6 – ELECTRICAL PARAMETERS

For power, low voltage and medium voltage cables, cross section nominal areas are calculated in taking into account several parameters as:

- permissible current carrying capacities
- voltage drop
- short circuit values

6-1 Permissible current carrying capacities:

Permissible current carrying capacities are stated by the rules of the vessel approval authority and in line with IEC 60092-352 and IEC 61894-4 standards.

These values are applicable for DC and AC with a nominal frequency of 50 Hz or 60Hz.

For higher frequency, current ratings shall be calculated with appropriate method.

First, these values depend on the temperature class of the cable, and mainly on the maximum service temperature suitable for the insulation compound. Nowadays, in shipbuilding industry, 90°C rated cables are mostly installed on board.

Other important parameters are to be taken into account for the choice of the nominal cross section areas of conductors:

- ambient temperature
- mutual heating effect due to cables grouping
- short time duty
- solar radiation

This catalogue gives only an extract of IEC 60092-352 standard that selected 2 methods for the determination of current carrying capacities for continuous service. These methods are derived from experimental data and from IEC 60287 (Electric cables- Calculation of current rating).

Method A: calculation with the formula

$I = A\,S^{m} - B\,S^{n}$ *where*

I	*is the current rating capacity (in Ampere).*
S	*is the nominal cross section area of conductor (in mm2).*
A and B	*are coefficients, m and n are exponents according to cable type and method of installation.*

This method allows for greater choice of use in different installation configurations (see IEC 60092-352 and/or IEC 60364-5-52).

Method B: calculation with the formula

$I = A\,S^{0.625}$ *where*

I	*is the current rating capacity (in Ampere).*
S	*is the nominal cross section area of conductor (in mm2).*
A	*is a coefficient depending on the conductor temperature class, e.g. A = 18 for MPRX and MPRXCX cables.*

6-1-1 Ambient temperature

For other ambient air temperatures, correction factors have to be applied.

Ambient temperature									
35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C
1.10	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47

6-1-2 Cables grouping

When cables are installed in group, due to thermal effect, a correction factor 0.85 must be applied to reduce the current carrying capacities.

Current ratings are recommended as being applicable to both unarmoured and armoured cables laid in free air as a group of 4 bunched together. These ratings may be considered applicable, without correction factors for a group of maximum 6 cables bunched together on cable trays, operating simultaneously at their full rated capacity, without free air circulation around them.

When, it is to be expected that air temperature around cables could be higher than 45°C (due to heat transfer or in compartments where heat is produced) the current rating given in the table shall be reduced.

6-1-3 Short time duty

Correction factor could be also applied to maximise current ratings when cables are operating during a short period (less than 1 hour).

This factor depends on the cable time constant and also on the cable diameter.

For more details, see IEC 60092-352.

6-1-4 U.V. solar radiation

We recommend shielding cables from direct solar exposition, but in case of solar radiation, a correction factors must be applied to the current carrying capacities given in the table:

- 0.8 for black colour of outer sheath
- 0.9 for light colour of outer sheath (e.g. light grey).

6-2 Voltage drop:

Current carrying in an electrical link induces a voltage drop. This value is the difference between the measured voltages at both ends of the link.

In general, accepted values (in percentage) are 3% for lighting and 5% for motors or other uses.

Voltage drop depends on:

- type of current: direct current (DC) or alternative current (AC) in single or tri-phased systems
- length of the link : directly proportional
- carrying current (amperage) and power factor (cos phi)
- cable and conductor electrical parameters: electrical resistance and inductance.

In direct current system: $\Delta U = 2\,L\,R\,I$

In single phased alternative current system:
$\Delta U = 2\,L\,I\,(R \cos \varphi + Z \sin \varphi)$

In tri-phased alternative current system:
$\Delta U = L\,I\,\wp 3\,(R \cos \varphi + Z\,\text{Sin}\,\varphi)$

where

ΔU	*voltage drop (in Volts).*
R	*electrical conductor resistance in operating temperature (in Ohm/km).*
L	*cable length (in km).*
I	*current rating value (in Ampere).*
$\cos \varphi$	*power factor, if no details, power factor is* $\cos \varphi = 0.8$ *and* $\sin \varphi = 0.6$.
Z	*reactance (in Ohm/km).*

For a quick calculation, the following table gives the voltage drop for most of low voltage cables with XLPE (90°C temperature class) and for various values of $\cos \varphi$.

Values are for a tri-phased system (3 or 4 conductor cable, or 3 single core cables).

Cross-section area (mm²)	Voltage drop (V/ A x km)			
	$\cos \varphi = 1$	$\cos \varphi = 0.9$	$\cos \varphi = 0.8$	$\cos \varphi = 0.6$
1.5	26.00	24.20	21.50	16.20
2.5	15.50	14.40	12.80	9.60
4	10.00	9.00	8.00	6.10
5	6.60	6.10	5.40	4.20
10	3.90	3.60	3.20	2.50
16	2.50	2.30	2.10	1.50
25	1.60	1.50	1.35	1.10
35	1.15	1.10	1.00	0.85
50	0.85	0.80	0.75	0.65
70	0.57	0.60	0.55	0.50
95	0.42	0.45	0.42	0.40
120	0.35	0.35	0.36	0.34
150	0.28	0.30	0.32	0.31
185	0.23	0.25	0.28	0.24
240	0.18	0.21	0.26	0.23
300	0.14	0.18	0.24	0.21

6-3 Short circuit values:

Cables and their insulated conductors must withstand the thermal effect produced by the short circuit which can flow in the circuit.

As the duration is low, normally less than 5 seconds, adiabatic heating in insulation compound is only considered.

The short circuit current rating calculation is based on the difference of conductor temperature before and at the end of the short circuit.

These temperatures are depending on the insulation compound, e.g. for XLPE, initial temperature is 90°C (maximum operating conductor temperature) and final max temperature is 250°C.

Short circuit current ratings are also depending on the duration of the short circuit before the setting off the electrical protection (circuit breaker or fuse).

The following table gives values for cables insulated with XLPE, HEPR and HF90 compounds as MPRX®, MPRXCX®, MPRX® 331 and MPRXCX® 331.

Cross sectional area (mm^2)	Short circuit current ratings (A)			
	Time duration (s)			
	0.1s	0.2s	0.5s	1s
1.0	453	320	202	143
1.5	680	480	304	215
2.5	1 133	800	506	358
4	1 810	1 280	810	572
6	2 720	1 920	1 210	860
10	4 520	3 200	2 020	1 430
16	7 250	5 100	3 240	2 290
25	11 300	7 950	5 050	3 570
35	15 800	11 200	7 070	5 000
50	22 600	16 000	10 100	7 150
70	31 600	22 300	14 100	10 000
95	43 300	30 600	19 300	13 700
120	54 100	38 200	24 200	17 100
150	67 700	47 800	30 200	21 400
185	83 500	59 000	37 300	26 400
240	108 000	76 700	48 500	34 300
300	135 000	96 000	60 600	42 900

For other short circuit duration, the maximum short circuit rating is calculated with the formula:

$I_{sc} = A/\sqrt{t}$ *where*

I sc *is the short circuit rating during "t" second.*

t *is the short circuit duration.*

A *is the short circuit rating for 1 second.*

The following table gives current carrying capacities in continuous service for 90°C rated cables for an ambient air temperature of 45°C.

Nominal cross-sectional area mm^2	Current carrying capacity		
	Single core (A)	2 cores (A)	3 or 4 cores (A)
1.5	21	18	15
2.5	28	24	20
4	38	32	27
6	49	42	34
10	67	57	47
16	91	77	64
25	120	102	84
35	148	126	104
50	184	156	129
70	228	194	160
95	276	235	193
120	319	271	223
150	367	312	257
185	418	355	293
240	492	418	344
300	565	480	396

7 – ELECTRICAL PARAMETERS FOR INSTRUMENTATION CABLES

For instrumentation cables, main electrical parameters are:

- electrical resistance and loop resistance
- current ratings
- voltage drop
- mutual capacitance
- loop inductance and L/R ratio
- insulation resistance (conductors, screen, armour)

All these values are given in the following table for Nexans TX® and TCX® range with bare copper conductor.

	Number of pairs	0.5 mm²	0.75 mm²	1.5 mm²
Electrical conductor resistance in DC at 20°C (Ohm/km) **Loop resistance (Ohm/km)**		40.4 80.8	26.0 52.0	12.8 25.6
Current carrying capacity (A)	″ 4 p > 4 p	8 4	12 6	14 7
Voltage drop in DC (V/A.km)		52	39	26
Capacitance at 1 kHz **Individual screen (nF/km)**		81	82	92
Capacitance at 1 kHz **Collective screen (nF/km)**	2 p 4 p 7 p to 24 p	63 53 51 to 49 p	62 52 51 to 48 p	69 56 54 to 52 p
Capacitance for 331 types with HF 90 compound **Individual screen (nF/km)**		-	100	115
Loop Inductance (mH/km) at 1 kHz		0.63	0.64	0.60
L/R ratio at 20°C		0.0078	0.0123	0.0234
Cores insulation resistance (M Ohm - km) **Screen insulation resistance (M Ohm - km)** **Screen/Armour insulation resistance (M Ohm - km)**		> 1000 > 1 > 0.25	> 1000 > 1 > 0.25	> 800 > 1 > 0.25

Permissible current carrying capacity is given for an ambient temperature of 45°C and for a maximum conductor temperature of 90°C.

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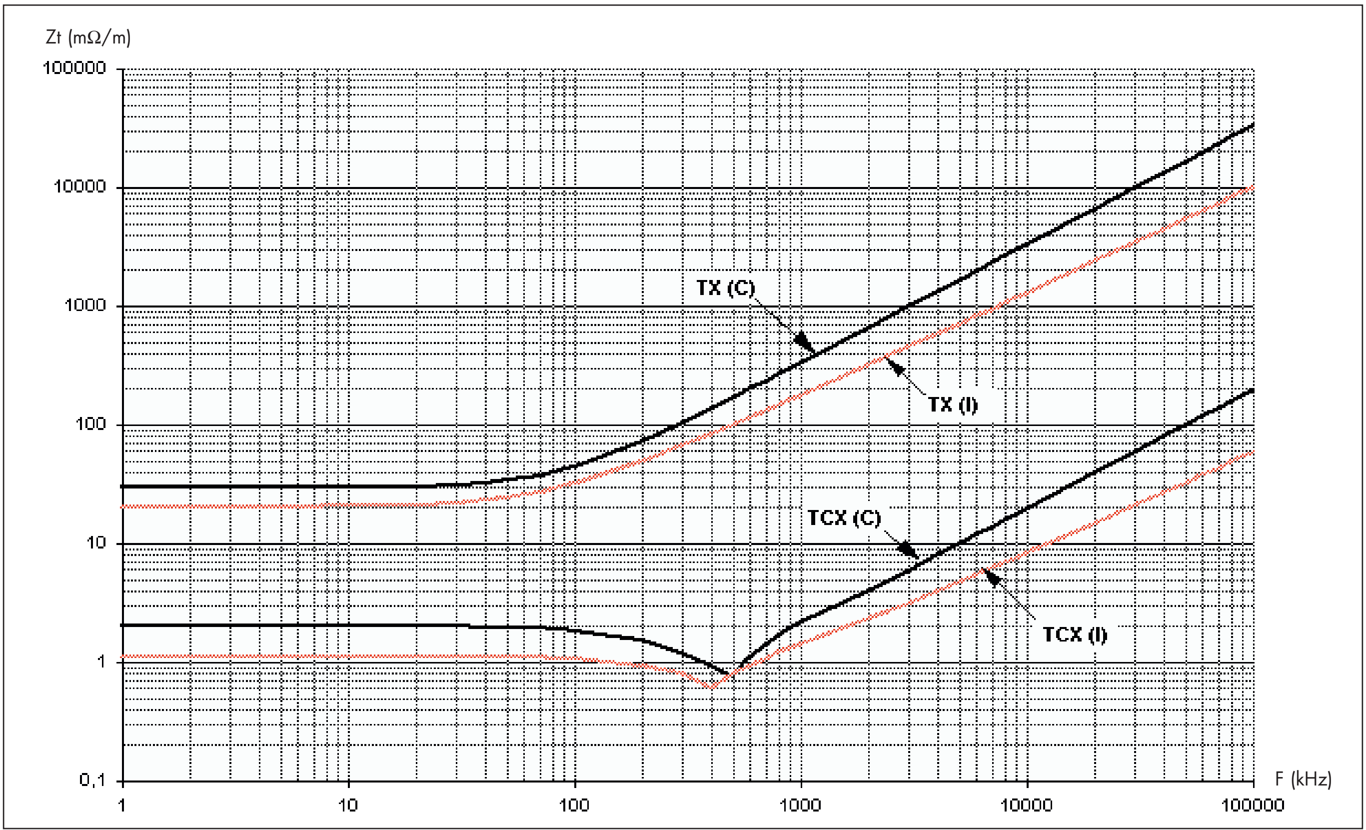
An other important parameter for these instrumentation cables could be the screen efficiency and the transfer impedance value designated by Zt.

Nexans has studied screening efficiency for TX® and TCX® range. Curves (transfer impedance related to frequency) have been established for various 7 pairs.

Transfer impedance Value (Zt) according to the frequency (F)



- ***TX®(C):***
  (Unarmoured, collective screen)
  Electromagnetic screening of the TX (C) cable is simple and shows a medium protection in polluted electromagnetic surroundings.

- ***TX®(I):***
  (Unarmoured, individual screen)
  TX (I) is an excellent compromise between TX (C) and TCX (C) cables.

- ***TCX®(C):***
  (Armoured, collective screen)
  The TCX (C) cable shows a low transfer impedance in low frequency and an effective screening in high frequency. TCX (C) would be recommended in polluted electromagnetic surroundings.

- ***TCX®(I):***
  (Armoured, individual screen)
  This cable type shows an excellent protection in both low and high frequency runs.