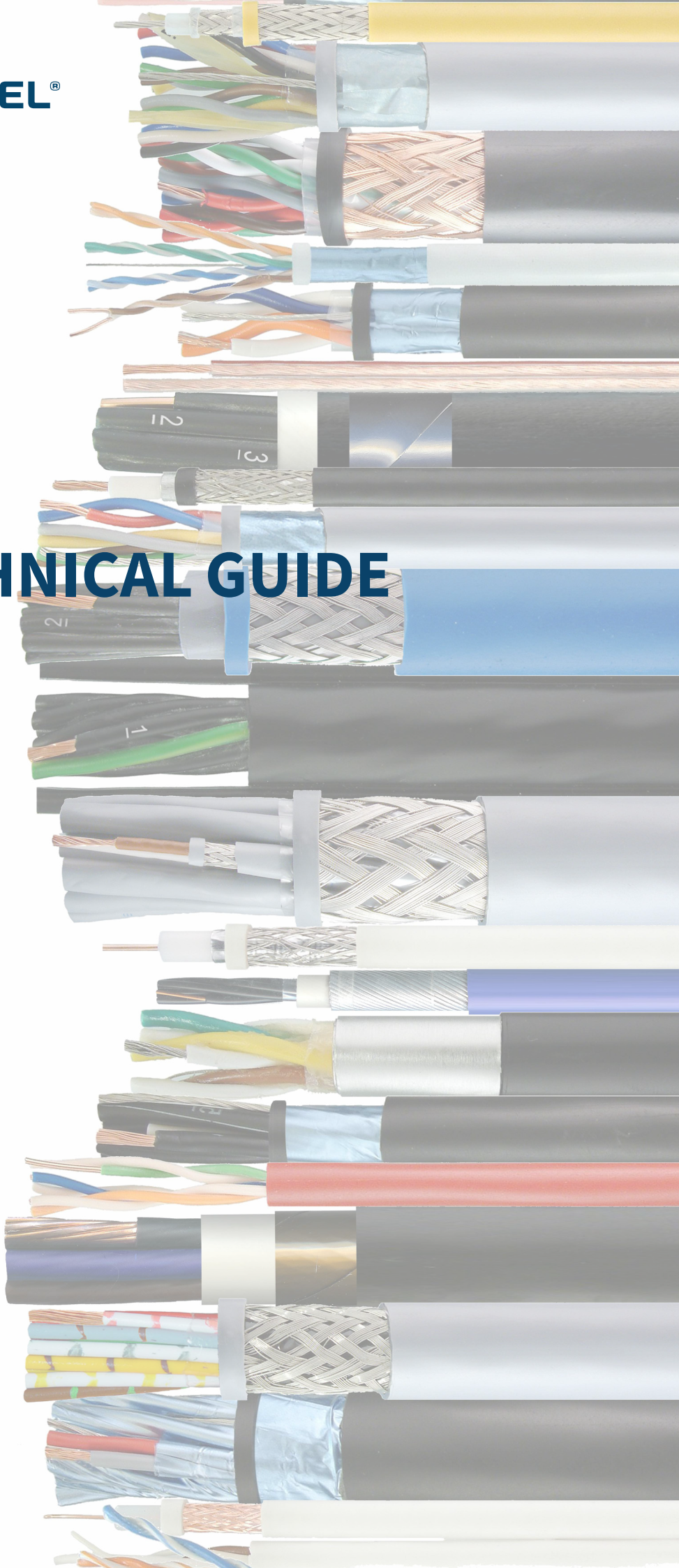




**TECHNOKABEL®**

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# TECHNICAL GUIDE





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## Cable marking

All cables are marked with symbols that usually create a logical combination of letters and numbers. These markings contain information about the purpose and construction of the cables. In practice, each country has its own marking system included in national standards. However, it happens that cable manufacturers introduce their own additional markings and use them instead of, or in addition to, recognized national markings. This is due to very rapid technical progress, which the standardized national marking system cannot keep up with. It also happens that cable markings used in one country are gradually adopted, without changes, in other countries. This was the case, for example, with UTP and STP cables (the designations are abbreviations for „unshielded twisted pair” and „shielded twisted pair” cable construction), developed in the USA and then adopted throughout the world with identical designations.

An international cable marking system has also been developed, covering only the so-called harmonized types of cables and wires, consistent with the requirements of the so-called harmonization documents. The system was developed and adopted by CENELEC, and currently also has the status of the Polish Standard PN-HD 361. The system is used in European Union countries and allows for the coding of information regarding cable construction.

It is very important to know the symbols used to mark cables. It is a common, unambiguous and very concise **language of communication** between the manufacturer and the customer (cable user).

Technokabel produces cables according to Polish, German, American and other countries' standards. Cables are marked in accordance with the requirements of these standards. We also introduce our own markings.

### MARKING OF CABLES BY POLISH MANUFACTURERS

**Table 1.1** lists the symbols used to mark cables by Polish manufacturers, the meaning of these symbols and their equivalents used by German manufacturers. In addition to the standardized symbols, there are also additional symbols not provided for in the standards, but used by many manufacturers.

The order in which the symbols appear is specified. The more complicated the cable design, the more symbols there are in the cable marking. We will discuss the principle of marking with symbols on the example of the **YKSLYekw-P-O 300/500 V 10x2x0.5 mm<sup>2</sup>** cable. This marking applies to a control cable (**KS**) with PVC insulation (the second **Y**) and a PVC sheath (the first **Y**) resistant to oil (**-O**), in a common screen (**ekw**) applied cable core, made of 10 pairs (**-P**, and additionally **x2**) flexible copper conductors (**L**) with a cross-section of **0.5mm<sup>2</sup>**, intended for use with devices with a three-phase rated voltage not exceeding **300/500 V**.

Y	sheath material
KS	Cable type
L	type of conductor
Y	insulation material
ekw	types of screens
	protective conductor
	type of armor
	cover material
-P -O	additional features
300/500 V	rated voltage
10 x 2	number of cable elements (twisted cores –pairs, triples, quads)
x 0,5 mm <sup>2</sup>	conductor cross-section

Please note that sometimes the same symbol written in lower or upper case letters may indicate a different cable structure (see **Table 1.1** and **1.2**). Moreover, the same symbols may apply to different cable elements and their proper meaning results from the place in the marking and the meaning of the remaining symbols. Some symbols appear only as a few letters and traditionally have an extended meaning - for example, TKS means a telecommunications station cable, and since this cable only has conductors twisted into pairs, an additional symbol (-P) is not used to designate the pair construction of this cable. When reading, we always pronounce each letter of the symbol separately, i.e. we do not combine them into words.

The way power cables are marked is based on a similar sequence of symbols. Let's consider the cable marking **YKYFty 0,6/1 kV 3x35 SM/16 RE mm<sup>2</sup>**. This marking describes a power cable (**K**) with PVC insulation (the second **Y**) and a PVC sheath (the first **Y**), on which a steel tape armor (**Ft**) is applied, with a PVC cover (**y**), made of three sector(**S**) multi-wire (**M**) working conductors with a cross-section of **35 mm<sup>2</sup>** and a round (**R**) single-wire (**E**) neutral conductor with a cross-section of **16 mm<sup>2</sup>**, intended for powering devices with a rated three-phase voltage not exceeding **0.6/1 kV**.

Y	sheath material
K	cable type
	type of conductor
Y	insulation material
	types of screens
	protective conductor
Ft	type of armor
y	cover material
	additional features
0,6/1 kV	rated voltage
3 x 35 SM	number, cross-section and shape of working conductors
/16 RE mm <sup>2</sup>	cross-section and shape of the neutral (protective) conductor

**TABLE 1.1 CABLE MARKINGS USED BY POLISH MANUFACTURERS**

Symbol	Meaning	German equivalent
A	power cable with aluminum conductors	
c	tinned core (wire) (appears after the wire cross-section marking)	V
d	reinforced insulation (thickened)	v
D	single-wire conductor	
ek	screen, in power cables made of copper wires	
ekfo	screen in the form of Al/PET tape and braid	
eko	shield in the form of braid on microphone cables (marking not included in Polish standards)	
eko	screen in the form of a double braid of coaxial cables (not included in Polish standards)	C
ekp	every pair on screen	PIMF
ekt	triple screen (designation not included in Polish standards)	TIMF
ekt	Al/PET tape screen in coaxial cables (marking not included in Polish standards)	
ektm	screen made of copper tapes	
ekw	common screen (on the cable core)	
ekwo	common screen (on the cable core) in the form of a braid	
ekż	every insulated conductor in the screen	
Fo	armor made of galvanized round steel wires	R
Ft	armor made of galvanized steel tapes	B
Ftl	armor made of lacquered steel tapes	
H	(first) sheath, (second) insulation made of halogen-free, flame-retardant thermoplastic (HFFR)	H
H	radial field power cable (Hochstädter)	
K	cable (power cable)	
KA	alarm cable (marking not included in Polish standards)	
KG	mining cable	
KO	ship cable	
KS	control cable	
L	multi-wire conductor (stranded)	Li
Lg	multi-wire flexible conductor	LiF
Lgg	very flexible multi-wire conductor	
LAN-Tn	cable for multimedia IT networks, type no = 1, 2, ... (not included in Polish standards)	
n	self-supporting telecommunications cable	T
-Nr	cable with wires marked with numbers (marking not included in Polish standards)	-Z
-O	oil-resistant (designation not included in Polish standards)	Ö
OFC	oxygen-free copper conductors (Oxygen Free Copper)	
OMY	PVC insulated and sheathed flexible cable	
OWY	workshop flexible cable with PVC insulation and sheath	
p	flat cable	-Zw
-P	insulated conductors twisted into pairs (designation not included in Polish standards)	

Symbol	Meaning	German equivalent
PG	guitar cable (marking not included in Polish standards)	
PGW	coaxial speaker cable (marking not included in Polish standards)	
PI	braid (designation not included in Polish standards)	
Plc	braid made of tinned wires (designation not included in Polish standards)	
PM	microphone cable	
PMon	monitor cable (designation not included in Polish standards)	
R	in power cables, radial seal made of Al tape covered with copolymer	
Ra	in power cables, sealing with Al tape with a copolymer as a neutral concentric conductor	
RE	power cables with round single-wire conductors	
RM	power cables with round multi-wire conductors	
RMC	power cables with round multi-wire compacted conductors	
s	self-supporting power cable	
SM	power cables with multi-wire sector conductors	
St	control cable (marking not included in Polish standards)	
-S	for automotive	
-Sp	cable with capillary (designation not included in Polish standards)	
TKM	local telecommunications cable	
TKS	telecommunications station cable	
TD	telecommunications cable with single-wire conductors	
TL	telecommunications cable with multi-wire conductors	
u	reinforcement (a type of armor in the form of a braid of steel wires)	
U	longitudinal seal of the cable with tapes that swell under the influence of moisture	
v	reinforced sheathing (thicker, marking not included in Polish standards)	v
w	gel filling	F
w	in power cables, filling made of non-vulcanized rubber	
W	coaxial (concentric) cable	
W	ribbon cable	
X	(first) sheathing, (second) insulation made of polyethylene (PE)	2Y
Xp	polyethylene foam insulation	O2Y
XS	cross-linked polyethylene insulation (XLPE)	2X
y	PVC cover	
Y	(first) coating, (second) insulation made of PVC	Y
Yc	heat-resistant PVC insulation or sheathing	Yw
Yn	flame retardant PVC sheathing	Yu
y	(at the beginning) in the filling coating, (at the end) in the outer PVC cover	
z	moisture barrier	(L)
-żo	green-yellow protective conductor	-J

## MARKING OF CABLES BY GERMAN MANUFACTURERS

Table 1.2 lists the symbols used to mark cables by German manufacturers, the meaning of these symbols and their equivalents used by Polish manufacturers. The marking usually does not specify the type of cable, as in the Polish marking. The order of symbols is also slightly different than in Polish markings - it starts with the purpose and structure of the internal elements (strands) and ends with the external coating.

We will discuss the marking principle on the example of the **LiYCY-C11Y-P 4x2x0,75 mm<sup>2</sup>** cable given below. This marking applies to a cable with multi-wire copper conductors (Li) in PVC insulation (first Y), twisted into pairs (-P), each of which has a braided screen (first C) and a PVC sheath,

(second Y), and on the center of the cable consisting of 4 pairs of conductors with a cross-section of 0,75 mm<sup>2</sup> (**4x2x0,75 mm<sup>2</sup>**) there is a second screen in the form of a braid (second C) and a sheath made of polyurethane (**11Y**). Please note that the rated voltage is not given and you should know that for this type of cables it should not exceed **500 V**.

	application
	additional information
Li	type of conductor
Y	insulation material
CY-C	additional features
11Y	sheath material
-P	additional features
4x	number of cable elements (cores, pairs, triples, quads)
2x	number of conductors twisted together
0,75 mm <sup>2</sup>	cross-section of conductors
	method of twisting the cable elements
	way of laying up the cable core

The way of marking power cables is similar. Let's consider the cable designation **N2XY-0 0,6/1 kV 3x35SM/16RE mm<sup>2</sup>**. This marking describes a power cable made in accordance with German VDE standards (N), with cross-linked polyethylene insulation (2X) and a PVC coating (Y), without a green-yellow protective conductor (-0), with three sector-shaped working conductors (S) multi-wire (M) with a cross-section of 35 mm<sup>2</sup> and a round (R) single-wire (E) neutral conductor with a cross-section of **16 mm<sup>2</sup>**, intended for powering devices with a rated three-phase voltage not exceeding **0,6/1 kV**.

	application
N	additional information
	type of conductor
2X	insulation material
	additional features
Y	sheath material
	additional features
0,6/1 kV	rated voltage
3x35 SM	number, cross-section and shape of working conductors
/16 RE mm <sup>2</sup>	cross-section and shape of the neutral (protective) conductor

**TABLE 1.2. CABLE MARKINGS USED BY GERMAN MANUFACTURERS**

Symbol	Meaning	Polish equivalent
A	cable for outdoor use	
B	armor made of steel tapes	Ft
Bd	a cable core with a unit structure	
C	screen in the form of a braid of tinned copper wires	
C	concentric protective conductor in the form of a wrap of copper wires and shorted with tape	
CW	concentric protective conductor made of copper wires wound alternately and connected with a tape	
D	screen in the form of a wrapping of copper wires	
E	ground wire under the screen	
F	armor made of galvanized flat steel wires	Fp
F	filling the cable core with gel	In
FR	increased resistance to fire conditions ( Fire Resistance )	
G	anti-twisting spiral made of galvanized steel tape	
H	halogen-free and flame-retardant	
H	marking according to harmonized standards	
HK	halogen-free cross-linked polymers	
J	installation cable	
JE	installation cable for electronics	
-J	cable with green-yellow protective conductor	żo
-JZ	cable with cores marked with numbers and a green-yellow protective conductor	żo-Nr
-J0	cable with color-coded cores and a green-yellow protective conductor	żo
Lg	a cable core with a layered structure	
Li	multi-wire conductor	L
LiF	multi-wire flexible conductor	Lg
(L)Y	PVC sheathing with aluminum tape laminated with plastic	
(L)2Y	polyethylene sheathing with aluminum tape laminated with plastic	Xz
N	cable compliant with DIN VDE standards	
O2Y	foam polyethylene (PE) insulation	Xp
O2YS	foam polyethylene (PE) insulation with skin	
Ö	resistant to oils	O
PIMF	pairs wrapped with polyester-aluminum tape ( Paired, Individually Metal Foiled)	ekp
re	single-wire round conductor	
rm	multi-wire round conductor	
R	armor made of round galvanized steel wires	Fo
RD	Rhenomatic cable for data transmission	
RE	instrumentation cable	
S	control cable	
S	steel wire braid	u

Symbol	Meaning	Polish equivalent
se	single-wire sector-shaped conductor	
sm	multi-wire sector-shaped conductor	
(St)	electrostatic screen made of aluminum-polyester tape	ek, ekp, ekw
T	self-supporting	n
v	reinforced sheathing (thickened)	
V	tinned copper wires/strands	c
XPE	cross-linked polyethylene (XLPE)	
Y	PVC	Y
Yu	flame retardant PVC	Yn
Yw	heat-resistant PVC (up to 90°C)	Yc
Zw	flat cable	p
-0	cable without green-yellow protective conductor	
-0Z	cable without a green-yellow protective conductor and cores marked with numbers	
2X	cross-linked polyethylene (XLPE)	
2Y	polyethylene (PE)	X
4Y	polyamide (PA)	
5Y	polytetrafluoroethylene (PTFE), Teflon®	
6Y	copolymer fluoroethylene (FEP), Teflon®	
7Y	ethylenetetrafluoroethylene (ETFE)	
9Y	polypropylene (PP)	
11Y	polyurethane (PUR)	
12Y	ester type thermoplastic elastomer (TPE-E)	
31Y	styrene type thermoplastic elastomer (TPE-S)	
91Y	olefin type thermoplastic elastomer (TPE-O)	

**TABLE 1.3 MARKING OF HARMONIZED TYPES OF WIRES AND CABLES**

Symbol	Meaning
<b>Part 1</b>	
<b>Connection with standards</b>	
H	cable meeting the requirements of harmonized standards
-	non-harmonized cable
<b>Rated voltage</b>	
01	100/100 V
03	300/300 V
05	300/500 V
07	450/750 V
1	1000/1000 V

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**Part 2**


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**Insulation or coating material**


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B	ethylene-propylene rubber for continuous operation at 90°C
G	ethylene-vinyl acetate copolymer
J	fiberglass braid
M	mineral
N	Polychloroprene
N2	special polychloroprene mixture (for sheathing of welding cables)
N4	chlorosulfonated or chlorinated polyethylene
N8	special waterproof polychloroprene mixture
Q	polyurethane
Q4	polyamide
R	ordinary ethylene-propylene rubber for continuous operation at a temperature of 60°C
S	silicone rubber
T	fibrous braid wound around the assembled cores
T6	fibrous braid wound on individual cores of a multi-core cable
V	ordinary PVC
V2	Heat-resistant PVC for continuous operation at 90°C
V3	PVC for cables laid at low temperatures
V4	cross-linked PVC
V5	special oil-resistant PVC
Z	cross-linked material based on polyolefins, low emission of corrosive gases and smoke during fire
Z1	thermoplastic material based on polyolefins with low emission of corrosive gases and fumes during fire
Z2	cross-linked material based on polyolefins, low emission of corrosive gases and smoke during fire for photovoltaic cable
Z5	thermoplastic compound EVM-1 for cable with low emission of corrosive gases and fumes during fire for EV charging cable
Z6	cross-linked compound EVM-2 for cable with low emission of corrosive gases and fumes during fire for EV charging cable

**Metal covering**


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C	concentric copper conductor
C4	copper screen applied to the medium

**Special constructional elements**


---

D3	a supporting element placed in the middle of a round duct or inside a flat duct
D5	central element (in lifting cables, not being a load-bearing element)

**Special construction**


---

(no symbol)	round cable
H	flat cable with tearable conductors
H2	flat cable with unbreakable conductors
H6	flat cable with three or more cores

---

H7	cable with extruded double layer of insulation
H8	spiral cable
<b>Conductor material</b>	
(no symbol)	copper
-A	aluminum
<b>Conductor structure</b>	
-D	flexible conductor of welding cables
-E	highly flexible conductor of welding cables
-F	flexible conductor of flexible cable or cord
-H	highly flexible conductor of flexible cable or cord
-K	flexible conductor of cables for fixed installation
-R	rigid, round multi-wire conductor
-S	rigid, sector multi-wire conductor
-U	rigid, round, single-wire conductor
-Y	tinsel conductor
<b>Part 3</b>	
<b>Number of conductors</b>	
(number)	number of cores in the cable
<b>Protective conductor</b>	
X	no protective core (green-yellow)
G	with protective core (green-yellow)
<b>Cross-section of conductors</b>	
(number)	nominal cross-section of conductors in mm <sup>2</sup>
Y	for tinsel conductor (cross-section not specified)
<b>Identification of cores by numbering</b>	
N	digital print highlighting cores

## LONG-TERM CURRENT CARRYING CAPACITY

The current flow in the cable core (conductor) causes heat to be released. According to Joule's law, the power (P) of heat released is directly proportional to the square of the intensity of the flowing current (I) and to the resistance (R) of the conductor and is

$$P = I^2 \cdot R.$$

The generated heat heats the wires and flows to other layers of the cable, causing their temperature to rise gradually. This heat is simultaneously dissipated (given off) to the environment. There are three ways of dissipating heat that occur simultaneously. These are: **convection**, i.e. receiving and lifting heat by flowing air streams, **conduction** to the surrounding medium and **radiation** to the environment. It is easy to see that the contribution of each of these factors to the dissipation depends mainly on the way the cable is laid. Cables suspended in the air will give off heat mainly through convection, while cables buried in the ground - through conduction.

If the flowing current is not too high and the heat released does not degrade the insulation then, after some time, **thermal equilibrium** will occur and the amount of heat released in the conductor will be equal to the amount of heat given off

to the environment. The temperature of the cable cores will also be established. In a single cable the cores will have the highest temperature and the sheaths or cable sheaths in contact will have the lowest temperature with the surroundings. The temperature of the cores (conductors) should not exceed a certain permissible temperature. The **permissible temperature** is the limit temperature above which unfavorable and **irreversible** phenomena occur, e.g. excessive softening and deformation of the insulation material and the movement of the core inside the insulation due to internal stresses. At even higher temperatures, the aforementioned **degradation** may occur, i.e. changes in the chemical structure and physical insulation, e.g. foaming by gases originating from chemical decomposition, and even charring, i.e. destruction of electrical properties and a decrease in thermal conductivity. These phenomena, often slow and unnoticed, may continue or repeat for a long time, gradually reducing the strength of the cable and loss of its reliability. Current value in the state of thermal equilibrium, when the conductors reach the permissible temperature, it is called the **long-term current capacity**, or shortly the **load capacity**.

Many factors influence the long-term load capacity of cables. The most important of them are:

- conductor **cross-section** - the larger the cross-section, the lower the resistance of the conductor and the greater the load capacity,
- insulation **material** - the more resistant to softening and deformation, the higher the allowable temperature, and thus the higher the load capacity of the cores; also when the greater thermal conductivity of the material,
- **thickness** of the insulation and coating, i.e. the thickness of the thermally insulating layers that hinder heat transfer to the environment - the thicker the insulation layers, the lower the load capacity,
- **number** of loaded conductors in a bundle - the more loaded conductors in a cable or in a bundle of cables, the lower the load capacity of a single conductor, because the loaded conductors heat each other and make it difficult to emit heat to the environment,
- ambient **temperature** - the lower it is, the more distant it is from the permissible temperature, and then the load capacity is greater,
- **place** of laying - the load capacity of cables and wires laid in sunny places is lower than in shaded places, while the load capacity of cables laid in the ground may be higher than those laid in the air, because heat dissipation in the ground is usually better
- the **presence** of external heat sources near the cable reduces its load capacity.

The long-term load capacity is significantly influenced not only by the cable structure, but most of all by the **method of installation**. There are dozens of ways to install cables. Cables can be laid in the air, singly or in bundles, on ladders, in trays, in conduits, or directly on a wall or ceiling. They can also be laid in cable ducts or buried directly in the ground. The intensity of heat dissipation depends on the place and method of installation. An additional factor limiting the load capacity may be external heat sources near the cable route, such as steam or hot water pipelines (even thermally insulated), as well as sunny places.

It should be remembered that the external factors that affect the long-term load capacity may change over time and along the cable route, and the **most unfavorable** factors will always be critical for the load capacity, even if they occur on a short section of the route or in a short time.

In order to accurately determine the long-term load capacity, at least three factors must be known:

- conditions of heat dissipation along the entire cable route, which may change throughout the day, e.g. air temperature, and seasonally throughout the year, e.g. soil temperature or humidity - these are obtained by costly measurements,
- the nature of the cable load, taking into account the daily and seasonal variability of the current flow over time - obtained by recording loads and analyzing the anticipated and planned loads,
- cable construction.

Then, laborious calculations are performed. Due to costs, the load capacity is calculated only for high and very high voltage power cables, where the use of transmission possibilities gives significant economic benefits. It may then be advisable to shape the conditions of heat dissipation, e.g. by using the so-called stabilized soils, which are characterized by relatively small and little changeable thermal resistivity during the year.

In the case of low voltage cables, the typical construction of the cable and its constant current load are assumed, and the common environmental conditions and selected, typical methods of cable installation are assumed. For these assumed conditions, the load capacity is calculated based on the results of many years of research conducted in many research centres around the world.

### **LONG-TERM CURRENT CARRYING CAPACITY ACCORDING TO THE REQUIREMENTS OF THE PN-IEC 60364-5-523 STANDARD**

This standard defines the long-term load capacity of unarmored cables for a rated voltage of not more than 0.6 / 1 kV, and its scope is defined by the title of the standard: “Electrical installations in building structures. Selection and assembly of electrical equipment. Long-term current carrying capacity of wires.”. The load capacity values were calculated from the formula:

$$I = A \cdot S^m - B \cdot S^n [A],$$

where A and B as well as m and n are the coefficients depending on the type of cable and the method of installation, determined on the basis of many years of research carried out in various places around the world. In practice, it is sufficient to take into account only the first part of the formula, because the second part applies only to single-core cables with large cross-sections.

When calculating the load capacity specified in the standard, it was assumed that the ambient temperature of cables installed in the air, regardless of the method of their laying, is 30°C, and the ambient temperature of cables laid in the ground, directly or in sheaths, is 20°C, with the thermal resistivity of the ground equal to 2.5 K • m / W, which corresponds to the resistivity of the sand bed used to fill the space around cables laid in cable trench.

It was also assumed that the permissible temperature of conductors in PVC insulation is 70 °C, and the permissible temperature of conductors insulated with cross-linked polyethylene (XLPE) is 90 °C. Note that for the assumed ambient temperature of 30°C in the air, the permissible temperature increase of the conductor insulated with PVC is 40 °C, while for cross-linked polyethylene it is as much as 60°C. If we assume that the temperature increase of the conductor is approximately proportional to the amount of heat released, which increases with the square of the current intensity, the **load capacity of cables with cross-linked polyethylene (XLPE) insulation is approximately 20% higher than the load capacity of cables with PVC insulation (PVC) or thermoplastic polyethylene (PE).**

The standard includes as many as fifty ways to install cables, and more are under development. But the long-term current-carrying capacity was calculated according to the above-mentioned formula only for the selected and characteristic nine cases, which are called the basic methods of installation. They are listed in Table 2.1. The standard specifies which of these nine basic methods should be rated for each of the fifty cable installation methods mentioned. It follows that the load capacity of one basic method may be used for several actual cable installation methods.

Load capacities for the basic methods of installation are given in the standard tables. Correction factors for other than assumed (30 °C in air and 20 °C in soil) ambient temperatures of cables and for other than assumed (2 or 3) number of current-loaded cores are also given. In the attached **Table 2.2**, we present the long-term current carrying capacity for several of the most commonly used methods of installing cables with PVC and XLPE insulation, for two and three loaded copper conductors.

**Table 2.3** contains the standard correction factors for the ambient air temperature other than 30°C. They concern the basic methods B1 and E of the installation. The standard also provides, not mentioned here, correction factors for ground temperature other than 20°C and thermal resistivity of soil other than 2.5 K • m / W.

**TABLE 2.1 BASIC METHODS OF INSTALLATION ACCORDING TO PN-IEC 60364-5-523**

Symbol	Description of the basic method of installation
A1	single-core wires in a an installation pipe in a heat-insulated wall
A2	multi-core cables in a an installation pipe in a heat-insulated wall
B1	single-core cables in an installation pipe in a wooden wall
B2	multi-core cables in an installation pipe in a wooden wall
C	single-core or multi-core cable on a wooden wall
D	sheathed multi-core cable in the ground
E	multi-core wire in the air, more than 0.3 wire diameter away from the wall
F	single-core wires in air touching each other, spaced more than the wire diameter from the wall
G	single-core conductors in the air spaced apart by at least one conductor diameter
in development	wires attached to or built into a masonry wall

**TABLE 2.2 LONG-TERM CURRENT CARRYING CAPACITY OF CABLES WITH COPPER CONDUCTORS INSULATED WITH PVC AND XLPE, FOR SELECTED INSTALLATION METHODS, ACCORDING TO THE PN-IEC 60364-5-523 STANDARD**

Installation number and description	31. in perforated trays, 32. on supports, 34. on ladders, 35. with a carrying cable				56. in open or ventilated cable ducts				72. directly in the ground			
Basic method of installation	E				B1				D			
Insulation material	PVC		XLPE		PVC		XLPE		PVC		XLPE	
Number of loaded cores	2	3	2	3	2	3	2	3	2	3	2	2
Nominal cross-section [mm <sup>2</sup> ]	Long-term current carrying capacity [A]											
1,5	22	18.5	26	23	17.5	15.5	23	20	22	18	26	22
2,5	30	25	36	32	24	21	31	28	29	24	34	29
4	40	34	49	42	32	28	42	37	38	31	44	37
6	51	43	63	54	41	36	54	48	47	39	56	46
10	70	60	86	75	57	50	75	66	63	52	73	61
16	94	80	115	100	76	68	100	88	81	67	95	79
25	119	101	149	127	101	89	133	117	104	86	121	101
35	148	126	185	158	125	110	164	144	125	103	146	122
50	180	153	225	192	151	134	198	175	148	122	173	144
70	232	196	289	246	192	171	253	222	183	151	213	178
95	282	238	352	298	232	207	306	269	216	179	252	211
120	328	276	410	346	269	239	354	312	246	203	287	240
150	379	319	473	399	-	-	-	-	278	230	324	271
185	434	364	542	456	-	-	-	-	312	258	363	304
240	514	430	641	538	-	-	-	-	361	297	419	351
300	593	497	741	621	-	-	-	-	408	336	474	396

**TABLE 2.3 CORRECTION FACTORS FOR AIR TEMPERATURE OTHER THAN 30°C (REFER TO THE BASIC METHODS E AND B1 GIVEN IN TABLE 2.2 FOR THE INSTALLATION)**

Ambient temperature [°C]	Insulation material	
	PVC	XLPE
10	1.22	1.15
15	1.17	1.12
20	1.12	1.08
25	1.06	1.04
30	1.00	1.00
35	0.94	0.96
40	0.87	0.91
45	0.79	0.87
50	0.71	0.82
55	0.61	0.76
60	0.50	0.71
65	-	0.65
70	-	0.58
75	-	0.50
80	-	0.41

**TABLE 2.4 FACTORS REDUCING THE LOAD CAPACITY OF BUNDLES CONSISTING OF MORE THAN ONE CIRCUIT OR WITH MORE THAN ONE MULTI-CORE CONDUCTOR (REFER TO THE BASIC METHODS E AND B1 FOR THE INSTALLATION PROVIDED IN TABLE 2.2)**

Number of circuits or multi-core cables	Installation number and description		
	31. in perforated trays	32. on supports, 34. on ladders, 35. with a carrying cable	56. in cable channels exposed or ventilated
1	1.00	1.00	1.00
2	0.88	0.87	0.80
3	0.82	8.82	0.70
4	0.77	0.80	0.65
5	0.75	0.80	0.60
6	0.73	0.79	0.57
7	0.73	0.79	0.54
8	0.72	0.78	0.52
9	0.72	0.78	0.50
12	-	-	0.45
16	-	-	0.41
20	-	-	0.38

## CABLES FOR ELECTRONICS AND AUTOMATION

In cables used to transmit analog and digital signals, the choice of the cable conductor cross-section is determined by the signal attenuation, which increases with the cable length and decreases with the conductor cross-section. It often happens that users of our cables, in addition to transmitting signals, want to use the wires of these cables to power small devices, such as automation actuators, lighting, fans, computers and other low-power receivers. The question arises whether the cross-section of the cable cores is large enough and the flowing current will not damage the cable due to excessive temperature rise?

Cables for electronics and automation have a slightly different design from the design of the cables adopted for the calculation of the load capacity in the above mentioned PN-IEC 60364-5-523 standard. The cross-sections of these cables do not exceed 2.5 mm<sup>2</sup>, and most often they are much smaller. Very often, these cables are of a pair construction, but pairs and cables are wrapped with plastic strips. The proportions between the dimensions of the conductors and the thicknesses of insulation and coatings are different - they contain more plastic and air, and less copper. Therefore, heat dissipation is more difficult in them. It can be expected that the long-term current carrying capacity of these cables will be lower.

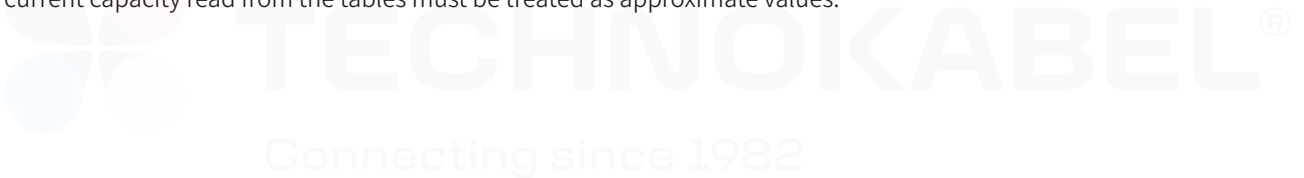
For the needs of our cable users, we have calculated the current capacity of cables intended mainly for signal transmission, with copper conductors with PVC (PVC) and PE (thermoplastic polyethylene) insulation. We have adopted a typical installation method, i.e. in rooms where the air temperature is 30 °C, as in the above-mentioned standard, in perforated trays, on supports or on installation ladders, in places protected from direct sunlight

and away from heat sources. We have also assumed that two or three cores of the cable are loaded, i.e. they supply a single or three-phase device. The calculated long-term current carrying capacity is given in **Table 2.5**.

Often, the route of the cable deviates from the assumptions given above and the ambient temperature may be higher, or the cable route runs in a place where the sun's rays reach, near a radiator or in the vicinity of a pipeline. In such a case, the ambient temperature in which the cable or bundle of cables will be located should be estimated, and the permissible load capacity, read from **Table 2.5**, should be multiplied by the factor corresponding to the estimated temperature, given in **Table 2.6**.

For more loaded cores in a cable or in a bundle of adjoining cables, the readout should be made multiply the value of the load capacity from the table by the correction factor given in **Table 2.7**.

As the calculations do not take into account all the previously discussed conditions for laying the cable and not always all the actual operating conditions of the cable are unchanged and consistent with the assumed ones, the long-term current capacity read from the tables must be treated as approximate values.



**TABLE 2.5 LONG-TERM CURRENT CARRYING CAPACITY OF CABLES WITH COPPER CONDUCTORS, PVC OR PE INSULATION, LAID IN THE AIR AT 30°C, FOR VOLTAGE UP TO 300/500 V, INTENDED FOR USE IN ELECTRONICS AND AUTOMATION**

Conductor cross-sectiony [mm <sup>2</sup> ]	Long-term current carrying capacity [A]
0,05	1.2
0,08	1.7
0,12	2.2
0,14	2.5
0,15	2.6
0,20	3.2
0,22	3.4
0,25	3.8
0,34	4.7
0,5	6.1
0,75	7.9
1,0	9.4
1,5	12.0
2,5	16.4

**TABLE 2.6 RECALCULATION OF THE CURRENT CARRYING CAPACITY FROM TABLE 2.4 FOR AIR TEMPERATURE**

Ambient air temperature [°C]	20	25	30	35	40	45	50	55
Conversion factor	1.10	1.05	1.00	0.94	0.88	0.82	0.75	0.67

**TABLE 2.7 CONVERTING THE CURRENT CARRYING CAPACITY FROM TABLE 2.4 FOR THE NUMBER OF LOADED CORES**

Number of cores*	1	2 or 3	4 – 6	7 – 9	10 – 20	21 – 30	31 – 40	over 40
Conversion factor	1.6	1.0	0.8	0.7	0.5	0.45	0.40	0.35

\* If screens are conduction current, they must be taken into account

**Supplementary information for table 2.8:**

Correction factors for:

- Different temperatures: table 2.3
- Multi-core cables in trays: table 2.10
- Mounting method: table 2.9

A: single-core cables, LiY, LiYw; TLY, TLYc, LY, LgY, LgYc, h05V-K, H05V2-K, H05Z1-K, H07V-K, H07V2-K, halogen free cables: LiH, TLH, H05Z1-K; H07Z-K,

B: wires and multi-core cables for powering home and portable devices, OMY, H05VV-F, OWY,

C: multi-core control and power cables (except for applications as in point B), LiYY, LiYCY, YKSLY, YKSLYekw,

D: single-core and multi-core cables and wires in rubber insulation and sheath,

\* : current carrying capacity taken from the standard VDE 0891-1

\*\* : based on VDE 0298-4, 2003-08, table 11 column 2 extended range for 0.5 mm<sup>2</sup>

All information provided by VDE is subject to change.

**TABLE 2.8 CURRENT CARRYING CAPACITY, RATED VALUES**

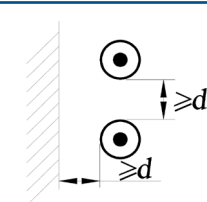
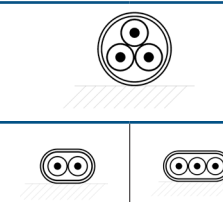
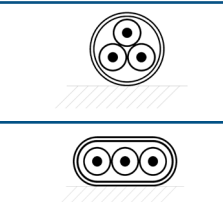
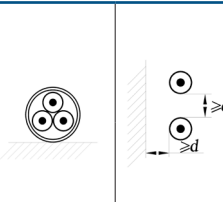
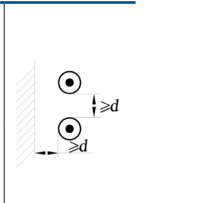
For cables and wires

For loads in a static installation

For telephone and transmission cables

For electrical components in machines

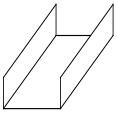
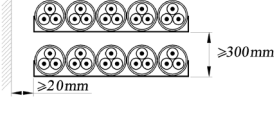
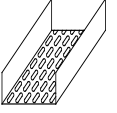
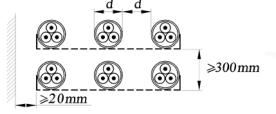
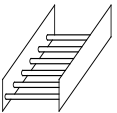
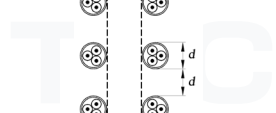
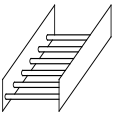
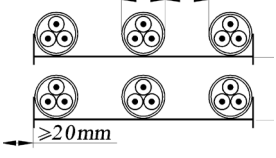
Current carrying capacity at + 30°C ambient temperature (in accordance with VDE 0298-4 and DIN VDE 0113-1)

Products (description given below)	A	B		C	D	
Mounting method						
Number of wires	1	2	3	2 lub 3	3	1
Nominal cross-section [mm <sup>2</sup> ]	Current [A]					
0,08*	1,5	-	-	1	-	-
0,14*	3	-	-	2	-	-
0,25*	5	-	-	4	-	-
0,34*	8	-	-	6	-	-
0,5	12**	3	3	9**	-	-
0,75	15	6	6	12	-	-
1,0	19	10	10	15	-	-
1,5	24	16	16	18	23	30
2,5	32	25	20	26	30	41
4	42	32	25	34	41	55
6	54	40	-	44	53	70
10	73	63	-	61	74	98
16	98	-	-	82	99	132
25	129	-	-	108	131	176
35	158	-	-	135	162	218
50	198	-	-	168	202	276
70	245	-	-	207	250	347
95	292	-	-	250	301	416
120	344	-	-	292	-	488
150	391	-	-	335	-	566
185	448	-	-	382	-	644
240	528	-	-	453	-	775
300	608	-	-	523	-	898
400	726	-	-	-	-	-
500	830	-	-	-	-	-



**TABLE 2.10 CURRENT CARRYING CAPACITY - CORRECTION FACTORS FOR CABLES IN TRAYS**

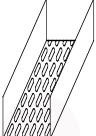

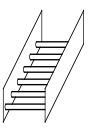
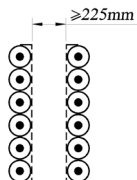
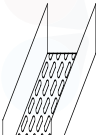
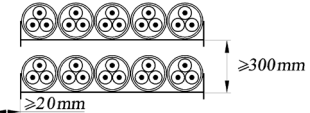

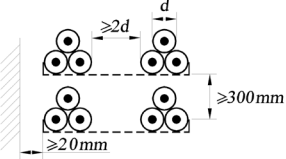
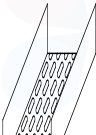
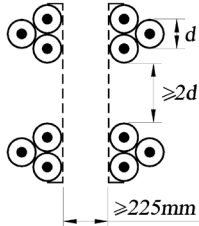

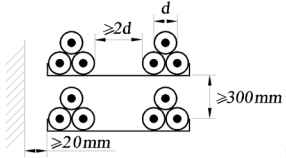
Correction factors for groups / bundles of multi-core cables laid in cable trays (according to DIN VDE 0298-4).

Cable tray type	Arrangement of cables	Number of cable trays	Number of multi-wire cables							
			1	2	3	4	6	9		
			Correction factors for Table 2.8							
		1	0.97	0.84	0.78	0.75	0.71	0.68		
		2	0.97	0.83	0.76	0.72	0.68	0.63		
		3	0.97	0.82	0.75	0.71	0.66	0.61		
		6	0.97	0.81	0.73	0.69	0.63	0.58		
		Contact between the cables		1	1.00	0.88	0.82	0.79	0.76	0.73
		2	1.00	0.87	0.80	0.77	0.73	0.68		
		1	1.00	1.00	0.98	0.95	0.91	---		
		2	1.00	0.99	0.96	0.92	0.87	---		
		3	1.00	0.99	0.95	0.91	0.85	---		
		Distance between the cables		1	1.00	0.88	0.82	0.78	0.73	0.72
		2	1.00	0.88	0.81	0.76	0.71	0.70		
				1	1.00	0.91	0.89	0.88	0.87	---
2	1.00			0.91	0.88	0.87	0.85	---		
Distance between the cables				1	1.00	0.87	0.82	0.80	0.79	0.78
2	1.00			0.86	0.81	0.78	0.76	0.73		
3	1.00			0.85	0.79	0.76	0.73	0.70		
6	1.00			0.83	0.76	0.73	0.69	0.66		
		1	1.00	1.00	1.00	1.00	1.00	---		
		2	1.00	0.99	0.98	0.97	0.96	---		
		3	1.00	0.98	0.97	0.96	0.93	---		
		Distance between the cables		1	1.00	0.87	0.82	0.80	0.79	0.78
		2	1.00	0.86	0.81	0.78	0.76	0.73		
		3	1.00	0.85	0.79	0.76	0.73	0.70		

The correction factors apply to cables of similar load, with a similar method of assembling groups of cables, laid only in a single layer, as shown in the figures on this page. The correction factors do not apply to cables laid on top of each other, or when the minimum spacing required in this table is not met. In such cases, the correction factors must be additionally corrected, i.e. in accordance with Table 2.9.

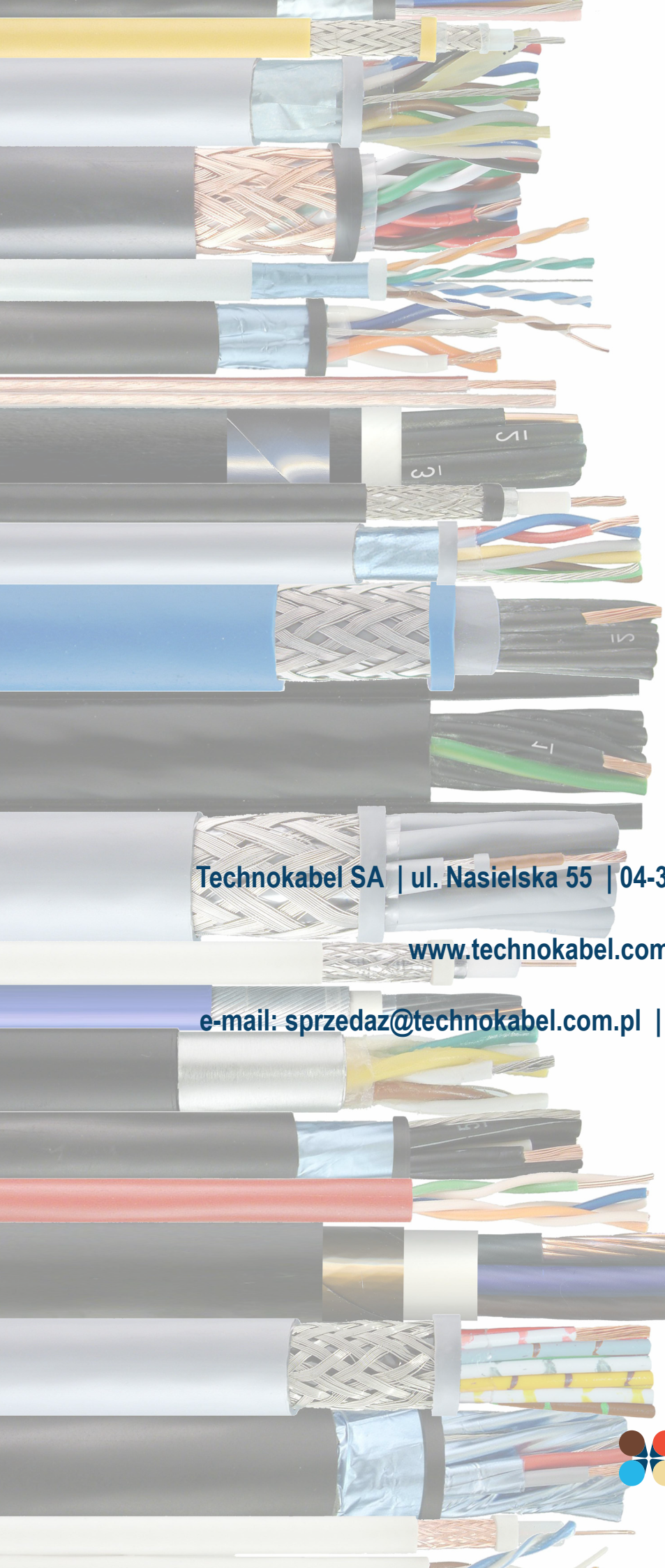
**TABLE 2.11 CURRENT CARRYING CAPACITY - REDUCTION TABLES**

Correction factors for groups / bundles of single-core cables run in cable trays. They apply to the current values given in Table 2.8 (according to DIN VDE 0298-4)

Cable tray type	Arrangement of cables	Number of cable trays	Number of 3-phase circuits with wires or single-core cables				Use as a multiplier of the rating for:
			1	2	3	Correction factor	
	 Contact between the cables	1	0.98	0.91	0.87	Three cables, horizontal layout, single layer	
		2	0.96	0.87	0.81		
		3	0.96	0.85	0.78		
	 Contact between the cables	1	0.96	0.86	---	Three cables, vertical layout, single layer	
		2	0.95	0.84	---		
	 Contact between the cables	1	1.00	0.97	0.96	Three cables, horizontal layout, single layer	
		2	0.98	0.93	0.89		
		3	0.97	0.90	0.86		
	 Contact between the cables	1	1.00	0.98	0.96	Three cables, horizontal, triangular layout	
		2	0.97	0.93	0.89		
		3	0.96	0.92	0.86		
	 Contact between the cables	1	1.00	0.91	0.89	Three cables, vertical, triangular layout	
		2	1.00	0.90	0.86		
	 Contact between the cables	1	1.00	1.00	1.00	Three cables, horizontal, triangular layout	
		2	0.97	0.95	0.93		
		3	0.96	0.94	0.90		

The correction factors apply to cables of similar load, with a similar method of mounting groups of single-core cables in a single layer or triangular configuration, as shown in the figures on this page. The correction factors do not apply to cables laid on top of each other, as well as when the minimum spacing required in this table is not complied with. In such cases, the correction factors must be additionally corrected, i.e. in accordance with Table 2.9. In cases where it is necessary to divide into several groups of parallel conductors, each group of 3 conductors carrying a current load is treated as one complete circuit.





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