1c.2 Construction

The construction of the underground power cables shall be according to the following requirements and technical data as shown in **Table 1** and **Table 2**.

1. Conductor

The conductor shall be plain anncaled copper and compact round concentric lay stranded construction conformable to TIS 2427.

2. Conductor Screen

Over the conductor, semi-conductive XLPE shall be extruded as conductor sereen layer.

The average thickness of the conductor screen shall be as the value specified in **Table 1** and **Table 2**.

3. Insulation

The insulation shall be unfilled, no carbon black, XLPE. The conductor screen layer, the insulation layer and the insulation screen layer shall be provided by tandem extrusion or simultaneous extrusion and continuous vulcanizer.

Only the dry curing process is required. Conventional steam or hot water curing processes are not accepted.

The average thickness of the insulation shall not be less than the nominal value specified in **Table 1** and **Table 2**.

The minimum thickness of the insulation shall not be less than 90 per cent of the nominal value.

4. Insulation Screen

Over the XLPE insulation, semi-conductive XLPE shall be extruded as insulation screen layer.

The average thickness of the insulation screen shall be as the value specified in **Table 1** and **Table 2**.

5. Metallic Screen (Grounding Screen)

The metallic screen shall be a concentric layer of copper wires which is electrically continuous and bonded together throughout the cable length with copper contact tape.

The total cross-sectional area and minimum number of wires of the metallic screen shall not be less than the value specified in **Table 1** and **Table 2**.

6. Synthetic Water Blocking & Cushioning Tape

A non-conductive non-biodegradable water blocking tape shall be applied either under or over the metallic screen to provide a continuous longitudinal watertight barrier throughout the cable length.

The tape shall have sufficient thickness to perform well as a thermal stress relief layer and shall be served as cushioning and bedding.

The tape shall be compatible with other cable materials and shall not create corroding effect on adjacent metal layer during heat ageing of the cable.

7. Non-metallic Sheath

The sheath shall be black PE suitable for use with the cable having maximum conductor temperature of 90°C and 130°C under normal and emergency condition respectively.

The average thickness of the sheath shall not be less than the nominal value specified in **Table 1** and **Table 2**.

The minimum thickness of the sheath shall not be less than 80 per cent of the nominal value.

1c.3 Cable marking

The outer sheath of cable shall be marked legibly and durably in Thai language, at the interval of about 50 cm, as follows :

"การไฟฟ้าส่วนภูมิภาค สายเคเบิลใต้ดินทองแดงหุ้มด้วยฉนวนครอสลิงค์โพลิเอทิลีน สำหรับใช้กับระบบ A โวลต์, ขนาด B ตร.มม., สัญญาเลขที่ C , D , E , F , G"

Where

A : Rated voltage

B : Nominal cross-sectional area

C : The purchase contract number

D : Manufacturer's name and/or Trade mark

E : PEA trade-mark as the figure below

F : Year of manufacture

G : Others according to manufacturer's design

The cable length markings shall be made on the outer sheath through whole length started from "0" with 1 meter increment.

1c.4 Terminal marking

Both terminals of cable in each reel shall be permanently marks with manufacturer's symbol for verifying the original length. The method of marking shall be stated.

1c.5 Cable end sealing

Immediately after factory tests the cable ends shall be sealed or covered with moisture-proof end caps.

Table 1 Data for XLPE underground cable rated voltage 12/20(24) kV

Nominal cross-sectional area of conductor	mm^2	35	50	95	120	185	240	400	500
Min. number of wires in conductor	-	6	6	15	18	30	34	53	53
Diameter of conductor ±1%	mm	6.95	8.33	11.45	12.95	15.98	18.47	23.39	26.67
Thickness of conductor screen, approx.	mm	0.5							
Thickness of insulation	mm	5.5							
Diameter over insulation, approx.	mm	19.0	20.5	23.5	25.0	28.0	30.5	35.5	39.0
Thickness of insulation screen, approx.	mm	0.5							
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	10	10	25	25	25	25
Number of wire screen, minimum	-	20	20	20	20	30	30	30	30
Thickness of non-metallic sheath	mm	1.8	1.8	1.9	2.0	2.1	2.2	2.4	2.6
Overall diameter, approx.	mm	28	30	33	34	38	42	48	52
Max. d.c. resistance of conductor at 20° C	Ω/km	0.524	0.387	0.193	0.153	0.0991	0.0754	0.0470	0.0366

Table 2 Data for XLPE underground cable rated voltage 18/30(36) kV

Nominal cross-sectional area of conductor	mm^2	50	95	120	185	240	400	500
Min. number of wires in conductor	-	6	15	18	30	34	53	53
Diameter of conductor ±1%	mm	8.33	11.45	12.95	15.98	18.47	23.39	26.67
Thickness of conductor screen, approx.	mm	0.5						
Thickness of insulation	mm	8.0						
Diameter over insulation, approx.	mm	25.5	28.5	30.0	33.0	35.5	40.5	44.0
Thickness of insulation screen, approx.	mm	0.5						
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	10	25	25	25	25
Number of wire screen, minimum	-	20	20	20	30	30	30	30
Thickness of non-metallic sheath	mm	2.0	2.1	2.2	2.3	2.4	2.6	2.7
Overall diameter, approx.	mm	35	38	40	44	47	55	58
Max. d.c. resistance of conductor at 20° C	Ω/km	0.387	0.193	0.153	0.0991	0.0754	0.0470	0.0366

1d Packing

The cables shall be packed on non-returnable wooden reels with hub reinforcements. Reels shall be closely lagged with suitable wooden battens to protect the cables against damage. After lagging, the galvanized steel wire or steel strap shall be fitted to the battens over each flange of the reel. Overall outside diameter of reel shall not exceed 2.0 meters . The wooden parts of reels shall be treated with water-borne wood preservatives, Chromated Copper Arsenate (CCA), according to Group 3 of TIS 515, see Table 3, to a dry net salt retention of 12.0 kg/m^3; or suitably impregnated under pressure with an approved wood preservative.

Table 3

Active Ingredients of CCA

Description		TIS 515 - 2539 Group 3		
		Formula A	Formula B	Formula C
Copper, as CuO	%	16.0 - 20.9	18.0 - 22.0	17.0 - 21.0
Chromium, as CrO_3	%	59.4 - 69.3	33.0 - 38.0	44.5 - 50.5
Arsenic, as, As_2O_5	%	14.7 - 19.7	42.0 - 48.0	30.0 - 38.0

The standard length of cable per reel, size up to 240 mm^2 shall be 500 m $\pm$10 m.

The length of cable per reel if proposed more than the specified standard length can be accepted but the overall outside diameter of reel shall not exceed 2.0 m.

Cable length of the last reel can be adjustable to meet the length specified in the purchase contract but not less than 50 per cent of the length of cable per reel.

On acceptance, the measured length of cable in each reel shall not be less than the packing length shown on the reel.

The reel shall be marked with at least the followings :

1) Cable type and size
2) System voltage
3) Manufacturer's name and/or Trade mark
4) Contract number and Year of manufacture
5) Length of cable
6) Gross weight and Net weight
7) Other according to manufacturer's design

1e Tests and Test reports

1e.1 Type tests

The proposed cable shall have successfully passed the type tests in accordance with the latest relevant standard.

The test reports shall be submitted within fifteen (15) calendar days from the bid closing date.

The above type tests may be omitted if a record of tests made on identical ones can be supplied.

The type tests shall be as follows :

Electrical type tests

a) Partial discharge test

b) Bending test, followed by a partial discharge test

c) Tan δ measurement

d) Heating cycle test, followed by a partial discharge test

e) Impulse test followed by a voltage test

f) Voltage test for 4 h

g) Resistivity of semi-conducting screens

Non-electrical type tests

a) Measurement of thickness of insulation

b) Measurement of thickness of non-metallic sheaths

c) Tests for determining the mechanical properties of insulation before and after ageing

d) Tests for determining the mechanical properties of non-metallic sheaths before and after ageing

e) Additional ageing test on pieces of completed cables

f) Pressure test at high temperature on insulations and non-metallic sheaths

g) Hot set test for XLPE insulations

h) Water absorption test on insulation

i) Measurement of carbon black content of black PE non-metallic sheaths

j) Shrinkage test for XLPE insulation

k) Shrinkage test for PE non-metallic sheaths

l) Water penetration test

1e.2 Routine tests

Routine tests shall be made on all cable lengths in each reel in accordance with the reference standard as follows :

a) Measurement of the electrical resistance of conductors

b) Partial discharge test

c) Voltage test

1e.3 Sample tests

Sample tests shall be made in accordance with the reference standard as follows :

a) Conductor examination

b) Check of dimensions

c) Voltage test for 4 h

d) Hot set test for XLPE insulation

1e.4 Three (3) sets of routine tests and sample tests reports shall be submitted at the time of delivery.

1e.5 The costs of all tests and test reports shall be borne by the Contractor.

C2 Material and packing data to be given by bidder

For each item offered, the following details shall be submitted :

2a Guarantee performance data of 22 and 33 kV underground power cables (See Pages 9 of 11 to 11 of 11).

2b Illustration of the cable

An illustration shall be submitted, showing the conductor, screen, insulation, and sheath.

2c Packing detail

Packing method (shown by drawing(s), describe packing materials, and details of wood treatment, name and composition.

Principal dimensions of reel in cm

Gross weight of each reel in kg

Net weight of each reel in kg

Length of uncut cable per reel in m

Invitation to Bid No.:

Guarantee performance data of 22 and 33 kV underground power cables

Manufacturer's name			
Country of origin			
Applied standard, publication number and year			
Type / Model / Catalogue No.	-		
Nominal cross-sectional area	mm^2		
Rated voltage, phase to phase	kV r.m.s.		
Design for highest system voltage	kV r.m.s.		
Rated frequency	Hz		
Number of cores	-		
Rated current, in free air (40°C)	A		
<u>Conductor</u>			
Material	-		
Actual cross-sectional area	mm^2		
Minimum number of wires	-		
Diameter of wires	mm		
Stranding(concentric, compress, or compact)	-		
Maximum volume resistivity at 20°C	Ω - m		
Maximum d.c. resistance at 20°C	Ω /km		
Outside diameter, with tolerance	mm±1%		
Weight	kg/km		
<u>Conductor screen</u>	-		
Material			
Average thickness	mm		
Thickness at any place, not less than	mm		
D.C. volume resistivity at 90°C	Ω - m		

Invitation to Bid No.:

Guarantee performance data of 22 and 33 kV underground power cables

Insulation	-		
Material			
Cross-linking agent (peroxide, silane, etc)	-		
Curing process (steam, nitrogen, etc.)	-		
Average thickness	mm		
Thickness at any place, not less than	mm		
Dielectric constant, measured at a conductor temperature of 90°C			
Power factor, measured at a conductor temperature of 90°C	-		
Range of diameters over insulation	mm		
Insulation screen			
Material	-		
Average thickness	mm		
Thickness at any place, not less than	mm		
D.C. volume resistivity at 90°C	Ω - m		
Metallic screen			
Type of wire	-		
Total cross-sectional area	mm^2		
Diameter of wire, with tolerance	mm±%		
Minimum number of wires	-		
Type of contact tape	-		
Thickness	mm		
Width	mm		
Synthetic water blocking tape			
Manufacturer	-		
Material	-		
Thickness, approx.	mm		
Swelling height, approx.	mm		
Over sheath			
Material	-		
Average thickness	mm		
Thickness at any place, not less than	mm		

Invitation to Bid No.:

Guarantee performance data of 22 and 33 kV underground power cables

Cable Electrical properties Capacitance	 μF/km		
Inductance	mH/km		
Charging current/core	A/km		
Dielectric loss factor	-		
Maximum current carrying capacity, triangular laying, in : - ground (earth temperature 30°C) - duct (ambient air temperature 40°C)	 A A		
Total losses based on values for maximum current	kW/km		
Maximum short-circuit current (1 sec) after full load : - conductor - screen	 kA kA		
Maximum permissible conductor temperature : - continuous service	 °C		
- in case of short-circuit	°C		
Insulation resistance constant, minimum At 20°C	 MΩ - km		
At 90°C	MΩ - km		
Maximum partial discharge	pC at...kV		
A.C. test voltage for 5 minutes	kV		
D.C. test voltage for 5 minutes	kV		
Physical properties : Minimum bending radius Permissible pulling force Cable weight	 mm N kg/km		
Packing Length per reel Gross weight Net weight	 m kg kg		
Name of wood preservative	-		

C3 Schedule of detailed requirement

Invitation to Bid No.:

Item	PEA Material No.	Quantity	Description
1	1020040000		Underground power cable, with XLPE insulation, copper wire screen, PE sheath, single-core, copper conductor size 35 mm^2, rated voltage 22 kV.
2	1020040001		Ditto as Item 1, but copper conductor size 50 mm^2.
3	1020040003		Ditto as Item 1, but copper conductor size 95 mm^2.
4	1020040004		Ditto as Item 1, but copper conductor size 120 mm^2.
5	1020040006		Ditto as Item 1, but copper conductor size 185 mm^2.
6	1020040007		Ditto as Item 1, but copper conductor size 240 mm^2.
7	1020040009		Ditto as Item 1, but copper conductor size 400 mm^2.
8	1020040008		Ditto as Item 1, but copper conductor size 500 mm^2.
9	1020040101		Underground power cable, with XLPE insulation, copper wire screen, PE sheath, single-core, copper conductor size 50 mm^2, rated voltage 33 kV.
10	1020040103		Ditto as Item 9, but copper conductor size 95 mm^2.
11	1020040104		Ditto as Item 9, but copper conductor size 120 mm^2.
12	1020040106		Ditto as Item 9, but copper conductor size 185 mm^2.
13	1020040107		Ditto as Item 9, but copper conductor size 240 mm^2.
14	1020040108		Ditto as Item 9, but copper conductor size 400 mm^2.
15	1020040109		Ditto as Item 9, but copper conductor size 500 mm^2.

2.4.2 Space Aerial Cable for 22/33 kV

Invitation to Bid No.:

C Material, equipment, and specifications for SPACED AERIAL CABLES FOR RATED VOLTAGES OF 22 kV AND 33 kV

C1 General material and packing instructions

Additional to the general instructions, the following shall be observed:

1a Scope

These specifications cover 22 kV and 33 kV spaced aerial cables with compact stranded aluminium conductor, shield, insulation and jacket.

1b Standards

The spaced aerial cables shall be manufactured and tested in accordance with the following standards:

Thailand Industrial Standard (TIS)

TIS 2341-2555 Aluminium space aerial power cables with XLPE insulated and sheathed for rated voltage of 25 kV and 35 kV (Except insulation and jacket thickness used the technical data in **Table 1** and **Table 2**)

And all other relevant standards, unless otherwise specified in these specification.

PEA will also accept the spaced aerial cables tested in accordance with the later edition of the above standards.

1c Principal requirement

1c.1 General

The cables shall be compact stranded aluminium conductors, single-core type, with semi-conducting material conductor shield, cross-linked polyethylene insulation, and cross-linked polyethylene jacket.

The cables shall be capable of installing and operating under the following conditions:

System voltage	:	3-phase, 22 kV and 33 kV
Rated frequency	:	50 Hz
Conductor temperature		
- for normal operation	:	90°C continuously
- for emergency overload condition	:	130°C
- for short-circuit condition	:	250°C
Ambient air temperature	:	up to 40°C

1c.2 Construction

The construction of 22 kV and 33 kV spaced aerial cables shall conform to the following requirements and technical data as shown in **Table 1** and **Table 2** respectively.

(1) Conductor

The aluminium conductor shall be compact round concentric-lay-stranded in accordance with the TIS 293 and technical data shown in **Table 1** and **Table 2**.

(2) Conductor shield

Over the conductor, semi-conductive cross-linked polyethylene shall be extruded as conductor shield layer. The semi-conductive extrusion shall be made in the process of tandem or simultaneous extrusion with the insulation and jacket. The conductor shield shall be of a material compatible with the conductor metal, and shall be uniformly and firmly bonded to the overlying insulation.

The average thickness and the minimum thickness of the conductor shield of 22 kV and 33 kV spaced aerial cables are specified in **Table 1** and **Table 2** respectively.

(3) Insulation

The insulation shall be unfilled, no carbon black cross-linked polyethylene (XLPE) processed from peroxide cross linking agent, whose properties meet all the requirements as specified in TIS 2341.

The average thickness of the insulation of 22 kV and 33 kV spaced aerial cables shall not be less than the nominal value specified in **Table 1** and **Table 2** respectively.

The minimum thickness of the insulation shall not be less than 90 percent of the nominal value.

(4) Jacket

The jacket shall be filled carbon black cross-linked polyethylene which contains no less than 2% and no more than 10% of carbon black by weight with tracking resistance, whose properties meet all the requirements as specified in TIS 2341.

The average thickness of the jacket of 22 kV and 33 kV spaced aerial cables shall not be less than the nominal value specified in **Table 1** and **Table 2** respectively.

The minimum thickness of the jacket shall not be less than 90 percent of the nominal value.

Table 1

Technical data of 22 kV spaced aerial cables

Description			Unit	Technical data			
Nominal system voltage			kV	22			
Conductor	Type of conductor		-	Aluminium			
	Nominal cross-sectional area		mm^2	50	95	120	185
	Stranding		-	Compact stranded			
	Outside diameter ± 1%		mm	8.00	11.45	12.95	15.98
	Calculated breaking strength	Minimum	N	7,313	14,098	18,518	28,974
	Volume resistivity at 20°C	Maximum	Ω-mm^2/m	0.028264			
	DC resistance at 20°C	Maximum	Ω/km	0.641	0.320	0.253	0.164
Conductor shield	Thickness	Minimum	mm	0.07			
		Average	mm	0.3			
	Volume resistivity at 90°C	Maximum	Ω-cm	50,000			
Insulation	Thickness		mm	4.85			
Jacket	Thickness		mm	1.75			
Cable	Overall outside diameter		mm	21.7-23.8	25.1-27.1	26.5-28.5	29.6-31.8
Electrical test voltage	AC test voltage for 5 minutes		kV	38			

Table 2

Technical data of 33 kV spaced aerial cables

Description			Unit	Technical data			
Nominal system voltage			kV	33			
Conductor	Type of conductor		-	Aluminium			
	Nominal cross-sectional area		mm^2	50	95	120	185
	Stranding		-	Compact stranded			
	Outside diameter ± 1%		mm	8.00	11.45	12.95	15.98
	Calculated breaking strength	Minimum	N	7,313	14,098	18,518	28,974
	Volume resistivity at 20°C	Maximum	Ω-mm^2/m	0.028264			
	DC resistance at 20°C	Maximum	Ω/km	0.641	0.320	0.253	0.164
Conductor shield	Thickness	Minimum	mm	0.07			
		Average	mm	0.3			
	Volume resistivity at 90°C	Maximum	Ω-cm	50,000			
Insulation	Thickness		mm	7.18			
Jacket	Thickness		mm	1.75			
Cable	Overall outside diameter		mm	26.3-28.3	29.7-31.7	31.1-33.1	34.2-36.2
Electrical test voltage	AC test voltage for 5 minutes		kV	49			

1c.3 Cable marking

The surface of the jacket shall be marked in **Thai** language, a distance of about 50 cm, by printing in white, as follows:

" การไฟฟ้าส่วนภูมิภาค สายเคเบิลอากาศอะลูมิเนียม หุ้มด้วยฉนวน และเปลือกนอกครอสลิงกด์พอลิเอทิลีน สำหรับใช้กับระบบ A เควี ขนาด B ตร.มม., สัญญาเลขที่ C , D , E , F , G "

Where

A : Rated voltage (22 kV or 33 kV)

B : Nominal cross-sectional area in mm^2

C : The purchase contract number

D : Manufacturer's name and/or Trade mark

E : PEA trade-mark as the figure below

F : Year of manufacture

G : Others according to manufacturer's design

The **cable length markings** shall be made on the cable jacket through whole length started from "0" with 1 meter increment.

1c.4 Terminal marking

Both terminals of cable in each reel shall be permanently marks with manufacturer's symbol for verifying the original length. The method of marking shall be stated.

1c.5 Cable end sealing

Immediately after factory tests the cable ends shall be sealed or covered with moisture-proof end caps.

1d Packing

The cables shall be packed on non-returnable wooden reels with hub reinforcements. Reels shall be closely lagged with suitable wooden battens to protect the cables against damage. After lagging, the galvanized steel wire or steel strap shall be fitted to the battens over each flange of the reel. Overall outside diameter of reel shall not exceed 2.0 meters.

The wooden parts of reels shall be treated with water-borne wood preservatives, Chromated Copper Arsenate (CCA), according to Group 3 of TIS 515, see **Table 3**, to a dry net salt retention of 12.0 kg/m^3.

Table 3

Active Ingredients of CCA

Description	TIS 515–2539 Group 3		
	Formular A	Formular B	Formular C
Copper, as CuO %	16.0 - 20.9	18.0 - 22.0	17.0 - 21.0
Chromium, as CrO_3 %	59.4 - 69.3	33.0 - 38.0	44.5 - 50.5
Arsenic, as As_2O_5 %	14.7 - 19.7	42.0 - 48.0	30.0 - 38.0

The cables shall be supplied in length per reel as mentioned in **Table 4** with variation of ±10%.

An amount not exceeding 10% of the total length may be delivered in random length, but any such length shall not be less than 50% and not exceed of the standard length on one reel.

On acceptance, the measured length of cable in each reel shall not be less than the packing length shown on the reel.

The reel shall be marked with at least the followings:

(1) Cable type and size

(2) System voltage

(3) Manufacturer's name and/or Trade mark

(4) Contract number and/or Year of manufacture

(5) Length of cable

(6) Gross weight and Net weight

(7) Other according to standard and manufacturer's design

Table 4

Packing details for spaced aerial cables

PEA Material No.	Nominal cross-sectional area (mm^2)	System voltage (kV)	Production length per reel (m)
1020050000	50	22	1,500
1020050001	95	22	1,000
1020050002	120	22	1,000
1020050004	185	22	1,000
1020050100	50	33	1,000
1020050101	95	33	1,000
1020050102	120	33	1,000
1020050104	185	33	1,000

1e Tests and Test reports

1e.1 Type tests

The cables shall be successfully passed type tests in accordance with the relevant TIS standards by the following test items:

a) Marking durability test
b) Test for determining the mechanical properties of insulation and jacket before and after ageing
c) Hot creep test for insulation and jacket
d) Determination of physical for conductor and dimension for each layer
e) Resistance test on conductor
f) Dielectric test
g) Insulation resistance test
h) Tracking resistance test on jacket
i) Volume resistance test on conductor shield
j) Capacitance and power factor test
k) Accelerated water absorption test

The type tests shall be conducted or inspected by the acknowledged testing laboratories/institutes as following:

(1) Independent laboratories/institutes which are members of the Short-circuit Testing Liaison (STL) or independent laboratories/institutes which are accredited according to TIS 17025 or ISO/IEC 17025 with the scope of accreditation covered the relevant test items, standards and equipment. The certification and scope of accreditation of the independent laboratories/institutes shall be submitted with the bid for consideration.

(2) Thailand's national laboratories, institutes, universities and electric utilities, as follows:
- National Metal and Materials Technology Center (MTEC)
- Electrical and Electronic Products Testing Center (PTEC)
- Thai Industrial Standards Institute (TISI)
- Electrical and Electronics Institute (EEI)
- Department of Science Service (DSS)
- Testing Laboratory, Electrical Engineering Department, Faculty of Engineering, Chulalongkorn University
- Electricity Generating Authority of Thailand (EGAT)
- Metropolitan Electricity Authority (MEA)
- Provincial Electricity Authority (PEA)
- Other laboratories, institutes, universities or electric utilities approved by PEA

In case of the foreign manufacturers having experience of more than twenty (20) years in design, manufacture and sell spaced aerial cables, PEA will accept type test report(s) conducted by the manufacturer's laboratory or other independent laboratories without qualification mentioned in (1) or (2). Documents showing the manufacturer's experience such as reference list shall be submitted with the bid for consideration.

The bidders or manufacturers who prefer to carry out the type tests of the spaced aerial cables with the laboratories or by the manufacturer themselves without the qualification mentioned above, the detail of the test facilities of the laboratories or the manufacturer shall be submitted to PEA for approval before proceeding the tests and before the bid closing date. PEA reserves the right to send representatives to inspect and witness the tests with the cost of the bidders or manufacturers.

The type test report done by the laboratories in Thailand or local manufacturers shall be valid within five (5) years counted from the issued date in the test report to the bid closing date.

The costs of all tests and reports shall be borne by the Contractor.

1e.2 Acceptance tests

The proposed spaced aerial cables shall be passed the acceptance tests in accordance with the relevant TIS standards by the test items shown in **1e.1 Type tests** except capacitance and power factor test and accelerated water absorption test are not require.

The Test Form for Acceptance test is according to **Annex 1**.

For item b) Test for determining the mechanical properties of insulation and jacket before and after ageing, PEA will accept a test report which is carried out before acceptance tests process.

PEA reserves the right to have the acceptance test made by the supplier's factory or by acknowledge independent testing laboratories.

The costs of all tests and reports shall be borne by the Contractor.

Three (3) sets of test reports shall be submitted at the time of delivery.

Number of sample

Number of reels per lot	Number of sample for acceptance test
1 to 100	1
101 to 200	2
201 to 300	3
301 to 400	4
401 to 500	5
More than 501	6

C2 Material and packing data of the spaced aerial cables

The following critical documents and details shall be submitted with the bid:

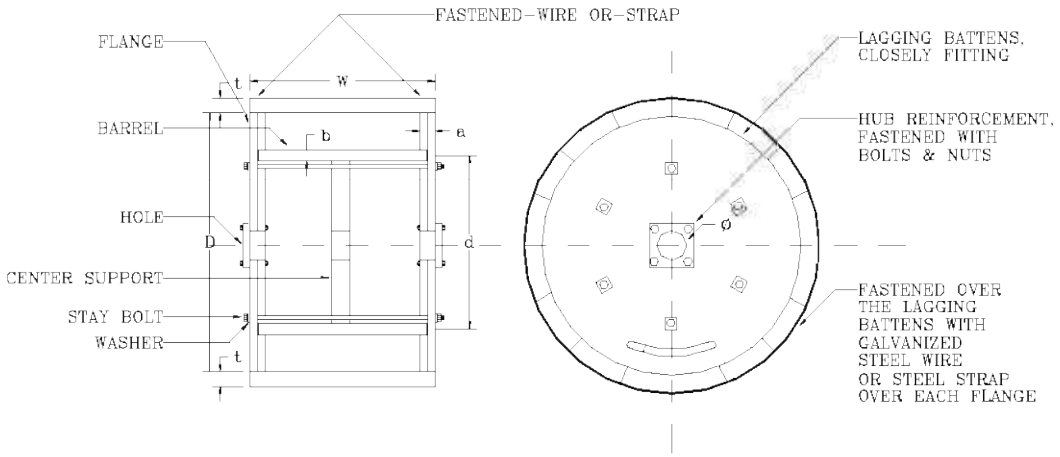
Critical documents of the proposed spaced aerial cables shall be submitted with the bid for each item offered:

Item	Description of document	Confirmation	Reference (Page No./folder)
1	Guarantee performance data of spaced aerial cables (See Pages 10 of 11 to 11 of 11)	☐ Yes ☐ No	
2	Type test certification and/or type test reports	☐ Yes ☐ No	
3	Illustration of the cable	☐ Yes ☐ No	
4	Packing detail	☐ Yes ☐ No	

Note:

The bidders who do not submit all critical documents mentioned in the above table with the bid shall be rejected.

WOODEN REELS



Reel size mm	D mm	d (min) mm	W mm	a (min) mm	b (min) mm	t (min) mm	Ø mm	Number of stay bolts (min.)
1,000	980-1,020	500	660-700	50	19	25	75-100	6
1,400	1,380-1,420	710	875-915	63	25	38	75-100	6
1,800	1,780-1,820	965	880-920	75	35	38	75-100	6
1,900	1,880-1,920	*	*	75	35	38	75-100	6

Note:

1. Minimum clearance between cable and the lagging battens shall not be less than 25 mm.
2. Both ends of barrel battens shall be embedded in the flanges.
3. If PEA requests, the bidders have to state the reel manufacturer's name; and PEA reserves the right to observe the manufacturing process from time to time.
4. *According to manufacturer's design.

Invitation to Bid No.:

Guarantee performance data of spaced aerial cables

Manufacturer's name					
Country of origin					
Applied standard, publication number and year					
Type/Model/Catalogue No.	-				
Nominal cross-sectional area	mm^2	50	95	120	185
Rated voltage, phase to phase	kV r.m.s.				
Design for highest system voltage	kV r.m.s.				
Rated frequency	Hz				
Number of cores	-				
Rated current, in free air ($40^{\circ}C$)	A				
Conductor					
Material	-				
Actual cross-sectional area	mm^2				
Minimum number of wires	-				
Diameter of wires	mm				
Stranding	-				
Maximum volume resistivity at $20^{\circ}C$	Ω-mm^2/m				
Maximum d.c. resistance at $20^{\circ}C$	Ω/km				
Conductor shield					
Material	-				
Average thickness	mm				
Thickness at any place, not less than	mm				
Maximum DC volume resistivity at $90^{\circ}C$	Ω-cm				

Invitation to Bid No.:

Guarantee performance data of spaced aerial cables (Continue)

Insulation					
Material	-				
Cross-linking agent (peroxide, silane, etc)	-				
Curing process (steam, nitrogen, etc.)	-				
Average thickness	mm				
Thickness at any place, not less than	mm				
Dielectric constant, measured at a conductor temperature of 90°C	-				
Power factor, measured at a conductor temperature of 90°C	-				
Range of diameters over insulation	mm				
Jacket					
Material	-				
Average thickness	mm				
Thickness at any place, not less than	mm				
Overall diameter	mm				
AC test voltage for 5 minutes	kV				
Packing					
Length per reel	m				
Gross weight	kg				
Net weight	kg				
Name of wood preservative	-				

C3 Schedule of detailed requirement

Invitation to Bid No.:

Item	PEA Material No.	Quantity	Description
1	1020050000		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 50 mm^2, for system voltage 22 kV 50 Hz.
2	1020050001		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 95 mm^2, for system voltage 22 kV 50 Hz.
3	1020050002		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 120 mm^2, for system voltage 22 kV 50 Hz.
4	1020050004		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 185 mm^2, for system voltage 22 kV 50 Hz.
5	1020050100		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 50 mm^2, for system voltage 33 kV 50 Hz.
6	1020050101		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 95 mm^2, for system voltage 33 kV 50 Hz.
7	1020050102		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 120 mm^2, for system voltage 33 kV 50 Hz.
8	1020050104		Spaced aerial cable, XLPE insulation and jacket, single-core, aluminium conductor size 185 mm^2, for system voltage 33 kV 50 Hz.

Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 22 kV ขนาด 50 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	21.7-23.8	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	7.92-8.08	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 4.37	mm.					
			Average 4.85	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.641	Ω/km					
(f)	**HV dielectric**	Test at 38 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 6100 \log_{10} \frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 22 kV ขนาด 95 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Real No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	25.1-27.1	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	11.33-11.56	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 4.37	mm.					
			Average 4.85	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.320	Ω/km					
(f)	**HV dielectric**	Test at 38 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 61001og_{10}\frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			PASS						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 22 kV ขนาด 120 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for Jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	21.7-23.8	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	7.92-8.08	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 4.37	mm.					
			Average 4.85	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.641	Ω/km					
(f)	**HV dielectric**	Test at 38 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 6100 \log_{10} \frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 22kV ขนาด 185 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	29.6-31.8	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	15.82-16.14	mm.					
		No. of wire in conductor	Min. 30	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 4.37	mm.					
			Average 4.85	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.164	Ω/km					
(f)	**HV dielectric**	Test at 38 kVac for 5 min	**No Breakdown**	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 6100 \log_{10} \frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	**No Failure**	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 33 kV ขนาด 50 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	26.3-28.3	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	7.92-8.08	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 6.462	mm.					
			Average 7.18	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.641	Ω/km					
(f)	**HV dielectric**	Test at 49 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 6100 \log_{10} \frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			PASS						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 33kV ขนาด 95 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	26.3-28.3	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	12.82-13.07	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 6.462	mm.					
			Average 7.18	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.641	Ω/km					
(f)	**HV dielectric**	Test at 49 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 61001o_{g_{10}}\frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 33 kV ขนาด 120 mm^2

Factory ..... **Contract No.** ..... **Date** _____

No.	Description		Requirement	Reel No. / Unit	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	26.3-28.3	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	12.82-13.07	mm.					
		No. of wire in conductor	Min. 6	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 6.462	mm.					
			Average 7.18	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Reaistance at 20 °c	Max. 0.641	Ω/km					
(f)	**HV dielectric**	Test at 49 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 6100 \log_{10} \frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Faihure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Annex 1

Test Form for Acceptance test

รายงานผลการตรวจรับสาย SAC ระดับแรงดัน 33 kV ขนาด 185 mm^2

Factory ..... **Contract No.** ..... **Date** .....

No.	Description		Requirement	Unit \ Reel No.	1	2	3	4	5
Physical Properties									
(a)	**Marking Durability**	Rub with cloth 10 time	Durable	-					
(b)	**Tensile strength of insulation**	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of insulation	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
	Tensile strength of jacket	Before Aging	Min. 12.5	N/mm^2					
		After Aging	-	N/mm^2					
			Min. 75	% of unaged					
	Elongation of Jacket	Before Aging	Min. 250	%					
		After Aging	-	%					
			Min. 75	% of unaged					
(c)	**Hot creep for Insulation**	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
	Hot creep for Jacket	Under Load at 150°C at 15 min	Max. 175	%					
		Elongation After Cooling	Max. 10	%					
Dimension Properties									
(d)	**Dimension cable**	Overall diameter (D)	34.2-36.2	mm.					
		Material Conductor	Al Compact	-					
		Conductor diameter (d)	15.82-16.14	mm.					
		No. of wire in conductor	Min. 30	mm.					
		Conductor screen Thinkness	Min. 0.07	mm.					
			Average 0.3	mm.					
		Material Insulation	XLPE	-					
		Insulation Thinkness	Min. 6.46	mm.					
			Average 7.18	mm.					
		Material Jacket	XLPE	-					
		Jacket Thinkness	Min. 1.58	mm.					
			Average 1.75	mm.					
Electrical Properties									
(e)	**Conductor resistance**	Resistance at 20 °c	Max. 0.164	Ω/km					
(f)	**HV dielectric**	Test at 49 kVac for 5 min	No Breakdown	-					
(g)	**Insulation resistance**	Test at 500 Vdc at 15.6 °C	$IR = 61001og_{10}\frac{D}{d}$	MΩ-km					
(h)	**Tracking Jacket**	Test at 2kVac test 10 cycle	No Failure	-					
(i)	**Volume conductor shield**	at least 30 min at 90 °C	Max. 50,000	Ω-cm					
สรุปผลการทดสอบ			**PASS**						

Witness By 1. _____

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Invitation to Bid No. :

Specification No. : R-775/2539

C Material, equipment, and specifications for SPLICING KITS FOR 22 kV AND 33 kV XLPE CABLES

C1 General material and packing instructions

Additional to the general instructions, the following shall be observed :

1a Scope

These specifications cover splicing kits to be used with underground cable 22 kV & 33 kV, single-core, copper conductor, cross-linked polyethylene insulated, copper wires screen and polyethylene sheath.

1b Standard

The splicing kits shall be manufactured and tested in accordance with the latest revision of IEEE standard 404, DIN 57 278/VDE 0278, or equivalent; unless otherwise specified in these specifications.

1c Principal requirement

1c.1 General

The splicing kits shall be suitable for use in tropical climatic area and highly contaminated atmosphere and shall be capable of operating at its full ratings in the following condition mentioned.

1c.2 Site and service conditions

The splicing kits shall be designed and constructed for direct burial installation and operation under the following conditions :

Ultitude	: up to 1,500 m above sea level
Ambient air temperature	: 40^{o} C, maximum
Maximum soil temperature	: 35^{o} C, average on one (1) day
System voltage	: 3-phase, 22 kV & 33 kV solidly grounded neutral
Rated frequency	: 50 Hz

1c.3 Constructions

The splicing kit shall be premolded slip-on type, cold shrinkable type, or heat shrinkable type; but in case of the type specified in C3 Schedule of detailed requirement, the bidder shall quote such, otherwise the offer shall not be considered. Splicing method with tape wrapping shall not be accepted.

Stress control for the cable shield terminus may be molded stress cone or voltage gradient tube. Stress control by tape wrapping shall not be accepted.

Outer covering of splicing kit shall be semiconductive having grounding eye to provide a dead front ground shield for the insulation body.

Ground screen connection device shall be provided; and the connector for ground screen connection, if necessary, shall also be provided.

The splicing kits shall be suitable for cable having diameter over insulation and overall diameter as specified in Table 1 and Table 2.

The provided connector shall be suitable for copper conductor having diameter as specified in Table 1 and Table 2.

Outer sheath of shrinkable tube for protecting from mechanical and humidity, and sealing for preventing water entering into the cable when earthing the joint shall be provided.

Each splicing kit shall be supplied with parts ready for earthing in order to reduce the induced voltage at the joint.

1c.4 Tests and Test reports

The proposed splicing kit shall have successfully passed all the type tests or design tests in accordance with the reference standards.

The test reports shall be submitted either prior to receipt of bids or fifteen (15) days counted from the bid closing date.

The above type tests may be omitted if a record of tests made on identical ones can be supplied.

Standard factory tests shall be made in accordance with routine tests stated in reference standards.

There (3) sets of routine test reports shall be submitted at the time of delivery.

1d Packing

Each splicing kit shall be packed individually with installation instructions and list of materials to be supplied for each kit.

If any parts are packed in the cartons for containerized shipment, the cartons shall be arranged into pallets so as to facilitate their movement by fork lift trucks.

Plastic foam shall not be accepted.

C2 Material and packing data to be given by bidder

2a Technical proposals

The attached sheets for splicing kits are the form for filling technical data.

All blanks shall be filled in with the required information and figures.

(1) Catalog .

(2) Outline drawing .

(3) Installation instruction .

(4) Applied standard .

2b Drawing with main dimensions and exact installation instruction of splicing kits shall be submitted.

2c List of special tools with itemized price, if any.

2d Packing details

Principal dimensions of each package in cm .

Gross weight of each package in kg .

Number of packages in each case .

Principal dimensions of each case in cm .

Gross weight of each case in kg .

Volume of each case in m^3.

Number of cases .

Table 1

Physical Dimensions of 22 kV Single-core XLPE Underground Power Cable

Nominal cross-sectional area of conductor	mm^2	35	50	185	240	400	500
Diameter of conductor ± 1%	mm	6.95	8.33	15.98	18.47	23.39	26.67
Diameter over insulation, approx.	mm	19.0	20.5	28.0	30.5	35.5	39.0
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	25	25	25	25
Overall diameter, approx.	mm	28	30	38	42	48	52

Table 2

Physical Dimensions of 33 kV Single-core XLPE Underground Power Cable

Nominal cross-sectional area of conductor	mm^2	50	120	185	240	400	500
Diameter of conductor ± 1%	mm	8.33	12.95	15.98	18.47	23.39	26.67
Diameter over insulation, approx.	mm	25.5	30.0	33.0	35.5	40.5	44.0
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	25	25	25	25
Overall diameter, approx.	mm	35	40	44	47	55	58

Invitation to Bid No. :

Specification No. :

Proposed Technical Data for Splicing Kit

Material Number		
Manufacturer		
Country		
Catalog number (to be attached)		
Outline drawing number (to be attached)		
Installation instruction number (to be attached)		
Applied standard, publication number and year		
Confirm to attach list of standard factory tests including descriptive details (yes or no)		
Voltage rating kV		
Lightning impulse withstand voltage, dry kV crest		
Power frequency withstand voltage For 1 minute, dry kV		
For 6 hours, dry kV		
DC withstand voltage for 15 minutes, dry kV		
Partial discharge extinction voltage at .....pC kV		

Invitation to Bid No. :

Specification No. :

Proposed Technical Data for Splicing Kit

Material Number		
Hight voltage time test For 5 h kV		
For 1 h kV		
Stress control Method (stress cone, voltage gradient material, etc.		
Type (slip on, heat shrink, tape wrapping etc.)		
Material		
Splicing housing Type (slip on, heat shrink, tape wrapping etc.)		
Material		
Single piece or two piece design		
Range of diameter over insulation to be accommodated with mm		
Range of overall diameter to be accommodated with mm		
Compression connector Manufacturer		

Invitation to Bid No. :

Specification No. :

Proposed Technical Data for Splicing Kit,

Material Number		
Applied standard, publication number and year		
Catalog number (to be attached)		
Material		
Conductor type and size to be accommodated with mm^2		
Range of diameter of conductor to be accommodated with mm		
Ground screen connection Connection device (wire or mesh tube)		
Material		
Confirm to be provided with connector for wire connection (yes or no)		

Invitation to Bid No. :

Specification No. :

Proposed Technical Data for Splicing Kit

Material Number		
Earthing device Catalog number (to be attached kV		
Specify type of cable screen to be used with (wire screen or tape screen)		
Material of housing		
Outer sheath Type (slip on, heat shrink, tape wrapping etc.		
Material		
Guaranteed period after shipment years		
Storage condition for the guaranteed period (to be specified)		
Expected service life after installation years		
Packing Confirm to be packed individually for each kit (yes or no)		
Confirm to be included with installtion instruction for each kit (yes or no)		
Net weight kg		
Packing detailed drawing number (to be attached)		

Invitation to Bid No. :

Specification No. : R-775/2539

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
1	02170006		Splicing kit, premolded slip-on type or shrinkable type, for 22 kV system voltage, single-core, cross-linked polyethylene insulated copper cable, conductor size 185 mm^2 . Each kit complete with : 1) Stress control, splicing housing , connector, ground screen connection, outer sheath, and earthing device. 2) Necessary installation materials, installation instructions, and accessories.
2	02170007		Ditto as Item 1, but conductor size 240 mm^2 .
3	02170009		Ditto as Item 1, but conductor size 400 mm^2 .
4	02170008		Ditto as Item 1, but conductor size 500 mm^2 .

Invitation to Bid No. :

Specification No. : R-775/2539

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
5	02170106		Splicing kit, premolded slip-on type or shrinkable type, for 33 kV system voltage, single-core, cross-linked polyethylene insulated copper cable, conductor size 185 mm^2 . Each kit complete with : 1) Stress control, splicing housing , connector, ground screen connection, outer sheath, and earthing device. 2) Necessary installation materials, installation instructions, and accessories.
6	02170107		Ditto as Item 5, but conductor size 240 mm^2 .
7	02170108		Ditto as Item 5, but conductor size 400 mm^2 .
8	02170109		Ditto as Item 5, but conductor size 500 mm^2 .

Specification No. : R-775/2539

Proposed Technical Data for Splicing Kit

PEA Material No._____

Manufacturer	-	
Country of origin	-	
Catalog No. (to be attached)	-	
Outline drawing No. (to be attached)	-	
Installation instruction No. (to be attached)	-	
Applied standard, publication No. and year	-	
Confirm to attach list of standard factory tests including descriptive details	(Yes/No)	
Rated voltage	kV	
Lightning impulse withstand voltage	kV crest	
Power frequency withstand voltage		
For 1 minute, dry	kV	
For 6 hours, dry	kV	
DC withstand voltage, for 15 minutes, dry	kV	
Partial discharge extinction voltage at .....pC	kV	
Hight voltage time test		
For 5 hours	kV	
For 1 hour	kV	
Stress control		
Method (stress cone, voltage gradient material, etc.)	-	
Type (slip on, heat shrink, tape wrapping, etc.)	-	
Material	-	
Splicing housing		
Type (slip on, heat shrink, tape wrapping, etc.)	-	
Material	-	
Single-piece or two-piece design	-	
Range of diameter over insulation to be accommodated with	mm	
Range of overall diameter to be accommodated with	mm	

Specification No. : R-775/2539

Proposed Technical Data for Splicing Kit

PEA Material No._____

Compression connector Manufacturer	-	
Applied standard, publication No. and year	-	
Catalog No. (to be attached)	-	
Material	-	
Conductor type and size to be accommodated with	mm^2	
Range of diameter of conductor to be accommodated with	mm	
Ground screen connection Connection device (wire or mesh tube)	-	
Material	-	
Confirm to be provided with connector for wire connection	(Yes/No)	
Earthing device Catalog No. (to be attached)		
Specify type of cable screen to be used with (wire screen or tape screen)	-	
Material of housing	-	
Outer sheath Type (slip on, heat shrink, tape wrapping, etc).	-	
Material	-	
Guaranteed period after shipment/delivery	Years	
Storage condition for the guaranteed period (to be specified)	-	
Expected service life after installation	Years	
Packing Confirm to be packed individually for each kit	(Yes/No)	
Confirm to be included with installtion instruction for each kit	(Yes/No)	
Net weight	kg	
Packing detailed drawing No. (to be attached)	-	

2.4.3 Outdoor Termination kit for 22/33 kV

Invitation to Bid No. :

Specification No. : RCBL-033/2548

C Material, equipment, and specifications for CABLE TERMINATION KITS FOR 22 kV AND 33 kV XLPE CABLES

C1 General material and packing instructions

Additional to the general instructions, the following shall be observed :

1a Scope

These specifications cover outdoor and indoor cable termination kits to be used with underground cable 22 kV & 33 kV single-core copper conductor, cross-linked polyethlene insulated, copper wires screen and polyethylene or polyvinyl chloride sheath.

1b Standard

The cable termination kits shall be manufactured and tested in accordance with the latest revision of IEEE standard 48, DIN 57278/VDE 0278 or equivalent; unless otherwise specified in these specifications. The cable termination kits conforming to other national standards having similar characteristics and quality may be proposed.

1c Principal requirement

1c.1 General

The cable termination kits shall be suitable for use in tropical climatic area and highly contaminated atmosphere and shall be capable of operating at its full ratings in the following conditions mentioned.

Termination housing, modules or skirt shall be made of non-tracking, weather and ultra violet resistant materials. Stress control for cable shield terminus may be molded stress cone, voltage gradient tube, or stress grading pad. Stress control by tape wrapping shall not be accepted.

1c.2 Site and service conditions

The cable termination kits shall be designed and manufactured for installation and operation under the following conditions :

Altitude	: up to 1,500 m above sea level
Ambient air terperature	: 70° C, maximum
	: 35° C, average on one (1) day
System voltage	: 3-phase, 22 kV & 33 kV solidly grounded neutral
Rated frequency	: 50 Hz

1c.3 Outdoor cable termination kit

The outdoor cable termination kit shall be Class 1 in accordance with IEEE Standard 48 or equivalent, and housing materials shall be Silicone rubber or EPDM rubber of premolded slip-on type, premolded shrinkable type (cold shrinkable), or heat shrinkable tubing type; but in case of being specified the particular type in the C3 Schedule of detailed requirement the bidder shall quote the same type as specified, otherwise the quotation shall not be considered.

The termination kit shall be provided with :

1) The cable lug at underground copper cable side, compression type, two-hole NEMA pad, made of copper or copper alloy with tin plated, suitable for connecting to copper conductor having diameter as specified in Table 1 and Table 2. The connector shall be furnished with mounting hardware : two (2) bolts, two (2) nuts, two (2) flat round washers, and two (2) spring lock washers of stainless steel.

2) The cable lug at bare aluminium conductor side, compression type, two-hole NENA pad, made of aluminium alloy suitable for connecting to aluminium conductor having diameter as specified in Table 3. If not required it shall be specified in C3 Schedule of detailed requirement.

3) Termination mounting bracket, for cross-arm section range of 100 mm x 100 mm to 120 mm x 120 mm (with carriage bolts of not less than 150 mm long). The bracket shall be similar to NEMA type, and hot-dip galvanized conforming to ASTM Designation A 153 or equivalent.

4) Installation materials ; such as :
   - clamping device for fixing the cable and termination to the mounting bracket, if any, made of non-magnetic corrosion resistant material.
   - grounding device for earthing.
   - seal to prevent the entrance of the foreign particle and moisture into the cable.
   - instruction and accessories.

1c.4 Indoor cable termination kit

The indoor cable termination kit shall be in accordance with IEEE standard 48, DIN 57278/VDE 0278, or equivalent, and may be premolded slip-on type, premolded shrinkable type (cold shrinkable) or heat shrinkable tubing type.

Each termination kit shall be provided with :

1) The cable lug at underground copper cable, compression type, 1-hole NEMA pad.
2) Grounding device for earthing, instruction, and accessories.

1c.5 Manufacturing Experience

The manufacturer of the required cable termination kits must have experience in producing the terminations which are in the same types as specified herein not less than five (5) years and which have successfully passed all the type tests and design tests according to the stated reference standard or any reputable standards.

As an evidence that all the foregoing requirements have been met, a bidder will provide the documents when submitting his bid.

1c.6 Tests and Test reports

The proposed cable termination kit shall have successfully passed all the type tests or design tests in accordance with the reference standards.

The test reports shall be submitted either prior to receipt of bids or fifteen (15) days from the bid closing date.

The above type tests may be omitted if a record of tests made on identical ones can be supplied.

Standard factory tests shall be made in accordance with routine tests stated in reference standards.

Three (3) sets of routine tests shall be submitted at the time of delivery.

1d Packing

The cable termination kits shall be packed individually with installation instructions and list of materials to be supplied for each termination kit.

If any part is packed in the cartons for containerized shipment, the cartons shall be arranged into pallets so as to facilitate their movement by fork lift trucks.

C2 Material and packing data to be given by bidder

2a Technical proposals

The attached sheets for outdoor and indoor terminations are the forms for filling technical data.

All blanks shall be filled in with the required information and figures.

2b Drawing with main dimensions and exact installation instruction of termination and drawing of mounting bracket shall be submitted with the bid.

2c List of special tools with itemized prices, if any.

2d Packing details

Principal dimensions of each package in cm .

Gross weight of each package in kg .

Number of packages in each case .

Principal dimensions of each case in cm .

Gross weight of each case in kg .

Volume of each case in m^3.

Number of cases .

Table 1

Physical Dimensions of 22 kV Single-core XLPE Underground Power Cable

Nominal cross-sectional area of conductor	mm^2	35	50	95	120	185	240	400	500
Diameter of conductor ± 1%	mm	6.95	8.33	11.45	12.95	15.98	18.47	23.39	26.67
Diameter over insulation, approx.	mm	19.0	20.5	23.5	25.0	28.0	30.5	35.5	39.0
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	10	10	25	25	25	25
Overall diameter, approx.	mm	28	30	32	34	38	42	48	52

Table 2

Physical Dimensions of 33 kV Single-core XLPE Underground Power Cable

Nominal cross-sectional area of conductor	mm^2	50	95	120	185	240	400	500
Diameter of conductor ± 1%	mm	8.33	11.45	12.95	15.98	18.47	23.39	26.67
Diameter over insulation, approx.	mm	25.5	28.5	30.0	33.0	35.5	40.5	44.0
Total cross-sectional area of copper wire screen, minimum	mm^2	10	10	10	25	25	25	25
Overall diameter, approx.	mm	35	38	40	44	47	55	58

Table 3

Physical Dimensions of Aluminium Stranded conductor

Nominal cross-sectional area (mm^2)	Outer diameter ± 1% (mm)
35	7.56
50	9.06
95	12.60
120	14.25
185	17.64
240	20.25
400	25.65

Invitation to Bid No. :

Specification No. : RCBL-033/2548

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
1	02150000	set(s)	Outdoor cable termination kit, housing of Silicone rubber or EPDM rubber, for 22 kV underground cable, copper conductor size 35 mm^2; and cable lug for bare aluminium conductor size 120 mm^2 .
2	02150001	set(s)	Ditto as Item 1, but for copper conductor size 50 mm^2.
3	02150003	set(s)	Ditto as Item 1, but for copper conductor size 95 mm^2 .
4	02150004	set(s)	Ditto as Item 1, but for copper conductor size 120 mm^2 .
5	02150006	set(s)	Ditto as Item 1, but for copper conductor size 185 mm^2; and cable lug for bare aluminium conductor size 185 mm^2 .
6	02150007	set(s)	Ditto as Item 1, but for copper conductor size 240 mm^2; and cable lug for bare aluminium conductor size 185 mm^2 .
7	02150009	set(s)	Ditto as Item 1, but for copper conductor size 400 mm^2; and cable lug for bare aluminium conductor size 185 mm^2 .
8	02150008	set(s)	Ditto as Item 1, but for copper conductor size 500 mm^2 . The cable lug for bare aluminium conductor is not required .

Invitation to Bid No. :

Specification No. : RCBL-033/2548

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
9	02150101	set(s)	Outdoor cable termination kit, housing of Silicone rubber or EPDM rubber, for 33 kV underground cable, copper conductor size 50 mm^2; and cable lug for bare aluminium conductor size 120 mm^2.
10	02150103	set(s)	Ditto as Item 9, but for copper conductor size 95 mm^2 .
11	02150104	set(s)	Ditto as Item 9, but for copper conductor size 120 mm^2 .
12	02150106	set(s)	Ditto as Item 9, but for copper conductor size 185 mm^2 .
13	02150107	set(s)	Ditto as Item 9, but for copper conductor size 240 mm^2; and cable lug for bare aluminium conductor size 185 mm^2 .
14	02150108	set(s)	Ditto as Item 9, but for copper conductor size 400 mm^2; and cable lug for bare aluminium conductor size 185 mm^2 .
15	02150109	set(s)	Ditto as Item 9, but for copper conductor size 500 mm^2. The cable lug for bare aluminium conductor is not required .

Invitation to Bid No. :

Specification No. : RCBL-033/2548

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
16	02160000	set(s)	Indoor cable termination kit, for 22 kV underground cable, copper conductor size 35 mm^2 .
17	02160001	set(s)	Ditto as Item 16, but for copper conductor size 50 mm^2 .
18	02160003	set(s)	Ditto as Item 16, but for copper conductor size 95 mm^2 .
19	02160004	set(s)	Ditto as Item 16, but for copper conductor size 120 mm^2 .
20	02160006	set(s)	Ditto as Item 16, but for copper conductor size 185 mm^2 .
21	02160007	set(s)	Ditto as Item 16, but for copper conductor size 240 mm^2 .
22	02160009	set(s)	Ditto as Item 16, but for copper conductor size 400 mm^2 .
23	02160008	set(s)	Ditto as Item 16, but for copper conductor size 500 mm^2 .

Invitation to Bid No. :

Specification No. : RCBL-033/2548

C3 Schedule of detailed requirement

Item	PEA Material No.	Quantity	Description
24	02160101	set(s)	Indoor cable termination kit, for 33 kV underground cable, copper conductor size 50 mm^2 .
25	02160103	set(s)	Ditto as Item 24, but for copper conductor size 95 mm^2 .
26	02160104	set(s)	Ditto as Item 24, but for copper conductor size 120 mm^2 .
27	02160106	set(s)	Ditto as Item 24, but for copper conductor size 185 mm^2 .
28	02160107	set(s)	Ditto as Item 24, but for copper conductor size 240 mm^2 .
29	02160108	set(s)	Ditto as Item 24, but for copper conductor size 400 mm^2 .
30	02160109	set(s)	Ditto as Item 24, but for copper conductor size 500 mm^2 .

2.4.4 Surge Arrester for 22/33 kV

เอกสารเพิ่มเติมแนบท้ายรายละเอียดสเปค
(ADDENDUM)

เอกสารเพิ่มเติม (ADDENDUM) นี้ ให้ถือเป็นส่วนหนึ่งของรายละเอียดสเปคเลขที่ RPRO-006/2561: High voltage surge arresters

สำหรับการจัดซื้อที่มีการชาย หรือแจกแบบ ก่อนวันที่ 1 ตุลาคม 2562 กฟภ. จะยอมรับวิธีการทดสอบ และห้องปฏิบัติการทดสอบเพื่อการตรวจรับ (Acceptance tests) แทนหัวข้อการทดสอบ Lighting impulse residual voltage tests on complete arresters or arrester units ตามที่ระบุไว้ในข้อ 1.d.3 Acceptance tests เฉพาะในกรณีจำนวนการส่งของต่อล็อต (Lot) ไม่เกิน 250 ชุด ดังนี้.

- Lighting impulse residual voltage tests โดยการทดสอบ Blocks ณ โรงงานผู้ผลิต โดยการนำ High voltage surge arrester ที่ได้จากการสุ่มมาทำการผ่า และนำเอา Metal Oxide Varistor (MOV) blocks ทุก Blocks ที่อยู่ภายในไปทำการทดสอบ Lighting impulse residual voltage แล้วนำค่า Residual voltage ที่ทดสอบได้ในแต่ละ Blocks มารวมกัน จะต้องไม่เกินค่า Lighting impulse residual voltage test ของ High voltage surge arresters ที่กำหนดไว้ในสัญญาฯ

โดยโรงงานผู้ผลิตที่จะทำการทดสอบดังกล่าว จะต้องมีห้องทดสอบ และเครื่องมือทดสอบที่มีคุณสมบัติเป็นไปตามที่มาตรฐานที่เกี่ยวข้องกำหนด

ทั้งนี้ คู่สัญญาจะต้องจัดส่ง HV surge arresters ใหม่ที่ผลิตในล็อต (Lot) การผลิตเดียวกัน มาทดแทนตามจำนวนตัวอย่างที่มีการสุ่มไปทดสอบเพื่อให้ครบจำนวนตามสัญญา

TSP
PEA

Invitation to Bid No.:

C Material, equipment, and specifications for HIGH VOLTAGESURGE ARRESTERS

C1 General material and packing instructions

Additional to the general instructions, the following shall be observed:

1a Scope

These specifications cover HV surge arresters of non-linear metal-oxide resistor type without spark gaps, for a.c. power systems and outdoor installation.

1b Standards

The HV surge arresters shall be manufactured and tested in accordance with the following standard:

Thai Industrial Standards (TIS):

TIS 2366-2551 [IEC 60099-4 Edition 2.1 (2006-07)] Metal-oxide surge arresters without gaps for a.c. systems

or International Electrotechnical Commission (IEC):

IEC 60099-4: 2009 Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems

And all other relevant standards, unless otherwise specified in these specification.

PEA will also accept the HV surge arresters tested in accordance with the later edition of the above standard.

PEA will also accept the type test report in accordance with the previous edition of the above standards, if there is no significant change in any test items or no additional test item(s) compared with the above standards. On the other hand, if there is significant change in any test items or there are any additional test items, the previous edition type test report with the additional test report(s) of the significant change test item(s) and/or additional test item(s) will be also accepted.

1c Principal requirement

1c.1 General

The housing of the HV surge arresters shall be polymeric material.

Each HV surge arrester shall be hermetically sealed and suitable for outdoor installation and using in tropical climatic area and highly contaminated atmosphere or heavy pollution level.