Technical Guidelines

TWENTSCHE KABEL DEUTSCHLAND TKD

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Codes

Cables

A-	Outdoor cable
A	Recognized national type
AB	Outdoor cable with lightning protection
AD	Outdoor cable with differential protection
AJ-	Outdoor cable with induction safety rating
ASLH	Self-supporting overhead telecommunications cables for high-tension overhead lines
B	Reinforcement/Armouring
B	Braiding consisting of textile threads
b	Reinforcement/Armouring
(1B..)	One layer steel strip, steel-strip thickness in mm
(2B..)	Two layers steel strip, steel-strip thickness in mm
BD	Bundle stranding
BLK	Bright, copper conductor with no insulating cover
BZ	Bronze conductor
C	Copper wire screening braiding
C	Protective cover consists of jute and compound
C	Outer conductor consisting of copper wire braiding
Cu	Copper wire
(-Cu)	Total cross-section of copper shielding (mm^2)
D	Copper wire shielding
(D)	Copper wire shielding braiding
DM	Dieselhorst-Martin quad
E	Copper wire
E(e)	Protective cover consisting of compound with embedded plastic tape
e	Single-wire
F	Filled cable-core assembly with petrolatum filling
F	Foil winding
F	Flat cable
F	Star-quad for railway cable
F	Star-quad for phantom circuits
(F..)	Flat-wire reinforcement, thickness in mm
OF	Filled cable-core assembly, filling compound with solid content
f	Fine-wired
ff	Ultra-fine-wired
G	Insulation or sheath consisting of Neoprene rubber (NR) or (SBR)
G-	Mine cable
GJ	Mine cable with induction safety rating
GS	Glass-filament braiding

2G	Insulation or sheath consisting of silicone rubber
3G	Insulation or sheath consisting of ethylene propylene (EPR)
4G	Insulation or sheath consisting of ethylene vinyl acetate (EVA)
5G	Insulation or sheath consisting of chloroprene rubber (CR)
6G	Insulation or sheath consisting of chlorosulfonated polyethylene (CSM), Hypalon®
7G	Insulation or sheath consisting of fluoroelastomers, Viton FKM
8G	Insulation or sheath consisting of nitrile butadiene rubber (NBR)
9G	PE-C rubber (CM)
53G	CM, chlorinated polyethylene
H	Insulation or sheath consisting of halogen-free material
H	Harmonized standards
(H..)	Maximum values for effective working capacitance (nF/km)
(HS)	Layer of semi-conductor material
HX	Cross-linked halogen-free polymer mixture
..IMF	Individual stranding elements (core or pairs) in metal foil and with sheath wire
IMF	Multiple stranding elements in metal foil, with sheath wire
-J	Cable with one green-yellow protective conductor
-JZ	Cable with one green-yellow protective conductor and printed code numbering
K	Copper strip applied longitudinally and welded
(K)	Copper strip applied longitudinally over inner sheath, with overlapping
LA	Tinsel conductor (tinsel strips (Cu) stranded around carrier element consisting of chemical fibers)
LD	Corrugated aluminium sheath
Lg	Concentrically stranded
Li	Stranded wire conductor
(L)Y	Multi-layer sheath consisting of Al strip and PVC sheath
(L)2Y	Multi-layer sheath consisting of Al strip and PE sheath
2L	Double enamelled-wire insulation
M	Sheathed cable
M	Lead sheath
Mz	Lead sheath with hardener additive
(mS)	Magnetic screening
N	VDE standard
(N)	with reference to VDE standard
NC	Non-corrosive, flue-gas non-corrosive
NF	Natural colour

Codes

Cables

-O	Cable with no green-yellow protective conductor
-OZ	Cable with no green-yellow protective conductor but with printed code numbering
ö	Oil resistant
O2Y	Foam PE. Insulating cover consisting of zinc-plated PE
Q	Steel-wire braiding
(R..)	Round wire, diameter in mm
RAGL-	Compensating cable for thermocouples
RD-	Rhenomatic cables
RE	Computer cables
RG-	Coaxial cable as per MIL specification
re	Round, single-wire
rm	Round, multi-wire
RS-	Computer installation cables
S	Filament braiding
S	Signal cable
(S..)	Effective working capacitance, rating in (nF/km)
-S	Signal cable for German Federal Railways
S-	Hook-up cables
SL	Hose cable
2S	Filament braiding, consisting of two layers
St	Star-quad for phantom circuits
St I	Star-quad in telephone cables for larger distances
ST III	Star-quad in local cables
(St)	Static screening
Staku	Steel/copper conductor
Staku-Li	Steel/copper lead
..t	Anti-termite protection
T	Support element for overhead cable
T-	Breakout cable
TF	Carrie-frequency pair or quad
TIC	Triple, copper wire braiding
TIMF	Triple in metal foil
U	Braiding consisting of textile threads
VGD	Gold-plated
VN	Nickel-plated
VS	Silver-plated
VZK	Zinc-plated
VZN	Tin-plated
W	Corrugated-steel sheath
W	Enhanced heat-resistance
W	Corrugated sheath
X	Cross-linked polyvinyl chloride (X-PVC) or other materials
XPE	Cross-linked polyethylene (X-PE)
2X	Cross-linked polyethylene
7X	Cross-linked ethylene tetrafluoroethylene (X-ETFE)
10X	Cross-linked polyvinylidene fluoride (X-PVDF)
Y	PVC, polyvinyl chloride
Yu	PVC, polyvinyl chloride, non-combustible, flame resistant
Yv	PVC, polyvinyl chloride, with reinforced sheath
YV	Hook-up wire with tin-plated copper conductor
Yw	PVC, polyvinyl chloride, heat resistant up to 90° C
2Y	Polyethylene (PE)
2Yv	Polyethylene, reinforced sheath
02Y	Foam PE, cellular polyethylene
02YS	PE with skin layer, foam-skin
2YHO	Insulation consisting of polyethylene with cavity
3Y	Insulation consisting of polystyrene (PS), Styroflex®
4Y	Insulation and sheath consisting of polyamide (PA)
5Y	Insulation and sheath consisting of polytetrafluoroethylene (PTFE)
(PTFE)	Teflon® (DuPont)
5YX	Perfluoroalkoxy (PFA)
6Y	Fluorinated ethylene propylene (FEP), Teflon® (DuPont)
7Y	Insulation or sheath ethylene tetrafluoroethylene (ETFE)
8Y	Insulating cover consisting of polyimide (PI), Kapton®
9Y	Polypropylene (PP)
10Y	PVDF, polyvinylidene fluoride
11Y	Polyurethane (PUR)
12Y	TPE-E, TPE (polyether-ester based)
13Y	TPE-EE, TPE (polyether-ester based)
31Y	TPE-S, TPE (polystyrene based)
41Y	TPE-A, TPE (polyamide based)
51Y	PFA, perfluoroalkoxy alkan
71Y	ECTFE, monochlorotrifluoroethylene
91Y	TPE-O, TPE (polyolefin based)
-Z	Numbered cores
Z	Twin cables
(Z)	High-tensile strength braiding consisting of steel wires
(ZG)	Strain-relief element consisting of glass threads
(ZN)	Strain-relief element consisting of non-metallic elements

Codes

Telecommunications cables, hook-up wires and flexible leads

1 2 3 4 5 6 7 8 9 10

1. Basic cable types and types with supplementary data

A	Outdoor cable
AB	Outdoor cable with lightning-safety rating
AD	Outdoor cable with differential protection
AJ	Outdoor cable with induction safety rating
G	Mine cable
I	Installation cable
IE	Installation cable for industrial electronics
IE-H	as IE, plus halogen-free
S	Hook-up cables
T	Breakout cables
YV/Li	Hook-up wires/stranded interconnecting wire

2. Insulation

Y	PVC
2Y	PE
3Y	Polystyrene
5Y	PTFE
6Y	FEP
7Y	ETFE
02Y	Cellular PE
02YS	Cellular PE with skin-layer
P	Dry paper

3. Shielding

C	Shielding consisting of Cu braiding
D	Shielding consisting of Cu braiding
F	Petrolatum filling
(K)	Shielding consisting of Cu strip over PE inner sheath
(L)	Aluminium strip
(ms)	Magnetic steel-strip shielding
(St)	Static shielding consisting of plastic-backed metal strip
(Z)	High-tensile strength steel-wire braiding

4. Sheath

L	Smooth aluminium sheath
(L)2Y	PE-coated Al multi-layer sheath
LD	Corrugated Al sheath
M	Lead sheath
Mz	Lead sheath wit hardener additive
W	Corrugated steel sheath

5. Protective cover

Y	PVC sheath
Yv	PVC sheath, reinforced
Yw	PVC sheath, heat-resistant
Yu	PVC, flame resistant (non-combustible)
2Y	PE sheath
2Yv	PE sheath, reinforced
E	Layer with embedded plastic strip
C	Jute cover and compound

6. Number of stranding elements

..x1x	Single core
..x2x	Pair (double core), etc.

7. Conductor diameter (in mm)

8. Stranding pattern and type

F	Star-quad for phantom circuits for German Federal Railways
S	Signal cable (German Federal Railways)
StO	Star stranding, general
St	Star-quad for phantom circuits for greater distances
St I	Star-quad with no phantom circuits
St II	as St III, but with higher capacity couplings
St III	Star-quad for local cables
St IV	Star-quad for transmission range at f = 120 kHz
St V	Star-quad for transmission range at f = 550 kHz
St VI	Star-quad for transmission range at f = 17 kHz
DM	Dieselhorst-Martin quad
TF	Star-quad for carrier frequency
P	Paired type
PiMF	Pairs in metal foil
ViMF	Quad in metal foil
BdiMF	Bundle in metal foil
Kx	Coaxial pair

9. Stranding layout

Lg	Concentric stranding
Bd	Bundle stranding

10. Reinforcement

A	Layer Al wires for induction safety rating
b	Reinforcement
B	Steel-strip reinforcement for induction safety rating
1B 0,31	Steel strip layer, thickness 0.3 mm
2B	Two layers of steel strip, thickness 0.5 mm
D	Layer Cu wires for induction safety rating (reuse)
(T)	Bearer wire consisting of steel wires in overhead cable

Codes

Control cables

1	2	3	4	5		6	7	x	8

1. Basic type

N	VDE standard
(N) or X	with reference to VDE

2. Insulating material

Y	Thermoplastics
X	Cross-linked thermoplastics
G	Elastomers
HX	Halogen-free materials

3. Cable designation

A	Single-core non-sheathed cable
D	Solid wire
AF	Single-core non-sheathed cable, fine-wired
F	Flexible luminaire wire
L	Fluorescent-tube cable
LH	Connecting cable, light mechanical load
MH	Connecting cable, moderate mechanical load
SH	Connecting cable, severe mechanical load
SSH	Connecting cable, special load
SL	Control cable/welding cable
S	Control cable
LS	Lightweight control cable
FL	Flat cable
Si	Silicone cable
Z	Twin cable
GL	Glass filament
Li	Stranded wire conductor as per VDE 0812
LiF	Stranded wire conductor as per VDE 0812, ultra-fine-wired

4. Number of stranding elements

T	Strainer core
Ö	Enhance oil resistance
U	Flame resistant
w	Heat-resistant, weather-resistant
FE	Specified-life insulation
C	Shielding braid
D	Shielding in form of spiral copper shield with Cu wire
S	Steel-wire braiding as mechanical protection

5. Sheaths

as per Item 2., "Insulating material"

P/PUR	Polyurethan

6. Protective conductor

-O	without protective conductor
-J	with protective conductor

7. Number of cores

... Number of cores

8. Conductor cross-section

Data in mm²

Codes

High-voltage cables according to DIN VDE 0271/0276

Structure-type codes

1 Code

N	DIN VDE standard type
(N)	with reference to DIN VDE standard

2 Type of conductor

A	Aluminium conductor
-	Copper

3 Insulating material

Y	PVC
2X	cross-linked PE (VPE)

4 Concentric conductor, shielding

C	Concentric Cu conductor, in longitudinal twist
CW	Concentric Cu conductor, corrugated
CE	Concentric Cu conductor for individual core
S	Cu shielding
SE	Cu screening per individual core in multi-core cables
H	Conductive layer
(F)	Longitudinally watertight shielding

5 Reinforcement

B	Steel strip reinforcement
F	Flat wire, zinc-plated
G	Counterhelix consisting of zinc-plated steel strip
R	Round-section wire, zinc-plated

6 Sheath

A	Protective cover consisting of fiber materials
K	Lead sheath
KL	Aluminium sheath
Y	PVC
2Y	PE

7 Protective conductor

I	with protective conductor
O	without protective conductor

8 Number of cores

9 Nominal conductor cross-section in mm²

10 Conductor type

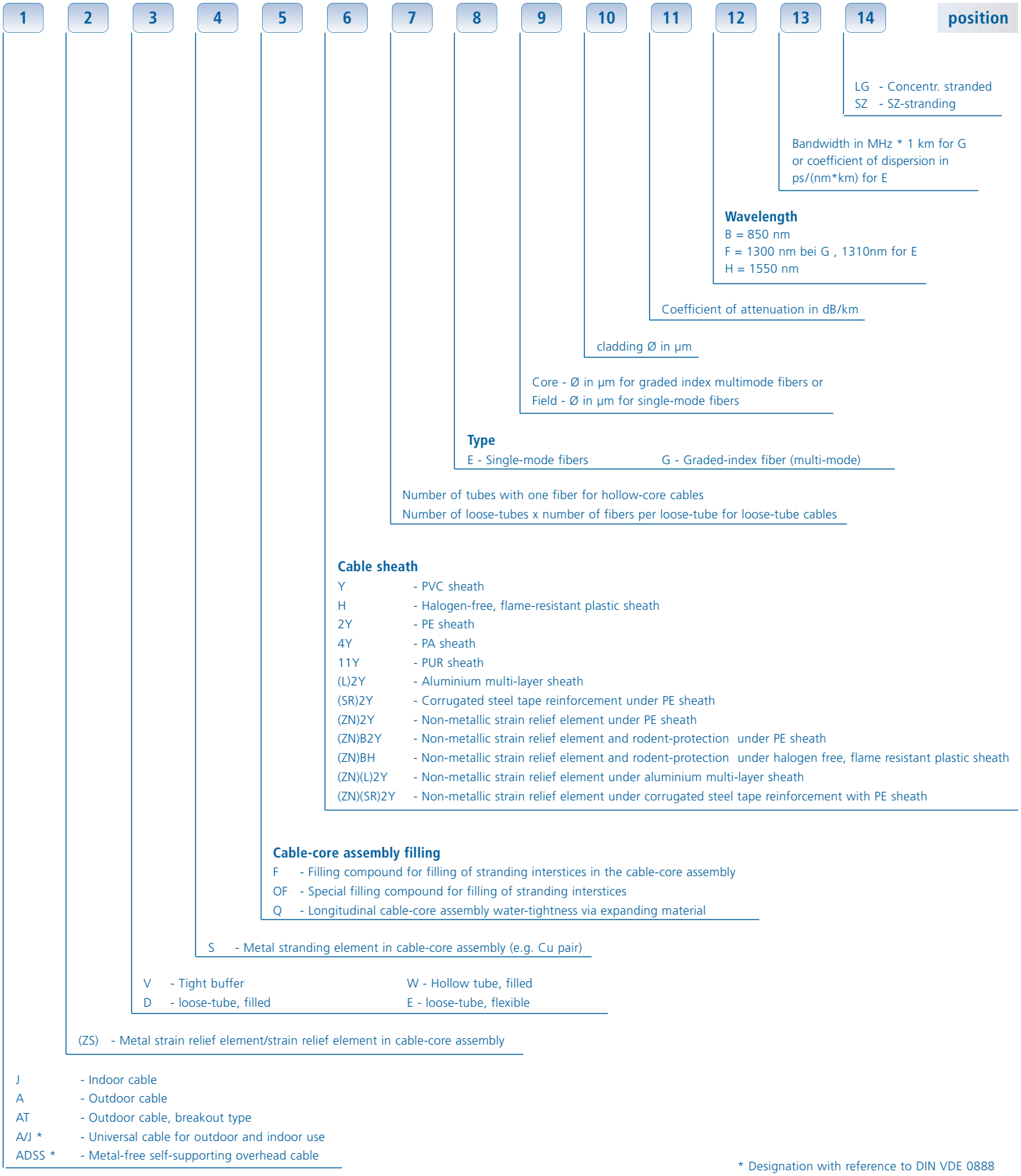
r...	Round-section conductor
s...	Sector-section conductor
o...	Oval conductor
..e...	Single-wire conductor
...m	Multi-wire conductor
..h	Hollow conductor
/V	Compacted conductor

11 Working voltage

0,6/1 kV
3,6/6 kV
6,0/10 kV
12/20 kV
18/30 kV

Codes

Fiber-optics cables, coding according to DIN VDE 0888



* Designation with reference to DIN VDE 0888

Codes

Harmonized cables as per DIN VDE 0281/DIN VDE 0282/DIN VDE 0292

Structure-type codes

1	2	3	4	5	6	-	7		8	9	10

1. Utilization codes

A	Recognized national type
H	Harmonized types

2. Working voltage U

01	100 V
03	300/300 V
05	300/500 V
07	450/750 V

3. Insulating material

B	(EPR) ethylene propylene rubber
G	(EVA) ethylene vinyl acetate copolymer
N2	(CR) Chloroprene rubber for welding cables
R	(NR and/or SR) natural and/or synthetic rubber
S	(SiR) Silicone rubber
V	(PVC) polyvinyl chloride
V2	(PVC) polyvinyl chloride, heat-resistant, +90 °C
V3	(PVC) polyvinyl chloride, low-temperature resistant
V4	(PVC) polyvinyl chloride, cross-linked
Z	(PE) polyethylene, cross-linked
E	(PE) polyethylene

4. Structural elements

C	Shielding
Q4	(PA) additional polyamide core covering
T	additional textile braiding over stranded cores
T6	additional textile braiding over individual core

5. Sheath material

B	(EPR) ethylene propylene rubber
-J	Glass-fiber braiding
N	(CR) chloroprene rubber
N2	(CR) chloroprene rubber for welding cables
N4	(CR) chloroprene rubber, heat-resistant
Q	(PUR) polyurethane
R	(NR and/or SR) natural and/or synthetic rubber
T	Textile braiding
T2	Textile braiding, with flame-resistant compound
V	(PVC) polyvinyl chloride
V2	(PVC) polyvinyl chloride, heat-resistant
V3	(PVC) polyvinyl chloride, low-temperature resistant
V4	(PVC) polyvinyl chloride, cross-linked
V5	(PVC) oil resistant

6. Special structural features

D3	Strain-relief elements (strainer core)
D5	Strain-bearing centre (no strainer core)
FM	Telecommunications core in high-voltage cables
H	Flat, divisible cable (twin cable)
H2	Flat, non-divisible cable (two-core sheathed cable)
H6	Flat, non-divisible cable (multi-core sheathed cable)
H7	Two-layer insulating cover
H8	Spiral cables

7. Conductor type

D	Fine-wired, for welding cables
E	(Ultra) fine-wired, for welding cables
F	Fine-wired in flexible cables
H	(Ultra) fine-wired in flexible cables
K	Fine-wired in cables for fixed installation
R	Multi-wire, round-section, Class 2
U	Single-wire, round-section, Class 1
Y	Tinsel wire, DIN 47104

8. Number of cores

9. Protective conductor

G	with protective conductor
X	without protective conductor

10. Nominal conductor cross-section in mm²

Examples:

H07V-U 2.5 black (according to DIN VDE 0281)
harmonized PVC single-core non-sheathed cable, single-core, 2.5 mm², single-wire, rated voltage 750 V

H07RN-F 3 G 1,5 (according to DIN VDE 0282)
harmonized rubber-sheathed cable for moderate loads,
three-core, 1,5 mm² fine-wired, protective conductor green-yellow,
rated voltage 750 V

Codes

Harmonized cables as per DIN 0292 and HD 361 S2/S3

This code system is under development at CENELEC for harmonized high-voltage cables and insulated high-voltage cables and is defined in Harmonization Document HD 361 S2 and 361 S3.

Types of standard

Code	Assignment to standards
H	Cables as per harmonized standards
A	Recognized national cable type

Conductor material

No symbol	Copper
-A	Aluminium
-Z	Special-material and/or special geometry conductors

Conductors and conductor geometries

-D	Fine-wired conductor for welding cables
-E	Ultra-fine-wired conductor for welding cables
-F	Fine-wired conductor for a flexible cable according to DIN VDE 0295, Class 6
-H	Ultrafine-wired conductor of a flexible cable according to DIN VDE 0295, class 6
-K	Fine-wired conductor in a cable for fixed installation (in accordance with DIN VDE 0295, Class 5 if no definition to the contrary)
-M	Segmental (Milliken) conductor
-R	Multi-wire round-section cable
-S	Multi-wire sector cross-section conductor
-U	Single-wire round-section cable
-W	Single-wire sector conductor
-Y	Tinsel conductor
-Z	Special-geometry and/or special material conductor

Code number of cores and nominal conductor cross-section

Number	Number n of cores
X	Multiplication symbol for types with no green-yellow core
G	Multiplication symbol for types with green-yellow core
Y	Tinsel conductor with non-specified nominal cross-section

Insulating and sheath materials

B	Ethylene propylene rubber for temps. up to +90° C
B2	Ethylene propylene rubber, adjusted hard
B3	Butyl rubber (isobutylene isoprene rubber)
E	Polyethylene
E2	Polyethylene, high density (HD)
E4	Polytetrafluoroethylene
E5	Fluorinated (ethylene propylene) copolymers
E6	Ethylene tetrafluoroethylene copolymers
E7	Polypropylene

Material

G	Ethylene vinyl acetate
J	Glass-fiber braid
J2	Glass-fiber wrapping
M	Mineral insulation
N	Chloroprene rubber (or equivalent material)
N2	Special chloroprene rubber mixture
N4	Chlorosulfonated or chlorinated polyethylene
N5	Nitrile butadiene rubber
N6	Fluorinated rubber
N7	PVC nitrile butadiene rubber mixture
N8	Special polychloroprene rubber mixture, water-resistant
P	Compound-impregnated paper insulation for multi-core belted cables
Q	Polyurethane
Q2	Polyethylene terephthalate
Q3	Polystyrene
Q4	Polyamide
Q5	Polyimide
Q6	Polyvinylidene fluoride
R	Ethylene propylene rubber or equivalent synthetic elastomer for temperatures of up to + 60° C, for continuous-operation temperature of 60° C
S	Silicone rubber
T	Textile braid over the stranded cores, impregnated/non-impregnated
T2	Textile braid with flame-resistant compound, impregnated
T3	Textile layers, wrapping or tape
T4	Textile layers, but with flame-resistant compound, impregnated
T5	Anti-corrosion protection
T6	Textile braid over every core of a multi-core cable, impregnated/non-impregnated
V	PVC flexible
V2	PVC flexible, enhanced temp.-resistance, +90° C
V3	PVC flexible, for low temperatures
V4	PVC flexible, cross-linked
V5	PVC flexible, oil resistant
X	Cross-linked polyethylene
Z	Cross-linked mixture on polyolefin basis (less evolution of corrosive gases and fuels in case of fire)
Z1	Thermoplastic mixture on polyolefin basis (less evolution of corrosive gases and fuels in case of fire)

Codes

Harmonized cables according to DIN 0292 and HD 361 S2/S3

This system of codes is under development at CENELEC for harmonized high-voltage cables and insulated high-voltage cables and is defined in Harmonization Document HD 361 S2 and 361 S3.

Metal sheaths, concentric conductors and shield

Code	Metal sheath
A2	Aluminium sheath, extruded or welded, smooth
A3	Aluminium sheath, extruded or welded, corrugated
A4	Aluminium sheath on every core
A5	Aluminium sheath, consisting of strip
C2	Copper sheath
C3	Copper sheath, corrugated
F	Steel sheath
F3	Steel sheath, corrugated
K	Zinc sheath
L	Alloyed lead sheath for general use
L2	Non-alloyed lead sheath, pure commercially available lead
L4	Alloyed lead sheath on every core
L5	non-alloyed lead sheath on every core
L6	Alloyed lead sheath, but composition different to above

Concentric conductors

A	Concentric aluminium conductor
A6	Concentric aluminium conductor, meander-pattern
C	Concentric copper conductor
C6	Concentric copper conductor, meander-pattern
C9	Divided concentric copper conductor

Code	Shielding
A7	Aluminium shielding
A8	Aluminium shielding on each core
C4	Copper shielding in form of braiding over the stranded cores
C5	Copper shielding in form of braiding over each stranded cores
C7	Copper shielding in form of strips, round-section or special-section wire over the stranded cores
C8	Copper shielding acoording to C7 over every core
D	Shielding consisting of one or several thin steel strips which are located directly over the stranded cores and are in contact with a stranded-in bright conductor

Reinforcement (see DIN VDE 0292)

Z2	Round-section steel-wire reinforcement (with counterhelix if specified), zinc-plated/non-zinc-plated
Z3	Flat-section steel-wire reinforcement (with counterhelix if specified), zinc-plated/non-zinc-plated
Z4	Iron-strip reinforcement, zinc-plated/non-zinc-plated
Z5	Steel-wire braid, zinc-plated/non-zinc-plated
Z6	Steel-wire support braiding
Z7	Special-section steel-wire reinforcement
Y2	Round-section aluminium wire reinforcement
Y3	Flat-section aluminium wire reinforcement
Y5	Reinforcement consisting of special materials
Y6	Steel-wire and/or steel-strip + copper wire reinforcement

Special structural elements

D2	Textile or steel-wire strainer cores over cable core assembly
D3	Textile strainer core consisting of one or several structural elements, located in center of a round-section cable or divided in a flat cable
D4	Self-supporting cable, the conductors of which perform the function of the strain-relief element
D5	Strain-bearing centre (no strainer core), intended for elevator control cables
D7	as D3, but strainer core connected externally with cable
D8	as D7, but section perpendicular to the axis of the cable or line produces the Figure "8"

Special types

No code	Round-section cable structure
H	Flat type, divisible cables, with or without sheath
H2	Flat type, non-divisible
H3	Flat-webbed cable
H4	Flat multi-core cable with one bright conductor
H5	Arrangement of two or more single-core non-sheathed cables stranded with one another
H6	Flat cable according to HD 359 or EN 50214 with three or more cores
H7	Cable with two-layer extruded insulating cover
H8	Spiral cable

International color coding for UL-/CSA-Control Cable

Core No.	Color	Core No.	Color
1	black	31	green-red
2	brown	32	green-orange
3	red	33	green-blue
4	orange	34	green-violet
5	yellow	35	green-grey
6	green	36	green-white
7	blue	37	yellow-black
8	violet	38	yellow-brown
9	grey	39	yellow-red
10	white	40	yellow-orange
11	white-black	41	yellow-blue
12	white-brown	42	yellow-violet
13	white-red	43	yellow-grey
14	white-orange	44	yellow-white
15	white-yellow	45	grey-black
16	white-green	46	grey-brown
17	white-blue	47	grey-red
18	white-violet	48	grey-orange
19	white-grey	49	grey-yellow
20	brown-black	50	grey-green
21	brown-red	51	grey-blue
22	brown-orange	52	grey-violet
23	brown-yellow	53	grey-white
24	brown-green	54	orange-black
25	brown-blue	55	orange-brown
26	brown-violet	56	orange-red
27	brown-grey	57	orange-yellow
28	brown-white	58	orange-geen
29	green-black	59	orange-blue
30	green-brown	60	orange-violet

Core marking

New core markings for low-voltage cables

European standardization of core marking (HD 308 S2) has achieved a joint step toward a common "language" for manufacturers and cable-using industries throughout Europe. The mandatory character of the new colour-coding system will in future make these products comparable beyond national boundaries.

Innovation
A significant innovation is the introduction of the core colour "Grey" for outer conductors for improved differentiation of the cores. The provision concerning colours for cores with a reduced cross-section (green-yellow or blue, depending on type) remains unchanged.
The new core identification colours for two to five-core cables are shown in the following overview:

Core markings for cables **with green-yellow core**

Number of cores	Core colours				
	Protective conductor	other conductors			
3	green-yellow	blue	brown		
4	green-yellow		brown	black	grey
5	green-yellow	blue	brown	black	grey

Core markings for cables **with no green-yellow core**

Number of cores	Core colours				
2	blue	brown			
3		brown	black	grey	
4	blue	brown	black	grey	
5	blue	brown	black	grey	black

The transitional phase
This new standard has been in effective since January 2003. There are, nonetheless, long periods allowed for the transitional phases, and cables with the old core markings may still be used without restriction until April 1, 2006. Users of cables, and also manufacturers and traders, will be able during the transitional period to complete projects already started using products identical to those which have in some cases already been installed.
Our Technical Support department is available for further information.

Core marking

Core colours according to DIN IEC 304

The colours stipulated should conform with DIN IEC 304.

- **Single-core cables**
  - Rated voltage Uo/U 300/500 V

  The following colours are recommended for insulated wire cables:
  Black, blue, brown, orange, pink, turquoise, violet, white, also (with certain restrictions) green, depending on the provisions of the applicable safety regulations.
  Green is permitted for identification of illumination set cables.

  All two-colour combinations of the individual colours stated above are permissible.

  - Rated voltage Uo/U 450/750 V

  The following colours are recommended for single-core non-sheathed cables:
  Black, blue, brown, orange, pink, turquoise, violet and white. No two-colour combinations (with the exception of green-yellow) are permitted.

- **Single-core and single-core sheathed cables**
  Correct colour is black or green-yellow, with the exception of illumination and illumination set cables (for which the colour brown is permitted).

Note

- In multi-core cables, the green-yellow cores must be located in the outer layer.
- Correct order of counting and configuration of cores bearing printed numbers is from inside, starting at No. 1, and counting sequentially through all layers analogously.

Colour codes according to DIN IEC 757, identical to CENELEC-HAR Document HD 457

Colour	**Code** up to now **according to DIN 47002**	New **code** **according to DIN IEC 757**
Black	sw	BK
Brown	br	BN
Red	rt	RD
Orange	or	OG
Yellow	ge	YE
Green	gn	GN
Blue	bl	BU
Violet	vi	VT
Grey	gr	GY
White	ws	WH
Pink	rs	PK
Turquoise	tk	TQ
Green-Yellow	gnge	GNYE
Silver	-	SR

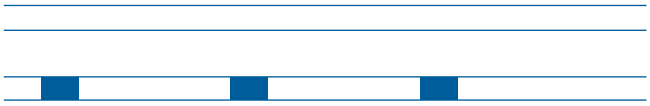
Core marking

Marking according to VDE 0813 layer stranded

The cores are marked in colour groups in such a way that each 4, 5, 6, and 10 different core colours repeat sequentially in accordance with the following pattern:

Number of cores in a colour group	Core colour sequence
4	blue, red, grey, green
5	blue, red, grey, green, brown
6	blue, red, grey, green, brown, black
10	blue, red, grey, green, brown, black, yellow, white, pink, violet

The cores are to marked by means of black rings.



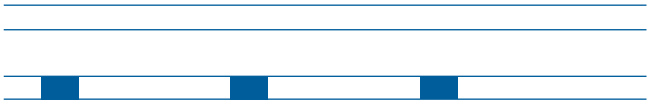
Marking according to VDE 0813 bundle stranded

Bundle No.	Sequential number of stranding element					Ring colour of a-core	Ring colour of b-core
1	1	2	3	4	5	blue	white
2	6	7	8	9	10	yellow	white
3	11	12	13	14	15	green	white
4	16	17	18	19	20	brown	white
5	21	22	23	24	25	black	white
6	26	27	28	29	30	blue	grey
7	31	32	33	34	35	yellow	grey
8	36	37	38	39	40	green	grey
9	41	42	43	44	45	brown	grey
10	46	47	48	49	50	black	grey
	blue	yellow	green	brown	black		
	Ring colour of b-core Ring colour of c-core red Ring colour of d-core pink Ring colour of e-core black						

Colour repetition starts with the 1st stranding element as from the 51st stranding element.

Stranding elements are pairs, triples and quins
Pairs a- and b-cores
Triples a-, b- and c-cores
Quins a-, b- c-, d- and e-cores
Five stranding elements with the same ring colour for the a-core are to be grouped into a bundle.

The cores are marked with rings.



a-core

b-core

Core marking

Core Identification Code according to VDE colour code for telephone cables

VDE 0815 and 0816 for Bundle stranding
Colour code for cable types J-YY, J-2Y(ST)Y, A-2Y(L)2Y, A-2YF(L)2Y

The cores are marked by means of rings.

Trunk 1

a-core — without ring

b-core

Trunk 2

a-core

b-core

Basic colours for the core insulation of the five star-quad of a bundle

Quad 1 red
Quad 2 green
Quad 3 grey
Quad 4 yellow
Quad 5 white

The numbered bundles are marked with red spirals.

VDE 0815
Colour code for indoor telephone cable J-Y(ST)Y...LG
Pairs stranded in layers, by numbers from outside to inside

a-core: 1st pair of each layer red, white for all other pairs

b-core: blue, yellow, green, brown, black continuously repeating

Exception: The two-pair installation cable is stranded star quad.

Trunk 1 (Pair 1): a-core red b-core black
Trunk 2 (Pair 2): a-core white b-core yellow

VDE 0815
Colour code for industrial electronics cables JE...

Marking:
The cores of the pairs of each bundle are identified by the basic colours of the insulating cover, which repeat in the same order in each bundle.

Basic pair colour

Pair	1	2	3	4
a-core	blue	grey	green	white
b-core	red	yellow	brown	black

The bundles are identified by the colour of the rings on the insulating core covers and the sequence of the coloured rings in groups. The spacing of the groups of rings is approx. 60 mm.

In cables with more than twelve bundles, the 13th and subsequent bundles have coloured spirals.

Counting of the bundles starts at the innermost layer.

Bundle	Ring colour	Ring group	Bundle spiral	Bundle	Ring colour	Ring group	Bundle spiral
1	pink		-	12	violet		-
2	pink		-	13	pink		blue
3	pink		-	14	pink		blue
4	pink		-	15	pink		blue
				16	pink		blue
5	orange		-	17	orange		red
6	orange		-	18	orange		red
7	orange		-	19	orange		red
8	orange		-	20	orange		red
9	violet		-				
10	violet		-				
11	violet		-				

Core coding

TKD Core Colour Code for ÖPVC-JB cables, core coloured and with green-yellow protective conductor

The TKD Colour Code and its colour combinations for up to 102 cores has been drafted in accordance with the requirements of the cable-using industry.

These colour combinations consist of eleven basic colours.

Coding as from Core No. 12 is accomplished by means of one or two coloured rings or longitudinal stripes, with a ring width of approx. 2 mm, in order to permit unequivocal identification of each core.

Counting procedure: Cores must be counted starting from the innermost layer and proceeding through layers sequentially outward and analogously.
Protective conductors: The green-yellow protective conductor is the final core in the outermost layer.

TKD-colour code **for 6 and more cores:**

Core No.	Core colour	Core No.	Core colour	Core No.	Core colour
0	green-yellow	36	orange-green	71	blue-white-red
1	black	37	brown-green	72	yellow-white-red
2	blue			73	green-white-red
3	brown	38	red-yellow	74	brown-white-red
4	beige	39	blue-yellow		
5	yellow	40	violet-yellow	75	red-white-black
6	green	41	weiß-yellow	76	blue-white-black
7	violet	42	brown-yellow	77	yellow-white-black
8	pink			78	green-white-black
9	orange	43	red-blue	79	violett-white-black
10	transparent	44	white-blue	80	orange-white-black
		45	orange-blue	81	brown-white-black
11	red-white	46	brown-blue		
12	blue-white			82	red-white-green
13	yellow-white	47	yellow-violet	83	yellow-white-green
14	green-white	48	green-violet	84	violett-white-green
15	violet-white	49	white-violet	85	orange-white-green
16	orange-white	50	orange-violet	86	brown-white-green
17	brown-white	51	braun-violet		
		52	black-white	87	red-white-blue
18	blue-red	53	black-yellow	88	yellow-white-blue
19	yellow-red	54	black-red	89	orange-white-blue
20	green-red	55	black-green	90	brown-white-blue
21	white-red	56	black-blue		
22	orange-red	57	black-violet	91	yellow-white-violet
23	brown-red			92	green-white-violet
		58	grey-white	93	orange-white-violet
24	red-black	59	grey-black	94	brown-white-violet
25	blue-black	60	grey-yellow		
26	yellow-black	61	grey-red	95	blue-red-black
27	green-black	62	grey-blue	96	yellow-red-black
28	violet-black	63	grey-violet	97	green-red-black
29	white-black			98	white-red-black
30	orange-black	64	red-grey	99	brown-red-black
31	brown-black	65	blue-grey		
		66	yellow-grey	100	yellow-red-green
32	red-green	67	green-grey	101	white-red-green
33	grau-green	68	violet-grey	102	orange-red-green
34	violet-green	69	white-grey		
35	white-green	70	orange-grey		

Core coding

Colour code according to DIN 47100 (layer stranding) with colour repetition/without colour repetition

Core coding and the colour of the insulating covers are executed in accordance with DIN 47002 and DIN IEC304 (in conformity with Harmonization Document HD 402 S2).

The configuration of the cores or pairs of cores is in accordance with the tables shown below.
In order to improve identification and also for safety reasons, the **brighter colour (the first colour)** is specified as the **basic colour** and the **darker colour (second colour)** as the **top colour.**

The colour combination consists of 10 basic colours. As from Core No. 11, marking is accomplished by means of one or two coloured rings, with a ring width of 2 to 3 mm.
Ring spacing is approx. 7 mm.

Counting procedure: Counting of cores starts at the innermost layer, proceeding through all layers sequentially and analogously to the outside

Colour code according to DIN 47100 with colour repetition as from the 45th core

Core No.	Core colour	Core No.	Core colour	Core No.	Core colour	Core No.	Core colour
1	white	17	white-grey	33	green-red	49	grey
2	brown	18	grey-brown	34	yellow-red	50	pink
3	green	19	white-pink	35	green-black	51	blue
4	yellow	20	pink-brown	36	yellow-black	52	red
5	grey	21	white-blue	37	grey-blue	53	black
6	pink	22	brown-blue	38	pink-blue	54	violet
7	blue	23	white-red	39	grey-red	55	grey-pink
8	red	24	brown-red	40	pink-red	56	red-blue
9	black	25	white-black	41	grey-black	57	white-green
10	violet	26	brown-black	42	pink-black	58	brown-green
11	grey-pink	27	grey-green	43	blue-black	59	white-yellow
12	red-blue	28	yellow-grey	44	red-black	60	yellow-brown
13	white-green	29	pink-green	45	white	61	white-grey
14	brown-green	30	yellow-pink	46	brown		
15	white-yellow	31	green-blue	47	green		
16	yellow-brown	32	yellow-blue	48	yellow		

Note: The four-core cable is an exception and is marked using a white, yellow, brown, green colour sequence.

Colour code according to DIN 47100 without colour repetition

Core No.	Core colour	Core No.	Core colour	Core No.	Core colour	Core No.	Core colour
1	white	17	white-grey	33	green-red	49	white-green-black
2	brown	18	grey-brown	34	yellow-red	50	green-brown-black
3	green	19	white-pink	35	green-black	51	white-yellow-black
4	yellow	20	pink-brown	36	yellow-black	52	yellow-brown-black
5	grey	21	white-blue	37	grey-blue	53	white-grey-black
6	pink	22	brown-blue	38	pink-blue	54	grey-brown-black
7	blue	23	white-red	39	grey-red	55	white-pink-black
8	red	24	brown-red	40	pink-red	56	pink-brown-black
9	black	25	white-black	41	grey-black	57	white-blue-black
10	violet	26	brown-black	42	pink-black	58	brown-blue-black
11	grey-pink	27	grey-green	43	blue-black	59	white-red-black
12	red-blue	28	yellow-grey	44	red-black	60	brown-red-black
13	white-green	29	pink-green	45	white-brown-black	61	black-white
14	brown-green	30	yellow-pink	46	yellow-green-black		
15	white-yellow	31	green-blue	47	grey-pink-black		
16	yellow-brown	32	yellow-blue	48	blue-red-black		

Please note: Always state from the 45th core whether this is to be with or without colour repetition!

Core marking

Colour code according to DIN 47100 (twisted pairs) with colour repetition

Core marking and the colours of the insulating cover are executed in accordance with DIN 47002 and DIN IEC 304 (in conformity with Harmonization Document HD 402 S2).

Configuration of the cores or core pairs is effected in accordance with the tables shown below.
To improve identification and also for safety reasons, the **brighter colour (the first colour)** is defined as the **basic colour** and the **darker colour (second colour)** as the **top colour.**

The colour combination consists of 10 basic colours. As from Core No. 11, marking is accomplished by means of one or two coloured rings, with a ring width of 2 to 10 mm. Ring spacing is approx. 7 mm.

Counting procedure: Counting starts at the outermost layer and proceeds consecutively and in the same direction inward through all the layers.

Pair number			Pair colours	
			a-core	b-core
1	23	45	white	brown
2	24	46	green	yellow
3	25	47	grey	pink
4	26	48	blue	red
5	27	49	black	violet
6	28	50	greypink	redblue
7	29	51	whitegreen	browngreen
8	30	52	whiteyellow	yellowbrown
9	31	53	whitegrey	greybrown
10	32	54	whitepink	pinkbrown
11	33	55	whiteblue	brownblue
12	34	56	whitered	brownred
13	35	57	whiteblack	brownblack
14	36	58	greygreen	yellowgrey
15	37	59	pinkgreen	yellowpink
16	38	60	greenblue	yellowblue
17	39	61	greenred	yellowred
18	40		greenblack	yellowblack
19	41		greyblau	pinkblue
20	42		greyrot	pinkred
21	43		greyblack	pinkblack
22	44		blueblack	redblack

Please note: From the 45th core onward, please always state whether with or without colour repetition!

Stranded conductor structure

Copper stranded conductor structure according to DIN VDE 0295 and IEC 228

Stranded conductor structure according to DIN VDE 0295 has been defined in conformity with IEC 228 for conductor class 2 column 1, conductor class 5 column 3 and conductor Class 6 Column 4 as from 0.5 mm².
The diameters of the individual wires of each conductor must not exceed the maximum value stated for each nominal cross-section, see table below.

Cross section	Multi-wire round-section conductor VDE 0295 **class 2** [2] column 1	Multi-wire flexible strands **Standard structure** column 2	Fine-wired flexible strands VDE 0295 **class 5** [1] column 3	**Ultra-fine-wired flexible strands**			
				VDE 0295 **class 6** [1] column 4	**Standard structure**		
					column 5	column 6	column 7
0,035		7x0,08					
0,05						14x0,07	26x0,05
0,08							40x0,05
0,09					7x0,124	24x0,07*	
0,14			18x0,10	18x0,10	18x0,10	36x0,07	72x0,05
0,25			14x0,15	32x0,10	32x0,10	65x0,07	128x0,05
0,34		7x0,25	19x0,15	42x0,10	42x0,10	88x0,07	174x0,05
0,38		7x0,27	12x0,20	21x0,15	48x0,10	100x0,07	194x0,05
0,5	7x0,30	7x0,30	16x0,20	28x0,15	64x0,10	131x0,07	256x0,05
0,75	7x0,37	7x0,37	24x0,20	42x0,15	96x0,10	195x0,07	384x0,05
1,0	7x0,43	7x0,43	32x0,20	56x0,15	128x0,10	260x0,07	512x0,05
1,5	7x0,52	7x0,52	30x0,25	84x0,15	192x0,10	392x0,07	768x0,05
2,5	7x0,67	19x0,41	50x0,25	140x0,15	320x0,10	651x0,07	1280x0,05
4	7x0,85	19x0,52	56x0,30	224x0,15	512x0,10	1040x0,07	
6	7x1,05	19x0,64	84x0,30	192x0,20	768x0,10	1560x0,07	
10	7x1,35	49x0,51	80x0,40	320x0,20	1280x0,10	2600x0,07	
16	7x1,70	49x0,65	128x0,40	512x0,20	2048x0,10	4116x0,07	
25	7x2,13	84x0,62	200x0,40	800x0,20	3200x0,10	6370x0,07	
35	7x2,52	133x0,58	280x0,40	1120x0,20	4410x010	9100x0,07	
50	19x1,83	133x0,69	400x0,40	705x0,30			
70	19x2,17	189x0,69	356x0,50	990x0,30			
95	19x2,52	259x0,69	485x0,50	1340x0,30			
120	37x2,03	336x0,67	614x0,50	1690x0,30			
150	37x2,27	392x0,69	765x0,50	2123x0,30			
185	37x2,52	494x0,69	944x0,50	1470x0,40			
240	61x2,24	627x0,70	1225x0,50	1905x0,40			
300	61x2,50	790x0,70	1530x0,50	2385x0,40			
400	61x2,89		2034x0,50				
500	61x3,23		1768x0,60				
630	91x2,97		2228x0,60				

Maximum permissible largest individual wire Ø	
Nominal wire-Ø	Maximum value for individual wire-Ø
mm	mm
0,2	0,21
0,25	0,26
0,3	0,31
0,4	0,41
0,5	0,51
0,6	0,61

* Alternative 19x0,08

Note:

[1] DIN VDE 0295, in conformity with IEC 228, specifies only the maximum individual-wire diameter for **Conductor Class 5 and Conductor Class 6.** The number of wires is in no case binding.

[2] For **Conductor Class 2,** however, the minimum number of individual wires in the round-section conductor and not the individual-wire diameter applies. The required maximum values for conductor resistance in each conductor at 20° C are definitive. The respective nominal cross-section for the specified maximum values must not be exceeded.

Explanatory notes on ultra-fine-wired stranded conductors, Class 6

Column 4 Standard flexible structure as per DIN VDE
Column 5 High flexibility
Column 6 Ultra-high flexibility
Column 7 Extreme flexibility

Wires and stranded conductors

Desina®

Property	Requirement	Guideline figure
Shielded power cables: Servo cables, frequency converters, etc.	orange	RAL2003
Encoder cables: Linear and rotary transmitters, analog sensors, etc.	green	RAL6018
Field bus: Hybrid field-bus cables (see D_spec. 3)	violet, 4 x 1,5 mm² Cu, 2 x POF	RAL 4001
Switched peripherals, sensor systems: Pneumatic and hydraulic valves, proximity switches, pressure switches, etc.	yellow, 4 x 0,34 mm²	RAL1021
Power cables: Equipment power supply, three-phase motors	black	RAL 9005
Control cables: 24V supply	grey	RAL 7040

AWG wires and stranded conductors

AWG No.	AWG-structure n x AWG	Cable structure n x wire-Ø mm	Conductor cross-section mm²	Outer conductor Ø mm	Conductor resistance Ω/km	Conductor weight kg/km
36	solid	solid	0,013	0,127	1460,0	0,116
36	7/44	7 x 0,05	0,014	0,152	1271,0	0,125
34	solid	solid	0,020	0,160	918,0	0,178
34	7/42	7 x 0,064	0,022	0,192	777,0	0,196
32	solid	solid	0,032	0,203	571,0	0,284
32	7/40	7 x 0,078	0,034	0,203	538,0	0,302
32	19/44	19 x 0,05	0,037	0,229	448,0	0,329
30	solid	solid	0,051	0,254	365,0	0,45
30	7/38	7 x 0,102	0,057	0,305	339,0	0,507
30	19/42	19 x 0,064	0,061	0,305	286,7	0,543
28	solid	solid	0,080	0,330	232,0	0,71
28	7/36	7 x 0,127	0,087	0,381	213,0	0,774
28	19/40	19 x 0,078	0,091	0,406	186,0	0,81
27	7/35	7 x 0,142	0,111	0,457	179,0	0,988
26	solid	solid	0,128	0,409	143,0	1,14
26	10/36	10 x 0,127	0,127	0,533	137,0	1,13
26	19/38	19 x 0,102	0,155	0,508	113,0	1,38
26	7/34	7 x 0,160	0,141	0,483	122,0	1,25

Wires and stranded conductors

AWG wires and stranded conductors

AWG No.	AWG-structure n x AWG	Cable structure n x wire-Ø mm	Conductor cross-section mm²	Outer conductor Ø mm	Conductor resistance Ω/km	Conductor weight kg/km
24	solid	solid	0,205	0,511	89,4	1,82
24	7/32	7 x 0,203	0,227	0,610	76,4	2,02
24	10/34	10 x 0,160	0,201	0,582	85,6	1,79
24	19/36	19 x 0,127	0,241	0,610	69,2	2,14
24	41/40	41 x 0,078	0,196	0,582	84,0	1,74
22	solid	solid	0,324	0,643	55,3	2,88
22	7/30	7 x 0,254	0,355	0,762	48,4	3,16
22	19/34	19 x 0,160	0,382	0,787	45,1	3,40
22	26/36	26 x 0,127	0,330	0,762	52,3	2,94
20	solid	solid	0,519	0,813	34,6	4,61
20	7/28	7 x 0,320	0,562	0,965	33,8	5,00
20	10/30	10 x 0,254	0,507	0,889	33,9	4,51
20	19/32	19 x 0,203	0,520	0,940	28,3	5,47
20	26/34	26 x 0,160	0,523	0,914	33,0	4,65
20	41/36	41 x 0,127	0,20	0,914	32,9	4,63
18	solid	solid	0,823	1,020	21,8	7,32
18	7/26	7 x 0,404	0,897	1,219	19,2	7,98
18	16/30	16 x 0,254	0,811	1,194	21,3	7,22
18	19/30	19 x 0,254	0,963	1,245	17,9	8,57
18	41/34	41 x 0,160	0,824	1,194	20,9	7,33
18	65/36	65 x 0,127	0,823	1,194	21,0	7,32
16	solid	solid	1,310	1,290	13,7	11,66
16	7/24	7 x 0,511	1,440	1,524	12,0	12,81
16	65/34	65 x 0,160	1,310	1,499	13,2	11,65
16	26/30	26 x 0,254	1,317	1,499	13,1	11,72
16	19/29	19 x 0,287	1,229	1,473	14,0	10,94
16	105/36	105 x 0,127	1,330	1,499	13,1	11,84
14	solid	solid	2,080	1,630	8,6	18,51
14	7/22	7 x 0,643	2,238	1,854	7,6	19,92
14	19/27	19 x 0,361	1,945	1,854	8,9	17,31
14	41/30	41 x 0,254	2,078	1,854	8,3	18,49
14	105/34	105 x 0,160	2,111	1,854	8,2	18,79
12	solid	solid	3,31	2,05	5,4	29,46
12	7/20	7 x 0,813	3,63	2,438	4,8	32,30
12	19/25	19 x 0,455	3,09	2,369	5,6	27,50
12	65/30	65 x 0,254	3,292	2,413	5,7	29,29
12	165/34	165 x 0,60	3,316	2,413	5,2	29,51
10	solid	solid	5,26	2,59	3,4	46,81
10	37/26	37 x 0,404	4,74	2,921	3,6	42,18
10	49/27	49 x 0,363	5,068	2,946	3,6	45,10
10	105/30	105 x 0,254	5,317	2,946	3,2	47,32
8	49/25	49 x 0,455	7,963	3,734	2,2	70,87
8	133/29	133 x 0,287	8,604	3,734	2,0	76,57
8	655/36	655 x 0,127	8,297	3,734	2,0	73,84

Wires and stranded conductors

AWG wires and stranded conductors

AWG No.	AWG-structure n x AWG	Cable structure n x wire-Ø mm	Conductor cross-section mm^2	Outer conductor Ø mm	Conductor resistance Ω/km	Conductor weight kg/km
4	133/25	133 x 0,455	21,625	5,898	0,80	192,46
4	259/27	259 x 0,363	26,804	5,898	0,66	238,55
4	1666/36	1666 x 0,127	21,104	5,898	0,82	187,82
2	133/23	133 x 0,574	34,416	7,417	0,50	306,30
2	259/25	259 x 0,404	33,201	7,417	0,52	295,49
2	665/30	665 x 0,254	33,696	7,417	0,52	299,89
2	2646/36	2646 x 0,127	33,518	7,417	0,52	298,31
1	133/22	133 x 0,643	43,187	8,331	0,40	384,37
1	259/25	259 x 0,455	42,112	8,331	0,41	374,80
1	817/30	817 x 0,254	41,397	8,331	0,42	368,43
1	2109/34	2109 x 0,160	42,403	8,331	0,41	377,39
1/0	133/21	133 x 0,724	54,75	9,347	0,31	487,28
1/0	259/24	259 x 0,511	53,116	9,347	0,32	472,73
2/0	133/20	133 x 0,813	69,043	10,516	0,25	614,48
2/0	259/23	259 x 0,574	67,021	10,516	0,25	596,49
3/0	259/22	259 x 0,643	84,102	11,786	0,20	748,51
3/0	427/24	427 x 0,511	87,570	11,786	0,19	779,37
4/0	259/21	259 x 0,724	106,626	13,259	0,16	948,97
4/0	427/23	427 x 0,574	110,494	13,259	0,15	983,39

AWG wires (solid conductors)

AWG Nr.	Wire Ø mm	AWG Nr.	Wire Ø mm	AWG Nr.	Wire Ø mm
44	0,050	26	0,404	10	2,588
41	0,070	25	0,455	9	2,906
40	0,079	24	0,511	8	3,268
39	0,089	23	0,574	7	3,665
38	0,102	22	0,643	6	4,115
37	0,144	21	0,724	5	4,620
36	0,127	20	0,813	4	5,189
35	0,142	19	0,912	3	5,827
34	0,160	18	1,024	2	6,543
33	0,180	17	1,151	1	7,348
32	0,203	16	1,290	1/0	8,252
31	0,226	15	1,450	2/0	9,266
30	0,254	14	1,628	3/0	10,404
29	0,287	13	1,829	4/0	11,684
28	0,320	12	2,052		
27	0,363	11	2,304		

Conductor resistance data

Conductor resistance data according to VDE 0295 and IEC 228

Conductor resistance data for cables and insulated cables for high-voltage systems are executed in accordance with DIN VDE 0295 in conformity with IEC 228, depending on conductor class, as from 0.5 mm². The resistance of each conductor at 20° C must not exceed the maximum specified for the particular nominal cross-section. Adherence to the maximum values for conductor resistance is verified by means of an ohmmeter applied to the conductor or of the finished cable. Measurement is performed in accordance with DIN VDE 0472, Part 501.
This does not apply to conductors in telecommunications cables.

Conductor dimensions	High-voltage cables						Welding cable	
	Cu conductors				Al conductors		Cu conductors	
Nominal cross-section mm²	consisting of **tin-plated** wires Class 1 Class 2 ΩΩ/km	Class 5 Class 6 ΩΩ/km	consisting of **bright** wires Class 1 Class 2 ΩΩ/km	Class 5 Class 6 ΩΩ/km	consisting of **bright** wires Class 1 ΩΩ/km	Class 2 ΩΩ/km	consisting of **bright** wires ΩΩ/km	consisting of **tin-plated** wires ΩΩ/km
0,05	-	~380,0	-	~360,0	-	-	-	-
0,08	-	~240,0	-	~230,0	-	-	-	-
0,09	-	~230,0	-	~215,0	-	-	-	-
0,14	-	~140,0	-	~138,0	-	-	-	-
0,22	-	~96,8	-	~95,0	-	-	-	-
0,25	-	~79,3	-	~77,8	-	-	-	-
0,34	-	~57,1	-	~56,0	-	-	-	-
0,5	36,7	40,1	36,0	39,0	-	-	-	-
0,75	24,8	26,7	24,5	26,0	-	-	-	-
1,0	18,2	20,0	18,1	19,5	-	-	-	-
1,5	12,2	13,7	12,1	13,3	-	-	-	-
2,5	7,56	8,21	7,41	7,98	-	-	-	-
4,0	4,70	5,09	4,61	4,95	-	-	-	-
6,0	3,11	3,39	3,08	3,30	-	-	-	-
10,0	1,84	1,95	1,83	1,91	-	-	-	-
16,0	1,16	1,24	1,15	1,21	-	1,91[2)]	1,16	1,19
25,0	0,734	0,795	0,727[1)]	0,780	1,20	1,20	0,758	0,780
35,0	0,529	0,565	0,524[1)]	0,554	0,868	0,868	0,536	0,552
50,0	0,391	0,393	0,387[1)]	0,386	0,641	0,641	0,379	0,390
70,0	0,270	0,277	0,268[1)]	0,272	0,443	0,443	0,268	0,276
95,0	0,195	0,210	0,193[1)]	0,206	0,320	0,320	0,198	0,204
120,0	0,154	0,164	0,153[1)]	0,161	0,253	0,253	0,155	0,159
150,0	0,126	0,132	0,124[1)]	0,129	0,206	0,206	0,125	0,129
185,0	0,100	0,108	0,0991	0,106	0,164	0,164	0,102	0,105
240,0	0,0762	0,0817	0,0754	0,0801	0,125	0,125	-	-
300,0	0,0607	0,0654	0,0601	0,0641	0,100	0,100	-	-
400,0	0,0475	0,0495	0,0470	0,0486	-	0,0778	-	-
500,0	0,0369	0,0391	0,0366	0,0384	-	0,0605	-	-
630,0	0,0286	0,0292	0,0283	0,0287	-	0,0469	-	-

[1)] applies to mineral insulated Class 1 cables
[2)] applies only to conductors with reduced cross-section for NAYCWY 4 x 25/16

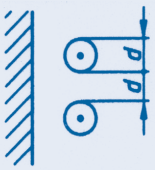
Explanatory notes
Class 1 - for single-wire conductors
Class 2 - for multi-wire conductors
Class 5 - for fine-wired conductors
Class 6 - for ultra-fine-wired conductors

Current-carrying capacity

Basic table

for cables	VDE 0276 Part1000
for cables for fixed installation	VDE 0298 Part 4
for flexible cables	VDE 0298 Part 4
for telephone and data cables	VDE 0891
for electrical equipment in machines	DIN VDE 0113 Part 1

Table 1: Current-carrying capacity at ambient temperature +30° C with reference to VDE

	A	B		C	D
Installation typre					
Number of loaded cores	1	2	3	2 or 3	
Nominal cross-section in mm²	Current-carrying capacity in A				
0,08[1]	1,5	-	-	1	-
0,14[1]	3	-	-	2	-
0,25[1]	5	-	-	4	-
0,34[1]	8	-	-	6	-
0,5	12[2]	3	3	9[1]	-
0,75	15	6	6	12	-
1	19	10	10	15	-
1,5	24	16	16	18	23
2,5	32	25	20	26	30
4	42	32	25	34	41
6	54	40	-	44	53
10	73	63	-	61	74
16	98	-	-	82	99
25	129	-	-	108	131
35	158	-	-	135	162
50	198	-	-	168	202
70	245	-	-	207	250
95	292	-	-	250	301
120	344	-	-	292	-
150	391	-	-	335	-
185	448	-	-	382	-
240	528	-	-	453	-
300	608	-	-	523	-
400	726	-	-	-	-
500	830	-	-	-	-
Current-carrying capacity	DIN VDE 0100-523: 1981-06; group 3	HD 21.1 S2 resp. HD 22.1 S2		DIN VDE 0100-523: 1981-062; group 2	according to DIN VDE 0100-523: 1981-06; group 2

The table as shown deviates from the version in the standard. Please under all circumstances take the conversion factors into account.

Conversion factors for

Divergent environment factors	see Table 2
Multi-core cables	see Table 3
Accumulation	see Table 4

1. For smaller cross-sections current carrying capacitiy according to VDE 0891 part 1.
2. According VDE 0100 part 523 extended range, which is not accounted by VDE 0298.

Current-carrying capacity

Reduction table

Table 2: Conversion factors
for divergent ambient temperatures according to VDE 0298 (Table 5 applies in the case of cables with enhanced temperature-resistance)

Ambient temperature °C	Permissible/recommended operating temperature 60° C	70° C	80° C	90° C
	Conversion factors applicable to the current-carrying capacity data in table 1			
10	1,29	1,22	1,18	1,15
15	1,22	1,17	1,14	1,12
20	1,15	1,12	1,10	1,08
25	1,08	1,06	1,05	1,04
30	1,00	1,00	1,00	1,00
35	0,91	0,94	0,95	0,96
40	0,82	0,87	0,89	0,91
45	0,71	0,79	0,84	0,87
50	0,58	0,71	0,77	0,82
55	0,41	0,61	0,71	0,76
60	-	0,50	0,63	0,71
65	-	0,35	0,55	0,65
70	-	-	0,45	0,58
75	-	-	0,32	0,50
80	-	-	-	0,41
85	-	-	-	0,29

Table 3: Conversion factors
for multi-core cables with conductor cross-sections up to 10 mm² (according to VDE 0298)

Number of loaded cores	Conversion factors
5	0,75
7	0,65
10	0,55
14	0,50
19	0,45
24	0,40
40	0,35
61	0,30

Table 4: Conversion factors
for accumulation according to VDE 0298

Arrangement	Number of multi-core cables or number of AC or three-phase circuits consisting of single-core cables (2 or 3 live conductors)														
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20
Bundled directly on wall, floor, in electrical installation trunking or duct, on or in wall	1,00	0,80	0,70	0,65	0,60	0,57	0,54	0,52	0,50	0,48	0,45	0,43	0,41	0,39	0,38
Single-layer on wall or floor, with contact	1,00	0,85	0,79	0,75	0,73	0,72	0,72	0,71	0,70	0,70	0,70	0,70	0,70	0,70	0,70
Single-layer on wall or floor, with intermediate space equal to cable diameter	1,00	0,94	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
Single-layer under ceiling with contact	0,95	0,81	0,72	0,68	0,66	0,64	0,63	0,62	0,61	0,61	0,61	0,61	0,61	0,61	0,61
Single-layer under ceiling with intermediate space equal to cable diameter	0,95	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85

Current-carrying capacity

Reduction table

Table 5: Conversion factors
for current-carrying capacity of cables with enhanced temperature-resistance according to VDE 0298

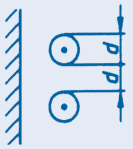
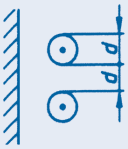
Insulating material	Enhanced temperature-resistance, PVC		Silicone SIR	
Products	Individual cores	Cable	Individual cores	Cable
Number of loaded cores	1	2 or 3	1	2 or 3
Installation type				
Ambient temperature in °C				
50	1,00			
55	1,00			
60	1,00			
65	1,00			
70	1,00			
75	1,00			
80	1,00			
85	1,00			
90	1,00			
95	1,00			
100	-		1,00	
105	-		1,00	
110	-		1,00	
115	-		1,00	
120	-		1,00	
125	-		1,00	
130	-		1,00	
135	-		1,00	
140	-		1,00	
145	-		1,00	
150	-		1,00	
155	-		0,91	
160	-		0,82	
165	-		0,71	
170	-		0,58	
175	-		0,41	

Table 6: Conversion factors
for wound cables (according to VDE 0298)

Number of layers on coil/drum	1	2	3	4	5
Conversion factors	0,80	0,61	0,49	0,42	0,38

Current-carrying capacity

Current-carrying capacity for flexible cables (where not shown in the table above!)

Permissible current-loading for insulated high-voltage cables with copper conductors at ambient temperatures up to 25° C according to DIN VDE 0100, 0812 and 0890.
These figures are intended as guide figures. The DIN VDE provisions are definitive and mandatory.

Current-loading and fuse in Ampere (A) up to 25° C

Nominal cross-section	Group 1 One or more multi-core cables, single-core cables installed in trunking, e.g. H07V-U		Group 2 Multi-core cables, e.g. sheath cables, flat-webbed cables, mobile cables		Group 3 Single-core cables installed open in air, with cables installed with an intermediate space of not less than cable diameter, and single-core wiring in switchgear and distribution installations	
mm²	Current-loading A	Fuse A	Current-loading A	Fuse A	Current-loading A	Fuse A
0,08	2,5		0,5	-	-	-
0,14	6,0		1,5	-	6,0	-
0,25	8,5		2,5	-	8,5	-
0,34	9		3,5	-	10	-
0,50	10		5	-	12	-
0,75	11		13	10	16	16
1	12	10	16	16	20	20
1,5	16	16	20	20	25	25
2,5	21	20	27	25	34	35
4	27	25	36	35	45	50
6	35	35	47	50	57	63
10	48	50	65	63	78	80
16	65	63	87	80	104	100
25	88	80	115	100	137	125
35	110	100	143	125	168	160
50	140	125	178	160	210	200
70	175	160	220	224	260	250
95	210	200	265	250	310	310
120	250	250	310	300	365	355
150	-	-	355	355	415	425
185	-	-	405	355	475	425
240	-	-	480	425	560	500
300	-	-	555	500	645	600
400	-	-	-	-	770	630
500	-	-	-	-	890	850

Permissible long-term loading of insulated cables at ambient temperature higher than +25 °C

Ambient temperature °C	Permissible continuous load rating in % of the figures in the above table		
	Plastic insulation %	Rubber insulation %	Cables with 100° C limit temperature %
from 25 to 30	94	92	100
> 30 to 35	88	85	100
> 35 to 40	82	75	100
> 40 to 45	75	65	100
> 45 to 50	67	53	100
> 50 to 55	58	38	100
> 55 to 65	-	-	100
> 65 to 70	-	-	92
> 70 to 75	-	-	85
> 75 to 80	-	-	75
> 80 to 85	-	-	65
> 85 to 90	-	-	53
> 90 to 95	-	-	38

Properties

Properties* of insulating and sheath materials

	Designation			electrical					thermal					
	VDE des.	Code	Material	Density g/cm³	Electr. strength kV/mm	Specific insulation resistance ΩΩ·cm 20 °C	Dielectr. coeffi-cient 50 Hz/ 20 °C	Tangent of loss angle tan ∂∂	Service temperature contin. °C	Service temperature short °C	Melting-point + °C	Burning behav.	Oxygen LOI (% O_2)	Heating value Ho $MJ \cdot kg^{-1}$
Thermoplastics	Y	PVC	Polyvinyl chloride mixtures	1,35-1,5	25	10^{13}-10^{15}	3,6-6	$4x10^{-2}$ bis	- 30 + 70	+ 100	> 140	self-exting-	23-42	17-25
	Yw	PVC	temperature resistance to 90°C	1,3-1,5	25	10^{12}-10^{15}	4-6,5	$1x10^{-1}$	- 20 + 90	+ 120	> 140	uishing	23-42	16-22
	Yw	PVC	temperature resistance to 105°C	1,3-1,5	25	10^{12}-10^{15}	4,5-6,5		- 20 + 105	+ 120	> 140		24-42	16-20
	Yk	PVC	low temperature resistance	1,2-1,4	25	10^{12}-10^{15}	4,5-6,5		- 40 + 70	+ 100	> 140		24-42	17-24
	2Y	LDPE	PE (low density)	0,92-0,94	70	10^{17}	2,3	$2x10^{-4}$	- 50 + 70	+ 100	105-110	combus-tible	≤ 22	42-44
	2Y	HDPE	PE (high density)	0,94-0,98	85	10^{17}	2,3	$3x10^{-4}$	- 50 + 100	+ 120	130		≤ 22	42-44
	2X	VPE	Cross-linked polyethylene	0,92	50	10^{12}-10^{16}	4-6	$2x10^{-3}$	- 35 + 90	+ 100	-		≤ 22	42-44
	O2Y		Polyethylene foam	~0,65	30	10^{17}	~1,55	$5x10^{-4}$	- 40 + 70	+ 100	105		18-30	42-44
	3Y	PS	Polystyrene	1,05	30	10^{16}	2,5	$1x10^{-4}$	- 50 + 80	+ 100	> 120		≤ 22	40-43
	4Y	PA	Polyamide	1,02-1,1	30	10^{15}	4	$2x10^{-2}$ bis $1x10^{-3}$	- 60 + 105	+ 125	210		≤ 22	27-31
	9Y	PP	Polypropylene	0,91	75	10^{16}	2,3-2,4	$4x10^{-7}$	- 10 + 100	+ 140	160		≤ 22	42-44
	11Y	PUR	Polyurethan	1,15-1,2	20	10^{10}-10^{12}	4-7	$23x10^{-7}$	- 55 + 80	+ 100	150		20-26	20-26
	TPE-E (12Y/13Y)		Polyester elastomer	1,2-1,4	40	$>10^{10}$	3,7-5,1	$18x10^{-2}$	- 50 + 100	+ 140	190		≤ 29	20-25
	TPE-O (18 Y)		Polyolefin elastomer	0,89-1,0	30	$>10^{14}$	2,7-3,6	$18x10^{-2}$	- 50 + 100	+ 130	150		≤ 25	23-28
Elastomers	G	NR SBR	Natural rubber styrene-butadiene rubber mixtures	1,5-1,7	20	10^{12}-10^{15}	3-5	$1,9x10^{-2}$	- 65 + 60	+ 120	-	combus-tible	≤ 22	21-25
	2G	SIR	Sillicone rubber	1,2-1,3	20	10^{15}	3-4	$6x10^{-3}$	- 60 + 180	+ 260	-	low flam-mability	25-35	17-19
	3G	EPR	Ethylene-propylene mixed polymer mixtures	1,3-1,55	20	10^{14}	3-3,8	$3,4x10^{-3}$	- 30 + 90	+ 160	-	combus-tible	≤ 22	21-25
	4G	EVA	Ethylene-vinyl acetate copolymer mixture	1,3-1,5	30	10^{12}	5-6,5	$2x10^{-2}$	- 30 + 125	+ 200	-		≤ 22	19-23
	5G	CR	Polychloroprene mixtures	1,4-1,65	20	10^{10}	6-8,5	$5x10^{-2}$	- 40 + 100	+ 140	-	self-exting-	30-35	14-19
	6G	CSM	Chlorosulfonated polyethylene mixtures	13-1,6	25	10^{12}	6-9	$2,8x10^{-2}$	- 30 + 80	+ 140	+160	uishing	30-35	19-23
Hightemp. materials	10Y	PVDF	Polyvinylidene fluoride Kynar®/Dyflor®	1,7-1,9	20	10^{14}	9-7	$1,4x10^{-2}$	- 40 + 135	+ 160	> 170	non-combus-	40-45	15
	7Y	ETFE	Ethylentetrafluor-ethylene Tefzel®	1,6-1,8	36	10^{16}	2,6	$8x10^{-4}$	- 100 + 150	+ 180	>265	tible	30-35	14
	6Y	FEP	Fluorinated ethylene propylene Teflon®	2,0-2,3	25	10^{18}	2,1	$3x10^{-4}$	- 100 + 205	+ 230	> 225		> 95	5
	5YX	PFA	Perfluoralkoxy Teflon®	2,0-2,3	25	10^{18}	2,1	$3x10^{-4}$	- 190 + 260	+ 280	> 290		> 95	5
	5Y	PTFE	Polytetrafluorethylene Teflon®	2,0-2,3	20	10^{18}	2,1	$3x10^{-4}$	- 190 + 260	+ 300	> 325		> 95	5
halogen-free mixtures	H	Cross-linked	Halogen-free polymer mixture	1,4-1,6	25	10^{12}-10^{14}	3,4-5	$\sim 10^{-3}$	- 30 + 70	+ 100	> 130	self-exting-	≤ 40	17-22
	HX	Cross-linked	Halogen-free polymer mixture	1,4-1,6	25	10^{13}-10^{14}	3,4-5	10^{-2}-10^{-3}	- 30 + 90	+ 150	-	uishing	≤ 40	16-25

*Properties apply to unprocessed material

Properties

Properties* of insulating and sheath materials

	Designation			thermal			mechanical					free from halogens	Weathering	
	VDE des.	Code	Material	Thermal conductivity $W \cdot K^{-1} \cdot m^{-1}$	corrosive gases in case of fire	Radiation resist. max. Mrad	Tensile strength N/mm^2	Breaking strain %	Shore-hardness	Abrasion performance	Water absorption %	halogen free	Weathering resist.	Low temp. performance
Thermoplastics	Y	PVC	Polyvinyl chloride mixtures	0,17	Hydrogen chloride	80	10 - 25	130 - 350	70 - 95 (A)	average	0,4	no	moderate, good in black	mod.-good
	Yw	PVC	temperature resistance to 90°C											
	Yw	PVC	temperature resistance to 105°C											
	Yk	PVC	low temperature resistance											very good
	2Y	LDPE	PE (low density)	0,3	no	100	10 - 20	400 - 600	43 - 50 (D)	average	0,1	yes		good
	2Y	HDPE	PE (high density)	0,4			20 - 30	500 - 1000	60 - 63 (D)	good				
	2X	VPE	Cross-linked polyethylene	0,3			12,5-20	300 - 400	40 - 45 (D)	average			good	
	O2Y		Polyethylene foam	0,25			8 - 12	350 - 450	-	-	-	restrict.[1]	-	
	3Y	PS	Polystyrene			80	55 - 65	300 - 400	35 - 50 (D)	good	0,4	ja	mod. good	moderately good
	4Y	PA	Polyamide	0,23		10	50 - 60	50 - 170	-	very good	1,0-1,5		good	good
	9Y	PP	Polypropylene	0,19			20 - 35	300	55 - 60 (D)	average	0,1		moderate	
	11Y	PUR	Polyurethan	0,25		100 (500)	30 - 45	500 - 700	70-100 (A)	very good	1,5		very good	very good
	TPE-E (12Y/13Y)		Polyester elastomer	0,5		10	30	> 300	85 (A) 70 (D)	good				
	TPE-O (18 Y)		Polyolefin elastomer	1,5			20		55 (A) 70 (D)					
Elastomers	G	NR SBR	Natural rubber styrene-butadiene rubber mixtures	-	no	100	5 - 10	300 - 600	60 - 70 (A)	mod.	1,0	no	moderate	very good
	2G	SIR	Sillicone rubber	0,22		50		300 - 600	40 - 80 (A)			yes	good	
	3G	EPR	Ethylene-propylene mixed polymer mixtures	-		200		200 - 400	65 - 85 (A)				very good	good
	4G	EVA	Ethylene-vinyl acetate copolymer mixture	-		100	8 - 12	250 - 350	70 - 80 (A)				good	
	5G	CR	Polychloroprene-mixtures	-	Hydrogen chloride	50	10 - 20	400 - 700	55 - 70 (A)	average	1,0	no	very good	moderately good
	6G	CSM	Chlorosulfonated polyethylene mixtures	-				350 - 600	60 - 70 (A)		1,5			moderate
Hightemp. materials	10Y	PVDF	Polyvinylidene fluoride Kynar®/Dyflor®	0,17	Hydrogen fluoride	10	50 - 80	150	75 - 80 (D)	very good	0,01			very good
	7Y	ETFE	Ethylentetrafluor-ethylene Tefzel®	0,24	yes	10	40 - 50	150	70 - 75 (D)		0,02			
	6Y	FEP	Fluorinated ethylene propylene Teflon®	0,26	yes	1	15 - 25	250	55 - 60 (D)		0,01			
	5YX	PFA	Perfluoralkoxy Teflon®	0,21	yes	0,1	25 - 30	250	55 - 60 (D)					
	5Y	PTFE	Polytetrafluorethylene Teflon®	0,26	ja	0,1	80	50	55 - 60 (D)					
halogen-free mixtures	H	non cr. linked	Halogen-free polymer mixture	0,17	no	100	8 - 13	150 - 250	65 - 95 (A)	average	0,2-1,5	ja	moderate, good in black	average
	HX	Cross-linked	Halogen-free polymer mixture	0,20	no	200	8 - 13	150 - 250						

*Properties apply to unprocessed material

[1] Propellants, for example, may consist of or contain fluorinated chlorinated hydrocarbons (HCFCs)
[2] depending on mixture group

Chemical Resistance

Resistance to organic substances

Substance	Concen-tration in %	Temp. up to in °C	PVC	PE	PUR	H	Silicone	Neoprene rubber	Teflon	PETP
Acetic acid	20		O	O		-			+	+
Acetone		20	-		O			O		
Aniline		50	-							
Benzene		50	-		-		-			
Brake fluid		100	O		-					
Butane		20	+				O			
Butter		50	+		O		+		+	
Carbon tetrachloride	100	20	+		-		-			
Chlorobenzene		30	-		-		-			
Chloroprene		20	-		-		-			
Citric acid			+			O	+	+	+	+
Cutting oil			O		+*	-	+	O	+	
Diesel oil			-		+	-	O		+	O
Diethylene glycol		20	O		+		-			
Engine oil		120	+	-		-		+		+
Ethyl alcohol	100	20	-	+	O	-	+	+	+	+
Ethylene chloride		50	-		O					
Ethylene glycol		100	O		-	+				
Formic acid	30	20	-	+	-			+	+	-
Freon		20	-		O		-			
Gasoline		50	-	-	+	-	O	-	+	+
Gearbox oil		100	+		O		O			O
Glacial acetic acid	20	50	-		-		+		+	+
Glycerin	any	50	+		+		+			
Hydraulic fluid		20	-		O*	-	-		+	
Isopropyl alcohol	100	20	-	+	O*		O	O	+	+
Kerosene		20			+					
Lactic acid	10		-		-		-		+	O
Machine lubricating oil		20	O		O	-	+	O	+	O
Methanol		20	-		-		+			+
Methyl alcohol	100		O	+	O	O		O	+	+
Methylene chloride		20	-		-		-			O
Mineral oil					O*					+
Olive oil		50	+	+	+		+		+	-
Oxalic acid (cold sat.)	cold sat.	20	+O		O		O	+		
Paraffin oil					+					
Succinic acid, aqu.	cold sat.	20	+						+	
Tar acid		20	+		-					
Tartaric acid, aqu.			+			O	+	+	+	+
Toluene							-			O
Trichloroethylene	100	20	+				+			
Vegetable oils			+	+	+	-		O	+	O
Vegetable fats			+	+	+	-		O	+	O

+	resistant	any	= any concentration
O	moderately resistant	cold sat.	= cold saturated
-	not resistant	aqu.	= aqueous
*	must be checked in each individual case		

This information is provided on the basis of our knowledge and of our many years of experience. We must point out, however, that no liability can be accepted for any of the information provided here.
In many cases, ultimate assessment is possible only under practical conditions of use

Chemical Resistance

Resistance to inorganic substances

Substance	Concen-tration in %	Temp. up to in °C	PVC	PE	PUR	H	Silicone	Neoprene rubber	Teflon	PETP
Aluminum salts	any	20	+				O			+
Alums	cold sat.	20	+			O	O	-	+	+
Ammonia, aqu.	10	20	+			+	-	+	+	+
Ammonium acetate, aqu.	any	20	+					+		+
Ammonium carbonate, aqu.	any	20	+						+	+
Ammonium chloride, aqu.	any	20	+			+			+	+
Barium salts	any	20	+		+	+	O	+	+	+
Boric acid	100	20	+	+	O	O	+	+	+	+
Calcium chloride, aqu.	cold sat.	20	+		+	O	O		+	+
Calcium chloride, aqu.	10-40	20				+				
Calcium nitrate, aqu.	cold sat.	20	+		+		O		+	+
Chromium salts, aqu.	cold sat.	20	+							+
Copper salts	cold sat.	20	+		+	+	O	+	+	+
Detergent solutions	2	100	-		-		-			+
Hydrochloric acid	conc.	20	-	+	-	-	-	-	+	O
Hydrogen peroxide, aqu.		20	+		O		+	+	+	+
Hydrogen sulfide		20	-		-	-	-	-	-	+
Magnesium salts	cold sat.	20	+		+	O	O			+
Mercury	100	20	+	+	+	+	+	+	+	+
Mercury salts	cold sat.	20	+	+	+	O	+	+	+	+
Nickel salts, aqu.	cold sat.	20	+		+	+	O	+	+	+
Nitric acid	30	20	-	-	-	-	-	-	+	O
Nitrobenzene	100	50	-			-				
Phosphoric acid	50	20	+		+	-		O		+
Potassium carbonate, aqu		20	+		+			+	+	+
Potassium chlorate, aqu.	cold sat.	20	+		O		O		+	+
Potassium chloride, aqu.	cold sat.	20	+	+	+	-		+		+
Potassium dichromate, aqu.		20	+	+				+	+	+
Potassium iodide, aqu.		20	+		+		O	+	+	+
Potassium nitrate, aqu.	cold sat.	20	+	+	+	+	O	+	+	+
Pot. permanganate, aqu.		20	O		+	-			+	+
Potassium sulfate, aqu.		20	+		+	+	O	+	+	+
Sodium bicarbonate, aqu.		20	+		O	O		+	+	+
Sodium bisulfate, aqu.		20	+		+	-		+	+	+
Sodium chloride, aqu.		20	+		+	+	O	+	+	+
Sodium hydroxide soln.	50	50	+							+
Sodium thiosulfate, aqu.		20	+		+	O		+	+	+
Seawater		20	+		+	+	O	+	+	+
Silver salts, aqu.		20	+		+	+	O	+	+	+
Sulfur dioxide		20	+	O	-		-	-	+	O
Sulfureous water		20	+		+				+	+
Sulfuric acid	50	50	+							+
Tin (II) chloride		20	+				O	+	+	+
Water (dist.)		20	+							+
Zinc salts, aqu.		20	+		-	O		+	+	+

+	resistant	any	= any concentration
O	moderately resistant	cold sat.	= cold saturated
-	not resistant	aqu.	= aqueous
*	must be checked in each individual case		

This information is provided on the basis of our knowledge and of our many years of experience. We must point out, however, that no liability can be accepted for any of the information provided here. In many cases, ultimate assessment is possible only under practical conditions of use.

Bending radii

Minimum permissible bending radii for flat cable acc. to DIN VDE 0298 part 3

Cable type	Rated voltage up to 0.6/1 kV				Rated voltage above 0,6/1 kV
Cables for fixed installation	Outer diameter of cable or thickness of flat cable in mm				
	up to 10	above 10 up to 25	above 25		
Fixed installation	4 d	4 d	4 d		6 d
Single-bended installation	1 d	2 d	3 d		4 d
Flexible cables	Outer diameter of cables or thickness of flat cables in mm				
	up to 8	above 8 up to 12	above 12 up to 20	above 20	
Fixed installation	3 d	3 d	4 d	4 d	6 d
Freely movable	3 d	4 d	5 d	5 d	10 d
Cable entry/gland	3 d	4 d	5 d	5 d	10 d
Mechanical restraint [1]					
as for cable-drum mode	5 d	5 d	5 d	6 d	12 d
Festoon mode	3 d	4 d	5 d	5 d	10 d
Drag-chain mode	4 d	4 d	5 d	5 d	10 d
Roller reversing	7,5 d	7,5 d	7,5 d	7,5 d	15 d

Notes:

d = Outer diameter of cable or thickness of flat cable.
[1] Suitability for this application must be assured by means of special structural features.

Please consult manufacturer in the case of cable types suitable for multiple application types.

Basic electrical-engineering formulas

Cross-section and diameter calculation of flexible leads

$A = d^2 \cdot 0{,}785 \cdot n$

$Z = \sqrt{\sqrt{1{,}34 \cdot n \cdot d}}$

A = lead cross-section in mm²
Z = lead diameter in mm
n = number of individual wires
d = individual wire-Ø in mm

Conductor resistance

$R = \frac{\rho \cdot L}{S}$ $\quad R = \frac{L}{\kappa \cdot S}$

$G = \frac{1}{R}$ $\quad \rho = \frac{1}{\kappa}$

R = electrical resistance in Ω
G = electrical conductivity in S
S = conductor cross-section in mm²
L = length of conductor in m
ρ = specific resistance (Rho)
κ = conductivity (Kappa)

Example given: L = 800 m, R = 100 Ω, S = 0,15 mm²
required: κ = Conductivity

Calculation route $\kappa = \frac{L}{R \cdot S} = \frac{800\ m}{100\ \Omega \cdot 0{,}15\ mm^2} = 53{,}3 \frac{m}{\Omega \cdot mm^2}$

Ohm's Law

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

I = electrical current in A
U = electrical voltage in V
R = electrical resistance in Ω
d = individual wire-Ø in mm

Example
U = 220 V ; R = 980 Ω

$I = \frac{U}{R} = \frac{220\ V}{980\ \Omega}$

I = 0,22 A

Characteristic wave impedance

$Z = \sqrt{\frac{L}{C}}$

$Z = \frac{60}{\sqrt{\epsilon r}} \cdot \ln \frac{D}{d}$

Z = characteristic wave impedance in Ω
L = inductance in H
C = capacity in F

εr = dielectric constant
ln = natural logarithm
D = Ø above dielectric
d = Ø of inner conductor

Effective capacitance conductor/mass

$C = \frac{\epsilon r \cdot 10^3}{18 \cdot \ln \frac{D}{d}}$

C = capacity in pF/m
εr = dielectric constant
D = Ø above dielectric
d = Ø of inner conductor
ln = natural logarithm

Resistance/Temperature

$R_W = R_K (1 + \Delta \cdot \vartheta)$

$R_W = R_K + \Delta R$

$\Delta R = \alpha \cdot R_K \cdot \Delta \vartheta$

$\Delta\Delta\vartheta = \frac{R_W \cdot R_K}{R_K \cdot \alpha}$

R_K = cold resistance at +20°C in Ω
R_W = hot resistance in Ω
ΔR = change in resistance in Ω
Δϑ = temperature changes in °C
Δα = temperature coefficient

Cu = 0,0039 1/°C
Alu = 0,00467 1/°C

Example
Δϑ = 70 °C
R_K = 100 Ω
α = 0,0039 1/°C
$R_W = R_K \cdot (1 + \alpha \cdot \Delta\vartheta)$
R_W = 100 W(1+0,0039·70)
R_W = 127,3 Ω

Installation in series of ...

Resistors: $R_g = R_1 + R_2 + R_3 + \ldots$

Capacitors: $\frac{1}{L_g} \quad \frac{1}{L_1} + \quad \frac{1}{L_2} + \quad \frac{1}{L_3} + \ldots$

Inductances: $L_g = L_1 + L_2 + L_3 + \ldots$

Installation in parallel of ...

Resistors: $\frac{1}{R_g} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

Two Resistors: $R_g = \frac{R_1 \cdot R_2}{R_1 + R_2}$

Capacitors: $C_g = C_1 + C_2 + C_3 + \ldots$

Inductances: $\frac{1}{L_g} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots$

Powers of ten

10^{12}	Tera	T	1 000 000 000 000
10^{9}	Giga	G	1 000 000 000
10^{6}	Mega	M	1 000 000
10^{3}	kilo	k	1 000
10^{2}	hekto	h	100
10^{1}	deka	da	10
10^{0}			1
10^{-1}	dezi	d	0,1
10^{-2}	centi	c	0,01
10^{-3}	milli	m	0,001
10^{-6}	mikro	m	0,000 001
10^{-9}	nano	n	0,000 000 001
10^{-12}	piko	p	0,000 000 000 001

Basic electrical-engineering formulas

Voltage drop (power engineering)

Symbol	Designation and unit	Formula
u	voltage drop in V	
	at given current	
	- for AC	$u = \frac{2 \cdot I \cdot l}{\kappa \cdot q}$
	- for single-phase AC	$U = \frac{2 \cdot I \cdot \cos\varphi \cdot l}{\kappa \cdot q}$
	- for three-phase current	$u = \frac{1{,}732 \cdot I \cdot \cos\varphi \cdot l}{\kappa \cdot q}$
	at given power	
	- for AC	$u = \frac{2 \cdot I \cdot P}{\kappa \cdot q \cdot U}$
	- for single-phase AC	$u = \frac{2 \cdot I \cdot P}{\kappa \cdot q \cdot U}$
	- for three-phase current	$u = \frac{I \cdot P}{\kappa \cdot q \cdot U}$

I	operating current in A
l	single length of power cable in m
κ (Kappa)	conductivity of conductor (m/Ω·mm²) (κ-Cu-conductor: 56, κ-Al-conductor: 33)
u	voltage drop in Volt (V)
U	operating voltage in V (V)
P	power in Watt (W)
q	conductor cross-section in mm²

Conductor cross-section (power engineering)

Symbol	Designation and unit	Formula
q	conductor cross-section in mm²	
	at given current	
	- for DC and single-phase AC	$q = \frac{2 \cdot I \cdot l}{\kappa \cdot q}$
	- for three-phase current	$q = \frac{1{,}732 \cdot I \cdot \cos\varphi \cdot l}{\kappa \cdot q}$
	at given power	
	- for DC and single-phase AC	$q = \frac{2 \cdot I \cdot P}{\kappa \cdot u \cdot U}$
	- for three-phase current	$u = \frac{I \cdot P}{\kappa \cdot u \cdot U}$

I	operating current in A
l	single length of power cable in m
κ (Kappa)	conductivity of conductor (m/Ω · mm²) (κ-Cu-conductor: 56, κ-Al-conductor: 33)
u	voltage drop in Volt (V)
U	operating voltage in V (V)
P	power in Watt (W)
q	conductor cross-section in mm²

Rated voltage (continuous rated voltage is expressed by statement of two AC values U_0/U in V)

U_0/U	= conductor earth/conductor line-to-line voltage
U_0	voltage between conductor and Earth or metallic sheath (screening, reinforcement, concentric conductor)
U	voltage between the outer conductors
U_0	U/3 for three-phase moments
U_0	U/2 for single-phase and AC moments
U_0/U_0	one outer conductor earthed, for single-phase and AC moments

Electrical energy

Abbreviation	Designation	Symbol	Formula
W	electr. energy	Ws	W = P·t
P	electr. power	W	
t	time (duration)	S	$W = \frac{U2 \cdot t}{R}$
I	current	A	
U	voltage	V	W = I²·R·t
R	resistance	Ω	W = U·I·t

Example	given	t = 0,05 s, U = 220 V, I = 0,25 A
	required	electrical energy Ws (wattseconds)
Calculation route	W = U·I·t	
	W = 220 V·0,25 A·0,05 s = 2,25 Ws	

Mathematical symbols

=	equal to	<	smaller than	sin	sine
≠	not equal to	>	greater than	cos	cosine
~	proportional to	≤	smaller than or equal to	tan	tangent
≈	appr. equal to	≥≥	greater than or equal to	cot	cotangent
Σ	sum, total	∞	infinite	∩	intersection
Δ	difference	π	(3,14)	∪	set union

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Definition	Meaning/Reference	
AC	Alternating Current	
Address-bus	The address of the functional module addressed in each case is signalized on the address-bus	
Ampere	Unit of electrical current (I)	
Amplitude	Oscillation width (maximum deflection) of an oscillation process	
AS interface	Actuator Sensor Interface; intended for networking of actuators, solenoid valves, power relays, etc., and sensors (optical, inductive, capacitive, etc.).	see chapter 3
ATEX	Atmosphère explosible (ATEX): EC Code of Practice	
Attenuation	Reduction of signal amplitude during transmission within media. Increases as frequency and cable length increase. Thus results in a lower signal level.	
AWG	American Wire Gauge: Expression for wire diameter. The greater the AWG number, the smaller the diameter of the wire. The conductor structure (number of wires) determines the actual cross-section (in mm).	
AWM	Appliance Wiring Material (UL designation)	
Braid density	Percentage coverage of the surface of a cable by a braided screening.	
Braiding angle	Angle between braiding wire and the perpendicular direction of a cable.	
Breaking strain	Ratio of extension to initial length upon breakage.	
Bus / Bus system	Network in which a single line leads to all work stations. Information is transmitted in the form of data packages in the bus system.	see also Address Bus, Data bus,Control bus
Byte	1 Byte = 8 Bit. Data unit which is processed as a unit.	
Bit-rate	Rate of transmission (bit sequence) of a binary signal.	
Cable	The DIN standards contain no unequivocal definition of this term.	
Cable drum	Motor- or spring-driven coiling device for drum-capable cables and trailing cable systems. Coiling-types: spiral or cylindrical.	see Cable Drums
CAN (-Bus)	Controller Area Network: ISO 11898 bus system.	
Capacitance	Capacitive resistance (AC resistance) of a capacitor.	see also Inductance and Reactance
Capacitive coupling	Connection of two circuits via a capacitor.	
Carrier frequency	The carrier frequency is the basic frequency which is modulated with the modulation frequency. It carriers a modulated signal. The carrier frequency is a fixed frequency, the amplitude, phase angle or frequency of which is modified at the rhythm of the modulation frequency, depending on modulation type.	
CE	European Conformity; e.g. European Low-Voltage Code of Practice 73/23/EEC. Load-Voltage Code of Practice	
CENELEC	Comité Européen de Normalisation Electrotechnique	
Characteristic wave impedance	Ratio of voltage and current of an electrical wave propagating along a homogeneous cable; measured in Ohm; simultaneously, input resistance of an infinitely long cable or resistance, with which a finitely long cable must be terminated.	
Coaxial cable	Consists of a cylindrical inner conductor and one or more hollow outer conductors (asymmetrical copper conductors). This permits enhanced immunity to interference. Coaxial cables are used for transmission of asymmetrical signals.	
Combustion behaviour	Test performed in accordance with VDE 0472, Part 804 or IEC standards. Describes the behaviour of cables under (direct) exposure to flame.	
Concentric conductor	Used as fourth conductor and, in some cases, as reinforcement simultaneously.	
Condensance	Capacitive reactance of an AC circuit.	
Conductance	Equivalent conductance of an AC circuit.	
Conductor types	Single-wire, multi-wire, fine-wired, ultra-fine-wired, and sector-type	see Tech. Guidelines, Page =23ff
Conductor geometries	re: round, single-wire conductor rm: round, multi-wire conductor se: sector-type, single-wire conductor sm: sector-type, multi-wire conductor	
Conductor resistance	AC resistance of electromagnetic waves in a vacuum.	

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Definition	Meaning/Reference	
Control bus	The functional module in each case is instructed to perform a function via the control bus.	
Copper conductors	cycles, drums or axial twisting (torsion), thanks to high bending strengths. Appropriate conductor structure makes it possible to guarantee long service-life.	see also "drag-chain applications"
Coupling	Electrical influencing of two or more spatially close conductors (e.g. telephone cables). Causes cross-talk.	
Crimping	Mechanical compression joint between conductor and metal sleeve (e.g. connectors, connector sleeves, etc.).	
cross-section	Total of all dimensions of all conductors.	
Data bus	The data signals between the CPU and the individual functional modules are transmitted via the data bus.	
Data transmission rate	Unit for the rate of transmission of data. Stated in bit/sec. or byte/sec.	see Bit-rate
DC	Direct Current	see also AC
DEL (quotation)	German electrolytic copper for conduction purposes. Purity 99.5%.	see Technical Guidelines "Copper Calculation"
Dielectric	Substance between the outer conductor (screening) and the inner conductor (cable assembly) of a coaxial cable, as a result of which the properties of the cable are determined.	
DIN	Deutsches Institut für Normung (German Standardization Institute)	
Dissipation (or loss) factor	Ratio between true wattage and reactive power under constant wave (sinusoidal) voltage. Depends on capacity, frequency and the temperature of the conductor.	
Drag-chain applications	Assembly of movable elements for directional routing of cables. Such systems require special design.	
Drain wire	The drain wire is generally tin-plated and is in contact with the screening throughout the length of the cable. It serves to earth the screening and t o bridge any gaps in the screening caused by damage.	
Earthing (Grounding)	Conductive connection between electrical equipment for protection against electric shock and/or lightning.	
Effective capacitance	Capacity between one conductor and all the other conductors connected to one another in a cable.	
Electrical (conductor) cross-section	Determination is accomplished by means of calculation of the ohmic (electrical) resistance on the conductors.	
Electrical resistance	Also "Ohmic" resistance; resistance opposing the current on a conductor.	
Electrical field	Occurs as a result of the application of voltages to conductors. These may be of various forms.	see also EMC
EMF	Electromotive force.	
EMC (Electromagn. compatibility)	Avoidance of spread of electromagnetic fields from electrical equipment, by means of screening.	
Exposure to high-tension cables	Powerful electrical fields occur and are capable of causing interference in other conductors.	see also "Shielding"
Extension	Lengthening of a body under exposure to mechanical forces.	see also tensile load, tensile strength, tensile-loaded cables, "chapter6"
Extrusion / Extruder	Process for application of plastics or metal to conductors, cores, stranded assemblies, etc. Granulate is plasticized in the extruder and applied around the object to be extruded. Rough differentiation is made between pressure extrusion and hose extrusion.	
Field bus	Special bus systems for industrial service. They differ in terms of their access procedures.	
Fillers	Dummy cores for filling of cavities around a stranding assembly.	
Fire load	Energy liberated upon combustion of cables and other building materials. See also VDE 0108, Supplement 1 and the "Fire Load" data sheet.	see Technical Guidelines "Formulas"
Flame resistant	Material in which flames occurring after exposure to flame extinguish automatically (self-extinguishing, e.g. PVC).	
Flexibility	Mobility of a cable during operation. Energy transmission cables (also referred to as drag-chain-capable cables) are required for application involving continuous movement.	see also "drag-chain applications"

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Definition	Meaning/Reference	
Foil screening	Generally takes the form a metal-backed plastic film or plastic-backed metal foil or an all-metal foil which is located in a twisted winding around the element requiring screening, or axially along it (longitudinal).	
Frequency / Frequency band	Number of oscillations per second within a certain (frequency) bandwidth.	
Frequency range	Subdivision of frequency bands into individual ranges.	see also "Frequency / Frequency band
Galvanic coupling	Existence of direct connection between two circuits.	
Halogen-free	Produces no corrosive gases in case of fire; toxicity is also low. Smoke production may nonetheless be high and fire propagation extremely rapid. The "halogens" are fluorine, chlorine, bromine, iodine and astatine.	
Harmonization	Specification of uniform standards throughout the EU by CENELEC (see CENELEC).	
Henry		Unit of inductance (Symbol = H).
Hertz	Symbol = Hz; unit of frequency (per second)	
High-frequency	Abbreviation = HF; AC with extremely high number of oscillations (in telecommunications engineering and information-technology [IT])	
Hose cable	Flexible, single- or multi-core cables for connection to mobile equipment.	see also "Extrusion / Extruder"
Hybrid cable	Cable composed of a number of different conductors, e.g. supply and control cores or copper and fiber-optics cables.	see chapters 4 and 5
IEC	International Electrotechnical Commission	
Impedance	AC resistance of a circuit.	
Inductance	Inductive resistance of a circuit.	see also "Capacitance" and "Reactance"
Induction	Electromagnetic phenomenon, in which an electromotive force is generated within a conductor. Results in closed circuits in an induction current.	
Inductive (magnetic) coupling	Connection between two circuits via coils located opposite to one another.	
Inherently short-circuit-proof	Conducting paths and electrical devices are considered inherently short-circuit-proof if no short-circuits can occur under the proper and intended operating conditions.	
Installation temperatures	Particular attention must be devoted to cable temperature during installation of electrical cables. Plastic-insulated cables are sensitive to impact and to low temperatures.	
Insulation	Materials which surround the conductor to provide electrical separation from other conductors. The inner and outer sheaths frequently consist of the same insulating material. Also serves as protection against electric shock.	
Insulation resistance	Insulation resistance is length-dependent and is stated in Ω x m or GΩ x km. Its values should be around 1 GΩ x km. Insulation resistance falls as length increases, as a result of dependence on length. Insulation resistance is a measure of the quality of the insulating material between two conductors or between one conductor and the screening. Insulation resistance is essentially determined by the insulation material.	
Interface	Connecting point (point of intersection) between different hardware units.	see also "Interface"
ISO	International Organization for Standardization	
Kilo	1000	
kV	Kilovolt = 1000 Volt	
KVA	Kilovolt x Ampere	
kW	Kilowatt = 1000 Watt	
LAN	Local Area Network	
LON	Local Operating Network	
Longitudinal water-tightness	Incorporation of expanding material into cables, in order to prevent the ingress of water in case of damage to the outer sheath. Mainly used in telephone cables.	
Loop resistance	Sum of the ohmic resistances of two cores. Supply and return line for a cable circuit.	
Low-Voltage Code of Practice	European Low-Voltage Code of Practice 73/23/EEC. Applicable to 50 to 1000 V AC and 75 to 1500 V DC.	
MAN	Metropolitan Area Network; large, generally municipally operated, network.	
MAU	Medium Attachment Unit; active component of an Ethernet® LAN for connection of terminal devices to the bus cable.	

Index

Definition	Meaning/Reference	
MCM	Statement of dimensions for larger AWG cross-sections; 1 MCM = 1000 circular mills = 0.5067 mm^2	
Mechanical loading of copper conductors	Possess the best mechanical properties for high loads caused by reversing bending	
Mega	1 million (1,000,000)	
Megarad	1 million rad	
MHz Megahertz	see Hertz	
Modulation	Method of adding information content to a carrier wave. Either the deflection width (amplitude) of the carrier wave can be changed (Amplitude Modulation = AM) or its frequency can be manipulated (Frequency Modulation = FM). In Digital Modulation, the information is converted to a digital signal, which, after suitable encoding, is either transmitted directly in the form of a pulse signal, or impressed on a carrier oscillation. At the receiver end, the information is recovered by means of a demodulator and a Digital/Analog converter.	
MTW	Machine Tool Wire	
Mutual inductance coupling	Mutual inductance of two voice circuits (telecommunications engineering)	
MylarPolyester film (DuPont)		
(Near-end) cross-talk	see "Coupling"	see also
Nominal cross-sectional area	Electrically effective conductor cross-section at 20° C ambient temperature.	see also "Electrical (conductor) cross-section"
Neutral conductor (grounding conductor)	Zero-current conductor in circuits featuring more than two conductors. They may have geometries and cross-sections differing from those of the other conductors.	
Ohm	Unit of electrical resistance	see also "Resistance"
Operating voltage	Actual voltage in a network. It may fluctuate by up to 5% as a result of varying use of loads.	
Outer conductor	Conductor arranged concentrically around the inner conductor of a coaxial pair.	
Operating current	Maximum permissible current which may be transmitted by a network.	
Pair / Pair-type stranding	Two conductors stranded with one another and forming a circuit.	
Permitted current	Maximum permissible current which may be transmitted by a network.	see also "Operating current"
PiMF Pairs in metal foil.		
Potential	A voltage between a measuring point and a reference point (e.g. earth).	
Potential equalization	The term "potential equalization" signifies adjusting elements which each have a different potential to the same or approximately the same level by connecting the points of differing potential with one another (elimination of differences in potential between bodies and extraneous conductive components, including connection between each other).	
Power loss	The power converted to heat or other lost energy.	
Pressure extrusion	Solid extrusion of the insulation onto the element to be insulated.	see also "Hose cable"
Profibus	Process Field Bus; field-bus system of a three-layer structure incorporating complete network management.	
Propagation time	Time required by a signal to cover a certain distance.	
Pump cable	Also referred to as "immersion-motor cable"; its special feature is its waterproof inner and outer sheath.	see chapter 7
Rad	Unit of resistance to radiation.	
Reactance	Sum of inductance and capacitance.	see also "Inductance" and "Capacitance"
Rated current	Effective value of the current flowing through a conductor.	
Rated voltage	Voltage, for which cables are designed in terms of their electrical properties. Stated in U_0/U in kV.	
Rated voltage	Abbreviation for the effective value of rated voltage between one or more outer conductors and Earth.	
Reinforcement	System for protection of a cable against mechanical damage. May also take the form of protection against gnawing (rodents!). Common forms of reinforcement are steel braids, strips and wires. They are generally located immediately under the outer sheath.	
Resistance	Resistance to AC current (also referred to as "equivalent resistance" or "ohmic resistance").	

Index

Definition	Meaning/Reference	
Sealing ends, terminations	For connection of trailing cables in interior rooms and in the open air.	
Shaft lighting system	Lighting system for elevator (lift) shafts in accordance with DIN EN 81.	
Shielding	Serves for avoidance of internal and external interference by electrical fields. Braided shielding systems (C shielding), spiral copper shielding or screening (D shielding) and foil shielding systems (F shielding) are the main types used. Copper-wire shielding is generally tin-plated.	
Short-circuit current	Leakage current between two or more conductors.	
Short-circuit-proof	A device is considered short-circuit-proof if it is capable of withstanding the thermal and dynamic (mechanical) effects of the short-circuit current anticipated at an installation location without impairment of its correct functioning.	
Spiral copper shield	Twisted-configuration spiral shield by means of copper wires running parallel to each other	see also "Shielding"
Steel/copper	Copper-plated steel wire (electrolytic plating process).	
Strainer core	Design element which absorbs the tensile forces of a cable. Various materials may be used (e.g. steel cord, hemp cord, plastic threads). The strainer core may be located, for example, in the center, on the exterior or in the outer sheath.	
Strain relief/Strain relief element	Design provisions to permit absorption of tensile forces in installed cables.	see also "Strainer core"
Stranding	Twisting of two or more elements (individual cores or stranding groups). Makes the cable flexible.	
Stranded group	Two or more elements twisted with one another.	see also "Pair / Pair Stranding"
Surface transfer resistance	Measure of the quality of the screening; is defined as the ratio of the voltage along the screening of the disrupted system to the current of the disrupting system.	
Tensile load	Maximum tensile force which may be applied to a cable, as a results of such cable's design.	
Tensile strength	Cross-section-dependent tensile stress to which an element can be exposed for a certain time without the element breaking.	
Tensile limiter	Tensile forces acting as a result of production methods and originating from production equipment on cores, stranding assemblies and cables are kept to a minimum by means of electronically controlled drive and withdrawal systems.	
Tensile stress	Force which acts on the entire surface of the conductor cross-section under exposure to tensile load.	
Test voltage	Voltage at which a cable is tested. It is higher (by a multiple) than the rated voltage.	
Trailing cable systems	Three or four-core flexible, rubber-insulated cables for the low-voltage and high-voltage sectors.	see chapter 6
Transceiver	Compound word from "Transmitter" and "Receiver"; device capable of transmitting and receiving signals simultaneously.	
Transceiver cable	15-pole connection between transceiver and Ethernet® controller. Maximum length: approx. 50 m. Impedance is 78 W.	
Triaxial cable	Three-conductor cable containing one central inner conductor and two electrically separate concentric conductors.	
Twist length	Length in which a stranding element (e.g. a core) runs once through 360° around the stranding axis.	
Twist direction	Direction of the stranded elements. Differentiation is made between left-hand twist (S twist) and right-hand twist (Z twist). Stranding elements consisting of multiple layers frequently have opposing directions of twist (counter-twist), in order to improve the flexibility and strength of the cable as a whole.	
Ultimate load	Product of tensile strength and nominal cross-section of a cable.	
VDE	Association of German Electrical-engineers	
Volt	Unit of electrical voltage	see also "Voltage"
Voltage	Electrical voltage is the pressure or force acting on free electrons. Voltage (pressure) occurs as a result of the inclination of electrical charges to equalize. It is the cause of electrical current. Unit: Volt (V).	
Voltage drop	Difference in potential between two points in a conductor.	

Index, Determination of fire load

Definition	Meaning/Reference
WAN	Wide Area Network; extremely large or even global network. Various LANs are generally connected to one another via WANs.
Wall thickness	Thickness of a cable or sheath insulation system.
Watt	Unit of power.
Wavelength	Interval between two identical and consecutive oscillations in a periodic wave motion.
Waveguide	Coaxial cable; conductor consisting of one conductive and one dielectric material for low-loss transmission of high-frequency signals.
ZVEI	Zentralverband der Deutschen Elektrohandwerke e.V. (Central Association of German Electrical Trades).

Determination of fire load

e.g. KAWEFLEX® 4220-SK-C-PUR 4 G 10

Formula:
(cable weight - Cu weight) x Heating Value of most unfavourable material

Example:

Total weight:	656,0 kg/km
- Cu weight:	- 464,0 kg/km
Plastic =	212,0 kg/km

Heating Value Hu for PELON® = 25 kJ/g
Heating Value Hu for PU = 25 - 29 kJ/g (normal to flame resistant)
PUR average is assumed at 27 kJ/g equating to 27.000 kJ/kg

Calculation:

27.000 kJ/kg x 212,0 kg/km = 5.724.000,0 kJ/km = 5.724,0 MJ/km
there results from this the value:
5.724 MJ/km = 1.591,27 kWh/km (old units)

Fire load is = 1,59 kWh/m

Heating Values in kJ/kg:	PVC	15,3 kJ/g
	PE	46,5 kJ/g
	PP	46,0 kJ/g
	PELON®	25,0 kJ/g
	PUR	25,0 - 29,0 kJ/g

Conversion:	1 MJ/m²	equating to	0,278 kWh/m²
	1 kWh/m²	equating to	3,6 MJ/m²
	1 Wh/m²	equating to	3,6 kJ/m²

British and US dimensions

Dimensions are normally stated in the USA in AWG numbers (AWG = American Wire Gauge).
These AWG numbers accord with the British B&S numbers (BS = Brown&Sharp).

AWG No.	Cross-section mm²	Diameter mm	Conductor resistance Ω/km
1000 MCM*	507	25,4	0,035
750	380	22,0	0,047
600	304	19,7	0,059
500	254	20,7	0,07
400	203	18,9	0,09
350	178	17,3	0,10
300	152	16,0	0,12
250	127	14,6	0,14
4/0	107,20	11,68	0,18
3/0	85,00	10,40	0,23
2/0	67,50	9,27	0,29
0	53,40	8,25	0,37
1	42,40	7,35	0,47
2	33,60	6,54	0,57
3	26,70	5,83	0,71
4	21,20	5,19	0,91
5	16,80	4,62	1,12
6	13,30	4,11	1,44
7	10,60	3,67	1,78
8	8,366	3,26	2,36
9	6,63	2,91	2,77
10	5,26	2,59	3,64
11	4,15	2,30	4,44
12	3,30	2,05	5,41
13	2,62	1,83	7,02
14	2,08	1,63	8,79
15	1,65	1,45	11,20
16	1,31	1,29	14,70
17	1,04	1,15	17,80
18	0,8230	1,0240	23,0
19	0,6530	0,9120	28,3
20	0,5190	0,8120	34,5
21	0,4120	0,7230	44,0
22	0,3250	0,6440	54,8
23	0,2590	0,5730	70,1
24	0,2050	0,5110	89,2
25	0,1630	0,4550	111,0
26	0,1280	0,4050	146,0
27	0,1020	0,3610	176,0
28	0,0804	0,3210	232,0
29	0,0646	0,2860	282,0
30	0,0503	0,2550	350,0
31	0,0400	0,2270	446,0
32	0,0320	0,2020	578,0
33	0,0252	0,1800	710,0
34	0,0200	0,1600	899,0
35	0,0161	0,1430	1125,0
36	0,0123	0,1270	1426,0
37	0,0100	0,1130	1800,0
38	0,00795	0,1010	2255,0
39	0,00632	0,0897	2860,0
40	0,00487	0,079	3802
42	0,00317	0,064	5842
44	0,00203	0,051	9123

4/0 can also be written: 0000; 1 mil= 0,001 inch = 0,0254 mm
*Dimensions stated in MCM (circular mils) for larger cross-sections
1 CM = 1 Circ. Mil. = 0,0005067 mm²
1 MCM = 1000 Circ. Mils = 0,5067 mm²

British and US dimensions

Mass	
1 grain	= 64,8 mg
1 dram	= 1,77 g
1 oz (ounze)	= 28,35 g
1 lb (pound)	= 0,4536 Kp
1 stone	= 6,35 Kp
1 qu (quart)	= 12,7 Kp
1 US-cwt (hundred-weight)	= 45,36 Kp
1 US ton (short ton)	=0,907 t
1 brit ton (long ton)	= 1,016 t
Length	
1 mil	= 0,0254 mm
1 in (inch)	= 25,4 mm
1 ft (foot)	= 0,3048 m
1 yd (yard)	= 0,9144 m
1 ch (chain)	= 20,1 m
1 mm	= 0,039370 in
1 m	=39,370079 in
1 mile (Landmeile)	= 1,609 km
1 mile (Seemeile)	= 1,852 km
Area	
1CM (circ.mil)	= 0,507x0,001 mm^2
1MCM	= 0,5067 mm
1sq. inch (sq.inch)	= 645,16 mm^2
Temperature	
F (Fahrenheit)	= (1,8xC) + 32°
C /Celcius)	= 0,5556 x (F - 32°)
Speed / Velocity	
1mile/h	= 1,609 km/h
1 Knoten	= 1,852 km/h
Volume	
1 cu. Inch	= 16,387 cm^3
1 cu. Foot	= 28,3167 dm^3
1cu. Yard	=0,764551 m^3
1 gallon (US)	= 3,78540 l
1 gallon (brit.)	= 4,546 l
1 quart (US)	=0,946 l
1 barrel (US)	=158,8 l
1 m3	= 35,3148 cu.ft.
1 dm3	= 61,0239 cu. in.
Electrical units	
1 ohm/1000 yd	= 1,0936 Ω/km
1 ohm/1000 ft	= 3,28 Ω/km
1 µF/mile	= 0,62 µF/km
1 megohm/mile	= 1,61 MΩ/km
1 µµf/foot	= 3,28 pF/m
1decibel/mile	= 71,5 mN/m

Force	
1lb	= 4,448 N
1 brit. Ton	= 9954 N
1 pdl (poundal)	= 0,1383 N
1kp	= 9,81 N
1N	= 1,02 kp
Energy	
1 hp x h	= 1,0139 PS x h
	= 2,684 x 100000 J
	= 746 W x h
1BTU (brit.therm. unit)	= 1055 Joul
Power	
1 PS	= 0,736 kW
1 kW	= 1,36 PS
1 hp	= 0,7457 kW
1 kW	= 1,31 hp
Weight per unit of length	
1 lb/mile	= 0,282 kg/m
1 lb/yard	= 0,496 kg/m
1 lb/foot	= 1,488 kg/m
Pressure	
1 psi(lb/sq.)	= 68,95 mbar
1 lb/sq. ft.	= 0,478 mbar
1 pdl/sq. ft.	= 1,489 N/m^2
1 in Hg	= 33,86 mbar
1 ft H2O	= 2,491 mbar
1 in H2O	= 2,491 mbar
1 N/mm2	= 10 bar
1 kp/mm2	=1422 psi
1 at	=1 kp/cm^2
1 Torr	= 1 mm Hag
1 bar	= 0,1 H Pa
1Pa	= 1 N/m^2
Density	
1 lb/cu. ft.	= 16,02 kg/m^3
1lb/su. In.	=27,68 t/m^3
Weight	
1ounce (oz)	= 28,35 p
1 pound (lb)	= 0,4536 kp
1 quarter	= 12,7 kp
1 hundredweight	
(centweignt, cwt)	= 50,802 kp
1kp	= 2,2046 lbs.
	= 35,274 oz.

Copper calculation

The price of copper

Cables are marketed at day copper prices (DEL). The DEL is the stock-market quotation for German Electrolytic Copper for conductor purposes, i.e., 99.5 % pure copper. The DEL is stated in Euro per 100 kg. It can be found in the Business section of the daily newspapers, under the heading "Commodities Market".

Example: DEL 161,40 signifies:
100 kg copper (Cu) costs 161,40 Euro

1% purchasing costs must be added to the day's quotation for cables.

The copper basis

A portion of the price of copper is already contained in the list price of a large proportion of cables. It, too, is stated in Euro per 100 kg.

- Euro 150,00/100 kg for most cables
- Euro 100,00/100 kg for telephone cables
- Euro 000,00/100 kg for e.g. earthing cables (e.g. NYY power cables), i.e., hollow price

Copper weight

The copper index is the "copper weight" of a cable (it is stated for every item in the catalogue).

Example: KAWEFLEX® 3130
4 G 1,5 mm²
Copper weight as per catalogue 60 kg/km
The copper contained in 1 km of cable therefore weights 60 kg.

Formula for calculation of copper surcharge

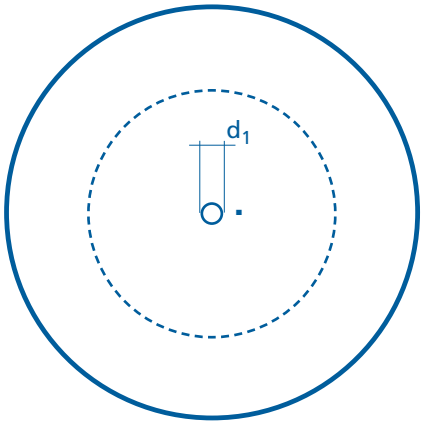
Copper weight (kg/km) x (DEL + 1% purchasing costs – copper basis): 100 = copper surcharge in Euro/km

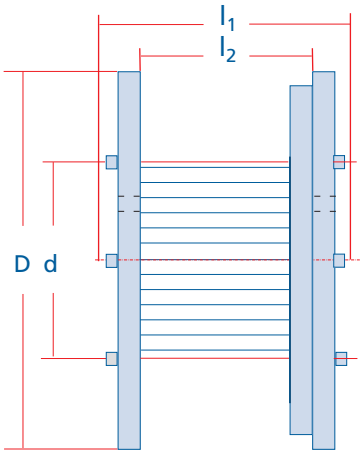
Example:	KAWEFLEX® 3130	4 G 1,5 mm²
	DEL	400,0 Euro/100 kg
	Cu base	150,00 Euro/100 kg
	Cu weight	60 kg/km

60 kg/km x (400,00 + 4,0 – 150,00) : 100 = 152,4 Euro/km

Assuming a DEL quotation of Euro 400,00, this amount would be the copper surcharge for 1 km of KAWEFLEX® 3130 4 G 1,5 mm².
The copper surcharge is normally shown separately on all invoices.

KTG Cable Drums, dimensions, weights and capacities





D = Flange-ø
d = Core-ø
d_1 = Drilling-ø
l_1 = Width over all
l_2 = Range of winding

Cable drums plastic

Drum Normalsize	Flange-Ø mm	Core-Ø mm	Width over all l_1 mm	Range of winding l_2 mm	Drum unloaded weight ca. kg	Maxim. Load-bearing capacity kg
050/7	500	150	456	404	4	100
070	710	355	510	400	15	250
080	800	400	510	400	16	350
090	900	450	680	560	23	400
100	1000	500	704	560	32	500

Cable dums wood (Standard)

Drum Normalsize	Flange-Ø mm	Core-Ø mm	Width over all l_1 mm	Range of winding l_2 mm	Drum unloaded weight ca. kg	Maxim. Load-bearing capacity kg
051	500	150	470	410	8	100
071	710	355	520	400	25	250
081	800	400	520	400	31	400
091	900	450	690	560	47	750
101	1000	500	710	560	71	900
121	1250	630	890	670	144	1700
141	1400	710	890	670	175	2000
161	1600	800	1100	850	280	3000
181	1800	1000	1100	840	380	4000
201	2000	1250	1350	1045	550	5000
221	2240	1400	1450	1140	710	6000
250	2500	1400	1450	1140	875	7500
251	2500	1600	1450	1130	900	7500
281	2800	1800	1635	1280	1175	10000

Cable lengths (m) according to KTG (Part 1)

cable-Ø mm	071 07	081 08	091 09	101 10	121 12	141 14	161 16/8	181 18/10	201 20/12	221 22/14	250 25/14	251 25/16	281 28/18	
6	2024	2755												6
7	1481	2340												7
8	1064	1463	2731											8
9	892	1152	2202	2866						K_d = core · Ø of drum				9
10	677	980	1768	2349						D = cable · Ø				10
11	564	761	1404	1912										11
12	468	643	1206	1540										12
13	385	542	1032	1339	2727									13
14	364	454	881	1159	2255	2967								14
15	297	430	749	1000	1991	2479								15
16	239	358	632	860	1756	2205								16
17	228	294	603	736	1545	1959								17
18	218	281	505	705	1355	1737								18
19	172	228	485	599	1184	1535	2722							19
20	165	219	402	576	1139	1352	2435	2831						20
21	159	211	387	485	991	1304	2172	2527						21
22	122	167	315	468	856	1145	1931	2248						22
23	117	161	304	389	827	999	1869	2172	2953					23
24	113	156	294	377	709	967	1657	1927	2608					24
25	110	151	285	365	688	839	1608	1867	2522					25
26	80	116	228	299	668	814	1419	1650	2218					26
27	78	113	221	290	567	700	1244	1450	2150	2861				27
28	76	109	215	282	551	681	1211	1409	1879	2777				28
29	73	106	209	226	462	663	1180	1371	1826	2450				29
30	71	103	162	220	450	564	1028	1197	1583	2383				30
31		76	157	214	438	550	1003	1166	1540	2089				31
32		74	153	209	428	537	866	1009	1500	2035	2978	2491		32
33		72	150	204	352	451	846	985	1289	1984	2908	2428		33
34			146	158	344	441	828	962	1257	1726	2605	2134		34
35			108	154	336	431	707	824	1227	1685	2547	2083	2890	35
36			105	151	329	422	692	806	1041	1646	2271	2035	2822	36
37			103	148	265	348	678	788	1017	1418	2223	1774	2759	37
38				144	259	341	664	772	994	1386	1969	1735	2432	38
39				107	254	334	560	653	972	1356	1930	1697	2379	39
40				105	249	327	549	640	812	1328	1892	1466	2329	40
41				102	244	264	539	627	795	1130	1664	1435	2036	41
42				100	190	259	529	615	779	1107	1633	1406	1995	42
43					187	254	437	511	763	1085	1603	1199	1956	43
44					183	249	430	502	749	1064	1574	1175	1693	44
45					180	245	422	492	611	890	1373	1153	1661	45
46					177	240	415	484	600	874	1349	1131	1630	46
47					174	187	408	475	589	858	1326	1110	1600	47
48					129	184	330	386	578	842	1144	931	1367	48
49					127	181	325	380	568	828	1125	914	1343	49
50					125	178	319	373	558	678	1107	898	1320	50
51					123	175	314	367	442	666	1089	883	1298	51
52					121	172	310	361	435	655	1072	869	1276	52
53						170	305	356	428	644	912	713	1073	53
54						126	239	280	421	634	898	701	1055	54
55						124	235	276	414	624	885	690	1039	55
56						122	232	271	408	614	872	679	1022	56
57						121	228	267	401	488	860	668	1006	57
58						119	225	263	304	480	719	658	991	58
59						117	222	260	300	473	709	649	815	59
60							219	256	295	466	699	639	803	60
61							216	252	291	460	689	609	791	61
62							161	190	287	453	680	501	780	62
63							159	187	282	447	671	494	769	63
64							157	184	279	441	663	487	759	64
65							155	182	275	335	541	481	748	65
66							153	180	271	330	534	474	739	66
67							151	177	267	326	528	468	589	67
68								175	264	321	521	462	581	68
69								173	186	317	515	456	574	69
70								171	184	313	509	450	566	70
71								168	182	309	503	343	559	71
72								166	179	305	497	338	552	72
73								164	177	301	491	334	545	73
74								162	175	298	486	330	539	74

Registered Trademarks

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PAARTRONIC®

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PELON®

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KAPTON®	(DuPont)
KEVLAR®	(DuPont)
NEOPRENE®	(DuPont)
TEFLON®	(DuPont)
TEFZEL®	(DuPont)
THERMI-POINT®	(AMP)
MAXI-THERMI-POINT®	(AMP)
KYNAR®	(Atofina)
STYROFLEX®	(BASF)
DYFLOR®	(Degussa)
INTERBUS-S®	(Phoenix Contact)
SUCCOnet P®	(Klöckner-Möller)
MODULINK P®	(Weidmüller)
VariNet-P®	(Pepperl+Fuchs)
INTERBUS-P®	(Phoenix Contact)
SINCE®	(SIEMENS)
F.I.P®	(F.I.P. Nutzergruppe)
PROFIBUS®	(PROFIBUS® Nutzerorganisation, PNO)
Thinwire (net)®	(Digital Equipment Corporation)
DeviceNeTM®	(Open Device Vendors Association, ODVA)
ETHERNET®	(Xerox)
SIMATIC®	(SIEMENS)
SafetyBUS p®	(Pilz)
DESINA®	German Machine Tool Builders Association VDW

CORDAFLEX®	(Prysmian Cables + sytems)
RONDOFLEX®	(Prysmian Cables + sytems)
SPREADERFLEX®	(Prysmian Cables + sytems)
BASKETHEAVYFLEX®	(Prysmian Cables + sytems)

Printed cable markings

Short date code with reference to DIN EN 60062

Our modern INKJET printer enables us to print any text required on a cable. Character height and the spacing of character groups are selectable without restriction. Company logos can also be printed on cables. Programming of an EPROM is necessary for this purpose, however.
The printing of the production date on a cable is also good practice. We add the date of production, encoded in accordance with DIN EN 60062, to the printed data, as a standard procedure.

Year	Code	Year	Code
2001	N	2007	V
2002	P	2008	W
2003	R	2009	X
2004	S	2010	A
2005	T	2011	B
2006	U	2012	C

Month	Code	Month	Code
January	1	July	7
February	2	August	8
March	3	September	9
April	4	October	O
May	5	November	N
June	6	December	**D**

Example: "**U3**" signifies date of production March 2006

font size: 1/3 des Kabeldurchmesser, min. 3 mm
printing: per INK-JET

Recommendations for installation of cables in drag-chain applications

Basic cable-handling recommendations

- Tensile and torsional forces must never be applied to cables. The only exception occurs in the case of cables which are designed and manufactured to withstand such loads.
  Plug-type connections must always be disconnected by pulling on the plug, and never by pulling on the cable.
- Cables must never kinked. Bending to a radius tighter than the minimum bending radius stated in our data sheets is not permissible.
  The same also applies to storage of cables. Please note the core diameter of cable drums and rings.
- Cables should not be exposed to large temperature fluctuations and extremes of weather. Avoid outdoor storage wherever possible.
- Cables must always be rolled off of drums or cable rings. Pulling off in loops (over the drum side) causes kinks, which may result in failures.
- Cables which have suffered mechanical damage as a result of pressure, jamming or crushing must be withdrawn from use.

Selection and installation recommendations for cables in drag-chain applications

There are many more factors to be taken into account in the case of installation of cables in drag-chain applications. The importance of an energy-supply system in complex machinery installations generally only becomes clear when a problem or a failure occurs. Costly downtimes and losses of production are inevitable without careful and informed selection and correct installation of drag-chains and the appurtenant drag-chain-capable cables.

The correct cables are available in the corresponding sections of our catalogue. If you do not find what you need, please ask us. We are at your disposal at any time for advice and assistance in the selection of the most suitable types for your application. The best solution: Make use of our know-how and experience as early as the development and design phases. Together, we'll find the best solutions for your drag cable.

Installation of cables into drag-chain applications must be performed with the greatest care. The following recommendations for installation are based on our many years of practical experience with drag-chain cables, and also on joint research and interchange of experience with chain manufacturers and a large range of users of mobile drag-chain applications.

1. The cables must be selected extremely carefully. Always use only cables which are suitable for your needs in your drag-chain applications.

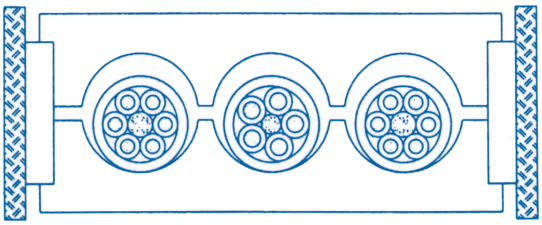
2. Single-layer cables should be preferred over multi-layer designs. Where a large number of cores is necessary, they should, if possible, be distributed to a number of single-layer cables. This makes it possible to achieve smaller bending radii and a higher number of bending cycles.

3. The cable with the largest outer diameter is definitive for dimensioning of the minimum bending radius of the chain system. Note the minimum bending radius for continuous reversing bending stated in our data sheets.

4. Twist-free installation, with no tensile load being exerted on the cables, is of the greatest importance! Cables must always be rolled off of cable rings and cable drums. They must never be lifted off in loops "over the side" (danger of kinks). We recommend that cables be laid out before installation or, even better, hung up.
   This permits the cables' intrinsic or residual twist to "relax" out. Axial twisting of the cables must be avoided under all circumstances.
   Only then the cable should be installed in the laid-out drag-chain. The completed chain should then be installed in the machine.

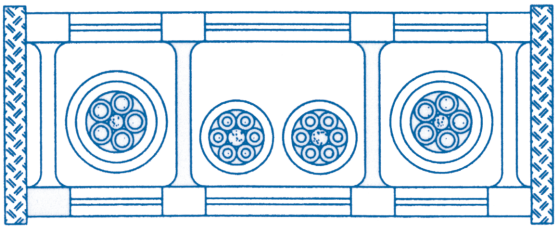
   Caution: As a result of production techniques, the data printed on the cable runs in a slight spiral around the cable. It must therefore never be used as an indicator of twist-free alignment of the cable!

5. The cables must not cross in the energy-supply chain and must not lay one on top of the other. Forced restraint in the chain must be avoided, i.e., the cables must be able to move freely, both vertically and horizontally and, in particular, at and around the bending radius.
   The total cross-section of the chain, or of the web or guide plate should be filled not more than 80 to 85 % with cables.
   The cables must neither be fixed nor tied together in the chain.



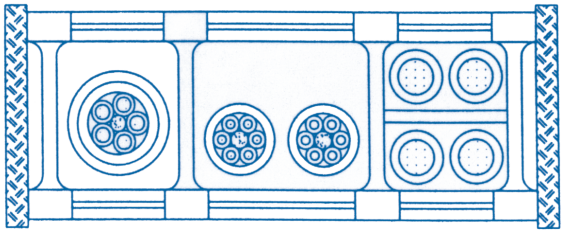
Recommendations for installation of cables in drag-chain applications

6. Distribution of weight in the drag-chain should be as symmetrical as possible. The heavier cables should be installed on the outside, the lighter cables to the inside.



7. The use of chains with subdivided chambers or webs is recommendable in the case of chains consisting of cable with greatly differing diameters.

   This is not absolutely necessary in the case of differences in diameter of up to ± 20 %.
   Dividing bars should be installed between the layers of multi-layer cable arrangements.



8. Before fixing cables to a fixed point, it is advisable to operate the energy-supply chain system for around 10 to 20 cycles, in order to relax the cables and bring them into a neutral position. Cable lengths should be readjusted after the first around 24 hours of operating time, if possible.

9. It is recommendable to replace all the cables after failure of a power-supply chain. Otherwise, reduced service-life may occur, as a result of possible overstretching of the cables.

10. Cables should be fixed or guided at both ends, with a minimum distance of 30-fold the cable diameter from the end point of bending movement.

    There are various types of fixing; all have their pros and cons. Ultimately, the designer must decide which type of fixing produces the most advantages for his particular application. We recommend:

    Cables with high flexibility/low intrinsic stiffness:
    Clamping on the driver side and at the fixed point.

    Cables in vertically installed drag-chain applications:
    Clamping on the driver side and at the fixed point.

    In case of travel paths within the self-supporting range of the power-chain:
    Clamping on the driver side and at the fixed point.

    In case of greater travel paths, with the exception of cables with high flexibility/low intrinsic stiffness:
    Clamping on the driver side, guide at the fixed point.

    Clamping should be applied across a large area over the outer sheath. This means that the core assembly (cable center) must not be crushed; shifting of the cable should nonetheless no longer be possible. Crushing of cores significantly shortens the service-life of cables.

    The term "guide" used here signifies that the cable should be able to move backwards and forwards, but not to the sides.

You need more information?
Just call us, we'll be pleased to help.

Assembly details

for reeling cables, trailing cables and tough rubber cables suitable for reeling

1. Move the shipping reel to the deployment site using a cable trolley ort truck. Roll the reel only in exceptional situations. Roll the reel in the direction of the arrow printed on the reel.

2. Where possible, before laying on the working reel, lay out the cable at full length, using cable-laying rollers when feasible. Pull of the cable only from top.

3. If there is not enough space to lay out the cable at full length, proceed as follows: Position the supply and the equipment reel as far apart as possible. Pull the cable off the supply reel only from top. When transferring, do not allow the cable to lie in a S-shape or fall in a different plane (see illustration).

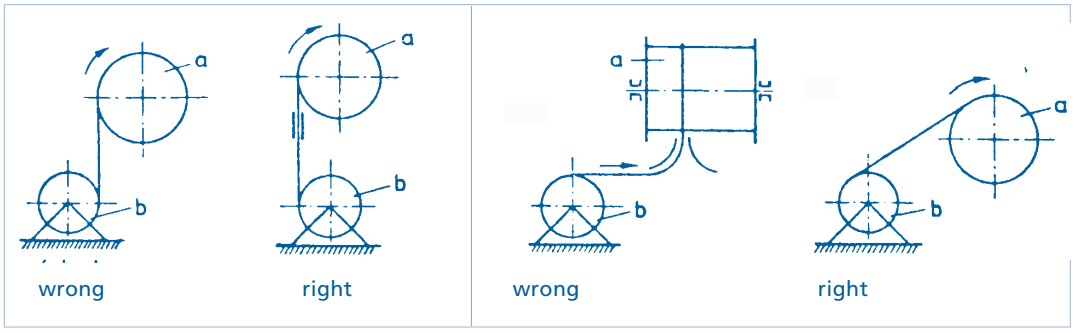
4. For ready-made cables, first attach the termination to the equipment reel (slip-ring-body) twist-free, clamp on the cable, wind it onto the equipment reel and then connect it twist-free to the power feed and attach it. Do not allow the terminations to drag over the floor.

5. Where the cables are supplied without terminations, attach the terminations after winding

6. At least two cables turns should remain on the equipment reel when the device is fully extended

7. If the power feed is:
   a) underground in the middle of the track, wrap one or two cable turns around an equalising ring behind the entry funnel. Then clamp down and connect the cable.
   b) above-ground at the end of the track, the cable section off the reel should be at least 40 times the cable diameter in front of the mounting clamp at the feed point when the installation is in its end position, or wrap one or two cable turns around an equalising ring and then clamp down and connect the cable.

8. Protect the cable from external damage during mounting and operation.



Transferring cable to the working reel (a) from the supply reel (b)

Assembly details

for cables on mobile cable supports tough rubber cables suitable for reeling

1. **Inspect the cable supports:**
   for proper movement, no skewing over the travel distance; easy running of the deflection pulleys; the groove width of the deflection pulleys must be at least 12% greater than the cable diameter.

2. Move the shipping reel to the deployment site using a cable trolley or truck. Roll the reel only in exceptional situations. Roll the reel in the direction of the arrow printed on the reel.

3. Wind the deployment lengths on the installation reel twist-free. Do **not** pull off the cable over the reel flange, **use a winding apparatus**.

   Observe the bending diameter when performing this task.
   For cables of up to 21.5 mm in diameter, bending diameter = 10 x cable diameter.
   For cables greater than 21.5 mm in diameter, bending diameter = 12.5 x cable diameter (VDE 0100)

4. Do not pull off the cable onto installation in a loose coil or stretched.

   Mount the installation reel on the installation at the end of the cable support so that the cable can be pulled off from top of the reel. The reel should always be at the opposite end from the side to be installed.

5. Install the new cable either using a pulling rope or the cable to be removed (connect them using a cable stocking) over the top of the cable support and position the deflecting pulley at the bottom attachment point on the cable support. **Make sure that the cable cannot become twisted or kinked.**

6. Adjust the cable so that it hangs loosely in the middle position of the cable support.

7. Where possible, move the device along ist path several times slowly before fixing the cables in place and then attach them using broad clamps - **avoid oval pinching**

8. Lay each length individually

Operational areas for drumable lines

Cable Guidance Systems	Reel						
Stress	simple	high	extreme				
FESTOONFLEX PUR HF	+	o	-	++	o	++	-
Trommelflex (K) - NSHTÖU	++	+	o	++	o	+	-
Cordaflex (SMK) - (N)SHTÖU	+	++	++	+	++	-	++
Trommelflex PUR-HF	+	++	++	+	++	+	++

++	**main use**	o	partly suitbale - after consulation
+	suitable	-	not suitable

GENERAL TERMS AND CONDITIONS OF SUPPLY, PAYMENT AND DELIVERY

I. Defence clause / applicability

1. We supply cables, leads and accessories (hereinafter referred to as 'goods') exclusively under the following conditions. Any other or additional conditions are not binding on us, even if we do not protest them. If, as an exception, we accept other or additional conditions, this will apply only to the respective single transaction.
2. These conditions apply only to proprietors of businesses who, on concluding the contract, are carrying out their commercial or independent professional activity, to bodies corporate under public law or separate entities under public law.

II. Quotations / orders

1. Our quotations are without obligation. Even without our written confirmation, the buyer's order is binding on him for two weeks.
2. Orders (including supplements and amendments thereto) will only be deemed to have been accepted if we have confirmed them in writing. The receipt of an invoice by the buyer or the execution of the delivery will count as confirmation.
3. If, in an individual case, a trial delivery is agreed, the purchasing contract will become effective if the buyer does not declare his disapproval within eight working days of receipt of the goods and we have previously drawn the attention of the buyer to the significance of his silence. If no purchase order is placed, the buyer will be under an obligation to return the goods to us, carriage paid and in the same condition.
4. We reserve title and the copyrights to all cost estimates, design drawings, samples and similar documents (hereinafter referred to as 'documents'). Documents may only be made accessible to third parties or made use of in any other way with our prior written consent. If no purchase order is placed, or the order is cancelled or with drawn, they are to be returned to us. This applies analogously to documents belonging to the buyer. We may, however, pass these to a third party to whom we have been permitted to assign the shipment.

III. Prices and metal surcharges / terms of payment and delivery / delayed acceptances

1. Prices are quoted in EUROS, excluding statutory Value Added Tax, which is notified separately. The provisions laid down in clauses 2 and 5 remain unaffected hereby.
2. In addition to the agreed prices, we may levy metal surcharges. Unless other rates are specified in our pricing information, the prices for copper cables include a base price of EUR 150 per 100 kg of copper, except for telecommunications cables with copper at EUR 100 per 100 kg of copper and earthing cables at the hollow cable price. The basis for calculation of the selling price is the published DEL commodities exchange quotation for copper on the day before receipt of the order, plus 1% for metal delivery costs. The selling price will increase or decrease by the difference between the copper base price and the DEL quotation. The price of metal articles made of brass is based on the metal quotation for MS 58 of EUR 150. If the metal quotation increases by EUR 13.00 in each case, a surcharge of 5% will be invoiced accordingly. If other metals are used (e.g. aluminium, lead), invoices will be based on the equivalentof the treatment of copper prices. The starting base is the prices specified in the quotation. The prices of metals and raw materials, surcharges and reductions are all nett.
3. Unless otherwise agreed in individual cases, all our shipments are made EX WORKS (EXW-INCOTERMS 2000). In principle, the risk of the acc idental destruction ordeterioration of the goods passes to the buyer with our notification to the buyer of readiness for dispatch or, in the case of a consignment sale, with the handover of the goods to the company or person responsible for their transportation.
4. Any offsetting right or the exercising of any rights of retention on the part of the buyer will only exist if the counterclaim is undisputed, capable o f being decided or established as legally valid. Rights of retention on the part of the buyer due to deficiencies in the goods remain unaffected hereby.
5. We reserve the right to deliver surpluses or shortages of goods (lengths) of up to +/- 10% and to invoice these accordingly. In the case of orders for fixed lengths, the permitted variations will be determined in accordance with the respective agreements. Deliveries may be made in different part lengths for compelling technical or commercial reasons. If we manufacture goods to customers' specifications, we reserve the right to deliver up to 15% of the ordered quantity in under- or overlengths. The measuring tolerance for lengths is +/- 0.4%.
6. In so far as it is reasonable to the buyer, we will be entitled to make part deliveries which we will invoice to the buyer individually.

IV. Lead-times /compensation for non-fulfilment / withdrawal

1. Unless otherwise agreed (or agreed as non-binding), delivery dates and lead-times are only approximations. Lead- times will only begin after any financial or technical questions have been clarified. In particular, this applies to our receiving any documents which may be necessary from the buyer as provided for under II, clause 4. If clearance by the buyer is required in accordance with clause 2, sentence 3, lead-times will not begin before clearance has been given. Our obligation to supply will be suspended if the buyer is in arrears with a not inconsiderable payment.
2. The orderer undertakes in the case of special custom products to define in written form the requirements for the goods and to supply the documents stated in Section II No. 4 to us. We shall be deemed obliged neither to check the orderer's documents (for correctness and/or completeness) nor to obtain the orderer's permission to proceed with production of the goods once we have received the documents. This latter provision shall be deemed not to apply in cases of obvious errors in and/or missions from the documents. In case of such obvious errors and/or omissions, we undertake to propose to the orderer corrective action, which corrective action shall be deemed to require the orderer's express approval.
3. The lead-time and delivery date will be deemed to have been met if notification of readiness for dispatch is given in due time in accordance with III, clause 3 or, in the case of a consignment sale, the goods arrive at the agreed place at the right time.
4. We will only be in default if the buyer has reminded us accordingly after the due date of our delivery. Claims for compensatory damages for default by the buyer will be subject to the provisions laid down in VII, clause 1.
5. If we fail to fulfil an obligation or do not do so in full, the buyer may only claim compensatory damages instead of our fulfilling the (entire) obligation (Article 281, Section 1 of the Civil Code) or reimbursement for wasted expenditures (Article 284 of the Civil Code) if the buyer has previously set a reasonable period of grace for the obligation to be fulfilled, with a threat to claim compensatory damages, and the period expires without result. This notwithstanding, the buyer will still not loose his entitlement to the obligation being fulfilled. This will not apply:

a) if it is unnecessary to set a period of grace (e.g. in the event of infeasibility or our solemn, final refusal to fulfil the obligation or in the event of special circumstances arising which justify the immediate assertion of a claim for compensation);
b) in cases of deliveries of defective goods (poor performance); in this case, the provisions in VI, clauses 4 and 5 will apply.
The provision of compensation instead of fulfilment or the reimbursement of wasted expenditures will be determined in accordance with the provisions laid down in VII, clause 2.

6. If we delay in fulfilling an obligation, the buyer may only withdraw from the contract in accordance with the statutory provisions (Articles 323, 324 of the Civil Code, i.e. essentially only on the expiry of a reasonable period of grace set by the buyer) if we are responsible for the delay. No shift of the burden of proof onto the buyer is associated herewith.

GENERAL TERMS AND CONDITIONS OF SUPPLY, PAYMENT AND DELIVERY

V. Reservation of title

1. We reserve title to the goods until all the debts owing to us from the contract or sale have been paid in full, including any debts arising out of an ongoing business relationship. The discounting of any bills of exchange or cheques endorsed to us will only constitute the fulfilment of a payment if the bill of exchange is paid on the due date or the sum for which the cheque is drawn is irrevocably credited to one of our accounts.
2. The buyer is authorised (subject to this being revoked) to resell the goods within the framework of the ordinary course of his business. In accepting these conditions, he assigns to us all the debts owing to him equal to the value of his invoices, but not exceeding the value of the debt owing to us by the buyer. We will accept the assignment. The buyer is authorised to collect the debts himself. We oursel ves may collect the debts and revoke his authorisation if the buyer falls into arrears.
3. The buyer is authorised (subject to this being revoked) to process the goods within the framework of the ordinary course of his business. Any processing will take place in our name and on our order. If our goods are combined with articles belonging to the buyer, we will acquire co- ownership thereof in the proportion of the value of our goods relative to the value of the said articles.
4. If requested to do so by the buyer, we undertake to release goods to which we own title or to assign debts as under clause 2 or co-ownership as under clause 3, at our discretion, in so far as the security value of the reserved goods or the debts assigned as under clause 2 or co- ownership acquired as under clause 3 exceed the debt on our selling price. The security value corresponds to the sum of the selling price less 10% for re-utilisation losses and costs. Release will take the form of (re-)assignment or reconveyance.
5. In the event of arrears of payment, we may either:

a) after a further warning without result, demand the return of the reserved goods. This demand will not, however, be deemed as a withdrawal from the contract;
b) or withdraw from the contract with the buyer and demand the return of the reserved goods.

VI. Defects in the goods

1. The goods will be free of defects if they comply with the agreed quality.

a) Unless otherwise agreed with the buyer, the agreed quality of goods manufactured to specification will be determined exclusively from the buyer's documents as per II, clause 5, IV, clause 2, otherwise wholly and solely by our product descriptions.
b) Characteristics which the buyer can expect on the strength of our public statements, particularly statements in publicity or indications given in the marking of the goods do not form part of the agreed quality.
c) Any data relating to the diameter or weights of goods are non-binding. Variations of up to +/- 20% thereof do not represent a defect if no specified diameters or weights have been agreed.The provisions laid down in IX remain unaffected hereby.

2. We offer no guarantee on the quality or usability of the goods. We offer no guarantee of durability to the effect that the goods will retain their quality for a specified period of time.
3. If the goods exhibit a defect, we will, at our discretion, make amends by eliminating the defect or making a fresh delivery (repairs or replacements), which we are entitled to do twice. If requested by us to do so, the buyer is under an obligation to permit the goods to be inspected, even by a third party. During the period between our request and our declaration that the defect is not present or has been rectified, or our refusal to rectify the defect, the period of limitation as provided for in clause 7 will be suspended.
4. If the repair or replacement comes to nothing, the buyer will be entitled to a reduction in the purchasing price or, in the event of serious defects, to withdraw from the purchasing contract. In the case of minor defects, he may not withdraw from the contract or demand compensatory damages instead of our fulfilling our obligation in its entirety.
5. Regardless of any other commercial obligations to carry out inspections or submit complaints in accordance with Article 377 of the Code of Commercial Law and our duties as the manufacturer, the buyer has a duty, before using the goods, to inspect them for compliance with the agreed specifications and suitability for the purpose intended by the user.
6. Article 377 of the Code of Commercial Law will apply with the proviso that the buyer notifies us without fail of any obvious defects within a period of two weeks from receipt of the goods. Defects discovered only as a result of the inspection, which must take place without delay, must be notified within two weeks of their being discovered.
7. The period of limitation for all contractual rights on the part of the buyer due to defects (guarantee period) is one year from the delivery of the goods.
   This will not apply:
   - if we (exceptionally contrary to clause 2) have given a guarantee;
   - if we have fraudulently concealed a defect;
   - if the defect was caused through the malicious intent or gross negligence of us, our legal representatives or vicarious agents;
   - if a defect attributable to us has led to a fatal or physical injury or harm to the health.

   This notwithstanding, in the event that goods have been used in the construction of a building in accordance with their usual method of use and have caused it to be deficient, the guarantee period is five years. The period of limitation in a case of our non-contractual liability is given in VII, clause 3.

VII. Liability / infeasibility / statute of limitations

1. The following apply to non-contractual claims in respect of defects, claims for arrears, other infringements of obligations from the contractual relationship and for impermissible acts:

a) There is no limit to our liability for fatal or personal injury or harm to the health of the buyer caused by the culpability of us, our legal representatives or vicarious agents or officers.
b) In cases of infringements of essential contractual obligations (cardinal duties) attributable to minor negligence, also on the part of our legal representatives or vicarious agents or officers, our liability for other damages is limited to foreseeable losses typical of the contract. In a case of infringement of lesser contractual obligations attributable to minor negligence, our liability is excluded.

2. Compensatory damages instead of the fulfilment of obligations, or the reimbursement of wasted expenditures (if we cannot or do not need to fulfil the obligation (infeasibility) will be limited to foreseeable damages or expenses typical of the contract. This will not apply:

a) in cases specified in clause 1a;
b) if we were aware of the hindrance to fulfilment or were unaware of it due to gross negligence;
c) if we have taken a purchasing risk (II, clause 4 remains unaffected hereby.

GENERAL TERMS AND CONDITIONS OF SUPPLY, PAYMENT AND DELIVERY

3. For all claims against us, the regular period of limitation is two years commencing at the end of the calendar year in which the claim arose and the buyer was aware of the facts of the claim or should have known thereof without gross negligence. This will not apply:
a) to claims established as valid in law, including claims arising out of enforceable settlements, executory deeds or an insolvency finding;
b) to contractual claims due to defects which will fall within the guarantee periods specified in VI, clause 7;
c) if we or one of our legal representatives or vicarious agents or officers are/is culpable of malicious intent or gross negligence;
d) to claims due to a fatal or physical injury, harm to the health or loss of freedom or an essential contractual obligation (cardinal duty) for which we are culpable.
4. Our liability and the statute of limitations provided for by the Product Liability Act remain unaffected hereby.

VII.Liability / infeasibility / statute of limitations

1. The following apply to non-contractual claims in respect of defects, claims for arrears, other infringements of obligations from the contractual relationship and for impermissible acts:
a) There is no limit to our liability for fatal or personal injury or harm to the health of the buyer caused by the culpability of us, our legal representatives or vicarious agents or officers.
b) In cases of infringements of essential contractual obligations (cardinal duties) attributable to minor negligence, also on the part of our legal representatives or vicarious agents or officers, our liability for other damages is limited to foreseeable losses typical of the contract. In a case of infringement of lesser contractual obligations attributable to minor negligence, our liability is excluded.
2. Compensatory damages instead of the fulfilment of obligations, or the reimbursement of wasted expenditures (if we cannot or do not need to fulfil the obligation (infeasibility)) will be limited to foreseeable damages or expenses typical of the contract. This will not apply:
a) in cases specified in clause 1a);
b) if we were aware of the hindrance to fulfilment or were unaware of it due to gross negligence;
c) if we have taken a purchasing risk (II, clause 4 remains unaffected hereby).
3. For all claims against us, the regular period of limitation is two years commencing at the end of the calendar year in which the claim arose and the buyer was aware of the facts of the claim or should have known thereof without gross negligence. This will not apply:
a) to claims established as valid in law, including claims arising out of enforceable settlements, executory deeds or an insolvency finding;
b) to contractual claims due to defects which will fall within the guarantee periods specified in VI, clause 7;
c) if we or one of our legal representatives or vicarious agents or officers are/is culpable of malicious intent or gross negligence;
d) to claims due to a fatal or physical injury, harm to the health or loss of freedom or an essential contractual obligation (cardinal duty) for which we are culpable.
4. Our liability and the statute of limitations provided for by the Product Liability Act remain unaffected hereby.

VIII. Drums on loan and charges

1. We reserve the right to supply goods on our own drums or on drums on loan from Kabeltrommel GmbH & Co. KG (KTG).
2. If the delivery is made on drums loaned from KTG, the buyer is to pay KTG direct in accordance with the drum rentals calculated in accordance with KTG's General Terms and Conditions. In this case, KTG will acquire its own right to make claims on the buyer. If the buyer so wishes, we will provide him with a copy of KTG's General Terms and Conditions.
3. When the material on KTG drums is exhausted, the buyer has a duty to notify KTG of the availability of the empty drums without delay.
4. We do not charge rentals on our own drums. The buyer is under no obligation to return them. He is only entitled to return them subject to a corresponding agreement having been concluded, and then only if our loaned drums can be re-used and the buyer bears the costs of returning them.

IX. Export restrictions

1. Our goods comply with the German and European provisions for the manufacture and usability of electrical cables.
2. We give no guarantee that the goods can be exported abroad or used there. Before exporting our goods, the buyer is himself to comply with any export or import restrictions as laid down in the German External Trading Act or the external trading rights of the USA.

X. Legal venue / applicable law

1. The exclusive legal venue shall be the locations of the TKD-companies in the Federal Republic of Germany. We will, however, also be entitled to bring proceedings at any general or specific legal venue of the buyer.
2. German law will apply to our business relationships with the buyer. Any applicability of the UN Convention on Contracts for the International Sale of Goods is, however, excluded.

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