INSTRUCTIONS FOR THE SAFE APPLICATION OF CABLES

The cables manufactured by SAB 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 S2 + A1: 2003
► Test voltage	DIN VDE 0250 T1 10.81 ; HD 21.1 S 4:2002; HD 22.1 S 4:2002 as well as relevant cable standards
► Minimum bending radius	HD 516 S 2 + A1:2003
► Temperature range	HD 516 S 2 + A1:2003
► Fire performance	IEC 60332 as well as relevant cable standards
► Resistances	EN 60811-2-1 + A1: 2001 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 S2 + A1:2003 pos.4.1
► General requirements	HD 516 S2 + A1:2003 pos.4.2
► Current-carrying capacity for undisturbed service	DIN VDE 0298 T4 08/03 pos.5
► Operating conditions	DIN VDE 0298 T4 08/03 pos.5.3.1
► Ambient conditions	DIN VDE 0298 T4 08/03 pos.5.3.3
► Requirements for fixed laying	HD 516 S2 + A1:2003 pos.4.3
► Requirements for flexible cables	HD 516 S2 + A1:2003 pos.4.4

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 S2 + A1:2003 pos.5
► Voltage	HD 516 S2 + A1:2003 pos.5.1
► Current-carrying capacity	HD 516 S2 + A1:2003 pos.5.2
► Current-carrying capacity: tables:	
Capacity, cables with a nominal voltage up to 1000 V and heat resistant cables	DIN VDE 0298 T4 08/03 table 11
Conversion factors for deviating ambient temperatures	DIN VDE 0298 T4 08/03 table 17+18

Conversion factors for the accumulation on walls, in tubes and conduits, on the floor and at the ceiling	DIN VDE 0298 T4 08/03 table 21
Conversion factors for multi-conductor cables with conductor cross sections up to 10 mm^2	DIN VDE 0298 T4 08/03 table 26
► Thermal influences	HD 516 S2 + A1:2003 pos.5.3
► Mechanical stress	HD 516 S2 + A1:2003 pos.5.4
► Tensile load	HD 516 S2 + A1:2003 pos.5.4.1
► Bending load	HD 516 S2 + A1:2003 pos.5.4.2
► Compression stress	HD 516 S2 + A1:2003 pos.5.4.3
► Torsional stress	HD 516 S2 + A1:2003 pos.5.4.4
► Compatibility	HD 516 S2 + A1:2003 pos.5.5
► Types of rooms	DIN VDE 0100 -200 06/98 appendix A Pos.A.6
► Applicatcion in rooms and in the open air	HD 516 S2 + A1:2003 appendix A
► Stress classification	HD 516 S2 + A1:2003 appendix B
► Construction of strands	EN 60228:2005 + IEC 60228:2004

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.

Security requirements

Basic requirements

Cables can be regarded to be safe when they are used for their intended purpose. If not otherwise specified, insulated cables shall only be used for the transmission of electric energy.

General requirements

Cables should be chosen to meet existing voltages and currents occuring 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 harm.

Current carrying capacity for undisturbed service

The cable construction must be selected so that the given current-carrying capacity never leads to a heating of the conductor over the allowed service temperature. The heat 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 considered and avoided.

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 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 (p.e. solar radiation).

Conditions and requirements for fixed laying

The fixed laying 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 prolonged period of 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, abraison, 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 + A1:2003 pos.4.4

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. mould 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 Uo/U; Uo is the r.m.s. value of the voltage between external conductor and earth (metal sheathing 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 Uo 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.

Current-carrying capacity

The nominal size of a conductor has to be chosen so 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
- Heat insulating insulation
- Current frequency (deviating from 50 Hz)
- Cable accumulation
- Wound up cables
- Effects of harmonic waves
- Type of excess-current protection

The current-carrying capacity is not the only criteria for choosing the cable construction; 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 T4 08/03 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 T4 08/03 table 11, column 2 and 5

	column 2	column 5
way of laying	in air	on or at surfaces
	mono conductors - rubber insulated - PVC insulated - heat resistant	multi conductor cables (except for house or handheld units) - rubber insulated - PVC insulated - heat resistant
number of charged conductors	1	2 or 3
Nominal section	Capacity	
0,75 mm²	15 A	12 A
1,00 mm²	19 A	15 A
1,50 mm²	24 A	18 A
2,50 mm²	32 A	26 A
4,00 mm²	42 A	34 A
6,00 mm²	54 A	44 A
10,00 mm²	73 A	61 A
16,00 mm²	98 A	82 A
25,00 mm²	129 A	108 A
35,00 mm²	158 A	135 A
50,00 mm²	198 A	168 A
70,00 mm²	245 A	207 A
95,00 mm²	292 A	250 A
120,00 mm²	344 A	292 A
150,00 mm²	391 A	335 A
185,00 mm²	448 A	382 A
240,00 mm²	528 A	453 A
300,00 mm²	608 A	523 A

Conversion factors for deviating ambient temperatures VDE 0298 T4 08/03 table 15, column 4 [1)]

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

Conversion factors for multi-core cables with a nominal section up to 10 mm² VDE 0298 T4 08/03 table 26.
With installation in the open air.

No.of the loaded cores	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

[1)] for cables with a service temperature of max. 70°C at the conductor

Conversion factors for deviating ambient temperatures for heat resistant cables VDE 0298 T4 08/03 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

Conversion factors for the accumulation on walls, in tubes and conduits, on the floor and at the ceiling VDE 0298 T4 08/03 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 T4 08/03 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 doesn't create any fire risk for adjacent materials. The limit temperatures of the individual conductor 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 strength

The following values for the tensile strength of each conductor shall not be exceeded. This is valid for a max. value of 1000 N for the tensile strength of each conductor, as far as not other deviating values have been accepted by SAB. 25 N/MCM (50 N/mm^2) for the installation of cables for fixed laying. 7.5 N/MCM (15 N/mm^2) static tensile strength for flexible cables and for fixed laying 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 strength (including tensile load due to mass reactance, for example on unwinding spools), the allowed tensile strength or the wear of the cable have to be agreed upon by the user and SAB. Instructions for the vertical laying of cables without any intermediate fixing are shown under pr HD 516 S2 + A1:2003 pos. 5.4.1.

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 radius for the different cable constructions are indicated in table 6 of HD 516. The choice of smaller bending radius than indicated in the cable catalog has to be agreed upon with SAB.

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

The indicated bending radius is valid for ambient temperatures of (20 ± 10) °C. For other ambient temperatures please contact SAB.

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 can't be avoided, the construction of the cable and installation should be recommended by SAB.

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 devices.
- 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 S2 + A1:2003.

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.

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 4 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 swith boards of a automated 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 sunglight there. with outdoor stroage, the ends of cables and cords must be 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, s2 have be considered for storage. Especially in the range of low temperatures, mechanical loading by vibration, shock, bending and twisting is to be avoided.

Construction of strands acc. to EN 60228:2005, IEC 60228:2004

- Fine copper strands for single- or multi-conductor cables (class 5)
- 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	
			bare single wires	metal sheathed single wires
AWG	mm²	mm	Ω/km	Ω/km
20	0.5	0.21	39.0000	40.1000
19	0.75	0.21	26.0000	26.7000
18	1	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
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	
			bare single wires	metal sheathed single wires
AWG	mm²	mm	Ω/km	Ω/km
20	0.5	0.16	39.0000	40.1000
19	0.75	0.16	26.0000	26.7000
18	1	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	0.31	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.