Section 12

Cable Network

A. Choice of Cables and Wires

1. General instructions

Cables and conductors shall conform to the requirements stated in Section 20, F.

2. Rated voltage

The rated voltage of a cable shall be not less than the operating voltage of the relevant circuit.

In insulated distribution systems, the outer conductor voltage of the system shall be deemed to be the rated voltage of the cable between a conductor and the ship's hull.

3. Temperatures

At places where higher ambient temperatures are expected, cables shall be used whose permissible temperature is at least 10 K above the maximum anticipated ambient temperature.

A correction of the permissible current rating shall be made in accordance with Table 12.1.

Cables on diesel engines, turbines, boilers etc., where there is danger of excessive heating, shall be so routed that they are protected against inadmissible external heating stress, or cables are to be used which are approved for the maximum arising ambient temperature.

4. Mechanical protection

The choice of cables shall consider the mechanical stressing, see D.

5. Mobility

5.1 Machines or equipment mounted on vibration absorbers (rubber or springs) shall be connected with cables or wires of sufficient flexibility and installed with compensating bends.

5.2 Mobile equipment shall be connected via flexible cables, e.g. of type HO7RN-F, CENELEC HD 22 or equivalent.

For voltages above 50 V, flexible connecting cables or -wires intended for equipment without double insulation shall also include an earthing conductor.

The earthing conductor shall have a green/yellow coloured marking.

5.3 For mobile parts of installations or lifting wheelhouses supplied via scissor-type cable supports, suspended loops, festoon systems etc., the use of suitable, flexible cables is required.

6. Application of cables and wires

Cables and wires shall be used according to the application categories, Table 12.2.

B. Determination of Conductor Cross-Sections

1. Rating method on the basis of maximum current-carrying capacity

Conductor cross-sections are to be determined on the basis of load with due regard for C.1. - C.3.

The calculated current shall be equal to, or smaller than, the permissible current for the chosen conductor cross-section.

The permissible current-carrying capacities of cables listed in Tables 12.6 - 12.9 apply to an ambient temperature of 45°C and to the stated permissible operating temperature of the cables or wires.

1.1 The current-carrying capacities listed in Tables 12.6 - 12.9 apply to flat cable configurations containing not more than 6 cables laid side by side, or to groupings of not more than 3 cables or insulated wires, as follows:

Flat arrangement:

 etc.

Groupings of not more than 3 cables:

 etc.
or
 etc.

The triple groups shall be laid in each direction with a spacing corresponding to at least one outer diameter of the largest cable or largest insulated wire.

1.2 If the specified configurations cannot be adhered to, or the passage of cooling air is not assured, the current-carrying capacity shall be reduced to 85 % of the values given in the tables, and the overcurrent protection shall be modified accordingly.

Exceptions are made for bundles of cables and insulated wires which are not part of the same circuit and/or which will not be loaded with their rated currents simultaneously.

Table 12.1 Corrective factors for rating capacity of conductor cross-sectional areas

Permissible operating temperature		Ambient temperature [°C]										
		35	40	45	50	55	60	65	70	75	80	85
[°C]	Table	Correction factor										
60	12.6	1,29	1,15	1,0	0,82	–	–	–	–	–	–	–
75	12.6	1,15	1,08	1,0	0,91	0,82	0,71	0,58	–	–	–	–
80	12.7	1,13	1,07	1,0	0,93	0,85	0,76	0,65	0,53	–	–	–
85	12.7, 12.8	1,12	1,06	1,0	0,94	0,87	0,79	0,71	0,61	0,50	–	–
90	12.9	1,10	1,05	1,0	0,94	0,88	0,82	0,74	0,67	0,58	0,47	–
95	12.9	1,10	1,05	1,0	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 12.2 Application categories for power, control and communication cables

Category	Range of application	Remarks
1	Within the ship in all areas and on open deck	Cables with shielding and outer sheath
2	Within the ship in all areas, except where EMC requirements exist and not in hazardous areas	Cables without shielding
3	Only in crew and passenger accommodation/ day rooms, for final supply circuits of lighting, sockets and space heating	Cables without shielding, with single-wire (solid) conductors up to 4 mm^2
4	At diesel engines, turbines, boilers and other devices with higher temperatures	Heat-resistant cables (wires)
5	Other application areas, not specified in 1 – 4	See type test certificate

1.3 For the laying of single-core cables and wires in single-phase and three-phase alternating current systems, see D.7.

1.4 Cables whose maximum permissible conductor temperatures differ from each other by more than 5 K may be bundled together only if the permissible current-carrying capacity of the lowest-capacity type is taken as the rating-basis for all cables.

1.5 Parallel cables are permitted only with conductor cross-sections of 10 mm^2 (AWG 7) and over.

Only cables of the same length and having the same conductor cross-section may be installed as parallel cables. Equal current-distribution shall be ensured.

Parallel cables may be loaded to the sum of their individual current-carrying capacities, and shall be common fused.

2. Rating on the basis of voltage drop

2.1 Under normal service conditions, the voltage drop between the busbars (main/emergency switchboard) and the consumers shall not exceed 6 %, or 10 % in the case of battery-supplied networks of 50 V or less. Navigation lights are subject to the requirements of Section 4, I.6.

2.2 Where short-term peak loads are possible, for instance due to starting processes, it is to ensure that the voltage drop in the cable does not cause malfunctions.

3. Consideration of current peaks

The cross-section shall be so chosen that the conductor temperatures do not exceed the maximum limits specified below neither under short-circuit nor start-up conditions:

for PVC (60 °C) 150 °C

for PVC (75 °C) 150 °C

for EPR (85 °C) 200 °C

(EPM or EPDM)

for XLPE (VPE) (85 °C) 250 °C

for silicone (95 °C) according to specification

The figures in brackets are the permissible operating temperatures at the conductor in continuous operation.

4. Minimum cross-sectional areas and their current-carrying capacity

4.1 The conductor cross-sections indicated in Table 12.3 are the minimum cross-sections for external cabling respective for internal wiring, e.g. of switchgear and consoles.

4.2 The maximum current-carrying capacity of conductor cross-sections for external cabling is indicated in Tables 12.6 - 12.9. For cables and wires in telecommunications systems apply the values listed in Table 12.4.

A maximum permissible current of 1,0 A is applicable to the 0,2 mm^2 (AWG 24) conductor cross-section regardless of the number of cores.

4.3 In accommodation and day rooms, flexible cables with a conductor cross-section of not less than 0,75 mm^2 (AWG 18) may also be used for the connection of movable equipment with a current consumption of up to 6 A.

4.4 For ship's hull return, see Section 1, G.3. and Section 4, I.1.2.

4.5 For earthing conductors, see Section 1, K.

4.6 Neutral conductors in three-phase distribution systems shall be in cross-section equal to at least half the cross-section of the outer conductors. If the outer conductor cross-section is 16 mm^2 (AWG 5) or less, the cross-section of the neutral conductor shall be the same as that of the outer conductors.

4.7 Exciter equalizer cables for three-phase generators in parallel operation shall be rated for half the nominal exciter current of the largest generator.

C. Rating, Protection and Installation of Circuits

1. Individual consumers and rating of final subcircuits

1.1 Cables shall be rated according to the expected operating load based on the connected load and the mode of operation of the consumers. The values shown on the name plate of a consumer are valid.

1.2 The following loads are to be assumed for 250 V AC lighting circuits and socket-outlet circuits:

– for each lighting point, at least 100 W
– for each socket-outlet, at least 200 W

2. Consideration of a diversity factor for group supply cables

2.1 If all the connected consumers in a part of the system are not simultaneously in operation, a diversity factor may be used for determining the cross-section.

A diversity factor is the ratio of the highest operating load expected under normal operating conditions to the sum of the rated loads of all the connected consumers.

2.2 The load ascertained by the application of a diversity factor shall be deemed to be the continuous load for the determination of the cross-section.

2.3 The diversity factors shown in Table 12.5 may be applied to the rating of cables used to supply groups of winches.

The values given in the Table 12.5 shall be related to the rated motor current, or, in the case of motors with several different outputs, to the current corresponding to the highest output.

2.4 Group supply feeders for hydraulic winches shall be rated for the installed power without the application of a diversity factor.

2.5 The cross-section of group supply feeders for cargo cranes shall be determined in the same way as for cargo winches.

2.6 For cargo cranes with one drive motor, the supply cable shall be rated according to the current rating of the maximum load capacity.

2.7 Where cargo cranes have more than one motor, the feeder cable to an individual crane can be rated as follows:

The value of the current used for cross-section determination shall be equal to 100 % of the output of the lifting motors plus 50 % of the output of all the other motors. With this calculated current the cross-section of the cable shall be selected for continuous operation.

2.8 If current diagrams for the various operating conditions of cranes or groups of winches have been ascertained, the average current based on the diagram may be used instead of application of a diversity factor.

2.9 Cross-sections of group supply feeders for refrigerated container socket-outlets are to be designed in accordance with power calculation considering the corresponding diversity factor (see Section 3, B.).

3. Cables overload protection

3.1 Cables shall be protected against short circuit and overcurrent.

3.2 Rating and setting of the protection devices shall be in compliance with the requirements in Section 4.

3.3 Cables protected against overcurrent at the consumers side require only short-circuit protection at the supply side.

For steering gear, see Section 7, A.

Table 12.3 Minimum cross-sectional areas

	Nominal cross-section			
	external wiring		internal wiring	
	international	AWG	international	AWG
Power, heating and lighting systems	1,0 mm^2	17	1,0 mm^2	17
Control circuits for power plants	1,0 mm^2	17	1,0 mm^2	17
Control circuits in general, safety systems in accordance with Section 9	0,75 mm^2	18	0,5 mm^2	20
Telecommunications equipment in general, automation equipment	0,5 mm^2	20	0,1 mm^2	28
Telephone and bell installations, not relevant for the safety of the ship or crew call installations	0,2 mm^2	24	0,1 mm^2	28
Data bus and data cables	0,2 mm^2	24	0,1 mm^2	28

Table 12.4 Rating of telecommunication and control cables

Number of core pairs [2 cores]	Number of cores	Nominal cross-section 0,5 mm^2 (AWG 20)		Nominal cross-section 0,75 mm^2 (AWG 18)	
		Permissible load	Rated fuse current	Permissible load	Fuse rating
		A max.	A	A max.	A
1 x 2	2	–	–	10,5	10
2 x 2	4	5	6	7,5	6
4 x 2	8	4	4	6	6
7 x 2	14	3,5	4	4,5	4
10 x 2	20	3	4	4	4
14 x 2	28	3	2	3,5	4
19 x 2	38	3	2	3,5	4
24 x 2	48	2	2	3	2
48 x 2	96	2	2	–	–
The values in the Table relate to an ambient temperature of 45 °C and a conductor temperature of 85 °C.					

3.4 Exciter cables for DC motors and DC generators operating in parallel shall not be fused.

Exciter cables for individually connected DC generators and synchronous three-phase alternators shall be fused only if there are special reasons for it, e.g. where the cables are passing through various compartments of the ship.

4. Separation of circuits

4.1 A separate cable shall normally be provided for each circuit having its own overcurrent- and short-circuit protection. Deviating from this requirement the following may be combined in a common cable:

– a main circuit and its control circuits which have their tapping off after the main switch

– various control circuits laid separately from the main circuits

– various main circuits and their control circuits belonging to a common system, e.g. for several drives of an air-conditioning system, if all the cores of the cable can be centrally disconnected from the supply

Table 12.5 Diversity factors during operation with winches

Number of winches	The following values shall be used for determining the cable cross-section	
	Winches with DC motors	Winches with induction motors
2	100 % of the largest motor + 30 % of the second motor, or, with identical motors, 65 % of their combined full current	100 % of the largest motor + 50 % of the second motor, or, with identical motors 75 % of their combined full load current
3	100 % of the largest motor + 25 % of the remaining motors, or, with identical motors 50 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 67 % of their combined full current
4	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors 40 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 62 % of their combined full current
5	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors 36 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 60 % of their combined full current
6 and more	33 % of the combined full load current	58 % of the combined full load current

4.2 Separate cables shall be provided for safety voltage circuits.

4.3 Separate cables shall be provided for intrinsically safe circuits.

5. Cable laying for circuits

5.1 For single-phase and three-phase AC systems, multi-core cables are to be used wherever possible.

5.2 Should it be necessary to lay single-core cables for the carriage of more than 10 A in single-phase or three-phase AC circuits, the special requirements of D.7. shall be fulfilled.

5.3 In three-phase systems without hull return, three-core cables shall be used for three-phase connections; four-core cables are required for circuits with loaded neutral point.

5.4 In three-phase systems with hull return the asymmetry of the currents in the three conductors of three-core cables shall not exceed 20 A (see Section 4, I.).

5.5 In DC systems without hull return multi-core cables shall be provided in all cases of smaller cross-sections.

Where single-core cables are used for large cross-sections, the outgoing- and return-cables shall be laid as close as possible to each other over their entire length to avoid magnetic stray fields.

5.6 The generator cables, all cables run from the main or emergency switchboard or an auxiliary switchboard, and all interconnecting cables for essential equipment, shall be laid as far as possible uninterrupted in length to the distribution panels or to the equipment.

5.7 The cables of intrinsically safe circuits shall be laid at a distance of at least 50 mm separated from the cables of non-intrinsically safe circuits. The laying of intrinsically safe circuits together with non-intrinsically safe circuits in a pipe is not permitted.

Cables of intrinsically safe circuits shall be marked.

D. Installation

1. Routing of cables

1.1 The routes of cables shall be such that cables are laid as straight as possible and are not exposed to mechanical damage.

1.2 For bends, the minimum bending radius permitted by the manufacturer shall be observed. The radius shall be not smaller than 6 times of the outer diameters of the cables.

1.3 Heat sources such as boilers, hot pipes etc. shall be bypassed, so that the cables are not subjected to additional heating. If this is not possible, the cables are to be shielded from thermal radiation.

1.4 The tensile stress of the cables at long cable runs caused by thermal expansion and/or movement of ship structure shall not damage the cables, cable runs or cable penetration systems.

At long and straight cable runs like in passage ways or void spaces etc. or at other positions where unacceptable tensile stresses are liable to occur at the cables and

cable trays, precautions shall be taken to distribute the expansion movement uniformly over a cable loop provided for such purpose, so that there is no damaging of the cables, cable runs or cable penetration systems.

The diameter of the cable loop shall be at least 12 times the diameter of the thickest cable. In each division should be provided at least one cable loop.

1.5 Cables shall not be laid within room isolations.

Exceptions are permitted for lighting, socket-outlets and control circuits in accommodation and refrigerated rooms, provided that the maximum loading of the cables does not exceed 70 % of their current carrying capacity.

1.6 Where, for safety reasons, a system shall have duplicated supply- and/or control cables, the cable routes are to be placed as far apart as possible.

1.7 Supply cables for emergency consumers shall not be run through fire zones containing the main source of electrical power and associated facilities. Exceptions are made for cables for supply of emergency consumers located within such areas.

1.8 The electrical cables to the emergency fire pump shall not pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers. If the electrical cables to the emergency fire pump pass through other high fire risk areas, they are to be of a fire resistant type.

1.9 Cables for supply of essential equipment and emergency consumers, e.g. lighting and important communications- and signalling systems shall, wherever possible, bypass galleys, laundries, category A engine rooms and their casings and areas with a high fire risk.

On ships whose construction or small size precludes fulfilment of these requirements, measures shall be taken to ensure the effective protection of these cables where they have to be run through the rooms mentioned above, e.g. by the use of fire-resistant cables or by flame-retardant coating such an installation shall be approved by GL.

1.10 Cable installation for medium-voltage equipment Section 8, E. is to be observed.

2. Fastening of cables and wires

2.1 Cable trays and cableways shall be made preferably of metallic materials which are protected against corrosion.

Cables and wires shall be fastened with corrosion-resistant, flame retardant clips or bindings. Exceptions are made for cables which are laid in pipes or cable ducts.

Cables and wiring shall be installed and supported in such a manner as to avoid chafing or other damage.

This also applies for the installation of cables and wires in connection boxes of electrical equipment and switchboards.

2.2 Suitable materials shall be placed together when fasten cables to aluminium walls.

Clips for mineral-insulated cables with copper sheaths shall be made of copper alloy if they are in electrical contact with the latter.

2.3 Single-core cables are to be fastened in such a manner that they are able to withstand the electrodynamic forces occurring in the event of short circuits.

2.4 The distances between the supports for cable racks and the fastenings used shall be selected with due regard to the cable type, cross-section and number of cables concerned.

2.5 Where cables suspended are fastened by the use of plastic clips or straps, metallic cable fixing devices, spaced not more than 1 m apart shall be used additionally in the following areas:

– generally in escape routes and emergency exits, on the open deck, in refrigeration rooms and in boiler rooms

– cargo holds, machinery rooms, control rooms and service rooms where bunched cables are fastened on riser cable trays or under the cable trays

2.6 Cable trays/protective casings made of plastic materials shall be tightened in such a way that they do not obstruct together with the cables the escape routes in case of fire, see 6.2.

The suitability of cable trays shall be proved, see Section 21, E.5.1.1 d). Installation, see also 2.5.

2.7 It is recommended, that cables and cable bunches shall not be painted.

If they still would be painted the following shall be observed:

– the paint shall be compatible with the material of the cables, and

– the flame-retardant property respectively fire resistance of the cables and cable bunches shall be maintained.

3. Stress relief

Cables shall be so installed that any tensile stresses which may occur remain within the permitted limits. This shall be particularly observed for cables on vertical runs or in vertical conduits.

4. Protection against mechanical damage

4.1 Cables in cargo holds, on open decks and at positions where they are exposed to a particularly high risk of mechanical damage shall be protected by pipes, covers or closed cable ducts.

4.2 Cables passing through decks shall be protected against damage by pipe sockets or casings extending to a height of about 200 mm over deck.

5. Installation of cables and wires in metallic pipes, conduits or closed metal ducts

5.1 If cables are installed in pipes or ducts, attention shall be paid that the heat from the cables can be dissipated into the environment.

5.2 The inside of the pipes or ducts shall be smooth, and their ends shaped in such a way as to avoid damage to the cable sheath.

They shall be effectively protected inside against corrosion. The accumulation of condensation water shall be avoided.

5.3 The clear width and any bends shall be such that the cables can be drawn through without difficulty. The bending radius of the pipe shall be equivalent to at least 9 times of the outer cable diameter.

5.4 Where pipes or ducts passing through areas where panting is expected, suitable means of compensation shall be provided.

5.5 Not more than 40 % of the clear cross-section of pipes and ducts shall be filled with cables. The total cross-section of the cables is deemed to be the sum of their individual cross-sections based on their outside diameters.

5.6 Pipes and ducts shall be earthed.

5.7 Single-core cables of single- and three phase AC systems shall be provided with plastic outer sheaths if they are installed in metallic pipes or ducts.

5.8 Long cable ducts and pipes shall be provided with a sufficient number of inspection- and pull boxes.

6. Installation in non-metallic pipes and ducts

6.1 Cable trays/protective casings made of plastic materials are to be type tested in accordance with IACS UR E 16, see Section 21, E.5.1.1 d).

Note:

"Plastics" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as polyvinyl chloride (PVC) and fibre reinforced plastics (FRP).

"Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

Applicable for pipes with a diameter of more than 80 mm.

6.2 Non-metallic pipes or cable ducts shall be made of flame-retardant material.

Additional requirements for passenger vessels in Section 14, F.2.1 are to be observed.

6.3 Cable trays/protective casings made of plastic materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, spaced not more than 1 m apart are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note

When plastic cable trays/protective casings are used on open deck, they are additionally to be protected against UV light.

6.4 The load on the cable trays/protective casings is to be within the Safe Working Load (SWL). The support spacing is not to be greater than the Manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing is not to exceed 1 meter.

Note

The selection and spacing of cable tray/protective casing supports are to take into account:

- *cable trays/protective casings' dimensions*
- *mechanical and physical properties of their material*
- *mass of cable trays/protective casings*
- *loads due to weight of cables, external forces, thrust forces and vibrations*
- *maximum accelerations to which the system may be subjected*
- *combination of loads*

6.5 The sum of the cables' total cross-sectional area, based on the cables' external diameter, is not to exceed 40 % of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

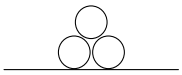
7. Laying of single-core cables and wires in single-phase and three-phase AC systems

In cases where use of multi-core cables is not possible, single-core cables and -wires may be permitted for installation if the following provisions are made and the requirements of IEC publication 60092-352 are observed:

7.1 The cables shall not be armoured or shrouded with magnetic material.

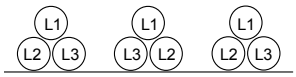
7.2 All conductors belonging to one circuit shall be run together in the same pipe or duct, or clamped by common clamps, unless the clamps are made of non-magnetic materials.

7.3 The cables forming a circuit shall be laid immediately beside of each other and preferably in triangular configuration. If spacings cannot be avoided, the spacings shall not exceed one cable diameter.



7.4 No magnetic material shall be placed between single-core cables passing through steel walls. No magnetic materials shall be between the cables of deck and bulkhead penetrations. Care shall be taken to ensure that the distance between the cables and the steel wall is at least 75 mm, unless the cables belonging to the same AC circuit are installed in trefoil formation, see 7.3.

For the installation of single core parallel cables between the cable groups these measures are not necessary, if the cable groups are arranged in trefoil formation.



7.5 Single-core parallel cables shall be of the same length and cross-section. Furthermore, to avoid unequal division of the current, the cables of one phase shall be laid, as far as is practicable, alternatively with the cables of the other phases, e.g. in the case of two cables for each phase:

L1, L2, L3, L3, L2, L1		or	L1, L2, L3
			L3, L2, L1
or	L3, L1, L2	or	L2, L3, L1
	L2, L1, L3		L1, L3, L2

7.6 To balance the impedance of the circuit in single-core cables more than 30 m long and with a cable cross-section of more than 150 mm^2, the phases are to be alternated at intervals of not more than 15 m.

7.7 For single-core cables, metallic sheaths are to be insulated from each other and from the ship's hull over their entire length. They shall be earthed at one end only, except earthing is required at both ends for technical reasons (e.g. for medium voltage cables). In such cases the cables shall be laid over their entire length in triangular configuration.

8. Bulkhead and deck penetrations

8.1 Cable penetrations shall conform to the partition categories laid down by **SOLAS**, and shall not impair the mechanical strength or watertightness of the bulkhead.

8.2 Bulkhead and deck penetrations shall have been type-tested by GL. The GL Guidelines for Test Requirements for Sealing Systems of Bulkhead and Deck Penetrations (VI-7-4) are to be taken into consideration.

8.3 The cables shall not occupy more than 40 % of the cross-section of a penetration.

8.4 Vertical cable ducts shall be so constructed that a fire on one deck cannot spread through the duct to the next higher or lower deck (see also 14.2.2).

9. Cables in the vicinity of radio-communication and -navigation equipment

9.1 Except where laid in metallic pipes or ducts, cables and wires with metal sheaths or metal braiding are to be used above the uppermost metallic deck and in positions where the cables and wires are not separated by metallic bulkheads or decks from aerials, aerial downleads, the radio room, direction finder or other radio navigation- or receiving equipment. The metallic sheaths and shields are to be earthed.

9.2 Only cables required in the radio room shall be laid there. If cables without a braid shielding have to be run through a radio room, they shall be installed in a continuous metallic pipe or -duct which is earthed at the entrance to and exit from the room.

9.3 Single-core cables are not permitted in the radio room.

9.4 If the radio equipment is installed on the bridge, the requirements stated above are to be complied with as and where applicable.

10. Magnetic compass zone

All electrical cables, wires, machines and apparatuses shall be laid, installed or magnetically shielded in order to avoid inadmissible interference (deviation < 0,5 degree) with the magnetic compass.

11. Cable installation in refrigeration spaces

11.1 Only cables with outer sheaths resistant to corrosion and cold-resistant shall be laid in refrigerated rooms.

11.2 Where cables are led through the thermal isolation, 1.5 shall be observed.

11.3 Only cables without hull return are permitted in refrigerated rooms and in the associated air cooler spaces. The earthing conductors shall be run together with the other cables from the relevant distribution panel.

12. Earthing of the braided screens of cable network and accessories

12.1 Metallic cable sheaths, armouring and shields in power installations shall be electrically connected to the ship's hull at each end; single-core cables shall be earthed at one end only. For cables and wires for electronic equipment, the manufacturer's recommendations shall be observed, earthing at one end only is recommended.

12.2 Electrical continuity of all metallic cable coverings shall also be maintained inside of cable junction- and connection boxes.

12.3 Metallic cable sheaths, armouring and shields shall be earthed, preferably by the use of standard cable gland fittings designed for that purpose, or by suitable equivalent clips or joints.

12.4 Metallic cable sheaths, armourings and shields shall in no case be deemed to constitute earthing conductors for the protective earthing of the connected electrical equipment.

13. Cable joints and branches

13.1 Cables shall be extended only with the approval of GL. The used material shall maintain the flame-retardant and where required the fire-resistant properties of the cables.

13.2 Junction- and distribution boxes shall be accessible and marked for identification.

13.3 Cables for safety low voltage shall not pass a junction- or distribution box together with cables for higher voltage systems.

13.4 The terminals for different types of systems, especially such of differently operating voltages, shall be separated.

14. Measures for limitation of the propagation of fire along cable- and wire bundles

14.1 All cables shall be so installed that the original flame-retardant properties of the individual cables are not impaired. This requirement can be considered to be fulfilled if:

– the bundled cables are individually flame-retardant and have been successfully passed the bundle fire test in accordance with IEC publication 60332-3 category A/F

– suitable measures have been taken during the installation, e.g. by providing of fire stops or application of flameproof coatings

14.2 For cable bundles consisting of cables which have not been subjected to a bundle fire test, the following precautions shall be taken to limit the fire propagation:

14.2.1 Fire stops shall be provided:

a) at main- and emergency switchboards

b) at cable entries to engine control rooms

c) at central control panels and -consoles for the main propulsion plant and for important auxiliaries

14.2.2 In closed- and semi-enclosed rooms, fire stops shall be provided at the following locations:

– at each entry- and exit point of cable runs in enclosed metallic installation shafts

– for open vertical cable runs, at least for every second deck, limited to a maximum interval of 6 m

– every 14 m for open horizontal cable runs

14.3 Exceptions

Fire stops in accordance with 14.2.1 a) and c) can be omitted if the switchboards or consoles are installed in separate rooms and measures have already been taken at the cable entrances to these rooms, in cargo holds and in under-deck service passageways in the cargo zone. Fire stops shall be provided only for the boundaries of these rooms.

14.4 Version of fire stops

The flame propagation of cables passing through fire stops shall fulfil the **SOLAS** requirements for B-O partitions.

Fire stops may, for example, be formed by existing partitions or by a steel plate (min. 3 mm in thickness) together with a B-O penetration in each case.

The steel plate shall be so formed that it extends around the cables as specified below:

– twice the maximum dimension of the cable run with vertically laid cables

– the maximum dimension of the cable run with horizontally laid cables

The steel plates, however, need not to be extended through upper covers, decks, bulkheads or trunk walls.

14.5 Application of flameproof coatings

Instead of the fire stops prescribed in 14.4, installed cable bundles may be provided with (GL type approved) flameproof coatings as follows:

– on horizontal cable runs for every 14 m, a length of 1 m

– on vertical cable runs over the entire length

Other distances for the coatings may be approved after special testing.

14.6 Alternative methods

Other methods which have been proved to be equivalent to the measures stated in 14.4 and 14.5 may be accepted.

14.7 Explanatory sketches

Explanatory notes to the installation provisions described above are given in Figs 12.1 - 12.4.

15. Application of fire-resistant cables

15.1 Scope of installations

15.1.1 Where cables specified in Section 20, F.1.3 for services (see 15.1.3) including their power supplies pass through high fire risk areas, and in addition for passenger ships, main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables being of a fire resistant type complying with IEC publication 60331-21, 60331-23, 60331-25, or 60331-1 for cables of greater than 20 mm overall diameter, are installed and run continuous to keep the fire integrity within the high fire risk area, see Fig. 12.5.

b) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

15.1.2 Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted provided their functionality can be maintained.

Notes

a) The definition for "high fire risk areas" is the following:

- *Machinery spaces as defined in Chap. II-2/ Reg. 3.30 of **SOLAS***
- *Spaces containing fuel treatment equipment and other highly flammable substances*
- *Galley and Pantries containing cooking appliances*
- *Laundry containing drying equipment*
- *Spaces as defined in paragraphs (8), (12), and (14) of Chap. II-2 / Reg. 9.2.2.3.2.2 of **SOLAS** for ships carrying more than 36 passengers.*

b) Fire resistant type cables shall be easily distinguishable.

c) For special cables, requirements in the following standards may be used:

IEC60331-23: Procedures and requirements – Electric data cables

IEC60331-25: Procedures and requirements – Optical fibre cables

15.1.3 Emergency services required to be operable under fire conditions on the cables include:

- fire and general alarm system
- fire extinguishing systems and fire extinguishing medium alarms
- fire detection system
- control and power systems to power operated fire doors and status indication for all fire doors
- control and power systems to power operated watertight doors and their status indication
- emergency lighting
- public address system
- low location lighting (see UISC 135)
- emergency fire pump
- remote emergency stop / shutdown arrangements for systems which may support the propagation of fire and/or explosion

15.2 Installation

For installation of fire-resistant cables the following shall be observed:

- The cables shall be arranged in such a way as to minimise the loss of operational availability as a result of a limited fire in any area.
- The cables shall be installed as straight as possible and with strict observance of special installation requirements, e.g. permitted bending radii.

E. Requirements for Busbar Trunking Systems intended for the Electrical Supply of Distribution Panels and Single Consumers

1. Scope

The following listed additional requirements are valid for the design and the installation of busbar trunking systems, which are installed outside of switchboards and are intended for the supply of distribution boards or single consumers.

Busbar trunking systems shall not be installed in explosion endangered areas and on the open deck.

2. Components of the busbar trunking system

A busbar trunking system consists of the following components:

- Electrical conductors including neutral and protective conductors, their insulation and the encasement of the busbar trunking system
- connecting elements
- separation units
- insulators and fixing elements
- arc barriers
- tap-off units
- bulkhead and deck penetrations
- protection devices

3. Requirements

3.1 Basic requirements

The safety standard and availability of ship mains designed to include busbar trunking systems shall be at least equivalent to those of conventionally cables ship mains, even in case of failure.

Busbar trunking systems shall comply with the requirements of IEC publication 60439-1 and IEC publication 60439-2.

3.2 Requirements for components

3.2.1 Degree of protection

The design of the busbar trunking system shall comply with the following minimum degrees of protection:

– dry spaces, e.g. accommodation, IP 54

– wet spaces, e.g. engine rooms, IP 56

The operational readiness of the busbar trunking system shall be not impaired by condensed moisture. Where required means for automatic draining shall be provided.

Busbar trunking systems shall be protected against mechanical damage.

3.2.2 Bulkhead and deck penetrations, fire protection

The used materials shall be halogen-free and shall be flame-retardant according to IEC publication 60695-2.

The whole busbar trunking system shall meet with regard to the flame-spread the test requirements of IEC publication 60332-3, category A/F.

Bulkhead and deck penetrations for busbar trunking systems shall conform to categories laid down by **SOLAS** and shall not impair the mechanical strength and the watertightness of bulkheads and decks.

The propagation of smoke via the busbar trunking system shall be effectively prevented.

3.3 System requirements

3.3.1 System configuration

The design of busbar trunking systems shall be such that in case of a single failure the supply to redundant essential equipment continues. Redundant essential equipment shall be supplied via separate busbar trunking systems. Common busbar systems for main and emergency supply are not permitted.

Where a busbar trunking system is arranged below the uppermost continuous deck, the vessel's manoeuvrability and the operation of all installations necessary for the main purpose of the vessel as well as the safety of the crew and passengers shall not be impaired in the event of one or more watertight compartments outside the engine room being flooded.

Where busbar trunking systems are led through several watertight sections, means for separation at the supply-side of the transitions shall be provided. The units for separation shall be approachable, marked for identification and secured against unauthorized uncovering.

3.3.2 Protection devices

Busbar trunking systems shall be protected against overload and short-circuit.

Switchgear of the busbar trunking system shall be arranged with regard to selectivity.

The propagation of electric areas along the busbar trunking system shall be prevented by arc barriers or other means. If current limiting circuit breakers are used, those means are not required.

4. Tests

4.1 Aboard tests

On the basis of approved documentation an aboard test of the completed installation shall be made. This includes the functional testing of the busbar trunking system and the check of settings for protection devices.

4.2 Type-approval

Busbar trunking systems are subject to mandatory type approval.

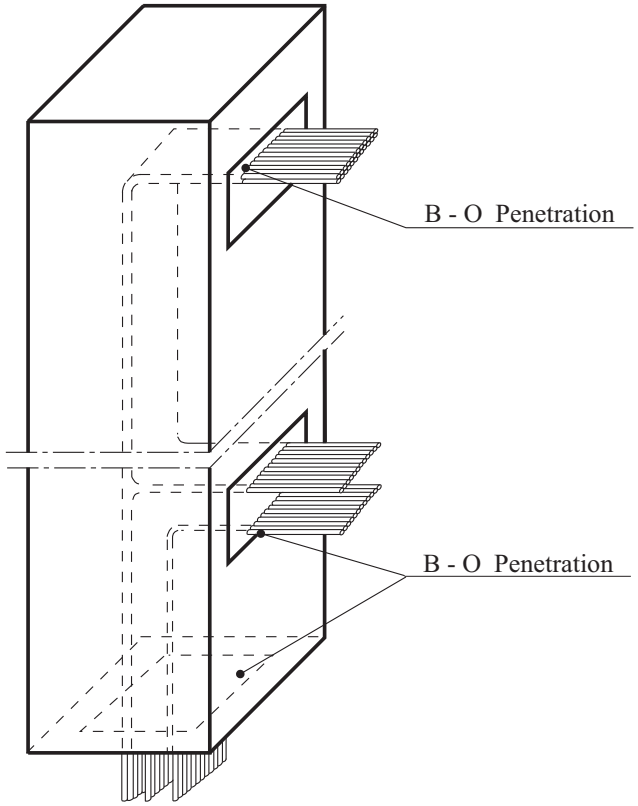


Fig. 12.1 Fire stops, all steel plates at least 3 mm thick

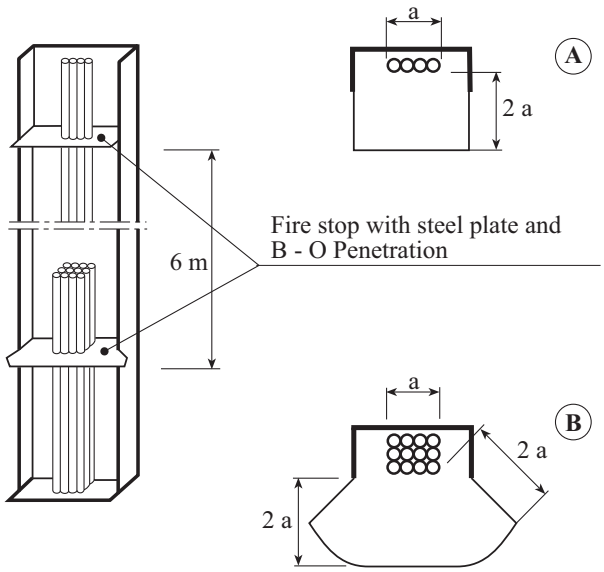


Fig. 12.2 Partly enclosed ducts, vertical

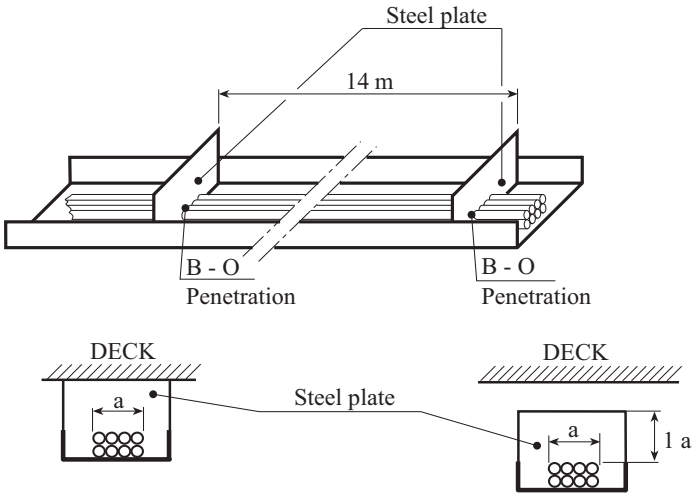


Fig. 12.3 Partly enclosed ducts, horizontal

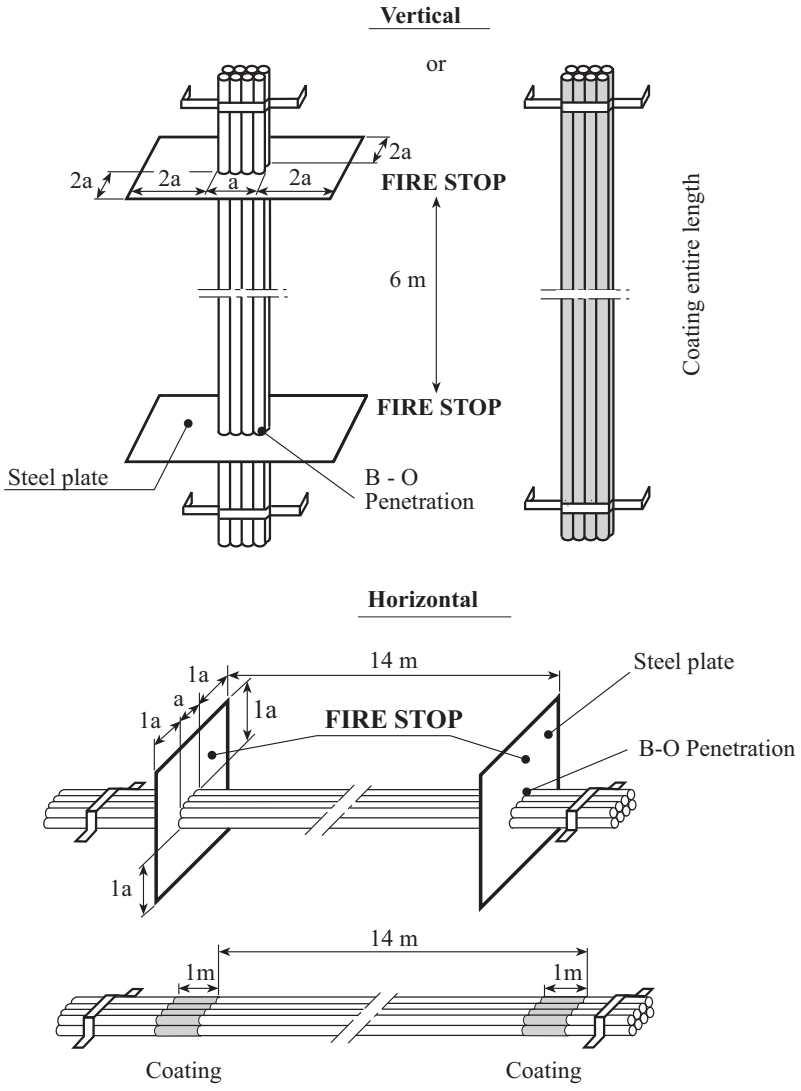


Fig. 12.4 Open cable runs

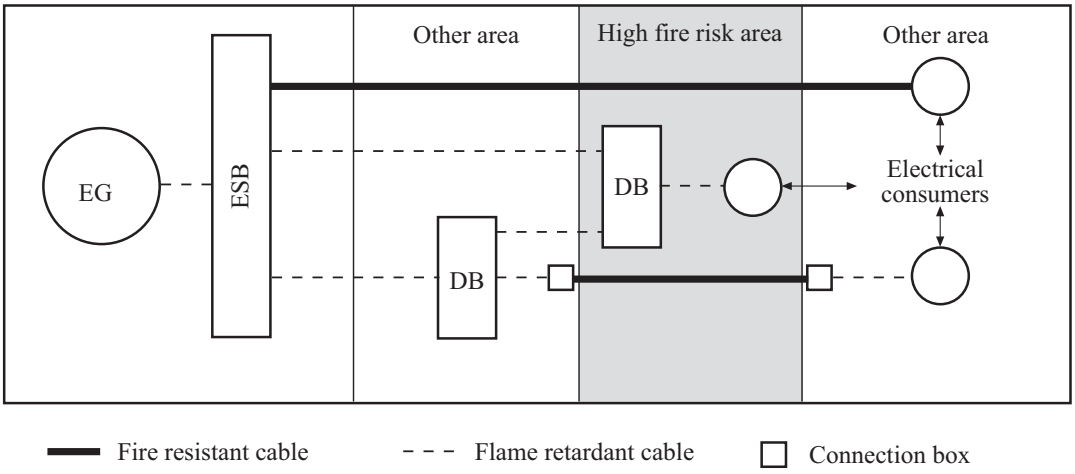


Fig. 12.5 Installation of fire resistant cables through high fire risk areas

Table 12.6 Current-carrying capacity of cables, max. permissible conductor operating temperature of 60 °C and 75 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature of					
		60 °C			75 °C		
		S 1 cont. operation	S 2- 30 min	S 2- 60 min	S 1 cont. operation	S 2- 30 min	S 2- 60 min
mm^2	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single core cables							
1,0	17	8	8	8	13	14	14
1,5	15	12	13	13	17	18	18
2,5	13	17	18	18	24	25	25
4	11	22	23	23	32	34	34
6	9	29	31	31	41	43	43
10	7	40	42	42	57	60	60
16	5	54	57	57	76	81	81
25	3	71	76	75	100	107	106
35	2	87	94	92	125	135	133
50	0	105	114	111	150	164	159
70	2/0	135	150	143	190	211	201
95	4/0	165	186	177	230	260	246
120	250	190	220	203	270	313	289
150	300	220	260	238	310	366	335
185	400	250	305	273	350	427	382
240	500	290	365	322	415	523	461
300	600	335	439	379	475	622	537
2-core cables							
1,0	17	7	7	7	11	12	12
1,5	15	10	11	11	14	15	15
2,5	13	14	15	15	20	21	21
4	11	19	21	20	27	29	29
6	9	25	27	27	35	38	37
10	7	34	38	36	48	53	51
16	5	46	52	49	65	73	70
25	3	60	71	65	85	101	92
3- or 4-core cables							
1,0	17	6	6	6	9	10	10
1,5	15	8	9	8	12	13	13
2,5	13	12	13	13	17	18	18
4	11	15	16	16	22	24	23
6	9	20	22	21	29	32	31
10	7	28	31	30	40	45	42
16	5	38	43	41	53	60	57
25	3	50	60	55	70	84	76
35	2	61	76	67	87	108	96
50	0	73	95	82	105	137	118
70	2/0	94	129	108	133	182	153
95	4/0	115	165	137	161	232	192
120	250	133	200	162	189	284	231
Multi-core cables							
5 × 1,5	5 × 15	7			10		
7 × 1,5	7 × 15	6			9		
10 × 1,5	10 × 15	6			8		
12 × 1,5	12 × 15	5			7		
14 × 1,5	14 × 15	5			7		
16 × 1,5	16 × 15	5			7		
19 × 1,5	19 × 15	4			6		
24 × 1,5	24 × 15	4			6		

AWG: American Wire Gauge
MCM: Mille Circular Mil

Table 12.7 Current-carrying capacity of cables, max. permissible conductor operating temperature of 80 °C and 85 °C

Nominal cross-section		Current-carrying based on a maximum conductor operating temperature of					
		80 °C			85 °C		
		S 1 cont. operation	S 2- 30 min	S 2- 60 min	S 1 cont. operation	S 2- 30 min	S 2- 60 min
mm^2	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single-core cables							
1,0	17	15	16	16	16	17	17
1,5	15	19	20	20	20	21	21
2,5	13	26	28	28	28	30	30
4	11	35	37	37	38	40	40
6	9	45	48	43	48	51	51
10	7	63	67	67	67	71	71
16	5	84	89	89	90	95	95
25	3	110	118	117	120	128	127
35	2	140	151	148	145	157	154
50	0	165	180	175	180	196	191
70	2/0	215	239	228	225	250	239
95	4/0	260	294	278	275	311	294
120	250	300	348	321	320	371	342
150	300	340	401	367	365	431	394
185	400	390	476	425	415	506	452
240	500	460	580	511	490	617	544
300	600	530	694	599	560	734	633
2-core cables							
1,0	17	13	13	13	14	14	14
1,5	15	16	17	17	17	18	18
2,5	13	22	24	23	24	26	25
4	11	30	32	32	32	35	34
6	9	38	41	40	41	45	43
10	7	53	59	56	57	63	60
16	5	71	80	76	76	86	81
25	3	93	111	100	102	121	110
3- or 4-core cables							
1,0	17	10	11	11	11	12	12
1,5	15	13	14	14	14	15	15
2,5	13	18	19	19	20	22	21
4	11	24	26	25	27	29	29
6	9	31	34	33	34	37	36
10	7	44	49	47	47	53	50
16	5	59	67	63	63	72	67
25	3	77	92	84	84	101	92
35	2	98	122	108	101	125	111
50	0	115	150	129	126	164	141
70	2/0	150	206	173	157	215	181
95	4/0	182	262	217	192	276	228
120	250	210	315	256	224	336	273
Multi-core cables							
5 × 1,5	5 × 15	11			12		
7 × 1,5	7 × 15	11			10		
10 × 1,5	10 × 15	9			9		
12 × 1,5	12 × 15	8			9		
14 × 1,5	14 × 15	8			8		
16 × 1,5	16 × 15	7			8		
19 × 1,5	19 × 15	7			7		
24 × 1,5	24 × 15	7			7		

AWG: American Wire Gauge
MCM: Mille Circular Mil

Table 12.8 Current-carrying capacity of cables, max. permissible conductor operating temperature of 85 °C (JIS) *

Nominal cross-section to JIS *	Current-carrying capacity based on a maximum conductor operating temperature of 85 °C		
	S 1 continuous operation	S 2 - 30 min	S 2 - 60 min
[mm^2]	A max.	A max.	A max.
Single-core cables			
1,25	18	19	19
2,0	25	26	26
3,5	35	37	37
5,5	46	49	49
8,0	59	63	63
14,0	83	88	88
22,0	110	117	117
30,0	135	144	143
38,0	155	167	164
50,0	185	202	196
60,0	205	228	217
80,0	245	277	262
100,0	285	331	305
125,0	325	384	351
150,0	365	445	398
200,0	440	554	488
250,0	505	662	571
2-core cables			
1,25	16	17	17
2,0	21	22	22
3,5	30	32	32
5,5	39	42	41
8,0	50	55	53
14,0	71	79	75
22,0	94	106	101
30,0	115	137	124
3-core cables			
1,25	13	14	14
2,0	17	18	18
3,5	25	27	27
5,5	32	35	34
8,0	41	45	43
14,0	58	65	61
22,0	77	88	82
30,0	94	113	102
38,0	110	136	121
50,0	130	169	146
60,0	145	199	167
80,0	175	252	208
100,0	200	300	244
Multi-core cables			
5 × 1,25	11		
7 × 1,25	10		
9 × 1,25	9		
12 × 1,25	8		
16 × 1,25	7		
19 × 1,25	6		
23 × 1,25	6		
27 × 1,25	6		
* Japanese Industrial Standard			

Table 12.9 Current-carrying capacity of cables, max. permissible conductor operating temperature of 90 °C and 95 °C

Nominal cross-section		Current-carrying based on a maximum conductor operating temperature					
		90 °C			95 °C		
		S 1 cont. operation	S 2- 30 min	S 2- 60 min	S 1 cont. operation	S 2- 30 min	S 2- 60 min
mm^2	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single-core cables							
1,0	17	18	19	19	20	21	21
1,5	15	23	24	24	24	25	25
2,5	13	40	43	43	32	34	34
4	11	51	54	54	42	45	45
6	9	52	55	55	55	58	58
10	7	72	77	77	75	80	80
16	5	96	102	102	100	106	106
25	3	127	135	134	135	144	143
35	2	157	170	167	165	178	175
50	0	196	214	208	200	218	212
70	2/0	242	269	257	255	283	270
95	4/0	293	331	314	310	350	332
120	250	339	390	362	360	410	385
150	300	389	459	420	410	484	443
185	400	444	541	484	470	573	512
2-core cables							
1,0	17				17	18	18
1,5	15	20	21	21	20	21	21
2,5	13	26	28	28	27	29	29
4	11	34	37	36	36	39	38
6	9	44	48	46	47	51	50
10	7	61	68	65	64	71	68
16	5	82	93	88	85	96	91
25	3	108	128	116	115	137	124
3- or 4-core cables							
1,0	17				14	15	15
1,5	15	16	17	17	17	18	18
2,5	13	21	23	22	22	24	23
4	11	28	30	30	29	32	31
6	9	36	39	38	38	42	40
10	7	50	56	53	52	58	55
16	5	67	77	72	70	80	75
25	3	89	107	97	94	113	102
35	2	110	136	121	115	143	127
50	0	137	178	153	140	182	157
70	2/0	169	232	195	178	244	205
95	4/0	205	295	244	217	312	258
120	250	237	356	289	252	378	307
Multi-core cables							
5 × 1,5	5 × 15				14		
7 × 1,5	7 × 15				13		
10 × 1,5	10 × 15				11		
12 × 1,5	12 × 15				10		
14 × 1,5	14 × 15				10		
16 × 1,5	16 × 15				9		
19 × 1,5	19 × 15				9		
24 × 1,5	24 × 15				8		

AWG: American Wire Gauge
MCM: Mille Circular Mil