Test Report
No. TR-009-2019

For

Type Testing of
3×500/35mm^2, AL/XLPE/LLDPE
15kV Medium Voltage Power Cable

Test carried out at

The High Voltage Laboratory

Ramadan, 1440 H
May, 2019 G

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

Total No. of Pages including Appendix: ***18***

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TEST REPORT No. TR-009-2019

OBJECT	Medium Voltage Electric Power Cable
TYPE	3 × 500/35mm^2 AL/XLPE/LLDPE, 15kV
MANUFACTURER	NATIONAL CABLES INDUSTRIES, Sharjah - UAE
TRADE NAME	NATIONAL CABLES INDUSTRIES
DATE OF TEST	May, 2019
TEST REFERENCE STANDARDS	**IEC 60502-2:2014 & 11-SDMS-04 Rev. 0:2018**

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.

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1. IDENTIFICATION OF THE TEST OBJECT

1.1 Description of the test object

OBJECT	Medium Voltage Cable
KSU LAB ID #	**HVS – 009/2019**
MANUFACTURER	NATIONAL CABLES INDUSTRIES Sharjah, UAE
TYPE	15kV , 3 × 500/35 mm^2 , AL/XLPE/LLDPE
YEAR OF MANUFACTURE	2019
SAMPLING PROCEDURE	22 meter cable sample cut from the drum
RATED VOLTAGE	15 kV
NO. OF CORES	3

Manufacturer specified values

1. Conductor		
Material	**Aluminum**	
Size	**500**	mm^2
Shape	**RMC**	
Minimum no. of wires	**61**	
Conductor diameter	**26.7** (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	**0.51**	mm
3. Insulation		
Material	**Cross-linked Polyethylene [XLPE]**	
Thickness :		
- Nominal	**4.5**	mm
Diameter over insulation	**37.3** (Approximate)	mm
4. Insulation Screen *		
Material	**Extruded Semi-conducting material**	
Type	**Cold Strippable Type**	
Thickness :		
- Maximum	**1.91**	mm
- Minimum	**1.02**	mm
5. Metallic Screen		
Material	**Copper Wires + Copper Tape**	
No. of wires	**27 / Core**	
Wire diameter	**0.7**	mm
No. of open helix tapes	**1 / Core**	
Width x Thickness	**15 x 0.1**	mm

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6. Assembly

Material	**Polypropylene [Filler + Tape]**	
Diameter under binding tape	**90.6** (Approximate)	mm
Binding tape material	**Mylar tape**	
- Thickness	**0.075**	mm

7. Outer Sheath

Material	**LLDPE TYPE ST-7**	
Color	Black	
Thickness :		
- Nominal	3.9	mm
Diameter under outer sheath	90.9	mm
Overall cable diameter	99 (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	TITLE
11-SDMS-04	**Rev. 0**	**July 2018**	**Design data sheet for three core AL/XLPE/LLDPE, 15kV power cable Size: 3 x 500/35 mm²**

2. GENERAL INFORMATION

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

i. **Prof. Yasin Khan**

ii. **Eng. Nissar R. Wani**

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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

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	0.0600	0.0600	0.0600	pass

4 MEASUREMENTS ON CONDUCTOR

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	26.7 (Approx.)	26.99	27.12	27.10	Pass

4.2 Measurement of the dimension of metallic screen

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Plain copper wire Screen Dimension	No. x mm	27 / Core X 0.7	27 x 0.71	27 x 0.71	27 x 0.71	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 0.10			

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5 ELECTRICAL TYPE TESTS

5.1 Bending test

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

Sample length 17m

Description	Size	Voltage	D	d	Calculated test cylinder diameter 15(d + D)+5% (Maximum)	Actual measured Barrel Diameter
Unit	mm^2	kV	mm	mm	mm	mm
Al / XLPE / LLDPE	3 x 500	15	96.77	27	1949	1800

** Carried out at Riyadh 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_0)	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Partial Discharge Test	15 kV	≤ 5 pC	1.2 pC	1.2 pC	1.2 pC	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
			Red	Yellow	Blue	
Tan Delta measurement	≥ 2 kV	≤ $40x10^{-4}$	2 X 10^{-4}	1 X 10^{-4}	1 X 10^{-4}	Pass

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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_o)	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Partial Discharge Test	15 kV	≤ 5 pC	3.3 pC	3.2 pC	3.3 pC	Pass

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
				Red	Yellow	Blue	
Impulse test	15	95	No Breakdown	No Breakdown	No Breakdown	No Breakdown	Pass

Impulse test waveforms are shown next.

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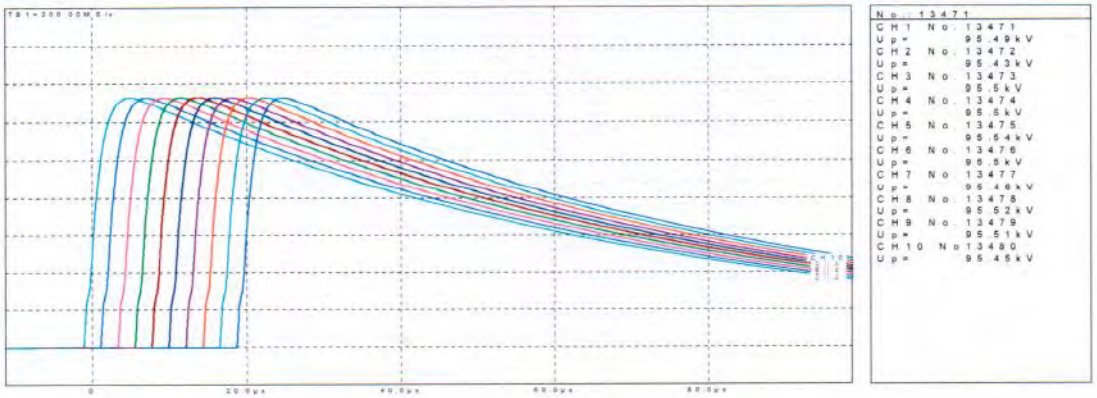
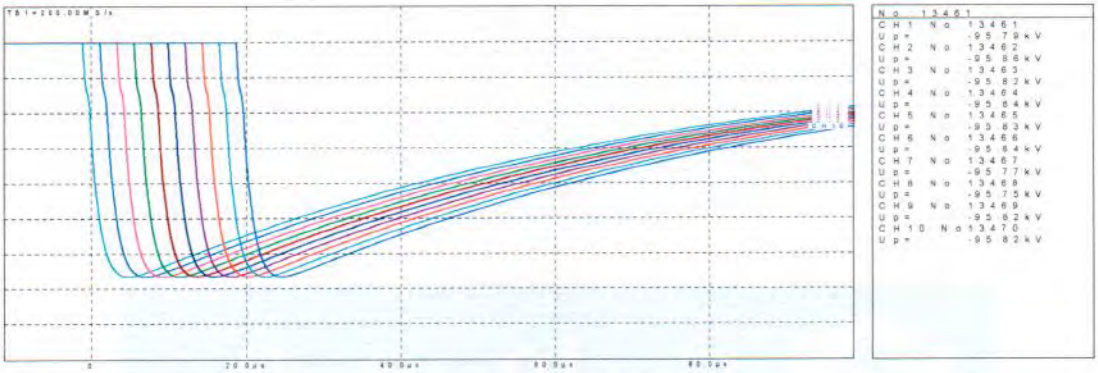
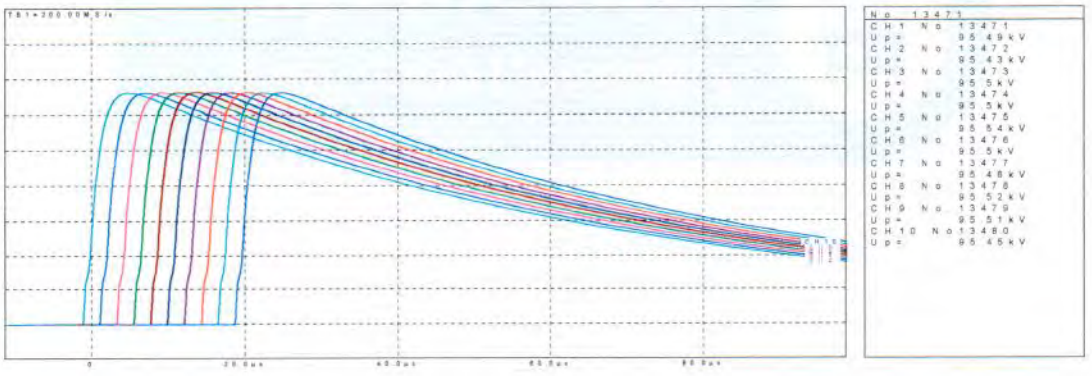
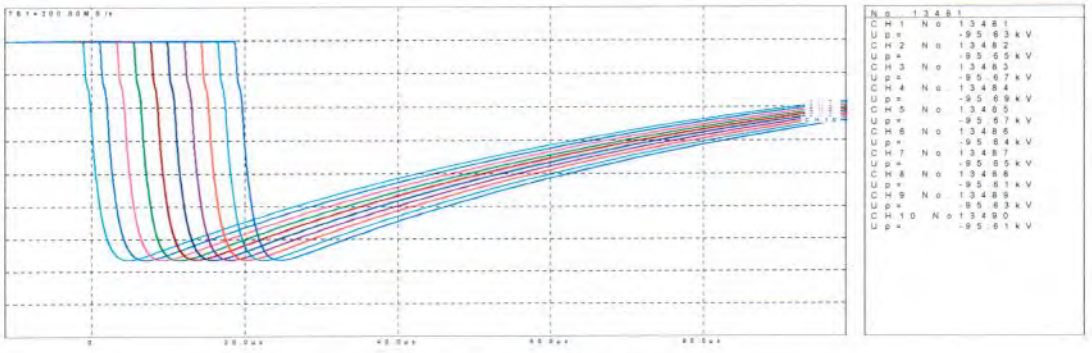




PHASE – RED





PHASE- YELLOW

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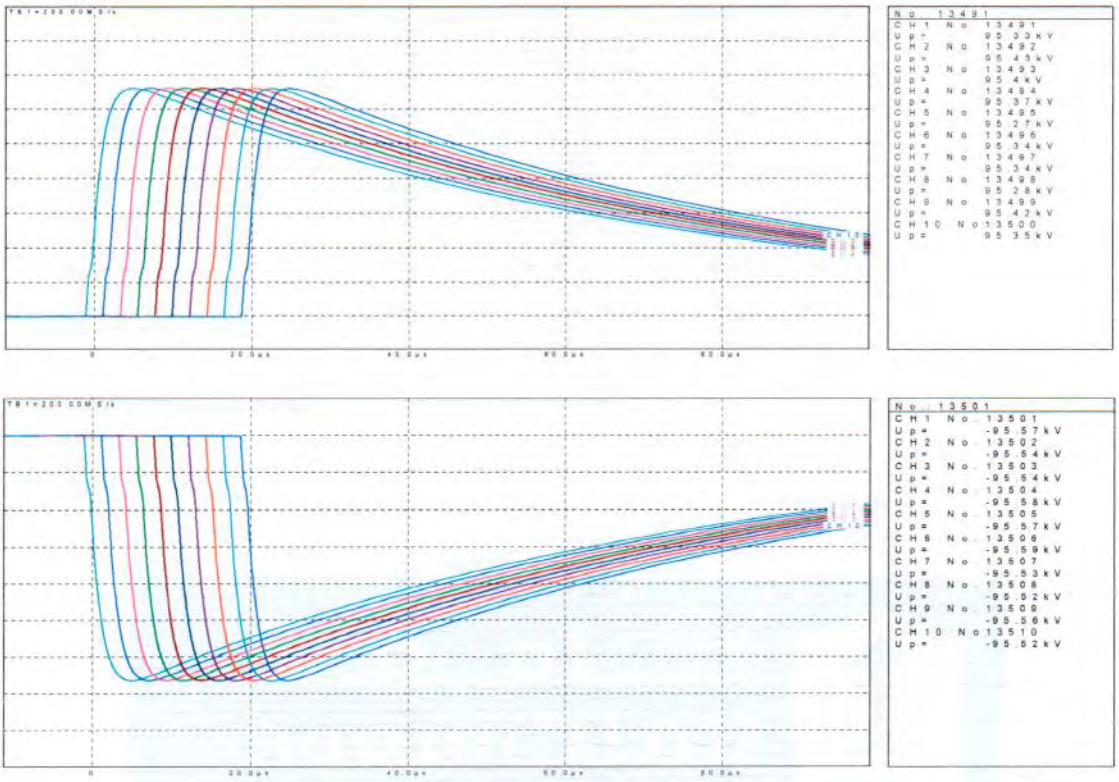

PHASE- BLUE

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	31	31	15	No Breakdown in any core	Pass

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5.7 AC Voltage test for 4 hrs.

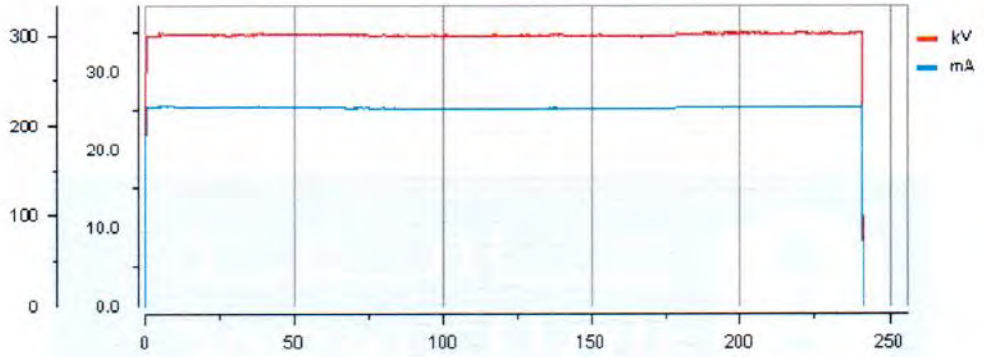
Standard

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 in any core	Pass



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	7.77	18.98	28.79	Pass
- After ageing	Ω.m	≤ 1000	1.09	12.04	28.63	
Insulation Screen						
- Before ageing	Ω.m	≤ 500	3.17	5.42	8.41	Pass
- After ageing	Ω.m	≤ 500	1.38	2.19	2.72	

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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	4.67	4.63	4.60	Pass
Minimum ($T_{min.}$)	mm	≥ 3.95	4.61	4.46	4.45	
($T_{max.}$ - $T_{min.}$)/ $T_{max.}$	mm	≤ 0.15	0.03	0.05	0.06	

Results of the measurement of thickness of conductor screen

thickness	Unit	Requirement specified	Measured/Determined			Result
			Red	Yellow	Blue	
Minimum	mm	≥ 0.51	0.88	0.81	0.85	Pass

Results of the measurement of thickness of insulation screen

thickness	Unit	Requirement specified	Measured/Determined			Result
			Red	Yellow	Blue	
Minimum	mm	≥ 1.02	1.14	1.10	1.12	Pass
Maximum	mm	≤ 1.91	1.26	1.32	1.31	

6.2 Measurement of thickness of non-metallic sheathing

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

Outer Sheath

Thickness Requirement		Unit	Measured/Determined		Result
nominal	minimum		nominal	minimum	
3.9	≥ 3.12	mm	3.9	3.21	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

Mechanical properties before ageing

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Tensile strength before ageing	N/mm^2	≥ 12.5	22.50	24.46	24.37	Pass
Elongation before ageing	%	≥200	638.40	741.95	567.00	

Mechanical properties after ageing

Item	Unit	Requirement	Measured/Determined			Result
			Red	Yellow	Blue	
Tensile strength	N/mm^2	----------	23.22	26.42	20.60	Pass
Variation with samples without ageing	%	± 25 max.	+3.2	+8.01	- 15.45	
Elongation	%	----------	643.65	665.25	523.45	Pass
Variation with samples without ageing	%	± 25 max.	+0.82	- 10.34	- 7.68	

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	LLDPE – TYPE ST-7
Temperature during ageing	110 °C ± 2K
Duration	10 days

Mechanical properties before ageing

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength Without ageing	N/mm^2	≥ 12.5	19.79	Pass
Elongation Without ageing	%	≥ 300	859.60	

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Mechanical properties after ageing

Item	Unit	Requirement	Measured/Determined	Result
Tensile strength	N/mm^2	----------	18.11	Pass
Variation with samples without ageing	%	----------	-8.48	
Elongation	%	≥ 300	950.40	Pass
Variation with samples without ageing	%	----------	+10.56	

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	----------	23.56	22.43	24.74	Pass
variation with samples without ageing	%	± 25 max.	+ 4.71	- 8.29	+1.52	
elongation	%	----------	641.10	658.90	521.25	Pass
variation with samples without ageing	%	± 25 max.	+ 0.42	- 11.19	- 8.07	

Outer Sheath (LLDPE)

Item	Unit	Requirement	Measured/Determined	Result
tensile strength	N/mm^2	----------	19.20	Pass
variation with samples without ageing	%	----------	- 2.98	
Elongation	%	≥ 300	902.95	Pass
variation with samples without ageing	%	----------	+ 5.04	

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6.6 Pressure test at high temperature on non-metallic sheaths

Standard
IEC 60502-2 (2014) clause 19.9

Characteristic test data (Outer Sheath) LLDPE

- Oven Temperature 110°C ± 2K
- Time under load 6h
- Load 1926 grams

Calculated as per the specified test method

Item	Unit	Requirement	Measured/Determined	Result
			Median value of 3 samples	
Depth of indentation	%	≤ 50	8.29 %	Pass

6.7 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	60.73	67.59	62.88	Pass
Permanent elongation	%	≤15	2.94	0.64	2.28	Pass

6.8 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	0.012	0.018	0.018	Pass

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هاتف : ٤٦٧٦١٤٢ ١١ ٩٦٦+ - ٤٦٧٦١٦٩ ١١ ٩٦٦+
فاكس : ٤٦٧٦١٤٠ ١١ ٩٦٦+

6.9 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	0.85	1.16	1.17	Pass

6.10 Shrinkage test for LLDPE Sheath

Standard
Standard IEC 60502-2(2014), clause 19.22

Characteristic test data
Temperature 80 °C ± 2K
Duration 5 Hrs , 5 Cycles

Item	Unit	Requirement	Measured/Determined	Result
Shrinkage	%	≤ 3	1.3	Pass

6.11 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	22.47	12.45 ~ 31.02	Pass

After ageing

Item	Unit	Requirement	Measured/Determined (Max.)		Result
			Mean (all cores)	Range (all cores)	
Strippability force	N	4 ≤ N ≤ 45	11.12	6.10 ~ 17.50	Pass

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6.12 Carbon black contents (Outer LLDPE sheath)

Standard
Standard IEC 60502-2(2014), clause 19.17

Characteristic test data
- Purging gas 850 ~ 950 °C
- End temperature 950 °C

Item	Unit	Requirement	Measured/Determined (Max.)	Result
Carbon black content	%	Min/Max: 2/3	2.717	Pass

- This test was conducted at Riyadh Cables test lab under KSU witness

7 VERIFICATION OF CABLE CONSTRUCTION

Verification of cable construction was carried out in accordance with clauses 5 to 14 of IEC 60502-2. (2014)
The results are presented below.

	Measured / Determined
Marking of the cable	***Arabic Embossing***: ٣ X ٣٥/٥٠٠ مم٢ الومنيوم/اكس ال بي اي/ ال ال دي بي اي، ١٥ ك ف ، الوطنية لصناعة الكابلات ، الامارات العربية المتحدة، ٢٠١٩ ، املاك الشركة السعودية للكهرباء. ***English Embossing:*** **3X500/35 MM2, AL/XLPE/LLDPE, 15kV NATIONAL CABLES INDUSTRIES - UAE, 2019, PROPERTY OF SAUDI ELECTRICITY COMPANY**
Color of the cores	Red, Yellow, Blue identification tape
Color of the outer sheath	Black with two red strips
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- LLDPE – ST7 Outer Sheath
Outer diameter of the cable (mm)	96.77mm approx. (average)

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

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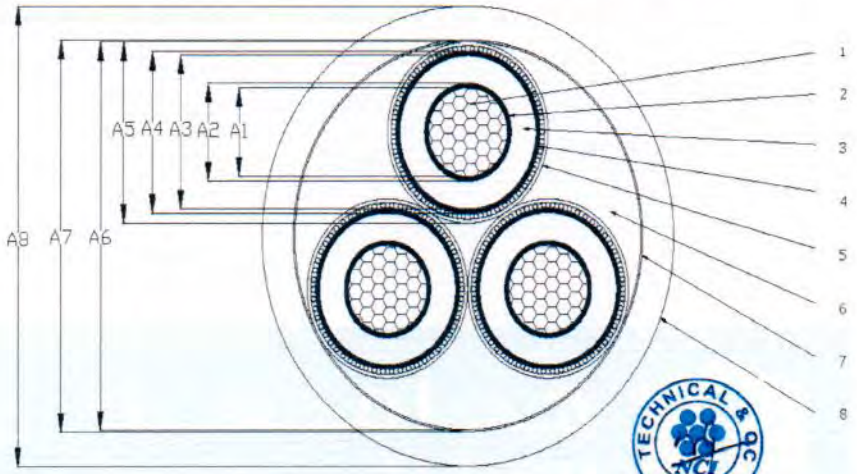
فاكس : ٤٦٧٦١٤٠ ١١ ٩٦٦+

8 Appendix A. Manufacturer's drawing / data sheet

NCI
الوطنيـــة لصناعـــة الكابلات
NATIONAL CABLES INDUSTRY

TYPICAL CROSS SECTIONAL DRAWING FOR
3x500/35 mm² AL/XLPE/LLDPE 15 kV Cable
Reference standard: IEC 60502-2 & 11-SDMS-04 REV. 0



TECHNICAL & QC NCI DEPT

DIMENSIONS:

No.	DETAILS	
	Conductor Cross Section, mm²	500
1	Conductor (Circular stranded compacted)	Aluminium
2	Conductor screen (Extruded semi-conductive compound)	0.51 (Min.)
3	Nominal thickness of XLPE insulation, mm	4.5
4	Insulation screen (Extruded semi-conductive compound)	1.02 (Min.)
5	Plain Annealed Copper Wires + Copper Binder Tape (open helix)	27 x 0.7 (No. of wires x diameter) 15 x 0.1 (Open helix width x thickness)
6	Filler (Assembling)	Polypropylene String
7	Nominal thickness of binder tape, mm	0.075
8	Nominal thickness of LLDPE outer sheath, mm	3.9
A1	Approximate diameter over conductor, mm	26.7
A2	Approximate diameter over conductor screen, mm	28.3
A3	Approximate diameter over insulation, mm	37.3
A4	Approximate diameter over insulation screen, mm	39.3
A5	Approximate diameter over metallic screen, mm	41.9
A6	Approximate diameter over assembling, mm	90.6
A7	Approximate diameter over binder tape, mm	90.9
A8	Approximate diameter over outer sheath, mm	99

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شهادة اعتماد
ACCREDITATION CERTIFICATE

اللجنة السعودية للاعتماد
Saudi Accreditation Committee

تشهد اللجنة السعودية للاعتماد (ساك) بأن
Saudi Accreditation Committee (SAC) Declare that

High Voltage King Saud University Laboratory

Address: Riyadh

Scope : Electrical and electronic

مختبر الجهد العالي بجامعة الملك سعود

العنوان: الرياض

المجال : الكهربائية والإلكترونية

قد حقق متطلبات اللجنة السعودية للاعتماد (ساك) وتم اعتماده وفقاً لمتطلبات المواصفة القياسية السعودية ساسو / آيزو/ آى إي سي **17025** وذلك في المجال الملحق بهذه الشهادة

Has met the Requirements of Saudi Accreditation Committee (SAC) and has been accredited in compliance with SASO/ISO/IEC **17025** for the scope attached with this Certificate

رئيس اللجنة
SAC Chairman

سعد بن عثمان القصبي
Saad O. Alkasabi

اللجنة السعودية للاعتماد
Saudi Accreditation Committee

تاريخ الانتهاء / Expire Date : 12/06/1441

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