TEST REPORT

Report No. (162/2011)

- **CLIENT: ELSWEDY CABLES- EGYPT.**

- **Place:**
  - ***LABORATORIES OF EXTRA HIGH VOLTAGE RESEARCH CENTER.***
  - ***Internal Code : TO-AC-11-05-08-03.***

- **Standard Specification:**
  - ***IEC 62067 "Power cables with extruded insulation and their accessories for rated voltages above 150 kV (Um= 170 kV) up to 500 kV (Um = 550 kV) .***

- **Requirements:**
  - ***Type tests according to IEC 62067.***

- **Description of The Specimen:**

127/230 kV Power cable with the following specification:

- Manufacturer	:	ELSWEDY CABLES- EGYPT.
- Type	:	130/230 kV/CU/XLPE/LEAD /HDPE - 1×1600 mm2
- No. of Phases	:	1
- Insulation	:	XLPE
- Conductor Material	:	Copper
- Conductor cross-section	:	1600 mm^2
- Sheath Material	:	HDPE- ST7
- Sheath Color	:	Black
- Rated Frequency	:	50 Hz
- Water Penetration Design	:	A barriers are included which prevents longitudinal water penetration along the conductor (swelling tape), the gap between the outer surface of the insulation screen and the metallic screen .

- **Description of The Equipment:**
  - High voltage reactor – 400 kV – 5000 KVA – Type: (RSK) – Serial No. 204322/99.
  - PD detector – Type: (TE57).
  - Tan δ measurement devises – Type 254/321/02 Serial No. 144281.
  - Standard capacitor – Type NK400 Serial No. 434321.
  - Impulse voltage generator 2400 kV – 180 kJ – Type SGV 2400/180 SPZ.
  - Air oven up to 300 °C – Type BINDER - Serial No. 02-32772.
  - Universal testing machine 25 kN – Type TABLE TOP – Model APEX-T5000 Serial No. 2095.

- Test Samples:
  - Test sample were choose under the responsibility of the client.

- *Tests:*

1. Electrical Type Tests on Completed Cable:

1.1- Check on insulation thickness of cable for electrical type tests
1.2- Bending test on the cable followed by partial discharge test at ambient temperature.
1.3- *Tan δ* measurement.
1.4- Heating cycle voltage test.
1.5- Partial discharge test:
At ambient temperature.
At high temperature
1.6- Lightning impulse voltage test followed by a power frequency voltage test.
1.7- Resistivity of semi-conducting screens.

2. Non-Electrical Type Tests:

2.1- Check of cable construction.
2.2- Tests for determining the mechanical properties of insulation before and after ageing
2.3- Tests for determining the mechanical properties of non-metallic sheaths before and after ageing
2.4- Ageing tests on pieces of complete cable to check compatibility of materials
2.5- Hot set test for XLPE insulation.
2.6- Water penetration test.
2.7- Measurement of carbon black content.

- Test Method and Results:

1- Electrical Type Tests on Completed Cable:

1.1-Check on insulation thickness before electrical type tests:

- Prior to the electrical type tests the insulation thickness was measured in accordance with clause 12.4.1 of IEC 62067.
- The measured value of the insulation thickness is shown in the following table:

Average thickness (mm)	Specified thickness (mm)	Requirement
25.8	25	The average thickness of the insulation doesn't exceed the specified value by more than 5%

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1.2- Bending test on the cable followed by partial discharge test at ambient temperature:

1.2.1- Bending test:

- The test cable was subjected to a bending test at ambient temperature in accordance with clause 12.4.4 of IEC 62067. The test cable was bent around a test cylinder. The diameter of the cylinder was 4.2 m. The test consisted of three cycles. The test object was bent for one complete turn. It was then unwound. The process repeated, except that the bending of the sample was in the reverse direction..

Outer diameter of cable D (mm)	Diameter of conductor d (mm)	Requirement of bending diameter < 25(D+d)+5% (mm)	Hub diameter of drum (mm)
128.9	52.1	< 4751.2	4200

1.2.2 - Partial discharge test:

- After bending test the terminations were installed on the cable and the test cable was subjected to a partial discharge test at ambient temperature in accordance with clause 12.4.5 of IEC 62067. The test voltage was raised gradually to and held at 1.75 U_o for 10 s and then slowly reduced to 1.5 U_o.
- The measured value of the partial discharge level is shown in the following table

Applied voltage (kV)	Duration (S)	Max. Partial discharge level (PC)	Measured partial Discharge level (PC)
1.75 U_o	10	--	--
1.5 U_o	--	≤ 5	1.2

- The Figure of the PD- Scope is illustrated in page (10) of this report.
- ***The test results met the requirements.***

1.3- Tan δ measurement:

- Another sample test cable was subjected to a tanδ measurement in accordance with clause 12.4.6 of IEC 62067. The test cable was heated by passing a current through the conductor until it reached a steady temperature, which was 98 °C. The tan δ was measured at a power frequency voltage of U_o at the temperature specified above.
- The measured value of the Tan δ measurement is shown in the following table

Applied voltage (kV)	Maximum allowable value for *tan δ* (x 10^{-4})	*tan δ* (x 10^{-4}) [Measured value]

1.4- Heating Cycle Voltage Test:

- The test cable was subjected to a heating cycle voltage test in accordance with clause 12.4.7 of IEC 62067. The test cable was heated by passing a current through the conductor until it reached a steady temperature, which was 98 °C. The heating was applied for 8 h. The conductor temperature was maintained within the stated temperature limits for 2 h of each heating period. This was followed by 16 h of natural cooling. The cycle of heating and cooling was carried out 20 times. During the whole of the test period a voltage of 2 Uo was applied to the test object.

- The result of the heating cycle voltage test is shown in the following table.

No. of heating cycles	Required conductor temperature (°C)	Heating		Cooling time (h)	Applied voltage continuously (kV)
		Total heating time (h)	Duration of heating at 98 °C (h)		
20	95 ≤ t ≤ 100	8	2	16	260

- *The test results met the requirements.*

1.5- Partial discharge test:

1.5.1- At ambient temperature:

- After the last heat cycle, partial discharge was measured for the test cable at ambient temperature in accordance with clause 12.4.5 of IEC 62067. The measurement was carried out as mentioned above under item 2.2.
- The measured value of the partial discharge level is shown in the following table.

Applied voltage (kV)	Duration (S)	Max. Partial discharge level (PC)	Measured partial Discharge level (PC)
1.75 U_o	10	--	--
1.5 U_o	--	≤ 5	2.3

- The Figure of the PD- Scope is illustrated in page (11) of this report.
- *The test results met the requirements.*

1.5.2- At high temperature:

- After test cable was subjected to a partial discharge test at ambient temperature, partial discharge was measured for the test cable at the conductor temperature 98 °C in accordance with clause 12.4.5 of IEC 62067. The measurement was carried out as mentioned above under item 2.2.
- The measured value of the partial discharge level is shown in the following table:

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Applied voltage (kV)	Duration (S)	Max. Partial discharge level (PC)	Partial Discharge level (PC)
1.75 U_o	10	--	--
1.5 U_o	--	≤ 5	1.3

- The Figure of the PD- Scope is illustrated in page (12) of this report.
- *The test results met the requirements.*

1.6- Lightning impulse voltage test followed by a power frequency voltage test:

1.6.1- Lightning impulse voltage test:

- The test cable was subjected to a lightning impulse voltage withstand test in accordance with clauses 12.4.9 of IEC 62067. The test was performed on the test cable at a conductor temperature of 98 °C. The cable withstood 10 positive and 10 negative voltage impulses with crest value of 1050 kV without failure.
- The results were illustrated by the Figures in pages No. (13:15) of this report.
- *The test results met the requirements.*

1.6.2- Power frequency voltage test:

- After the impulse voltage test, the test cable was subjected to power frequency voltage test of 2Uo for 15 min. in accordance with clause 12.4.9 of IEC 62067.
- The result of the power frequency voltage test is shown in the following table

Applied voltage (kV)	Frequency (Hz)	Duration (min)	Observations
260	50	15	No breakdown

- *The test results met the requirements.*

1.7- Resistivity of semi-conducting screens:

- The measurement of the resistivity of the semi-conducting screens was carried out in accordance with clause 12.4.11 of IEC 62067. The resistivity of extruded semi-conducting screens applied over the conductor and over the insulation was determined by measurements on test pieces taken from the core of a sample of cable as manufactured and a sample of cable which has been subjected to the ageing treatment to test the compatibility of component materials specified in IEC 62067. The measurements were made at a temperature of 90 °C.
- The result of the resistivity of the semi-conducting screens are shown in the following table:

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Item	Unit	Requirement	Measured/ Determined
Conductor screen			
- without ageing	Ωm	≤ 1000	54
- after ageing	Ωm	≤ 1000	75
Insulation screen			
- without ageing	Ωm	≤ 500	1.68
- after ageing	Ωm	≤ 500	4.72

- ***The test results met the requirements.***

2- *Non-Electrical Type Tests:*

2.1- *Check of Cable Construction:*

- The examination of the conductor and measurements of insulation and sheath thickness was carried out in accordance with clause 12.5.1 of IEC 62067.
- The result of examination of the conductor and measurements are shown in the following table

No.	Items	Unit	requirement	Measured Values
1	Color of the outer sheath		--------	Black
2	Conductor Material Diameter No. of wires Water blocking	 mm No 	 52.1 nom. 7+ 5×61 -------	 Copper 52.8 . 7+ 5×61 Swelling Tape .
3	Semi Conductive Tape. Diameter	 mm	 53.8	 53.8
4	Inner extruded Semi-Conducting Thickness	 mm	 nom 1.5	 1.518
5	XLPE Insulation - minimum thickness - $(t_{max} - t_{min}) / t_{max}$	 mm	 ≥ 22.5 ≤ 0.10	 25.26 0.096
6	Outer extruded semi-conducting material - thickness (Av.)	 mm	 nom 1.5	 1.498
7	Semi-conductive water blocking tape - Thickness (Av.)	 mm	 nom 2	 2.1
8	Metallic sheath - material - diameter (Av.) - minimum thickness	 mm mm	 --- nom 118.9 ≥ 3.225	 Lead 121.81 3.7
9	Over sheath - material - diameter (Av.) - thickness - minimum thickness.	 mm mm mm	 --- nom 128.9 nom 5 ≥ 4.15	 (HDPE) – ST_7 130.95 6 5.96

- ***The test results met the requirements.***

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2.2- *Tests for determining the mechanical properties of insulation before and after ageing:*

- The mechanical properties of insulation before and after ageing were determined in accordance with clause 12.5.2 of IEC 62067.
- The results of the mechanical properties of insulation before and after ageing are shown in the following table:

Item	Unit	Requirement	Measured/determined
Without ageing			
-Min. tensile strength	N/mm^2	12.5	23.1
-Min. elongation at break	%	200	640.7
after ageing in air oven			
-Min. tensile strength	N/mm^2	---	25.25
-Max. variation with samples without ageing	%	± 25	9.30
-Min. elongation at break	%	---	710.65
-Max. variation with samples without ageing	%	± 25	10.9

- ***The test results met the requirements.***

2.3- *Tests for determining the mechanical properties of non metallic sheath before and after ageing:*

- The mechanical properties of the outer sheath before and after ageing were determined in accordance with clause 12.5.3 of IEC 62067.
- The results of the mechanical properties of non-metallic sheaths before and after ageing are shown in the following table:

Item	Unit	Requirement	Measured / determined
Without ageing			
-Min. tensile strength	N/mm^2	12.5	26.7
-Min. elongation at break	%	300	928.2
after ageing			
-Min. elongation at break	%	300	610.6

- ***The test results met the requirements.***

2.4- *Ageing Tests on Pieces of Completed Cable to Check Compatibility of Materials:*

- Ageing tests on pieces of completed cable were carried out in accordance with clause 12.5.4of IEC 62067.
- The results of the mechanical properties of completed cable are shown in the following table:

Item	Unit	Requirement	Measured/determined
Insulation			
-Min. tensile strength	N/mm^2	----	22.45
-Max. variation with samples without ageing	%	± 25	-2.81
-Min. elongation at break	%	----	618.25
-Max. variation with samples without ageing	%	± 25	-3.50
Sheath			
- Min. elongation at break	%	300	735

- ***The test results met the requirements.***

2.5- *Hot set test for XLPE insulation:*

- A hot set test for the XLPE insulation was carried out in accordance with clause 12.5.10 of IEC 62067.
- The results of the hot set test for the XLPE insulation are shown in the following table:

Item	Unit	Requirement	Measured
-elongation under load -permanent elongation	% %	≤ 175 ≤ 15	115 2.3

- *The test results met the requirements.*

2.6- *Water penetration test :*

- The water penetration test was carried out in accordance with clause 12.5.14 of IEC 62067. In total 8m cable was used for this test. The cable was tested for longitudinal water tightness along the outer surface of the conductor and the gap between the outer surface of the insulation screen and the metallic screen.

No. of heating cycle	Required conductor temperature (°C)	Heating		Cooling time (hour)
		Heating time(hour)	Duration at 98° C (hour)	
10	95≤ t ≤ 100	8	2	16

- After completion of the 10 heating cycles no water emerged from the end of the cable.
- *The test results met the requirements.*

2.7- *Measurement of Carbon Black Content :*

- Measurement of carbon black content was carried out in accordance with clause (12.5.12) of IEC (62067).
- The test results are shown in the following table :

Item	*Unit*	*Requirement*	*Measured*
Carbon black content	*%*	*2.5 ± 0.5*	*2.27*

- *The test results met the requirements.*

M. Rabey

- ***CONCLUSION :***

  - The cable 130/230 kV/CU/XLPE/LEAD /HDPE - 1 × 1600 mm2 manufactured by Elsewedy Cables Fulfilled the requirements of tests mentioned in this report according to IEC 62067. The user must be making sure of performing the remaining type tests which have not been mentioned in this report.

- *Notes:*
  - Tests were carried out on the above specimens only without any responsibility concerning other untested specimens.
  - The tests were carried out without any obligation on Egyptian Electricity Holding Company.
  - This test report shall not be reproduced except in full, without written approval of EHVRC.

- ***TEST ENGINEERS:***

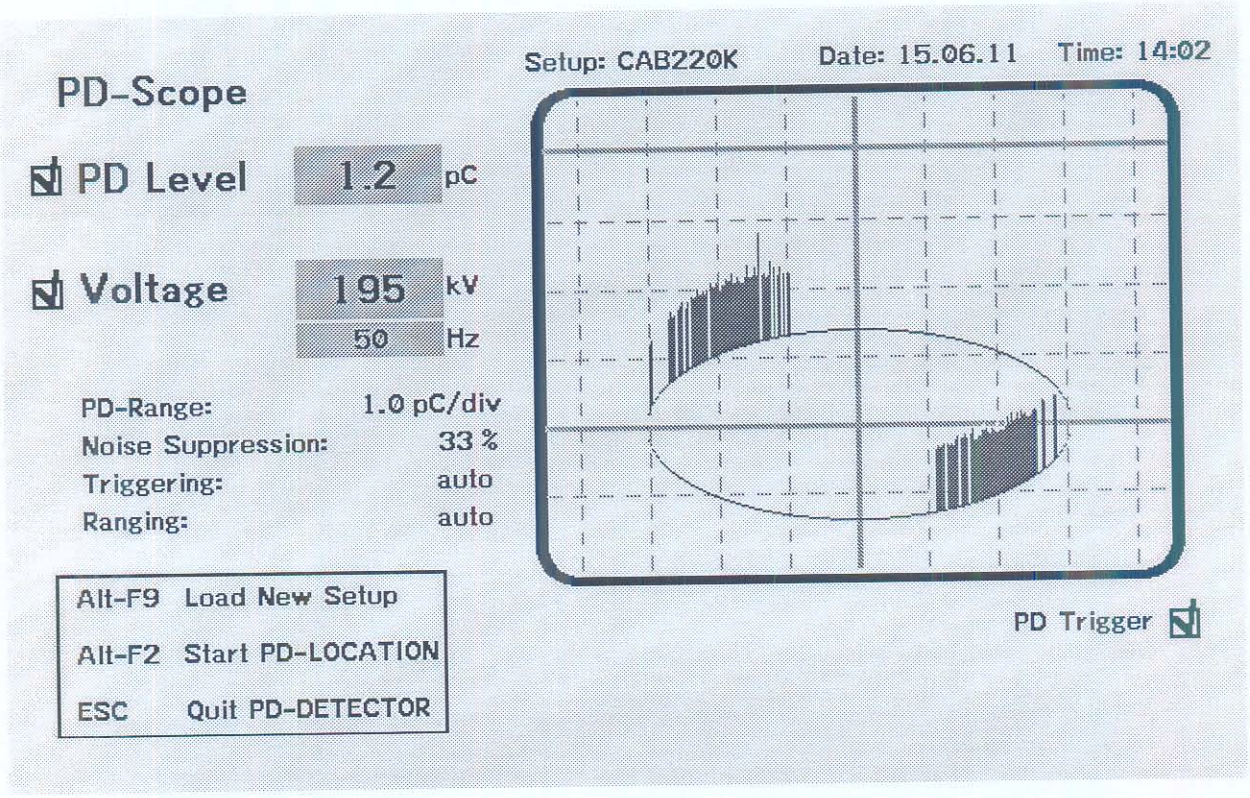
M. Rabey

GENERAL MANGER

10. 2011

Azza .

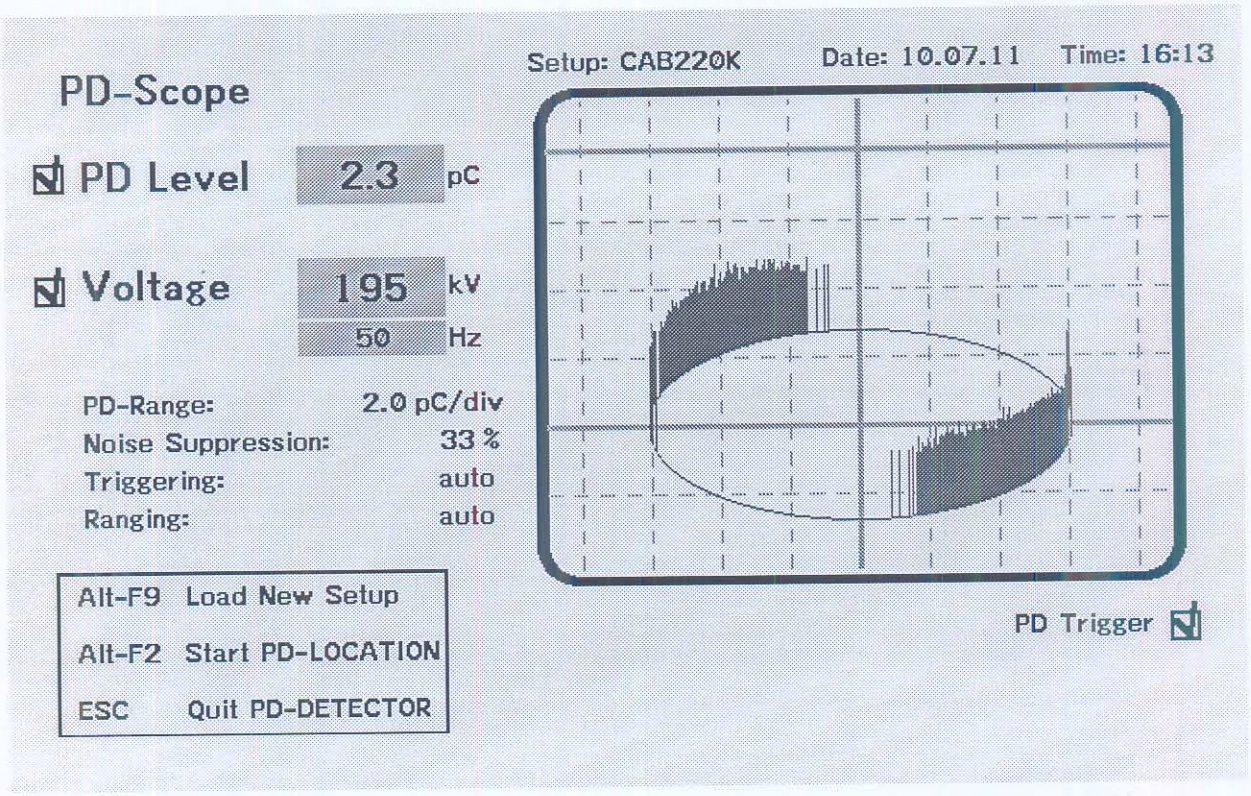
Measurement results of partial discharge
For 130/230 kV power cable – 1 × 1600 mm2 – XLPE - insulation
[ElSewedy Cables]



- **Case : Before heat cycle .**
- **Ambient temperature : 32 °C.**
- **Calibration at : 10 PC.**

Mostafa

Measurement results of partial discharge
For 130/230 kV power cable – 1 × 1600 mm2 – XLPE - insulation
[ElSewedy Cables]



- **Case : After heat cycle .**
- **Ambient temperature : 32 °C.**
- **Calibration at : 10 PC.**

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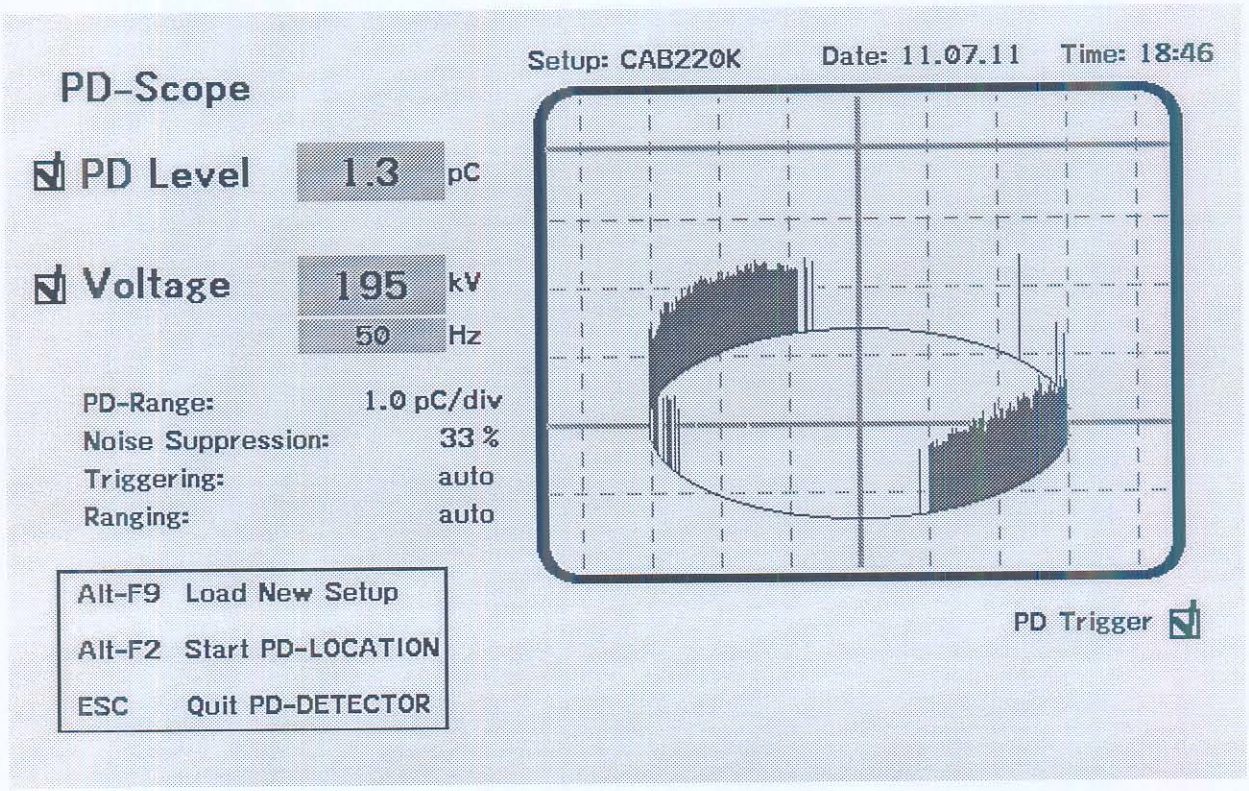
Measurement results of partial discharge
For 130/230 kV power cable – 1 × 1600 mm2 – XLPE - insulation
[ElSewedy Cables]



- **Case : After heat cycle .**
- **At conductor temperature : 95 °C.**
- **Calibration at : 10 PC.**

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130/230 KV Power cable- 1*1600mm2, CU/XLPE/HDPE

Elsewedy Cable- Egypt

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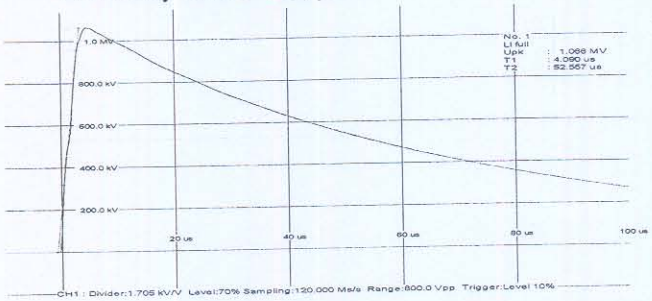
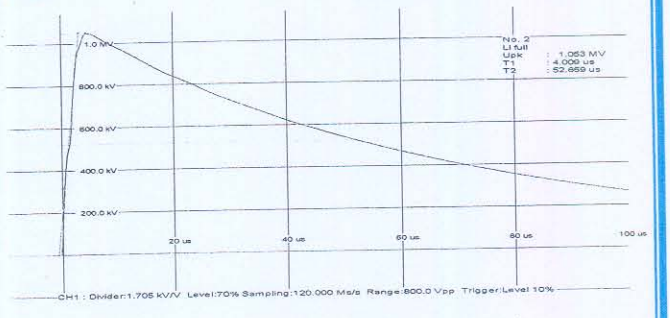
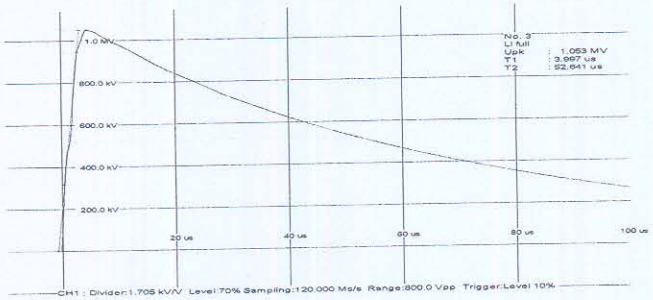
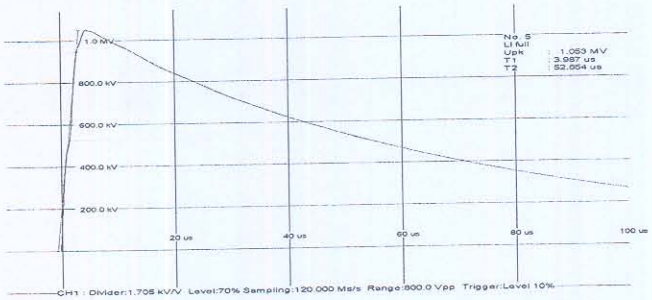
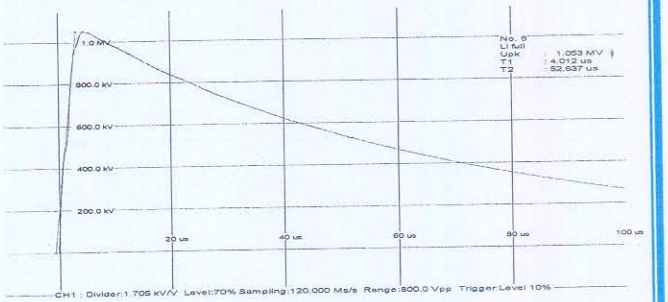
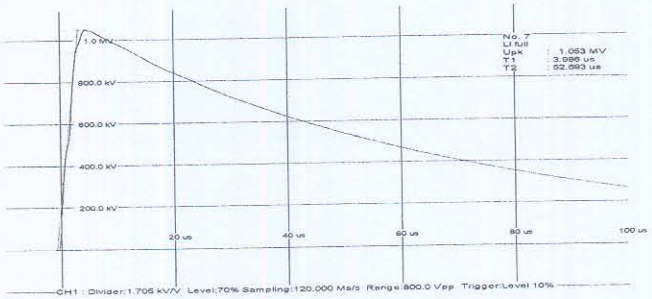


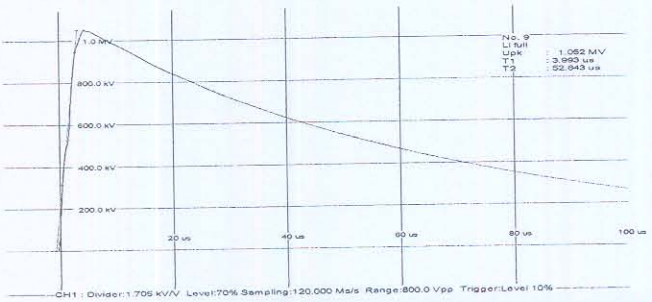


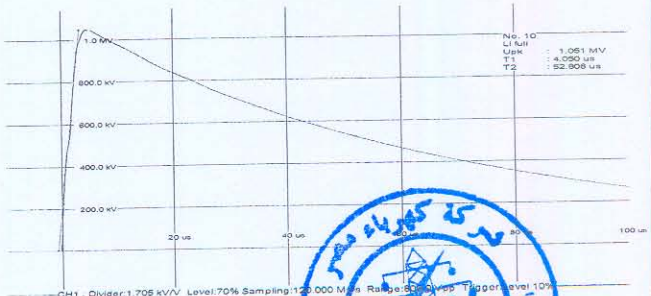




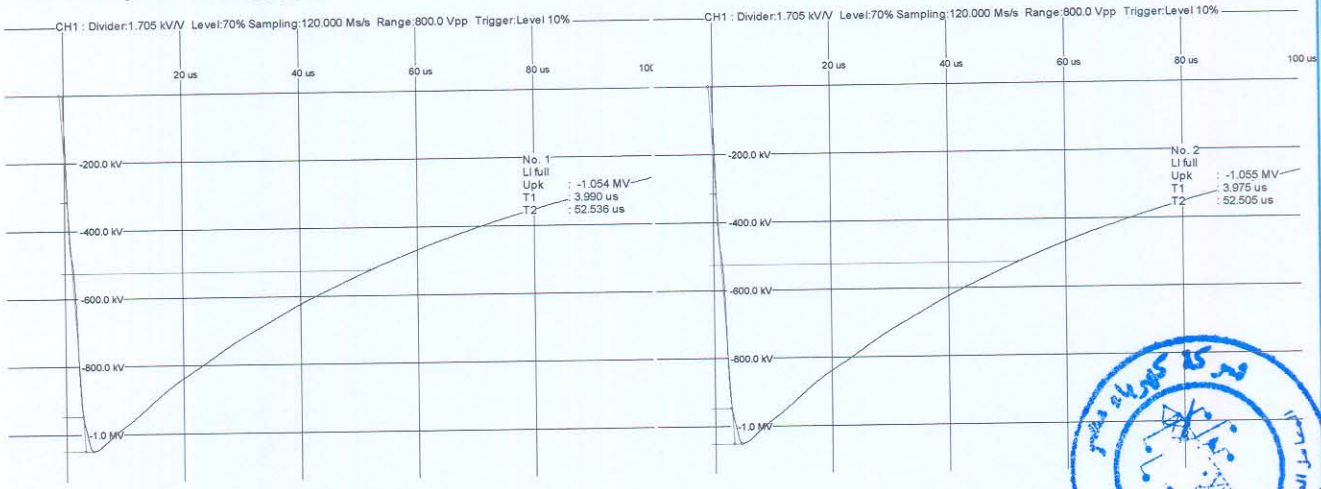








130/230 KV Power cable- 1*1600mm2, CU/XLPE/HDPE
Elsewedy Cable- Egypt -ve TO-AC-11-05-08-03



ELSEWEDY CABLES

التاريخ: ٢٠١١/٣/٣٠ الصفحة:١/١

عناية السيد المهندس الدكتور/ مدير عام مركز ابحاث الجهد الفائق

الموضوع: إجراء إختبارات النوعية على كابل (220 Kv 1x600 mm^2)

تحية طيبة وبعد ...

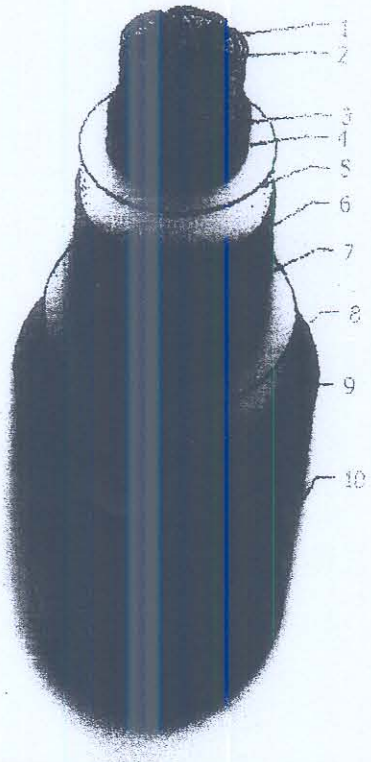
يرجى التكرم من سيادتكم بإجراء إختبارات نوعية على الكابل (220 Kv 1x600 mm^2) ونحن على إستعداد لدفع كافة الرسوم المطلوبة

وتفضلوا سيادتكم بقبول فائق التحية والإحترام...

مركز أبحاث الجهد الفائق
مرفق رقم /(١١)
للتقرير الفني رقم (٢٠١١/١٦٤)

م/هيثم محمد علي
مدير توكيد الجودة
مجموعة السويدي للكابلات
تليفون: ٠١٠٥٨١٩١٢١
فاكس: ٠١٥٤١١٣٦٦

ELSEWEDY CABLES



Size :	1 x 1600 mm^2	Type :	Cu/XLPE/LEAD/ HDPE
Voltage:	130/230 kV	Standard:	IEC 60228, 62067
Code :	GB8-TX01-N83-00-01		EL-SEWEDY CABLES

Sr.	Description
1.	Copper core *(In the Center)*
2.	Segmental Copper *Conductor+ Non-conductive water blocking tapes*
3.	Semi-Conductive Water Blocking Tape
4.	Inner Semi-Conductive
5.	XLPE *Insulation*
6.	Outer Semi-Conductive
7.	Semi -Conductive Water Blocking Tape
8.	LEAD ALLOY sheath
9.	HDPE Jacket
10.	Graphite Coating

Not to Scale	Drawn by Mr. Hussieny ahmed	Approved by Eng.

مركز أبحاث الكهرباء
مرفق رقم (٢٤)
التقرير الفني رقم (٢٤ / ١١ / ٢٠١٠)