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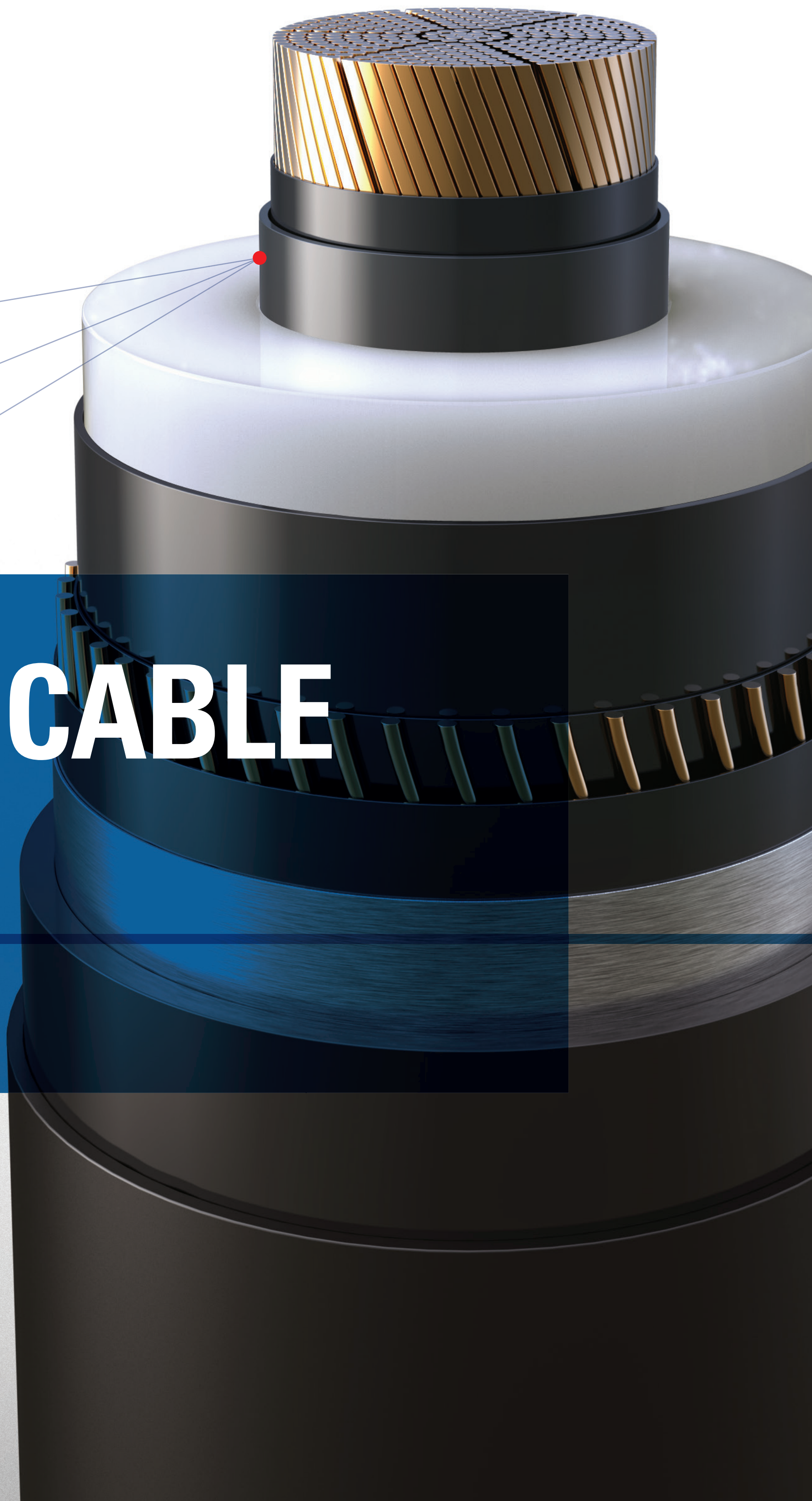
EHV XLPE CABLE SYSTEMS

CABLE · ACCESSORIES



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CABLE & SOLUTION


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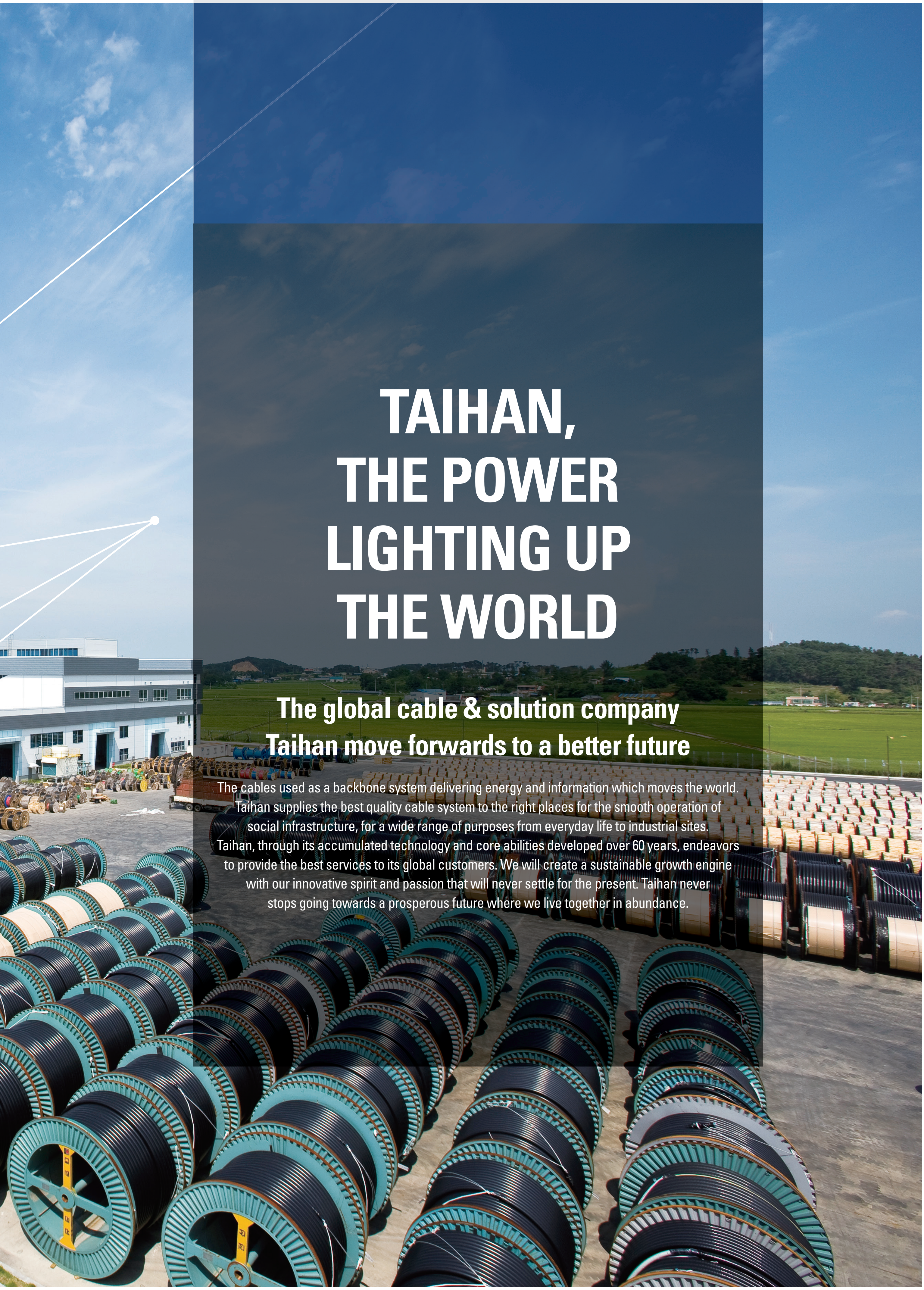


TAIHAN, THE POWER LIGHTING UP THE WORLD

The global cable & solution company Taihan move forwards to a better future

The cables used as a backbone system delivering energy and information which moves the world. Taihan supplies the best quality cable system to the right places for the smooth operation of social infrastructure, for a wide range of purposes from everyday life to industrial sites. Taihan, through its accumulated technology and core abilities developed over 60 years, endeavors to provide the best services to its global customers. We will create a sustainable growth engine with our innovative spirit and passion that will never settle for the present. Taihan never stops going towards a prosperous future where we live together in abundance.

XLPE Cable

Engineering

Quality Assurance

Accessories

Diagnosis System

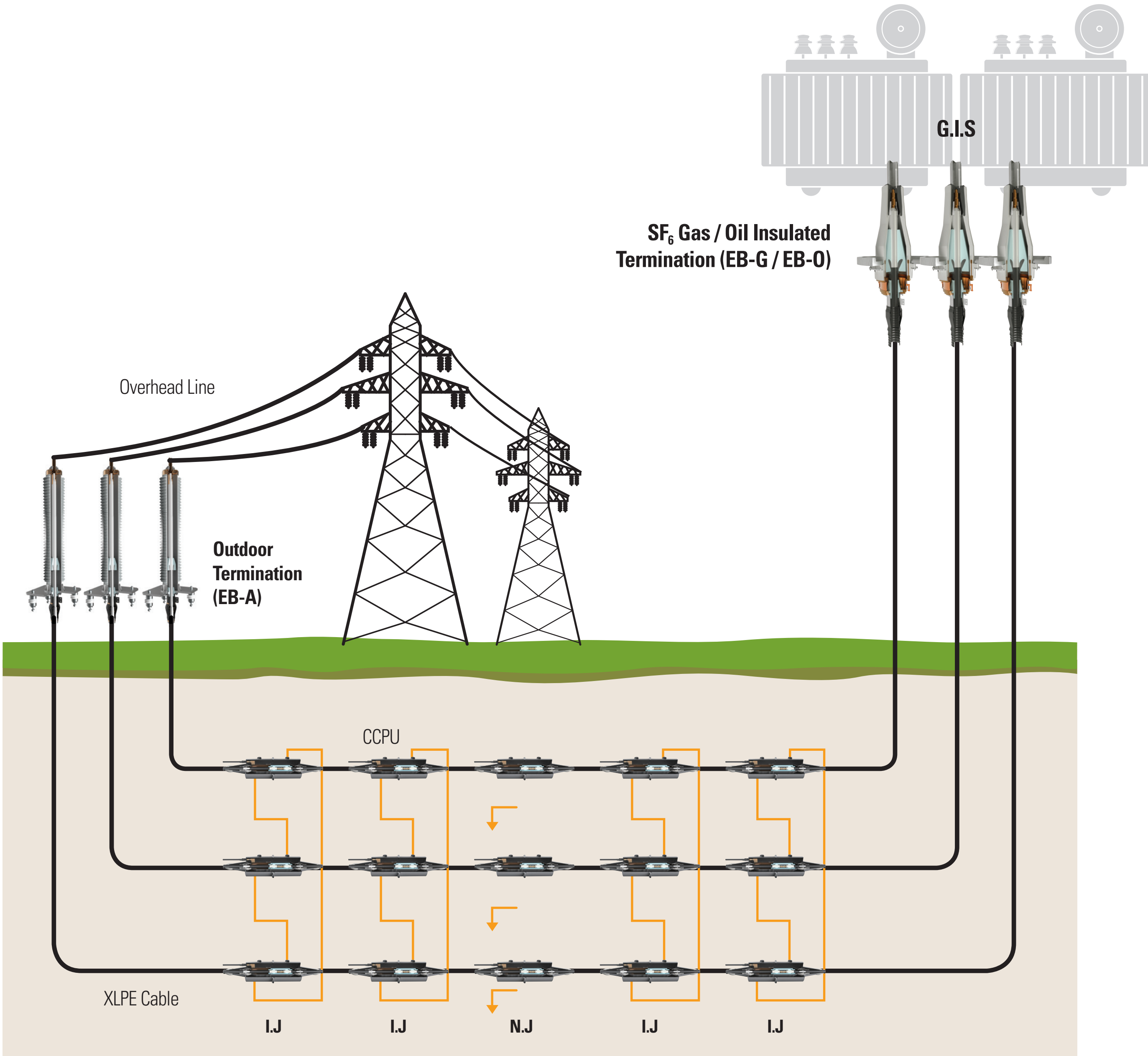
Contents

Test Requirements

Power Transmission Line

Taihan provides turnkey cabling solutions to ensure the reliability of energy networks

Having led the establishment of the nation's power network for the half-century, Taihan has led the development of extra high voltage cables since the 1970s and been recognized for the world class technology in XLPE underground cable. We have continued to increase its technology to 230kV and 345kV XLPE cables through advancement of technology and facilities. In step with the ever increasing power consumption and the expansion of extra high voltage cable demand, we reinforced the production capacity by equipping the 160.5 meters high VCV Tower, to produce high quality extra high voltage XLPE cable up to 500kV grade. Furthermore, we produce and supply quality accessories and joints materials for extra high voltage cables. From raw materials, production process, testing of products, to network design & installation, we have strictly controlled the quality of products and elevated ourselves to an extra high voltage cable specialist trusted by the world's major markets including Asia, Middle East, US, and Australia.



01

XLPE CABLE

Structure Details

Manufacturing Process

VCV Line

Design & Construction

XLPE(Cross-Linked Polyethylene) insulated cables have been widely used for electric power distribution of voltage up to 30kV grade since they were developed in 1960 to replace the paper insulated cables and other thermoplastic insulated cables. XLPE cables have many excellent characteristics, especially for use in higher operating temperature. Generally PE insulated cables can be used in maximum operating temperature of 70°C and paper insulated cables in 85°C, but XLPE cables, which have more compact crystallinity than PE by cross-linking process, can be used up to 90°C in normal condition.

The major merits of XLPE cables can be illustrated as follows;

- Excellent electrical properties
- Higher operating temperature, higher current capacity
- Excellent physical and mechanical properties
- Anti-chemical properties
- Ease of jointing, installation and maintenance

XLPE cables, however, had been scarcely used for extra high voltage exceeding 30kV grade because of its weakness for water treeing phenomena which occurs in the insulation in long-term operating situation. Water treeing is the phenomena of gradual insulation destroying due to water concentration onto some weak points in the insulation.

The water can be invaded through the polymeric materials in gaseous states and /or contained in insulation materials together with small voids and impurities during extrusion, steam-curing and cooling process. These waters can be concentrated onto weak points due to high electric intensity and repeating switching operation, and eventually formed a tree-shaped tunnel from inside to outer surface of insulation.

But nowadays, with the aid of technical development in cable manufacturing field, water treeing phenomena cannot be an obstacle any more to extent the voltage grade higher. Water invasion from the outside of cable can be prevented by adopting water-proof seamless metal sheath and water contents in insulation during manufacturing process can be practically minimized by adopting dry curing cross-linking process instead of steam-curing method.

Many researches and developments are accomplished in many developed countries including ourselves and it shows excellent operating experiences. 66kV and 77kV grade XLPE cables have already been used since early 1970s and now XLPE cables up to and including 230kV grade are popularly being adopted for power transmission lines. 345kV grade and 500kV grade cables are also developed and under operations.

Structure Details

Scope
This specification applies to materials and constructions of cross-linked poly-ethylene (XLPE) cables for extra high voltage transmission of rated voltage from 66kV grade up to and including 500kV grade. This specification deals manufacturer's standard models of the cable, however any other models as for buyer's standard are also available.

Conductor
The conductor shall be formed from plain copper or aluminum complying with Korean Standard KS C 3101, British Standard 6360/6791, IEC Publication 60228 or ICEA S-108-720. The conductor shall be stranded circular, compacted circular, or segmental compacted circular. Segmental compacted circular conductors shall be applied to cables of conductor nominal cross-sectional areas of 800mm above.

Conductor Shielding
Conductor shielding of an extruded semi-conducting thermosetting compound shall be applied over the conductor. One or two layer of semi-conducting tape(s) may be applied with a proper lapping between the conductor and the extruded semi-conducting layer.

Insulation
The insulation shall be of dry-cured XLPE compound with a thickness to meet dimensional, electrical and physical requirements specified. The compound shall be high quality, heat-, moisture-, ozone- and resistant. This insulation shall be suitable for operation in wet or dry locations at conductor temperature not exceeding 90°C for normal condition, 130°C for emergency overload conditions and 250°C for short circuit conditions.

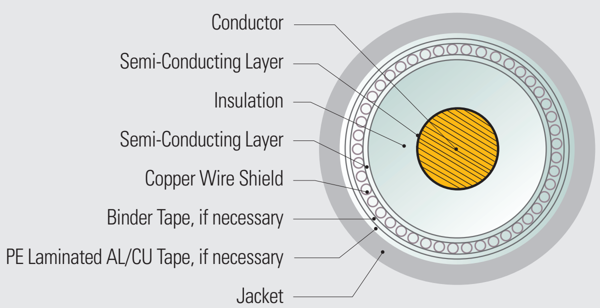
Insulation Thickness
The insulation thickness of XLPE cable must be based on its ability to withstand lightening impulse voltage as well as operating voltage throughout its expected life. For the design of XLPE cable, the nominal thickness of insulation is determined by AC withstand voltage (VAC) or impulse with stand voltage (Vimp), that can be determined by following formula. Larger value of TAC and Timp should be determined as minimum thickness of insulation.

Insulation Shielding
The insulation shielding shall be applied direct upon the insulation and shall consist of either a semi-conducting tape or a layer of extruded semi-conducting compound, or combination of these materials. The extruded semi-conducting compound shall be a thermosetting or thermosetting compound and firmly and totally bonded to the insulation.

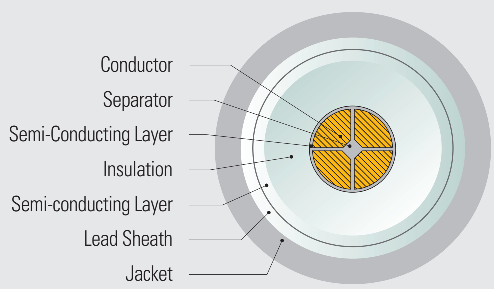
Metallic Layer
The metallic layer can be applied over the insulation shielding to reinforce the capability of carrying fault current specified, if required. The metallic layer will be one of the next forms.

Inner Plastic Bedding
If required, extruded layer of a thermoplastic compound, PVC or PE can be applied.

Copper Wire Shield Type



Metallic Sheath Type



Metal Tape Moisture Barrier
When the moisture barrier required, a layer of aluminum tape laminated at both or outer side with copolymer shall be applied longitudinally over the cable core with an overlap so as to lap parts of the tape on each other.

Outer Jacket
The outer jacket shall consist of thermoplastic compound (PVC, PE or similar materials) extruded continuously over the metallic layer or moisture barrier. A bituminous compound primer shall be applied under the outer jacket to protect the sheath against local corrosion when corrugated aluminum sheath or lead alloy sheath is adopted.

Copper Wire Shield (CWS)
When a layer of copper wire shield is required, it shall be applied directly over the insulation shielding with a length of lay of approximately 10 times the diameter over the screen conductors and with gaps not less than 0.1mm, if not specified. One or more layers of suitable separator tape may be applied helically over a layer of CWS.

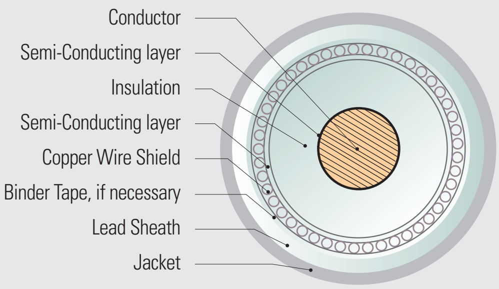
Corrugated Aluminum Sheath
When the corrugated aluminum sheath is required, it shall be applied by extrusion and then passing through a corrugating head. The corrugating head contains rotating dies to form the valleys between the ribs like sine wave and produce to correct diameter of sheath to fit over the insulation. The sheath shall be free from pinholes flaws and other imperfections. When the aluminum sheath is applied directly over the extruded semi-conducting layer or inner plastic bedding, suitable non-metallic tape(s) can be applied under the aluminum sheath to prevent heat transfer onto the plastic material during the manufacturing.

Lead Sheath
When the lead alloy sheath is required, it shall be applied by a continuous screw extrusion in high quality, smooth surface and free from pinholes and any other imperfections including one associated with oxide inclusions. When the lead sheath is applied directly over the extruded semi-conducting layer or inner plastic bedding, suitable non-magnetic tape(s) can be applied under the lead sheath to prevent heat transfer onto the plastic material during the manufacturing. The composition of lead alloy of composition of Cu 0.04%, Te 0.04% and the remainder for lead will be applied.

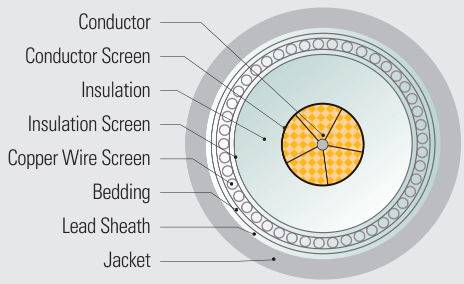
Smooth Sheath
The smooth sheath transmission cable is easy to develop the reduced diameter cable compared to the existing cable. Therefore, the construction cost of underground transmission can be reduced. Also, when the old cable is replaced, it is possible to increase the capacity by replacing the small conductor cable installed with the large conductor cable.

LSZH (Low Smoke Zero Halogen)
Low Smoke Zero Halogen (LSZH) or Low Smoke Free of Halogen (LSFH) is a material that improves safety due to low smoke and low choking probability when the cable is burned. So it is typically used for cable jacketing in the wire and cable industry. LSZH cable jacketing is composed of thermoplastic or thermoset compounds that emit limited smoke and no halogen when exposed to high sources of heat.

Copper Wire Shield & Lead Alloy Sheath Type



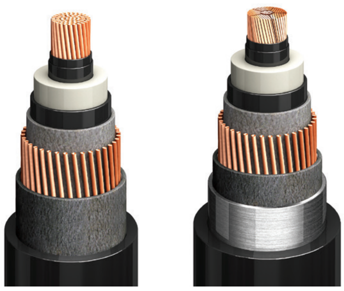
Insulated Wires, Copper Wire Shield & Lead Sheath Type
(Enamelled Copper Wire Cable)



Manufacturing Process

Wire Drawing — Copper or Aluminum Rod

Wire Stranding — **Segmental** — Conductor Assembling — Conductor Binder



Circular or Compact Circular

Taping — Semi-Conductive Tape

Extrusion Dry Curing Simultaneous Process — Inner Semi-Conductive PE, Insulation XLPE, Outer Semi-Conductive PE

Taping — Semi-Conductive Tape

Wire Shield	Leads Alloy Sheath	Corrugated Aluminum Sheath
Wiring Machine — Copper Wire	Leads Screw Extrusion — Lead Alloy	Aluminum Press — Aluminum
Jacket Extrusion — Aluminum-Foil, PE or PVC	Jacket Extrusion — Flooding Compound, PE or PVC	Jacket Extrusion — Flooding Compound, PE or PVC

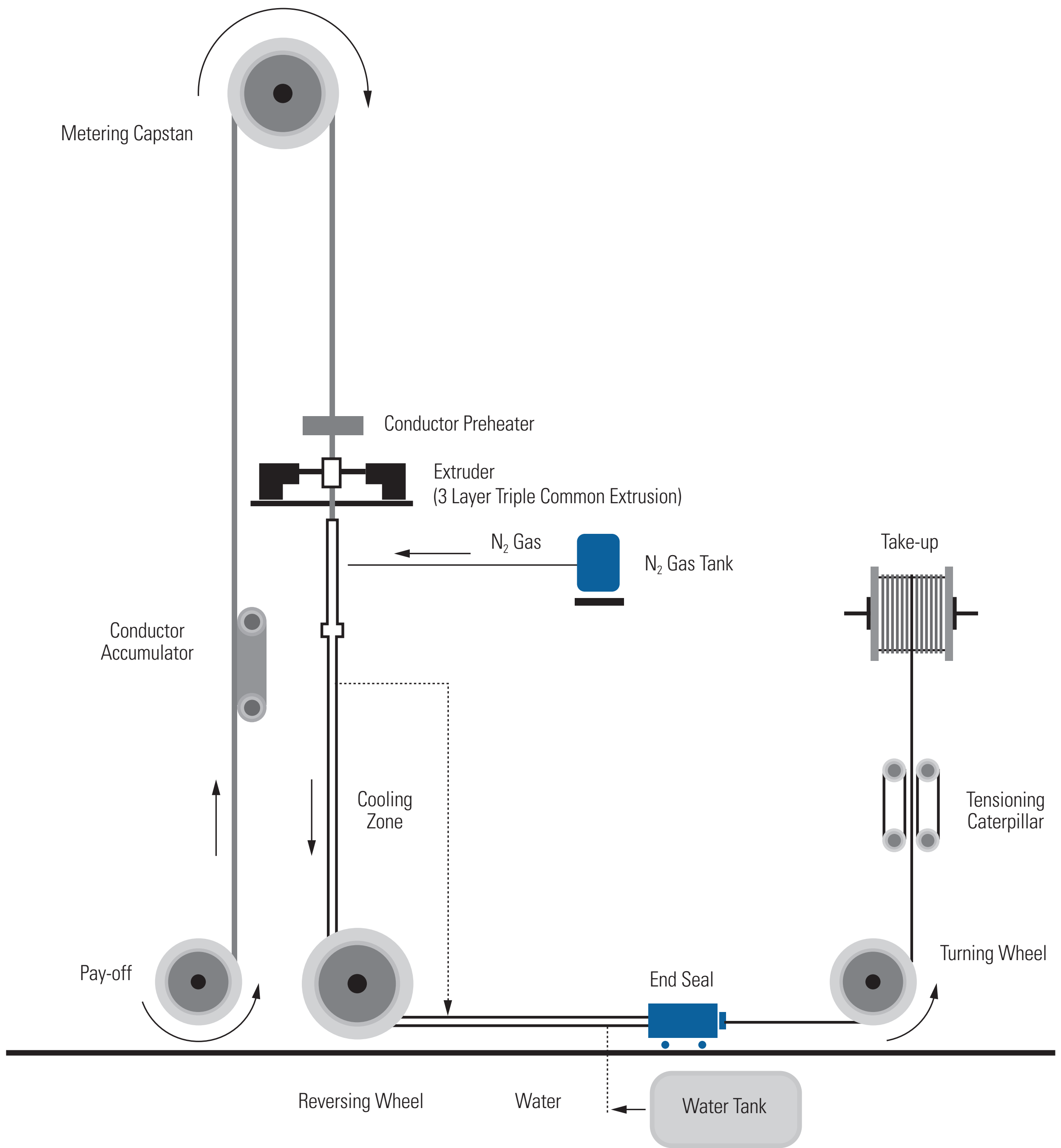
Test & Delivery

VCV Line

Vertical Type Continuous Vulcanizing Equipment

In case of Extra High Voltage Cable, the insulation thickness is so thick that center of the conductor and the insulation was not coincided each other when catenary type vulcanizing system was adopted. Due to the considerable eccentricity of the insulated core, the insulation thickness should be thicker than the electrically required value.

Our facility of vulcanizing process is installed in vertical in the tower of height of approximately 125m. The insulation is extruded on the highest place of the tower and passed through the vertical tube for vulcanizing and cooling purposes. Since the pass line of the insulated core is vertical, strengthen core is exposed to uniform gravity force through its cross-section that no eccentricity can be occurred. By adopting this method, the insulation thickness can be reduced remarkably and nowadays, and the extruded thermosetting insulated cables are enough competitive to conventional cables.



Design & Construction

Construction

$T_{AC} = V_{AC}/E_L(AC)$, $T_{imp} = V_{imp}/E_L(imp)$

Where,
V_{AC} : AC withstand voltage
V_{imp} : Impulse withstand voltage

1) Value of E_L

$E_L(AC)$: minimum breakdown stress obtained from weibull distribution plot for AC. (kV/mm)

$E_L(imp)$: minimum breakdown stress obtained from weibull distribution for impulse. (kV/mm)

2) Value of V_{AC}

$$*V_{AC} = \frac{E_0}{\sqrt{3}} \times \frac{1.1}{1.15} \times K_1 \times K_2 \times K_3$$

Where,
E_0 : Nominal voltage (kV)
K_1 : Safety factor
K_2 : Deterioration coefficient of XLPE cable under electrical stresses
K_3 : Temperature coefficient corresponding to the ratio of break down stresses of the cable at room temperature to those at maximum permissible temperature (90°C)

3) Value of V_{imp}

$V_{imp} = BIL \times K'_1 \times K'_2 \times K'_3$

Where,
BIL : Basic impulse level (kV)
K'_1 : Safety factor
K'_2 : Deterioration coefficient of XLPE cable under electrical stresses
K'_3 : Temperature coefficient corresponding to the ratio of breakdown stresses of the cable at room temperature to those at maximum permissible temperature (90°C)

66kV Single Core Cable

Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
200	C.C	1.0	11.0	1.5	1.5	3.5	64.0	5.2
250	C.C	1.0	11.0	1.5	1.6	3.5	67.0	5.9
325	C.C	1.0	11.0	1.5	1.6	3.5	70.0	7.0
400	C.C	1.0	11.0	1.5	1.7	3.5	74.0	8.1
500	C.C	1.0	11.0	1.5	1.7	3.5	76.0	9.1
600	C.C	1.0	11.0	1.5	1.8	3.5	80.0	10.4
800	C.C	1.0	11.0	1.5	1.9	3.5	87.0	13.2
1000	SEG	1.5	11.0	1.5	2.0	3.5	92.0	15.6
1200	SEG	1.5	11.0	1.5	2.1	3.5	98.0	18.0
1400	SEG	1.5	11.0	1.5	2.1	3.5	101.0	20.3
1600	SEG	1.5	11.0	1.5	2.2	3.5	105.0	22.5
1800	SEG	1.5	11.0	1.5	2.3	3.5	108.0	24.5
2000	SEG	1.5	11.0	1.5	2.3	3.5	111.0	26.9

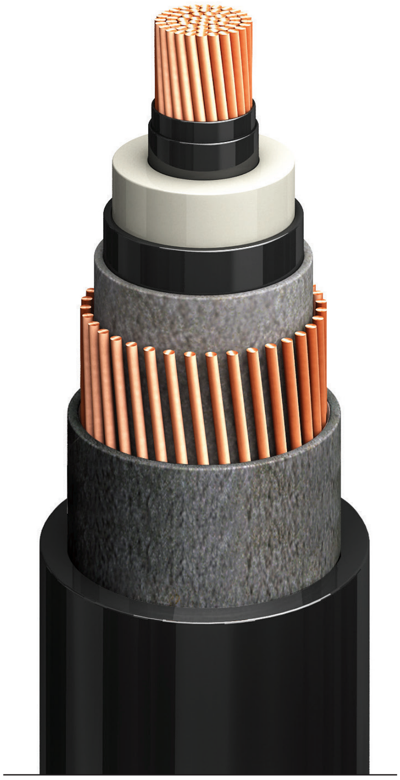
*C.C : Circular Compacted *SEG : Segmental Compacted

Copper Wire Shield Type

Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
200	C.C	1.0	11.0	1.5	40	1.2	3.5	56.0	4.5
250	C.C	1.0	11.0	1.5	40	1.2	3.5	58.0	5.1
325	C.C	1.0	11.0	1.5	40	1.2	3.5	60.0	5.9
400	C.C	1.0	11.0	1.5	40	1.2	3.5	64.0	6.9
500	C.C	1.0	11.0	1.5	40	1.2	3.5	67.0	8.0
600	C.C	1.0	11.0	1.5	40	1.2	3.5	69.0	9.1
800	C.C	1.0	11.0	1.5	40	1.2	3.5	77.0	11.7
1000	SEG	1.5	11.0	1.5	40	1.2	3.5	81.0	13.7
1200	SEG	1.5	11.0	1.5	40	1.2	3.5	85.0	15.7
1400	SEG	1.5	11.0	1.5	40	1.2	3.5	89.0	17.9
1600	SEG	1.5	11.0	1.5	40	1.2	3.5	92.0	19.8
1800	SEG	1.5	11.0	1.5	40	1.2	3.5	95.0	21.8
2000	SEG	1.5	11.0	1.5	40	1.2	3.5	98.0	23.8

*C.C : Circular Compacted *SEG : Segmental Compacted



77kV Single Core Cable

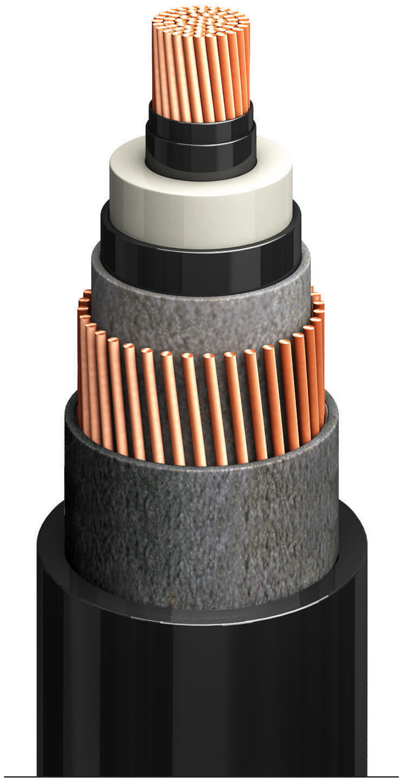
Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
200	C.C	1.2	13.0	1.5	1.6	3.5	69.0	5.2
250	C.C	1.2	13.0	1.5	1.6	3.5	72.0	6.6
325	C.C	1.2	13.0	1.5	1.7	3.5	75.0	7.5
400	C.C	1.2	13.0	1.5	1.8	3.5	78.0	8.5
500	C.C	1.2	13.0	1.5	1.8	3.5	81.0	9.6
600	C.C	1.2	13.0	1.5	1.9	3.5	84.0	10.9
800	C.C	1.2	13.0	1.5	2.0	3.5	92.0	14.0
1000	SEG	1.5	13.0	1.5	2.1	3.5	97.0	16.4
1200	SEG	1.5	13.0	1.5	2.2	3.5	102.0	18.7
1400	SEG	1.5	13.0	1.5	2.2	3.5	106.0	21.0
1600	SEG	1.5	13.0	1.5	2.3	3.5	110.0	23.3
1800	SEG	1.5	13.0	1.5	2.3	3.5	112.0	25.2
2000	SEG	1.5	13.0	1.5	2.4	3.5	116.0	27.7

*C.C : Circular Compacted *SEG : Segmental Compacted

Copper Wire Shield Type



Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
200	C.C	1.2	13.0	1.5	40	1.2	3.5	60.0	4.8
250	C.C	1.2	13.0	1.5	40	1.2	3.5	62.0	5.3
325	C.C	1.2	13.0	1.5	40	1.2	3.5	64.0	6.2
400	C.C	1.2	13.0	1.5	40	1.2	3.5	67.0	7.2
500	C.C	1.2	13.0	1.5	40	1.2	3.5	70.0	8.3
600	C.C	1.2	13.0	1.5	40	1.2	3.5	73.0	9.4
800	C.C	1.2	13.0	1.5	40	1.2	3.5	81.0	12.1
1000	SEG	1.5	13.0	1.5	40	1.2	3.5	86.0	14.2
1200	SEG	1.5	13.0	1.5	40	1.2	3.5	90.0	16.3
1400	SEG	1.5	13.0	1.5	40	1.2	3.5	94.0	18.4
1600	SEG	1.5	13.0	1.5	40	1.2	3.5	97.0	20.4
1800	SEG	1.5	13.0	1.5	40	1.2	3.5	100.0	22.4
2000	SEG	1.5	13.0	1.5	40	1.2	3.5	103.0	24.4

*C.C : Circular Compacted *SEG : Segmental Compacted

110kV Single Core Cable

Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor Cross-Sectional Area	Conductor Shape	Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
400	C.C	1.2	15.0	1.5	1.8	4.0	83	9.3
500	C.C	1.2	15.0	1.5	1.9	4.0	86	10.8
630	C.C	1.2	15.0	1.5	2.0	4.0	92	12.7
800	C.C	1.2	15.0	1.5	2.1	4.0	97	15.4
1000	SEG	1.5	15.0	1.5	2.2	4.0	102	17.9
1200	SEG	1.5	15.0	1.5	2.3	4.0	108	20.2
2000	SEG	1.5	15.0	1.5	2.5	4.0	122	29.6

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (40kA/1sec)

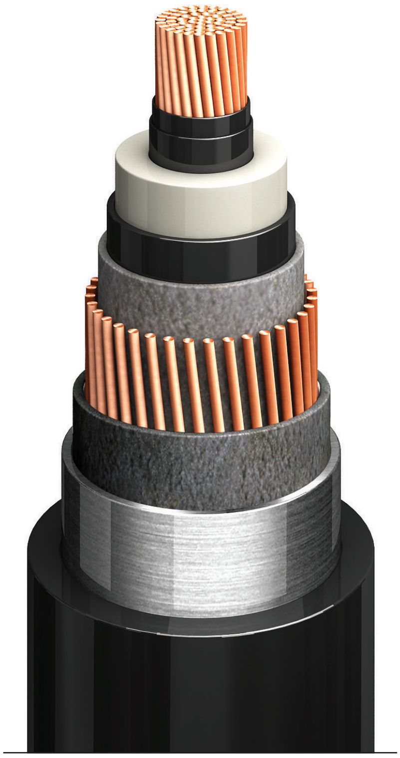
Copper Wire Shield & Lead Sheath Type

Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield / Lead Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor Cross-Sectional Area	Conductor Shape	Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
400	C.C	1.2	15.0	1.5	Ø2.0x67ea	2.5	4.0	81	15.5
500	C.C	1.2	15.0	1.5	Ø2.0x70ea	2.6	4.0	84	17.4
630	C.C	1.2	15.0	1.5	Ø1.9x67ea	2.7	4.0	88	19.3
800	C.C	1.2	15.0	1.5	Ø1.8x70ea	2.9	4.0	94	22.8
1000	SEG	1.5	15.0	1.5	Ø1.8x65ea	3.0	4.0	98	25.6
1200	SEG	1.5	15.0	1.5	Ø1.7x67ea	3.1	4.0	102	28.1
2000	SEG	1.5	15.0	1.5	Ø1.4x70ea	3.5	4.0	115	39.1

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (40kA/1sec)



132kV Single Core Cable

Corrugated Aluminum Sheath Type

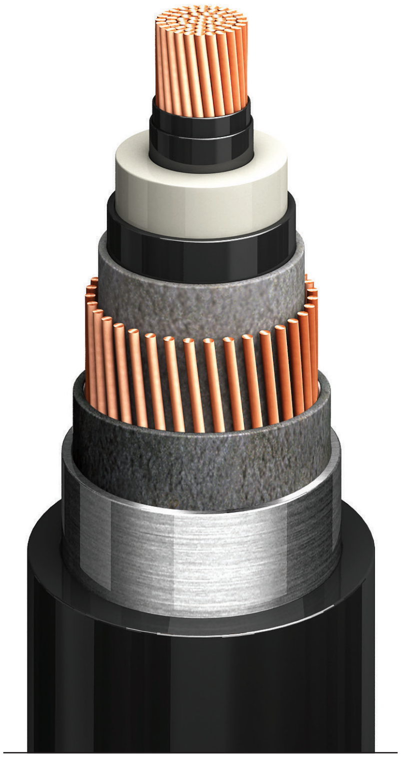
Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
400	C.C	1.2	16	1.5	1.9	4.0	88	9.8
500	C.C	1.2	16	1.5	2.0	4.0	92	11.2
630	C.C	1.2	16	1.5	2.1	4.0	96	13.1
800	C.C	1.2	16	1.5	2.2	4.0	102	15.7
1000	SEG	1.5	16	1.5	2.3	4.0	109	18.4
1200	SEG	1.5	16	1.5	2.3	4.0	113	20.4
2000	SEG	1.5	16	1.5	2.6	4.0	126	29.9

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (40kA/1sec)

Copper Wire Shield & Lead Sheath Type



Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield/ Lead Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
400	C.C	1.2	16	1.5	Ø2.0x67ea	2.5	4.0	82	15.5
500	C.C	1.2	16	1.5	Ø1.9x70ea	2.6	4.0	85	17.2
630	C.C	1.2	16	1.5	Ø1.9x67ea	2.7	4.0	89	19.4
800	C.C	1.2	16	1.5	Ø1.8x67ea	2.9	4.0	95	22.6
1000	SEG	1.5	16	1.5	Ø1.7x70ea	3.0	4.0	99	25.4
1200	SEG	1.5	16	1.5	Ø1.7x65ea	3.1	4.0	103	27.9
2000	SEG	1.5	16	1.5	Ø1.4x65ea	3.5	4.0	116	38.8

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (40kA/1sec)

154kV Single Core Cable

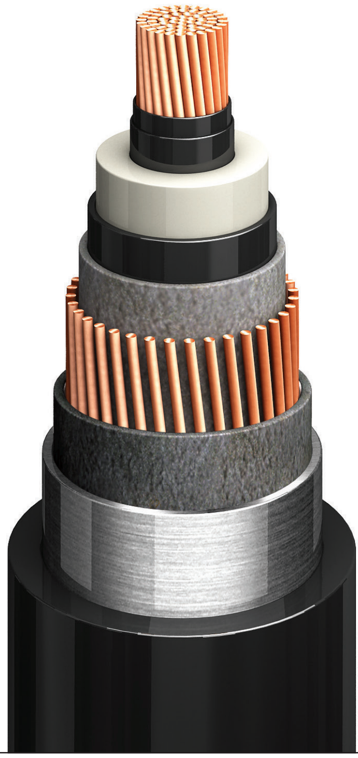
Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm²	-	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.2	17	1.5	2.9	4.5	103	15.0
1200	SEG	1.5	17	1.5	2.5	4.5	115	21.8
2000	SEG	1.5	17	1.5	2.6	4.5	127	31.2
2500	SEG	1.5	17	1.5	2.8	4.5	135	36.2

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (50kA/1.7sec)



Copper Wire Shield & Lead Sheath Type

Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield/ Lead Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm²	-	mm	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.2	17	1.5	Ø2.6x70ea	2.9	4.5	95	22.7
1200	SEG	1.5	17	1.5	Ø2.5x65ea	3.3	4.5	109	31.7
2000	SEG	1.5	17	1.5	Ø2.3x68ea	3.6	4.5	122	42.7
2500	SEG	1.5	17	1.5	Ø2.2x66ea	3.8	4.5	129	48.5

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (40kA/1sec)

230kV Single Core Cable

Corrugated Aluminum Sheath Type

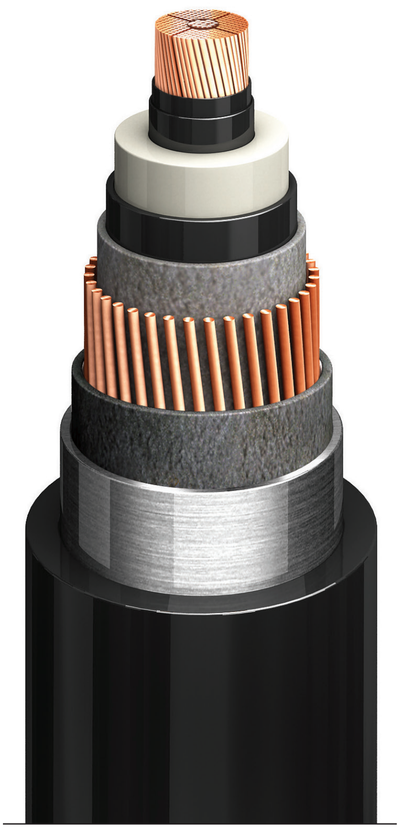
Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	23	1.5	2.4	5.0	117	16.8
1200	SEG	1.5	23	1.5	2.6	5.0	132	24.2
2000	SEG	1.5	23	1.5	2.9	5.0	146	34.1
2500	SEG	1.5	23	1.5	3.0	5.0	153	39.1

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1sec)

Copper Wire Shield & Lead Sheath Type



Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield/ Lead Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	23	1.5	Ø2.3x66ea	3.2	5.0	108	25.7
1200	SEG	1.5	23	1.5	Ø2.2x68ea	3.6	5.0	121	35.0
2000	SEG	1.5	23	1.5	Ø2.0x65ea	4.0	5.0	134	46.7
2500	SEG	1.5	23	1.5	Ø1.9x65ea	4.1	5.0	141	52.4

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1sec)

345kV Single Core Cable

Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	27	1.5	3.0	6.0	132	19.3
1200	SEG	1.5	27	1.5	2.8	6.0	143	27.4
2000	SEG	1.5	27	1.5	3.0	6.0	157	37.5
2500	SEG	1.5	27	1.5	3.2	6.0	165	43.0

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1.7sec)

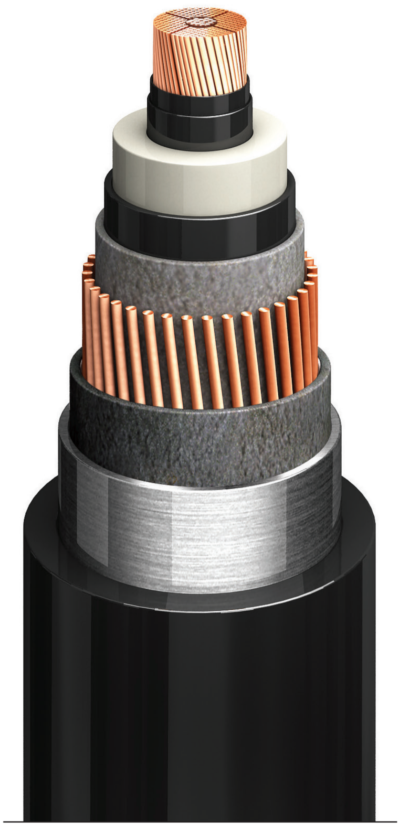
Copper Wire Shield & Lead Sheath Type

Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield/ Lead Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	27	1.5	Ø2.9x84ea	3.1	6.0	119	31.2
1200	SEG	1.5	27	1.5	Ø2.9x81ea	3.4	6.0	132	41.1
2000	SEG	1.5	27	1.5	Ø2.9x78ea	3.7	6.0	145	53.0
2500	SEG	1.5	27	1.5	Ø2.9x75ea	3.9	6.0	153	60.2

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1.7sec)



380/400kV Single Core Cable

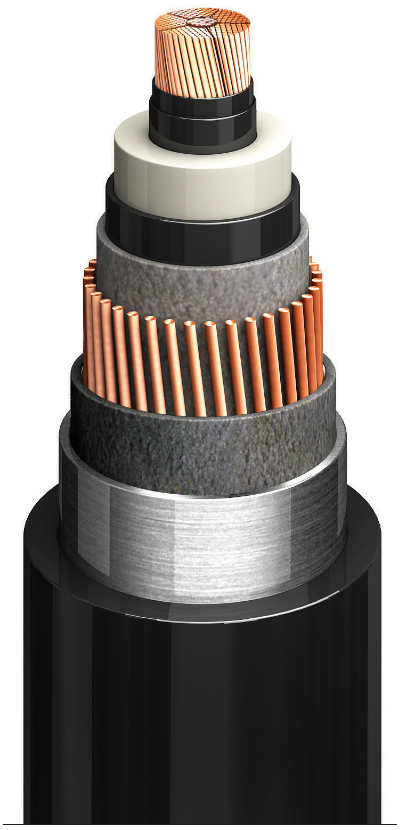
Corrugated Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Aluminum Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	29	1.5	2.6	6.0	132	19.9
1200	SEG	1.5	29	1.5	2.9	6.0	146	27.6
2000	SEG	1.5	27	1.5	3.0	6.0	157	37.5
2500	SEG	1.5	27	1.5	3.2	6.0	165	43.8

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1sec)



Copper Wire Shield & Lead Sheath Type

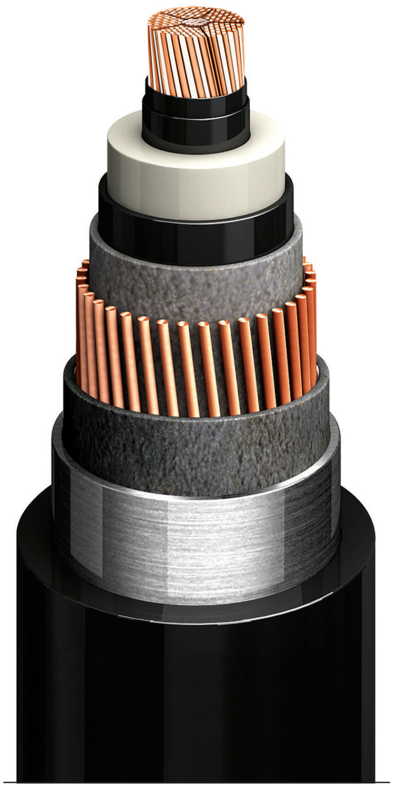
Construction : Copper Conductor / XLPE Insulation / Copper Wire Shield / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
600	C.C	1.3	29	1.5	Ø2.5x82ea	3.1	6.0	122	31.4
1200	SEG	1.5	29	1.5	Ø2.5x77ea	3.5	6.0	135	41.3
2000	SEG	1.5	27	1.5	Ø2.5x74ea	3.7	6.0	145	51.6
2500	SEG	1.5	27	1.5	Ø2.5x71ea	3.9	6.0	153	58.8

*C.C : Circular Compacted
*SEG : Segmental Compacted

*Fault Current Capacity (63kA/1sec)

380/400kV Single Core Cable

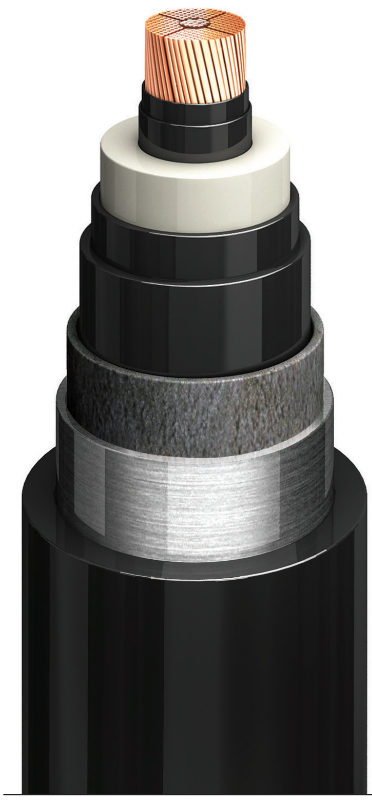


Insulated Wires, Copper Wire Shield & Lead Sheath Type

Construction : Copper Conductor with Insulated Wires / XLPE Insulation / Copper Wire Shield / Lead Sheath / PVC (or PE) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
2000	SEG	1.5	27	1.5	Ø2.54x84ea	4.0	6.0	152	55
2500	SEG	1.5	27	1.5	Ø2.54x79ea	4.0	6.0	160	61

*SEG : Segmental Compacted
*Construction of metallic sheath is subject to change under the fault current condition



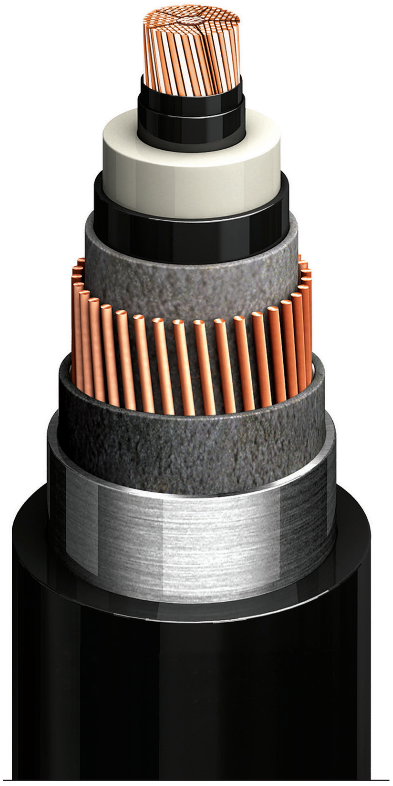
Plain Aluminum Sheath Type

Construction : Copper Conductor / XLPE Insulation / Plain (Smooth) AL Sheath / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	Thickness of Sheath	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape							
mm^2	-	mm	mm	mm	mm	mm	mm	kg/m
2000	SEG	1.5	27	1.5	1.5	6.0	134.5	30.4
2500	SEG	1.5	27	1.5	1.5	6.0	141.2	35.6

*SEG : Segmental Compacted

500kV Single Core Cable



Insulated Wires,
Copper Wire Shield & Aluminum-Laminated Tape Type

Construction : Copper Conductor with Insulated Wires / XLPE Insulation / Copper Wire Shield / AL Laminated Tape / PVC (or PE or LSZH) Outer Jacket

Conductor		Thickness of Conductor Shield (Approx.)	Thickness of Insulation	Thickness of Insulation Shield (Approx.)	No. of Wire	Dia. of Wire	Thickness of Jacket	Overall Dia.	Weight (Approx.)
Cross-Sectional Area	Shape								
mm^2	-	mm	mm	mm	mm	mm	mm	mm	kg/m
2000	SEG	2.0	30	2.0	Ø2.6x66ea	4.0	6.0	151	35
2500	SEG	2.0	30	2.0	Ø2.6x66ea	4.0	6.0	156	40

*SEG : Segmental Compacted

02

ACCESSORIES

Pre-Molded Joint

Transition Joint

Y Branch Joint

Outdoor Termination (EB-A)

SF_6 Gas / Oil Insulated Termination (EB-G / EB-O)

RIP Bushing

Composite Hollow Bushing

GIS Epoxy Insulator

For the accessories of XLPE cable, Pre-molded joint and Slip-on type termination using silicone rubber have been developed and are under an operation. Pre-molded joint and Slip-on type termination have several advantages as less jointing skill and time and quality control in the factory. For the electrical test on the pre-molded rubber unit, epoxy insulator and stress cone, special electrical test facilities have been developed and all insulation parts of accessories are carried out routine test according to IEC standard (IEC60840 & IEC62067).

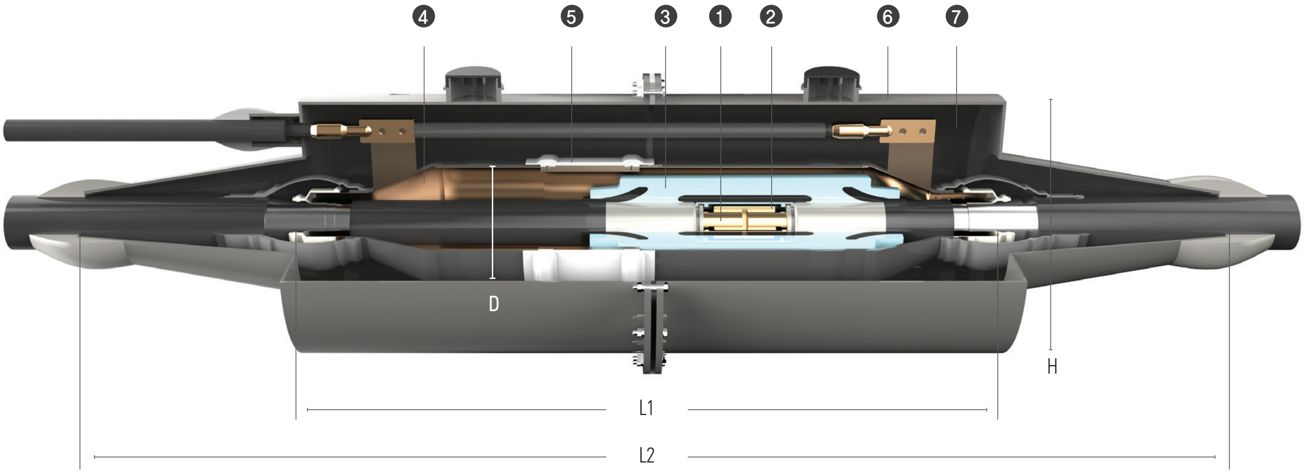
Silicone rubber also has several advantages in mechanical and electrical properties in comparison with Ethylene-Propylene Rubber(EPR) as lower elasticity, lower permanent set and so on.

And most manufacturers of EHV cable accessories are using silicone rubber for the rubber unit and stress cone. So we adopted silicone rubber as insulation and electrode materials and studied mechanical and electrical properties of silicone rubber to apply it to our design prototype of pre-molded rubber unit.

We have developed accessories for XLPE cable up to 500kV class in accordance with IEC standard (IEC60840 & IEC62067).

Pre-Molded Joint

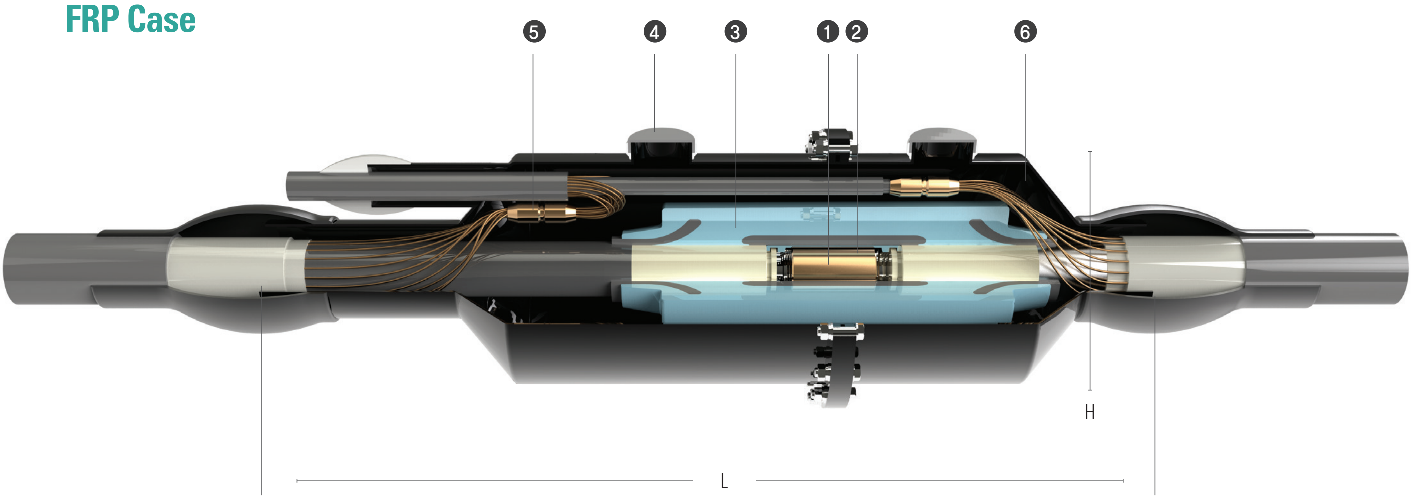
Copper Case with Coffin Box



No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	Corona Shield	Aluminum
3	PMJ Rubber Unit	Silicone Rubber
4	Outer Case	Copper
5	Insulating Flange	P.E
6	Coffin Box	F.R.P
7	Filling Compound	Polyurethane

Rated Voltage	L1 [mm]	L2 [mm]	D [mm]	H [mm]
66kV~69kV	1150	1650	190	420
110kV~161kV	1350	2300	255	540
220kV~275kV	1800	2500	315	600
330kV~400kV	2000	2750	360	660
500kV	2000	2750	400	680

FRP Case

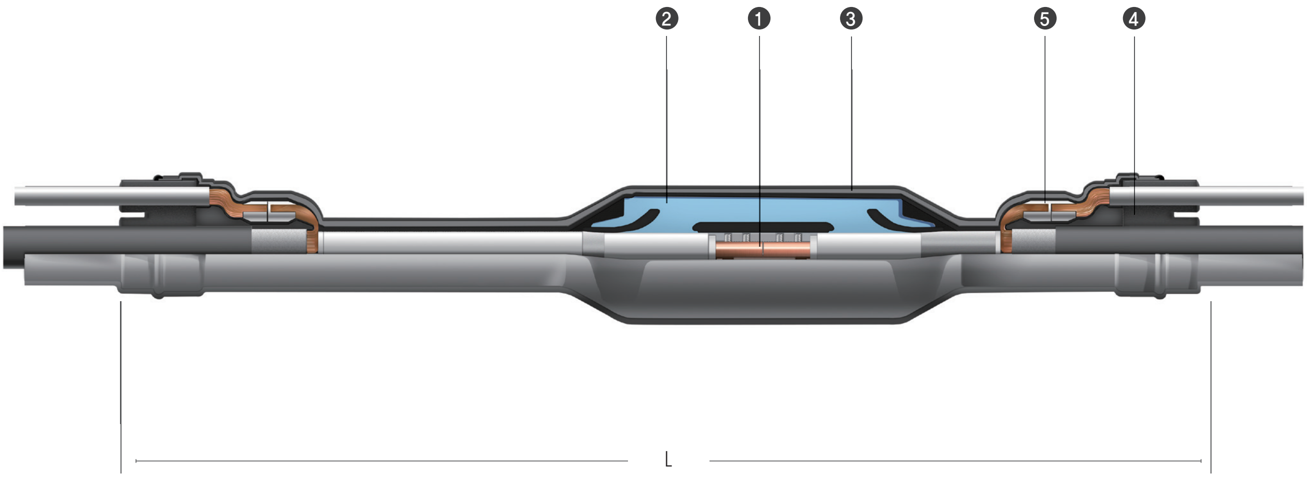


No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	Corona Shield	Aluminum
3	PMJ Rubber Unit	Silicone Rubber
4	Outer Case	F.R.P
5	Earthing Sleeve	Copper
6	Filling Compound	Polyurethane

Rated Voltage	L [mm]	H [mm]
110kV~161kV	1400	310
220kV~275kV	1800	370

Pre-Molded Joint

Heat Shrinkable Tube Case

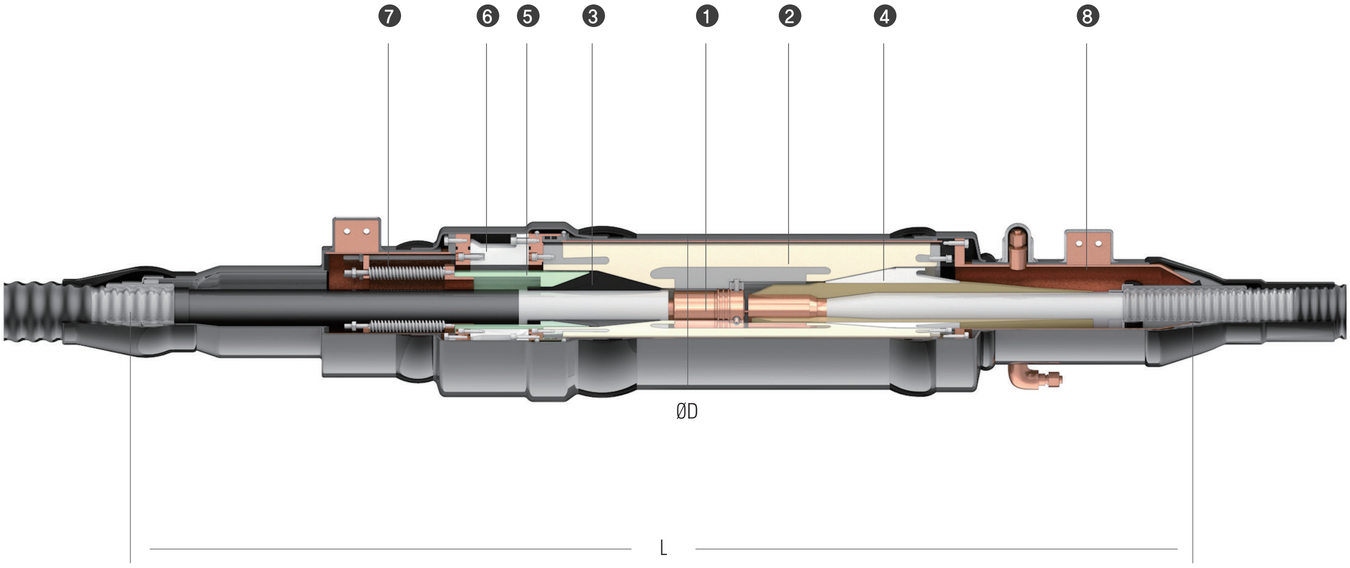


No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	PMJ Rubber Unit	Silicone Rubber
3	Heat Shrinkable Tube	P.E
4	Cable Support	Silicone Rubber
5	Earthing Sleeve	Copper

Rated Voltage	L [mm]
66kV-161kV	1900

Transition Joint

66kV ~ 275kV



No.	Description
1	Conductor Sleeve
2	Epoxy Unit
3	Stress Relief Cone
4	Bell Mouth

No.	Description
5	FRP Pipe
6	Insulator
7	Compression Ring
8	Lower Metal Case

* All of cable diameters between Ø60 and Ø104 are also available

Insulated Joint

Product No.	XLPE Diameter [mm]	O.F Diameter [mm]	ØD [mm]	L [mm]
TCIO-13C-I01	66 - 68	45 - 87	370	2150
TCIO-13C-I02	71 - 73			
TCIO-13C-I03	77 - 79			
TCIO-13C-I04	91 - 93			
TCIO-13C-I05	98 - 100			

Normal Joint

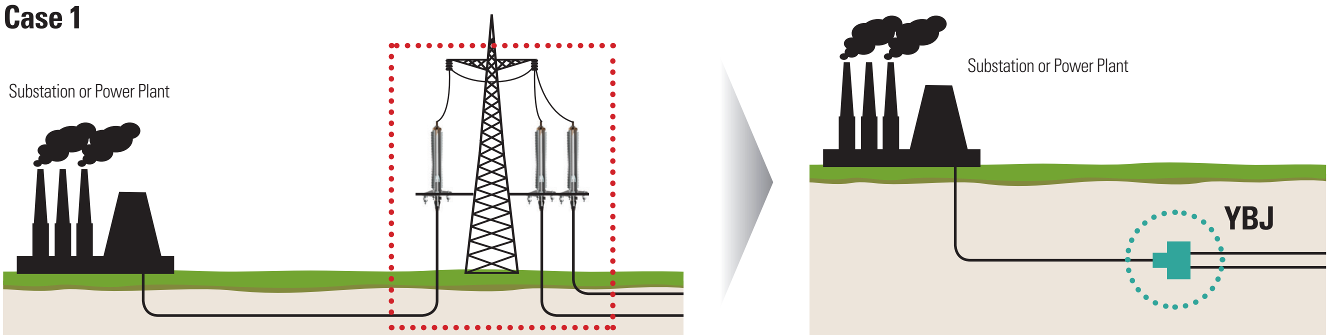
Product No.	XLPE Diameter [mm]	O.F Diameter [mm]	ØD [mm]	L [mm]
TCIO-13C-N01	66 - 68	45 - 87	370	2150
TCIO-13C-N02	71 - 73			
TCIO-13C-N03	77 - 79			
TCIO-13C-N04	91 - 93			
TCIO-13C-N05	98 - 100			

Y Branch Joint

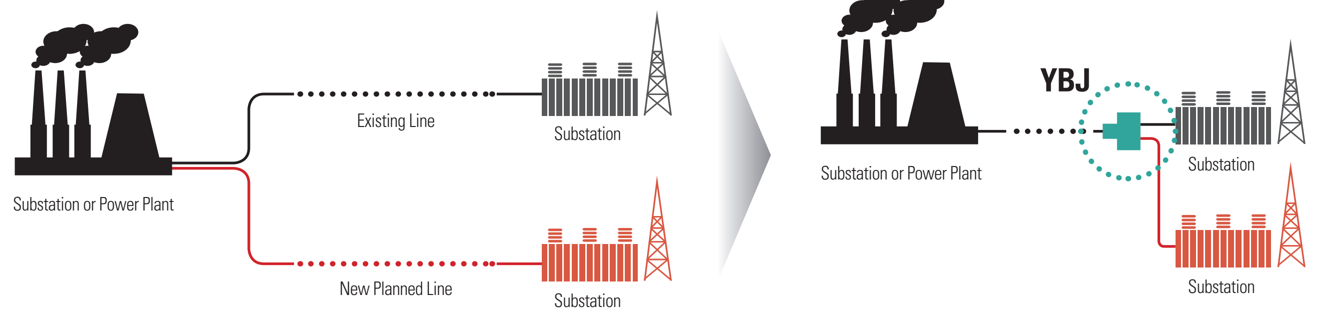
Y Branch Joint can be used in all the transmission & distribution system to make a branch connection with minimum cost.
If new substations are planned using the existing transmission line, Y branch joint is usually used.

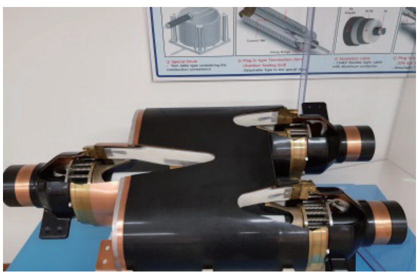
Any of 3 connections can be connected regardless of cable type(XLPE cable or OF cable) or conductor size.
XLPE Cable : 600SQ~2500 / OF Cable : 600SQ~2500SQ

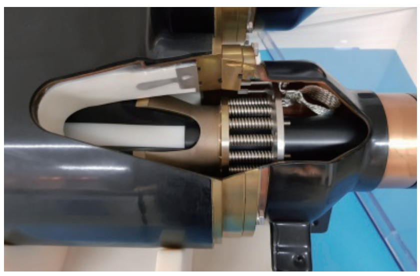
Case 1



Case 2

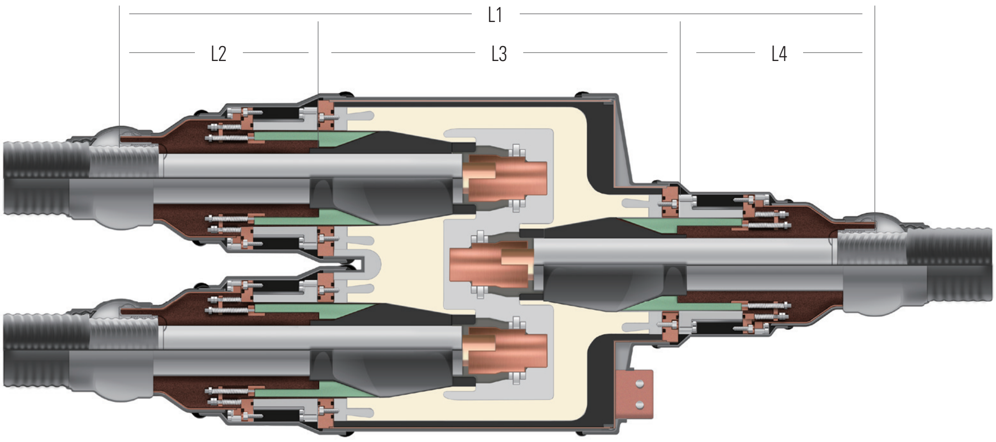




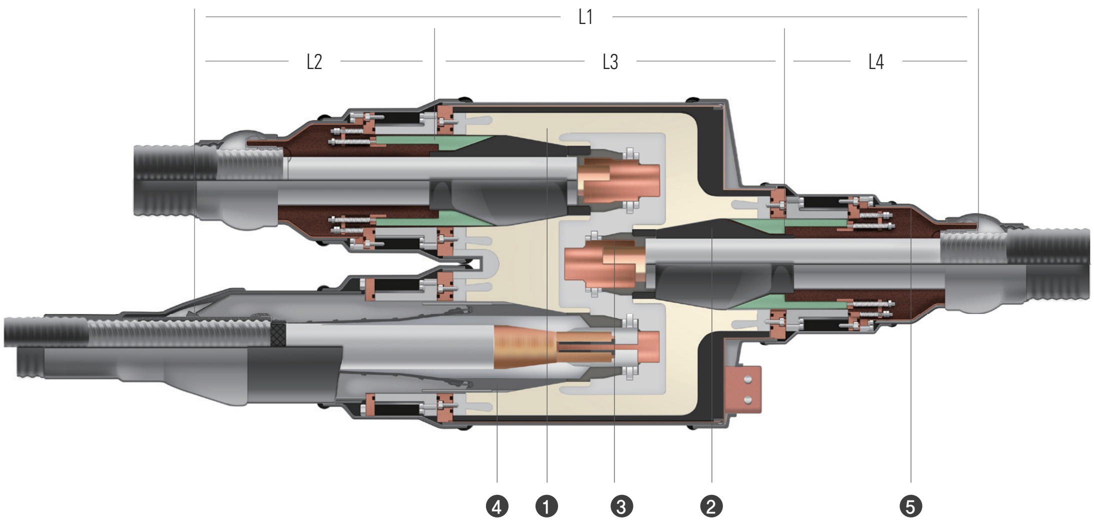


Y Branch Joint

110kV ~ 170kV



XLPE to XLPE



XLPE to XLPE/OF

No.	Description
1	Epoxy Unit
2	Stress Cone
3	Connector

No.	Description
4	Bell Mouth & Paper
5	Protecting Case

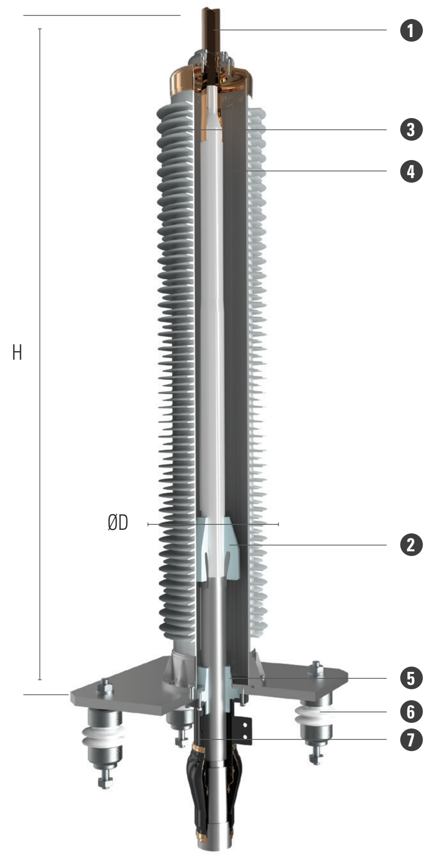
Product No.	L1 [mm]	L2 [mm]	L3 [mm]	L4 [mm]
XLPE to XLPE	1182	255	672	255
XLPE to XLPE/OF	1447	520	672	255

Outdoor Termination (EB-A)

Slip-on Type

No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	Stress Relief Cone	Silicone Rubber
3	Hollow Insulator	Polymeric or Porcelain
4	Compound	Polybutene Oil
5	Sealing Unit	Silicone Rubber
6	Post Insulator	Porcelain or Epoxy
7	Lower Metal Case	Aluminum

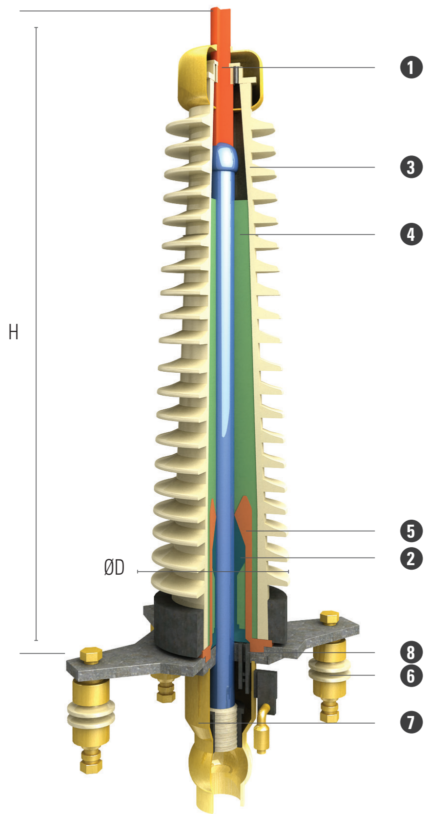
Rated Voltage	H [mm]	ØD [mm]	Creepage Distance [mm]
66kV~69kV	Max. 1890	Max.355	Max.5215
110kV~161kV	Max. 2650	Max.355	Max.8300
220kV~275kV	Max. 4250	Max.600	Max.12600
330kV~400kV	Max. 6250	Max.780	Max.23100
500kV	Max. 7750	Max.780	Max.24800



Prefabricated Type

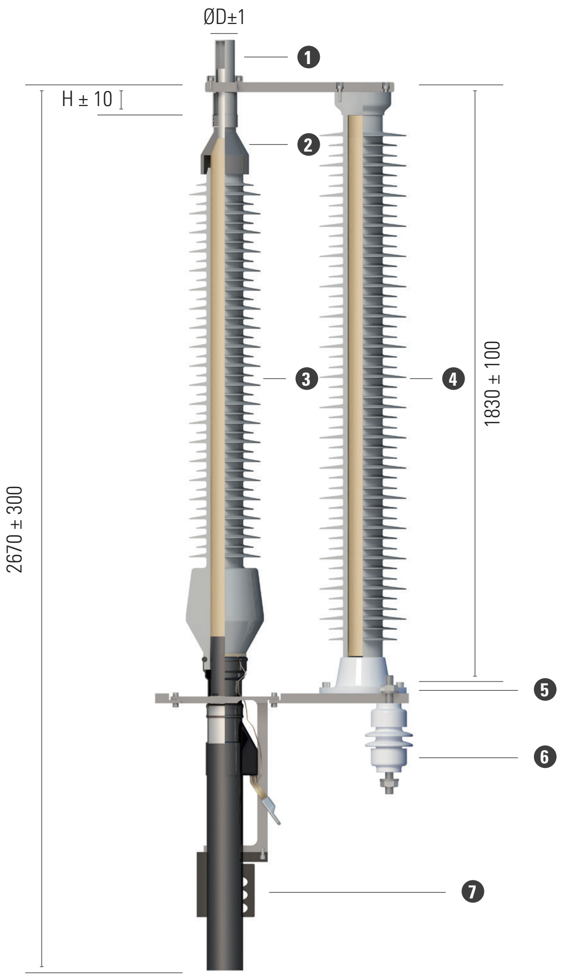
No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	Stress Relief Cone	EPR
3	Hollow Insulator	Polymeric or Porcelain
4	Compound	Silicone Oil
5	Epoxy Support	Epoxy
6	Post Insulator	Porcelain or Epoxy
7	Lower Metal Case	Aluminum or Copper
8	Compression Ring	Stainless Steel

Rated Voltage	H [mm]	ØD [mm]	Creepage Distance [mm]
110kV~161kV	Max. 2650	Max. 355	Max. 8300
220kV~275kV	Max. 2750	Max. 560	Max. 8800

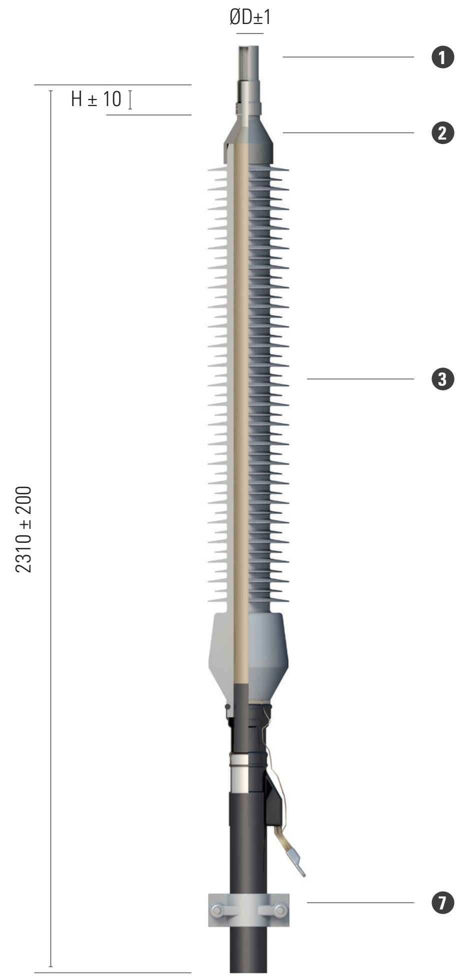


Outdoor Termination (EB-A)

Dry Type



Self Supporting Type



Flexible Type

Features

- Single piece termination body with pre-molded stress relief cone and sheds
- Light weight approx. 20kg (66kV)
- Easy installation (Vertical or Horizontal position)
- No oil
- Tested in accordance to IEC 60840

No.	Description	Material
1	Conductor Sleeve	Copper or Aluminum
2	Sealing Cap	Silicone Rubber
3	Rubber Housing	Silicone Rubber
4	Composite Insulator	Silicone Rubber & Aluminum
5	Mounting Metal	Aluminum
6	Post Insulator	Porcelain
7	Cable Cleat	Aluminum

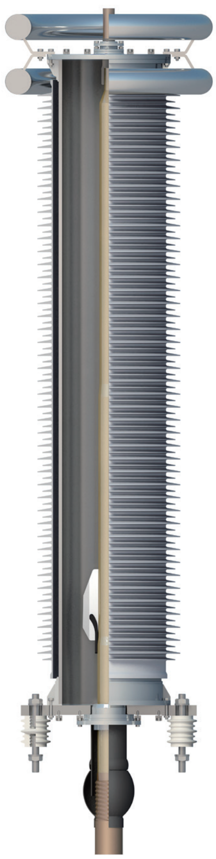
Rated Voltage	H [mm]	Creepage Distance [mm]
66kV~69kV	Max. 1600	Min. 2250
110kV~161kV	Max. 2510	Min. 5270

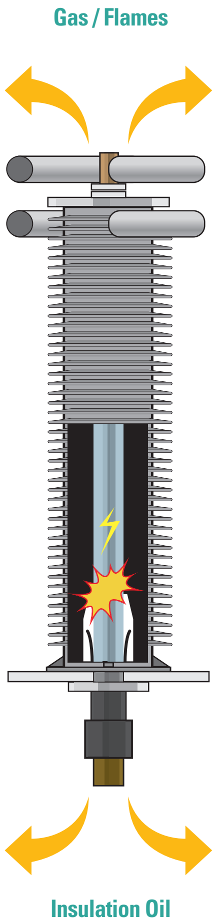
Outdoor Termination (EB-A)

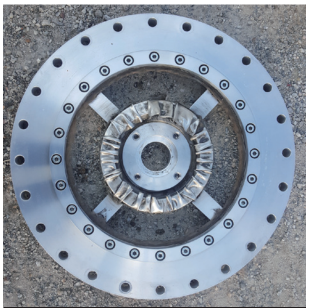
Rupture Disc

If there are failures in outdoor terminations, there are severe explosions of termination.
These are caused by maximum short-circuit currents, which are too high.

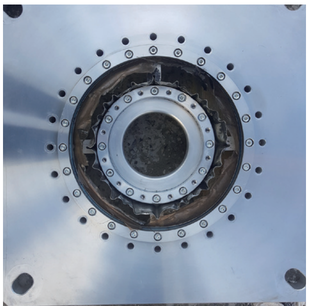
Rupture disc terminations are designed to prevent major parts of the termination from flying into the surrounding area when an internal power arc at the fault point,Specially around stress cone, with max. short-circuit currents occurs.







Upper Rupture Disc



Bottom Rupture Disc

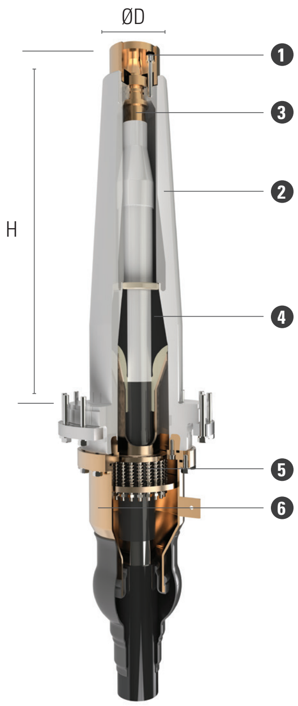
SF_6 Gas / Oil Insulated Termination (EB-G / EB-O)

Prefabricated Type

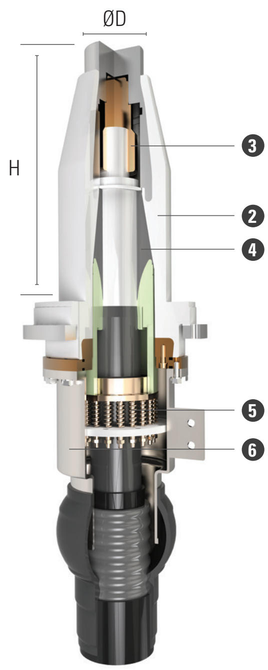
No.	Description	Material
1	Upper Metal	Aluminum
2	Epoxy Bushing	Epoxy
3	Conductor Sleeve	Copper or Aluminum
4	Stress Relief Cone	Rubber
5	Compression Ring	Stainless Steel
6	Lower Metal Case	Copper or Aluminum

Rated Voltage	Fluid Filled Type		Dry Type	
	H [mm]	ØD [mm]	H [mm]	ØD [mm]
66kV~88kV	583	110	310	110
110kV~161kV	757	110	470	110
220kV~275kV	960	200	620	140
330kV~500kV	1400	250	960	160

* All dimensions are complying with IEC60859 and IEC62271-209



Fluid Filled Type



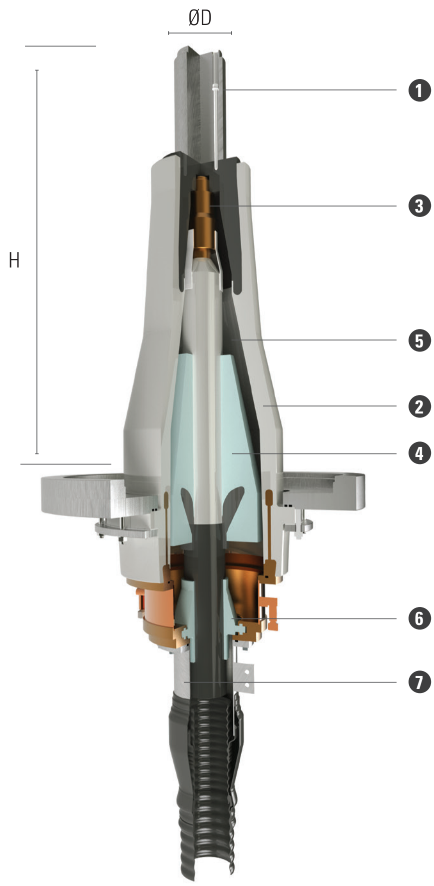
Dry Type

Slip-on Type

No.	Description	Material
1	Upper Metal	Aluminum
2	Epoxy Bushing	Epoxy
3	Conductor Sleeve	Copper or Aluminum
4	Stress Relief Cone	Silicone Rubber
5	Compound	Insulation Oil
6	Sealing Unit	Silicone Rubber
7	Lower Metal Case	Copper or Aluminum

Rated Voltage	H [mm]	ØD [mm]
110kV~161kV	757	110
220kV~275kV	960	140
330kV~500kV	1400	160

* All dimensions are complying with IEC60859 and IEC62271-209

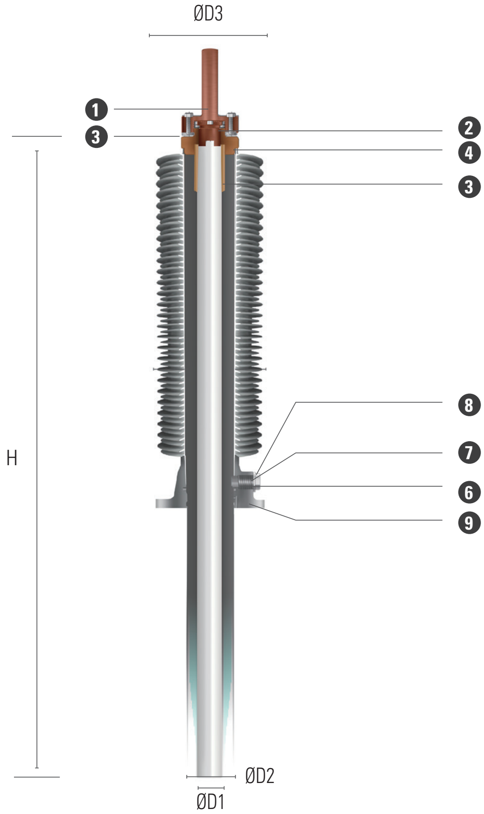


RIP Bushing

Taihan has been developing and producing RIP(Resin Impregnated paper) Bushing which consist of crepe paper, Al-foil, epoxy resin and silicone rubber sheds.
RIP condenser cores are wound from crepe paper, followed by vacuums drying and impregnating by epoxy resin.
The demand and interest of RIP bushing in the market is increasing due to the advantages of RIP bushing.

Advantages

- Safe from fire due to oil free bushing
- Non-brittle materials so, No explosion risk (pressure free bushing)
- High thermal endurance (about 120˚C)
- Light weight, compact; less than comparable OIP (oil impregnated paper) bushing.



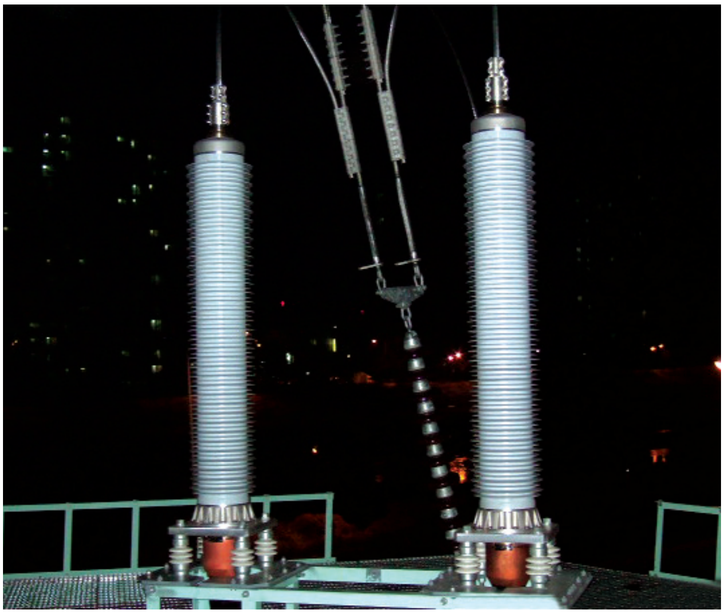
No.	Description
1	Outer Terminal
2	Inner Terminal
3	Upper Metal-A
4	Upper Metal-B
5	Upper Metal-C

No.	Description
6	Cap Nut
7	Test Tap
8	Cover
9	Mounting Flange

Rated Voltage	Current Transfer	Creepage Distance	H [mm]	ØD1 [mm]	ØD2 [mm]	ØD3 [mm]
72.5V	CT 0	2332mm	2032	51	96	230
	CT 300	2332mm	2332	51	96	230
	CT 500	2332mm	2532	51	96	230
170kV	CT 0	5510mm	2019	51	96	281
	CT 300	5510mm	2319	51	96	282
	CT 300	5510mm	2519	51	96	281

Composite Hollow Bushing

Taihan has been developing and producing composite hollow bushing which consists of FRP tube and silicone rubber sheds to withstand various environmental conditions. The advantage of composite bushing over traditional porcelain bushing has been proven and is well known and accepted.



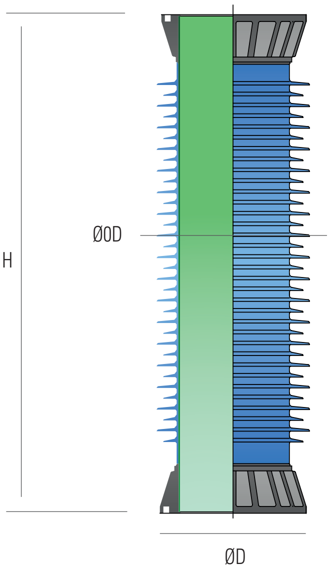
Advantages

- Reduced Risk for transport and assembly (no broken sheds)
- Explosion Safety for personnel and installation
- Excellent Seismic Performance
- High Insulating Performance in highly polluted environment

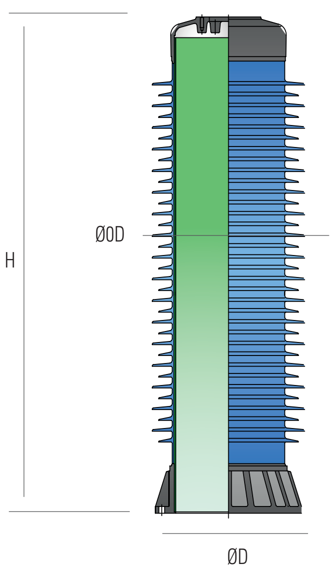
Applications

- Cable Terminations
- Circuit Breakers
- Instrument Transformers
- Lightning Arrester

Normal Flange



Cap Flange



Rated Voltage	Creepage Distance [mm]	Arcing Distance [mm]	H [mm]	ØD [mm]	ØOD [mm]
110kV~161kV	5280	1495	1676	260	378
	6720	1879	2060	260	378
	8150	2263	2444	260	378
220kV~275kV	Max.9100	Max.2308	2535	370	505

*Other creepage distances are on request

GIS Epoxy Insulator

Taihan has been manufacturing several kinds of cast epoxy insulators which are using in GIS systems. With our extensive knowledge regarding material technology with advanced process engineering skills, we have been developed and produced GIS insulator upto 800kV grade.

Vacuum Casting Technology

- Void-free Insulation
- Excellent Adhesion to Metallic Parts
- Net Shape Casting

Product

- Insulation Spacer
- Tri-post Insulator
- Earthing Terminal
- Insulation Supporter

420kV × 1P Spacer

170kV × 3P Spacer

550kV × 1P Spacer

420kV × Tri-Post Insulator

03

QUALITY ASSURANCE & TEST REQUIREMENTS

Extra high voltage cables are the most important cable because they are generally adopted to massive power transmission system. Therefore the quality of the cable shall be not only tested for finished cable products but also controlled during the whole manufacturing processes. All the materials and manufacturing processes are stringently controlled, tested and reported according to quality standards.

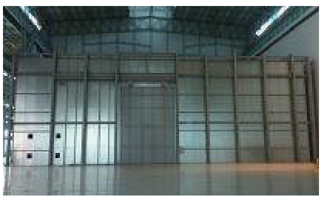
Drum test and type test are performed on completed cables. Drum test is done for every length of cables by measuring conductor resistance, capacitance, power factor, partial discharge, etc.

Electrical quality assurance for D/M length test program is done for sampled cable, generally one out of ten lengths by measuring impulse breakdown, long-time AC withstand voltage, power factor, partial discharge, etc. Testing procedure is one of the important process and every necessary test equipments and devices are installed, such as 3600kV impulse generator, 600kV AC testing transformer, schering bridge, 1200kV dielectric breakdown tester and shield room.

Test Item		Requirements
Routine Test	Conductor Resistance	Not exceed the specified value
	AC Voltage Withstand	2.5U0 for 30 min
	Insulation Resistance	Not less than specified value (þ:2.5 x 1015Ω·cm at 20˚C)
	Capacitance	Not exceed the specified value by more than 8%
	Power Factor	Not more than 0.1% at U0
	Partial Discharge	Step 1:1.75U0 for 10 sec Step 2:Not more than 10pC at 1.5U0
Type Test (Sequence Test)	Bending Test	The diameter of the test cylinder : 25(d+D)+5% D : measured external diameter of the cable in mm d : measured diameter of the conductor in mm
	Partial Discharge Test	The sensitivity being 5pC or less The magnitude of the discharge at 1.5U0 shall not exceed 5pC.
	Tan & Measurement	Not exceed the value 10x 10-4
	Heating Cycle Voltage Test	The cycle of heating and cooling shall be carried out 20 times.
	Impulse Withstand Test	BIL/+10 times
	Power Frequency Voltage Test	At 2.5U_0 for 15 min

U_0 is the rated power-frequency voltage between conductor and earth or metallic screen.
Standard : IEC 60840 & IEC 62067


Partial Discharge Equipment


Shield Room


Test Termination


X-Ray Equipment

04

ENGINEERING

System Design & Engineering Work

Cable System Design

Most of the extra high voltage cable projects include not only the manufacturing and supply of cables and accessories but also cable system design, civil works, cable laying, erection works, site testing and commissioning. A cable system should be designed to meet the user's requirements in various respects in technology, economy, and stability. The design flow of cable system is shown in #1.

Determining Cable Size

The selection of conductor size depends on various system and installation conditions. The system conditions consist of required current ratings, rated system voltages, system frequency, short-circuit current and its duration, and so on. For the maximum current ratings, there are continuous current and emergency current. For the rated system voltages, there are nominal voltage, highest voltage, and basic impulse insulation voltage. The installation conditions consist of cable laying arrangements, laying methods, laying depth, soil thermal resistivity, ambient temperatures, other heat sources, and so on. For the cable laying arrangements, there are flat formation, trefoil formation and distances between phases and circuits. For the laying methods, there are directburial laying, in-duct laying, in-air laying and others.

Determining Sheath Bonding Methed

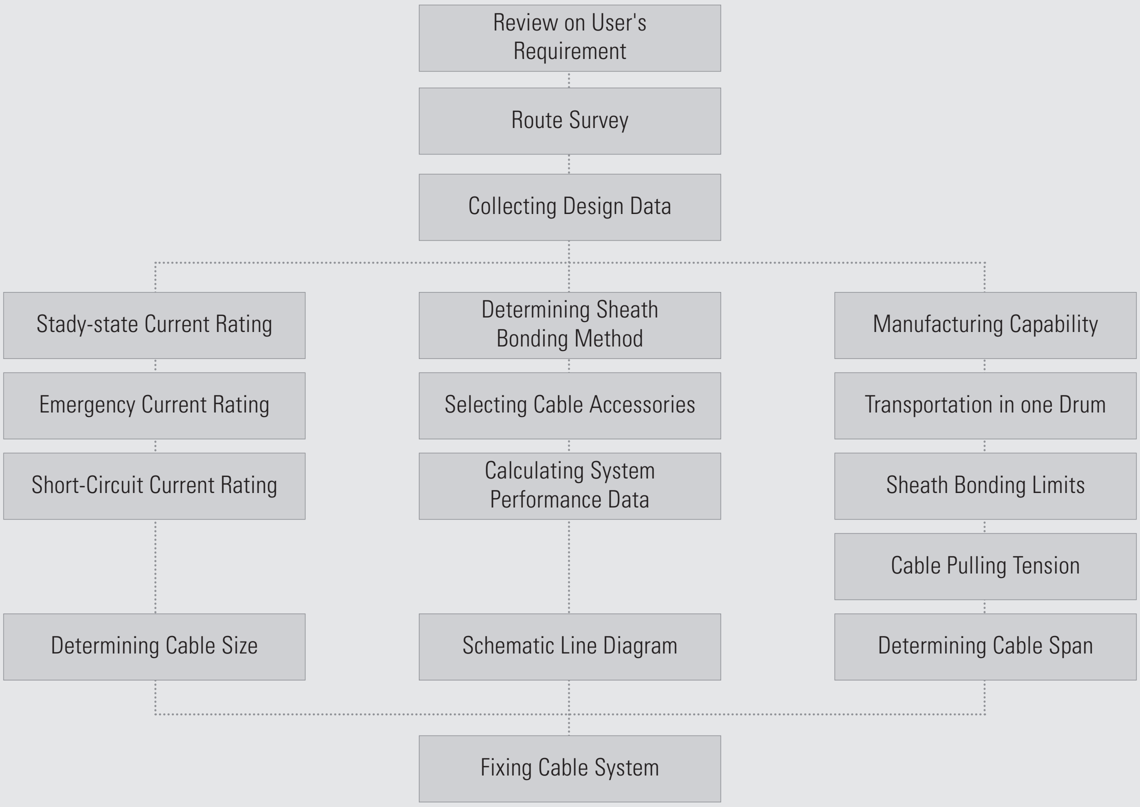
Cable sheaths are grounded by various methods. A solid bonding method presents the simplest solution. But the grounded sheaths produce large cable losses and, in turn, it largely reduces the power capacity of cable system. Special bonding methods are applied to reduce the cable losses. A single-point bonding method is applied in case of short route and less then two joints, and a cross bonding method is applied in case of long route and many joints. But these methods produce standing sheath-induced voltages, while the cable system shall be designed not to exceed the required maximum sheath voltage.

Determining Cable Span

Since cable products are produced at a certain length, cable jointing is required at a long cable route. Cable drum lengths and number of joints are determined generally on the various terms, cable manufacturing, transportation of drum, cable laying, cable system design and so on. In general, the followings are the most important terms to determine the maximum cable drum length.

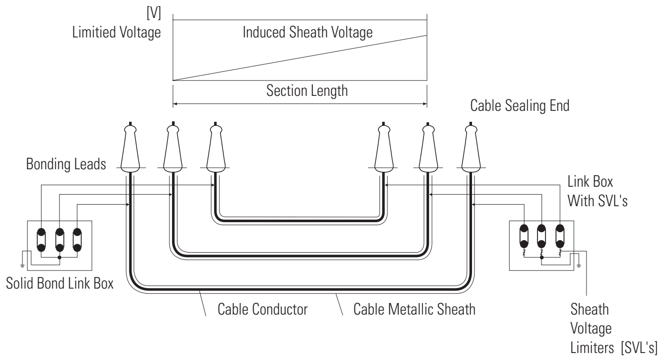
- Maximum manufacturing length of cables
- Related regulations on transportation of cable drums to site
- Maximum pulling tension and sidewall pressure during cable installation
- Cable sheath bonding and maximum sheath-induced voltage

#1.



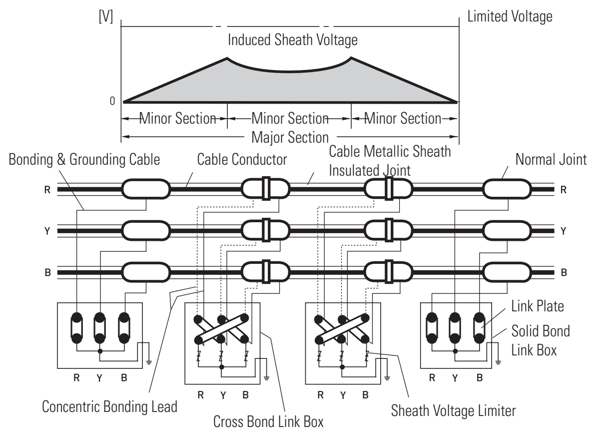
1. Single Point Bonding System

This system is adopted for short length of the single core cable, generally without any joint, or circuit extension portion in addition to cross-bonding system. In this case, induced voltage on the metal layer cannot be diminished, therefore the system can be used, provided the induced voltage is less than dangerous level approximately 65V.



2. Cross-Bonding System

This system is generally adopted for single core cable circuit having two or more joints. In the system, metallic layer of a cable is electrically separated(insulated) and connected to other cable's metallic layer at ends of every three section of the circuit, and then it will be connected to the another cable's layer. In the first section of the circuit, induced voltage is increased in proportion to cable length, but in the next section, it is decreased first time and increased again because induced voltages from two otherphase is mixed together in this section. In same reason, induced voltage at the end of this three section circuit becomes almost zero level remaining small amount of residual voltage due to unbalance of the joint section, etc.



Installation

Taihan has many achievements and excellent techniques related to turnkey-base projects. The turnkey-base projects include the installation and engineering services as well as the supply of cable system. The quality of the cable system at the site depends mainly on cable laying work, and jointing and terminating works. Taihan has most qualified engineers and workers who are skillful and experienced in carrying out the installation works. Also Taihan has much experience on various cable laying methods. The followings are generally applied as a cable laying method.

Direct in the Ground

This method is shown in #1, and is employed in following cases;

· Where road is narrow so the construction of conduit under the road not permitted.
· Where the number of cables is few and nofuture increase is expected.
· Where the road digging is easy.

Underground Duct or Tunnel

This method is shown in #2, #3, and is employed in following cases;

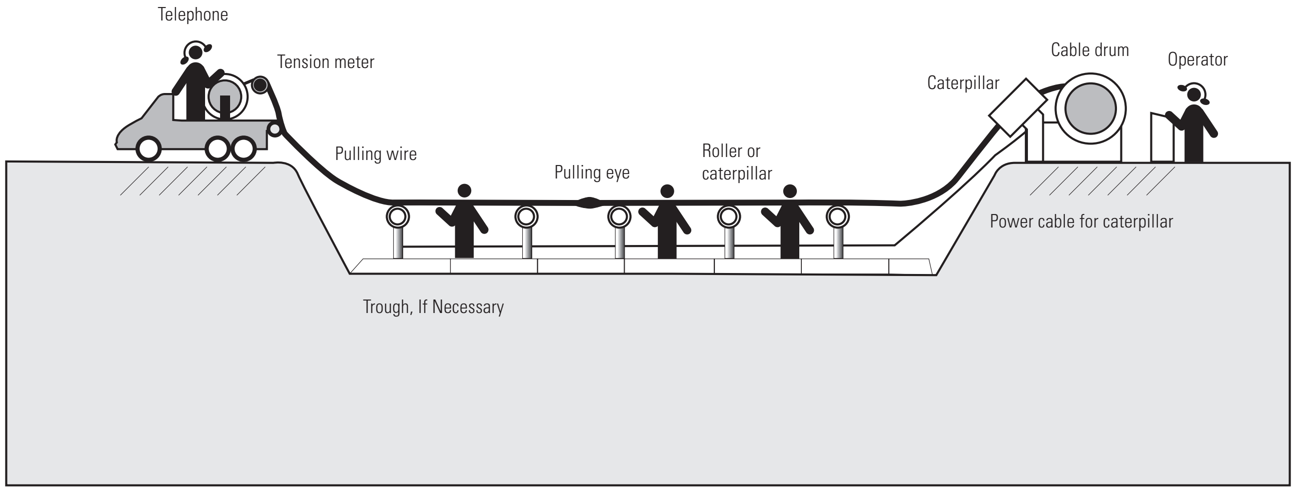
· The case of main underground transmission line where the number of cables are many or expected to be increased in near future.
· The case of hard pavement or where hard pavement will be constructed in future.
· Where digging is difficult due to heavy traffic.
· The case of the very long length such as 1~2km for one span, specific methods can be considered.
  a. The fore-end of the cable can be pulled by a number of the caterpillar or transported by a batter vehicle through the guided line on the route.
  b. In situation of the inevitable road occupation during the cable laying, the traversing pay-off equipment can be used to reduce it.

Special Laying

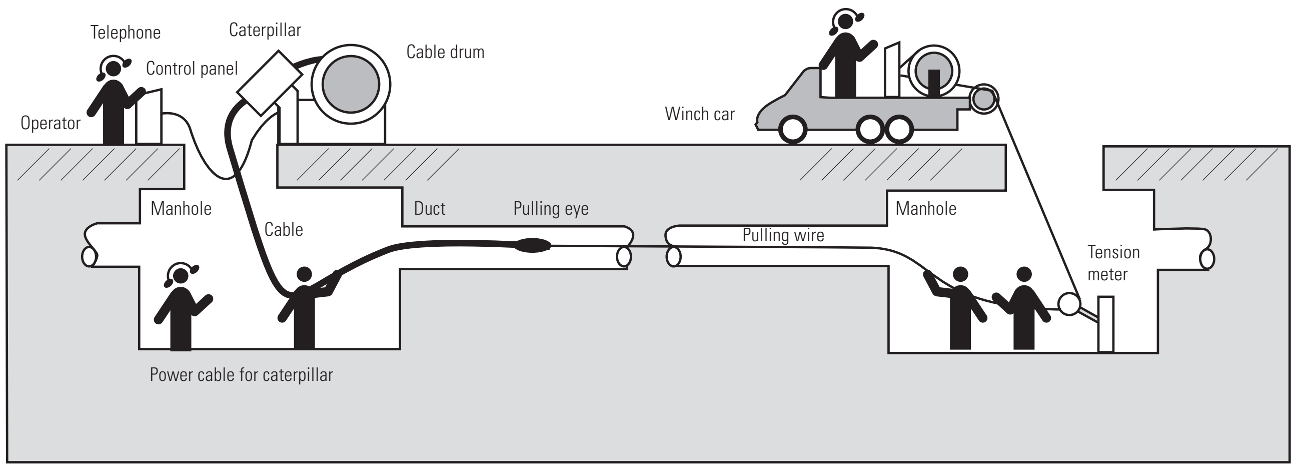
In case cables are installed in special places where there are bridges or railways, special laying methods are employed as follows;

· When a cable crosses a river or canal, cables are attached to the bridge. If there is no suitable bridge in the neighborhood, an exclusive bridge should be built or a method of submarine laying should be adopted. As long as the strength and space of the bridge permits, it is best to attach the cables to the bridge. Whether it is better to build an exclusive bridge or to lay submarine cable depends on the cost and difficulty of construction.
· In case of crossing a railway, there are two methods; one is digging through the railway bed, and the other is piercing from the side of the railway by using an excavator, when the cable crosses many tracks like a surface from railroad or suburban railway, digging the railway bed is usually adopted. Except for the above case, piercing by using an excavator is adopted.

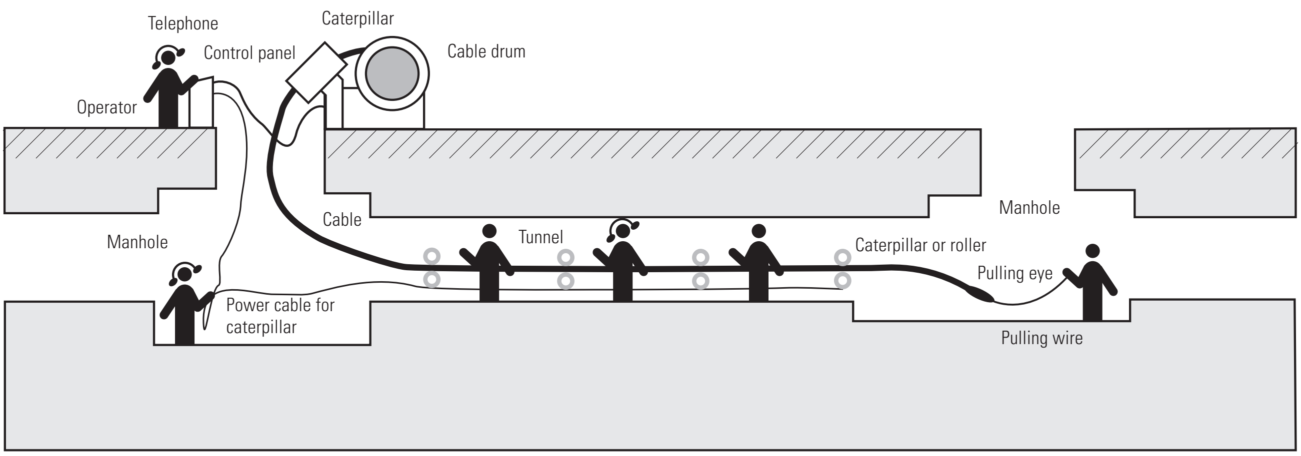
#1. Direct Burial



#2. Cable Laying at Duct



#3. Cable Laying at Tunnel



Current Rating & Rating Factors

The continuous current carrying capacity is defined as continuous current that underground power cable can safely carry in the condition not to reduce the capacity of insulation, and the mount of current passed through the conductor can be increased until heat generation reaches to the maximum temperature of the insulation material. The current carrying capacity is basically calculated in accordance with IEC 60287, and there are many determining factors that will limit the amount of current such as size of conductor, ambient temperature, installation condition and etc.

Laying Conditions

Maximum Withstanding Temperature of Insulation Material	90˚C
Maximum Resistance of Conductor at 20˚C	As per IEC 60228
Maximum Soil Temperature	25˚C
Maximum Air Temperature	40˚C
Cable Laying Depth	1m
Phases Spacing in Flat Formation	250mm
Phases Spacing in Trefoil Formation	Cable Diameter
Number of Circuit	Single Circuit
Maximum Soil Thermal Resistivity	1.0 K.m/W
Frequency	50Hz
Load Factor	100%
Basic Construction of Cable	XLPE Insulation / Copper Wire Shield - 300mm^2 / PE Outer Sheath

Table 1-1. 66kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20˚C		Current Rating							
			Flat Formation ●●●				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
240	0.0754	0.125	587	457	693	539	531	413	615	479
300	0.0601	0.100	664	518	794	622	600	469	703	551
400	0.0470	0.0778	758	595	923	730	684	538	813	644
500	0.0366	0.0605	863	679	1070	846	776	614	937	743
630	0.0283	0.0469	984	778	1246	988	880	702	1081	864
800	0.0221	0.0367	1107	883	1431	1143	984	794	1229	993
1000	0.0176	0.0291	1296	994	1709	1315	1173	890	1488	1133
1200	0.0151	0.0247	1403	1076	1881	1445	1269	959	1631	1235
1600	0.0113	0.0186	1623	1293	2246	1796	1459	1176	1924	1555
2000	0.0090	0.0149	1802	1446	2550	2052	1610	1313	2161	1765
2500	0.0072	0.0127	1984	1572	2882	2295	1760	1426	2410	1957
Insulated Wires - 2500	0.0072		2096		3069		1903		2620	

Table 1-2. 110kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation •••				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
240	0.0754	0.125	579	450	679	528	528	411	610	475
300	0.0601	0.100	654	510	778	610	596	466	696	546
400	0.0470	0.0778	747	586	904	714	680	535	806	637
500	0.0366	0.0605	852	670	1048	829	773	611	930	737
630	0.0283	0.0469	970	768	1220	967	877	699	1072	856
800	0.0221	0.0367	1093	871	1401	1119	983	792	1221	985
1000	0.0176	0.0291	1279	981	1671	1286	1168	888	1473	1123
1200	0.0151	0.0247	1386	1062	1839	1412	1264	957	1614	1225
1600	0.0113	0.0186	1602	1277	2192	1754	1455	1171	1903	1537
2000	0.0090	0.0149	1780	1429	2489	2001	1608	1309	2139	1743
2500	0.0072	0.0127	1960	1553	2811	2236	1761	1422	2387	1935
Insulated Wires - 2500	0.0072		2070		2989		1898		2588	

Table 1-3. 132kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation •••				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
240	0.0754	0.125	576	448	676	526	527	410	608	473
300	0.0601	0.100	651	508	774	606	595	465	694	545
400	0.0470	0.0778	744	584	899	710	679	534	803	635
500	0.0366	0.0605	848	667	1042	823	771	610	926	734
630	0.0283	0.0469	966	764	1212	961	876	697	1069	853
800	0.0221	0.0367	1088	868	1392	1111	982	791	1218	982
1000	0.0176	0.0291	1274	977	1662	1278	1166	886	1469	1120
1200	0.0151	0.0247	1380	1057	1828	1403	1262	956	1609	1221
1600	0.0113	0.0186	1596	1271	2179	1741	1453	1169	1898	1530
2000	0.0090	0.0149	1773	1423	2473	1988	1606	1306	2133	1737
2500	0.0072	0.0127	1952	1547	2789	2220	1759	1419	2380	1926
Insulated Wires - 2500	0.0072		2061		2968		1894		2577	

Table 1-4. 161kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation •••				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
240	0.0754	0.125	573	445	671	522	526	409	607	472
300	0.0601	0.100	648	505	768	602	594	464	692	543
400	0.0470	0.0778	739	580	891	704	677	532	800	633
500	0.0366	0.0605	843	664	1035	817	770	608	923	731
630	0.0283	0.0469	961	760	1203	953	875	696	1066	850
800	0.0221	0.0367	1082	863	1380	1103	981	789	1214	979
1000	0.0176	0.0291	1267	971	1647	1267	1163	885	1463	1116
1200	0.0151	0.0247	1373	1052	1812	1391	1259	955	1602	1217
1600	0.0113	0.0186	1587	1265	2156	1725	1451	1166	1888	1522
2000	0.0090	0.0149	1763	1415	2448	1968	1604	1303	2123	1728
2500	0.0072	0.0127	1941	1539	2761	2200	1758	1417	2370	1917
Insulated Wires - 2500	0.0072		2051		2938		1891		2565	

Table 1-5. 220kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation ●●●				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
300	0.0601	0.100	634	494	747	585	589	459	682	534
400	0.0470	0.0778	724	568	866	683	672	528	789	623
500	0.0366	0.0605	825	649	1003	792	764	603	910	720
630	0.0283	0.0469	941	744	1165	923	869	691	1051	836
800	0.0221	0.0367	1060	845	1336	1067	976	784	1197	962
1000	0.0176	0.0291	1241	951	1592	1224	1155	880	1435	1097
1200	0.0151	0.0247	1345	1030	1750	1343	1250	951	1573	1197
1600	0.0113	0.0186	1555	1239	2080	1662	1443	1157	1854	1491
2000	0.0090	0.0149	1728	1387	2358	1896	1598	1295	2084	1691
2500	0.0072	0.0127	1903	1509	2658	2114	1754	1408	2330	1875
Insulated Wires - 2500	0.0072		2010		2824		1878		2507	

Table 1-6. 330kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation ●●●				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
630	0.0283	0.0469	921	728	1136	900	858	681	1034	822
800	0.0221	0.0367	1037	827	1302	1040	964	773	1178	946
1000	0.0176	0.0291	1213	930	1549	1191	1137	868	1409	1077
1200	0.0151	0.0247	1315	1007	1703	1307	1232	938	1543	1176
1600	0.0113	0.0186	1519	1210	2021	1616	1421	1138	1818	1464
2000	0.0090	0.0149	1687	1354	2289	1841	1575	1274	2046	1657
2500	0.0072	0.0127	1856	1472	2575	2049	1728	1385	2284	1836
Insulated Wires - 2500	0.0072		1961		2738		1847		2453	

Table 1-7. 400kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation ●●●				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm^2	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
630	0.0283	0.0469	911	720	1123	890	851	676	1025	815
800	0.0221	0.0367	1027	819	1292	1032	956	766	1170	939
1000	0.0176	0.0291	1203	922	1544	1184	1126	859	1402	1072
1200	0.0151	0.0247	1303	998	1696	1302	1220	928	1535	1171
1600	0.0113	0.0186	1505	1199	2013	1609	1406	1126	1809	1453
2000	0.0090	0.0149	1670	1340	2280	1833	1557	1259	2035	1648
2500	0.0072	0.0127	1836	1456	2563	2042	1708	1368	2271	1826
Insulated Wires - 2500	0.0072		1939		2726		1824		2440	

Table 1-8. 500kV Single Core Cable

Nominal Cross-Sectional Area	Maximum Resistance of Conductor at 20°C		Current Rating							
			Flat Formation ●●●				Trefoil Formation			
			Buried in Ground		In Air		Buried in Ground		In Air	
	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor	Copper Conductor	Aluminum Conductor
mm²	Ω/km	Ω/km	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
800	0.0221	0.0367	993	792	1240	991	938	751	1139	913
1000	0.0176	0.0291	1164	892	1482	1140	1104	843	1361	1043
1200	0.0151	0.0247	1261	966	1632	1252	1193	910	1493	1140
1600	0.0113	0.0186	1456	1160	1945	1554	1373	1098	1763	1414
2000	0.0090	0.0149	1615	1296	2201	1770	1520	1227	1984	1603
2500	0.0072	0.0127	1775	1408	2494	1987	1660	1328	2222	1784
Insulated Wires - 2500	0.0072		1872		2649		1769		2379	

Derating Factor for cables installed directly in the ground

Table 2

Soil Temperature (°C)	Derating Factor
10	1.12
15	1.08
20	1.04
25	1.00
30	0.95
35	0.91
40	0.86
45	0.81

Table 3

Thermal Resistivity (K.m/W)	Derating Factor
0.7	1.14
1.0	1.00
1.2	0.93
1.5	0.84
2.0	0.73
2.5	0.65
3.0	0.59
3.5	0.54

Table 4

Laying Depth (m)	Derating Factor
0.7	1.05
1.0	1.00
1.2	0.97
1.5	0.95
2.0	0.92
2.5	0.89
3.0	0.87
3.5	0.86

Table 5

Phases Spacing (mm)	Derating Factor
200	0.97
250	1.00
300	1.01
400	1.05
500	1.07
600	1.10
700	1.11
800	1.12

Table 6

In Flat Formation						
Circuits Spacing	Number of Circuits					
mm	1	2	3	4	5	6
700	1.00	0.83	0.76	0.70	0.69	0.67
900	1.00	0.87	0.80	0.75	0.74	0.73
1100	1.00	0.90	0.82	0.80	0.78	0.76
1300	1.00	0.92	0.85	0.83	0.81	0.80
1500	1.00	0.93	0.87	0.85	0.83	0.82
2000	1.00	0.95	0.91	0.89	0.88	0.88
2500	1.00	0.96	0.93	0.92	0.91	0.91
3000	1.00	0.97	0.95	0.94	0.94	0.93

Table 7

In Trefoil Formation						
Circuits Spacing	Number of Circuits					
mm	1	2	3	4	5	6
400	1.00	0.82	0.72	0.66	0.63	0.60
600	1.00	0.86	0.76	0.72	0.69	0.67
800	1.00	0.88	0.80	0.77	0.74	0.73
1000	1.00	0.90	0.83	0.81	0.79	0.77
1500	1.00	0.93	0.88	0.87	0.85	0.85
2000	1.00	0.96	0.92	0.91	0.90	0.89
2500	1.00	0.97	0.94	0.93	0.92	0.92

Note Cables in ducts which have been completely filled with a pumpable material having a thermal resistivity not exceeding that of the surrounding soil, either in the dry state or when sealed to preserve the moisture content of the filling material, may be treated as directly buried cables.

Derating Factor for cables installed in air

Table 8

Circuits Spacing (°C)	10	15	20	25	30	35	40	45	50	55
Derating Factor	1.30	1.26	1.21	1.16	1.10	1.05	1.00	0.94	0.88	0.81

Use of derating factors enables to assume the continuous current carrying capacity in various circuit layout plannings. Once the circuit layout is determined, an actual calculation should be conducted to confirm the assumption value.

Checklist for EHV Cable Enquiry

General Conditions

Commercial information *= Required information		**Technical information** *= Required information	
Name of project*	______	**Cable System Input**	
Customer*	______	Rated system voltage Uo/U/Um*	______ kV
Location of site for delivery*	______	BIL	______ kV
Country of site for delivery*	______	Continuous current capacity*	______ A
Enquiry for budget or purchase*	☐ Budget ☐ Purchase	Maximum short-circuit current and duration*	______ kA/sec
Tender submission date*	______	Maximum earth-fault current and duration*	______ kA/sec
Any special condition apply	______	Route length*	______ m
How long should the tender be valid*	______	Conductor material	☐ Copper ☐ Aluminum
Required delivery/completion time*	______	Conductor cross-section*	______ mm^2
Terms of delivery (FCA/CPT etc)*	______	Longitudinal water protection*	☐ Yes ☐ No
Special requirements on cable length per delivered drum	______	Radial water protection*	☐ Yes ☐ No
Any specific metal prices apply	______	Any special cable design requirements*	______
Installation*:		Customer specification	______
Turnkey by Taihan	☐		
Installation by Taihan	☐	**Tests***	
Supervision by Taihan	☐	Routine, sample and after installation test standard	______
		Type test requirements	______

Installation data

General		**Installed in Ground?***	☐ Yes ☐ No
Cable configuration*	☐ Flat ☐ Trefoil	Soil, ground temperature at laying depth*	______ ˚C
Number of parallel circuit*	______	Laying depth*	______ mm
Distance between parallel circuit	______ mm	Thermal resistivity of backfill*	______ K.m/W
		If drying out, thermal resistivity of dry out backfill close to cable	______ K.m/W
Heating from existing cables*	☐ Yes ☐ No	Backfill material: selected sand, CBS, etc.*	______
If yes, distances to and losses of parallel cables	______ mm, W/m	Special requirements for trench*	______
Other heat sources, distance to andlosses of sources*	______ mm, W/m		
Metal sheath bonding	______	**Installed in Ducts or Pipes?***	☐ Yes ☐ No
		Material: PVC, PE, Fiber, Steel, etc.*	______
Installed in Air?*	☐ Yes ☐ No	Axial distance between ducts/pipes	______ mm
Air Temperature maximum*	______ ˚C	Outside duct/pipe diameter	______ mm
Exposed to solar radiation*	☐ Yes ☐ No	inside duct/pipe diameter	______ mm
		Ambient temperature at burial depth*	______ ˚C
Installed in Trough?*	☐ Yes ☐ No	Thermal resistivity of ground *	______ K.m/W
If yes, inside dimension of trough		Thermal resistivity of backfill *	______ K.m/W
(Width, height)*	______ mm x mm	If drying out, thermal resistivity of dry backfill close to duct	______ K.m/W
If trough, filled of unfilled*	☐ Filled ☐ Unfilled	Laying depth*	______ mm
		Backfill material: selected sand, CBS, etc.*	______

Accessories

Terminations		**Joints**	
Types of termination and quantity*:		Types of joint and quantity*:	
Outdoor termination	______ set	Pre-mold type	______ set
GIS termination	______ set	Prefabrication type	______ set
T ransformer termination	______ set	Metal case required?	☐ Yes ☐ No
| Special requirements, pollution level or etc.		Sheath interrupter required?	☐ Yes ☐ No
Rod gap required?	☐ Yes ☐ No	Bonding lead	☐ Concentric ☐ Single core
Polymer insulator?	☐ Yes ☐ No	Special requirements	______
Other relevant information	______		
		Other accessories:	______
Link Boxes			
Type or standard	______		
IP level	______		
Special requirements	______		
Questionnaires filled out by:		**Telephone No.:**	**Date:**

05

DIAGNOSIS SYSTEM

PD Measurement

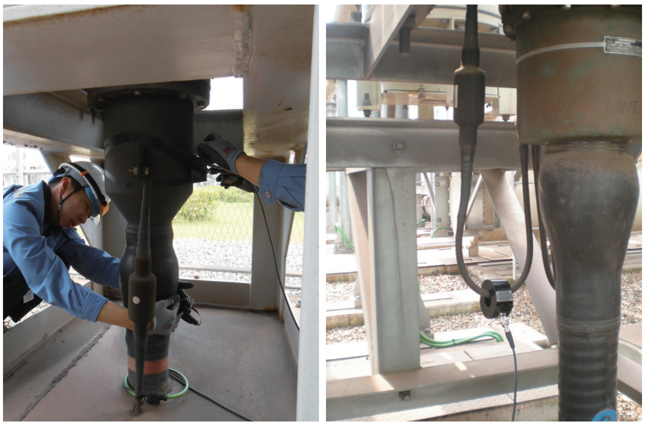
PD(Partial discharge) is an incomplete breakdown of insulation and a kind of discharging phenomenon, which is generated by or at air-gap of solid insulator, gas foam of liquid insulator, contacting surfaces of different insulating materials and peaks on metallic surface.
It is generated by the reason that as the permittivity of gas area is lower than that of solid or liquid, electric field is concentrated, and thus electric discharges occur in the gas due to the low dielectric strength of the gas.

Measurement Method

Apply an AC voltage of commercial cycle to a conductor to detect partial discharge of the insulator between the conductor and a shielding layer. And measure the starting electric charge and frequency of the partial discharge.

Solution

Our PD diagnostics solutions are suitable for quality control, commissioning test and condition based maintenance and asset management. Based on various experience and know-how of power cable manufacturers, we can provide powerful and reliable PD diagnosis technology.



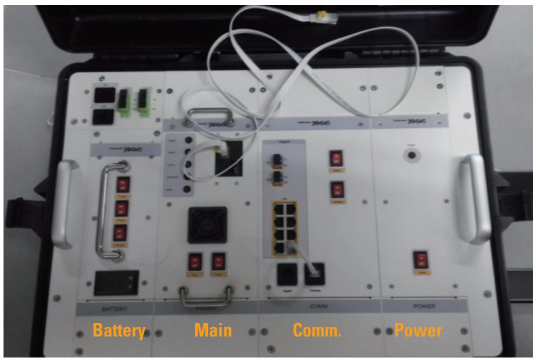
Sensor installation

PD test

Portable PD measurement System

Portable PD measurement system has various communication functions and can be operated by batteries for effective application in various fields environment

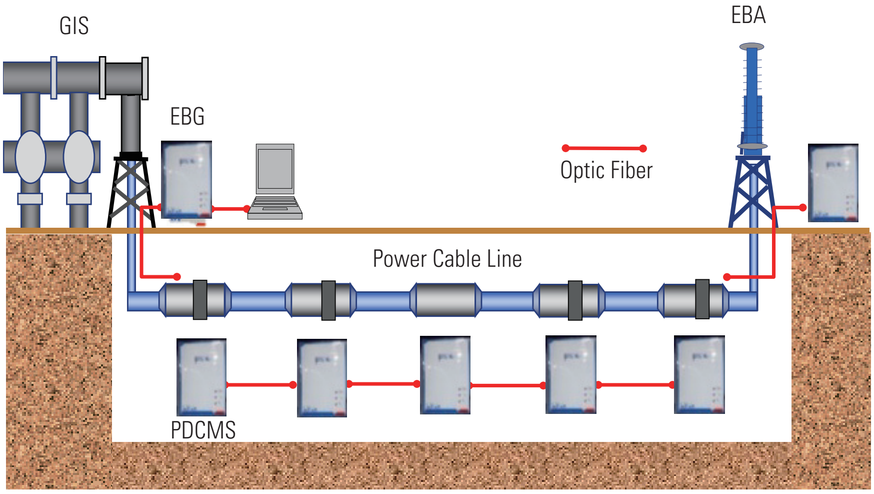
Portable PD measurement equipment



Specification	
Sensitivity	1pC
Bandwidth	1~50MHz
Sampling frequency	100MS/s
Channel	PD 6CH, Sync 2CH
Comm.	Wifi, Lan, Optical
Power	Dc 12V / 2.62A

On-line PD Monitoring System

On-line PD monitoring System consists of PDCMS, sensor and D/B server, Client PC and it is permanently installed in customer's power cable line. With the smart alarm function, the customer can immediately detect the PD occurrence of the power cable line.



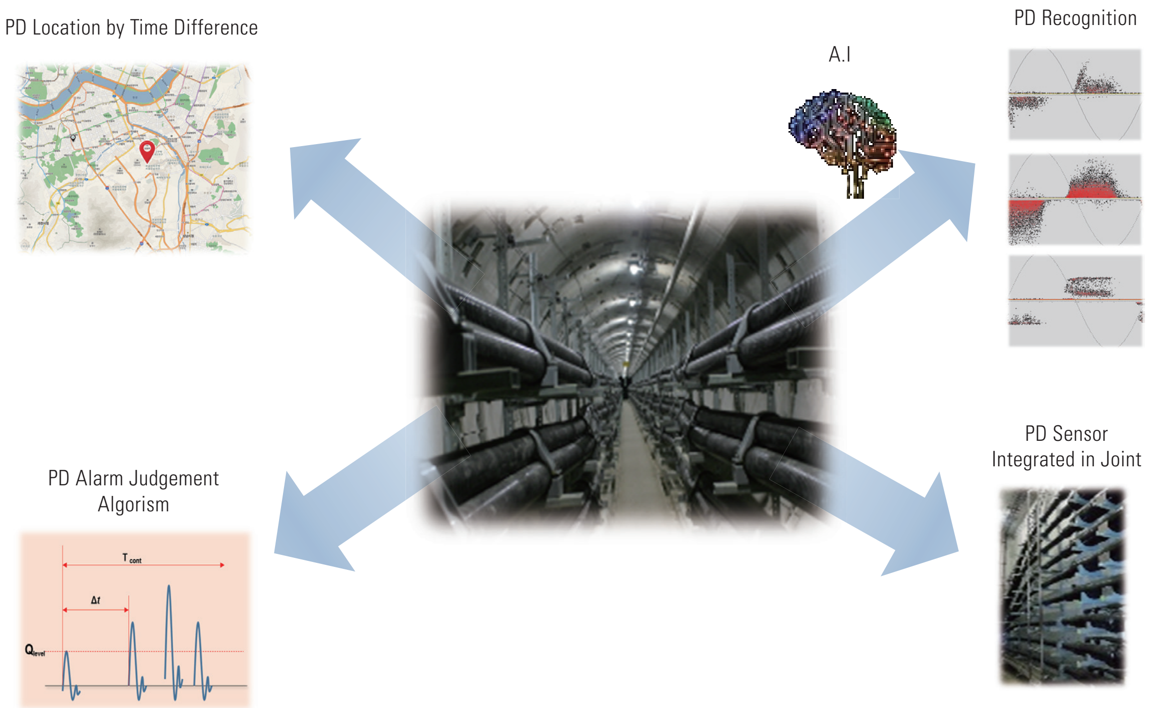
pdcms

PD Monitoring S/W

- Realtime PRPD
- Smart Alarm
- Remote configuration
- Event View
- Data storing in DB

On-line PD Monitoring S/W

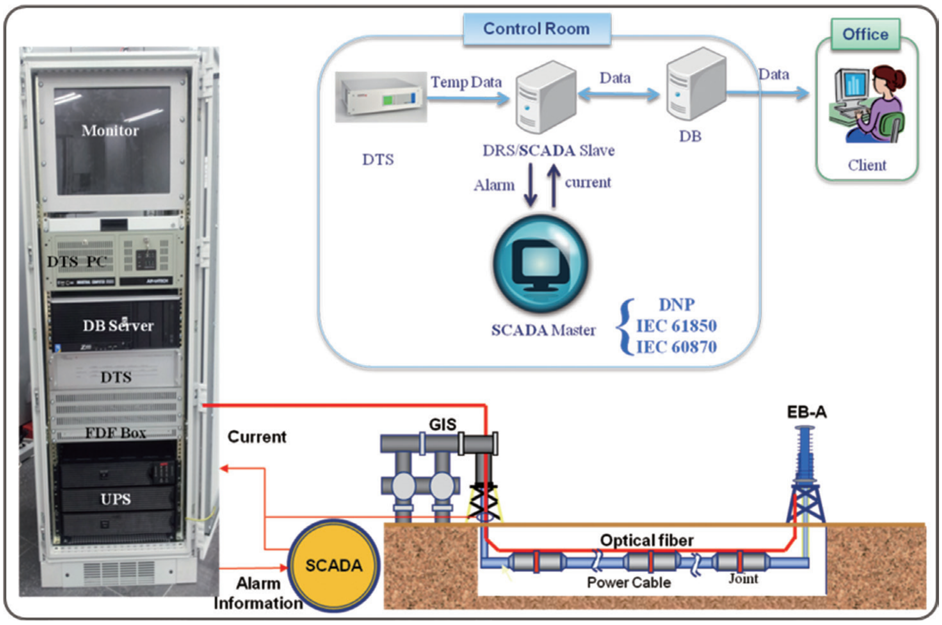
Advantages



DTS Monitoring System

Distributed temperature monitoring provides continuous monitoring of high power cable temperatures, detecting hot spots, delivering operational status, condition assessment and power circuit rating data. This helps operators to optimize the transmission and distribution networks, and reduce cost of operation and capital. The sensing fiber is either embedded in the power cable, close to the conductors or deployed along the outside of the cable. It is intrinsically immune to electromagnetic interference and provides reliable temperature measurements, ideal for use in a high voltage environment.

Configuration of DTS Monitoring System

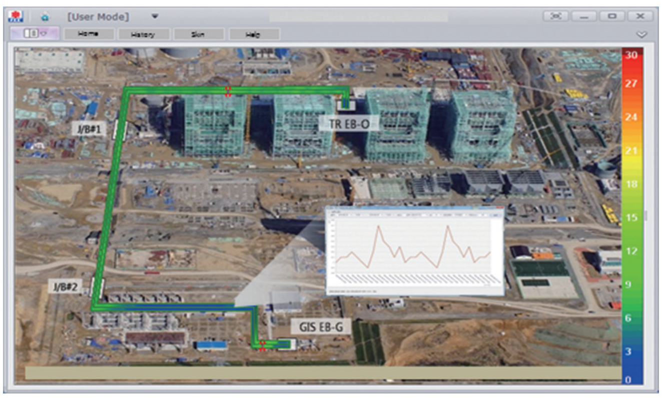


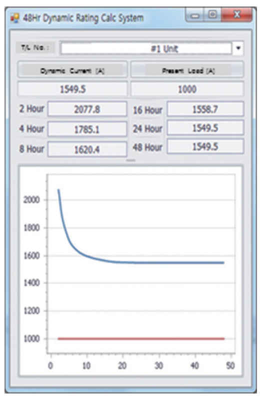
DTS Hardware
- DTS (AP-sensing, LIOS, Yokogawa)
- Industrial PC, Server
- UPS
- 19" Rack Panel

DTS Software
- GUI Program
- DRS(RTTR) Algorism

SCADA Interface
- DNP 3.0
- IEC 61850(61870)

DTS Program

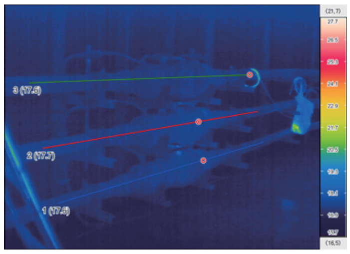




Main Function
- Temp. Profile
- Heating Map
- Hotspot
- Alarm Information
- Temp. History
- DRS (option)

As a distributed temperature monitoring systems, consists of three parts functionally, DTS system which can monitor distributed temperature of the cable, cable model data which includes thermal resistance and capacitance, and cable current value acquisition module. Menus of DMS are DTS, DRS, Alarm, Setting and History.

Thermal Infrared Imaging Measurement



Objects of Measurement

· All kinds of cable joint box (Insulating Joint, Normal straight Joint and Termination)
· End box in Air & cable connecting part of outdoor substation
· Earth wire, Cross-Bonding wire, anti-corrosion layer (insulator) protecting device etc.

Measurement Cycle

· Regular Measurement : Every 6 month
· Occasional Measurement : In case a partial temperature difference occurs.

Analyzing Measurement

· Investing data of temperate difference which occurs partially or over 2°C at the same section.

Available Equipment

Equipment	Manufacturer	Diagnosis Performances
Therma CAM QuickView	FLIR System (Sweden)	· KEPCO (Many works including 154kV, 345kV underground cable circuit) · Commercial Clients (Many sites including Korea LNG Gas, Changwon Specialty Steel, San-Cheong Pumping-up Power Plant etc.)
NEC San-ei TH9100MLN	NEC社(Japan)	

Other Inspection & Measurements

Inspection & Measurement Items	Method of Evaluation
Inspecting Manhole / Electric Power Culvert (tray) & Cable (On-line)	Locking device of exits, installation state of ladder & guard rail, leakage & crack in electric power culvert, cleaning state of electric power culvert, prevention of disaster in electric power culvert, snake deformation of cable, prevention of disaster for cable, state of curvature, disorder of fire shielding plate.
Inspecting Metallic Support & Joint Box (On-line)	Deformation of metallic support, measuring current of metallic sheath, measuring temperature of joint box, measuring insulation resistance of anti-corrosion layer of cable, disorder of cross-bonding wire, water-tightness of anti-corrosion layer protecting device.
Inspecting Cable Head (On-line)	Measuring temperature of overheated place for conductor joining part / PG clamp / lightening arrester joining part, measuring insulation resistance, double Test.
Sheath Megger Test / Withstand Voltage Test (10kV / Off-line)	Joint places / Cable
Inspecting Fire Detecting Facility (On-line)	Fixed temperature detector, firefighting device, etc.
Partial Discharge Measurement (On-line / Off-line)	Joint places
Thermal Infrared Imaging Measurement (On-line)	Measuring image temperature with thermal-vision / follow-up

Inspection of power transmission facilities can be performed in on-line or off-line state according to the properties of a facility

Certification

The outstanding quality of Taihan's EHV XLPE cables are verified by internationally accredited certification institutes.

bsi.

By Royal Charter

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2015

This is to certify that: Taihan Electric Wire Co., Ltd.
Dangjin Plant
870, Daehoman-ro
Godae-myeon, Dangjin-si
Chungcheongnam-do
31791
Republic of Korea

Holds Certificate No: **FM 555130**

and operates a Quality Management System which complies with the requirements of ISO 9001:2015 for the following scope:

The design and manufacture of copper rods, electric cables including instrument cable, cable joint accessories and high voltage insulations.

For and on behalf of BSI: Chris Cheung, Head of Compliance & Risk - Asia Pacific

Original Registration Date: 2009-07-14
Latest Revision Date: 2018-08-21

Effective Date: 2018-03-07
Expiry Date: 2021-03-06

Page: 1 of 2

...making excellence a habit.™

This certificate was issued electronically and remains the property of BSI and is bound by the conditions of contract.
An electronic certificate can be authenticated online.
Printed copies can be validated at www.bsigroup.com/ClientDirectory or telephone +82 2 777 4123.

Information and Contact: BSI, Kitemark Court, Davy Avenue, Knowlhill, Milton Keynes MK5 8PP. Tel: + 44 345 080 9000
BSI Assurance UK Limited, registered in England under number 7805321 at 389 Chiswick High Road, London W4 4AL, UK.
A Member of the BSI Group of Companies.

CERTIFICATE

EQA European Quality Assurance

Certificate of Assessment

TAIHAN ELECTRIC WIRE CO.,LTD.

Dangj Plant : 870, Daehoman-ro, Godae-myeon, Dangjin-si, Chungcheongnamdo, Korea
Dangjin EHV Accessories Plant : 542, Bodeokpo-ro, Godae-myeon, Dangjin-si, Chungcheongnam-do, Korea

EQA's certification is hereby granted to the above company's Environmental Management System conforming to the standard and scope below

ISO 14001:2015 & KS I ISO 14001:2015

Scope

Dangj Plant : Design and manufacture of communication cable, copper rod, electrical cable
Dangjin EHV Accessories Plant : Design and manufacture of cable joint accessories and high voltage insulators

Registration No. EA140179
First issued on 5 April, 2014
Re-issued on 4 May, 2018
This certificate is valid from 4 May, 2018 to 8 April, 2019

The Chief Executive

CERTIFIED EQA ISO 14001

ANAB ACCREDITED MANAGEMENT SYSTEMS CERTIFICATION BODY

AE 10444

KEMA

TYPE – APPROVAL

Based on tests witnessed

KEMA Nederland B.V. operating as an independent inspection body accredited according to the International standard EN 45004 hereby declares that the manufacturer

Taihan Electric Wire Co., Ltd.
at Anyang, South Korea

has successfully type tested the product as mentioned below:

XLPE Insulated high voltage Cable

Of type: 132 kV 1C x 1200 sqmm

The type test programme comprised all relevant type tests of the international standard

IEC 60840 (1999-02)

The tests were carried out strictly in accordance with the standard.
The tests were carried out in the laboratories of the manufacturer and were witnessed by KEMA inspectors.
This approval with number
00-13727TA
is issued based on the results of witnessed tests as stated in the inspection report 40040029.001 TDP 00-13117A issued by KEMA Nederland B.V.

The tests have been carried out on one single test object submitted by the manufacturer. The approval does not include an assessment of the manufacturer's production. Conformity of the production with the object tested is the responsibility of the manufacturer.

The approval is issued on
13-06-2000

The validity of this document expires five years after the date of issue or at the moment that modifications are introduced that might affect the performance of the equipment tested.

On behalf of KEMA Nederland B.V.

Managing Director KEMA T&D Power — Ir. H.N.E. Sibbel

Productmanager Inspection Services — Ing. J.C. Jansen

STERIN

Type Test Certificates

No.	Date	Type	Item						Institute
			Cable	Accessories					
				N.J	I.J	EB-A	EB-G	EB-O	
1	1986. 06.	132kV XLPE Cable 1C x 630sqmm (CU)	O	O	O	O	-	-	KEMA
2	1987. 03.	132kV XLPE Cable 1C x 630sqmm (CU)	O	-	O	O	-	-	Crown Agents
3	1990. 11.	154kV XLPE Cable 1C x 800sqmm (CU)	O	-	-	-	-	-	KERI
4	1991. 09.	154kV XLPE Cable 1C x 2000sqmm (CU)	O	-	-	-	-	-	KERI
5	1992. 05.	154kV XLPE Cable 1C x 400sqmm (CU)	O	-	-	-	-	-	KERI
6	1995. 03.	132kV XLPE Cable 1C x 1000sqmm (CU)	O	-	-	-	-	-	Crown Agents
7	1997. 12.	154kV XLPE Cable 1C x 2000sqmm (CU)	O	O	O	O	O	-	KERI
8	1998. 08.	230kV XLPE Cable 1C x 2000sqmm (CU)	O	-	O	O	O	-	KEMA
9	1999. 09.	154kV XLPE Cable 1C x 2000sqmm (CU)	O	O	O	O	O	-	KERI
10	2000. 08.	132kV XLPE Cable 1C x 1200sqmm (CU)	O	O	O	O	O	-	KEMA
11	2001. 07.	345kV XLPE Cable 1C x 2000sqmm (CU)	O	O	O	O	O	-	KERI
12	2004. 03.	345kV XLPE Cable 1C x 600sqmm (CU)	O	-	O	O	O	O	KERI
13	2005. 01.	400kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
14	2005. 02.	138kV XLPE Cable 1C x 1000kcmil (CU)	O	-	-	-	-	-	CTL (USA)
15	2005. 04.	230kV XLPE Cable 1C x 2000sqmm (CU)	O	-	O	-	O	-	SGS
16	2005. 07.	345kV XLPE Cable 1C x 1200sqmm (CU)	O	-	O	O	O	-	KERI
17	2005. 09.	154kV XLPE Cable 1C x 2500sqmm (CU) with Fiber Optic Cable	O	O	O	O	O	-	KERI
18	2006. 09.	220kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
19	2007. 02.	132kV XLPE Cable 1C x 630sqmm (CU)	O	O	O	O	-	-	KEMA
20	2007. 12.	380kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
21	2007. 12.	400kV XLPE Cable 1C x 2500sqmm (CU)	-	O	O	-	-	-	KEMA
22	2008. 07.	345kV XLPE Cable 1C x 2500sqmm (CU) with Fiber Optic Cable	O	O	O	O	O	-	KERI
23	2008. 10.	400kV XLPE Cable 1C x 630sqmm (CU)	O	-	O	O	O	O	KEMA
24	2009. 07.	132kV XLPE Cable 1C x 1000sqmm (CU)	O	-	O	O	O	O	KEMA
25	2009. 07.	220kV XLPE Cable 1C x 2000sqmm (CU)	O	-	O	O	O	-	KEMA

No.	Date	Type	Item						Institute
			Cable	Accessories					
				N.J	I.J	EB-A	EB-G	EB-O	
26	2009. 08.	275kV XLPE Cable 1C x 2000sqmm (CU)	O	-	-	O	O	O	KEMA
27	2009. 12.	400kV XLPE Cable 1C x 2500sqmm (CU)	O	-	O	O	O	-	KEMA
28	2010. 01.	400kV XLPE Cable 1C x 800sqmm (CU)	O	-	O	O	O	-	KEMA
29	2010. 07.	230kV XLPE Cable 1C x 2000sqmm (CU)	O	-	O	O	O	-	SP-POWERGRID
30	2010. 10.	220kV XLPE Cable 1C x 2500sqmm (CU)	O	-	O	O	O	-	TRANSPOWER
31	2010. 11.	500kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
32	2011. 01.	230kV XLPE Cable 1C x 1400sqmm (AL) with Fiber Optic Cable	O	-	O	O	-	-	TAPE
33	2011. 03.	220kV XLPE Cable 1C x 1200sqmm (AL)	O	O	O	O	-	-	KEMA
34	2011. 05.	132kV XLPE Cable 1C x 630sqmm (CU)	O	-	O	O	O	-	DEWA
35	2012. 06.	345kV XLPE Cable 1C x 1200sqmm (CU)	O	-	-	-	-	-	KERI
36	2012. 07.	400kV XLPE Cable 1C x 800sqmm (CU)	O	-	-	-	-	-	INDIABULLS
37	2012. 12.	230kV XLPE Cable 1C x 800sqmm (CU)	O	-	-	O	O	O	SP-POWERGRID
38	2013. 09.	500kV XLPE Cable 1C x 5000kcmil (CU)	O	-	O	O	-	-	KEMA
39	2013. 12	132kV XLPE Cable 1C x 2500sqmm (CU)	O	-	O	O	O	-	CLP
40	2014. 01	380kV XLPE Cable 1C x 2500sqmm (CU)	O	-	O	O	O	-	KEMA
41	2014. 05	220kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
42	2014. 05	380kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
43	2014. 10.	500kV XLPE Cable 1C x 2500sqmm (CU) with Fiber Optic Cable	O	O	O	O	O	-	KEMA
44	2015. 05.	220kV XLPE Cable 1C x 1600sqmm (CU)	O	-	O	O	O	O	KEMA
45	2015. 03.	154kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KERI
46	2015. 03.	400kV XLPE Cable 1C x 2500sqmm (CU)	O	-	O	O	O		KEMA
47	2015. 11.	132kV XLPE Cable 1C x 800sqmm (CU)	O	-	O	O	-	-	SGS
48	2016. 04	345kV XLPE Cable 1C x 600sqmm (CU) with Fiber Optic Cable	-	O	O	O	-	-	KERI
49	2016. 07	400kV XLPE Cable 1C x 2500sqmm (AL)	O	-	O	O	O	-	KEMA
50	2016.08	132kV XLPE Cable 1C x 2500sqmm (CU)	O	O	O	O	O	-	KEMA
51	2016.08	132kV XLPE Cable 1C x 630sqmm (CU)	O	-	O	O	O	O	DEWA
52	2017.01.	138kV XLPE Cable 1C x 2000kcmil (CU)	O	-	O	O	-	-	SGS
53	2017.05	500kV MI 2500sqmm HVDC Land Type (CU)	O	O	-	O	-	-	KERI
54	2017.06	154kV XLPE Cable 1C x 2500sqmm (CU) with Fiber Optic Cable	O	-	-	-	O	-	KERI
55	2017.08	154kV XLPE Cable 1C x 2500sqmm (CU) (Nano Semi-Conducting Compact Cable)	O	O	-	O	-	-	KEPRI
56	2017.10	400kV XLPE Cable 1C x 2500sqmm (CU)	O		O	-	O	-	KEMA
57	2017.11	138kV XLPE Cable TripleX x 2500kcmil (CU)	O	-	O	O	O	-	KEMA
58	2017.11	400kV XLPE Cable 1C x 2000sqmm (CU)	O	-	O	-	O	-	SGS

* KERI : Korea Electrotechnology Research Institute
* KEPRI : Korea Electric Power Research Institute

System Certificates

No.	Description of Cable & Accessories	Institute	Date	Specification
1	Design and manufacture of high voltage insulators and cable joint accessories	SGS-ICS	2001.02	ISO 14001
2	Design and manufacture of electric cable	SGS-ICS	2003.03	ISO 9001

* SGS-ICS : Systems & Services Certification

Global Network

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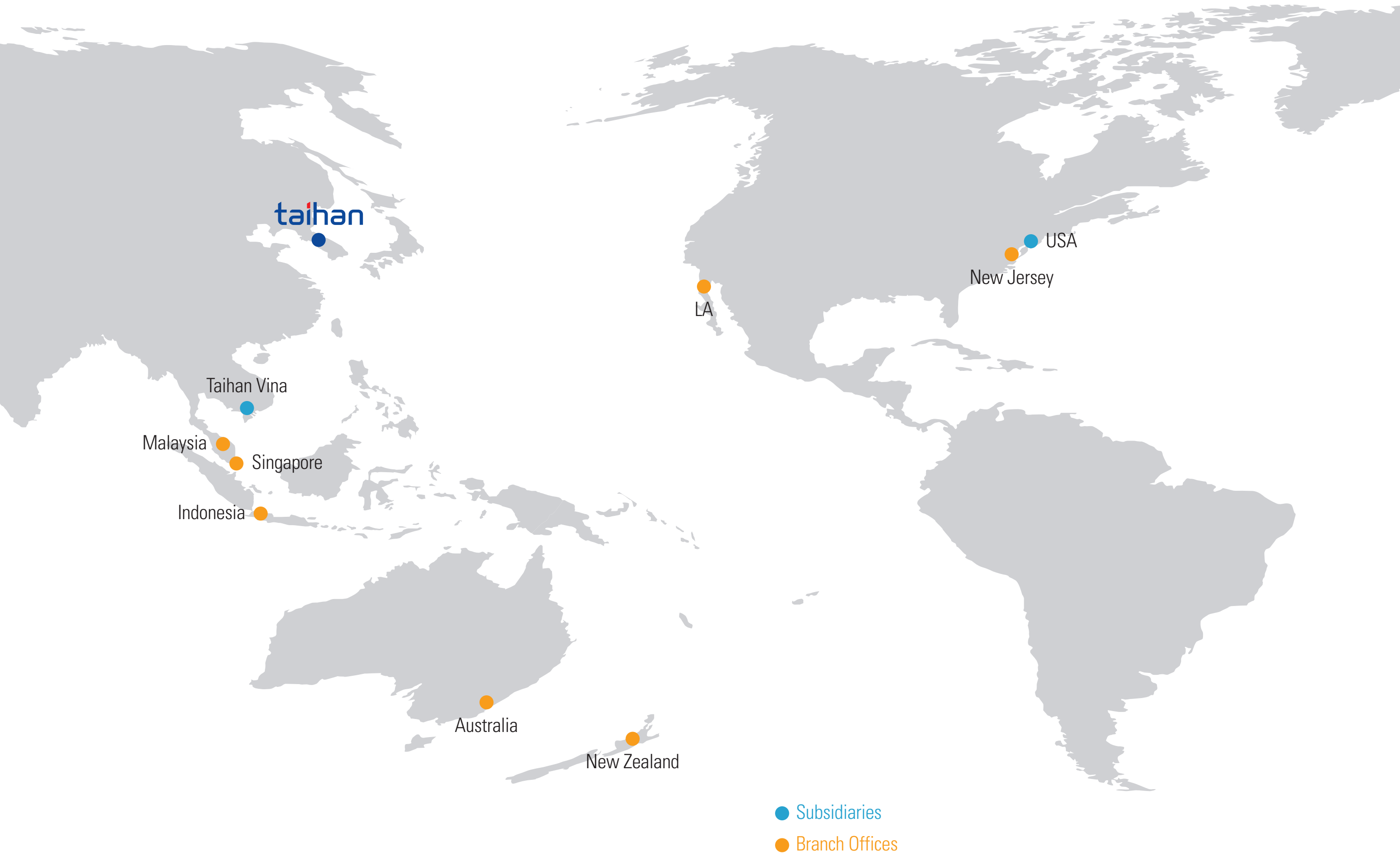

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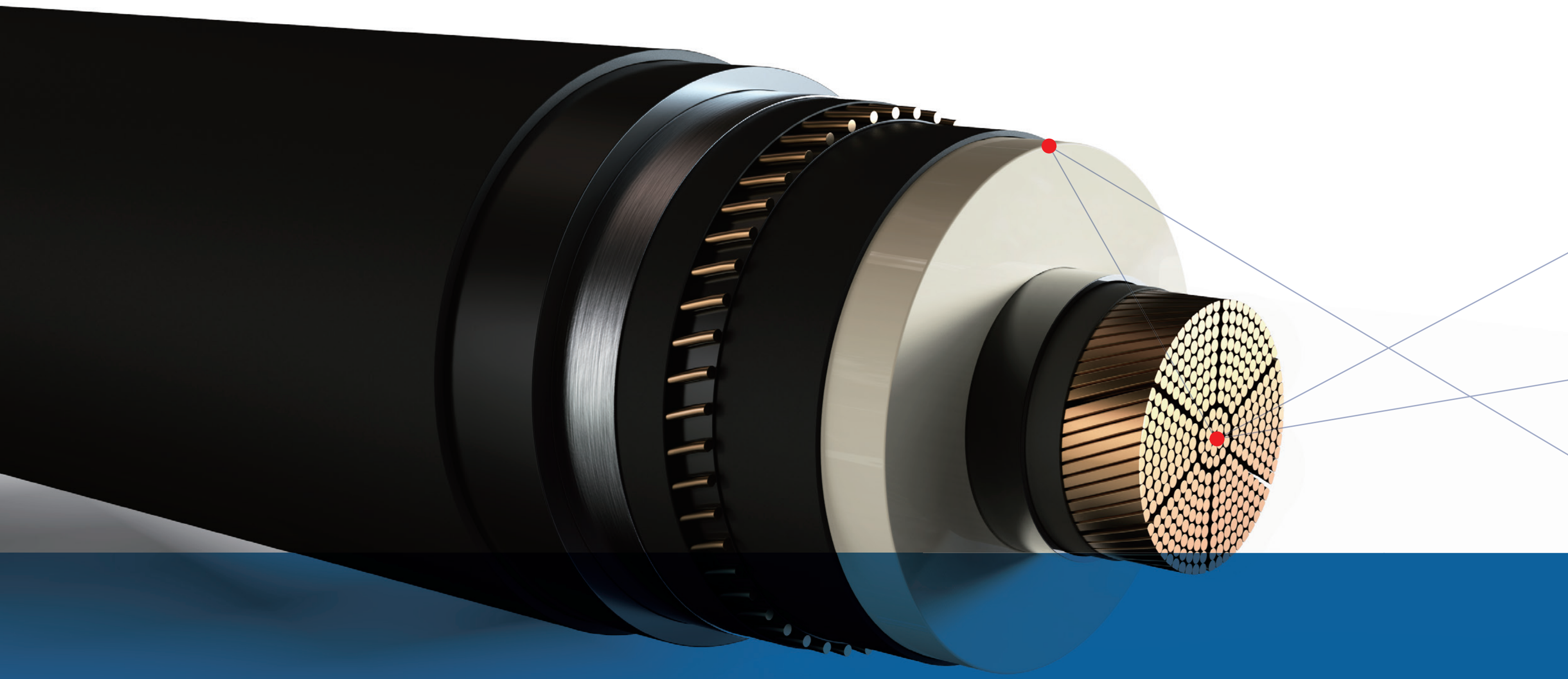

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