For enclosure experts

Data, facts and information

FRIEDHELM LOH GROUP

RITTAL®

All clear?!

Our tried-and-trusted collection of data and facts covering all aspects of enclosures is designed to help you in your day-to-day work.
It covers the technical background, whilst details of the products best-suited to your application can be found in the latest Rittal catalogue.
What is more, our products are available in next to no time, and with such an extensive network of delivery centres, there's sure to be one in your area!

Rittal CM – Compact system enclosure

for compact systems with the installation diversity of the Top enclosure system TS 8. Infinite possibilities!

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Sizes and units

Length	Metres m
Area	Square metres m^2, 1 a = 100 m^2, 1 ha = 100 a, 1 km^2 = 100 ha
Volume	Cubic metres m^3, litre l
Mass, weight	Kilograms kg; grams g; tonnes t
Force, force due to weight	Newtons N; 1 N = 1 kgm/s^2
Pressure	Bar bar, Pascal Pa, 1 bar = 10^5 Pa, 1 Pa = 1 N/m^2
Time	Seconds s, minutes min, hours h, days d, years a
Frequency	Hertz Hz, 1 Hz = 1/s
Speed	Metres per second m/s
Acceleration	Metres per second squared m/s^2
Work, energy	Joules J, watt seconds Ws, kilowatt hours kWh
Quantity of heat	1 J = 1 Ws = 1 Nm
Power	Watts W (active power), 1 W = 1 Nm/s = 1 J/s Volt-ampere VA (apparent power) Var var (reactive power)
Temperature	Kelvin K, degrees Celsius °C, 0°C = 273.15 K
Temperature difference	1 K = 1°C
Luminous intensity	Candela
Luminance	Candela per square metre cd/m^2
Luminous flux	Lumen lm
Illuminance	Lux lx
Current	Amperes A
Voltage	Volts V
Resistance	Ohm Ω, 1 Ω = 1 V/A
Conductivity	Siemens S, 1 S = 1 $\frac{1}{\Omega}$
Electric charge	Coulomb C, ampere seconds As, ampere hours Ah, 1 C = 1 As
Capacity	Farads F, 1 F = 1 As/V
Electrical field strength	Volts per metre V/m
Electrical flux density	Coulombs per square metre C/m^2
Current density	Amperes per mm^2, A/mm^2
Magnetic field strength	Amperes per metre A/m
Magnetic flux	Weber Wb, volt-seconds Vs, 1 Wb = 1 Vs
Magnetic flux density	Tesla T, 1 T = 1 Vs/m^2
Induction, inductance	Henry H, 1 H = 1 Vs/A

According to the international system of units, the basic units are the metre m, the kilogram kg, the second s, the ampere A, the Kelvin K, the candela cd and the mole mol. All other units are derived from these.

Basic units

1 kilogramm (1 kg) is the mass of the international prototype of the kilogram which is kept at the Bureau International des Poids et Mesures in Sèvres near Paris.

1 metre (1 m) is the length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second.

1 second (1 s) is 9 162 631 770 times the period of the radiation corresponding to the transition between the two hyperfine structure levels of the fundamental state of atoms of the nuclide ^{133}Cs.

1 kelvin (1 K) is the 1/273.16th part of the thermodynamic temperature of the triple point of water.

1 candela (1 cd) is the luminous intensity in a given direction of a source that emits monochromatic radiation of frequency 540 x 10^{12} hertz and has a radiant intensity in that same direction of 1/683 watt per steradian (unit solid angle).

1 ampere (1 A) is the intensity of an electric current, non-vaying with time, whereupon when flowing through two conductors of negligibly small circular cross section arranged parallel to one another at a distance of 1 m in a vacuum, an electrodynamic force of 2 x 10^{-7} N per m of conductor length is exerted between these.

1 mole (1 mol) is the amount of substance in a system that contains as many elementary entities as there are atoms in 12/1000 kilogram of carbon 12.

Derived units

1 volt (1 V) is equal to the electrical current between two points in a thread-like, homogeneous conductor of even temperature carrying a current of 1 A when the power dissipated between the points is one watt.
The resistance of this conductor is 1 Ω.

1 joule (1 J) is equivalent to the work done when a force of one newton moves its point of application one metre in the direction of the force.

1 watt (1 W) is equal to one joule (1 J) of work performed per second.

General technical factors

International system of units (SI)

Basic factors Physical factor	Symbol	Basic SI unit	Other SI units
Length	l	m (metres)	km, dm, cm, mm, µm, nm, pm
Mass	m	kg (kilograms)	Mg, g, mg, µg
Time	t	s (seconds)	ks, ms, µs, ns
Electrical current intensity	I	A (amperes)	kA, mA, µA, nA, pA
Thermodynamic temperature	T	K (kelvins)	–
Amount of substance	n	mole (Mol)	Gmol, Mmol, Kmol, mmol, µmol
Luminous intensity	I_v	cd (candela)	Mcd, kcd, mcd

Conversion factors for old units to SI units

Factor	Old unit	Precise SI unit	~
Force	1 kp 1 dyn	9.80665 N $1 \cdot 10^{-5}$ N	10 N $1 \cdot 10^{-5}$ N
Moment of force	1 mkp	9.80665 Nm	10 Nm
Pressure	1 at 1 Atm = 760 Torr 1 Torr 1 mWS 1 mmWS 1 mmWS	0.980665 bar 1.01325 bar 1.3332 mbar 0.0980665 bar 0.0980665 mbar 9.80665 Pa	1 bar 1.01 bar 1.33 mbar 0.1 bar 0.1 mbar 10 Pa
Strength, voltage	$1 \frac{kp}{mm^2}$	$9.80665 \frac{N}{mm^2}$	$10 \frac{N}{mm^2}$
Energy	1 mkp 1 kcal 1 erg	9.80665 J 4.1868 kJ $1 \cdot 10^{-7}$ J	10 J 4.2 kJ $1 \cdot 10^{-7}$ J
Power	$1 \frac{kcal}{h}$ $1 \frac{kcal}{h}$ 1 PS	$4.1868 \frac{kJ}{h}$ 1.163 W 0.735499 kW	$4.2 \frac{kJ}{h}$ 1.16 W 0.74 kW

Conversion factors (continued)

Factor	Old unit	Precise SI unit	~
Heat transfer coefficient	$1 \frac{kcal}{m^2\,h\,°C}$	$4.1868 \frac{kJ}{m^2\,h\,K}$	$4.2 \frac{kJ}{m^2\,h\,K}$
	$1 \frac{kcal}{m^2\,h\,°C}$	$1.163 \frac{W}{m^2\,K}$	$1.16 \frac{W}{m^2\,K}$

Selection of electrotechnical formulae

Ohm's law

$U = R \cdot I$ $\qquad I = \frac{U}{R}$ $\qquad R = \frac{U}{I}$

Line resistance

$R = \frac{L}{\chi \cdot A}$ $\qquad R = \frac{\rho \cdot L}{A}$

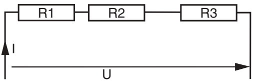
Copper: $\chi = 56\ m/\Omega\ mm^2$; $\frac{1}{\chi} = \rho = 0.0178\ \Omega\ mm^2/m$

Aluminium: $\chi = 36\ m/\Omega\ mm^2$; $\frac{1}{\chi} = \rho = 0.0278\ \Omega\ mm^2/m$

L = Length of conductor (m)
χ = Conductivity ($m/\Omega\ mm^2$)

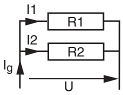
ρ = Specific resistance ($\Omega\ mm^2/m$)
A = Cross-section of conductor (mm^2)

Connection in series



$R_g = R_1 + R_2 + \ldots + R_n$

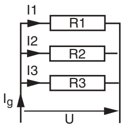
Connection in parallel
For two resistors, the following applies:



$$R = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

For three or more resistors:



$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n}$$

$$G = G_1 + G_2 + G_3 + \ldots$$

$$G = \frac{1}{R} \qquad I_g = \Sigma I \qquad I_g = U \cdot G$$

Rittal compact enclosures AE

The original – proven a million times over.
Top quality and excellent value for money with more than 60 size variants and unbeatable accessories.

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Unlimited diversity . . .

These are the features that characterise the Rittal range of individual system solutions at the human/machine interface, such as the Comfort Panel.

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Voltage drop

DC current

$$U_v = \frac{2 \cdot L \cdot P}{\chi \cdot A \cdot U}$$

$$U_v = \frac{2 \cdot L \cdot I}{\chi \cdot A}$$

AC current

$$U_v = \frac{2 \cdot L \cdot P}{\chi \cdot A \cdot U}$$

$$U_v = \frac{2 \cdot L \cdot I \cdot \cos\varphi}{\chi \cdot A}$$

3-phase current

$$U_v = \frac{L \cdot P}{\chi \cdot A \cdot U}$$

U_v = Voltage drop
U = Mains voltage
A = Cross-section
I = Overall current
P = Overall power
L = Length of conductor
x = Conductivity

Example:

L = 100 m
A = 2.5 mm^2
x = 56 $m/\Omega\, mm^2$
I = 10 A

$$U_v = \frac{2 \cdot L \cdot I}{\chi \cdot A}$$

$$U_v = \frac{2 \cdot 100 \cdot 10}{56 \cdot 2.5}$$

U_v = 14.3 V

Resistance in an AC circuit

Inductive resistance

$X_L = \omega \cdot L$ $\omega = 2 \cdot \pi \cdot f$

$$I = \frac{U}{X_L} \qquad I = \frac{U}{\omega \cdot L}$$

X_L = Inductive resistance (Ω)
L = Inductance (H)
I = Current (A)
ω, f = Angular frequency, frequency (1/s)

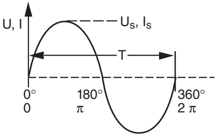
Capacitive resistance

$$X_C = \frac{1}{\omega \cdot C} \qquad \omega = 2 \cdot \pi \cdot f$$

$$I = \frac{U}{X_C}$$

X_C = Capacitive resistance (Ω)
C = Capacity (F)
I = Current (A)
ω, f = Angular frequency, frequency (1/s)

Various values of sinusoidal quantities



$$i = I_s \cdot \sin \omega t$$

$$u = U_s \cdot \sin \omega t$$

$$\omega = 2 \cdot \pi \cdot f$$

$$f = \frac{1}{T}$$

$$T = \frac{1}{f}$$

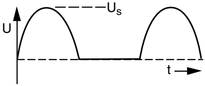
$$U_{eff} = \frac{U_s}{\sqrt{2}}$$

$$I_{eff} = \frac{I_s}{\sqrt{2}}$$

$$U_{ar} = 0.637 \cdot U_s$$

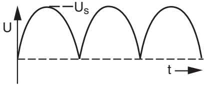
$$I_{ar} = 0.637 \cdot I_s$$

Voltage characteristic



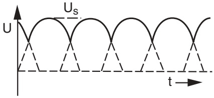
Half-wave rectification

$U_{ar} = 0.318 \cdot U_s$
$U_{eff} = 0.5 \cdot U_s$



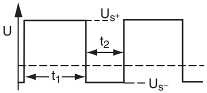
Full-wave rectification

$U_{ar} = 0.637 \cdot U_s$
$U_{eff} = 0.707 \cdot U_s$



3-phase rectification characteristic

$U_{ar} = 0.827 \cdot U_s$
$U_{ar} = 0.841 \cdot U_s$



Square-wave voltage

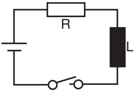
$$U_{ar} = \frac{U_{s+} \cdot t_1 + U_{s-} \cdot t_2}{t_1 + t_2}$$

$$U_{ar} = \sqrt{\frac{U^2_{s+} \cdot t_1 + U^2_{s-} \cdot t_2}{t_1 + t_2}}$$

i, u = Instantaneous values (A, V)
I_s, U_s = Peak values (A, V)
I_{eff}, U_{eff} = Effective values (A, V)
I_{ar}, U_{ar} = Arithmetic mean values (A, V)
f = Frequency (1/s)
ω = Angular frequency (1/s)
T = Duration of a period (s)

On/off operations

With inductivities

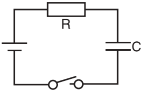


$$\tau = \frac{L}{R}$$

$$i = I \cdot \left(1 - e^{\frac{-t}{\tau}}\right)$$ Current after switching on

$$i = I \cdot e^{\frac{-t}{\tau}}$$ Current after switching off

With capacities



$$\tau = R \cdot C$$

$$i = I \cdot e^{\frac{-t}{\tau}}$$ Charging current

$$u = U \cdot \left(1 - e^{\frac{-t}{\tau}}\right)$$ Charging voltage

$$u = U \cdot e^{\frac{-t}{\tau}}$$ Discharge voltage

τ = Time constant (s)
t = Time (s)
e = Basis of natural Logarithms

u, i = Instantaneous values of current and voltage (V, A)
U, I = Initial/final values of current and voltage (V, A)

Electrical power of motors

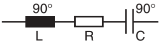
	Power supplied	Current consumption
DC current	$P_1 = U \cdot I \cdot \eta$	$I = \frac{P_1}{U \cdot \eta}$
AC current	$P_1 = U \cdot I \cdot \eta \cdot \cos \varphi$	$I = \frac{P_1}{U \cdot \eta \cdot \cos \varphi}$

P_1 = Mechanical power supplied at the motor shaft as per rating plate
P_2 = Electrical power input

Operating ratio $\eta = \frac{P_1}{P_2} \cdot (100\ \%)$ $P_2 = \frac{P_1}{\eta}$

Resonance in an AC circuit

Series resonant circuit

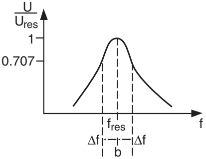


$$f_{res} = \frac{1}{2 \cdot \pi \sqrt{L \cdot C}}$$

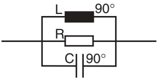
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$b = \frac{f_{res}}{Q}; \; b = \frac{R}{X_{res}} f_{res}$$

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$



Parallel resonant circuit

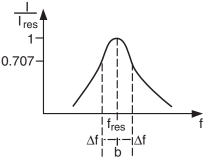


$$f_{res} = \frac{1}{2 \cdot \pi \sqrt{L \cdot C}}$$

$$Q = R\sqrt{\frac{C}{L}}$$

$$b = \frac{f_{res}}{Q}; \; b = \frac{G}{B_{res}} f_{res}$$

$$Z = \frac{1}{\sqrt{G^2 + \left(\frac{1}{\omega L} - \omega C\right)^2}}$$



f_{res} = Resonance frequency (1/s)

Q = Circuit quality

G = $\frac{1}{R}$ = Conductance

b = Bandwidth

Z = Impedance (Ω)

B = Susceptance

Electrical power

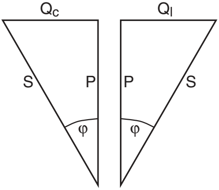
DC current

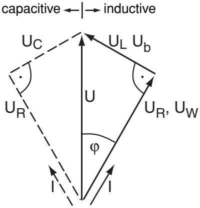
$$P = U \cdot I$$

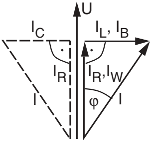
AC current

$$P = U \cdot I \cdot \cos \varphi$$

Calculation of power in an AC circuit







$P = S \cdot \cos\varphi$ $\quad U_w = U \cdot \cos\varphi$ $\quad I_w = I \cdot \cos\varphi$

$Q = S \cdot \sin\varphi$ $\quad U_b = U \cdot \sin\varphi$ $\quad I_b = I \cdot \sin\varphi$

$S = \sqrt{P^2 + Q^2}$ $\quad U = \sqrt{U_w^2 + U_b^2}$ $\quad I = \sqrt{I_w^2 + I_b^2}$

$S = U \cdot I$

$\cos\varphi = \frac{R}{Z}$

$\sin\varphi = \frac{X}{Z}$

$Z = \sqrt{R^2 + X^2}$

S	= Apparent power (VA)	X	= Reactance
P	= Active power (W)	U_w, U_b	= Active/reactive voltage (V)
Q	= Reactive power (VA)	I_w, I_b	= Active/reactive current (A)
Z	= Apparent resistance (Ω)	sin φ, cos φ	= Power factors
R	= Active resistance (Ω)		

Important regulations and standards for enclosures

Rittal created a market breakthrough with the idea of standardising enclosures.
By using models with set dimensions, produced extremely cost-effectively in large batches, Rittal offers astounding price benefits and exemplary delivery capabilities, with over 100 well-stocked depots worldwide.
Today, Rittal enclosure systems, with their modern, user-friendly design, enjoy a reputation as pace-setters within the industry. Reliable quality and technical dependability are top of the list in Rittal's spectrum of services.
Rittal enclosures meet all relevant standards, regulations and guidelines, such as:

DIN EN 62 208	Empty enclosures for low-voltage switchgear assemblies
IEC 60 297-2 Sheets 1 – 3	Panel widths for enclosures
DIN 41 488 Part 2	Low-voltage switchgear
DIN 41 488 Part 3	High-voltage switchgear
DIN 41 494 Part 1	Construction of electronic equipment, front panels and racks (dimensions for the 482.6 mm (19˝) system)
DIN 43 668	Keys for cells or enclosure doors of electrical switchgear (double-bit) Size 3: Low-voltage installations Size 5: High and low-voltage installations
DIN 7417	Piped keys with square sockets, size 7 for shipbuilding
DIN 43 656	Colours for indoor electrical switchgear

The German Energy Management Act states that: **"Electrical power installations and power-consuming equipment shall be set up and maintained propely, i.e. in accordance with the recognised technical rules, such as the provisions of the Association of German Electrical Engineers (VDE)".** As systems below 1000 V are so widespread and diverse, special significance is attaced to VDE 0100 "Provisions for the construction of heavy current installations with rated voltages of less than 1000 V". Other regulations which must be observed in the case of heavy current installations are the Technical Connection Conditions of the electricity supply companies, and in the case of telecommunications and aerial installations, VDE 0800 Regulations for Telecommunications Installations and VDE 0855 Provisions for Aerial Installations.
New installations should have provision for extension and should be economical. Important notes in this respect can be found in the **DIN** standards published by the German Standards Committee.

Rittal Electronic Systems

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At a high level – up to Level 4.
Complete solutions for CPCI, VME, ATCA and MTCA.

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Important regulations and standards for electronic cases and enclosures

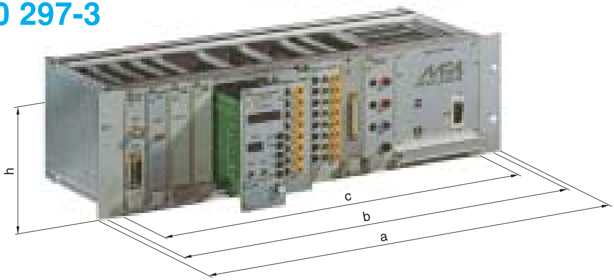
The 482.6 mm (19˝) system is based on American standard ASAC 83.9, equivalent to DIN 41 494 Part 1 and IEC publication 60 297. On the basis of this basic standard, individual standards sheets have been published which, when compiled in the corresponding order, constitute a harmonised modular system with the respective dimensional rules. The assembly is formed from the smallest unit of the "Eurocard" PCB with the corresponding rack connectors. This plug-in assembly is inserted into the subrack with the corresponding front panel. Finally, the subrack is accommodated in the electronic case and electronic enclosure.

Subracks and assemblies	DIN 41 494 Part 2 IEC 60 297-3	Dimensions of plug-in assemblies, module spacing and female multi-point connectors
Front plates	DIN 41 494 Part 2 IEC 60 297-3	Dimensions of the front panels and their attachment holes, dimensions of the racks and attachment holes for front panels
PCBs	DIN 41 494 Part 2 IEC 60 297-3	Dimensions of the PCB
Rack connectors	DIN 41 494 Part 4 IEC 60 603-2	PCB with connector, mounting dimensions for direct and indirect connection
	DIN 41 611	Solderless connections, wire-wrap, crimped, spring-loaded and insulation displacement connections

The editions of the VDE provisions and DIN sheets which have entered into force shall always be binding.
Copies are available from:
VDE regulations: VDE-Verlag GmbH, D-10625 Berlin, Bismarckstraße 33
DIN sheets: Beuth-Verlag GmbH, D-10787 Berlin

Basic dimensions of the 482.6 mm (19″) system

Subrack
IEC 60 297-3



a) External dimension = 482.6 mm (19″)

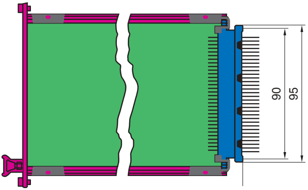
b) Distance between mounting holes = 465 mm

c) Installation space: Horizontal pitch: 84 HP = 84 x 5.08 mm (useful installation width in subrack)

h) Height unit: 3 U = 3 x 44.45 mm (smallest subrack height dimension for PCBs/Eurocards)

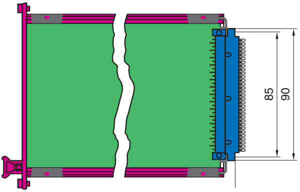
Plug-in assemblies

Connector to DIN 41 626



Mounting level
of female multi-point connector

Connector to DIN 41 617



Mounting level
of plug connector

Description	Height	Depth
Eurocard	100 mm	160 mm
Double-Eurocard	233.4 mm	160 mm

Rittal TopTherm-Plus

Embodies energy efficiency and state-of-the-art nano-technology, combined with functionality. Cooling output – efficiently generated and distributed in a targeted manner. Design – Aesthetics with an eye-catching effect.

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Excerpt from VDE 0113-1/DIN EN 60 204-1

Machine safety;
Electrical equipment of machines, general requirements

5.2 External PE conductor connection

One terminal for connecting the external PE conductor must be provided in the vicinity of the corresponding external conductor contact.
The terminal must be dimensioned such that it facilitates the connection of an external copper conductor with a cross-section in accordance with the following table.
If a PE conductor from a material other than copper is used, the terminal size must be selected accordingly.

Minimum cross-section of copper external PE conductor

Cross-section S of external conductors for mains connection (mm^2)	Minimum cross-section of external PE conductor (mm^2)
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	S/2

The terminal for the external PE conductor must be labelled with the letters “PE”. Use of the designation “PE” should be confined to the terminal for connecting the PE conductor system of the machine to the external PE conductor of the mains connection.

In order to avoid misunderstandings, other terminals used for the connection of machine parts to the PE conductor system must not be designated “PE”. Instead, they should be labelled with the symbol 417 IEC 5019 or by using the two-colour combination GREEN/YELLOW.

6. Protection against electric shock

6.1 General

The electrical equipment must provide protection against electric shock, namely:

– against direct contact and
– indirect contact.

This must be achieved by using the protective measures outlined in 6.2 and 6.3. By using PELV in accordance with 6.4, protection against both direct contact and indirect contact is ensured.

6.2 Protection against direct contact

The measures outlined in 6.2.1 or 6.2.2 and, where applicable, 6.2.3, must be applied to each circuit or each part of the electrical equipment.

6.2.1 Protection via enclosures (housings)

Active parts must be positioned within enclosures which meet the relevant requirements from sections 4, 13 and 16.
For top covers of enclosures that are readily accessible, protection against direct contact, protection category IP 4X or IP XXD, must be met as a minimum requirement (see EN 60 529).
It must only be possible to open an enclosure (i.e. opening doors, removing lids, covers and the like) if one of the following conditions is met:

a) Use of a key or tool for access by electricians or electrical staff if switching off the equipment is inappropriate. The master switch may be switched with the door open, if necessary.
b) Disconnection of active parts within the enclosure before the enclosure can be opened.
   This can be achieved by locking the door with an isolator (e.g. master switch) so that the door may only be opened if the isolator is open, and the isolator may only be activated when the door is closed. However, it is permissible for electrical staff to override the lock via a special device or tool as per the supplier's specifications, provided:

– it is possible at all times to open the isolator whilst the lock is overriden, and
– when the door is closed, the lock is automatically reactivated.

If more than one door provides access to active parts, this requirement should be applied analogously.

All parts which remain live after disconnection must provide protection against direct contact, protection category IP 2X or IP XXB (see EN 60 529), as a minimum requirement. Such parts must be labelled with a warning notice in accordance with 18.2.
The mains connection terminals of the master switch are exempted from this ruling, provided the latter is housed in a separate enclosure.

c) Opening without using a key or tool and without deactivating the active parts must only be possible if all active parts are protected against direct contact in accordance with protection category IP 2X or IP XXB (see EN 60 529) as a minimum requirement. If covers provide this protection, they must either only be removed using a tool, or else they must automatically deactivate all protected active parts when the cover is removed.

8.2 PE conductor system

8.2.1 General

The PE conductor system consists of:

– the PE terminal (see 5.2)
– the conductive structural parts of the electrical equipment and the machine, and
– the PE conductors in the machine equipment.

All parts of the PE conductor system must be designed in such a way that they are capable of withstanding the highest thermal and mechanical stresses from earth-fault currents which could flow in the respective part of the PE conductor system.
A structural part of the electrical equipment or the machine may serve as part of the PE conductor system, provided the cross-section of this part is at least equivalent, in electrical terms, to the cross-section of the copper conductor required.

8.2.2 PE conductor

PE conductors must be labelled in accordance with 15.2.2.
Copper conductors should be used. If another conductor material is used instead of copper, the electrical resistance per unit of length must not exceed that of the permissible copper conductor. Such conductors must have a cross-section of no less than 16 mm².
The cross-section of PE conductors must determined in accordance with the requirements of IEC 364-5-54, 543.1 or EN 60 439-1, 7.4.1.7, depending on which applies.
This requirement is met in most cases if the ratio between the cross-section of the external conductor and that of the corresponding PE conductor connected to the part of the equipment matches Table 1.

8.2.3 Continuity of the PE conductor system

All exposed conductive parts in the electrical equipment and the machine(s) must be connected to the PE conductor system.
If electrical equipment is attached to lids, doors or cover plates, the continuity of the PE conductor system must be ensured. This must not be dependent upon mounting components, hinges or support rails. The PE conductor(s) must belong to the conductors supplying the equipment.
If no electrical equipment is attached to lids, doors or cover plates or if only PELV circuits are present, then metal hinges and the like shall be considered adequate to ensure continuity.
If a part is removed for some reason (e.g. regular servicing), the PE conductor system for the remaining parts must not be interrupted.

8.2.5 Parts which need not be connected to the PE conductor

It is not necessary to connect exposed conductive parts to the PE conductor system if these are mounted in such a way that they do not pose any risk because:

– they cannot be contacted over a large area or surrounded by a person’s hand and have small dimensions (less than approximately 50 mm x 50 mm)
  or
– they are arranged in such a way that contact with active parts or an insulation fault is unlikely.

This applies to small parts such as screws, rivets and identification labels, and to parts within enclosures, irrespective of their size (such as electromagnets of contactors or relays, and mechanical parts of devices).

8.2.7 PE conductor connection points

All PE conductors must be connected in compliance with 15.1.1. PE conductors must not be connected to connection parts used to secure or connect devices or parts.
Each PE conductor connection point must be labelled as such using the symbol 417-IEC-5019. Optionally, terminals for the connection of PE conductors may be indicated as such via the two-colour combination GREEN/YELLOW. The letters “PE” are reserved for the terminal used to connect the external PE conductor (see 5.2.).

13.3 Protection categories

Switchgear must be adequately protected against the ingress of solid foreign bodies and liquids, with due regard for the external influences under which the machine is likely to be operated (i.e. the installation site and the physical ambient conditions), and must provide sufficient protection against dust, coolants, metal swarf and mechanical damage.
The enclosures of switchgear must have a minimum protection category of IP 54 (see EN 60 529).
Exceptions to this requirement for a minimum protection category are:

– Vented enclosures which only contain motor starter resistors, dynamic braking resistors or similar equipment: IP 22
– Motors: IP 23
– Vented enclosures containing other equipment: IP 33.

The above are minimum protection categories. A higher protection category may be necessary depending on the siting conditions, e.g. switchgear at a site where water jets are used for cleaning should have a minimum protection level of IP 66.
Switchgear which is exposed to fine dust must have a minimum protection category of IP 65.

13.4 Enclosures, doors and openings

Locks used to secure doors and covers should be captive. Windows intended for monitoring the display devices inside must be made from a material that is capable of withstanding mechanical stresses and chemical influences, e.g. toughened glass, polycarbonate plates (3 mm thick).
We advise that enclosure doors should have vertical hinges, preferably of a type where the doors can be lifted out. The opening angle should be at least 95°. The doors should be no wider than 0.9 m.

Enclosures which are easily entered must be supplied with equipment enabling the individual to escape, e.g. panic locks on the inside of the doors. Enclosures designed for such access, e.g. for servicing purposes, must have a clear width of at least 0.7 m and a clear height of at least 2.0 m.
In cases whereby:
– The equipment is most likely to be live during access
  and
– conductive parts are exposed,

the clear width must be at least 1.0 m. In cases where such parts are present on both sides of the access route, the clear width must be at least 1.5 m.

10.2 Push-buttons

10.2.1 Colours

Push-button operating parts must be colour-coded in accordance with the following table.
The preferred colours for START/ON parts should be WHITE, GREY or BLACK, preferably WHITE. GREEN may be used; RED must not be used.
The colour RED must be used for emergency-off actuators. The colours for STOP/OFF actuators should be BLACK, GREY or WHITE, preferably BLACK. RED is likewise permissible. GREEN must not be used.
WHITE, GREY and BLACK are the preferred colours for push-button actuators which function alternately as START/ON and STOP/OFF push-buttons. The colours RED, YELLOW or GREEN must not be used.
WHITE, GREY and BLACK are the preferred colours for push-button actuators which effect an operation whilst they are actuated and terminate operation when they are released (e.g. jogging).
The colours RED, YELLOW and GREEN must not be used.
The colour GREEN is reserved for functions indicating a safe or normal operation. The colour YELLOW is reserved for functions indicating a warning or abnormal status.
The colour BLUE is reserved for functions of urgent significance.
Reset push-buttons must be BLUE, WHITE, GREY or BLACK.
If these are also used as STOP/OFF buttons, the colours WHITE, GREY or BLACK are preferred, preferably BLACK. GREEN must not be used.

Guide to colour coding for push-button actuators

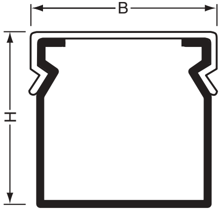
Colour	Meaning	Explanation	Examples of uses
RED	Emergency	Actuate in a dangerous condition or emergency	Emergency off, initiation of emergency off functions cf. also 10.2.1
YELLOW	Abnormal	Actuate in an abnormal condition	Intervention to suppress ab-normal condition Intervention to re-start an interrupted procedure.
GREEN	Safe	Actuate in a safe condition or to prepare for a normal status	See 10.2.1
BLUE	Compulsory	Actuate in a condition requiring a compulsory action	Reset function
WHITE	No particular meaning assigned	For the general initiation of functions apart from emergency off (see note)	START/ON (preferred) STOP/OFF
GREY			START/ON STOP/OFF
BLACK			START/ON STOP/OFF (preferred)

Note: Provided an additional method of labelling (e.g. structure, form, position) is used to mark push-button actuators, the same colours WHITE, GREY or BLACK may be used for different functions, e.g. WHITE for START/ON and STOP/OFF actuators.

10.2.2 Labelling

In addition to the functional labelling described in 18.3, it is advisable to label push-buttons with symbols, either adjacent to or – preferably – directly on the actuator, e.g.:

START or ON	STOP or OFF	Push-buttons which optionally function as START and STOP or ON and OFF buttons	Push-buttons which effect a movement when actuated and discontinue the movement when released (i.e. jogging)
417-IEC-5007	417-IEC-5008	417-IEC-5010	417-IEC-5011
			



Dimensions of cable duct		Sufficient for n wires e.g. HO 7 V-U/R/k		
H mm	W (B) mm	1 mm^2	1.5 mm^2	2.5 mm^2
18	19	21	19	14
23	31	45	36	29
32	18	36	32	23
33	30	63	55	41
34	46	100	87	65
44	19	53	46	34
44	30	84	73	53
44	45	126	110	79
45	67	193	168	120
45	86	247	216	155
45	126	360	315	225
63	19	76	67	48
65	30	124	109	81
65	46	191	167	124
65	66	274	240	178
65	86	357	313	232
65	107	445	389	289
65	126	524	458	340
65	156	576	504	374
65	206	768	672	498
85	31	168	147	109
85	47	255	226	166
85	67	364	322	236
85	87	473	418	307
85	107	581	514	377
85	127	690	610	448

In accordance with VDE 0113/EN 60 204, Part 1, 30 % must be kept free as reserve space.

Maximum permissible total break time of short-circuit protection devices for copper conductors and rated currents of standardised fuses

Nominal cross-section of cable	Minimum short-circuit current I_m	Maximum permissible total break time t	Rated currents of fuses to IEC 269 gII	gI	aM
mm²	A	s	A	A	A
0.196[1]	50	0.20	6	4	2
0.283[2]	70	0.21	8	6	4
0.5	120	0.23	12	10	8
0.75	180	0.23	16	12	12
1	240	0.23	25	20	16
1.5	310	0.30	32	25	20
2.5	420	0.46	40	40	32
4	560	0.66	50	50	40
6	720	0.90	80	80	63
10	1000	1.3	100	100	100
16	1350	1.8	–	160	125
25	1800	2.5	–	200	200
35	2200	3.3	–	250	250
50[3]	2700	4.5	–	315	315
70	3400	5	–	400	400
95	4100	5	–	500	400
120	4800	5	–	500	500
150	5500	5	–	630	630
185	6300	5	–	630	630
240	7400	5	–	800	800

1) Nominal diameter 0.5 mm
2) Nominal diameter 0.6 mm
3) Actual cross-section 47 mm²

Protection category to DIN EN 50 102, protection from external mechanical loads (IK code)

1. This standard addresses

a) The definitions for levels of protection from harmful impacts of mechanical loads within the enclosure on installed electrical components,
b) Codes for the various levels of protection,
c) The requirements for each code,
d) The tests to be carried out.

2. Structure of the IK code IK 08

Code letter — IK

Characteristic numerals (00 to 10) — 08

3. Application
The specified value (level of protection) must apply to the entire enclosure. In the event of varying levels of protection on the enclosure, these must be labelled separately (e.g. PS enclosure with acrylic glazed door).

IK code	Stress energy (joules)	Height of fall (cm)	Test piece
01	0.15	–	Spring hammer
02	0.20	–	Spring hammer
03	0.35	–	Spring hammer
04	0.50	–	Spring hammer
05	0.70	–	Spring hammer
06	1.00	–	Spring hammer
07	2.00	40.0	Hammer, mass 0.5 kg
08	5.00	29.5	Hammer, mass 1.7 kg
09	10.00	20.0	Hammer, mass 5.0 kg
10	20.00	40.0	Hammer, mass 5.0 kg

4. Assessment
After testing, the test piece must be fully functional. In particular, the protection category to EN 60 529 must not be impaired (e.g. hinge bent, seal cut, gap in friction-locked connections or similar).
Safety and reliability must not be impaired.

Protection categories to DIN EN 60 529

Standard EN 60 529 addresses the protection of electrical operating equipment via enclosures, covers and the like and includes the following:

1. Protection of persons against contact with live or moving parts within the enclosure, and protection of the operating equipment against the ingress of solid bodies (contact and foreign body protection).
2. Protection of operating equipment against the ingress of water (water protection).
3. Codes for internationally agreed protection categories and degrees of protection.

Protection categories are indicated by a code consisting of the two code letters IP, which always remain constant, and two characteristic numerals for the degree of protection.

Example of protection category: IP 4 4

Code letters — IP
First numeral — 4
Second numeral — 4

For contact and foreign object protection

First numeral	Degree of protection	
	Description	Explanation
0	Non-protected	–
1	Protected against solid foreign objects with a diameter of 50 mm and greater	The object probe, a sphere 50 mm in diameter, must not fully penetrate.*)
2	Protected against solid foreign objects with a diameter of 12.5 mm and greater	The object probe, a sphere 12.5 mm in diameter, must not penetrate fully.*) The jointed test finger may penetrate up to a length of 80 mm.
3	Protected against solid foreign objects with a diameter of 2.5 mm and greater	The object probe, a sphere 2.5 mm in diameter, must not penetrate at all.*)
4	Protected against solid foreign objects with a diameter of 1.0 mm and greater	The object probe, a sphere 1.0 mm in diameter, must not penetrate at all.*)
5	Dust-protected	The ingress of dust is not totally prevented, but dust must not penetrate in a quantity to interfere with satisfactory operation of the device or safety.
6	Dust-tight	No ingress of dust at a partial vacuum of 20 mbar inside the enclosure.

*) Note: The full diameter of the object probe must not pass through an opening of the enclosure.

Rittal recooling systems

Convincing dissipation of high heat loads in enclosure, machine and process cooling.

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For protection against water

Second numeral	Degree of protection	
	Description	Explanation
0	Non-protected	No particular protection
1	Protected against vertically falling water drops	Vertically falling drops shall have no harmful effects.
2	Protected against vertically falling water drops when the enclosure is tilted up to 15°	Vertically falling drops must not have any harmful effects when the enclosure is tilted up to 15° on either side of the vertical.
3	Protected against spraying water	Water sprayed at an angle of up to 60° on either side of the vertical shall have no harmful effects.
4	Protected against splashing water	Water splashed on the enclosure from any direction shall have no harmful effects.
5	Protected against water jets	Water directed at the enclosure from any direction in a jet shall have no harmful effects.
6	Protected against powerful water jets	Water directed at the enclosure from every direction in a powerful jet shall have no harmful effects.
7	Protected against the effects of temporary immersion in water	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water under standardised conditions of pressure and time.
8	Protected against the effects of continuous immersion in water	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions to be agreed between the manufacturer and the user but which are more severe than for numeral 7.

Continued from page 33

Second numeral	Degree of protection	
	Description	Explanation
9K	Protected against the ingress of water in case of high-pressure/steam-jet cleaning	Note: from DIN 40 050 part 9 (German national standard) on protection categories for vehicles.

Fundamental principles and basic facts on explosion protection

Many segments of the chemical and petrochemical industries, as well as industrial mills and the landfill gas extraction and mining industries, have certain areas where mixtures of combustible materials and oxygen may occur rarely, occasionally or frequently.

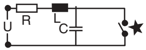
Zone classification
Areas where a hazardous, potentially explosive atmosphere may arise are classified into zones according to the probability of such an atmosphere arising. Gas atmospheres are classified into zones 0, 1 and 2, whilst dust atmospheres are classified into zones 20, 21 and 22.

Zone		Definition	Guideline values (non-standardised)
0	20	Constant or long-term or frequent risk	> 1000 h/a
1	21	Occasional risk	between 10 and 1000 h/a
2	22	Rare risk	< 10 h/a

If it is additionally necessary to install electrical equipment at such locations, it must be designed in such a way as to prevent ignition and hence explosion of the mixtures.
Measures designed to prevent the occurrence of potentially explosive atmospheres are described as primary explosion protection measures.

Types of ignition protection

If the occurrence of a potentially explosive atmosphere cannot be excluded by means of primary explosion protection measures, then secondary protective measures must come into play. Such measures prevent the ignition of the atmosphere in a variety of ways, and are referred to as protection types.

	Protection type		Application areas (selection)	Standards
	Requirements			DIN EN 60 079
	Oil immersion	o	Electronics, transformers, capacitors, relays	DIN EN 50 015
	Sand filling	q	Electronics, transformers, capacitors, relays	DIN EN 50 017
	Encapsu-lation	m	Electronics, transformers, capacitors, relays	DIN EN 60 079-18
	Pressuri-sation	p	Machines, motors, enclosures	DIN EN 60 079-2
	Flameproof enclosure	d	Motors, switchgear, power electronics	DIN EN 60 079-1
	Increased safety	e	Terminals, cases, lights, motors	DIN EN 60 079-7
	Intrinsic safety	i*	Electronics, measurement and control systems	DIN EN 50 020
	"Non-trigger"	n**	Motors, cases, lights, electronics	DIN EN 60 079-15
	Special protection	s	Sensors, over-voltage protection	None

* ia For use in zone 0, 1, 2 ib For use in zone 1, 2 ** For use in zone 2

Simple electrical equipment in intrinsically safe circuits:
These include energy sources which generate no more than 1.5 V, 100 mA and 25 mW, and energy stores with precisely defined parameters and passive components such as switches, distributor boxes, terminals etc. Such simple electronic equipment must conform to standard DIN EN 50 020 and does not require a licence.

Labelling of explosion-protected electrical equipment to DIN EN 60 079

Ex **EEx** **e** **II** **C** **T 6**

Design designation to EN 50 014

Prototype-tested to EG RL 94/9 (ATEX 100a) or EN 50 014 A1

Symbol for electrical equipment which has been built to European standards

Protection category applied
- **o** = Oil immersion
- **p** = Pressurisation
- **q** = Sand filling
- **d** = Flameproof enclosure
- **e** = Increased safety
- **i** = Intrinsic safety (ia, ib)

Category “ia”	Category “ib”
In the event of two independent faults occurring, intrinsic safety must be guaranteed; Zone 0: Avoidance of ignition sources with rare malfunctions	Intrinsic safety must be guaranteed in the event of a fault occurring; Zone 1: Avoidance of ignition sources with frequent mal-functions

Area of application (group)
I = Flameproof protection/mines **II** = Explosion protection, others

Protection types d and i are further sub-divided into equipment groups IIA to IIC depending on ignition energy.

CENELEC code	Typical gas	Ignition energy/µJ
I	Methane	280
IIA	Propane	> 180
IIB	Ethylene	60 . . . 180
IIC	Hydrogen	< 60

Temperature category
- **T 1** = > 450°C ignition temperature, 450°C
- **T 2** = > 300°C ignition temperature, 300°C
- **T 3** = > 200°C ignition temperature, 200°C
- **T 4** = > 135°C ignition temperature, 135°C
- **T 5** = > 100°C ignition temperature, 100°C
- **T 6** = > 85°C ignition temperature, 85°C

(T 1 – T 6:) Maximum surface temperature for electrical equipment in group II

Additional labelling to EG RL 94/9 (ATEX 100a) or DIN EN 60 079

Additional labelling to EG RL 94/9 (ATEX 100a) or DIN EN 60 079 — Ex — **II (1) G**

0102

Test offices (excerpt) in Europe and North America

Test centre	Country	Identifier
PTB	Germany	0102
DMT (BVS)	Germany	0158
DQS	Germany	0297
BAM	Germany	0589
EECS (BASEEFA)	UK	0600
SCS	UK	0518
INERIS	France	0080
LCIE	France	0081
LOM	Spain	0163
KEMA	Netherlands	0344
CESI	Italy	
INIEX	Belgium	
DEMKO	Denmark	
NEMKO	Norway	
UL	USA	–
FM	USA	–
CSA	Canada	–

Operational area

Electrical equipment which is certified to the ATEX 100a guidelines is given an additional code which refers to the place of use (or in the case of associated electrical equipment, defines where the signal cables may lead to). The component group is shown first, followed by the category and finally a reference to the atmosphere (gas and/or dust). The following sub-division applies to equipment group II:

Safety standard	Category 1 Very high		Category 2 High		Category 3 Normal	
Adequate safety	By 2 protective measures/for 2 faults		For frequent malfunctions/for 1 fault		For fault-free operation	
Use in	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22
Atmosphere	G (gas)	D (dust)	G (gas)	D (dust)	G (gas)	D (dust)

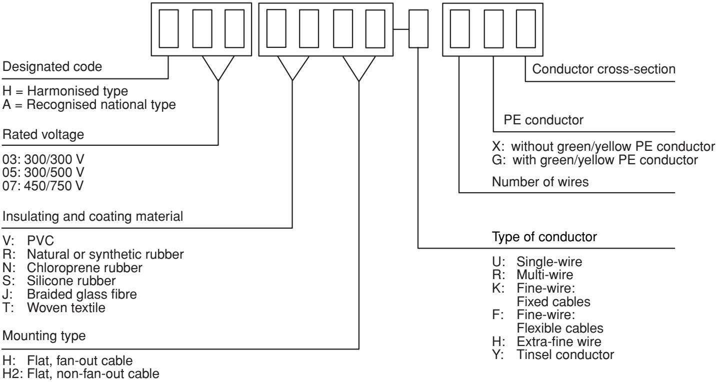
Some key safety figures for combustible gases and vapours

Name of substance	Ignition temperature °C	Temperature category	Explosion group
Acetaldehyde	140	T 4	II A
Acetone	540	T 1	II A
Carbon disulphide	95	T 6	II C (1)
Hydrogen sulphide	270	T 3	II B
Hydrogen	560	T 1	II C (2)
Ethylene	425	T 2	II B
Ethylene oxide	440	T 2	II B
Benzines, petrol fuels Initial boiling point < 135°C	220 to 300	T 3	II A
Special benzines Initial boiling point > 135°C	220 to 300	T 3	II A
Benzole (pure)	500	T 1	II A
Diesel fuels DIN EN 590: 2004	220 to 300	T 3	II A
Jet fuels	220 to 300	T 3	II A
Fuel oil EL DIN 51 603-1 2003-09	220 to 300	T 3	II A
Fuel oil L DIN 51 603-2 1992-04	220 to 300	T 3	II A
Fuel oils M and S DIN 51 603-3 2003-05	220 to 300	T 3	II A

Insulated power cables to VDE 0281 and 0282 – Harmonised version –

The regulations for PVC and rubber-insulated power cables have been harmonised with European standards – DIN 57 821/VDE 0281 for power cables with thermoplastic insulation based on PVC, and DIN 57 282/VDE 0282 for power cables with rubber insulation. The harmonised cable types are given harmonised type codes to VDE 0292. The same also applies to the recognised national types, which represent an extension to the harmonised type series. For the national types not covered by harmonisation, the previous type codes to VDE 0250 still apply.

Type codes
of the harmonised power cables:



Flammability test for plastics to UL 94

Test:
The flame is directed at the test piece for 10 seconds then withdrawn, and a note is made of the time taken until all flames are extinguished. The flame is then directed at the test piece for a further 10 seconds.
The experiment is performed on 5 test pieces. The average values of the 5 experiments are determined.

The materials are classified as follows:

94 V-0: The test piece is extinguished within 5 seconds on average. No test piece burns for longer than 10 seconds. Burning particles are not lost from any of the test pieces.

94 V-1: The test pieces are extinguished within 25 seconds. No test piece burns for longer than 60 seconds. Burning particles are not lost from any of the test pieces.

94 V-2: Like 94 V-1, but the test pieces lose burning particles during the experiment.

Plastic-insulated cables to DIN VDE 298-4 2003-08 T4 2/89

Designation to VDE 0281 or VDE 0282	Type codes	Rated voltage Uo/U	No. of wires	Nominal cross-section	Suitable for
Light twin cord	H03VH-Y	300/300	2	0.1	Dry rooms for connecting light hand-held appliances (not hot appliances); max. 1 A and maximum 2 m cable length
Twin cord	H03VH-H	300/300	2	0.5 and 0.75	Dry rooms with very low mechanical stresses (not hot appliances)
Light PVC sheathed cable (round)	H03VV-F	300/300	2 and 3	0.5 and 0.75	Dry rooms with very low mechanical stresses (light hand-held appliances)
Light PVC sheathed cable (flat)	H03VVH2-F	300/300	2	0.75	Dry rooms with low mechanical stresses
Medium PVC sheathed cable	H05VV-F	300/500	2…5	1…2.5	Dry rooms with medium mechanical stresses, for domestic appliances also in damp rooms
PVC non-sheathed cable with single-wire conductor	H05V-U	300/500	1	0.5…1	Wiring in switchgear, distributors and lighting
PVC non-sheathed cable with fine-wire conductor	H05V-K	300/500	1	0.5…1	Wiring in switchgear, distributors and lighting
PVC single-core non-sheathed cable with single-wire conductor	H07V-U	450/750	1	1.5…16	Wiring in switchgear and distributors
PVC single-core non-sheathed cable with multi-wire conductor	H07V-R	450/750	1	6…500	Wiring in switchgear and distributors
PVC single-core non-sheathed cable with fine-wire conductor	H07V-K	450/750	1	1.5…240	Wiring in switchgear and distributors

Rubber-insulated cables

Heat-resistant silicone rubber-insulated cable	H05SJ-K	300/500	1	0.5…16	Lighting and operating equipment, and in switchgear and distributors
Braided flexible cords	H03RT-F	300/300	2+	0.75…1.5	Dry rooms with low mechanical stresses
Light rubber-sheathed cable	H05RR-F	300/500	2…5	0.75…2.5	For domestic appliances with medium mechanical stresses
Heavy rubber-sheathed cable	H07RN-F	450/750	1 2 + 5 3 + 4	1.5…400 1…25 1…95	Dry and damp rooms and outdoors for heavy appliances with high mechanical stresses and in industrial water

Colour coding of green and yellow conductors:
PE conductors and PEN conductors. Green and yellow must not be used for any other conductor.
Blue:
Neutral conductor
Black:
Recommended for systems with single-wire cables.
Brown:
Recommended for systems where one group of cables is to be distinguished from another.

Allocation to various conductor codes

Conductor designation		Letter, numerals	Symbol	Colours
AC current network	Phase conductor 1	L1		–
	Phase conductor 2	L2		–
	Phase conductor 3	L3		–
	Neutral conductor	N		Blue
DC current network	Positive	L+	+	–
	Negative	L–	–	–
	Neutral conductor	M		Blue
PE conductor		PE		Green and yellow
PEN conductor (neutral conductor with protective function)		PEN		Green and yellow
Earth		E		–
Ground		MM	⊥	–

Abbreviations for colours

Colour	Green and yellow	Blue	Black	Brown	Red	Grey	White
Abbreviation to DIN IEC 60 757	GNYE	BU	BK	BN	RD	GY	WH
Old abbreviation to DIN 47 002	gnge	bl	sw	br	rt	gr	ws

External diameters of lines and cables

Cable	Cross-section [mm^2]	Mean external diameter Minimum [mm]	Maximum [mm]
H03VV-F	2 x 0.5	4.8	6.0
	2 x 0.75	5.2	6.4
	3 x 0.5	5.0	6.2
	3 x 0.75	5.4	6.8
	4 x 0.5	5.6	6.8
	4 x 0.75	6.0	7.4
H05VV-F	2 x 4	10.0	12.0
	3 G 4	11.0	13.0
	3 x 4	11.0	13.0
	5 G 4	13.5	15.5
	5 x 4	13.5	15.5
H07RN-F	3 x 70	39.0	49.5
	3 x 95	44.0	54.0
	3 x 120	47.5	59.0
	3 x 150	52.5	66.5
	6 x 1.5	14.0	17.0
	6 x 2.5	16.0	19.5
	6 x 4	19.0	22.0
H05SJ-K	1 x 0.5	3.4	
	1 x 0.75	3.6	
	1 x 1.0	3.8	
	1 x 1.5	4.3	
	1 x 2.5	5.0	
	1 x 4.0	5.6	
	1 x 6.0	6.2	
	1 x 10.0	8.2	

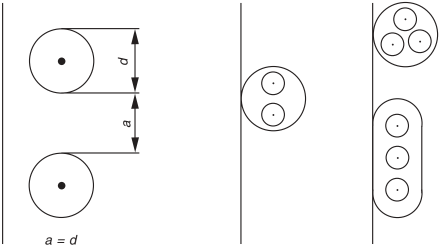
Current carrying capacity of cables at an ambient temperature $\vartheta_U = 30°C$

Load capacity of flexible cables with $U_n \leq 1000$ V

No. of current carrying conductors Installation type	ϑ_B in °C Insulating material	Design code Examples	Load in A at a nominal cross-section in mm²												
			0.75	1	1.5	2.5	4	6	10	16	25	35	50	70	95
1 V1	70 Polyvinyl chloride	H05V-U H07V-U H07V-K NFYW	15	19	24	32	42	54	73	98	129	158	198	245	292
2 or 3 V2, V3	60 Natural rubber, synthetic rubber	H05RND5-F H07RND5-F NMHVöu NSHCöu	12	15	18	26	34	44	61	82	108	135	168	207	250
2 or 3 V2, V3	70 Polyvinyl chloride	H05VVH6-F H07VVH6-F NYMHYV NYSLYö	12	15	18	26	34	44	61	82	108	–	–	–	–

Load capacity of flexible cables with $U_n > 0.6$ kV/1 kV

Number of loaded wires Rated voltage Installation type	ϑ_B in °C Insulating material	Design code Examples	Load in A at a nominal cross-section in mm²												
			2.5	4	6	10	16	25	35	50	70	95	120	150	185
3 ≤ 6 kV/10 kV V2	80 Ethylene-propylene rubber	NSSHöu	30	41	53	74	99	131	162	202	250	301	352	404	461
3 ≥ 6 kV/10 kV V2	80 Ethylene-propylene rubber	NSSHöu	–	–	–	–	105	139	172	215	265	319	371	428	488



V1 V2 V3

Conversion of conductor cross-sections and diameters into AWG numbers (American Wire Gauge)

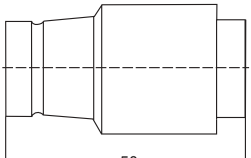
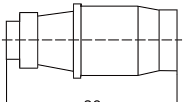
British and US dimensions for cables and lines

Within the US sphere of influence, the dimensions of copper conductors for power and telecommunications applications are generally given in AWG numbers.

These correspond as follows:

AWG No.	Diameter mm	Cross-section mm^2	Conductor resistance Ω/km
500	17.96	253	0.07
350	15.03	177	0.1
250	12.7	127	0.14
4/0	11.68	107.2	0.18
3/0	10.4	85	0.23
2/0	9.27	67.5	0.29
1/0	8.25	53.5	0.37
1	7.35	42.4	0.47
2	6.54	33.6	0.57
4	5.19	21.2	0.91
6	4.12	13.3	1.44
8	3.26	8.37	2.36
10	2.59	5.26	3.64
12	2.05	3.31	5.41
14	1.63	2.08	8.79
16	1.29	1.31	14.7
18	1.024	0.823	23

Overcurrent protection devices (low-voltage fuses)

Fuse inserts									
System, rated voltage	Rated current in A	Colour of indicator	Size of fuse insert System D	Size of fuse insert System DO	Rated heat loss in W System D	Rated heat loss in W System DO	Screw cap System	Screw cap Thread	Screw cap Gauge piece
 50	2	Pink			3.3	2.5	ND	E16	Gauge ring
	4	Brown			2.3	1.8	D II	E27	Adaptor screw
	6	Green	ND and D II	DO1	2.3	1.8	D III	E33	Adaptor screw
	10	Red			2.6	2.0	DIV H	R1 1/4″	Adaptor sleeve
D system (Diazed), 500 V to 100 A AC 660 V, DC 600 V to 63 A	16	Grey			2.8	2.2	DO1	E14	
	20	Blue	D II		3.3	2.5	DO2	E18	Socket fitting insert
	25	Yellow			3.9	3.0	DO3	M30 x 2	
 36	35	Black		DO2	5.2	4.0			
	50	White	D III		6.5	5.0			
	63	Copper			7.1	5.5	The dimensions of the fuse inserts depend on the rated current.		
DO system (Neozed), AC 400 V, DC 250 V to 100 A	80	Silver	D IV H	DO3	8.5	6.5			
	100	Red			9.1	7.0			

Categories of low-voltage fuses

Functional categories	
g	Full-range fuses provide overload protection and short-circuit protection. They are able to continuously conduct currents up to their rated current, and reliably disconnect currents from the smallest fusing current to the rated breaking current.
a	Partial-range fuses only protect against short-circuits. They are able to continuously conduct currents up to their rated current, but can only disconnect currents above a multiple of their rated current up to the rated breaking current.

Operating categories	
gL	Full-range cable and line protection
gR	Full-range semi-conductor protection
gB	Full-range mining installation protection
gTr	Full-range transformer protection
aM	Partial-range switchgear protection
aR	Partial-range semi-conductor protection

Types of protected objects	
L	Cable and line protection
R	Semi-conductor protection
M	Switchgear protection
B	Mining and plant protection
Tr	Transformer protection
	The low-voltage fuses are indicated by 2 letters, e.g. gL.

Explanation of fuses as protective devices in the low-voltage range

Fuses are high-quality technical protection elements which reliably disconnect even the highest short-circuit currents within a very limited space. Before an impermissible overcurrent load can result in damage to equipment and cables, the fuse inserts in the fuse systems D 02, D and NH to DIN EN 60 269-1/VDE 0636 will disconnect reliably. Reliable functioning in continuous operation over many years and prompt disconnection in the event of a fault are attributable to the careful design of the individual components, particularly the fuse-element. The fuse-elements, designed as so-called rupture points in the circuit, are dimensioned in such a way that not only do they disconnect safely and reliably in conjunction with the arc extinguishing medium (quartz sand), but also ensure a high level of resistance to ageing, a low intrinsic temperature of the fuse, and only minimal power losses. The fusible link which acts in the overload range is attached to the fuse-element strip so precisely that the quantity and position of the solder to the narrow points is only subject to negligible deviations. Consequently, D 02, D and NH fuse inserts have extremely low variance in their time/current response, thereby enabling a narrow selective grading of fuse inserts. The fusible link used has a relatively high melting point in order to exclude influences of the ambient temperature on time/current response as far as possible. The time/current curves of the fuse insert manufacturers indicate the melting time / break time depending on an uninfluenced overcurrent. The time/current curves provided in these characteristic sheets are mean values for the ratio between melting time/current, and do not apply to pre-loaded fuse inserts.

In general, these values refer to an ambient temperature of 20 ± 5 degrees C. In the range of higher short-circuit currents, the current curve is divided into melt time and break time, whereby the difference between these on the time axis is the respective arcing time. This, in turn, also depends to a large extent on the operating voltage and the level of the breaking current, as well as the power factor of the network. The time/current curve values are specified by VDE regulation 0636 and and must not deviate from these specifications by more than 10 % in the direction of the current axis. Regarding the ambient temperature, fuse inserts are capable of conducting their rated current continuously at 55 degrees C. Fuses have excellent properties for limiting current. At very high currents, they melt so quickly that the short-circuit current (Is) can only occur at a low level.

The highest instantaneous value of the current achieved during the breaking procedure is known as the cut-off current (ID). Values for current limitation, and hence specification of the cut-off current ID, can be found in the manufacturers' data sheets for the respective fuse inserts.

Type-tested and partially type-tested combinations

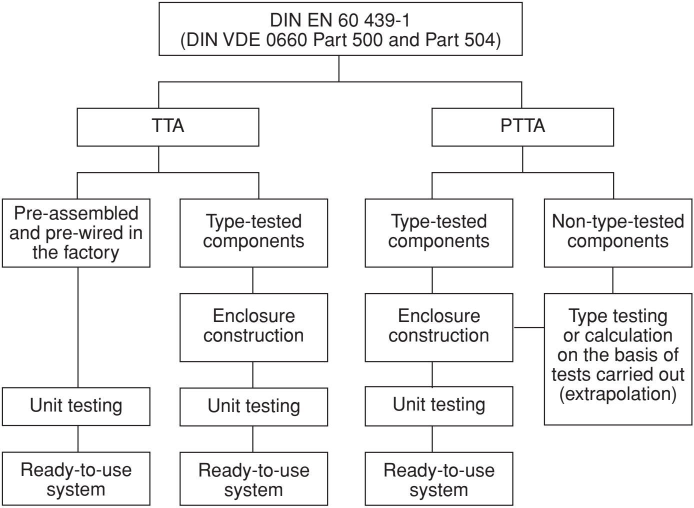
The standard governing the manufacture of low-voltage switchgear and distributors is:
DIN EN 60 439-1 (DIN VDE 0660 Part 500)
Low-voltage switchgear combinations – Requirements for type-tested and partially type-tested assemblies.

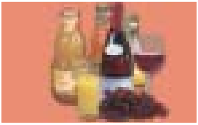
This standard makes a distinction between

- type-tested assemblies (TTA) and
- partially type-tested assemblies (PTTA).

The diagram below indicates the procedure for constructing a ready-to-use system as a type-tested or partially type-tested assembly.

Difference between TTA and PTTA





Hygienic Design

For the design of production plant in open processes in the food and consumables industry where ease of cleaning is crucial.

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RITTAL

Rittal TopConsole System

Powerful partner to the TS/CM platform. Without limitations, both inside and out – the TopConsole with integrated modularity. Suitable for configuration with the extensive range of Rittal system accessories.

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Terms to DIN EN 60 909-0 VDE 0102/0103 for short-circuit currents in three-phase systems

Peak short-circuit current i_p
The maximum permissible instantaneous value of the anticipated short-circuit current.

Note: The size of the peak short-circuit current depends on the moment when the short-circuit occurs. Calculation of the peak short-circuit current i_p in a three-pole short-circuit refers to the conductor and the moment at which the maximum possible current occurs.

Sustained short-circuit current I_k
The effective value of the short-circuit current which is retained once all transient reactions have decayed.

Initial symmetrical short-circuit current I_k''
The effective value of the symmetrical AC component of an anticipated short-circuit current at the moment of occurrence of the short-circuit, if the short-circuit impedance retains the value at the time zero.

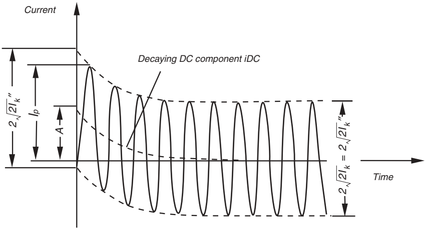

Illustration: Progression of the short-circuit current over time with remote short-circuit (diagrammatic representation).

I_k'' Initial symmetrical short-circuit current
i_p Peak short-circuit current
i_k Sustained short-circuit current
i_{DC} Decaying DC component of the short-circuit current
A Initial value of DC component i_{DC}

Thermal short-circuit current I_{th}
Busbars, including their operating equipment, are likewise subject to thermal stress in the event of a short-circuit. The thermal stress depends on the level, time pattern and duration of the short-time current. The short-circuit current I_{th} is defined as the thermally effective mean whose effective value generates the same amount of heat as the short-circuit current which is variable in its DC and AC components during the short-circuit period i_k.

D system, DO system (D-type fuse-links)
The D system and the DO system are distinguished by the fact that the fuse insert is non-interchangeable in terms of its rated current and contact hazard protection. It is suitable for both industrial applications and domestic installations, and can be used by laypersons. D fuses consist of a fuse base, a fuse insert, a screw cap and a gauge piece.
The following points should be observed with the DO system: DO fuses consist of a fuse base, a fuse insert, a screw cap and a gauge piece. The DO system differs from the D system in that it has a different rated voltage and different dimensions.
– Approval: Still only approved in Germany, Austria, Denmark and Norway.
– Rated voltage: 400 V, compared with DII for 500 (660 V), DIII always for 660 V.

NH system
The NH system (low-voltage high-breaking-capacity fuse system) is a standardised fuse system consisting of a fuse base, the replaceable fuse insert and the control component for replacing the fuse insert. NH fuses may also have fuse monitors and tripping mechanisms.
It is not non-interchangeable with regard to the rated current and contact hazard protection; consequently, the NH system is not suitable for use by laypeople.

Operating categories
Operating categories are indicated by two letters, the first showing the functional category, the second the object to be protected.

Functional categories
These specify the current range within with the fuse protection is able to disconnect.
– Functional category g:
  Full range breaking capacity fuse-links. Fuse inserts which continuously conduct currents at least up to their rated current and are able to disconnect currents from the smallest fusing current up to the rated breaking current (protection against overload and short-circuit).
– Functional category a:
  Partial range breaking capacity fuse-links. Fuse inserts which continuously conduct currents at least up to their rated current and are able to disconnect currents above a given multiple of their rated current up to the rated breaking current (protection against short-circuits).

Specified protection objects
L: Cable and line
M: Switchgear
R: Semi-conductors
B: Mining installations
Tr: Transformers

This produces the following operating categories:
gL: Full-range cable and line protection
aM: Partial-range switchgear protection
aR: Partial-range semi-conductor protection
gR: Full-range semi-conductor protection
gB: Full-range mining installation protection
gTr: Full-range transformer protection

Rated voltages/rated currents

(NH and D system)

Size	Rated voltage ⎓ 440 V			
	~ 500 V		~ 660 V	
NH 00, NH 00/000	6 A – 160 A		6 A – 100 A	
NH 0[1]	6 A – 160 A		–	
NH 1	80 A – 250 A		80 A – 250 A	a)
NH 2	125 A – 400 A		125 A – 315 A	
NH 3	315 A – 630 A		315 A – 500 A	
NH 4a	500 A – 1250 A		500 A – 800 A	
D 01 (E 14)	max. 16 A	–	–	
D 02 (E 18)	max. 63 A	–	–	b)
D II (E 27)	max. 25 A	max. 25 A	–	
D III (E 33)	max. 63 A	max. 63 A	max. 63 A	

a) NH… fuse insert
b) D… fuse insert
1) Only as a spare

Heat loss (NH and D system)

Size	Heat loss			
	max. fuse insert gL at rated current		max. fuse insert aM at rated current	
	500 V	660 V	500 V	660 V
NH 00	7.5 W	10 W	7.5 W	9 W
NH 0	16 W	–	–	–
NH 1	23 W	23 W	23 W	28 W
NH 2	34 W	34 W	34 W	41 W
NH 3	48 W	48 W	48 W	58 W
NH 4a	110 W	70 W	110 W	110 W

Rated current of a fuse insert	Heat loss	
	500 V	660 V
2 A	3.3 W	3.6 W
4/6 A	2.3 W	2.6 W
10 A	2.6 W	2.8 W
16 A	2.8 W	3.1 W
20 A	3.3 W	3.6 W
25 A	3.9 W	4.3 W
35 A	5.2 W	5.7 W
50 A	6.5 W	7.2 W
63 A	7.1 W	7.8 W
80 A	8.5 W	–
100 A	9.1 W	–

Continuous currents for busbars

Made from copper to DIN 43 671:1975-12 with square cross-section in indoor locations at 35°C air temperature and 65°C bar temperature, vertical position or horizontal position of the bar width.

Width x thickness	Cross-section	Weight [1]	Material [2]	Continuous current in A			
				AC current up to 60 Hz		DC current + AC current 16 2/3 Hz	
				Bare busbar	Coated busbar	Bare busar	Coated busbar
mm	mm^2						
12 x 2	23.5	0.209	E-Cu F 30	108	123	108	123
15 x 2	29.5	0.262		128	148	128	148
15 x 3	44.5	0.396		162	187	162	187
20 x 2	39.5	0.351		162	189	162	189
20 x 3	59.5	0.529		204	237	204	237
20 x 5	99.1	0.882		274	319	274	320
20 x 10	199	1.77		427	497	428	499
25 x 3	74.5	0.663		245	287	245	287
25 x 5	124	1.11		327	384	327	384
30 x 3	89.5	0.796		285	337	286	337
30 x 5	149	1.33		379	447	380	448
30 x 10	299	2.66		573	676	579	683
40 x 3	119	1.06		366	435	367	436
40 x 5	199	1.77		482	573	484	576
40 x 10	399	3.55		715	850	728	865
50 x 5	249	2.22		583	697	588	703
50 x 10	499	4.44		852	1020	875	1050
60 x 5	299	2.66		688	826	996	836
60 x 10	599	5.33		985	1180	1020	1230
80 x 5	399	3.55		885	1070	902	1090
80 x 10	799	7.11		1240	1500	1310	1590

1) Calculated with a density of 8.9 kg/dm^3
2) Reference basis for continuous current values
(Values taken from DIN 43 671)

RiLine60 – Perfection in a 60 mm system

Time-saving assembly, versatile applications and individual modularity are the winning features of the new Rittal RiLine60 busbar system.

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Calculation of heat loss in busbars

The heat loss of busbars and individual circuits must be calculated by the system manufacturers themselves, using the following formula:

$$P_v = \frac{I_B^2 \cdot r \cdot l}{1000} \; [W]$$

Where:

P_v Heat loss in W;
I_B Rated current of affected circuit/busbars in A;
l Length of conductor through which I_B flows in m;
r Resistance of cable system, or in the case of busbars, resistance of busbar system in mΩ/m.

Note:
The rated current specified for a busbar arrangement is the maximum permissible current which this busbar is able to conduct on its entire length. Often, the heat loss calculated with this rated current does not represent a realistic value.
Depending on the spatial division of the power supply (or supplies) and outlets, busbars conduct graduated "operating currents". Therefore, it is expedient for heat loss to be calculated section by section directly with these actual currents.
In order to calculate heat loss according to the above formula, in individual cases, the following can be assumed to be known: the rated current of a circuit or the "operating currents" of the busbar sections, and the corresponding length of the conductor system in the installation or distributor. By contrast, the resistance of conductor systems – particularly the AC current resistance of busbar arrangements – cannot simply be taken from a document or determined yourself. For this reason, and in order to obtain comparable results when determining heat losses, the table on page 61 shows the resistance values in mΩ/m for the most common cross-sections of copper busbars.

Background information on UL 508 and UL 508A

Application areas for UL 508 and UL 508A

UL 508 describes **industrial control equipment** and is therefore the decisive standard for the assessment of Rittal SV components.
By contrast, UL 508A describes **industrial control panels** and is the decisive standard for the construction of control enclosures for the switchgear manufacturer. Standard UL 508A makes a distinction between feeder circuits and branch & control circuits. Generally speaking, the term “feeder circuits” refers to the part of the circuit located at the supply end before the last over-current protective device. Increased requirements with regard to creepage distances and clearances apply to this part of the circuit. The term “branch & control circuits” refers to the part of the circuit located after the last over-current protective device. When using busbar systems, it is important to know whether the application is in the feeder section or the branch section, as the requirements governing the required creepage distances and clearances are significantly higher for feeder circuits.

Important notes for the use of busbar systems to UL 508

One of the principal changes in UL 508A is the amendment to the required creepage distances and clearances for feeder circuits. The following distances are required for applications > 250 V:

Between phases:

- Creepage distance 50.8 mm (2 inches)
- Clearance 25.4 mm (1 inch)

Between phase and earthed, uninsulated metal parts:

- Creepage distance 25.4 mm (1 inch)
- Clearance 25.4 mm (1 inch)

Rittal RiLine60 complies with these requirements. All busbar connection adaptors and component adaptors (OM with standard AWG connection cables and circuit-breaker adaptors) in the new system have been designed in accordance with these requirements. However, users should bear in mind a small number of differences from the IEC version:

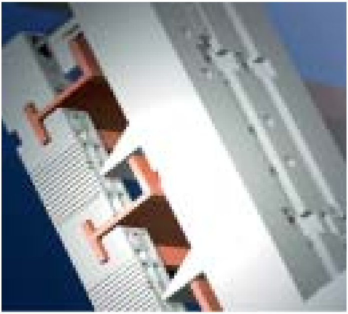
- Special UL busbar supports for flat bars and Rittal PLS with increased creepage distances and clearances.
- Use of the Rittal RiLine60 base tray is required in order to comply with the necessary minimum distances from the mounting plate.

1. Rated currents

For untested busbar applications, UL 508A specifies a current carrying capacity of 1000 A/inch^2 (1.55 A/mm^2) in the absence of testing. This value may be higher if the product or application has undergone suitable testing. Rittal has conducted extensive testing in this respect in order to give users the maximum benefits when using the RiLine60 busbar system. The benefit of such testing is that busbar systems with higher rated currents may be used than permitted by the default value. For example, a busbar with the dimensions 30 x 10 mm can carry 700 A instead of 465 A.

2. Terminals for factory or field wiring

In accordance with the UL standards, connection clamps may be approved for factory or field wiring. If a terminal is approved for factory wiring, it may only be used in switchgear assembly by suitably trained professionals.
If connection clamps are to be used in the field (e.g. on a construction site), the component must be approved for field wiring. For this reason, the terminals of RiLine60 busbar connection and component adaptors meet the requirements for field wiring.



Rittal Power Engineering

The configurator for Ri4Power low-voltage switchgear

For

- Form 1: High-current power distributors
- Form 2-4: Low-voltage switchgear
- ISV: Distribution enclosures

The multi-lingual software package includes the following functions:

- Project handling, from the initial enquiry through to ordering
- Complete, automatic function for the generation of bills of materials and a calculation program for producing a quote
- Calculation of assembly times
- Access to the entire range of Rittal products
- Output of orders, including combining of several projects into one order
- Generation of special fields configured by the customer with graphical processing in the CAD view
- Import/export interfaces for product and CAD data
- Export function for order and parts lists in Excel or CSV format
- Calculation based on current copper price
- Integration of the new product range with subdivisions to Forms 2, 3 and 4 (Ri4Power).
- Interface to Eplan Electric P8, for the export of CAD data and bills of materials
- The extra benefit for engineering and planning offices: Output of detailed tender texts on the basis of systems project-planned in Power Engineering in MS Word/GAEB format.

Model No. SV	3020.300

Resistance of copper busbars in order to calculate their heat loss when used for DC current (r_{GS}) or AC current (r_{WS})

	Dimensions of strand[2]	Resistance per 1 m of busbar system per mΩ/m[1]							
		I 1 main conductor		III 3 main conductors		II II II 3 x 2 main conductors		III III III 3 x 3 main conductors	
		r_{GS}	r_{WS}	r_{GS}	r_{WS}	r_{GS}	r_{WS}	r_{GS}	r_{WS}
	1	2	3	4	5	6	7	8	9
1	12 x 2	0.871	0.871	2.613	2.613				
2	15 x 2	0.697	0.697	2.091	2.091				
3	15 x 3	0.464	0.464	1.392	1.392				
4	20 x 2	0.523	0.523	1.569	1.569				
5	20 x 3	0.348	0.348	1.044	1.044				
6	20 x 5	0.209	0.209	0.627	0.627				
7	20 x 10	0.105	0.106	0.315	0.318	0.158	0.160		
8	25 x 3	0.279	0.279	0.837	0.837	0.419	0.419		
9	25 x 5	0.167	0.167	0.501	0.501	0.251	0.254		
10	30 x 3	0.348	0.348	1.044	1.044	0.522	0.527		
11	30 x 5	0.139	0.140	0.417	0.421	0.209	0.211		
12	40 x 10	0.070	0.071	0.210	0.214	0.105	0.109		
13	40 x 3	0.174	0.174	0.522	0.522	0.261	0.266		
14	40 x 5	0.105	0.106	0.315	0.318	0.158	0.163		
15	40 x 10	0.052	0.054	0.156	0.162	0.078	0.084	0.052	0.061
16	50 x 5	0.084	0.086	0.252	0.257	0.126	0.132	0.084	0.092
18	60 x 5	0.070	0.071	0.210	0.214	0.105	0.112	0.070	0.079
19	60 x 10	0.035	0.037	0.105	0.112	0.053	0.062	0.035	0.047
20	80 x 5	0.052	0.054	0.156	0.162	0.078	0.087	0.052	0.062
21	80 x 10	0.026	0.029	0.078	0.087	0.039	0.049	0.026	0.039
22	100 x 5	0.042	0.045	0.126	0.134	0.063	0.072	0.042	0.053
23	100 x 10	0.021	0.024	0.063	0.072	0.032	0.042	0.021	0.033
24	120 x 10	0.017	0.020	0.051	0.060	0.026	0.036	0.017	0.028

Key to symbols:

r_{GS} Total resistance of busbar system when used for DC current in mΩ/m

r_{WS} Total resistance of busbar system when used for AC current in mΩ/m

Footnotes:

[1] The resistance figures are based on an assumed average conductor temperature of 65°C (ambient temperature + self-heating) and a specific resistance of $\rho = 20.9 \left[\frac{m\Omega \cdot mm^2}{m} \right]$

[2] Dimensions match those of standard DIN 43 671

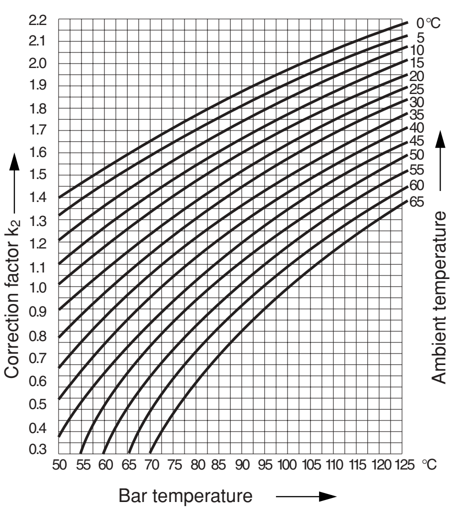
Current correction for Cu busbar systems

In DIN 43 671 on measuring continuous current for copper busbars, Table 1 shows continuous currents which generate a busbar temperature of 65°C in busbars of E-Cu with a square cross-section in internal installations at an air temperature of 35°C.
Higher bar temperatures are permissible and depend on the material coming into direct contact with the bars.
For other temperature conditions, Figure 2 of DIN 43 671 shows a correction factor which is multiplied by the original rated current to obtain the new permissible rated current.
Generally speaking, busbar systems are purpose-designed for use in enclosures. In addition, because an enclosure protection category of IP 54 or IP 55 is usually required, a more favourable emission level of copper bars than 0.4 can be assumed compared with the table figures in DIN 43 671 for bare Cu bars, and consequently, a higher rated current load of around 6 – 10 % of the levels specified in the DIN table is possible.
On this basis, the following current correction may be implemented:

Example:
Bar cross-section
30 x 10 mm
Permissible bar
temperature 85°C
Ambient temperature
35°C
From Figure 2 correction
factor
$K_2 = 1.29$
$I_1 = I_N \cdot k_2 = 573\ A \cdot 1.29 = 740\ A$

To this end, 8 % = 60 A is added to the (assumed) more favourable emission level of the bars, producing the new permissible rated current:

$I_N = I_1 + I_1 \cdot 8/100 = 740\ A + 60\ A = 800\ A$



Rated motor currents of three-phase motors

(Guideline values for squirrel-cage rotors)
The smallest possible short-circuit fuse for three-phase motors
The maximum value is based on the switchgear or motor protective relay.
The rated motor currents apply to standard, internally and surface-cooled three-phase motors with 1500 rpm.
Direct start:
Start-up current max. 6 x rated motor current; start-up time max. 5 s.
Y/Δ start:
Start-up current max. 2 x rated motor current; start-up time 15 s.
Rated fuse currents with Y/Δ start also apply to three-phase motors with slipring rotors. For a higher rated/start-up current and /or longer start-up time, a larger fuse should be used.
The table applies to “slow”/“gl” fuses (VDE 0636).
In the case of NH fuses with aM characteristics, a fuse is selected which matches the rated current.

Motor output			220 V/230 V			380 V/400 V			500 V			660 V/690 V		
		η	Rated motor cur-rent	Fuse Start-up direct	Fuse Y/Δ	Rated motor cur-rent	Fuse Start-up direct	Fuse Y/Δ	Rated motor cur-rent	Fuse Start-up direct	Fuse Y/Δ	Rated motor cur-rent	Fuse Start-up direct	Fuse Y/Δ
kW	cos φ	%	A	A	A	A	A	A	A	A	A	A	A	A
0.25	0.7	62	1.4	4	2	0.8	2	2	0.6	2	–	0.5	2	–
0.37	0.72	64	2.1	6	4	1.2	4	2	0.9	2	2	0.7	2	–
0.55	0.75	69	2.7	10	4	1.6	4	2	1.2	4	2	0.9	4	2
0.75	0.8	74	3.4	10	4	2	6	4	1.5	4	2	1.1	4	2
1.1	0.83	77	4.5	10	6	2.6	6	4	2	6	4	1.5	4	2
1.5	0.83	78	6	16	10	3.5	6	4	2.6	6	4	2	6	4
2.2	0.83	81	8.7	20	10	5	10	6	3.7	10	4	2.9	10	4
3	0.84	81	11.5	25	16	6.6	16	10	5	16	6	3.5	10	4
4	0.84	82	15	32	16	8.5	20	10	6.4	16	10	4.9	16	6
5.5	0.85	83	20	32	25	11.5	25	16	9	20	16	6.7	16	10
7.5	0.86	85	27	50	32	15.5	32	16	11.5	25	16	9	20	10
11	0.86	87	39	80	40	22.5	40	25	17	32	20	13	25	16
15	0.86	87	52	100	63	30	63	32	22.5	50	25	17.5	32	20
18.5	0.86	88	64	125	80	36	63	40	28	50	32	21	32	25
22	0.87	89	75	125	80	43	80	50	32	63	32	25	50	25
30	0.87	90	100	200	100	58	100	63	43	80	50	33	63	32
37	0.87	90	124	200	125	72	125	80	54	100	63	42	80	50
45	0.88	91	147	250	160	85	160	100	64	125	80	49	80	63
55	0.88	91	180	250	200	104	200	125	78	160	80	60	100	63
75	0.88	91	246	315	250	142	200	160	106	200	125	82	160	100
90	0.88	92	292	400	315	169	250	200	127	200	160	98	160	100
110	0.88	92	357	500	400	204	315	200	154	250	160	118	200	125
132	0.88	92	423	630	500	243	400	250	182	250	200	140	250	160
160	0.88	93	500	630	630	292	400	315	220	315	250	170	250	200
200	0.88	93	620	800	630	368	500	400	283	400	315	214	315	250
250	0.88	93	–	–	–	465	630	500	355	500	400	268	400	315

Cable glands to standard: DIN EN 50 262

Safety standard, no requirements governing the shape of the cable gland

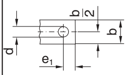
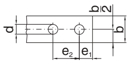
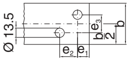
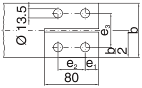
Metric thread	Hole diameter $^{+0.2}_{-0.4}$
M6	6.5
M8	8.5
M10	10.5
M12	12.5
M16	16.5
M20	20.5
M25	25.5
M32	32.5
M40	40.5
M50	50.5
M63	64.5
M75	75.5

Technical specifications for the installation of PG screwed cable glands

PG thread DIN 40 430	Nominal thread			
	Ø d_1	Ø d_2	p	Ø d_3
PG 7	11.28	12.50	1.27	13.0 ± 0.2
PG 9	13.35	15.20	1.41	15.7 ± 0.2
PG 11	17.26	18.60	1.41	19.0 ± 0.2
PG 13.5	19.06	20.40	1.41	21.0 ± 0.2
PG 16	21.16	22.50	1.41	23.0 ± 0.2
PG 21	26.78	28.30	1.588	28.8 ± 0.2
PG 29	35.48	37.00	1.588	37.5 ± 0.3
PG 36	45.48	47.00	1.588	47.5 ± 0.3
PG 42	52.48	54.00	1.588	54.5 ± 0.3
PG 48	57.73	59.30	1.588	59.8 ± 0.3

d_1 = Core diameter
d_2 = External diameter
d_3 = Hole diameter
p = Pitch

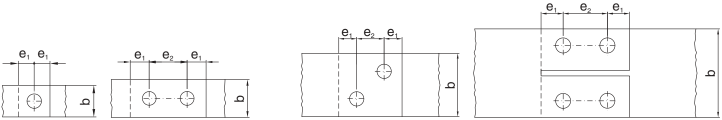
Hole patterns and holes to DIN 43 673

Bar widths		12 to 50		25 to 60			60			80 to 100		
Shape[1]		1		2			3			4		
Holes in the bar ends (drilling pattern)												
	Nominal width b	d	e_1	d	e_1	e_2	e_1	e_2	e_3	e_1	e_2	e_3
Hole size	12	5.5	6	–	–	–	–	–	–	–	–	–
	15	6.6	7.5	–	–	–	–	–	–	–	–	–
	20	9.0	10	–	–	–	–	–	–	–	–	–
	25	11	12.5	11	12.5	30	–	–	–	–	–	–
	30	11	15	11	15	30	–	–	–	–	–	–
Hole size	40	13.5	20	13.5	20	40	–	–	–	–	–	–
	50	13.5	25	13.5	20	40	–	–	–	–	–	–
	60	–	–	13.5	20	40	17	26	26	–	–	–
	80	–	–	–	–	–	–	–	–	20	40	40
	100	–	–	–	–	–	–	–	–	20	40	50
Permissible deviations for hole-centre distances ± 0.3 mm												

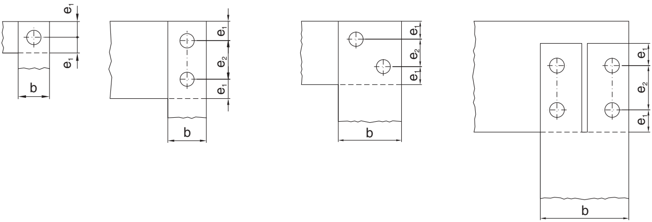
[1] Shape designations 1 – 4 match DIN 46 206, part 2 – Flat-type screw terminal

Examples of busbar screw connections

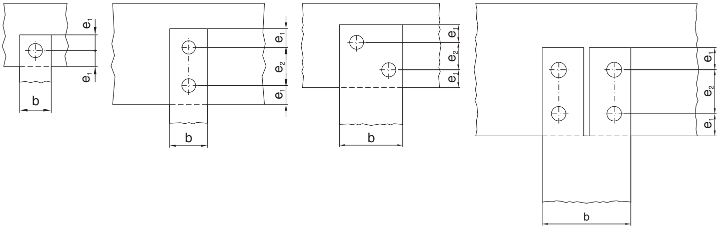
Longitudinal connections



Angular connections



T-connections



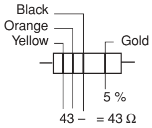
Dimensions b, d, e_1 and e_2 as shown in the table on page 65.
Slots are permissible in the end of a bar or end of a bar stack.

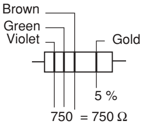
Internal and external diameters of conduits

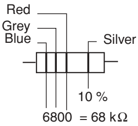
Nominal conduit size (type)	Plastic insulated conduits								Armoured steel conduit and steel conduit				
	Rigid insulating conduits Mechanical stresses				Flexible insulated conduits, corrugated Mechanical stress				Armoured steel conduit			Flexible steel conduit	
	Light		Medium and heavy		Medium and light		Heavy						
	Diameter		Diameter		Diameter		Diameter		Thread	Diameter		Diameter	
mm	internal mm	external mm	internal mm	external mm	internal mm	external mm	internal mm	external mm	Short-term	internal mm	external mm	internal mm	external mm
9	8.8	10.1	12.6	15.2	9.6	13	–	–	PG 9	13.2	15.2	10.8	15.2
11	11.6	13	16	18.6	11.3	15.8	13.5	18.6	PG 11	16.4	18.6	14	18.6
13.5	14.2	15.8	17.5	20.4	14.3	18.7	14.2	20.4	PG 13.5	18	20.4	15.6	20.4
16	16.7	18.7	19.4	22.5	16.5	21.2	16	22.5	PG 16	19.9	22.5	17.4	22.5
21	19.2	21.2	24.9	28.3	–	–	22	28.3	PG 21	25.5	28.3	23.2	28.3
23	25.9	28.5	–	–	23.3	28.5	–	–	–	–	–	–	–
29	–	–	33.6	37	29	34.5	29.8	37	PG 29	34.2	37	31.4	37
36	–	–	42.8	47	36.2	42.5	38.5	47	PG 36	44	47	40.8	47
42	–	–	49.6	54	–	–	–	–	PG 42	51	54	46.7	54
48	–	–	54.7	59.3	47.7	54.5	–	–	PG 48	55.8	59.3	51.8	59.3

Colour coding of resistors

Colour	1st ring ≙ 1st digit	2nd ring ≙ 2nd digit	3rd ring ≙ Multiplier	4th ring ≙ Tolerance
Black	–	0	1	–
Brown	1	1	10	± 1 %
Red	2	2	10^2	± 2 %
Orange	3	3	10^3	–
Yellow	4	4	10^4	–
Green	5	5	10^5	± 0.5 %
Blue	6	6	10^6	–
Violet	7	7	10^7	–
Grey	8	8	10^8	–
White	9	9	10^9	–
Gold	–	–	0.1	± 5 %
Silver	–	–	0.01	± 10 %
Colourless	–	–	–	± 20 %







Designation of terminals and power cables

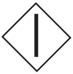
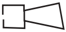
For DC current

	Positive conductor			L+
	Negative conductor			L–
	Neutral conductor			M
	Armature			A-B
	Parallel winding for self-excitation			C-D
	Series winding			E-F
	Commutating or compensating winding Commutating winding with compensating winding			G-H
	Separate commutating and compensating winding	Commutating winding		GW-HW
		Compensating winding		GK-HK
	Separately excited field windings			J-K
	Starter	Terminal for connection to	Mains	L
			Armature	R
			Parallel winding	M
	Field rheostat for voltage and speed control	Terminal for connection to	Parallel winding	s
			Armature or mains	t
			Armature or mains for short-circuit	q
Current converter				

For three-phase and AC current

	Three-phase current	Outer conductor		L1, L2, L3
		Neutral conductor		N
	Single-phase current	Delta voltage	Connection to three-phase network	L1, L2 or L2, L3 or L3, L1
			Independent network	L1, L2
		Star voltage		N with L1 or L2 or L3
	Three-phase current	Interlinked	Primary U. V. W	Secondary u. v. w
		Non-interlinked	Primary U-X, V-Y, W-Z	Secondary u-x, v-y, w-z
	Single-phase current	General	U-V	–
		Main winding	U-V	–
		Auxiliary winding	W-Z	–
	Multi-phase current	Neutral or star point	N	n
	DC current excitation winding		J-K	
	Secondary starter	Three-phase current	Interlinked	u. v. w
			Non-interlinked	u-x, v-y, w-z
	Primary starter	Three-phase current	connected in star point	X, Y, Z
			Between mains and motor	U-X, V-Y, W-Z
	Field rheostat	DC current	Terminals for connection to: Field winding	s
			Exciter mains to field rheostat	t
			Exciter mains short-circuit	q
Current converter	Primary side K-L			Secondary side k-l

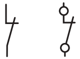
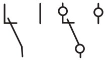
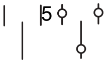
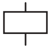
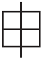
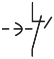
Electronic symbols to DIN 30 600

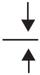
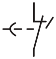
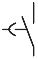
	Off		Mains switch on/off		Unlock
	On		Mains switch		Lock
	Start		Jog		Pause
	Quick start		Disconnect		Brake
	STOP		Connect		Release brake
	Quick stop, prepare		Preliminary switching		Pump
	Manual switch		Horn	 	Light, illumination
	Foot-switch		Result	 	Bell, acoustic signal
	Manual actuation		Change of size		

Protection category symbols to DIN EN 60 529

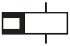
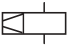
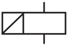
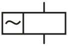
Abbreviation to DIN EN 60 529	Comparable with NEMA Standard 250	Symbol		Degree of protection
		Water	Foreign body	
IP 00	–	–	–	No protection
IP 20	–	–	–	Protection against contact with the fingers; protection against medium-sized foreign bodies (> 12 mm); no protection against water
IP 30	2	–	–	Protection against contact with the fingers; protection against small foreign bodies (> 2.5 mm); no protection against water
IP 40	–	–	–	Protection against contact with tools; protection against solid bodies (> 1 mm); no protection against water
IP 43	3 R		—	Protection against contact with tools; protection against solid bodies (> 1 mm); protection against spraying water
IP 54	–			Complete contact hazard protection; protection against dust deposits; protection against splashing water
IP 65	12/13			Complete contact hazard protection; complete protection against dust (dust-tight); protection against water jets
IP 66	4/4 x			Complete contact hazard protection; complete protection against dust (dust-tight); protection in case of flooding
IP 67	6			Complete contact hazard protection; complete protection against dust (dust-tight); protection against immersion (water-tight)

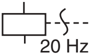
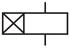
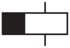
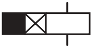
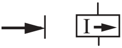
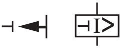
Graphical symbols to DIN EN 60 617/IEC 60 617

Graphical symbols and description	
	Make contact, normally open contact
	Break contact, normally closed contact
	Change-over contact
	Make contact, 2-way make contact with 3 switching positions
	Drive, general e.g. for relays, protection
	Latching mechanism with electromechani-cal release
	Normally closed contact, with delayed closing
	Normally open contact, with delayed opening
	Isolator switch, off-load switch
	Fuse-disconnector

Graphical symbols and description	
	Fuse, general
	Fuse with labelling of the mains-end connection
	Surge voltage protector, overvoltage protector
	Spark gap
	Double spark gap
	Normally closed contact, with delayed opening
	Normally open contact, with delayed closing
	Electromechanical drive with two opposite windings
	Electromechanical drive, with wattmetric action

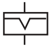
Graphical symbols to DIN EN 60 617 (continued)

Graphical symbols and description	
	Electromechanical drive, e.g. with specification of an effective winding
	Electromechanical drive with specification of an effective winding, optional portrayal
	Electromechanical drive with two equidirectional windings
	Electromechanical drive with two equidirectional windings, optional portrayal
	Electromechanical drive with two equidirectional windings, optional portrayal
	Polarized relay with permanent magnet
	Latching relay
	Remanence relay
	AC relay

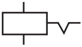
Graphical symbols and description	
	Electromechanical drive with specification of DC current resistance, e.g. 500 Ohm
	Electromechanical drive with specification of the electrical variable
	Electromechanical drive with natural resonance, e.g. 20 Hz
	Thermal relay
	Electromechanical drive with pickup delay
	Electromechanical drive with dropout delay
	Electromechanical drive with pickup and dropout delay
	Reverse-current release
	Fault current circuit breaker
	Electrothermal over-current trip
	Overvoltage release

Graphical symbols to DIN EN 60 617 (continued)

Graphical symbols and description	Graphical symbols and description



Electromechanical drive with two switching positions



Electromechanical drive with two switching positions, optional portrayal

Electromechanical drive with three switching positions

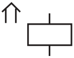
Electromechanical overcurrent release with delayed release

Undercurrent release

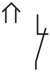
Undervoltage release

Undervoltage release with delayed release

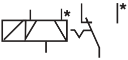
Fault voltage release



Electromechanical drive, excited



Normally open contact with automatic return, actuated

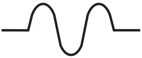


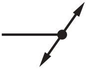
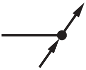
Remanence relay
If voltage is applied to the winding connection marked with an * (asterisk), then contact is made at the point on the contact element marked with an * (asterisk).

Code letters for labelling operating equipment to DIN EN 61 346-1/IEC 61 346-1

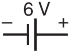
Device categories	Code letters	Examples
Assemblies	A	Equipment combinations, amplifiers
Converters of non-electrical variables to electrical variables	B	Measurement converters, sensors, microphones, photoelectric components, sound pick-ups, speakers
Capacitors	C	All types of capacitor
Binary elements, delay and memory devices	D	Digital integrated circuits and components, delay lines, bistable elements, monostable elements, core memory, registers, magnetic tape devices, disk storage
Miscellaneous	E	Equipment not listed elsewhere, such as lighting, heaters
Protective equipment	F	Fuses, releases
Generators	G	Power supply units, batteries, oscillators
Indicator devices	H	Optical and acoustic indicator devices
Contactors, relays	K	Power contactors, contactor relays, auxiliary, time and flasher relays
Inductors	L	Coils, throttles
Motors	M	Short circuit motor, slipring rotor motor
Analog components	N	Operational amplifiers, hybrid analog/digital elements
Measurement and test equipment	P	Displaying, recording and counting measuring equipment
Circuit-breakers	Q	Power circuit-breakers, protective circuit-breakers, miniature circuit-breakers
Resistors	R	Shunt resistors, rheostats, NTC and PTC resistors
Switches, selectors	S	Switches, end switches, control switches
Transformers	T	Power transformers, current converters
Modulators	U	Power inverters, transducers, converters
Tubes, semi-conductors	V	Vacuum tubes, gas-filled tubes, diodes, transistors, thyristors
Transmission paths, hollow conductors	W	Jumper wires, cables, busbars, aerials
Plug-and-socket devices	X	Terminal strips, solder tag strips, test plugs
Electrically actuated mechanical devices	Y	Magnetic valves, couplings, electric brakes
Covers, filters	Z	Cable emulations, crystal filters

Graphical symbols for electrical installation to DIN EN 60 617/IEC 60 617

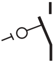
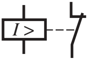
Graphical symbol	Description
General	
	DC current
	AC current, particularly technical AC current
3/N  50 Hz	Three-phase current with neutral conductor and specification of the frequency, e.g. 50 Hz
	Audio-frequency AC current
	High-frequency AC current
Conductor systems and labelling for types of installation	
	Conductor, general
	Conductor, mobile
	Underground conductor, e.g. earth cable
	Overground conductor, e.g. overhead cable
	Conductor on isolators
	Surface-mounted conductor
	Semi-flush-mounted conductor
	Concealed conductor
	Conductor in electrical conduit

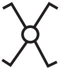
Graphical symbol	Description
Labelling of the intended purpose with cables	
	Heavy current cable, neutral conductor (N), middle conductor (M)
	PE conductor (PE), PEN conductor (PEN), equipotential bonding conductor (PL)
	Signal track
	Telecommunications cable
	Radio cable
Infeed, earth	
	Socket
	Cable coming from below or leading downwards
	With supply pointing downwards
	With supply from below
	Cable routed downwards and upwards
	With supply pointing upwards

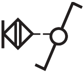
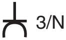
Graphical symbol	Description
Infeed, earth	
	Conductor connection
	Tapping box or distributor box
	Sealing end, distribution point (short side = cable entry)
	Power service box, general
 IP 44	Ditto, specifying the protection category to DIN EN 60 529, e.g. IP 44
	Distributor, switchgear
	Frame for equipment, e.g. case, enclosure, control panel
	Earthing in general

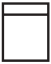
Graphical symbol	Description
Infeed, earth	
	Connection point for PE conductor to VDE 0100
 [4]	Ground
[4] Graphical symbols IEC 117	
Power supply equipment, converters	
	Element, accumulator or battery
	Ditto, specifying the polarity and voltage, e.g. 6 V
 230/5 V	Transformer, e.g. bell transformer 230/5 V
	Converter, general
	Rectifier, e.g. AC current power pack
	Inverter, e.g. pole changer, chopper

Graphical symbol	Description
Switchgear	
	Fuse, general
	Fuse, 3-pole
 10 A	Fuse specifying the rated current, e.g. 10 A
	Switches, normally open contacts, general
 IP 40	Switch specifying the protection category to DIN EN 60 529, e.g. IP 40
	Miniature circuit-breaker (m.c.b.)
	Earth-leakage circuit-breaker, 4-pole
	Motor circuit-breaker, 3-pole

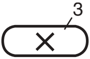
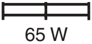
Graphical symbol	Description
Switchgear	
	Undervoltage circuit-breaker
	Fault-voltage-operated circuit-breaker
	Overcurrent relay Priority switch
	EMERGENCY OFF switch
Installation switches	
	Switch, general
	Switch with control lamp
	One-way switch, single-pole
	One-way switch, 2-pole
	One-way switch, 3-pole

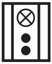
Graphical symbol	Description
Installation switches	
	Two-way switch with two off positions, single-pole
	Two-circuit switch, single-pole
	Changeover switch, single-pole
	Intermediate switch, single-pole
	Time-delay switch
	Push-button
	Illuminated push-button
	Remote-control switch
	Proximity switch (one-way switch)

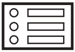
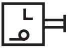
Graphical symbol	Description
Installation switches	
	Touch switch (two-way switch)
	Dimmer (one-way switch)
Plug-and-socket devices	
	Single socket, without earthing contact
	Double socket
	Single socket with earthing contact
	Single socket with earthing contact for three-phase current
	Double socket with earthing contact
	Socket earthing contact, switched
	Socket earthing contact, lockable

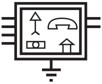
Graphical symbol	Description
Plug-and-socket devices	
	Telecommunications socket
	Aerial socket
Test equipment, display devices, relays and audio frequency ripple control devices	
 10 A	Meter panel e.g. with a fuse or 10 A miniature circuit-breaker
	Time switch, e.g. for switching between electricity tariffs
	Time-delay relay, e.g. for stairwell illumination
	Flasher relay, flasher switch
	Audio frequency ripple control
	Audio frequency blocking device

Graphical symbol	Description
Lights	
	Light, general
 5 x 60 W	Multiple lights specifying the number of lights and output, e.g. with 5 lamps, 60 W each
	Light with switch
	Light with jumpering for lamp chains
	Light with variable brightness
	Maintained emergency light
	Emergency light in stand-by circuit
	Spotlight
	Light with additional emergency light in stand-by circuit
	Light with additional maintained emergency light

Graphical symbol	Description
Discharge lamps and accessories	
	Light for discharge lamp, general
	Multiple light for discharge lamps specifying the number of lamps, e.g. with 3 lamps
	Light for fluorescent lamps, general
	Long row of luminaires for fluorescent lamps, e.g. 3 luminaires each 40 W
	Long row of luminaires for fluorescent lamps, e.g. 2 luminaires each 2 x 65 W
	Fluorescent lamp with preheating
	Ballast, general
	Ballast, compensated
	Ballast, compensated, with audio frequency blocking device

Graphical symbol	Description
Signalling devices	
	Alarm bell
	Buzzer
	Gong
	Horn
	Siren
	Indicator light, signal lamp, light signal
	Group or directional indicator light
 6	Multiple indicator lights, signal lamp panel, e.g. for 6 indicators
	Acknowledgement indicator, indicator light with cut-out button
	Call and cut-out button
	Interphone

Graphical symbol	Description
Signalling devices	
	Call buttons with name plates
	Door opener
	Electrical clock, e.g. slave clock
	Master clock
	Signal master clock
	Card control device; manually actuated
	Fire alarm with clockwork
	Push-button fire detector
	Temperature indicator
	Temperature indicator based on the fusible link principle

Graphical symbol	Description
Signalling devices	
	Temperature indicator based on the bimetal principle
	Temperature indicator based on the differential principle
	Control centre of a fire alarm system for 4 loops in fail-safe circuit, siren system for 2 loops, telephones for both systems
	Police alarm
	Watchdog alarm, e.g. with failsafe circuit
	Vibration alarm (vault-type pendulum)
	Traverse lock for travel in security systems
	Light beam indicator, light barrier
	Fire detector, automatic
	Photo-electric switch

Rittal TS 8 Top enclosure system

The Top enclosure system TS 8 with its infinite configuration possibilities meets individual requirements cost-effectively and to perfection.

FRIEDHELM **LOH** GROUP

RITTAL®

Decimal parts and multiples of units

Exponent	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d

Exponent	Prefix	Symbol
10	deca	da
10^{2}	hecto	h
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E

Allocation of connector/cable types

Jack/coupling	Cable types
Twinax BNC-E BNC-F	Coaxial cable
RJ 11 – 45 48 modular jacks 32 modular jacks	Shielded/unshielded 2-wire cables
F-SMA 6.5 F-SMA 7.5 DIN 47 256 SC (duplex) LC (duplex)	Fibre-optics
Sub-D 9-pole Sub-D 15-pole Sub-D 25-pole ADo 4/8 TAE 4/6	Shielded/unshielded cables

Important standards for the data and telecommunications industry

List of standards, general

DIN EN 61 000-6-3 (VDE 0839 Part 6-3)	Electromagnetic compatibility (EMC) basic specification, interference emissions, residential areas etc.;
DIN EN 61 000-6-1 (VDE 0839 Part 6-1)	Electromagnetic compatibility (EMC) basic specification, immunity to interference, residential areas etc.;
DIN EN 50 098-1	Information technology cabling of building complexes – Part 1: Basic ISDN connection;
DIN EN 50 288-2 (VDE 0819 Part 5)	Framework specifications for equipment connection cables for digital and analog communications;
DIN EN 55 022 (VDE 0878 Part 22)	Limits and measurement techniques for radio interference in information technology equipment;

DIN EN 60 603-7	Rack connectors for frequencies below 3 MHz for printed circuit boards;
DIN EN 60 794 (VDE 0888-100-1)	Fibre-optic cables;
DIN EN 60 825-2 (VDE 0837 Part 2)	Safety of laser equipment – Part 2: Safety of fibre-optic communications systems.

Installation of terminal equipment

DIN VDE 0100-551	Electrical installations of enclosures;
DIN VDE 0800-174-2	Installation of communications cabling;
DIN VDE 0845-1	Protection of telecommunications installations from lightning, static charges and overvoltage from heavy current installations; measures to counteract overvoltage;
DIN EN 50 310 (VDE 0800 Part 2-310)	Use of potential equalisation and earthing measures in buildings containing information technology installations.

Types and use of communications cables

DIN VDE 0815	Installation cables and lines for telecommunications and information processing installations;
DIN VDE 0891-1	Use of cables and insulated leads for telecommunications and information processing installations;
DIN EN 60 794 (VDE 0888-100-1)	Fibre-optic cables;
DIN EN 50 174-2 (VDE 0800 Part 174-2)	Information technology – Installation of communications cabling, Installation planning and practices in buildings.

Network installation

**Excerpt from application-neutral wiring
(structured cabling) to DIN EN 50 173-1: 2003-06**

1. Scope of application and confirmity to DIN EN 50 173

1.1 Scope of application

This European standard specifies a universal wiring system used within locations with one or more buildings. It covers cabling with symmetrical copper cables and fibre-optic cables.

This standard is optimised for sites where the largest distance over which the information technology services are to be distributed is 2000 m. The procedures of this European standard may also be applied to larger installations.
The cabling specified in this standard supports a broad range of services, including language, data, text, still and moving images.

EN 50 173 specifies, for example:

a) The structure and configuration of a communications cable installation,
b) The performance requirements governing the cabling,
c) Implementation options.

Safety requirements (electrical safety and protection from destruction, fire etc.) and electromagnetic compatibility (EMC) are not covered by this European standard and are dealt with by other standards and regulations. However, the information contained in this European standard may prove useful for compliance with these standards and regulations.

4. Structure of the application-neutral communications cable system

4.1 General

This section identifies the functional elements of universal cabling, how they are connected to one another to create subsystems, and cites the interfaces to which application-specific components are connected via the universal cabling. Furthermore, general requirements are provided for the implementation of universal cabling.
Network applications are supported by connecting application-specific equipment to the information technology connections and distributors.
The components used for this connection do not form part of the universal cabling.

4.2 Functional components

Universal cabling consists of the following functional components:

- Site distributors (SD)
- Primary cable
- Building distributors (BD)
- Secondary cable
- Corridor distributors (CD)
- Tertiary cable
- Consolidation point (CP)
- Consolidation point cable (CP cable)
- Information technology multiple connection
- Information technology connection (I).

Groups of these functional components are combined to form cabling subsystems.

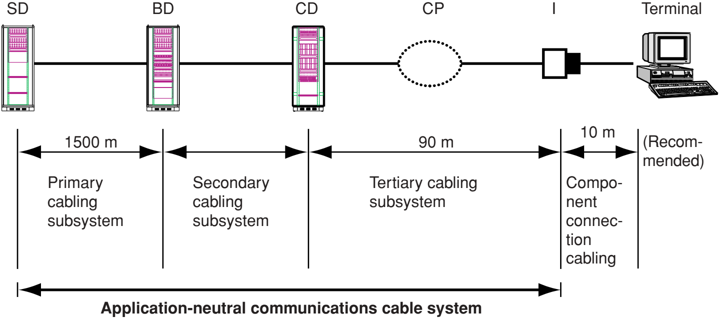


Figure 1: Structure of the application-neutral communications cable system

4.3 Cabling subsystems
A universal cabling system consists of up to three cabling subsystems: Primary, secondary and tertiary cabling. Together, the cabling subsystems form an application-neutral communications cable system.
The distributors can be used to achieve any given network topologies such as bus, star and ring.

4.4.1 Primary cabling subsystem
Ranges from the site distributor to the building distributors, which are usually located in different buildings. Where applicable, it contains the primary cables, their support points (at the site and building distributors) and the routing devices in the site distributor. A primary cable may also be used to connect building distributors to one another.

4.4.2 Secondary cabling subsystem
Ranges from the building distributors to the corridor distributors. The subsystem contains the secondary cables, their mechanical support points (on the building and corridor distributors) and the routing devices in the building distributor. Secondary cables should not contain any cable distribution boxes; copper cables should not contain any splices.

4.4.3 Tertiary cabling subsystem
Ranges from the corridor distributor to the connected information technology connections. The subsystem contains the tertiary cable, its mechanical support points on the corridor distributor, the marshalling distributor in the corridor distributor, and the information technology connections.
The tertiary cables should connect the corridor distributors and the information technology connections without interruption. If necessary, a consolidation point is permissible between the corridor distributor and any information technology connections.

4.3 Structural overview

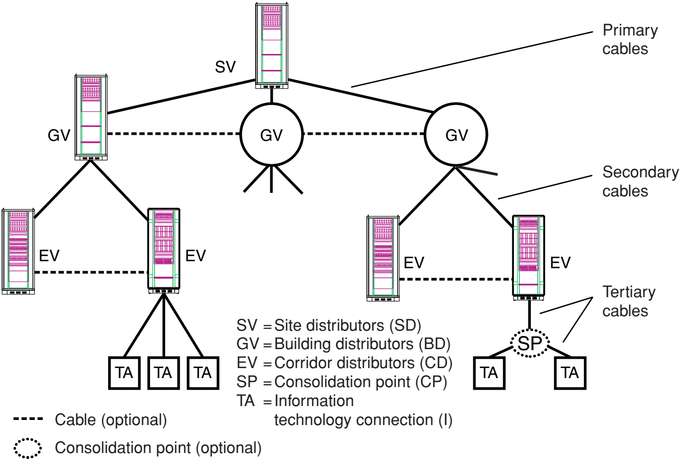


Figure 2: Connection between functional elements

4.7 Dimensioning and configuration

4.7.1 Distributors

The number and nature of the sub-systems contained in an application-neutral cabling system is dependent upon the geography and size of the site or building and also on the user's procedures. There is usually one site distributor per site, one building distributor per building, and one corridor distributor per floor. If the property only consists of one building which is small enough to be supplied by a single building distributor, a primary cabling sub-system will not be required. Similarly, larger buildings may be supplied by several building distributors which are linked together via the site distributor. The design of the corridor distributor must ensure that the lengths of the patch cords, patch pairs and device connection cords are minimised, and the system distribution should ensure that the planned lengths are retained during operation.

4.9 Earthing and potential equalisation

The standards of series EN 50 174 and EN 50 310 specify requirements for earthing and potential equalisation.

5.3 Classification of data transmission sections for symmetrical cabling

5.3.1 Classification of network applications

Category A, up to 100 kHz:	Comprises the voice-frequency band and low-frequency network applications.
Category B, up to 1 MHz:	Comprises data applications with a medium bit rate.
Category C, up to 16 MHz:	Comprises data applications with a high bit rate.
Category D, up to 100 MHz:	Comprises data applications with a very high bit rate.
Category E, up to 250 MHz:	Comprises data applications with a very high bit rate.
Category F, up to 600 MHz:	Comprises data applications with a very high bit rate.

5.5 Classification of transmission sections with fibre-optic cabling

5.5.1 General

This standard specifies the following categories for fibre-optic cabling:

a) Transmission sections in category OF-300 support the network applications listed in Annex E via the fibre-optic categories cited in section 7 over a minimum of 300 m;
b) Transmission sections in category OF-500 support the network applications listed in Annex E via the fibre-optic categories cited in section 7 over a minimum of 500 m;
c) Transmission sections in category OF-2000 support the network applications listed in Annex E via the fibre-optic categories cited in section 7 over a minimum of 2000 m;

The requirements pertaining to the performance capability of transmission sections with optical fibres are based on the assumption that every fibre-optic transmission section only uses a single optical wavelength in a transmission window.

Supported network applications (Appendix E)

Cat.	Network application	Source	Alternative name
A	PBX X.21 V.11	National requirement ITU-T recomm. X.21 ITU-T recomm. X.21	
B	S_0 bus (extended) S_0 point-to-point S_1/S_2 CSMA/CD 1Base5	ITU-T recomm. 1.430 ITU-T recomm. 1.430 ITU-T recomm. 1.431 ISO/IEC 8802-3	Basic ISDN connection Basic ISDN connection ISDN primary multiplex connection Star LAN
C	CSMA/CD 10Base-T CSMA/CD 100Base-T4 Token Ring 4 Mbit/s	ISO/IEC 8802-3 ISO/IEC 8802-3 ISO/IEC 8802-5	Ethernet Fast Ethernet
D	TP-PMD CSMA/CD 100Base-TX Token Ring 100 Mbit/s CSMA/CD 1000Base-T	ISO/IEC FCD 9314-10 ISO/IEC 8802-3 ISO/IEC 8802-5t ISO/IEC 8802-3	Media-dependent physical layer for twisted pairs High Speed Token Ring Gigabit Ethernet
E	ATM LAN 1.2 Gbit/s	ATM Forum af-phy-0162.000	ATM-1200/category 6
F	FC-100-TP	ISO/IEC 14 165-114	
Cabling section, fibre-optic category			
CSMA/CD 10Base-F		ISO/IEC 8802 AM	
Token Ring		ISO/IEC TR 11802-4	Connection of stations to fibre-optic cables
FDDI		EN ISO/IEC 9314-3	Distributed data inter-face with fibre-optics
SM-FDDI		ISO/IEC 9314-4	Monomode FDDI
LCF-FDDI		ISO/IEC C 9314-9	FDDI with inexpensive fibre-optics
FC-PH		ISO/IEC CD 14165-1	Fibre Channel
ATM		ITU-T recomm. I.432	B-ISDN

Terms used in data communications technology

Address

– An encoded piece of information specifying the origin or destination of a data record.
– Identification of a memory location where a data record is stored.

B/s (bits/second)

Unit measuring the output of serial data transmission.

Bit rate

A unit of measurement for the transmission speed. The bit rate specifies how many bits may be transmitted within a given period of time.

Bus

A connection system between digital stations (often between several memory areas) consisting of one or more cables.

Duplex

In transmission circuits, the option of transmitting and receiving simultaneously.

Ethernet

A local baseband network from Xerox (registered trademark) developed jointly by Xerox, Digital Equipment Corporation and Intel.

ISDN

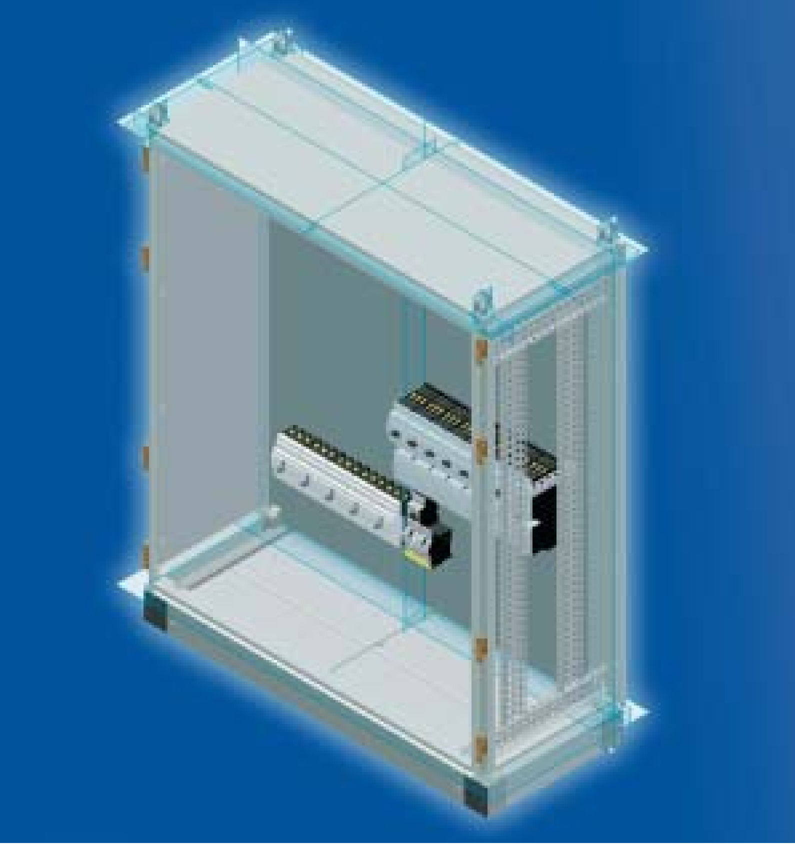
Abbreviation for Integrated Services Digital Network. Integrated digital network for combining the various mail services via shared digital switches and digital paths, e.g. telephony, data transmission etc.

Channel

Transmission channel = transmission medium in simplex operation.

Coaxial cable

A cable for transmission in broadband and baseband systems.
Coaxial cables consist of a neutral conductor, an insulation and a braided screen.



Rittal data – To match your system

Whichever CAD system you use, RiCAD 3D saves you time, and effectively supports the efficiency and productivity of your plant design.

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RITTAL

Fibre-optics
Glass or plastic fibres used to transfer information with the aid of light.

Modem
Derived from the words modulator – demodulator. A device which converts analog signals into digital signals and vice versa.

Modulation
Procedure whereby one or more features of a carrier (frequency, amplitude, phase) are modified so as to portray analog or digital signals.

Multiplexer
A device which combines information from several channels with a low transmission speed in a single, fast channel.

RS232
Electronic Industries Association (EIA) standard for interfaces between data terminal equipment and data transfer equipment. Also known as V24 (25-pole rack connectors).

Terminal
Umbrella term for data stations which may be connected to a network node and which facilitate the transmission and reception of data.

Twisted pair cable
A cable consisting of conductors which may be either shielded or unshielded.

Four-core cable
A cable which works with two pairs of conductors, whereby one pair acts as a transmission channel and the other as a reception channel.

Brief EMC information for EMC/RF-shielded enclosures and CE labels

What is meant by EMC?

Electromagnetic compatibility (EMC) is the ability of an electrical appliance to operate satisfactorily in its electromagnetic environment without adversely affecting this environment, which may also contain other equipment.
High packaging densities in electronic assemblies and ever-increasing signal processing speeds often cause faults in complex electronic equipment, measurement and control systems, data processing and transmission systems and communications technology, which are attributable to electromagnetic influences.

Basic EMC concepts

- **Electromagnetic influence** is the effect of electromagnetic factors on circuits, appliances, systems or living things.
- **Interference source** refers to the origin of interference.
- **Potentially susceptible equipment** refers to electrical equipment whose function may be influenced by interference factors.
- **Coupling** refers to the reciprocal relationship between circuits, whereby energy can be transferred from one circuit to another. Interference is an electromagnetic factor which may induce an undesirable influence in an electrical installation (interference voltage, current or field strength).

Interference sources and interference factors

Interference sources may be divided into:

- Internal sources of interference
  – Artificial, i.e. technically induced
- External sources of interference
  – Natural, e.g. lightning; electrostatic discharges
  – Artificial, i.e. technically induced

In the case of technically induced interference sources, a distinction must be made between the effects of electromagnetic factors created and used for business purposes (such as radio transmitters, radar etc.), and electromagnetic factors which occur within the context of operations or in the event of a failure which are not purposely generated (e.g. spark discharges on switch contacts, magnetic fields around heavy currents etc.).

Interference may take the form of voltages, currents, electrical, magnetic and electromagnetic fields, which may either occur continuously, periodically, or randomly in a pulse shape.

In low-voltage networks, the following applies:

- The most intensive temporary interference processes are caused in low-voltage networks by the switching of inductive loads, e.g. power tools, household electrical appliances, fluorescent lamps.
- The most dangerous overvoltages (in terms of level, duration and energy content) are caused by deactivating fuses in the event of a short-circuit (duration in the millisecond range).

Influence mechanisms and counter-measures

A distinction may be made between the following types of coupling influence:

- Conducted influence
- Field-related influence
  – Field influence
  – Radiation influence.

Field-bound interference (low-frequency)

Very low-frequency currents cause a low-frequency magnetic field which may induce interference voltage or initiate interference via direct magnetic effects (magnetic memory in computers, monitors, sensitive electromagnetic test equipment such as EEG). Low-frequency electric fields of high intensity may be generated by low-frequency high voltages (high-voltage overhead cables), resulting in interference voltage (capacitive interference). Of practical significance are magnetic fields, the effects of which can be reduced via

- Shielded cables
- Shielding enclosures (decisive here is the material property of permeability, which is inadequate in the case of sheet steel; nickel iron, for example, is far better).

Radiation influence (high-frequency)

The electromagnetic waves which radiate from electrical circuits in an open space can produce interference voltages, whereby such interference must then be considered in relation to the distance to its source (near field or distant field).
In a near field, either the electrical component (E) or the magnetic component (H) of the electromagnetic field will predominate, depending on whether the source of the interference carries high voltages and low currents, or high currents and low voltages. In a distant field, generally speaking, E and H can no longer be considered separately.

Interference can be reduced via:
- Shielded cables
- **Shielding enclosures** (Faraday cage!).

Enclosure/RF-shielding
The requirement profile can be determined using the following check-list.

Check-list to determine the requirement profile for EMC enclosures
• What types of interference occur in the given application? (electric, magnetic or electromagnetic field)
• What are the limits of interference which may occur in the application? (field strengths, frequency range)
• Can the requirements be met by a standard enclosure or an RF-shielded enclosure? (Comparison with attenuation diagrams)
• Are there any other EMC requirements? (shielding in the enclosure, special potential equalisation within the enclosure etc.)
• Are there other mechanical requirements? (cut-outs, glazed doors/viewing windows, cable glands, etc.)

Every sheet metal enclosure already offers good **basic shielding** within a broad frequency range, i.e. attenuation of electromagnetic fields.
For large enclosures, **medium shield attenuation** can be achieved via cost-effective measures to create multiple conductive connections between all enclosure parts.
High shielding attenuation levels in the frequency range above approx. 5 MHz can be achieved via special seals which connect the conductive inner surfaces of doors and removable panels, roof and gland plates to the conductive sealing edges of the enclosure body or frame, in a largely slot-free manner. The higher the frequencies occurring, the more critical openings in the enclosure become.

How do I interpret an EMC diagram?

In all diagrams, the attenuation value of an enclosure is obtained from the anticipated interference frequency and the nature of the interference field (electrical field E, magnetic field H or electromagnetic field). For example, in the diagram below, the following attenuation values are obtained with a frequency of 10 MHz.

Point 1: Electrical field, high: $a_1 \approx 65$ dB

Point 2: Electrical field, standard: $a_2 \approx 35$ dB

In all diagrams, the level of attenuation "a" is shown on the Y axis (vertical) in the unit "dB".

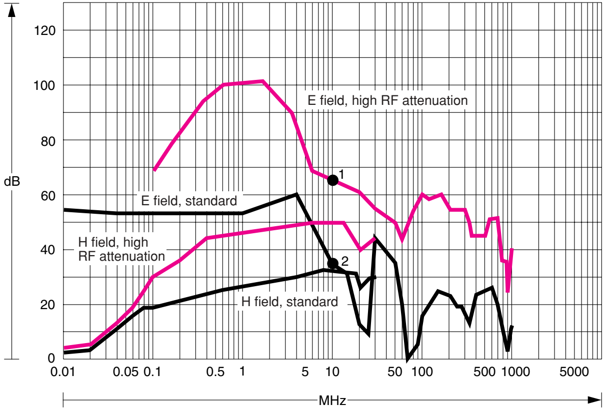
This unit indicates the logarithmic ratio between the field in the environment and the field in the enclosure interior.

The frequency band is entered on the X axis (horizontal) on a logarithmic scale. Attenuation "a" is obtained using the following equation:

$$a = 20 \log \frac{E_0}{E_1} \text{ and}$$

$$a = 20 \log \frac{H_0}{H_1}$$

with
Index 0 for unchielded values
Index 1 for shielded values



MHz = Frequency
dB = RF attenuation

Table of examples

Attenuation in dB	Ratio inside/outside
6	1/2
20	1/10
40	1/100
60	1/1000

CE labelling

What does CE stand for?
The abbreviation stands for European Communities (= Communautés Européennes) and documents a product's compliance with the respective EU Directives.

Fundamental principles
CE labelling is **not** the same as certification, where a manufacturer voluntarily has the positive properties of his products confirmed by test institutes. It is a legally prescribed label for all products which meet EU Directives.

The main aim of CE labelling is to eliminate trading barriers within EU member states. The CE symbol is an administrative symbol, and was not originally intended for consumers and end clients. It serves as an indication to market supervisory authorities that the labelled products meet the requirements of the technical harmonisation directives, particularly safety requirements. It should be viewed as a kind of "technical passport" for certain products within the European Economic Area.

The basis for CE labelling is the harmonisation concept of the European Union and the associated growing importance of European standardisation. The main content is mutual recognition of existing national regulations, standards and specifications. This is particularly for the purpose of consumer protection, with the main emphasis on health, safety and the environment.

What does this mean in concrete terms for Rittal products?
Enclosures, empty enclosures and mechanical accessory components are currently not subject to any valid EU Directive. These products must not be labelled with a CE symbol, nor must a declaration of conformity or manufacturers' declaration be issued for them.
Electrical appliances must meet all the relevant EU Directives with respect to their hazard potential, fields of application and the Directive definitions.

All Rittal products which meet these Directives are labelled with the CE symbol, either on the product itself or on the insert. This symbol is also reproduced in the manual. Upon request, a corresponding declaration of conformity (in German or English) will be issued.

Directives which apply to Rittal products:

The EMC Directive	2004/108/EC
The Low-Voltage Directive	73/23/EEC and amendments

Enclosure climate control

Device type	Operational area
Enclosure heaters	To heat or stabilise the enclosure internal temperature compared with the ambient temperature in order to avoid condensation, or achieve minimum temperatures for switchgear and control gear. For use as a frost monitor e.g. with pneumatic control devices.
Enclosure fan-and-filter units	To dissipate heat from enclosures, and to distribute heat evenly. To avoid condensation. Used in situations where no aggressive media and no excessive incidence of dust is present in the ambient air.
Enclosure heat exchangers air/air	To dissipate heat from enclosures. Thanks to two separate air circuits, no ambient air is able to enter the enclosure. Consequently, it may be used in an environment contaminated with dust and aggressive media.
Enclosure heat exchangers air/water	To dissipate heat and to cool enclosures to below the ambient temperature. For use in extreme environments (temperature/dirt).

Enclosure climate control (continued)

Device type	Operational area
Enclosure cooling unit	To dissipate heat and to cool enclosures to below the ambient temperature. The ambient air is separated from the enclosure internal air.
Direct Cooling Package (DCP)	To effectively dissipate heat directly from the component. A water-cooled mounting plate dissipates the heat loss directly from the component, and is completely silent.
Recooling systems	Supply air/water heat exchangers, DCPs and machines/processes with cold water. These systems are distinguished by a high level of temperature precision and excellent performance.

Constant climates to DIN 50 015

Code	Temperature		Relative humidity %		Air pressure	Comment
	°C	Standard deviation	Nominal value	Standard deviation	mbar	
23/83	23	± 2°C	83	± 3	800	Damp
40/92	40	± 2°C	92	± 3	up to	Warm & humid
55/20	55	± 2°C	≦ 20	–	1060	Warm & dry

Damp alternating climate to DIN 50 016

Exposure to a damp alternating climate as defined in this standard consists of the alternating effects of climate 23/83 and climate 40/92 to DIN 50 015. In the alternating climate chamber, changeovers are implemented as follows: After 14 hours 40/92 = warm and humid, switch to 10 hours 23/83 = damp on a 24-hour cycle.

Basis of calculation for enclosure climate control

$\dot{Q}_v$ = Installed heat loss in the enclosure [W]

$\dot{Q}_s$ = Heat radiated by the enclosure surface [W]

$\dot{Q}_s > 0$: radiation ($T_i > T_u$)

$\dot{Q}_s < 0$: irradiation ($T_i < T_u$)

$\dot{Q}_K$ = Required cooling output of an enclosure cooling unit [W]

$\dot{Q}_H$ = Required thermal output of an enclosure heater [W]

q_W = Specific thermal output of a heat exchanger [W/K]

$\dot{V}$ = Required air volume flow of a fan-and-filter unit in order to stay below the maximum permissible temperature difference between the extracted air and the emitted air [m^3/h]

T_i = Required interior temperature of enclosure [°C]

T_u = Ambient temperature of enclosure [°C]

ΔT = $T_i - T_u$ = max. permissible temperature difference [K]

A = Effective enclosure surface area which radiates heat in accordance with VDE 0660 Part 500 [m^2]

k = Heat transfer coefficient [W/m^2 K] with static air for sheet steel k = 5.5 W/m^2 K

Heat radiated by the enclosure surface

$\dot{Q}_s = k \cdot A \cdot (T_i - T_u)$

$\dot{Q}_s < 0$: irradiation ($T_i < T_u$)

$\dot{Q}_s > 0$: radiation ($T_i > T_u$)

In addition, the following applies:

$\dot{Q}_s = \dot{Q}_v - \dot{Q}_K$ and $\dot{Q}_s = \dot{Q}_v + \dot{Q}_H$

If $\dot{Q}_K = \dot{Q}_H = 0$ then:

$\dot{Q}_s = \dot{Q}_v = k \cdot A \cdot (T_i - T_u)$

Enclosure cooling unit

– Required cooling output:

$\dot{Q}_K = \dot{Q}_v - \dot{Q}_s$

$\dot{Q}_K = \dot{Q}_v - k \cdot A \cdot (T_i - T_u)$ or $T_i = T_u + \frac{\dot{Q}_v - \dot{Q}_K}{k \cdot A}$

Enclosure heater

– Required thermal output:

$$\dot{Q}_H = -\dot{Q}_v + \dot{Q}_s$$

$$\dot{Q}_H = -\dot{Q}_v + k \cdot A \cdot (T_i - T_u)$$

Heat exchanger

– Specific thermal output:

$$q_w = \frac{\dot{Q}_v}{\Delta T} - k \cdot A$$

$$q_w = \frac{\dot{Q}_v}{(T_i - T_u)} - k \cdot A$$

Fan-and-filter units

– Required air volume flow:

$$\dot{V} = f(h) \cdot \frac{\dot{Q}_v - \dot{Q}_s}{\Delta T}\ [m^3/h]$$

where

h = Operating altitude above sea level (h = 0) [m]

f (0 – 100) = 3.1 $m^3 \cdot K/W \cdot h$

f (100 – 250) = 3.2 $m^3 \cdot K/W \cdot h$

f (250 – 500) = 3.3 $m^3 \cdot K/W \cdot h$

f (500 – 750) = 3.4 $m^3 \cdot K/W \cdot h$

f (750 – 1000) = 3.5 $m^3 \cdot K/W \cdot h$

Example: Operating altitude h = 300 m

$$\dot{V} = 3.3 \cdot \frac{\dot{Q}_v - k \cdot A \cdot (T_i - T_u)}{T_i - T_u}\ [m^3/h]$$

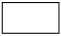
Rough calculation

$$\dot{V} = 3.1 \frac{\dot{Q}_v}{\Delta T}\ [m^3/h]$$

Calculation of effective enclosure surface area

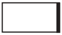
A is calculated in accordance with VDE 0660, Part 500 with due regard for the type of installation.

Type of enclosure installation and formula calculation
to IEC 60 890



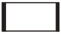
Single enclosure, free-standing on all sides
$A = 1.8 \cdot H \cdot (W + D) + 1.4 \cdot W \cdot D$

Single enclosure for wall mounting
$A = 1.4 \cdot B \cdot (H + D) + 1.8 \cdot D \cdot H$



First or last enclosure in a suite, free-standing
$A = 1.4 \cdot D \cdot (H + W) + 1.8 \cdot W \cdot H$

First or last enclosure in a suite for wall mounting
$A = 1.4 \cdot H \cdot (W + D) + 1.4 \cdot W \cdot D$



Enclosure within a suite, free-standing
$A = 1.8 \cdot W \cdot H \quad + 1.4 \cdot W \cdot D + D \cdot H$

Enclosure within a suite for wall mounting
$A = 1.4 \cdot W \cdot (H + D) + D \cdot H$

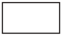
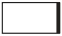
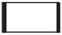
Enclosure within a suite for wall mounting,
with covered roof areas
$A = 1.4 \cdot W \cdot H \quad + 0.7 \cdot W \cdot D + D \cdot H$

A = Area [m^2]
W = Enclosure width [m]
H = Enclosure height [m]
D = Enclosure depth [m]

Conversions:
°C → °F: $T_F = T_C \cdot 1.8 + 32$
°F → °C: $T_C = (T_F - 32) : 1.8$
W → BTU: 1 BTU = $2.930 \cdot 10^{-4}$ kWh
(BTU = British Thermal Unit)

T_F = Temperature in Fahrenheit
T_C = Temperature in Celsius

Examples: Effective enclosure surface area for defined dimensions [m^2]

Width mm	Height mm	Depth mm							
300	400	210	0.46	0.41	0.42	0.29	0.39	0.34	0.30
380	600	210	0.75	0.66	0.70	0.50	0.65	0.56	0.50
500	500	210	0.79	0.69	0.74	0.50	0.70	0.60	0.53
500	700	250	1.12	0.98	1.05	0.74	0.98	0.84	0.75
600	380	350	0.94	0.85	0.89	0.51	0.84	0.75	0.60
600	600	350	1.32	1.18	1.24	0.80	1.15	1.01	0.86
600	760	210	1.28	1.10	1.22	0.86	1.16	0.97	0.89
600	760	350	1.59	1.41	1.49	1.01	1.38	1.20	1.05
760	760	300	1.77	1.54	1.68	1.13	1.59	1.36	1.20
1000	1000	300	2.76	2.36	2.64	1.82	2.52	2.12	1.91
600	1200	600	3.10	2.81	2.81	2.02	2.52	2.23	1.98
600	1400	600	3.53	3.19	3.19	2.35	2.86	2.52	2.27
600	1600	600	3.96	3.58	3.58	2.69	3.19	2.81	2.56
800	1600	600	4.70	4.19	4.32	3.14	3.94	3.42	3.09
600	1800	600	4.39	3.96	3.96	3.03	3.53	3.10	2.84
800	1800	600	5.21	4.63	4.78	3.53	4.34	3.77	3.43
800	1800	800	6.08	5.50	5.50	4.03	4.93	4.35	3.90
600	2000	600	4.82	4.34	4.34	3.36	3.86	3.38	3.13
800	2000	600	5.71	5.07	5.23	3.92	4.75	4.11	3.78
800	2000	800	6.66	6.02	6.02	4.48	5.38	4.74	4.29
600	2200	600	5.26	4.73	4.73	3.70	4.20	3.67	3.42
800	2200	800	7.23	6.53	6.53	4.93	5.82	5.12	4.67

Product selection

Therm Software

Rittal Therm is a calculation program for enclosure climate control.

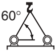
All electrical and electronic components have a certain power loss which is dissipated to the environment in the form of heat. Because an increasing number of components are now being housed in ever smaller spaces, the heat produced can soon reach levels which are harmful to electronic components and may severely curtail their useful lives.

The Therm software package takes care of the complex calculation of climate control requirements. A user-friendly interface guides the operator to the most suitable, correctly dimensioned climate control component. All evaluations are closely based on the requirements of IEC/TR 60 890 AMD 1/02.95 and DIN 3168 for enclosure cooling units.

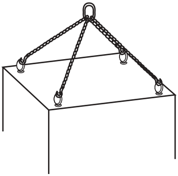
Model No. SK	**3121.000**

Examples of crane transportation for Rittal enclosures

Max. suspension load in N for Rittal enclosures with the rope angle shown opposite.

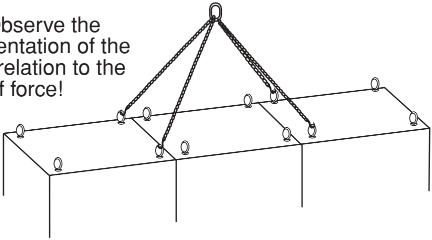
		ES	TS 8	AK
	For one eyebolt	3400	3400	2500
	For four eyebolts	6400	6400	4000

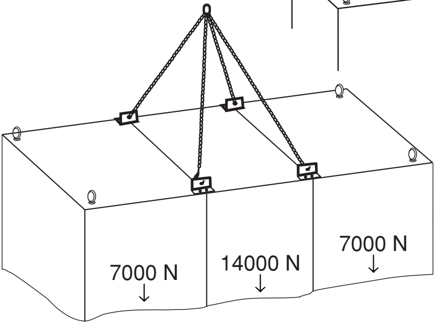
Normal crane suspension



Caution: Observe the correct orientation of the eyebolt in relation to the direction of force!

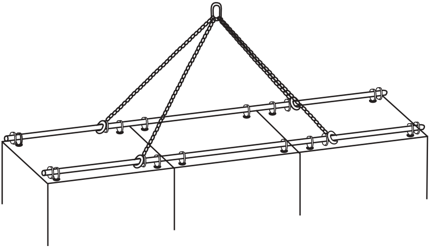
Normal crane suspension of bayed enclosures



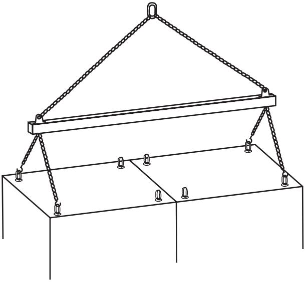


A load capacity of 2.8 t is achieved with the aid of combination angle PS 4540.000 and simultaneous use of a quick-fit baying clamp (TS 8800.500) and angular baying bracket TS 8800.430 (with at least three enclosures).

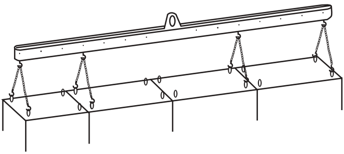
Normal crane suspension with
additional pipe stabilisation



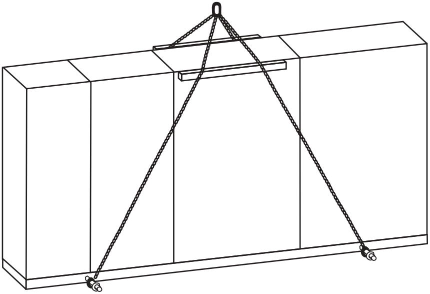
Adjustable girders



Adjustable girders



Normal crane suspension with
additional transport plinth



Principal marks of conformity and symbols

Marks of conformity issued by the VDE testing agency

VDE symbol
Equipment and installation material

VDE tracer thread
Cables and insulated lines

VDE cable symbol
Cables and insulated lines

VDE interference suppression symbol
Equipment with interference suppression

VDE mark of conformity for electronics
Electronic components

VDE GS symbol
Technical equipment within the scope of the VDE testing agency

CEE mark of conformity (E symbol)
Equipment and installation material

CEE tracer thread, insulated lines

VDE harmonisation symbol
Cables and insulated lines

VDE harmonisation symbol
(as tracer thread)
Cables and insulated lines

CECC mark of conformity
Electronic components
(under preparation)

Approvals and permits

Product certifications and approvals are key requirements for the global acceptance of industrial products.

Rittal products meet the highest internationally recognised quality standards. All components are subjected to the most stringent testing in accordance with international standards and regulations.
The consistently high product quality is ensured by a comprehensive quality management system. Regular production inspections by external test institutes also guarantee compliance with global standards.

Precise details of the test symbols allocated to our products can be found in our catalogues and brochures.
In most cases, the approved symbols are also displayed on the rating plates or products as proof of the approvals and licences. Furthermore, copies of the marks licence badges or test certificates are available directly from your personal Rittal advisor.

Additional tests conducted at our own accredited laboratories, such as the mechanical load-bearing capacity of enclosures, are published in our own load capacity brochures. These brochures contain detailed information to assist you with the use of Rittal products. Copies of this documentation are likewise available from your Rittal advisor.

Further interesting information and product documentation can be found on the Internet at **http://www.rittal.com**

Notes

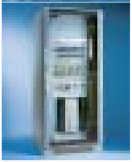
Notes

Notes

All in all – solutions from Rittal

Industrial Enclosures

Electronic Packaging



IT Solutions

Power Distribution

System Climate Control

Communication Systems

Rittal has one of the largest ranges of enclosures available for immediate delivery. However, Rittal also supplies integrated solutions – up to Level 4. This comprises mechanical installation, power supply, electronic components, climate control and central monitoring. For all of your requirements. Fully assembled and functional. Wherever in the world you develop and implement solutions for yourself and your customers, we are close at hand. The global alliance between production, distribution and service guarantees closeness to the customer. Worldwide!

09/08 · E186

Rittal GmbH & Co. KG · Postfach 1662 · D-35726 Herborn
Telephone: +49(0)2772 505-0 · Telefax: +49(0)2772 505-2319
eMail: info@rittal.de · www.rittal.com

Switch to perfection