

BS EN 62135-1:2008



BSI Standards Publication

Resistance welding equipment —

Part 1: Safety requirements for design,
manufacture and installation

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National foreword

This British Standard is the UK implementation of EN 62135-1:2008. It is identical to IEC 62135-1:2008. It supersedes BS 5924:1989 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/29, Resistance welding.

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

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ISBN 978 0 580 56067 5

ICS 25.160.30

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2009

Amendments issued since publication

Amd. No.	Date	Text affected
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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 62135-1

November 2008

ICS 25.160

Supersedes EN 50063:1989

English version

Resistance welding equipment - Part 1: Safety requirements for design, manufacture and installation (IEC 62135-1:2008)

Matériels de soudage par résistance -
Partie 1: Exigences de sécurité
pour la conception,
la fabrication et l'installation
(CEI 62135-1:2008)

Widerstandsschweißeinrichtungen -
Teil 1: Sicherheitsanforderungen
für die Konstruktion,
Herstellung und Errichtung
(IEC 62135-1:2008)

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CENELEC

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

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Ref. No. EN 62135-1:2008 E

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Foreword

The text of document 26/377/FDIS, future edition 1 of IEC 62135-1, prepared by IEC TC 26, Electric welding, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62135-1 on 2008-10-01.

This European standard supersedes EN 50063:1989 + corrigendum August 1990.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2009-01-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2011-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62135-1:2008 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60085	NOTE Harmonized as EN 60085:2008 (not modified).
IEC 60112	NOTE Harmonized as EN 60112:2003 (not modified).
IEC 60364	NOTE Harmonized in HD 384 / HD 60364 series (modified).
IEC 60990	NOTE Harmonized as EN 60990:1999 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60204-1 (mod)	- ¹⁾	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	EN 60204-1	2006 ²⁾
IEC 60364-4-41 (mod)	2005	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock	HD 60364-4-41 + corr. July	2007 2007
IEC 60364-6 (mod)	- ¹⁾	Low voltage electrical installations - Part 6: Verification	HD 60364-6	2007 ²⁾
IEC 60439-1	- ¹⁾	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies	EN 60439-1	1999 ²⁾
IEC 60529	- ¹⁾	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 ²⁾ 1993
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007
IEC 60664-3	- ¹⁾	Insulation coordination for equipment within low-voltage systems - Part 3: Use of coating, potting or moulding for protection against pollution	EN 60664-3	2003 ²⁾
IEC 61140	- ¹⁾	Protection against electric shock - Common aspects for installation and equipment	EN 61140	2002 ²⁾
ISO 669	- ¹⁾	Resistance welding - Resistance welding equipment - Mechanical and electrical requirements	-	-
ISO 5828	- ¹⁾	Resistance welding equipment - Secondary connecting cables with terminals connected to water-cooled lugs - Dimensions and characteristics	EN ISO 5828	2001 ²⁾
ISO 8205-1	- ¹⁾	Water-cooled secondary connection cables for resistance welding - Part 1: Dimensions and requirements for double-conductor connection cables	EN ISO 8205-1	2002 ²⁾

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
ISO 8205-2	- ¹⁾	Water-cooled secondary connection cables for resistance welding - Part 2: Dimensions and requirements for single-conductor connection cables	EN ISO 8205-2	2002 ²⁾
ISO 12100-1	- ¹⁾	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology	EN ISO 12100-1	2003 ²⁾
ISO 12100-2	- ¹⁾	Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles	EN ISO 12100-2	2003 ²⁾
ISO 13849-1	- ¹⁾	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	EN ISO 13849-1	2006 ²⁾
ISO 14121-1	- ¹⁾	Safety of machinery - Risk assessment - Part 1: Principles	EN ISO 14121-1	2001 ²⁾

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RESISTANCE WELDING EQUIPMENT ±

Part 1: Safety requirements for design, manufacture and installation

1 Scope

This part of IEC 62135 applies to equipment for resistance welding and allied processes and includes single and multiple welding stations which may be manually or automatically loaded and/or started.

This standard covers stationary and portable equipment.

It specifies safety requirements for design, manufacture and installation.

To comply with this standard, all safety risks involved in loading, feeding, operating and unloading the equipment, where applicable, should be assessed and the requirements of related standards should be observed.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 62135. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60204-1, *Safety of machinery ± Electrical equipment of machines ± Part 1: General requirements*

IEC 60364-4-41:2005, *Low-voltage electrical installations ± Part 4-41: Protection for safety ± Protection against electric shock*

IEC 60364-6, *Low-voltage electrical installations ± Part 6: Verification*

IEC 60439-1, *Low-voltage switchgear and controlgear assemblies ± Part 1: Type-tested and partially type-tested assemblies*

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems ± Part 1: Principles, requirements and tests*

IEC 60664-3, *Insulation coordination for equipment within low-voltage systems ± Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 61140, *Protection against electric shock ± Common aspects for installation and equipment*

ISO 669, *Resistance welding ± Resistance welding equipment ± Mechanical and electrical requirements*

ISO 5828, *Resistance welding equipment ± Secondary connecting cables with terminals connected to water-cooled lugs ± Dimensions and characteristics*

ISO 8205-1, *Water-cooled secondary connection cables for resistance welding ± Part 1: Dimensions and requirements for double-conductor connection cables*

ISO 8205-2, *Water-cooled secondary connection cables for resistance welding ± Part 2: Dimensions and requirements for single-conductor connection cables*

ISO 12100-1, *Safety of machinery ± Basic concepts, general principles for design ± Part 1: Basic terminology, methodology*

ISO 12100-2, *Safety of machinery ± Basic concepts, general principles for design ± Part 2: Technical principles*

ISO 13849-1, *Safety of machinery ± Safety-related parts of control systems ± Part 1: General principles for design*

ISO 14121-1, *Safety of machinery ± Risk assessment ± Part 1: Principles*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, together with those given in ISO 669, IEC 60664-1 and IEC 60204-1, apply.

3.1

equipment for resistance welding and allied processes

equipment associated with carrying out the processes of resistance welding or allied processes consisting of, for example, power source, electrodes, tooling and associated control equipment

NOTE 1 It may be a separate unit or part of a complex machine.

NOTE 2 The term "resistance welding equipment" is used in the following text.

3.2

processes allied to resistance welding

processes carried out on machines comparable to resistance welding equipment considered as allied to resistance welding, for example, resistance brazing, soldering or heating

3.3

type test

test of one or more devices made to a given design, to check if these devices comply with the requirements of the standard concerned

[IEV 851-02-09]

3.4

routine test

test made on each individual device during or after manufacture to check if it complies with the requirements of the standard concerned or the criteria specified

[IEV 851-02-10]

3.5

welding circuit

conductive material through which the welding current is intended to flow

3.6**control circuit**

circuit for the operational control of welding equipment, and/or for protection of the power circuits

3.7**conventional value**

standardized value that is used as a measure of a parameter for the purposes of comparison, calibration, testing, etc.

NOTE Conventional values do not necessarily apply during the actual welding process.

3.8**rated value**

value assigned, generally by the manufacturer, for a specified operating condition of a component, device or equipment

3.9**rating**

set of rated values and operating conditions

3.10**hand-held equipment**

resistance welding equipment with built-in or external transformer, which is intended to be held in the hand during use, suspended or not

3.11**portable equipment**

resistance welding equipment that is connected to the mains supply by means of a plug.

3.12**stationary equipment**

resistance welding equipment permanently connected to the mains supply

3.13**material group**

materials are separated into four groups by their comparative tracking index (CTI) values, as follows:

Material group I	600	≤	CTI	
Material group II	400	≤	CTI	< 600
Material group IIIa	175	≤	CTI	< 400
Material group IIIb	100	≤	CTI	< 175

The CTI values above refer to values in accordance with IEC 60112.

NOTE For inorganic insulating materials, for example, glass or ceramics, which do not track, creepage distances need not be greater than their associated clearance for the purpose of insulation coordination.

3.14**thermal equilibrium**

state reached when the observed temperature rise of any part of the welding equipment does not exceed 2 K/h

3.15**thermal protection**

system intended to ensure the protection of all or part of the welding equipment against excessive temperatures resulting from certain conditions of thermal overload

NOTE It is capable of being reset (either manually or automatically) when the temperature falls to the reset value.

3.16

supply circuit

conductive material of the power source through which the supply current is intended to flow

3.17

general visual inspection

inspection by eye to verify that there are no apparent discrepancies with respect to provisions of the standard concerned

3.18

working voltage

highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

NOTE 1 Transients are disregarded.

NOTE 2 Both open-circuit conditions and normal operating conditions are taken into account.

4 Environmental conditions

Resistance welding equipment complying with this standard shall be safe to operate under the following service conditions.

- a) At an ambient air temperature from 5 °C to 40 °C at a relative humidity of
 - up to 50 % at 40 °C;
 - up to 90 % at 20 °C.

The ambient air shall be free from excessive amounts of dust, acids, corrosive gases or substances etc. other than those generated by the welding process. These environmental conditions apply to equipment intended for indoor use only.

- b) The temperature of the cooling medium does not exceed
 - 1) in the case of a liquid: 30 °C at the inlet;
 - 2) in the case of the ambient air: 40 °C.
- c) The altitude above sea-level does not exceed 1 000 m.

NOTE Different environmental conditions may be agreed upon between the manufacturer and the purchaser and the resulting welding equipment so marked. Examples of these conditions are: outdoor use, different altitude, different temperature of cooling medium, high humidity, unusually corrosive fumes, steam, excessive oil vapour, abnormal vibration or shock, excessive dust, unusual sea coast or shipboard conditions.

5 Tests

5.1 Test condition

The tests shall be carried out on new, dry and completely assembled resistance welding equipment at an ambient air temperature between 10 °C and 40 °C. It is recommended that the thermal tests be carried out at 40 °C. Liquid-cooled resistance welding equipment shall be tested with liquid conditions as specified by the manufacturer.

5.2 Measuring instruments

The accuracy of measuring instruments shall be as follows.

- a) Electrical measuring instruments: class 0,5 ($\pm 0,5$ % of full-scale reading), except for the measurement of insulation resistance and dielectric strength where the accuracy of the instruments is not specified, but shall be taken into account for the measurement.
- b) Instruments for measuring welding current: class 5.

c) Temperature measuring instruments: ± 2 K.

5.3 Type tests

Unless otherwise specified, the tests in this standard are type tests.

The resistance welding equipment shall be tested with all ancillary equipment fitted that could affect the test results.

All type tests shall be carried out on the same resistance welding equipment except where it is specified that a test may be carried out on another resistance welding equipment.

As a condition of conformity, the type tests given below shall be carried out in the following sequence:

- a) general visual inspection, see 3.17;
- b) insulation resistance, see 6.2.4 (preliminary check);
- c) protection provided by the enclosure, see 6.3.3;
- d) insulation resistance, see 6.2.4;
- e) dielectric strength, see 6.2.5;
- f) general visual inspection, see 3.17.

The other tests included in this standard and not listed here may be carried out in any convenient sequence.

5.4 Routine tests

All routine tests shall be carried out on each resistance welding equipment. The following sequence is recommended:

- a) general visual inspection, see 3.17;
- b) continuity of the protective circuit, see 6.4.7;
- c) dielectric strength, see 6.2.5;
- d) no-load voltage, see 6.3.2;
- e) test to ensure rated minimum and maximum output values in accordance with ISO 669;
- f) general visual inspection, see 3.17.

6 Protection against electric shock

6.1 General

Hazardous-live-parts shall not be accessible and accessible conductive parts shall not be hazardous live

- either under normal conditions (operation in intended use, and absence of a fault); or
- under single-fault conditions.

The requirements for provisions for normal conditions protection are given in 6.3.

The requirements for provisions for fault condition protection are given in 6.4.

6.2 Insulation

6.2.1 General

The majority of resistance welding equipment falls within overvoltage category III in accordance with IEC 60664-1. All resistance welding equipments shall be designed for use in environmental conditions of pollution degree 3 as a minimum.

Design of liquid cooled equipment shall consider possible condensation which may require different conditions.

Components or subassemblies with clearances or creepage distances corresponding to pollution degree 2 are permitted, if they are completely coated, potted or moulded in accordance with IEC 60664-3.

Equipment designed with insulation based on line-to-neutral voltage values shall be provided with a caution that such equipment shall only be used on a supply system that is either a three-phase, four-wire system with an earthed neutral or a single-phase, three-wire, system with an earthed neutral.

6.2.2 Clearances

For basic insulation or supplementary and reinforced insulation, minimum clearances shall be in accordance with IEC 60664-1, as partially summarized in Table 1 for overvoltage category III.

Table 1 ± Minimum clearances for overvoltage category III

Voltage ¹	Basic or supplementary insulation					Reinforced insulation				
	Rated impulse test voltage	AC test voltage	Pollution degree			Rated impulse test voltage	AC test voltage	Pollution degree		
			2	3	4			2	3	4
			Clearance					Clearance		
V r.m.s.	Peak V	V r.m.s.	mm			Peak V	V r.m.s.	mm		
50	800	566	0,2	0,8	1,6	1 500	1 061	0,5	0,8	1,6
100	1 500	1 061	0,5			1,5				
150	2 500	1 768	1,5			4 000	2 828	3		
300	4 000	2 828	3			6 000	4 243	5,5		
600	6 000	4 243	5,5			8 000	5 657	8		
1 000	8 000	5 657	8			12 000	8 485	14		
NOTE 1 Values taken from Tables F.1 and F.2 of IEC 60664-1.										
NOTE 2 For other pollution degrees and overvoltage categories, see IEC 60664-1.										
¹ See Annex A for voltage value.										

For dimensioning clearances to accessible non-conductive surfaces, such surfaces shall be considered to be covered by metal foil wherever they can be touched by the standard test finger in accordance with IEC 60529.

Clearances shall not be interpolated.

For supply circuit terminals, see Annex B.

Clearances between parts of resistance welding equipment (for example, circuits or components) which are protected by an overvoltage limiting device (for example, oxide varistor) may be rated in accordance with overvoltage category I (see IEC 60664-1).

The values of Table 1 shall also apply to control circuits when separated from the supply circuit, for example, by a transformer.

If the control circuit is connected direct to the supply circuit, the values for the supply voltage shall apply.

Conformity shall be checked by measurement in accordance with 6.2 of IEC 60664-1 or where this is not possible, by submitting the welding equipment to an impulse test using the voltages given in Table 1.

For the impulse test, a minimum of three impulses of each polarity at the voltage given in Table 1 are applied with an interval of at least 1 s between impulses using a generator with an output waveform of 1,2/50 μ s and an output impedance of less than 500 Ω .

Alternatively, either an a.c. test voltage as given in Table 1 may be applied for three cycles or a ripple free d.c. voltage, the value of which is equal to the impulse voltage, may be applied three times for 10 ms, for each polarity.

The equipment shall withstand the test voltages without any flashover or breakdown.

6.2.3 Creepage distances

For basic insulation or supplementary insulation, minimum creepage distances shall be in accordance with IEC 60664-1, as summarized in Table 2.

Creepage distances for reinforced or double insulation shall be twice those determined for basic insulation.

For the purpose of dimensioning creepage distances to accessible surfaces of insulation material, such surfaces shall be considered to be covered by metal foil wherever they can be touched by the standard test finger in accordance with IEC 60529.

Creepage distances are given for the highest rated voltage of each line of Table 2. In the case of a lower rated voltage, interpolation is allowed.

For supply circuit terminals, see Annex B.

The values of Table 2 shall also be applicable to control circuits when separated from the supply circuit by, for example, a transformer.

A creepage distance cannot be less than the associated clearance, so the shortest possible creepage distance is equal to the required clearance.

If the control circuit is connected directly to the supply circuit, the values for the supply voltage shall apply.

Conformity shall be checked by linear measurement in accordance with 6.2 of IEC 60664-1.

Table 2 ± Minimum creepage distances

Working voltage	Creepage distances in millimetres													
	Basic or supplementary insulation													
	Printed wiring material		Pollution degree											
	Pollution degree		1	2			3			4				
	1	2		I	II	III	I	II	III	I	II	III		
V r.m.s	a	b	a	I	II	III	I	II	III	I	II	III		
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm		
10	0,025	0,04	0,08	0,4	0,4	0,4	1	1	1	1,6	1,6	1,6		
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,0	1,05	1,05	1,6	1,6	1,6		
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6		
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6		
25	0,025	0,04	0,12	0,5	0,5	0,5	1,2	1,25	1,25	1,7	1,7	1,7		
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8		
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3		
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2		
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4		
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6		
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8		
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4		
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5		
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3		
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8		
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10		
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5		
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16		
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	20		
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25		
1 000	3,2	5	3,2	5	7,1	10	12,5	14	16	20	25	32		
1 250			4,2	6,3	9	12,5	16	18	20	25	32	40		
1 600			5,6	8	11	16	20	22	25	32	40	50		
2 000			7,5	10	14	20	25	28	32	40	50	63		
2 500			10	12,5	18	25	32	36	40	50	63	80		
3 200			12,5	16	22	32	40	45	50	63	80	100		
4 000			16	20	28	40	50	56	63	80	100	125		
5 000			20	25	36	50	63	71	80	100	125	160		
6 300			25	32	45	63	80	90	100	125	160	200		
8 000			32	40	56	80	100	110	125	160	200	250		
10 000			40	50	71	100	125	140	160	200	250	320		
^a Material group I, II, IIIa and IIIb.														
^b Material group I, II and IIIa.														

6.2.4 Insulation resistance

The insulation resistance shall be not less than the values given in Table 3.

Table 3 ± Insulation resistance

Supply circuit (including control circuits connected to it) with protection provision specified in 6.4.2.2	to	welding circuit (including control circuits connected to it)	5 MΩ
Supply circuit (including control circuits connected to it) with protection provision different from those specified in 6.4.2.2	to	welding circuit (including control circuits connected to it)	2,5 MΩ
Control circuits and exposed conductive parts	to	all circuits	2,5 MΩ

Any control or auxiliary circuit connected to the protective conductor terminal shall be considered as an exposed conductive part for the purpose of this test.

Conformity shall be checked by the stabilized measurement of the insulation resistance without interference suppression or protection capacitors (see 6.4.2.2) by application of a d.c. voltage of 500 V at room temperature.

Solid-state electronic components and their protective devices may be short-circuited during the measurement.

6.2.5 Dielectric strength

The insulation shall withstand the following test voltages without any flashover or breakdown:

- first test of a welding power source: test voltages given in Table 4;
- repetition of the test of the same resistance welding equipment: test voltage 80 % of the values given in Table 4.

Table 4 ± Dielectric test voltages

Maximum rated voltage ^a V r.m.s.	AC dielectric test voltage				
	V r.m.s.				
All circuits	All circuits to exposed conductive parts, supply circuit to all circuits except the welding circuit		All circuits except supply circuit to welding circuit	Supply circuit to welding circuit with protection provision different from those specified in 6.4.2.2	Supply circuit to welding circuit with protection provision specified in 6.4.2.2
	Class I equipment	Class II equipment			
Up to 50	250	500	500	-	—
200	1 000	2 000	1 000	1 000	2 000
450	1 875	3 750	1 875	1 875	3 750
700	2 500	5 000	2 500	2 500	5 000
1 000	2 750	5 500	—	2 750	5 500

NOTE 1 The maximum rated voltage is valid for earthed and unearthed systems.

NOTE 2 In this standard the dielectric strength test of control circuits is limited to any circuit that enters or exits the enclosure apart from the supply circuit and the welding circuit.

^a For intermediate values, except between 200 V and 450 V, interpolation of the test voltages is allowed. Interpolation of the test voltage between 200 V and 450 V is allowed for equipment designed to be installed on delta corner grounded supply networks only

The a.c. test voltage shall be of an approximate sine wave-form with a peak value not exceeding 1,45 times the r.m.s. value, having a frequency of approximately 50 Hz or 60 Hz.

The high-voltage transformer shall deliver the prescribed voltage up to the tripping current. Tripping is regarded as a flashover or a breakdown. The tripping current setting can be

selected according transformer capacitive dispersion current. The maximum permissible setting of the tripping current shall be 100 mA.

NOTE For operator's safety, the lowest setting of the tripping current (less than 10 mA) is recommended.

Alternative test: A d.c. test voltage of 1,4 times the r.m.s. test voltage may be used.

Components or subassemblies shall not be disconnected or short-circuited unless the conditions of a), b) or c) below are met.

- a) The components or subassemblies are designed and tested to relevant standards that specify a voltage lower than the test voltage level of this standard. These components or subassemblies are not connected between supply and welding circuits and their disconnection or short-circuiting does not prevent a part of that circuit from being tested. Example: fan motors and pump motors.
- b) The components or subassemblies are completely incorporated within either the supply or the welding circuit and their disconnection does not prevent a part of that circuit from being tested. Example: electronic circuits.
- c) Interference suppression networks or protection capacitors between the supply or welding circuit and any exposed conductive part conform to the relevant standards.

Control circuits connected to the protective conductor terminal shall not be disconnected during testing and they are then tested as exposed conductive parts.

The test voltage may be raised to the full value slowly at the discretion of the manufacturer.

Resistance welding equipment incorporating a rectifier shall be tested after assembly of the complete resistance welding equipment, with the power rectifier remaining properly connected to the output circuit of the transformer. Rectifiers, their protective devices and other solid-state electronic components or capacitors, may be short-circuited during the test.

Liquid-cooled equipments shall be tested before being filled with the cooling liquid.

Conformity shall be checked by application of the test voltage for

- a) 60 s (type test);
- b) 5 s (routine test); or
- c) 1 s (routine test with the test voltage increased by 20 %).

6.2.6 Liquid cooling

Coolant-hoses between parts of the input circuit having different polarity shall have a length of at least 0,5 m and a resistance of at least 1 MΩ per metre; resistivity of the cooling liquid shall be at least 20 Ωm.

Accessible connections of a cooling-system being in contact with the input circuit shall be provided with a metal part to be connected to the protective conductor.

Compliance is checked by visual inspection and measurement.

6.3 Protection against electric shock in normal service (direct contact)

6.3.1 General

Protection against electric shock in normal service shall consist of one or more provisions that under normal conditions prevent contact with hazardous-live-parts. These provisions include

- basic insulation;

- barriers or enclosures;
- limitation of voltage;
- limitation of steady-state touch current and charge.

More details may be found in IEC 61140.

6.3.2 Rated no-load voltage at the output

If the welding circuit is accessible during welding process, the rated no-load voltage at the output, at all possible settings, shall not exceed 25 V a.c. r.m.s. or 60 V ripple-free d.c.

NOTE Ripple-free is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10 % r.m.s.

Voltage measured between any two accessible parts of the equipment shall not exceed the above values. This measurement shall be performed with a 5 k Ω shunt across the probes of the voltmeter.

6.3.3 Protection provided by barriers or the enclosure

Barriers or enclosures shall prevent access to hazardous-live-parts by providing an adequate degree of protection against electric shock. Barriers or enclosures shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection, taking account of all relevant influences from the environment and from inside the enclosure.

Resistance welding equipment specifically designed for indoor use shall have a minimum degree of protection of IP20 (except external welding circuit, for example, electrodes) using IEC 60529 test procedures and conditions.

Resistance welding equipment specifically designed for outdoor use shall have a minimum degree of protection of IP23 using IEC 60529 test procedures and conditions.

Conformity shall be checked as follows.

Welding equipment shall be subjected to the appropriate water test without being energized. Immediately after the test, the unit shall be moved to a safe environment and subjected to the insulation resistance and dielectric strength tests.

Where the design or construction allows for the removal of barriers, the opening of enclosures or the removal of parts of enclosures, access to hazardous-live-parts shall only be possible

- by the use of a key or tool;
- after isolation of hazardous-live-parts from the supply circuit where the enclosure would no longer provide protection, restoration of the supply shall become possible only after replacement of barriers or parts of enclosures or after the closing of doors;
- where an intermediate barrier still maintains the required degree of protection, such barrier being removable only by the use of a key or tool.

Conformity shall be checked by visual inspection.

6.3.4 Capacitors

A capacitor provided as part of a resistance welding equipment and connected across supply circuit shall

- a) not contain more than 1 l of flammable liquid;
- b) be designed not to leak during normal service;