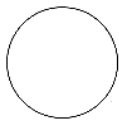
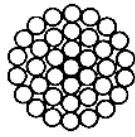


Conductor Construction for Insulated Cables and Wires

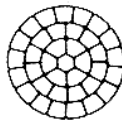
Conductor Construction



circular
solid
RE



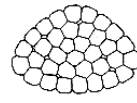
circular
stranded
RM



circular
stranded
compacted
RM



sector-shaped
solid
SE



sector-shaped
stranded
SM

Construction and Conductor Resistance according DIN EN 60228 (VDE 0295)

Circular copper conductor

nominal cross section mm ²			solid (class 1) max. conductor diameter mm	stranded (class 2)				
				not compacted		compacted		
				number of single wires (min.)	max. conductor diameter	number of single wires (min.)	conductor diameter	
	bare Ohm / km	metal sheathed Ohm / km					minimum mm	maximum mm
0,5	36,0	36,7	0,9	7	1,1			
0,75	24,5	24,8	1,0	7	1,2			
1	18,1	18,2	1,2	7	1,4			
1,5	12,1	12,2	1,5	7	1,7			
2,5	7,41	7,56	1,9	7	2,2			
4	4,61	4,7	2,4	7	2,7			
6	3,08	3,11	2,9	7	3,3			
10	1,83	1,84	3,7	7	4,2			
16	1,15	1,16	4,6	7	5,3			
25	0,727	0,734		7	6,6	6	5,6	6,5
35	0,524	0,529		7	7,9	6	6,6	7,5
50	0,387	0,391		19	9,1	6	7,7	8,6
70	0,268	0,270		19	11,0	12	9,3	10,2
95	0,193	0,195		19	12,9	15	11,0	12,0
120	0,153	0,154		37	14,5	18	12,3	13,5
150	0,124	0,126		37	16,2	18	13,7	15,0
185	0,0991	0,100		37	18,0	30	15,3	16,8
240	0,0754	0,0762		61	20,6	34	17,6	19,2
300	0,0601	0,0607		61	23,1	34	19,7	21,6
400	0,0470	0,0475		61	26,1	53	22,3	24,6
500	0,0366	0,0369		61	29,2	53	25,3	27,6
630	0,0283	0,0286		91	33,2	53	28,7	32,5
800	0,0221	0,0224		91	37,6	-	-	-
1000	0,0176	0,0177		91	42,2	-	-	-

Sector-shaped copper conductor

nominal cross-section mm ²	max. conductor resistance at 20°C Ohm / km	stranded (class 2) compacted	nominal cross-section mm ²	max. conductor resistance at 20°C Ohm / km	stranded (class 2) compacted
		number of single wires (min.)			number of single wires (min.)
25	-	-	150	0,124	18
35	0,524	6	185	0,0991	30
50	0,387	6	240	0,0754	34
70	0,268	12	300	0,0601	34
95	0,193	15	400	0,0470	53
120	0,153	18	500	-	-

Fine-stranded and very fine stranded copper conductor

nominal cross-section mm ²	max. conductor resistance at 20°C		max. conductor diameter	number & largest diameter of single wire	
	bare Ohm / km	metal-sheathed Ohm / km		fine-stranded (class 5) mm	very fine-stranded (class 6) mm
0,5	39,0	40,1	1,1	12 x 0,21	28 x 0,16
0,75	26,0	26,7	1,3	24 x 0,21	42 x 0,16
1	19,5	20,0	1,5	32 x 0,21	56 x 0,16
1,5	13,3	13,7	1,8	30 x 0,26	84 x 0,16
2,5	7,98	8,21	2,6	50 x 0,26	140 x 0,16
4	4,95	5,09	3,2	56 x 0,31	224 x 0,16
6	3,30	3,39	3,9	84 x 0,31	192 x 0,21
10	1,91	1,95	5,1	80 x 0,41	320 x 0,21
16	1,21	1,24	6,3	128 x 0,41	512 x 0,21
25	0,780	0,795	7,8	200 x 0,41	800 x 0,21
35	0,554	0,565	9,2	280 x 0,41	1120 x 0,21
50	0,386	0,393	11,0	400 x 0,41	705 x 0,31
70	0,272	0,277	13,1	356 x 0,51	990 x 0,31
95	0,206	0,210	15,1	485 x 0,51	1340 x 0,31
120	0,161	0,164	17,0	614 x 0,51	1690 x 0,31
150	0,129	0,132	19,0	765 x 0,51	2123 x 0,31
185	0,106	0,108	21,0	944 x 0,51	1470 x 0,41
240	0,0801	0,0817	24,0	1225 x 0,51	1905 x 0,41
300	0,0641	0,0654	27,0	1530 x 0,51	2385 x 0,41
400	0,0486	0,0495	31,0	2035 x 0,51	-
500	0,0384	0,0391	35,0	1768 x 0,61	-

Aluminium conductor

nominal cross-section mm ²	max. conductor re- sistance at 20°C Ohm / km	circular conductor (class 2) stranded ¹ , compacted			sector-shaped conduc- tor (class 2) stranded ² , compacted
		number of single wires (min.)	conductor diameter		number of single wires (min.)
			minimum (mm)	maximum (mm)	
25	1,20	6	5,6	6,5	6
35	0,868	6	6,6	7,5	6
50	0,641	6	7,7	8,6	6
70	0,443	12	9,3	10,2	12
95	0,320	15	11,0	12,0	15
120	0,253	15	12,5	13,5	15
150	0,206	15	13,9	15,0	15
185	0,164	30	15,5	16,8	30
240	0,125	30	17,8	19,2	30
300	0,100	30	20,0	21,6	30
400	0,0778	53	22,9	24,6	53
500	0,0605	53	25,7	27,6	-
630	0,0469	53	29,3	32,5	-

¹⁾ Single core circular conductor (class1) are permissible till 300 mm². The diameter of the non compacted conductor from 25 mm² till 630 mm² is to be taken from DIN EN 60332.

²⁾ Single core sector-shaped conductors (class1) are permissible from 50 mm² till 240 mm²

Conversion table for standard cross-sections

Comparison between the metrical and the American standard cross sections

AWG No.	Wire-Ø mm	Wire cross section	Conductor re- sistance max. Ohm/km	AWG Nr.	Wire-Ø mm	Wire cross section	Conductor re- sistance max. Ohm/km
28	0,320	0,0804	229	14	1,630	2,08	8,50
27	0,361	0,102	181	13	1,830	2,63	7,30
26	0,404	0,128	146	12	2,050	3,31	5,75
25	0,455	0,162	114	11	2,300	4,17	4,54
24	0,511	0,205	84	10	2,588	5,261	3,59
23	0,574	0,259	67	9	2,906	6,631	2,99
22	0,643	0,324	54	8	3,264	8,367	2,25
21	0,724	0,412	43	7	3,665	10,55	1,79
20	0,813	0,519	34	6	4,115	13,30	1,42
19	0,912	0,653	27	5	4,620	16,77	1,12
18	1,020	0,823	21	4	5,189	21,15	0,89
17	1,150	1,04	16,90	3	5,827	26,67	0,70
16	1,290	1,31	13,50	2	6,543	33,62	0,56
15	1,450	1,65	10,60	1	7,348	42,41	0,44

Rating as per the National Electrical Code (NEC)

Extract from NEC Table 310-16

Permissible current ratings for single insulated copper conductors, nominal voltage from

0 to 2000 V, 60°C-90°C.

Not more than three loaded cores laid in one cable duct or in a multicore cable or in the ground.

Based on ambient temperature of 30°C

Extract from NEC Table 310-17

Allowable Ampacities of single insulated conductors, nominal voltage from

0-2000 V, on Air,

Based on Ambient Temperature of 30°C

Rating [A]			
nominal cross section	Temperature Rating of Conductor		
	60°C	75°C	90°C
AWG			
18	-	-	14
16	-	-	18
14	20*	20	25
12	25*	25*	30
10	30	35*	40
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	355	380
500	320	380	430
600	355	420	475

Capacitance [A]			
nominal cross section	Temperature Rating of Conductor		
	60°C	75°C	90°C
AWG			
18	-	-	18
16	-	-	24
14	25*	30*	35*
12	30*	35*	40*
10	40*	50*	55*
8	60	70	80
6	80	95	105
4	105	125	140
3	120	145	165
2	140	170	190
1	165	195	220
1/0	195	230	260
2/0	225	265	300
3/0	260	310	350
4/0	300	360	405
250	340	405	455
300	375	445	505
350	420	505	570
400	455	545	615
500	515	620	700
600	575	690	780

* Note

Unless otherwise specifically permitted in this Code, the over current protection for conductor types marked with a star shall not exceed 15 amperes for No. 14, 20 amperes for No. 10 copper, after any correction factors for ambient temperature and number of conductors have been applied.

Insulation and Sheath Materials

Overview of the most important polymers used in cable technology

thermoplastics (plastomere)		cross-linked thermoplast		thermoplastic elastomere	elastomere		duroplastic (duromere)	
PVC	polyvinylchloride	XLPE (VPE)	cross-linked polyethylene	blends of polyolefinens and rubber	NR	natural rubber	EP	epoxy resin
PE	polyethylene		cross-linked ethylene-copolymere	Three-masspolymere (Styrol-Alkylen-Styrol)	EPM	ethylene-propylene-rubber compounds	PUR	polyurethane resin
EVA	ethylene-vinylacetate-copolymere (VA < 30%)			thermoplastic polyurethane (PUR) and polyester	SBR	Styrol-butadiene-rubber compounds		
EEA	ethylene-alkylacrylate-copolymer, e.g.: ethylene-ethylakrylate				EPDM	ethylene-propylene-terpolymer-rubber compounds		
EBA	ethylene-butylakrylate							
PP	polypropylene				IIR	butyl rubber		
PA	polyamide				CR	Polychloropren compounds		
ETFE	ethylene-tetrafluoric-ethylen-copolymere				EVA	ethylene-vinylacetate-copolymer (VA > 30%)		
FEP	tetrafluor-ethylene-hexafluor-propylene-copolymere				CSM	Chloro-sulfonated polyethylene compounds		
					CM	chlorinated polyethylene		
					SiK	silicone rubber		
					ECO	epichlorhydrin-rubber comp.		
					NBR	nitril-butadiene-rubber compounds		

Mechanical, Thermal, Electrical and Chemical Properties of Insulation and Sheath Materials

Designations				Properties (guide values)												
symbol	chemical	VDE	permissible operating temperature to VDE C°	mechanical			thermal			electrical			chemical resistance (guide values)			
				tensile strength	elongation mm	resistance to abrasion	behaviour at low temperature	flame resistance	corrosive gases during a combustion	specific volume resistance	permittivity constant	factor of loss	oils - fats	solvents	diluted acids	water
	Thermoplastic															
PVC	polyvinylchloride compounds	Y	70-105	12,5-25	125-350	averance to good	averance to good	averance to good	hydrogen chloride	10 ¹² - 10 ¹⁵	4,0-6,5	10 ⁻² - 10 ⁻³	moderate to averance	averance	good	moderate
LDPE	low-density – polyethylene	2Y	70,00	10-20	400-600	averance	good	bad	-	> 10 ¹⁶	2,25-2,6	~ 10 ⁻⁴	moderate	moderate	very good	very good
HPE	high-density – polyethylene	2X	90,00	25-40	500-1000	good	good	bad	-	> 10 ¹⁶	2,4-2,5	~ 10 ⁻⁴	moderate	moderate	very good	very good
VPE	cross-linked polyethylene	2X	90,00	12,5-20	300-450	averance	good	bad	-	~ 10 ¹⁶	2,3-2,6	~ 10 ⁻⁴	moderate	moderate	very good	very good
	foamed polyethylene	02Y	70,00	8-12	350-500	-	good	bad	-	~ 10 ¹⁷	~ 1,6	~ 10 ⁻⁴	moderate	moderate	very good	very good
PA	polyamide	4Y	80,00	50-60	50-200	very good	good	good	-	~ 10 ¹⁵	~ 4,0	~ 10 ⁻² - 10 ⁻³	very good	good	very good	moderate
PUR	polyurethane	11Y	80,00	35-50	500-700	very good	good	moderate	-	~ 10 ¹²	~6,0	~ 10 ⁻²	good	good	averance	moderate
	Elastomers															
NR SBR	natural rubber styrol – butadien – rubber	G	60,00	5,0-10,0	300-600	moderate to averance	very good	bad	-	**	**	**	bad	bad	moderate	moderate
SiR	silicone rubber	2G	180,00	5,0-10,0	300-600	moderate	very good	averance to good	-	~ 10 ⁻¹⁵	~ 3,0	~ 10 ⁻³	good	bad	averance	very good
EPR	ethylene – propylene rubber compounds	3G	90,00	5,0-10,0	300-500	moderate to averance	good	averance to bad	-	~ 10 ¹² - 10 ¹⁵	3,0 - 3,8	~ 10 ⁻² - 10 ⁻³	moderate to averance	averance	good	very good to good
EVM	ethylene – vinylacetate - Copolymer compounds	4G	120,00	8,0-12,0	200-350	moderate to averance	good	averance to moderate	-	~ 10 ¹³	~ 6,0	~ 10 ⁻²	moderate to averance	averance	moderate	moderate
CR	polychloroprene compounds	5G	60-90	5,0-20,0	500-800	averance to good	averance to good	good	hydrogen chloride	**	**	**	good to very good	moderate	good	averance
CM	chlorinated polyethylene compounds	9G	80-100	8,0-20,0	350-650	averance to good	averance	good	hydrogen chloride	**	**	**	good to very good	moderate	good	averance
CSM	clorosulfonated polyethylene compounds	6G	100,00	8,0-20,0	400-700	averance to good	averance	good	hydrogen chloride	**	**	**	good to very good	moderate	good	averance
	Special Compounds															
ohne	cross-linked flame retardant halogen-free polymere	H	70-90	5,0-1,2	> 125	moderate to averance	moderate	good to very good	-	~10 ¹³ - 10 ¹⁴	~ 4	10 ⁻² - 10 ⁻³	moderate to averance	averance	good	good
ohne	flame retardant halogen-free polymere, not cross-linked	H	70-90	5,0-1,2	> 125	moderate to averance	moderate	good	-	~10 ¹² - 10 ¹⁴	~ 4	~ 10 ⁻³	moderate	moderate	gut	moderate