

# **33kV Power Cable Sizing.doc**

**Electrical Engineer**

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***-KUWAIT CABLE COMPANY***

***-HES TURKISH COMPANY***

## ***1-SCOPE***

This specification covers design, engineering, manufacture, testing, delivery, off-loading to the specified destinations and performance requirement of Medium Voltage Cables for use in the 33kV and 11kV networks of the Kurdistan Regional Government, Ministry of Electricity (MOE). The equipment offered shall have been successfully type tested. Compliance shall be demonstrated by submitting with the bid:-

- authenticated copies of the type test reports

However where the Bidder offers similar but not identical equipment to that which has been type tested, the difference shall be stated in Test Certificate Schedule. Whether to accept or reject the offered equipment and test data presented shall be adjudged by the Project Manager.

The Purchaser reserves the right to waive type tests as indicated in the section on Quality Assurance, Inspection and Testing in this specification.

The equipment shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revisions of relevant standards at the time of offer and the Purchaser shall have the power to reject any work or material, which, in his judgement, is not in full accordance therewith.

## ***2-STANDARDS***

Except where modified by this specification the cables shall be designed, manufactured and tested in accordance with latest editions of the following standards:

Governing Standards

Table 2

<b>IEC</b>	<b>Subject</b>
IEC 60811	Testing cables
IEC 60228	Conductors for insulated cables
IEC 60502	XLPE Cables
IEC 60540	Test Methods for insulation and sheaths of electric cables and cords
IEC 60287	Calculation of the continuous current rating of cables

The bidder may propose alternative standards, provided it is demonstrated that they give a degree of quality and performance equivalent to or better than the referenced standards. Whether to accept or reject any alternative standard shall be adjudged by the Project Manager. The Bidder shall furnish a copy of the alternative standard proposed along with his bid. If the alternative standard is in a language other than English, an English translation shall be submitted with the standard.

In case of conflict, the order of precedence shall be

- IEC or ISO standards
- other alternative standards.

This list is not to be considered exhaustive and reference to a particular standard or recommendation in this Specification does not relieve the Contractor of the necessity of providing the goods and services complying with other relevant standards or recommendations.

### 3-RELATED SPECIFICATIONS

- MOE/DIST/0170 – MV Cable Joints and Terminations

### 4-SERVICE CONDITIONS

Table 4

<b>Service Conditions</b>	
<b>Altitude:</b>	Up to 1000metres above sea level
<b>Ambient temperatures:</b>	
<i>Outdoor:</i>	
Maximum peak:	+55°C
Maximum daily average:	+40°C
Maximum yearly average:	+30°C
Lowest minimum:	-10°C
Highest one day variation:	+25°C
Ground maximum:	+35°C
Black objects in direct sunlight could reach temperatures of 80°C	
<i>Indoor:</i>	
Maximum Daily Average:	+35°C
<b>Humidity:</b>	
Max relative humidity:	92%
Min relative humidity:	12%
Yearly average:	44%
<b>Wind:</b>	
Max wind velocity:	140km/hr (for design purposes)
<b>Rain fall:</b>	
Minimum yearly:	50mm
Maximum yearly:	500mm
Maximum in one day:	65mm
Yearly average:	150mm
<b>Atmosphere:</b>	
General:	Subject to sand storms and windblown dust.
Average number of days of dust storms:	21.5
Average number of day of thunder storms:	15
<b>Soil Conditions:</b>	
Ground Thermal Resistivity:	1.20°C m/watt or as determined by local test

## **5-SYSTEM CONDITIONS**

The equipment shall be suitable for installation in supply systems of the following characteristics:

Table 5

<b>Parameter</b>	<b>11kV System</b>	<b>33kV System</b>
Nominal Voltage	11kV	33 kV
Highest System Voltage	12kV	36 kV
Number of Phases	3	3
Frequency	50Hz	50Hz
Neutral Point	21Ω Resistance	17Ω Reactance
3 Phase Short Circuit Capability	31.5kA	31.5kA
Duration of Short Circuit	1sec	1 sec
Impulse Withstand Voltage	75kV	170kV
Power Freq. Withstand Voltage 1 min	28kV	70kV

## **6- 33KV XLPE CABLES**

### **6-1 Rated voltage and temperature**

The rated voltage of the cable shall be 19/33(36)kV and the maximum operating voltage shall not exceed 110% of the rated voltage.

The maximum operating temperature (combination of ambient temperature plus temperature rise due to load) shall be 90°C under normal operation and 250°C under short circuit conditions.

### **6-2Cable design**

The cable design offered shall be triple extruded dielectric single core or three core cable to meet the following requirements:

#### **6-2-1 Conductor**

The cable conductor shall be compacted, round, stranded copper conforming to IEC 60228

#### **6-2-2 Conductor screening**

Screening shall be provided over the conductor by extrusion of semiconducting compound conforming to IEC 60502.

#### **6-2-3 Insulation**

Insulation shall be extruded dry cured, cross linked, polyethylene conforming to IEC 60502. Insulation thickness shall not be less than 8.1mm.

#### **6-2-4 Core Identification**

Core identification is not applicable to single core cables. Core identification in three core cables shall be by colouring of the XLPE insulation to the phase colour convention of red, yellow and blue.

#### 6-2-5 Insulation screening

The insulation screening shall consist of two parts, namely metallic and non-metallic. The non-metallic part shall be applied directly over the insulation of the core and shall consist of an extruded thermosetting semi-conducting material extruded simultaneously with the semi-conducting conductor screen and insulation (triple extrusion). The screen colour shall be in contrast to that of the XLPE insulation so that any particles of insulation screen, adhering to the insulation, after stripping, will be visible. The semi-conductive layer shall be semi-bonded to the insulation for easier stripping during jointing and termination.

The metallic part shall consist of copper tape and concentric serving of wires and shall be applied over the non-metallic part. The cross-sectional area of the metallic screen for all conductor sizes shall be  $35\text{mm}^2$ .

#### 6-2-6 Inner Sheath

##### 6-2-6.1 Single Core Cables

The cable shall have an extruded inner sheath between the metallic screen and the armour.

The inner sheath shall be made of thermoplastic material (PVC) applied by extrusion and shall be suitable for the operating temperature of the cable and compatible with the insulating material.

The properties and thickness of the sheath shall conform to IEC 60502.

##### 6-2-6.2 Three Core Cables

The laid up cores shall be covered with an inner sheath made of thermoplastic material (PVC) applied by extrusion. The interstices between the round cores shall be substantially filled so as to ensure the overall shape is as circular as possible. The PVC material used for fillers shall be the same as that for the sheath and both shall be suitable for the operating temperature of the cable and compatible with the insulating material.

#### 6-2-7 Armour

Three core cables shall have steel wire armour applied helically over the inner sheath. Armour shall comply with the requirements of IEC 60502. Armouring for single core cables shall be applied helically in a layer of non-magnetic material over the inner sheath. Armour shall comply with the requirements of IEC 60502.

#### 6-2-8 Outer Jacket

An outer jacket of high density polyethylene (HDPE) for single core cables and medium density polyethylene (MDPE) for three core cables shall be applied over the armour wires. The jacket shall be embossed at regular intervals as per the Cable Identification clause of this specification and the minimum thickness and properties shall comply with the requirements of IEC 60502.

The outer jacket shall incorporate an effective anti-termite barrier and, in addition, shall be treated with a covering of graphite. The outer jacket shall be capable of withstanding a 10kV DC test voltage for five minutes after installation and annually thereafter.

Cables shall be installed as three single phase cables in a close trefoil formation.

Current ratings shall be calculated in accordance with IEC 60287 "Calculation of the continuous current rating of cables with 100% load factor".

#### 6-2-9 Conductor Sizes

The following conductor sizes will be used on the Employer's 33kV distribution system:

$400\text{mm}^2$  Single Core

$240\text{mm}^2$  Single Core

$150\text{mm}^2$  Three Core

#### 6-2-10 Cable Drum Length

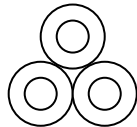
The cable shall be supplied in 250m drum lengths for all three core cables and 500m drum lengths for single core cables.

## **7- OBJECTIVE:**

The objective of this sheet is to select a proper size of power cable in 33kV system for use of Kurdistan Regional Government.

## **8- SELECTION CONDITIONS:**

- 1) The power cable is of copper conductor, XLPE insulated PVC sheathed type,  
Single or three core depending on cable size.
- 2) Power cable runs through “Underground” or “Air”
- 3) In case of single core, the Cable for Three phases runs Trefoil



- 4) The impedance ( $Z$ ) of cable is quoted from manufacturer's catalogue.
- 5) Power factor of load is assumed 0.8.
- 6) The circuit-breaker shall be tripped within 0.5 sec. when short-circuit fault Occurs.

Thus, the duration of fault is assumed 0.5 sec.

## **9- POWER CABLE SPECIFICATION:**

Any possible cable specification is listed below. The data is quoted from manufacture's catalogue.

### 1) Power cable

NO	VOLTAGE	POWER CABLE SIZE	IMPEDANCE(Z)		CURRENT RATING	
			R( $\Omega$ /KM)	X( $\Omega$ /KM)	IN AIR	IN GROUND
1	19/33KV	120mm <sup>2</sup> X 1C /Ph	0.196	0.192	360A	314A
2	19/33KV	150mm <sup>2</sup> X 1C /Ph	0.159	0.19	410A	352A
3	19/33KV	240mm <sup>2</sup> X 1C /Ph	0.0972	0.179	560A	464A
4	19/33KV	300mm <sup>2</sup> X 1C /Ph	0.078	0.176	640A	525A
5	19/33KV	400mm <sup>2</sup> X 1C /Ph	0.0617	0.172	750A	600A

### 2) Attachments

- Power cable data (Impedance and current rating):  
Kuwait Cable Company  
HES Turkish Company

## **10- CRITERIA OF CABLE SIZING:**

The power size will be selected on the basis of the following aspects.

### 1) Current rating

The current rating of the cable shall be larger than the full load current of the connected load.

### 2) Voltage drop

The Voltage drop rate of cable shall be less than 2(%) .the voltage drop rate shall be Calculated as below.

$$\varepsilon = [(E_s - E_r) / E_r] \times 100\% = [I \times (R \cos\theta + X \sin\theta) / E_r] \times 100\%$$

Where,

$E_s$  : Sending voltage [V], (Phase-to-ground)

$E_r$  : Receiving voltage [V], (Phase-to-ground)

$I$  : Load current [A]

$R$  : Resistance of cable [ $\Omega$ ]

$X$  : Inductive Reactance of cable [ $\Omega$ ]

$\cos\theta$  : Power factor of load. (Assumed 0.8)

$\varepsilon$  : Voltage drop rate.



## **11- Short-circuit withstand current**

The short-circuit withstand current (Isc) of the cable shall be larger than short-circuit current of the system. Isc can be calculated based on the formula in case of XLPE insulated cable.

$$I_{sc} = Kx [(A/\sqrt{t}) \times 1/1000] KA$$

Where,

- A : Cross section of conductor of cable [mm<sup>2</sup> ]
- t : Duration of short-circuit current flow [s]  $\approx$  0.5sec
- K: 143 for PVC, copper conductor
- In: Normal current
- X: Impedance at 75° C

## **12- CALCULATION OF CABLE SIZE:**

### **1) 33kV SYSTEM BETWEEN EXISTING 33kV DISTRIBUTION BUS and 33kV D.S GROUP#1 (A Cable) 11MVA (assumed /GROUP #1)**

a. Design parameter

1- Full load current

$$I = 3x[11MVA/\sqrt{3}x33KV] = 577.5$$

2- Cable length : 0.5

3- Cable Installation : in Ground

4- Short-circuit current : **25kA (Assumed)**

b. Selection of cable size

1- Base on full load current, 400×1C ×2 / Ph is selected.

2- Voltage drop rate

$$\epsilon = \frac{[577.5x(0.0617x0.8 + 0.172x0.6)x0.5]}{\sqrt{3}x33000} \times 100\% = 0.077\%$$

3- Short-circuit (ISC)

$$I_{sc} = 143 * (400/\sqrt{0.5}) = 81 KA$$

4-Conclusion:

The selected size satisfies with the "CRITERIA OF CABLE SIZING"

(Alternatively, 400 ×1C ×2 / Ph also satisfies)

## 2) 33kV SYSTEM BETWEEN STEP-UP TR #1 and 33kV D.S GROUP#1 (B Cable)

a. Design parameter

1- Full load current

$$I = 11\text{MVA} / (\sqrt{3} \times 33\text{KV}) = 192.5\text{A}$$

2- Cable length : 0.5KM

3- Cable Installation : in Air

4- Short-circuit current : 25KA (Assumed)

b. Selection of cable size

1- Base on full load current, 150×1C / Ph is selected.

2- Voltage drop rate

$$V_{\text{drop}} = Z \times \sqrt{3} \times I \times \text{distance}$$

$$= 0.1698 \times 1.73 \times 192.5 \times 500$$

$$= 28.273\text{Voltage (0.086\% of 33KV)}$$

Conclusion:

The selected size satisfies with the "CRITERIA OF CABLE SIZING

***150mm<sup>2</sup>***

**MEDIUM VOLTAGE CABLES 3.8/6.6KV TO 19/33KV**

**COPPER OR ALUMINIUM CONDUCTOR  
XLPE INSULATED CABLES**

**A. SINGLE CORE CABLES**

CURRENT CARRYING CAPACITY IN AMPERES								
Nominal Area of Conductor Sqmm	In Air				In Ground			
	Copper		Aluminium		Copper		Aluminium	
	Trefoil	Flat	Trefoil	Flat	Trefoil	Flat	Trefoil	Flat
35	152	170	117	132	154	160	119	124
50	182	203	140	158	182	189	141	146
70	227	254	175	198	222	231	172	179
95	274	313	211	240	264	275	204	212
120	318	360	244	278	300	314	232	242
150	360	410	278	316	335	352	261	272
185	410	470	330	365	376	399	294	309
240	481	560	380	435	428	464	339	360
300	545	640	430	498	472	525	379	407
400	625	750	500	585	517	600	427	468
500	700	873	570	685	553	684	465	537
630	784	1035	655	810	605	772	516	615
***	I.a.2	I.a.3	I.a.2	I.a.3	II.a.2	II.a.3	II.a.2	II.a.3

**B. THREE CORE CABLES**

CURRENT CARRYING CAPACITY IN AMPERES				
Nominal Area of Conductor Sqmm	In Air		In Ground	
	Copper	Aluminium	Copper	Aluminium
35	130	100	145	110
50	160	120	170	130
70	196	151	210	160
95	240	184	250	193
120	275	214	284	220
150	312	240	318	246
185	355	277	360	279
240	415	326	410	323
300	469	370	458	362
400	530	427	510	411
***	I.b.1	I.b.1	II.b.1	II.b.1

Note  
Above values can be applied safely for unarmoured cables also.  
\*\*\* Installation condition (please refer at the beginning of this section).

19/33 KV CABLES

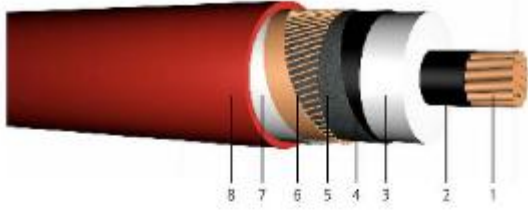
A.C. RESISTANCE, REACTANCE AND CAPACITANCE VALUES

Conductor size  Sq.mm	* Single Core Cables					3-Core Cables			
	A.C. Resistance at 90°C		Reactance (50 Hz)		Capacitance ( $\mu$ F/km)	A.C. Resistance at 90°C		Reactance (50 Hz) ( $\Omega$ /km)	Capacitance ( $\mu$ F/Km)
	Copper ( $\Omega$ /km)	Aluminium ( $\Omega$ /km)	Trefoil ( $\Omega$ /km)	Flat* ( $\Omega$ /km)		Copper ( $\Omega$ /km)	Aluminium ( $\Omega$ /km)		
50	0.494	0.822	0.157	0.215	0.14	0.494	0.817	0.138	0.14
70	0.342	0.568	0.148	0.206	0.15	0.342	0.568	0.130	0.16
95	0.247	0.411	0.140	0.198	0.17	0.246	0.411	0.123	0.18
120	0.196	0.325	0.134	0.192	0.19	0.196	0.325	0.118	0.19
150	0.159	0.265	0.132	0.190	0.20	0.159	0.264	0.114	0.20
185	0.127	0.211	0.128	0.186	0.21	0.127	0.211	0.110	0.22
240	0.0972	0.161	0.121	0.179	0.24	0.0970	0.161	0.105	0.24
300	0.0780	0.129	0.118	0.176	0.25	0.0777	0.129	0.102	0.26
400	0.0617	0.101	0.113	0.172	0.28	-	-	-	-
500	0.0491	0.0793	0.110	0.168	0.31	-	-	-	-

\* Twice Cable diameter spacing between centres.

## 18/30 kV veya 19/33 kV XLPE izoleli, tek damarlı, bakır iletkenli kablolar

### 18/30 kV or 19/33 kV XLPE insulated single core cables with copper conductor



#### Kod

YXC7V-R, N2XSY, CU/XLPE/CWS/PVC  
R: Örgülü rijt iletken

#### Standartlar

TS IEC 60502, BS 6622, VDE 0276

#### Teknik Veriler

Maksimum çalışma sıcaklığı : 90°C  
Maksimum kısa devre sıcaklığı : 250°C (max. 5 sn.)  
Anma Gerilimi : 18/30 kV-19/33 kV  
Minimum bükülme yarıçapı : 15 x D  
D : Kablo çapı

#### Kullanıldığı Yerler

Dielektrik kayıplar çok düşük olan bu kablolar, ani yük değişimlerinin olduğu şebekeler ile kısa devre akımlarının büyük olduğu yerleşim ve endüstri bölgelerinde, kablo kanallarında, toprak altında ve havada kullanılır.

#### Yapısı

- 1 Çok telli bakır iletken
- 2 İç yarı iletken
- 3 XLPE izole
- 4 Dış yarı iletken
- 5 Yarı iletken bant
- 6 Bakır ekran
- 7 Polyester bant
- 8 PVC dış kılıf

#### Code

YXC7V-R, N2XSY, CU/XLPE/CWS/PVC  
R: Stranded conductor

#### Standarts

TS IEC 60502, BS 6622, VDE 0276

#### Technical Data

Max. operating temperature : 90°C  
Max. short circuit temperature : 250°C (max. 5 sec.)  
Rated voltage : 18/30 kV-19/33 kV  
Min. bending radius : 15 x D  
D : Cable outer diameter

#### Application

These are cables with low dielectric losses used in energy networks with sudden load changes. Laid in residential or industrial areas, underground or in ducts.

#### Construction

- 1 Stranded copper conductor
- 2 Inner semi-conductive layer
- 3 XLPE insulation
- 4 Outer semi-conductive layer
- 5 Semi-conductive tape
- 6 Copper wire screen
- 7 Polyester tape
- 8 PVC outer jacket

BOYUT VE AĞIRLIKLAR (DIMENSIONS AND WEIGHTS)				ELEKTRİKSEL ÖZELLİKLER (ELECTRICAL PROPERTIES)								
Nominal Kesit (Nominal Cross- Section)	Dış Çap (yaklaşık) Diana Diameter (approx.)	Net Ağırlık (yaklaşık) Net Weight (approx.)	Sevki Uzunluğu Delivery Length	İletken DC Direnci 20°C'de max. DC Conductor Resistance at 20°C	İletken DC Direnci 90°C'de max. DC Conductor Resistance at 90°C	Çıkarma İnduktansı (yaklaşık) Operation Inductance (approx.)		İşleme Kap. (yaklaşık) Operation Capacitance (approx.)	Akım Taşıma Kapasitesi Current Carrying Capacity			
mm <sup>2</sup>	mm	kg/km	m	ohm/km	ohm/km	mH/km	mH/km	µF/km	Toprakta 20°C'de In Ground at 20°C		Havada 30°C'de In Air at 30°C	
						A	A		A	A	A	A
1x25/16	31.0	1100	1000	0.7270	0.9306	0.707	0.472	0.113	-	-	-	-
1x35/16	32.0	1200	1000	0.5240	0.6707	0.680	0.451	0.123	214	192	233	202
1x50/16	33.5	1400	1000	0.3870	0.4954	0.655	0.432	0.135	251	226	279	241
1x70/16	35.0	1650	1000	0.2680	0.3430	0.624	0.408	0.151	306	276	348	299
1x95/16	37.0	1950	1000	0.1930	0.2470	0.600	0.391	0.166	363	329	421	362
1x120/16	39.0	2250	1000	0.1530	0.1958	0.581	0.377	0.180	410	373	483	416
1x150/25	40.5	2700	1000	0.1240	0.1587	0.564	0.366	0.194	449	415	540	469
1x185/25	42.5	3050	1000	0.0991	0.1268	0.547	0.355	0.208	503	468	615	536
1x240/25	45.0	3650	1000	0.0754	0.0965	0.527	0.342	0.229	576	541	718	630
1x300/25	47.5	4300	1000	0.0601	0.0769	0.510	0.332	0.248	641	608	812	717
1x400/35	50.5	5450	500	0.0470	0.0602	0.489	0.320	0.276	697	684	904	823
1x500/35	54.0	6500	500	0.0366	0.0468	0.473	0.310	0.301	768	762	1011	929
1x630/35	57.5	7850	500	0.0283	0.0362	0.457	0.301	0.330	858	847	1128	1043