Test Report
PPR-2559

Test object:	24 kV Cold Applied Medium Voltage Termination Type **MVTI-5131**
Test performed:	**Type Test acc. to CENELEC HD 629.1 S2 2006**
Pages:	26 + Installation instruction EPP-1622-11/08

Report prepared by:	**Dipl. Ing Richard Graf** (Development Engineer)	Signature:	Date: Jan. 8th, 2009 Corrigendum Date: Oct. 4th, 2011
Released by:	**Per Christian Olving** (Product Manager)	Signature:	Date: Jan. 8th, 2008

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1 Abstract

1.1 Tested product

Tested product was a medium voltage cold applied terminations type MVTI-5131. These terminations are covering an application range from 95mm² up to and including 300mm² single core polymeric cables.

The product is designed for use with mechanical and crimp lugs. The test was conducted using the current range of Tyco Electronics mechanical lugs type BLMT within the application range of 95 to 300mm².

The product is designed for rated voltage $U_0/U(U_m)$ = 12.7/22(24) kV

1.2 Test specification

Test specification and procedures were according to CENELEC HD 629.1 S2:2006 Test requirements on accessories for use on power cables of rated voltage from 3.6/6(7.2) kV up to 20.8/36(42) kV",

Test sequences according to table 3 column A1 (dielectric tests and heat cycling), table 3 column A3 (humidity) and table 10 (compliance for smallest and largest cable cross section) have been conducted.

1.3 Conclusion

All samples fully met the electrical requirements of CENELEC HD 629.1 S2.

The product was successfully type tested to CENELEC for indoor applications on polymeric insulated cables from 95mm² up to and including 300mm² at a rated voltage $U_0/U(U_m)$ = 12.7/22(24) kV.

2 Test samples

2.1 Product

The following product was used for the tests

Raychem reference: MVTI-5131

Medium voltage cold applied (push on) termination for single core polymeric insulated cables.

Voltage class $U_0/U(U_m)$ = 12.7/22(24) kV

Test samples of the termination body MVTC-3-276-19 were produced on Oct. 8th 2008 with the final manufacturing mould.

2.2 Cables

Following cables were used for the tests:

Common type: single core aluminium or copper round stranded conductor, cross linked polyethylene insulation, bonded polymeric screen, copper wire shielded, polyethylene sheath.

Voltage class $U_0/U(U_m)$: 12/20(24)kV

Cross section	**95 mm²**	**150 mm²**	**150 mm²**	**300 mm²**
Conductor material	Al	Al	Cu	Al
Cable Manufacturer	Pirelli	NKT Cables	Nexans	Nexans
Type	NA2XS(F)2Y	NA2XS2Y	N2XS2Y	NA2XS2Y
overall diameter	31.5 mm	35 mm	35.5 mm	41 mm
screen diameter	25 mm	28 mm	28 mm	34 mm
insulation diameter	23 mm	26 mm	26 mm	32 mm
insulation wall thickness	5.5 mm	5.5 mm	5.5 mm	5.5 mm

Table 1: Cables used for testing

2.3 Installations

In total thirteen test samples were installed on nine test loops for type testing. The terminations were built according to the relevant installation instruction EPP-1622-11/08. Installations were done between October 10th and November 17th 2008 in Tyco Electronics Raychem GmbH laboratories in Ottobrunn / Germany by Michael Ongerth and Richard Graf.

All terminations have been installed together with current Tyco Electronics mechanical lugs type BLMT. Table 2 shows the combination of cables and lugs used for the different test sequences of the type test.

On samples 1, 2, 6, 7, two terminations were tested on each loop, on samples 9-12 only one termination was tested according to figure 1 of HD 629.1

Sample #	**Test sequence**	**conductor**	**cable lug**
1	Table 3 Sequence A1	150 mm² copper	BLMT-120/300
2			BLMT-95/240
6	Table 10	95 mm² aluminium	BLMT-35/150
7		300 mm² aluminium	BLMT-120/300
9	Table 3 Sequence A3	300 mm² aluminium	BLMT-120/300
10		95 mm² aluminium	BLMT-25/95
11		150 mm² aluminium	BLMT-120/300
12			BLMT-95/240
13			BLMT-35/150

Table 2: Test loops

The termination bodies on test loops 1, 2, 6, 7 were taken directly from moulding process, the mould flash was fettled on samples 9-13.

3 Test procedure

	§EN 61442	Test	Test sequence			Values	Requirement
			#1+#2 Table 3 A1	#6+#7 Table 10	#9-#13 Table 3 A3		
1	5	DC voltage dry	x	x		15 min at 6 U_0	No breakdown
2	4	AC voltage dry	x	x		5 min. at 4.5 U_0	No breakdown
3	7	Partial Discharge at ambient temperature	x	x		Discharge at 2 U_0	Discharge < 10pC
4	6	Impulse voltage at elevated temperature	x			10 pulses 125 kV each polarity	No breakdown
5	6	Impulse voltage at ambient temperature		x		10 pulses 125 kV each polarity	No breakdown
6	9	Electrical heat cycling in air	x 126 cycles	x 10 cycles		95℃ at 2.5 U_0	No breakdown
7	7	Partial Discharge at elevated temperature	x	x		Discharge at 2 U_0	Discharge < 10pC
8	7	Partial Discharge at ambient temperature	x	x		Discharge at 2 U_0	Discharge < 10pC
9	6	Impulse voltage at ambient temperature	x	(x)		10 pulses 125kV each polarity	No breakdown
10	4	AC voltage withstand	x	x		15min. at 2.5 U_0	No breakdown
11	13	Humidity			x	300 hours at 1.25 U_0	No breakdown or substantial damage
12	-	Examination	x	x	x	-	For information only

Table 3: Test sequences

x: Test is part of test sequence

(x): Test is not part of test sequence but was conducted

4 Test results

4.1 DC voltage dry withstand

A DC-voltage of 6 U_0 = 76 kV of negative polarity was applied for a time of 15 minutes to the cable conductors at ambient temperature. Samples #1, 2, 6, 7 were tested together.

Requirement: No insulation breakdown nor flash over.

sample #	voltage reading	result	ambient conditions:
1, 2, 6, 7	-76.2…-77.3kV	no breakdown nor flash over	25℃ – 952hPa – 37%rh

Result: All terminations passed the test.

4.2 AC voltage dry withstand

An AC-voltage of 4.5 U_0 = 57 kV phase to ground was applied for a time of 5 minutes to the cable conductors at ambient temperature. Samples #1, 2, 6, 7 were tested together (picture 1).

Requirement: No insulation breakdown nor flash over.

sample #	voltage reading	result	ambient conditions:
1, 2, 6, 7	57.2…57.4kV	no breakdown nor flash over	25℃ – 952hPa – 37%rh

Result: All terminations passed the test.

4.3 Partial discharge at ambient temperature

An AC-voltage of 28.5 kV phase to ground was applied for a time of less than 1 minute to the cable conductors at ambient temperature. After this, the voltage was lowered down to 25kV and the partial discharge level was measured. After the measurement the voltage was increased to 50kV to determine the discharge insertion and extinction voltage (picture 2).

Requirement: Partial discharge at 25 kV below or equal to 10pC

sample #	partial discharge level @25kV	insertion / extinction (DIV/DEV)	ambient conditions:
1	≤1.2 pC	>50 kV / -	25℃ – 952hPa – 37%rh
2	≤1.2 pC	38 kV / 29 kV	25℃ – 952hPa – 37%rh
6	≤1.2 pC	>50 kV / -	25℃ – 952hPa – 37%rh
7	≤1.2 pC	48 kV / 33kV	25℃ – 952hPa – 37%rh

Result: All terminations passed the test.

4.4 Impulse voltage at elevated temperature

The conductors of test samples #1 and #2 were heated with means of an alternating current to a temperature of at least 95℃. The temperature was kept nearly constant for more than two hours. The core temperature was measured directly on the conductor of a reference cable in the same loop as the tested samples (picture 3).

The samples were subjected to 10 positive impulses of 125 kV peak voltage and subsequently 10 negative impulses of 125 kV peak voltage. Each impulse was recorded. Samples #1 and #2 were tested together in one loop. A record of the first and the last impulse of each set of ten are shown in appendix 1.

Requirement: No insulation breakdown

sample #	measured temperature	result 10+/10-	ambient conditions:
1, 2	98.9℃	no breakdown	25℃ – 960hPa – 38%rh

Result: All terminations passed the test.

4.5 Impulse voltage at ambient temperature

The samples #6 and #7 were subjected to 10 positive impulses of 125 kV peak voltage and subsequently 10 negative impulses of 125 kV peak voltage under ambient conditions. Each impulse was recorded. Samples #6 and #7 were tested together in parallel. A record of the first and the last impulse of each set of ten is shown in appendix 1.

Requirement: No insulation breakdown

sample #	result 10+/10-	ambient conditions:
6, 7	no breakdown	25℃ – 960hPa – 38%rh

Result: All terminations passed the test.

4.6 Heat cycling in air

The test loops were subjected to heating cycles under ambient conditions. Each cycle consisted of a 5 hours current heating and a 3 hours cooling period. The cables were heated to 97℃ with means of a programm able temperature regulator. During all heating cycles the core temperature of a reference cable in the same loop was recorded as well as the ambient temperature and the voltage applied (examples see appendix 2). During all heating cycles an AC voltage of $2.5U_0$ = 32kV phase to ground was applied to the cable conductors.

After 10 cycles the heat cycling was stopped for samples #6 and #7. The samples were removed from the test cage later to perform the further testing.

sample	#1 + #2	#6	#7
number of cycles	126	10	10

Ambient conditions during heating cycles:

Temperature:	16℃	….	24℃
Humidity:	29%rh	….	55%rh
Barometric pressure:	920hPa	….	962hPa

Requirement: No insulation breakdown

Result: All terminations passed the test.

4.7 Partial discharge at elevated temperature

The test sample's conductors were heated with means of an alternating current to a temperature of at least 95℃. This temperature wa s kept above 95℃ for more than two hours. The core temperature was measured directly on the conductor of a reference cable in the same loop as the tested samples.

For the measurement, no current was applied to the test samples but the measurement was done quickly to minimise the temperature decrease during the measurement.

An AC-voltage of 28.5 kV phase to ground was applied for a time of less than 1 minute to the cable conductors at ambient temperature. After this, the voltage was lowered down to 25kV and the partial discharge level was measured. After the measurement the voltage was increased to 50kV to determine the discharge insertion and extinction voltage.

Requirement: Partial discharge at 25kV below or equal to 10pC

sample #	**partial discharge level @25kV**	**insertion / extinction (DIV/DEV)**	**ambient conditions:**
1	≤1.0 pC	>50 kV / -	22℃ – 950hPa – 32%rh
2	≤1.0 pC	>50 kV / -	22℃ – 950hPa – 32%rh
6	≤2.5 pC	>50 kV / -	25℃ – 949hPa – 42%rh
7	≤1.8 pC	50 kV / 37kV	25℃ – 949hPa – 42%rh

Result: All terminations passed the test.

4.8 Partial discharge at ambient temperature

An AC-voltage of 28.5 kV phase to ground was applied for a time of less than 1 minute to the cable conductors at ambient temperature. After this, the voltage was lowered down to 25kV and the partial discharge level was measured. After the measurement the voltage was increased to 50kV to determine the discharge insertion and extinction voltage.

Requirement: Partial discharge at 25 kV below or equal to 10pC

sample #	partial discharge level @25kV	insertion / extinction (DIV/DEV)	ambient conditions:
1	≤1.0 pC	>50 kV / -	23℃ – 944hPa – 32%rh
2	≤1.0 pC	>50 kV / -	23℃ – 944hPa – 32%rh
6	≤1.0 pC	45 kV / 34 kV	23℃ – 952hPa – 45%rh
7	≤1.1 pC	45 kV / 32 kV-	23℃ – 952hPa – 45%rh

Result: All terminations passed the test.

4.9 Impulse voltage at ambient temperature

The samples were subjected to 10 positive impulses of 125 kV peak voltage and subsequently 10 negative impulses of 125 kV peak voltage under ambient conditions. Each impulse was recorded. Samples #1 and #2 were tested together in parallel as well as Samples #6 and #7. A record of the first and the last impulse of each set of ten are shown in appendix 1.

Requirement: No insulation breakdown

sample #	result 10+/10-	ambient conditions:
1, 2	no breakdown	23℃ – 944hPa – 32%rh
6, 7	no breakdown	24℃ – 952hPa – 45%rh

Result: All terminations passed the test.

4.10 AC voltage dry withstand

An AC-voltage of 2.5 U_0 = 32 kV phase to ground was applied for a time of 15 minutes to the cable conductors at ambient temperature. Samples #1 and #2 were tested together in parallel as well as samples #6 and #7.

Requirement: No insulation breakdown nor flash over.

sample #	voltage reading	result	ambient conditions:
1, 2	regulated	no breakdown nor flash over	20℃ – 943hPa – 37%rh
6, 7	32.1…32.9kV	no breakdown nor flash over	24℃ – 952hPa – 44%rh

Result: All terminations passed the test.

4.11 Humidity

Five samples (#9 - #13) were positioned in a closed chamber of 10 m³ cubage. Deionised water was salted to get a conductivity 700 µS/cm and was atomized with means of pressurized air. A voltage of 16 kV phase to ground was applied to the cable conductors. All samples have been tested together in parallel for 300h.

Requirement: No insulation breakdown, nor flash over, no substantial damage (splitting, puncture, tracking, erosion < 2 mm).

sample #	measured conductivity of water	measured flow rate	duration
9 - 13	707 µS/cm	0.43 l/h·m³	300.5 h

Result:

There was no insulation breakdown, no splitting, no puncture, no tracking. Some erosion was found on the surfaces with a depth smaller than 0.3 mm, most distinct on sample #13. On Sample #10 erosion was found at the lower end next to a screen wire with a depth of about 0.5 mm (picture 4).

All terminations passed the test.

4.12 Examination

Inspection showed no substantial damage or deterioration or damages after the test. One sample was damaged by mechanical impact during assembly work before heating cycles, but the damage did not develop or propagate further during testing.

5 Test facility

All installations and tests described herein were carried out at Tyco Electronics Raychem GmbH High Voltage Test Laboratories, Finsinger Feld 1, 85521 Ottobrunn, Germany

Tests were carried out in the time from October 22nd 2008 to December 15th 2008. All test results are available in detail in Laboratory Notebook #ED1037 issued April 5th 2007 according to ISO 9001.

All values for the high voltage are not corrected to standard ambient conditions (20℃, 1013 hPa, 11 g H_2O/m^3).

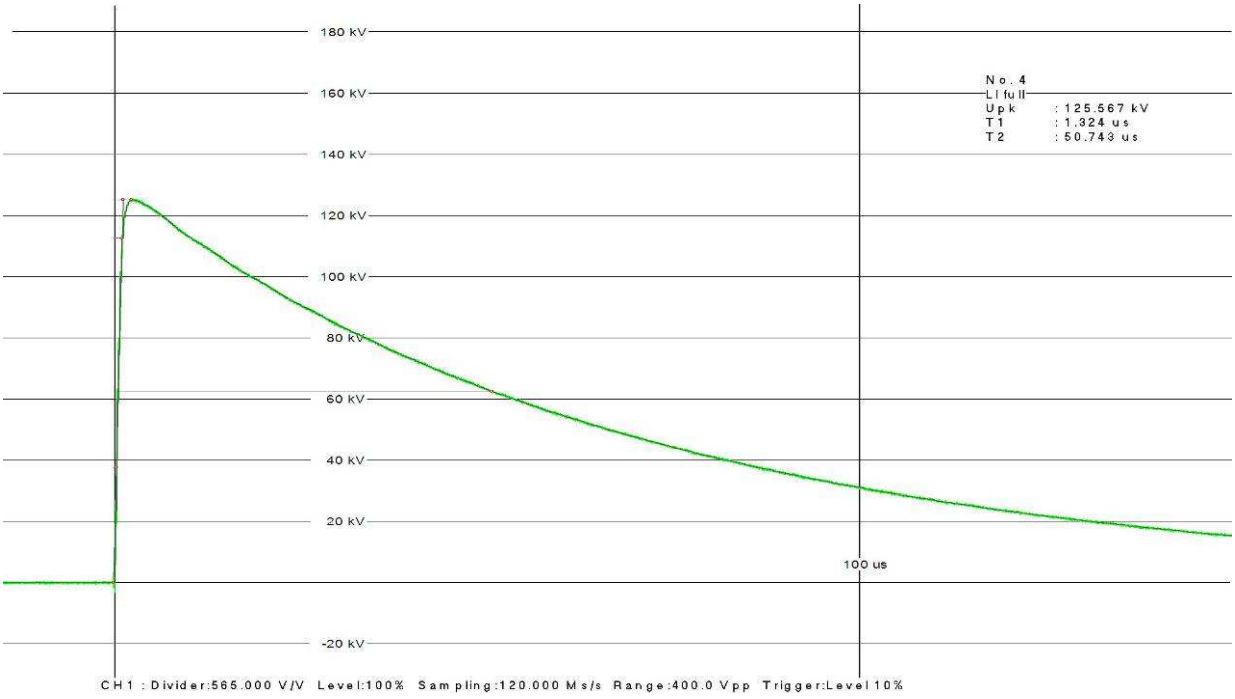
6 Equipment used for measuring

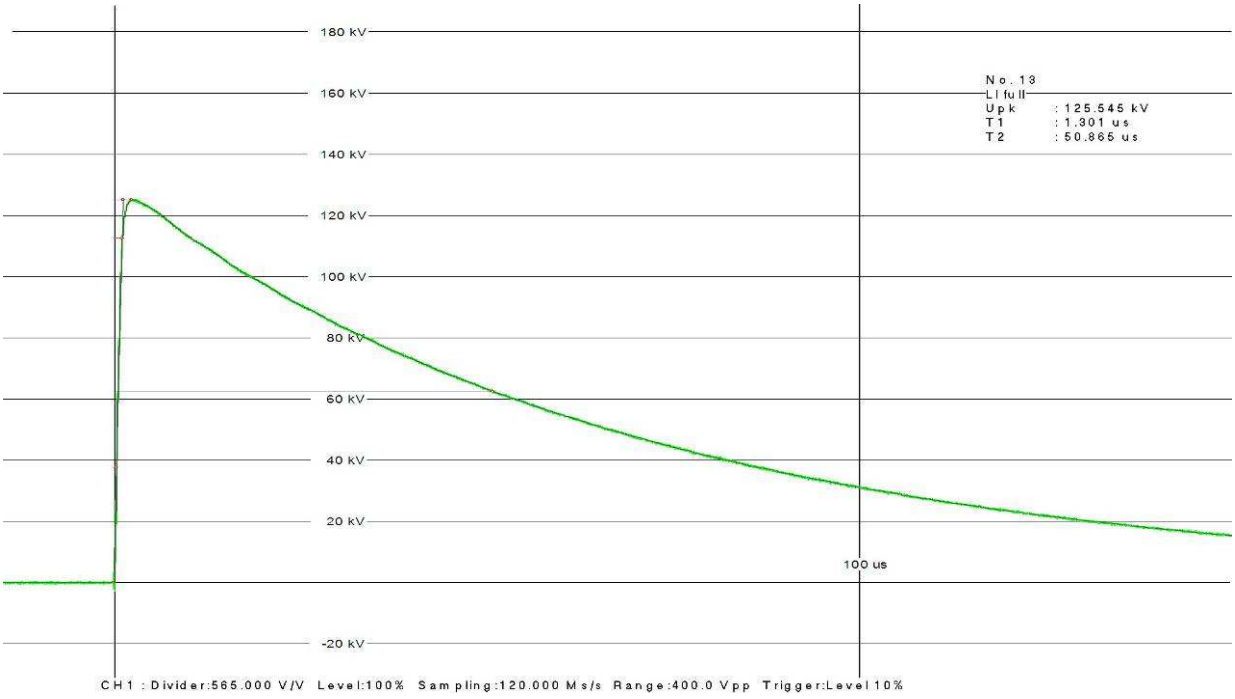
Equipment **Calibration or identification number**	**used at tests**
400 kV DC measuring System DKD-24501-2000	1
350 kV AC measuring system DKD-24501-1999	2, 3, 7, 8, 10
800kV impulse voltage measuring system DKD-24501-1998	4, 5, 9
100kV AC measuring system (DKD-24501-2007	6, 11
200 KV AC measuring system (step test) DKD-24501-2001	10
200 kV partial discharge measurement system with calibrator Ry – E0037	3, 7, 8
thermometer with thermocouple Ry-0630	4, 7
recorder unit (Inv. 754910) with thermocouple and 3 fibre optical temperature measurement units (Inv. 752091/ 755622 / 755625)	6
ambient conditions measurement unit RY-E0022	1, 2, 3, 4, 5, 7, 8, 9, 10
ambient conditions measurement unit RY-E0023	6, 10

Where applicable, calibration certificates are available according to ISO 9001.

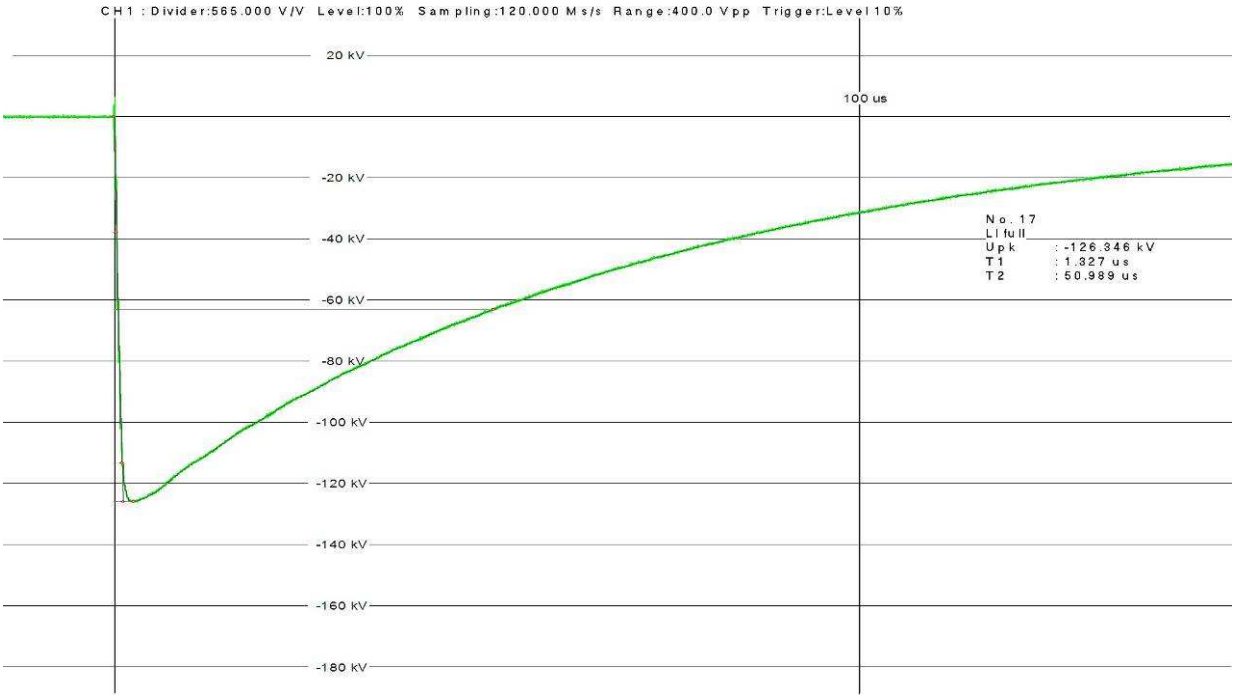
Appendix 1: Impulse readings

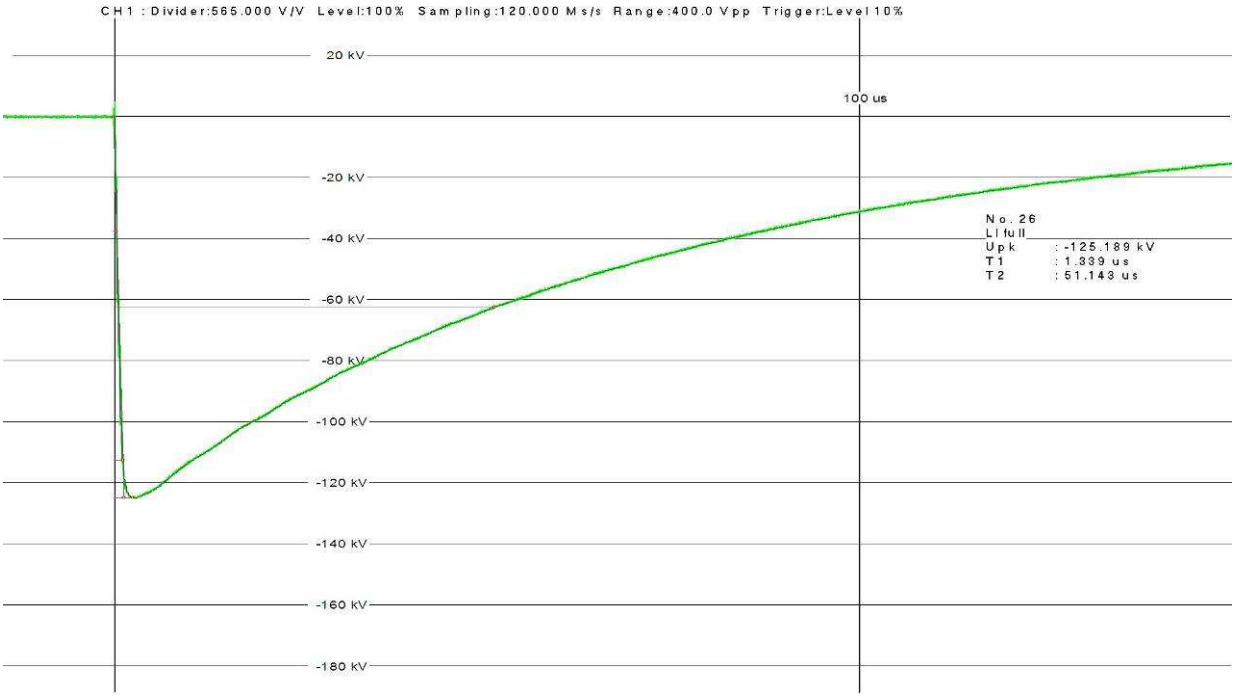
Positive pulses at elevated temperature samples #1, #2 (4.4)



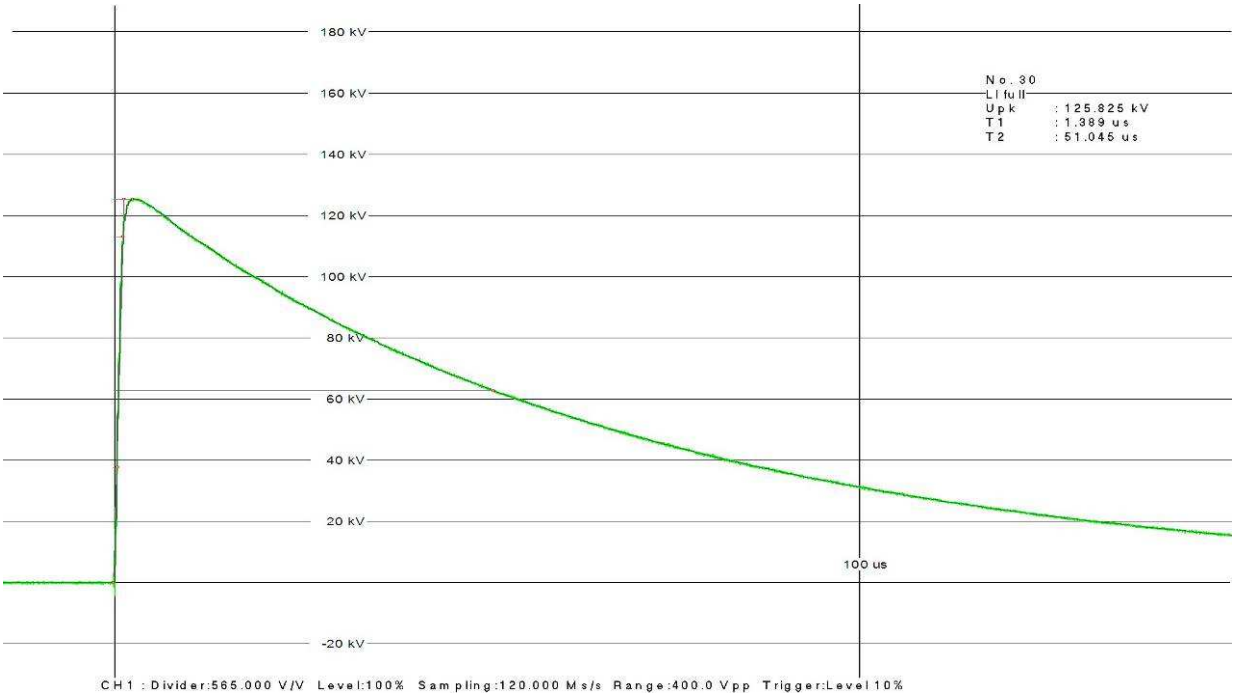


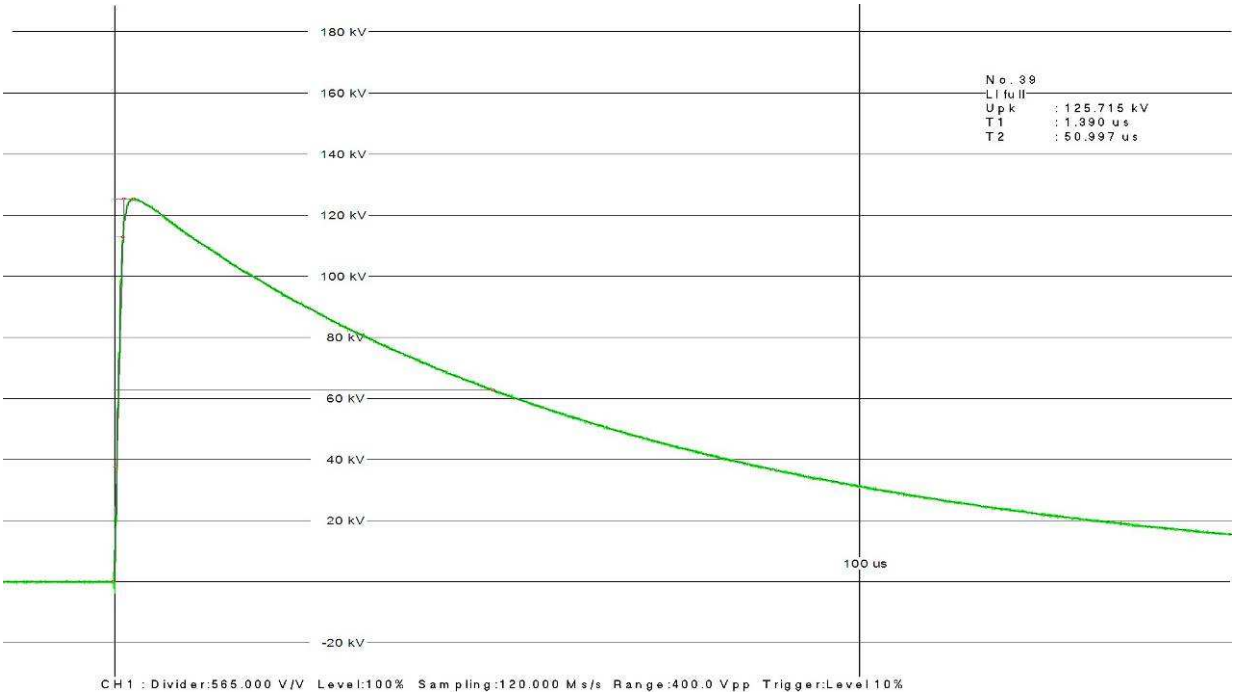
Negative pulses at elevated temperature samples #1, #2 (4.4)



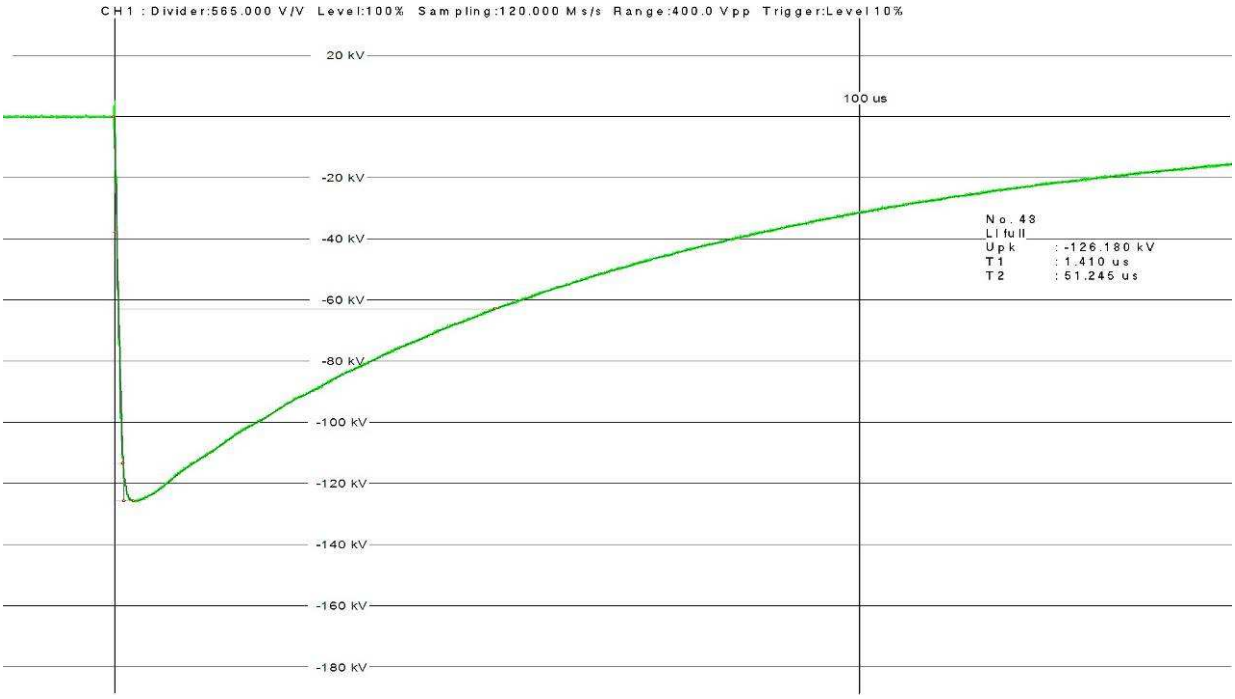


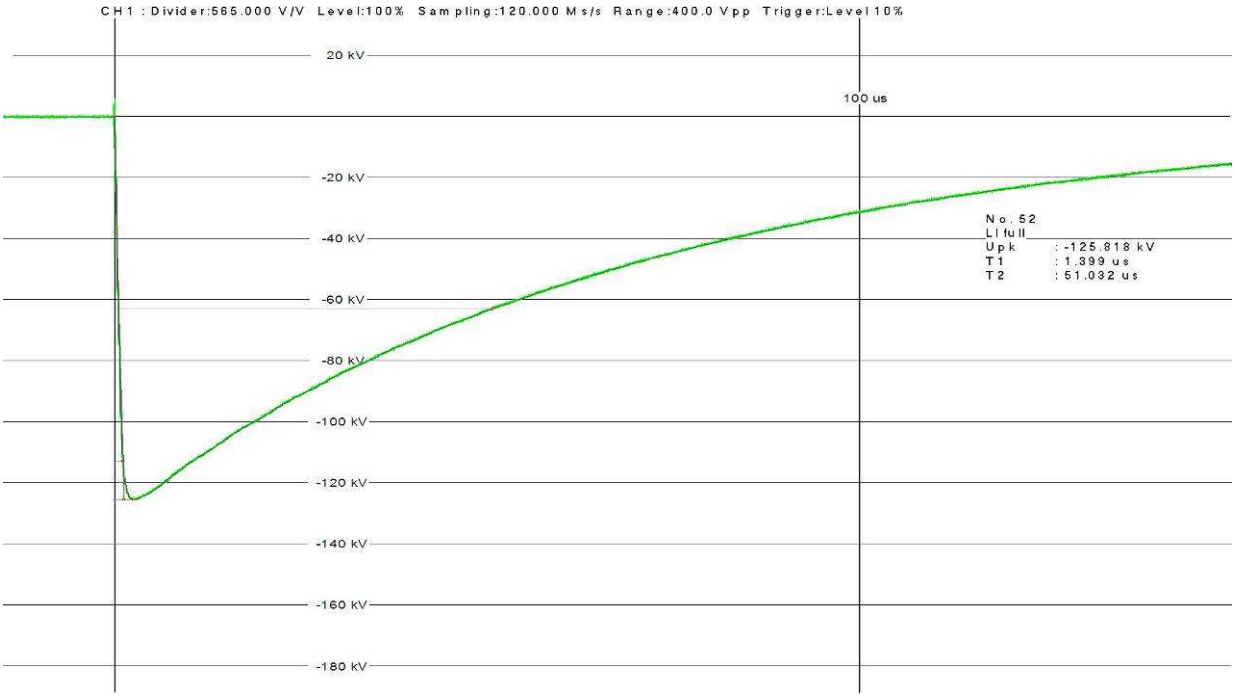
Positive pulses at ambient temperature samples #6, #7 (4.5)



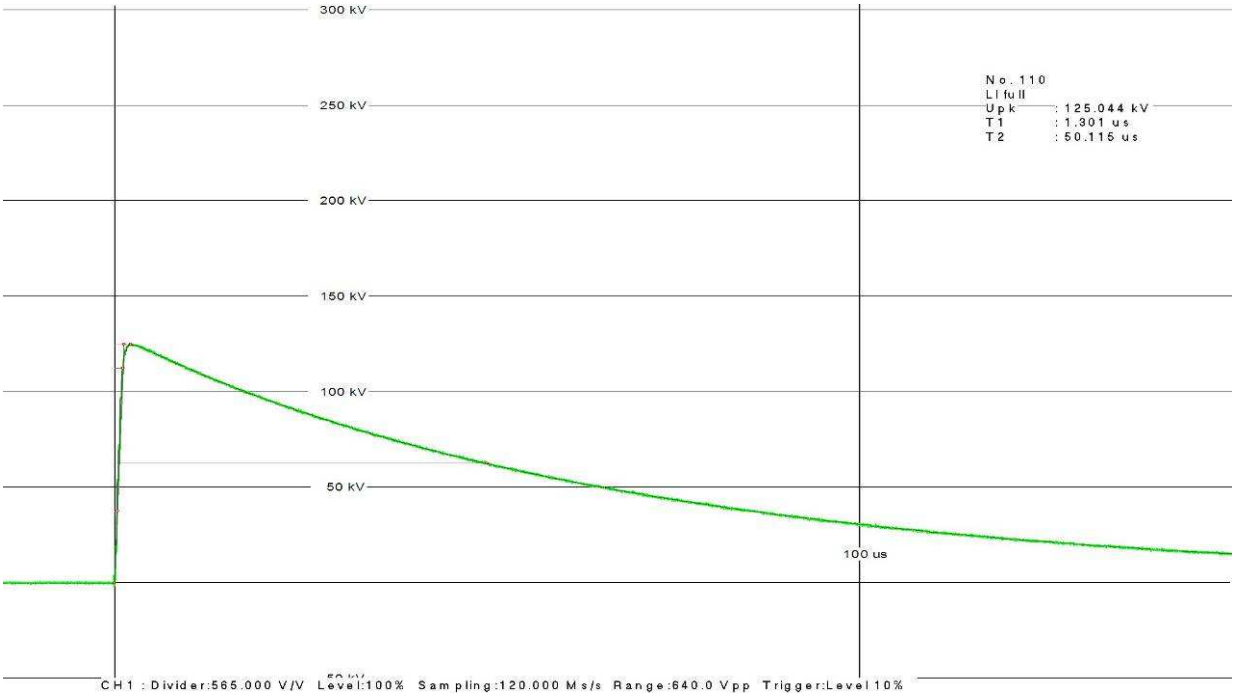


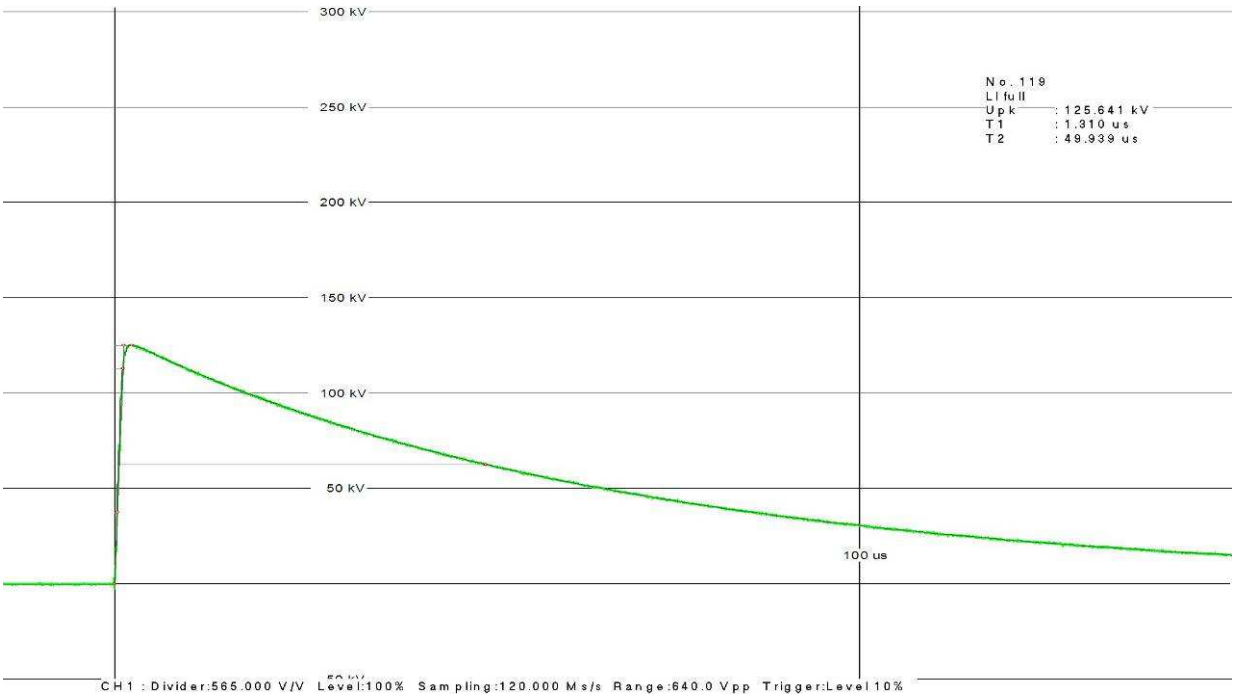
Negative pulses at ambient temperature samples #6, #7 (4.5)



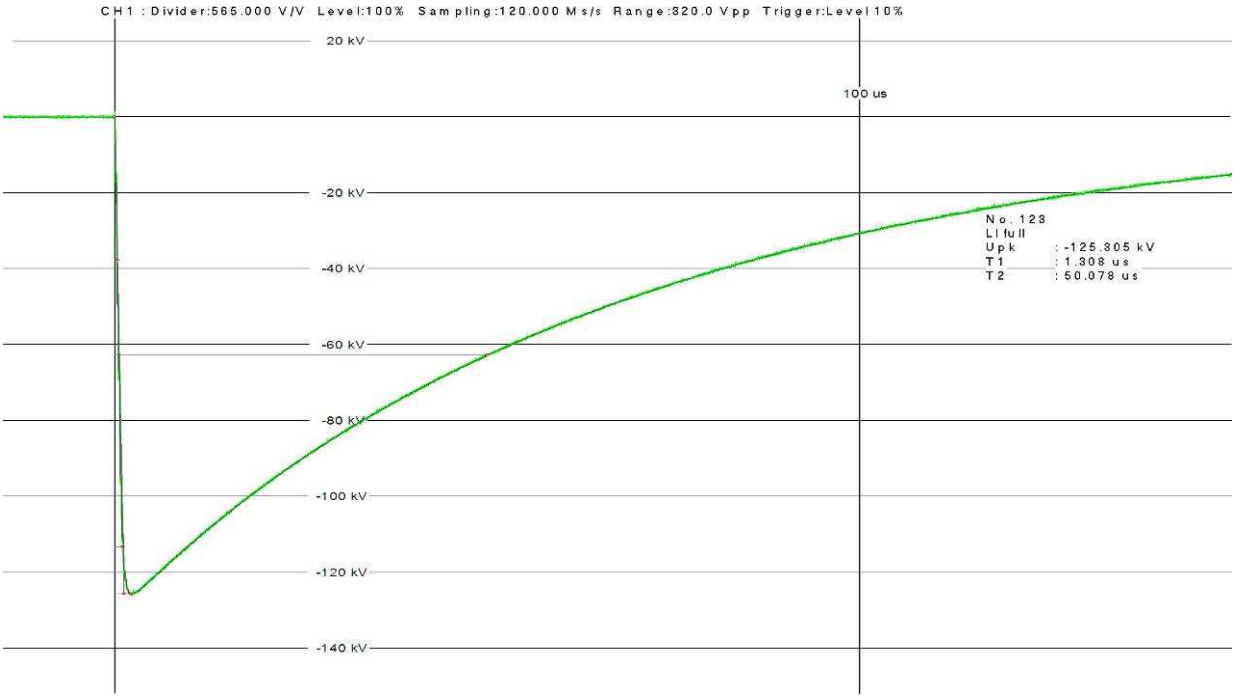


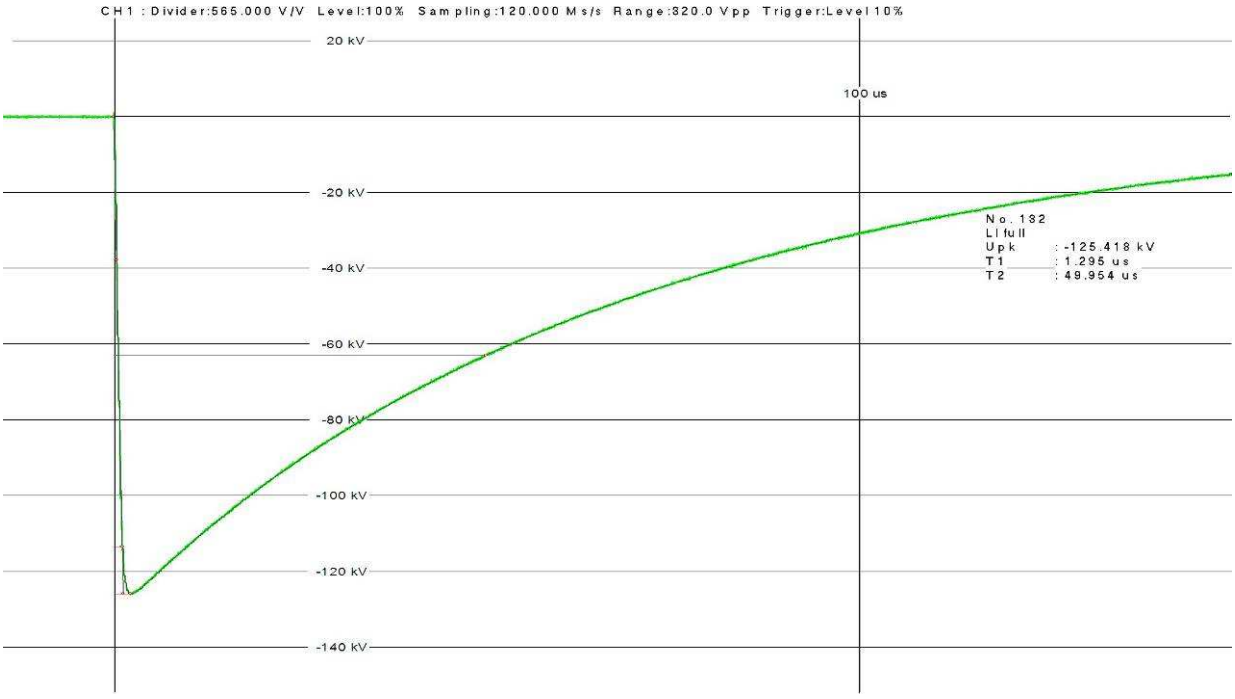
Positive pulses at ambient temperature samples #1, #2 (4.9)



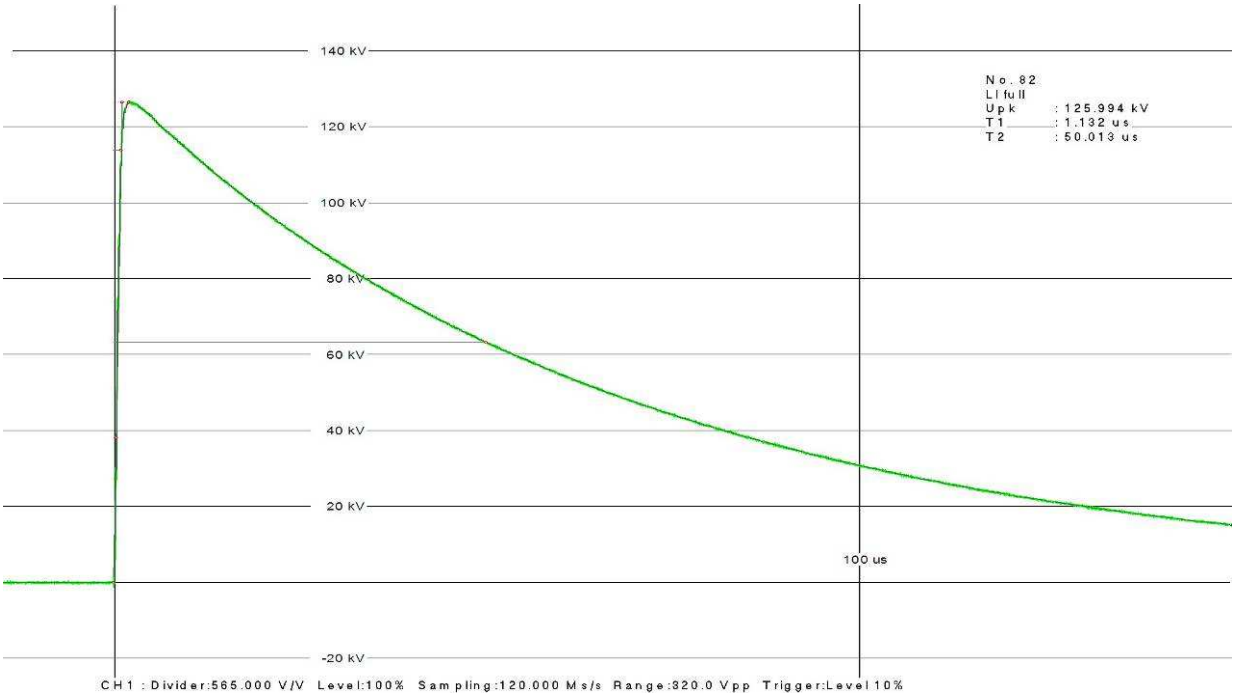


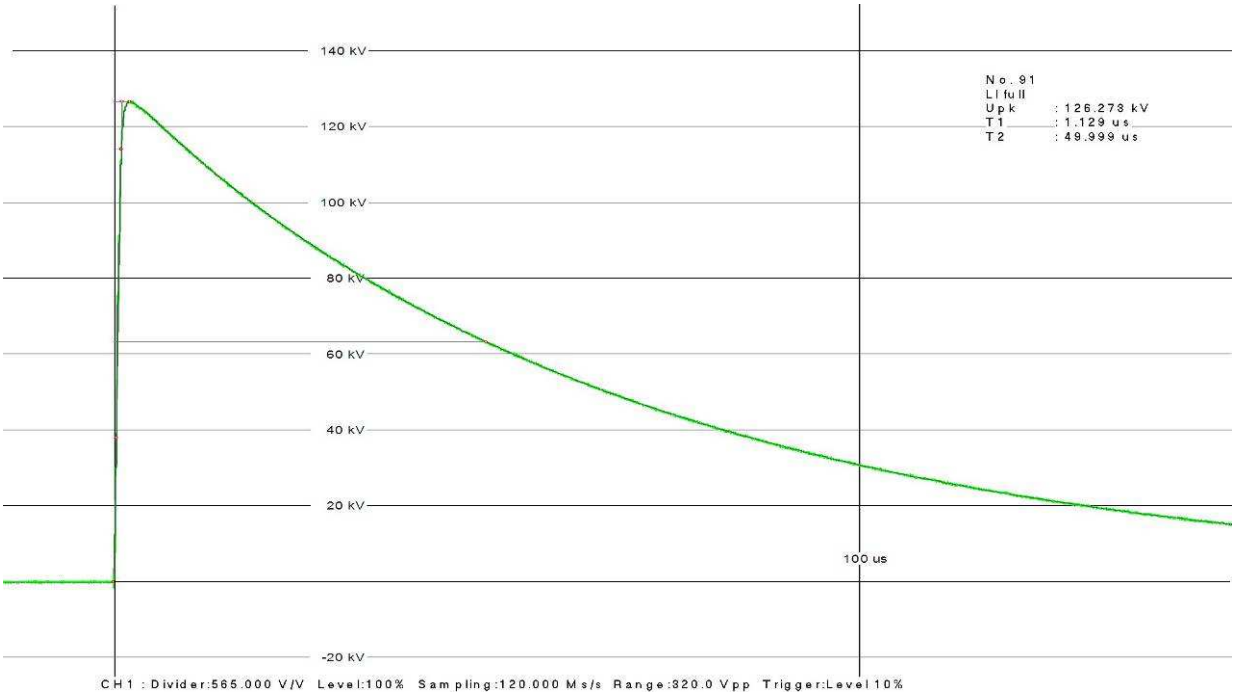
Negative pulses at ambient temperature samples #1, #2 (4.9)



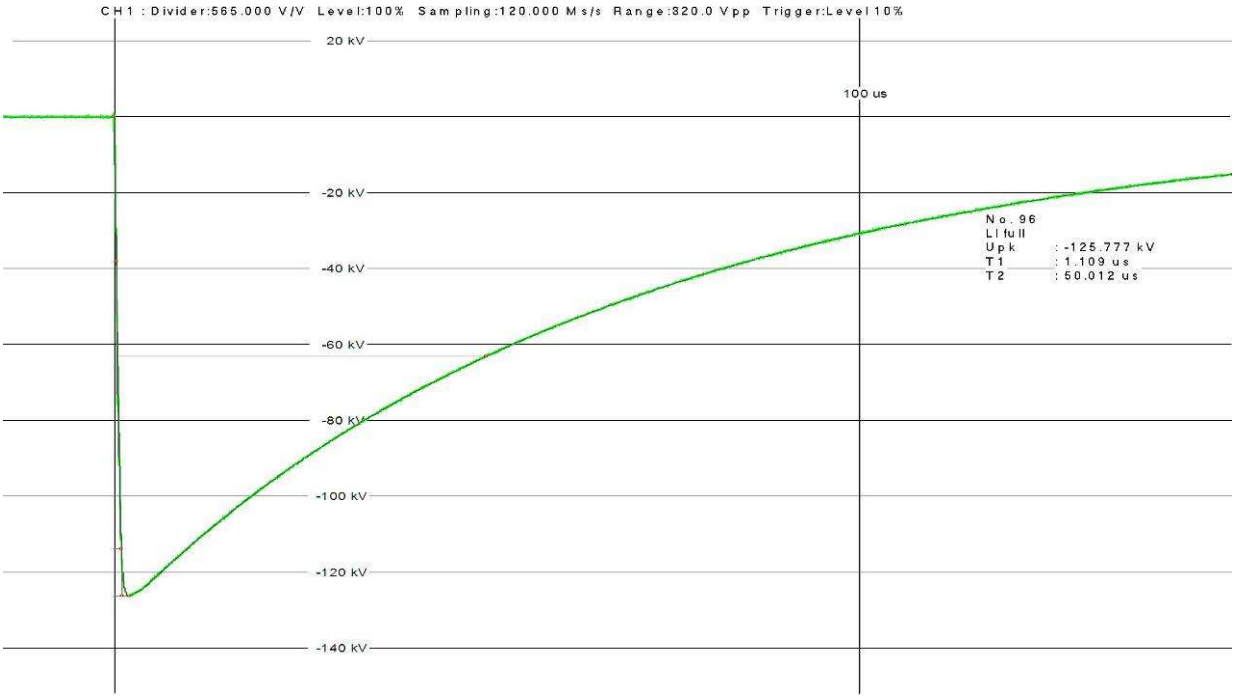


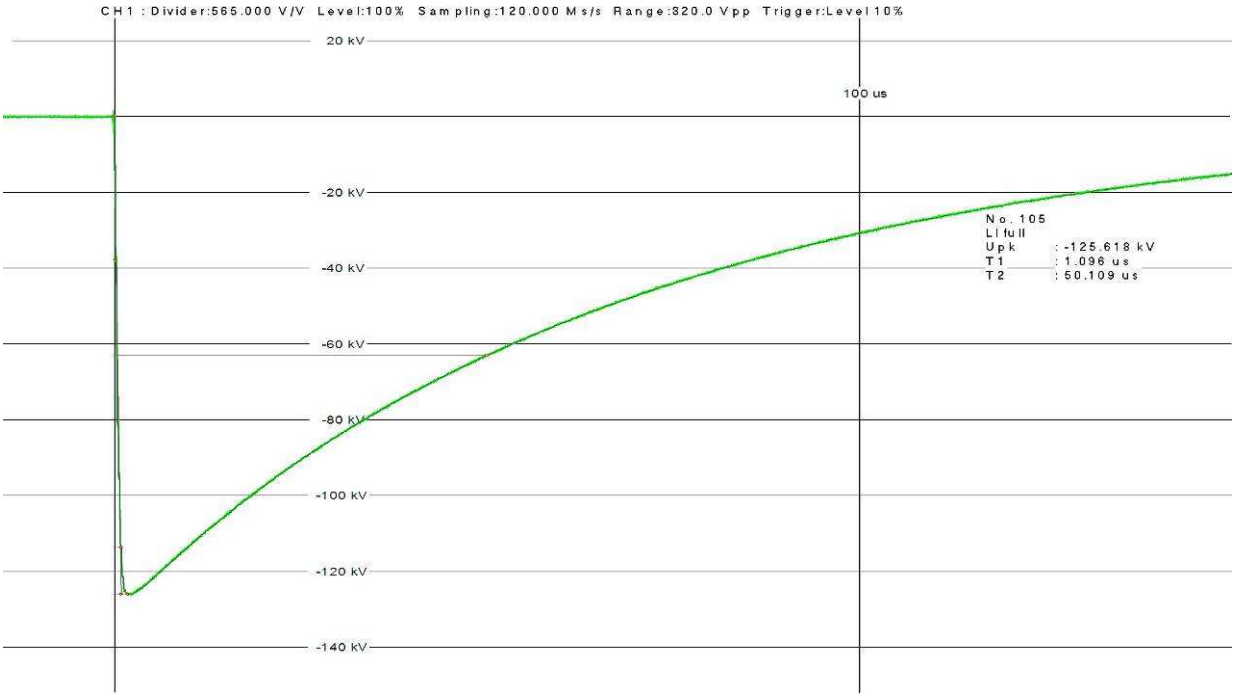
Positive pulses at ambient temperature samples #6, #7 (4.9)



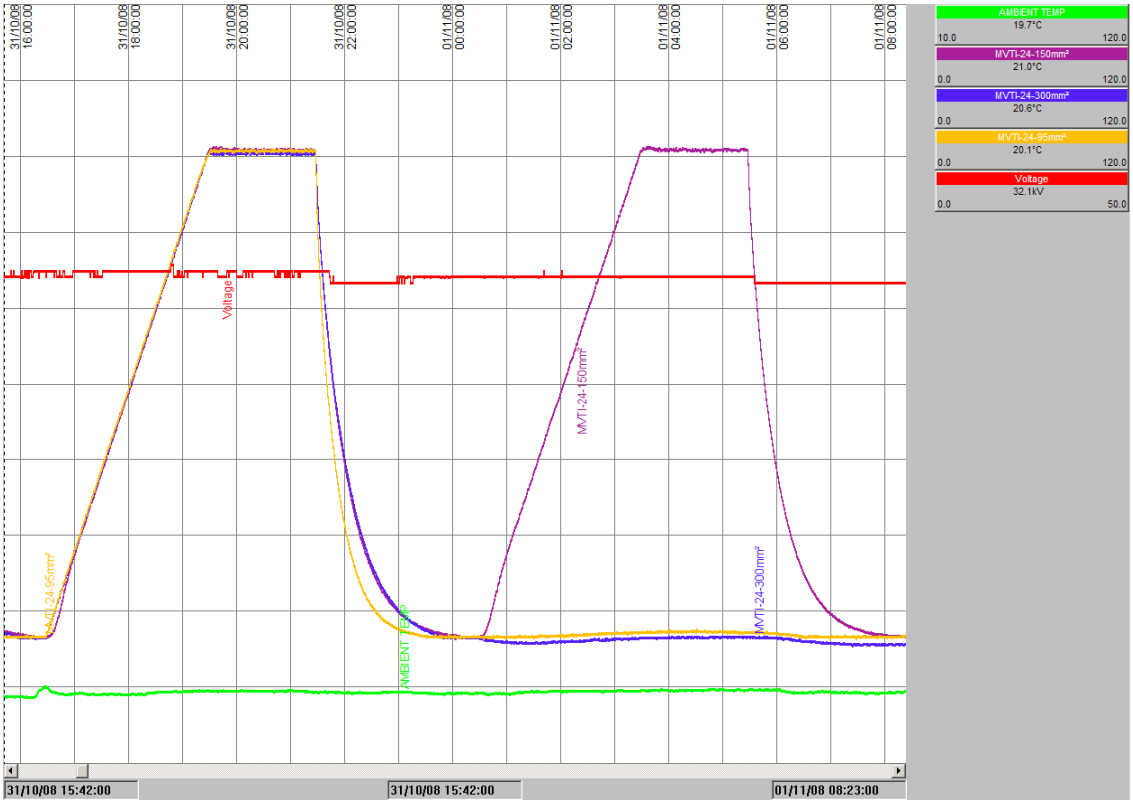


Negative pulses at ambient temperature samples #6, #7 (4.9)

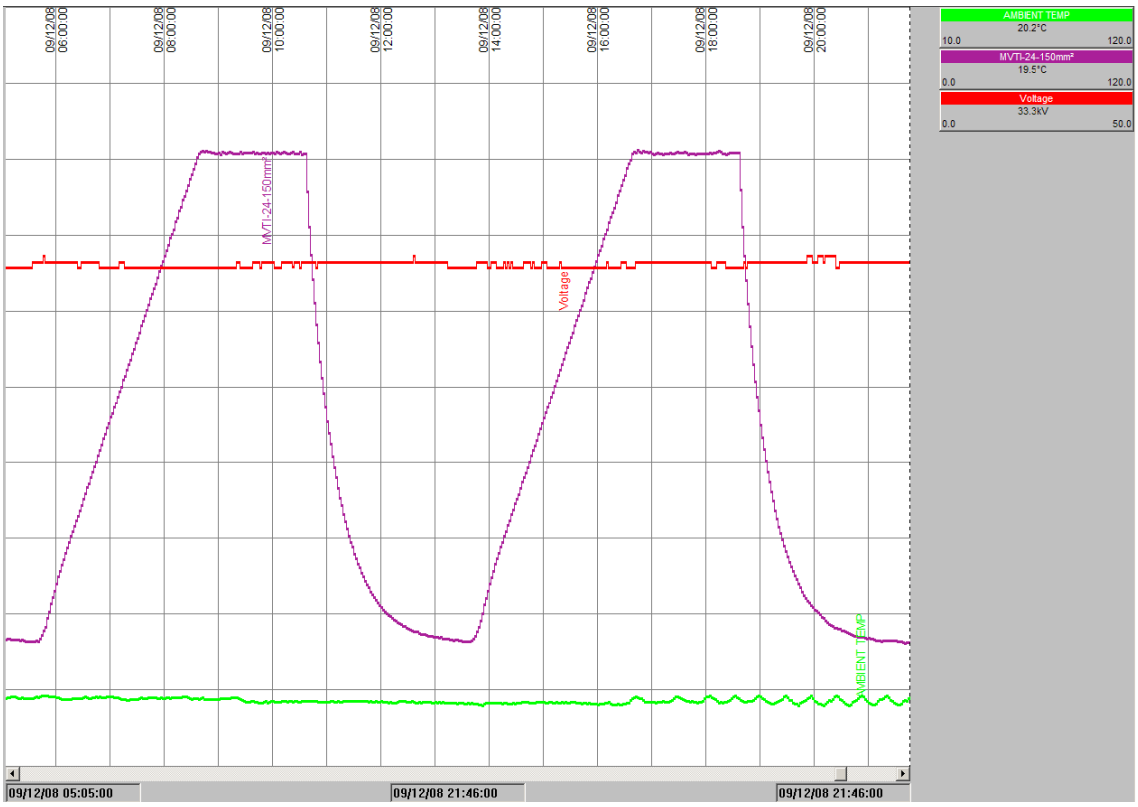




Appendix 2: Examples of heating cycling readings

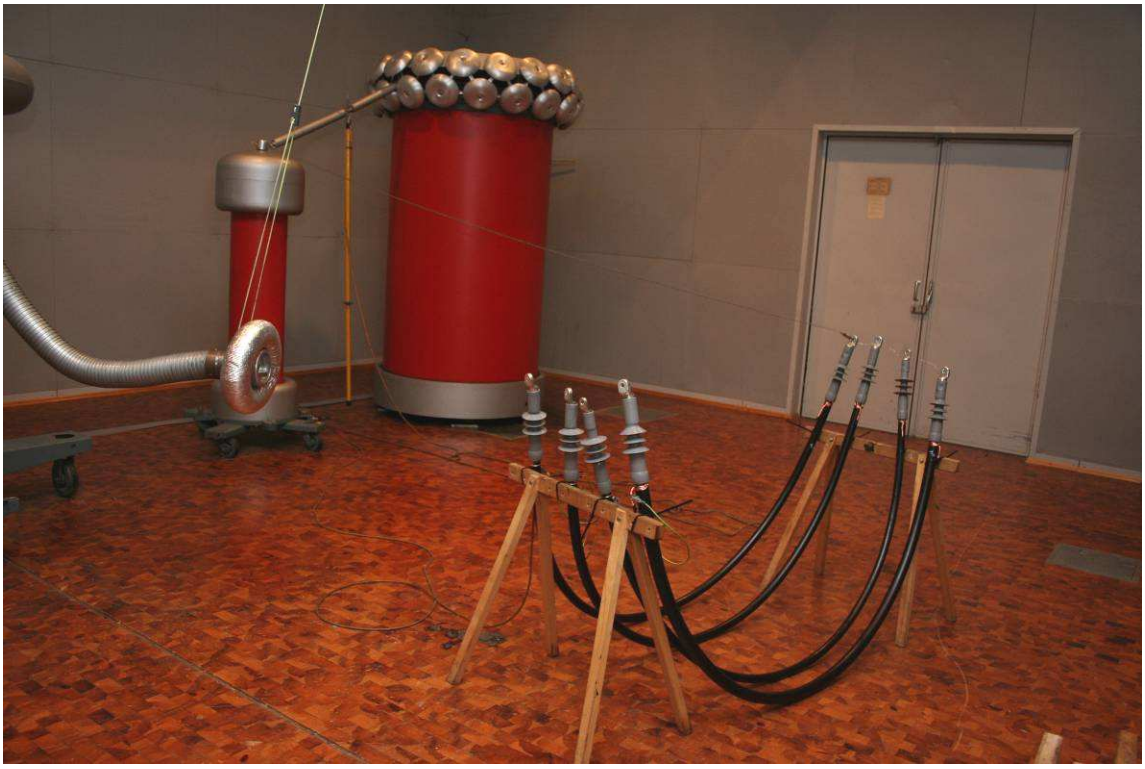


Heating cycles #10 + #11

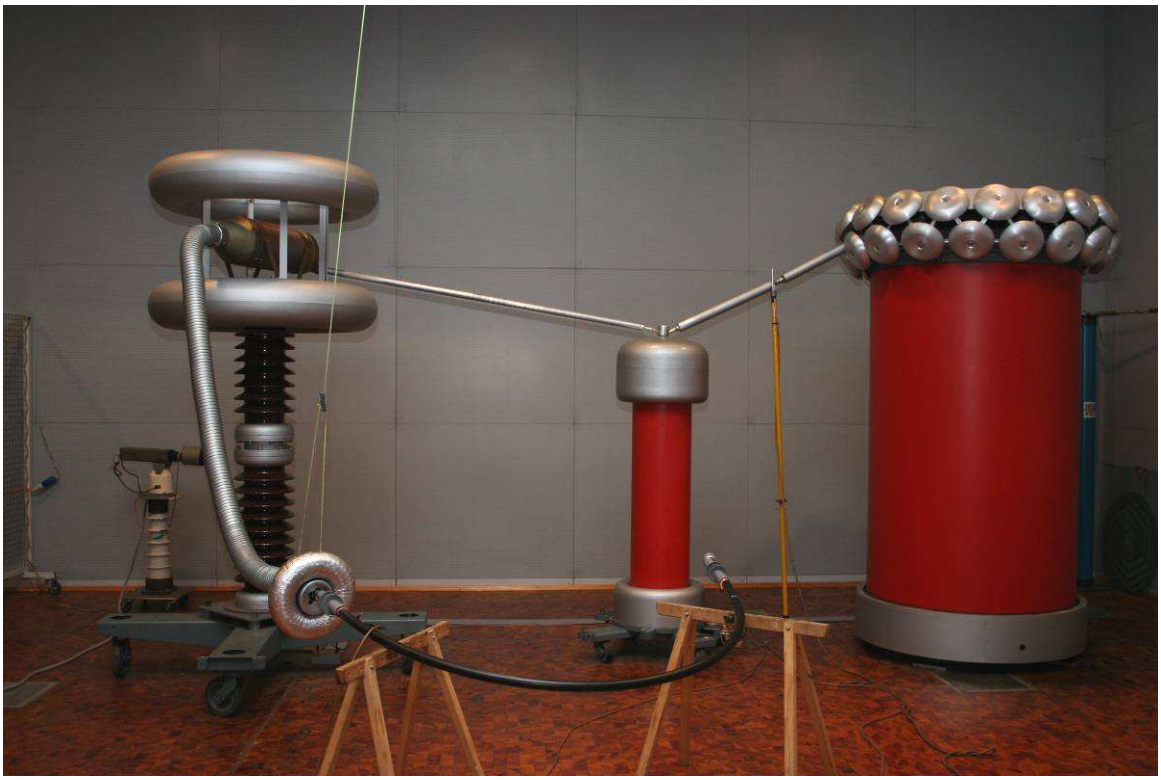


Heating cycles #125 + #126

Appendix 3: Pictures

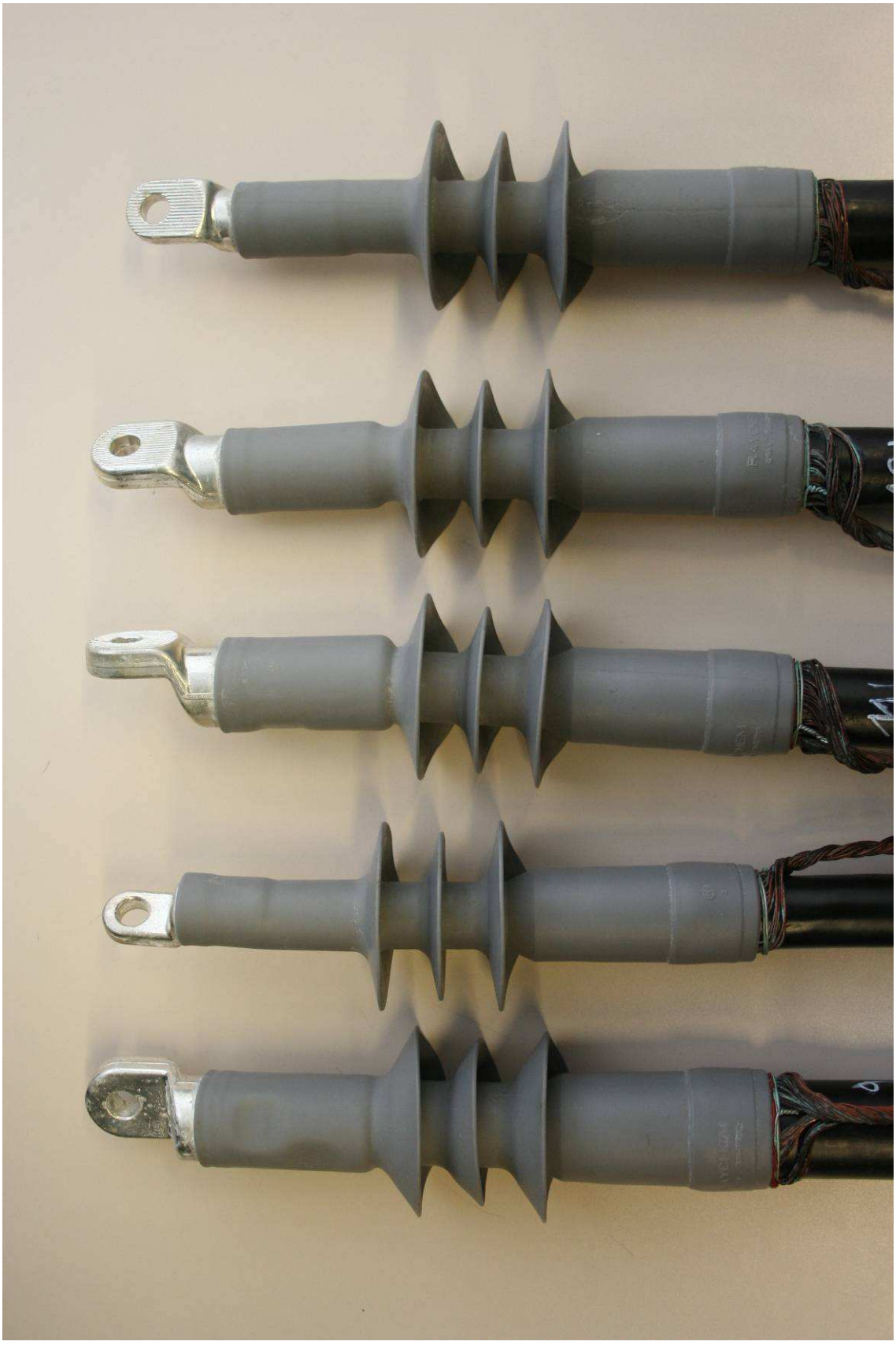


Picture 1: AC voltage withstand



Picture 2: Partial Discharge measurement

Picture 3: Impulse voltage at elevated temperature



Picture 4: Terminations after humidity test

Appendix 4: Installation Instruction

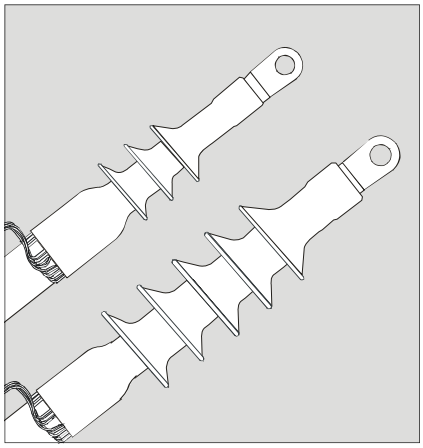
The test loops were built according to the installation instruction EPP-1622-11/08.

Remark:

The final version of the instruction was issued after successful completion of all test listed in this report. All improvements and details found during the installation of the test objects have been worked into the final version.

Energy Division

Tyco Electronics



Installation Instruction EPP-1622-11/08

Raychem Termination for Single Core Polymeric Cable without Armour for Mechanical Connector (25 - 95 mm²) (95 - 300 mm²)

24 kV

MVTI(O)

Tyco Electronics Raychem GmbH
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0049-89-6089-0 tel
0049-89-6089-345 fax
http://energy.tycoelectronics.com

Cable Preparation

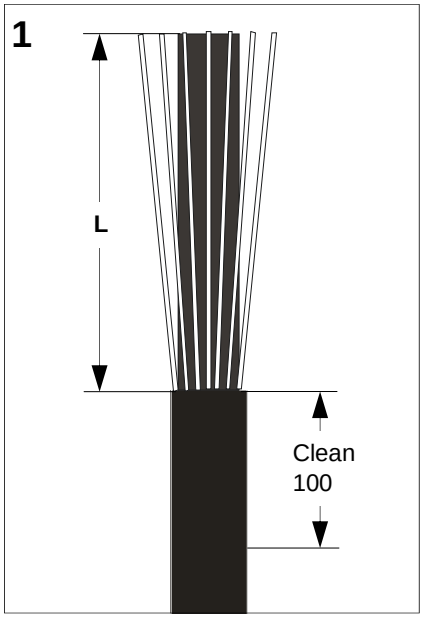
Before Starting

Check to ensure that the kit you are going to use fits the cable.
Refer to the kit label and the title of the installation instruction.
Components or work steps may have been improved since you last installed this product.
Carefully read and follow the steps in the installation instruction.
Keep the protection bag (assembly tool) clean and free from dust and contamination.

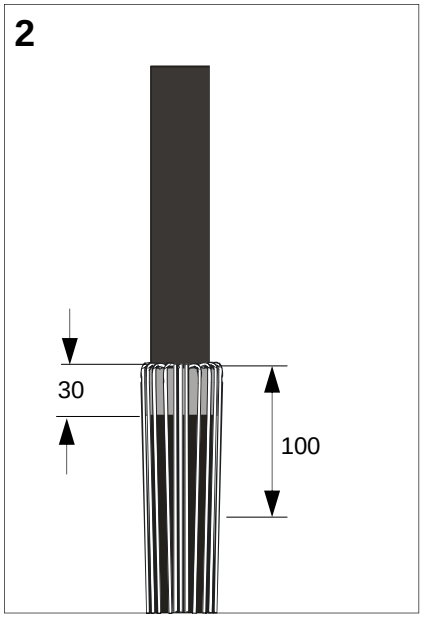
Table 1

Cross Section of Round Stranded Conductor	Diameter of Insulation		Diameter of Cable Lug Barrel		Cut back dimension L for Cable with Wire Shield 24k V	
mm²	mm		mm		mm	
	min.	max.	min.	max.	Indoor	Outdoor
25-95	17.9	25.0	17	30	205	285
95-300	23.5	34.6	21	37	205	285

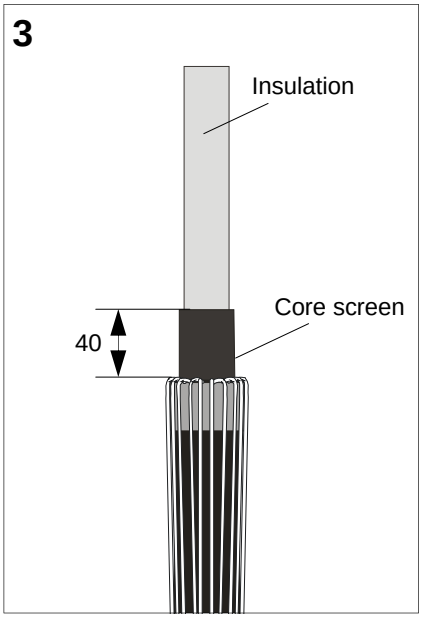
Cut the cable to the required length.
Remove the oversheath according to dimension **L** (see Table 1).
Clean and degrease the end of the oversheath for approximately 100 mm.



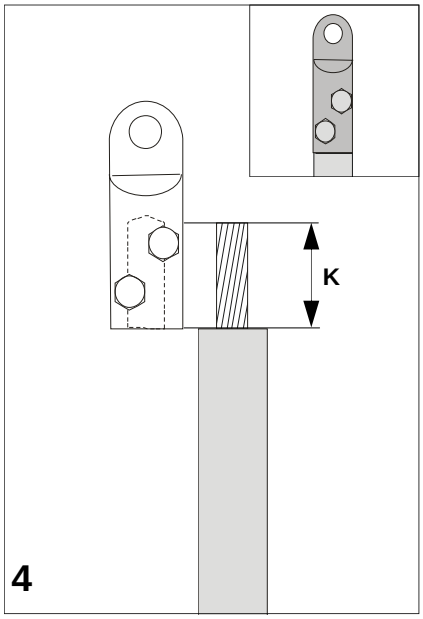
Wrap the entire length of the of sealant tape (red) around the end of the oversheath as shown. Do not stretch the tape. Cut off the helical copper tape. Remove any sharp edges. Bend the shielding wires back onto the oversheath. Avoid crossing the individual wires. Temporarily fix the shielding wires with a tape to the oversheath 100 mm from the oversheath cut.



Thoroughly remove the core screen to within 40 mm above the oversheath cut. The surface of the insulation must be free from all traces of conductive material.
Smooth out any irregularities.
Note: Do not nick the insulation.

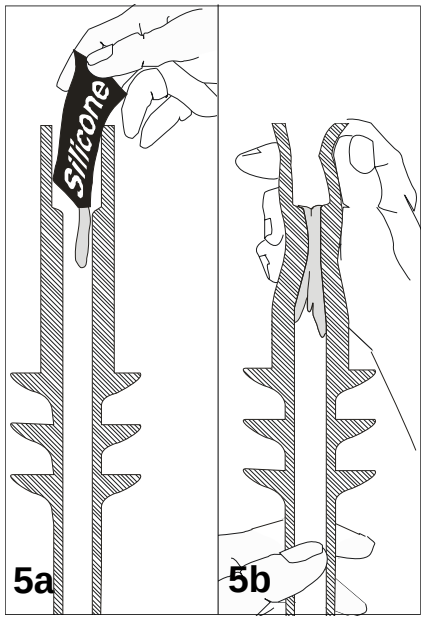


Completion of the Termination



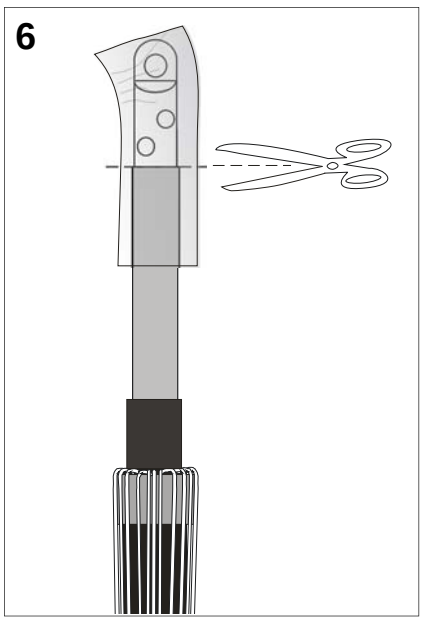
Installation of mechanical lug:

Cut back the insulation according to dimension **K = depth of cable lug barrel hole**.
Install the cable lug according to the installation instruction supplied with the lug. Remove all sharp edges of the ruptured bolts.
Clean and degrease the cable lug and core insulation.

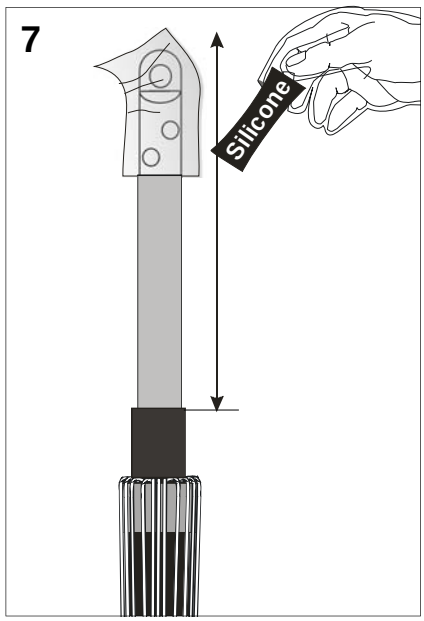


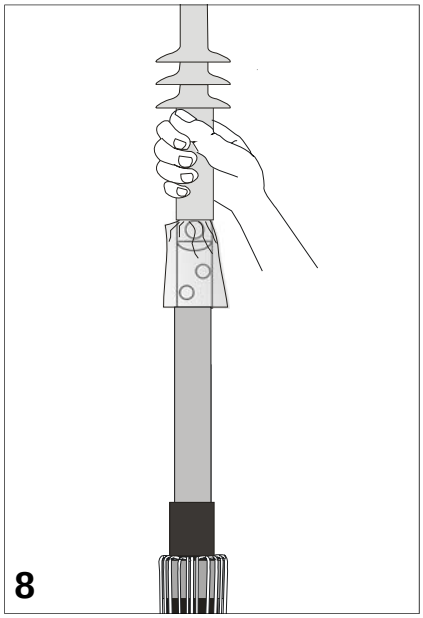
a. Turn the termination body upside down.
Fill the bottom of the termination body with the content of one tube of silicone grease as shown.
b. Thoroughly distribute the silicone grease inside by squeezing the termination body.

Place the protection bag (assembly aid) on the cable lug as shown.
Cut off the protection bag at the end of the cable lug barrel.



Put back the protection bag on the cable lug and apply silicone grease over the whole termination including the bag. Distribute the grease evenly on the surface.

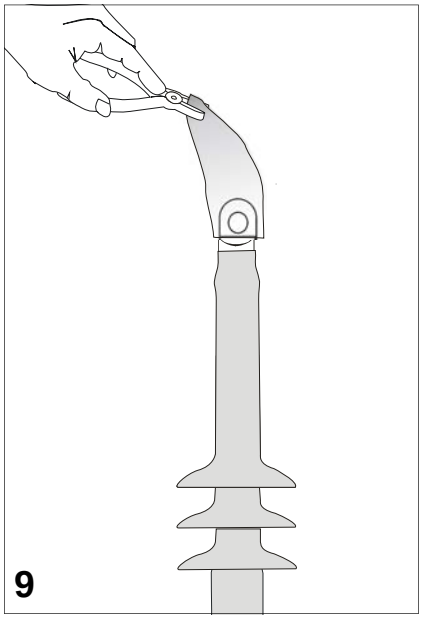




Slide the termination body over the protection bag onto the cable insulation.

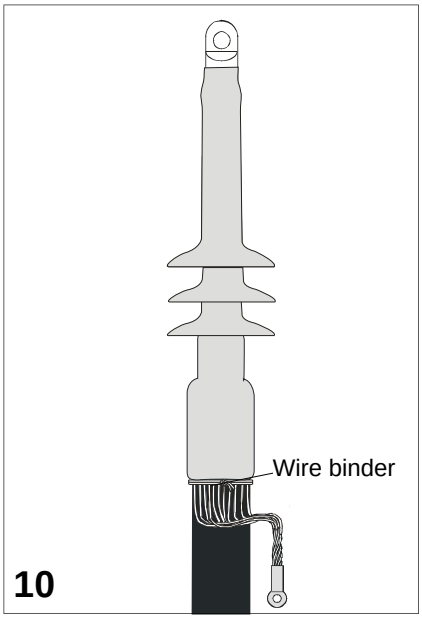
If necessary, slide also the sheds over the cable lug until the termination body sits on the oversheath cut.

Note: The termination should be pushed rather than pulled to make it slide even easier.



Remove the protection bag by pushing and pulling the upper end of the termination body.

Position the termination body to the end of the cable lug barrel if necessary.



Degrease and clean the termination.

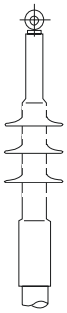
Fix the shield wires and wire binder along the lower edge of the termination body. Install the cable lug at the end of the shield wires as shown.

Termination completed.

Please dispose of all waste according to environmental regulations.

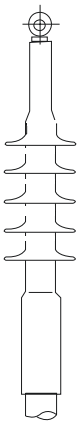
Number of Skirts

Indoor



24 kV

Outdoor



24 kV