KINECTRICS

NATIONAL CABLES INDUSTRY

TYPE TEST REPORT OF
8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC CABLE

Performed May 14, 2013 to June 24, 2013 in accordance with

IEC 60502-2:2005

Kinectrics Report: K-422899-RC-0001-R00
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1.0 INTRODUCTION

At the request of National Cables Industry, Kinectrics International Inc. performed type tests on a 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry in accordance with IEC 60502-2:2005. A drawing showing the details of the cable is given in Appendix A.

1.1 Test Program:

A listing of type tests performed on a 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable including electrical and non-electrical type tests manufactured by National Cables Industry is detailed below in Table 1.

Table 1: List of type tests performed on 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable
ELECTRICAL TYPE TEST

Sr. No	Description	IEC Sub-Clause
1	Bending Test	IEC 60502-2, 18.1.3
2	Partial Discharge Test	IEC 60502-2, 18.1.4
3	Tan δ measurements	IEC 60502-2, 18.1.5
4	Heating cycle test	IEC 60502-2, 18.1.6
5	Impulse test	IEC 60502-2, 18.1.7
6	Voltage test 4 h	IEC 60502-2, 18.1.8
7	Resistivity of semi-conducting screen	IEC 60502-2, 18.1.9
8	Electrical resistance of conductors	IEC 60502-2, 16.2

NON-ELECTRICAL TYPE TEST BASED ON TABLE 16 OF IEC 60502-2-2005

Sr. No	Description	IEC Sub-Clause
1	Measurement of thickness of Insulation	IEC 60502-2, 19.1
2	Measurement of thickness of non-metallic sheaths (including extruded separation, but excluding inner covering)	IEC 60502-2, 19.2
3	Examination of conductor per IEC 60228	IEC 60502-2, 17.4
4	Test for determination of the mechanical properties of insulation before and after ageing	IEC 60502-2, 19.3
5	Test for determination of the mechanical properties of non-metallic sheaths before and after ageing	IEC 60502-2, 19.4
6	Additional ageing test on piece of completed cable	IEC 60502-2, 19.5
7	Loss of mass on PVC sheaths of type ST2	IEC 60502-2, 19.6
8	Pressure test at high temperature on insulation and non-metallic sheaths	IEC 60502-2, 19.7
9	Test on PVC insulation and sheaths at low temperature	IEC 60502-2, 19.8
10	Test for resistance of PVC insulation and sheaths to cracking (hot shock test)	IEC 60502-2, 19.9
11	Hot set test for XLPE insulation	IEC 60502-2, 19.11
12	Water absorption test for insulation	IEC 60502-2, 19.13
13	Flame spread test on single cables	IEC 60502-2, 19.14
14	Shrinkage test for XLPE insulation	IEC 60502-2, 19.16
15	Strippability test for insulation screen	IEC 60502-2, 19.21
16	Measurement of Insulation and Conductor Screens	For Information

2.0 ELECTRICAL TESTS

At the request of National Cables Industry, Kinectrics International Inc. performed type tests on a 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry in accordance with IEC 60502-2:2005.

The tests were performed from May 14th to June 19th, 2013 at Kinectrics' High Voltage Laboratories. The following tests were included in the electrical test sequence:

1. Bending Test (IEC 60502-2, Clause 18.1.3)
2. Partial Discharge Test (IEC 60502-2, Clause 18.1.4)
3. Tan δ Measurement (IEC 60502-2, Clause 18.1.5)
4. Heat Cycle Test (IEC 60502-2, Clause 18.1.6)
5. Partial Discharge Test (IEC 60502-2, Clause 18.1.4)
6. Impulse Test (IEC 60502-2, Clause 18.1.7)
7. Voltage Test (IEC 60502-2, Clause 18.1.7)
8. High Voltage A.C. Test for 4 H (IEC 60502-2, Clause 18.1.8).
9. Resistivity of semi-conducting screen (IEC 60502-2, Clause 18.1.9)
10. Electrical resistance of conductors (IEC 60502-2, Clause 16.2)

The results of the tests show that the tested cable is in compliance with IEC 60502-2:2005.

2.1 TEST SET UP, TEST PROCEDURES AND TEST RESULTS

2.1.1 Bending Test (IEC 60502-2, Clause 18.1.3)

A 25 m long piece of the test specimen was subjected to a bending test in accordance with clause 18.1.3 of IEC 60502-2-2005-03. The test piece was bent around a wooden reel on May 14, 2013 at ambient temperature. The diameter of the reel was 1783 mm. The test consisted of three cycles. During each cycle the whole sample was bent and unwound around the reel at ambient temperature for at least one complete turn and then the process was repeated in the reverse direction without axial rotation.

The test results are summarized in Table 2.1.

Table 2.1: Test Results from Bending Test

Outer diameter of the cable D (mm)	Diameter of the conductor d (mm)	Required bending diameter 15(D+d) ± 5% (mm)	Diameter of bending drum (mm)	Comments
94.0	20.5	1718 ± 85.9	1783	Performed 3 cycles (wind/unwind and wind /unwind in opposite direction)

NOTE: Two pieces were cut from the bent 25m long bent piece. A 17m long piece was assigned for the following electrical type test procedures. A 8m long piece was assigned for the water penetration test.

Result: *The test was completed successfully.*

2.1.2 Partial Discharge Test (IEC 60502-2, Clause 18.1.4)

A 15m long test piece was cut from the specimen subjected to the bending test (described in 2.1.1) and was subjected to a partial discharge test in accordance with clause 18.1.4 of IEC 60502-2-2005-03.
The sensitivity of the measuring equipment was better than 5 pC. The test voltage was raised gradually to and held at 17.4 kV for 10 s and then slowly reduced to 15 kV. There was no detectable discharge exceeding the declared sensitivity from the test object at 15 kV.

The test results are presented in Table 2.2.

Table 2.2: Test Results from initial PD Test

Date	Voltage (kV)	Partial Discharge (PD) level (pC)	Maximum allowable PD level (pC)	Result
May 17, 2013	15	0	5	pass

Result: *The test was completed successfully.*

2.1.3 Tan δ measurement (IEC 60502-2, Clause 18.1.5)

A Tan δ measurement in accord with clause 18.1.5 of IEC 60502-2-2005-03 was performed on the test piece that was subjected to the partial discharge test (described in 2.1.2).
The sample was heated by passing current through the conductor until the conductor reached a temperature which was 5 °C to 10 °C above the maximum conductor temperature in normal operation. The actual measurement was taken at conductor temperature of 96.7 °C and applied alternating voltage of 2.45kV.
The measured value was 1.59×10^{-4}.

The test results are presented in Table 2.3.

Table 2.3: Test Results from Tan δ Test

Date	Applied Voltage (kV)	Tan δ ($x10^{-4}$)	Maximum allowable Tan δ ($x10^{-4}$)	Result
May 24, 2013	2.45	1.59	40	Pass

Result: *The test was completed successfully.*

2.1.4 Heating cycle test followed by partial discharge test (IEC 60502-2, Clause 18.1.6)

A heating cycle test in accord with clause 18.1.6 of IEC 60502-2-2005-03 was performed on the test piece that was subjected to the Tan δ test (described in 2.1.3).

The test sample was heated by passing a current through the conductor, until the conductor reached a steady temperature 5 °C to 10 °C above the maximum conductor temperature in normal operation.
Each heating cycle was of at least 8 h duration. The conductor temperature was maintained within the stated temperature limits for at least 2 h of each heating period. This was followed by at least 3 h of natural cooling in air to a conductor temperature within 10 K of ambient temperature. This cycle was carried out 20 times.

The test results are presented in Table 2.4. A plot of the completed 20 heat cycles is in Appendix B.

Table 2.4: Test Results from Heating cycle Test

No of heating cycles	Dates	Required conductor temperature (^{o}C)	Applied heating current (A)	Heating (h)	Soaking (h)	Cooling (h)	Result
20	May 24, 2013 to June 1, 2013	95 – 100 ^{o}C	550-700	3	2	3	Pass

Result: *The test was completed successfully.*

2.1.5 Partial Discharge Test (IEC 60502-2, Clause 18.1.4)

After cooling down to ambient temperature, after the last heat cycle, the test specimen was subjected to a partial discharge test in accordance with clause 18.1.4 of IEC 60502-2-2005-03 on June 4, 2013. The measurements were performed once again as described in item 2.1.2 above.

The test results are presented in Table 2.5.

Table 2.5: Test Results from PD Test

Date	Voltage (kV)	Partial Discharge (PD) level (pC)	Maximum allowable PD level (pC)	Result
June 4, 2013	15	0	5	pass

Result: *The test was completed successfully.*

2.1.6 Impulse test followed by a voltage test (IEC 60502-2, Clause 18.1.7)

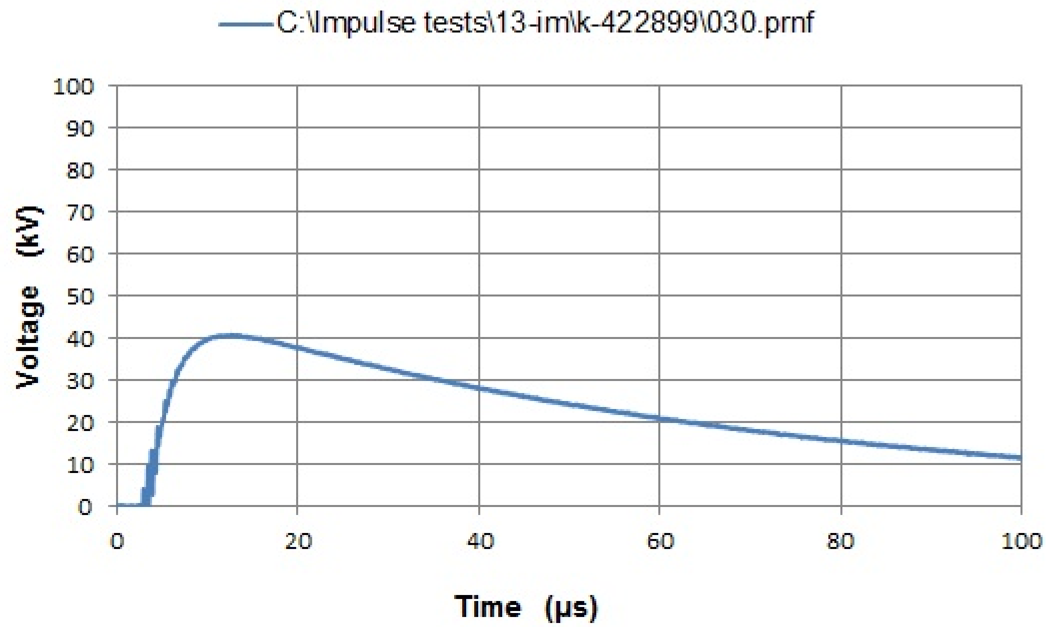
Following the partial discharge test described in item 2.1.5 above, the cable test piece was subjected to a lightning impulse test as described in clause 18.1.7 of IEC 60502-2-2005-03 on June 5, 2013. The test consisted of applying 10 positive and 10 negative impulses with peak values of 95 kV. The voltage was applied between the conductor and the screen which was earthed. At the beginning of the test the temperature of the conductor was 99.5 ^{o}C. The temperature was maintained stable around this value during the test by keeping the heating current on while charging the impulse generator capacitors. At the end of the test, the temperature of the conductor was 95.3^{o}C.

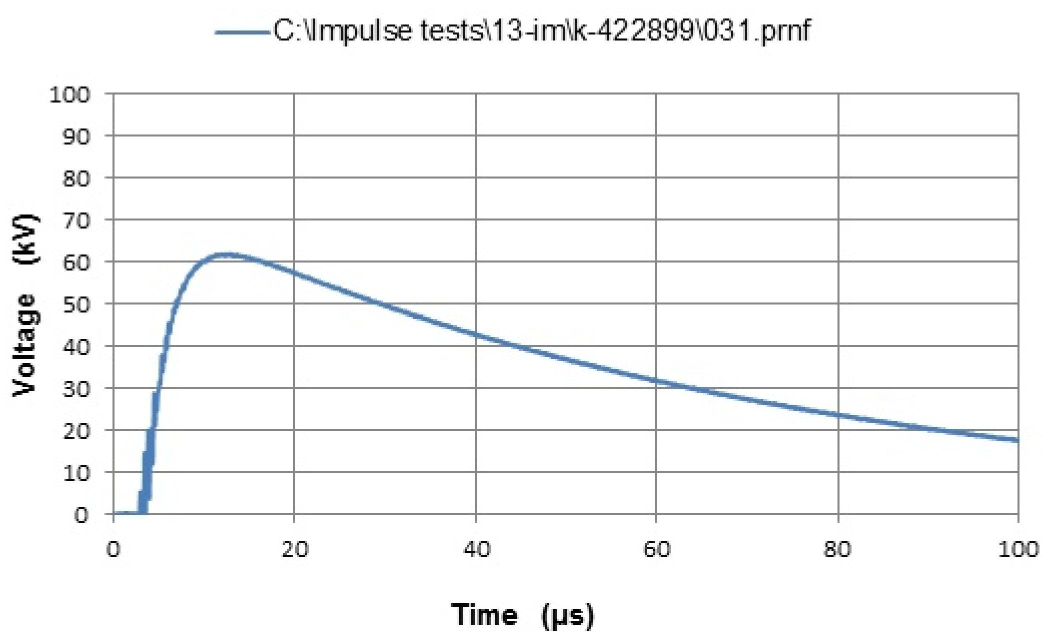
The test results are presented in Table 2.6. The plots in Fig. 2.1 show all positive lightning impulses applied to the test specimen and Fig.2.2 shows all negative lightning impulses applied to the test specimen.

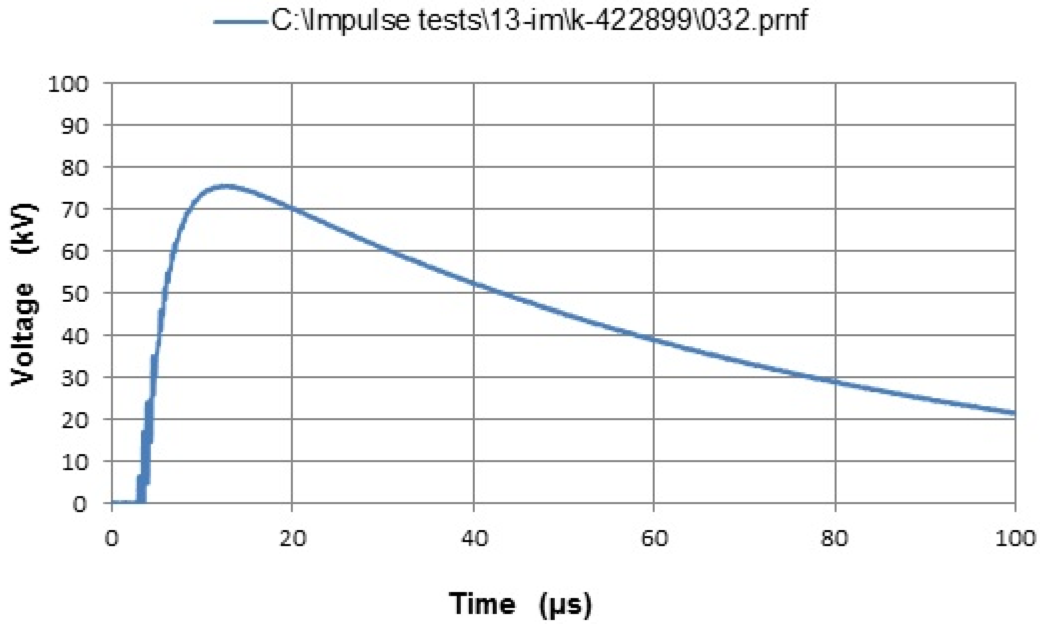
Table 2.6: Test Results from Lightning Impulse Test

Waveform No.	Peak (kV)	Front (µs)	Tail (µs)	Comment
C:\Impulse tests\13-im\k-422899\030.prnf	41.1	3.8	48.9	Conditioning
C:\Impulse tests\13-im\k-422899\031.prnf	62.2	3.9	49.0	Conditioning
C:\Impulse tests\13-im\k-422899\032.prnf	76.0	3.8	49.1	Conditioning
C:\Impulse tests\13-im\k-422899\033.prnf	94.8	4.0	49.2	1
C:\Impulse tests\13-im\k-422899\034.prnf	94.8	4.0	49.1	2
C:\Impulse tests\13-im\k-422899\035.prnf	94.7	3.9	49.0	3
C:\Impulse tests\13-im\k-422899\036.prnf	94.8	4.0	49.2	4
C:\Impulse tests\13-im\k-422899\037.prnf	94.5	3.9	49.1	5
C:\Impulse tests\13-im\k-422899\038.prnf	95.4	3.9	49.1	6
C:\Impulse tests\13-im\k-422899\039.prnf	95.5	3.9	49.2	7
C:\Impulse tests\13-im\k-422899\040.prnf	95.4	4.0	49.1	8
C:\Impulse tests\13-im\k-422899\041.prnf	95.4	3.9	49.0	9
C:\Impulse tests\13-im\k-422899\042.prnf	95.5	3.9	49.2	10
C:\Impulse tests\13-im\k-422899\043.prnf	-41.1	4.0	48.9	Conditioning
C:\Impulse tests\13-im\k-422899\044.prnf	-62.3	4.0	49.0	Conditioning
C:\Impulse tests\13-im\k-422899\045.prnf	-76.1	4.0	49.0	Conditioning
C:\Impulse tests\13-im\k-422899\046.prnf	-94.8	4.0	49.1	1
C:\Impulse tests\13-im\k-422899\047.prnf	-94.7	4.0	49.0	2
C:\Impulse tests\13-im\k-422899\048.prnf	-94.8	4.0	49.0	3
C:\Impulse tests\13-im\k-422899\049.prnf	-94.8	4.0	49.1	4
C:\Impulse tests\13-im\k-422899\050.prnf	-94.8	4.0	49.0	5
C:\Impulse tests\13-im\k-422899\051.prnf	-94.9	4.0	49.1	6
C:\Impulse tests\13-im\k-422899\052.prnf	-94.8	4.0	49.1	7
C:\Impulse tests\13-im\k-422899\053.prnf	-94.7	4.0	49.1	8
C:\Impulse tests\13-im\k-422899\054.prnf	-94.8	4.0	49.1	9
C:\Impulse tests\13-im\k-422899\055.prnf	-94.7	4.3	49.6	10

Fig 2.1: Positive lightning impulses captured during lightning impulse testing



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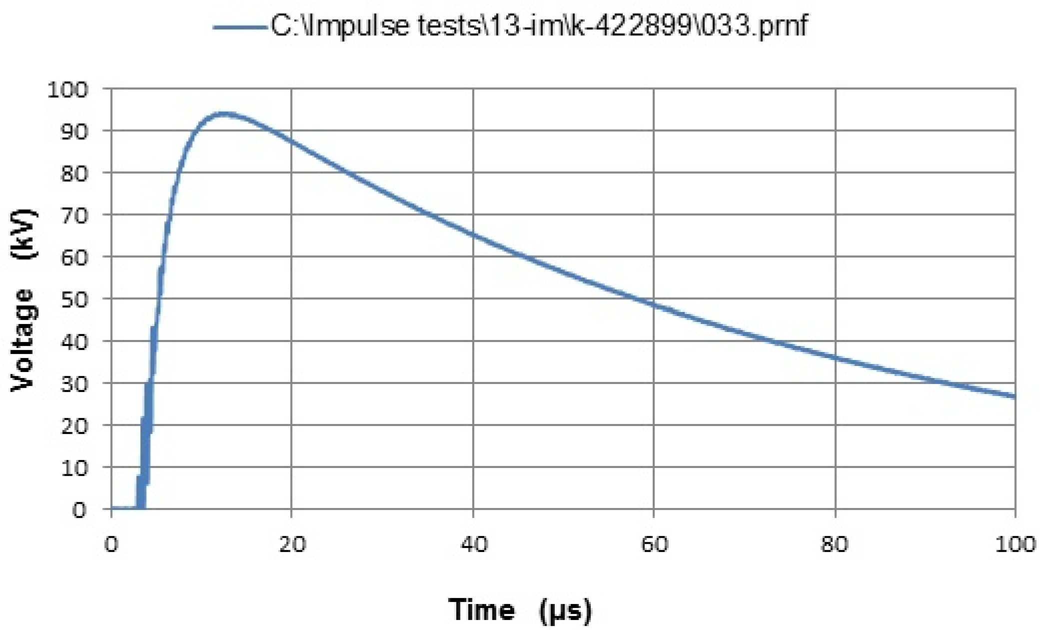
20
40
60
80
100
Time (µs)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Voltage (kV)
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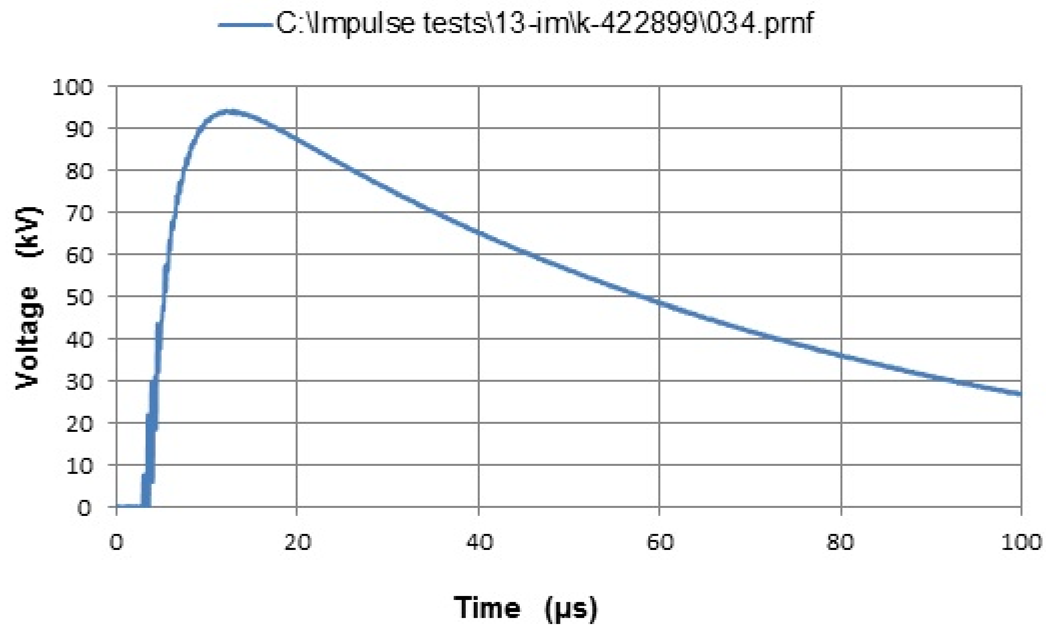
40
60
80
100
Time (µs)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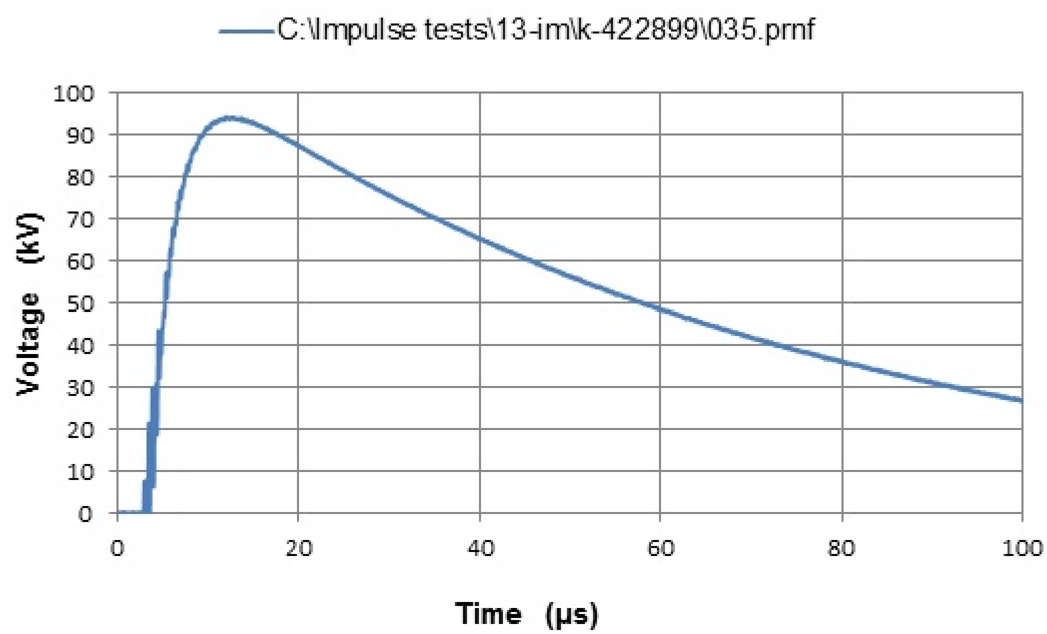
0
20
40
60
80
100
Time (µs)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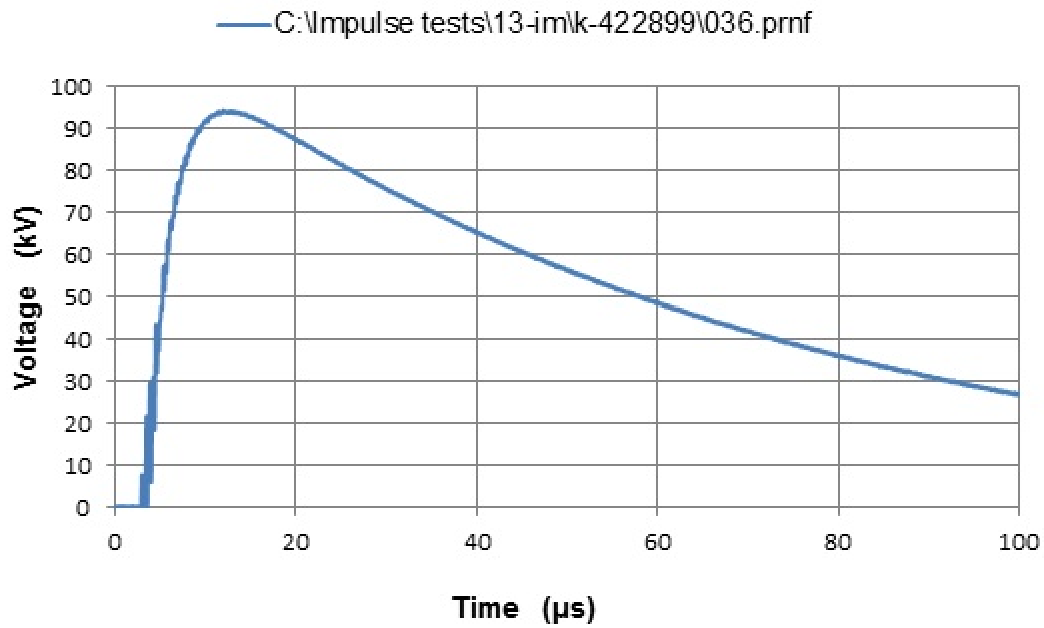
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)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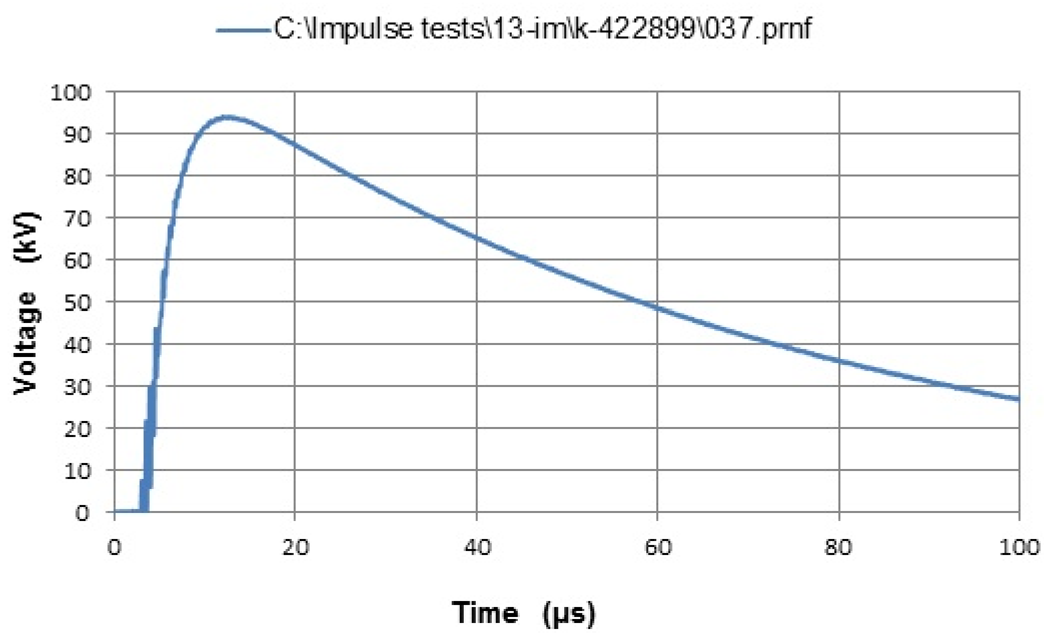
20
40
60
80
100
Time (µs)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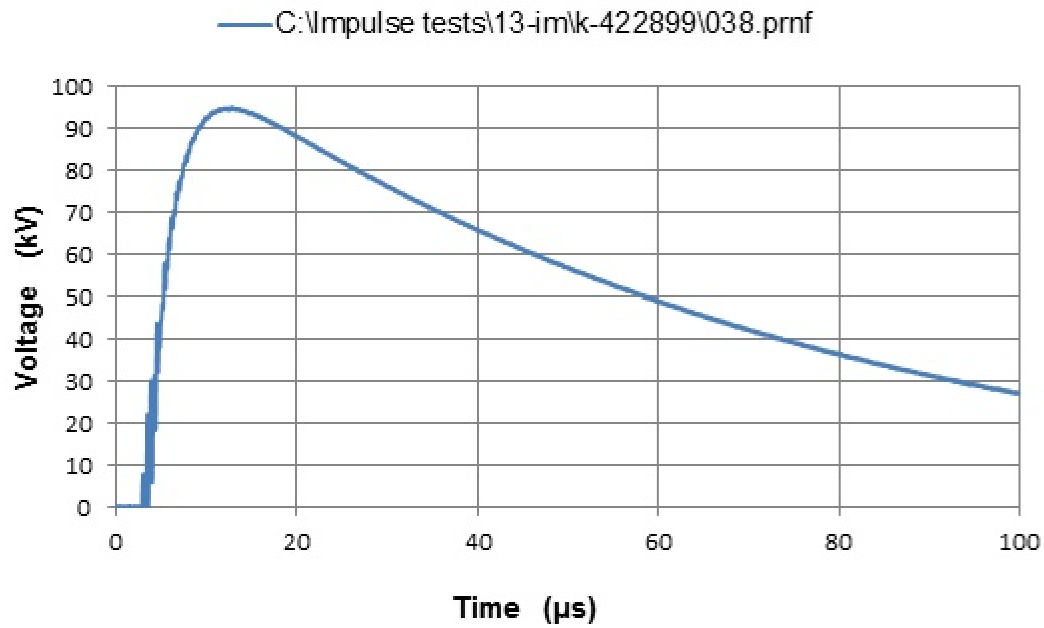
40
60
80
100
Time (µs)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60
50
40
30
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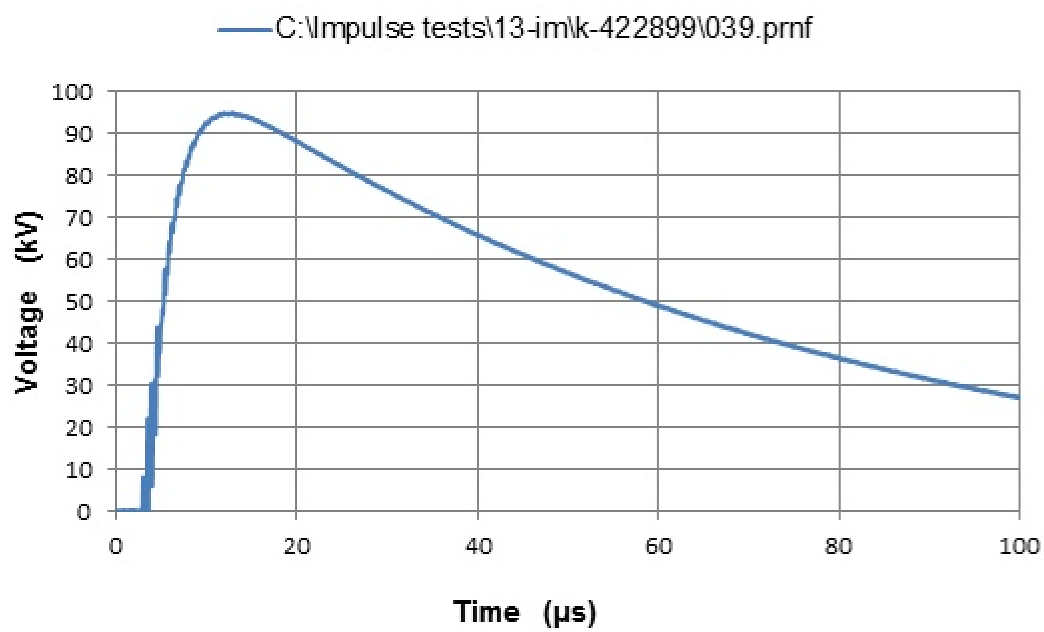
0
20
40
60
80
100
Time (µs)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Voltage (kV)
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60
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40
30
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10
0
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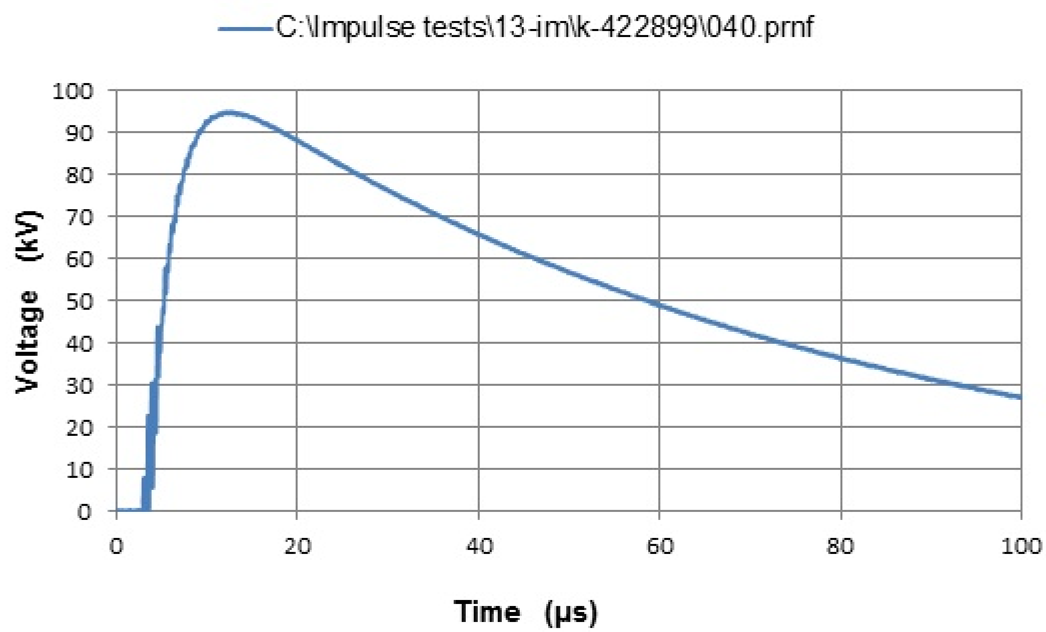
20
40
60
80
100
Time (µs)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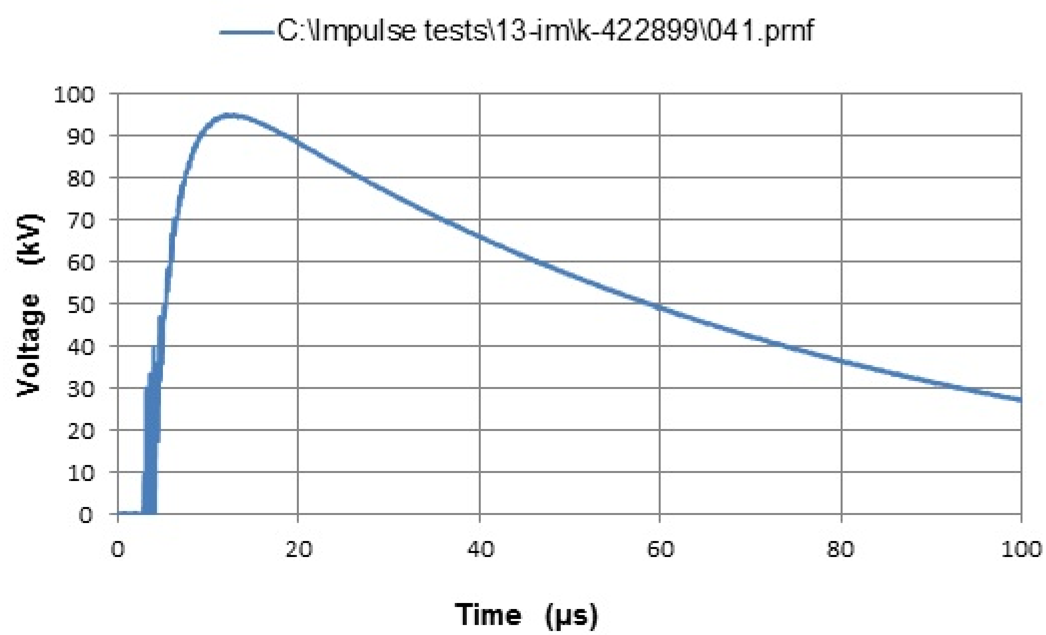
60
80
100
Voltage (kV)
Time (µs)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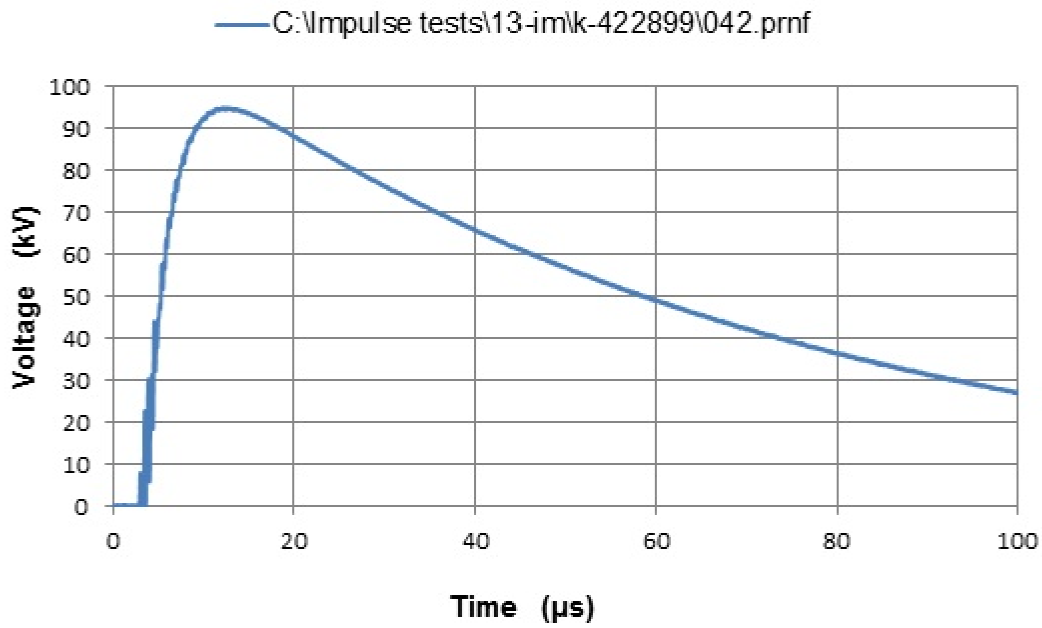
60
80
100
Voltage (kV)
Time (µs)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80
70
60
50
40
30
20
10
0
Voltage (kV)
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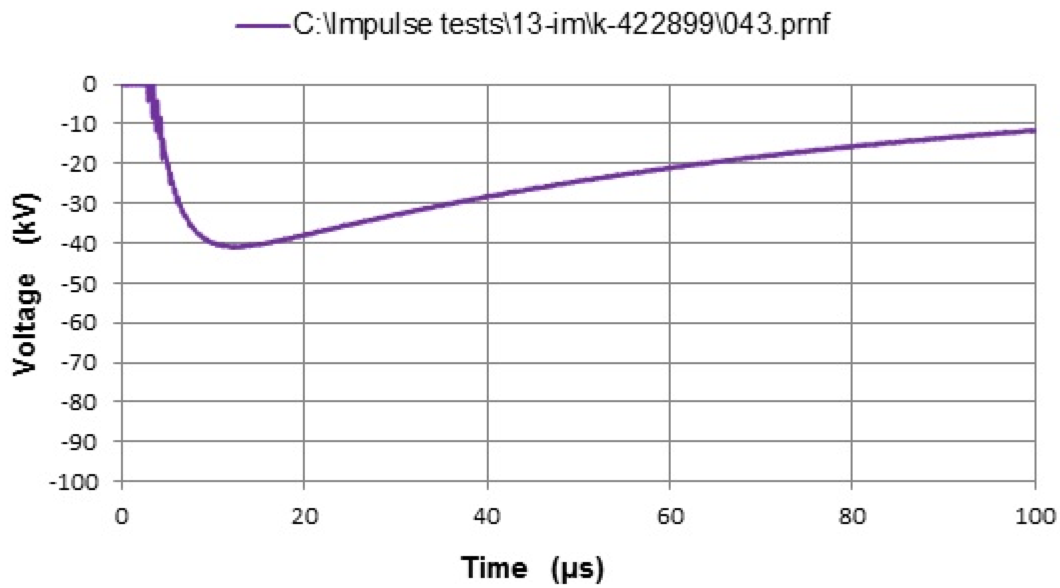
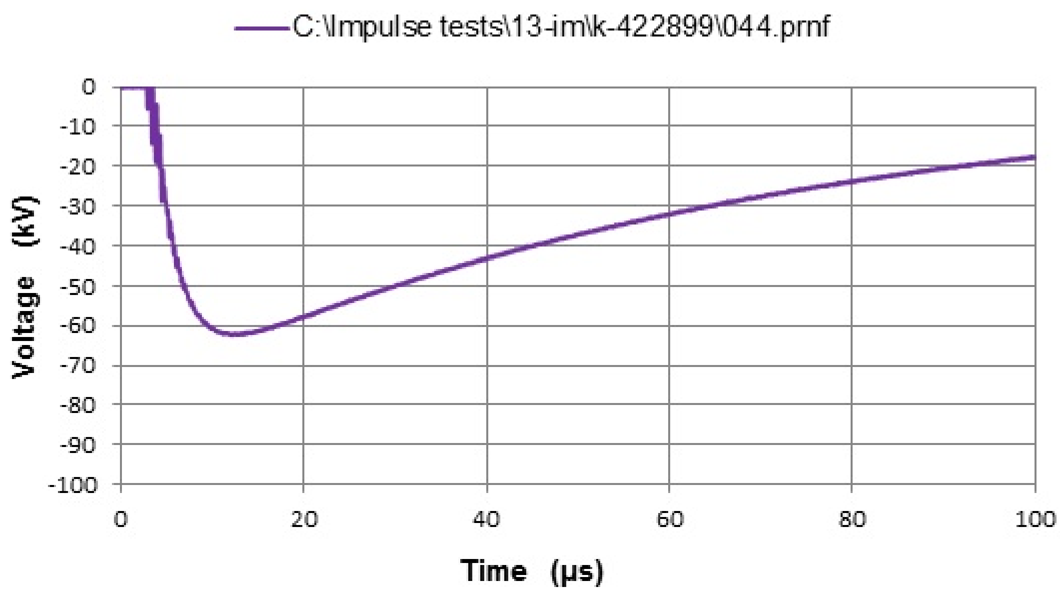
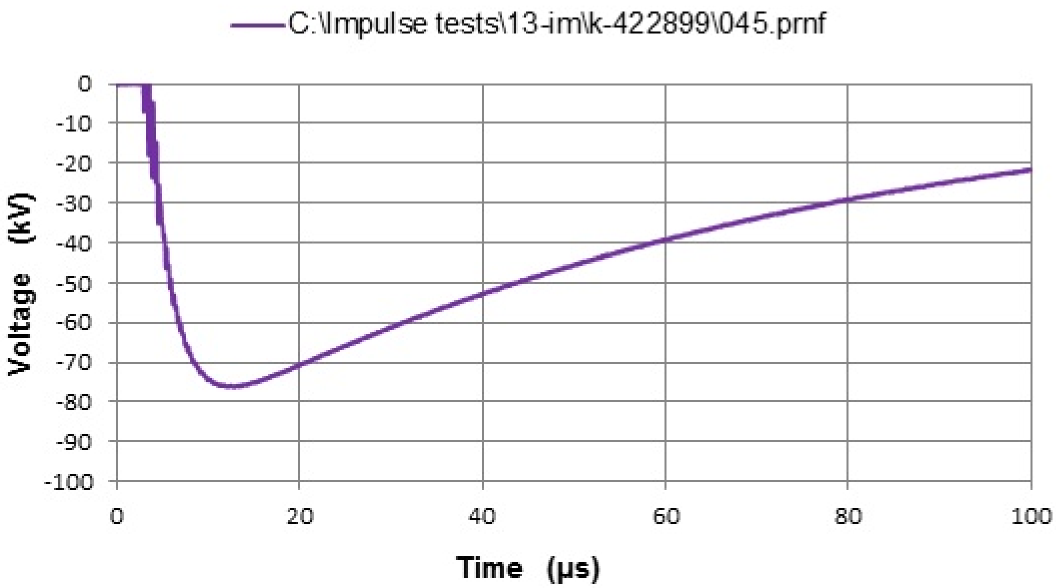
20
40
60
80
100
Time (µs)

Fig 2.2: Negative lightning impulses captured during lightning impulse testing



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Voltage (kV)
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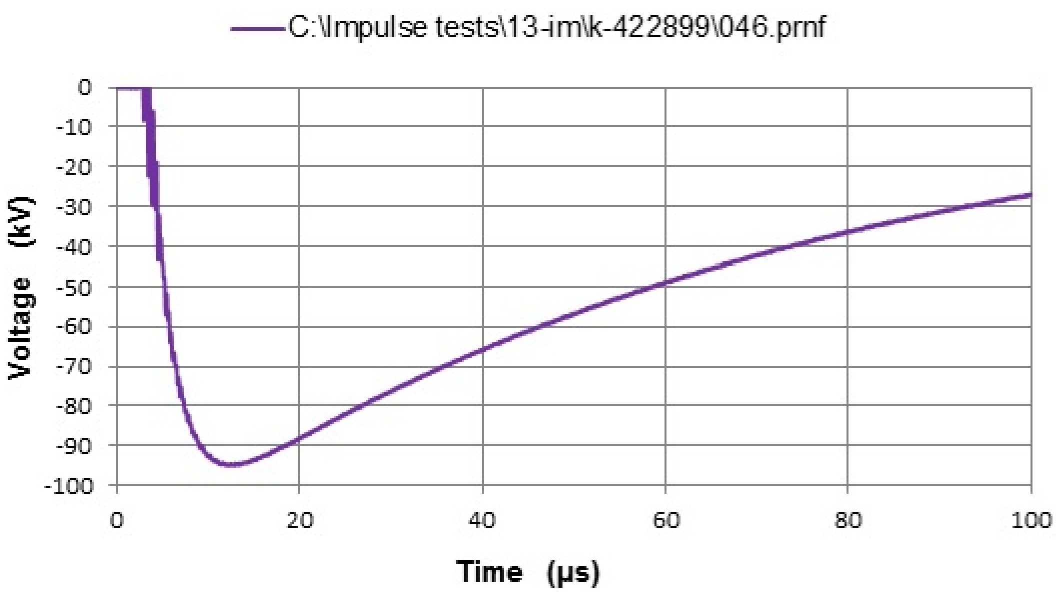
20
40
60
80
100
Time (μs)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Voltage (kV)
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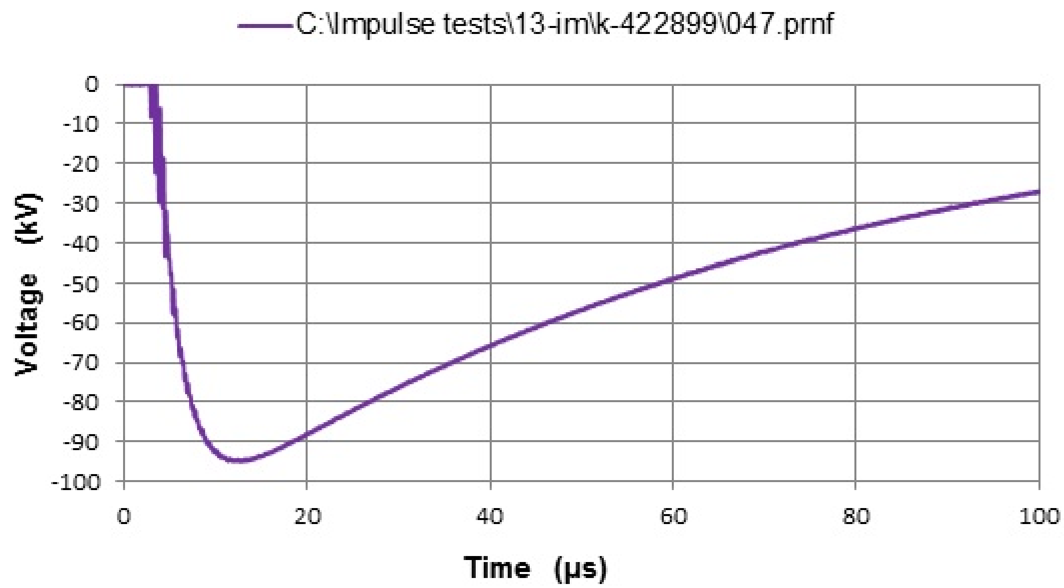
40
60
80
100
Time (μs)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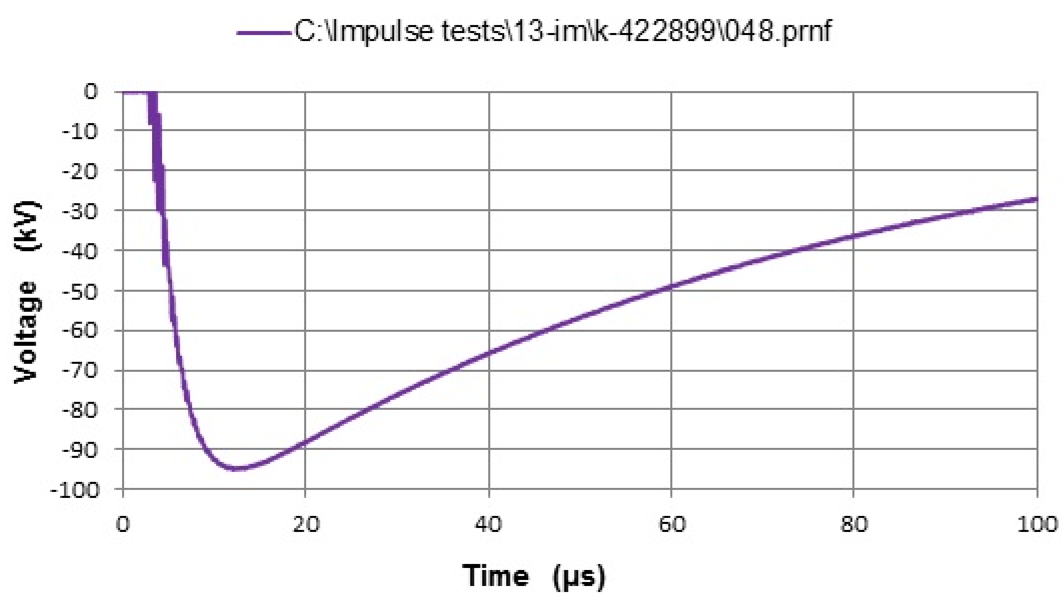
-100
0
20
40
60
80
100
Time (µs)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0
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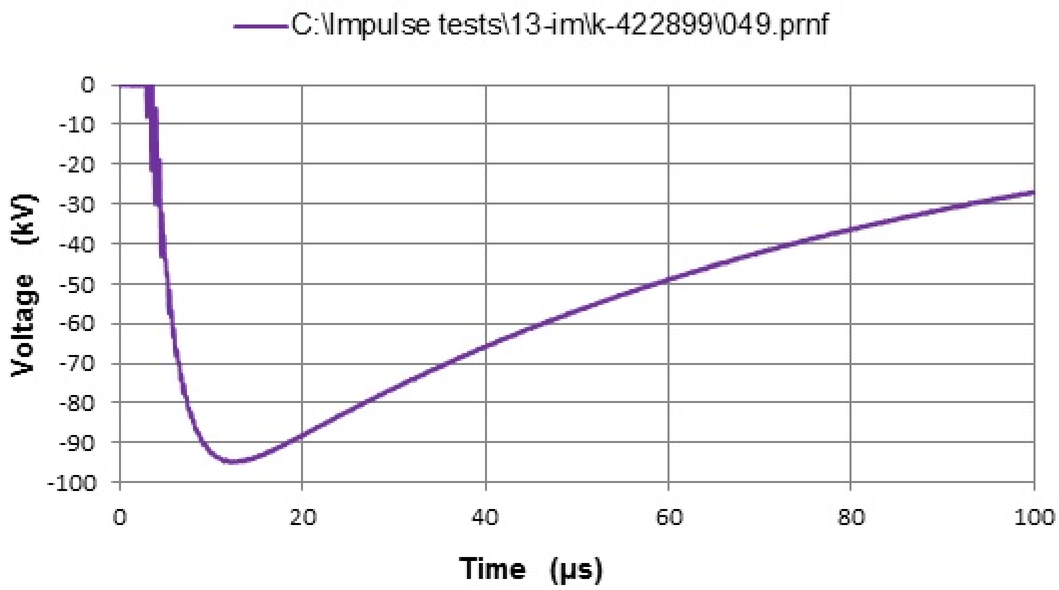
40
60
80
100
Time (µs)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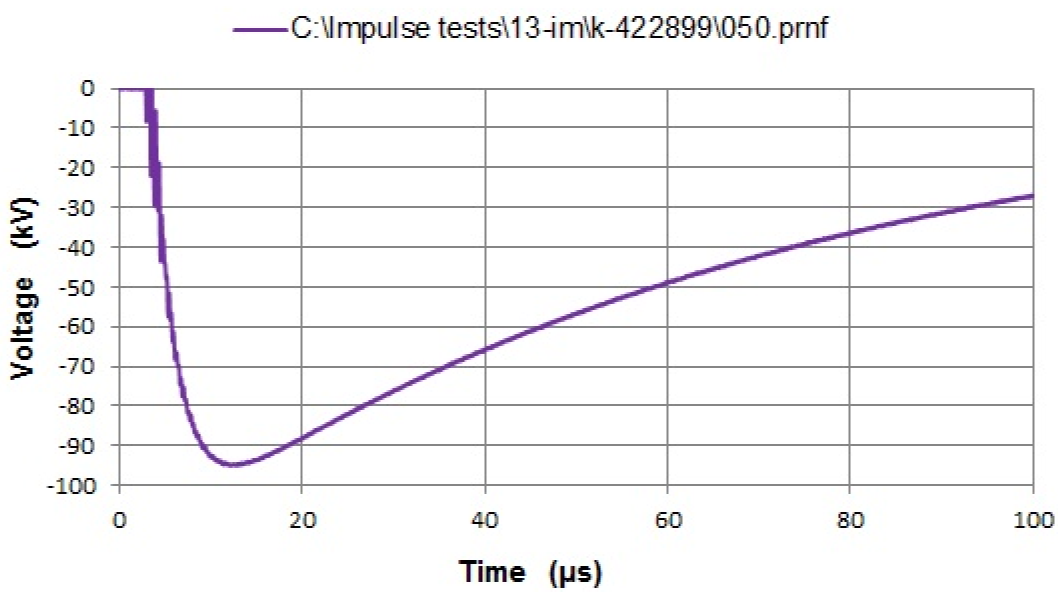
60
80
100
Time (µs)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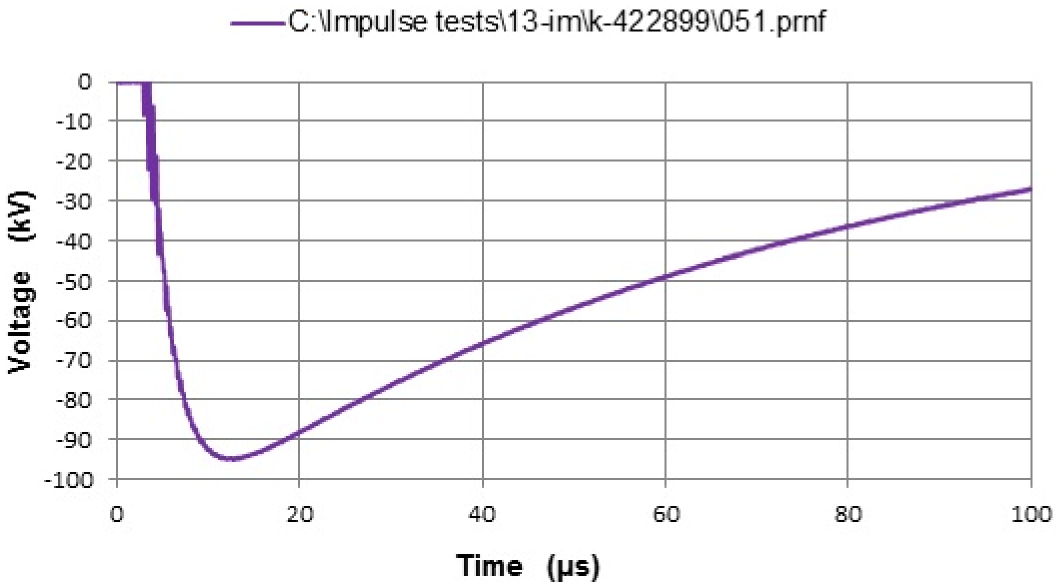
40
60
80
100
Time (µs)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-80
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Voltage (kV)
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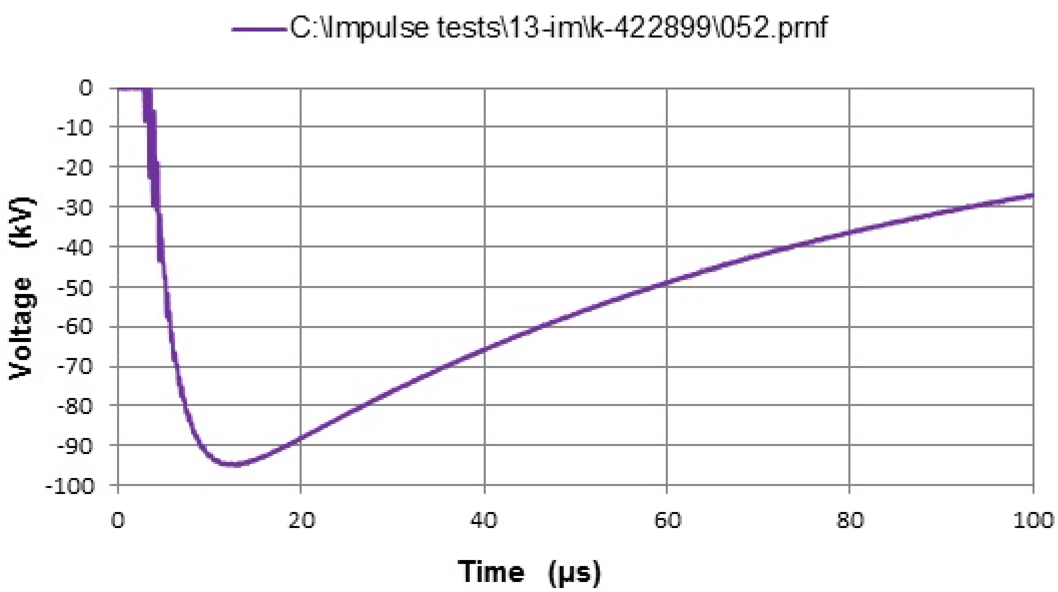
60
80
100
Time (µs)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Voltage (kV)
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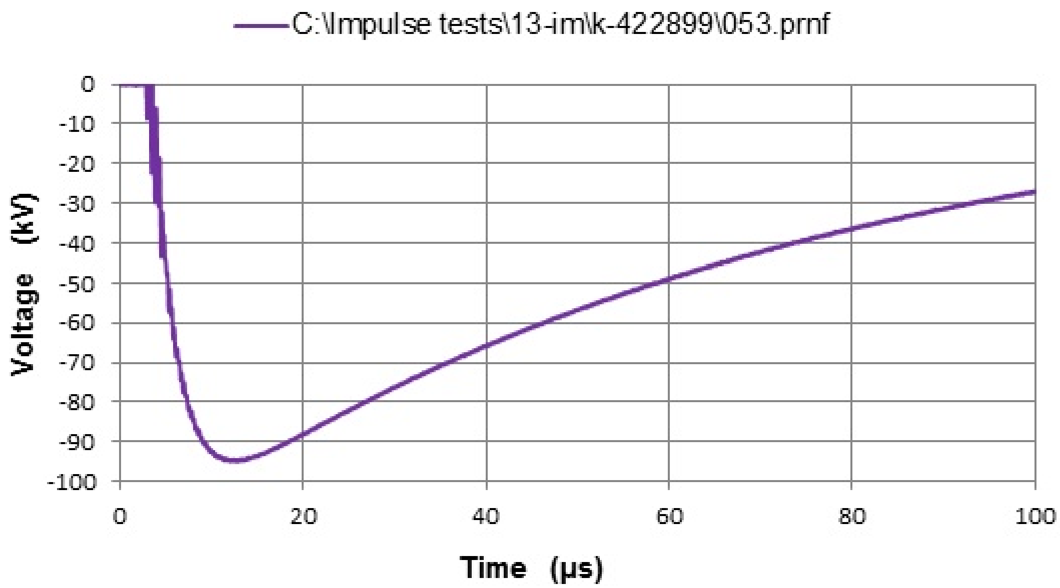
Time (µs)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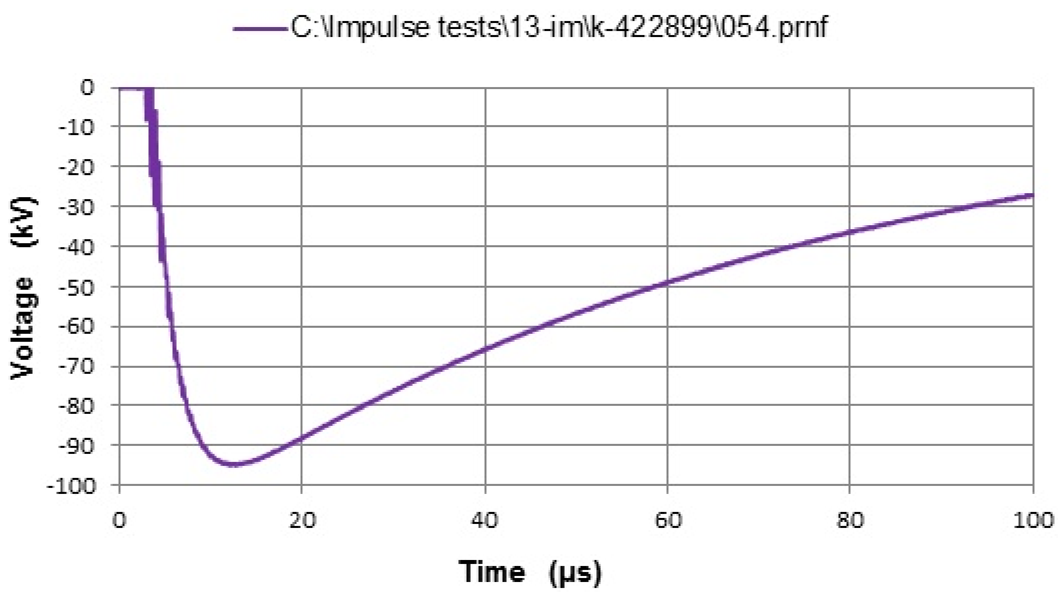
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Voltage (kV)
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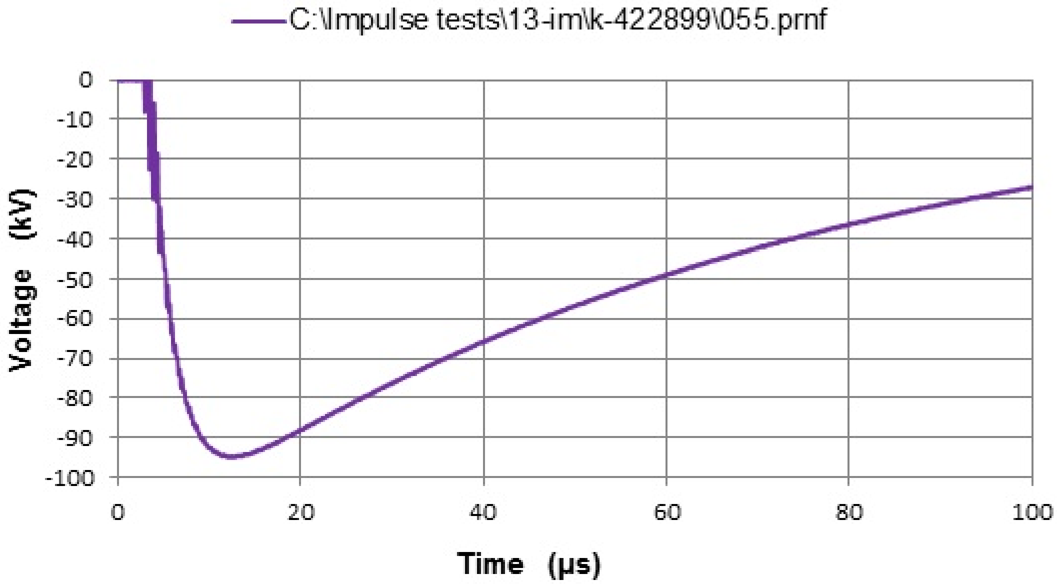
Time (µs)



Result: *The test was completed successfully.*

2.1.7 Voltage test (IEC 60502-2, Clause 18.1.7)

The cable test piece was subjected to a voltage withstand test as per the requirements of clause 18.1.7 of IEC 60502-2-2005-03.

Upon completion of the hot lightning impulse test, described in item 2.1.6 above, the test piece was subjected to a power frequency voltage of 30.5 kV, 60 Hz for 15 minutes without flashover.

The test results are presented in Table 2.7.

Table 2.7: Test Results from 15 min. Voltage Test

Date	Applied Voltage (kV)	Frequency (Hz)	Duration (min)	Comments	Result
June 6, 2013	30.5	60	15	No breakdown	Pass

Result: *The test was completed successfully.*

2.1.8 Voltage test for 4 hours (IEC 60502-2, Clause 18.1.8)

The cable test piece was subjected to a voltage test for 4 hours in accordance with clause 18.1.8 of IEC 60502-2-2005-03. The test was performed at power frequency voltage of 34.8 kV, 60 Hz, for 4 hours. The voltage was applied between the conductor and core screen at ambient temperature.

The test results are presented in Table 2.8.

Table 2.8: Test Results from 4 hr Voltage Test

Date	Applied Voltage (kV)	Frequency (Hz)	Duration (h)	Comments	Result
June 6, 2013	34.8	60	4	No breakdown	Pass

Result: *The test was completed successfully.*

2.1.9 Resistivity of semi-conducting screen (IEC 60502-2, Clause 18.1.9)

Two test pieces were prepared from 150 mm samples of each cable core that were not involved in the rest of the electrical test sequence. From each core, half-cross-section samples were prepared for measuring the conductor screen. The full-cross-section samples were prepared for the measurement of the insulation screen. Electrodes were applied with silver paint and connection leads applied with silver epoxy. All samples were placed in an oven preheated to 100^{o}C. After at least 30 min. in the oven the resistance between the electrodes was measured.

The results are given in Table 2.9. The measured resistivity before and after thermal ageing of both the insulation and conductor screens were within the standard requirements.

Table 2.9: Semicon Resistivity Test Results

Test Item	Requirement	Measured Value			Result
		Yellow	Red	Blue	
Conductor screen as made	Max: 1000 Ωm	14.1 Ωm	17.4 Ωm	16.3 Ωm	Pass
Conductor screen after ageing	Max: 1000 Ωm	13.8 Ωm	17.3 Ωm	16.1 Ωm	Pass
Insulation screen as made	Max: 500 Ωm	9.7 Ωm	10.7 Ωm	9.8 Ωm	Pass
Insulation screen after ageing	Max: 500 Ωm	23.5 Ωm	28.7 Ωm	25.6 Ωm	Pass

Result: *The test was completed successfully.*

2.1.10 Electrical resistance of conductors (IEC 60502-2, Clause 16.2)

The test was based on the method described in IEC 60502-2, Clause 16.2. The test was performed on June 19, 2013. A 1.0 meter sample of conductor was used for the test. Alligator-type clips were used to connect a calibrated current source of 10 A to the wire.

Three measurements were taken to assure that the lowest reading is recorded. The DC resistance was corrected to a 1 km length and 20ºC in accordance with the formulae and factors given in IEC 60228: 2004; Annex 'A'.

$$R_{20} = R_t \times k_t \times \frac{1\,000}{L}$$

Where:
k_t – temperature correction factor taken from Table A.1 of IEC 60228 (equal to 1.000 for 20ºC)
R_{20} – conductor resistance at 20ºC, in Ω/km
R_t – measured conductor resistance, in Ω.
L – length of the cable, in m.

R_{20} = 0.0000564 x 0.980 x 1000 = 0.0553 Ω/km

Tested By: P. Fong
Date: June 19, 2013
Equipment: Micro-Ohmmeter Model 6250 KIN-253986 Calibration due: August 17, 2013

A summary of individual results for Electrical resistance of conductors Test is given in Table 2.10. The test results show that the measured dc resistance of the copper conductor core meets the requirements for a maximum resistance of 0.0601 Ω/km at 20ºC as specified in Table 2 of IEC 60228.

Table 2.10 Summary of Electrical resistance of conductors

Core No.	Measured DC Resistance in micro-Ohms at 25 ºC, Gauge Length is 1.0 m	Calculated DC Resistance in Ohms per 1 km of cable at 20 ºC	Result
1	56.3	0.0552	Pass
2	56.5	0.0554	Pass
3	56.4	0.0553	Pass

Result: *The test was completed successfully.*

3.0 NON-ELECTRICAL TESTS

At the request of National Cables Industry, Kinectrics International Inc. performed type tests on a 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry in accordance with IEC 60502-2:2005.

The tests were performed from May 25 to June 24, 2013 at Kinectrics' Laboratories. The following tests in accordance with IEC 60502-2:2005 were included in the non-electrical test sequence:

1. Measurement of insulation thickness (IEC 60502-2, 19.1 and IEC 60811-201: 2012)
2. Measurement of thickness of non-metallic sheaths (including extruded separation, but excluding inner covering); (IEC 60502-2, 19.2 and IEC 60811-202: 2012)
3. Determination of conductor diameter and number of wires (IEC 60502-2, 17.4)
4. Test for determination of the mechanical properties of insulation before and after ageing (IEC 60502-2, 19.3 IEC 60811-401: 2012, IEC 60811-501: 2012, and IEC 60811-512: 2012)
5. Test for determination of the mechanical properties of non-metallic sheaths before and after ageing (IEC 60502-2, 19.4, IEC 60811-401: 2012, IEC 60811-501: 2012, and IEC 60811-512: 2012)
6. Additional ageing test on pieces of completed cable (IEC 60502-2, 19.5, IEC 60811-401: 2012, and IEC 60811-501: 2012)
7. Loss of mass test on PVC sheaths of type ST2 (IEC 60502-2, 19.6 and IEC 60811-409: 2012)
8. Pressure test at high temperature on sheath (IEC 60502-2, 19.7 and IEC 60811-508: 2012)
9. Test on PVC sheaths at low temperature (IEC 60502-2, 19.8, IEC 60811-505: 2012, and IEC 60811-506: 2012)
10. Test for resistance of PVC sheaths to cracking (heat shock test); (IEC 60502-2, 19.9 and IEC 60811-509: 2012)
11. Hot set test for XLPE insulation (IEC 60502-2, 19.11 and IEC 60811-507: 2012)
12. Water absorption test on insulation (IEC 60502-2, 19.13 and IEC 60811-402: 2012)
13. Flame spread test on single cables (IEC 60502-2, 19.14 and IEC 60332-1-2: 2004)
14. Shrinkage test for XLPE insulation (IEC 60502-2, 19.16 and IEC 60811-502: 2012)
15. Strippability test for insulation screen (IEC 60502-2, 19.21)
16. Measurement of Insulation and Conductor Screens (For Information).

The results of the tests show that the tested cable is in compliance with IEC 60502-2:2005, and therefore meets the requirements of IEC 60502-2: 2005, "**Power cables with extruded insulation and their accessories for rated voltages from 1 kV (*U*m = 1,2 kV) up to 30 kV (*U*m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (*U*m = 7,2 kV) up to 30 kV (*U*m = 36 kV)**"

3.1 TEST SET UP, TEST PROCEDURES AND TEST RESULTS

3.1.1 Measurement of insulation thickness

The insulation thickness was measured according to IEC 60502-2; clause 19.1 and IEC 60811-201: 2012.

The minimum insulation thickness at any point shall be ≥ 3.95 mm and the nominal thickness of insulation at rated voltage is 4.50 mm per IEC 60502-2:2005. The concentricity shall be ≤ 0.15.

Table 3.1 shows the measured thicknesses.

Table 3.1: Insulation Thickness

Item	Nominal Thickness (mm)	Minimum Thickness (mm)	Minimum Thickness Requirement (mm)	Result
Yellow Conductor	4.50	4.31	3.95	PASS
Red Conductor	4.50	4.37	3.95	PASS
Blue Conductor	4.50	4.34	3.95	PASS

Item	Calculated Concentricity	Maximum Concentricity Requirement	Result
Yellow Conductor	0.08	0.15	PASS
Red Conductor	0.04	0.15	PASS
Blue Conductor	0.04	0.15	PASS

Tested By: E. Rasile / N. Sek
Date: May 27, 2013
Equipment: Nikon V-12 133736-0 Calibration due: September 25, 2013

Result: *The insulation for the yellow, red and blue conductors meets the thickness and concentricity requirements.*

3.1.2 Measurement of thickness of non-metallic sheaths

Measurement of thickness of the non-metallic sheaths was carried out in accordance with IEC 60502-2: 2005 clause 19.2.

The minimum thickness of the outer non-metallic sheath at any point shall be ≥ 2.76 mm and the nominal thickness of the outer non-metallic sheath at rated voltage is 3.70 mm per IEC 60502-2:2005.

The minimum thickness of the inner non-metallic sheath at any point shall be ≥ 1.40 mm and the nominal thickness of the outer non-metallic sheath at rated voltage is 2.00 mm per IEC 60502-2:2005.

Table 3.2 shows the measured thicknesses.

Table 3.2: Non-Metallic Sheath Thickness

Item	Nominal Thickness	Minimum Thickness (mm)	Minimum Thickness Requirement (mm)	Result
Thickness of ST_2 PVC outer sheath	3.70	4.88	2.76	PASS
Thickness of ST_2 PVC inner sheath	2.00	2.20	1.40	PASS

Tested By: E. Rasile / N. Sek
Date: June 14, 2013
Equipment: Nikon SMZ-1500 200 2027-0 Calibration due: April 19, 2014

Result: *The non-metallic outer and inner sheaths meet the thickness requirements.*

3.1.3 Determination of conductor diameter and number of wires

The conductor was examined according to IEC 60502-2; clause 17.4.

The conductor diameter shall be between 19.7 and 21.6 mm, and the conductor shall be made up of no less than 34 wires as specified in Table C.2 and Table 2 of IEC 60228:2004, respectively.

The conductor diameter measurements are summarized in Table 3.3. A visual inspection showed that each conductor was made up of 61 wires.

Table 3.3: Conductor Diameter

Item	Conductor Diameter (mm)		Minimum Diameter Requirement (mm)	Maximum Diameter Requirement (mm)	Result
	Min	Max			
Yellow Conductor	20.57	20.70	19.7	21.6	PASS
Red Conductor	20.63	20.75	19.7	21.6	PASS
Blue Conductor	20.61	20.71	19.7	21.6	PASS

Tested By: E. Rasile / N. Sek
Date: June 15, 2013
Equipment: Nikon V-12 KIN-133736 Calibration due: September 25, 2013

Results: *The yellow, red and blue conductors meet the requirements.*

3.1.4 Tests determining the mechanical properties of insulation before and after ageing

The mechanical properties of insulation before and after ageing were determined in accordance with IEC 60502-2: 2005 clause 19.3.

Table 3.4 shows the mechanical properties of insulation before and after ageing.

Table 3.4: Results: Determining mechanical properties of insulation before & after ageing

Item	Unit	Requirement	Measured for Each Conductor (Median Value)			Result
			Yellow	Red	Blue	
Without Ageing						
Tensile strength	N/mm²	≥12.5	28.4	27.5	28.7	PASS
Elongation	%	≥200	597.5	573.5	597	PASS
After Ageing						
Tensile strength	N/mm²	-	28.9	27.6	26.6	PASS
Measured variation with samples without ageing	%	±25 max.	1.7	0.2	-7.4	PASS
Elongation	%	-	615.6	610.4	601.3	PASS
Measured variation with samples without ageing	%	±25 max.	3.0	6.4	0.7	PASS

Tested By: E. Rasile / N. Sek
Date: May 23, 2013 / June 6, 2013
Equipment: Mitutoyo CD_6’’ CP 10098-0 Calibration due: August 16, 2013
JJ Lloyd Instruments T5K KIN-11640-0 October 2, 2013.
Scale 0-450 mm KIN-02595 April 3, 2014

Result: *The insulation for the yellow, red and blue conductors meets the test requirements before and after ageing.*

3.1.5 Tests for determining mechanical properties of non-metallic sheaths before and after ageing

The mechanical properties of non-metallic sheaths before and after ageing were determined in accordance with IEC 60502-2: 2005 clause 19.4.

Table 3.5 shows the properties of the non-metallic sheaths before and after ageing.

Table 3.5: Results: Mechanical properties of non-metallic sheaths before & after ageing

Item	Unit	Requirement	Measured (Median Value)		Result
			Inner Sheath	Outer Sheath	
Without Ageing					
Tensile strength	N/mm²	≥12.5	20.8	16.2	PASS
Elongation	%	≥150	284.0	297.0	PASS
After Ageing					
Tensile strength	N/mm²	≥12.5	20.4	15.3	PASS
Measured variation with samples without ageing	%	±25 max.	-2.0	-5.4	PASS
Elongation	%	≥150	266.7	261.0	PASS
Measured variation with samples without ageing	%	±25 max.	-6.1	-12.1	PASS

Tested By: E. Rasile / N. Sek
Date: May 24, 2013 / June 6, 2013
Equipment: Mitutoyo CD_6'' CP 10098-0 Calibration due: August 16, 2013
JJ Lloyd Instruments T5K KIN-11640-0 October 2, 2013.
Scale 0-450 mm KIN-02595 April 3, 2014

Result: *The inner and outer non-metallic sheaths meet the requirements.*

3.1.6 Additional ageing on pieces of completed cable

An additional ageing test on pieces of completed cable was performed in accordance to IEC 60502-2: 2005 clause 19.5.

Tables 3.6 and 3.7 show the results of the additional ageing tests on pieces of completed cables.

Table 3.6: Additional ageing test results of insulation

Item	Unit	Requirement	Measured for Each Conductor (Median Value)			Result
			Yellow	Red	Blue	
Tensile strength	N/mm²	-	24.8	25.6	24.6	PASS
Measured variation with samples without ageing	%	±25 max.	-12.8	-7.0	-14.1	PASS
Elongation	%	-	574.3	572.3	552.0	PASS
Measured variation with samples without ageing	%	±25 max.	-3.9	-0.2	-7.6	PASS

Table 3.7: Additional ageing test results of outer sheath

Item	Unit	Requirement	Measured (Median Value)		Result
			Inner Sheath	Outer Sheath	
Tensile strength	N/mm²	≥12.5	17.9	13.1	PASS
Measured variation with samples without ageing	%	±25 max.	-13.8	-19.1	PASS
Elongation	%	≥150	253.3	249.6	PASS
Measured variation with samples without ageing	%	±25 max.	-10.8	-16.0	PASS

Tested By: E. Rasile / N. Sek
Date: June 13, 2013
Equipment: Mitutoyo CD_6'' CP 10098-0 Calibration due: August 16, 2013
JJ Lloyd Instruments T5K KIN-11640-0 October 2, 2013.
Scale 0-450 mm KIN-02595 April 3, 2014

Result: *The additional ageing tests on pieces of completed cables meet the requirements.*

3.1.7 Loss of mass test on PVC sheaths of type ST_2

Loss of mass test on PVC sheaths of type ST_2 was performed in accordance to IEC 60502-2: 2005 clause 19.6.

The test results are shown below in Table 3.8.

Table 3.8: Loss of mass on PVC sheaths of type ST_2

Item	Unit	Requirement	Measured	Result
Loss of mass of inner sheath	mg/cm²	≤1.5	0.0004	PASS
Loss of mass of outer sheath	mg/cm²	≤1.5	0.0027	PASS

Tested By: E. Rasile / N. Sek
Date: June 7, 2013
Equipment: Mitutoyo CD_6'' CS 50232-0 Calibration due: December 19, 2015
Mettler AE160 KIN-014218 Calibration due: May 22, 2014

Results: *The sheaths samples meet the requirements of the loss of mass test.*

3.1.8 Pressure test at high temperature on non-metallic sheaths

A pressure test on the non-metallic sheaths at high temperature was carried out in accordance with IEC 60502-2: 2005 clause 19.7.

The test results as per Table 3.9.

Table 3.9: Pressure test at high temperature on non-metallic sheaths

Item	Unit	Requirement	Measured (Median)	Result
Depth of indentation of inner sheath	%	≤50	20.5	PASS
Depth of indentation of outer sheath	%	≤50	11.6	PASS

Tested By: E. Rasile / N. Sek
Date: June 4, 2013
Equipment: Mitutoyo CD_6'' BS 007386 Calibration due: September 20, 2013
Nikon V-12 287187 Calibration due: September 25, 2013

Results: *The sheaths samples meet the requirements for the pressure test at high temperature.*

3.1.9 Test on PVC sheaths at low temperature

Test on PVC sheaths at low temperature was performed in accordance to IEC 60502-2: 2005 clause 19.8.

The test results are shown in Table 3.10.

Table 3.10: Test on PVC sheath at low temperature

Item	Unit	Requirement	Measured		Result
			Sample 1	Sample 2	
Inner Sheath					
Elongation	%	≥20	124.0	129.2	PASS
Cold Impact	Visual	No cracks	No cracks	No cracks	PASS
Outer Sheath					
Elongation	%	≥20	175.7	115.2	PASS
Cold Impact	Visual	No cracks	No cracks	No cracks	PASS

Tested By: E. Rasile / N. Sek
Date: June 13, 2013
Equipment: Mitutoyo CD_6'' CP 10098-0 Calibration due: August 16, 2013
JJ Lloyd Instruments T5K KIN-11640-0 October 1, 2013.
Scale 0-450 mm KIN-02595 April 3, 2014
Fluke 52 KIN-12897-0

Results: *The non-metallic sheaths samples meet the requirements for the test on PVC at low temperature.*

3.1.10 Test for resistance of PVC sheaths to cracking (heat shock test)

Test for resistance of PVC sheaths to cracking (heat shock test) was performed in accordance to IEC 60502-2: 2005 clause 19.9.

The test results are shown in Table 3.11.

Table 3.11: Test for resistance of PVC sheaths to cracking (heat shock test)

Item	Unit	Requirement	Observed Cracks (Yes/No)						Result
Inner sheath	-	No Cracks	No	No	No	No	No	No	PASS
Outer sheath	-	No Cracks	No	No					PASS

Tested By: E. Rasile / N. Sek
Date: June 3, 2013
Equipment: Mitutoyo CD_6'' CS 0415686 Calibration due: September 19, 2015

Results: *The non-metallic sheaths samples meet the requirements for heat shock test.*

3.1.11 Hot Set Test for XLPE Insulation

Hot set test for XLPE was conducted according in accordance to IEC 60502-2: 2005 clause 19.11.

Insulation specimens with 10 mm gauge marks were attached to the upper jaw and weights were added to the lower jaw so that the insulation specimen was subjected to stress of 200 kPa. The test set up was placed inside a heated oven (Baxter Gravity Convection Oven) and allowed the oven to reach the required temperature of 200°C in 5 minutes. After an additional 15 minutes, the distance between the gauge marks was measured. The load was then removed from the test pieces and the test pieces left to recover in the oven. The results are shown in Table 3.12.

The requirements of the hot set test are that the maximum elongation under load is 175 %, and the maximum permanent elongation after removing the load is 15 %.

Table 3.12: Hot Set Test Results

Item	Unit	Requirement	Measurement (Mean)			Result
			Yellow	Red	Blue	
Mean elongation	%	≤175	65.7	62.8	62.5	PASS
Mean residual elongation	%	≤15	0.5	0.4	0.4	PASS

Tested By: E. Rasile / N. Sek
Date: June 5, 2013
Equipment: Mitutoyo CD_6'' CS 50232-0 Calibration due: December 19, 2015
Agilent 34901A MY41086167 Calibration due: November 12, 2013
Agilent 34970A KIN-00793 Calibration due: November 12, 2013
Scale 0-450 mm KIN-02595 April 3, 2014
Ohaus T54000 17619-0 Calibration due: February 2014
Omega K type KIN-01428 Calibration due: September 29, 2013

Results: *The insulation samples meet the requirements of the hot set test.*

3.1.12 Water absorption test on Insulation

Water absorption test on insulation was conducted according in accordance to IEC 60502-2: 2005 clause 19.13.

The results are shown in Table 3.13.

Table 3.13: Water absorption test on insulation

Item	Unit	Requirement	Measured (Mean)			Result
			Yellow	Red	Blue	
Variation of Mass	mg/cm²	≤1	0.34	0.32	0.34	PASS

Tested By: E. Rasile / N. Sek
Date: June 21, 2013
Equipment: Mitutoyo CD_6'' CS 50232-0 Calibration due: December 19, 2015
Thermocouple KIN-00687 Calibration due: September 29, 2013
Temperature readout Fluke 52 KIN-12897-0 Calibration due: September 29, 2013
Vacuum gauge Ashcroft KIN-02588 Calibration due: March 14, 2014
Mettler AE163 K-11514-0 May 22, 2014

Results: *The insulation samples meet the requirements of water absorption test.*

3.1.13 Flame spread test on single cables

Flame spread test on single cables was conducted according in accordance to IEC 60502-2: 2005 clause 19.14.

The maximum flame propagation height along the length of the specimens, as measured from the lower edge of the top support, was determined by visual observation. The distance from the lower edge of the top support to the upper onset of charring and the distance from the lower edge of the top support to the lower onset of charring downward from the top support were measured in mm.

The results are shown in Table 3.14.

Table 3.14: Flame spread test on single cables

Item	Flame Application Time (sec)	Requirement (mm)	Measured (mm)	Results
Distance from lower edge of top support to upper onset of charring (mm)	480	≥ 50	342	Pass
Distance from lower edge of top support to lower onset of charring (mm)	480	≤ 540	461	Pass

Tested By: E. Rasile / N. Sek
Date: June 4, 2013
Equipment: Mitutoyo CD-8’’ CSX KIN-01283 Calibration due: May 10, 2016
Stanley tape measure FatMax 33-726 KIN-01825 Calibration due: January 3, 2014

Results: *The cable sample meets the requirements of flame spread test.*

3.1.14 Shrinkage Test for XLPE Insulation

The shrinkage test for insulation was carried out in accordance to IEC 60502-2: 2005 clause 19.16.

The test results are shown in Table 3.15.

Table 3.15: Shrinkage Test Results for XLPE Insulation

Item	Unit	Requirement	Measured			Result
			Yellow	Red	Blue	
Shrinkage	%	≤4	1.81	1.55	1.45	PASS

Tested By: E. Rasile / N. Sek
Date: June 4, 2013
Equipment: Mitutoyo CD_12’’ CS 1053244 Calibration due: September 7, 2014

Results: *The insulation for each conductor meets the requirements of shrinkage test.*

3.1.15 Strippability test for insulation screen

The strippability test for insulation screen was performed in accordance to IEC 60502-2: 2005 clause 19.21.

The test results are shown in Table 3.16.

Table 3.16: Strippability test for insulation screen

Item	Unit	Requirement	Measured (Sample 1/Sample 2/Sample 3)			Result
			Yellow	Red	Blue	
Before ageing	N	4 ≤ F ≤ 45	41.9/32.2/33.8	40.3/41.2/34.4	38.6/38.8/36.9	PASS
After ageing	N	4 ≤ F ≤ 45	20.4/20.4/21.2	23.3/22.7/22.8	22.9/22.2/24.6	PASS

Tested By: E. Rasile / N. Sek
Date: June 4, 2013
Equipment: Mitutoyo CD_6’’ CP 10098-0 Calibration due: August 16, 2013
JJ Lloyd Instruments T5K KIN-11640-0 October 2, 2013.

Results: *The insulation screen samples meet the requirements of strippability test.*

3.1.17 Measurement of Conductor and Insulation Screens

The thickness of the insulation and conductor screens was measured and is provided here for information only.

Table 3.18: Thickness of Insulation and Conductor Screens

Item	Minimum Thickness (mm)			Minimum Average Thickness (mm)			
	Yellow	Red	Blue	Yellow	Red	Blue	Result
Conductor Screens	1.121	1.065	1.019	1.208	1.125	1.201	Pass
Insulation Screens	1.138	1.136	1.111	1.222	1.238	1.259	Pass

Tested By: E. Rasile / N. Sek
Date: June 4, 2013
Equipment: Nikon V-12 133736-0 Calibration due: September 25, 2013

4.0 CONCLUSIONS

The 8.7/15 kV 3x300 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry successfully passed the quality test requirements of IEC 60502-2:2005 for the electrical and non-electrical type tests detailed in the body of this report.

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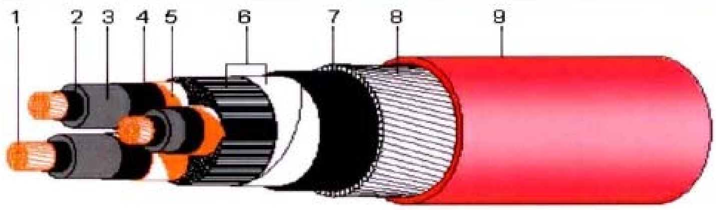
APPENDIX A

DRAWING OF THE TESTED CABLE

TECHNICAL & QC DEPARTMENT	الوطنيــــة لصناعـــة الكابلات NATIONAL CABLES INDUSTRY	NCI

DIMENSIONAL DRAWING

Cable Description:	3x300 MM² CU/XLPE/SWA/PVC, 8.7/15 (17.5) kV
Reference Standards:	IEC 60502-2 & UAE DEFENCE FORCES



S. NO	DESCRIPTION	Unit	OFFER DETAILS
1	**CONDUCTOR:**		
	Material		Plain Annealed Copper
	Form of stranding		Stranded circular compacted
	Diameter over conductor (Approx.)	mm	20.5
2	**CONDUCTOR SCREEN:**		
	Material		Extruded semiconductive compound
	Nominal thickness	mm	0.6
	Diameter over conductor screen (Approx.)	mm	24.0
3	**INSULATION:**		
	Material		Extruded XLPE
	Nominal thickness	mm	4.5
	Diameter over insulation (Approx.)	mm	32.0
4	**INSULATION SCREEN:**		
	Material		Extruded semiconductive compound
	Type		Strippable type
	Nominal thickness	mm	0.8
	Diameter over insulation screen (Approx.)	mm	34.0
	Identification core colour		Red, Yellow, Blue coloured strips
5	**METALLIC SCREEN:**		
	Material		Plain Copper tape(s)
	Thickness	mm	0.075
	Area each core (effective)	mm²	6.2
	Diameter over the screen (Approx.)	mm	34.3
6	**LAID UP CORES / ASSEMBLY:**		
	Assembly diameter (Approx.)	mm	73.0
	Fillers		Polypropylene yarns
	Binding tape		Polypropylene Tape
7	**INNER SHEATH:**		
	Material		Extruded PVC
	Nominal thickness	mm	2.0
	Diameter over inner sheath (Approx.)	mm	77.0
8	**ARMOUR:**		
	Material		Galvanised Steel Wires
	Wire diameter	mm	3.15
	Diameter over armour (Approx.)	mm	83.0
9	**OUTER SHEATH:**		
	Material		Extruded PVC
	Nominal thickness	mm	3.7
	Overall diameter (Approx.)	mm	94.0
	Color		**RED**

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Embossing on the outer sheath in max 50 cm spacing:

NATIONAL CABLES INDUSTRY, U.A.E, "YEAR", 3x300 MM², CU/XLPE/SWA/PVC, 15 kV, ACC TO IEC 60502 U.A.E. DEFENCE FORCES

APPENDIX B

HEATING CYCLE PLOT