

# Technical appendix

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# Plastics and metals

All the materials used for Weidmüller products are subject to the strict quality control measures of the Weidmüller QM system, which is accredited to DIN ISO 9001.

At Weidmüller, environmental compatibility plays a decisive role in the choice of materials.

## Insulating materials

In order to do justice to the most diverse requirements placed on our products, it is necessary to use different insulating materials tailored to the needs of the applications. None of the insulating materials used by Weidmüller contain asbestos or any pigments based on cadmium.

## Thermoplastics

**Polyamide (PA)** is one of the most common commercial plastics. The advantages of this material are its good electrical and mechanical properties, its flexibility and resistance to breakage. Furthermore, owing to its chemical structure PA achieves good fire resistance even without the use of flame-retardant agents (so-called self-extinguishing behaviour).

- flexible, virtually unbreakable
- good electrical and mechanical properties
- self-extinguishing behaviour

Specific volume resistance:  $10^{12} \Omega \times \text{cm}$   
 Electric strength: 30 kV/mm  
 Tracking resistance: 600 CTI  
 Temperature range:  $-50 \text{ }^\circ\text{C}$  to  $+100 \text{ }^\circ\text{C}$   
 UL94 flammability rating: UL 94 V-2

**Wemid (PA)** is a modified thermoplastic whose properties have been specially devised to suit the requirements of our connectors. The advantages in comparison with PA are the better fire protection and the higher continuous operating temperature.

- modified thermoplastic
- higher continuous operating temperature
- improved fire resistance
- halogen- and phosphor-free flame-retardant agent
- no formation of dioxin or furan

Specific volume resistance:  $10^{12} \Omega \times \text{cm}$   
 Electric strength: 25 kV/mm  
 Tracking resistance: 600 CTI  
 Temperature range:  $-50 \text{ }^\circ\text{C}$  to  $+120 \text{ }^\circ\text{C}$   
 UL94 flammability rating: UL 94 V-0

**Thermoplastic polyester (polybutylene terephthalate – PBT)** offers excellent dimensional stability (and is therefore ideal for plug-in connectors) plus a high continuous operating temperature. But the resistance to leakage currents is lower than other insulating materials.

- high dimensional stability
- good electrical and mechanical properties
- flame-retardant substances do not lead to the formation of dioxin or furan

Specific volume resistance:  $10^{13} \Omega \times \text{cm}$   
 Electric strength: 28 kV/mm  
 Tracking resistance: 200 CTI  
 Temperature range:  $-50 \text{ }^\circ\text{C}$  to  $+110 \text{ }^\circ\text{C}$   
 UL94 flammability rating: UL 94 V-0

## Thermoplastic polyester

**(glass fibre-reinforced PBT)** offers excellent dimensional stability, very good mechanical properties and a high continuous operating temperature.

Specific volume resistance:  $10^{13} \Omega \times \text{cm}$   
 Electric strength: 29 kV/mm  
 Tracking resistance: 200 CTI  
 Temperature range:  $-50 \text{ }^\circ\text{C}$  to  $+130 \text{ }^\circ\text{C}$   
 UL94 flammability rating: UL 94 V-0

## Liquid crystal polymer

**(glass fibre-reinforced LCP)** offers excellent dimensional stability, especially at high temperatures. The very low coefficient of thermal expansion is similar to that of the material used for PCBs and therefore makes this material particularly interesting for components that need to be soldered in the reflow oven.

Specific volume resistance:  $10^{15} \Omega \times \text{cm}$   
 Electric strength: 35 kV/mm  
 Tracking resistance: 175 CTI  
 Temperature range:  $-55 \text{ }^\circ\text{C}$  to  $+240 \text{ }^\circ\text{C}$   
 UL94 flammability rating: UL 94 V-0

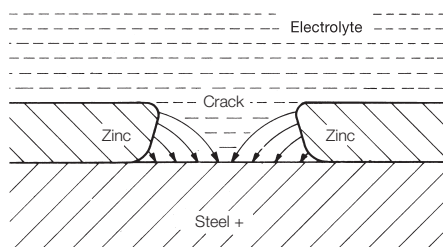
## Metals

All the metals used by Weidmüller are selected and processed and their surfaces treated according to the latest technical standards.

## Steels

Steel parts are electrogalvanised and treated with an additional Weidmüller passivation technique, WInQ®. The surface protection conforms to the highest standards, is matched to the special requirements of the connection systems used and is RoHS-compatible (RoHS = Restriction of Hazardous Substances). Experience gained from storage in outdoor test racks at different locations (industrial, marine, tropical and normal atmospheres) has been incorporated into the design of the surface protection.

Zinc protects against corrosion for a long time even after the zinc coating has been partially damaged by scratches or pores. In the presence of an electrolyte, zinc acts as a cathode (i.e. negative) with respect to steel. The metal ions of the zinc migrate to the steel, which provides long-term protection for the parent metal.



## Conductive materials

The current-carrying materials copper, brass and bronze are characterised by a high conductivity plus good mechanical properties. The surfaces are usually given

a coating of tin, which creates an extremely good, “malleable” contact with a low contact resistance. Apart from ensuring consistently good electrical properties, the tin coating provides excellent protection against corrosion. Solder connections are also given a coating of tin.

In order to guarantee the long-term solderability (shelf life), the brass parts are given an additional nickel coating as a diffusion barrier. The nickel coating provides effective protection against the loss of zinc atoms from the brass.

# Design of clearances and creepage distances in electrical equipment

**General:**

Since April 1997 the sizing of clearances and creepage distances has been covered by DIN VDE 0110 part 1 “Insulation coordination for electrical equipment in low-voltage systems”.

DIN VDE 0110 part 1 contains the modified edition of IEC Report 664-1 (see also IEC 664-1/Oct 1992). The design data resulting from these provisions is – if applicable – specified in this catalogue for each product.

**Dimensioning of clearances and creepage distances to VDE 0110/Apr 1997 (IEC Report 664-1) “Insulation coordination for electrical equipment in low-voltage systems”**

The provisions for insulation coordination result in the following relationships for dimensioning of clearances and creepage distances:

- **Clearances** are dimensioned according to the anticipated **over-voltages** taking into account the ratings of the **overvoltage protection precautions** in use and the anticipated environmental conditions taking into account the protective measures taken to prevent **pollution**.
- **Creepage distances** are dimensioned according to the **operating voltage** and the anticipated environmental conditions taking into account the **insulating materials** used and the protective measures taken to prevent **pollution**.

**Table 1: Rated impulse withstand voltages for electrical equipment**

Rated voltage of power supply system*) in V		Rated impulse withstand voltage in kV			
Three-phase systems	Single-phase systems with neutral point	Electrical equipment at the supply point of the installation <b>(Overvoltage category IV)</b>	Electrical equipment as part of the permanent installation <b>(Overvoltage category III)</b>	Electrical equipment to be connected to the permanent installation <b>(Overvoltage category II)</b>	Specially protected electrical equipment <b>(Overvoltage category I)</b>
	120 to 240	4.00	2.50	1.50	0.80
230/400 277/480		6.00	4.00	2.50	1.50
400/690		8.00	6.00	4.00	2.50
1000		Values depend on the particular project or, if no values are available, the values above for 400/690 V can be used.			

\*) to IEC 38

**Category I** is valid for specially rated equipment.

**Category II** is valid for technical committees responsible for electrical equipment specified for connecting to the mains power supply.

**Category III** is valid for technical committees responsible for installation materials, and for some specific technical committees.

**Category IV** is valid for power supply companies and particular projects.

**Table 2a: Minimum clearances to VDE 0110-1/Apr 1997**

Rated impulse withstand volt. in kV	Minimum clearance distances in mm for sites up to 2000 m above sea level									
	Case A (inhomogeneous field)					Case B (homogeneous field)				
	Pollution severity					Pollution severity				
	1	2	1)	3	4	1	2	1)	3	4
0.33	0.01					0.01				
0.40	0.02		0.10			0.02		0.10		
0.50	0.04	0.20				0.04				
0.60	0.06		0.12	0.80		0.06	0.20	0.12		
0.80	0.10				1.60	0.10				
1.00	0.15		0.20			0.15		0.20	0.80	
1.20	0.25	0.25				0.20				1.60
1.50	0.50	0.25				0.30	0.30			
2.00	1.00	1.00		1.00		0.45	0.45			
2.50	1.50	1.50		1.50		0.60	0.60			
3.00	2.00	2.00		2.00	2.00	0.80	0.80			
4.00	3.00	3.00		3.00	3.00	1.20	1.20		1.20	
5.00	4.00	4.00		4.00	4.00	1.50	1.50		1.50	
6.00	5.50	5.50		5.50	5.50	2.00	2.00		2.00	2.00
8.00	8.00	8.00		8.00	8.00	3.00	3.00		3.00	3.00
10.00	11.00	11.00		11.00	11.00	3.50	3.50		3.50	3.50
12.00	14.00	14.00		14.00	14.00	4.50	4.50		4.50	4.50
15.00	18.00	18.00		18.00	18.00	5.50	5.50		5.50	5.50

1) Pollution severity 2 is split for impulse voltages up to 1.00 kV (case A) or 1.20 kV (case B). These values apply for printed circuits but deviate from those in IEC Report 664.

**Dimensioning of clearances**

Decisive for the dimensioning of clearances are the **rated impulse withstand voltages** shown in table 1, which are derived from the **over-voltage category** and the **phase-to-earth voltage** depending on the rated mains voltage (taking into account all types of supply systems).

The minimum clearances (up to site altitudes of 2000 m above mean sea level) are determined from table 2a based on the **rated impulse withstand voltage** and the **pollution severity**.

Note: Clearances that do not comply with case A must be subjected to an impulse withstand voltage test (see table 2a, footnote 1).

The **pollution severity categories** are as follows:

Pollution severity category 1:  
No pollution, or only dry, non-conductive pollution that has no influence.

Pollution severity category 2:  
Non-conductive pollution only; occasional condensation may cause temporary conductivity.

Pollution severity category 3:  
Conductive pollution, or dry, non-conductive pollution that is liable to be rendered conductive through condensation.

Pollution severity category 4:  
Contamination results in constant conductivity, e.g. caused by conductive dust, rain or snow.

The following aspects apply to the **over-voltage categories** in accordance with the German standard DIN VDE 0110-1:

*Electrical equipment fed directly from the low-voltage mains*

Specification of a specific overvoltage category shall be based on the following:

– Equipment of *overvoltage category I* is equipment that is intended to be connected to the permanent electrical installation of a building. Measures to limit transient overvoltages to the specific level are taken outside the equipment, either in the permanent installation or between the permanent installation and the equipment.

– Equipment of *overvoltage category II* is equipment to be connected to the permanent electrical installation of a building.

Note: Examples of such equipment are household appliances, portable tools and similar loads.

– Equipment of *overvoltage category III* is equipment that is part of the permanent electrical installation and other equipment where a higher degree of availability is expected.

Note: Examples of such equipment are distribution boards, circuit-breakers, wiring systems (IEV 826-06-01, including cables, busbars, junction boxes, switches, power sockets) in the permanent installation, and equipment for industrial use and some other equipment, e.g. stationary motors with permanent connections to the permanent installation.

– Equipment of *overvoltage category IV* is for use at or in the proximity of the incoming supply point of the electrical

Table 3a: Single-phase 2- or 3-wire AC or DC systems

Rated voltage of the power supply (mains) <sup>1)</sup>	Voltages for table 4	
	For insulation phase-to-phase <sup>1)</sup>	For insulation phase-to-earth <sup>1)</sup>
	All systems	3-wire systems, neutr. point earthing
<b>V</b>	<b>V</b>	<b>V</b>
12.5	12.5	–
24 25	25	–
30	32	–
42 48 50 <sup>*)</sup>	50	–
60	63	–
30–60	63	32
100 <sup>*)</sup>	100	–
110 120	125	–
150 <sup>*)</sup>	160	–
220	250	–
110–220 120–240	250	125
300 <sup>*)</sup>	320	–
220–440	500	250
600 <sup>*)</sup>	630	–
480–960	1000	500
1000 <sup>*)</sup>	1000	–

1) Phase-to-earth insulation levels for unearthed or impedance-earthed systems are equal to those of phase-to-phase because the operating voltage to earth of any phase can, in practice, reach full phase-to-phase voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each phase to earth; thus, a low (but acceptable) insulation resistance of one phase can earth it and raise the other two to full phase-to-phase voltage to earth.

\*) It is assumed that the rated voltage of the electrical equipment is not lower than the nominal voltage of the power supply.

\*\*) Because of the common changes, the meaning of the \*\* symbol has not been used in table 1; i.e. the / symbol indicates a 4-wire 3-phase distribution system. The lower value is the phase-to-neutral voltage, while the higher value is the phase-to-phase voltage. Where only one value is indicated, it refers to 3-wire, 3-phase systems and specifies the value phase-to-phase. The values given in table 1 are still taken into account in tables 3a and 3b by the \*\* symbol.

Table 3b: 3-phase 3- or 4-wire AC systems

Rated voltage of the power supply (mains) <sup>1)</sup>	Voltages for table 4		
	For insulation phase-to-phase	For insulation phase-to-earth	
	All systems	3-phase 4-wire systems with earthed neutral wire	3-phase 3-wire systems unearthed <sup>1)</sup> or phase-earthed
<b>V</b>	<b>V</b>	<b>V</b>	<b>V</b>
60	63	32	63
110/120/127	125	80	125
150 <sup>*)</sup>	160	–	160
208	200	125	200
220/230/240	250	160	250
300 <sup>*)</sup>	320	–	320
380/400/415	400	250	400
440	500	250	500
480/500	500	320	500
575	630	400	630
600 <sup>*)</sup>	630	–	630
660/690	630	400	630
720/830	800	500	800
960	1000	630	1000
1000 <sup>*)</sup>	1000	–	1000

1) Phase-to-earth insulation levels for unearthed or impedance-earthed systems are equal to those of phase-to-phase because the operating voltage to earth of any phase can, in practice, reach full phase-to-phase voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each phase to earth; thus, a low (but acceptable) insulation resistance of one phase can earth it and raise the other two to full phase-to-phase voltage to earth.

2) For electrical equipment for use in both 3-phase 4-wire and 3-phase 3-wire supplies, earthed and unearthed, use the values for 3-wire systems only.

\*) It is assumed that the rated voltage of the electrical equipment is not lower than the nominal voltage of the power supply.

\*\*) Because of the common changes, the meaning of the \*\* symbol has not been used in table 1; i.e. the / symbol indicates a 4-wire 3-phase distribution system. The lower value is the phase-to-neutral voltage, while the higher value is the phase-to-phase voltage. Where only one value is indicated, it refers to 3-wire, 3-phase systems and specifies the value phase-to-phase. The values given in table 1 are still taken into account in tables 3a and 3b by the \*\* symbol.

## Clearances and creepage distances

installations of buildings upstream of the main distribution board.

Note: Examples of such equipment are electricity meters, circuit-breakers and ripple control units.

### Note on application of pollution severity and overvoltage categories

The pollution severity and rated impulse withstand voltage derived from the overvoltage category are each specified in this catalogue and are product-related. In principle, the dimensioning of clearance and creepage distances, and the resulting specification of ratings for electromechanical products (terminal blocks, terminal strips, PCB terminals/connectors) is based on pollution severity 3 and *overvoltage category III* considering all types of systems.

### Dimensioning of creepage distances

Decisive for dimensioning of creepage distances are the rated voltages derived from the **system voltages** of the power supply for the respective **type of supply system** in conjunction with the **pollution severity** (classification, see "Clearances") and the **insulating material** used.

Taking into account tables 3a and 3b and the CTI (Comparative Tracking Index) of the insulating material, the minimum creepage distances are determined from table 4.

Table 4: Minimum creepage distances

Rated voltage $U_{-eff}$ or $U_n$ in V	Creepage distance in mm											
	Printed circuits		Other electrical equipment									
	Pollution severity			2			3			4		
	1	2	1	Insulating material group			Insulating material group			Insulating material group		
Insul. mat. 2)	Insul. mat. 3)	Insul. mat. 2)	I	II	III	I	II	III 4)	I	II	III 4)	
10	0.025	0.04	0.08	0.40	0.40	0.40	1.00	1.00	1.00	1.60	1.60	1.60
12.5	0.025	0.04	0.09	0.42	0.42	0.42	1.05	1.05	1.05	1.60	1.60	1.60
16	0.025	0.04	0.10	0.45	0.45	0.45	1.10	1.10	1.10	1.60	1.60	1.60
20	0.025	0.04	0.11	0.48	0.48	0.48	1.20	1.20	1.20	1.60	1.60	1.60
25	0.025	0.04	0.125	0.50	0.50	0.50	1.25	1.25	1.25	1.70	1.70	1.70
32	0.025	0.04	0.14	0.53	0.53	0.53	1.30	1.30	1.30	1.80	1.80	1.80
40	0.025	0.04	0.16	0.56	0.80	1.10	1.40	1.60	1.80	1.90	2.40	3.00
50	0.025	0.04	0.18	0.60	0.85	1.20	1.50	1.70	1.90	2.00	2.50	3.20
63	0.040	0.63	0.20	0.63	0.90	1.25	1.60	1.80	2.00	2.10	2.60	3.40
80	0.063	0.10	0.22	0.67	0.95	1.30	1.70	1.90	2.10	2.20	2.80	3.60
100	0.10	0.16	0.25	0.71	1.00	1.40	1.80	2.00	2.20	2.40	3.00	3.80
125	0.16	0.25	0.28	0.75	1.05	1.50	1.90	2.10	2.40	2.50	3.20	4.00
160	0.25	0.40	0.32	0.80	1.10	1.60	2.00	2.20	2.50	3.20	4.00	5.00
200	0.40	0.63	0.42	1.00	1.40	2.00	2.50	2.80	3.20	4.00	5.00	6.30
250	0.56	1.00	0.56	1.25	1.80	2.50	3.20	3.60	4.00	5.00	6.30	8.00
320	0.75	1.60	0.75	1.60	2.20	3.20	4.00	4.50	5.00	6.30	8.00	10.00
400	1.00	2.00	1.00	2.00	2.80	4.00	5.00	5.60	6.30	8.00	10.00	12.50
500	1.30	2.50	1.30	2.50	3.60	5.00	6.30	7.10	8.00	10.00	12.50	16.00
630	1.80	3.20	1.80	3.20	4.50	6.30	8.00	9.00	10.00	12.50	16.00	20.00
800	2.40	4.00	2.40	4.00	5.60	8.00	10.00	11.00	12.50	16.00	20.00	25.00
1000	3.20	5.00	3.20	5.00	7.10	10.00	12.50	14.00	16.00	20.00	25.00	32.00

2) Insulating materials I, II, IIIa, IIIb

3) Insulating materials I, II, IIIa

4) Creepage distances are not determined in this range.

Insulation group IIIb is generally not recommended for pollution severity 3 with voltages > 630 V, and is never recommended for pollution severity 4.

The insulating materials are subdivided into four groups according to their CTI (Comparative Tracking Index):

Insulating material	
I	$600 \leq \text{CTI}$
II	$400 \leq \text{CTI} < 600$
III a	$175 \leq \text{CTI} < 400$
III b	$100 \leq \text{CTI} < 175$

The comparative tracking index must be determined according to DIN IEC 112/VDE 0303 part 1 on the basis of specially prepared samples with test solution A.

**Slots** are taken into account in the measurement of creepage distances when their minimum width  $x$  is dimensioned according to the following table:

Pollution-severity	Minimum width $x$ mm
1	0.25
2	1.0
3	1.5
4	2.5

If the associated clearance is less than 3 mm, the minimum slot width can be reduced to 1/3 of the clearance.

# Design-in recommendations: applications for 600 V in accordance with UL

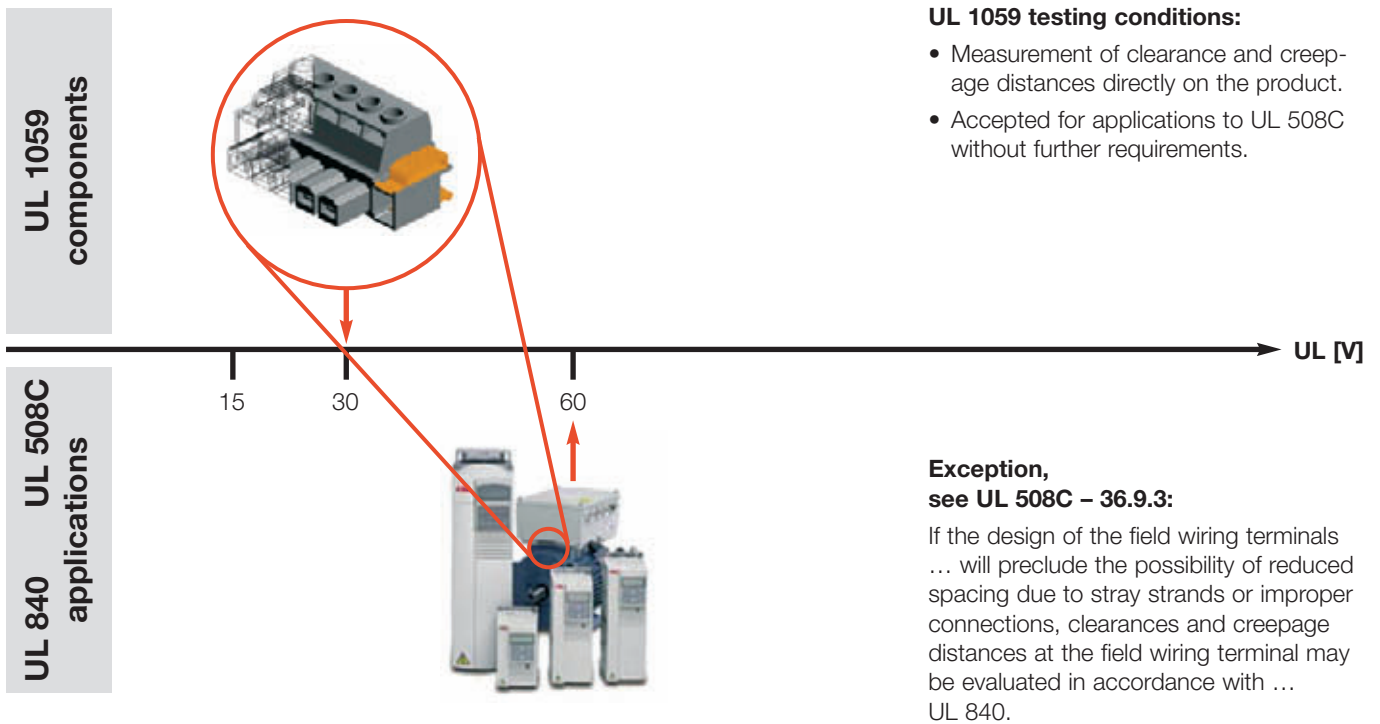
Summary of the most important UL requirements:

- PCB components are approved to UL 1059 and are tested without a PCB or application environment.
- Applications are approved to UL 508 (or UL 508C for motor controls, e.g. frequency converters).
- The application designer must refer to the application-related UL standards, not to UL 1059.
- UL 508C enables the use of field terminals approved to UL 1059 for 300 V to be used for 600 V applications under certain conditions.
- Weidmüller Powermate Range plug-in

connectors and power terminals comply with the conditions and may be used for 600 V applications to UL 508C.

- For more detailed information, please refer to the drawing below.

## The approval for higher voltages to UL 508C / UL 840:



## Extract from UL 5.08C: (36.9 Spacings for drives evaluated in accordance with UL 840)

36.9.1 Other than as noted in 36.9.2 and 36.9.3, clearances and creepage distances are able to be evaluated in accordance with the requirements in the “Standard for insulation coordination including clearance and creepage distances for electrical equipment”, UL 840. See 36.9.4 for details on applying UL 840.

36.9.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings

for conduit or armoured cable, shall be in accordance with 36.2.2. The clearances shall be determined by physical measurement.

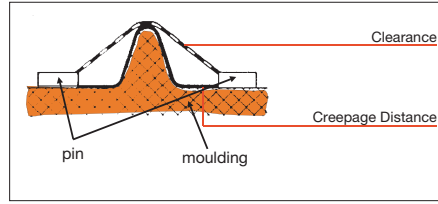
36.9.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in 36.3.1.

Exception: When the design of the field wiring terminals precludes the possibility of reduced spacing due

to stray strands or improper wiring installation, then clearance and creepage distances at these terminals are able to be evaluated in accordance with the “Standard for insulation coordination including clearance and creepage distances for electrical equipment”, UL 840.



The maximum voltage to be applied to the connector depends on the distance between two connections.



Two distances have to be taken in account:

- Clearance = shortest distance between two conductive parts (in air)
- Creepage distance = distance along surface

Comparison of UL clearance and creepage distances for 300 V

Standard	Voltage	Clearance	Creepage distance
UL 1059 minimum spacing (table 8.1)	151 – 300 V	6.4 mm	9.5 mm
UL508C minimum spacing (table 36.1)	151 – 300 V	6.4 mm	9.5 mm
UL 508C minimum spacing for products with known and controlled overvoltages (table 36.2)	peak: 226 – 450 V > 10 kVA peak: 226 – 400 V 500 VA – 10 kVA	3.81 mm 2.54 mm	5.08 mm 2.54 mm
UL 840 Tables 5.1 and 6.1, pollution severity 3 (exception 36.9.3 of UL 508C) UL 840 is similar to IEC 664-1	320 V (400 V) [500 V]	related to 300 V: II / 2.5 kV / 1.5 mm III / 4.0 kV / 3.0 mm IV / 6.0 kV / 5.5 mm	4.0 / 4.5 / 5.0 mm (5.0 / 5.6 / 6.3 mm) [6.3 / 7.1 / 8.0 mm]
UL 840 Tables 5.1 and 6.1, pollution severity 2 (exception 36.9.3 UL 508C) UL 840 is similar to IEC 664-1	320 V (400 V) [500 V]	related to 300 V: II / 2.5 kV / 1.5 mm III / 4.0 kV / 3.0 mm IV / 6.0 kV / 5.5 mm	1.6 / 2.2 / 3.2 mm* (2.0 / 2.8 / 4.0 mm) [2.5 / 3.6 / 5.0 mm]

Comparison of UL clearance and creepage distances for 600 V

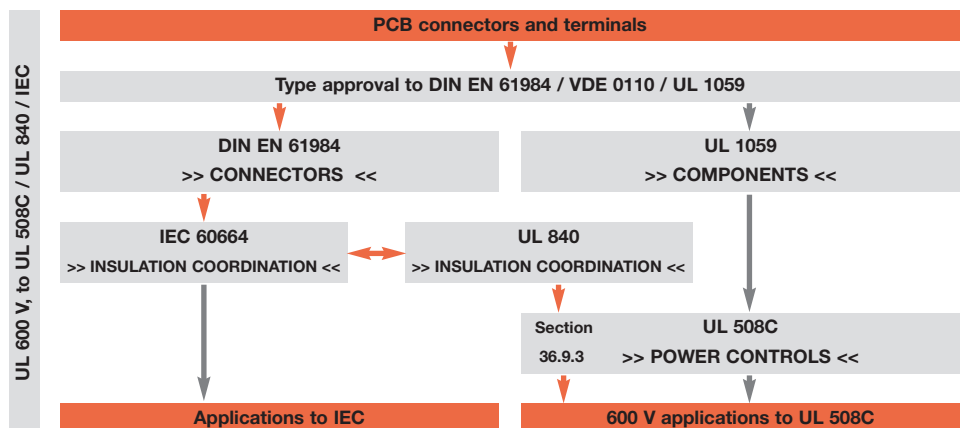
Standard	Voltage	Clearance	Creepage distance
UL 1059 minimum spacing (table 8.1)	301 – 600 V	9.5 mm	12.7 mm
UL508C minimum spacing (table 36.1)	301 – 600 V	9.5 mm	12.7 mm
UL 508C minimum spacing for products with known and controlled overvoltages (table 36.2)	peak: 451 – 900 V > 10 kVA peak: 451 – 900 V 500 VA – 10 kVA	7.62 mm 5.08 mm	10.16 mm 5.08 mm
UL 840 Tables 5.1 and 6.1, pollution severity 3 (exception 36.9.3 of UL 508C) UL 840 is similar to IEC 664-1	630 V 800 V	related to 600 V: II / 4.0 kV / 3.0 mm III / 6.0 kV / 5.5 mm IV / 8.0 kV / 8.0 mm	8.0 / 9.0 / 10.0 mm 10.0 / 11.0 / 12.5 mm
UL 840 Tables 5.1 and 6.1, pollution severity 2 (exception 36.9.3 of UL 508C) UL 840 is similar to IEC 664-1	630 V 800 V	related to 600 V: II / 4.0 kV / 3.0 mm III / 6.0 kV / 5.5 mm IV / 8.0 kV / 8.0 mm	3.2 / 4.5 / 6.3 mm* 4.0 / 5.6 / 8.0 mm

General data:

The overvoltage category relates to the clearance distance, insulation groups I/II/IIIa to the creepage distance.  
All clearance and creepage distances to UL/USEGROUP C (industrial).

\*) Not less than the clearance distance

Guideline: relationship between approvals



Derating curve

# Derating curve (current-carrying capacity curve)

The **derating curve** shows which currents may flow continuously and simultaneously via all possible connections when the component is subjected to various ambient temperatures below its upper limit temperature.

The **upper limit temperature** of a component is the rated value determined by the materials used. The total of the ambient temperature plus the temperature rise caused by the current load (power loss at volume resistance) may not exceed the upper limit temperature of the component, otherwise it will be damaged or even completely ruined.

The current-carrying capacity is hence not a constant value, but rather decreases as the component ambient temperature increases.

Furthermore, the current-carrying capacity is influenced by the geometry of the component, the number of poles and the conductor(s) connected to it.

The current-carrying capacity is determined empirically according to DIN IEC 60512-3. To do this, the resulting component temperatures  $t_{b1}$ ,  $t_{b2}$  ... and the ambient temperatures  $t_{u1}$ ,  $t_{u2}$  are measured for three different currents  $I_1$ ,  $I_2$ ,  $I_3$  ...

The values are entered on a graph with a system of linear coordinates to illustrate the relationships between the currents, the ambient temperatures and the temperature rise in the component.

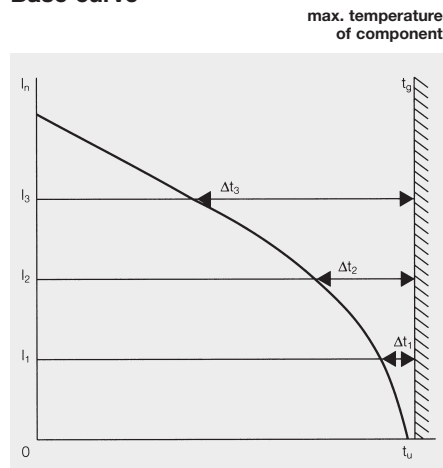
The **loading currents** are plotted on the y-axis, the **component ambient temperatures** on the x-axis.

A line drawn perpendicular to the x-axis at the upper limit temperature  $t_g$  of the component completes the system of coordinates.

The associated average values of the temperature rise in the component,  $t_1 = t_{b1} - t_{u1}$ ,  $t_2 = t_{b2} - t_{u2}$ , ... are plotted for every current  $I_1$ ,  $I_2$ , ... to the left of the perpendicular line. The points generated in this way are joined to form a roughly parabolic curve.

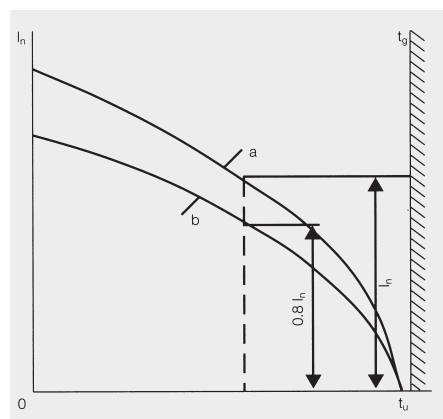
As it is practically impossible to choose components with the maximum permissible volume resistances for the measurements, the base curve must be reduced. Reducing the currents to 80 % results in the **“derating curve”** in which the maximum permissible volume resistances and the measuring uncertainties in the temperature measurements are taken into account in such a way that they are suitable for practical applications, as experience has shown. If the derating curve exceeds the currents in the low ambient temperature zone, which is given by the current-carrying capacity of the conductor cross-sections to be connected, then the derating curve should be limited to the smaller current in this zone.

## Base curve



$t_g$  = upper limit temperature of component  
 $t_u$  = ambient temperature  
 $I_n$  = current

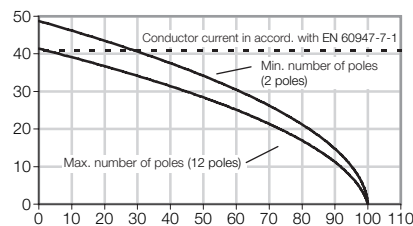
## Derating curve



$t_g$  = upper limit temperature of component  
 $t_u$  = ambient temperature  
 $I_n$  = current  
 a = base curve  
 b = reduced base curve (derating curve)

## Example: derating curve for minimum and maximum number of poles

SV7.62/90 / BVZ / H07V-K6.0



# Practical THR recommendations

The volume of paste and hence the degree of filling of the solder paste in the paste printing method is critical for optimum soldering results in the SMT process.

We recommend determining the quantity of solder paste as follows:

## Volume of paste (or rather, degree of filling):

for solder joint filling and solder joint form within the tolerances to IPC-A610

Male conn. (open and closed): Male conn. (solder flange LF):	2 to 8 poles –	9 to 24 poles 2 to 24 poles
Recommended finished hole I.D. *1) :	$d_i = 1.4^{+0.1}$ mm	$d_i = 1.5^{+0.1}$ mm
	Paste volume $V_p$ [mm <sup>3</sup> ] / filling level $f_p$ [%] after stencil print	
Minimum solder joint shape Optimum solder joint shape	2.4 mm <sup>3</sup> / 70 % 2.9 mm <sup>3</sup> / 90 %	3.1 mm <sup>3</sup> / 85 % 3.5 mm <sup>3</sup> / 100 %

Valid with the following parameters for all SL-SMT variations:

### Male connector:

Pin length	= $L$	[mm]	= $1.5^{+0.3}$
Min. height of space without paste	= $h_L$	[mm]	= min. 0,3
Pin diameter	= $d$	[mm]	= 1.2

### PCB:

Thickness	= $H$	[mm]	= 1.6
Placement hole			= metallised
Placement hole I.D.	= $d_i$	[mm]	= see table <sup>1)</sup>
Placement hole O.D.	= $d_A$	[mm]	= 2,3
Positioning tolerance to IEC 326-3			= very fine

### Stencil:

Thickness	= $D_s$	[ $\mu$ m]	= 120 – 180
Stencil hole diameter	= $d_s$	[mm]	= $2.1^{+0.2}$

### Solder paste:

Solder paste particle size	[ $\mu$ m]	= 20 - 40 = Type 3
Evaporation volume of solder paste	[%]	= approx. 50

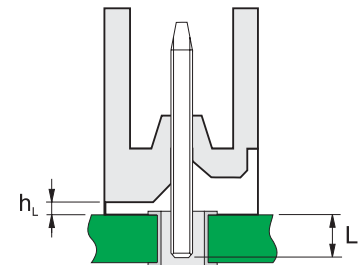
### Process:

Stencil print method		= squeegee print, single
Filling level in placement hole	= $f_p$	[%] = see table
Method for automatic assembly		= pick&place
Temperature profile		= to EN 61760-1

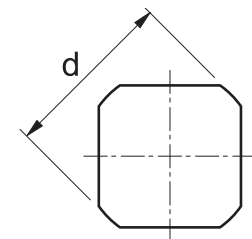
<sup>1)</sup> Tolerances for components, PCBs and automatic machines must be taken into account: recommendation for 9 poles or more, or for variations with solder flange LF:  $d_i = 1.5^{+0.1}$  mm

<sup>2)</sup> Stencil hole diameter approx. 10% smaller than placement hole O.D.  $d_A$

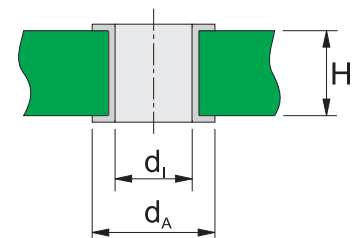
Calculation aids for S2L-SMT 3.5 and LSF-SMT or different parameters on request and also at [www.smt-technology.com](http://www.smt-technology.com)



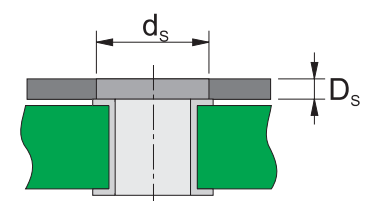
Male connector parameters



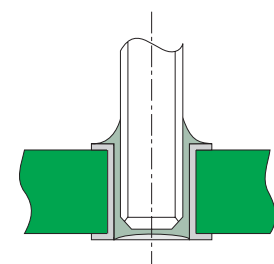
Pin cross-section



PCB parameters



Stencil parameters



Optimum solder joint form

# Conversion table

## AWG to mm<sup>2</sup> conductors

**AWG** is the abbreviation for “**A**merican **W**ire **G**auge”. This designation bears no resemblance to the actual cross-section of the conductor.

The relationship between AWG and mm<sup>2</sup> is shown in the following table.

AWG	mm <sup>2</sup>
28	0.08
26	0.13
24	0.21
22	0.22
20	0.52
19	0.65
18	0.82
17	1.04
16	1.31
15	1.65
14	2.08
13	2.63
12	3.31
11	4.17
10	5.26
9	6.63
8	8.37
7	10.55
6	13.30
5	16.77
4	21.15
3	26.67
2	33.63
1	42.41
0	53.48