Report

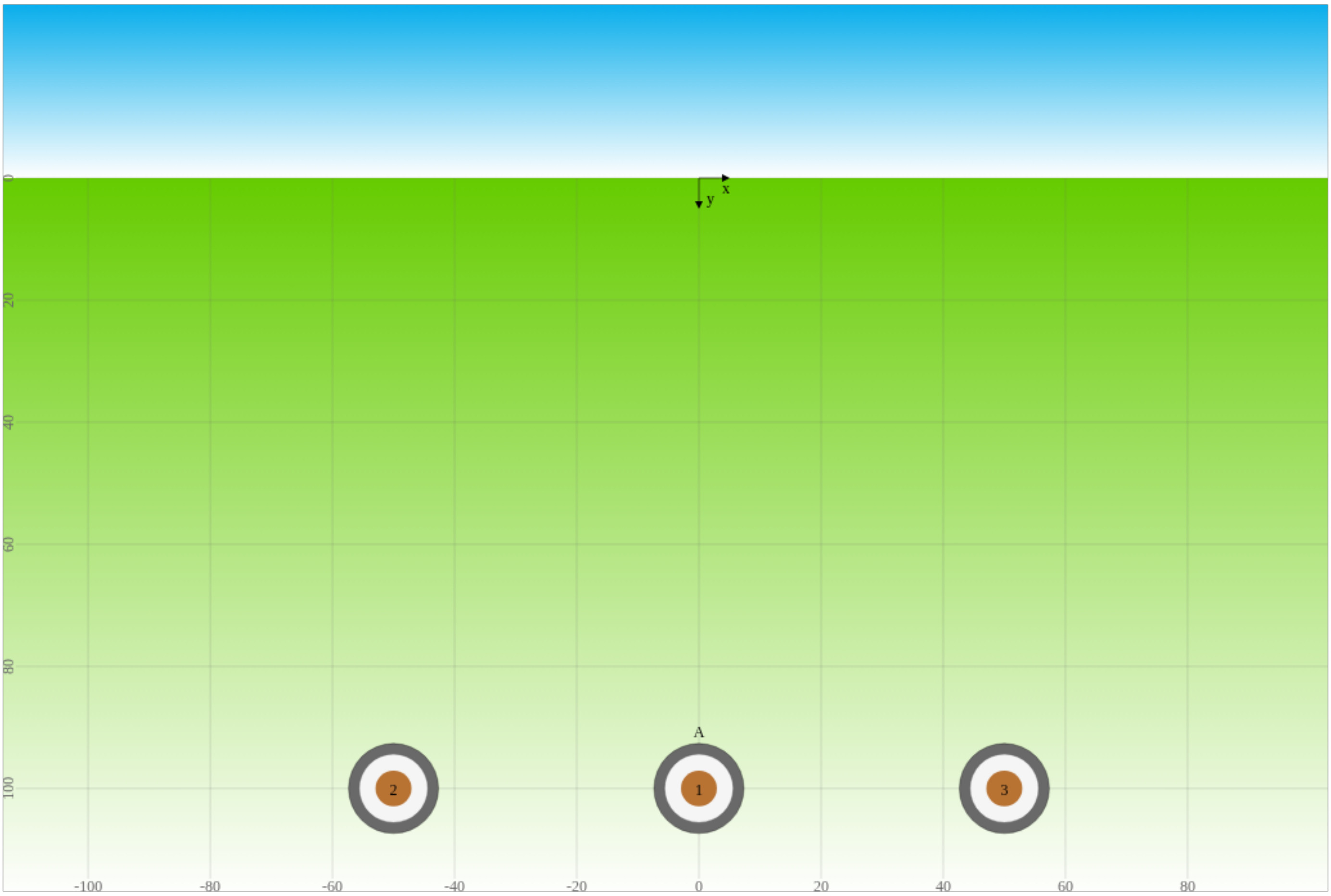
Title	Case study 5-2: A 400kV LPOF Cable (flat, cb)
Project	Verification CIGRE TB 880
Created	Date: 2025-05-26 Time: 09:30 Software version: f8c9 (2025-05-24)

Arrangement

Arrangement	**buried project** (#46706)
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	31
Sum of currents from all systems	I_{sum}	1570.64 A
Sum of average conductor temperatures from all systems	θ_{sum}	80.83 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	115.651 W/m



Systems

Following systems are active in the arrangement:

#	Object	Current [A]	Temp. [°C]	Losses [W/m]	Load
		I_c	θ_c | θ_e	W_{sys}	LF
A	16320 CIGRE TB 880 Case 5 400kV LPOF Cable	1570.6	85.0 | 59.7	115.7	1.00

Objects

Following objects are used:

16320 CIGRE TB 880 Case 5 400kV LPOF Cable

Ambient

Calculation method		IEC Standard (directly buried)
Ambient temperature	θ_a	20 °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^2K^4
Vacuum permeability	μ_0	1.2566370614359173e-6 H/m
Vacuum permittivity	ϵ_0	8.854187817620389e-12 F/m

System A (Extra high voltage cable)

Warning! The conductor temperature exceeds the maximum allowable temperature of 80.0 °C under emergency overload operation.

Ampacity

Cable		CIGRE TB 880 Case 5 400kV LPOF Cable
Rounded value, CIGRE TB 880	I_c	1570 A
Conductor current	I_c	1570.64 A

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

Operating voltage	U_o	400 kV
Angular frequency $2\pi f$	ω	314.2 rad/s
Number of sources in system	N_c	3
Number of conductors combined	n_{cc}	1

Load

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

Arrangement

Arrangement		flat
Position cable 1	$x_1\|y_1$	0.0 | 1000.0 mm
Position cable 2	$x_2\|y_2$	-500.0 | 1000.0 mm
Position cable 3	$x_3\|y_3$	500.0 | 1000.0 mm
Separation of conductors in a system	s_c	500 mm
Mean distance between the phases	a_m	629.96 mm
Geometric mean distance between phases of the same system $2^{\frac{1}{3}}S_m$	GMD	0.62996 m
Depth of laying of sources	L_c	1000 mm
Depth of laying	L_{cm}	1 m
Outer diameter	D_o	0.148 m
Substitution coefficient u $\frac{2L_{cm}}{D_o}$	u	13.5135
Geometric constant of circle buried $u+\sqrt{u^2-1}$	g_u	26.99

Temperature

Temperature conductor $\theta_a+\Delta\theta_c-(v_4-1)\,\Delta\theta_x+v_4\Delta\theta_p$	θ_c	1: 85 | 2: 78.72 | 3: 78.76 °C
Temperature screen/sheath	θ_s	1: 64.03 | 2: 58.06 | 3: 58.09 °C
Temperature sheath $\theta_c-T_1\left(W_c+\frac{W_d}{2}\right)$	θ_{sh}	1: 64.03 | 2: 58.06 | 3: 58.09 °C
External temperature object	θ_e	1: 59.66 | 2: 54.03 | 3: 54.06 °C

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

Temperature rise

Temperature rise conductor	$\Delta\theta_c$	1: 46.6667 | 2: 44.3447 | 3: 44.3833 K

$$n_{ph}\left(W_c T_{int} + W_d T_d\right) + n_{cc}\left(W_d\left(T_{4i} + T_{4ii} + v_4 T_{4ss}\right) + \left(W_c + W_s + W_{ar} + W_{sp}\right)\left(T_{4i} + T_{4ii} + v_4 T_{4\mu}\right) + W_{duct}\left(\frac{T_{4ii}}{2} + v_4 T_{4\mu}\right)\right)$$

Temperature rise dielectric losses	$\Delta\theta_d$	5.5892 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	$\Delta\theta_p$	1: 18.3334 | 2: 14.3742 | 3: 14.3742 K

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

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

Losses

Ohmic

Conductor losses (phase)	W_c	1: 31.076 | 2: 30.58 | 3: 30.583 W/m

$${I_c}^2 R_c$$

Screen/sheath losses (phase)	W_s	1: 3.636 | 2: 0.942 | 3: 0.997 W/m

$$\lambda_1 W_c$$

Duct losses	W_{duct}	0 W/m
Ohmic losses (phase)	W_I	1: 34.712 | 2: 31.521 | 3: 31.58 W/m

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

Dielectric

Dielectric losses (phase)	W_d	5.946 W/m

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

Total

Total losses (phase)	W_t	1: 40.658 | 2: 37.468 | 3: 37.526 W/m

$$W_I + W_d$$

Total losses (object)	W_{tot}	1: 40.658 | 2: 37.468 | 3: 37.526 W/m

$$n_{ph} W_t$$

Total losses (system)	W_{sys}	115.651 W/m

Thermal resistance

Thermal resistance ambient	$T_{4\mu}$	0.5245 K.m/W

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

Mutual heating coefficient	F_{mh}	1: 17 | 2: 9.22 | 3: 9.22

$$\prod_{k=1}^{q} \frac{d_{pk1}}{d_{pk2}}$$

Cable

Internal thermal resistance for current losses	T_{int}	1: 0.736 | 2: 0.7267 | 3: 0.7269 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	0.41548 K.m/W

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

Other characteristics

Earthing

earthing screen/sheath		Cross-bonding
Length of sections	a_S	1.0 | 1.0 | 1.0 p.u.
Minor ratio of section lengths $\frac{a_{S2}}{a_{S1}}$	p_{cb}	1
Major ratio of section lengths $\frac{a_{S3}}{a_{S1}}$	q_{cb}	1

Loss factor

Loss factor shield (screen/sheath) $\lambda_{11} + \lambda_{12}$	λ_1	1: 0.117 | 2: 0.0308 | 3: 0.0326
Loss factor shield, circulating currents	λ_{11}	0
Loss factor shield, eddy currents $\frac{R_{sh}}{R_c}\left(g_s\lambda_0\left(1+\Delta_1+\Delta_2\right)+\frac{\left(\beta_1 t_{sh}\right)^4}{12{\cdot}10^{12}}\right)$	λ_{12}	1: 0.117 | 2: 0.0308 | 3: 0.0326
Electrical resistance shield/armour	R_e	1: 3.3434e-2 | 2: 3.2750e-2 | 3: 3.2754e-2 Ω/km
Substitution coefficient λ_0 for eddy-currents $6\frac{{m_0}^2}{1+{m_0}^2}\left(\frac{d_e}{2s_c}\right)^2$ $1.5\frac{{m_0}^2}{1+{m_0}^2}\left(\frac{d_e}{2s_c}\right)^2$ $1.5\frac{{m_0}^2}{1+{m_0}^2}\left(\frac{d_e}{2s_c}\right)^2$	λ_0	1: 0.0421 | 2: 0.0108 | 3: 0.0108
Substitution coefficient Δ_1 for eddy-currents $0.86{m_0}^{3.08}\left(\frac{d_e}{2s_c}\right)^{1.4m_0+0.7}$ $\frac{-0.74\left(m_0+2\right)\sqrt{m_0}}{2+\left(m_0-0.3\right)^2}\left(\frac{d_e}{2s_c}\right)^{m_0+1}$ $4.7{m_0}^{0.7}\left(\frac{d_e}{2s_c}\right)^{0.16m_0+2}$	Δ_1	1: 0.0103 | 2: -0.0144 | 3: 0.0495
Substitution coefficient Δ_2 for eddy-currents 0 $0.92{m_0}^{3.7}\left(\frac{d_e}{2s_c}\right)^{m_0+2}$ $21{m_0}^{3.3}\left(\frac{d_e}{2s_c}\right)^{1.47m_0+5.06}$	Δ_2	1: 0 | 2: 0.0015 | 3: 0
Substitution coefficient m_0 for eddy-currents $10^{-7}\frac{\omega}{R_{sh}}$	m_0	1: 0.9397 | 2: 0.9593 | 3: 0.9591 Hz.m/Ω
Substitution coefficient β_1 for eddy-currents $\sqrt{\frac{4\pi\omega}{10^7\rho_{sh}\left(1+\alpha_{sh}\left(\theta_{sh}-20\right)\right)}}$	β_1	1: 108.6552 | 2: 109.7836 | 3: 109.7766

Substitution coefficient g_s for eddy-currents	g_s	1: 1.016643 | 2: 1.016838 | 3: 1.016837
$1+\left(\frac{t_{sh}}{D_{sh}}\right)^{1.74}\left(10^{-3}\beta_1 D_{sh}-1.6\right)$		
Factor F_e eddy-current losses	F_e	1
Loss factor armour	λ_2	0

Drying-out of soil

Characteristic diameter drying zone	D_{dry}	0.148 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_c	1: 1.2597e-5 | 2: 1.2396e-5 | 3: 1.2397e-5 Ω/m
$R_{cDC}\left(1+y_s+y_p\right)$		
Electrical resistance DC conductor	R_{cDC}	1: 1.1299e-5 | 2: 1.1077e-5 | 3: 1.1078e-5 Ω/m
$R_{c20}\left(1+\alpha_c\left(\theta_c-20\right)\right)$		
Skin effect factor conductor	y_s	1: 0.11107 | 2: 0.11516 | 3: 0.11513
$\frac{{x_s}^4}{192+0.8{x_s}^4}$		
Factor for skin effect on conductor	x_s	1: 2.19952 | 2: 2.22147 | 3: 2.22133
$\sqrt{10^{-7}\frac{8\pi f}{R_{cDC}}k_s}$		
Proximity effect factor conductor	y_p	1: 0.00382 | 2: 0.00393 | 3: 0.00393
$\frac{{x_p}^4}{192+0.8{x_p}^4}\left(\frac{d_c}{s_c}\right)^2\left(0.312\left(\frac{d_c}{s_c}\right)^2+\frac{1.18}{\frac{{x_p}^4}{192+0.8{x_p}^4}+0.27}\right)$		
Factor for proximity effect of conductors	x_p	1: 2.02855 | 2: 2.04879 | 3: 2.04866
$\sqrt{10^{-7}\frac{8\pi f}{R_{cDC}}k_p}$		
Electrical resistance sheath	R_{sh}	1: 3.3434e-5 | 2: 3.2750e-5 | 3: 3.2754e-5 Ω/m
$R_{sh}\left(1+\alpha_{sh}\left(\theta_{sh}-20\right)\right)$		
Electrical resistance shield	R_s	1: 3.3434e-5 | 2: 3.2750e-5 | 3: 3.2754e-5 Ω/m
Reduction factor	RF	1: 0.0552 | 2: 0.0541 | 3: 0.0541
$\frac{R_s}{\sqrt{{R_s}^2+{X_s}^2}}$		

Electrical field strength, capacitive load current

Electrical field strength insulation inner/outer	E_i	12.503 | 6.769 kV/mm
$\frac{U_e}{1000}\frac{1}{r_x\ln\left(\frac{r_{osc}}{r_{isc}}\right)}$		
Radius to point x in insulation	r_x	30.1 | 55.6 mm

Line-to-ground voltage $\frac{1000U_o}{\sqrt{3}}$	U_e	230940.11 V
Capacitance insulation $\frac{1}{2\pi\epsilon_0}\frac{10^{-9}}{18}C_b$	C_b	2.535e-10 F/m → 0.2535 μF
Capacitive load current $U_e\omega C_b$	I_C	1.839e-2 A/m → 18.3911 A
Charging capacity $n_{ph}{U_e}^2\omega C_b$	P_C	4247.2488 var/m → 4247.2488 kvar
Capacitive earth short-circuit current $U_e\omega C_E$	I_{Ce}	1.839e-2 A/m

Reactance

Self reactance conductor $\omega\frac{\mu_0}{2\pi}\ln\left(\frac{D_E}{GMR_c}\right)$	X_a	6.668e-4 Ω/m → 0.6668 Ω
Self reactance screen/sheath $\omega\frac{\mu_0}{2\pi}\ln\left(\frac{2s_c}{d_s}\right)$	X_e	1.320e-4 Ω/m → 0.132 Ω
Mutual reactance between conductors flat formation without transposition $\omega\frac{\mu_0}{2\pi}\ln 2$	X_m	4.355e-5 Ω/m

Induced current (approximate)

Induced circulating current shield $\max\left(I_c\sqrt{\frac{\lambda_{11,sb}R_c}{R_s}}\right)I_k$	I_s	1: -22.957+39.762j | 2: 45.913+0.000j | 3: -22.957-39.762j A
Loss factor shield, circulating currents	$\lambda_{11,sb}$	1: 0.0020+0.0000j | 2: 0.0023+0.0000j | 3: 0.0019+0.0000j

Load, Voltage drop

Apparent power generator-side $\sqrt{3}U_oI_c$	S_G	1.088 GVA
Voltage drop $\sqrt{3}\left(R_c\cos\varphi+\omega L_m\sin\varphi\right)$	V_{drop}	0.022 V/(A.km) → 34.3 V = 0.01%
Inductance (mean) $\frac{\mu_0}{2\pi}\ln\left(\frac{GMD}{GMR_c}\right)$	L_m	6.629e-7+0.000e0j H/m → 0.6629 mH

Telegrapher equation

Surge impedance $\sqrt{\frac{Z_1}{Y_1}}$	Z_C	1: 51.1627-1.5459j | 2: 51.1620-1.5212j | 3: 51.1620-1.5214j Ω

Propagation constant $\sqrt{Z_1 Y_1}$	γ_C	1: 1.231e-7+4.074e-6j | 2: 1.211e-7+4.074e-6j | 3: 1.212e-7+4.074e-6j

Impedance valid up to 100 Hz without earth return

Positive sequence admittance $G + j\omega C_b$	Y_1	0.000e0+7.964e-8j S/m → 0.0000+0.0001j S
Positive sequence impedance $R_1 + jX_1$	Z_1	1: 1.260e-5+2.083e-4j | 2: 1.240e-5+2.083e-4j | 3: 1.240e-5+2.083e-4j Ω/m
Positive sequence reactance $\omega \frac{\mu_0}{2\pi} \ln\left(\frac{GMD}{GMR_c}\right)$	X_1	2.083e-4 Ω/m → 0.2083 Ω

Cable datasheet

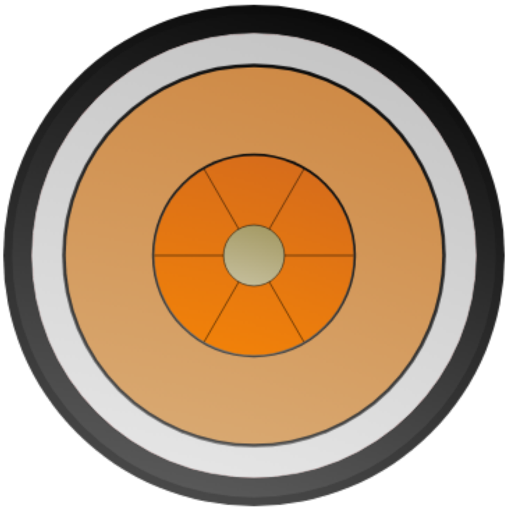
Title CIGRE TB 880 Case 5 400kV LPOF Cable (#16320)

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	400 kV
Base voltage for tests	U_0	230 kV
Highest voltage for equipment	U_m	420 kV
Nominal system frequency	f	50 Hz
Number of conductors cable	n_c	1
Number of phases in a cable	n_{ph}	1



Cable elements

Conductor

Cross-sectional area conductor	A_c	1 x 2461 mm^2
Conductor material	M_c	Copper, round Milliken, compacted
External diameter conductor	d_c	58.8 mm
Internal diameter conductor	d_{ci}	18 mm
Radius conductor $\frac{d_c}{2}$	r_c	29.4 mm
Thickness of hollow conductor $\frac{d_c}{2} - \frac{d_{ci}}{2}$	t_c	20.4 mm

Insulation

Insulation material	M_i	Polypropylene laminated paper (PPLP)
Thickness conductor tape	t_{ct}	0.25 mm
Thickness conductor shield	t_{cs}	0.45 mm
Thickness insulation	t_{ins}	25.5 mm
Thickness insulation screen	t_{is}	0.6 mm

Thickness insulation $t_{ct} + t_{cs} + t_{ins} + t_{is}$	t_i	26.8 mm
Material of conductor tapes		Semiconducting tapes

Screen bedding

Screen bedding material		Water-blocking tapes, semi-conducting
Thickness screen bedding	t_{scb}	0.45 mm

Sheath

Sheath material	M_{sh}	Aluminium
Thickness sheath	t_{sh}	2.9 mm
corrugated		Yes
Depth of corrugation	H_{sh}	5.9 mm
Length corrugated sheath (pitch)	L_{pitch}	28 mm

Armour bedding

Armour bedding material	M_{ab}	PVC/bitumen tapes
Thickness armour bedding	t_{ab}	0.2 mm

Jacket

Jacket material	M_j	Polyethylene (LD/MDPE, ST3)
Thickness jacket	t_j	5.5 mm
Thickness of additional layer over jacket	t_{jj}	2.6 mm

Overall

External diameter object	D_e	148 mm
Absorption coefficient solar radiation	σ_{sun}	0.4
Emissivity cable	ϵ_e	0.9
Reflectivity cable $1 - \epsilon_e$	η_e	0.1
Mass cable $m_{hollow} + m_{metal}$	m_{tot}	34.957 kg/m

Electrical

Conductor

Electrical resistance DC conductor 20°C	R_{c20}	9.0000e-6 Ω/m
Standard DC resistance of conductor	R_{co}	0.009 Ω/km
Coating of wires		plain
Insulation of wires		bare uni-directional wires
Skin effect coefficient	k_s	0.435
Proximity effect coefficient	k_p	0.37
Geometric mean radius conductor $K_{GMR} r_{z1}$	GMR_c	0.0229 m
Factor geometric mean radius	K_{GMR}	0.779
Constant relating to conductor formation	K_{BICC}	0.051
Number of wires conductor	n_{cw}	127
Diameter of wires conductor (average)	d_{cw}	58.8 mm

Insulation

Capacitance, with approximation (CIGRE TB 880) $\frac{1}{2\pi\epsilon_0}\frac{10^{-9}}{18}C_b$	C_b	2.535e-10 F/m
Capacitance (exact) $\frac{2\pi\epsilon_0\epsilon_i}{\ln\left(\frac{r_{osc}}{r_{isc}}\right)}$	C_b	2.538e-10 F/m
Capacitance to earth C_b	C_E	2.535e-10 F/m
Vacuum permittivity	ϵ_0	8.854187817620389e-12 F/m
Radius above the inner semi-conducting layer $\frac{d_c}{2}+t_{ct}+t_{cs}$	r_{isc}	30.1 mm
Radius over capacitive insulation layers $\frac{D_{ins}}{2}$	r_{osc}	55.6 mm
Velocity of propagation $\frac{1}{1000\sqrt{\mu_0\epsilon_0\epsilon_i}}$	v_{prop}	179160.3 km/s

Screen + Sheath

Electrical resistance sheath $10^6\frac{F_{cor,sh}\rho_{sh}}{A_{sh}}$	R_{sh}	2.8395e-5 Ω/m
Length corrugated sheath $\frac{0.25{L_{pitch}}^2+{H_{sh}}^2}{H_{sh}}\left(arcsin\left(\frac{L_{pitch}H_{sh}}{0.25{L_{pitch}}^2+{H_{sh}}^2}\right)+0\right)$	$L_{cor,sh}$	31.2 mm
Effective length per unit pitch length corrugated sheath $\frac{0.25{L_{pitch}}^2+{H_{sh}}^2}{L_{pitch}H_{sh}}\left(arcsin\left(\frac{L_{pitch}H_{sh}}{0.25{L_{pitch}}^2+{H_{sh}}^2}\right)+0\right)$	$F_{cor,sh}$	1.1145
Electrical resistance screen/sheath 20°C	R_{so}	2.839e-2 Ω/km

Radius

Radius conductor	r_{z1}	0.0294 m
Radius shield (inner)	r_{z2}	0.0552 m
Radius shield (outer)	r_{z3}	0.0552 m
Radius sheath (inner)	$r_{z2,sh}$	0.0552 m
Radius sheath (outer)	$r_{z3,sh}$	0.06715 m
Radius outersheath	r_{z6}	0.074 m

Material parameters

Conductor

Electrical resistivity conductor material	ρ_c	1.724e-8 Ω.m
Temperature coefficient conductor material	α_c	3.93e-3 1/K
Reciprocal of temperature coefficient conductor material	β_c	2.345e2 K
Volumetric heat capacity conductor material	σ_c	3.45e6 J/(K.m^3)
Thermal conductivity conductor material	k_c	384.62 W/(m.K)
Density conductor material	ζ_c	8.94 g/cm^3

Insulation

Relative permittivity insulation material	ϵ_i	2.8
Loss factor insulation material	$\tan\delta_i$	0.0014
Thermal resistivity insulation material	ρ_i	5.42 K.m/W
Volumetric heat capacity insulation material	σ_i	2.00e6 J/(K.m^3)
Density insulation material	ζ_i	0.9 g/cm^3
Max. temperature conductor	θ_{cmax}	70 °C
Max. temperature conductor, emergency overload	θ_{cmaxeo}	80 °C
Max. temperature conductor, short-circuit	θ_{cmaxsc}	130 °C
Conductor tape		
Thermal resistivity conductor tape	ρ_{ct}	6 K.m/W
Density tape material	ζ_{tape}	0.34 g/cm^3
Conductor shield		
Thermal resistivity conductor shield	ρ_{cs}	5 K.m/W
Insulation screen		
Thermal resistivity insulation screen	ρ_{is}	5 K.m/W

Screen bedding

Thermal resistivity screen bedding	ρ_{scb}	6 K.m/W
Volumetric heat capacity screen bedding	σ_{scb}	2.00e6 J/(K.m^3)
Density tape material	ζ_{tape}	0.34 g/cm^3

Sheath

Specific electrical resistivity sheath material	ρ_{sh}	2.840e-8 Ω.m
Temperature coefficient sheath material	α_{sh}	4.03e-3 1/K
Reciprocal of temperature coefficient sheath material	β_{sh}	2.281e2 K
Volumetric heat capacity sheath material	σ_{sh}	2.50e6 J/(K.m^3)
Thermal conductivity sheath material	k_{sh}	208.3 W/(m.K)
Density sheath material	ζ_{sh}	2.712 g/cm^3

Armour bedding

Thermal resistivity armour bedding	ρ_{ab}	6 K.m/W
Volumetric heat capacity armour bedding	σ_{ab}	2.00e6 J/(K.m^3)
Density armour bedding material	ζ_{ab}	1.2 g/cm^3

Jacket

Thermal resistivity jacket material	ρ_j	3.5 K.m/W
Thermal resistivity additional layer	ρ_{jj}	2.5 K.m/W
Volumetric heat capacity jacket material	σ_j	2.40e6 J/(K.m^3)
Electrical conductivity jacket material	κ_j	1.00e-16 S/m
Density jacket material	ζ_j	0.93 g/cm^3

Thermal resistance

Internal thermal resistances for rating calculation

Thermal resistance conductor—sheath $T_{ct} + T_{cs} + T_{ins} + T_{is} + T_{scb} + T_{scs} + T_{dsh}$	T_1	0.6158 K.m/W
Thermal resistance armour bedding	T_2	0 K.m/W
Thermal resistance jacket $T_{ab} + T_j + T_{jj}$	T_3	0.1076 K.m/W

Thickness conductor—sheath | t_1 | 30.32 mm
$t_i + t_{scb} + t_{scs} + \frac{H_{sh} + \Delta H}{2}$

Thickness sheath—armour | t_2 | 3.28 mm
$\frac{H_{sh} + \Delta H}{2} + t_{ab}$

Thickness armour—surface | t_3 | 8.1 mm
$t_j + t_{jj}$

Cable elements

Thermal resistance, transient | T_{tot} | 0.7234 K.m/W
$T_1 + T_2 + T_3$

Thermal resistance insulation | T_i | 0.55775 K.m/W
$T_{ct} + T_{cs} + T_{ins} + T_{is}$

Thermal resistance conductor tape | T_{ct} | 0.00809 K.m/W
$\frac{\rho_{ct}}{2\pi} \ln\left(\frac{d_c + 2t_{ct}}{d_c}\right)$

Thermal resistance conductor shield | T_{cs} | 0.01199 K.m/W
$\frac{\rho_{cs}}{2\pi} \ln\left(\frac{D_{cs}}{D_{cs} - 2t_{cs}}\right)$

Thermal resistance insulation | T_{ins} | 0.52914 K.m/W
$\frac{\rho_i}{2\pi} \ln\left(\frac{D_{ins}}{D_{ins} - 2t_{ins}}\right)$

Thermal resistance insulation screen | T_{is} | 0.00854 K.m/W
$\frac{\rho_{is}}{2\pi} \ln\left(\frac{D_{ins} + 2t_{is}}{D_{ins}}\right)$

Thermal resistance screen bedding | T_{scb} | 0.00762 K.m/W
$\frac{\rho_{scb}}{2\pi} \ln\left(\frac{D_{scb}}{D_i}\right)$

Thermal resistance corrugation filling | T_{dsh} | 0.05048 K.m/W
$\frac{\rho_{scs}}{2\pi} \ln\left(1 + \frac{2\frac{H_{sh}+\Delta H}{2}}{D_{scs}}\right)$

Thermal resistance armour bedding | T_{ab} | 0.04868 K.m/W
$\frac{\rho_{ab}}{2\pi} \ln\left(\frac{D_{ab}}{D_{shj} - (H_{sh} + \Delta H)}\right)$

Thermal resistance jacket | T_j | 0.04465 K.m/W
$\frac{\rho_j}{2\pi} \ln\left(\frac{D_j - 2t_{jj}}{D_j - 2(t_j + t_{jj})}\right)$

Thermal resistance additional layer | T_{jj} | 0.01423 K.m/W
$\frac{\rho_{jj}}{2\pi} \ln\left(\frac{D_j}{D_j - 2t_{jj}}\right)$

Dimensions

Diameter

External diameter conductor | d_c | 58.8 mm

Diameter over conductor shield | D_{cs} | 60.2 mm
$d_c + 2(t_{ct} + t_{cs})$

Diameter over insulation $d_c + 2(t_{ct} + t_{cs} + t_{ins})$	D_{ins}	111.2 mm
Diameter over insulation incl. insulation screen $d_c + 2(t_{ct} + t_{cs} + t_{ins} + t_{is})$	D_i	112.4 mm
Diameter over insulation screen $d_c + 2t_i$	D_{is}	112.4 mm
Diameter over screen bedding $d_c + t_{i1} + 2t_{scb}$	D_{scb}	113.3 mm
Equivalent diameter of screen and sheath	d_s	122.35 mm
Mean diameter sheath $D_{shb} + t_{sh} + H_{sh} + \Delta H$	d_{sh}	122.35 mm
Diameter over sheath $D_{shb} + 2(t_{sh} + H_{sh} + \Delta H)$	D_{sh}	131.4 mm
Diameter over sheath jacket	D_{shj}	131.4 mm
Diameter over armour bedding $D_{sh} + 2t_{ab}$	D_{ab}	131.8 mm
Diameter over jacket $D_{ar} + 2(t_j + t_{jj})$	D_j	148 mm

Area

Cross-sectional area conductor	A_c	2461 mm^2
cross-sectional area (calculated) $\frac{\pi}{4}\left({d_c}^2 - {d_{ci}}^2\right)$	A_c	2461 mm^2
Cross-sectional area insulation $\frac{\pi}{4}\left({D_{is}}^2 - {d_c}^2\right)$	A_i	7207.1 mm^2
Cross-sectional area screen bedding $\pi t_{scb}(D_{scb} - t_{scb})$	A_{scb}	159.5 mm^2
Cross-sectional area sheath $d_{sh} t_{sh} \pi$	A_{sh}	1114.68 mm^2
Cross-sectional area armour bedding $\frac{\pi}{4}\left({D_{ab}}^2 - (D_{ab} - t_{ab})^2\right)$	A_{ab}	41.4 mm^2
Cross-sectional area jacket $\frac{\pi}{4}\left({D_j}^2 - (D_j - 2(t_j + t_{jj}))^2\right)$	A_j	3560 mm^2