Electrical parameters

Voltages

For therated,operating and test voltages of cables, the definitions given in DIN VDE 0298, Part3, apply. Some of these are mentioned in table 4/3 below.

AC - alternating current

DC - direct current

Rated voltage

The rated voltage of an insulated electric cable is the voltage which is used as the basis for the design and the testing of the cable with regard to its electrical characteristics.

The rated voltage is expressed by the two values of power frequency voltage U_0/U in V.

- U_0 rms value between one conductor and "earth"
- U rms value between two conductors of a multi-core cable or of a system of single-core cables

In a system with AC voltage, the rated voltage of a cable must be at least equal to the rated voltage of the system for which it is used. This requirement applies both to the value U_0 and the value U.

In a system with DC voltage, its rated voltage must not be more than 1.5 times the value of the rated voltage of the cable.

Operating voltage

The operating voltage is the voltage applied between the conductors and earth of a power installation with respect to time and place with trouble-free operation.

- *I Cables with a rated voltage U_0/U up to 0.6/1 kV*
  These cables are suitable for use in three-phase AC, single-phase AC and DC installations, the maximum continuously permissible operating voltage of which does not exceed the rated voltage of the cables by more than 10% for cables with a rated voltage U_0/U up to and including 450/750 V 20% for cables with a rated voltge U_0/U = 0.6/1 kV.
- *I Cables with a rated voltage U_0/U greater than 0.6/1 kV*
  These cables are suitable for use in three-phase and single-phase AC installations, the maximum operating voltage of which does not exceed the rated voltage of the cable by more than 20%.
- *Cables in DC installations*

  If the cables are used in DC installations, the continuously permissible DC operating voltage between the conductors must not exceed 1.5 times the value of the permissible AC operating voltage. In single-phase earthed DC installations, this value should be multiplied by a factor of 0.5.

Test voltage

Regarding the test voltage of flexible cables, the values given in the corresponding parts of DIN VDE 0250 apply.

Table 2

FLEXIBLE CABLE	RATED VOLTAGE	MAX PERMISSIBLE OPERATING VOLTAGE			TEST VOLTAGE APPLIED TO THE COMPLETE CABLE		
		IN AC SISTEM	IN DC SISTEM	SINGLE-PHASE EARTHED	POWER CORES	CONTROL CORES	PILOT CORES
	Uo/U	Uo/U	U	U			
			kV	kV	kV	kV	kV
BasketHeavyFlex	300/500 V	318/550 V	0.825	0.413	2	-	-
Flexiflat	450/750 V	476/825 V	1.238	0.619	2.5	-	-
Panzerflex-L / Panzerflex-VS / Panzerlite	0.6/1 kV	0.7/1.2 kV	1.8	0.9	3.5	2	-
Panzerflex-EL / Panzerflat	3.6/6 kV	4.2/7.2 kV	10.8	5.4	11	2	2
	6/10 kV	6.9/12 kV	18	8	17	2	2
	8.7/15 k1V	10.4/18 kV	27	14	24	2	2
	12/20 kV	13.9/24 kV	36	18	29	2	2
	18/30 kV	20.8/36 kV	54	27	43	2	2

Calculation of cable cross section

For the transmission of a given current under given operating conditions, the current carrying capacities for standard conditions of continuous operation discussed herewith must be adopted and necessary corrected.
Downwards adjustment may be required using correction factors for conditions relating to:

- ambient temperature
- number of layers and turns on reels
- number of conductors simultaneously under tension

It should not be forgotten that non continuous operation will mean better cable performance.

With the actual tendency to increase cable operating lengths it is wise to check voltage drop, not just for Low Voltages but for Medium to High Voltages too.

In some circumstances it may be necessary to check the resistance of the cable to short circuit currents both from a thermal view point and electro-dynamically induced forces.

Current carrying capacity for continuous operation
The values for current carrying capacity and various correction factors given in the below table are the same as those defined by standard VDE 0298 Part 4, Feb '88.
Although the cables contained in this catalogue are insulated with ethylene propylene rubber (EPR) for which the admissible operating temperature for continuous operation is 90 °C, the current carrying capacities given here are for conductor temperature of 80 °C.

This is to conform to VDE standards and also as a precautionary measure to take into account greater difficulties with heat dispersion for this type of cable.

The values are for three core cable, with or without earth conductor, not wound and resting on the ground with ambient air temperature of 30°C. For installations where it is known that the life of the cable will be reduced as a result of high mechanical stress or wear in the sheathing, then thermal ageing will be of less importance. In this cases a maximum operating temperature of 90 °C can be considered and the capacities given in the below table can be increased by, approximately, 7%.

Table 3

Cables up to 10 kV — **CURRENT CARRING CAPACITY**

CROSS-SECTION mm2	STRECHTED LAYING A Factor 1	SUSPENDED FREELY IN AIR A 1.05	1 LAYER A 0,8	2 LAYERS A 0,61	REELED IN 3 LAYERS* A 0,49	4 LAYERS A 0,42	5 LAYERS A 0,34	6 LAYERS A 0,27	7 LAYERS A 0,22
1	18	19	14	11	9	8	6	5	4
1,5	23	24	18	14	11	10	8	6	5
2,5	30	32	24	18	15	13	10	8	7
4	41	43	33	25	20	17	14	11	9
6	53	56	42	32	26	22	18	14	12
10	74	78	59	45	36	31	25	20	16
16	99	104	79	60	49	42	34	27	22
25	131	138	105	80	64	55	45	35	29
35	162	170	130	99	79	68	55	44	36
50	202	212	162	123	99	85	69	55	44
70	250	263	200	153	123	105	85	68	55
95	301	316	241	184	147	126	102	81	66
120	352	370	282	215	172	148	120	95	77
150	404	424	323	246	198	170	137	109	89
185	461	484	369	281	226	194	157	124	101
240	540	567	432	329	275	227	184	146	119
300	620	651	496	378	304	260	211	167	136

Cables above 10 kV

16	105	84	64	51	44	36	28	23
25	139	111	85	68	58	47	38	31
35	172	138	105	84	72	58	46	38
50	215	172	131	105	90	73	58	47
70	265	212	162	130	111	90	72	58
95	319	255	195	156	134	108	86	70
120	371	297	226	182	156	126	100	82
150	428	342	261	210	180	146	116	94
185	488	390	298	239	205	166	132	107
240	574	459	350	281	241	195	155	126
300	660	528	403	323	277	224	178	145

***** The reduction factor is also valid for flat reeling cables (spirally)

De rating factors

The de-rating factors take into account the installation and operating conditions, such as temperature, grouping, intermittent periodic duty and the number of simultaneously loaded cores.

They are to be used for determining the current-carrying capacity in accordance with table.

Technical information

Table 4

DE-RATING FACTORS FOR VARYING AMBIENT TEMPERATURES

AMBIENT TEMPERATURE °C	10	15	20	25	30	35	40	45	50	55	60	65	70
	1.18	1.14	1.10	1.05	1.00	0.95	0.98	0.84	0.77	0.71	0.63	0.55	0.45

Table 5

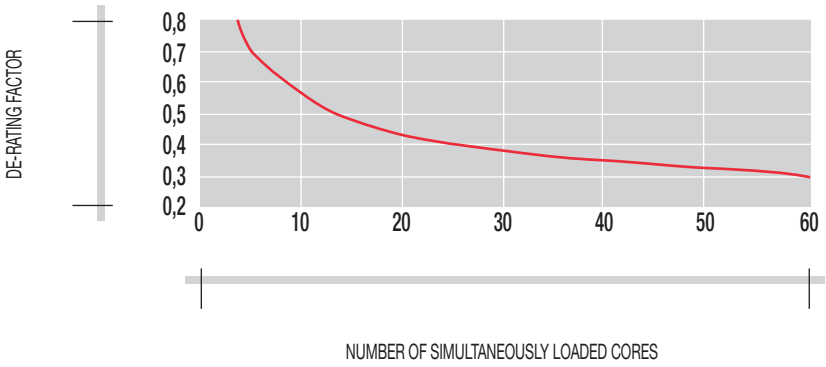
DE-RATING FACTORS FOR GROUPING

ARRANGEMENT	Number of multi-core cables or number of single or three-phase circuits made up of single-core cables (2 or 3 loaded conductors)														
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20
Bunched directly at the wall, the floor, in conduit or ducting, on or in the wall	1,0	0,8	0,7	0,65	0,6	0,57	0,54	0,52	0,5	0,48	0,45	0,43	0,41	0,39	0,38
Single layer on the wall or floor, touching	1,0	0,85	0,79	0,75	0,73	0,72	0,72	0,72	0,71	0,70					
Single layer on the wall or floor, spaced with a clearance of 1 x cable diameter between adjacent cables	1,0	0,94	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
Single layer under ceiling, touching	0,95	0,81	0,72	0,68	0,66	0,64	0,63	0,62	0,61						
Single layer under ceiling, spaced with a clearance of 1 x cable diameter between adjacent cables	0,95	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,45	0,85	0,85	0,85	0,85

Table 6

DE-RATING FACTORS FOR MULTI-CORE CABLES WITH CONDUCTOR CROSS-SECTIONS UP TO 10 mm²

NUMBER OF LOADED CORES	DE-RATING FACTORS
5	0.75
7	0.65
12	0.53
18	0.44
24	0.40
30	0.37
36	0.36
42	0.35
61	0.30



Current carrying capacities for NON continuous operation

In some cases electrical operation is not continuous or it is only partially continuous. It may therefore be advisable to check the values for current circulating and operating times, to see whether the cross cection of the cable can be reduced.

A typical example of intermittent operation with hoisting equipment consists of repeated cycles where, for example, an operating period of 10 minutes of full load is followed by a longer period with no load.

These 10 minutes taken as a percentage of total duration DT of the cycle provides provides a percentage load factor.

Load Factor FC % =(10 mi / DT) x 100

this case the current carrying capacity as calculated using **table 1**, can be increased using factors given in **table 3.**

Table 7

CORRECTION FACTORS FOR INTERMITTENT OPERATION

CABLE CROSS SECTION (mm^2)	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
LOAD FACTOR (FC %)	CORRECTION FACTORS															
60 %	1.00	1.00	1.00	1.00	1.03	1.07	1.10	1.13	1.16	1.18	1.20	1.21	1.22	1.23	1.24	1.25
40 %	1.00	1.00	1.03	1.04	1.09	1.16	1.23	1.28	1.34	1.38	1.42	1.44	1.46	1.48	1.49	1.50
25 %	1.00	1.02	1.05	1.13	1.21	1.34	1.45	1.53	1.62	1.69	1.74	1.78	1.81	1.82	1.85	1.87
20 %	1.00	1.04	1.11	1.18	1.31	1.45	1.59	1.69	1.79	1.87	1.93	1.97	2.01	2.04	2.10	2.15
15 %	1.00	1.08	1.19	1.27	1.44	1.62	1.79	1.90	2.03	2.13	2.21	2.26	2.30	2.32	2.36	2.39

Short circuit current

THERMAL limit of short circuit

In accordance with VDE standards 0250 c.8/75 the admissible THERMAL limits for short circuit current in heavy duty mobile service cables, must be calculated using the following reference values:

Initial = 80 °C (cable under full load)
Final short circuit temperature = 200 °C

The short circuit currents (thermal limit) given in the above table 5 have been calculated using these reference values and are valid for a base time of 1 sec.

For other time periods, taking into account the protection characteristics of the apparatus, the value in the table must be divided by the square root of the effective time (in seconds).
For different initial and final temperatures (i.e. with 90 °C and 250 °C admissible according to standards for EPR), the short circuit current (thermal limit) can be calculated using the following formula:

$$\text{Icc (A)} = \frac{\text{kcc} \times \text{cond. cross section (mm}^2\text{)}}{\sqrt{t}\ \text{(sec)}}$$

where the coefficient **kkc** assumes the values in **table 6**.

Table 8

SHORT CIRCUIT CURRENT	
NOMINAL CABLE CROSS SECTION (mm^2)	ONE SECOND THERMAL LIMIT FOR ALL VOLTAGES (kA)
1.5	0.20
2.5	0.32
4	0.51
6	0.77
10	1.29
16	2.06
25	3.22
35	4.50
50	6.43
70	9.00
95	12.2
120	15.4
150	19.3
185	23.8
240	31.0

Table 9

FINAL SHORT CIRCUIT TEMPERATURE IN C	INITIAL SHORT CIRCUIT TEMPERATURE OF THE CONDUCTOR UNDER NORMAL OPERATING CONDITIONS						
	30 °C	40 °C	50° C	60 °C	70 °C	80 °C	90 °C
160	143	136	129	122	115	107	100
200	159	153	147	141	135	128	122
250	176	170	159	159	154	148	143

Table 10

VOLTAGE DROP CALCULATION

NOMINAL CROSS SECTION	A.C. RESISTANCE AT %= Hz and 80 °C	REACTANCE AT 50 Hz FOR THERE CORE CABLE (3 PHASE + EARTH) AT OPERATING VOLTAGE:				
		≤ 0,6/1 kV	3,6/6 kV	6/10	8,7/15	12/20
mm^2	(R) Ohm/km	(X) Ohm/km	(X) Ohm/km	(X) Ohm/km	(X) Ohm/km	(X) Ohm/km
1,5	16,9	0,103				
2,5	10,1	0,095				
4	6,29	0,092				
6	4,19	0,086				
10	2,41	0,083				
16	1,53	0,078				
25	0,983	0,078	0,108	0,111	0,118	0,126
35	0,699	0,075	0,102	0,105	0,111	0,118
50	0,486	0,075	0,097	0,100	0,105	0,112
70	0,343	0,073	0,092	0,095	0,100	0,106
95	0,261	0,072	0,088	0,091	0,095	0,101
120	0,204	0,071	0,085	0,087	0,092	0,097
150	0,165	0,071	0,083	0,085	0,089	0,094
185	0,136	0,071	0,081	0,083	0,087	0,091
240	0,104	0,070	0,080	0,082	0,084	

Calculation of voltage drop

Three phase voltage drop

Voltage drop should be checked not just for Low Voltage but also for Medium Voltage connections where lengths are long.

The value is calculated by multiplying the factors **K** (mV/Am)* (1 given in the above **table 4** by the effective current capacity **I** (A) of the cable then by the length of the connection **L** (in km).

The formula to calculate the voltage drop is the following:

$\Delta V = I \times L \times K$ (Volt)

where $k = 1{,}73 \times (R \cos\varphi + X \operatorname{sen}\varphi)$

I = (A) effective current capacity

L = (km) length of the connection

R = (Ohm/km) a.c. conductor resistance at 80 °C (see table 10 above)

X = (Ohm/km) cable reactance at 50 Hz (see table 10 above)

It should be noted that for conductor temperature of 90 °C the resistance R must be multiplied by 1,03 and, for frequency of 60 Hz the reactance X must be multiplied by 1,2.

Values for electrical resistance **R** (80°C) and for reactance **X** (calculated for round cables, 3 cores + 3 earth, but valid also for flat cables with sufficient approximation) are also given in the above **table 4**.

It should be noted that for conductor temperatures of 90 °C the resistance **R** must be multiplied by 1.03 while for a frequency of 60Hz the reactance **X** must be multiplied by 1.2 and the value for **K** (mV/Am) recalculated.