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MANUAL FOR SELECTION, INSTALLATION AND OPERATION OF CABLES WITH CROSS-LINKED POLYETHYLENE INSULATION with a voltage of 6-35 kV

Sixth Edition

CONTENTS

INTRODUCTION

This manual provides recommendations on the selection, transportation and storage, the technological process of installation and operation of cable lines with cross-linked polyethylene insulation with a voltage of 6–35 kV.

1. SCOPE OF APPLICATION

The cables are intended for transmission and distribution of electric power in stationary installations with a rated AC voltage of 6, 10, 15, 20, and 35 kV and a rated frequency of 50 Hz for networks with grounded and insulated neutral.
The construction, technical characteristics and performance properties of the cables comply with national standard GOST R 55025–2012, international standard IEC 60502-2 and technical committee Harmonization Documents HD 620 S2[2] and HD 605 S2[3].

Cable characteristics, scope of application	**Manufactured according to technical specifications (TU)**
Cables with a voltage of 6 kV	TU 16.K71-359–2005
Cables with a voltage of 10, 15, 20, 35 kV	TU 16.K71-335–2004
Cables with a voltage of 6, 10, 20, and 35 kV for cold regions	TU 3530-033-05742781–2010
Cables with a voltage of 6, 10, 20 and 35 kV, flame-retardant including low smoke and fume emission characteristics	TU 16.K22-028–2007
Cables with a voltage of 6, 10, 20 and 35 kV, with wire armoring	TU 3530-031-05742781–2009
Cables with a voltage of 6, 10, 15, 20 and 35 kV, with aluminum wire screen	TU 3530-042-05742781–2013
Cables with a voltage of 6, 10 and 35 kV	TU 3530-046-05742781–2015
Cables with a voltage of 6, 10, 15, 20 and 35 kV	TU 3530-050-05742781–2016
Cables with a voltage of 6, 10, 15 and 20 kV with sector-shaped current-carrying conductors, including flame-retardant	TU 3530-039-05742781–2016

The climatic version is U, UKhL, location categories are 1 and 2 according to GOST 15150–69 including laying in ground and water. Cables according to TU 3530-033-05742781–2010 may be used under KhL conditions of location categories 1 and 2 according to GOST 15150–69.
Cables according to TU 3530-031-05742781–2009 may be used under UKhL conditions of location categories 1 and 5 including laying in ground and water as well as cables may be used under UKhL1a, UKhL5a conditions according to GOST 15150–69.

Examples

Examples of cable ordering codes and designation codes in documentation for other products:

- Cable of PvP type with one copper multiwire round conductor of a cross-section of 120 mm^2, a copper screen of a cross-section of 16 mm^2, with a voltage of 35 kV:

  Cable PvP 1×120mk/16–35 TU 16.K71-335–2004

- Cable of APvV-KhL type with three aluminum multiwire round conductors of a nominal cross-section of 240 mm^2, a copper screen of a nominal cross-section of 25 mm^2, with a voltage of 10 kV:

  Cable APvV-KhL 3×240mk/25–10 TU 3530-033-05742781–2010

- Cable of APvPu2g type with one aluminum multiwire round conductor of a nominal cross-section of 400 mm^2, a copper screen of a nominal cross-section of 35 mm^2, with a voltage of 6 kV, with longitudinal and transverse water blocking:

  Cable APvPu2g 1×400mk/35–6 TU 16.K71-359–2005

- Cable of PvVng(V)-LS type with three copper multiwire round conductors of a nominal cross-section of 95 mm^2, a copper screen of a nominal cross-section of 16 mm^2, with a voltage of 10 kV:

  Cable PvVng(V)-LS 3×95mk/16–10 TU 16.K22-028–2007

- Cable of APvEaPg type with one aluminum multiwire round conductor of a cross-section of 500 mm^2, an aluminum screen of a cross-section of 60 mm^2, with a voltage of 35 kV:

  Cable APvEaPg 1×500mk/60–35 TU 3530-042-05742781–2013

- Cable of PvKPg type with three copper multiwire round conductors of a nominal cross-section of 150 mm^2, a copper screen of a nominal cross-section of 25 mm^2, a zinc-coated steel wire armoring, with a voltage of 10 kV:

  Cable PvKPg 3×150mk/25–10 TU 3530-031-05742781–2009

- Cable of PvV type with one copper multiwire round conductor of a cross-section of 120 mm^2, a copper screen of a cross-section of 16 mm^2, with a voltage of 20 kV:

  Cable PvV 1×120mk/16–20 TU 3530-050-05742781–2016

- Cable of APvBVng(A)-LS type with three aluminum multiwire round conductors of a nominal cross-section of 70 mm^2, a copper screen of a nominal cross-section of 16 mm^2, an armor of 2 zinc-coated steel tapes, with a voltage of 10 kV:

  Cable APvBVng(A)-LS 3×70mk/16–10 TU 3530-046-05742781–2015

- Cable of PvVng(A)-LS type with three copper multiwire sector-shaped conductors of a nominal cross-section of 240 mm^2, a copper screen of a nominal cross-section of 25 mm^2, with a voltage of 6 kV:

  Cable PvVng(A)-LS 3×240ms/25–6 TU 3530-039-05742781–2016

The cables are manufactured with one or three cores. Cable types, construction elements and fire hazard designations according to GOST 31565 are given in Table 1.

Table 1. Cable types, construction elements, fire hazard designation.

Type of cable	Construction elements	Fire hazard designation
APvP PvP	One or three current-carrying conductors, cross-linked polyethylene insulation, polyethylene jacket	O2.8.2.5.4
APvPu PvPu	The same, in a reinforced polyethylene jacket	
APvV PvV	One or three current-carrying conductors, cross-linked polyethylene insulation, PVC plastic jacket	O1.8.2.5.4
APvV-KhL PvV-KhL		
APvVng(A)-LS PvVng(A)-LS	One or three current-carrying conductors, cross-linked polyethylene insulation, low fire hazard PVC plastic jacket	P1b.8.2.2.2
APvVng(V)-LS PvVng(V)-LS		P2.8.2.2.2
APvBP PvBP	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, polyethylene jacket	O2.8.2.5.4
APvBV PvBV	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, PVC plastic jacket	O1.8.2.5.4
APvBV-KhL PvBV-KhL		
APvBVng(A)-LS PvBVng(A)-LS	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, low fire hazard PVC plastic jacket	P1b.8.2.2.2
APvBVng(V)-LS PvBVng(V)-LS		P2.8.2.2.2
APvVng(A)-KhL PvVng(A)-KhL	One or three current-carrying conductors, cross-linked polyethylene insulation, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvVng(V)-KhL PvVng(V)-KhL		P2.8.2.5.4
APvBVng(A)-KhL PvBVng(A)-KhL	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, fire-resistant PVC plastic jacket	P1b.8.2.5.4

Table 1, continued.

Type of cable	Construction elements	Fire hazard designation
APvBVng(V)-KhL PvBVng(V)-KhL	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, fire-resistant PVC plastic jacket	P2.8.2.5.4
APvVng(A) PvVng(A)	One or three current-carrying conductors, cross-linked polyethylene insulation, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvVng(V) PvVng(V)		P2.8.2.5.4
APvBVng(A) PvBVng(A)	Three current-carrying conductors, cross-linked polyethylene insulation, metal tape armoring, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvBVng(V) PvBVng(V)		P2.8.2.5.4
APvVng(A) PvVng(A)	One or three current-carrying conductors, cross-linked polyethylene insulation, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvVng(V) PvVng(V)		P2.8.2.5.4
APvKaP PvKaP	One current-carrying conductor, cross-linked polyethylene insulation, aluminum wire armoring, polyethylene jacket	O2.8.2.5.4
APvKaV PvKaV	One current-carrying conductor, cross-linked polyethylene insulation, aluminum wire armoring, PVC plastic jacket	O1.8.2.5.4
APvKaV-KhL PvKaV-KhL		
APvKP PvKP	Three current-carrying conductors, cross-linked polyethylene insulation, zinc-coated steel wire armoring, polyethylene jacket	O2.8.2.5.4
APvKV PvKV	Three current-carrying conductors, cross-linked polyethylene insulation, zinc-coated steel wire armoring, PVC plastic jacket	O1.8.2.5.4
APvKV-KhL PvKV-KhL		

Table 1, continued.

Type of cable	Construction elements	Fire hazard designation
APvKaVng(A)-KhL PvKaVng(A)-KhL	One current-carrying conductor, cross-linked polyethylene insulation, aluminum wire armoring, fire-resistant PVC plastic jacket	O1.8.2.5.4
APvKaVng(A)-KhL PvKaVng(A)-KhL	Three current-carrying conductors, cross-linked polyethylene insulation, zinc-coated steel wire armoring, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvKaVng(V)-KhL PvKaVng(V)-KhL		P2.8.2.5.4
APvEaP PvEaP	One or three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, polyethylene jacket	O2.8.2.5.4
APvEaV PvEaV	One or three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, PVC plastic jacket	O1.8.2.5.4
APvEaVng(A) PvEaVng(A)	One or three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, fire-resistant PVC plastic jacket	P1b.8.2.5.4
APvEaVng(A)-LS PvEaVng(A)-LS	One or three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, low fire hazard PVC plastic jacket	P1b.8.2.2.2
APvEaBP PvEaBP	Three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, metal tape armoring, polyethylene jacket	O2.8.2.5.4
APvEaBV PvEaBV	Three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, metal tape armoring, PVC plastic jacket	O1.8.2.5.4
APvEaBVng(A) PvEaBVng(A)	Three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, metal tape armoring, fire-resistant PVC plastic jacket	P1b.8.2.5.4

Table 1, end.

Type of cable	Construction elements	Fire hazard designation
APvEaBVng(A)-LS PvEaBVng(A)-LS	Three current-carrying conductors, cross-linked polyethylene insulation, aluminum wire screen, metal tape armoring, low fire hazard PVC plastic jacket	P1b.8.2.2.2

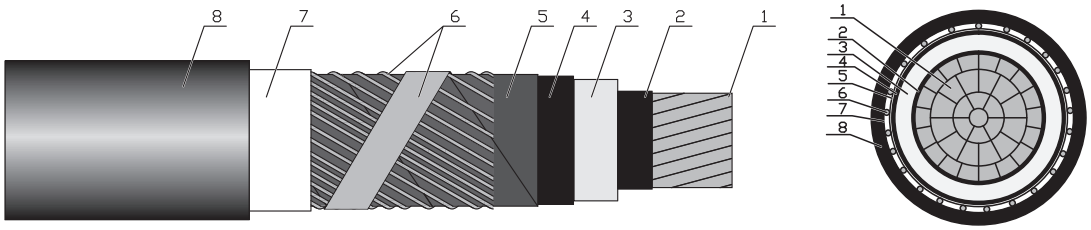
* The "numerator" contains types of cables with aluminum current-carrying conductors, the "denominator" contains types of cables with copper current-carrying conductors.

Notes

1. "KhL" suffix to the cable type designation means that cable construction contains cold-resistant materials.
2. "ng(A;V)-LS" letters in the type designation mean Low Smoke.
3. "ng(A;V)" letters in the type designation mean that cable construction contains non-combustible materials.
4. "B" letter in the type designation means that zinc-coated steel tape armor is used.
5. "Ka" letters in the type designation mean that an aluminum round wire armor is used.
6. "K" letter in the type designation means that a steel round wire armor is used.

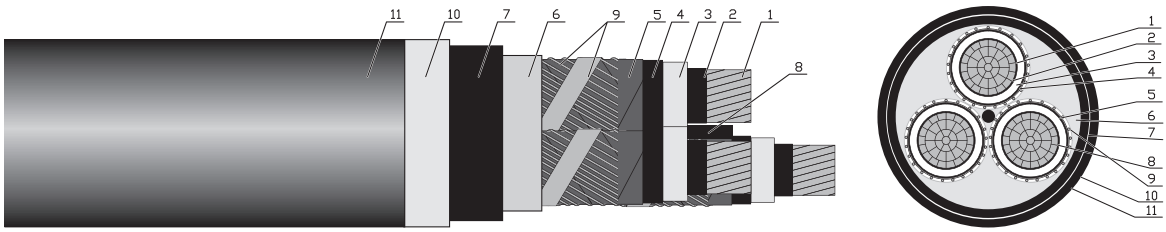
- If the construction of cables of APvP, PvP, PvBP, APvBP, PvPu, APvPu, APvKP, PvKP, APvKaP, PvKaP, APvEaP, PvEaP, PvEaBP, APvEaBP, PvEaPu, and APvEaPu types contains sealing elements, the following letters are added to the cable type designation:
  - g – water-blocking tapes for metal screen sealing, for example, PvPg;
  - 2g – additional polymer coated aluminum tape over the sealed screen, for example, PvP2g
  - 2gzh – additional longitudinal sealing of current-carrying conductors with water-blocking threads, for example, PvP2gzh.
- In cables with aluminum alloy wire armor, "as" letters are used in the cable type designation instead of "a" letter, for example, PvKasP.
- In cables with aluminum alloy wire screen, "as" letters are used in the cable type designation instead of "a" letter, for example, APvEasPg.
- For cable types with "ng-LS" letters in the type designation, depending on the flame spread limit according to the classification of GOST 31565–2012, the following letters are added to the type designation:
  - A – flame spread limit PRGP 1b, for example PvVng(A)–LS;
  - V – flame spread limit PRGP 2, for example PvVng(V)–LS;

A schematic view of a single and three core cable is shown in Figures 1 and 2.



1. copper current-carrying conductor;
2. cross-linked polyethylene compound screen;
3. cross-linked polyethylene insulation;
4. cross-linked polyethylene compound screen;
5. a layer of current-conducting polymer tape or crepe paper;
6. screen of copper wires fastened with a copper tape or skein;
7. inner sheath of low fire hazard PVC plastic;
8. thermal barrier of 2 glass tapes
9. jacket of low fire hazard PVC plastic.

Figure 1. Single core cable construction.
Cable of PvVng(A)-LS type according to TU 16.K71-335–2004.



1. copper current-carrying conductor;
2. cross-linked polyethylene compound screen;
3. cross-linked polyethylene insulation;
4. cross-linked polyethylene compound screen;
5. a layer of current-conducting polymer tape or crepe paper;
6. inner sheath of chalk-filled compound;
7. armor polyethylene bedding;
8. central filler;
9. screen of copper wires fastened with a copper tape;
10. armor of 2 zinc-coated steel tapes;
11. polyethylene jacket.

Figure 2. Three core cable construction.
Cable of PvBP type according to TU 16.K71-359–2005.

The cables are intended for use in AC voltage networks with isolated or grounded neutral of “A”, “B” and “C” categories in accordance with international standard IEC 60183[6].
The electrical network category is characterized by duration of overvoltage in the network caused by a single-phase ground fault. Category “A” includes networks that remain operational

for not longer than 1 minute after a ground fault. Category “B” includes networks that remain operational for not longer than 1 hour after a single-phase ground fault. Category “C” includes all the networks that are not included in either category “A” or category “B”. The rated voltage of the cables recommended for use in three-phase networks of the corresponding categories is given in Table 2.

Table 2. The cable rated voltage is selected depending on the network category.

Maximum network voltage, U_m, kV	**Rated cable voltage, U_0/U, kV**	
	Network category “A” and “B”	**Network category “C”**
7.2	3.6/6	6/10
12	6/10	8.7/15
17.5	8.7/15	12/20
24	12/20	18/30
42	20.2/35	20.2/35

Cables are laid and installed based on the documentation approved in accordance with the established procedure and developed taking into account the requirements of the applicable Regulations for Electrical Installations and building standards.

WARNING! Laying a single core cable in a steel pipe is not permitted.

The cables are intended for use in a stationary state at an ambient temperature of:
- from minus 60 °C to plus 50 °C for cables with “KhL” suffix.
- from minus 60 °C to plus 50 °C for cables with a polyethylene jacket;
- from minus 50 °C to plus 50 °C for other cables.

The cables should be resistant to high air humidity up to 98% at an ambient temperature of 35 °C. Waterproof cables should be resistant to longitudinal moisture migration when jacket is damaged. Water ingress into cable should not exceed 1,500 mm on either side of the jacket fault location.

The main applications of cables taking into account their type are given in Table 3.
Table 3. Main applications of cables

Cable type	**Fire hazard designation**	**Main application**
Without designation	O1.8.2.5.4	For laying a single cable in cable structures and industrial spaces Laying groups of cables is permitted only in outdoor electrical installations and industrial spaces attended by service personnel only occasionally and requires passive fire protection.

Cable type	Fire hazard designation	Main application
ng(A) ng(A)-KhL ng(V) ng(V)-KhL	P1b.8.2.5.4 P2.8.2.5.4	For laying in open cable structures (overhead tray systems, galleries) of outdoor electrical installations taking into account cable fire performance.
ng(A)-LS ng(V)-LS	P1b.8.2.2.2 P2.8.2.2.2	For laying in indoor electrical installations as well as in buildings, structures and closed cable structures taking into account cable fire performance.
Note. The main scope of application of waterproof cables was expanded to include the use in areas where moisture penetration into the cable is possible.		

Cables with a polyethylene jacket are intended for operation when laid in ground regardless of the degree of soil corrosion activity. These cables may be laid in air, including in cable structures, provided that additional fire protection measures are taken, for example, application of flame-retardant coatings.

It is permitted to lay the cables within complex sections of routes containing more than 4 turns at an angle greater than 30 degrees or straight sections with more than four crossings in pipes longer than 20 m or with more than two crossings in pipes longer than 40 m.

Cables of the said types with “g”, “2g” and “2gzh” characters in the type designation are intended for laying in ground,as well as in water (in non-navigable water bodies) if measures preventing mechanical damage to the cable are adopted.

Cables with a PVC plastic, low fire hazard PVC plastic or fire-resistant PVC plastic jacket can be laid in explosion hazardous areas of any category.

The cables are intended for installation on routes with unlimited elevation difference.

Single core cables with aluminum wire armor (“Ka” letters in the cable type designation) are intended for operation without tensile loads during operation if measures preventing mechanical damage to the cable are adopted.

Single core cables with aluminum alloy wire armor (“Kas” letters in the cable type designation) and three core cables with steel wire armor (“K” letter in the cable type designation) are intended for laying on routes where they may be exposed to tensile forces during operation including laying in seismically active areas, in areas where soil displacement is possible, in permafrost conditions and in earth banked areas. The seismic resistance of cables is ensured when exposed to earthquakes of up to “IX” intensity degree according to MSK-64[8] scale.

Three core cables with steel tape armor or single core cables with aluminum tape or aluminum alloy tape armor are intended for operation without tensile loads during operation if measures preventing mechanical damage to the cable are adopted.

Cables, including armored ones, with a PVC plastic and fire-resistant PVC plastic jacket, intended for laying cable lines in dry soils, in air.

Cables, including armored ones, with a low fire hazard PVC plastic jacket, intended for use in cable power transmission lines and laid in groups in air in cable structures and spaces where higher requirements for smoke density during a fire apply.

2. TRANSPORTATION AND STORAGE OF CABLES

Storage of reels with cable as well as their transportation should be in accordance with GOST 18690.
When performing transportation as well as loading and unloading operations there should be observed the following conditions:

- ends of the cables during transportation and storage should be secured and sealed with heat-shrinkable caps to prevent water penetration;
- reels should be always kept in a vertical position;
- reels should be lifted, it is prohibited to drop or roll reels;
- each reel should be secured separately;
- reels with cable should be loaded and unloaded using lifting equipment of the required lifting capacity in compliance with the applicable safety rules.

It is permitted to store cables on reels wrapped at outdoor sites for not more than 2 years, under an overhead roof for not more than 5 years and indoors (in warehouses) for not more than 10 years.

3. CABLE LAYING INSTRUCTIONS

3.1. General instructions

- Cable laying may commence only if a method statement is in place. Cables should be laid by a specialized installation organization that has the appropriate equipment, accessories, tools, materials and qualified personnel.
- By the time the cable laying works commence there should be fully completed all erection works involving construction of tunnels, ducts, overpasses and wells, including installation of embedded parts for securing cable structures, and finishing works as well as installed electric lighting, ventilation, fire extinguishing and drainage systems. Trenches and blocks for laying cables should be fully prepared in accordance with requirements of SNiP 3.05.06 by the time the works commence.
- The laying technology described in the Manual applies to methods of cables laying in ground (trenches), cable structures, in blocks (pipes) and in industrial spaces.
- The cable laying process should also comply with the applicable standards and rules stipulated by other regulatory documents approved or agreed upon in accordance with the established procedure.
- In the process of laying the cables should be pulled using a cable pulling wire stocking secured to the cable jacket or using a wedge grip secured to the current-carrying conductor. Cable pulling forces that arise during cable laying should not exceed the values calculated using the formula:

$$P = \sigma \times S$$

where P is the cable pulling force, N (kgf)
S is the cable conductor cross-sectio, mm^2
σ is the maximum permissible mechanical stress in the cable conductor when cable is pulled, equal to:

50 N/mm^2 (5.1 kgf/mm^2) for cables with a copper conductor;
30 N/mm^2 (3.06 kgf/mm^2) for cables with an aluminum conductor.

- The minimum cable bending radius during laying should be not less than
  $15D_e$ – for single core cables,
  $12D_e$ – for three core cables,
  where D_e is the external diameter of the cable.
- When laying single core cables using a special forming board, a minimum cable bending radius of $7.5D_e$ is acceptable and it is recommended to heat the point of cable bending to a temperature of 20 °C.
- The number of cable bends at an angle of up to 90 °C on the lying routes should not exceed 8 over the cable factory length.
- Cables should be laid with a length reserve of 1–2% sufficient to compensate for thermal deformations of cables and structures as well as possible soil displacements. In trenches and inside buildings and structures the cable reserve is formed by laying it on a solid surface in a serpentine manner and on cable structures (racks) – by letting the cable sag.

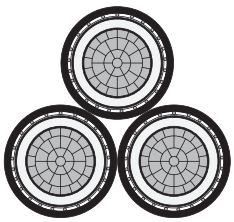
WARNING! Laying the cable reserve in the form of coils (turns) is prohibited!

- Cable metal structures should be grounded in accordance with the Regulations for Electrical Installations and SNiP 3.05.06.
- When a cable line is laid, cables of three phases should be laid in parallel in a trefoil or flat formation as shown in Figure 3.
- When cables are laid in a flat formation, the distance between outer surfaces of two adjacent cables in one cable line should not be less than the cable external diameter.
- Cables in a trefoil formation are fastened along the cable line length (except for sections near joints or terminations) with fasteners spaced 1–1.5 m and 1 m at points where the route turns. It should be taken into account that cables laid in ground should not change their position when they are backfilled.
- Cables laid in cable structures in a flat formation in air should be fastened with a spacing of 1 to 1.5 m along the cable line length.
- Individual cables should be laid in such a way that there are no closed magnetic metal loops around each of them.
- When fastening cables, it is necessary to take into account possible thermal expansion of cables and mechanical loads that occur during short circuits.

3.2. Cable laying methods

Cables with cross-linked polyethylene insulation can be laid in ground (in trenches), in cable spaces (tunnels, galleries, overpasses), in blocks (pipes), in industrial spaces (in cable ducts, on walls). The cable laying method is selected at the cable line design stage.

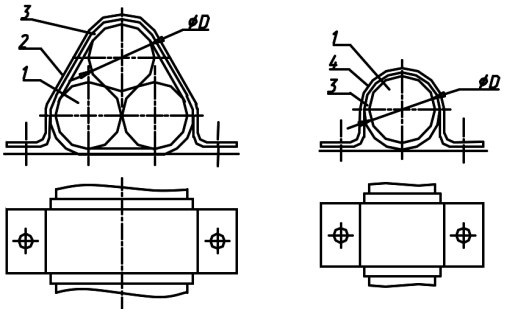
Consideration should be given to the following:
– When laid in ground, it is recommended to lay not more than six cables in one trench. When the number of cables is greater than six, it is recommended to lay them in separate trenches or in ducts, tunnels, on overpasses and in galleries.
– Laying cables in tunnels, on overpasses and in galleries is recommended when the number of cables running in one direction is greater than twenty.
– Cable laying in blocks is used when there is a serious lack of space on the route, at intersections with railways and roads, when the risk of metal spills exists, etc.



a). Trefoil formation

b). Flat formation

Figure 3. Cable laying methods.



1. Cable;
2. Metal clamp (bracket);
3. Elastic gasket;
4. A metal clamp (bracket) of non-magnetic material.

Figure 4. Methods of cable fastening with clamps.

– Cables should be fastened in such a way as to prevent deformation of cables under own weight and as a result of mechanical stresses from heating-cooling cycles and electromagnetic interactions under short circuit conditions.

3.2.1. Cable laying in ground

- In cable lines laid in ground the cables are laid in trenches with a bedding underneath and backfill on top comprising sand and gravel mix or fine soil not containing stones or construction debris. Cables should be protected from mechanical damage along their entire length by reinforced concrete slabs, bricks or plastic warning tapes. Trenchless cable laying using cable ploughs is not permitted.
- The depth of cable laying in ground should be at least 0.7 m for cables of a rated voltage of up to 10 kV. If the depth of cable laying is less or if the route crosses with utility facilities and natural obstacles, additional protection should be provided (for example, laying in pipes).
- Cables should be protected from mechanical damage along their entire length by reinforced concrete slabs, bricks or plastic warning tapes.
- The soil for cable backfilling should not contain stones or other materials that could damage the cable.
- When cables are laid in trenches, the ends of the cables intended for subsequent installation of joints should be positioned with a connection point shift and there should be left a cable reserve at least 350 mm long at each end for cables with a rated voltage of up to and including 10 kV.
- For the installation of the joints on the route there should be excavated pits that are in alignment with the axis of the trench and have a width of at least 1.5 m for cables with a rated voltage of up to and including 10 kV and at least 1.7 m for cables with a higher rated voltage. The length of the pit for the installation of three joints in a staggered order is not less than 5 m for cables with a rated voltage of up to and including 10 kV and not less than 7 m for cables with a higher rated voltage.
- For cables protection at intersections with roads, utility facilities and natural obstacles as well as for the construction of cable blocks there should be used pipes (asbestos cement, ceramic, plastic or of other non-magnetic material). When laying three phases of one circuit in one pipe, it is permissible to use pipes of magnetic materials.

- The internal diameter of the pipe when laying one cable should be at least $1.5D_e$ but not less than 50 mm for pipes up to 5 m long and 100 mm for longer pipes. The internal diameter of the pipe when laying three cables in a trefoil formation should be at least $3D_e$ but not less than 150 mm.

3.2.1.1. Cable laying in permafrost soils

The depth of cable laying in permafrost soils is determined at the cable line design stage taking into account specific soil and climatic conditions.

- Local soil used for the backfilling of trenches should be crushed and compacted. No ice and snow in the trench is allowed.
- The soil for backfilling should be taken from places located at least 5 m away from the axis of the cable route. The soil in the trench after settling should be covered with a moss and peat layer.
- As additional measures to prevent frost cracks, the following should be used:
  — sand or gravel and pebble mix backfilling of trenches with cable;
  — construction of drainage ditches or cuts up to 0.6 m deep on both sides of the route at a distance of 2–3 m from its axis;
  — planting grass and shrubs on the cable route.

3.2.2. Cable laying in cable structures and industrial spaces

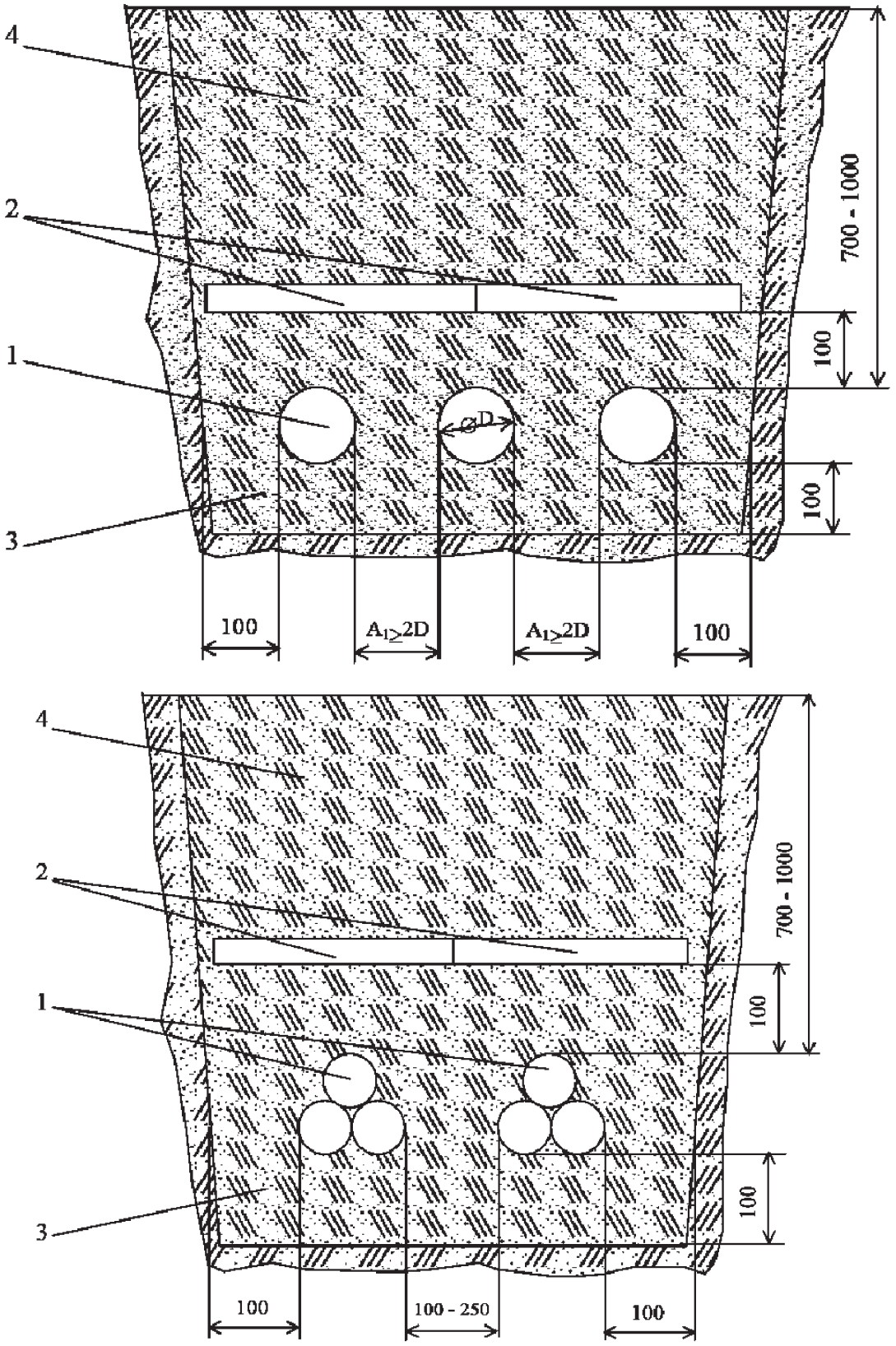
- When laying cables in air in cable structures and industrial spaces, it is necessary to use additional fire protection measures by applying special flame-retardant coatings approved by the fire safety inspectorate and manufacturer.
- It is recommended that in cable structures full factory lengths of cables should be laid avoiding the use of joints in them.
- The joints of cables laid in blocks should be installed in wells.
- Joints to be installed on a route comprising a tunnel accessible to service personnel that transitions to a semi-accessible tunnel or an inaccessible duct should be installed in the accessible tunnel.
- The structures for fastening cables and frames for fire partitions should be installed before cable laying in a cable tunnel.

WARNING! No welding in the tunnel after completion of cable laying is allowed.

- Bricklaying for the partitions can be done after cables have been laid observing the appropriate precautions.
- The distances between supporting structures are determined based on the design documentation and requirements of the Regulations for Electrical Installations. The design of the metal structures on which cables are laid should eliminate the possibility of cable jacket being damaged by sharp edges, burrs, etc.
- For joints installed in cable structures there should be provided separate shelves on the supporting structures for each joint.
- The cables laid horizontally on structures, walls, ceiling slabs, trusses, etc., should be rigidly secured at the end points, directly near the terminations, at the points where the route turns (on both sides of the bend) and near joints as well as along the route taking into account the above requirements.
- Cables laid horizontally on structures on open overhead tray systems, in addition to fastening in the points specified above, should be secured to prevent their displacement under wind loads

on straight horizontal sections of the route in accordance with the instructions given in the design documentation.

- Cables that are not tied in a trefoil formation should be secured to structures at points spaced 1 to 1.5 m along the cable line length (when laid on trays, in boxes or on solid shelves).
- Cables laid on consoles should be secured to each console. The distance between consoles should not exceed 1 m, the console useful length on straight sections of the route should not exceed 500 mm.
- Cables laid vertically on structures and walls should be secured to each cable structure. The cable fastening design should prevent jacket deformation and disruption of the conductor connections in joints under cable own weight. The fastening points are determined at the design stage.
- At the points of cable rigid fastening to structures there should be installed gaskets of an elastic material (e.g., soft rubber). The gaskets should extend beyond the edges of the clamps or brackets by about 5 mm in width.
- In order to prevent possible mechanical damage (vehicles traffic, movement of cargo and equipment, accessibility for unqualified personnel), cables indoors and outdoors should be protected to a safe height but not less than 2 m from the ground or floor level and to a depth of 0.3 m in the ground.
- Cable penetrations through walls, partitions and ceiling slabs in industrial spaces and cable structures should be made using sections of pipes (plastic, non-pressure asbestos cement, etc.) or open apertures. Gaps in pipe sections, holes and openings after laying cables should be filled in with non-combustible material (for example, cement with sand, clay with sand, etc.) to the entire wall or partition thickness.
- Cable penetrations into buildings, cable structures and other indoor spaces should be made using asbestos cement, concrete, ceramic or plastic pipes. The pipe ends should protrude into the trench from the wall of the building or foundation (if there is a perimeter pavement, beyond its border) by at least 0.6 m and have a slope towards the trench.



1. Cables
2. Reinforced concrete slabs or bricks
3. Sand and gravel mix or loose soil
4. Backfill soil

Figure 5. Options for cables laying in a trench (all dimensions are given in millimeters).

3.2.3. Cable laying in pipes and blocks

- When cables are laid in block ducts, the total length of the ducts should be determined based on the maximum permissible pulling forces taking into account the cable construction and laying conditions. The maximum length of the block duct and pulling forces should be determined at the cable line design stage.
- In order to reduce the pulling force when pulling cables through pipes and block channels, the cable surfaces should be coated with a lubricant that does not contain any substances damaging the cable jacket (for cables with a PE jacket it is possible to use technical vaseline; for cables with a PVC jacket – tallow, solidol grease, technical vaseline). For the same purposes, it is possible to pour water through ducts or pipes instead of using lubrication.

WARNING! When pulling three phases of a cable into a pipe or block duct, it is prohibited to pull individual cables sequentially using a steel rope because the already laid cables may be damaged by the rope.

- In pipes up to 20 m long, it is possible to pull individual cables sequentially by hand using a rope.
- The pulling speed should not exceed 17 m/min and the cable should be pulled without stopping if possible.

3.3. Cable laying at low temperatures

- Laying cables without preheating is permitted at the following temperatures:
  — cables with a PVC plastic jacket including cables with “KhL” suffix, with a fire-resistant PVC plastic jacket including cables with “KhL” suffix, with a low fire hazard PVC plastic and polymer compound jacket can be laid without preheating at an ambient temperature not lower than minus 15 °C;
  — cables with a polyethylene jacket may be laid without preheating at an ambient temperature not lower than minus 20 °C;
- At temperatures from minus 15 °C to minus 40 °C cable laying is permitted only after cable preheating.
- For preheating reels with cable there should be constructed a “warm enclosure” with stove or air blower heating. Using open flame for preheating is not permitted.
  The duration of cable preheating in the “warm enclosure” at a temperature from plus 25 °C to plus 40 °C is at least 18 hours. For temperature monitoring there should be used a thermometer installed on the cable turns.
- Cable laying should be completed within 30 minutes after preheating immediately followed by cable backfilling with the first layer of sand and gravel mix or loosened soil.
- Cable laying at temperatures below minus 40 °C is prohibited.

4. SAFETY MEASURES

When laying cable lines, safety rules should be observed in accordance with the following documents:

– Safety rules for electrical installation and adjustment works (M.: USSR Ministry of Installation and Special Construction Works, 1990);
– Inter-industry occupational safety rules for operation of electrical installations POT PM-016;
– SNiP III-4 Construction safety rules (as amended);
– Fire safety rules in the Russian Federation;
– Safety rules for working with tools and accessories (M.: Energoatomizdat, 1988).

5. ROUTE ACCEPTANCE

- Route acceptance should be completed before cable laying commences and an acceptance certificate should be issued.
- The route should comply with the design documentation and requirements of this manual.
- Before laying cables, the following works should be completed:
  — support stands for terminations should be installed;
  — intersections with other utility lines should be completed;
  — penetrations for cable transit systems in buildings and structures should be prepared by inserting pipes into them;
  — supports required by the design should be installed in the cable structures;
  — water should be pumped out of trenches, stones, other foreign objects and construction debris removed;
  — a 100 mm thick sand and gravel mix bedding should be made;
  — block duct bore should be checked with special gauges.

6. CABLE LAYING

6.1. General conditions

- Approximate positions of workers in the process of cable pulling:
  — reel brake – 1 worker;
  — cable unreeling roller decks – 1 worker;
  — pulling the cable down into a trench (entrance to / exit from the tunnel) – 1 worker;
  — winch – 2 workers;
  — following cable end – 1 worker;
  — at each route turning point – 1 worker;
  — at each penetration in pipes through partitions or ceiling slabs, at the entrance to a chamber or building – 1 worker;
  — on straight sections – as necessary.
- When pulling three cables at the same time, there should be 2 workers at the cable grouping device to fasten the cables in a trefoil formation (if required by the design).
- The work leader follows the movement of the cable end along the route. The command to turn on the winch for pulling is given only by the work leader. The command to turn off the winch can be given by anyone who notices problems during pulling.
- The laying speed should not exceed 30 m/min and should be selected depending on the route characteristics, weather conditions and pulling forces.
- If the pulling force exceeds the permissible value, it is necessary to stop laying and check the correct installation and serviceability of linear and corner rollers as well as presence of lubricant (water) in the pipes and make sure there is no risk of the cable jamming in the pipes. Cable laying can be resumed only after eliminating the causes of exceeding the permissible pulling force.
- Light braking should be applied to the reel with cable so that there are no jerks, slacking or sagging of cable turns and without creating excessive braking force at the same time.
- When pulling the cable down into a trench or tunnel, it is necessary to ensure that the cable does not slip off rollers and does not rub against pipes and walls in passages.
- At the entrances to asbestos cement, ceramic or plastic pipes, care should be taken to ensure that cable protective coverings are not damaged.
- If the cable jacket is damaged, it is necessary to stop laying, inspect the fault location and make a decision on the method of repairing the jacket (Appendix A).

- The workers following the cable end should ensure that the cable runs on the rollers, adjust the rollers if necessary, and also guide the cable end using a special hook.
- The cable is paid out in such a way that when it is laid as the design requires, the distance from the top of the termination or from the approximate center of the joint is at least 2 meters.
- Disconnect the pulling rope and remove the stocking or grip from the cable end. If the reel contains cable for several sections of the route or if the cable length is significantly greater than the section length, the cable should be cut.
- After cutting the cable its ends should be sealed with caps. For more reliable sealing of the cable ends double caps can be used.
- The inner cap is shrunk on the conducting layer of the cable insulation and the outer cap – on the inner cap and the cable jacket. It is also possible to apply a layer of molten bitumen to the cable cut end before cap installation.
- If necessary, cable ends are led into chambers, wells, cable rooms. The cable bending radius should be within the permissible range.
- Cable should be removed from the rollers, laid and fastened as the design requires.
- When laid in a trench, the cable should be backfilled with a sand and gravel mix and or fine soil to form a 100 mm layer and the cable jacket should be tested.

The jacket of the cable factory length should withstand a test with a DC voltage of 10 kV for 1 minute. The test voltage is applied between the cable metal screen and the grounding electrode.

If the jacket fails the tests, it is necessary to localize the fault, repair the jacket and repeat the test. The recommended devices are REIS 205.
After jacket testing, cover the cable laid in the trench with the first layer of soil, place mechanical protection (slabs, bricks) or warning tape and complete the trench backfilling.

6.2. Preparatory works

It is recommended to deliver reels with cable to the route not earlier than one day before laying commences so as not to expose the cable to possible damage during long-term storage on the route.

- Visually inspect the reels with cable. Make sure the lagging and cable end caps are not damaged.
- Place the reel with cable on payoffs so that the cable is paid out from the top of the reel.
- Place the equipment and accessories for cable laying along the route in accordance with the method statement.
- Install guide roller decks to ensure smooth cable unreeling, the width of the first of them should not be less than the width of the reel.
- Place linear rollers along the route. The distance between the rollers should not exceed 4 meters. Install corner rollers at the points where the route turns to ensure that the cable bending radius is within the permissible range. The rollers should rotate freely and easily.
- Install other equipment in accordance with the method statement (spacer fasteners, funnels, special guide rollers, etc.) when cables are laid in a tunnel or blocks.
- Install a pulling device (winch) at the end of the route or behind the cable well.
- Establish telephone or VHF communication between the locations of the winch, reels, points of turn, partitions and route crossings.
- Remove lagging from the reel. Check the fastening of the reel insert bushings, tighten nuts on the studs if necessary. Check the fastening of the cable lower end (secure it if necessary).
- Install braking devices on the reel to regulate the reel rotation speed during cable pulling or stop it as well as to prevent inertial reel rotation.

- Attach a wire stocking or wedge grip to the end of the cable. Bandage the stocking with a thin steel wire and adhesive PVC tape. Connect the stocking or grip to the anti-twisting device with a short rope.
- Stretch the pulling winch rope along the route. Connect it to the anti-twisting device.
- In case of simultaneous pulling of three cables, the stockings and grips should be connected to the anti-twisting device in a staggered manner. Install a device for grouping cables into a trefoil formation at the point where the cables are paid out from the reels.
- Prepare the tools and materials required for cable pulling.

6.3. Cables unreeling

Cables can be paid out from a moving cable transporter, vehicle or pipelayer when they can move freely along the route and there are no structures in the trench requiring that cables should be pulled through them (pipes, blocks, underground structures).

- Their speed in the process of cable unreeling should be within the range of 0.6–1 km/h and the distance between the trench edge and the vehicle wheel should be not less than the trench depth multiplied by a factor of *1.25*.
- Any cable jerks should be avoided when the cable is paid out from the reel because it may cause damage to the cable. Attention should be paid that the cable unreels smoothly and has some sagging.
- When the cable is unreeled on the bottom of the trench, workers should walk along following the cable paid out from the reel, receiving it and laying on the bottom of the trench.

6.4. Joints and terminations installation

Upon completion of cable laying and subsequent jacket testing, all types of joints and terminations as required by the design are installed.

- The installation should be performed by a specialized installation organization that has the appropriate equipment, specialized tools, necessary materials as well as qualified personnel that underwent training at the cable fittings supplier and are authorized to carry out these works on the basis of the relevant certification documents.
- The installation should be mandatorily overseen by a supervising engineer designated by the cable fittings supplier.
- When preparing a cable for installation of joints and terminations, the jacket, copper screen and semi-conducting elements are stripped over a certain length of the cable and conductor wires are crimped in a sleeve. The semiconducting screen along the insulation is cut off using a special tool. The wound structural elements and layers of armor wires and copper screen are secured with bandages and the unsecured parts are removed. For screen grounding the copper wires are bent onto the jacket, secured with a bandage, and the unsecured ends of the wires are twisted into a bundle. If the cable construction includes armor, there should be ensured its contact with the copper screen at the point of grounding.
- Fittings installation should involve careful cleaning of surfaces of the screen wires and tapes and cable conductor, connectors and terminals of the fittings.
- The method of conductors connection should ensure sufficient conductivity and mechanical strength of the connection.
- In the process of cable joints and terminations installation it is necessary to level differences in the electric field at the conductor connection point and in the area where the screen is cut off as well as ensure leak proofness and absence of trapped air.
- Closures of joints and terminations for outdoor installation should be resistant to atmospheric conditions, solar radiation, tracking and erosion.
- The elements of the joints restoring the copper screen should provide sufficient conductivity to shunt short-circuit currents and good contact with the cable screen.

- The joint and termination kits should have a detailed installation manual.
- The cable screen should be grounded at both ends of the line. The grounding should ensure shunting of short-circuit currents (i.e. ensure sufficient conductivity of the grounding conductor, the screen and grounding conductor should not have any breaks or high resistance sections). It is also desirable to install additional grounding of the screen over the line length.
- It is recommended to take measures to reduce the risk of corrosion of grounding elements especially when dissimilar metals are used.
- The design of the joint and termination connectors should ensure proper connection to the screen elements, and the contact resistance at the connection point should not exceed the cable screen resistance. Terminal clamps should be properly crimped to ensure good electrical connection.
- The material of terminal clamps and connectors should ensure:
  — electrical resistance not exceeding the electrical resistance of the screen material;
  — sufficient thermal capacity preventing excessive temperature rise during a short circuit.

6.5. Cable testing after laying

- It is recommended that cables after their laying and installation of fittings should be tested with alternating voltage $2U_0$ with a nominal frequency of 50 Hz for 60 minutes or alternating voltage U_0 with a nominal frequency of 50 Hz for 24 hours or alternating voltage $3U_0$ with a nominal frequency of 0.1 Hz for 60 minutes where U_0 is the cable rated voltage between the conductor and the screen under normal operating conditions, kV.
- The jacket of cables laid in ground should be tested with a fixed voltage of 10 kV for 1 minute. The test voltage should be applied between the metal screen or armor and the grounding electrode.

WARNING! After testing with fixed voltage, the current-carrying conductor should be grounded or connected to the copper screen for at least 1 hour.

7. OPERATION OF CABLES

7.1. General provisions

- Cable lines should be operated in compliance with general provisions of the Safety Regulations for the Operation of Electrical Installations, Rules for the Technical Operation of Electrical Stations and Networks and the Guidelines for the Operation of Power Cable Lines.
- The cable line operator is responsible for technical supervision of cable laying and cable line installation in accordance with this manual.
- After reading the technical documentation, the operator, before energizing the cable line, inspects the route and structures and tests the cable line. The test results are recorded in a report made available to the operator.
- Information on the cable line operation is recorded in the technical documentation. The technical data sheet for a cable line should contain the following information: cable line number or designation, cable line length and circuit designations, main cable characteristics (type, voltage and cross-section), date of putting into operation, measurement of individual factory lengths, cable laying data (reel numbers, factory lengths, circuit section numbers, laying date, pulling forces, laying conditions), route plan on a scale of 1:5,000 or 1:2,000, phase sequence diagram, enlarged longitudinal profile, information on cable line laying depth deviations, information on grounding resistance and check of continuity of the connection with the substation grounding, characteristics of “bottlenecks” limiting current load, permissible sustained load current and permissible overload current.

- The information recorded in the technical data sheet during operation includes insulation and jacket voltage testing results, measurements of cable temperature rise and ambient temperature, measurements of cable line load and overload currents, information on excavation works on the route and on cable line damage and repairs.
- Open laid cables, as well as all cable joints, should be provided with tags containing the following information: cable type, voltage, cross-section, cable line number or designation and phase designation at the end and beginning of the cable line; tags on joints should contain the joint number and the date of its installation.

The cable line is operated according to the list of works whose frequency is specified below. The description and frequency of cable line maintenance works are given in Table 4.

Table 4. Description and frequency of cable line maintenance works.

Work description	Frequency	Notes
Inspection of a route of a cable line laid in ground	Once a month	Unscheduled inspections are conducted after each emergency shutdown.
Inspection of cable lines in utility vaults, tunnels, wells	Once every 3 months	Unscheduled inspections are conducted after each emergency shutdown.
Measurement of termination grounding resistance	As part of grounding device overhaul	—
Check of continuity of the connection of metal structures with the grounding device of the substation	Once every 3 years	—
Conductor temperature measurement	As required by local instructions, including systematic monitoring in areas close to heating pipelines	—
Cable line insulation testing	Before putting into operation, then in accordance with local instructions	Unscheduled inspections are conducted after each emergency shutdown, cable and fittings repair
Cable jacket testing with rectified voltage	Before putting into operation, in a year, then in accordance with local instructions	Unscheduled inspections are conducted after each emergency shutdown, cable and fittings repair
Overhaul	As necessary	—

7.2. Performance characteristics of cables

- The permissible sustained temperature rise of cable conductors is to 90 °C. The maximum permissible temperature of cable conductors during a short circuit is 250 °C, the maximum permissible temperature of a cable copper screen during a short circuit is 350 °C, the maximum temperature rise of a cable conductor during a short circuit as per the cable non-flammability requirements is to 400 °C for a short circuit duration of up to 5 seconds.
- The permissible temperature rise of cable conductors under overload conditions is to not higher than 130 °C.
- The duration of cable operation under overload conditions should not exceed 8 hours per day and 1,000 hours during the service life.

Design values of capacitance of cables with round conductors are given in Table 5 as reference values.

Table 5. Design values of capacitance of cables with round conductors.

Nominal cross-section, mm²	6 kV		10 kV		15 kV		20 kV		35 kV	
	C_0, μF	I_C, A	C_0, μF	I_C, A	C_0, μF	I_C, A	C_0, μF	I_C, A	C_0, μF	I_C, A
35	0.29	0.947	0.22	1.197	—	—	—	—	—	—
50	0.32	1.044	0.25	1.360	0.20	1.632	0.17	1.850	0.14	2.666
70	0.37	1.208	0.29	1.578	0.23	1.877	0.19	2.067	0.16	3.046
95	0.41	1.338	0.32	1.741	0.25	2.040	0.21	2.285	0.18	3.427
120	0.45	1.469	0.35	1.904	0.27	2.203	0.23	2.502	0.19	3.618
150	0.50	1.632	0.38	2.067	0.30	2.448	0.26	2.829	0.20	3.808
185	0.54	1.763	0.42	2.285	0.32	2.611	0.27	2.938	0.22	4.189
240	0.59	1.926	0.46	2.502	0.35	2.856	0.29	3.155	0.24	4.570
300	0.60	1.958	0.51	2.774	0.38	3.101	0.32	3.482	0.26	4.950
400	0.64	2.089	0.57	3.101	0.42	3.427	0.35	3.808	0.29	5.522
500	0.66	2.154	0.63	3.427	0.47	3.835	0.39	4.243	0.32	6.093
630	0.73	2.383	0.70	3.808	0.52	4.243	0.43	4.678	0.35	6.664
800	0.82	2.676	0.77	4.189	0.58	4.733	0.49	5.331	0.40	7.616

Designations of physical quantities
C_0 is the design value of capacitance of 1 km of cable, μF
I_C is the capacitive ground fault current of 1 km of cable, A/km

Table 6. Electrical resistance of current-carrying conductors.

Nominal conductor cross-section, mm²	DC resistance of 1 km of conductor at a temperature of 90 °C, Ω	
	Copper conductor	Aluminum conductor
35	0.668	1.112
50	0.493	0.821
70	0.342	0.567
95	0.246	0.410
120	0.195	0.324

150	0.158	0.264
185	0.126	0.210
240	0.096	0.160
300	0.077	0.128
400	0.060	0.100
500	0.047	0.077
630	0.036	0.060
800	—	0.047

Table 7. Design values of inductance of single core cables with round conductors.

Nominal conductor cross-section, mm²	Inductance, mH/km, for cables of rated voltage, kV									
	6 kV		10 kV		15 kV		20 kV		35 kV	
	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂
35	0.604	0.448	0.620	0.465	0.637	0.485	0.652	0.501	—	—
50	0.578	0.421	0.594	0.437	0.611	0.456	0.625	0.472	0.669	0.518
70	0.552	0.391	0.567	0.407	0.583	0.426	0.597	0.441	0.639	0.486
95	0.533	0.370	0.547	0.386	0.563	0.403	0.576	0.418	0.617	0.462
120	0.508	0.342	0.521	0.357	0.536	0.373	0.549	0.387	0.587	0.430
150	0.497	0.329	0.509	0.343	0.524	0.359	0.536	0.373	0.573	0.415
185	0.482	0.312	0.494	0.325	0.508	0.341	0.519	0.354	0.555	0.395
240	0.469	0.296	0.479	0.308	0.492	0.323	0.503	0.336	0.537	0.375
300	0.461	0.286	0.468	0.294	0.480	0.309	0.490	0.321	0.523	0.359
400	0.451	0.275	0.455	0.280	0.467	0.294	0.477	0.305	0.508	0.342
500	0.440	0.261	0.442	0.264	0.453	0.277	0.462	0.288	0.492	0.323
630	0.427	0.245	0.429	0.247	0.439	0.260	0.447	0.270	0.475	0.303
800	0.418	0.234	0.42	0.236	0.429	0.248	0.437	0.258	0.463	0.289

Under other laying conditions, the inductance is calculated using the formula:

$$L = 0.1 + 0.2 \times \ln\left(\frac{h - r}{r}\right)$$

where L is the inductance, mH/km; h is the distance between centers of cores, mm; r is the core radius, mm.

Table 8. Design values of inductive resistance of single core cables with round conductors.

Nominal conductor cross-section, mm²	Reactive inductive resistance, Ω/km, for single core cables									
	6 kV		10 kV		15 kV		20 kV		35 kV	
	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂
35	0.190	0.141	0.195	0.146	0.200	0.152	0.205	0.157	—	—
50	0.182	0.132	0.187	0.137	0.192	0.143	0.196	0.148	0.210	0.163
70	0.173	0.123	0.178	0.128	0.183	0.134	0.188	0.139	0.201	0.153
95	0.167	0.116	0.172	0.121	0.177	0.127	0.181	0.131	0.194	0.145

Nominal conductor cross-section, mm²	Reactive inductive resistance, Ω/km, for single core cables									
	6 kV		10 kV		15 kV		20 kV		35 kV	
	○ ○ ○	⁂	○ ○ ○	⁂	○ ○ ○	⁂	○ ○ ○	⁂	○ ○ ○	⁂
120	0.160	0.107	0.164	0.112	0.168	0.117	0.172	0.122	0.184	0.135
150	0.156	0.103	0.160	0.108	0.165	0.133	0.168	0.117	0.180	0.130
185	0.151	0.098	0.155	0.102	0.160	0.107	0.163	0.111	0.174	0.124
240	0.147	0.093	0.150	0.097	0.155	0.101	0.158	0.106	0.169	0.118
300	0.145	0.090	0.147	0.092	0.151	0.097	0.154	0.101	0.164	0.113
400	0.142	0.086	0.143	0.088	0.147	0.092	0.150	0.096	0.160	0.107
500	0.138	0.082	0.139	0.083	0.142	0.087	0.145	0.090	0.155	0.101
630	0.134	0.077	0.135	0.078	0.138	0.082	0.140	0.085	0.149	0.095
800	0.131	0.074	0.132	0.074	0.135	0.078	0.137	0.081	0.145	0.091
Symbols for cable laying formations: flat – ○ ○ ○, trefoil – ⁂.										

Table 9. Design values of inductance of three core cables with round conductors.

Nominal conductor cross-section, mm²	Inductance, mH/km, for three core cables of rated voltage, kV				
	6 kV	10 kV	15 kV	20 kV	35 kV
35	0.382	0.406	0.431	0.452	—
50	0.357	0.380	0.404	0.424	0.482
70	0.331	0.352	0.376	0.395	0.451
95	0.312	0.333	0.355	0.374	0.428
120	0.287	0.307	0.328	0.345	0.397
150	0.276	0.294	0.315	0.332	0.382
185	0.261	0.279	0.299	0.315	0.363
240	0.249	0.264	0.282	0.298	—

The permissible sustained currents of cables are calculated based on load factor $K = 1.0$ for an ambient temperature of:

- 25 °C when laid in air,
- 15 °C when laid in ground.

Design conditions for laying cables in ground:

- the depth of laying is 0.7 m;
- specific thermal resistance of normalized soil is 1.2 K• m/W.

Table 10. Design values of inductive resistance of three core cables with round conductors.

Nominal conductor cross-section, mm²	Reactive inductive resistance, Ω/km, for cables of rated voltage, kV				
	6 kV	10 kV	15 kV	20 kV	35 kV
35	0.120	0.128	0.135	0.142	—
50	0.112	0.119	0.127	0.133	0.151
70	0.104	0.111	0.118	0.124	0.142
95	0.098	0.105	0.112	0.117	0.134

Nominal conductor cross-section, mm²	Reactive inductive resistance, Ω/km, for cables of rated voltage, kV				
	6 kV	10 kV	15 kV	20 kV	35 kV
120	0.090	0.096	1.103	0.108	0.125
150	0.087	0.092	0.099	0.104	0.120
185	0.082	0.088	0.094	0.099	0.114
240	0.078	0.083	0.089	0.094	—

Permissible currents of single core cables are calculated for cables laid in a tightly close trefoil formation and in a flat formation with the distance between outer surfaces of two adjacent cables equal to the cable diameter. In this case metal screens of the cables are connected and grounded on both sides.

Table 11. Permissible sustained currents when single core cables are laid in ground.

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in ground**, A											
	6 kV				10 and 15 kV				20 and 35 kV			
	Cu-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor	
	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂
35	221	193	172	147	220	193	172	147	—	—	—	—
50	250	225	195	170	250	225	195	170	230	225	185	175
70	310	275	240	210	310	275	240	210	290	270	225	215
95	336	326	263	253	336	326	263	253	336	326	263	253
120	380	370	298	288	380	370	298	288	380	371	298	288
150	416	413	329	322	416	413	329	322	417	413	330	322
185	466	466	371	364	466	466	371	364	466	466	371	365
240	531	537	426	422	531	537	426	422	532	538	426	422
300	590	604	477	476	590	604	477	476	582	605	477	476
400	633	677	525	541	633	677	525	541	635	678	526	541
500	697	759	587	614	697	759	587	614	700	762	588	615
630	792	848	653	695	762	848	653	695	766	851	655	699
800	825	933	719	780	825	933	719	780	830	942	722	782
Conductor material designation: “Cu” – copper, “Al” – aluminum.												

Table 12. Permissible sustained currents of single core cables laid in air.

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in air**, A											
	6 kV				10 and 15 kV				20 and 35 kV			
	Cu-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor	
	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂
35	250	203	188	155	217	192	189	150	—	—	—	—

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in air**, A											
	6 kV				10 and 15 kV				20 and 35 kV			
	Cu-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor		***Cu***-conductor		***Al***-conductor	
	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂	○○○	⁂
50	290	240	225	185	290	240	225	185	290	250	225	190
70	360	300	280	230	360	300	280	230	365	310	280	240
95	448	387	349	300	448	387	349	300	446	389	348	301
120	515	445	403	346	515	445	403	346	513	448	402	348
150	574	503	452	392	574	503	452	392	573	507	451	394
185	654	577	518	450	654	577	518	450	652	580	516	452
240	762	677	607	531	762	677	607	531	760	680	605	533
300	865	776	693	609	865	776	693	609	863	779	690	611
400	959	891	787	710	959	891	787	710	957	895	783	712
500	1,081	1,025	900	822	1,081	1,025	900	822	1,081	1,027	897	824
630	1,213	1,166	1,026	954	1,213	1,166	1,026	954	1,213	1,172	1,023	953
800	1,349	1,319	1,161	1,094	1,349	1,319	1,161	1,094	1,351	1,325	1,159	1,096

Table 13. Permissible sustained currents of three core cables, armored and unarmored, laid in ground.

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in ground**, A					
	Cu-conductors			***Al***-conductors		
	6 kV	10 and 15 kV	20 and 35 kV	6 kV	10 and 15 kV	20 and 35 kV
35	164	175	—	126	136	—
50	192	207	207	148	156	161
70	233	253	248	181	193	199
95	279	300	300	216	233	233
120	316	340	341	246	265	265
150	352	384	384	275	300	300
185	396	433	433	311	338	339
240	457	500	500	358	392	392
300	—	563	563	—	456	456
400	—	635	635	—	515	515

Table 14. Permissible sustained currents of three core cables, armored and unarmored, laid in air.

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in air**, A					
	Cu-conductors			***Al***-conductors		
	6 kV	10 and 15 kV	20 and 35 kV	6 kV	10 and 15 kV	20 and 35 kV
35	179	173	—	138	134	—
50	213	206	215	165	159	163

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in air**, A					
	Cu-conductors			***Al***-conductors		
	6 kV	10 and 15 kV	20 and 35 kV	6 kV	10 and 15 kV	20 and 35 kV
70	263	255	264	204	196	204
95	319	329	331	248	255	256
120	366	374	376	285	291	292
150	413	423	426	321	329	331
185	471	479	481	368	374	375
240	550	562	564	432	441	442
300	—	630	630	—	490	490
400	—	710	710	—	554	554

When determining the permissible currents for cables laid in an environment whose temperature differs from that specified, the correction factors given in Table 15 should be applied.

Table 15. Correction factors taking into account soil and ambient temperature for calculating the permissible sustained current in a cable.

Laying conditions	Correction factors at an ambient temperature, °C										
	10	15	20	25	30	35	40	45	50	55	60
Soil	1.07	1.04	1	0.96	0.93	0.89	0.85	0.80	0.76	—	—
Air	—	—	1.08	1.04	1	0.96	0.91	0.87	0.82	0.76	0.71

Permissible currents under overload conditions of cables laid in ground in single-duct ceramic pipes and in air can be calculated by multiplying the values specified
– in Tables 11 and 12 – by a factor of *1.17*
– in Tables 13 and 14 – by a factor of *1.20*

The permissible currents of cables laid in ground in pipes longer than 10 m should be reduced by multiplying the current values specified in Table 9
– by a factor of *0.94* if single core cables are laid in separate pipes;
– by a factor of *0.9* if three single core cables are laid in one pipe.

The permissible currents of three core cables laid in ground in pipes are given in Table 16.

Table 16. Permissible sustained currents of three core cables laid in ground in pipes.

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in ground in pipes**, A					
	Cu-conductors			***Al***-conductors		
	6 kV	10 and 15 kV	20 and 35 kV	6 kV	10 and 15 kV	20 and 35 kV
35	143	152	—	109	118	—
50	168	180	180	129	135	140
70	203	220	215	159	170	175
95	246	264	264	190	205	205
120	280	303	303	217	333	233
150	313	342	342	244	267	267
185	353	385	385	277	300	300

Nominal conductor cross-section, mm²	Permissible sustained current *I* when cable is laid **in ground in pipes**, A					
	Cu-conductors			***Al***-conductors		
	6 kV	10 and 15 kV	20 and 35 kV	6 kV	10 and 15 kV	20 and 35 kV
240	411	450	450	321	353	353
300	—	507	507	—	410	410
400	—	578	578	—	468	468

The permissible currents of several cables laid in ground including those laid in pipes should be reduced by multiplying the current values listed in Table 12 by the factor given in Table 17.

Table 17. Current reduction factors depending on the number of cables and the distance between them.

Distance between outer surfaces of cables, mm	Correction factors at an ambient temperature, °C					
	1	2	3	4	5	6
100	1.0	0.90	0.85	0.80	0.78	0.75
200	1.0	0.92	0.87	0.84	0.82	0.81
300	1.0	0.93	0.90	0.87	0.86	0.85

The permissible one-second short-circuit currents in cables should not exceed those specified in Table 18.

Table 18. Permissible one-second short-circuit currents.

Nominal conductor cross-section, mm²	Permissible one-second short-circuit current, kA	
	Cu-conductor	***Al***-conductor
35	5.0	—
50	7.15	4.7
70	10.0	6.6
95	13.6	8.9
120	17.2	11.3
150	21.5	14.2
185	26.5	17.5
240	34.3	22.7
300	42.9	28.2
400	57.2	37.6
500	71.5	47.0
630	90.1	59.2
800	—	75.2

Table 19. Permissible one-second short-circuit currents in a copper screen.

Copper screen nominal cross-section, mm²	One-second short-circuit current, not more than, kA
16	3.1
25	4.8
35	6.7
50	9.6
70	13.4
95	18.1
120	22.9
150	28.7
185	35.3
240	45.8

Short-circuit currents are calculated at a conductor temperature of 90 °C before a short circuit and maximum conductor temperature of 250 °C during a short circuit. The permissible one-second short-circuit currents in copper screens should not exceed those specified in Table 19.

Short-circuit currents are calculated at a screen temperature of 50 °C before a short circuit and maximum screen temperature of 350 °C during a short circuit.

For other values of the cable copper screen cross-section, the permissible one-second short-circuit current is calculated using the formula:

$$I_{sc} = k \times S_{scr}$$

where I_{sc} is the permissible one-second short-circuit current in cable copper screen, kA;
k is the factor of 0.191 kA/mm^2;
S_{scr} is the copper screen nominal cross-section, mm^2.

For a short circuit duration different from 1 second, the short circuit current values specified in Tables 18 and 19 should be multiplied by correction factor K calculated using the formula:

$$K = \frac{1}{\sqrt{\tau}}$$

where τ is the short circuit duration, s.

7.3. Joints and terminations

7.3.1. Joints for cables with cross-linked polyethylene insulation

It is recommended to use joints by domestic and foreign manufacturers. An example of selecting joints for 10 kV cables is in Table 20.

Table 20. Joints.

U, kV	Conductor cross-section, mm^2	Joint type and size	Note
Podolsk Plant of Electrical Installation Products			
10	70÷120 150÷240	PStO 10-70/120 PStO 10-150/240	TU 3599-009-04001953–2000 Heat-shrinkable tube based joints with shear head connectors
Raychem (heat-shrinkable tube based, with shear bolt connectors)			
10	25÷70 70÷150 120÷240 300÷400 500÷630 800 25÷70 70÷150 120÷240	POLJ 12/1x25-70 POLJ 12/1x70-150 POLJ 12/1x120-240 POLJ 12/1x300-400 POLJ 12/1x500-630 POLJ 12/1x800-Al-C* POLJ 12/1x25-70 AW POLJ 12/1x70-150AW POLJ 12/1x120- 240AW	AW for cables with aluminum wire armor or tape screen

Raychem (heat-shrinkable tube based, without shear bolt connectors)			
10	50÷70 95÷150 185÷300 400÷630	SXSU 4111 SXSU 4121 SXSU 4131 SXSU 4141	
10	35÷95 120÷185 240÷400	REPJ-12A/1XU REPJ-12B/1XU REPJ-12C/1XU	The great length of the repair joint makes it possible to remove the damaged part of the cable and replace this part by inserting a conductor section with two connectors
* includes a DIN-compression connector for aluminum conductors			

7.3.2. Terminations for cables with XLPE insulation

There is a wide product line of terminations for cables with cross-linked polyethylene insulation based on heat-shrinkable products.

In addition to heat-shrinkable terminations, Cellpack also offers cold-shrinkable terminations with an elastomer insulator. The installation of this termination does not require heating. The tip of the elastomer termination should be suitable for hermetic pressure-type connection. An example of selecting terminations for 10 kV cables is given in Table 21.

Table 21. Terminations, example of selection for 10 kV cables.

U, kV	Conductor cross-section, mm²	Termination type and size		Note
		outdoor installation	indoor installation	
Podolsk Plant of Electrical Installation Products				
10	70÷120 150÷240	PKNt0-70/120 PKNt0-150/240	PKVt0-70/120 PKVt0-150/240	TU 3599-009-04001953–2000
Raychem (heat-shrinkable tube based, with shear bolt connectors)				
10	25÷70 70÷150 120÷240 185÷400 400÷630	POLT-12C/1XO-L12 POLT-12D/1XIO-L12A POLT-12D/1XO-L12B POLT-12E/1XO-L12 POLT-12F/1XO-L12	POLT-12C/1XI-L12 POLT-12D/1XI-L12A POLT-12D/1XI-L12B POLT-12E/1XI-L12 POLT-12F/1XI-L12	
Raychem (heat-shrinkable tube based, without shear bolt connectors)				
10	25÷95 95÷240 240÷500 500÷800	POLT-12C/1XO POLT-12D/1XIO POLT-12E/1XO-L12B POLT-12F/1XO-L12	POLT-12C/1XI-L12 POLT-12D/1XI-L12A POLT-12E/1XI-L12B POLT-12F/1XI-L12	

NOTE Solder-connect fittings of the grounding wire (for cables with aluminum or copper tape screen) are ordered separately.

Hydraulic tool for crimping sleeves and tips:
– Foot-actuated hydraulic pump PO 700
– Hydraulic pressing head RH 230 for PO 700 pump
  (application range ***Al*** – 10÷500 mm^2, ***Cu*** – 10÷630 mm^2);
– Hexagonal pressing dies for RH 230 head.

Tools for stripping cable conducting polymer screen and installing fittings:
– Tool for conducting screen stripping IT 1000-017-2
  (application range 25÷500 mm^2);
– Set of cable stripping knives WL20/1, WM20/1;
– Set of gas burners SIEVER MATIC S.

8. DESIGN STRUCTURAL ELEMENTS OF CABLES

Table 22. Design diameter and weight of single core cables.

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
APvP, PvP, APvPg, PvPg												
50(16)	24.3	26.1	30.3	36.3	587	885	645	943	801	1,099	1,069	1,367
70(16)	25.9	27.7	31.9	37.9	671	1,088	734	1,150	899	1,316	1,181	1,597
95(16)	27.7	29.5	33.7	39.7	775	1,352	843	1,420	1,020	1,597	1,317	1,894
120(16)	29	30.8	35	41	859	1,594	930	1,665	1,114	1,849	1,423	2,158
150(25)	30.3	32.1	36.3	42.3	1,040	1,943	1,115	2,017	1,307	2,209	1,627	2,530
185(25)	32.1	33.9	38.1	44	1,170	2,297	1,248	2,376	1,452	2,579	1,787	2,915
240(25)	34.7	36.3	40.5	46.9	1,367	2,872	1,443	2,948	1,661	3,167	2,047	3,552
300(25)	37.1	38.3	42.5	48.9	1,590	3,482	1,650	3,543	1,881	3,774	2,286	4,179
400(35)	40.2	41	45.6	51.6	1,993	4,403	2,037	4,446	2,312	4,722	2,715	5,124
500(35)	43.7	44.1	48.8	54.7	2,360	5,464	2,384	5,488	2,681	5,785	3,112	6,216
630(35)	47.7	48.1	52.3	58.7	2,826	6,875	2,853	6,902	3,144	7,193	3,643	7,692
800(35)	51.6	52	56.6	62.6	3,356	—	3,385	—	3,736	—	4,236	—
APvPu, PvPu, APvPug, PvPug												
50(16)	25.3	27.1	31.3	37.3	625	923	686	984	848	1,146	1,125	1,423
70(16)	26.9	28.7	32.9	38.9	712	1,128	777	1,194	949	1,365	1,239	1,656
95(16)	28.7	30.5	34.7	40.7	819	1,396	889	1,466	1,072	1,649	1,379	1,956
120(16)	30	31.8	36	42	904	1,639	978	1,713	1,169	1,904	1,487	2,222
150(25)	31.3	33.1	37.3	43.3	1,088	1,990	1,165	2,067	1,364	2,266	1,693	2,595
185(25)	33.1	34.9	39.1	45.1	1,219	2,347	1,301	2,428	1,511	2,638	1,856	2,983
240(25)	35.7	37.3	41.5	47.9	1,422	2,927	1,500	3,005	1,723	3,229	2,117	3,623
300(25)	38.1	39.3	43.5	49.9	1,647	3,540	1,710	3,603	1,947	3,840	2,362	4,254
400(35)	41.2	42	46.6	52.6	2,055	4,465	2,100	4,510	2,383	4,792	2,794	5,204
500(35)	44.7	45.1	49.7	55.7	2,428	5,532	2,453	5,556	2,757	5,860	3,197	6,301
630(35)	48.7	49.1	53.3	59.7	2,900	6,949	2,928	6,976	3,225	7,274	3,733	7,782
800(35)	52.6	53	57.6	63.6	3,436	—	3,465	—	3,823	—	4,333	—
APvP2g, PvP2g												
50(16)	24.4	26.2	30.4	36.4	602	900	663	961	825	1,123	1,101	1,399
70(16)	26	27.8	32	38	689	1,105	754	1,171	925	1,342	1,215	1,631
95(16)	27.8	29.6	33.8	39.8	797	1,374	867	1,444	1,050	1,627	1,356	1,933
120(16)	29.1	30.9	35.1	41.1	882	1,617	956	1,691	1,147	1,882	1,464	2,199
150(25)	30.4	32.2	36.4	42.4	1,077	1,979	1,154	2,056	1,353	2,254	1,682	2,584
185(25)	32.2	34	38.2	44.2	1,208	2,336	1,290	2,417	1,499	2,627	1,844	2,971
240(25)	34.8	36.4	40.6	47	1,411	2,917	1,490	2,995	1,714	3,220	2,108	3,614

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
300(25)	37.2	38.4	42.6	49	1,637	3,530	1,700	3,593	1,937	3,830	2,350	4,243
400(35)	40.3	41.1	45.7	51.7	2,045	4,455	2,090	4,500	2,372	4,781	2,782	5,192
500(35)	43.8	44.2	48.8	54.8	2,418	5,521	2,442	5,546	2,745	5,849	3,184	6,287
630(35)	47.8	48.2	52.4	58.8	2,889	6,938	2,916	6,965	3,213	7,262	3,719	7,768
800(35)	51.7	52.1	56.7	62.7	3,424	—	3,453	—	3,809	—	4,317	—
APvPu2g, PvPu2g												
50(16)	25.4	27.2	31.4	37.4	640	938	704	1,002	872	1,170	1,157	1,455
70(16)	27	28.8	33	39	729	1,146	797	1,214	975	1,392	1,274	1,690
95(16)	28.8	30.6	34.8	40.8	840	1,418	913	1,491	1,103	1,680	1,418	1,995
120(16)	30.1	31.9	36.1	42.1	928	1,663	1,004	1,739	1,201	1,936	1,528	2,263
150(25)	31.4	33.2	37.4	43.4	1,124	2,026	1,204	2,106	1,409	2,311	1,747	2,650
185(25)	33.2	35	39.2	45.2	1,258	2,386	1,343	2,470	1,559	2,686	1,912	3,039
240(25)	35.8	37.4	41.6	48	1,465	2,971	1,546	3,052	1,777	3,283	2,181	3,687
300(25)	38.2	39.4	43.6	50	1,695	3,588	1,760	3,653	2,003	3,896	2,426	4,319
400(35)	41.3	42.1	46.7	52.7	2,098	4,508	2,144	4,554	2,433	4,843	2,852	5,262
500(35)	44.8	45.2	49.8	55.8	2,476	5,580	2,501	5,605	2,811	5,915	3,259	6,363
630(35)	48.8	49.2	53.4	59.8	2,953	7,002	2,981	7,030	3,284	7,333	3,800	7,849
800(35)	52.7	53.1	57.7	63.7	3,494	—	3,524	—	3,887	—	4,404	—
APvV, PvV, APvV-KhL, PvV-KhL												
50(16)	24.3	26.1	30.3	36.3	666	964	731	1,029	901	1,200	1,191	1,489
70(16)	25.9	27.7	31.9	37.9	756	1,173	825	1,242	1,005	1,422	1,309	1,725
95(16)	27.7	29.5	33.7	39.7	867	1,444	941	1,518	1,133	1,710	1,452	2,029
120(16)	29	30.8	35	41	955	1,690	1,033	1,767	1,232	1,967	1,563	2,298
150(25)	30.3	32.1	36.3	42.3	1,141	2,043	1,223	2,125	1,430	2,332	1,772	2,674
185(25)	32.1	33.9	38.1	44	1,277	2,404	1,362	2,489	1,580	2,708	1,938	3,065
240(25)	34.7	36.3	40.5	46.9	1,484	2,989	1,565	3,071	1,799	3,304	2,220	3,726
300(25)	37.1	38.3	42.5	48.9	1,715	3,608	1,780	3,673	2,026	3,919	2,467	4,360
400(35)	40.2	41	45.6	51.6	2,129	4,539	2,176	4,586	2,480	4,890	2,906	5,316
500(35)	43.7	44.1	48.8	54.7	2,510	5,613	2,535	5,639	2,862	5,966	3,316	6,420
630(35)	47.7	48.1	52.3	58.7	3,003	7,051	3,031	7,080	3,339	7,388	3,818	7,927
800(35)	51.6	52	56.6	62.6	3,548	—	3,578	—	3,962	—	4,488	—
APvVng(A)-LS, PvVng(A)-LS												
50(16)	28.1	32.1	38.5	44.5	1,008	1,306	1,291	1,589	1,781	2,079	2,233	2,531
70(16)	29.6	33.6	40	46.5	1,120	1,537	1,417	1,834	1,927	2,344	2,444	2,861
95(16)	31.5	35.5	41.9	48.3	1,259	1,837	1,573	2,151	2,106	2,684	2,643	3,220
120(16)	32.8	36.8	43.2	49.6	1,366	2,101	1,692	2,426	2,241	2,976	2,789	3,524
150(25)	34.1	38.1	44.5	50.9	1,583	2,485	1,920	2,822	2,485	3,387	3,047	3,949

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
185(25)	35.8	39.8	46.7	52.7	1,743	2,870	2,096	3,223	2,735	3,863	3,262	4,389
240(25)	38.4	42.2	49.1	55.1	1,990	3,495	2,351	3,856	3,024	4,529	3,571	5,077
300(25)	40.8	44.3	51.1	57.5	2,256	4,149	2,608	4,500	3,308	5,201	3,939	5,831
400(35)	43.9	47.3	53.8	60.2	2,705	5,115	3,103	5,513	3,786	6,196	4,443	6,853
500(35)	47.9	50.5	57.3	62.3	3,191	6,295	3,532	6,635	4,319	7,422	4,943	8,046
630(35)	51.4	54	609	67.3	3,696	7,745	4,060	8,109	4,896	8,945	5,627	9,676
800(35)	55.3	58.3	64.8	71.2	4,298	—	4,755	—	5,578	—	6,348	—
APvVng(V)-LS, PvVng(V)-LS												
50(16)	23.1	24.9	29.1	35	679	977	747	1,045	926	1,224	1,226	1,524
70(16)	24.6	26.4	30.6	36.6	772	1,188	844	1,261	1,032	1,449	1,346	1,763
95(16)	26.5	28.3	32.5	38.5	887	1,464	965	1,542	1,165	1,742	1,495	2,072
120(16)	27.8	29.6	33.8	39.8	978	1,713	1,059	1,794	1,267	2,001	1,608	2,343
150(25)	29.1	30.9	35.1	41.1	1,178	2,080	1,262	2,164	1,478	2,380	1,831	2,733
185(25)	30.8	32.6	36.8	42.8	1,316	2,443	1,405	2,533	1,632	2,759	2,000	3,127
240(25)	33.4	35	39.2	45.6	1,530	3,035	1,615	3,120	1,856	3,362	2,296	3,802
300(25)	35.9	37.1	41.2	47.7	1,766	3,658	1,833	3,726	2,087	3,980	2,548	4,440
400(35)	38.9	39.7	43.9	50.3	2,176	4,586	2,225	4,634	2,495	4,905	2,982	5,392
500(35)	42.5	42.9	47.5	53.5	2,563	5,667	2,589	5,693	2,932	6,036	3,398	6,501
630(35)	46.4	46.8	51	57.6	3,071	7,120	3,100	7,148	3,416	7,465	4,008	8,057
800(35)	50.3	50.7	55.5	61.5	3,624	—	3,655	—	4,087	—	4,628	—
APvVng(A)-KhL, PvVng(A)-KhL, APvVng(A), PvVng(A)												
50(16)	27.1	26.9	33.1	39.1	892	1,190	975	1,273	1,188	1,486	1,538	1,836
70(16)	28.6	30.4	34.6	40.6	997	1,414	1,085	1,502	1,308	1,724	1,671	2,087
95(16)	30.5	32.3	36.5	42.5	1,129	1,706	1,221	1,798	1,455	2,032	1,835	2,412
120(16)	31.8	33.6	37.8	43.8	1,230	1,965	1,326	2,061	1,568	2,303	1,959	2,693
150(25)	33.1	34.9	39.1	45.5	1,440	2,342	1,540	2,442	1,790	2,692	2,239	3,141
185(25)	34.8	36.6	40.8	47.2	1,593	2,720	1,697	2,824	1,958	3,085	2,424	3,551
240(25)	37.4	39	43.2	49.6	1,828	3,334	1,926	3,432	2,202	3,708	2,692	4,197
300(25)	39.9	41	45.7	51.7	2,084	3,977	2,162	4,054	2,496	4,389	2,959	4,852
400(35)	42.9	43.7	48.3	54.3	2,520	4,930	2,575	4,955	2,930	5,339	3,415	5,825
500(35)	46.9	47.3	51.5	58.1	2,954	6,088	3,014	6,118	3,342	6,446	3,946	7,049
630(35)	50.4	50.8	55	61.6	3,473	7,522	3,174	7,554	3,280	7,904	3,526	8,544
800(35)	54.3	54.7	59.5	65.5	4,057	—	4,092	—	4,557	—	5,146	—
APvVng(V)-KhL, PvVng(V)-KhL, APvVng(V), PvVng(V)												
50(16)	23.1	24.9	29.1	35.1	658	956	725	1,023	899	1,197	1,193	1,491
70(16)	24.6	26.4	30.6	36.6	749	1,166	820	1,237	1,004	1,421	1,312	1,729
95(16)	26.5	28.3	32.5	38.5	863	1,440	939	1,516	1,135	1,712	1,459	2,036

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
120(16)	27.8	29.6	33.8	39.8	953	1,688	1,032	1,767	1,235	1,970	1,571	2,306
150(25)	29.1	30.9	35.1	41.1	1,151	2,053	1,234	2,136	1,445	2,347	1,793	2,695
185(25)	30.8	32.6	36.8	42.8	1,288	2,415	1,375	2,502	1,597	2,725	1,960	3,087
240(25)	33.4	35	39.2	45.6	1,499	3,004	1,582	3,088	1,820	3,325	2,250	3,755
300(25)	35.9	37.1	41.3	47.7	1,732	3,625	1,799	3,692	2,049	3,941	2,499	4,392
400(35)	38.9	39.7	43.9	50.3	2,140	4,550	2,187	4,597	2,454	4,863	2,930	5,340
500(35)	42.5	42.9	47.5	53.5	2,523	5,627	2,549	5,653	2,883	5,987	3,343	6,446
630(35)	46.4	46.8	51	57.6	3,023	7,072	3,052	7,101	3,364	7,412	3,942	7,991
800(35)	50.3	50.7	55.5	61.5	3,572	—	3,603	—	4,023	—	4,557	—
APvKaP, PvKaP, APvKaPg, PvKaPg												
50(16)	31	32.8	37	43	1,067	1,365	1,153	1,451	1,386	1,684	1,769	2,067
70(16)	33.3	34.4	39.3	45.7	1,250	1,667	1,348	1,765	1,600	2,016	2,046	2,463
95(16)	35.2	36.2	41.2	47.6	1,390	1,967	1,506	2,083	1,769	2,347	2,220	2,797
120(16)	37.4	37.5	43.4	49.8	1,606	2,341	1,723	2,458	2,002	2,737	2,483	3,218
150(25)	38.7	40.5	44.7	51.1	1,812	2,715	1,933	2,835	2,220	3,122	2,732	3,634
185(25)	40.4	42.2	46.8	52.8	1,987	3,115	2,112	3,239	2,440	3,567	2,920	4,047
240(25)	43	43.7	49.2	55.2	2,248	3,754	2,369	3,874	2,713	4,219	3,213	4,719
300(25)	46.3	47	51.7	58.1	2,626	4,519	2,715	4,608	3,054	4,947	3,629	5,522
400(35)	50	49.7	55	61.4	3,197	5,607	3,271	5,681	3,647	6,057	4,250	6,660
500(35)	53.6	53.3	58.6	64.6	3,662	6,766	3,715	6,819	4,122	7,226	4,744	7,848
630(35)	58.5	57.4	63.1	70.3	4,441	8,490	4,469	8,518	4,887	8,936	5,692	9,741
800(35)	62.4	61.8	68.2	74.2	5,096	—	5,126	—	5,701	—	6,415	—
APvKaP2g, PvKaP2g												
50(16)	31.3	33.1	37.3	43.3	1,122	1,420	1,217	1,515	1,475	1,773	1,868	2,166
70(16)	32.8	34.6	38.8	45.6	1,241	1,658	1,340	1,757	1,594	2,011	2,075	2,491
95(16)	34.7	36.5	40.7	47.5	1,383	1,960	1,501	2,078	1,767	2,344	2,252	2,829
120(16)	36.9	38.7	42.9	49.7	1,600	2,335	1,718	2,453	1,999	2,734	2,518	3,253
150(25)	38.2	40	44.2	51	1,818	2,720	1,939	2,841	2,248	3,150	2,780	3,682
185(25)	39.9	41.7	46.7	52.7	1,993	3,121	2,120	3,247	2,482	3,609	2,988	4,116
240(25)	43	45.4	49.6	56.2	2,328	3,834	2,494	4,000	2,827	4,332	3,409	4,915
300(25)	46.2	47.4	51.6	58.2	2,668	4,560	2,758	4,651	3,104	4,996	3,706	5,599
400(35)	49.9	50.7	54.9	61.5	3,233	5,643	3,309	5,719	3,690	6,100	4,321	6,731
500(35)	53.5	53.9	58.7	64.7	3,730	6,834	3,757	6,861	4,216	7,319	4,820	7,924
630(35)	58.6	59	63.2	70	4,506	8,555	4,535	8,584	4,960	9,009	5,729	9,778
800(35)	62.5	62.9	67.9	73.9	5,168	—	5,199	—	5,738	—	6,456	—
APvKaV, PvKaV												
50(16)	31	32.8	37	43	1,293	1,591	1,399	1,698	1,673	1,971	2,121	2,419

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
70(16)	33.3	34.4	39.3	45.7	1,422	1,838	1,533	1,950	1,816	2,233	2,323	2,740
95(16)	35.2	36.2	41.2	47.6	1,576	2,153	1,692	2,269	2,000	2,577	2,513	3,090
120(16)	37.4	37.5	43.4	49.8	1,805	2,539	1,935	2,670	2,246	2,981	2,791	3,525
150(25)	38.7	40.5	44.7	51.1	2,031	2,933	2,165	3,067	2,484	3,386	3,061	3,963
185(25)	40.4	42.2	46.8	52.8	2,218	3,345	2,356	3,484	2,733	3,860	3,562	4,389
240(25)	43	43.7	49.2	55.2	25,499	4,054	2,733	4,239	3,095	4,600	3,719	5,225
300(25)	46.3	47	51.7	58.1	2,911	4,804	3,010	4,902	3,384	5,277	4,029	5,921
400(35)	50	49.7	55	61.4	3,498	5,908	3,580	5,989	3,990	6,400	4,664	7,074
500(35)	53.6	53.3	58.6	64.6	3,990	7,094	4,046	7,150	4,508	7,612	5,183	8,287
630(35)	58.5	57.4	63.1	70.3	4,819	8,868	4,851	8,899	5,306	9,354	6,235	10,284
800(35)	62.4	61.8	68.2	74.2	5,502	—	5,537	—	6,218	—	6,992	—
APvEaP, PvEaP, APvEaPg, PvEaPg												
50(30)	24.3	26.1	30.3	36.3	509	807	568	866	723	1,021	989	1,287
70(30)	25.9	27.7	31.9	37.9	594	1,010	656	1,073	820	1,237	1,100	1,505
95(30)	27.7	29.5	33.7	39.7	699	1,276	766	1,343	942	1,519	1,238	1,803
120(30)	29	30.8	35	41	782	1,517	853	1,588	1,037	1,772	1,344	2,067
150(45)	30.3	32.1	36.3	42.3	928	1,830	1,003	1,905	1,194	2,097	1,514	2,403
185(45)	32.1	33.9	38.1	44	1,057	2,184	1,136	2,263	1,338	2,466	1,673	2,787
240(45)	34.7	36.3	40.5	46.9	1,256	2,761	1,332	2,837	1,549	3,055	1,962	3,453
300(45)	37.1	38.3	42.5	48.9	1,478	3,371	1,539	3,432	1,769	3,662	2,202	4,094
400(60)	40.2	41	45.6	51.6	1,825	4,235	1,869	4,289	2,115	4,525	2,575	4,985
500(60)	43.7	44.1	48.8	54.7	2,192	5,296	2,216	5,320	2,541	5,645	2,973	6,077
630(60)	47.7	48.1	52.3	58.7	2,686	6,735	2,712	6,761	3,005	7,054	3,469	7,418
800(60)	51.6	52	56.6	62.6	3,217	—	3,246	—	3,563	—	4,061	—
APvEaPu, PvEaPu, APvEaPug, PvEaPug												
50(30)	25.3	27.1	31.3	37.3	547	845	608	906	769	1,067	1,044	1,342
70(30)	26.9	28.7	32.9	38.9	633	1,050	698	1,115	869	1,286	1,158	1,575
95(30)	28.7	30.5	34.7	40.7	741	1,318	811	1,388	994	1,571	1,299	1,876
120(30)	30	31.8	36	42	826	1,561	900	1,635	1,090	1,825	1,407	2,142
150(45)	31.3	33.1	37.3	43.3	975	1,877	1,052	1,954	1,250	2,152	1,578	2,480
185(45)	33.1	34.9	39.1	45.1	1,106	2,233	1,188	2,315	1,397	2,524	1,740	2,868
240(45)	35.7	37.3	41.5	47.9	1,309	2,814	1,387	2,893	1,611	3,117	2,005	3,510
300(45)	38.1	39.3	43.5	49.9	1,535	3,427	1,598	3,490	1,834	3,727	2,247	4,139
400(60)	41.2	42	46.6	52.6	1,886	4,296	1,932	4,342	2,185	4,594	2,623	5,032
500(60)	44.7	45.1	49.7	55.7	2,259	5,363	2,283	5,387	2,586	5,690	3,024	6,128
630(60)	48.7	49.1	53.3	59.7	2,730	6,779	2,757	6,806	3,053	7,102	3,559	7,608
800(60)	52.6	53	57.6	63.6	3,264	—	3,294	—	3,649	—	4,156	—

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
APvEaP2g, PvEaP2g												
50(30)	24.4	26.2	30.4	36.4	536	834	596	895	756	1,054	1,029	1,327
70(30)	26	27.8	32	38	621	1,037	686	1,103	855	1,272	1,142	1,559
95(30)	27.8	29.6	33.8	39.8	729	1,306	799	1,376	979	1,556	1,282	1,859
120(30)	29.1	30.9	35.1	41.1	814	1,549	887	1,622	1,075	1,810	1,390	2,124
150(45)	30.4	32.2	36.4	42.4	962	1,864	1,038	1,940	1,235	2,137	1,560	2,463
185(45)	32.2	34	38.2	44.2	1,092	2,220	1,173	2,301	1,281	2,508	1,722	2,849
240(45)	34.8	36.4	40.6	47	1,294	2,800	1,372	2,877	1,594	3,100	2,014	3,519
300(45)	37.2	38.4	42.6	49	1,519	3,412	1,581	3,474	1,816	3,709	2,256	4,149
400(60)	40.3	41.1	45.7	51.7	1,869	4,279	1,914	4,324	2,221	4,631	2,633	5,042
500(60)	43.8	44.2	48.8	54.8	2,240	5,344	2,265	5,369	2,595	5,700	3,034	6,138
630(60)	47.8	48.2	52.4	58.8	2,739	6,788	2,766	6,815	3,064	7,113	3,534	7,583
800(60)	51.7	52.1	56.7	62.7	3,274	—	3,004	—	3,625	—	4,130	—
APvEaPu2g, PvEaPu2g												
50(30)	25.4	27.2	31.4	37.4	574	872	637	935	803	1,101	1,085	1,383
70(30)	27	28.8	33	39	662	1,079	730	1,146	905	1,322	1,201	1,617
95(30)	28.8	30.6	34.8	40.8	773	1,350	845	1,422	1,032	1,609	1,344	1,921
120(30)	30.1	31.9	36.1	42.1	859	1,594	935	1,670	1,130	1,865	1,453	2,188
150(45)	31.4	33.2	37.4	43.4	1,009	1,911	1,088	1,990	1,291	2,193	1,626	2,528
185(45)	33.2	35	39.2	45.2	1,142	2,270	1,226	2,353	1,440	2,567	1,790	2,917
240(45)	35.8	37.4	41.6	48	1,348	2,853	1,428	2,934	1,657	3,162	2,058	3,563
300(45)	38.2	39.4	43.6	50	1,577	3,469	1,641	3,534	1,882	3,775	2,302	4,195
400(60)	41.3	42.1	46.7	52.7	1,932	4,342	1,978	4,388	2,264	4,674	2,681	5,090
500(60)	44.8	45.2	49.8	55.8	2,308	5,412	2,333	5,437	2,641	5,745	3,085	6189
630(60)	48.8	49.2	53.4	59.8	2,783	6,832	2,811	6,860	3,112	7,161	3,625	7,674
800(60)	52.7	53.1	57.7	63.7	3,323	—	3,352	—	3,713	—	4,227	—
APvEaV, PvEaV												
50(30)	24.3	26.1	30.3	36.3	587	885	651	949	821	1,119	1,109	1,407
70(30)	25.9	27.7	31.9	37.9	669	1,086	738	1,154	916	1,332	1,215	1,632
95(30)	27.7	29.5	33.7	39.7	780	1,358	854	1,431	1,043	1,620	1,359	1,936
120(30)	29	30.8	35	41	868	1,603	945	1,680	1,142	1,877	1,469	2,204
150(45)	30.3	32.1	36.3	42.3	1,019	1,921	1,099	2,001	1,304	2,206	1,643	2,545
185(45)	32.1	33.9	38.1	44	1,153	2,280	1,238	2,365	1,454	2,581	1,808	2,935
240(45)	34.7	36.3	40.5	46.9	1,360	2,866	1,441	2,947	1,673	3,178	2,090	3,596
300(45)	37.1	38.3	42.5	48.9	1,590	3,483	1,655	3,548	1,899	3,792	2,336	4,429
400(60)	40.2	41	45.6	51.6	1,947	4,357	1,994	4,404	2,254	4,664	2,717	5,127
500(60)	43.7	44.1	48.8	54.7	2,326	5,430	2,351	5,455	2,675	5,779	3,125	6,229

Nominal conductor (screen) cross-section, mm²	Single core cable external diameter, mm				Weight of 1 km of single core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
630(60)	47.7	48.1	52.3	58.7	2,817	6,865	2,844	6,839	3,150	7,199	3,684	7,733
800(60)	51.6	52	56.6	62.6	3,359	—	3,389	—	3,770	—	4,291	—
APvEaVng(A)-LS, PvEaVng(A)-LS												
50(30)	28.1	32.1	38.5	44.5	1,028	1,326	1,124	1,422	1,591	1,889	2,021	2,319
70(30)	29.6	33.6	40	46.5	1,144	1,561	1,245	1,661	1,731	2,148	2,174	2,591
95(30)	31.5	35.5	41.9	48.3	1,289	1,866	1,394	1,971	1,904	2,481	2,416	2,994
120(30)	32.8	36.8	43.2	49.6	1,399	2,134	1,507	2,242	2,033	2,768	2,559	3,294
150(45)	34.1	38.1	44.5	50.9	1,573	2,475	1,685	2,587	2,227	3,129	2,766	3,668
185(45)	35.8	39.8	46.7	52.7	1,738	2,865	1,854	2,982	2,418	3,546	2,974	4,101
240(45)	38.4	42.2	49.1	55.1	1,991	3,497	2,101	3,606	2,749	4,254	3,275	4,780
300(45)	40.8	44.3	51.1	57.5	2,264	4,157	2,350	4,243	3,026	4,918	3,569	5,462
400(60)	43.9	47.3	53.8	60.2	2,675	5,085	2,736	5,146	3,448	5,858	4,082	6,492
500(60)	47.9	50.5	57.3	62.3	3,172	6,276	3,205	6,309	3,904	7,008	4,570	7,673
630(60)	51.4	54	609	67.3	3,686	7,735	3,721	7,770	4,532	8,581	5,165	9,214
800(60)	55.3	58.3	64.8	71.2	4,363	4,363	4,400	4,400	5,199	5,199	5946	5946

Table 23. Design diameter and weight of tripple-core cables.

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
APvP, PvP, APvPg, PvPg												
50(16)	43	47	57	71	2,058	2,965	2,415	3,323	3,341	4,249	5,041	5,549
70(16)	47	51	60	75	2,471	3,740	2,829	4,098	3,818	5,087	5,612	6,881
95(16)	51	55	64	79	2,966	4,723	3,355	5,112	4,421	6,178	6,328	8,086
120(16)	54	58	68	81	3,349	5,586	3,795	6,033	5,003	7,240	6,863	9,101
150(25)	57	61	71	84	3,939	6,686	4,375	7,122	5,641	8,387	7,576	10,322
185(25)	61	64	75	88	4,532	7,965	4,997	8,430	6,338	9,771	8,372	11,804
240(25)	68	71	80	93	5,594	10,178	6,051	10,636	7,368	11,952	9,538	14,123
300(25)	73	75	85	97	6,629	12,392	6,997	12,761	8,394	14,158	10,679	16,442
400(35)	80	81	90	103	8,128	—	8,395	—	9,898	—	12,334	—
APvPu, PvPu, APvPug, PvPug												
50(16)	44	49	58	71	2,125	3,032	2,489	3,397	3,430	4,337	5,063	5,971
70(16)	48	52	61	75	2,544	3,813	2,908	4,177	3,912	5,181	5,635	6,904
95(16)	52	56	65	79	3,045	4,802	3,440	5,197	4,520	6,278	6,352	8,110
120(16)	55	59	69	82	3,432	5,670	3,885	6,123	5,024	7,262	6,888	9,126

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
150(25)	58	62	71	84	4,028	6,775	4,469	7,216	5,662	8,409	7,601	10,348
185(25)	62	66	75	88	4,626	8,059	5,097	8,530	6,361	9,794	8,398	11,831
240(25)	68	71	80	93	5,614	10,199	6,073	10,657	7,393	11,977	9,567	14,151
300(25)	73	76	85	98	6,651	12,414	7,020	12,784	8,420	14,183	10,708	16,472
400(35)	80	81	90	103	8,152	—	8,420	—	9,926	—	12,366	—
APvV, PvV, APvV-KhL, PvV-KhL												
50(16)	43	47	57	71	2,206	3,113	2,592	3,499	3,570	4,478	5,388	6,296
70(16)	47	51	60	75	2,646	3,915	3,018	4,287	4,061	5,330	5,976	7,245
95(16)	51	55	64	79	3,156	4,913	3,560	5,317	4,681	6,438	6,713	8,470
120(16)	54	58	68	81	3,549	5,787	4,028	6,266	5,336	7,573	7,262	9500
150(25)	57	61	71	84	4,169	6,915	4,620	7,367	5,988	8,735	7,989	10,736
185(25)	61	64	75	88	4,777	8,210	5,259	8,691	6,705	10,138	8,804	12,237
240(25)	68	71	80	93	5,923	10,507	6,398	10,982	7,761	12,345	9,998	14,582
300(25)	73	75	85	97	6,985	12,748	7,366	13,130	8,809	14,573	11,160	16,924
400(35)	80	81	90	103	8,518	—	8,794	—	10,346	—	12,845	—
APvVng(A)-LS, PvVng(A)-LS												
50(16)	43	48	57	71	2,331	3,239	2,744	3,651	3,781	4,689	5,603	6,510
70(16)	47	51	60	74	2,803	4,072	3,196	4,465	4,300	5,569	6,219	7,487
95(16)	51	55	64	78	3,334	5,091	3,760	5,517	4,946	6,703	6,980	8,738
120(16)	54	58	68	81	3,743	5,981	4,254	6,491	5,542	7,779	7,547	9,785
150(25)	57	61	71	84	4,390	7,137	4,866	7,613	6,213	8,960	8,296	11,043
185(25)	61	65	74	87	5,022	8,454	5,528	8,961	6,952	10,385	9,137	12,570
240(25)	67	71	80	93	6,127	10,711	6,622	10,711	8,041	12,626	10,369	14,953
300(25)	72	75	84	97	7,221	12,985	7,619	13,382	9,121	14,884	11,567	17,330
400(35)	79	81	90	103	8,795	—	9,083	—	10,695	—	13,298	—
APvVng(V)-LS, PvVng(V)-LS												
50(16)	43	47	57	70	2,276	3,183	2,682	3,589	3,735	4,642	5,506	6,413
70(16)	47	51	60	74	2,742	4,010	3,129	4,398	4,252	5,521	6,117	7,386
95(16)	51	55	64	78	3,267	5,025	3,688	5,445	4,894	6,651	6,873	8,631
120(16)	54	58	67	80	3,673	5,910	4,207	6,444	5,449	7,687	7,436	9,674
150(25)	57	61	70	83	4,343	7,090	4,816	7,563	6,115	8,862	8,180	10,927
185(25)	61	65	74	87	4,972	8,404	5,475	8,907	6,850	10,282	9,016	12,448
240(25)	67	70	79	92	6,035	10,619	6,525	11,110	7,932	12,516	10,240	14,824
300(25)	74	75	84	96	7,383	13,146	7,516	13,279	9,005	14,768	11,432	17,195
400(35)	79	80	89	102	8,828	—	8,972	—	10,571	—	13,155	—
APvVng(A)-KhL, PvVng(A)-KhL, APvVng(A), PvVng(A)												
50(16)	43	48	57	71	2,288	3,195	2,690	3,597	3,736	4,644	5,499	6,407

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
70(16)	47	51	61	74	2,742	4,011	3,129	4,398	4,244	5,513	6,102	7,371
95(16)	51	55	65	78	3,267	5,025	3,688	5,445	4,886	6,643	6,857	8,614
120(16)	54	58	68	81	3,673	5,910	4,200	6,438	5,435	7,673	7,419	9,657
150(25)	57	61	71	84	4,337	7,083	4,808	7,555	6,101	8,848	8,162	10,909
185(25)	61	65	74	87	4,964	8,397	5,467	8,899	6,834	10,267	8,997	12,429
240(25)	67	71	80	93	6,022	10,606	6,511	11,095	7,915	12,499	10,220	14,804
300(25)	72	75	84	97	7,107	12,870	7,500	13,263	8,987	14,750	11,411	17,174
400(35)	79	81	90	103	8,670	—	8,954	—	10,551	—	13,132	—
APvVng(V)-KhL, PvVng(V)-KhL, APvVng(V), PvVng(V)												
50(16)	43	47	57	70	2,246	3,153	2,644	3,551	3,681	4,589	5,431	6,339
70(16)	47	51	60	74	2,696	3,965	3,080	4,349	4,186	5,455	6,030	7,299
95(16)	51	55	64	78	3,218	4,976	3,635	5,392	4,823	6,581	6,782	8,539
120(16)	54	58	67	80	3,621	5,858	4,144	6,381	5,370	7,608	7,341	9,579
150(25)	57	61	70	83	4,281	7,028	4,749	7,496	6,033	8,780	8,081	10,828
185(25)	61	65	74	87	4,906	8,338	5,404	8,837	6,762	10,195	8,913	12,345
240(25)	67	70	79	92	5,957	10,541	6,443	11,027	7,838	12,422	10,130	14,715
300(25)	72	75	84	96	7,037	12,801	7,428	13,191	8,906	14,669	11,317	17,080
400(35)	79	80	89	102	8,594	—	8,877	—	10,465	—	13,033	—
APvBP, PvBP, APvBPg, PvBPg												
50(16)	47	51	61	75	2,661	3,568	3,043	3,951	4,094	5,001	5,980	6,888
70(16)	51	55	64	78	3,092	4,361	3,501	4,770	4,615	5,884	6,596	7,865
95(16)	55	59	69	82	3,640	5,397	4,119	5,876	5,405	7,162	7,366	9,123
120(16)	58	62	72	85	4,097	6,335	4,592	6,799	5,904	8,142	7,938	10,176
150(25)	61	65	75	88	4,692	7,439	5,180	7,927	6,580	9,327	8,689	11,435
185(25)	64	69	79	91	5,335	8,768	5,956	9,418	7,328	10,761	9,535	12,967
240(25)	71	75	84	97	6,485	11,070	6,990	11,574	8,428	13,012	10,772	15,356
300(25)	76	79	88	101	7,579	13,343	7,983	13,746	9,501	15,264	11,959	17,123
400(35)	83	85	94	107	9,167	—	9,458	—	11,082	—	13,692	—
APvBV, PvBV, APvBV-KhL, PvBV-KhL												
50(16)	47	51	61	75	2,918	3,825	3,323	4,231	4,447	5,324	6,485	7,392
70(16)	51	55	64	78	3,369	4,638	3,801	5,070	4,989	6,258	7,125	8,393
95(16)	55	59	69	82	3,941	5,698	4,461	6,218	5,869	7,627	7,924	9,681
120(16)	58	62	72	85	4,432	6,670	4,921	7,159	6,389	8,626	8,515	10,753
150(25)	61	65	75	88	5,045	7,792	5,557	8,304	7,085	9,831	9,286	12,033
185(25)	64	69	79	91	5,711	9,144	6,452	9,885	7,859	11,292	10,159	13,592
240(25)	71	75	84	97	6,964	11,548	7,493	12,077	8,997	13,581	11,433	16,018
300(25)	76	79	88	101	8,107	13,871	8,529	14,292	10,113	15,879	12,664	18,427

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
400(35)	83	85	94	107	9,743	—	10,046	—	11,735	—	14,438	—
APvBVng(A)-LS, PvBVng(A)-LS												
50(16)	47	51	61	74	3,103	4,010	3,531	4,438	4,722	5,630	6,766	7,674
70(16)	51	55	64	77	3,573	4,842	4,029	5,298	5,288	6,557	7,428	8,697
95(16)	55	59	69	81	4,170	5,927	4,725	6,482	6,115	7,872	8,256	10,013
120(16)	58	62	71	84	4,689	6,926	5,204	7,442	6,652	8,889	8,868	11,106
150(25)	61	65	74	87	5,223	8,070	5,862	8,609	7,368	10,115	9,662	12,409
185(25)	64	69	78	91	6,015	9,448	6,701	10,134	8,168	11,601	10,564	13,997
240(25)	71	74	83	96	7,225	11,809	7,776	12,360	9,343	13,927	11,881	16,465
300(25)	76	78	87	100	8,404	14,167	8,844	14,607	10,493	16,257	13,150	18,913
400(35)	82	84	93	106	10,086	—	10,402	—	12,161	—	14,975	—
APvBVng(V)-LS, PvBVng(V)-LS												
50(16)	47	51	60	74	3,038	3,946	3,461	4,369	4,672	5,579	6,661	7,568
70(16)	50	54	64	77	3,504	4,773	3,955	5,224	5,235	6,504	7,319	8,588
95(16)	54	59	68	81	4,095	5,853	4,676	6,433	6,018	7,775	8,140	9,898
120(16)	58	62	71	84	4,641	6,878	5,153	7,391	6,550	8,788	8,748	10,987
150(25)	60	64	74	87	5,273	8,020	5,808	8,555	7,263	10,010	9,539	12,286
185(25)	64	68	78	90	5,962	9,394	6,604	10,036	8,058	11,491	10,435	13,868
240(25)	70	74	83	96	7,125	11,709	7,671	12,255	9,225	13,810	11,744	16,329
300(25)	75	78	87	100	8,297	14,060	8,733	14,496	10,369	16,133	13,007	18,771
400(35)	82	84	93	106	9,969	—	10,282	—	12,029	—	14,824	—
APvBVng(A)-KhL, PvBVng(A)-KhL, APvBVng(A), PvBVng(A)												
50(16)	47	51	61	74	3,018	3,926	3,439	4,346	4,637	5,545	6,611	7,519
70(16)	51	55	64	77	3,482	4,751	3,931	5,200	5,198	6,467	7,266	8,535
95(16)	55	59	69	81	4,071	5,828	4,642	6,400	5,972	7,730	8,085	9,842
120(16)	58	62	71	84	4,619	6,856	5,128	7,366	6,513	8,751	8,701	10,939
150(25)	61	65	74	87	5,238	7,985	5,771	8,518	7,213	9,960	9,479	12,225
185(25)	64	69	78	91	5,924	9,357	6,558	9,991	8,005	11,438	10,372	13,805
240(25)	71	74	83	96	7,078	11,662	7,621	12,206	9,168	13,752	11,677	16,261
300(25)	76	78	87	100	8,245	14,009	8,679	14,443	10,309	16,072	12,937	18,700
400(35)	82	84	93	106	9,913	—	10,225	—	11,964	—	14,749	—
APvBVng(V)-KhL, PvBVng(V)-KhL, APvBVng(V), PvBVng(V)												
50(16)	47	51	60	74	2,970	3,877	3,387	4,294	4,575	5,483	6,535	7,443
70(16)	50	54	64	77	3,431	4,700	3,875	5,144	5,132	6,401	7,187	8,456
95(16)	54	59	68	81	4,015	5,773	4,582	6,340	5,902	7,660	8,002	9,759
120(16)	58	62	71	84	4,560	6,797	5,065	7,303	6,441	8,678	8,615	10,853
150(25)	60	64	74	87	5,176	7,923	5,705	8,452	7,138	9,884	9,390	12,137

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
185(25)	64	68	78	90	5,859	9,291	6,488	9,920	7,926	11,358	10,279	13,712
240(25)	70	74	83	96	7,006	11,590	7,546	12,130	9,083	13,667	11,579	16,163
300(25)	75	78	87	100	8,168	13,931	8,599	14,363	10,220	15,983	12,834	18,598
400(35)	82	84	93	106	9,829	—	10,139	—	11,869	—	14,641	—
APvKP, PvKP, APvKPg, PvKPg												
50(16)	54	59	68	—	5,832	6,732	6,552	7,452	8,319	9,219	—	—
70(16)	58	62	72	—	6,501	7,760	7,194	8,453	9,029	10,288	—	—
95(16)	62	67	—	—	7,332	9,075	8,146	9,889	—	—	—	—
120(16)	65	70	—	—	7,906	10,126	8,739	10,959	—	—	—	—
150(25)	68	72	—	—	8,889	11,614	9,557	12,282	—	—	—	—
185(25)	72	—	—	—	9,711	13,117	—	—	—	—	—	—
APvKV, PvKV												
50(16)	54	59	68	—	6,202	7,110	6,977	7,884	8,849	9,757	—	—
70(16)	58	62	72	—	6,776	8,045	7,482	8,751	9,390	10,659	—	—
95(16)	62	67	—	—	7,620	9,378	8,490	10,247	—	—	—	—
120(16)	65	70	—	—	8,238	10,476	9,135	11,372	—	—	—	—
150(25)	68	72	—	—	9,266	12,013	9,954	12,701	—	—	—	—
185(25)	72	—	—	—	10,311	13,717	—	—	—	—	—	—
APvEaP, PvEaP, APvEaPg, PvEaPg												
50(30)	46	50	59	73	2,083	2,990	2,421	3,328	3,365	4,273	5,093	6,000
70(30)	49	53	62	76	2,476	3,745	2,841	4,109	3,848	5,117	5,670	6,939
95(30)	53	57	67	80	2,978	4,735	3,409	5,167	4,582	6,339	6,394	8,151
120(30)	56	60	70	83	3,400	3,400	3,821	3,821	5,049	5,049	6,934	6,934
150(45)	59	63	73	86	3,905	5,903	4,348	6,346	5,634	7,632	7,593	9,591
185(45)	63	68	67	90	4,505	6,965	5,101	7,561	6,339	8,799	8,396	10,856
240(45)	70	73	82	95	5,580	8,583	6,044	9,047	7,378	10,381	9,573	12,576
APvEaV, PvEaV												
50(30)	46	50	59	73	2,251	3,159	2,604	3,512	3,602	4,509	5,449	6,357
70(30)	49	53	62	76	2,657	3,926	3,037	4,306	4,099	5,368	6,044	7,312
95(30)	53	57	67	80	3,175	4,932	3,639	5,396	4,907	6,667	6,788	8,545
120(30)	56	60	70	83	3,625	5,863	4,062	6,300	5,391	7,629	7,342	9,580
150(45)	59	63	73	86	4,142	6,889	4,601	7,348	5,990	8,737	8,016	10,763
185(45)	63	68	67	90	4,757	8,190	5,460	8,863	6,714	10,147	8,838	12,271
240(45)	70	73	82	95	5,919	10,503	6,401	10,985	7,781	12,365	10,041	14,626
APvEaVng(A)-LS, PvEaVng(A)-LS												
50(30)	47	50	59	72	2,543	3,450	2,930	3,838	4,020	4,928	5,917	6,824
70(30)	49	53	62	76	2,978	4,247	3,393	4,662	4,550	5,819	6,543	7,812

Nominal conductor (screen) cross-section, mm²	Three core cable external diameter, mm				Weight of 1 km of three core cable, kg							
	6 kV	10 kV	20 kV	35 kV	6 kV		10 kV		20 kV		35 kV	
					Al	***Cu***	***Al***	***Cu***	***Al***	***Cu***	***Al***	***Cu***
95(30)	53	57	67	80	3,532	5,289	4,041	5,798	5,325	7,083	7,328	9,085
120(30)	56	60	70	83	4,016	6,254	4,491	6,728	5,832	8,070	7,910	10,147
150(45)	59	63	72	85	4,562	7,308	5,059	7,806	6,459	9,206	8,615	11,362
185(45)	63	67	76	89	5,214	8,647	5,850	9,282	7,220	10,652	9,477	12,909
240(45)	69	72	81	94	6,354	10,938	6,868	11,453	8,338	12,922	10,737	15,321
APvEaBP, PvEaBP, APvEaBPg, PvEaBPg												
50(30)	49	53	62	77	2,820	3,727	3,223	4,130	4,323	5,230	6,281	7,189
70(30)	52	57	67	80	3,269	4,538	3,735	5,004	4,991	6,260	6,915	8,184
95(30)	57	61	71	84	3,875	5,632	4,338	6,096	5,676	7,434	7,706	9,464
120(30)	60	64	74	87	4,311	6,548	4,796	7,034	6,190	8,428	8,293	10,531
150(45)	62	68	77	89	4,863	7,610	5,501	8,248	6,823	9,670	9,000	11747
185(45)	67	71	80	93	5,656	9,088	6,200	9,633	7,591	11,024	9,866	13,299
240(45)	73	77	86	98	6,754	11,338	7,279	11,863	8,771	13,355	11,192	15,776
APvEaBV, PvEaBV												
50(30)	49	53	62	77	3,087	3,995	3,513	4,421	4,686	5,594	6,799	7,706
70(30)	52	57	67	80	3,556	4,825	4,063	5,332	5,439	6,708	7,456	8,725
95(30)	57	61	71	84	4,204	5,961	4,692	6,449	6,154	7,911	8,277	10,034
120(30)	60	64	74	87	4,657	6,895	5,167	7,405	6,687	8,925	8,883	11,121
150(45)	62	68	77	89	5,227	7,974	5,954	8,701	7,341	10,087	9,611	12,358
185(45)	67	71	80	93	6,107	9,540	6,680	10,112	8,135	11,568	10,504	13,936
240(45)	73	77	86	98	7,246	11,830	7,796	12,380	9,353	13,937	11,868	16,452
APvEaBVng(A)-LS, PvEaBVng(A)-LS												
50(30)	51	54	64	77	3,391	4,299	3,847	4,754	5,105	6,012	7,244	8,152
70(30)	54	58	68	81	3,885	5,154	4,434	5,703	5,808	7,077	7,930	9,199
95(30)	58	62	72	85	4,576	6,333	5,096	6,853	6,554	8,312	8,786	10,543
120(30)	61	65	75	87	5,052	7,289	5,594	7,832	7,110	9,348	9,417	11,654
150(45)	64	68	77	90	5,647	8,394	6,329	9,076	7,788	10,535	10,172	12,919
185(45)	67	71	80	93	6,153	9,585	6,737	10,169	8,223	11,656	10,646	14,079
240(45)	72	76	85	98	7,264	11,848	7,823	12,407	9,409	13,993	11,974	16,558

9. MANUFACTURER'S GUARANTEES

The manufacturer guarantees that the cables comply with the requirements of technical specifications provided that the customer (consumer) observes the transportation, storage, installation and operation conditions.

The warranty period of operation is 5 years.

The warranty period is calculated from the date of putting cables into operation but not later than 6 months from the date of manufacture.

The cables service life is not less than 30 years.

APPENDIX A. Cable jacket repair technology

Informative appendix

1. Repairs using heat-shrinkable wraparound sleeves

1.1. For cable jacket repairs it is recommended to use Raychem heat-shrinkable wraparound sleeves 1,500 mm long of various sizes depending on the external diameter of the cable being repaired. For information, Table A-1 contains the main characteristics and designation of sleeves for ordering.

Table A-1. Main characteristics and designation of sleeves.

External diameter of the cable being repaired, mm	Sleeve internal diameter before shrinkage, mm		Ordering code
	Before shrinkage D_a (min.)	After shrinkage D_b (max.)	
17 to 32	54	15	CRSM 53/13-1500/239
24 to 50	86	21	CRSM 84/20-1500/239
31 to 65	108	27	CRSM 107/29-1500/239
33 to 86	144	28	CRSM 143/36-1500/239

The sleeve size should be selected so as to ensure that after shrinkage on the cable its internal diameter is within the range from (D_b+15%D_b) to (D_a–20%D_a);

where D_b is the sleeve internal diameter after free shrinkage,

D_a is the sleeve internal diameter before shrinkage.

It is permissible to use heat-shrinkable sleeves of equivalent quality by other manufacturers.

1.2. Determine the boundaries of the cable jacket fault location for repair (at least 100 mm in both directions from the fault edges).

1.3. If there are stiffeners on the cable jacket at the repair location, remove them around the entire circumference.

1.4. Sand the jacket surface and degrease with acetone.

1.5. Cut the sleeve and lock to obtain a section equal in length to the length of the fault location for repair.

1.6. Remove the protective film from the cut section of the sleeve and wrap the sleeve around the cable so that the adhesive sublayer adheres to the cable jacket. Slide the lock onto the sleeve edges.

1.7. Use propane burner small flame to shrink the sleeve onto the cable and start heating from the middle of the side opposite to the lock.

1.8. Additionally heat up the area near the lock after complete sleeve shrinkage. In case of correct shrinkage an adhesive compound should be squeezed out as smooth beads from under the sleeve edges onto the cable jacket.

1.9. Let the sleeve cool down to a temperature below plus 35 °C. No mechanical impacts on the sleeve are allowed until it cools down.

2. Repairs using LETSAR LP tape

2.1. Determine the boundaries of the cable jacket fault location for repair (at least 150 mm in both directions from the fault edges).

2.2. If there are stiffeners on the cable jacket at the repair location, remove them around the entire circumference.
2.3. Sand the jacket surface and degrease with acetone.
2.4. If at the location of repair there are through holes, cracks or ruptures in the jacket whose width or diameter is more than 3 mm, pieces of LETSAR LP tape should be put in them and compressed so as to make the tape pieces level with the outer surface of the jacket or protrude above the jacket by not more than 1 mm.
2.5. Apply KO-916 varnish to the surface repaired and let the varnish dry.
2.6. Apply four layers of LETSAR LP tape with 50% overlap to the jacket surface coated with varnish.
2.7. Apply KO-916 varnish to the surface of the wound tape and cable jacket sections for a distance of 50 mm from the tape and apply two layers of PVC tape with 50% overlap.
2.8. Apply two layers of tar tape to the surface of the PVC tapes with 50% overlap preheating it with gas burner flame.
2.9. After application of the tar tape, let the cable cool down at the repair location to a temperature below 35 °C. No mechanical impacts on the repair location are allowed until it cools down.

3. Repairs using RULLE tape

3.1. RULLE tapes are made of ethylene-propylene rubber with an adhesive layer of butyl rubber covered with a protective film that is removed during installation. The thickness of the tapes is 2 mm, the width is 60 mm. Length in a roll: RULLE**1** tape – 3.5 m, RULLE**2** tape – 5.5 m.
3.2. Determine the boundaries of the cable jacket fault location for repair (at least 100 mm in both directions from the fault edges).
3.3. If there are stiffeners on the cable jacket at the repair location, remove them around the entire circumference.
3.4. Sand the jacket surface and degrease with acetone.
3.5. Apply two layers of RULLE tape with 50% overlap. Wind the tape with the adhesive layer facing the cable jacket removing the protective film. Wind the tape stretching it to such extent that the ovals drawn on its surface become circles.

APPENDIX B. Repair of cable routes

Informative appendix

Overhaul should be performed once every 5 years according to the following procedure:

1. Visual inspection of cable ducts, cable tunnels and elements of cable lines.
2. Detection of defects, scope of work specification.
3. Cleaning of vents, cable tunnels and ducts.
4. Restoring serviceability of hatches (doors) and locks.
5. Adjustment of cable sagging. Cleaning armor from dust and corrosion, application of anti-corrosion varnish or paint to the cable armor and metal structures.
6. Attachment of missing tags.
7. Checking the condition of cable joints/terminations and their fasteners, painting and fastening of joints/terminations.
8. Corrective actions to address identified issues with regard to design, fastening and fencing of cable lines.
9. Monitoring and measurement of cable temperature rise using a thermal imager.
10. Conducting high voltage tests.
11. Remedying defects identified based on the high-voltage testing results.
12. The route overhauls should be documented either by making records in the cable log or by drawing up a Report or using any other method adopted by the enterprise.

Cable routine repairs should be performed once every two years according to the following procedure:

1. Visual inspection of cable ducts, cable tunnels, cables.
2. Detection of defects, scope of work specification.
3. Technical inspection, cleaning of structures and elements of cable lines.
4. Check for compliance with technical specifications (temperature monitoring).
5. Remedying defects, restoration of markings, inscriptions, tags (attachment of missing tags).
6. Adjustment of cable sagging.
7. The cable routine repairs should be documented either by making records in the cable log or by drawing up a Report or using any other method adopted by the enterprise.

APPENDIX (informative)

Table C-1. Mechanical properties of aluminum, aluminum alloy and steel wires for armor.

Characteristics	Value of wire characteristics		
	aluminum	aluminum alloy	zinc-coated steel
1. Ultimate tensile strength, N/mm^2, not less than	165	305	340
2. Elongation at rupture, %, not less than	1.5	3.0	9
3. Modulus of elasticity, N/mm^2, not less than	$63 \cdot 10^3$	$63 \cdot 10^3$	$200 \cdot 10^3$
4. Linear expansion factor, °C^{-1}, not more than	$23 \cdot 10^{-6}$	$23 \cdot 10^{-6}$	$11.5 \cdot 10^{-6}$

Table C-1. Design values of the number of armor wires, tensile strength of armor wires and armor depending on the cable diameter.

Armor wire diameter, mm	Cable diameter under the armoring, mm	Number of wires**, pcs.		Tensile strength of wire, N			Tensile strength of wire armor, kN***		
		aluminum and aluminum alloy	steel	aluminum	aluminum alloy	steel	aluminum	aluminum alloy	steel
1.60	Less than 25	31–50	31–50	320	600.0	680.0	10.0–16.0	18.3–30.0	21.0–34.0
2.00	« 25 « 35	41–56	41–56	502.4	942.0	1,067.6	20.6–28.0	38.0–58.0	43.8–59.8
2.50	« 35 « 60	45–76	45–76	784.0	1,470.0	1,666.0	35.3–59.6	65.0–110.0	75.0–126.6
3.15 (3.00)*	« 60 « 80	60–80	63–84	1,248.0	2,340.0	2,400.0	80.0–100.0	138.0–184.0	151.0–201.6
(4.00)*	« 80	—	63 and more	—	—	4,284.0	—	—	270.0

* Diameters of zinc-coated steel wire

** The number of armor wires depending on the cable diameter is calculated using the formula:

$$N = \pi \cdot (D+d) / d \cdot Ktw,$$

where D is the cable diameter under the armor; d is the diameter of the armor wires;
Ktw is the twist factor of armor wires based on the pitch of twisting of the wires taken to be equal to 1.03–1.04.

*** The armor tensile strength is calculated using the formula

$$P = 0.95 \sum_{i=1}^{n} Pi,$$

where Pi is the tensile strength of one aluminum, aluminum alloy or zinc-coated steel wire, N; n is the number of armor wires.

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