Test Report
No. TR-001-2017

For

Type Testing of
3×500/35mm², AL/XLPE/STA/PVC
15kV Medium Voltage Power Cable

Test carried out at

The High Voltage Laboratory

جامعة الملك سعود
King Saud University
قسم
الهندسة الكهربائية - الرياض
Electrical Engineering
Department - Riyadh
مختبر الجهد العالي
High Voltage Laboratory

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

Total No. of Pages including Appendix: 19

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TEST REPORT No. TR-001 -2017

OBJECT	Medium Voltage Power Cable
TYPE	3 X 500/35mm^2 Al/XLPE/STA/PVC, 15 kV
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 Report of Performance applies only to the object tested. The responsibility for conformity of any production having the same designations as the tested sample rests with the manufacturer.

27-4-1438

Prof. Dr. Abdulrehman A. Al-Arainy
Manager
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King Saud University,
Riyadh, KSA

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This report consists of 19 pages in total.

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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, UAE
TYPE	8.7/15kV , 3 X 500/35 mm^2 , Al/XLPE/STA/PVC
YEAR OF MANUFACTURE	2016
SAMPLING PROCEDURE	19 meter cable sample cut from the drum
RATED VOLTAGE	8.7/15 kV
NO. OF CORES	3

1. Conductor		
Material	**Aluminum**	
Size	**500**	mm^2
Shape	**RMC**	
Minimum no. of wires	**61**	
Conductor diameter	**27** (Approximate)	mm
Max. DC Resistance at 20 °C	**0.0605**	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	**29.2** (Approximate)	mm
3. Insulation		
Material	**Cross-linked Polyethylene [XLPE]**	
Thickness :		
- Nominal	**4.50**	mm
- Minimum at any point	**3.95**	mm
Diameter over insulation	**38.2** (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	**41.4** (Approximate)	mm
5. Metallic Screen		
Material	**Copper Wires + Copper Tape**	
No. of wires	**31 / Core**	
Wire diameter	**0.7**	mm
No. of open helix tapes	**1 / Core**	
Width x Thickness	**15 x 0.10**	mm
Diameter over metallic screen	**43.1** (Approximate)	mm

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6. Assembly		
Material	**Polypropylene [Filler + Tape]**	
Diameter over assembly	**93.0** (Approximate)	mm
7. Separation Sheath		
Material	**MDPE ST-7**	
Thickness :		
- Nominal	**2.30**	mm
- Minimum at any point	**1.64**	mm
Diameter over separation sheath	**98.0** (Approximate)	mm
8. Armour		
Material	Galvanized Steel Tapes	
No. of tapes	2	
Thickness	0.80	mm
Width	60	mm
Maximum Gap	50	%
Diameter over armour	101.2 (Approximate)	mm
9. Outer Sheath		
Material	Extruded Polyvinyl Chloride [PVC - ST2]	
Color	Red	
Thickness :		
- Nominal	4.20	mm
- Minimum at any point	3.16	mm
Overall cable diameter	110 (Approximate)	mm

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 [data sheet]	TITLE
11-SDMS-03	**Rev. 02**	**March 2016**	**Design data sheet for three core AL/XLPE/STA/PVC, 8.7/15 (17.5) kV power cable Size: 3 × 500/35 mm²**

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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 test 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.

3 ROUTINE TESTS

3.1 Measurement of the resistance of Aluminum conductors

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Resistance	Ω/km	≤ 0.0605	0.0583	0.0600	0.0579	pass

4 MEASUREMENTS ON CONDUCTOR AND ARMOUR

Standard

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

4.1 Measurement on Aluminum Conductors

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Number of wires	No's	53	61	61	61	pass
Conductor diameter	mm	27.0 (Approx)	27.5	27.6	27.4	pass

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4.2 Measurement of the dimension of Metallic screen and Armour tapes

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Plain copper wire Screen Dimension	No. X mm	31 / Core x 0.70	31 x 0.70	31 x 0.70	31 x 0.70	pass
Open helix copper tape over copper wire screen dimension	mm	No x Width x Thickness (1 x 15 x 0.10)	1 x 15 x 0.12			
Armour Dimension	mm	No x Width x Thickness (2 x 60 x 0.8)	2 x 60 x 0.82			

5 ELECTRICAL TYPE TESTS

5.1 Bending Test

Standard
Standard IEC 60502-2 (2014), clause 18.2.4

Sample length 19 m

Description	Size	Voltage	D	d	Calculated test cylinder diameter15(d + D)+5% (Maximum)	Actual measured Barrel Diameter
Unit	mm^2	kV	mm	mm	mm	mm
AL / XLPE / STA / PVC	3 x 500	8.7 / 15	109.0	28	2158	2100

Carried out at National Cables test lab

Result
The test was done in a satisfactory manner

5.2 Partial Discharge Test after Bending

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

Item	Required test voltage (1.73 U_o)	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Partial Discharge Test	15.1 kV	≤ 5 pC	< 1pC	< 1pC	< 2pC	Pass (No detectable discharge)

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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
			Red	Yellow	Blue	
Tan Delta measurement	≥ 3 kV	≤ $40x10^{-4}$	15 x 10^{-4}	15 x 10^{-4}	15 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 Cycle

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
			Red	Yellow	Blue	
Partial Discharge Test	15.1 kV	≤ 5 pC	3.5 pC	3.3 pC	3.8 pC	Pass

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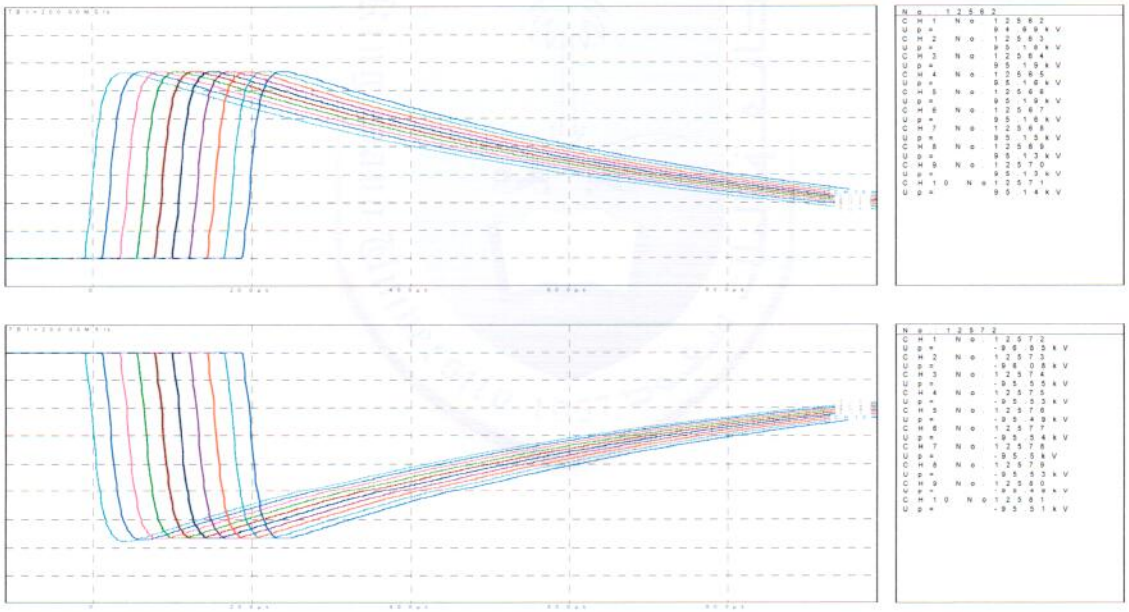
5.6 Impulse test followed by AC voltage test

5.6.1 Impulse test

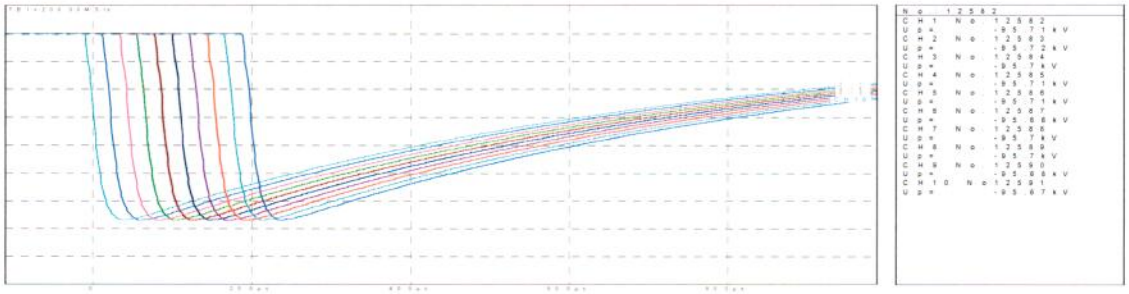
Standard
Standard IEC 60502-2 (2014), clause 18.2.8

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

Item	Sample rated voltage (kV) U_o/U ($U_{max.}$)	Test voltage Peak (kV)	Requirement	Measured/Determined			Result
				Red	Yellow	Blue	
Impulse test	8.7 / 15 (17.5)	95	No Breakdown	No Breakdown	No Breakdown	No Breakdown	Pass



Impulse waveforms for RED core



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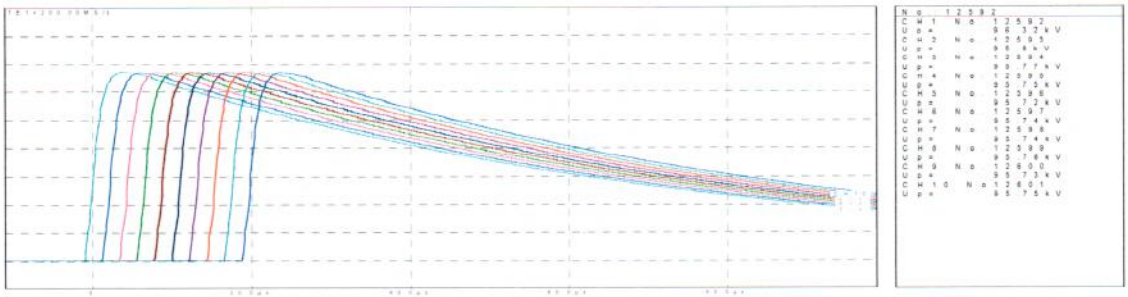
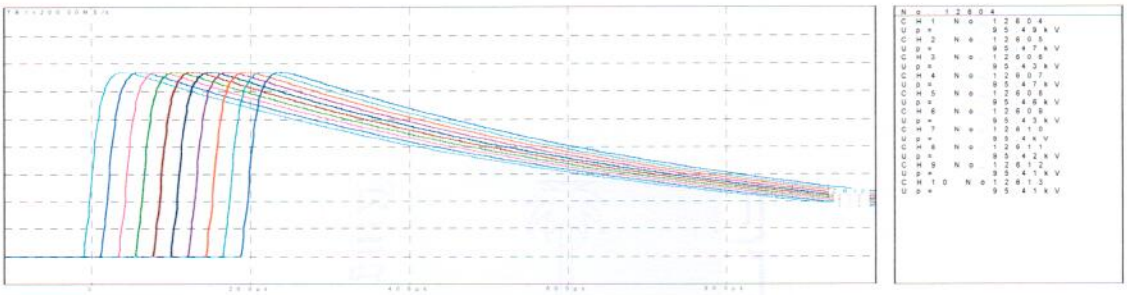


Impulse waveforms for YELLOW core



Impulse waveforms for BLUE core

Applied positive and negative Impulse waveforms

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	30.5	30.5	15	No Breakdown	Pass

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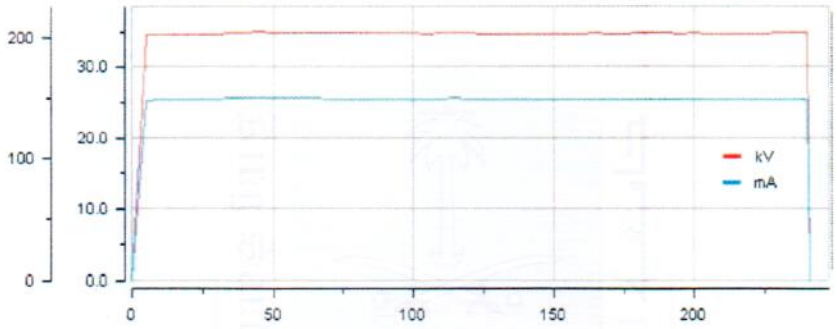
5.7 AC Voltage Test for 4 hrs

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

Environmental conditions
Temperature of test object 27 °C

Item	Required test voltage $4U_0$ (kV)	Applied test voltage (kV)	Duration (hrs)	Determined	Result
Voltage test	35	35	4	No Breakdown	Pass



Applied 4hr AC voltage test

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
			Red	Yellow	Blue	
Conductor Screen						
- Before ageing	Ω.m	≤ 1000	1.82	0.30	2.17	Pass
- After ageing	Ω.m	≤ 1000	16.95	1.02	24.83	
Insulation Screen						
- Before ageing	Ω.m	≤ 500	0.54	14.33	0.73	Pass
- After ageing	Ω.m	≤ 500	11.14	4.34	11.51	

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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
			Red	Yellow	Blue	
Nominal ($T_{nom.}$)	mm	4.50	4.65	4.54	4.72	Pass
Minimum ($T_{min.}$)	mm	≥ 3.95	4.52	4.33	4.54	
($T_{max.}$ - $T_{min.}$)/ $T_{max.}$	mm	≤ 0.15	0.04	0.08	0.07	

Results of the measurement of thickness of conductor screen

thickness	Unit	Requirement specified	Measured/Determined			Result
			Red	Yellow	Blue	
Minimum	mm	≥ 0.51	0.85	1.02	0.92	Pass

Results of the measurement of thickness of insulation screen

thickness	Unit	Requirement specified	Measured/Determined			Result
			Red	Yellow	Blue	
Minimum	mm	≥ 1.4	1.65	1.84	1.52	Pass
Maximum	mm	≤ 2.29	1.77	2.16	1.75	

6.2 Measurement of thickness of non-metallic sheathing

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

Separation Sheath

thickness	Unit	Requirement	Measured/Determined	Result
Minimum	mm	≥ 1.64	1.95	Pass

Outer Sheath

thickness	Unit	Requirement	Measured/Determined	Result
Minimum	mm	≥ 3.16	3.19	Pass

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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

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Tensile strength before ageing	N/mm^2	≥ 12.5	18.93	18.61	19.39	Pass
Elongation before ageing	%	≥200	543	536	542	

Mechanical properties after ageing without conductor 135°C / 7days

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Tensile strength	N/mm^2	----------	21.22	22.96	21.94	Pass
Variation with samples without ageing	%	± 25 max.	+12.10	+23.37	+13.15	
Elongation	%	----------	543	541	590	Pass
Variation with samples without ageing	%	± 25 max.	0	+0.93	+8.86	

6.4 Tests for determining the mechanical properties of the Non-Metallic Sheaths 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

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength Without ageing	N/mm^2	≥ 12.5	14.98	Pass
Elongation Without ageing	%	≥150	250.45	

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Mechanical properties after ageing without conductor 100°C / 7days

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength	N/mm^2	≥ 12.5	14.83	Pass
Variation with samples without ageing	%	± 25 max.	-1.00	
Elongation	%	≥150	265.65	Pass
Variation with samples without ageing	%	± 25 max.	+ 6.07	

Characteristic (Separation sheath)

Material PE ST7
Temperature during ageing 110 °C ± 2K
Duration 10 days

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength Without ageing	N/mm^2	≥ 12.5	18.05	Pass
Elongation Without ageing	%	≥ 300	819	

Mechanical properties after ageing without conductor 110°C / 10days

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength	N/mm^2	----------	17.13	Pass
Variation with samples without ageing	%	----------	-5.10	
Elongation	%	≥ 300	749	Pass
Variation with samples without ageing	%	----------	- 8.55	

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
			Red	Yellow	Blue	
tensile strength	N/mm^2	----------	18.56	19.95	18.82	Pass
variation with samples without ageing	%	± 25 max.	-1.95	+7.20	-2.94	
elongation	%	----------	558	521	536	Pass
variation with samples without ageing	%	± 25 max.	+2.76	-2.80	-1.11	

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هاتف : ٤٦٧٦١٦٩ ١ ٩٦٦+ - ٤٦٧٦١٤٢ ١ ٩٦٦+
فاكس : ٤٦٧٦١٤٠ ١ ٩٦٦+

Separation Sheath (ST-7)

Item	Unit	Requirement	Measured/Determined	Result
tensile strength	N/mm^2	----------	18.74	Pass
variation with samples without ageing	%	----------	+ 3.82	
Elongation	%	----------	755	Pass
variation with samples without ageing	%	----------	-7.81	

Outer Sheath (ST-2)

Item	Unit	Requirement	Measured/Determined	Result
tensile strength	N/mm^2	----------	15.28	Pass
variation with samples without ageing	%	± 25 max.	+ 2.00	
Elongation	%	----------	253	Pass
variation with samples without ageing	%	± 25 max.	+ 1.02	

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:-

Item	Unit	Requirement	Measured/Determined	Result
loss of mass	mg/cm^2	≤ 1.5	9.7×10^{-4}	Pass

6.7 Pressure test at high temperature on non-metallic sheaths

Characteristic test data (Outer Sheath) ST -2
- Oven Temperature 90 °C ± 2K
- Time under load 6h
- Load 2150 grams

Calculated as per the specified test method

Item	Unit	Requirement	Measured/Determined	Result
			Median value of 3 samples	
Depth of indentation	%	≤ 50	2.93 %	Pass

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فاكس: ٤٦٧٦١٤٠ ١ ٩٦٦+

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	287.55	Pass

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 1500gms

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 3.20 mm
Mandrel diameter 10 mm

Item	Unit	Requirement	Measured/Determined	Result
Soundness	-----	No cracks	No cracks	Pass

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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
			Red	Yellow	Blue	
Elongation under load	%	≤175	54.86	66.32	80.48	Pass
Permanent elongation	%	≤15	-3.85	-1.80	-3.60	Pass

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
			Red	Yellow	Blue	
Variation of mass	mg/cm^2	≤ 1	9.72 x10^{-2}	1.09 x10^{-2}	4.90 x10^{-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
			Red	Yellow	Blue	
Shrinkage	%	≤4	1.25	1.20	1.20	Pass

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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 (all cores)	Range (all cores)	
Strippability force	N	4 ≤ N ≤ 45	13.77	9 ~ 20	Pass

After ageing

Item	Unit	Requirement	Measured/Determined (Max.)		Result
			Mean (all cores)	Range (all cores)	
Strippability force	N	4 ≤ N ≤ 45	10.86	6 ~ 20	Pass

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 of the cable	Arabic Embossing: ٣*٣٥/٥٠٠ مم٢ المونيوم/اكس ال بي اى/مسلح/بى فى سى ١٥ ك.ف الوطنيه لصناعة الكابلات الامارات العربيه المتحدة ٢٠١٦ املاك الشركة السعوديه للكهرباء English Embossing: **3X500/35 MM², AL/XLPE/STA/PVC, 15 kV NATIONAL CABLES INDUSTRY, UAE, 2016, PROPERTY OF SAUDI ELECTRICITY COMPANY**
Color of the cores	Red, Yellow, Blue identification tape
Color of the outer sheath	Red
Construction	3 x 500/35 mm² -conductor of Aluminum wires -RMC shaped – Conductor Screen - XLPE Insulation - Strippable Type Insulation Screen - Copper Wires Metallic Screen - Open Helix Copper Tape Binder - Polypropylene Filler - Binder Tape- Extruded Polyethylene (PE - ST7) separation sheath- Double Galvanized Steel Tape Armour - PVC – ST2 Outer Sheath
Outer diameter of the cable (mm)	110 mm approx. (average)

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

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فاكس : ٤٦٧٦١٤٠ ١ ٩٦٦+

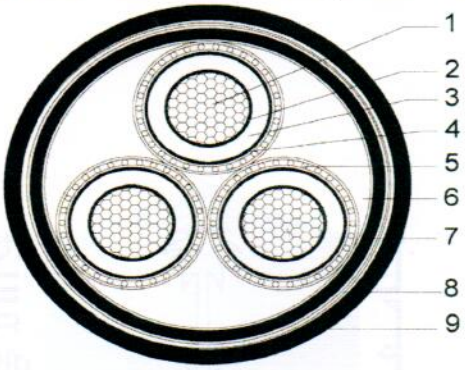
8 Appendix A. Manufacturer's drawing / data sheet

الوطنية لصناعة الكابلات
NATIONAL CABLES INDUSTRY

4500241339-3x500-03/2016

8.7/15 (17.5) kV, 3x500/35 mm² AL/XLPE/STA/PVC POWER CABLE

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



Size:3x500/35 mm², AL/XLPE/STA/PVC - 15 kV

1. Conductor	:	Aluminium, Circular Stranded Compacted	
Approximate diamete		*27.0 mm*	
2. Conductor Screen	:	Extruded semi-conductive compound	
Minimum thickness:		*0.51 mm / Approximate diameter:*	*29.2 mm*
3. Insulation	:	Extruded Cross linked Polyethylene (XLPE)	
Nominal thickness:		*4.5 mm / Approximate diameter:*	*38.2 mm*
4. Insulation Screen	:	Extruded semi-conductive compound	
Min. / Max. thickness:		*1.4 / 2.29 mm / Approximate diameter:*	*41.4 mm*
5. Metallic Screen	:	Plain annealed copper wires + copper tape (open helix)	
Nominal cross section:		*35 mm² / Approximate diameter:*	*43.1 mm*
6. Filler	:	Non-Hygroscopic Polypropylene Strings	
7. Separation Sheath	:	Extruded Polyethylene (PE)	
Nominal thickness:		*2.3 mm / Approximate diameter:*	*98.0 mm*
8. Armour	:	Double layers of Galvanized Steel Tapes (STA)	
Nominal tape's thickness:		*0.8 mm / Approximate diameter:*	*101.2 mm*
9. Outer Sheath	:	Extruded Polyvinyl Chloride (PVC, Type ST2), color: RED	
Nominal thickness:		*4.2 mm / Approximate diameter:*	*110 mm*

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Electrical Engineering Department - Riyadh
مختبر الجهد العالي
High Voltage Laboratory

Embossing on Outer Sheath in Max 100 cm Spacing (English & Arabic):
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PROPERTY OF SAUDI ELECTRICITY COMPANY

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