust;
- are used in mines;
- are used in potentially explosive atmospheres;
- give rise to special risks when processing certain materials.

Excluded from this scope are:

- power circuits where electrical power is directly used as a working tool (for instance welding, electrical discharge, electrochemical processes, etc.);
- the electrical and electronic equipment or parts of such equipment used for production and distribution of electrical energy;
- machines (devices, equipment) used for transportation of persons;
- cranes, lifts, conveyors (if not associated with industrial machines).

However, this standard may serve as a basis for rules for the electrical equipment of types of machines or parts of machines which are excluded from this scope.

NOTE The requirements related to the interface between numerical controls and industrial machines are dealt with in IEC Publication 550: Interface between numerical controls and industrial machines.

1.2 Object

The purpose of this standard is to provide detailed specifications relating to the electrical equipment of industrial machines, so as to promote:

- a) safety of personnel and property;
- b) uninterrupted production;
- c) long life of the equipment, as well as ease and economy of maintenance.

NOTE High performance shall not be obtained at the expense of the three essential factors mentioned above.

The use of the inquiry form given in Appendix A of this standard is intended to facilitate the agreement between the user and the manufacturer on basic data relating to the electrical equipment.

1.3 Additional user requirements

In this standard some optional user requirements are printed in italic type. These are additional requirements in order to:

- *facilitate maintenance and repair of the electrical equipment and of the machine;*
- *advance the reliability of the machine.*

An example of possible application of these additional requirements are industrial machines used in large series production processes, such as transfer machines, mass production machines, etc., where a failure, even when only momentary, may have serious economic consequences.

It shall be agreed between the user and the manufacturer if these additional requirements shall be applicable. Unless clearly stated, they do not apply. If it is specified to comply with these optional requirements, they all shall apply without exception.

1.4 General operating, transportation and storage conditions

1.4.1 Ambient air temperature

Electrical equipment shall be capable of operating in an ambient air temperature between + 5 °C and + 40 °C, and the average over a period of 24 h shall not exceed 35 °C.

Electrical equipment intended for operating in ambient air temperatures above 40 °C (for example in forges, in tropical countries) or below + 5 °C, shall be designed according to the actual conditions of temperature to be stated by the user or possibly be derated according to the instructions of the manufacturer.

NOTE The manufacturer shall give consideration to additional temperature rise resulting from the enclosures of the equipment.

1.4.2 Altitude

Electrical equipment shall be suitable for operating correctly at altitudes up to 2 000 m above mean sea level.

For electronic equipment, the design limit is 1 000 m.

Electrical equipment intended for operating at altitudes higher than 2 000 m—or 1 000 m for electronic equipment—shall be designed for the actual altitude in use as stated by the user or possibly be derated according to the instructions of the manufacturer, to take into account the reduction of the electric strength and cooling effect of the air.

1.4.3 Atmospheric conditions

Electrical equipment shall be suitable for operating correctly under atmospheric conditions with a relative humidity not exceeding 50 % at 40 °C and 90 % at 20 °C and less. If higher humidities may occur or abnormal amounts of dust, acids, corrosive gases, salt, etc., may be present, a special agreement between manufacturer and user is necessary.

NOTE Air with a relative humidity of 50 % and a temperature of 40 °C will be fully saturated (100 % relative humidity) if cooled to 28 °C.

Harmful effects of occasional condensation shall be avoided by proper design of the equipment and/or, if necessary, by proper additional measures, for example built-in air conditioners.

1.4.4 Installation and operating conditions

Electrical equipment shall be installed and operated in accordance with the manufacturer's instructions. In case of special circumstances, the user shall inform the manufacturer (see also question 5 of Appendix A).

1.4.5 Transportation and storage

Electrical equipment shall be designed to withstand storage and transportation temperatures within the range of – 25 °C to + 55 °C and for short periods not exceeding 24 h up to 70 °C. Suitable means shall be provided to prevent damage from humidity and from vibration stresses and shocks.

If it is expected that extreme conditions might be encountered or if particularly sensitive equipment is involved, proper warnings shall be placed on the shipping container (see also IEC Publications 68-2-6: Basic Environmental Testing Procedures, Part 2: Tests, Test Fc: Vibration (Sinusoidal), 68-2-31: Test Ec: Drop and Topple, Primarily for Equipment-type Specimens, 68-2-32: Test Ed: Free Fall).

2 Definitions

For the purpose of this standard, the following definitions apply:

2.1

electronic equipment

that part of the electrical equipment containing circuitry whereby conduction of electrons takes place through a vacuum, gas, or semi-conductor

NOTE Some examples of electronic equipment are:

- devices with semi-conductors or with valves;
- indicating devices such as gauging and feedback units;
- static control units and equipment;
- magnetic amplifiers and saturable reactors;
- industrial data processing;
- equipment and units associated electrically and mechanically with the electronic circuits (transducers, low-current electromagnetic relays, transformers, resistors, potentiometers, position sensors, servo components, etc.).

2.2

controlgear assembly

combination of one or more switching devices together with associated control, measuring, protective and regulating equipment, completely assembled with all the internal electrical and mechanical interconnections, supporting structures and enclosures

2.3

enclosure

housing providing protection for persons against direct contact with live parts contained therein and protection against certain defined external influences for the electrical equipment therein

NOTE An enclosure may be:

- a cabinet or a box, either mounted on the machine or separate from the machine;
- a compartment, consisting of an enclosed space within the machine structure;
- an enclosed room in a building.

2.4

duct

any channel for holding and protecting electrical conductors, used solely for this purpose

2.5**conduit**

tubular duct having rigid or flexible walls made of metal or insulating material

2.6**live part**

any conductor or conductive part which is at a voltage in normal use

NOTE Live parts also include the neutral conductor and conductive parts which are connected with it.

[Identical with Sub-clause **3.20** of IEC Publication 364-1: Electrical Installations of Buildings, Part 1: Scope, Object and Definitions (second edition, 1972).]

2.7**exposed conductive part**

conductive part which can readily be touched and which is not a live part but which may become alive under fault conditions

[Identical with Sub-clause **3.21** of IEC Publication 364-1 (second edition, 1972).]

2.8**protective conductor**

conductor used for some protective measures against shock in case of a fault and for connecting exposed conductive part with:

- other exposed conductive parts;
- extraneous conductive parts (which are not part of the electrical equipment);
- earth electrodes, an earthed conductor or an earthed live part (for example a neutral).

[Identical with Sub-clause **3.23** of IEC Publication 364-1 (second edition, 1972).]

2.9**protective circuit**

the whole of the protective conductors and conductive parts participating in protection against the consequences of earth-faults

2.10**power circuit**

circuit used for supplying power from the supply network to devices used for the productive operation (for example to electric motors)

2.11**control circuit**

circuit used for the operational control of the machine and for protection of the power circuits

NOTE Circuits supplying magnetically operated valves and clutches may be considered to be part of the control circuit.

2.12**signalling circuit**

circuit used for the operational control of signalling devices, such as indicators, acoustic warnings, etc

2.13**component**

constituent part of the electrical equipment, usually specified by function, but used in various applications. Examples: resistors, capacitors, transistors, integrated circuits, circuit boards, transducer

2.14**switching device**

device designed to make or break the current in one or more electric circuits

(Identical with I.E.V. 441-06-01.)

2.15**control device**

device connected into the control circuit and used for controlling the operation of the machine, such as position sensor, manual control switch, relay, magnetically operated valve, etc

2.16**actuator**

part of the actuating system of a control device to which an external actuating force is applied

NOTE The actuator may be, for example, a handle, knob, push-button, roller, plunger, etc.

(Similar to Sub-clause **2.1.5** of IEC Publication 337-1: Control Switches (Low-voltage switching Devices for Control and Auxiliary Circuits, Including Contactor Relays), Part 1: General Requirements.)

2.17**marking**

signs or inscriptions for identification of the type of a component or device, attached by the manufacturer of the component or device

2.18**item designation**

distinctive code, which serves to identify an item in a diagram, list, chart and on the equipment (Identical with Sub-clause **2.1** of IEC Publication 113-2: Diagrams, Charts, Tables, Part 2: Item Designation.)

NOTE It is affixed near the item or attached to the item before or during assembly of the control gear or when mounting the item on the machine.

2.19**servicing level**

level on which the maintenance person stands when servicing the electrical equipment

2.20**instructed persons**

persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff)

(Identical with BA 4, Section 322, of IEC Publication 364.)

2.21**skilled persons**

persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create (engineers and technicians)

(Identical with BA 5, Section 322, of IEC Publication 364.)

3 Warning signs, marking, item designation and technical documentation**3.1 Warning signs, marking and item designation****3.1.1 Warning signs on enclosures**

All enclosures which do not clearly show that they contain electrical devices shall be marked with a black lightning flash on yellow background within a black triangle, shaped in accordance with the graphical symbol 417-IEC-5036, the whole in accordance with symbol No. 13 of ISO 3864: Safety colours and safety signs.

**3.1.2 Marking of controlgear assemblies**

Controlgear assemblies shall be legibly and indelibly marked in such a way that the marking is readily visible when the equipment is installed. Whenever possible, a nameplate giving the following information shall be fixed to each controlgear assembly:

- name of the manufacturer of the controlgear assembly, or his trade mark.
- rated operational voltages with indication if d.c. or a.c., the rated frequencies and the number of phases if a.c. (for each supply if more than one);

- rated currents;
- serial number or other identification of the equipment.

The rated currents shown on the nameplate shall be not less than the sum of the full-load currents required for all motors and other equipment which may be in operation at the same time under normal conditions of use. Where unusual loads, duty cycles, etc., require oversized conductors, the required capacity shall be included in the rated current quoted on the main nameplate.

For simple electrical equipment (for example having only one motor starter) or where electrical equipment is housed in an enclosure within the machine structure, the nameplate of the machine may also serve as the nameplate of the electrical equipment, if it is plainly visible and shows the required information.

3.1.3 Marking of control devices

All control devices shall carry at least the following inscriptions:

INFORMATION as to original IEC text

It reads: All control devices which are electrically operated shall carry at least the following inscriptions:

- a) the manufacturer's name or trade mark;
- b) a designation or reference mark for identification of the type of device.

The following information shall be placed either on the device or on its operating coil in such a way as to be visible when the coil is mounted on the device:

- c) nature and value of the operating voltage (and frequency if a.c.).

Moreover, if the coil is removable, it shall bear the manufacturer's name or trade mark as well as a type designation or reference mark.

As an exception, where the device is too small to be marked, the necessary information shall be shown on a diagram or a list.

3.1.4 Marking of replaceable components

Such components shall be marked in a durable way as follows:

- if an international code for indicating rated values, tolerances, etc., exists, the components shall be marked in accordance with this code (for example, colour code for resistors);
- in other cases, these components shall have individual markings indicating the name of the manufacturer and technical information sufficient to identify the component for replacement. Where it is not practicable because of the small size of components to properly mark the components, they shall be recognizable from adequate layout diagrams and associated parts lists.

3.1.5 Item designations of components, devices, terminals, cables and conductors

If item designations are used for the individual elements, they shall be in accordance with Appendix D.

Devices and terminals to which cable connections are to be made at the time of installation or re-established after maintenance attention, shall be identified in a durable manner in accordance with the item designations and numbering used in the diagrams.

All the terminals, cables and conductors, whether they are located inside or outside enclosures, shall be designated in a durable manner. The designation of the cables and conductors can be done by sleeves or collars (non-metallic), permanently fixed, or by adhesive bands, resistant against hydrocarbons. For the designation of cables and conductors see also Appendix E.

Each individual device of the electrical equipment shall be identified by an item designation according to Appendix D, affixed near the device (preferably) or on it. If the identification is not physically possible, it shall be given in the technical documentation.

INFORMATION as to original IEC text

It reads: *Each individual device of the electrical equipment shall be identified by an item designation according to Appendix D, affixed near the device (preferably) or on it.*

3.1.6 Functional identification of actuators

Manual control devices, such as push-buttons, selector switches, etc., shall be clearly and permanently designated with regard to their functions, either on or adjacent to their actuators. Such inscriptions shall be in the language agreed by the user and the manufacturer prior to the acceptance of the order. However, the use of standard symbols given in IEC Publications 417: Graphical Symbols for Use on Equipment. Index, Survey and Compilation of the Single Sheets, and ISO 7000 is recommended.

INFORMATION as to original IEC text

In IEC Publication 204-1, ISO/R 369 is cited instead of ISO 7000.

3.2 Technical documentation

3.2.1 General

The information necessary for installation, operation and maintenance of the electrical equipment of a machine shall be supplied in the form of drawings, diagrams, charts, tables and instructions. This information shall be in the language agreed by the user and the manufacturer prior to the acceptance of the order.

The information to be given will vary with the number and complexity of the electrical equipment provided.

For simple equipment, the relevant documentation may be contained in one document, provided this document shows all the devices of the electrical equipment and enables the connection to the supply network to be made.

The main contractor (who is responsible for the proper co-ordination between the electrical and the electronic equipment and the machine) shall ensure that copies of a complete and fully co-ordinated technical documentation covering the electrical and the electronic equipment (if there is any) are supplied with each machine.

For electrical equipment having only a few electronic components and where these components can be readily identified for maintenance, replacement or adjustment, the required information may be included as part of the main circuit diagram. If these components are united into sub-assemblies, the connection points of such sub-assemblies to the other electrical equipment may be shown on the main circuit diagram and a separate drawing may show the necessary information of the sub-assemblies.

For electrical equipment having a substantial number of electronic components, diagrams shall be provided showing the electronic components and their relationship to the other electrical equipment of the machine, such that each electronic component can be identified and cross-referenced to the electronic diagrams. Where the same type of electronic component is used at several places in the equipment, the diagram shall show an individual item designation for each of them.

3.2.2 List of the different types of documents

The technical documentation shall contain the following data:

- installation drawing (see Sub-clause 3.2.4.1);
- block diagram (if necessary) (see Sub-clause 3.2.4.2);
- circuit diagram (U.S.A.: schematic or elementary diagram) (see Sub-clause 3.2.4.3);
- description of sequence of operations and/or sequence chart or table and/or any other suitable method for explaining the operation (if necessary) (see Sub-clause 3.2.4.4);
- interconnection diagram or equivalent table or suitable cross-references on diagrams to enable circuits to be traced throughout the equipment (if necessary) (see Sub-clause 3.2.4.5);
- parts list (see Sub-clause 3.2.4.6);
- maintenance instructions and adjustment procedures (if necessary) (see Sub-clause 3.2.4.7).
- any relevant information, where applicable; in particular data concerning the electrical equipment of the machine which are required by other standards and regulations covering safety aspects of the operation of the machine.

INFORMATION as to original IEC text.

The last indent is not included.

- list of wearing and spare parts usually recommended to be carried in stock (if necessary) (see Sub-clause 3.2.4.9).

INFORMATION as to original IEC text

This indent is printed in italics and is placed as second indent under “The technical documentation shall also contain”; “usually” is not included.

The technical documentation shall also contain:

- *location diagram or table (see Sub-clause 3.2.4.8);*

NOTE If an important part of the operation of the machine is controlled by hydraulic or pneumatic equipment, the manufacturer of the machine is responsible for supplying a diagram of the hydraulic or pneumatic circuits corresponding to the requirements of Sub-clause 3.2.

3.2.3 Requirements applicable to all documents

For referencing of the different documents, the manufacturer shall choose one of the following two methods:

- each of the documents shall carry as a cross-reference the reference numbers of all the other documents belonging to one and the same electrical equipment, or
- all the documents shall be listed with reference number and title in a table of contents.

Drawings, diagrams, charts, tables and instructions shall be issued in ISO-A Series sizes, in accordance with ISO Publication 216, maximum size A1. Sizes with one dimension 297 mm (height of A4) are recommended, their length preferably not to exceed 840 mm (4 times width of A4).

Single-line or multiple-line representation, as described in IEC Publication 113-1: Part 1: Definitions and Classifications, may be used in the diagrams according to the manufacturer's choice.

The symbols used on drawings, diagrams, charts and tables shall be uniform throughout and are to be selected from those shown in IEC Publications 117: Recommended Graphical Symbols, and 617: Graphical Symbols for Diagrams.

The identification (item designation) of components, devices, terminals and conductors shall be the same in all documents and in the electrical equipment (see Sub-clause 3.1.5).

3.2.4 Requirements applicable to particular documents

3.2.4.1 Installation drawing

The installation drawing shall give all information necessary for the preliminary work for setting up the machine.

The data necessary for choosing the type, characteristic and rated or setting current of the over-current protective device to be installed at the origin of the power supply cables of the electrical equipment shall be stated (see Sub-clause 5.2.1).

The position, size and — if not apparent from the rated currents — the minimum cross-section of cables to be installed on site, shall be clearly indicated. Where specific types of cable are necessary, this information shall also be given.

INFORMATION as to original text

The third paragraph contains only the first sentence.

Where necessary, the size, purpose and location of any cable ducts to be provided in the foundations by the user shall also be detailed.

Where space is required for the removal or servicing of electrical equipment, this shall also be indicated.

If no separate interconnection diagram is produced, the installation drawing shall also show details of the main ducts and cable routing. In addition, it shall show the position of the control devices placed outside the enclosure(s) and of the connection devices necessary for the reconnection of the electrical equipment after being broken down for shipment.

Example: See Appendix E, diagram E 100.

3.2.4.2 Block diagram

The block diagram is intended to facilitate the understanding of the principle of operation by means of a relatively simple representation. It is a diagram in which the electrical equipment together with its functional interrelationships are represented by symbols, block symbols or pictures without necessarily showing all the connections.

Example: See Appendix E, diagram E 310.

3.2.4.3 Circuit diagram (U.S.A.: schematic or elementary diagram)

The circuit diagram is intended to facilitate detailed understanding of the functioning of the electrical equipment. It represents all or part of the electrical equipment by means of symbols with the associated electrical connections and other links concerned with its operation.

NOTE The circuit diagram facilitates the understanding of the details of the operations performed by the machine: It shows by means of symbols the electrical devices and all the connections, particularly all the electrical connections concerned in the operation of the machine. The apparatus are shown in the condition adopted when de-energized and binary logic elements in the reset state. Mechanical devices, such as switches, are shown in the position adopted prior to the beginning of a cycle.

It is recommended that on the diagram the power, control and signal circuits shall be indicated separately, as far as they are separate electrically.

For all interconnection terminals, connected together directly by conductors and therefore having the same potential, it is recommended they be designated with the same reference.

The symbols for interconnection terminals (terminal strips) shall be distinguished from the symbols for the terminals of the devices.

Example: See Appendix E, diagram E 110 and if necessary IEC Publication 113-3: Part 3: General Recommendations for the Preparation of Diagrams.

For electronic equipment, a diagram similar to the block diagram, but indicating in detail the input-output relationships of the binary logic elements (by means of truth tables, for example), may appropriately replace the circuit diagram.

Example: See Appendix E, diagrams E 311 to E 315.

It is recommended that the circuit diagram contains such information as the following:

- *the polarities;*
- *the voltages and frequencies of the different supplies and the number of phases;*
- *the particular characteristics of certain control devices when these are necessary for the understanding of their operation (for example values of resistances, capacitances, etc.);*
- *the operating means and the function of devices which are not solely electrical devices (position sensors, hand-operated contacts, electrically operated hydraulic or pneumatic valves, timing devices).*

Such information may, for example, be recorded in the form of a description on the diagram.

Where the machine can perform several sequences (possibly with different starting points), the diagram shall show clearly which sequence it represents.

The detached representation according to IEC Publication 113-1 shall be used:

The various circuits shall be shown in such a way as to facilitate the study as well as the servicing and fault location. Circuits shall be shown separately (at different places) on the diagram:

- *if they are separate electrically;*
- *if they concern different operations.*

a) Power circuits

Power circuits are shown by one or several lines from which — at right angles — proceed subcircuits to each power unit receiving current (motors, etc.), with their protective devices.

b) Control circuits

Each of the individual circuits is shown between two or more parallel lines, at right angles to the latter, so far as possible in the form of one or more straight lines.

The source(s) of supply of the control circuits shall also be shown.

It is recommended that power consuming elements of devices (coils, electromagnets, etc.) be shown near the line to which they are directly connected and which is intended to be earthed, the control contacts being connected to the other line (see Sub-clause 6.2.3).

For easy reading of the diagram, it is recommended that the progression of successive operations be shown from left to right or from top to bottom.

The purpose of each circuit in the operation of the machine shall be clearly indicated.

NOTE As examples for such indication, see in Appendix E the text on top of diagram E 110 or E 210 or to the right of E 211, as well as E 140 with regard to push-buttons.

c) Signalling circuits

When signalling circuits are supplied separately from control circuits, it is recommended that they are shown between two or more parallel lines, at right angles to the latter. It is recommended that indicator lights and warning units are shown near the line to which they are directly connected and which is intended to be earthed, the control contacts being connected to the other line.

Example: See Appendix E, diagrams E 210 and E 211 and, if necessary, IEC Publication 113-4: Part 4: Recommendations for the Preparation of Circuit Diagrams.

3.2.4.4 Description of sequence of operations and/or sequence chart

Such information is only required for electrical equipment comprising several interrelated functions.

The description of sequence of operation may be complemented or replaced by a sequence chart.

Detailed information shall be given to allow the sequence of operations of the various parts to be understood by reference to the circuit diagram.

When the sequence of operations or other related data are program controlled, the information on the programming system shall be provided which is necessary for operation, trouble-shooting and maintenance.

All the information shall be given which is necessary for the understanding of the electrical operation in conjunction with the mechanical, hydraulic or pneumatic operations, etc.

If the machine can perform several sequences, the description of operation shall explain each of them.

Example: See Appendix E, sheets E 120 and E 121.

3.2.4.5 Interconnection diagram

The interconnection diagram is a diagram representing the connections between the different units of the electrical equipment. It may or may not show the path of each conductor.

It shall give full information about the external connections of the overall electrical equipment of the machine.

If the electrical equipment is intended to function from two or more voltages, the interconnection diagram shall indicate the connections, etc., to be modified for changing from one voltage to another.

The interconnection diagram shall show the connections of the protective circuit as well as the corresponding terminals.

Example: See Appendix E, diagram E 130 and if necessary IEC Publication 113-5.5: Preparation of Interconnection Diagrams and Tables.

The external connections of controlgear assemblies shall be shown on a diagram or in the form of tables of connections. The junctions to the source(s) of supply shall be named.

The interconnection diagrams shall specify the conductors (number, cross-section and insulation), as well as special provisions (if necessary), such as protective conduit sheaths or screened cables (with indication of the frame connections of the screens if their position is important) for external connections to assemblies or devices.

3.2.4.6 Parts list

The parts list or schedule of electrical equipment is an index of all electrical components, devices and sub-assemblies, with the necessary data for the ordering of spare parts.

The parts list shall show for each different component or device:

- *the item designation used in the diagram;*
- *its marking;*
- *general characteristics (power, torque, speed, voltage, current, frequency, degree of protection, insulation class, etc.);*
- *the name of the manufacturer(s) (an abbreviated form may be used) and his (their) reference for the component or device;*
- *the number of identical components and devices in the equipment.*

The list shall also show the characteristics of special types of cables (cross-section, type, insulation) with manufacturing reference.

— *Example: See Appendix E, sheets E 140 and E 141.*

3.2.4.7 Maintenance instruction

The maintenance instruction shall mention:

- the schedule of preventive maintenance;
- instructions for maintenance work, including those necessary in order to carry out certain replacements;
- instructions for adjustments.

It is recommended that the frequency of replacement of parts subject to wear be mentioned.

3.2.4.8 Location diagram or table

The location diagram or table shall contain detailed information about the location of parts of the electrical equipment, e.g. terminal blocks, plug-in units, sub-assemblies, modules, etc. It shall show the same item designations used in related diagrams and tables.

It shall show the spaces which have been reserved for modification as well as the location of ducts or conduits which are used for the wiring of the controlgear assembly.

NOTE The location diagram need not necessarily be to scale.

Example: See Appendix E, diagram E 150.

3.2.4.9 List of wearing and spare parts

The list of wearing and spare parts shall mention the parts which it is usually recommended to carry in stock.

If part(s) replacement is mentioned in the maintenance instruction, the necessary information for ordering such part(s) shall be given here.

Example: See Appendix E, list E 260.

INFORMATION as to original IEC text

The text of Sub-clause 3.2.4.9 is printed in italics; “usually” is not included in the first paragraph.

4 General requirements

4.1 Components and devices

4.1.1 Requirements

Electrical components and devices shall be suitable for industrial use and shall comply with the relevant IEC standards, where such exist.

Preference shall be given to components and devices which are obtainable from more than one source of supply under the same designation and, as far as possible, under the same reference number.

It is recommended to make no special selection of components, nor to modify them. If this cannot be avoided, for components which could be replaced in case of field repair, full information shall be given on such special selection or modification in the parts list or on the drawings.

Components and devices for which the degree of protection provided by the enclosure is not sufficient shall be given additional protection, e.g. by an individual enclosure inside the controlgear assembly.

NOTE For the marking of replaceable components, see Sub-clause 3.1.4.

4.1.2 Limitations of use

All components and devices shall be used within the limits specified by the manufacturer. This concerns limits of voltage, current, temperature, etc., as well as protection against impact, vibration, oil fumes, fluid vapour, etc. and requirements of cooling.

4.2 Supply

The electrical equipment shall be designed for operation from the supply voltages and frequency specified by the user. It shall operate satisfactorily under full load as well as without load in a range of 90 % to 110 % of the nominal supply voltage and with frequency deviations up to ± 2 %.

If for the warranted accuracy of certain devices (for example, timer circuits) a closer frequency tolerance than ± 2 % is necessary, this shall be so stated by the manufacturer.

NOTE The power rating of motors is defined in IEC Publication 34-1: Rotating Electrical Machines, Part 1: Rating and Performance, for 95 % to 105 % of their rated voltage.

4.2.1 The proper functioning of electronic equipment shall not be impaired by:

- voltage interruptions of up to 10 ms, power electronics excepted;
- voltage drops not exceeding 0.5 s and not exceeding 15 % of the nominal supply voltage;
- voltage impulses not exceeding 1.5 ms and with peak values of up to 200 % of the nominal r.m.s. supply voltage between phases.

NOTE If a numerical control equipment is supplied through the power supply of the electronic equipment, care shall be taken in fulfilling the requirements of Sub-clause 6.5 of IEC Publication 550: Interface Between Numerical Controls and Industrial Machines.

4.2.2 Interlocks shall be provided to stop the operations concerned, if electronic equipment is responsible for safety or continuous operation and might malfunction from a voltage interruption of a shorter duration than can be taken care of by the other equipment.

4.2.3 It is assumed that the a.c. supply voltage is practically sinusoidal (less than 7 % total harmonic distortion) and in case of polyphase circuits that the voltages between phases are balanced within 5 % of the higher value.

4.3 Connection to the supply network

4.3.1 It is recommended that the electrical equipment of a machine be connected to a single power supply (see also Sub-clause 5.6.2).

If it is necessary to use another voltage or another voltage system for certain parts of the equipment (electronic control, electro-magnetic clutches, etc.), this other voltage (or system) should, as far as possible, be supplied from devices (such as transformers, rectifiers, converters, etc.) forming part of the electrical equipment of the machine.

4.3.2 A neutral (N) shall be used only with the agreement of the user. If it is used, this shall be clearly stated in the technical documentation of the machine, such as on the installation drawing and the circuit diagram. There shall be no connection between the neutral (N) and the protective circuit (PE), nor shall a combined PEN conductor be used inside the electrical equipment.

INFORMATION as to original IEC text

The last sentence of Sub-clause 4.3.2 does not include “nor shall a combined PEN conductor be used”.

4.3.3 Unless a plug is provided with the machine for the connection to the supply system (see Item *d*) of Sub-clause 5.6.2), it is recommended to connect the conductors from the source of supply directly to the supply terminals of the supply disconnecting device. If this is not practicable, separate terminals shall be provided (see also Sub-clause 5.6.2.5 and the last paragraph of Sub-clause 7.2.4).

A terminal connected to the frame for the connection of the external protective conductor (PE) shall be provided in the vicinity of the associated phase conductor terminals (see also Sub-clause 5.1.2.1.6).

If a neutral is used, a separate insulated terminal shall be provided for the neutral conductor (N) (see Sub-clause 6.1.2 and Clause 12).

4.3.4 All terminals for the supply connection shall be clearly identified in accordance with IEC Publication 445: Identification of Apparatus Terminals and General Rules for a Uniform System of Terminal Marking, Using an Alphanumeric Notation (for the PE terminal see Sub-clause 5.1.2.1.6).

5 Protective measures

5.1 Protection against electric shock

The electrical equipment shall provide protection of persons against electric shock:

- in normal service, and
- in case of a fault.

This shall be achieved by the application of protective measures of both Sub-clauses 5.1.1 and 5.1.2. One type of protective measure described in each of the Sub-clauses 5.1.1 and 5.1.2 shall be applied to each circuit or to each part of the electrical equipment. However the use of “machine extra-low voltage (MELV)” according to Sub-clause 5.1.3 takes care of both, protection against electric shock in normal service and in case of a fault.

The protection against residual voltages according to Sub-clause 5.1.4 is additional to the above and shall apply where appropriate.

“Factory built assemblies of low-voltage switchgear and controlgear” in accordance with IEC Publication 439: Factory-built Assemblies of Low-voltage Switchgear and Controlgear, are acceptable concerning the whole of Sub-clause 5.1.

5.1.1 *Protection against electric shock in normal service*

This protection, also called basic protection, is intended to protect persons against dangers of direct contact with live parts.

For each circuit or part of the electrical equipment, the measures of at least one of the Sub-clauses 5.1.1.1 and 5.1.1.2 shall be applied.

5.1.1.1 *Protection by enclosures*

Live parts shall be located inside enclosures which comply with the relevant requirements of Clause 7 of this standard.

Opening an enclosure (opening doors, lids, covers and the like) shall only be possible under the condition that one of the following paragraphs a) to c) is respected:

- a) The use of a key or a tool is necessary. This method is only allowed for access by skilled or instructed persons.

Live parts on the inside of doors shall be protected so as to prevent unintentional contact with them when the doors are open. Live parts inside the enclosure, which are likely to be touched when restoring functions, shall be protected against unintentional contact with a finger or, where appropriate, with another part of the human body.

INFORMATION as to original IEC text

The last paragraph of a) contains only the first sentence.

NOTE 1 When other than skilled or instructed persons need to have access, for example to replace fuses, one of the methods b) or c) shall be used.

NOTE 2 For rooms used as enclosures for electrical equipment, which are accessible only to skilled persons, special requirements apply, see IEC Publications 364 or 439.

NOTE 3 An obstacle or a barrier intended to prevent unintentional contact with live parts (or accidentally touching them), does not prevent intentional contact by circumvention of the obstacle.

- b) Disconnection of all live parts inside the enclosure before the enclosure can be opened.

NOTE This may be achieved by interlocking the door or doors with a disconnecter (for example the supply disconnecting device), so that they can only be opened, when the disconnecter is open and so that the disconnecter can only be closed, when all doors are closed.

However, a special device may permit skilled persons to defeat the interlock and to make the equipment live with the doors open, provided that on closing the door or doors the interlock is automatically restored.

The requirements of Sub-clause 5.6.2.6 related to the protection against unintentional contact are applicable to all parts remaining live.

- c) Where an enclosure needs to be opened only occasionally (such as for the replacement of a lamp or of a fuse-link), the opening without the use of a key or a tool and without disconnection of live parts shall be possible only, if a barrier is provided inside the enclosure preventing contact with live parts (verified by means of the test finger according to IEC Publication 529: Classification of Degrees of Protection Provided by Enclosures), except those supplied by extra-low voltage and in accordance with Sub-clauses 5.1.2.3 or 5.1.3. Such barriers shall either require a tool for their removal, or all live parts protected by them shall be automatically disconnected when the barrier is removed.

5.1.1.2 *Protection by insulation of live parts*

Live parts shall be completely covered with insulation which can only be removed by destruction.

Such insulation shall be capable of durably withstanding the mechanical, electrical and thermal stresses to which it may be subjected in service. Paints, varnishes, lacquers and similar products alone are generally considered to be inadequate for protection against electric shock in normal service.

NOTE Examples are cables and electrical components embedded in insulation.

5.1.2 *Protection against electric shock in case of a fault*

This protection, also called protection against indirect contact, is intended to prevent danger to persons in the event of an insulation failure between live parts and exposed conductive parts.

For each circuit or part of the electrical equipment the measures of at least one of the Sub-clauses 5.1.2.1 to 5.1.2.4 shall be applied.