Report

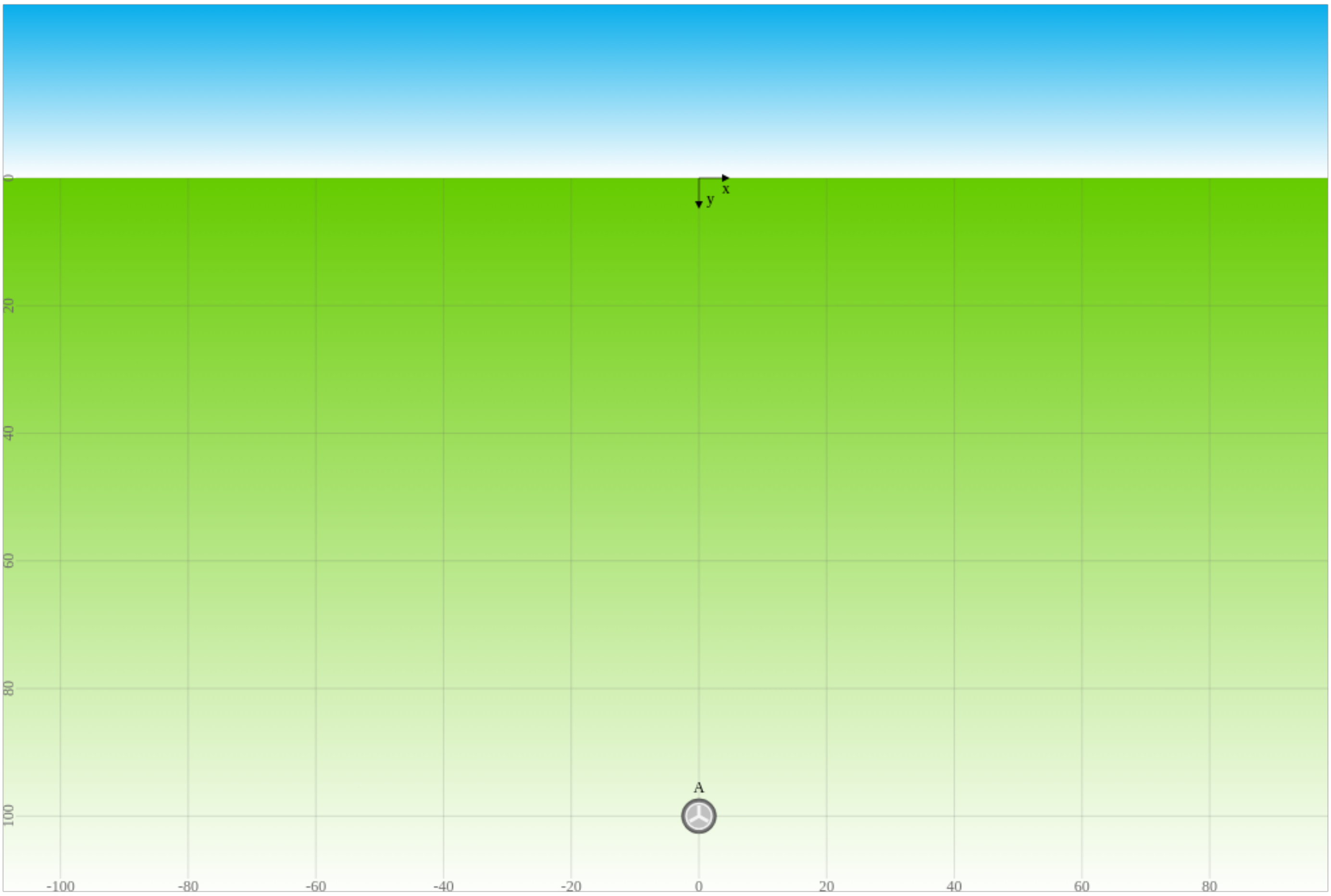
Title	Case study 10: A 10kV three core PILC cable
Project	Verication CIGRE TB 880
Created	Date: 2025-05-14 Time: 21:20 Software version: 51cac (2025-05-14)

Arrangement

Arrangement	**buried project** (#46709)
Options	None
CIGRE TB 880, guidance points	02, 06, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	10
Sum of currents from all systems	I_{sum}	165.74 A
Sum of average conductor temperatures from all systems	θ_{sum}	50 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	29.908 W/m



Systems

Following systems are active in the arrangement:

#	Object	Current [A] I_c	Temp. [°C] θ_c | θ_e	Losses [W/m] W_{sys}	Load LF
A	16328 CIGRE TB 880 Case 10 10kV three core ...	165.7	50.0 | 35.4	29.9	1.00

Objects

Following objects are used:

16328 CIGRE TB 880 Case 10 10kV three core PILC cable

Ambient

Calculation method		IEC Standard (directly buried)
Ambient temperature	θ_a	15 °C
Thermal resistivity soil	ρ_4	1 K.m/W
Thermal conductivity soil	k_4	1 W/(m.K)
Volumetric heat capacity soil material $10^{-4}\frac{{k_4}^{0.2}}{4.68}$	$c_{p,soil}$	2136.8 J/(kg.K)
Thermal diffusivity soil	δ_{soil}	5.00e-7 m^2/s
Ratio thermal resistivity dry/moist soil $\frac{\rho_{4d}}{\rho_4}$	v_4	1

Constants

Standard acceleration of gravity	g	9.80665 m/s^2
Archimedes' constant π	π	3.141592653589793
Absolute temperature	θ_{abs}	273.15 K
Stefan Boltzmann constant	σ	5.67036713e-8 W/m^{2}K^4
Vacuum permeability	μ_0	1.2566370614359173e-6 H/m
Vacuum permittivity	ϵ_0	8.854187817620389e-12 F/m

System A (Medium voltage cable)

Ampacity

Cable		CIGRE TB 880 Case 10 10kV three core PILC cable
Rounded value, CIGRE TB 880	I_c	165 A
Conductor current	I_c	165.74 A

$$\sqrt{\frac{\theta_c - \theta_a + (v_4 - 1)\Delta\theta_x - v_4\Delta\theta_p - \Delta\theta_d}{R_c\left(T_1 + n_{ph}(1+\lambda_1)T_2 + (1+\lambda_1+\lambda_2+\lambda_3)(n_{ph}T_3 + n_{cc}(T_{4i} + T_{4ii} + T_{4\mu}v_4)) + n_{cc}\lambda_4\left(\frac{T_{4ii}}{2} + T_{4\mu}v_4\right)\right)}}$$

Operating voltage	U_o	10 kV
Angular frequency	ω	314.2 rad/s

$2\pi f$

Number of sources in system	N_c	1
Number of conductors combined	n_{cc}	3

$N_c n_{ph}$

Load

System frequency	f	50 Hz
Continuous load	LF	1 p.u.

Arrangement

Arrangement		individual
Position cable 1	$x_1 \vert y_1$	0.0 | 1000.0 mm
Separation of conductors in a system	s_c	15.7 mm
Mean distance between the phases	a_m	15.7 mm
Geometric mean distance between phases of the same system	GMD	0.00255 m

GMR_{cc}

Depth of laying of sources	L_c	1000 mm
Depth of laying	L_{cm}	1 m
Outer diameter	D_o	0.055 m
Substitution coefficient u	u	36.3636

$$\frac{2L_{cm}}{D_o}$$

Geometric constant of circle buried	g_u	72.7135

$u + \sqrt{u^2 - 1}$

Temperature

Temperature conductor	θ_c	50 °C

$\theta_a + \Delta\theta_c - (v_4 - 1)\Delta\theta_x + v_4\Delta\theta_p$

Temperature screen/sheath	θ_s	42.04 °C
Temperature sheath	θ_{sh}	42.04 °C

$$\theta_c - T_1\left(W_c + \frac{W_d}{2}\right)$$

Temperature armour	θ_{ar}	38.06 °C

$$\theta_c - T_1\left(W_c + \frac{W_d}{2}\right) - n_{ph}T_2\left(W_c(1+\lambda_1) + W_d\right)$$

External temperature object	θ_e	35.4 °C

$$\theta_c - T_1\left(W_c + \frac{W_d}{2}\right) - n_{ph}T_2\left(W_c(1+\lambda_1) + W_d\right) - n_{ph}T_3\left(W_I + W_d\right)$$

Temperature rise

Temperature rise conductor $\Delta\theta_c$ 35 K

$$n_{ph}\left(W_cT_{int}+W_dT_d\right)+n_{cc}\left(W_d\left(T_{4i}+T_{4ii}+v_4T_{4ss}\right)+\left(W_c+W_s+W_{ar}+W_{sp}\right)\left(T_{4i}+T_{4ii}+v_4T_{4\mu}\right)+W_{duct}\left(\frac{T_{4ii}}{2}+v_4T_{4\mu}\right)\right)$$

Temperature rise dielectric losses $\Delta\theta_d$ 0.1172 K

$$W_d\left(n_{ph}T_d+n_{cc}\left(T_{4i}+T_{4ii}+T_{4ss}v_4\right)\right)$$

Temperature rise by other buried objects $\Delta\theta_p$ 0 K

$$\sum_{k=1}^{q}\Delta\theta_{kp}$$

Critical soil temperature rise $\Delta\theta_x$ 0 K

Losses

Ohmic

Conductor losses (phase) W_c 9.872 W/m

$$I_c{}^2R_c$$

Screen/sheath losses (phase) W_s 0.047 W/m

$$\lambda_1W_c$$

Armour losses (phase) W_{ar} 0.013 W/m

$$\lambda_2W_c$$

Duct losses W_{duct} 0 W/m

Ohmic losses (phase) W_I 9.932 W/m

$$W_c\left(1+\lambda_1+\lambda_2+\lambda_3+\lambda_4\right)$$

Dielectric

Dielectric losses (phase) W_d 0.038 W/m

$$\omega C_b\left(1000\frac{U_o}{\sqrt{3}}\right)^2\tan\delta_i$$

Total

Total losses (phase) W_t 9.969 W/m

$$W_I+W_d$$

Total losses (object) W_{tot} 29.908 W/m

$$n_{ph}W_t$$

Total losses (system) W_{sys} 29.908 W/m

Thermal resistance

Thermal resistance ambient $T_{4\mu}$ 0.6822 K.m/W

$$=T_{4ss}=T_{4iii}=\frac{\rho_4}{2\pi}\left(\ln\left(g_u\right)+\ln\left(F_{mh}\right)\right)$$

Mutual heating coefficient F_{mh} 1

Cable

Internal thermal resistance for current losses T_{int} 0.4915 K.m/W

$$\frac{T_1}{n_{ph}}+\left(1+\lambda_1\right)T_2+\left(1+\lambda_1+\lambda_2+\lambda_3\right)T_3$$

Internal thermal resistance for dielectric losses T_d 0.35624 K.m/W

$$\frac{T_1}{2n_c}+T_2+T_3$$

Other characteristics

Earthing

earthing screen/sheath		both-side bonding, regular transposition
Variation of spacing		No variation

Loss factor

Loss factor shield (screen/sheath) $\lambda_{11} + F_e \lambda_{12}$	λ_1	0.0048
Loss factor shield, circulating currents	λ_{11}	0
Loss factor shield, eddy currents $F_{ar}\lambda_{12}$	λ_{12}	0.0048
Electrical resistance shield/armour	R_e	9.7532e-1 Ω/km
Factor F_e eddy-current losses	F_e	1
Loss factor armour $\lambda_{21} + \lambda_{22}$	λ_2	0.0013
Loss factor armour, circulating currents $\frac{10^{-7} {s_c}^2 \left(\frac{1}{1+\frac{d_{ar}}{\mu_s \delta_{ar}}}\right)^2}{R_c d_{ar} \delta_{ar}} \left(\frac{f}{50}\right)^2$	λ_{21}	0.001
Loss factor shield, eddy currents $\frac{2.25 {s_c}^2 \left(\frac{1}{1+\frac{d_{ar}}{\mu_s \delta_{ar}}}\right)^2 \delta_{ar} \cdot 10^{-8}}{R_c d_{ar}} \left(\frac{f}{50}\right)^2$	λ_{22}	0.0003

Drying-out of soil

Characteristic diameter drying zone	D_{dry}	0.055 m
Depth characteristic diameter drying zone	L_{dry}	1 m
Geometric constant of circle drying zone	g_{dry}	1 p.u.
Substitution coefficient g	g_a	1

Electrical parameters

System

System length	L_{sys}	1000 m
Power factor	$\cos\varphi$	1

Resistance

Electrical resistance conductor $R_{cDC}\left(1 + 1.5\left(y_s + y_p\right)\right)$	R_c	3.5936e-4 Ω/m → 0.3594 Ω
Electrical resistance DC conductor $R_{c20}\left(1 + \alpha_c\left(\theta_c - 20\right)\right)$	R_{cDC}	3.5869e-4 Ω/m → 0.3587 Ω
Skin effect factor conductor $\frac{{x_s}^4}{192 + 0.8{x_s}^4}$	y_s	0.00064
Factor for skin effect on conductor $\sqrt{10^{-7}\frac{8\pi f}{R_{cDC}} k_s}$	x_s	0.5919

Proximity effect factor conductor $\frac{\frac{2}{3}{x_p}^4}{192+0.8{x_p}^4}\left(\frac{d_x}{s_c}\right)^2\left(0.312\left(\frac{d_x}{s_c}\right)^2+\frac{1.18}{\frac{{x_p}^4}{192+0.8{x_p}^4}+0.27}\right)$	y_p	0.0006
Factor for proximity effect of conductors $\sqrt{10^{-7}\frac{8\pi f}{R_{cDC}}k_p}$	x_p	0.52941
Electrical resistance sheath $R_{sh}\left(1+\alpha_{sh}\left(\theta_{sh}-20\right)\right)$	R_{sh}	9.7532e-04 Ω/m
Electrical resistance sheath, CIGRE TB 880 $F_{lay,3c}R_{sh}$	R_{sh}	9.7532e-04 Ω/m
Electrical resistance shield	R_s	9.7532e-4 Ω/m → 0.9753 Ω
Reduction factor $\frac{R_s}{\sqrt{{R_s}^2+{X_s}^2}}$	RF	0.8209
Electrical resistance armour $R_{ar}\left(1+\alpha_{ar}\left(\theta_{ar}-20\right)\right)$	R_{ar}	1.0477e-3 Ω/m → 1.0477 Ω

Electrical field strength, capacitive load current

Electrical field strength insulation inner/outer $\frac{U_e}{1000}\frac{1}{r_x\ln\left(\frac{r_{osc}}{r_{isc}}\right)}$	E_i	0.885 | 0.271 kV/mm
Radius to point x in insulation	r_x	5.5 | 18 mm
Line-to-ground voltage $\frac{1000U_o}{\sqrt{3}}$	U_e	5773.5 V
Capacitance insulation $\frac{1}{2\pi\epsilon_0}\frac{10^{-9}}{18}C_b$	C_b	3.593e-10 F/m → 0.3593 μF
Capacitive load current $U_e\omega C_b$	I_C	6.516e-4 A/m → 0.6516 A
Charging capacity $n_{ph}{U_e}^2\omega C_b$	P_C	11.2866 var/m → 11.2866 kvar
Capacitive earth short-circuit current $3U_e\omega C_E$	I_{Ce}	8.466e-4 A/m

Reactance

Self reactance conductor $\omega\frac{\mu_0}{2\pi}\ln\left(\frac{D_E}{GMR_c}\right)$	X_a	7.721e-4 Ω/m → 0.7721 Ω
Self reactance screen/sheath	X_e	0.000e0 Ω/m → 0 Ω

Induced current (approximate)

Induced circulating current shield $\max\left(I_c\sqrt{\frac{\lambda_{11,sb}R_c}{R_s}}\right)$	I_s	0.000+0.000j A
Loss factor shield, circulating currents	$\lambda_{11,sb}$	0.0000+0.0000j

Induced circulating current armour $\max\left(I_c\sqrt{\frac{\lambda_{21}R_c}{R_{ar}}}\right)$	I_{ar}	3.106 A

Load, Voltage drop

Apparent power generator-side $\sqrt{3}U_oI_c$	S_G	2.871 MVA
Voltage drop $\sqrt{3}\left(R_c\cos\varphi+\omega L_m\sin\varphi\right)$	V_{drop}	0.62 V/(A.km) → 103.2 V = 1.03%
Inductance (mean) $\frac{\mu_0}{2\pi}\ln\left(\frac{GMD}{GMR_c}\right)$	L_m	-1.037e-7+0.000e0j H/m → -0.1037 mH

Telegrapher equation

Surge impedance $\sqrt{\frac{Z_1}{Y_1}}$	Z_C	38.1211-41.7366j Ω
Propagation constant $\sqrt{Z_1Y_1}$	γ_C	4.711e-6+4.303e-6j

Impedance valid up to 100 Hz without earth return

Positive sequence admittance $G+j\omega C_b$	Y_1	0.000e0+1.129e-7j S/m → 0.0000+0.0001j S
Positive sequence impedance R_1+jX_1	Z_1	3.591e-4-3.259e-5j Ω/m → 0.3591-0.0326j Ω
Positive sequence reactance $\omega\frac{\mu_0}{2\pi}\ln\left(\frac{GMD}{GMR_c}\right)$	X_1	-3.259e-5 Ω/m → -0.0326 Ω

Cable datasheet

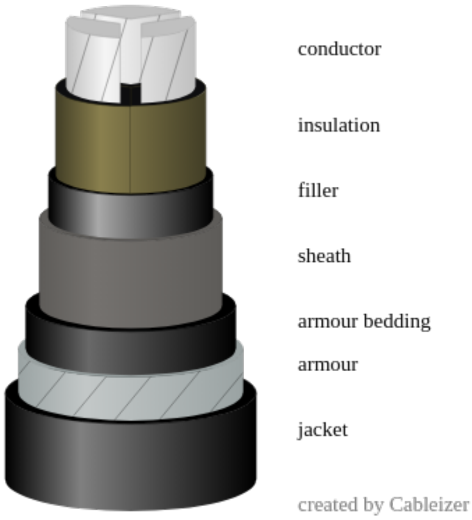
Title	CIGRE TB 880 Case 10 10kV three core PILC cable (#16328)

Warning! external diameter conductor deviates from value given in HD 603 S2 by more than 20 %.
Cable is used in following systems: A

CIGRE TB 880, guidance points	15, 20, 23, 25, 30, 32, 33, 34, 38, 39, 42, 44, 45

General Data

Rated line-to-line voltage	U_n	10 kV
Base voltage for tests	U_0	6 kV
Highest voltage for equipment	U_m	12 kV
Nominal system frequency	f	50 Hz
Number of conductors cable	n_c	3
Number of phases in a cable	n_{ph}	3



Cable elements

Conductor

Cross-sectional area conductor	A_c	3 x 95 mm^2
Conductor material	M_c	Aluminium, sector-shaped
diameter of the circle circumscribing the conductors	d_c	28.2 mm
Equivalent diameter conductor	d_x	11 mm
Equivalent radius of a conductor $\frac{d_x}{2}$	r_c	5.5 mm
Geometrical distance factor for multi-core cables	F_x	1
Distance conductor axis—cable axis $0.55 r_1 + 0.29{\cdot}2 t_i$	c_c	9.118 mm
Separation of conductors in a system $d_x + t_{i1}$	s_c	15.7 mm

Insulation

Insulation material	M_i	mass impregnated paper

Thickness conductor shield	t_{cs}	0 mm
Thickness insulation	t_{ins}	2.35 mm
Thickness insulation screen	t_{is}	0 mm
Thickness insulation $t_{ct} + t_{cs} + t_{ins} + t_{is}$	t_i	2.35 mm
Thickness of insulation between conductors $2t_i$	t_{i1}	4.7 mm
Thickness of insulation between conductor and metallic sheath $t_i + t_{scb} + t_{scs} + t_f$	t_{i2}	3.9 mm

Sheath

Sheath material	M_{sh}	Lead
Thickness sheath	t_{sh}	2 mm
corrugated		No

Filler

Filler material	M_f	User defined
Thickness of filler/belt insulation	t_f	1.55 mm

Armour bedding

Armour bedding material	M_{ab}	Fibrous polyolefin copolymer
Thickness armour bedding	t_{ab}	3 mm

Armour

Construction of armour	a_{type}	Steel tape touching
Thickness armour	t_{ar}	0.8 mm
Factor between AC and DC resistance armour $\frac{1.4-1.2}{5-2}(t_{ar}-2)+1.2$	f_{ar}	1.1200e0 Ω/m
Number of wires armour	n_{ar}	2
Width armour	w_{ar}	50 mm
Gap between	$g_{a,1}$	25 mm

Jacket

Jacket material	M_j	Polyvinyl chloride (PVC, ST1/2)
Thickness jacket	t_j	2.9 mm

Overall

External diameter object	D_e	55 mm
Absorption coefficient solar radiation	σ_{sun}	0.6
Emissivity cable	ϵ_e	0.9
Reflectivity cable $1-\epsilon_e$	η_e	0.1
Mass cable $m_{hollow} + m_{metal}$	m_{tot}	11.823 kg/m

Electrical

Conductor

Electrical resistance DC conductor 20°C R_{c20} 3.2000e-4 Ω/m

Standard DC resistance of conductor R_{co} 0.32 Ω/km

Skin effect coefficient k_s 1

Proximity effect coefficient k_p 0.8

Geometric mean radius conductor bundle GMR_{cc} 0.00255 mm

$$\left(GMR_c\left(\frac{s_c}{1000}\right)^{n_c}\right)^{\frac{1}{n_c}}$$

Geometric mean radius conductor GMR_c 0.00428 m

$$e^{-\left(\frac{1}{4}\right)}\sqrt{\frac{A_c}{\pi}}\frac{1}{1000}$$

Factor geometric mean radius K_{GMR} 0.776

Constant relating to conductor formation K_{BICC} 0.051

Number of wires conductor n_{cw} 127

Diameter of wires conductor (average) d_{cw} 2.84 mm

Insulation

Capacitance, with approximation (CIGRE TB 880) C_b 3.593e-10 F/m

$$\frac{1}{2\pi\epsilon_0}\frac{10^{-9}}{18}C_b$$

Capacitance (exact) C_b 3.598e-10 F/m

$$\frac{2\pi\epsilon_0\epsilon_i}{\ln\left(\sqrt{\frac{3c_c{}^2\left(r_{osc}{}^2-c_c{}^2\right)^3}{r_{isc}{}^2\left(r_{osc}{}^6-c_c{}^6\right)}}\right)}$$

Capacitance to earth C_E 1.556e-10 F/m

$$\frac{2\pi\epsilon_0\epsilon_i}{\ln\left(\frac{r_{osc}{}^6-c_c{}^6}{3c_c{}^2r_{isc}r_{osc}{}^3}\right)}$$

Vacuum permittivity ϵ_0 8.854187817620389e-12 F/m

Radius above the inner semi-conducting layer r_{isc} 5.5 mm

$$\frac{d_x}{2}+t_{ct}-t_{cs}$$

Radius over capacitive insulation layers r_{osc} 18 mm

$$\frac{D_f}{2}$$

Velocity of propagation v_{prop} 149896.2 km/s

$$\frac{1}{1000\sqrt{\mu_0\epsilon_0\epsilon_i}}$$

Screen + Sheath

Electrical resistance sheath R_{sh} 8.9629e-4 Ω/m

$$10^6\frac{\rho_{sh}}{A_{sh}}$$

Electrical resistance screen/sheath 20°C R_{so} 8.963e-1 Ω/km

Electrical resistance screen/sheath, CIGRE TB 880 R_{so} 8.9629e-04 Ω/m

Armour

Electrical resistance armour R_{ar} 9.6897e-4 Ω/m

$$10^6\frac{f_{ar}\rho_{ar}}{A_{ar}}$$

Relative permeability steel wires	μ_s	300
Equivalent thickness of armour $\frac{A_{ar}}{\pi d_{ar}}$	δ_{ar}	1.0667 mm

Radius

Radius conductor	r_{z1}	0.0055 m
Radius shield (inner)	r_{z2}	0.017 m
Radius shield (outer)	r_{z3}	0.017 m
Radius sheath (inner)	$r_{z2,sh}$	0.017 m
Radius sheath (outer)	$r_{z3,sh}$	0.021 m
Radius armour (inner)	r_{z4}	0.023 m
Radius armour (outer)	r_{z5}	0.0246 m
Radius outersheath	r_{z6}	0.0275 m

Material parameters

Conductor

Electrical resistivity conductor material	ρ_c	2.826e-8 Ω.m
Temperature coefficient conductor material	α_c	4.03e-3 1/K
Reciprocal of temperature coefficient conductor material	β_c	2.281e2 K
Volumetric heat capacity conductor material	σ_c	2.50e6 J/(K.m^3)
Thermal conductivity conductor material	k_c	204.08 W/(m.K)
Density conductor material	ζ_c	2.712 g/cm^3

Insulation

Relative permittivity insulation material	ϵ_i	4
Loss factor insulation material	$\tan\delta_i$	0.01
Thermal resistivity insulation material	ρ_i	6 K.m/W
Volumetric heat capacity insulation material	σ_i	2.00e6 J/(K.m^3)
Density insulation material	ζ_i	1.19 g/cm^3
Max. temperature conductor	θ_{cmax}	80 °C
Max. temperature conductor, emergency overload	θ_{cmaxeo}	95 °C
Max. temperature conductor, short-circuit	θ_{cmaxsc}	150 °C

Sheath

Specific electrical resistivity sheath material	ρ_{sh}	2.140e-7 Ω.m
Temperature coefficient sheath material	α_{sh}	4.00e-3 1/K
Reciprocal of temperature coefficient sheath material	β_{sh}	2.300e2 K
Volumetric heat capacity sheath material	σ_{sh}	1.45e6 J/(K.m^3)
Thermal conductivity sheath material	k_{sh}	33.4 W/(m.K)
Density sheath material	ζ_{sh}	11.34 g/cm^3

Filler

Thermal resistivity filler	ρ_f	6 K.m/W
Volumetric heat capacity filler	σ_f	1.26e6 J/(K.m^3)
Density filler material	ζ_f	0.64 g/cm^3

Armour bedding

Thermal resistivity armour bedding	ρ_{ab}	6 K.m/W
Volumetric heat capacity armour bedding	σ_{ab}	1.68e6 J/(K.m^3)
Density armour bedding material	ζ_{ab}	0.98 g/cm^3

Armour

Specific electrical resistivity armour material	ρ_{ar}	1.380e-7 Ω.m
Temperature coefficient armour material	α_{ar}	4.50e-3 1/K
Reciprocal of temperature coefficient armour material	β_{ar}	2.022e2 K
Volumetric heat capacity armour material	σ_{ar}	3.80e6 J/(K.m^3)
Thermal conductivity armour material	k_{ar}	36.1 W/(m.K)
Density armour material	ζ_{ar}	7.85 g/cm^3

Jacket

Thermal resistivity jacket material	ρ_j	5 K.m/W
Thermal resistivity additional layer	ρ_{jj}	2.5 K.m/W
Volumetric heat capacity jacket material	σ_j	1.70e6 J/(K.m^3)
Electrical conductivity jacket material	κ_j	1.00e-14 S/m
Density jacket material	ζ_j	1.4 g/cm^3

Thermal resistance

Internal thermal resistances for rating calculation

Thermal resistance conductor—sheath T_1 0.8046 K.m/W

$$\frac{\rho_i}{2\pi}G_1$$

Thermal resistance armour bedding T_2 0.1335 K.m/W

$$T_{ab}$$

Thermal resistance jacket T_3 0.0887 K.m/W

$$T_j + T_{jj}$$

Thickness conductor—sheath t_1 3.9 mm

$$t_i + t_f + t_{scb} + t_{scs} + \frac{H_{sh} + \Delta H}{2}$$

Thickness sheath—armour t_2 3 mm

$$\frac{H_{sh} + \Delta H}{2} + t_{ab}$$

Thickness armour—surface t_3 2.9 mm

$$t_j + t_{jj}$$

Geometric factor G_1 G_1 0.8425

$$3\left(1 + \frac{3t_{i1}}{2\pi\left(d_x + t_{i1}\right) - t_{i1}}\right)\ln\left(\frac{D_f}{d_c}\right)$$

Cable elements

Thermal resistance, transient T_{tot} 1.0267 K.m/W

$$T_1 + T_2 + T_3$$

Thermal resistance insulation T_i 0.1472 K.m/W

$$T_{ct} + T_{cs} + T_{ins} + T_{is}$$

Thermal resistance insulation T_{ins} 0.1472 K.m/W

$$\frac{\rho_i}{2\pi}\ln\left(\frac{D_{ins}}{D_{ins} - 2t_{ins}}\right)$$

Thermal resistance armour bedding $\frac{\rho_{ab}}{2\pi}\ln\left(\frac{D_{ab}}{D_{shj}-(H_{sh}+\Delta H)}\right)$	T_{ab}	0.13346 K.m/W
Thermal resistance jacket $\frac{\rho_j}{2\pi}\ln\left(\frac{D_j-2t_{jj}}{D_j-2\left(t_j+t_{jj}\right)}\right)$	T_j	0.08868 K.m/W

Dimensions

Diameter

External diameter conductor	d_c	28.2 mm
Diameter over insulation $d_c+2\left(t_{ct}+t_{cs}+t_{ins}\right)$	D_{ins}	32.9 mm
Diameter over insulation incl. insulation screen $d_c+2\left(t_{ct}+t_{cs}+t_{ins}+t_{is}\right)$	D_i	32.9 mm
Equivalent diameter of screen and sheath	d_s	38 mm
Mean diameter sheath $D_{shb}+t_{sh}+H_{sh}+\Delta H$	d_{sh}	38 mm
Diameter over sheath $D_{shb}+2\left(t_{sh}+H_{sh}+\Delta H\right)$	D_{sh}	40 mm
Diameter over sheath jacket	D_{shj}	40 mm
Diameter over core cable D_f-2t_f	D_{core}	32.9 mm
Diameter over filler $D_{scb}-2t_{scb}$	D_f	36 mm
Diameter over armour bedding $D_{sh}+2t_{ab}$	D_{ab}	46 mm
Equivalent diameter of screen/sheath and armour	d_e	38 mm
Mean diameter armour $D_{ab}+n_{a,1}t_{a,1}$	d_{ar}	47.6 mm
Diameter over armour $D_{ab}+2n_{a,1}t_{a,1}$	D_{ar}	49.2 mm
Diameter over jacket $D_{ar}+2\left(t_j+t_{jj}\right)$	D_j	55 mm

Area

		values are per phase
Cross-sectional area conductor	A_c	95 mm^2
cross-sectional area (calculated) $\frac{\frac{\pi}{4}{d_c}^2-n_c d_c t_i}{n_c}$	A_c	141.92 mm^2
Cross-sectional area insulation $\frac{\pi}{4}\left({D_{is}}^2-{d_c}^2\right)$	A_i	225.5 mm^2
Cross-sectional area sheath $d_{sh}t_{sh}\pi$	A_{sh}	238.76 mm^2

Cross-sectional area filler $\pi\left(\frac{D_f}{2}\right)^2-\left(\pi\left(\frac{D_f}{2}\right)^2-\pi\left(\frac{D_f}{2}-t_f\right)^2\right)$	A_f	850.1 mm^2
Cross-sectional area armour bedding $\frac{\pi}{4}\left({D_{ab}}^2-\left(D_{ab}-t_{ab}\right)^2\right)$	A_{ab}	209.7 mm^2
Cross-sectional area armour $\frac{w_{ar}}{w_{ar}+g_{a,1}}\pi t_{ar}n_{ar}\left(D_{ab}+n_{ar}t_{ar}\right)$	A_{ar}	159.51 mm^2
Cross-sectional area jacket $\frac{\pi}{4}\left({D_j}^2-\left(D_j-2\left(t_j+t_{jj}\right)\right)^2\right)$	A_j	474.7 mm^2