TYPE TEST REPORT

NATIONAL CABLES INDUSTRY

TYPE TEST REPORT OF 11 kV 3x240 mm² CU/XLPE/SWA/PVC CABLE

Performed September 26, 2011 to November 08, 2011 in accordance with

IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010.

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1.0 INTRODUCTION

At the request of National Cables Industry, Kinectrics International Inc. performed type tests in accordance with IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010 on an 11 kV 3x240 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry. A drawing showing the details of the cable is given in Appendix A.

1.1 Test Program:

A listing of type tests performed on an 11 kV 3x240 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 11 kV 3x240 mm² CU/XLPE/SWA/PVC

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

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

Sr. No	Description	IEC Sub-Clause
1	Measurement of thickness of Insulation	IEC 60502-2, 19.1
2	Measurement of thickness of non-metallic screen (including extruded separation, but excluding inner covering)	IEC 60502-2, 19.2
3	Test for determination of the mechanical properties of insulation before and after ageing	IEC 60502-2, 19.3
4	Test for determination of the mechanical properties of non-metallic sheaths before and after ageing	IEC 60502-2, 19.4
5	Additional ageing test on piece of completed cable	IEC 60502-2, 19.5
6	Loss of mass on PVC sheaths of type ST2	IEC 60502-2, 19.6
7	Pressure test at high temperature on insulation and non-metallic sheaths	IEC 60502-2, 19.7
8	Test on PVC insulation and sheaths at low temperature	IEC 60502-2, 19.8
9	Test for resistance of PVC insulation and sheaths to cracking (hot shock test)	IEC 60502-2, 19.9
10	Hot set test for XLPE insulation	IEC 60502-2, 19.11
11	Water absorption test for insulation	IEC 60502-2, 19.13
12	Flame spread test on single cables	IEC 60502-2, 19.14
13	Shrinkage test for XLPE insulation	IEC 60502-2, 19.16
14	Strippability test for insulation screen	IEC 60502-2, 19.21
15	Water penetration test	IEC 60502-2, 19.22
16	Examination of conductor per IEC 60228	

2.0 ELECTRICAL TESTS

At the request of National Cables Industry, Kinectrics International Inc. performed type tests on an 11 kV 3x240 mm^2 CU/XLPE/SWA/PVC cable manufactured by National Cables Industry in accordance with IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010.

The tests were performed from September 26 to November 6, 2011 at Kinectrics' High Voltage Laboratories. The following tests were included in the electrical test sequence:

- Bending Test (IEC 60502-2, Clause 18.1.3)
- Partial Discharge Test (IEC 60502-2, Clause 18.1.4)
- Tan δ Measurement (IEC 60502-2, Clause 18.1.5)
- Heat Cycle Test, followed by a Partial Discharge Test (IEC 60502-2, Clause 18.1.6)
- Impulse Test, followed by a Voltage Test (IEC 60502-2, Clause 18.1.7)
- High Voltage A.C. Test for 4 H (IEC 60502-2, Clause 18.1.8).
- Water Penetration Test (IEC 60502-2, Annex F).

The results of the tests show that the tested cable is in compliance with IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010.

2.1 TEST SET UP, TEST PROCEDURES AND TEST RESULTS

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

The bending test on the cable was carried out on September 27, 2011 using a bending wheel having a diameter of 1592 mm. The required bending diameter for this cable was calculated by 15(d+D)±5% as specified in IEC 60502-2, Clause 18.1.3., where d is the nominal diameter of the conductor; D is the nominal external diameter of the cable.

The nominal diameter of the conductor of this cable was 18.4 mm and the nominal external diameter of this cable was 83.0mm.

Figure 2.1 shows the setup for the bending test.

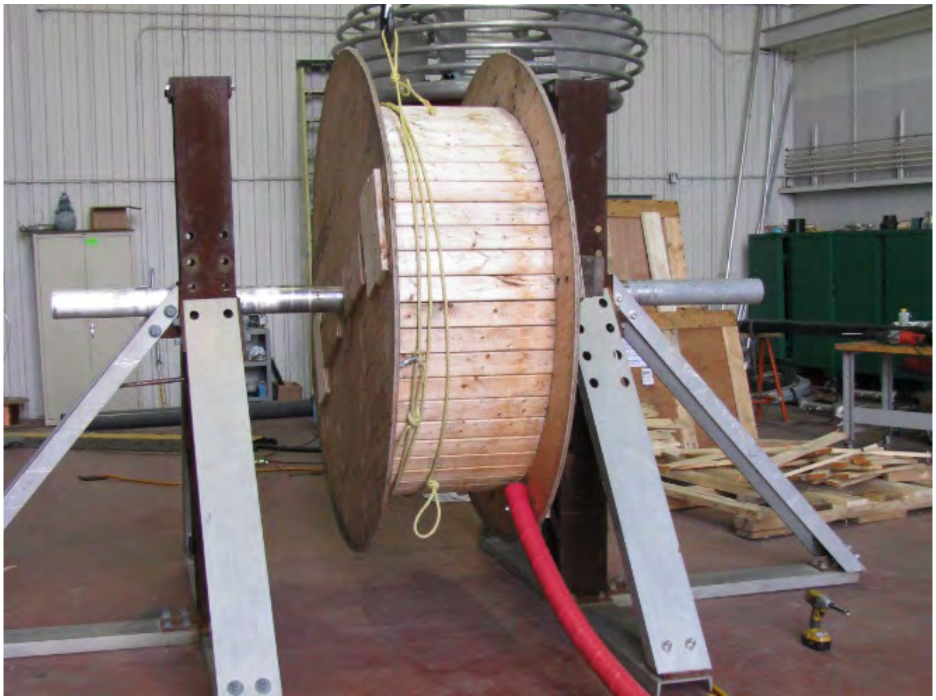

Figure 2.1: Setup for the bending test

A 16 m long sample was bent around the test cylinder at ambient temperature for at least one complete turn. It was then unwound and the process repeated, except that the bending of the sample was in the reverse direction without axial rotation. This process was carried out successfully three times.

Test performed by:
1. Ashfak SHAIKH
2. Ivan BOEV
3. Liancang ZHU
4. Paul SALVATORE
5. David SALVATORE

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

The partial discharge test was carried as per IEC 60502-2, Clause 18.1.4.; on the cable following the bending test on September 28, 2011. The results of the tests are shown in Table 2.1.

Table 2.1: Partial discharge test results

PD Test Date	Phase	Hipot @ 12.7kV (10 sec)	PD @ 11kV	Inception Voltage	Extinction Voltage
September 28, 2011	Red	Pass	0 pC	-	-
	Yellow	Pass	0 pC	-	-
	Blue	Pass	0 pC	-	-

Instruments used:

Manufacturer	Model Number	Serial Number	Cal Due Date
Hipotronics (60kV)	760 / 120 - PR	004485-00	Oct 13, 2012
Biddle	37200-610	37210302	Mar 9, 2012

Test performed by:
1. Ashfak SHAIKH
2. John DIPAUL

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

The Tan δ measurement at elevated temperature on the cable was performed on October 17, 2011. The tests were carried out at 2.3 kV with its conductor temperature 5 to 10°C above the maximum conductor temperature in normal operation. Table 2.2 shows the results.

Table 2.2: Tan δ Test Results

Test Date	Phase	Tan δ	Temperature	Pass/Fail
October 17, 2011	Red	1.76×10^{-4}	95°C<T<100°C	Pass
	Yellow			
	Blue			

Test performed by:
1. Stewart CRAMPTON
2. Ashfak SHAIKH
3. Ivan BOEV

2.1.4 Heat Cycle Test, followed by a Partial Discharge Test (IEC 60502-2, Clause 18.1.6)

The cable design underwent 20 heat cycles followed by a partial discharge tests as described below.

Each individual cycle was at least 8 hours long. It consisted of a heating period during which heating was applied for at least 5 hours. The cable conductor temperature was maintained at 97.5 ºC for at least 2 hours during each heating period. This was followed by at least 3 hours of natural cooling to a conductor temperature within 10 K of ambient temperature.

Figure 2.2 shows the complete record of conductor temperature and heating current during the heat cycle test. Table 2.3 shows the test results.

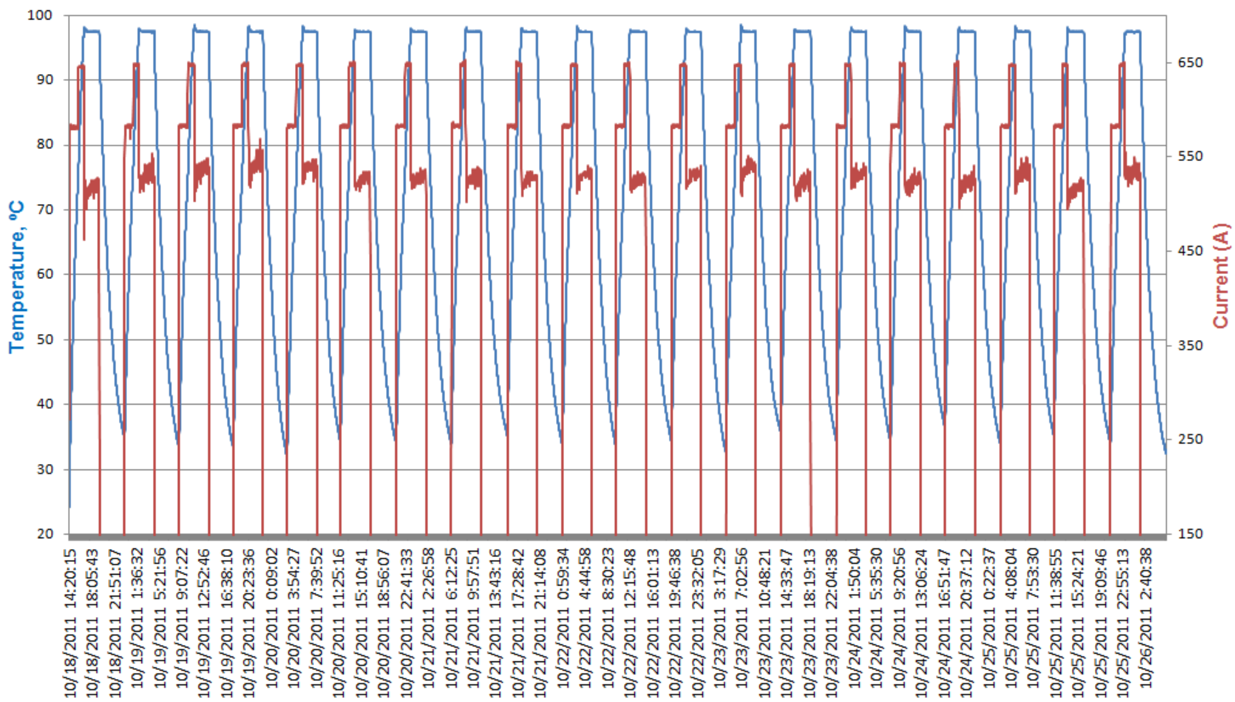

Figure 2.2: Complete record of conductor temperature and heating current for the heat cycle test

Table 2.3: Heat Cycling and PD Test Results

Heat Cycling Test Dates	PD Test Date	Phase	PD @ 25kV	PD @ 19kV	Inception Voltage	Extinction Voltage
October 18-25, 2011.	October 26, 2011	Red	0 pC	0 pC	-	-
		Yellow	0 pC	0 pC	-	-
		Blue	0 pC	0 pC	-	-

Instruments used:

Manufacturer	Model Number	Serial Number	Cal Due Date
MWB	300 kV Divider	015722-0	Nov 5, 2011
PD calibrator	Tettex	151187	June 20, 2012

Tests performed by:

1. Ivan BOEV
2. Silvano RIZZETTO

2.1.5 Impulse Test, followed by a Voltage Test (IEC 60502-2, Clause 18.1.7)

The lightning impulse test at elevated temperature was performed in accordance with IEC 60502-2, Clause 18.1.7. The ambient temperature at the time of testing was 25.5 °C. The cable temperature was maintained relatively constant during impulse testing by having the heating current on while charging the impulse generator's capacitors, turning the current off just prior to firing the generator, and turning it back on immediately after firing the generator. The cable temperature before the test sequence was 97.5 °C. The cable temperature at the end of the test sequence was 97.4 °C. Table 2.4 summarizes the impulse test sequence. The impulse waveforms are provided in Appendix B.

Table 2.4: Lightning Impulse Test Summary

Waveform No.	Peak (kV)	Front (μs)	Tail (μs)	Comment
E:\Impulse Records\11-im\023\a0070001.wft	37.3	4.3	52.1	Conditioning
E:\Impulse Records\11-im\023\a0080001.wft	48.4	3.7	53.2	Conditioning
E:\Impulse Records\11-im\023\a0090001.wft	60.1	4.2	52.6	Conditioning
E:\Impulse Records\11-im\023\a0110001.wft	74.5	4.4	52.8	1
E:\Impulse Records\11-im\023\a0120001.wft	74.6	4.4	52.8	2
E:\Impulse Records\11-im\023\a0130001.wft	74.5	4.3	52.8	3
E:\Impulse Records\11-im\023\a0140001.wft	74.6	4.4	52.7	4
E:\Impulse Records\11-im\023\a0150001.wft	74.5	4.3	52.8	5
E:\Impulse Records\11-im\023\a0160001.wft	74.5	4.3	52.7	6
E:\Impulse Records\11-im\023\a0170001.wft	74.5	4.3	52.8	7
E:\Impulse Records\11-im\023\a0180001.wft	74.5	4.3	52.8	8
E:\Impulse Records\11-im\023\a0190001.wft	74.5	4.3	52.8	9
E:\Impulse Records\11-im\023\a0200001.wft	74.5	4.3	52.7	10
E:\Impulse Records\11-im\023\a0210001.wft	-37.4	4.3	53.5	Conditioning
E:\Impulse Records\11-im\023\a0220001.wft	-48.7	4.1	53.3	Conditioning
E:\Impulse Records\11-im\023\a0230001.wft	-60.2	4.3	53.0	Conditioning
E:\Impulse Records\11-im\023\a0240001.wft	-75.0	4.2	53.2	1
E:\Impulse Records\11-im\023\a0250001.wft	-75.2	4.2	53.1	2
E:\Impulse Records\11-im\023\a0260001.wft	-75.1	4.2	53.2	3
E:\Impulse Records\11-im\023\a0270001.wft	-75.2	4.2	53.1	4
E:\Impulse Records\11-im\023\a0280001.wft	-75.2	4.2	53.2	5
E:\Impulse Records\11-im\023\a0290001.wft	-75.1	4.2	53.1	6
E:\Impulse Records\11-im\023\a0300001.wft	-75.0	4.2	53.2	7
E:\Impulse Records\11-im\023\a0310001.wft	-75.2	4.2	53.2	8
E:\Impulse Records\11-im\023\a0320001.wft	-75.1	4.2	53.3	9
E:\Impulse Records\11-im\023\a0330001.wft	-75.1	4.2	53.1	10

After the hot impulse test, the cable was allowed to cool down to ambient temperature, 25.5 ºC, before the 15-minute power frequency withstand voltage as specified in Clause 18.1.7. was carried out. The applied voltage for the 15-minute withstand voltage test was 21 kV and the voltage was applied between the conductors and the metallic screens, which were earthed.

The cable successfully withstood the applied voltage for 15 minutes. Based on this, the cable passed the impulse withstand test.

Instruments used:

Manufacturer	Model Number	Serial Number	Cal Due Date
Kinectrics	800 kV resistor Divider	19010-0	June 7, 2012
Nicolet	PowerPro 610	CAD0004040-0+19004-0	Dec. 11, 2011
MWB	300 kV Divider	015722-0	Nov 5, 2011

Test performed by:

1. Ziqin LI
2. Ivan BOEV
3. Liancang ZHU

2.1.7 High Voltage A.C. Test for 4 H (IEC 60502-2, Clause 18.1.8)

After the Impulse Test followed by a Voltage Test, the cable was subjected to 4 hours of High Voltage A.C. Test. The voltage was applied between the conductors and the metallic screens, which were earthed. The frequency of the power supply for this test was 60 Hz and the applied voltage was 25.4 kV as required. The voltage was increased gradually and maintained at the full value for 4 hours.

The cable successfully withstood the applied voltage of 25.4 kV for 4 hours. Based on this, the cable passed the High Voltage A.C. Test.

Instruments used:

Manufacturer	Model Number	Serial Number	Cal Due Date
MWB	300 kV Divider	015722-0	Nov 5, 2011

Test performed by:

1. Ivan BOEV

2.1.8 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 2.5.

Table 2.5: Semicon Resistivity Test Results

Test Item	Requirement	Measured Value
Conductor screen	Max: 1000 Ωm	405 Ωm
Insulation screen	Max: 500 Ωm	10.3 Ωm

The measured resistivity’s of both the insulation and conductor screens were within the standard requirements.

2.1.8 Water Penetration Test (IEC 60502-2, Annex F)

The bending test required for conditioning the sample for Water Penetration Test was performed on September 28, 2011. The setup is shown in Figure 2.3. The same bending wheel used for the Bending test described under section 2.1.1 of this report was utilized. A 7 m long sample was bent around the test cylinder at ambient temperature for at least one complete turn. It was then unwound and the process repeated, except that the bending of the sample was in the reverse direction without axial rotation. This process was carried out successfully three times.

Figure 2.3: Setup used for the Bending Test

After the bending test a 3 m long cable piece was cut from the bent sample and placed horizontally. A ring of 50 mm width comprising the outer sheath only was removed from the centre of the length as seen in Fig. 2.4. A custom made water tank, built as per the IEC 60502-2, Annex F specifications, was arranged around the exposed ring and sealed to the surface of the outer sheath. The seals where the cable exited the apparatus did not exert any mechanical stress on the cable. The water tank was filled within 5 min with tap water at an ambient temperature of (20±10)ºC and the water head was set to 1000 mm above the cable centre. The sample was then allowed to stand for 24 h. The sample was then subjected to 10 heating cycles by passing current through the conductor until the conductor reached a steady temperature of 97.5 ºC. The heating cycles took place from November 1-6, 2011. Each cycle was of 8 h duration and the conductor temperature was maintained at 97.5 ºC for at least 2 h of each heating period. This was followed by at least 3 h of natural cooling in air. The water head was maintained at 1000 mm throughout the duration of all heating cycles. The setup for Water Penetration test is shown in Figure 2.5 and Figure 2.6 shows the complete record of conductor temperature and heating current for the water penetration test.

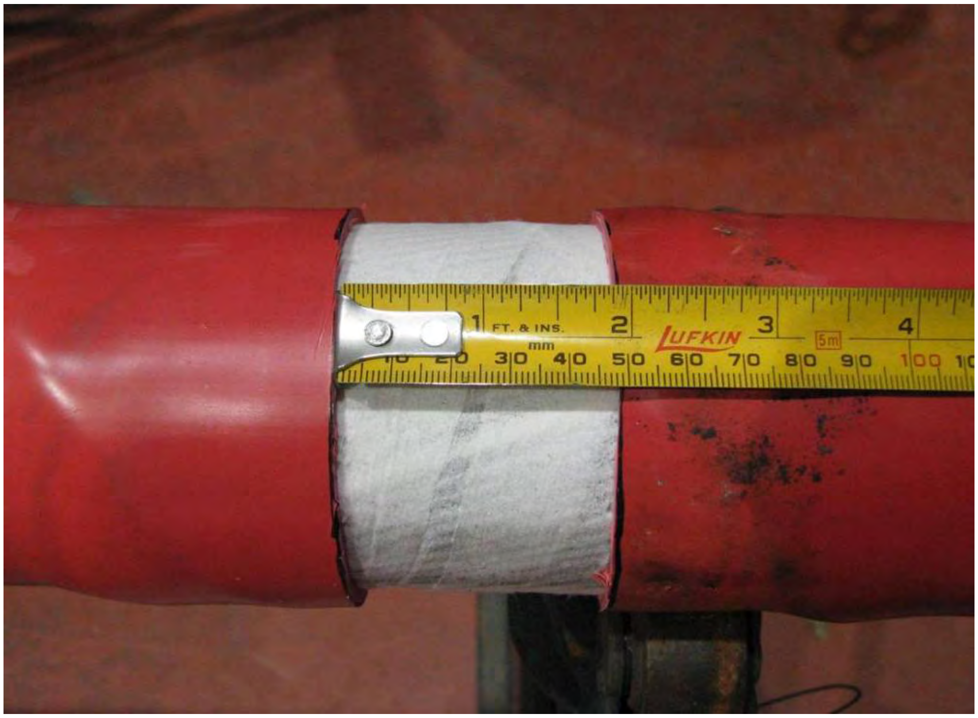

Figure 2.4: Test piece preparation

Figure 2.5: Water Penetration test setup

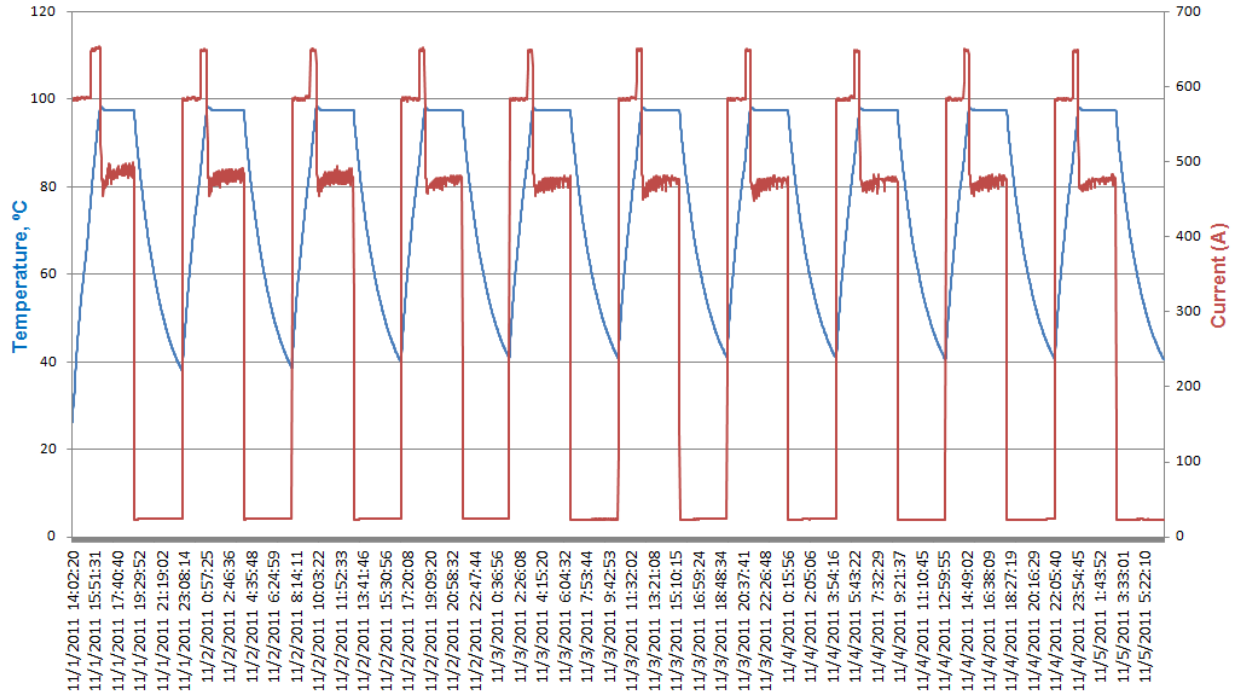

Figure 2.6: Complete record of conductor temperature and heating current

At the end of the heat cycling both ends of the sample were checked for water leakage and no water leakage was observed. Based on this the cable passed the Water Penetration test.

Tests performed by:

1. Ivan BOEV
2. Rick BOBKO
3. Liancang ZHU

3.0 NON-ELECTRICAL TESTS

At the request of National Cables Industry, Kinectrics International Inc. performed type tests on an 11 kV 3x240 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry in accordance with IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010.

The tests were performed from September 25 to November 08 11, 2011 at Kinectrics' Laboratories. The following tests in accordance with IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010; were included in the non-electrical test sequence:

- Measurement of insulation thickness (IEC 60502-2, 19.1)
- Measurement of thickness of non-metallic screen (including extruded separation, but excluding inner covering); (IEC 60502-2, 19.2)
- Test for determination of the mechanical properties of insulation before and after ageing (IEC 60502-2, 19.3)
- Test for determination of the mechanical properties of non-metallic sheaths before and after ageing (IEC 60502-2, 19.4)
- Additional ageing test on pieces of completed cable (IEC 60502-2, 19.5)
- Loss of mass test on PVC sheaths of type ST2 (IEC 60502-2, 19.6)
- Pressure test at high temperature on sheath (IEC 60502-2, 19.7)
- Test on PVC sheaths at low temperature (IEC 60502-2, 19.8)
- Test for resistance of PVC sheaths to cracking (heat shock test); (IEC 60502-2, 19.9)
- Hot set test for XLPE insulation (IEC 60502-2, 19.11)
- Water absorption test on insulation (IEC 60502-2, 19.13)
- Flame retardant test (IEC 60502-2, 19.14)
- Shrinkage test for XLPE insulation (IEC 60502-2, 19.16)
- Strippability test for insulation screen (IEC 60502-2, 19.21)
- Verification of construction and dimensions (IEC 60502-2, clause 5)

The results of the tests show that the tested cable is in compliance with IEC 60502-2, 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 Check of Cable construction

3.1.1.1 Conductor Inspection

The conductor was claimed by the manufacturer to be plain annealed copper. A visual inspection showed all strands to be approximately the same diameter in the 0.79 mm range

Results: The conductor meets the requirements.

3.1.1.2 Measurement of insulation thickness

The insulation and jacket thicknesses were measured according to IEC 60502-2; clause 19.1.

The minimum thickness at any point shall be ≥ 3.0 and the nominal thickness of insulation at rated voltage is around 3.4 mm respectively per IEC 60502-2:2005 (Table 6).

Table 3.1 shows the measured thicknesses.

Table 3.1: Insulation Thickness

Item	Unit	Requirement	Measured			Result
			Red	Yellow	Blue	
Conductor Screen						
Nominal	mm	0.70	1.07	0.92	0.94	Pass
Minimum	mm	0.50	0.95	0.82	0.84	Pass
Insulation						
Average	mm	3.4	3.69	3.52	3.74	Pass
Minimum	mm	3.0	3.69	3.41	3.68	
Insulation Screen						
Nominal	mm	0.80	0.87	0.86	0.89	Pass
Minimum	mm	0.60	0.87	0.78	0.83	Pass

Tested By: E Rasile
Date: October 19, 2011
Equipment: Olympus Stereo Microscope # 20002002-4

Result: The insulation met the thickness requirements.

3.1.1.3 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.

Tables 3.2 and 3.3 show results of the measured thicknesses.

Table 3.2: Inner sheath

Item	Unit	Requirement	Measured	Result
Nominal	mm	1.8	2.4	Pass
Minimum	mm	1.24	1.7	Pass

Table 3.3: Outer sheath

Item	Unit	Requirement	Measured	Result
Nominal	mm	3.5	3.7	Pass
Minimum	mm	2.6	2.95	Pass

Result: The inner sheath and the outer sheath meet the thickness requirements.

3.1.1.4 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			Result
			Red	Yellow	Blue	
Without Ageing						
Tensile strength	N/mm²	≥12.5	20.3	21.1	20.8	Pass
Elongation	%	≥200	458	484	480	Pass
After Ageing						
Tensile strength	N/mm²	-	20.1	20.0	19.5	Pass
Measured variation with samples without ageing	%	±25 max.	-1	-5	-6	Pass
Elongation	%	-	509	512	492	Pass
Measured variation with samples without ageing	%	±25 max.	11	5	2	Pass

Result: The insulation meet the test requirements before and after ageing.

3.1.1.5 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 and 3.6 shows the properties of non-metallic sheaths before and after ageing for inner and outer sheaths.

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

Item	Unit	Requirement	Measured	Result
Without Ageing				
Tensile strength	N/mm²	≥12.5	18.7	Pass
Elongation	%	≥150	274	Pass
After Ageing				
Tensile strength	N/mm²	≥12.5	19.4	Pass
Measured variation with samples without ageing	%	±25 max.	3.7	
Elongation	%	≥150	253	Pass
Measured variation with samples without ageing	%	±25 max.	-7.6	Pass

Table 3.6: Results: Mechanical properties of non-metallic outer sheath before & after ageing

Item	Unit	Requirement	Measured	Result
Without Ageing				
Tensile strength	N/mm²	≥12.5	20.6	Pass
Elongation	%	≥150	201	Pass
After Ageing				
Tensile strength	N/mm²	≥12.5	23.9	Pass
Measured variation with samples without ageing	%	±25 max.	16	Pass
Elongation	%	≥150	188	Pass
Measured variation with samples without ageing	%	±25 max.	-6.4	Pass

Result: The inner sheath and the outer sheath meet the requirements.

3.1.1.6 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 3.7 to 3.9 show the results of the additional ageing tests on pieces of completed cables.

Table 3.7: Additional ageing test results of insulation

Item	Unit	Requirement	Measured			Result
			Red	Yellow	Blue	
Tensile strength	N/mm²	-	22.7	21.8	21.8	Pass
Measured variation with samples without ageing	%	±25 max.	11.8	3.3	4.8	Pass
Elongation	%	-	504	493	488	Pass
Measured variation	%	±25 max.	10	1.8	1.6	Pass

Table 3.8: Additional ageing test results of inner sheath

Item	Unit	Requirement	Measured	Result
Tensile strength	N/mm²	-	19.0	Pass
Measured variation with samples without ageing	%	±25 max.	1.6	
Elongation	%	-	273	Pass
Measured variation with samples without ageing	%	±25 max.	-0.4	Pass

Table 3.9: Additional ageing test results of outer sheath

Item	Unit	Requirement	Measured	Result
Tensile strength	N/mm²	-	20.3	Pass
Measured variation with samples without ageing	%	±25 max.	-1.4	Pass
Elongation	%	-	225	Pass
Measured variation with samples without ageing	%	±25 max.	11.9	Pass

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

3.1.1.7 Loss of mass test on PVC sheaths of type ST2

Loss of mass test on PVC sheaths of type ST2 was performed in accordance to IEC 60502-2: 2005 clause 19.76.

The test results are shown below in Table 3.10

Table 3.10: Loss of mass on PVC sheaths of type ST2

Item	Unit	Requirement	Measured	Result
Loss of mass inner sheath	mg/cm²	≤1.5	0.94	Pass
Loss of mass outer sheath	mg/cm²	≤1.5	1.19	Pass

Results: The inner and outer sheath samples met the requirements of the loss of mass test.

3.1.1.8 Pressure test at high pressure and at high temperature on sheath

A pressure test on the inner sheath and outer sheath at high temperature was carried out in accordance with IEC 60502-2: 2005 clause 19.7.

The test results as per Table 3.10

Table 3.10: Pressure test at high pressure and at high temperature on sheath

Item	Unit	Requirement	Measured	Result
Depth of Indentation inner sheath	%	≤50	21.2	Pass
Depth of indentation outer sheath	%	≤50	21.9	Pass

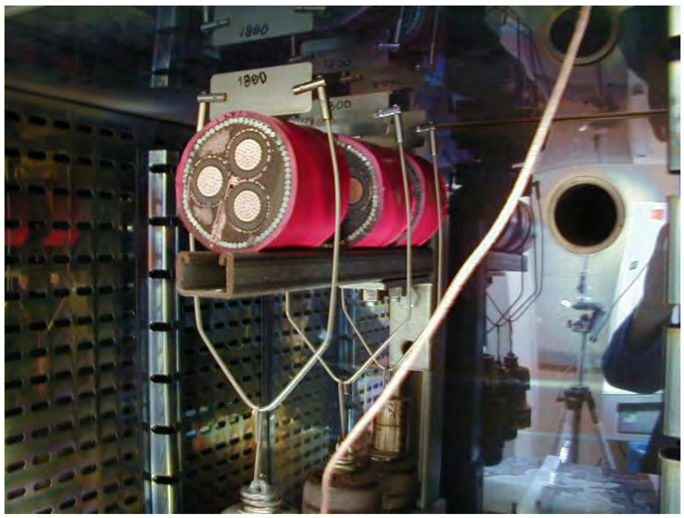

Figure 3.1: Pressure test set-up

Results: The sheath samples met the requirements for the pressure test at high temperature.

3.1.1.9 Test on PVC sheaths at low temperature

Test on PVC sheaths at low temperature was performed in accordance to IEC 20502-2: 2005 clause 19.8.

The test results are shown in Table 3.11

Table 3.11: Test on PVC sheaths at low temperature

Item	Unit	Requirement	Measured	Result
Elongation inner sheath	%	≥20	110	Pass
Elongation outer sheath	%	≥20	185	Pass

Results: The sheath samples met the requirements for the test on PVC at low temperature.

3.1.1.10 Test for resistance of PVC sheaths to cracking (heath shock test)

Test for resistance of PVC sheaths to cracking (heat shock test) was performed in accordance to IEC 20502-2: 2005 clause 19.9.

The test results are shown in Table 3.12

Table 3.12: Test for resistance of PVC sheaths to cracking (heath shock test)

Item	Unit	Requirement	Observation	Result
Appearance inner sheath	-	No Cracks	No Cracks	Pass
Appearance outer sheath	-	No Cracks	No Cracks	Pass

Results: The inner and outer sheath samples met the requirements for heat shock test.

3.1.1.11 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 20 N/cm^2. 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 10 minutes, the distance between the gauge marks was measured. The test was repeated. The results are shown in Table 3.13.

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 %.

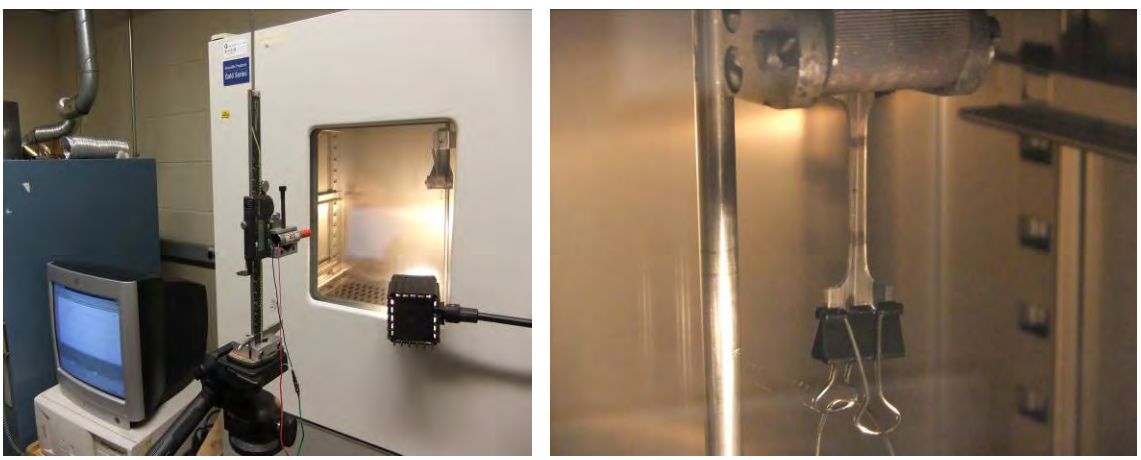

Figure 3.2 Hot Test Setup

Table 3.13: Hot Set Test Results

Sample	Initial Gauge (mm)	Thick-ness (mm)	Width (mm)	Cross Section Area (mm^2)	Mass Applied (g)	Gauge Length After 15 min @ 200 °C (mm)	% Elong-ation	Gauge Length After Removing the load (mm)	Residual Elongation (%)
Red	10	1.4	4.68	6.55	133.6	15.87	59	9.62	-4
	10	1.39	4.68	6.51	132.7	14.68	47	9.62	-4
Blue	10	1.71	4.68	8.00	163.2	15.96	60	9.34	-7
	10	1.52	4.68	7.11	145.1	15.96	60	9.44	-6

Yellow	10	1.65	4.68	7.72	157.5	16.77	68	9.47	-5
	10	1.75	4.68	8.19	167.0	16.45	65	9.51	-5

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

3.1.1.12 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 3.14

Table 3.14: Water absorption test on insulation

Item	Unit	Requirement	Measured			Result
			Red	Yellow	Blue	
Variation of Mass	mg/cm²	≤1	0.01	0.006	0.004	Pass

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

3.1.1.13 Flame spread test on single cables

Flame spread test on single cables was conducted according in accordance to IEC 60502-2: 2005 clause 19.13.

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 3.15

Table 3.15: Flame spread test on single cables

Sample ID	Flame Application Time (sec)	Downward Burn Length (mm)	Results	Damage (mm) Downward From Top Support		
				Melt	Char	Ash
11 kV CU/XLPE/SWA/PVC 3 x 240 SQ cable	480	535	Pass	350	370	410

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

3.1.1.14 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 3.16

Table 3.16: Shrinkage Test Results for XLPE Insulation

Item	Unit	Requirement	Measured			Result
			Red	Yellow	Blue	
Shrinkage	%	≤4	1.20	1.01	1.19	Pass

Results: The XLPE insulation sample met the requirements of shrinkage test.

3.1.1.15 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 3.17

Table 3.16: Strippability test for insulation screen

Item	Unit	Requirement	Measured			Result
			Red	Yellow	Blue	
Before ageing	N	4 ≤ F ≤ 45	15.2	15.3	21.9	Pass
After ageing	N	4 ≤ F ≤ 45	18.5	16.1	15.9	Pass

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

4.0 Verification of cable construction in accordance to 60502-2: 2005

The conductor was checked in accordance with IEC 60502-2: 2005 and as per manufacturer's specifications, dimensions and construction provide to Kinectrics Inc.

Item	Required/Specified	Measured/Determined			Result
Conductor (IEC 60228 Class 2) Material stranded copper wires (circular compacted)	Results recorded in non-electrical type test	Results recorded in non-electrical type test			
DC resistance at 20°C (Ω/Km)	≤ 0.0754	0.0751	0.0747	0.0743	Pass
No. of wires	≥ 34	61	61	61	Pass
Diameter max (mm)	-/18.4	18.3	18.44	18.63	Pass
Screening Conductor screening	Yes/yes	Extruded semi-conductive compound			Pass
Thickness, minimum (mm)	-/0.6	0.95	0.82	0.84	
Insulation screening Non-metallic part	Yes/yes	Extruded semi-conductive compound			Pass
Thickness, minimum (mm)	-/0.8	0.87	0.78	0.84	
Metallic part	Cu wire screen	Cu wire screen			
Insulation Material: extruded XLPE Nominal Thickness	-/XLPE 3.4	Results recorded in non-electrical type test.			Pass
Filler	Extruded PVC	Extruded PVC			Pass
Inner sheath Material: PVC ST2	Results in non-electrical type test	Results in non-electrical type test			
Non-Con Water swellable tape under armour	-/yes	yes			-
Armour wire	Yes/yes	Galvanized round steel wires and steel tape open helix			Pass

Non-con water swellable tape over armour	-/yes	yes	-
Outer sheath Material: PVC ST2	Results in non-electrical type test	Results in non-electrical type test	-
Marking of the cable		Karahma Qatar 11000 V 3X 240/84 mm² CU/XLPE/SWA/PVC IEC 60502 National Cables UAE-2011	-
Colour of the outer sheath Thickness of the sheath	-/- -/3.5	Red 3.7	-
Outer diameter of the cable average (mm)	-/83	83.6	-
Outer diameter of the core average (mm)	-/28.2	29.2	-

5.0 CONCLUSIONS

The 11 kV 3x240 mm² CU/XLPE/SWA/PVC cable manufactured by National Cables Industry successfully passed the quality test requirements of IEC 60502-2 & KAHRAMAA Qatar specification ED-03-030 Version #4 Rev-0/2010 for the electrical and non-electrical type tests detailed in the body of this report.

Prepared by:

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Department Manager
Transmission & Distribution Technologies Business

Approved by:

Dave Clarke
General Manager
Transmission & Distribution Technologies Business

APPENDIX A

DRAWING OF THE TESTED CABLE

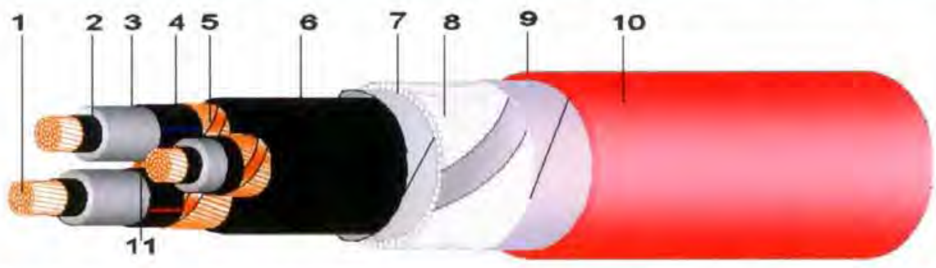
TECHNICAL & QC DEPARTMENT

الوطنيــــة لصنـاعــــة الكابـلات
NATIONAL CABLES INDUSTRY

NCI

DIMENSIONAL DRAWING

Cable Description:	**3x240 MM² CU/XLPE/SWA/PVC, 6.35/11 (12) kV**
Reference Standards:	**IEC 60502-2 & KAHRAMAA Qatar specs ED-03-030 Version # 4 Rev-0/2010**



S. NO	DESCRIPTION	Unit	DIMENSIONS
1	**CONDUCTOR:**		
	Material		Plain Annealed Copper
	Form of stranding		Stranded circular compacted
	Diameter over conductor (Approx.)	mm	18.4
2	**CONDUCTOR SCREEN:**		
	Material		Extruded semiconductive compound
	Nominal thickness	mm	0.6
	Diameter over conductor screen (Approx.)	mm	19.8
3	**INSULATION:**		
	Material		Extruded XLPE
	Nominal thickness	mm	3.4
	Diameter over insulation (Approx.)	mm	26.6
4	**INSULATION SCREEN:**		
	Material		Extruded semiconductive compound
	Type		Strippable type
	Nominal thickness	mm	0.8
	Diameter over insulation screen (Approx.)	mm	28.2
	Identification core colour		Red, Yellow, Blue coloured strips
5	**METALLIC SCREEN:**		
	Material		Copper wires+Binder+Ground Conductor
	Diameter over the screen (Approx.)	mm	30.1
6	**LAID UP CORES / ASSEMBLY & INNER SHEATH**		
	Assembly diameter (Approx.)	mm	65.0
	Filler and inner sheath material		Extruded PVC
	Nominal thickness of inner sheath	mm	1.8
	Diameter over inner sheath (Approx.)	mm	68.2
7	**Non-conductive water swellable tape**		Yes
8	**ARMOUR:**		
	Material		Galv. Steel Wires & steel tape open helix
	Nominal wire diameter	mm	3.15
	Diameter over armour (Approx.)	mm	75.0
9	**Non-conductive water swellable tape**		Yes
10	**OUTER SHEATH:**		
	Material		Extruded PVC
	Nominal thickness	mm	3.5
	Overall diameter (Approx.)	mm	83
	Color		Red
11	Bare Copper Ground Conductor		

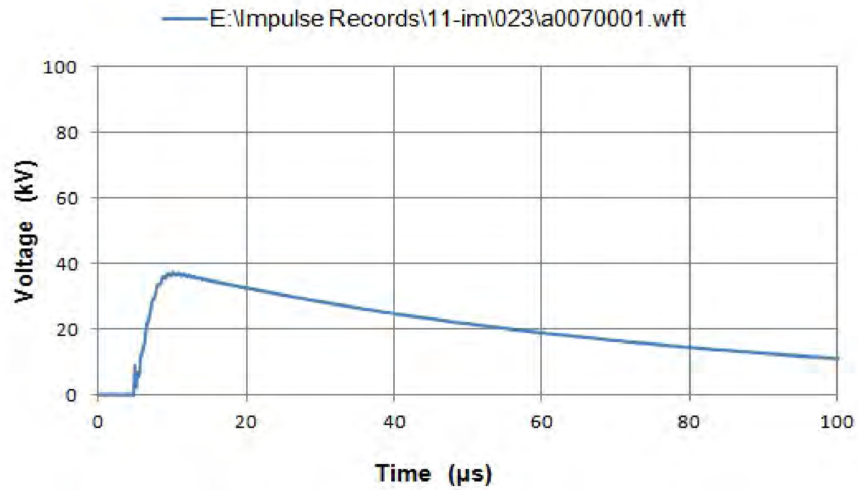
Embossing on the outer sheath in max 50 cm spacing:

KAHRAMAA QATAR, 11000 V, 3x240 MM², CU/XLPE/SWA/PVC, IEC 60502
NATIONAL CABLES INDUSTRY, U.A.E, 2011,

TECHNICAL & QC DEPT NCI

APPENDIX B

PLOTS OF THE IMPULSE WAVES USED FOR THE IMPULSE WITHSTAND TESTS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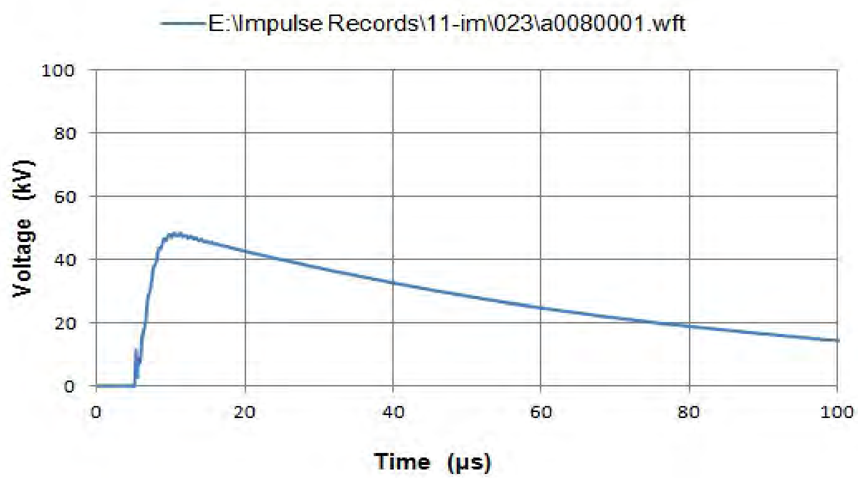
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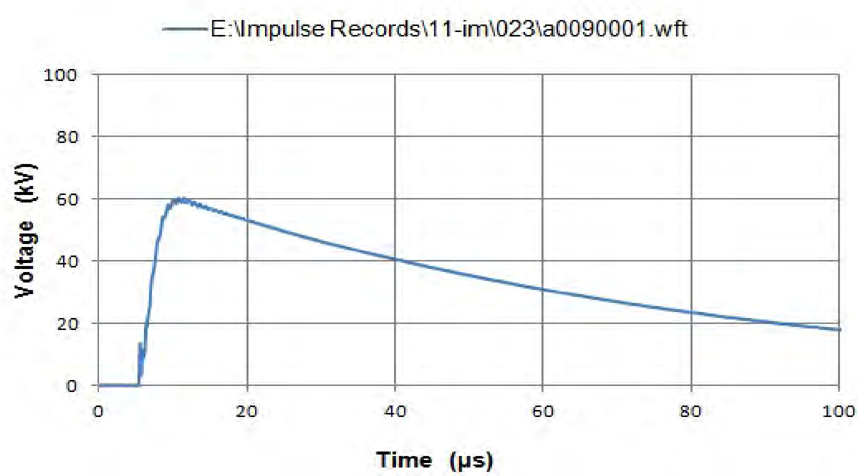
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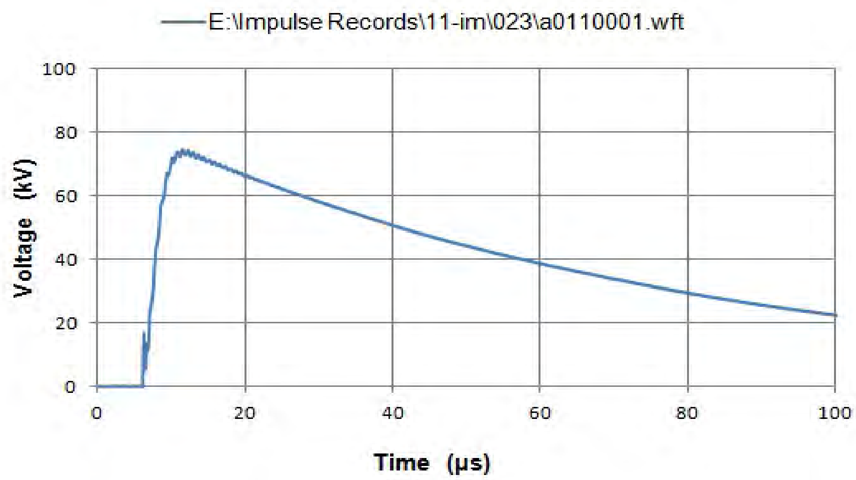
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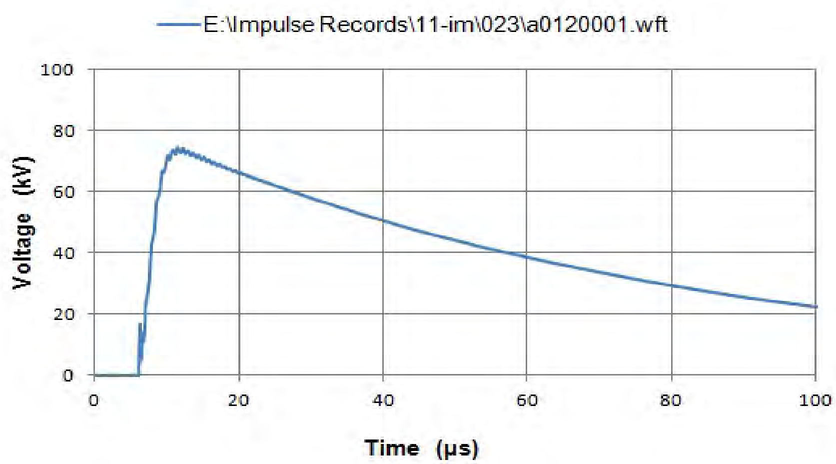
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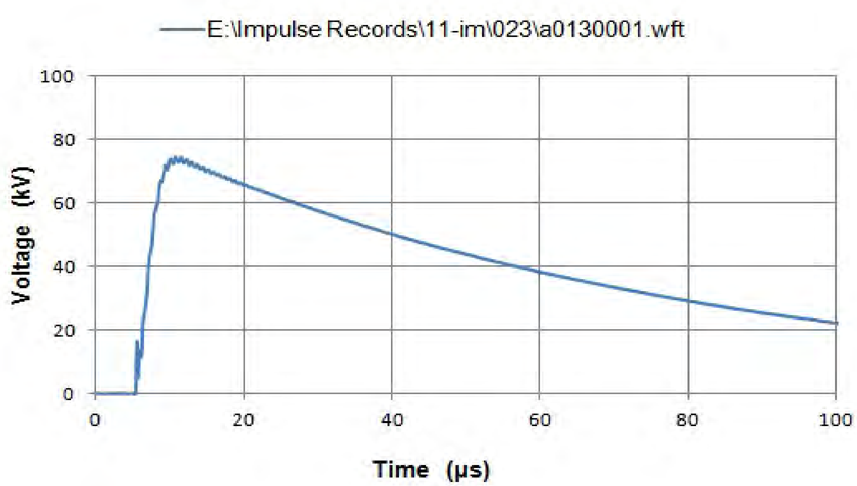
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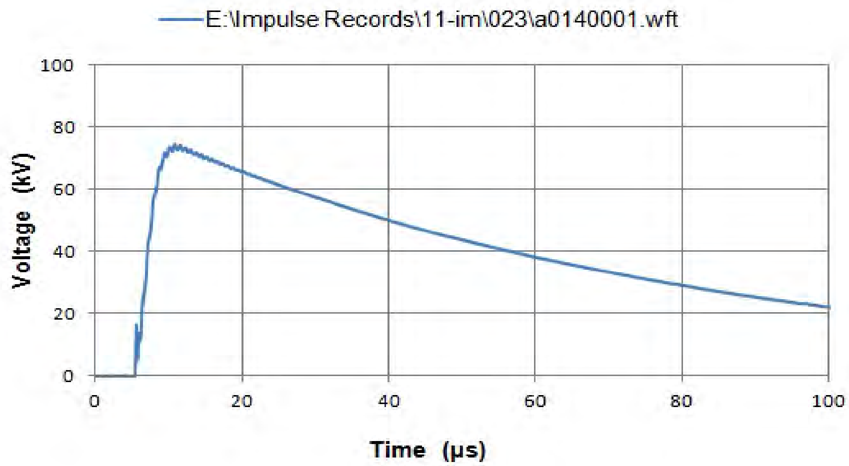
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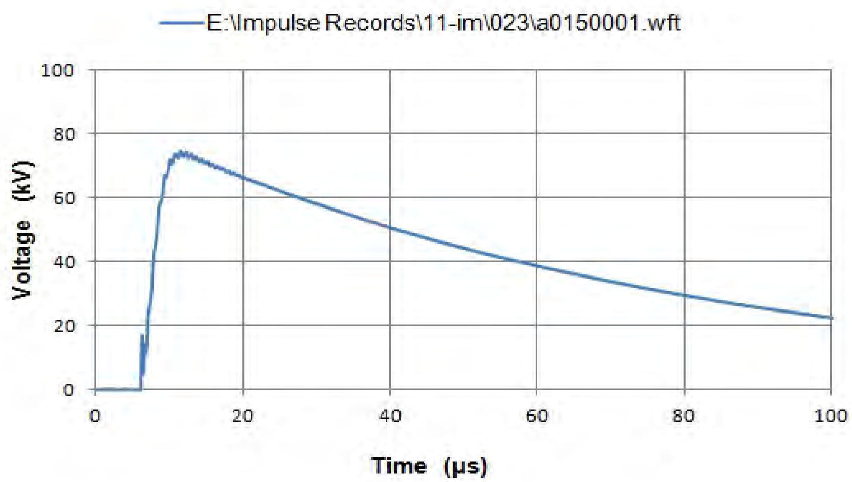
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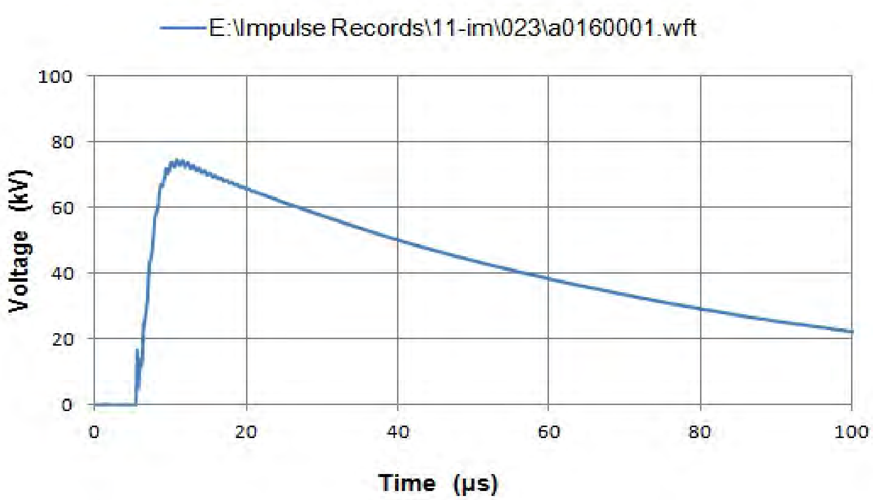
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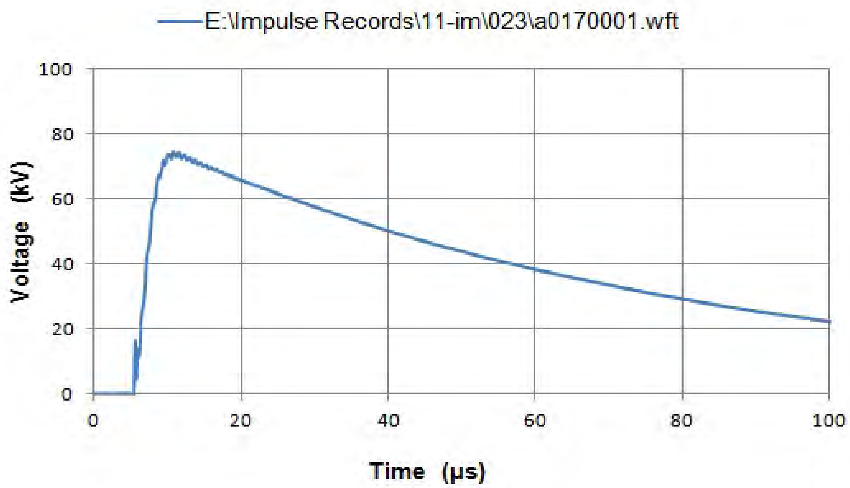
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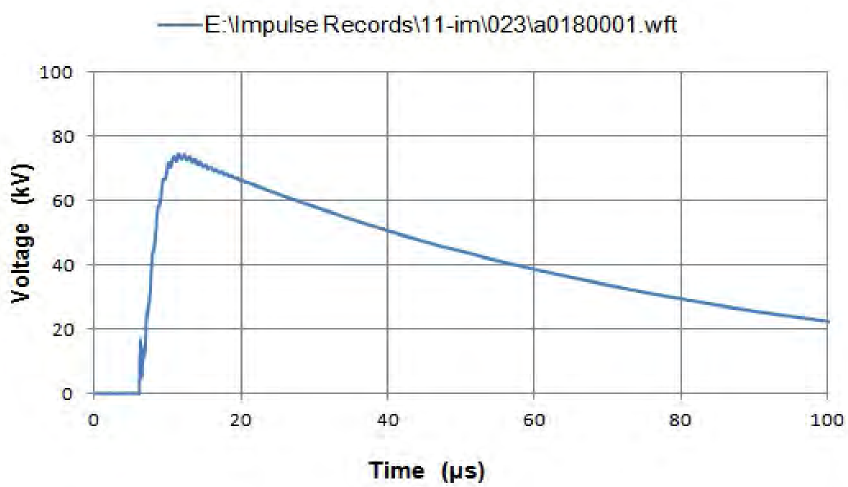
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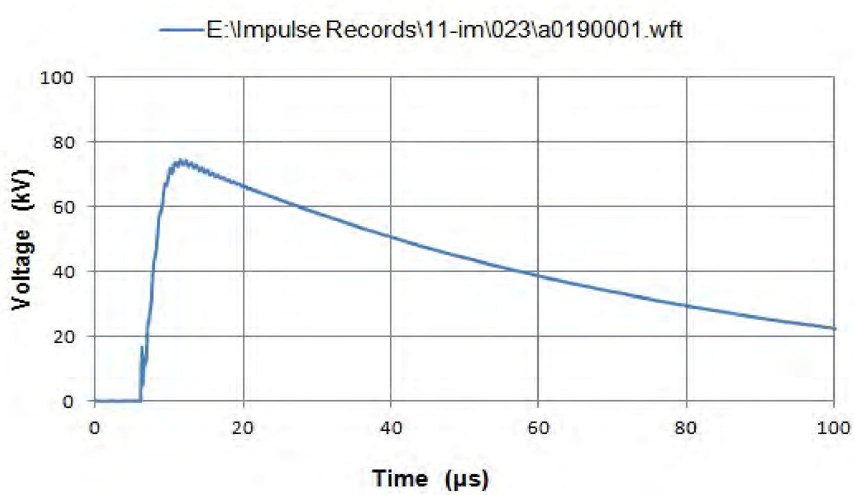
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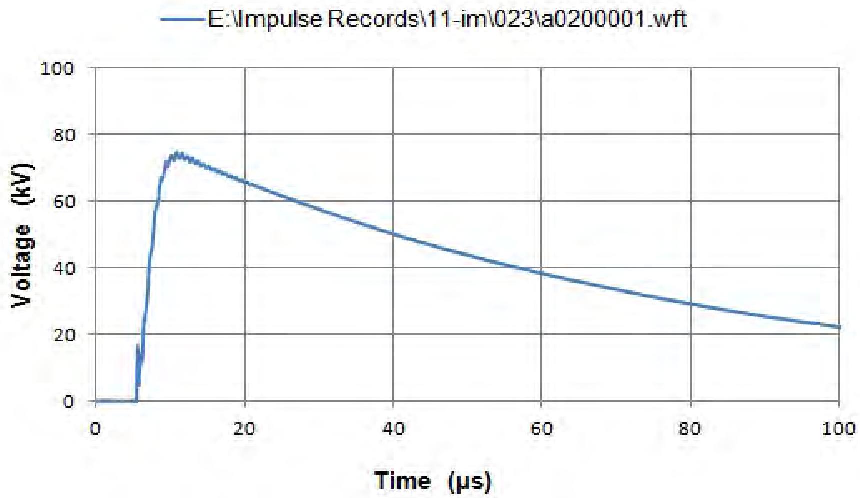
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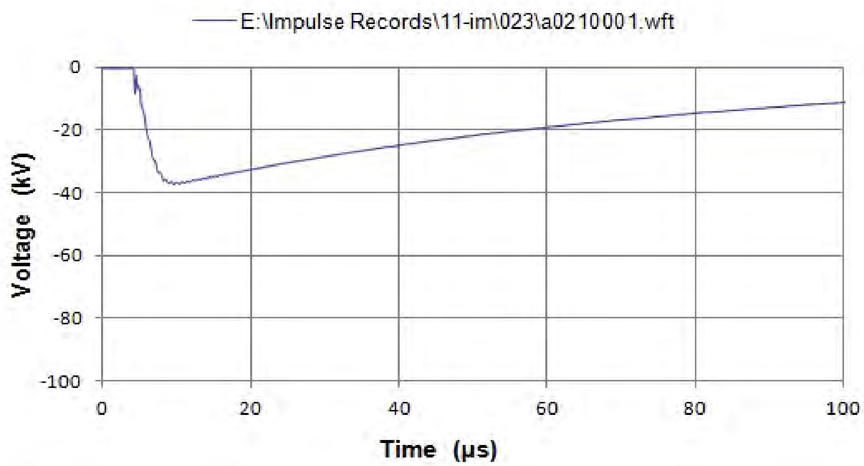
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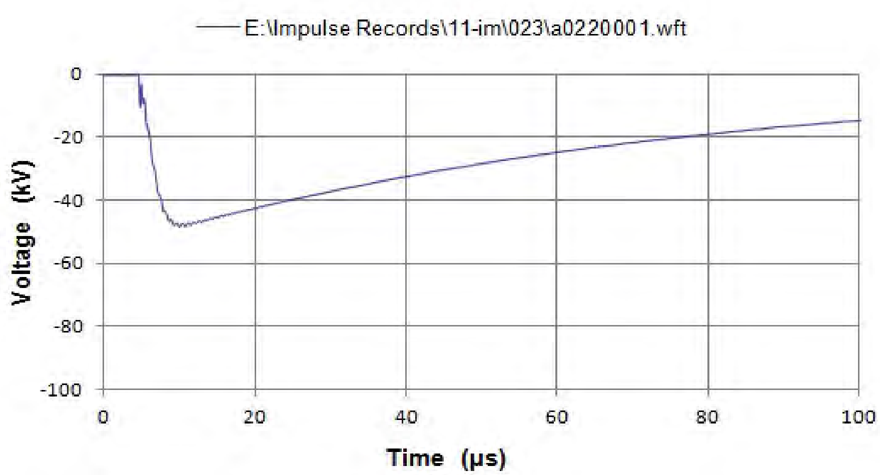
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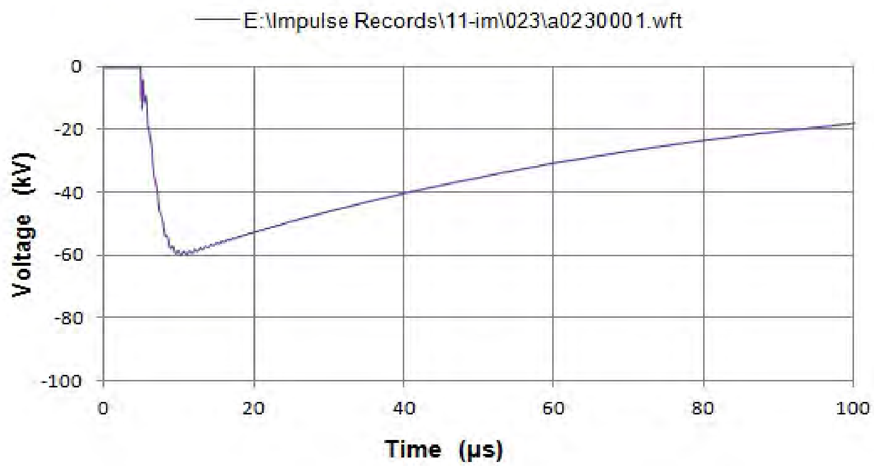
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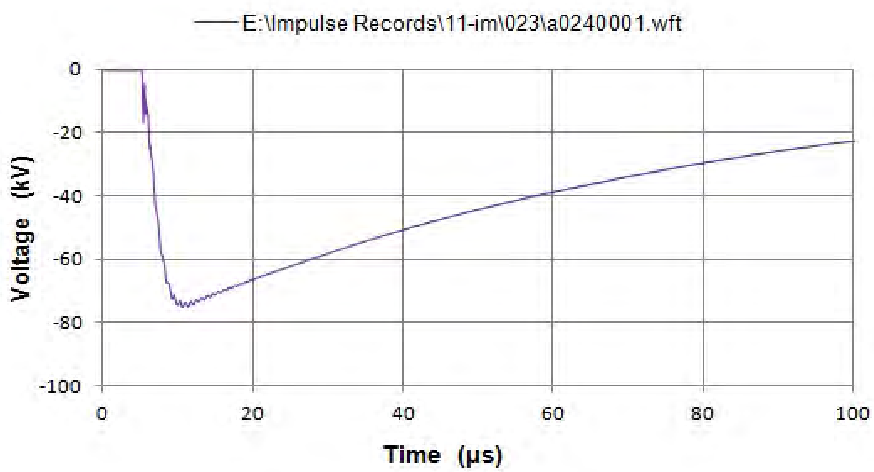
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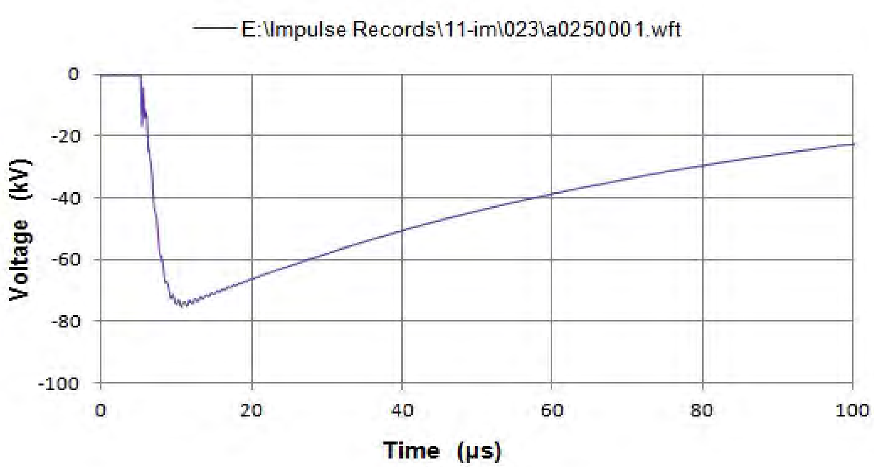
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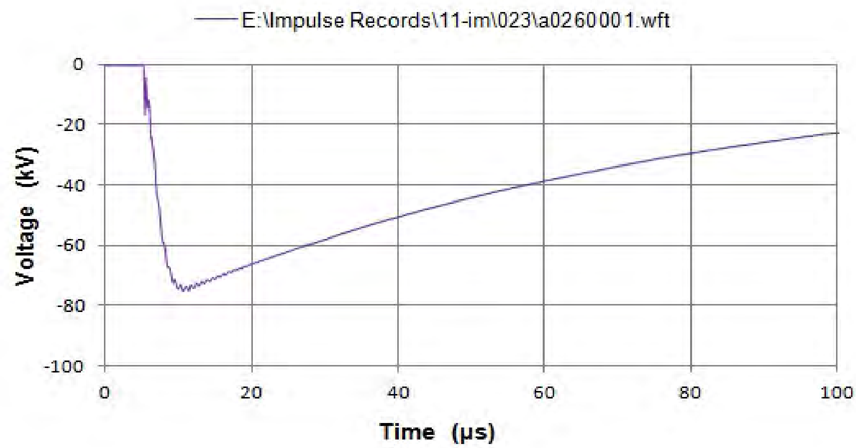

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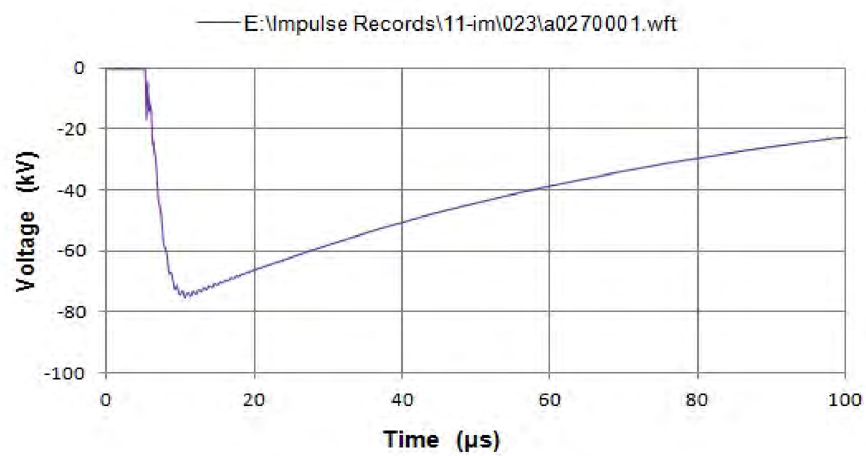

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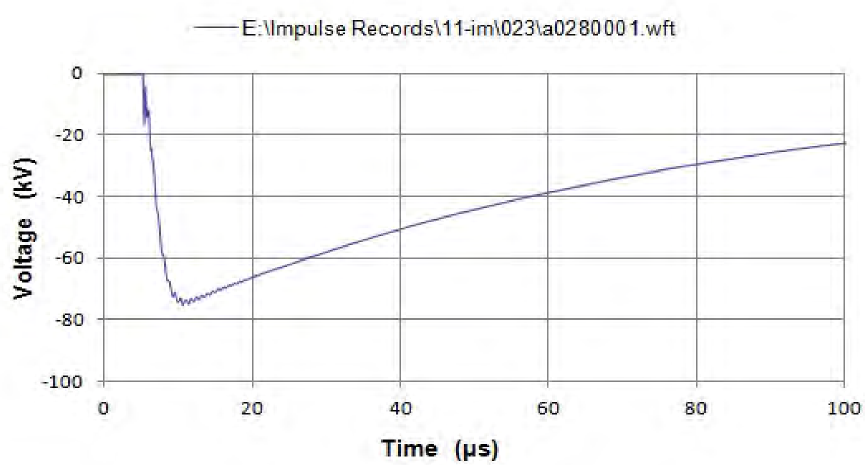

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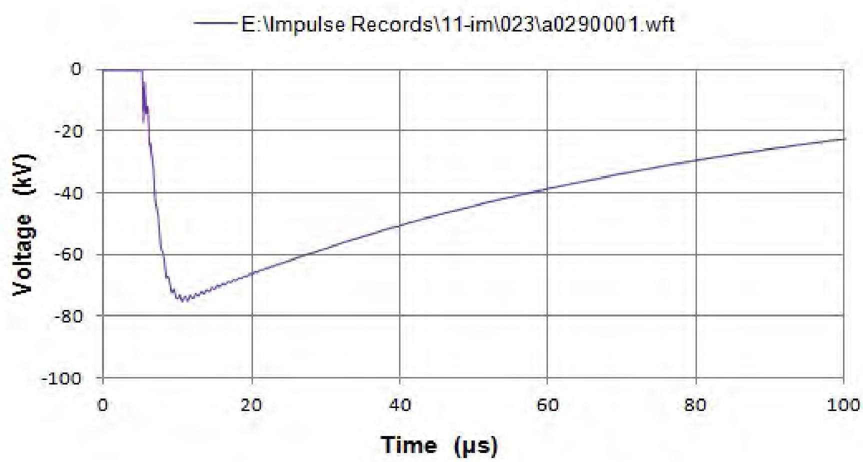
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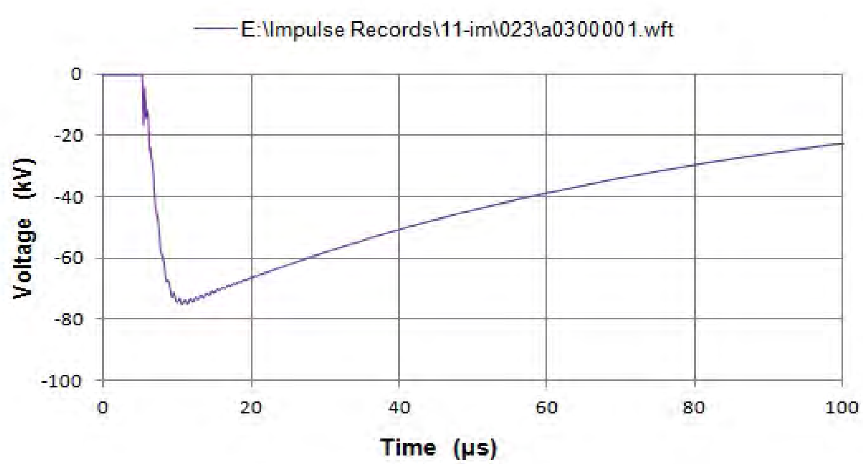
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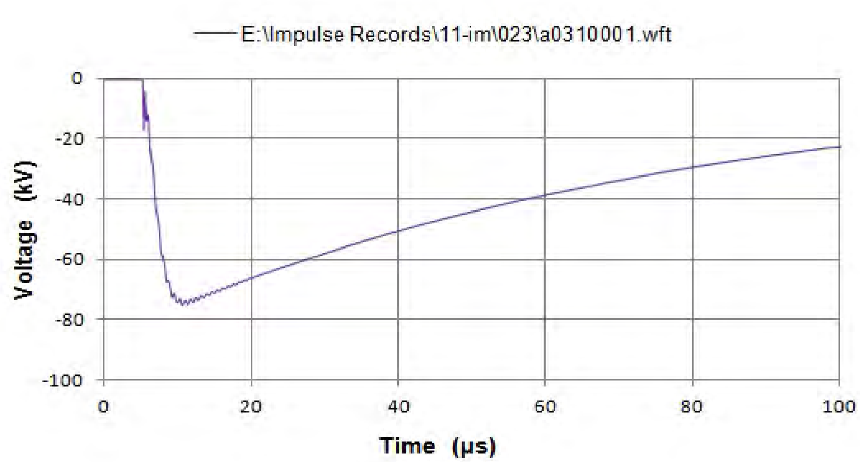
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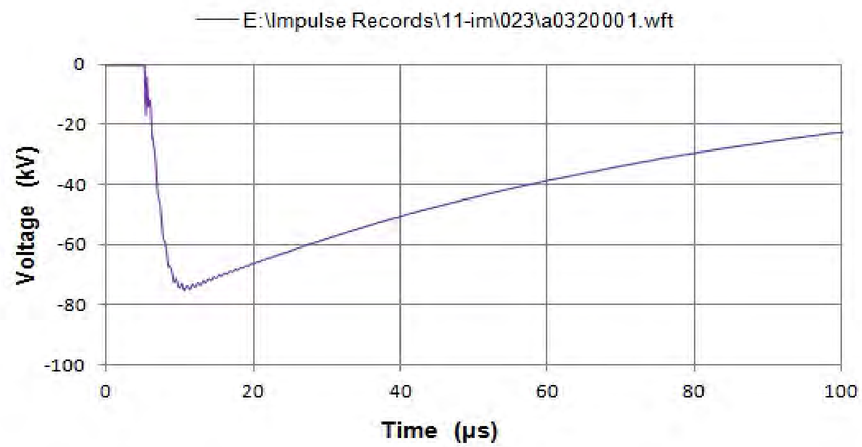
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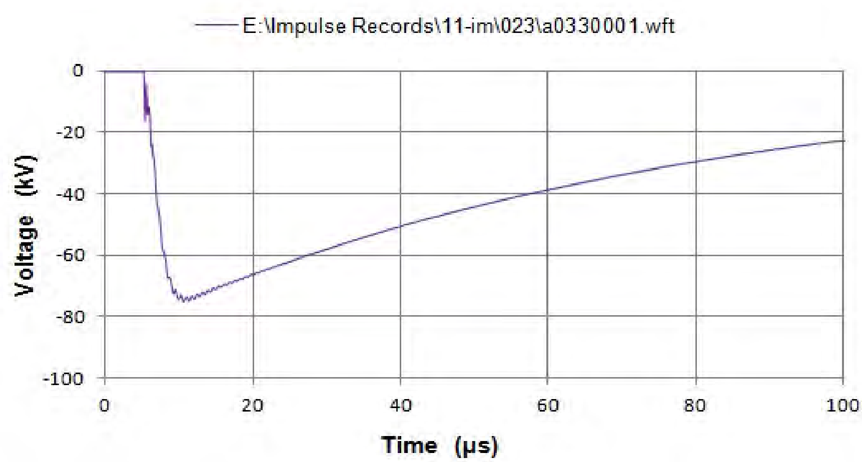
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