ELEK Cable HV™ Software Tutorial

Cable Modelling

05/12/2023

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Introduction

ELEK Cable HV™ Software can perform custom current rating calculations for a wide range of modern extruded power cables of varying constructions can be modelled including cables for DC and AC applications, single phase or three phases, multi-core of single core cables, sheathed and armoured cables. The built-in cable editor provides considerable flexibility in specifying the parameters for the various components of which a cable may be comprised.

To model a cable and determine its current rating requires knowledge about its physical construction. This information is obtained from cable manufacturer datasheets.

This tutorial will explain how to model several types of cables using Cable HV™ Software:

- Cable Model 1 - Single core 33 kV, XLPE insulated cable
- Cable Model 2 - Single core 1.5 kV DC, XLPO insulated cable for solar applications
- Cable Model 3 - Multi-core 400 kV, single-armour submarine fibre optic composite power cable

New methods to calculate the cable losses in three-core armoured cables was introduced with **CIGRE Technical Brochure 908** (2023). This technical brochure improves the IEC 60287-1-1 loss factor empirical equations, which are based on early research performed on cables with small conductor cross sections and common sheath. In general, for three-core armoured cables the current rating is increased by approximately 10 %.

The model is validated by calculating the current ratings in various standard configurations and comparing with results in the manufacturer datasheet (where provided).

Cable Model 1: Single core 33 kV, XLPE insulated cable

The full description of this cable is 19/33 kV, single-core, 95 mm^2 Cu, XLPE insulated cable.

Cable manufacturer datasheet

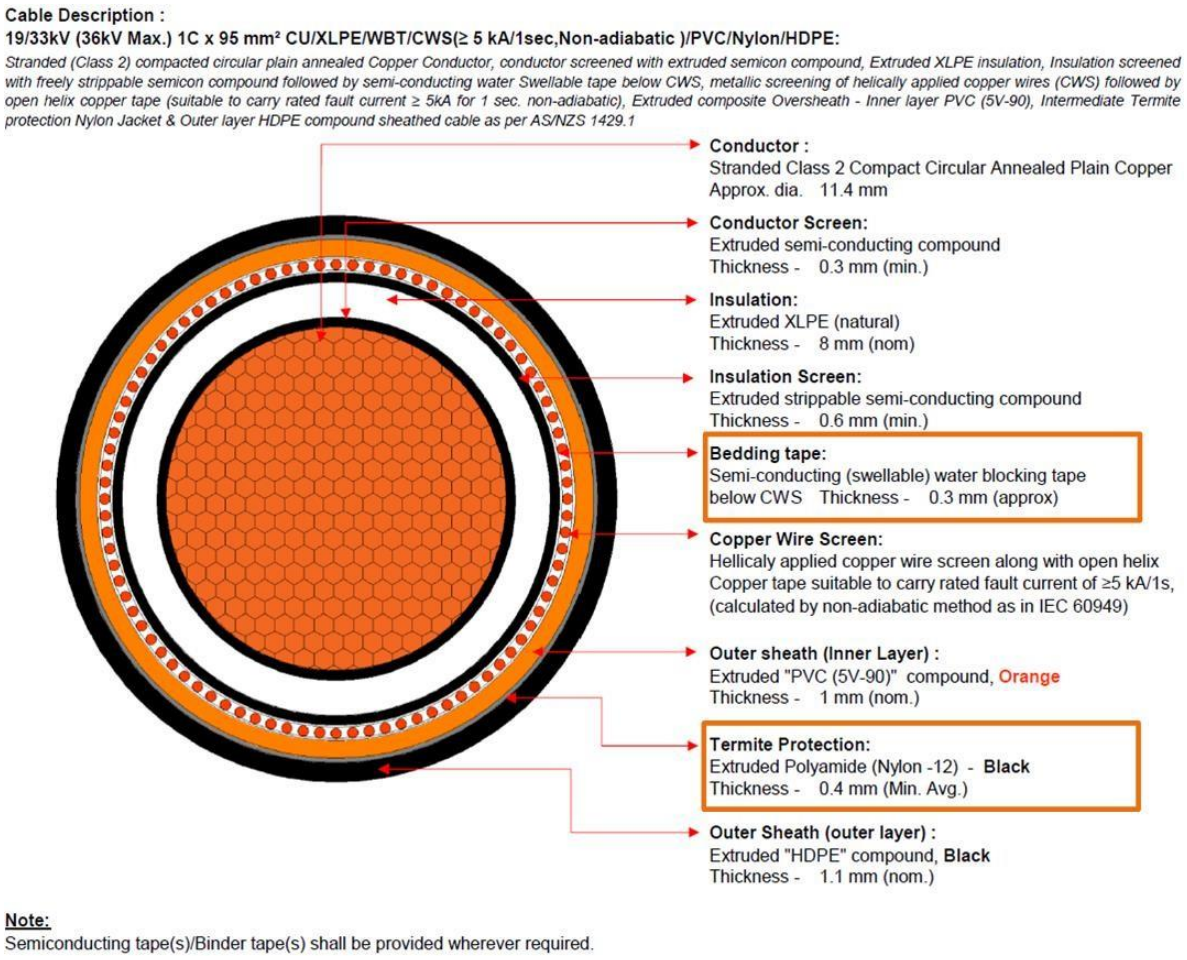


Figure 1 – Manufacturer datasheet for Cable Model 1

Based on the parameters shown in the datasheet, the cable can be modelled in Cable HV™ Software.

Modelling the cable

Step 1 – Select the cable layers

On the left-hand side of the Cable Editor window select the cable layers which are present for the Cable Model. In the case of Cable Model 1 the following cable layers are present:

1. **Conductor**
2. **Conductor shield** – For modelling the conductor screen in the datasheet.
3. **Insulation**
4. **Insulation screen**
5. **Bedding tape** – Custom layer added for Bedding (water-blocking) tape.
6. **Concentric neutral** - For modeling the copper wire screen in the datasheet.
7. **Outer sheath** - Custom layer added for outer sheath.
8. **Termite protection** - Custom layer added for termite protection layer.
9. **Jacket/Serving**

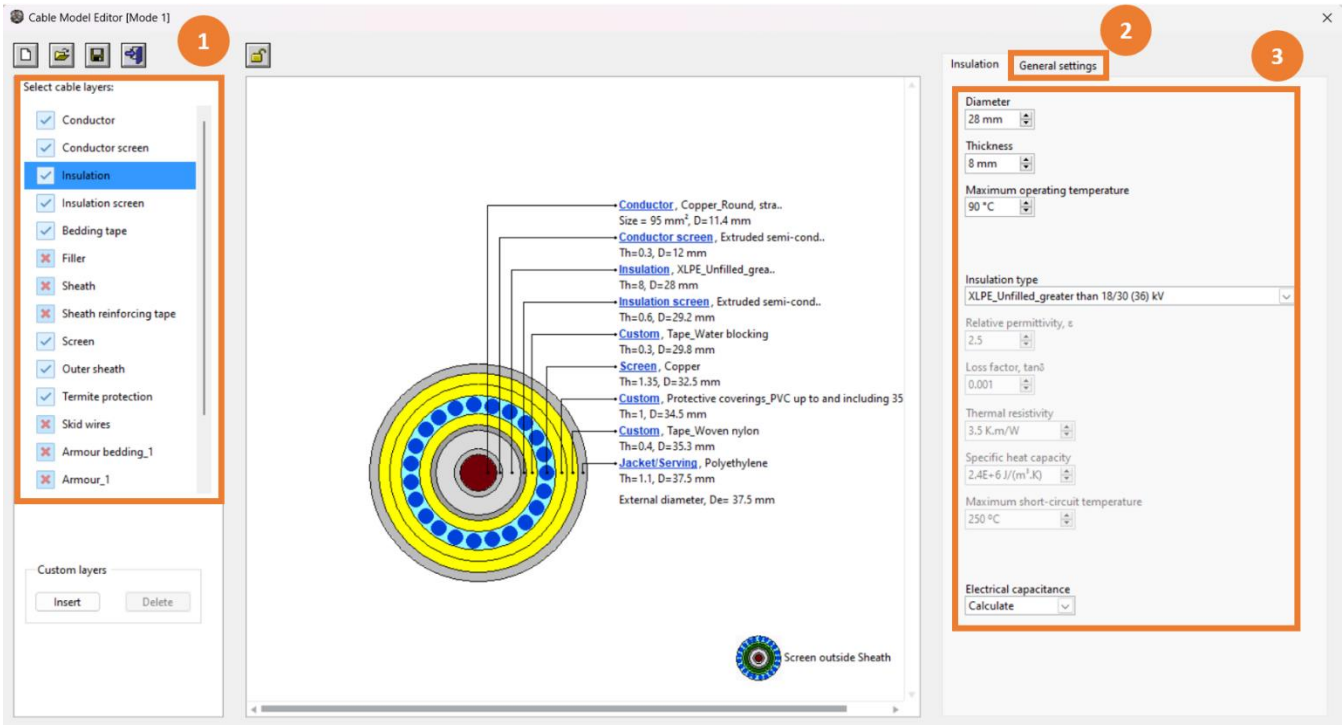


Figure 2 – Three steps of modelling the cable

Step 2 – Input the general settings

Input general settings – Description, Cable type, Phases, Cores, Voltage and Frequency – for the Cable Model.

Table 1 – General & installation settings of Cable Model 1

Setting	Value
Cable type	Extruded
Cores	Single-core
Phases	Three-phase
Voltage (phase to phase)	33 kV
Frequency	50 Hz
Installation Settings	
Calculation based on	Conductor Temperature
Maximum conductor operating temperature	Same as cable insulation
Load factor	1
Arrangement	Solidly bonded

Step 3 - Input the layer parameters

The input parameters from the datasheet are summarized in Table 2 and these values are entered into the Cable Editor by selecting the appropriate layer from the preview.

Table 2 – Parameters of Cable Model 1

Layer	Parameter	Value
Conductor	Size	95 mm^2
	Class	2
	Material	Copper, plain wires
	Conductor type	Copper_Round, stranded (Extruded/Mineral insulation)
	Nominal diameter	11.4 mm
Conductor shield	Material	Extruded semi-conductor
	Thickness	0.3 mm

Layer	Parameter	Value
Insulation	Material	XLPE_Unfilled_greater than 18/30 (36) kV
	Thickness	8 mm
	Maximum operating temperature	90 ℃
Insulation screen	Material	Extruded semi-conductor
	Thickness	0.6 mm
Bedding tape	Material	Tape_Water blocking
	Thickness	0.3 mm
Concentric neutral[1]	Material	Copper
	Construction	Round wires
	Thickness	1.35 mm
	Number of wires	48
Outer sheath	Material	Protective coverings_PVC up to and including 35 kV cables
	Thickness	1 mm
Termite protection	Material	Tape_Woven nylon
	Thickness	0.4 mm
Jacket/Serving	Material	Polyethylene
	Thickness	1.1 mm
Overall Diameter of all cables: 37.5 mm		

Notes:

1. According to the datasheet, lay length shall not exceed 10 times the pitch circle diameter of the wire screen. Here, pitch length of Screen is 31.15 mm. Therefore, Lay Length = 312 mm. The thickness of the Concentric neutral is not given in the datasheet. We assumed a thickness of 1.35 mm

2. **Validation of the current rating**

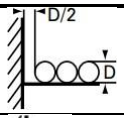
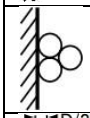
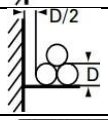
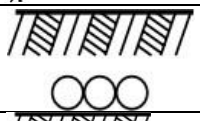
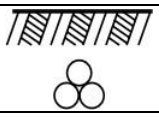
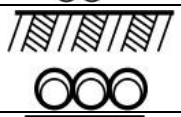
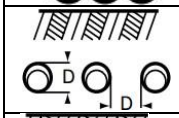
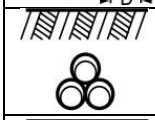
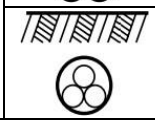
Cable Model 1 was validated by comparing the calculated current ratings from Cable HV™ Software with those for standard configurations from the manufacturer datasheet.

According to the manufacturer datasheet the installation conditions are:

- Ambient air temperature: 40 °C
- Ambient soil temperature: 25 °C
- Soil thermal resistivity: 1.2 K.m/W
- Depth of lying: 0.8

The Cable Model 1 current rating comparison is shown in Table 3

Table 3 – Validation of Cable Model 1

Installation		Current rating (A)		Variation (%)
		Datasheet	Cable HV™	
In Air		333	336.9	1.16
		315	314.02	0.31
		332	331.31	0.21
Buried Direct[1]		297	301.39	1.46
		292	301.11	3.03
		297	296.97	0.01
Buried in Ducts[2]		265	263.14	0.70
		258	268.72	3.99
		267	269.39	0.89
		258	251.72	2.43

As the current ratings between Cable HV™ and the manufacturer datasheet are close, it can be concluded that the cable has been modelled correctly.

Note:

1. From the datasheet, **D** is the diameter of the cable and the distance between two cables is **D.** Since separation is calculated from core to core for cables, the separation here will be (0.5D + 0.5D) + D = 2D. In the calculator, we put separation as 2.
2. Duct diameter is not provided in the datasheet.
   For cables combined in a single duct, duct outside diameter = 100 mm and duct inside diameter = 90 mm is assumed.
   For cables in separate ducts, duct outside diameter = 65 mm and duct inside diameter = 55 mm is assumed.
   For the duct settings, **PVC** is used as duct material and for fill type, **Air** is selected.

Cable Model 2: Single core 1.5 kV DC, XLPO insulated cable

The full description of this cable is 1.5 kV DC, single-core, 400 mm^2 Cu, XLPO insulated cable.

Cable manufacturer datasheet

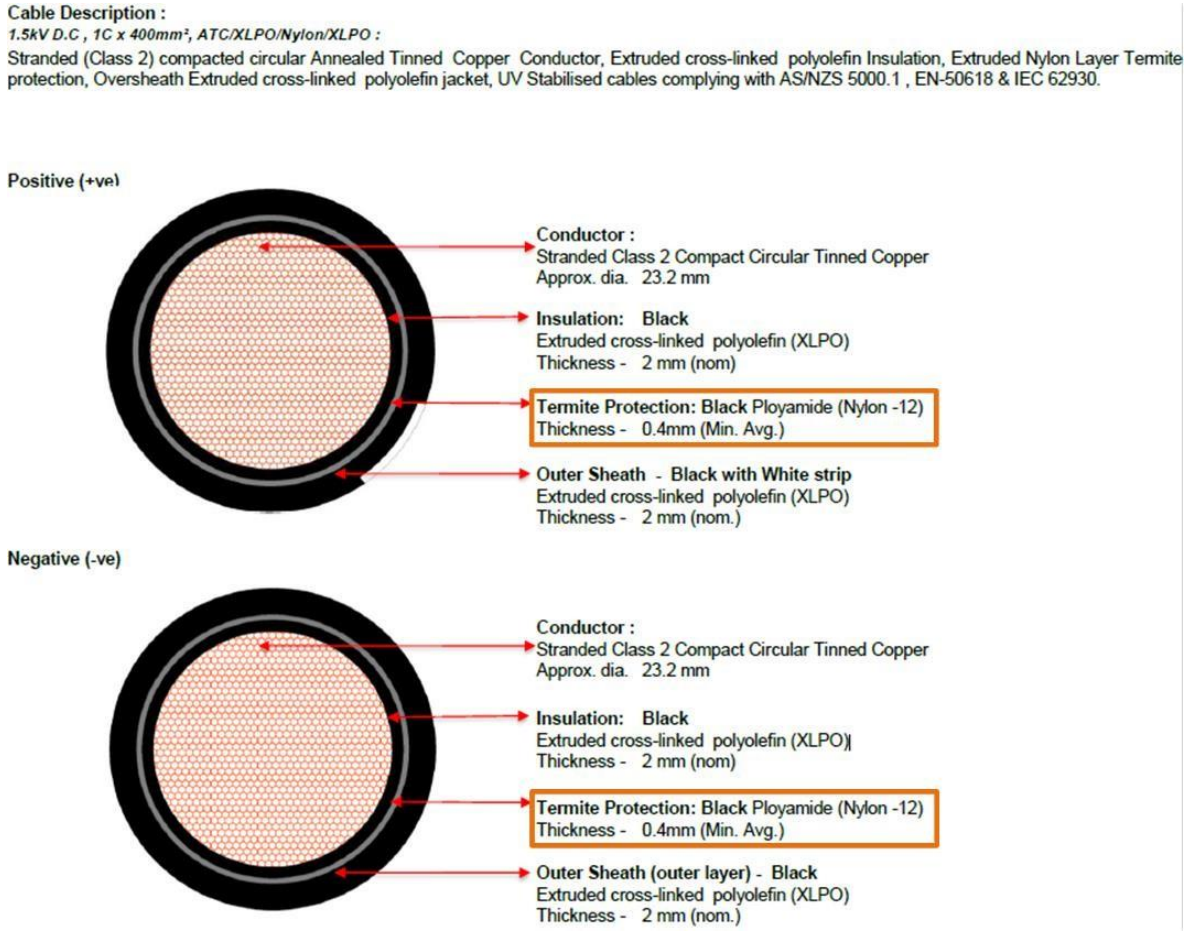


Figure 3 – Manufacturer datasheet of 1.5 kV DC single-core Cu cable

Based on the parameters shown in the datasheet, the cable can be modelled in Cable HV™.

Modelling the cable

Step 1 – Select the cable layers

On the left-hand side of the Cable Editor window select the cable layers which are present for the Cable Model. In the case of Cable Model 2 the following cable layers are present:

1. **Conductor**
2. **Insulation**
3. **Termite Protection** - Custom layer added for termite protection layer
4. **Jacket/Serving**

Step 2 – Input the general settings

Input general settings – Cable type, Phases, Cores, Voltage – for the Cable Model.

Table 4 – General Settings of Cable Model 2

Setting	Value
Cable type	Extruded
Cores	Single-core
Phases	DC
Voltage (phase to phase)	1.5 kV
Installation Settings	
Calculation based on	Conductor Temperature
Maximum conductor operating temperature	Same as cable insulation
Load factor	1
Arrangement	Solidly bonded

Step 3 - Input the layer parameters

The input parameters from the datasheet are summarized in Table 5 and these values are entered into the Cable Editor by selecting the appropriate layer from the preview.

Table 5 – Parameters of Cable Model 2

Layer	Parameter	Value
Conductor	Size	400 mm^2
	Class	2
	Material	Copper, metal-coated wires
	Conductor type	Copper_Round, stranded (Fluid/paper/PPL insulation)
	Nominal Diameter	23.2 mm
Insulation	Material	XLPE_Unfilled_greater than 18/30 (36) kV
	Thickness	2 mm
	Maximum operating temperature	120 ℃
Termite Protection	Material	Tape_Woven nylon
	Thickness	0.4 mm
Jacket/Serving	Material	Polyethylene
	Thickness	2 mm
Overall diameter of the cable: 32 mm		

Figure 4 shows the combined layer of the Cable Model in Cable HV™

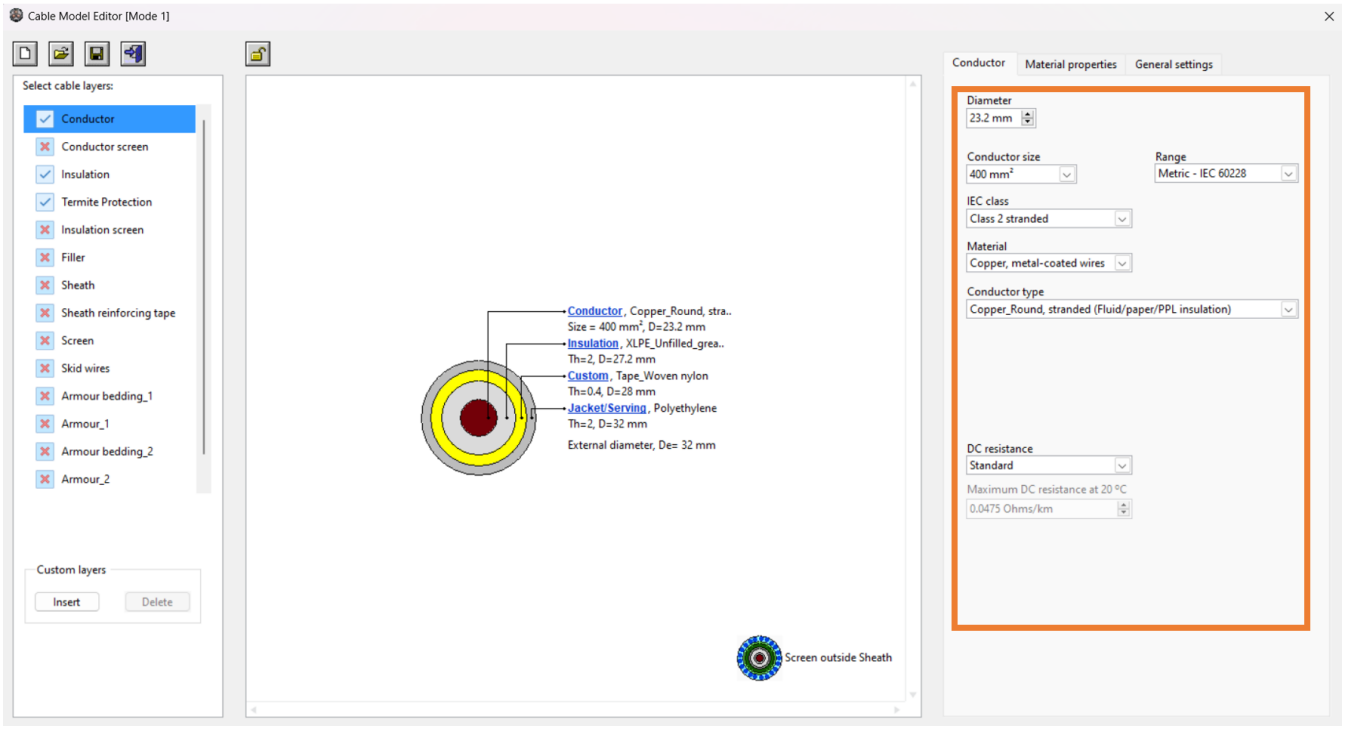


Figure 4 –Conductor layer of the Cable Model 2

Validation of the current rating

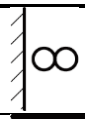
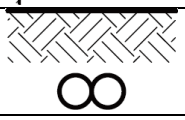
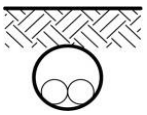
Cable Model 2 was validated by comparing the calculated current ratings from Cable HV™ Software with those for standard configurations from the manufacturer datasheet.

According to the manufacturer datasheet the installation conditions are:

- Ambient air temperature: 40 °C
- Ambient soil temperature: 25 °C
- Soil thermal resistivity: 1.2 K.m/W
- Depth of laying: 0.5 m

The current rating comparison is shown in Table 6.

Table 6 – Validation of Cable Model 2

Installation		Current rating (A)		Variation (%)
		Datasheet	Cable HV™	
In Air		1048	1062.83	1.40
Buried Direct		928	777.13	16.26
Buried in Duct[1]		768	779.64	1.49

As the current ratings are close, it can be concluded that the assumption of modelling termite protection is reasonable.

Note:

1. Duct diameter is not provided in the datasheet. For cables in separate ducts, duct outside diameter = 75 mm and duct inside diameter = 72 mm is assumed.
   For the duct settings, **PVC** is used as duct material and for fill type, **Air** is selected.

Cable Model 3: Multi-core 400 kV single-armour submarine fibre optic composite power cable

The full description of this cable is 400kV, 3 core, 1600 mm^2 single-armour submarine fibre optic composite power cable.

Cable manufacturer datasheet

No.	Description		Nom. Thickness (mm)	Approx. O.D (mm)
1	Copper conductor (round stranded compact)		Cross section: 1600mm^2	47.6
2	Conductor screen (semi-conducting tape +extruded layer)		0.27+2.0	52.7
3	XLPE insulation		27.0	106.7
4	Insulation screen		1.2	109.1
5	Sheath bedding (semi-conducting tape)		2×1.0	113.1
6	Metallic sheath (lead alloy)		3.0	119.1
7	Lead alloy sheath corrosion protection (semi-conducting PE)		3.0	125.1
8	Filler (shaped filler)		/	/
9	FOC unit	unit no.	1	/
		count /type	48G.652D	/
		stainless steel tube	0.25	3.8
		Semi-conducting PE outer sheath	3.5	15.9
	Assembly		/	269.1
10	Binder (polymeric tape)		0.1	269.3
11	Armour bedding(PP yarns)		Φ2.0	271.9
12	Galvanized steel wire armour, Grade34		(137±4)×Φ6.0	283.9
13	Armour serving (two layers of PP yarns)		2×Φ3.0	295.9
	Cable weight (approx.) in air in water		 155.1 kg/m 98.2 kg/m	

Figure 5 – Manufacturer datasheet of 400 kV three-core submarine cable

Based on the parameters shown in the datasheet, the cable can be modelled in Cable HV™.

Modelling the cable

Step 1 – Select the cable layers

On the left-hand side of the Cable Editor window select the cable layers which are present for the Cable Model. In the case of Cable Model 3 the following cable layers are present:

1. **Conductor**
2. **Conductor shield** - For modelling the conductor screen in the datasheet.
3. **Insulation**
4. **Insulation screen**
5. **Semi-conducting tape** – Custom layer for semi conducting tape.
6. **Sheath**
7. **Outer sheath** – Custom layer for outer sheath.
8. **Filler**
9. **Binding tape** - Custom layer for binding tape.
10. **Bedding** - Custom layer for bedding.
11. **Armour**
12. **Jacket/Serving**

Note:

FOC unit is ignored for this cable model.

Step 2 – Input the general settings

Input general settings – Description, Cable type, Phases, Cores, Voltage and Frequency – for the Cable Model.

Table 7 – General Settings of Cable Model 3

Setting	Value
Cable type	Submarine
Cores	Three-core
Phases	Three-phase

Setting	Value
Voltage (phase to phase)	400 kV
Frequency	50 Hz
Lay length	Calculate
Core lay length	3500 mm
Installation Settings	
Calculation based on	Conductor Temperature
Maximum conductor operating temperature	Same as cable insulation
Load factor	Varied according to experiment
Arrangement	Solidly bonded

Step 3 - Input the layer parameters

The input parameters from the datasheet are summarized in Table 8 and these values are entered into the Cable Editor by selecting the appropriate layer from the preview

Table 8 – Parameters of Cable Model 3

Cable Layer	Parameter	Value
Conductor[1]	Size	1600 mm^2
	Class	Class 2
	Material	Copper, plain wires
	Conductor Type	Copper_Round, stranded (Fluid/paper/insulation)
	Nominal diameter	47.6 mm
Conductor screen	Diameter	52.7 mm
	Material	Extruded semi-conductors
Insulation	Material	XLPE_Unfilled_greater than 18/30 (36) kV
	Diameter	106.7 mm
	Maximum operating temperature	90 ^{0}C
Insulation screen	Material	Extruded semi-conductor
	Diameter	109.1 mm
Semi-conducting tape	Material	Tape_Water blocking
	Diameter	113.1 mm
Sheath	Material	Lead
	Diameter	119.1 mm

Cable Layer	Parameter	Value
Outer sheath	Material	Insulation_PE (HD and LD)
	Diameter	125.1 mm
Filler	Material	Unknown – TR same as
	Diameter	269.553 mm
Binding tape[2]	Material	Tape_Water blocking
	Diameter	269.555 mm
Bedding[3]	Material	Polypropylene yarn
	Diameter	271.9 mm
Armour_1[4]	Material	Steel
	Construction	Wires touching
	Diameter	283.9 mm
	No. of wires	137
Jacket/Serving	Material	Polypropylene yarn
	Diameter	295.9 mm
Overall diameter of the cable: 295.9 mm		

Note:

1. For the conductor, skin effect coefficient (ks) of **0.7** is specified.
2. Since FOC unit is ignored, the thickness of the binding is set to minimum at 0.001 mm.
3. The thickness of the bedding is assumed to be 1.172 mm to match the diameter with the datasheet.
4. Armour length of lay is not specified, hence length of lay is specified to 2740 mm and Lay direction is Contralay.

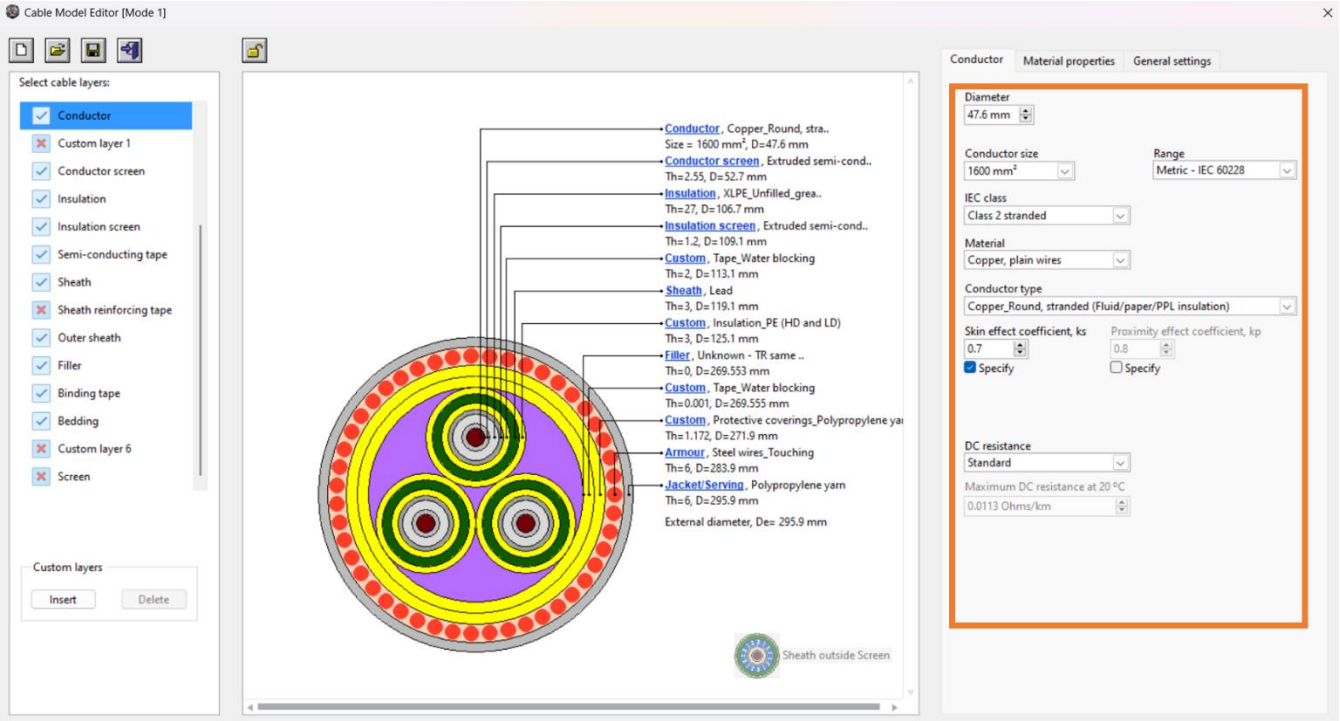


Figure 6 – Conductor layer of cable model 3

Validation of the current rating

Cable Model 3 was validated by comparing the calculated current ratings from Cable HV™ Software with those for standard configurations from the manufacturer datasheet. According to the manufacturer datasheet the installation conditions are:

- Ambient soil temperature: 26 °C
- Soil thermal resistivity: 0.8 K.m/W
- Depth of laying: 3 m

The current rating comparison is shown in Table 9.

Table 9 – Validation of Cable Model 3

Installation		Current rating (A)			Variation-IEC (%)	Variation-TB 908 (%)
Condition	Load Factor	Datasheet	Cable HV-IEC	Cable HV-TB 908		
	0.3	1394	1394.25	1444.59	0.01	3.50

Buried	0.4	1272	1263.37	1331.19	0.68	4.45
	0.5	1163	1147.94	1226.83	1.30	5.20
	0.6	1067	1047.48	1132.66	1.85	5.80

As the current ratings with the IEC method are close, it can be concluded that the assumption of modelling water blocking tape and outermost layer is reasonable.

Note:

By default, the calculator performs the calculations by TB 908 method. In order to change the calculation to IEC method, click on the tools dropdown and go to settings. From Cable HV Settings, go to the “Three-core Cable Armour Losses” tab, uncheck the TB 908 check box. See figure 7 for reference.

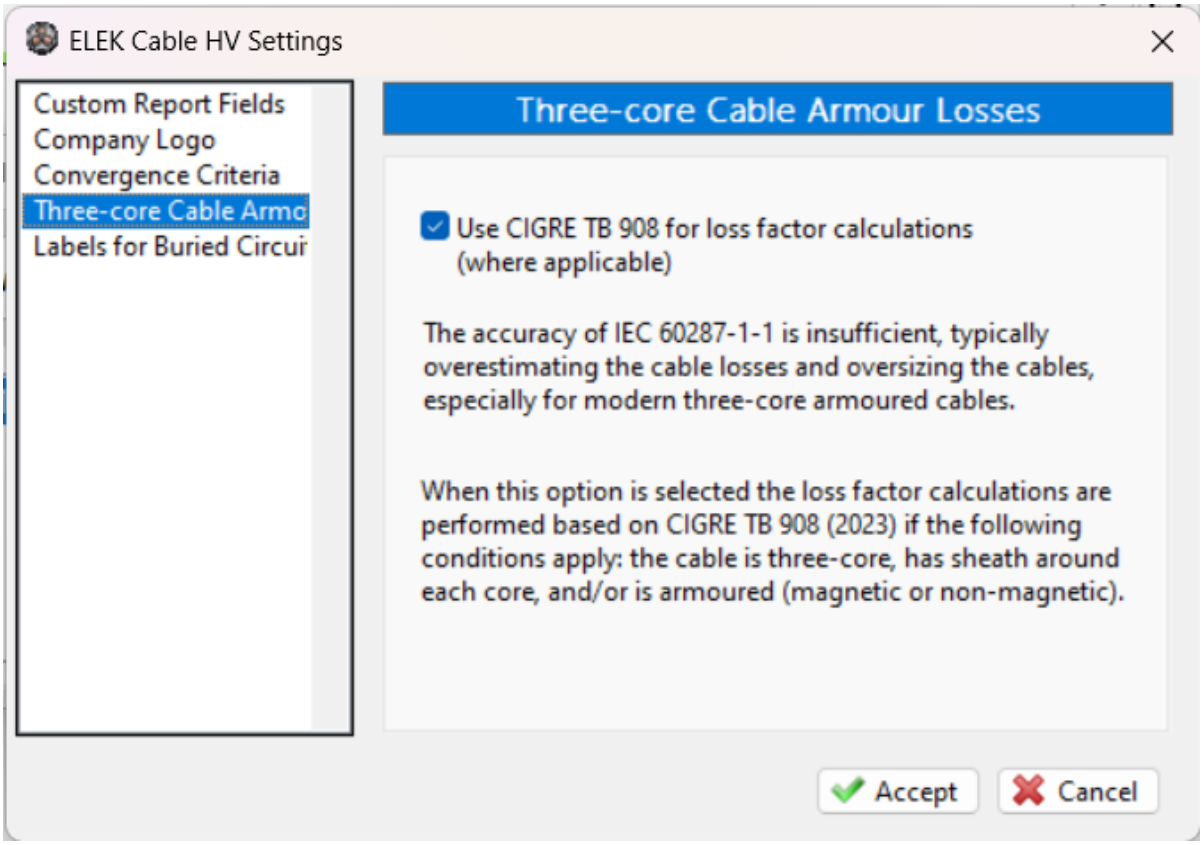


Figure 7 – Cable HV calculation settings tab

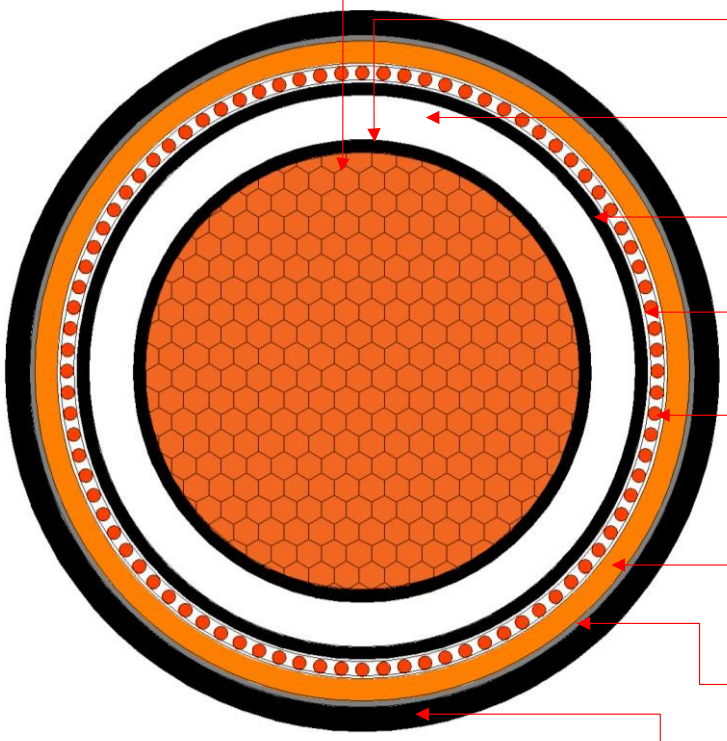
Appendix A: Cable Model 1 manufacturer datasheet

DIMENSIONAL DRAWING
CASE : C1880

Cable Description :

19/33kV (36kV Max.) 1C x 95 mm² CU/XLPE/WBT/CWS(≥ 5 kA/1sec,Non-adiabatic)/PVC/Nylon/HDPE:

Stranded (Class 2) compacted circular plain annealed Copper Conductor, conductor screened with extruded semicon compound, Extruded XLPE insulation, Insulation screened with freely strippable semicon compound followed by semi-conducting water Swellable tape below CWS, metallic screening of helically applied copper wires (CWS) followed by open helix copper tape (suitable to carry rated fault current ≥ 5kA for 1 sec. non-adiabatic), Extruded composite Oversheath - Inner layer PVC (5V-90), Intermediate Termite protection Nylon Jacket & Outer layer HDPE compound sheathed cable as per AS/NZS 1429.1



Conductor :
Stranded Class 2 Compact Circular Annealed Plain Copper
Approx. dia. 11.4 mm

Conductor Screen:
Extruded semi-conducting compound
Thickness - 0.3 mm (min.)

Insulation:
Extruded XLPE (natural)
Thickness - 8 mm (nom)

Insulation Screen:
Extruded strippable semi-conducting compound
Thickness - 0.6 mm (min.)

Bedding tape:
Semi-conducting (swellable) water blocking tape
below CWS Thickness - 0.3 mm (approx)

Copper Wire Screen:
Hellicaly applied copper wire screen along with open helix
Copper tape suitable to carry rated fault current of ≥5 kA/1s,
(calculated by non-adiabatic method as in IEC 60949)

Outer sheath (Inner Layer) :
Extruded "PVC (5V-90)" compound, **Orange**
Thickness - 1 mm (nom.)

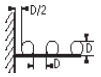
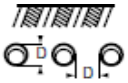
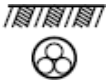
Termite Protection:
Extruded Polyamide (Nylon -12) - **Black**
Thickness - 0.4 mm (Min. Avg.)

Outer Sheath (outer layer) :
Extruded "HDPE" compound, **Black**
Thickness - 1.1 mm (nom.)

Note:
Semiconducting tape(s)/Binder tape(s) shall be provided wherever required.

Cable Technical Data:		Conductor Electrical Data:
1) Approx. overall cable diameter :	**39.9 ± 3 mm**	1) Conductor DC resistance at 20 °C Ω/Km
2) Approx. cable weight :	**2330 kg/km**	**0.1930** (max)
3) Maximum pulling force (N) when pulled by pulling eye		2) Conductor AC resistance at 90 °C Ω/Km
a) Copper Conductor cable	**6650 N**	**0.247** (max)
		3) Conductor short circuit rating
4) Cable minimum bending radius (mm)		**13.6** kA for 1 sec.
a) During Installation =	**1070**	4) Metal Screen earth fault rating (if applicable)
b) Installed =	**640**	**≥ 5 kA / 1sec, Non-adiabatic**

TECHNICAL DATA SHEET

(A)	**CABLE CURRENT RATINGS**		**1C x 95mm2, CU, 19/33kV (36kV Max.)**
	Max. conductor temperature	90 deg.C	
	Ambient air temperature	40 deg.C	
	Ambient soil temperature	25 deg.C	
	Soil thermal resistivity	1.2 K.m/W	
	Depth of laying	0.8m	
	(a) In Air		
	(i) 	Amps	(i) 333
	(ii) 	Amps	(ii) 369
	(iii) 	Amps	(iii) 315
	(iv) 	Amps	(iv) 332
	(b) In Ground		
	(i) 	Amps	(i) 297
	(ii) 	Amps	(ii) 292
	(iii) 	Amps	(iii) 297
	(c) In ducts		
	(i) 		(i) 265
	(ii) 		(ii) 258
	(iii) 		(iii) 267
	(iv) 		(iv) 258
(B)	Conductor to screen capacitance (approx.)	µF/km	0.165
(C)	Inductive reactance at 50Hz (approx.)	Ω/km	0.1430
(D)	Positive Sequence Impedance	Ω/km	0.247 + j 0.1381
(E)	Zero Sequence Impedance	Ω/km	0.7143 + j 0.0578
(F)	Short circuit current rating of conductor	KA/sec	13.6
(G)	**CWS (Metallic Screen)**		
	Material & Thickness		Metallic Copper Wire Screen followed by Open helix copper tape. Minimum diameter of each wire shall be 0.6mm and gap between adjacent wires shall not exceed 4mm. Lay length shall not exceed 10 times the pitch circle diameter of the wire screen
	Earth fault current carrying capacity		≥5 kA/1s calculated by non-adiabatic method set out in IEC 60949
	CABLE DATA		
(A)	EMBOSSING / PRINTING ON CABLES		KEI - CABLE GRID ELECTRIC CABLE, 19/33kV (36kV Max.), No. of Core x Size, CU/XLPE/WBT/CWS (5kA/1s)/5V-90/NYLON/HDPE , Year of Mfg., Country of Manufacturer
(B)	MARKING ON DRUMS		a) Cable Voltage and conductor material & size. b) Type of cable c) Length and weight of cable on drum d) Gross weight e) Dimension of reel f) KEI INDUSTRIES LIMITED. g) Contractor address and purchase order (contract) number, If applicable. h) Serial number of drum cross-referenced with test records i) Direction of rolling of drum (or arrow indicating the drum rotation during cable installation.
(C)	Drum Lengths/schedule		As per our drum schedule
	Each Drum length Tolerance		No positive, No negative
	Overall Quantity Toleranace		No positive, No negative
(D)	Sequential length marking at one meter by printing		As per Meter marking clause number 2.17 of AS 1429.1

Appendix B: Cable Model 2 manufacturer datasheet

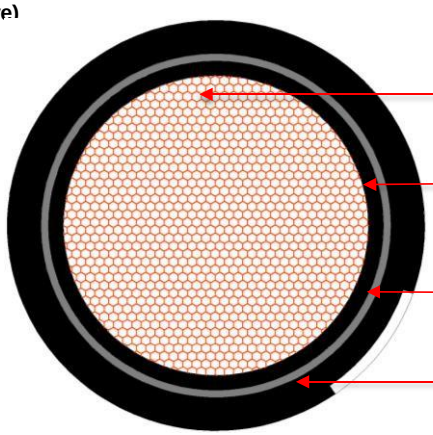
DIMENSIONAL DRAWING
CASE : C1880

Cable Description :

1.5kV D.C , 1C x 400mm², ATC/XLPO/Nylon/XLPO :

Stranded (Class 2) compacted circular Annealed Tinned Copper Conductor, Extruded cross-linked polyolefin Insulation, Extruded Nylon Layer Termite protection, Oversheath Extruded cross-linked polyolefin jacket, UV Stabilised cables complying with AS/NZS 5000.1 , EN-50618 & IEC 62930.

Positive (+ve)



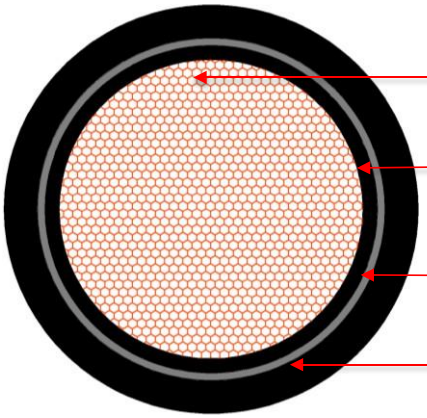
Conductor :
Stranded Class 2 Compact Circular Tinned Copper
Approx. dia. 23.2 mm

Insulation: Black
Extruded cross-linked polyolefin (XLPO)
Thickness - 2 mm (nom)

Termite Protection: Black Ployamide (Nylon -12)
Thickness - 0.4mm (Min. Avg.)

Outer Sheath - Black with White strip
Extruded cross-linked polyolefin (XLPO)
Thickness - 2 mm (nom.)

Negative (-ve)



Conductor :
Stranded Class 2 Compact Circular Tinned Copper
Approx. dia. 23.2 mm

Insulation: Black
Extruded cross-linked polyolefin (XLPO)
Thickness - 2 mm (nom)

Termite Protection: Black Ployamide (Nylon -12)
Thickness - 0.4mm (Min. Avg.)

Outer Sheath (outer layer) - Black
Extruded cross-linked polyolefin (XLPO)
Thickness - 2 mm (nom.)

Note:

Binder tape/tapes shall be provided wherever required.

insulation, Sheathing Compound, Cable construction & dimensions shall be as per AS/NZS 5000.1, EN 50618 & IEC 62930 as applicable & HV Test Shall be as per EN 50618/IEC 62930.

Cable Technical Data:		Conductor Electrical Data:
1) Approx. overall cable diameter :	**33.8 ± 3 mm**	1) Conductor DC resistance at 20 °C Ω/Km
2) Approx. cable weight :	**4093 kg/km**	**0.0475** (max)
3) Maximum pulling force (N) when pulled by pulling eye		2) Conductor DC resistance at 90 °C Ω/Km
a)Copper Conductor cable	**28000 N**	**0.0608** (max)
		3) Conductor short circuit rating
4) Cable minimum bending radius (mm)		**57.2 kA for 1 sec.**
a) During Installation =	**845**	4) Metal Screen earth fault rating (if applicable)
b) Installed =	**507**	**not applicable**

DATA SHEET FOR PV SOLAR CABLES

Sr. No.	Description	Cores x sq.mm	1C X 400 sqmm CU
1)	Name of Manufacture	M/s KEI INDUSTRIES LIMITED	
2)	Voltage Grade	1.5 / 1.5 KV DC	
3)	Standards Applicable	Constructed to AS / NZS 5000.1, EN - 50618 & IEC 62930.	
4)	**Current Ratings**		
	Max. conductor temperature	120deg.C (Max 20000 hrs)	
	Ambient air temperature	40 deg.C	
	Ambient soil temperature	25 deg.C	
	Soil thermal resistivity	1.2 K.m/W	
	Depth of Laying	0.5m	
a)	Unenclosed in air (A) 	1048	
a)	Unenclosed in air (A) 	893	
b)	In Ground (A) 	928	
c)	In Duct (A) 	768	
5)	Positive Sequence Impedance (Ω/km)	0.0608 + j 0.000	
6)	Zero Sequence Impedance (Ω/km)	0.0475 + j 0.000	
7)	**CABLE DATA**		
a)	Drum Lengths/schedule	As per our drum schedule	
	Each Drum length Tolerance	As per our drum schedule	
	Overall Quantity Toleranace	No positive, no negative	
b)	**SHEATH MARKING (Printing)**	KEI - CABLEGRID ELECTRIC CABLE, 1.5 kV DC size,ATC/XLPO/NYLON/XLPO, year & country of manufacture, FOR DC USE ONLY.	
	Note	Where cables have a phase conductor of nominal cross-sectional area greater than or equal to 16mm² the conductor material and conductor nominal cross-sectional area is to be marked	
c)	Marking on Drum	1500 V DC KEI INDUSTRIES LIMITED Constructed to EN 50618, IEC 62930 & AS/NZS 5000.1 as applicable No of cores and size of conductor and conductor material Designation of Insulation & Sheath Gross mass of the drum and cable. Year of Manufacture Length of the cable wound onto the drum An arrow to indicate the direction for rolling cable onto the drum Any special handling instructions PO or contract ref number KEI Unique Drum Identification No.	
d)	Sequential length marking by Printing	As per meter marking clause of AS 5000.1	

Appendix C: Cable Model 3 manufacturer datasheet

No.	Description		Nom. Thickness (mm)	Approx. O.D (mm)
1	Copper conductor (round stranded compact)		Cross section: 1600mm^2	47.6
2	Conductor screen (semi-conducting tape +extruded layer)		0.27+2.0	52.7
3	XLPE insulation		27.0	106.7
4	Insulation screen		1.2	109.1
5	Sheath bedding (semi-conducting tape)		2×1.0	113.1
6	Metallic sheath (lead alloy)		3.0	119.1
7	Lead alloy sheath corrosion protection (semi-conducting PE)		3.0	125.1
8	Filler (shaped filler)		/	/
9	FOC unit	unit no.	1	/
		count /type	48G.652D	/
		stainless steel tube	0.25	3.8
		Semi-conducting PE outer sheath	3.5	15.9
	Assembly		/	269.1
10	Binder (polymeric tape)		0.1	269.3
11	Armour bedding(PP yarns)		Φ2.0	271.9
12	Galvanized steel wire armour, Grade34		(137±4)×Φ6.0	283.9
13	Armour serving (two layers of PP yarns)		2×Φ3.0	295.9
	Cable weight (approx.) in air in water		 155.1 kg/m 98.2 kg/m	

Cable design voltage U_0/U(kV)		231/400
System frequency(Hz)		50
Max. operation temperature of power conductor(℃)		90
Max. short circuit temperature of power conductor(℃)		250
Power conductor DC resistance at 20℃(Ω/km)		0.0113
Power conductor AC resistance at 90℃(Ω/km)		0.0229
Calculated electrical stress at conductor screen (kV/mm)		12.4
Calculated electrical stress at insulation screen (kV/mm)		6.1
Ampacity (Load factor=1) IEC60287	In the seabed (A)	786
	In the land (A)	747
Dynamic current (Average load factor<1) IEC60853	In the seabed(A) -LF=0.6 -LF=0.5 -LF=0.4 -LF=0.3	 1067 1163 1272 1394
	In the land (A) -LF=0.6 -LF=0.5 -LF=0.4 -LF=0.3	 1015 1108 1213 1329
Non-adiabatic short circuit current of power conductor for 1s/3s(kA)		229.8/133.2 (90/250)
Non-adiabatic short circuit current of metallic screen for 1s/3s per phase(kA)		25.7/15.6 (80/180)
Capacitance between conductor and metallic screen, ε=2.3 (μF/km)		0.182
Charging current (A/km)		13.20