# Test Report
# No. TR-002-2017

**For**

## Type Testing of
## 1×500/35mm², CU/XLPE/PVC
## 33kV Medium Voltage Power Cable

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الهندسة الكهربائية - الرياض
Electrical Engineering
Department - Riyadh
مختبر الجهد العالي
High Voltage Laboratory

**Test carried out at**

***The High Voltage Laboratory***

Rabi' I / Rabi'II, 1438 H
December, 2016 / January, 2017 G

*Total No. of Pages including Appendix: 17*



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# TEST REPORT No. TR-002-2017

| | |
|---|---|
| OBJECT | Medium Voltage Electric Power Cable |
| TYPE | 1 × 500/35mm$^2$ CU/XLPE/PVC, 33kV |
| MANUFACTURER | NATIONAL CABLES INDUSTRY, SHARJAH, U.A.E |
| TRADE NAME | NATIONAL CABLES INDUSTRY |
| DATE OF TEST | December, 2016 / January, 2017 |
| TEST REFERENCE STANDARDS | **IEC 60502-2: 2014** |
| **SUMMARY AND CONCLUSION** | ***All tests passed.*** |

*This type test report applies only to the object tested. The responsibility for conformity of any production having the same designation as the tested sample rests with the manufacturer.*

27-4-1438

**Prof. Dr. Abdulrehman A. Al-Arainy**
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## 1. IDENTIFICATION OF THE TEST OBJECT

### 1.1 Description of the test object

| | |
|---|---|
| **OBJECT** | Medium Voltage Cable |
| **MANUFACTURER** | NATIONAL CABLES INDUSTRY, SHARJAH, U.A.E |
| **TYPE** | 33kV , 1 × 500/35 mm², CU/XLPE/PVC |
| **YEAR OF MANUFACTURE** | 2016 |
| **SAMPLING PROCEDURE** | 19 meter cable sample cut from the drum |
| **RATED VOLTAGE** | 33 kV |
| **NO. OF CORES** | 1 |

| | | |
|---|---|---|
| **1. Conductor** | | |
| **Material** | **Copper** | |
| **Size** | **500** | mm² |
| **Shape** | **RMC** | |
| **Minimum no. of wires** | **61** | |
| **Conductor diameter** | **26.7** (Approximate) | mm |
| **Max. DC Resistance at 20 °C** | **0.0366** | Ω / km |
| **2. Conductor Screen *** | | |
| **Material** | **Extruded Semi-conducting material** | |
| **Type** | **Bonded Type** | |
| **Thickness :** | | |
| **Min/nom** | **0.51/0.70** | mm |
| **Diameter over conductor screen** | **29.5** (Approximate) | mm |
| **3. Insulation** | | |
| **Material** | **Cross-linked Polyethylene [ XLPE ]** | |
| **Thickness :** | | |
| **- Nominal** | **8.0** | mm |
| **- Minimum at any point** | **7.1** | mm |
| **Diameter over insulation** | **45.5** (Approximate) | mm |
| **4. Insulation Screen *** | | |
| **Material** | **Extruded Semi-conducting material** | |
| **Type** | **Cold Strippable Type** | |
| **Thickness :** | | |
| **- Maximum** | **2.29** | mm |
| **- Minimum** | **1.40** | mm |
| **Diameter over insulation screen** | **48.7** (Approximate) | mm |
| **5. Metallic Screen** | | |
| **Material** | **Copper Wires + Copper Tape** | |
| **No. of wires** | **70 / Core** | |
| **Wire diameter** | **0.8** | mm |
| **No. of open helix tapes** | **1** | |
| **Width x Thickness** | **15 x 0.1** | mm |
| **6. Outer Sheath** | | |
| **Material** | Extruded Polyvinyl Chloride [ PVC - ST2 ] | |
| **Color** | Black | |
| **Thickness :** | | |
| **- Min/Nominal** | 2.08/2.60 | mm |
| **Overall cable diameter** | 57 (Approximate) | mm |



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### 1.2 List of documents

The manufacturer has guaranteed that the object submitted for tests has been manufactured in accordance with the following document.

The following document is included in this report:

| SPECIFICATION | REVISION | DATE | TITLE |
|---|---|---|---|
| 11-SDMS-03 | Rev. 02 | March 2016 | Design data sheet for single core CU/XLPE/PVC, 33kV power cable Size: 1 x 500/35 $mm^2$ |

## 2. GENERAL INFORMATION

**2.1 The tests were carried out by :** following members of HV laboratory of King Saud University

1. **Prof. Nazar H. Malik**
2. **Prof. Yasin Khan**
3. **Engr. Nissar R. Wani**

### 2.2 Purpose of the test

Purpose of the test was to verify whether the material complies with the specified requirements.

### 2.3 Applicable standards

**IEC 60502-2: 2014, AEIC CS8-13**

When reference is made to a standard and the date of issue is not stated, this applies to the latest issue, including amendments, which have been officially published prior to the date of the tests.



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## 3 ROUTINE TESTS

### 3.1 Measurement of the resistance of Copper conductors

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Resistance | Ω/km | ≤ 0.0366 | 0.0353 | pass |

## 4 MEASUREMENTS ON CONDUCTOR

**Standard**
Standard IEC 60228 & IEC 60502-2 (2014), Clause 17.4

### 4.1 Measurement on Copper Conductors

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Number of wires | No's | 53 | 61 | pass |
| Conductor diameter | mm | 26.7 (Approx.) | 27.2 | pass |

### 4.2 Measurement of the dimension of metallic screen

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Plain copper wire Screen Dimension | No. x mm | 70 x 0.8 | 70 x 0.85 | pass |
| Open helix copper tape over copper wire screen dimension | No. x mm x mm | No x Width x Thickness (1 x 15 x 0.10 ) | 1 x 15 x 0.11 | |

## 5 ELECTRICAL TYPE TESTS

### 5.1 Bending test

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.4
Sample length 19m

| Description | Size | Voltage | D | d | Calculated test cylinder diameter 20( d + D )+5% (Maximum) | Actual measured Barrel Diameter |
|---|---|---|---|---|---|---|
| **Unit** | $mm^2$ | kV | mm | mm | mm | mm |
| **CU / XLPE / PVC** | 1 x 500 | 33 | 58 | 26.9 | 1783 | 1700 |

**Carried out at National Cables test lab**

**Result**
The test was done in a satisfactory manner



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### 5.2 Partial Discharge Test after Bending

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.5

| Item | Required test voltage ( 1.73 $U_0$) | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Partial Discharge Test | 33 kV | ≤ 5 pC | < 2pC | Pass |

### 5.3 Tan Delta measurement

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.6
Conductor temperature during the test (95 - 100) °C

| Item | Applied voltage | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Tan Delta measurement | ≥ 2 kV | ≤ $40x10^{-4}$ | $5 X 10^{-4}$ | Pass |

### 5.4 Heating Cycle Test

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.7

**Duration** (8hrs/cycle)

| Heating Time/ Cycle | Heating Temp.( ° C ) | Maintaining Temp. ( at 96 ° C ) for | Cooling Time/ Cycle | Total Cycle Time ( Heating & Cooling ) | Total No. of Cycles |
|---|---|---|---|---|---|
| 5 Hours | (95 - 100) °C | 2 Hours | 3 Hours | 8 Hours | 20 |

**Result**
The test was done with satisfactory results

### 5.5 Partial Discharge Test after Heating Cycle

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.5

| Item | Required test voltage ( 1.73 $U_0$) | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Partial Discharge Test | 33 kV | ≤ 5 pC | 3.8 pC | Pass |



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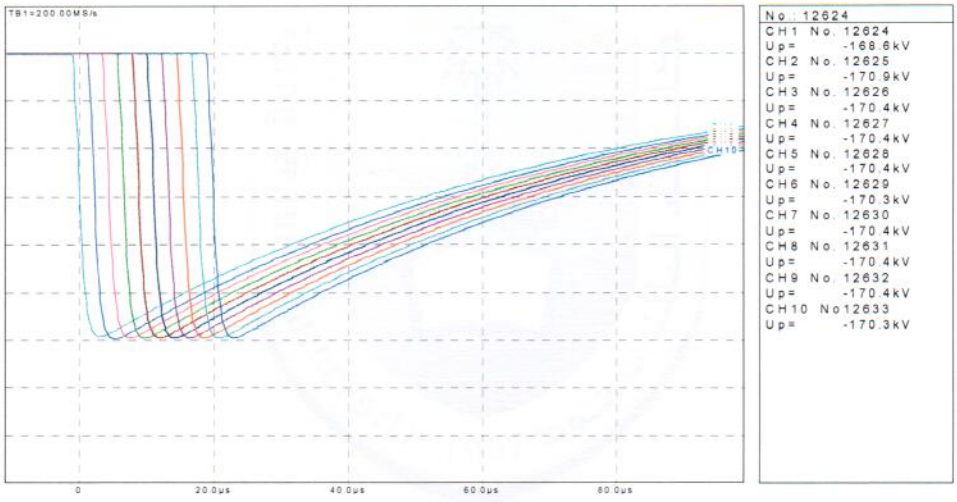
### 5.6 Impulse test followed by AC voltage test

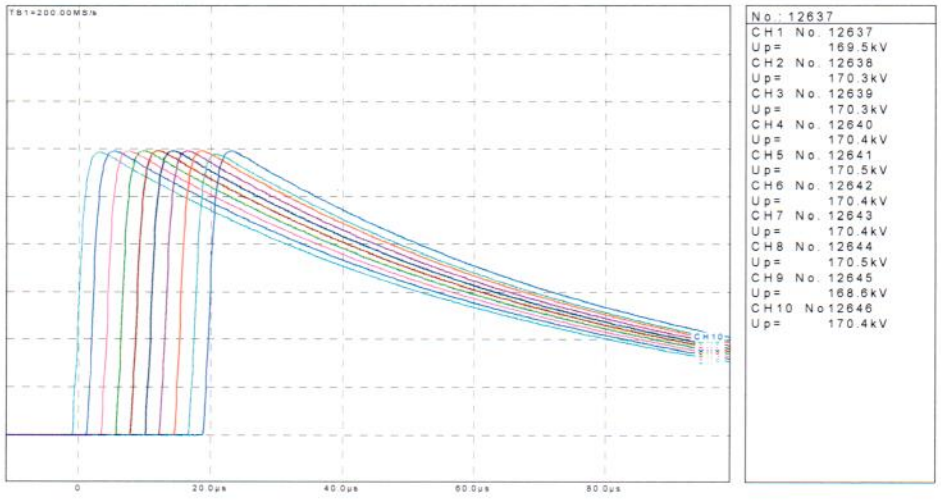
#### 5.6.1 Impulse test

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.8

**Characteristic**
Conductor temperature during the test (95 - 100) °C
No. of voltage impulses 10 Positive & 10 Negative

| Item | Sample rated voltage (kV) | Test voltage Peak (kV ) | Requirement | Measured/Determined | Result |
|---|---|---|---|---|---|
| Impulse test | 33 | 170 | No Breakdown | No Breakdown | Pass |




Applied Impulse waveforms



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### 5.6.2 AC Voltage test

**Standard**
Standard IEC 60502-2 (2014), clause 16.4

**Characteristic**
Temperature during Test 27°C
Duration of voltage 15 min

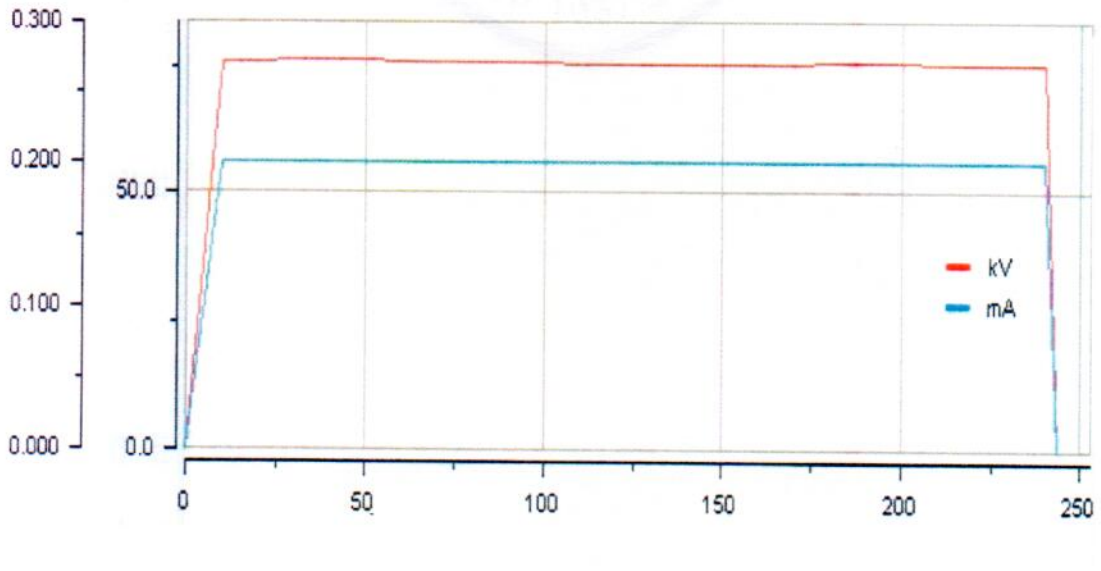
| Item | Required test voltage $3.5U_o$(kV) | Applied test voltage (kV) | Duration min | Measured/Determined | Result |
|---|---|---|---|---|---|
| Voltage test | 67 | 67.2 | 15 | No Breakdown | Pass |

### 5.7 AC Voltage test for 4 hrs.

**Standard**
Standard IEC 60502-2 (2014), clause 18.2.9

**Environmental conditions**
Temperature of test object 27 °C

| Item | Required test voltage $4U_o$(kV) | Applied test voltage (kV) | Duration (hrs) | Determined | Result |
|---|---|---|---|---|---|
| Voltage test | 76 | 76.1 | 4 | No Breakdown | Pass |



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### 5.8 Resistivity of Semi-Conducting Screens

**Standard**

Standard IEC 60502-2 (2014), clause 18.2.10

**Environmental conditions**

Temperature of test object 90 ± 2 °C

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Conductor Screen | | | | |
| - Before ageing | Ω.m | ≤ 1000 | 0.33 | Pass |
| - After ageing | Ω.m | ≤ 1000 | 0.78 | |
| Insulation Screen | | | | |
| - Before ageing | Ω.m | ≤ 500 | 3.47 | Pass |
| - After ageing | Ω.m | ≤ 500 | 1.91 | |

## 6 NON-ELECTRICAL TYPE TESTS

### 6.1 Measurement of thickness of insulation

**Standard**

Standard IEC 60502-2 (2014), clause 19.2

***Results of the measurement of thickness of XLPE insulation***

| thickness | Unit | Requirement specified | Measured/Determined | Result |
|---|---|---|---|---|
| Nominal ($T_{nom.}$) | mm | 8.0 | 8.41 | Pass |
| Minimum ($T_{min.}$) | mm | ≥ 7.1 | 8.22 | |
| ($T_{max.}$ - $T_{min.}$)/ $T_{max.}$ | mm | ≤ 0.15 | 0.06 | |

***Results of the measurement of thickness of conductor screen***

| thickness | Unit | Requirement specified | Measured/Determined | Result |
|---|---|---|---|---|
| Minimum | mm | ≥ 0.51 | 1.41 | Pass |

***Results of the measurement of thickness of insulation screen***

| thickness | Unit | Requirement specified | Measured/Determined | Result |
|---|---|---|---|---|
| Minimum | mm | ≥ 1.4 | 1.61 | Pass |
| Maximum | mm | ≤ 2.29 | 1.90 | |



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### 6.2 Measurement of thickness of non-metallic sheathing

**Standard**
Standard IEC 60502-2 (2014), clause 19.3

**Outer Sheath**

| Thickness (Nominal) | Unit | Requirement (Minimum) | Measured/Determined (Nom/Min) | Result |
|---|---|---|---|---|
| 2.60 | mm | ≥ 2.08 | 2.91/2.67 | Pass |

### 6.3 Tests for determining the mechanical properties of the insulation before and after ageing

**Standard**
Standard IEC 60502-2(2014), clause 19.5

**Characteristic**
Temperature during ageing 135°C ± 3K
Duration 7 days

**Mechanical properties before ageing**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Tensile strength before ageing | $N/mm^2$ | ≥ 12.5 | 20.63 | Pass |
| Elongation before ageing | % | ≥200 | 528.10 | |

**Mechanical properties after ageing**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Tensile strength | $N/mm^2$ | ---------- | 21.60 | Pass |
| Variation with samples without ageing | % | ± 25 max. | +4.7 | |
| Elongation | % | ---------- | 586.8 | Pass |
| Variation with samples without ageing | % | ± 25 max. | +11.11 | |

### 6.4 Tests for determining the mechanical properties of the non-metallic sheath before and after ageing

**Standard**
Standard IEC 60502-2(2014), clause 19.6

**Characteristic (Outer Sheath)**

| | |
|---|---|
| Material | PVC ST2 |
| Temperature during ageing | 100 °C ± 2K |
| Duration | 7 days |



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**Mechanical properties before ageing**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Tensile strength Without ageing | $N/mm^2$ | ≥ 12.5 | 13.69 | Pass |
| Elongation Without ageing | % | ≥150 | 293.36 | |

**Mechanical properties after ageing**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Tensile strength | $N/mm^2$ | ≥ 12.5 | 15.01 | Pass |
| Variation with samples without ageing | % | ± 25 max. | +9.64 | |
| Elongation | % | ≥150 | 306.6 | Pass |
| Variation with samples without ageing | % | ± 25 max. | + 4.51 | |

### 6.5 Additional ageing test on pieces of Completed cables

**Standard**
Standard IEC 60502-2(2014), clause 19.7

**Characteristic test data**
Temperature during ageing 100 °C ± 2K
Duration 7 days

**Insulation**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| tensile strength | $N/mm^2$ | ---------- | 20.47 | Pass |
| variation with samples without ageing | % | ± 25 max. | -0.78 | |
| elongation | % | ---------- | 545.35 | Pass |
| variation with samples without ageing | % | ± 25 max. | +3.27 | |

**Outer Sheath (ST-2)**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| tensile strength | $N/mm^2$ | ---------- | 15.20 | Pass |
| variation with samples without ageing | % | ± 25 max. | +11.03 | |
| Elongation | % | ---------- | 307.55 | Pass |
| variation with samples without ageing | % | ± 25 max. | +4.84 | |



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### 6.6 Loss of mass test on PVC sheathing

**Standard**
IEC 60502-2(2014), clause 19.8

**Characteristic test data**
Temperature during ageing 100 °C ± 2K
Duration 7 days

**Sheathing (outer ST2):**

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| loss of mass | $mg/cm^2$ | ≤ 1.5 | $1.01x10^{-3}$ | Pass |

### 6.7 Pressure test at high temperature on non-metallic sheath

**Standard**
IEC 60502-2 (2014) clause 19.9

**Characteristic test data (Outer Sheath) ST -2**
- Oven Temperature 90 °C ± 2K
- Time under load 6h
- Load 1304 grams

Calculated as per the specified test method

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| | | | Median value of 3 samples | |
| Depth of indentation | % | ≤ 50 | 4.59 % | Pass |

### 6.8 Test on PVC sheaths at low temperatures

**Standard**
IEC 60502-2 (2014) clause 19.10

**Characteristic test data**
- Temperature -15 °C ± 2K

| Item | Unit | Requirement | Measured/Determined mean value | Result |
|---|---|---|---|---|
| Elongation test at low temp. | % | ≥ 20 | 240.53 | Pass |



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### 6.9 Cold impact test

**Standard**
IEC 60502-2 (2014) clause 19.10

**Characteristic test data**

- Temperature -15 °C ± 2K
- Duration 16 h
- Mass of hammer 1500 g

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Soundness | ----- | no cracks | no cracks | Pass |

### 6.10 Test for resistance of sheaths to cracking (heat shock test)

**Standard**

IEC 60502-2 (2014), Clause 19.11
Characteristic test data:

| | |
|---|---|
| Temperature | 150 °C ± 3K |
| Duration | 1 h |
| Sample thickness | 2.6 mm |
| Mandrel diameter | 10 mm |

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Soundness | ----- | no cracks | no cracks | Pass |

### 6.11 Hot set test for XLPE insulation

**Standard**
Standard IEC 60502-2(2014), clause 19.13

**Characteristic test data**

| | |
|---|---|
| Temperature | 200 °C ± 3K |
| Time under load | 15 min |
| Mechanical stress | 20 N/cm$^2$ |

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Elongation under load | % | ≤175 | 69.30 | Pass |
| Permanent elongation | % | ≤15 | - 2.36 | Pass |



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### 6.12 Water absorption test on insulation

**Standard**
Standard IEC 60502-2(2014), clause 19.15

**Characteristic test data**
Temperature 85 °C ± 2K
Duration 14 days

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Variation of mass | $mg/cm^2$ | ≤ 1 | $2.73 \times 10^{-2}$ | Pass |

### 6.13 Shrinkage test for XLPE insulation

**Standard**
Standard IEC 60502-2(2014), clause 19.18

**Characteristic test data**
Temperature 130 °C ± 3K
Duration 1 h

| Item | Unit | Requirement | Measured/Determined | Result |
|---|---|---|---|---|
| Shrinkage | % | ≤4 | 1.95 | Pass |

### 6.14 Strippability test for insulation screen before and after ageing

**Standard**
Standard IEC 60502-2(2014), clause 19.23

**Characteristic test data**
- Grip to grip separation speed 250 mm/min
- Strip width 10 mm

**Before ageing**

| Item | Unit | Requirement | Measured/Determined (Max.) | | Result |
|---|---|---|---|---|---|
| | | | Mean | Range | |
| Strippability force | N | 4 ≤ N ≤ 45 | 12.58 | 10 ~ 15 | Pass |

**After ageing**

| Item | Unit | Requirement | Measured/Determined (Max.) | | Result |
|---|---|---|---|---|---|
| | | | Mean | Range | |
| Strippability force | N | 4 ≤ N ≤ 45 | 23.60 | 23 ~ 24 | Pass |



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## 7 VERIFICATION OF CABLE CONSTRUCTION

Verification of cable construction was carried out in accordance with clauses 5 to14 of IEC 60502-2. (2014)
The results are presented below.

| | Measured / Determined |
|---|---|
| **Marking on the Cable** | ***Arabic Embossing***:<br>١*٥٠٠/٣٥مم٢ نحاس/اكس ال بى اى / بى فى سى ،٣٣ ك.ف الوطنيه لصناعة الكابلات الامارات العربيه المتحدة، ٢٠١٦ ، املاك الشركة السعوديه للكهرباء<br>***English Embossing:***<br>**1×500/35 MM², CU/XLPE/PVC, 33 kV NATIONAL CABLES INDUSTRY, SHARJAH, UAE, 2016, PROPERTY OF SAUDI ELECTRICITY COMPANY** |
| **Color of the outer sheath** | Black |
| **Construction** | 1 x 500/35 mm² -conductor of copper wires -RMC shaped – Conductor Screen - XLPE Insulation - Strippable Type Insulation Screen - Copper Wires Metallic Screen - Open Helix Copper Tape Binder - PVC – ST2 Outer Sheath |
| Outer diameter of the cable (mm) | 58.9 mm approx. (average) |

**Note:** See also the manufacturer's drawing in **appendix A**.



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## 8 Appendix A.

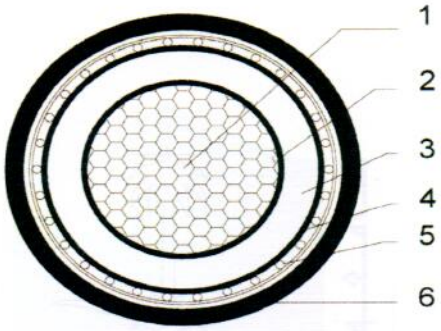
## Manufacturer's drawing / data sheet

الوطنية لصناعة الكابلات
NATIONAL CABLES INDUSTRY

**4500241339-1x500-03/2016**

**19/33 (36) kV, 1x500/35 mm² CU/XLPE/PVC POWER CABLE**

**Applicable Standard : IEC 60502-2 and SEC Specification 11-SDMS-03**




**Size:1x500/35 mm², CU/XLPE/PVC - 33 kV**

| | | | |
|---|---|---|---|
| 1. Conductor | : | Plain annealed Copper, Circular Stranded Compacted | |
| *Approximate diameter* | | *26.7 mm* | |
| 2. Conductor Screen | : | Extruded semi-conductive compound | |
| *Minimum thickness:* | | *0.51 mm / Approximate diameter:* | *29.5 mm* |
| 3. Insulation | : | Extruded Cross linked Polyethylene (XLPE) | |
| *Nominal thickness:* | | *8.0 mm / Approximate diameter:* | *45.5 mm* |
| 4. Insulation Screen | : | Extruded semi-conductive compound | |
| *Min. / Max. thickness:* | | *1.4 / 2.29 mm / Approximate diameter:* | *48.7 mm* |
| 5. Metallic Screen | : | Plain annealed copper wires + copper tape (open helix) | |
| *Nominal cross section:* | | *35 mm² / Approximate diameter:* | *50.6 mm* |
| 6. Outer Sheath | : | Extruded Polyvinyl Chloride (PVC, Type ST2), color: Black | |
| *Nominal thickness:* | | *2.6 mm / Approximate diameter:* | *57.0 mm* |

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مختبر الجهد العالي
High Voltage Laboratory

**Embossing on Outer Sheath in Max 100 cm Spacing (English & Arabic):**
**1x500/35 MM², CU/XLPE/PVC, 33 kV, NATIONAL CABLES INDUSTRY, UAE, 2016**
**PROPERTY OF SAUDI ELECTRICITY COMPANY**

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