

## Instructions for the safe application of cables

The cables manufactured by SAB Bröckskes are only appropriate for the transmission of electric energy for supply and signalling purposes.

**First of all the valid construction and installation prescriptions for the corresponding machine or equipment has to be observed. The valid VDE prescription 0100 can be regarded as base. Furthermore, the following security advice has to be observed for the use of cables.**

■ **For each cable type you can find under "technical data" information on fields that can also be found under the following standards. Among others these are**

- ▶ Nominal voltage, Peak operating voltage: HD 516
- ▶ Test voltage: VDE 0250 T1, EN 50525-1, as well as relevant cable standards
- ▶ Minimum bending radius: HD 516
- ▶ Temperature range: HD 516
- ▶ Fire performance : standards of series IEC 60332 as well as relevant cable standards
- ▶ Resistances: IEC 60811-404 as well as relevant cable standards
- ▶ Further special technical data

■ **The safe application is described under "security requirements" and "boundary conditions".**

**Under "security requirements" you will find information on fields that can also be found under the following standards. Among others these are**

- ▶ Basic requirements: HD 516 pos. 4.1
- ▶ General requirements: HD 516 pos. 4.2
- ▶ Current-carrying capacity for undisturbed service: VDE 0298-4 pos. 5
- ▶ Operating conditions: VDE 0298-4 pos. 5.3.1
- ▶ Ambient conditions: VDE 0298-4 pos. 5.3.3
- ▶ Requirements for fixed installation: HD 516 pos. 4.3
- ▶ Requirements for flexible cables: HD 516 pos. 4.4

## Instructions for the safe application of cables

Under "boundary conditions" you will find information on fields that can also be found under the following standards. Among others these are:

- ▶ Operating conditions: HD 516 pos. 5
- ▶ Voltage: HD 516 pos. 5.1
- ▶ Current-carrying capacity: HD 516 pos. 5.2
- ▶ Current-carrying capacity:
  - Capacity, cables with a nominal voltage up to 1000 V and heat resistant cables VDE 0298-4 table 11
  - Conversion factors for deviating ambient temperatures VDE 0298-4 table 17+18
  - Conversion factors for the accumulation on walls, in tubes and conduits, on the floor and at the ceiling VDE 0298-4 table 21
  - Conversion factors for multi-core cables with conductor cross sections up to 10 mm<sup>2</sup> VDE 0298-4 table 26
- ▶ Thermal influences: HD 516 pos. 5.3
- ▶ Mechanical stress: HD 516 pos. 5.4
- ▶ Tensile load: HD 516 pos. 5.4.1
- ▶ Bending load: HD 516 pos. 5.4.2
- ▶ Compression stress: HD 516 pos. 5.4.3
- ▶ Torsional stress: HD 516 pos. 5.4.4
- ▶ Compatibility: HD 516 pos. 5.5
- ▶ Application in rooms and in the open air: HD 516 Anhang A
- ▶ Stress classification: HD 516 Anhang B
- ▶ Construction of strands: IEC 60228 + VDE 295

Besides the generally known technical rules, please consider especially the following prescriptions for the application of our products

VDE...  
0100, 0105, 0106, 0108, 0110, 0113, 0116,  
0165, 0166, 0170, 0171, 0271, 0298, 0700,  
0720, 0727, 0730, 0737, 0740, 0745, 0750,  
0800, 0804, 0805, 0839, 0860, 0891, 1000, etc.

- ▶ You will find under the individual item groups further instructions and the description of the special application possibilities of our cables.

## Instructions for the safe application of cables

### ■ Security requirements

### ■ Basic requirements

Cables can be regarded to be safe in case that they are used for their intended purpose and don't mean any unacceptable risk for life and real values. If not otherwise specified, insulated cables shall only be used for the transmission and division of electric energy.

### ■ General requirements

Cables have to be chosen in a way that they meet the existing voltages and currents occurring in the machines, equipment of appliances or in their parts for which they are applied under any expected operating condition. Cables should be constructed, installed, protected and maintained to avoid any risks and harms.

### ■ Carrying capacity for undisturbed service (general info)

The cable section has to be chosen in a way that the given current-carrying capacity never leads to a heating of the conductor over the allowed service temperature. The heating resp. carrying-capacity of a cable depends on the construction, material characteristics and the operating conditions. Additional heating due to a cable accumulation, heating flues, solar radiation, etc. have to be considered resp. avoided. The use of covers requires an undisturbed air circulation.

### ■ Operating conditions

The temporary flow of current describes the operating conditions. Continuous operation means a constant current which is at least sufficient to reach the thermal equilibrium of the electrical equipment without any other time limit. The capacity values of cables are based on continuous service reaching the allowed operating temperature of the conductor.

### ■ Environmental conditions

Environmental conditions are among others characterized by the ambient temperature, heat loss and heat radiation. The ambient temperature is the temperature of the surrounding air, without any load on the respective cable. The reference point is a temperature of +30°C. The operating conditions of cables can change by heat loss for example in closed rooms, cable ducts or similar, as well as by heat radiation (e. g. solar radiation).

## Instructions for the safe application of cables

### ■ Conditions and requirements for fixed installation

#### ■ The fixed installation of cables requires among others

- ▶ The cable shall not be installed in direct or close contact with hot surfaces if they are not suitable for this application.
- ▶ Cables are not suitable for direct underground laying.
- ▶ Cables have to be fixed properly. The weight of the cable is important for the choice of the fixing distance.
- ▶ The used mechanical fixing devices shall not damage the cable.
- ▶ Cables that have been used for a long time may be damaged in case of removal. This can be a natural effect due to the aging of the physical characteristics of insulation and jacket material - they become brittle.

#### ■ Requirements for flexible cables

- ▶ Flexible cables should be used for mobile electrical equipment.
  - ▶ The length of the connection cable has to be chosen in a way that the reaction of short-circuit protective equipment is ensured.
  - ▶ For mobile electrical equipment the cable should be as short as possible.
  - ▶ Elevated stress due to tension, pressure, abrasion, torsion or knicking has to be avoided.
  - ▶ The cables shall not be damaged by strain relief or connection devices.
  - ▶ The cables shall not be layed under carpets or other devices. There is a risk due to elevated thermal covering and mechanical damage due to walking, furniture or operating material.
  - ▶ The cables shall not be in direct or close contact with hot surfaces.
- ▶ For further requirements please see HD 516 S2 pos. 4.4.

## Instructions for the safe application of cables

### ■ Boundary conditions

### ■ Operating conditions

The used cables have to be appropriate for the corresponding operating conditions as well as for the device protection class.

### ■ Operating conditions are among others:

- ▶ Voltage
- ▶ Current
- ▶ Safety apparatus
- ▶ Cable accumulation
- ▶ Type of laying
- ▶ Accessibility

The used cables have to be appropriate for all possible external impacts.

### ■ External impacts are among others:

- ▶ Ambient temperature
- ▶ Rain
- ▶ Steam or water
- ▶ Presence of corrosive, polluting or other chemical bodies
- ▶ Mechanical stress (e.g. sharp edges of metal constructions)
- ▶ Animals (e.g. rodents)
- ▶ Plants (e.g. mold fungus)
- ▶ Radiation (e.g. solar radiation)

Note: In this connection it has to be considered that the color is of greatest importance. The color black offers much more protection at radiation than all other colors.

### ■ Voltages

The nominal voltage of a cable means the voltage for which the cable has been constructed and defines the electrical tests. The nominal voltage is expressed in Volt by the relation of two values  $U_0/U$ ;  $U_0$  is the r.m.s. value of the voltage between external conductor and earth (metal jacketing of the cable or surrounding medium).  $U$  is the r.m.s. value between two external conductors of a multi-conductor cable or of a system of mono-conductor cables. In a system of alternating current (a.c.), the nominal voltage of a cable has to be at least equal to the values  $U_0$  and  $U$  of the system. In a system of direct-current (d.c.) the nominal voltage of the system shall not be higher than 1.5 times of the nominal voltage of the cable.

Note: The operating voltage of a system is allowed to be continuously 10% higher than the nominal voltage of the system.

## Instructions for the safe application of cables

### ■ Operating conditions

The nominal cross section of each conductor has to be chosen that the current-carrying capacity is not smaller than the max. constant current, passing the conductor under normal conditions. The limit temperatures to which the current-carrying capacity refers to, shall not be exceeded for the insulation and jacket of the corresponding cable types. A defined condition is also the type of laying of the used cable. This has to be considered for the determination of the allowed load currents. Conditions that have to be considered are among others

- ▶ Ambient temperature
- ▶ Cable accumulation
- ▶ Type of excess-current protection
- ▶ Heat insulation
- ▶ Wound up cables
- ▶ Current frequency (deviating from 50 Hz)
- ▶ Effects of harmonic waves

The current-carrying capacity is not the only criteria for choosing the cable section, furthermore, the requirements for the protection against harmful body currents, overload, short-circuit currents and voltage drop have to be considered. In case that cables are used for a longer period with temperatures exceeding the allowed values, they can be damaged considerably leading to an early failure and an important deterioration of its characteristics.

### ■ Current-carrying capacity: Tables

Extract from VDE 0298-4 06/13 table: 11, 17, 18, 21, 26 and 27

Current-carrying capacity, cables with a nominal voltage up to 1000 V and heat resistant cables VDE 0298-4 06/13 table 11, column 2 and 5			
		column 2	column 5
way of laying		in air	on or at surfaces
		mono conductors	multi-conductor cables (except for house or handheld units)
		- rubber insulated - PVC insulated - heat resistant	- rubber insulated - PVC insulated - heat resistant
number of charged conductors		1	2 or 3
nominal section		capacity	
AWG/kcmil	mm <sup>2</sup>		
19	0.75 mm <sup>2</sup>	15 A	12 A
18	1.00 mm <sup>2</sup>	19 A	15 A
16	1.50 mm <sup>2</sup>	24 A	18 A
14	2.50 mm <sup>2</sup>	32 A	26 A
12	4.00 mm <sup>2</sup>	42 A	34 A
10	6.00 mm <sup>2</sup>	54 A	44 A
8	10.00 mm <sup>2</sup>	73 A	61 A
6	16.00 mm <sup>2</sup>	98 A	82 A
4	25.00 mm <sup>2</sup>	129 A	108 A
2	35.00 mm <sup>2</sup>	158 A	135 A
1	50.00 mm <sup>2</sup>	198 A	168 A
2/0	70.00 mm <sup>2</sup>	245 A	207 A
3/0	95.00 mm <sup>2</sup>	292 A	250 A
4/0	120.00 mm <sup>2</sup>	344 A	292 A
250	150.00 mm <sup>2</sup>	391 A	335 A
350	185.00 mm <sup>2</sup>	448 A	382 A
450	240.00 mm <sup>2</sup>	528 A	453 A
550	300.00 mm <sup>2</sup>	608 A	523 A

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# Technical Data - Cable

## Instructions for the safe application of cables

**Conversion factors for deviating ambient temperatures**  
VDE 0298-4 06/13 table 17, column 4 <sup>1)</sup>

ambient temperature	factor
10°C	1.22
15°C	1.17
20°C	1.12
25°C	1.06
30°C	1.00
35°C	0.94
40°C	0.87
45°C	0.79
50°C	0.71
55°C	0.61
60°C	0.50
65°C	0.35

<sup>1)</sup> for cables with a service temperature of max. 70 °C at the conductor

**Conversion factors for multi-conductor cables with a nominal section up to 10 mm<sup>2</sup>**  
VDE 0298-4 06/13 table 26.  
With installation in the open air.

no. of the loaded conductors	factor
5	0.75
7	0.65
10	0.55
14	0.50
19	0.45
24	0.40
40	0.35
61	0.30

Please call your SAB sales specialist regarding 4 conductor amperage

**Conversion factors for deviating ambient temperatures for heat resistant cables**  
VDE 0298-4 06/13 table 18, column 3 - 6

	column 3	column 4	column 5	column 6
	allowed operating temperature			
	90°C	110°C	135°C	180°C
ambient temperature	conversion factors, to apply to the capacity of heat resistant cables in table 11, column 2 and 5			
up to 50°C	1.00	1.00	1.00	1.00
55°C	0.94	1.00	1.00	1.00
60°C	0.87	1.00	1.00	1.00
65°C	0.79	1.00	1.00	1.00
70°C	0.71	1.00	1.00	1.00
75°C	0.61	1.00	1.00	1.00
80°C	0.50	1.00	1.00	1.00
85°C	0.35	0.91	1.00	1.00
90°C	—	0.82	1.00	1.00
95°C	—	0.71	1.00	1.00
100°C	—	0.58	0.94	1.00
105°C	—	0.41	0.87	1.00
110°C	—	—	0.79	1.00
115°C	—	—	0.71	1.00
120°C	—	—	0.61	1.00
125°C	—	—	0.50	1.00
130°C	—	—	0.35	1.00
135°C	—	—	—	1.00
140°C	—	—	—	1.00
145°C	—	—	—	1.00
150°C	—	—	—	1.00
155°C	—	—	—	0.91
160°C	—	—	—	0.82
165°C	—	—	—	0.71
170°C	—	—	—	0.58
175°C	—	—	—	0.41

## Instructions for the safe application of cables

**Conversion factors for the accumulation on walls, in tubes and conduits, on the floor and at the ceiling VDE 0298-4 06/13 table 21**

no. of multi-conductor cables (2 or 3 current-carrying conductors)	factor
1	1.00
2	0.80
3	0.70
4	0.65
5	0.60
6	0.57
7	0.54
8	0.52
9	0.50
10	0.48
12	0.45
14	0.43
16	0.41
18	0.39
20	0.38

The maximum current-carrying capacity acc. to DIN VDE 0891 part 1, point 7 has to be considered for the application of insulated cables in telecommunications systems and data processing units.

**Conversion factors for wound up cables VDE 0298-4 06/13 table 27**

	1	2	3	4	5	6
no. of layers on one drum		1	2	3	4	5
conversion factors		0.80	0.61	0.49	0.42	0.38

**Note: For spiral winding the conversion factor of 0.80 is valid**

### ■ Thermal influences

Cables have to be chosen, layed or installed in a way that the expected current heat emission is not impeded and thus does not create any fire risk for adjacent materials. The limit temperatures of the individual cable types are shown in the catalog. The indicated values shall not be exceeded by the combined effects of internal current heat and environmental conditions.

### ■ Mechanical stress

Any possible mechanical stress which could lead to a mechanical damage of the layed cable has to be considered before installation.

### ■ Tensile load

The following values for the tensile load of each conductor shall not be exceeded. This is valid for a max. value of 1000 N for the tensile load of each conductor, as far as no other deviating values have been accepted by SAB Bröckskes. 50 N/mm<sup>2</sup> for the installation of cables for fixed installation. 15 N/mm<sup>2</sup> static tensile load for flexible cables and for fixed installation in case that the cables are used for fixed installed electric circuits. Wherever those values are exceeded, it is recommended to use separate strain relief elements or similar. The connection of such a strain relief element with the cable has to be executed without damaging the cable. In case that flexible cables are exposed to dynamic tensile load (including tensile load due to mass reactance, for example on unwinding spools), the allowed tensile load or the duration of wear of the cable have to be agreed upon by the user and SAB Bröckskes. Instructions for the vertical laying of cables without any intermediate fixing are shown under EN 50656-1 pos. 5.6.2.

## Instructions for the safe application of cables

### ■ Bending load

The inner bending radius of a cable has to be chosen in a way that any damage of the cable is avoided. The inner bending radii for the different cable constructions are indicated in table 6 of HD 516. The choice of smaller bending radii than indicated in the cable catalog has to be agreed upon with SAB Bröckskes.

The stripping of the cable jacket shall not cause any damage to the conductor as otherwise there will be a considerable deterioration of the bending characteristics.

The indicated bending radii are valid for ambient temperatures of  $(20 \pm 10)^\circ\text{C}$ . For other ambient temperatures please contact SAB Bröckskes.

Bendings directly beside external or internal fixing points have to be avoided.

### ■ Pressure stress

Any pressure causing a cable damage has to be avoided.

### ■ Torsional stress

Flexible cables are generally not appropriate for torsional stress. In cases where torsional stress cannot be avoided, the construction of the cable and the way of laying have to be agreed upon between the user and SAB Bröckskes.

### ■ Compatibility

For the choice and laying of cables the following points have to be considered

- ▶ Mechanical and electrical impacts between adjacent electric circuits have to be avoided.
- ▶ Heat loss of cables or chemical/physical influences of the cable materials on adjacent materials, for example construction or decoration materials, insulating tubes and fixing device.
- ▶ The influence of the current heat on the conductor material and connections has to be considered.

For further indications please see tables 3A, 3B, 4A and 4B of HD 516.

### ■ Room types

- ▶ Electric shops of the factory are rooms which are generally used for the operation of electric equipment and the access is only allowed to instructed staff members, for example switch rooms.
- ▶ Closed electric shops are rooms which are only used for the operation of electric equipment and are generally locked up. The access is only allowed for instructed staff members, for example closed switch and distribution systems.
- ▶ Dry rooms are rooms without any condensation water in which the air is not saturated with humidity, for example living rooms and hotel rooms.
- ▶ Damp rooms are rooms in which the safety of the operational devices is affected by humidity, condensation water, chemical or similar influences, for example in large kitchens.

### ■ General notes:

Rooms can only be classified in one of the above mentioned types by a careful inspection of the rooms and operational conditions. If there is only much humidity in a certain area of a room but the room is nevertheless dry due to good ventilation, there is no need to classify the room as a damp one.

## Instructions for the safe application of cables

### ■ Application in rooms and in the open air

#### **General**

These terms have to be understood in connection with the boundary conditions (for example min. and max. operating temperatures, influence of ambient temperatures) defined by the construction and the intended application.

#### **Terms for application types:**

##### **Application in rooms**

The cable is installed or connected to a device which is normally located in a building within "a planned surrounding". The building can be used for business, industrial or living purposes.

##### **Limited application in the open air**

The cable is appropriate for a short-time use in the open air, "planned surrounding" for example lawn mower.

##### **Permanent application in the open air**

The cable has been constructed for different conditions which can occur in the open air "planned surrounding" (including different weather conditions).

### ■ Stress classification

The term "stress" describes the use of cables in certain areas, connected to or installed in devices and for certain combinations of external influences which can occur in those areas. On the base of mechanical influences and general expressions the term "stress" has been divided into four categories.

#### **1. Very light stress**

Application areas, in which the risk of mechanical damage and stress is very small, for example electric razor.

#### **2. Light stress**

Application areas, in which the risk of mechanical damage and stress is small, for example hair dryer.

#### **3. Normal stress**

Application areas, in which the cables are exposed to small mechanical stress and the risk for mechanical damage is small, for example small stoves.

#### **4. Heavy stress**

Application areas, in which the risk of mechanical damage or mechanical stress is of medium impact, for example machines on construction sites.

#### **4a. Heavy stress (only multi-conductor cables)**

Application as before, however in connection with parts of production systems including machine tools and manual mechanical devices, for example in connection with switch boards of a production machine.

### ■ Transport and storage

Cable and cords that are not intended for outdoor use must be stored in dry indoor rooms and must also be protected from exposure to direct sunlight there. With outdoor storage, the ends of cables and cords must be closed off to prevent the entry of moisture. The ambient temperature during transport and storage is to be in the range from -25°C to +55°C (max. +70°C for not longer than 24 hours). Furthermore, the temperatures indicated in the tables of HD 516 have to be considered for storage. Especially in the range of low temperatures, mechanical loading by vibration, shock, bending and twisting is to be avoided.

## Instructions for the safe application of cables

### ■ Construction of strands acc. to EN 60228, IEC 60228

- ▶ Fine copper strands for single or multi-conductor cables (class 5)
- ▶ Extra fine copper strands for single or multi-conductor cables (class 6)

**table 3**  
Fine copper strands for single- or multi-conductor cables (class 5)

1		2	3		4
Nominal cross section		largest diameter of single wires	Conductor resistance at 20°C max. value		
AWG	mm <sup>2</sup>		bare single wires	metal jacketed single wires	
		mm	Ω/km	Ω/km	
20	0.50	0.21	39.0000	40.1000	
19	0.75	0.21	26.0000	26.7000	
18	1.0	0.21	19.5000	20.0000	
16	1.5	0.26	13.3000	13.7000	
14	2.5	0.26	7.9800	8.2100	
12	4	0.31	4.9500	5.0900	
10	6	0.31	3.3000	3.3900	
8	10	0.41	1.9100	1.9500	
6	16	0.41	1.2100	1.2400	
4	25	0.41	0.7800	0.7950	
2	35	0.41	0.5540	0.5650	
1	50	0.41	0.3860	0.3930	
2/0	70	0.51	0.2720	0.2770	
3/0	95	0.51	0.2060	0.2100	
4/0	120	0.51	0.1610	0.1640	
250 MCM	150	0.51	0.1290	0.1320	
350 MCM	185	0.51	0.1060	0.1080	
450 MCM	240	0.51	0.0801	0.0817	
550 MCM	300	0.51	0.0641	0.0654	
750 MCM	400	0.51	0.0486	0.0495	

**table 4**  
Extra fine copper strands for single- or multi-conductor cables (class 6)

1		2	3		4
Nominal cross section		largest diameter of single wires	Conductor resistance at 20°C max. value		
AWG	mm <sup>2</sup>		bare single wires	metal jacketed single wires	
		mm	Ω/km	Ω/km	
20	0.50	0.16	39.0000	40.1000	
19	0.75	0.16	26.0000	26.7000	
18	1.0	0.16	19.5000	20.0000	
16	1.5	0.16	13.3000	13.7000	
14	2.5	0.16	7.9800	8.2100	
12	4	0.16	4.9500	5.0900	
10	6	0.21	3.3000	3.3900	
8	10	0.21	1.9100	1.9500	
6	16	0.21	1.2100	1.2400	
4	25	0.21	0.7800	0.7950	
2	35	0.21	0.5540	0.5650	
1	50	0.21	0.3860	0.3930	
2/0	70	0.31	0.2720	0.2770	
3/0	95	0.31	0.2060	0.2100	
4/0	120	0.31	0.1610	0.1640	
250 MCM	150	0.31	0.1290	0.1320	
350 MCM	185	0.41	0.1060	0.1080	
450 MCM	240	0.41	0.0801	0.0817	
550 MCM	300	0.41	0.0641	0.0654	

#### Notes:

The above mentioned information and tables for the "safe application of cables" are extracts from the indicated standards and can't be judged to be complete. The responsible user has to be careful in the laying and installing of cables.