BV TWENTSCHE KABELFABRIEK

TWENPOWER

MEDIUM-VOLTAGE XLPE CABLES

C O N T E N T S

Over the years Twentsche Kabelfabriek (TKF) has built up a wide range of products. In doing so, it has accumulated a wealth of experience with a wide variety of materials. Moreover, by carefully structuring the product range, valuable relationships between various product lines emerged, which could be put to efficient use in developing new products.

Twenpower

Both developments have positively influenced production of the Twenpower medium-voltage cable launched by us in 1981. In 1998 TKF was able to optimize the process management with reference to the Twenpower. The increase in effectivity and quality has been put to use in the development of the Twenpower-opto medium-voltage cables.

Twenpower-opto

The Twenpower-opto is a cable featuring glass fibre(s) integrated in the copper screen. Thanks to the integration of this fibre package, this cable allows for effective cable management. By measuring the temperature and the mechanical tension (and in the near future the detection of moisture beyond a specified limit, as well), information is obtained with reference to the anticipated problems and bottlenecks. In addition, the signals from the protective equipment are more reliable owing to the fact that communication runs through one's own cable.

Turnkey projects

TKF also offers the Twenpower and the Twenpower-opto within the framework of Turnkey projects. They are mainly used in public power distribution, the industry and for special versions. Since their launch, TKF has been accumulating experience in the Turnkey version of highly diverse projects for medium-voltage cables.

Technical standard

Normally, the cables are in accordance with Dutch standard NEN 3620, being consistent with the Cenelec harmonisation documents (in particular, HD 620). Current-carrying capacity has been based on NPR 3626. Delivery according to IEC 60502-2 is of course also possible. The correct voltage rating of the cables is Uo/U (Um), with Um being the maximum system voltage.

Correct voltage rating:

'Designation'	10 kV	15 kV	20 kV	30 kV	50 kV
Uo/U	6/10 kV	8,7/15 kV	12/20 kV	18/30 kV	36/50 kV
(Um)	12 kV	17,5 kV	24 kV	36 kV	72,5 kV

Advantages of Twenpower Medium-voltage Cable

- **Dry vulcanized**
- **Lightweight**
- **High current-carrying capacity**
- **Clean to handle**
- **Low dielectric capacity and loss angle**
- **Longitudinally and quasi-transversally watertight or transversally watertight with the potential bonding wire ®**
- **Resistant to water trees**

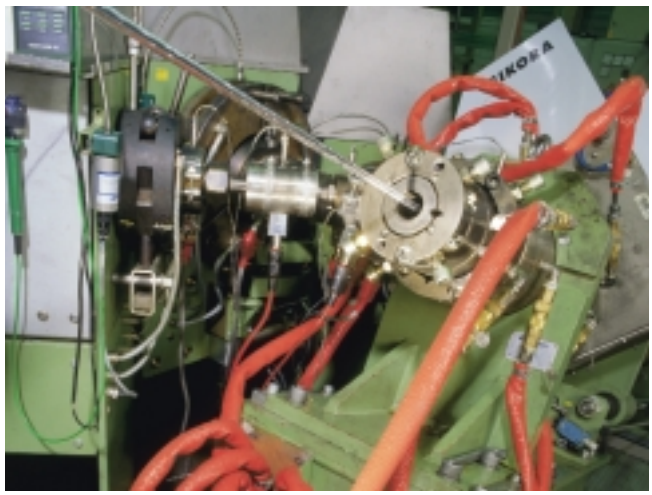
Optional for the Twenpower-opto

- **Cable management using integrated glass fibre(s)**
- **Protective applications**

MATERIALS

The materials used in Twenpower medium-voltage cables ensure excellent properties, both electrically and mechanically, and form a high-quality cable construction when used as elements in integral coherence.

Conductors are circular and made of solid or stranded aluminium, or of stranded copper wires.



Catenary line, three-layer extrusion process using triple-head, finished by a layer thickness check using X-ray

Unloading the insulating material from a hopper immediately above the extruder

On the catenary line the semi-conductive conductor screen, the insulation and the semi-conductive insulation screen are applied in a single three-layer extrusion process at one go. Because vulcanization takes place under nitrogen pressure, the three layers consist of XLPE. In this process, the layer thicknesses are measured individually, to check the thickness and the eccentricity of these layers.

The metallic screen mostly consists of copper wires with a copper counterwound tape to ensure potential bonding. The section of the screen is dictated by the network in which the cable will be used. In view of personal shock protection, the mutual distance between the copper wires has been limited. Should any mechanical cable damage occur, there is a risk of groundwater penetrating the cable. As a

protective measure and to provide a barrier against diffusion of moisture, Dutch standard NEN 3620 specifies cables being longitudinally watertight as the preferred design. This longitudinal watertightness of the screen is ensured by applying semi-conductive swelling fleece under and on top of the copper wires. In combination with the abrasion-resistant PE (ST7) outer sheath, the swelling fleeces also offer a quasi transversal watertightness.
A guaranteed longitudinal and transversal watertightness can only be obtained by applying a closed aluminium complex foil under the PE outer sheath on top of a semi-conductive rubber layer. The potential wire patented by TKF

Permanent monitoring of the process, here by way of visualization of the three-layer system

ensures a contact along the full cable length between the complex foil and the copper wire screen, thus preventing the rubber layer from burning in, should larger short-circuit currents occur.

With three-core cables mechanical protection is provided by a metallic screen consisting of a combination of steel and copper flat wires (or circular wires). The steel wires are galvanized to prevent corrosion.

A red plastic outer sheath of at least 2.5 mm thick provides mechanical protection for the cable when it is being laid and during service. It also protects the metallic screen against corrosion, which can possibly occur as a result of stray currents. Another feature of this plastic sheath is to provide insulation if the metallic sheath is not earthed at either end. The material is a tough, and consequently abrasion-resistant, polyethylene or, for industrial overhead use, a flame-retardant PVC. Alternatively, flame-retardant halogen-free sheath materials (MBZH) can be applied instead. The sheath carries a markstamp showing such data as the main design characteristics, the supplier, the year of manufacture and a batch number (optional).

Inspections satisfy at least the requirements as laid down in Dutch standard NEN 3620. Besides, a number of additional inspections are carried out at TKF. Inspection is focused on:

- raw material inspection (at TKF or the supplier);
- process inspection (with the use of data collection and trend monitoring);
- finished product inspection (routine test, sample test and type test).

VIEW OF TKF INSPECTION

The medium-voltage cables are - as is true for all other cables produced by TKF - subjected to a comprehensive inspection programme, using various testing techniques. This page gives an impression in pictures of a number of inspection stages.

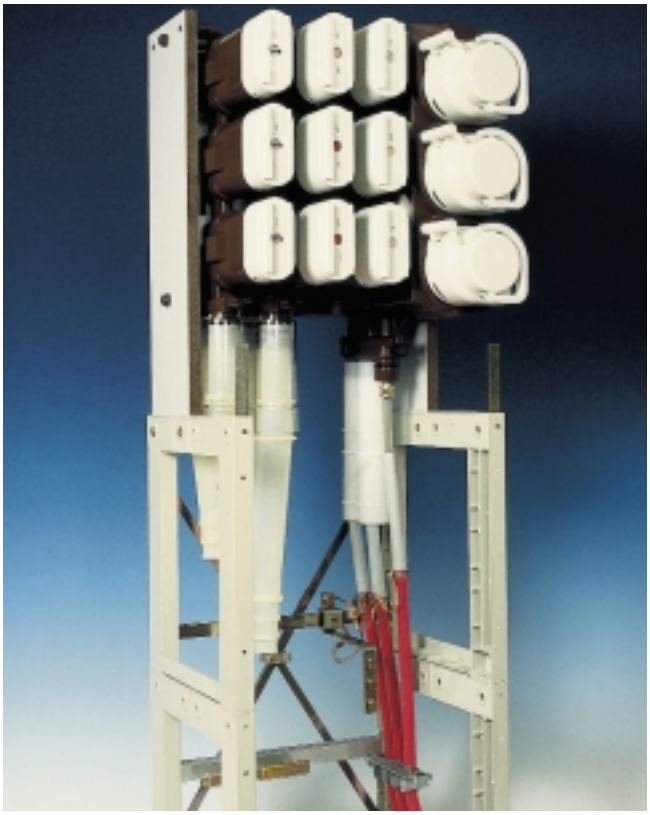
24-hour test: type test of 36/50 kV cable

Mechanical inspection: tensile strength check by means of a tensile strength tester

Increasing the tension in an aged 20 kV cable, often upward of 300 kV, until a disruptive breakdown occurs.

Voltage test and discharge detection in the Faraday cage

Final inspection of medium-voltage cables: conductor resistance check



Twenpower medium-voltage cables pre-terminated to a switchgear

A turnkey project in Eemshaven: fitting of a cable

TWENPOWER VERSIONS

Twenpower medium-voltage XLPE cables are available in various versions, in accordance with specific environmental conditions.

Flame-retardant (mb)
In the event of a fire, there is a risk of the fire spreading through overhead cables. To prevent this from happening, cables can be provided with sheaths made of a flame-retardant plastic.

Halogen-free (zh)
Halogen-containing materials, such as PVC, can cause highly toxic and corrosive substances to be released in the event of a fire. TKF has developed materials which do not contain any halogens nor heavy metals.

Flame-retardant and halogen-free (mbzh)
Materials which are flame-retardant as well as halogen-free are also some of the possible options.

Chemical resistance
Chemicals are capable of attacking a cable quickly. For instance, if cables are laid in a chemically contaminated environment, Twenpower cables can be provided with additional protection. To this end, TKF can provide cables with a lead sheath. Alternatively, the sheath can be provided with a special chemically resistant plastic coating. This plastic is capable of resisting a great many chemical substances.

Rodent-resistant
Rodents (such as rats and termites) like to line their nests with materials taken from cables. TKF has the experience required to make sheaths rodent-resistant in order to prevent the plastic cables from being attacked.

UV-resistant
As an option, TKF can supply the red plastic outer sheaths of medium-voltage cables in a version featuring a high degree of resistance to UV radiation.

TURNKEY PROJECTS

The execution of Turnkey cable projects is one of our core activities. TKF is increasingly commissioned to supply power cables within the framework of Turnkey projects. We have focused our organization on meeting these needs, calling upon the various disciplines available within the Twentsche Kabel Holding. In same cases, cooperation is sought with third parties. A list of references may be obtained from our Sales Department.

MINIMUM BENDING RADIUS

MINIMUM BENDING RADIUS (in mm)		
	during laying	installed (once-only)
1-core	12 x (D+d)	10 x (D+d)
1-core with glass fibres	17½ x (D+d)	15 x (D+d)
1-core with lead sheath	15 x (D+d)	75% of 15 x (D+d)
3-core	10 x (D+d)	75% of 10 x (D+d)

D = cable diameter (in mm)
d = conductor diameter (in mm)

MAXIMUM PULLING FORCE

MAXIMUM PULLING FORCE (in N)			
		with the use of a	
		pulling sleeve	pulling head
medium-voltage		KxS	KxS
medium-voltage with lead sheath	U<30 kV	3xD²	
	U≥30 kV	2xD²	

D = cable diameter (in mm)
The factor K for the following conductors is:

Cu	K = 50
Al stranded	K = 30
Al solid	K = 20

S = total surface area of the conductors (in mm²)

INSTALLATION TEMPERATURE

The minimum installation temperature is 0 ºC, in compliance with the conditions referred to above. This temperature applies to the cable to be installed, not to the ambient temperature. If possible, we recommend that the cable temperature should be raised to ± 5 ºC

MAX. CONDUCTOR RESISTANCE (in Ω/km)				
nominal	Copper conductor		Aluminium conductor	
core c.s.a.* (in mm²)	DC resistance at 20ºC	AC resistance at 50 Hz and 90ºC	DC resistance at 20ºC	AC resistance at 50 Hz and 90ºC
16	1,15	1,47	-	-
25	0,727	0,927	-	-
35	0,524	0,668	0,868	1,113
50	0,387	0,494	0,641	0,822
70	0,268	0,342	0,443	0,568
95	0,193	0,247	0,320	0,411
120	0,153	0,196	0,253	0,325
150	0,124	0,160	0,206	0,265
185	0,0991	0,128	0,164	0,212
240	0,0754	0,099	0,125	0,162
300	0,0601	0,080	0,100	0,130
400	0,0470	0,065	0,0778	0,103
500	0,0366	0,053	0,0605	0,082
630	0,0283	0,044	0,0469	0,065
800	-	-	0,0367	0,053

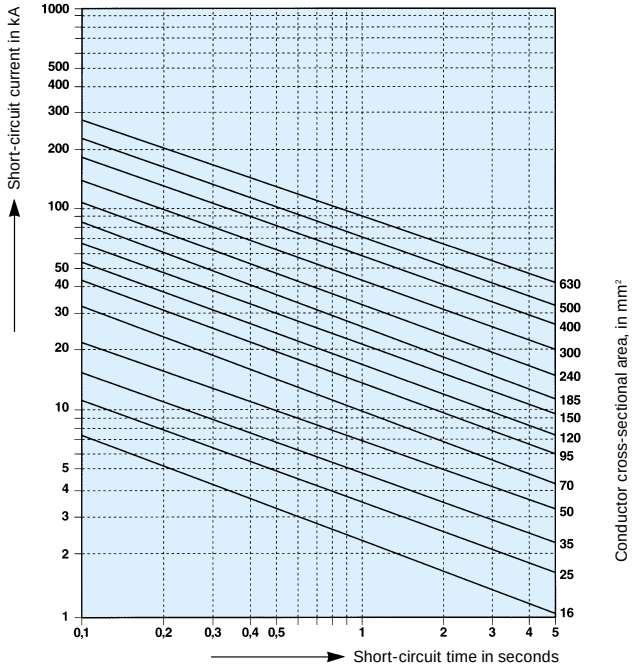
*) c.s.a. = cross sectional area

Used short cuts:

	rs	= round stranded copper conductor
	Alrm	= round solid aluminium conductor
	Alrs	= round stranded aluminium conductor
	as	= earthing screen

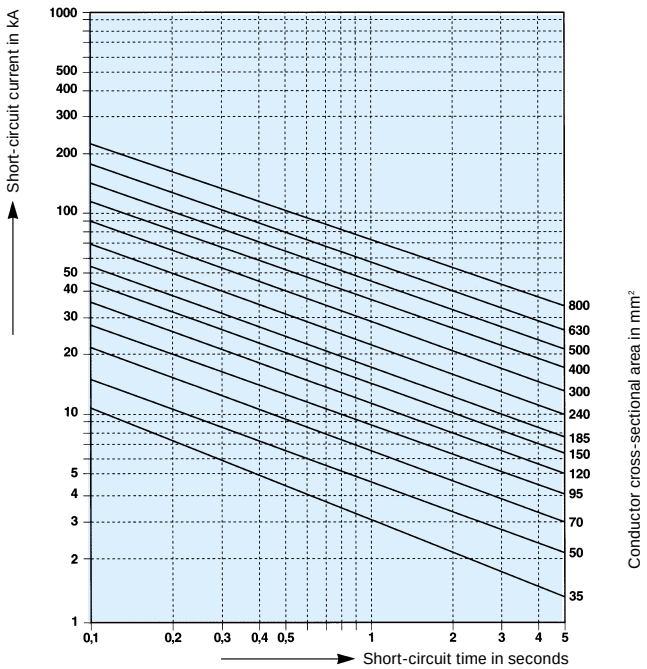
Thermally permissible short-circuit currents for copper conductors, with a final temperature not exceeding 250 ºC, in line with NEN 3620.

$$I_k = \frac{0{,}143}{\sqrt{t}} .S$$



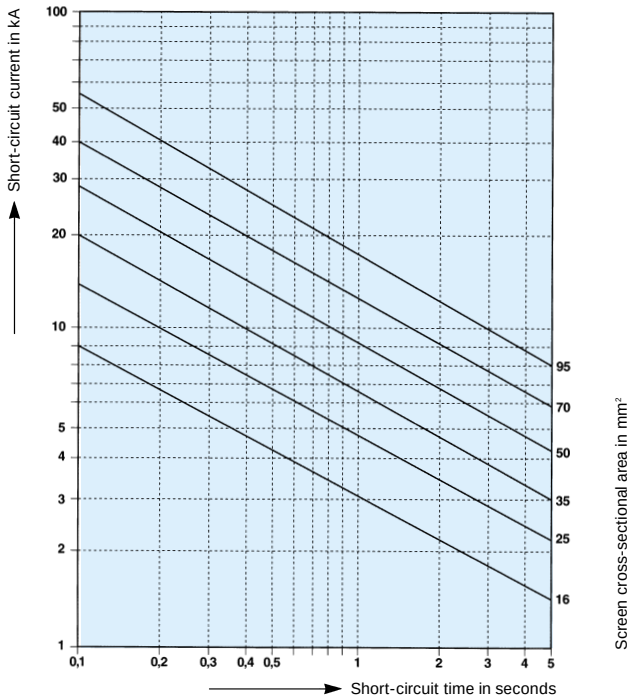
Thermally permissible short-circuit currents for aluminium conductors, with a final temperature not exceeding 250 ºC, in line with NEN 3620.

$$I_k = \frac{0{,}094}{\sqrt{t}} .S$$



Thermally permissible short-circuit currents of the screen, with a final temperature not exceeding 350 ºC, in line with NEN 3620.

$$I_k = \frac{0{,}178}{\sqrt{t}} .S$$



The graph alongside has been calculated in line with NEN 3620 for cables with a copper earthing screen only which is allowed to reach a temperature of 350 ºC. The temperature allowed for an aluminium foil screen is only 160 ºC. Even so, the thermally permissible short-circuit currents for the screen of transversally and longitudinally watertight cables are close to the values applying to copper wire screens. This is caused by the current distribution.

DESIGN OF TWENPOWER SINGLE-CORE MEDIUM-VOLTAGE CABLES

characteristics
- circular single-core cable
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing. It retains, even after ageing, a high electrical strength.
- application: public utilities, industry, non-residential construction and related fields.

Design:

conductors
circular conductors made of stranded copper wires or of solid aluminium. Optionally, aluminium conductors are also available in a stranded version, for greater flexibility.

conductor screen
semi-conductive polymer layer of at least 0.5 mm thick.

insulation
high-quality XLPE.

insulation screen
semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen
copper wires with an open pattern counterwound copper strip.

options
longitudinally and quasi transversally watertight design
with a longitudinally and quasi transversally watertight design, swelling tape is applied on top of the earthing screen.
transversally and longitudinally watertight design
with this option, the space between the earthing screen wires is filled with a semi-conductive rubber-based filling sheath. An aluminium foil and a PE sheath are sandwiched on top of the filling sheath, with a copper wire for equipotential bonding to prevent any potential difference between copper screen and aluminium foil.

outer sheath
abrasion-resistant PE (ST7)

options
- armouring of copper flat wire
- lead-sheathed, especially designed for contaminated soils, as found in the petrochemical industry
- designs according to customer specifications.

cable designation
longitudinally and quasi transversally watertight
YMeKrvaslqwd ../.. kV 1 x .. rs+as ..
YMeKrvaslqwd ../.. kV 1 x .. Alrm+as ..
YMeKrvaslqwd ../.. kV 1 x .. Alrs+as ..
transversally and longitudinally watertight
YMeKrvasdlwd ../.. kV 1 x .. rs+as ..
YMeKrvasdlwd ../.. kV 1 x .. Alrm+as ..
YMeKrvasdlwd ../.. kV 1 x .. Alrs+as ..

Twenpower single-core medium-voltage cables rated 6/10 kV with stranded copper conductors.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 25	16	6,0	14,8	19,7	27	0,8	0,153	0,246	0,22
1 x 35	25	7,1	15,9	20,8	28	1,0	0,144	0,231	0,24
1 x 50	25	8,2	17,0	21,9	29	1,1	0,138	0,224	0,26
1 x 70	25	9,9	18,7	23,6	30	1,4	0,129	0,214	0,30
1 x 95	25	11,5	20,3	25,2	32	1,7	0,123	0,206	0,33
1 x 120	25	13,0	21,8	26,7	34	1,9	0,119	0,200	0,36
1 x 150	25	14,5	23,3	28,2	35	2,2	0,114	0,194	0,39
1 x 185	25	16,1	24,9	29,8	37	2,6	0,111	0,189	0,42
1 x 240	25	18,6	27,4	32,3	39	3,2	0,106	0,182	0,47
1 x 300	25	20,6	29,4	34,3	41	3,7	0,103	0,177	0,51
1 x 400	50	24,0	32,8	37,7	45	4,9	0,099	0,172	0,58
1 x 500	50	27,2	36,0	40,9	48	5,9	0,095	0,166	0,64
1 x 630	50	31,1	39,9	44,8	52	7,3	0,092	0,160	0,72

Twenpower single-core medium-voltage cables rated 6/10 kV with solid aluminium conductors.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 70	25	9,1	17,9	22,8	30	0,9	0,141	0,226	0,28
1 x 95	25	10,8	19,6	24,5	31	1,0	0,134	0,218	0,31
1 x 120	25	12,1	20,9	25,8	33	1,1	0,130	0,212	0,34
1 x 150	25	13,3	22,1	27,0	34	1,2	0,127	0,207	0,36
1 x 185	25	14,9	23,7	28,6	35	1,4	0,122	0,202	0,40
1 x 240	25	17,1	25,9	30,8	38	1,6	0,118	0,195	0,44
1 x 300	25	19,1	27,9	32,8	40	1,8	0,114	0,190	0,48
1 x 400	50	21,7	30,5	35,4	42	2,3	0,111	0,186	0,53
1 x 500	50	24,6	33,4	38,3	45	2,7	0,107	0,180	0,59
1 x 630	50	27,9	36,7	41,6	48	3,1	0,103	0,174	0,66
1 x 800	50	31,5	40,3	45,2	52	3,7	0,101	0,168	0,73

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 8.7/15 kV with stranded copper conductors.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 16	16	5,0	16,1	21,0	28	0,8	0,168	0,257	0,16
1 x 25	16	6,0	17,1	22,0	29	0,9	0,159	0,247	0,18
1 x 35	25	7,1	18,2	23,1	30	1,1	0,149	0,232	0,19
1 x 50	25	8,2	19,3	24,2	31	1,2	0,143	0,225	0,21
1 x 70	25	9,9	21,0	25,9	33	1,5	0,134	0,215	0,24
1 x 95	25	11,5	22,6	27,5	34	1,8	0,128	0,207	0,26
1 x 120	25	13,0	24,1	29,0	36	2,0	0,123	0,201	0,28
1 x 150	25	14,5	25,6	30,5	37	2,3	0,118	0,195	0,31
1 x 185	25	16,1	27,2	32,1	39	2,7	0,114	0,190	0,33
1 x 240	25	18,6	29,7	34,6	41	3,3	0,109	0,183	0,37
1 x 300	25	20,6	31,7	36,6	43	3,9	0,106	0,178	0,40
1 x 400	50	24,0	35,1	40,0	47	5,0	0,102	0,174	0,45
1 x 500	50	27,2	38,3	43,2	50	6,1	0,098	0,168	0,50
1 x 630	50	31,1	42,2	47,1	54	7,5	0,095	0,161	0,56

Twenpower single-core medium-voltage cables rated 8.7/15 kV with solid aluminium conductors.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 70	25	9,1	20,2	25,1	32	1,0	0,146	0,228	0,22
1 x 95	25	10,8	21,9	26,8	34	1,1	0,139	0,219	0,25
1 x 120	25	12,1	23,2	28,1	35	1,2	0,134	0,213	0,27
1 x 150	25	13,3	24,4	29,3	36	1,3	0,131	0,209	0,29
1 x 185	25	14,9	26,0	30,9	38	1,5	0,126	0,203	0,31
1 x 240	25	17,1	28,2	33,1	40	1,7	0,121	0,196	0,35
1 x 300	25	19,1	30,2	35,1	42	1,9	0,118	0,191	0,38
1 x 400	50	21,7	32,8	37,7	45	2,4	0,114	0,188	0,42
1 x 500	50	24,6	35,7	40,6	47	2,8	0,110	0,181	0,46
1 x 630	50	27,9	39,0	43,9	51	3,3	0,107	0,175	0,51
1 x 800	50	31,5	42,6	47,5	55	3,9	0,104	0,170	0,56

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 12/20 kV with stranded copper conductors.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 25	16	6,0	19,3	24,2	31	1,0	0,163	0,248	0,15
1 x 35	25	7,1	20,4	25,3	32	1,2	0,153	0,234	0,17
1 x 50	25	8,2	21,5	26,4	33	1,3	0,147	0,226	0,18
1 x 70	25	9,9	23,2	28,1	35	1,6	0,138	0,216	0,20
1 x 95	25	11,5	24,8	29,7	37	1,9	0,131	0,208	0,22
1 x 120	25	13,0	26,3	31,2	38	2,1	0,126	0,202	0,24
1 x 150	25	14,5	27,8	32,7	40	2,4	0,122	0,196	0,26
1 x 185	25	16,1	29,4	34,3	41	2,8	0,118	0,191	0,28
1 x 240	25	18,6	31,9	36,8	44	3,4	0,112	0,184	0,31
1 x 300	25	20,6	33,9	38,8	46	4,0	0,109	0,179	0,34
1 x 400	50	24,0	37,3	42,2	49	5,2	0,105	0,175	0,38
1 x 500	50	27,2	40,5	45,4	53	6,3	0,101	0,169	0,42
1 x 630	50	31,1	44,4	49,3	57	7,7	0,097	0,162	0,47

Twenpower single-core medium-voltage cables rated 12/20 kV with solid aluminium conductors.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 95	25	10,8	24,1	29,0	36	1,2	0,143	0,220	0,22
1 x 120	25	12,1	25,4	30,3	37	1,3	0,138	0,214	0,23
1 x 150	25	13,3	26,6	31,5	38	1,4	0,134	0,210	0,25
1 x 185	25	14,9	28,2	33,1	40	1,6	0,130	0,204	0,27
1 x 240	25	17,1	30,4	35,3	42	1,8	0,124	0,197	0,29
1 x 300	25	19,1	32,4	37,3	44	2,0	0,121	0,192	0,32
1 x 400	50	21,7	35,0	39,9	47	2,6	0,117	0,189	0,35
1 x 500	50	24,6	37,9	42,8	50	3,0	0,113	0,183	0,39
1 x 630	50	27,9	41,2	46,1	53	3,5	0,109	0,177	0,43
1 x 800	50	31,5	44,8	49,7	57	4,1	0,106	0,171	0,47

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 18/30 kV with stranded copper conductors.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 35	25	7,1	25,7	30,6	37	1,4	0,162	0,236	0,13
1 x 50	25	8,2	26,8	31,7	39	1,6	0,156	0,229	0,14
1 x 70	25	9,9	28,5	33,4	40	1,8	0,146	0,219	0,16
1 x 95	25	11,5	30,1	35,0	42	2,1	0,140	0,211	0,17
1 x 120	25	13,0	31,6	36,5	43	2,4	0,134	0,205	0,18
1 x 150	25	14,5	33,1	38,0	45	2,7	0,129	0,199	0,20
1 x 185	25	16,1	34,7	39,6	46	3,1	0,125	0,194	0,21
1 x 240	25	18,6	37,2	42,1	49	3,8	0,120	0,187	0,23
1 x 300	25	20,6	39,2	44,1	51	4,3	0,116	0,182	0,25
1 x 400	50	24,0	42,6	47,5	55	5,6	0,112	0,178	0,28
1 x 500	50	27,2	45,8	50,7	58	6,7	0,108	0,172	0,30
1 x 630	50	31,1	49,7	54,6	62	8,1	0,103	0,165	0,34

Twenpower single-core medium-voltage cables rated 18/30 kV with solid aluminium conductors.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 120	25	12,1	30,7	35,6	42	1,6	0,146	0,217	0,18
1 x 150	25	13,3	31,9	36,8	44	1,7	0,142	0,212	0,19
1 x 185	25	14,9	33,5	38,4	45	1,9	0,137	0,207	0,20
1 x 240	25	17,1	35,7	40,6	47	2,1	0,132	0,200	0,22
1 x 300	25	19,1	37,7	42,6	49	2,4	0,128	0,195	0,24
1 x 400	50	21,7	40,3	45,2	52	3,0	0,124	0,192	0,26
1 x 500	50	24,6	43,2	48,1	55	3,4	0,120	0,186	0,28
1 x 630	50	27,9	46,5	51,4	59	3,9	0,116	0,179	0,31
1 x 800	50	31,5	50,1	55,0	63	4,5	0,112	0,174	0,34

Twenpower single-core medium-voltage cables rated 36/50 kV with solid aluminium conductors.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 240	95	17,1	42,0	46,9	54	3,3	0,124	0,160	0,17
1 x 300	95	19,1	44,0	48,9	56	3,5	0,122	0,159	0,19
1 x 400	95	21,7	46,6	51,5	59	3,9	0,132	0,195	0,20
1 x 500	95	24,6	49,5	54,4	62	4,4	0,127	0,189	0,22
1 x 630	95	27,9	52,8	57,7	66	4,9	0,123	0,183	0,24

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Effective Cable Managecment

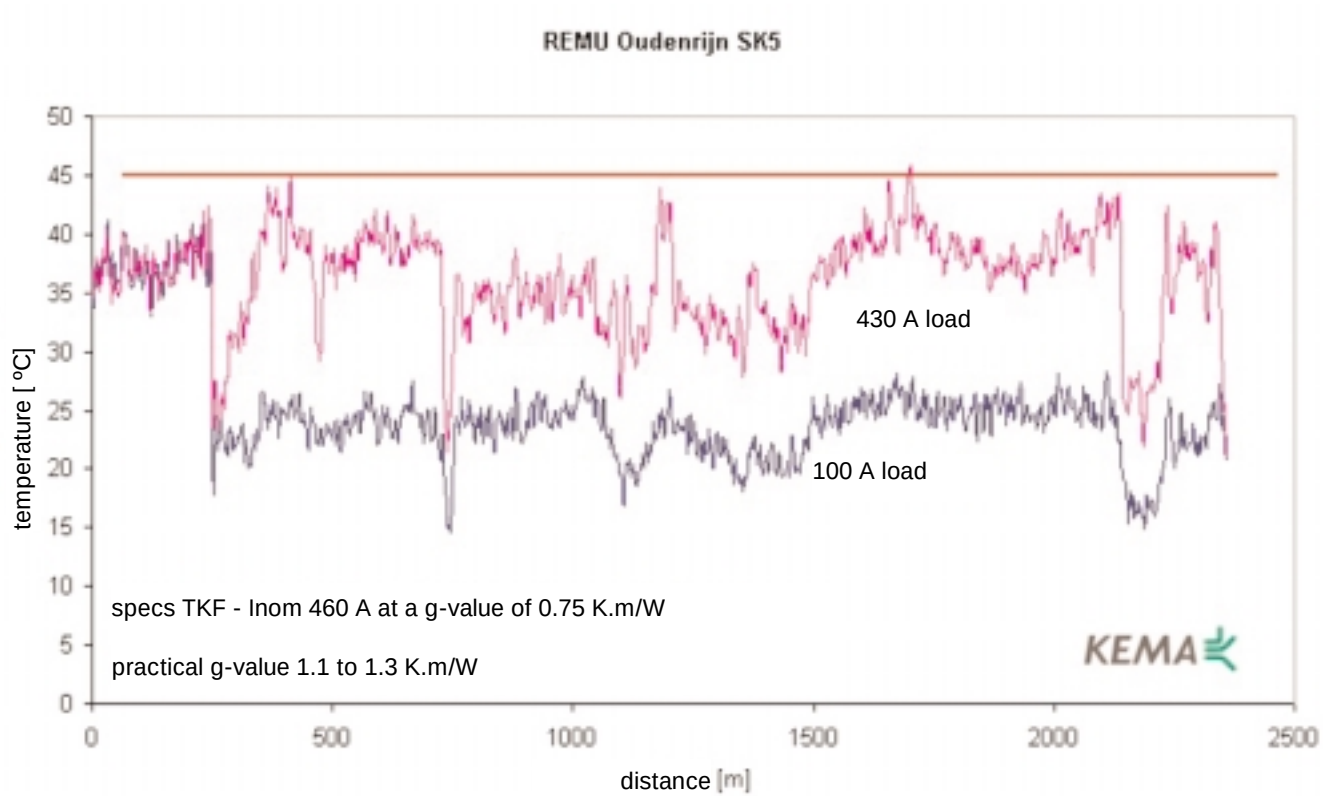
The Twenpower-opto medium-voltage cable can be described as an informative ‘auxiliary line’ for effective cable management (dynamic cable management). This is because this cable is fitted with glass fibres which act as optical sensors.

The application of these optical sensors makes it possible to intentionally load the medium-voltage cable to its limits. An added advantage is that any information about bottlenecks and any possible damage which may reduce the service life of the connection is quickly available. The sensors integrated into the earthing screen allow for accurate measurements and tracing of, among other things, temperature, moisture and mechanical tension in the cable. The measurements, the interpretation of the measuring results and the resultant reports are carried out by KEMA TDP.

Temperature Monitoring

The “Loose Tube” sensor and the available equipment allow - in section lengths up to 30 km - for temperatures and temperature variations to be determined with an accuracy of approx. 2 ºC. The locating capacity is approximately two metres. This way it is possible to determine the maximum (dynamic) load capability of the connection at any given moment, in which bottlenecks such as drillings, transitions in soil type, hot spots and cable connections that lie (partially) parallel are shown clearly. Figure 1 shows the temperature curve in the earthing screen of a YMeKrvaslwd 6/10 kV 1 x400Alrm+ as70+ 2xSM cable along the length of a connection at two different loads. At a 100A load the temperature profile is reasonably flat and the biggest temperature difference is 14 ºC. At a 430A load the temperature profile is far more irregular: the biggest temperature difference is 23 ºC and there is possibly at approx. 2/3 of the connection a bottleneck. Whether these are indeed bottlenecks depends on the soil conditions at the highest peaks.

Figure 1



Compressive and tensile stresses

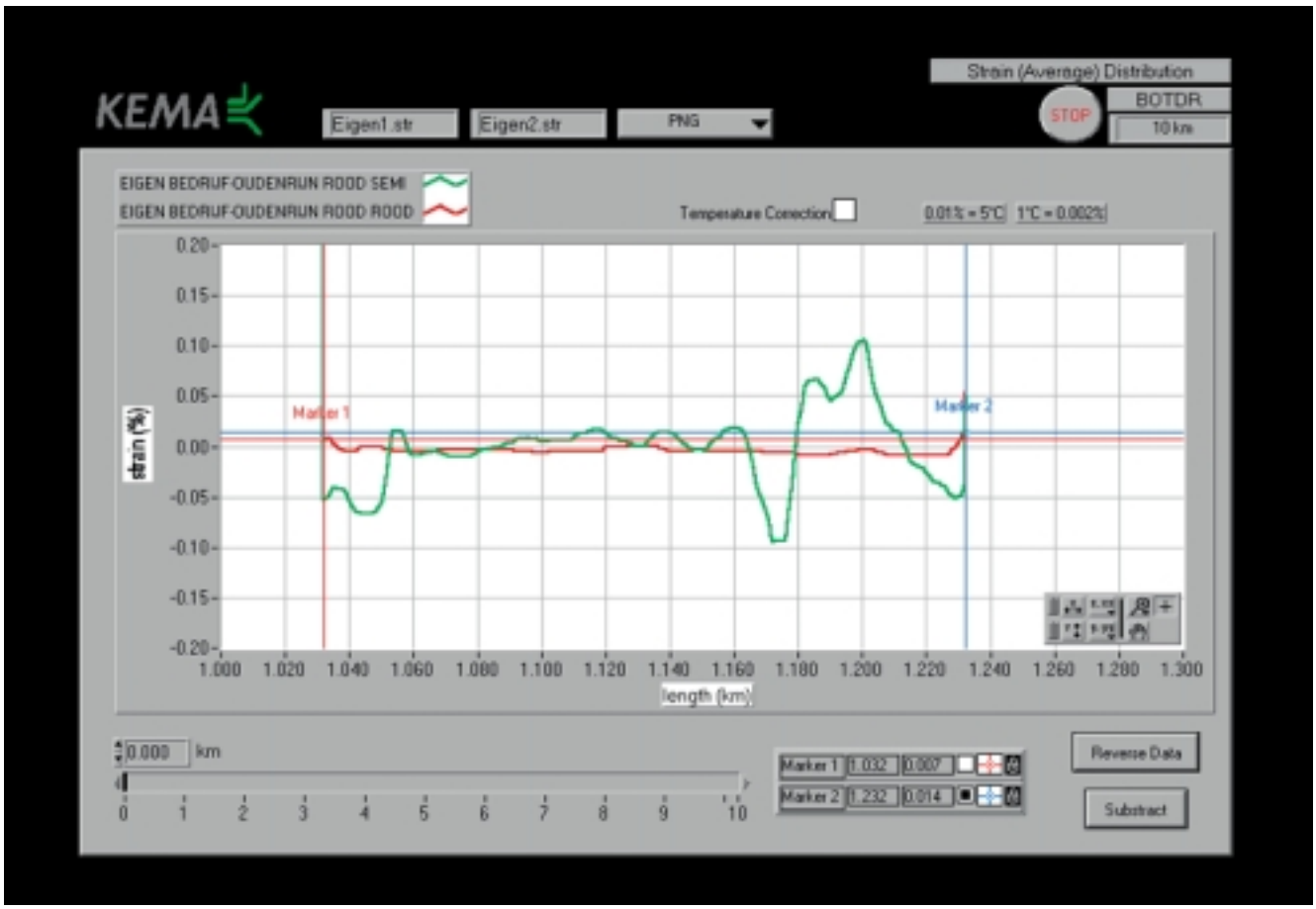
When installing the cable connection, but also at a later stage, due to e.g. ground settlements, excavation work or breaking down of the verge, compressive and/or tensile stresses may occur. The ‘Buffered tight’ sensor and the Brillouin Optical Time Domain Reflectometer (BOTDR) equipment can be used to measure the degree of upsetting or strain with a locating capacity of 8 metres. Figure 2 shows such a measurement. The green line indicates the compressive and tensile stresses in the ‘Buffered tight’ sensor. It is striking that the introduction into both stations has taken quite an effort. The red line shows that there is no mechanical tension present in the ‘Loose tube’ sensor.

Penetration of moisture

There where earthwork does indeed result in sheath damage, but not in mechanical tension, the ingress of moisture may well considerably reduce the service life of the cable section concerned.
A moisture-sensitive sensor provides an indication, which also gives information about the length along which the moisture has penetrated. With the help of these measurement data, it is possible to find out the cause and schedule a repair. Expectations are that this technology will be developed to a sufficient extent at the end of the year 2000 in order to be applied in actual practice.

The development of optical sensors integrated into plastic MV cables does not stop here. We are looking forward to taking up new challenges together with you.

Figure 2



DESIGN OF TWENPOWER OPTO SINGLE-CORE MEDIUM-VOLTAGE CABLES

characteristics:
- circular single-core cable
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength;
- application: public utilities, industry, non-residential construction and related fields.

Design

conductors

circular conductors made of stranded copper wires or of solid aluminium. Optionally, aluminium conductors are also available in a stranded version, for greater flexibility.

conductor screen

semi-conductive polymer layer of at least 0.5 mm thick.

insulation

high-quality XLPE

insulation screen

semi-conductive cross-linked polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen

copper wires, glass fibres, with an open pattern counterwound copper strip. The glass fibres have a monitoring function. They are protected by means of a special tube made of a high-quality plastic.

options

longitudinally and quasi transversally watertight design
with a longitudinally and quasi transversally watertight design, swelling tape is applied on top of the earthing screen.

transversally and longitudinally watertight design
with this option, the space between the earthing screen wires and the glass fibres is filled with a semi-conductive rubber-based filling sheath. An aluminium foil and a PE sheath are sandwiched on top of the filling sheath, with a copper wire for equipotential bonding to prevent any potential difference between copper screen and aluminium foil.

outer sheath

abrasion-resistant PE (ST7)

options
- armouring of copper flat wire;
- lead-sheathed, especially designed for contaminated soils, as found in the petrochemical industry;
- designs according to customer specifications.

cable designation

Longitudinally and quasi transversally watertight
YMeKrvaslqwd ../.. kV 1 x .. rs+as ..+ .. x SM
YMeKrvaslqwd ../.. kV 1 x .. Alrm+as .. + .. x SM
YMeKrvaslqwd ../.. kV 1 x .. Alrs+as .. + .. x SM

Transversally and longitudinally watertight
YMeKrvasdlwd ../.. kV 1 x ..rs+as .. + .. x SM
YMeKrvasdlwd ../.. kV 1 x .. Alrm+as .. + .. x SM
YMeKrvasdlwd ../.. kV 1 x .. Alrs+as ..+ .. x SM

Continuous current rating of underground or overhead single-core cables.

nominal core cross-sectional area	earthing of metallic screens	continuous current rating (in A) of 1-core copper and aluminium cable 10-30 kV							
		underground				overhead			
		trefoil		flat		trefoil		flat	
mm²		Cu	Al	Cu	Al	Cu	Al	Cu	Al
16		105	-	120	-	125	-	150	-
25		135	-	150	-	160	-	195	-
35		165	125	175	135	195	155	235	180
50	at either end	190	150	205	160	235	185	280	220
70		235	180	245	195	295	230	350	270
95		280	215	290	230	355	280	425	330
120		315	245	325	260	410	320	485	380
150		350	275	360	285	465	365	550	430
185		395	310	400	320	535	420	925	495
240		455	355	455	365	630	495	730	580
300		510	400	505	410	720	565	825	660
400		560	450	515	435	825	660	880	735
500		630	510	560	480	940	765	985	835
630		700	575	615	530	1070	880	1095	940
800		765	640	660	580	1200	1010	1205	1055
400	at one end	585	460	635	495	850	675	1050	825
500		655	520	715	565	980	780	1220	965
630		735	590	810	645	1120	910	1415	1125
800		810	665	905	725	1265	1045	1625	1310

The continuous current rating applies to the following conditions, in line with NPR 3626:

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The trefoil configuration is based on:
  - earthing at either end for conductor cross-sectional areas up to 400 mm²;
  - earthing at one end for conductor cross-sectional areas from 400 mm² upwards;
- Calculations for cables laid in a flat formation are based on:
  - transposed cable, earthed at either end, up to 400 mm²;
  - earthing at one end or cross-bonded earthing screens from 400 mm² onwards.
- Cable spacing of 70 mm.

In calculating the current-carrying capacities, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.[1])
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 1, 2 and 3, respectively.

OVERHEAD

- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that:
  - the area in which it is installed, should be sufficiently large, or it should be ventilated;
  - the cables are protected from direct solar radiation or radiation from other heat sources;
  - the distance between the cable perimeter and a wall, floor, etc. should at least be 0,3 times the cable outer diameter;
  - if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
  - if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
  - the racks are open; they are, for instance, made of perforated plate.
- The cables are laid in a flat formation, spacing between the cables should at least equal the cable diameter.

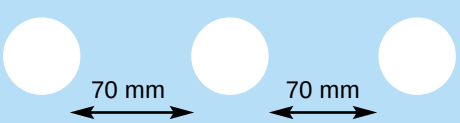
For different air temperatures, refer to Table 4.

[1]) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

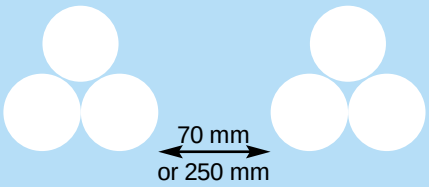
Table 1: Correction factors for different soil temperatures

Soil temperature in ºC	5	10	15	20	25
Correction factor	1,14	1,07	1,00	0,92	0,83

Table 2: Correction factors for different thermal resistivities of soil and/or parallel circuits of single-core cables.



cables in flat formation



cables in trefoil

g	number of parallel cable circuits							
	cables in flat formation			cables in trefoil				
	1	2	3	1	2		3	
					spacing in mm			
K.m/W					70	250	70	250
0,5	1,11	0,89	0,79	1,11	0,87	0,93	0,75	0,82
0,75	1,00	0,80	0,71	1,00	0,78	0,84	0,68	0,74
1,0	0,94	0,76	0,67	0,94	0,74	0,79	0,64	0,70
1,2	0,91	0,73	0,65	0,91	0,71	0,77	0,62	0,68
1,5	0,88	0,70	0,62	0,88	0,69	0,73	0,59	0,65

NOTE: This table is valid for a soil temperature of 15 ºC only. The correction factors have been determined using the double-shell model, starting from the 30 ºC critical isotherm.

Table 3: Correction factors depending on the groundwater level, soil temperature and thermal resistivity of soil (g) for single-core cables.

Groundwater level, in metres	2	3	4	5	
Correction factor	1,10	1,04	1,00	0,99	
Soil temperature, in ºC	5	10	15	20	25
Correction factor for trefoil formation	1,13	1,08	1,00	0,95	0,88
Correction factor for flat formation	1,12	1,06	1,00	0,92	0,85
Thermal resistivity of soil (g) in K.m/W		0,75	1,0	1,0	1,5
Correction factor		1,00	0,95	0,92	0,90

NOTE: The correction factors may be cumulated for different situations and they apply to a single circuit.

Note: Unlike the reduction factors shown in tables 1 and 2, which apply to the 30 ºC fixed isotherm, the critical isotherm for this table has been calculated depending on the groundwater level, the soil temperature and the thermal resistivity of soil. The isotherm calculated for these cases varies from 25 to 50 ºC.

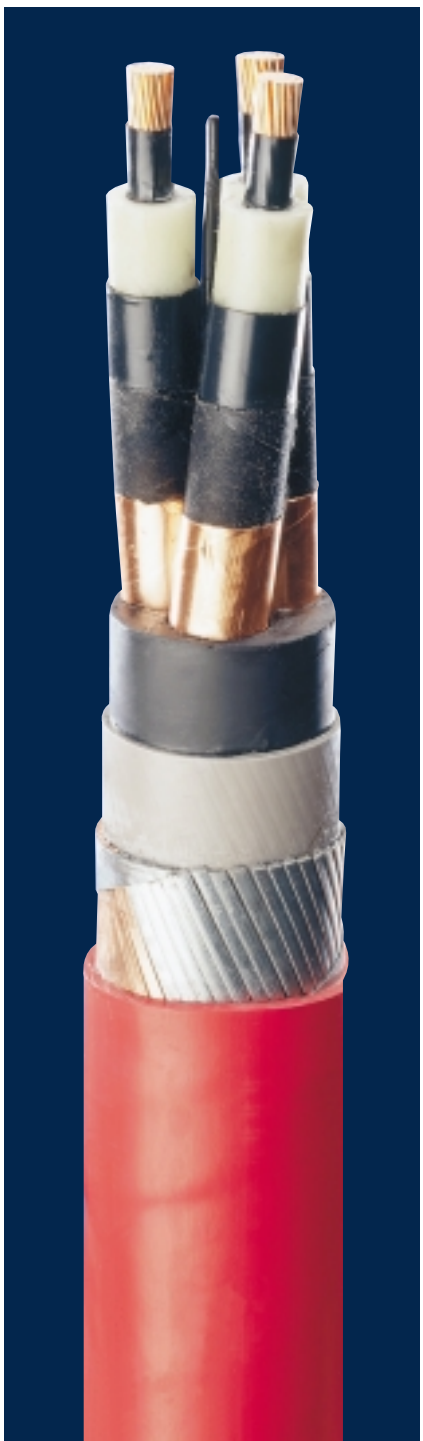
Table 4: Correction factors for different air temperatures

Air temperature, in ºC	15	20	25	30	35	40
Correction factor	1,14	1,10	1,05	1,00	0,95	0,90

NOTE: The correction factors also apply to several circuits under the conditions specified in NPR 3626 4.1.

DESIGN OF TWENPOWER THREE-CORE MEDIUM-VOLTAGE CABLES

characteristics:
- three circular cores, copper conductor, armoured, longitudinally watertight to a limited extent, flame-retardant PVC outer sheath.
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength;
- application: industry, non-residential construction and related fields.



Design:

conductors
circular conductors made up of copper wires (compacted).

conductor screen
semi-conductive polymer layer of at least 0.5 mm thick.

insulation
high-quality XLPE

insulation screen
semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen
copper foil on each core for capacitive loading current in a bedding of conductive (swelling) tape.

filling
interspaces between the three cores are filled to create a circular bedding for further construction. Rubber-based filling.

inner sheath
PVC

armouring
steel wires + copper wires for short-circuit current (in most cases 50 mm^2 copper wire).

outer sheath
Flame-retardant PVC.

options
lead sheath, especially designed for contaminated soils, as found in the petrochemical industry.

Flame-retardant, halogen-free version

cable designation
VG-YMvKrvasmb ../.. kV 3 x .. rs+as ..

Characteristics of Twenpower three-core medium-voltage cables rated 6/10 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 16	16	5,0	13,8	44,2	51	4,4	0,135	0,19
3 x 25	25	6,0	14,8	46,5	53	5,0	0,127	0,21
3 x 35	25	7,1	15,9	49,0	56	5,6	0,101	0,23
3 x 50	50	8,2	17,0	51,6	59	6,5	0,115	0,25
3 x 70	50	9,9	18,7	55,7	63	7,7	0,109	0,29
3 x 95	50	11,5	20,3	59,3	67	8,9	0,104	0,32
3 x 120	50	13,0	21,8	62,8	71	10,2	0,100	0,35
3 x 150	50	14,5	23,3	66,4	75	11,7	0,097	0,38
3 x 185	50	16,1	24,9	70,0	79	13,2	0,094	0,41
3 x 240	50	18,6	27,4	75,8	85	15,8	0,091	0,46

Characteristics of Twenpower three-core medium-voltage cables rated 8.7/15 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 16	16	5,0	16,1	49,7	57	5,3	0,143	0,16
3 x 25	25	6,0	17,1	51,9	59	5,9	0,135	0,17
3 x 35	25	7,1	18,2	54,4	62	6,5	0,128	0,19
3 x 50	50	8,2	19,3	57,1	65	7,4	0,122	0,20
3 x 70	50	9,9	21,0	61,1	69	8,7	0,115	0,23
3 x 95	50	11,5	22,6	64,7	73	10,0	0,110	0,25
3 x 120	50	13,0	24,1	68,3	77	11,3	0,106	0,28
3 x 150	50	14,5	25,6	71,9	81	13,0	0,103	0,30
3 x 185	50	16,1	27,2	75,4	85	14,4	0,099	0,32
3 x 240	50	18,6	29,6	81,3	91	17,1	0,095	0,36

Characteristics of Twenpower three-core medium-voltage cables rated 12/20 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 25	25	6,0	19,3	56,9	65	6,7	0,142	0,15
3 x 35	25	7,1	20,4	59,4	67	7,4	0,135	0,16
3 x 50	50	8,2	21,5	62,1	70	8,4	0,128	0,18
3 x 70	50	9,9	23,2	66,1	74	9,6	0,120	0,20
3 x 95	50	11,5	24,8	69,7	78	11,0	0,114	0,22
3 x 120	50	13,0	26,3	73,2	82	12,4	0,110	0,24
3 x 150	50	14,5	27,8	76,8	86	13,9	0,106	0,25
3 x 185	50	16,1	29,4	80,4	90	15,6	0,103	0,27

Characteristics of Twenpower three-core medium-voltage cables rated 18/30 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 35	25	7,1	25,7	71,9	81	10,0	0,148	0,13
3 x 50	50	8,2	26,8	74,4	83	10,9	0,141	0,14
3 x 70	50	9,9	28,5	78,4	88	12,3	0,132	0,15
3 x 95	50	11,5	30,1	82,2	92	13,8	0,126	0,17
3 x 120	50	13,0	31,6	85,6	96	15,3	0,122	0,18
3 x 150	50	14,5	33,1	89,1	99	16,9	0,117	0,19

Continuous current rating of underground or overhead three-core cables.

nominal core c.s.a.	continuous current rating (in A) of three-core cable with Cu conductor. 10-30 kV	
mm^2	underground	overhead
16	105	115
25	135	145
35	160	175
50	185	210
70	225	260
95	270	315
120	300	360
150	335	410
185	380	460
240	435	540

The continuous current rating applies to the following conditions, in line with NPR 3626:

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The cables are earthed at either end.

In calculating the current-carrying capacity, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.[1])
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 5, 6 and 7, respectively.

OVERHEAD

- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that: the area in which it is installed, should be sufficiently large, or it should be ventilated;
- the cables are protected from direct solar radiation or radiation from other heat sources;
- the distance between the cable perimeter and a wall, floor, etc. should at least be 0,3 times the cable outer diameter;
- if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
- if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
- the racks are open; they are, for instance, made of perforated plate.

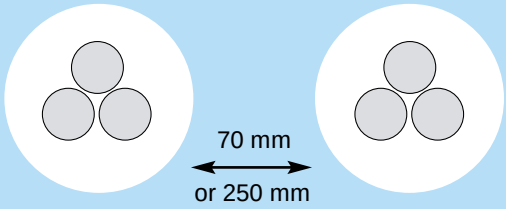
For different air temperatures, refer to Table 8.

[1]) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

Table 5: Correction factors for different soil temperatures

Soil temperature, in ºC	5	10	15	20	25
Correction factor	1,14	1,07	1,00	0,92	0,83

Table 6: Correction factors for different thermal resistivities of soil and/or parallel circuits of cable.



	number of parallel cable circuits				
g	1	2		3	
		spacing in mm			
K.m/W		70	250	70	250
0,5	1,11	0,87	0,93	0,75	0,82
0,75	1,00	0,78	0,83	0,68	0,74
1,0	0,94	0,74	0,79	0,64	0,70
1,2	0,91	0,71	0,77	0,62	0,68
1,5	0,88	0,69	0,73	0,59	0,65

NOTE: This table is valid for a soil temperature of 15 ºC only. The correction factors have been determined using the double-shell model, starting from the 30 ºC critical isotherm.

Table 7: Correction factors depending on the groundwater level, soil temperature and thermal resistivity of soil (g) for three-core cables.

Groundwater level, in metres	2	3	4	5	
Correction factor	1,10	1,04	1,00	0,99	
Soil temperature, in ºC	5	10	15	20	25
Correction factor	1,12	1,06	1,00	0,94	0,88
Thermal resistivity of soil (g) in K.m/W		0,75	1,0	1,2	1,5
Correction factor		1,00	0,95	0,92	0,90

Note: Unlike the reduction factors shown in tables 5 and 6, which apply to the 30 ºC fixed isotherm, the critical isotherm for this table has been calculated depending on the groundwater level, the soil temperature and the thermal resistivity of soil. The isotherm calculated for these cases varies from 25 to 50 ºC.

Table 8: Correction factors for different air temperatures

Air temperature, in ºC	15	20	25	30	35	40
Correction factor	1,14	1,10	1,05	1,00	0,95	0,90

NOTE: The correction factors also apply to several circuits under the conditions specified in NPR 3626 4.1.

TWENPOWER KUDI THREE-CORE CABLES

DESIGN OF TWENPOWER THREE-CORE PLASTIC DISTRIBUTION CABLES

characteristics:
- three circular cores with solid aluminium conductors, unarmoured, longitudinally and quasi transversally watertight, PE outer sheath.
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength.
- application: industry, non-residential construction and related fields.

Design:

conductors
circular conductors made of solid aluminium.

conductor screen
semi-conductive polymer layer of at least 0.5 mm thick.

insulation
high-quality XLPE

insulation screen
semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

filling
interspaces between the three cores are filled with rubber filling wires. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen
copper wires with an open pattern counterwound copper strip. This layer is covered by a bedding of swelling tape to ensure longitudinal watertightness.

outer sheath
abrasion-resistant PE (ST7)

cable designation
YMeKrvaslqwd ../.. kV 3 x ..Alrm+as ..

Twenpower three-core plastic distribution cables are available with glass fibre in the core as an option. This optical sensor is designed for temperature monitoring,
see page 15.

Characteristics of Twenpower plastic distribution cables								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable			
mm^2	mm	mm	mm	mm	mm	kg/m	Ω/km	µF/km
6/10 kV								
3 x 95	70	10,8	19,2	50,0	57	3,6	0,102	0,32
3 x 150	70	13,3	21,7	53,5	60	4,4	0,093	0,37
3 x 240	70	17,1	25,5	63,0	69	5,8	0,089	0,45
12/20 kV								
3 x 240	70	17,1	29,7	70,3	78	7,1	0,098	0,30

Continuous current rating of underground or overhead three-core cables

nominal core c.s.a.	continuous current rating (in A) of three-core plastic distribution cable with Al conductor 10-20 kV	
mm^2	underground	overhead
95	215	250
150	280	330
240	360	455

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The cables are earthed at either end.

In calculating the current-carrying capacity, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.*)
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 5, 6 and 7, respectively.

*) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

OVERHEAD

- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that:
  - the area in which it is installed, should be sufficiently large, or it should be ventilated;
  - the cables are protected from direct solar radiation or radiation from other heat sources;
  - the distance between the cable perimeter and a wall, floor, etc. should at least be 0,3 times the cable outer diameter;
  - if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
  - if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
  - the racks are open; they are, for instance, made of perforated plate.

For different air temperatures, refer to Table 8.

TRANSFORMER CONNECTION CABLE

characteristics:
- easy to install thanks to a strippable insulation screen.
- single-core flexible cable, circular stranded copper conductor, strippable insulation screen, flame-retardant PVC sheath for overhead cables (flexible PE sheath (LLDPE) for underground cables).
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength.

Design:

conductor:
circular conductors made up of copper wires (compacted). 1x16 mm² and 1x25 mm²

conductor screen:
as for standard cable.

insulation:
high-quality XLPE

insulation screen:
strippable, 0.8 mm nominal thickness.
Especially for ease of installation when it comes to making short connections, such as in transformer stations involving many terminations.

earthing screen:
wire screen on top of semi-conductive binding.
Mainly used in open-air installations, so no need for longitudinally watertight construction.

sheath:
Flame-retardant PVC

options:
earthing screen made from copper strip.
sheath:
- LLDPE + longitudinally watertight construction (for underground cables).
- PUR (for abrasion-resistant applications).

nominal core c.s.a.	earthing screen c.s.a.	diameter over				
		conductor	insulation	earthing screen	cable	weight
mm²	mm²	mm	mm	mm	mm	kg/m
				8,7/15 kV		
1 x 16[1])	2[2])	5,0	15,2[3])	16,6	22	0,59
1 x 16	16	5,0	16,0	18,7	24	0,77
1 x 25	16	6,0	17,4	21,4	30	1,05
				12/20 kV		
1 x 25	16	6,0	19,5	22,9	29	1,07

nominal core c.s.a.	designation with sheath of		reactance (at 50 Hz)		capacitance (at 50 Hz)
			trefoil	flat	
mm²	PVC	LLDPE	Ω/km	Ω/km	µF/km
				8,7/15 kV	
1 x 16[1])	YMvK	-	n.v.t.	n.v.t.	0,15
1 x 16	YMvK	YMeK	0,158	0,257	0,14
1 x 25	YMvK	YMeK	0,161	0,250	0,15
				12/20 kV	
1 x 25	YMvK	YMeK	0,160	0,250	0,13

[1]) especially in combination with certain switchgear.
[2]) copper strip instead of copper wire.
[3]) insolation thickness is not in line with NEN 3620.

LEAD-SHEATED CABLE

characteristics:
- lead sheath
- transversally watertight
- A copper wire screen enveloping the lead sheath if short-circuit currents require this.
- application: all cross-sectional areas of single-core and three-core medium-voltage cables.
- petrochemical industry: if chemically contaminated soil is suspected. Heavier construction, e.g. for submarine cables.

Design:

sheath:
PVC

options:
designs according to customer specifications.

TKF: HIGH-QUALITY CABLES FOR EVERY CONCEIVABLE APPLICATION

The Twentsche Kabelfabriek (TKF), founded in 1930, has grown into a leading producer of high-quality cables and offers a comprehensive range of cables for every conceivable application.

With a market-oriented management we keep a close track of market and technical developments. Decisive product development, focusing on continuous improvement and professionalizing, results in new cable designs, offering exactly those properties meeting the requirements and needs of the market.

TKF's intrinsic quality is clearly reflected in its ample awareness of investing in skilled staff members and ultra-modern production technologies. This quality can also be seen in the quality approach set up in line with the NEN/ISO 9001 standard and in the multitude of cables bearing the KEMA quality insurance label. In addition, TKF possesses the ISO 14001 environmental certificate, in which a continuous improvement process for production, waste processing as well as recycling has been laid down.

A flexible organizational form guarantees fast and punctual delivery: our word is our bond. For many years now TKF has been a constant factor, on which its customers have always been able to build. This goes to show that TKF is a reliable partner for a long-term business relationship, which is to the benefit of all parties concerned.

Should you wish any further information about Twenpower cables as well as other cables, please contact our Sales Department.

BV TWENTSCHE KABELFABRIEK

TKF: high-quality cables for every conceivable application

BV Twentsche Kabelfabriek, Spinnerstraat 15, P.O. Box 6, 7480 AA Haaksbergen,
The Netherlands Telephone +31(0)53-573 22 55, Telefax +31(0)53- 573 21 84
www.tkf.nl

2000-01