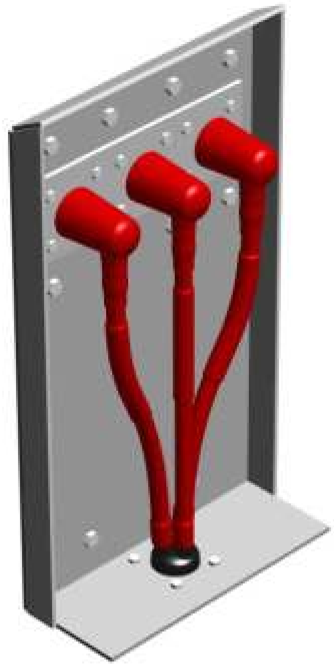
Shrink Polymer Systems
CONFIDENTIAL

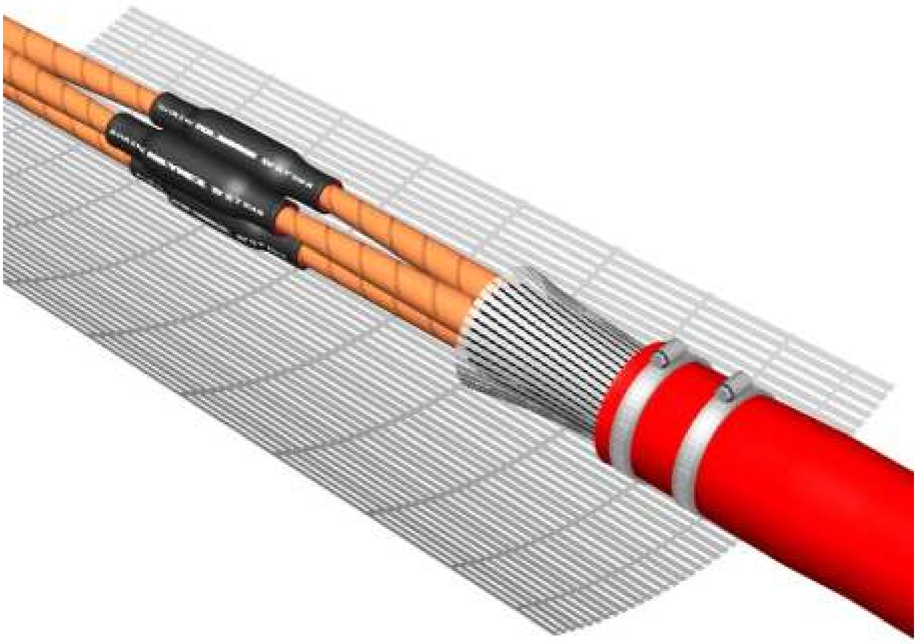
ASTA

TEST REPORT

NO: 2212



HEATSHRINK TERMINATIONS
3 CORE 12kV PILC AND XLPE



UNIVERSAL 12kV HEATSHRINK JOINT
TO SUIT 3 CORE XLPE / PILC CABLES
INLINE OR TRANSITION

SHRINK
POLYMER
SYSTEMS

ASTA TEST REPORT

Laboratory Ref. No. **AR/L/06/21** **Test Report No.** 2212

APPARATUS:	12kV 3–core 95mm^2 8m length indoor cable fitted with a universal straight joint and PILC (impregnated paper) terminations on one end and XLPE (polymeric) terminations at the other end.
DESIGNATIONS:	5PUJ 12U–95–185–3 3TIS–12P–C 3TIS–12X–C
MANUFACTURER:	Shrink Polymer Systems, Unit P1–P3 Grovemere Court, Bicton Industrial Park, Kimbolton, Cambs, England, UK
TESTED FOR:	Shrink Polymer Systems, Unit P1–P3 Grovemere Court, Bicton Industrial Park, Kimbolton, Cambs, England, UK.
TESTED BY:	The Tony Davis High Voltage Laboratory, Building 20, Highfield Campus, University Road, University of Southampton.
DATE(S) OF TESTS:	December 2005 – March 2006

The apparatus, constructed in accordance with the description, drawings and photographs attached hereto, has been examined and tested in accordance with client's instructions and :-

BS 7888 – 4.2 : 1998, Table 1 (Test Sequence A1) & Table 3 (Test Sequence B1)

TESTS

Tests on a length of INDOOR insulated cable with a universal straight transition joint & terminations
Tests from BS 7888–4.2, Table 1 – for indoor terminations
Tests from BS 7888–4.2, Table 3 – for universal transition joints

This is not a certificate of rating. A certificate of rating was not issued as part of the tests were made in accordance with client's instructions.

The documents forming part of this Test Report are :-

(1) Record of Proving Tests	Page Nos. 1 to 6
(2) Diagram Nos.	TLAB/05/11a.
Oscillogram Nos.	Fig 1, Fig. 2, Fig. 3, Fig. 4, TN051209/D1–D6, TN060321/D1–D6
(4) [illegible]wing Nos.	System A54 Pg 1–Pg 7, System A56 Pg 1–Pg 8, System A171 Pg 1–Pg 10
(5) Ph[illegible]h Nos.	P/06/69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79 & 80

The Reco[illegible]oving Tests applies only to the apparatus tested. The responsibility for conformity of any apparatus [illegible]he same designation with that tested rests with the Manufacturer.

Abdul Majid .... **ASTA Observer**
Abdul Majid

C. [signature] .... **DIRECTOR**

16th October 2006 .... **Date**

Laboratory Reference No.AR/L/06/21 Date of Tests December 2005 – March 2006

CONTENTS

This is not a Certificate of Rating

1. Apparatus Tested

12kV 3–core 95mm^2 8m length indoor cable fitted with a universal straight joint and PILC (impregnated paper) terminations on one end and XLPE (polymeric) terminations at the other end.

Transition joint – connecting extruded (XLPE) insulation cable to impregnated paper (PILC) insulated cable

Uo = 6.35kV – the rated power frequency voltage between conductor and earth
Um = 12kV – the maximum value of the highest system voltage for which the cable accessory may be used

The apparatus under test was constructed in accordance with the installation instructions listed on page 1

2. Test Specification

The tests were made to client's instructions and generally in accordance with :

BS 7888 – 4.2 : 1998, Table 1 (Test Sequence A1) & Table 3 (Test Sequence B1)

3. Test Arrangements

Due to laboratory limitations testing of cables were conducted at Southampton University and were witnessed by Mr Abdul Majid, NaREC Testing Authority Observer.

Calibration of test cable conductor temperature
To determine cable conductor temperature, a temperature calibration test was made in accordance with BS 7888–2, Annex B.2, by direct injection of a given current.

Thermocouples were used to measure the cable inner conductor and external surface temperatures in accordance with BS 7888–2, Annex B, Figures B.1 & B.2.

The cable was heated until the cable conductor temperature reached the maximum rated conductor temperature as specified in BS 7888–3, Table 1 for impregnated paper (80^{0}C+ 0K–5K).

The heating continued until the conductor and external surface temperatures had stabilised and did not show any variation greater than 2K within a 2hr period.

The corresponding external cable surface temperature (measured) was used during the elevated temperature tests.

Fig. 1 – Calibration / thermal cycle
Fig. 2 – Elevated temperature of the external surface during lightning impulse tests
Fig. 3 – Electrical heat cycles in Air
Fig. 4 – Electrical heat cycles in Water

Note on electrical heat cycles
Initial 63 cycles were made in AIR on both terminations and universal straight joint. Then a further 63 cycles were made with terminations being in AIR and universal straight joint in WATER - thus completing the 126 cycles.

Each cycle consisted of an 8-hour duration (Figure 1) in accordance with BS7888–2, sub-clauses 9.1 & 9.2

4. Tests Made

Tests to BS7888–4.2, Table 1 (indoor terminations for impregnated paper insulated cables - Test Seq. A1)
1. DC dry negative polarity voltage test at –38.1kV for 15 minutes
2. AC dry voltage test at 28.6kV for 5 minutes
3. Ten (positive & negative) lightning impulse voltages at 95kVpk (at elevated temperature)
4. 126 electrical heat cycles in air energised at 9.5kV
5. AC dry voltage test at 19.1kV for 4 hours
9. Ten (positive & negative) lightning impulse voltages at 95kVpk (at ambient temperature)
10. AC dry voltage test at 15.9kV for 15 minutes
12. Examination

Tests to BS7888–4.2, Table 3–Joints & transition joints for impregnated paper insulated cables (Test Seq. B1)
1. DC dry negative polarity voltage test at –38.1kV for 15 minutes
2. AC dry voltage test at 28.6kV for 5 minutes
4. Ten (positive & negative) lightning impulse voltages at 95kVpk (at elevated temperature)
5. 63 electrical heat cycles in air energised at 9.5kV
6. 63 electrical heat cycles in water energised at 9.5kV
7. AC dry voltage test at 15.9kV for 4 hours
11. Ten (positive & negative) lightning impulse voltages at 95kVpk (at ambient temperature)
12. AC dry voltage test at 15.9kV for 15 minutes
13. Examination

5. Test Results

Recorded atmospheric conditions are detailed on Table 1
Results of DC voltage tests are detailed on Table 2
Results of AC voltage tests at 4.5Uo are detailed on Table 3
Sample of results of cable conductor, external surface and ambient temperature during 2hr stabilization period as detailed in Table 4
Results of lightning impulse voltage tests at elevated temperature are detailed on Table 5
Results of AC voltage tests at 3Uo are detailed on Table 6
Results of lightning impulse voltage tests at ambient temperature are detailed on Table 7
Results of AC voltage tests at 2.5Uo are detailed on Table 8

Examination
Visual inspection of encapsulation exposed at the section end of the joints showed no cracks or large voids
45^0 cut on PILC (paper) end showed no ingress of water on the inside insulation
45^0 cut on XLPE (polymeric) end showed no ingress of water on the inside insulation
No froth was observed on unrolled insulation paper put into 135^0C hot oil, indicating that there was no moisture entered into the paper during the electrical heat cycling in water.

6. Conclusion

The results of the tests show that the MV cable has satisfactorily satisfied the criteria of tests from BS 7888–4.2, Tables 1 & 3

Table 1
Recorded atmospheric conditions

Atmospheric Conditions			
Date of Test(s)	08–12–2005	09–12–2005	20–03–2006
Atmospheric Pressure (millibar)	759.7	775.5	756.7
Ambient Temperature (^{0}C)	16.5	15.0	15.0

Table 2
Results of DC voltage tests at 6Uo

Test Arrangement	DC Test Voltage (kV)	Test Duration (minutes)	Comments	Test Number
HT on commoned phases L1, L2, L3 with cable screen EARTHED	– 38.1	15	Withstand	TN051208/D1

Table 3
Results of AC voltage tests at 4.5Uo

Test Arrangement	Test Voltage (kVrms)	Test Duration (minutes)	Comments	Test Number
L3	28.6	5.0	Withstand	TN051208/D2
L2	28.6	5.0	Withstand	TN051208/D3
L1	28.6	5.0	Withstand	TN051208/D4

Note
HT applied to each phase in turn with the other two phases and screen EARTHED

Table 4
Sample of results of cable conductor, external surface and ambient temperature during 2hr stabilization period

Time (seconds)	Conductor Temperature (^{0}C)	External surface Temperature (^{0}C)	Ambient Temperature (^{0}C)
10800	82.13	63.15	15.65
11800	82.09	63.03	16.18
12800	82.29	63.56	15.90
13800	82.40	63.42	15.94
14800	82.16	63.44	16.05
15800	81.41	63.61	16.06
16800	82.34	63.48	16.08
17800	82.28	63.13	16.09
18800	81.80	62.69	16.24

Note:
For the elevated temperature tests, the cable is energised and heated to the stabilized external surface temperature for at least 2hrs (i.e to 63^{0}C) before application lightning impulse tests

Table 5
Results of lightning impulse voltage tests at elevated temperature (63^{0}C)

Test Arrangement	Polarity ±	Applied Test Voltage (kVpk)										Test Number
		1	2	3	4	5	6	7	8	9	10	
L3	–	96.1	96.0	95.2	95.8	94.9	95.2	95.4	95.2	95.6	95.4	TN051209/D1
	+	95.0	94.5	94.8	94.6	95.4	95.5	95.5	95.7	95.6	95.2	TN051209/D2
L2	+	95.0	95.5	95.7	95.6	95.3	95.9	94.5	95.4	95.3	94.7	TN051209/D3
	–	95.1	95.7	95.9	95.7	95.4	95.3	95.4	95.5	95.4	95.6	TN051209/D4
L1	+	95.0	95.5	95.7	95.6	95.3	95.9	94.5	94.4	95.3	94.7	TN051209/D5
	–	94.7	94.5	94.9	95.1	95.2	94.9	95.2	95.3	94.2	95.4	TN051209/D6

Table 6
Results of AC voltage tests at 3.0Uo

Test Arrangement	Test Voltage (kVrms)	Test Duration (hours)	Comments	Test Number
L1	19.1	4.0	Withstand	TN051208/D4
L2	19.1	4.0	Withstand	TN051208/D5
L3	19.1	4.0	Withstand	TN051208/D6

Note
HT applied to each phase in turn with the other two phases and screen EARTHED

Table 7
Results of lightning impulse voltage tests at ambient temperature (15^{0}C)

Test Arrangement	Polarity ±	Applied Test Voltage (kVpk)										Test Number
		1	2	3	4	5	6	7	8	9	10	
L2	–	95.0	95.2	95.4	95.3	95.2	95.1	95.1	95.1	95.2	95.2	TN060321/D1
	+	94.5	94.8	94.8	94.6	95.2	95.1	95.2	94.9	95.0	95.1	TN060321/D2
L1	+	94.7	94.7	94.6	94.7	94.8	94.8	94.7	94.6	94.8	94.6	TN060321/D3
	–	94.6	95.2	95.5	95.7	95.5	95.3	95.3	95.2	95.4	95.3	TN060321/D4
L3	–	95.5	95.4	95.3	95.6	95.4	95.5	95.5	95.2	95.5	95.4	TN060321/D5
	+	94.6	95.0	95.2	94.1	94.8	95.0	94.8	95.4	95.0	95.4	TN060321/D6

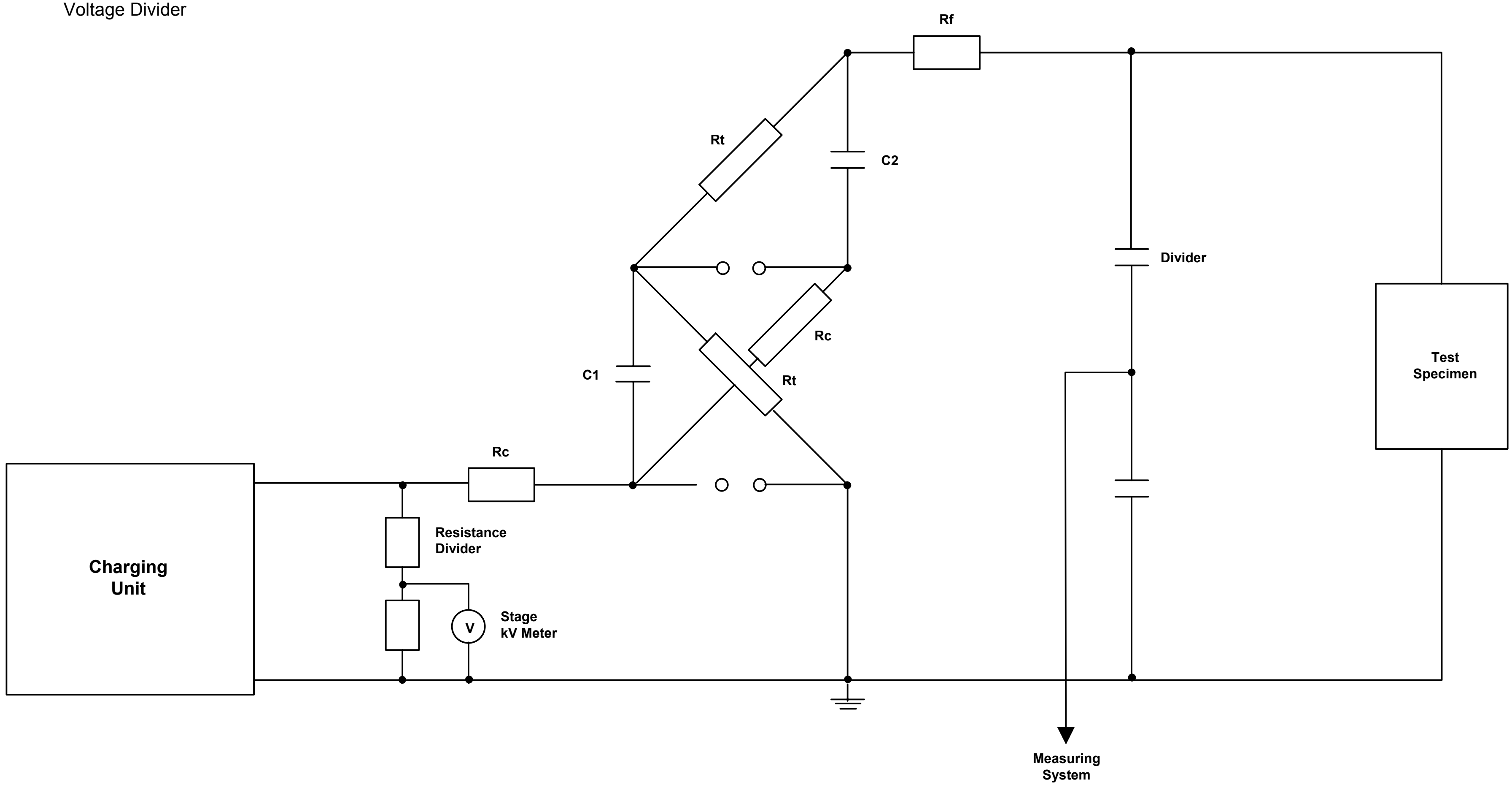
Table 8
Results of AC voltage tests at 2.5Uo

Test Arrangement	Test Voltage (kVrms)	Test Duration (minutes)	Comments	Test Number
L1	15.9	15.0	Withstand	TN060321/D7
L2	15.9	15.0	Withstand	TN060321/D8
L3	15.9	15.0	Withstand	TN060321/D9

Note
HT applied to each phase in turn with the other two phases and screen EARTHED

Impulse Generator

Number of Stages - Variable
Stage Capacitors - C1,C2, etc.
Tail Resistors - Rt
Front Resistor - Rf
Charging Resistors - Rc
Voltage Divider



Typical Test Circuit for Impulse Tests

TLAB/05/11a

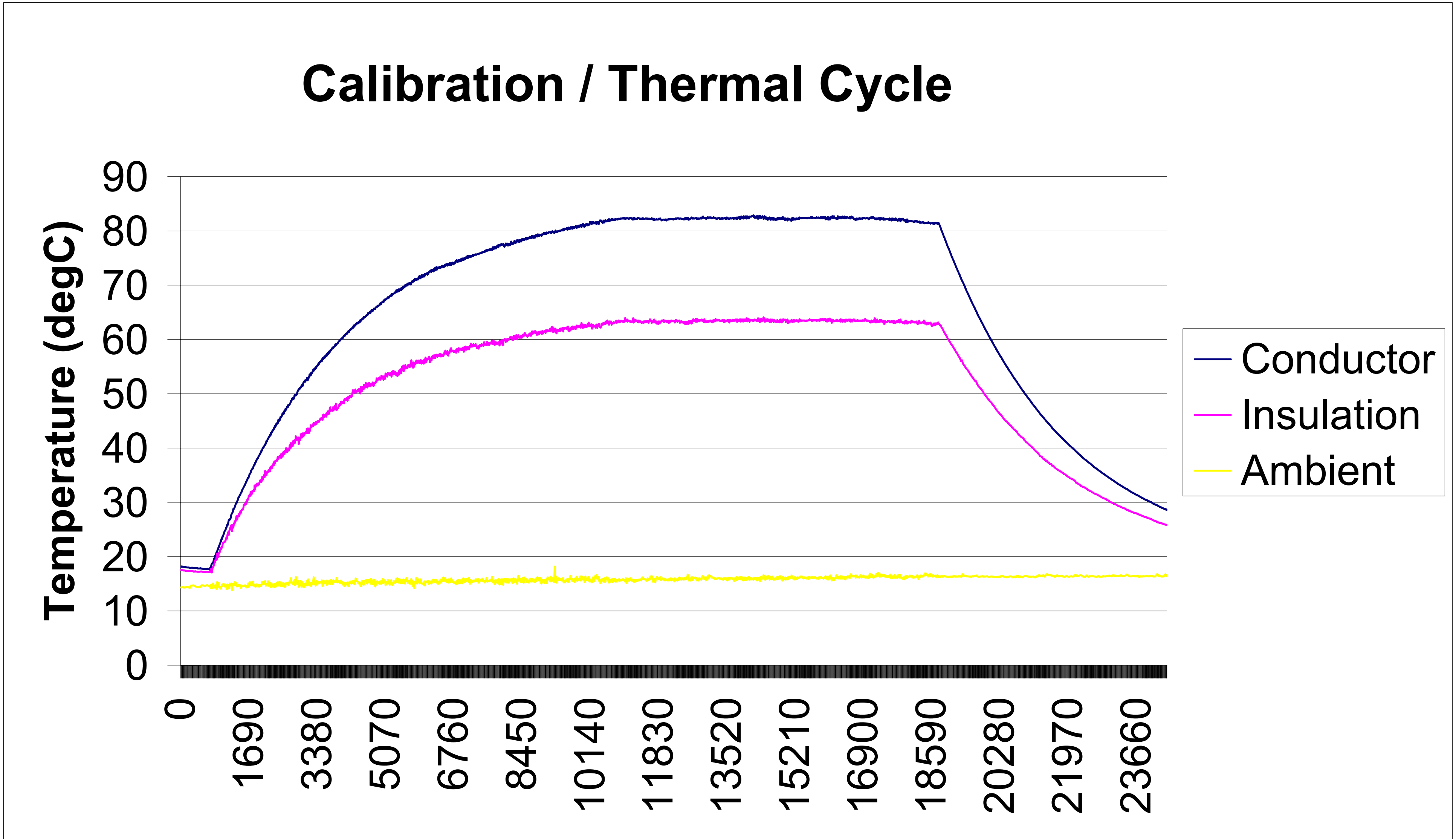

Calibration / Thermal Cycle
Temperature (degC)
90
80
70
60
50
40
30
20
10
0
0
1690
3380
5070
6760
8450
10140
11830
13520
15210
16900
18590
20280
21970
23660
Time (seconds)
Conductor
Insulation
Ambient

Fig. 1

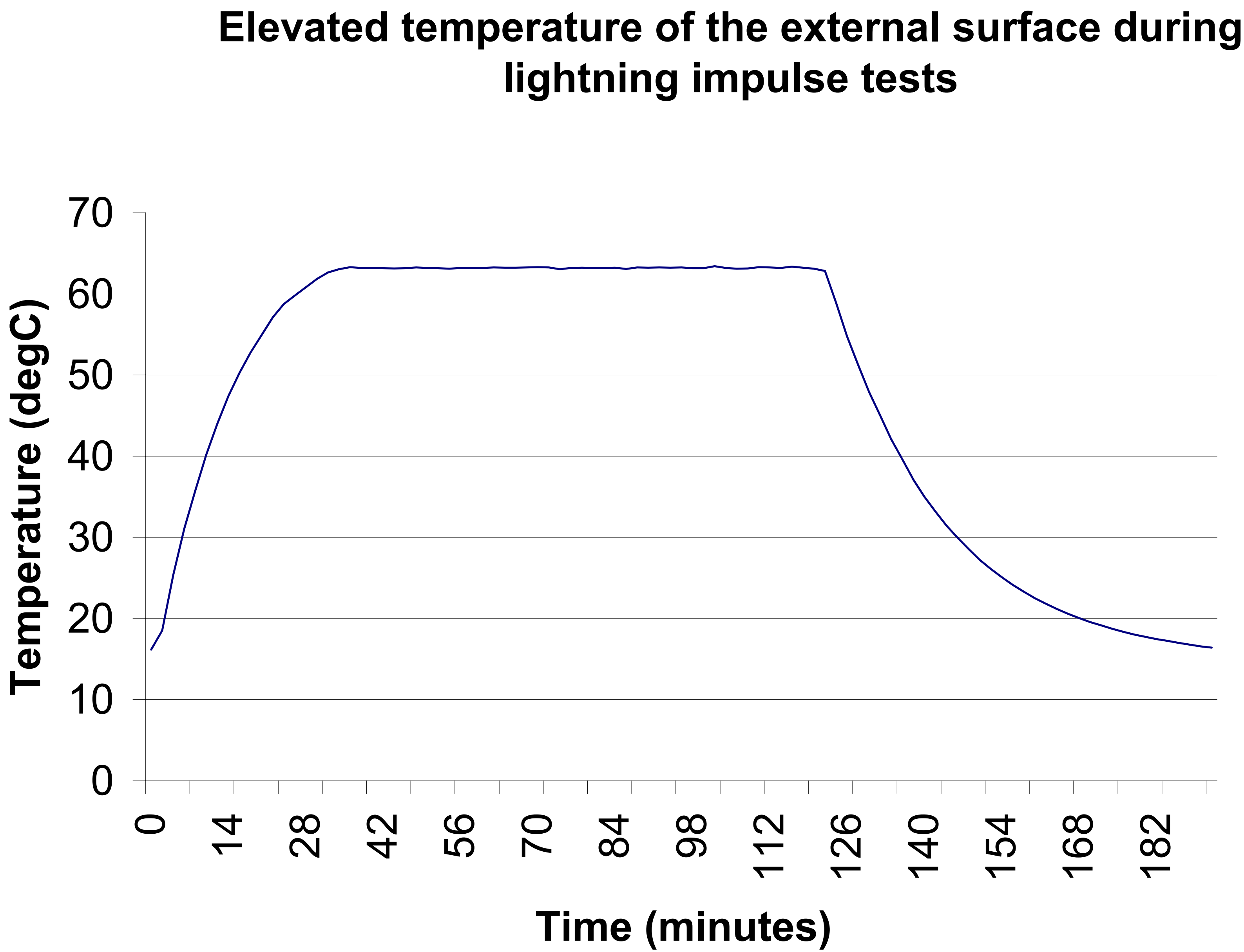
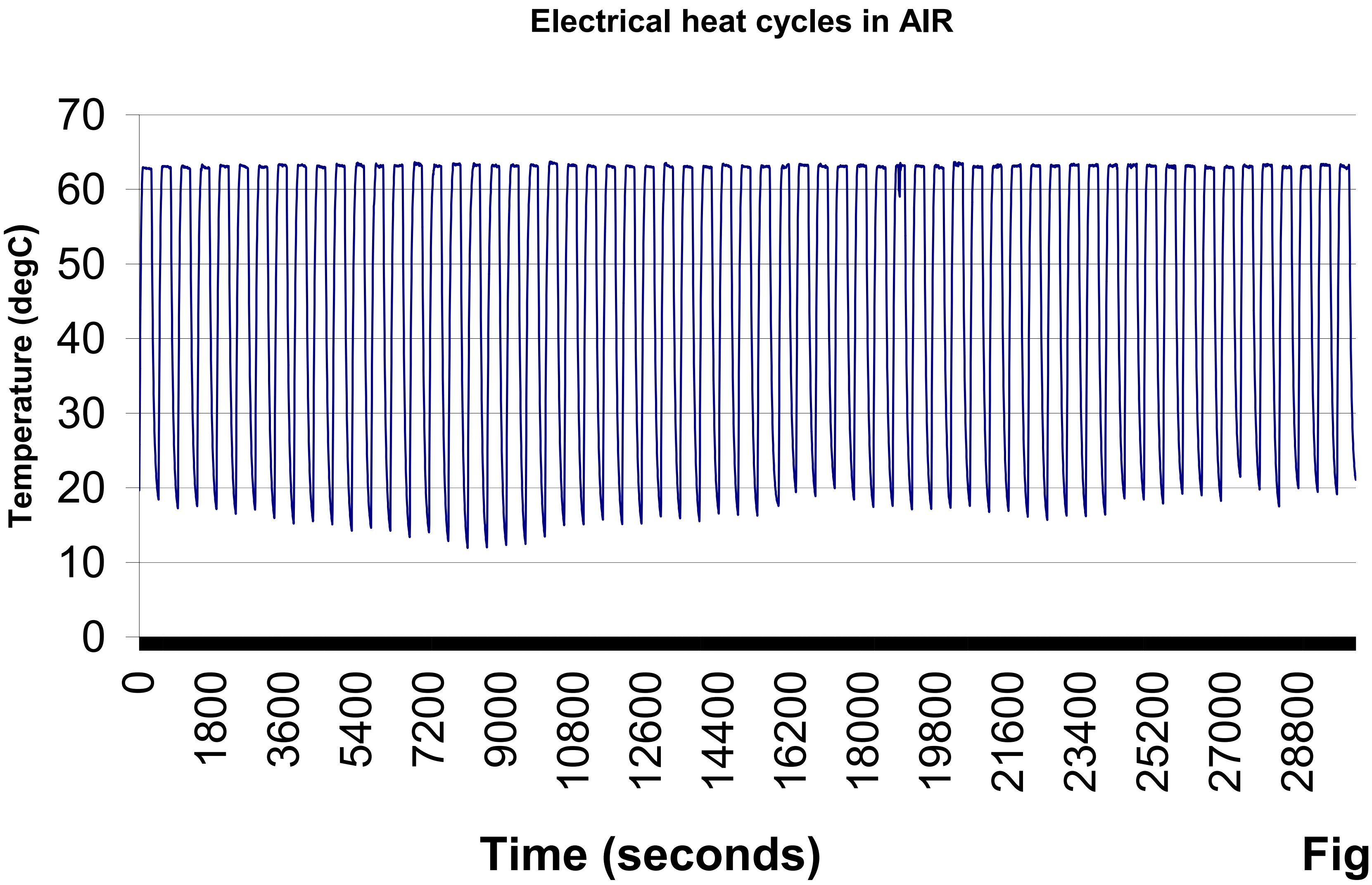

Elevated temperature of the external surface during lightning impulse tests
Temperature (degC)
70
60
50
40
30
20
10
0
0
14
28
42
56
70
84
98
112
126
140
154
168
182
Time (minutes)

Fig. 2



Electrical heat cycles in AIR
70
60
50
40
30
20
10
0
Temperature (degC)
0
1800
3600
5400
7200
9000
10800
12600
14400
16200
18000
19800
21600
23400
25200
27000
28800
Time (seconds)

Fig. 3

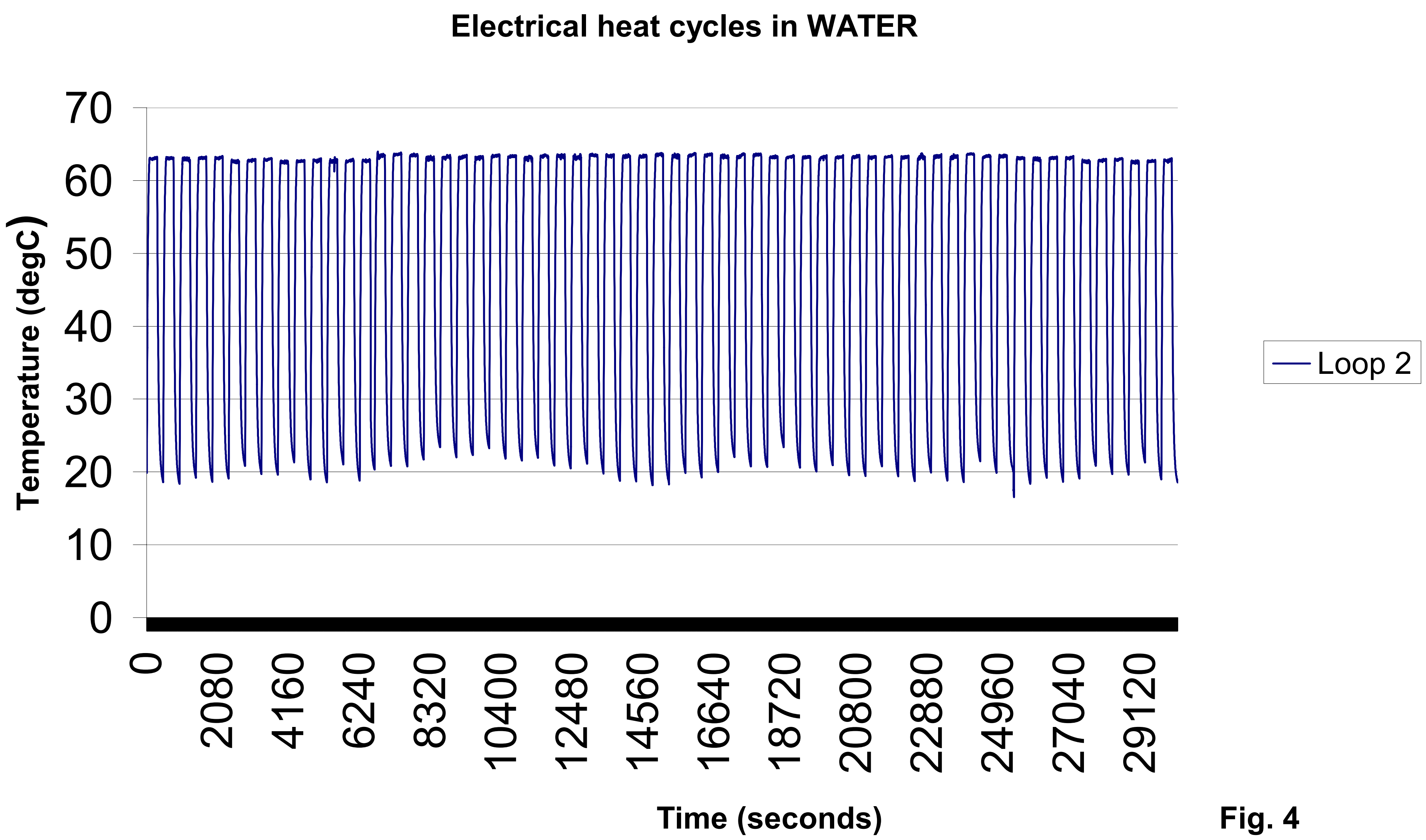

Electrical heat cycles in WATER
70
60
50
40
30
20
10
0
Temperature (degC)
0
2080
4160
6240
8320
10400
12480
14560
16640
18720
20800
22880
24960
27040
29120
Time (seconds)
Loop 2

Fig. 4

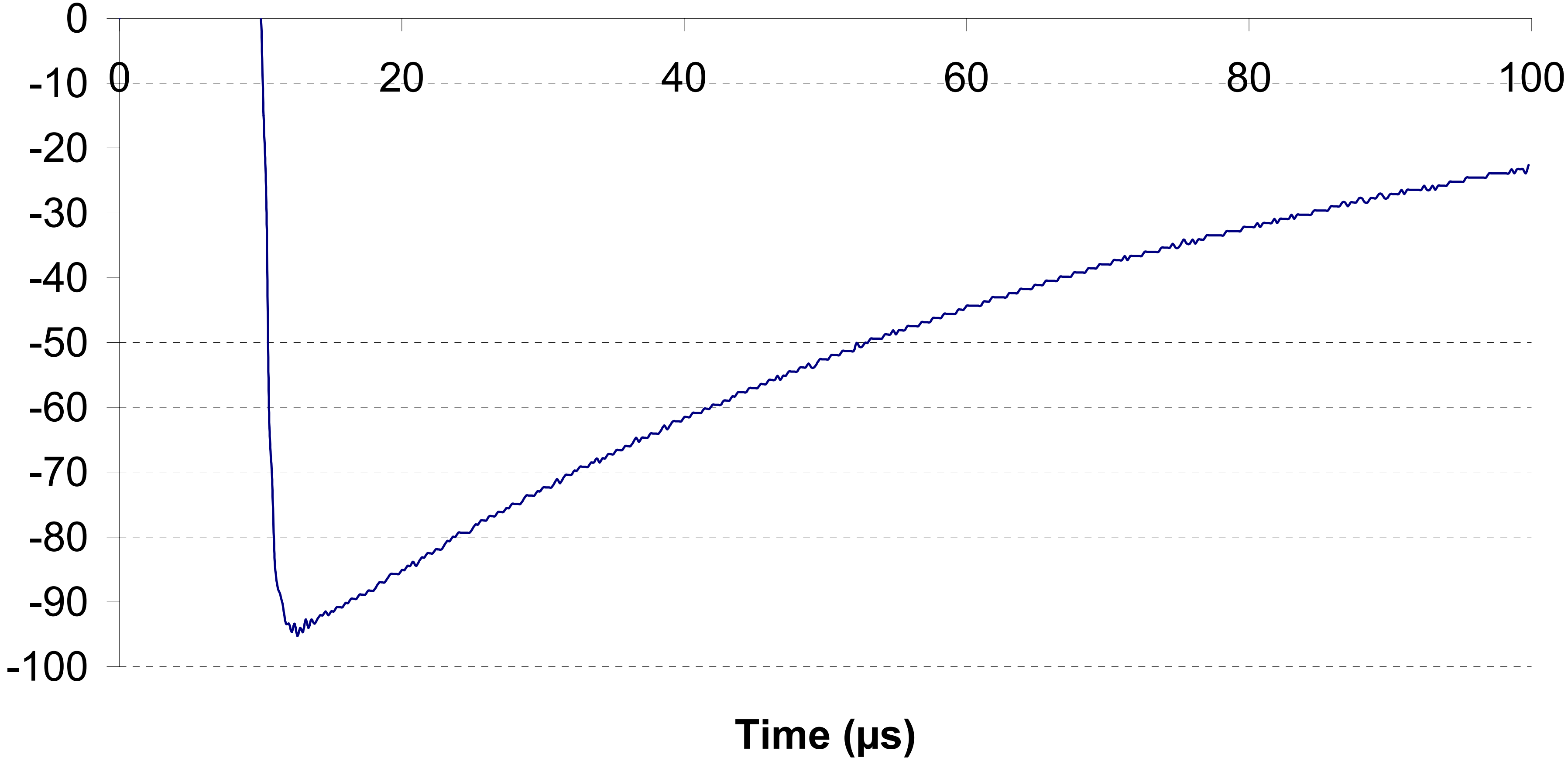
L3

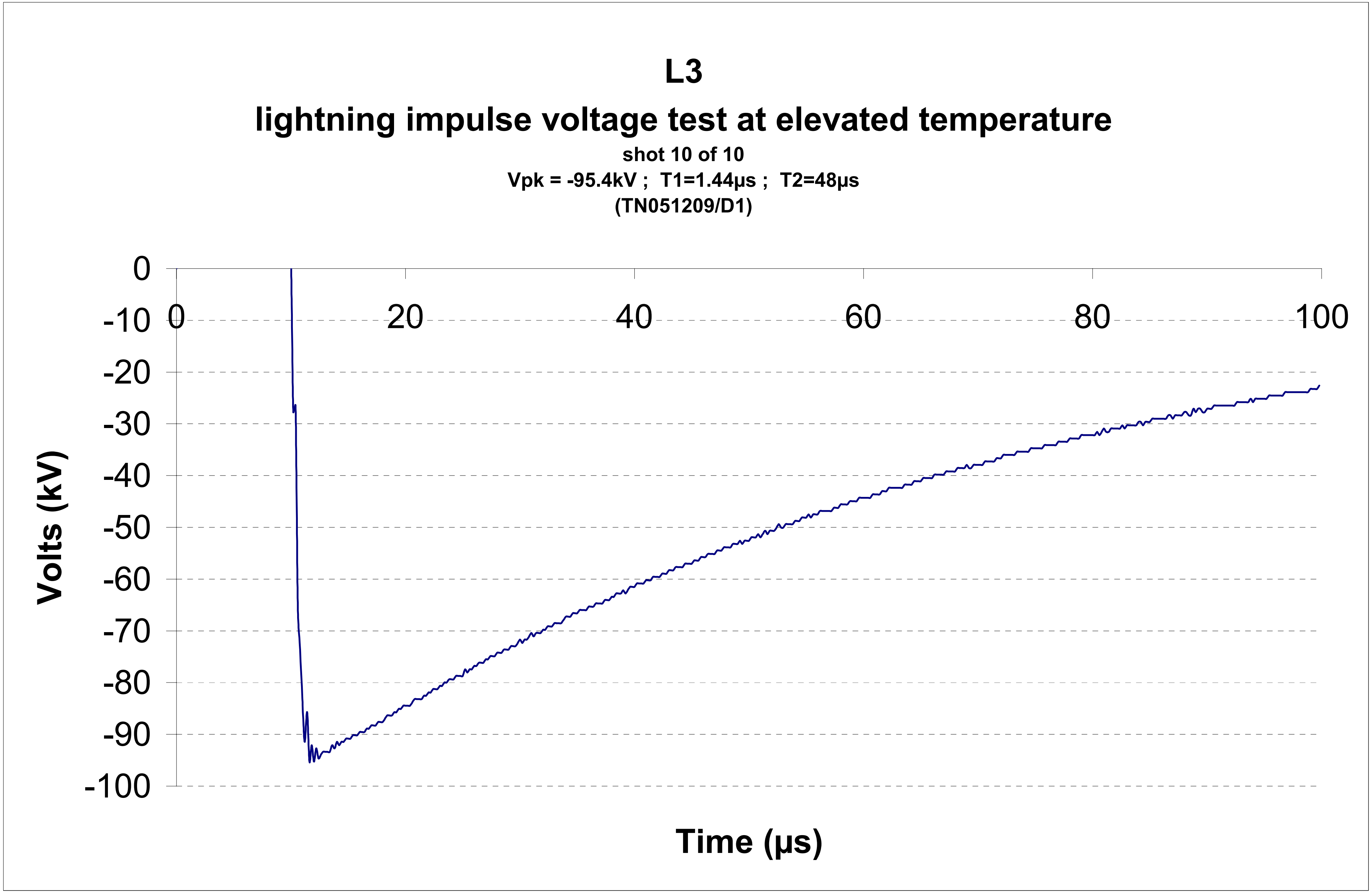
lightning impulse voltage test at elevated temperature

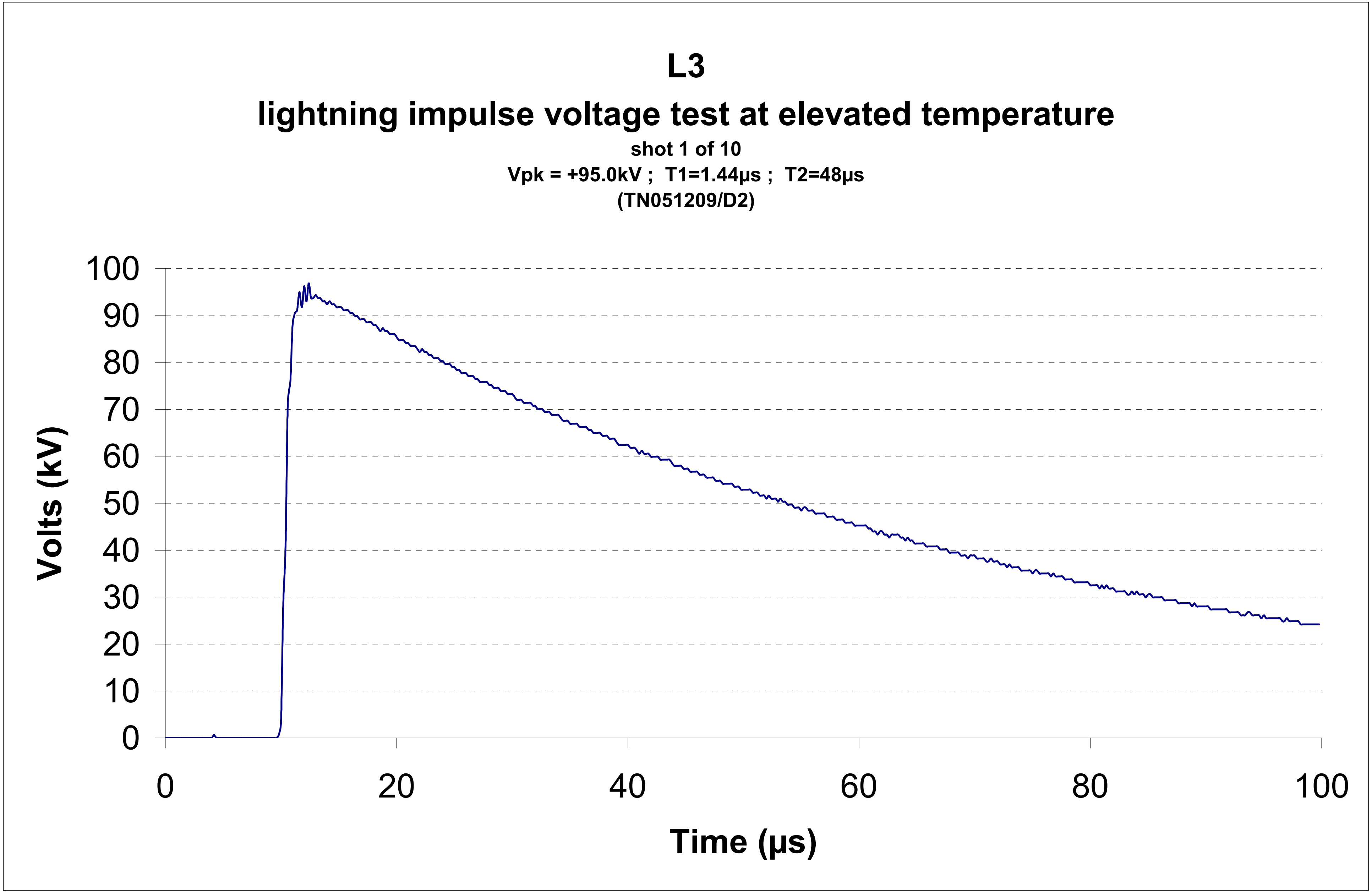
shot 1 of 10

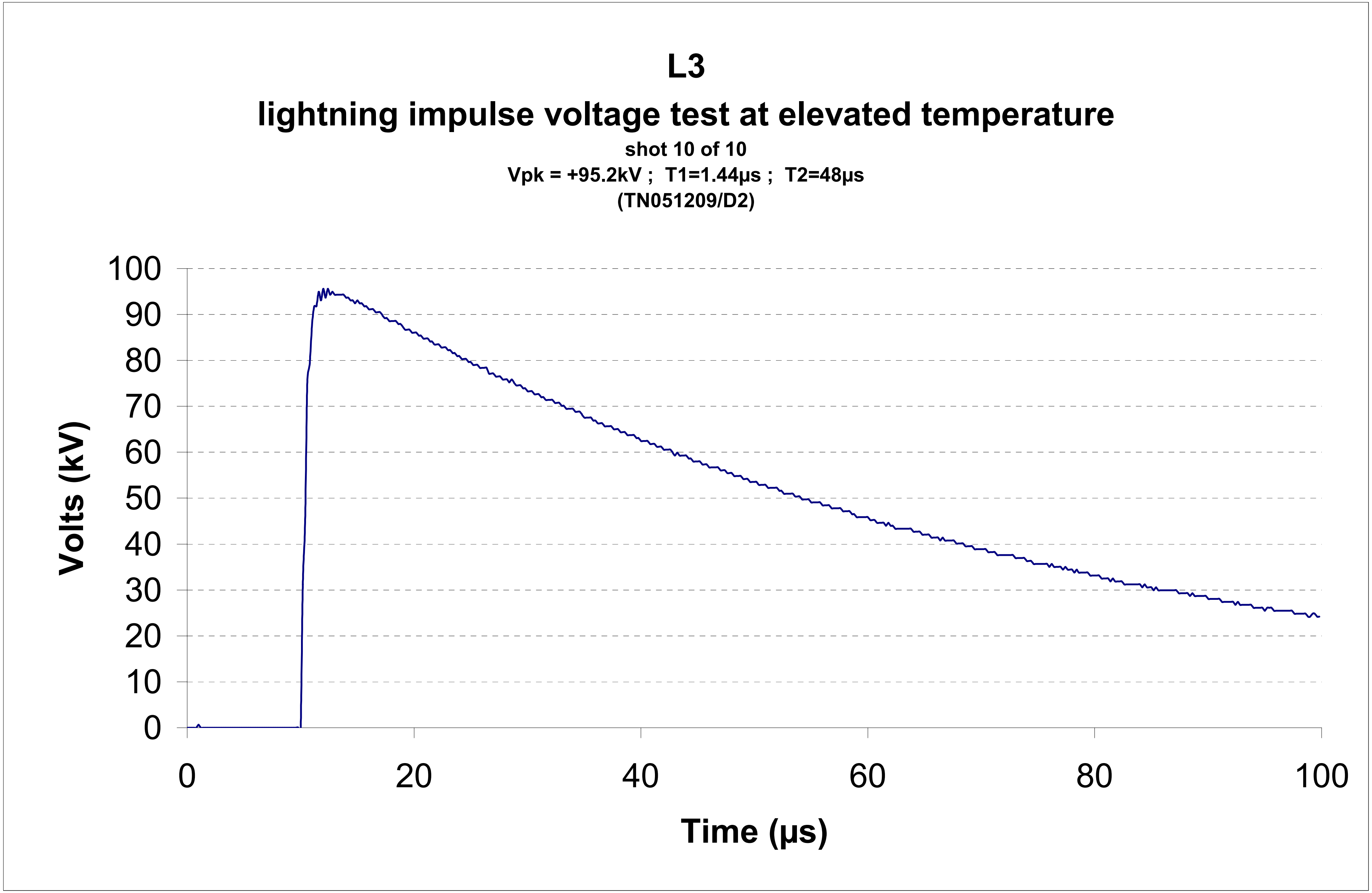
Vpk = -96.1kV ; T1=1.44µs ; T2=48µs

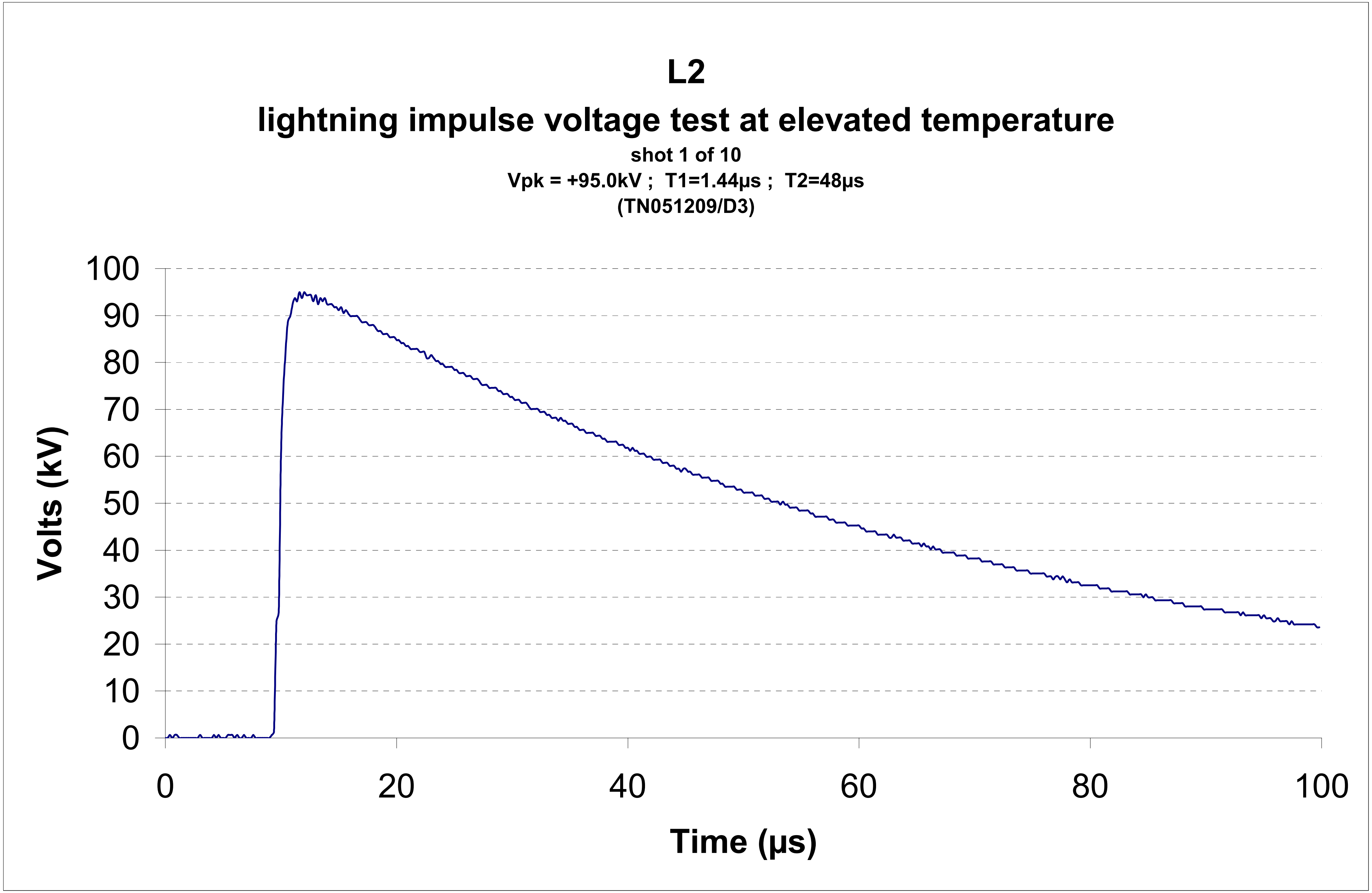
(TN051209/D1)




L3
lightning impulse voltage test at elevated temperature
shot 10 of 10
Vpk = -95.4kV ; T1=1.44µs ; T2=48µs
(TN051209/D1)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
20
40
60
80
100
Volts (kV)
Time (µs)


L3
lightning impulse voltage test at elevated temperature
shot 1 of 10
Vpk = +95.0kV ; T1=1.44µs ; T2=48µs
(TN051209/D2)
100
90
80
70
60
50
40
30
20
10
0
Volts (kV)
0
20
40
60
80
100
Time (µs)


L3
lightning impulse voltage test at elevated temperature
shot 10 of 10
Vpk = +95.2kV ; T1=1.44µs ; T2=48µs
(TN051209/D2)
Volts (kV)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)


L2
lightning impulse voltage test at elevated temperature
shot 1 of 10
Vpk = +95.0kV ; T1=1.44μs ; T2=48μs
(TN051209/D3)
Volts (kV)
Time (μs)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100

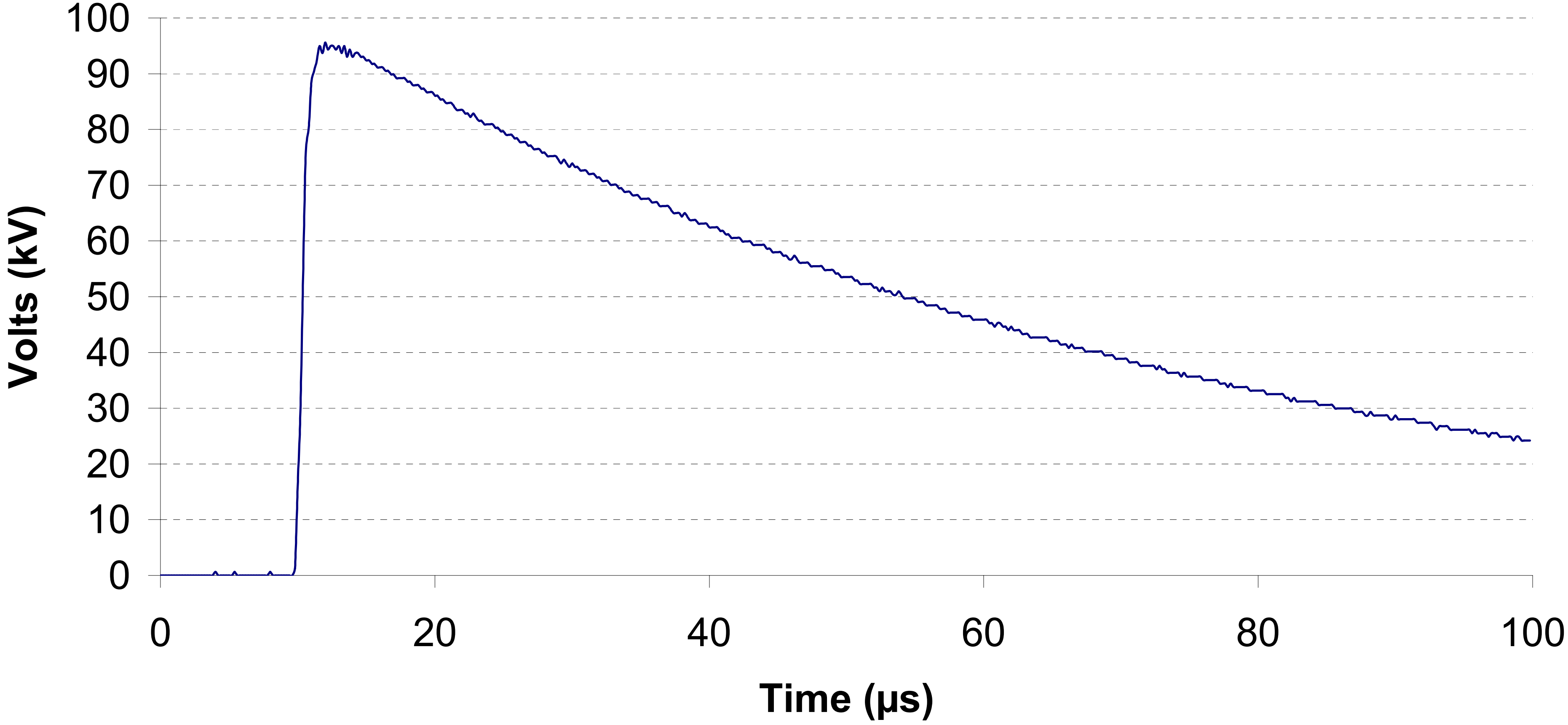
L2

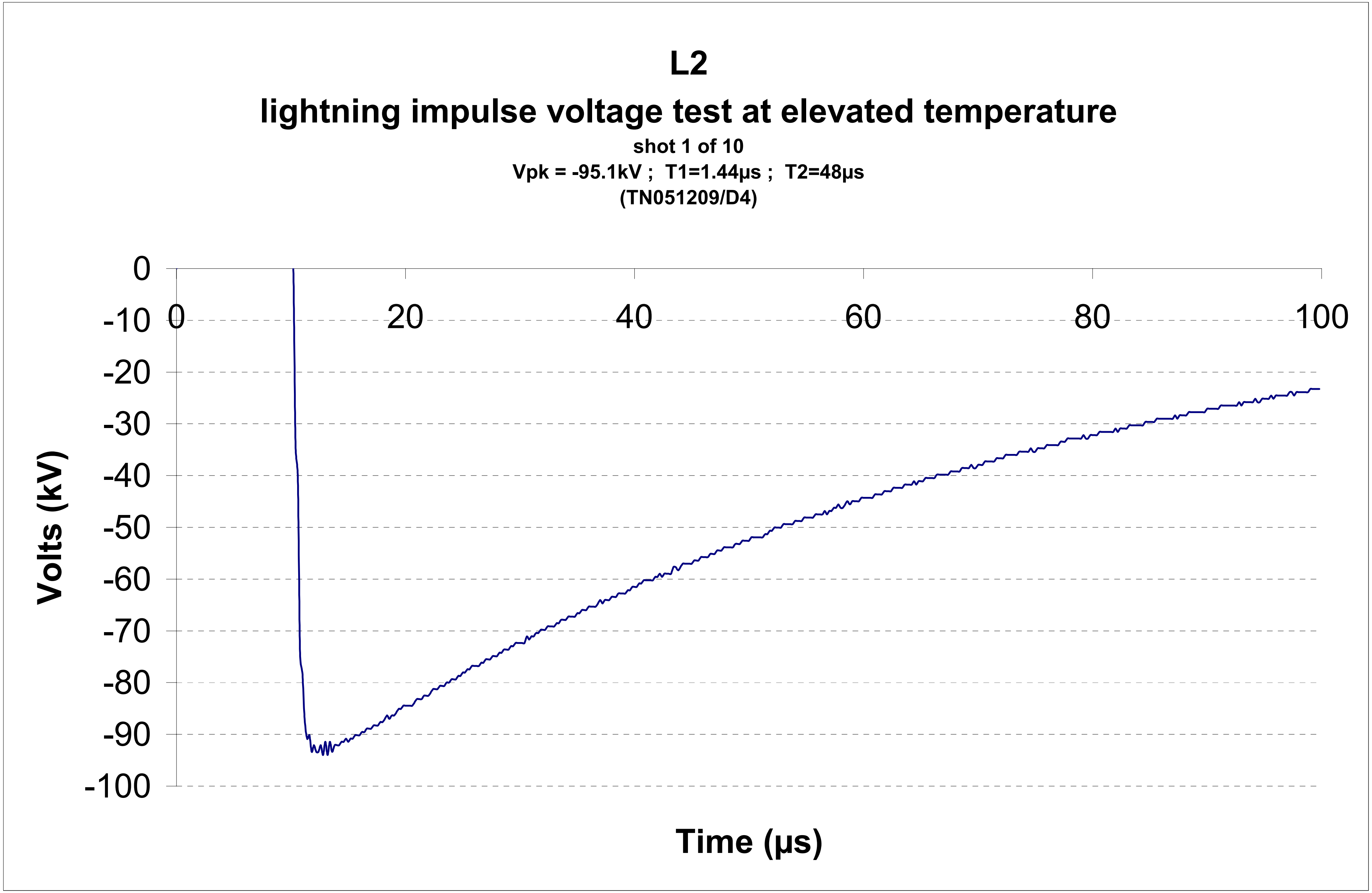
lightning impulse voltage test at elevated temperature

shot 10 of 10

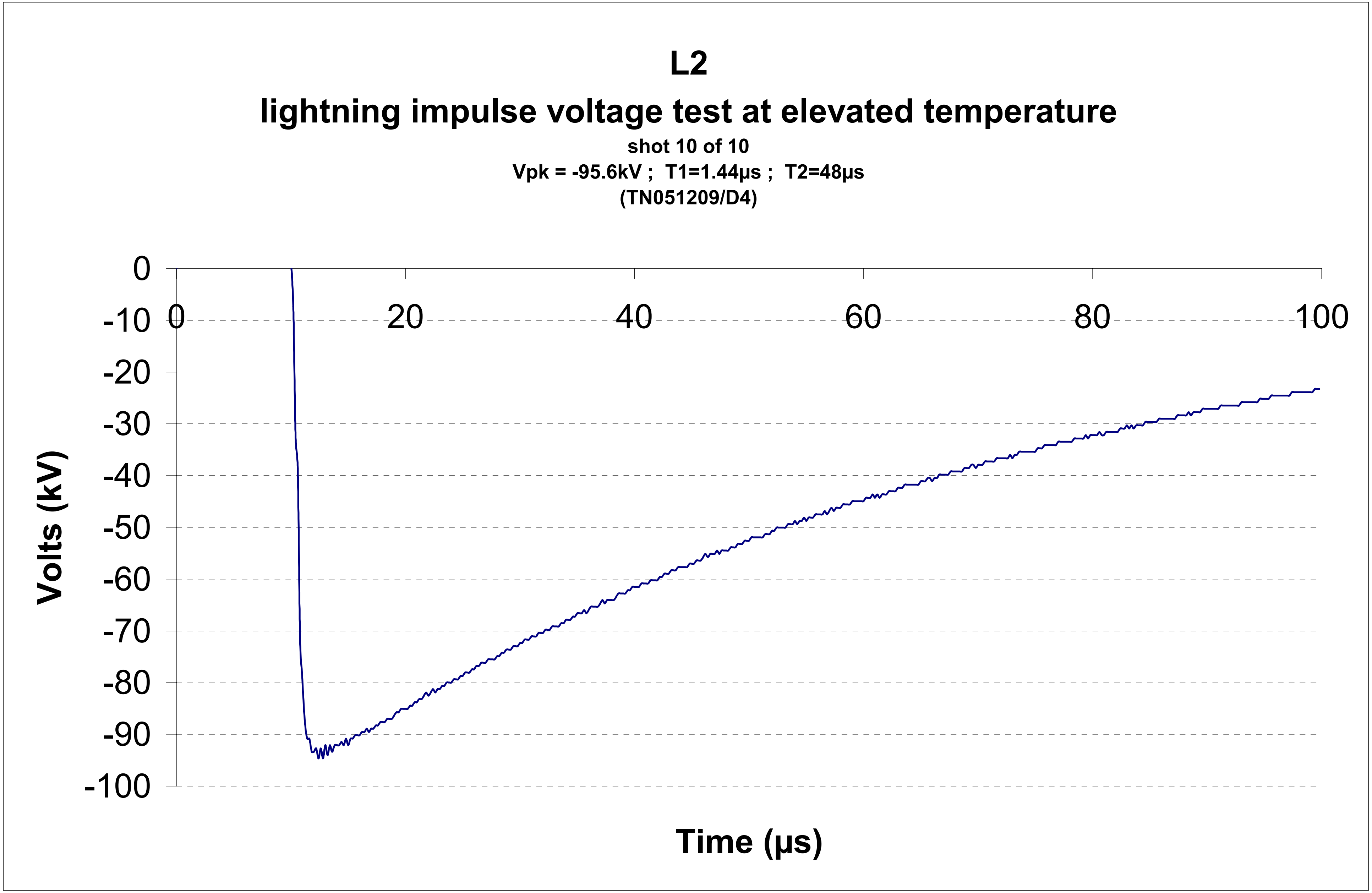
Vpk = +94.7kV ; T1=1.44µs ; T2=48µs

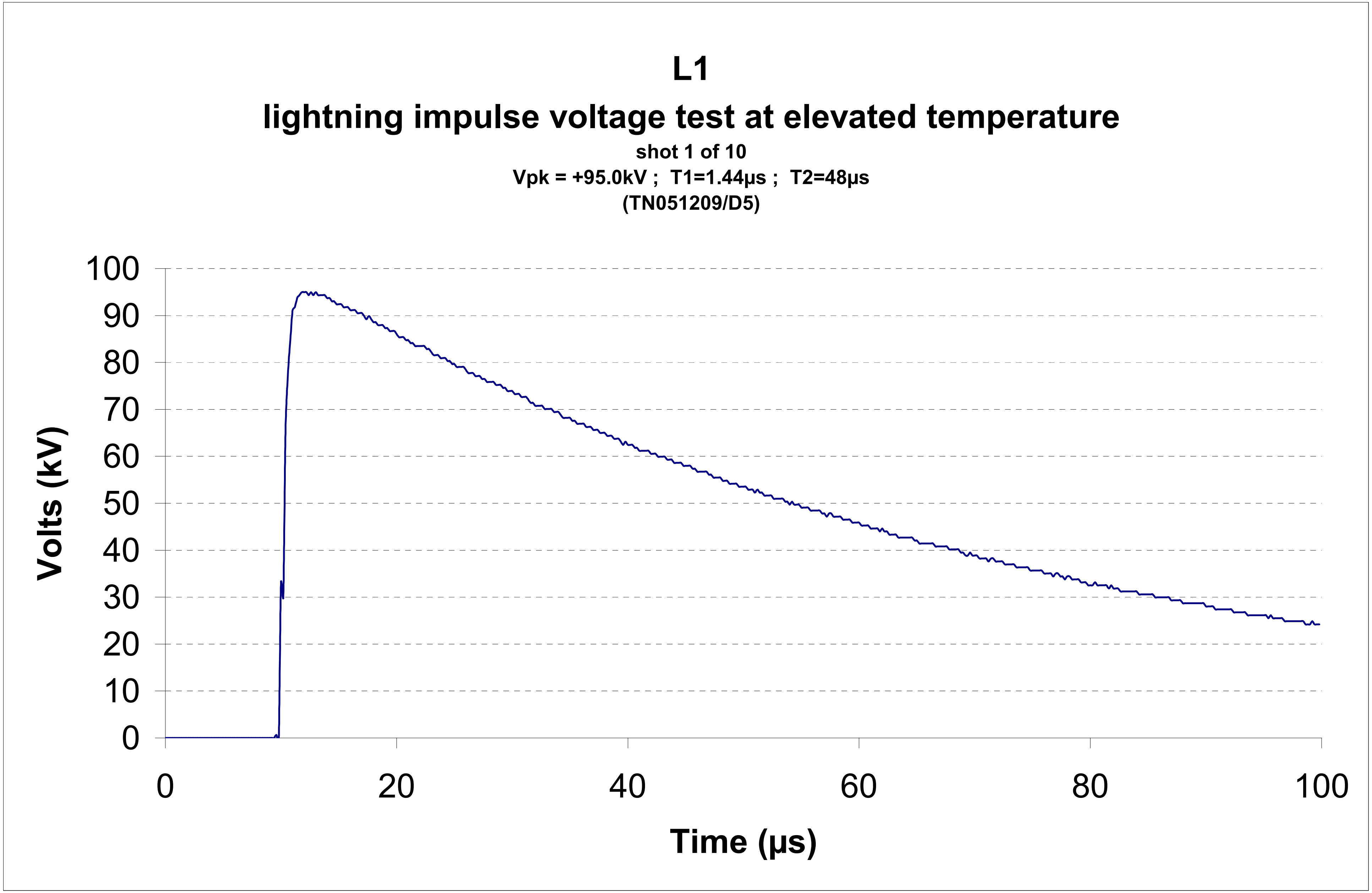
(TN051209/D3)

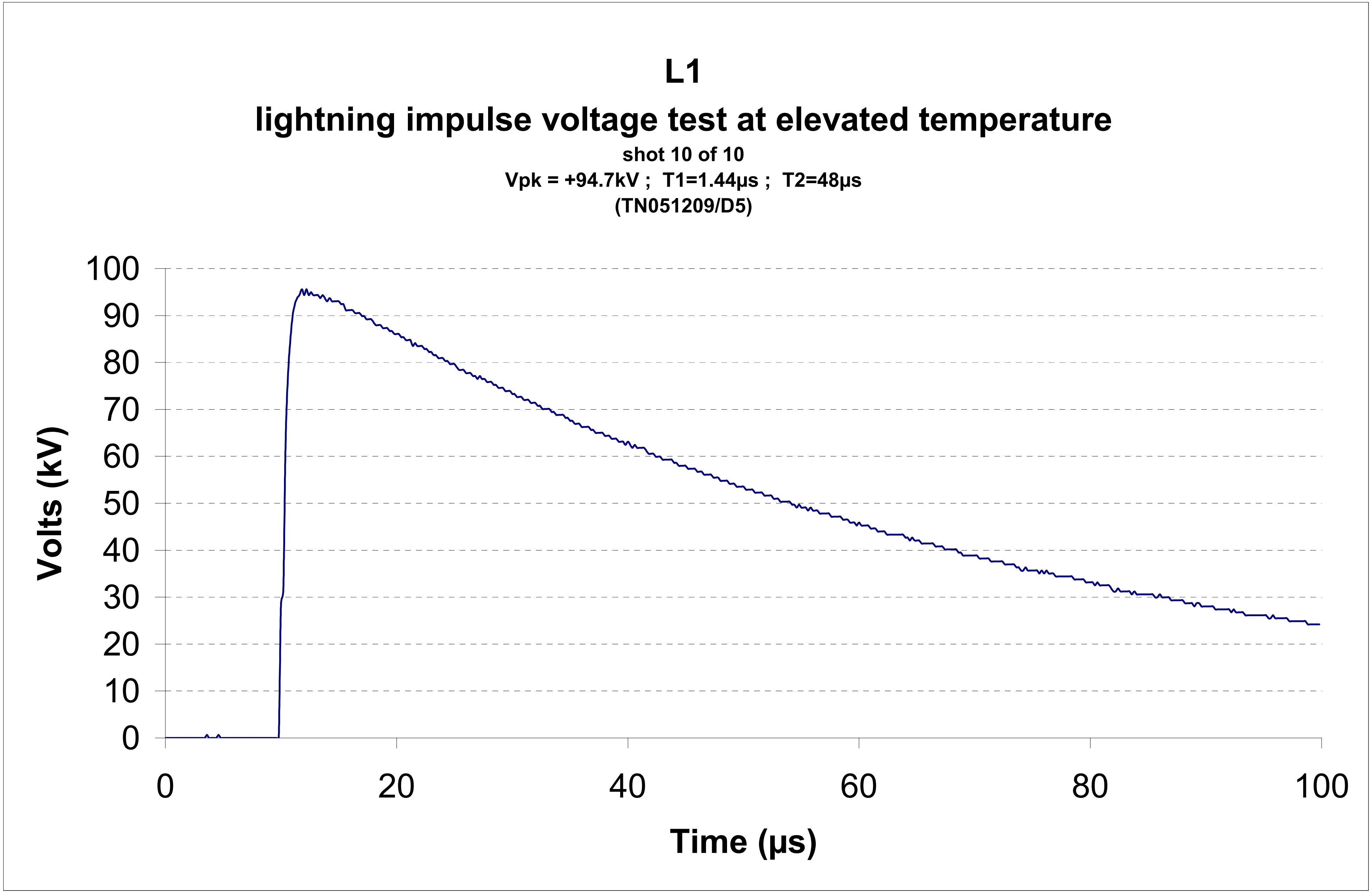


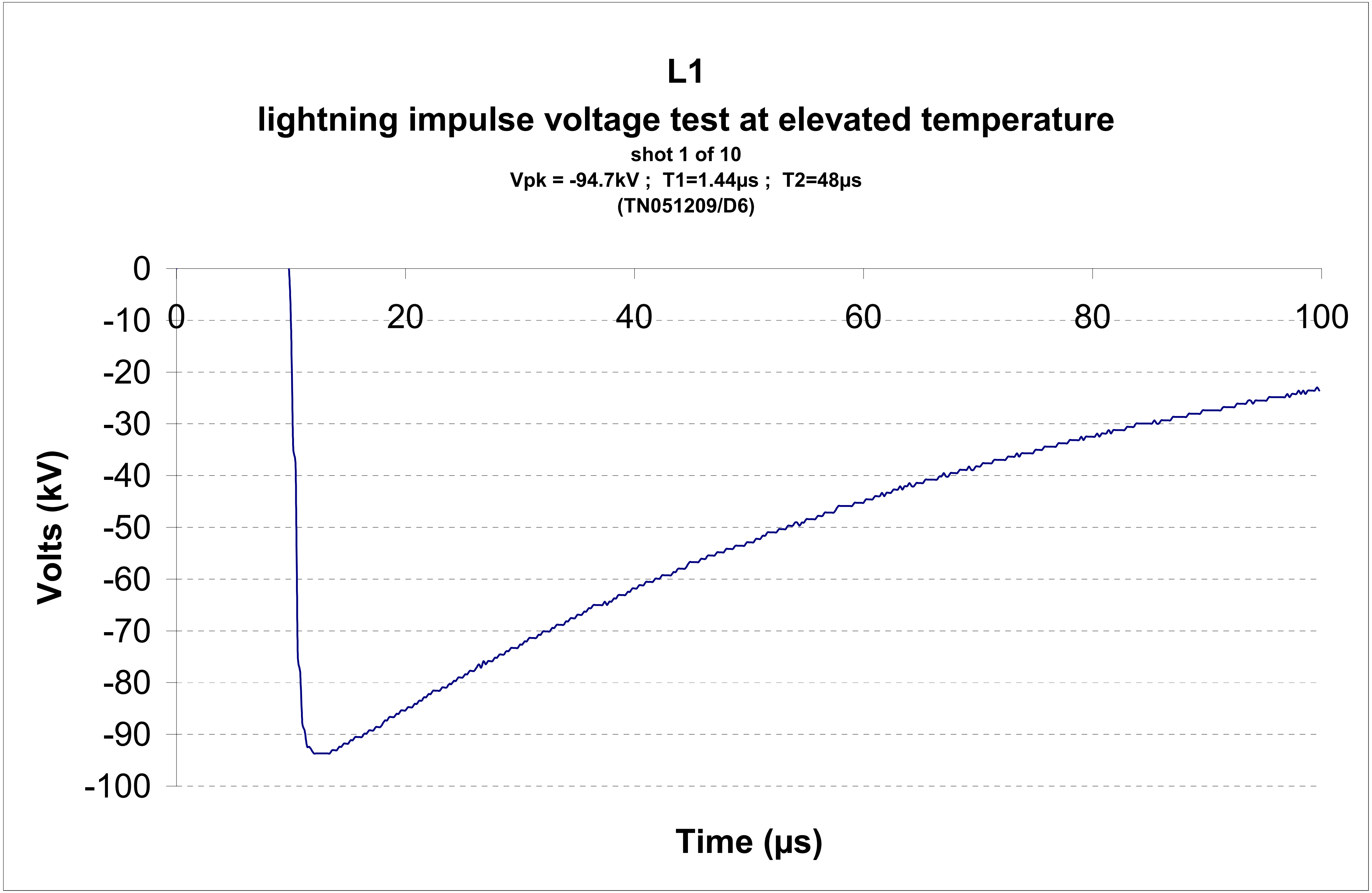


L2
lightning impulse voltage test at elevated temperature
shot 1 of 10
Vpk = -95.1kV ; T1=1.44µs ; T2=48µs
(TN051209/D4)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
20
40
60
80
100
Volts (kV)
Time (µs)


L2
lightning impulse voltage test at elevated temperature
shot 10 of 10
Vpk = -95.6kV ; T1=1.44µs ; T2=48µs
(TN051209/D4)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
20
40
60
80
100
Volts (kV)
Time (µs)


L1
lightning impulse voltage test at elevated temperature
shot 1 of 10
Vpk = +95.0kV ; T1=1.44µs ; T2=48µs
(TN051209/D5)
Volts (kV)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)


L1
lightning impulse voltage test at elevated temperature
shot 10 of 10
Vpk = +94.7kV ; T1=1.44µs ; T2=48µs
(TN051209/D5)
Volts (kV)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)


L1
lightning impulse voltage test at elevated temperature
shot 1 of 10
Vpk = -94.7kV ; T1=1.44μs ; T2=48μs
(TN051209/D6)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
20
40
60
80
100
Volts (kV)
Time (μs)

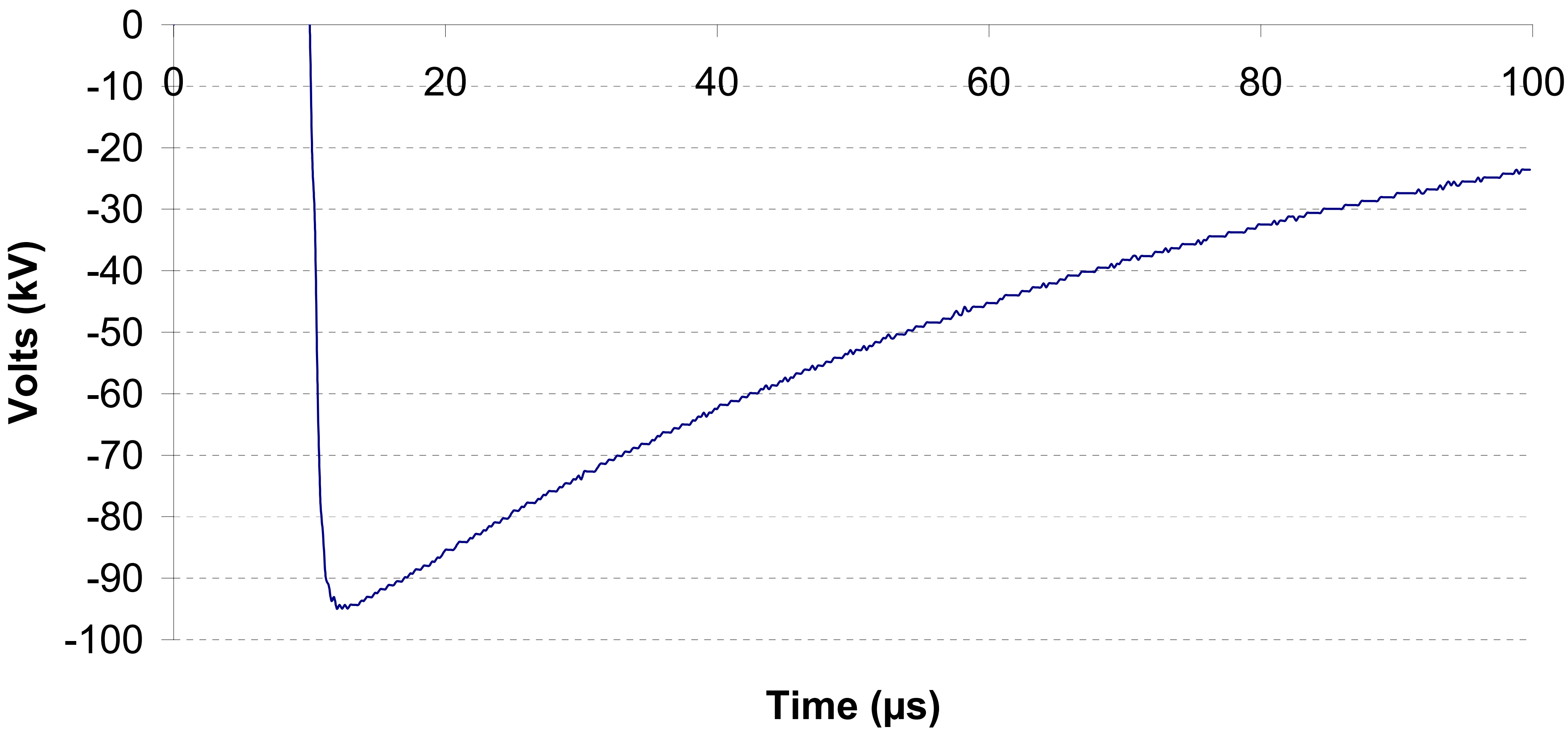
L1

lightning impulse voltage test at elevated temperature

shot 10 of 10

Vpk = -95.4kV ; T1=1.44µs ; T2=48µs

(TN051209/D6)



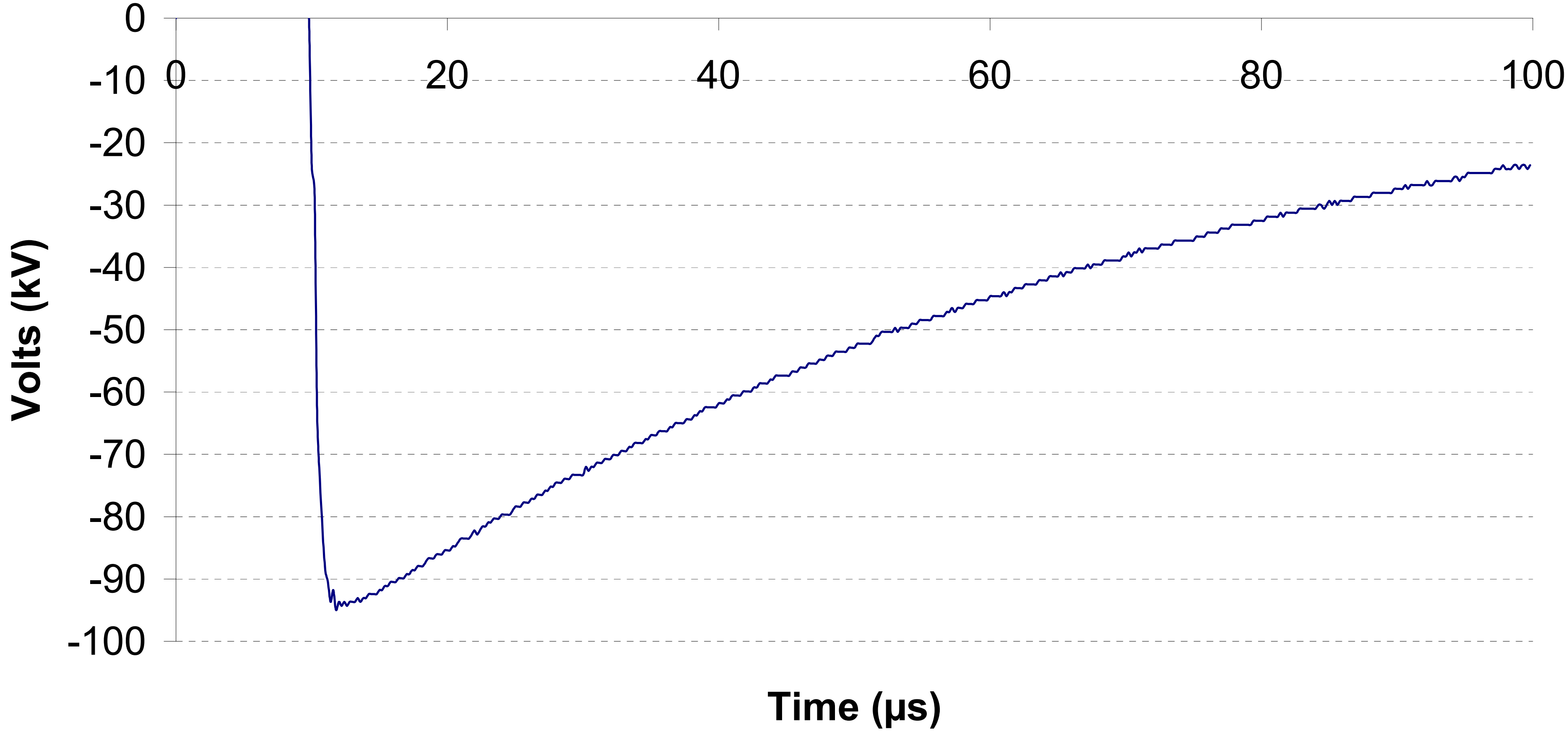
L2

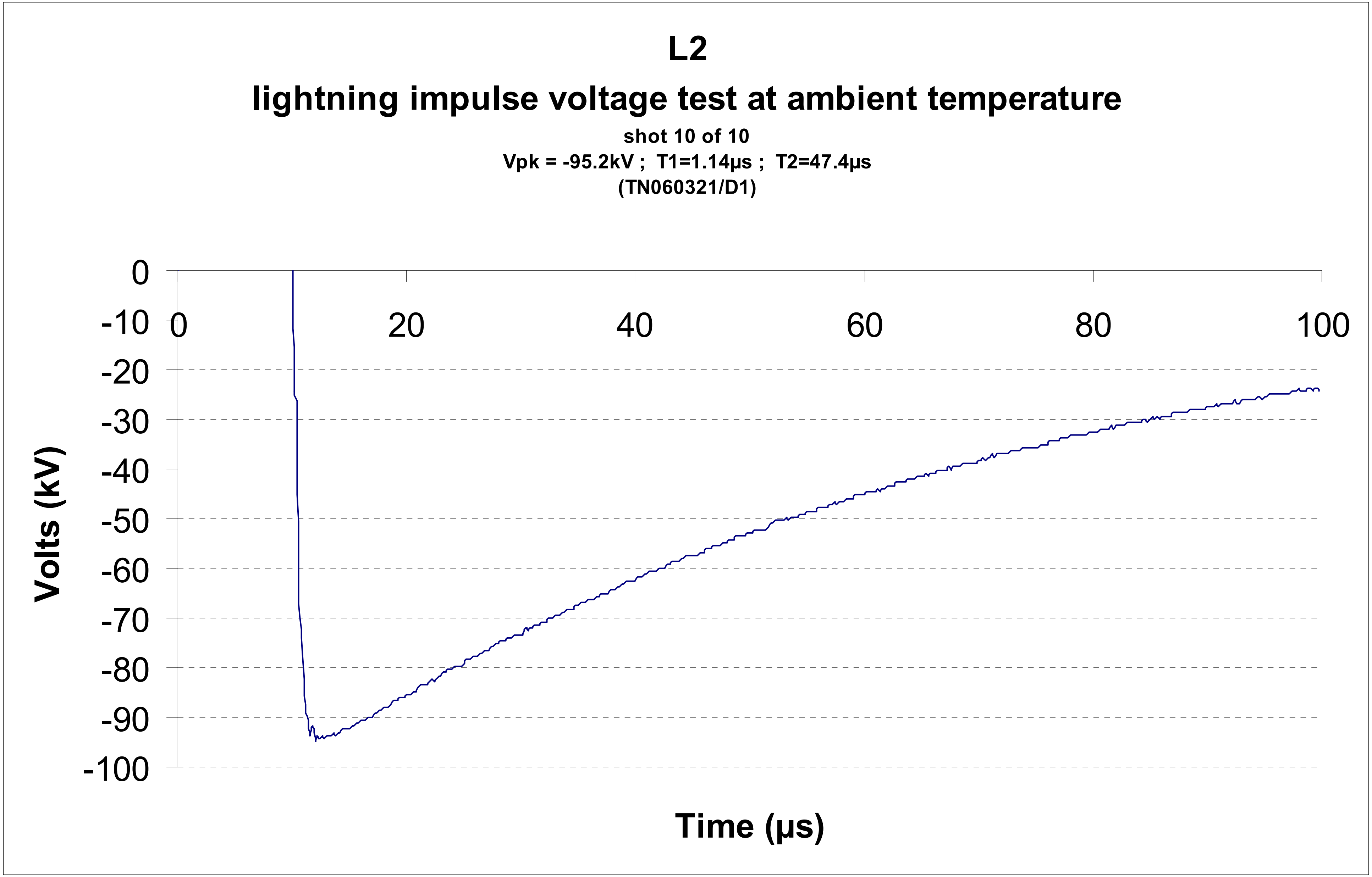
lightning impulse voltage test at ambient temperature

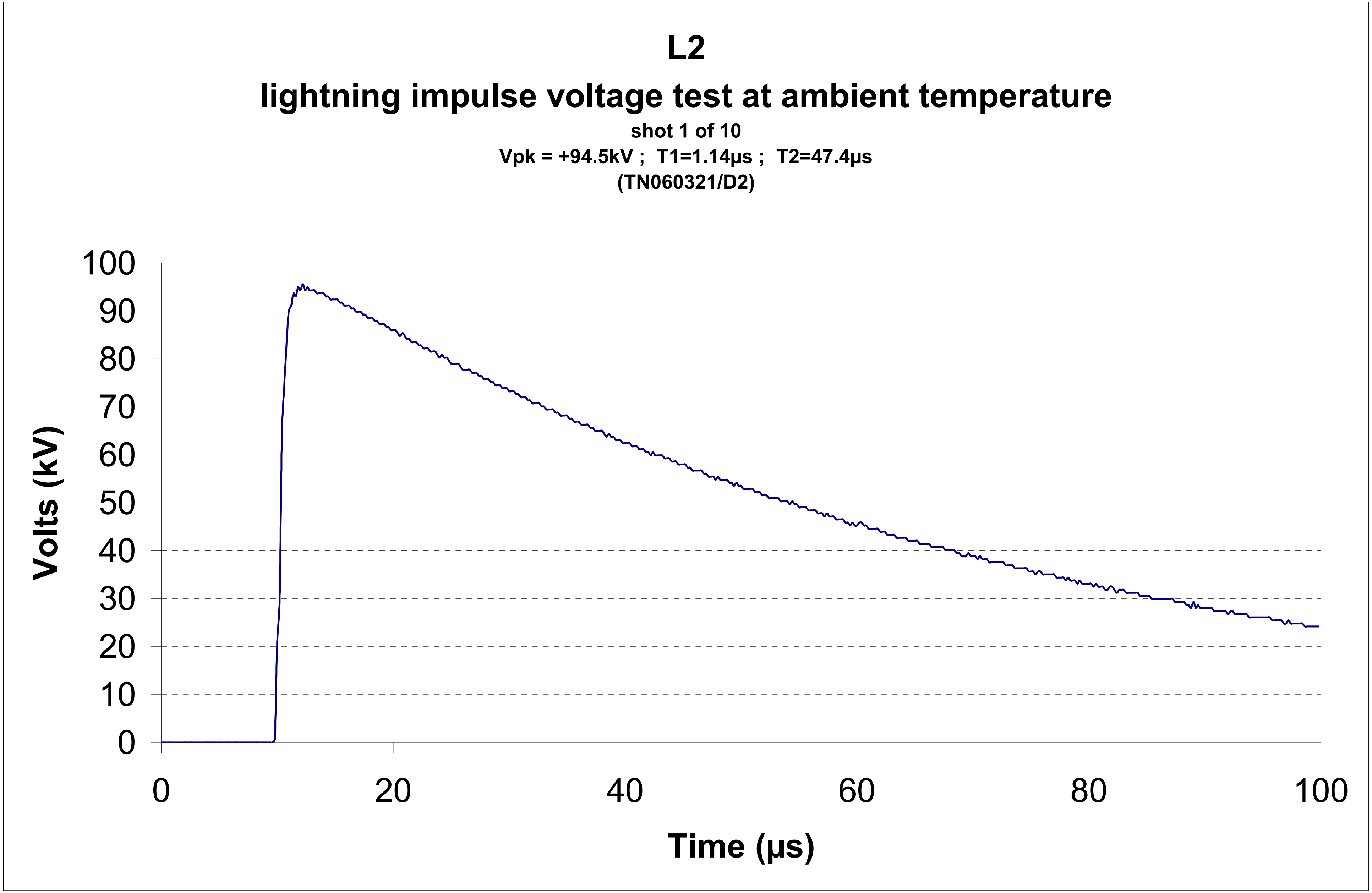
shot 1 of 10

Vpk = -95.0kV ; T1=1.14µs ; T2=47.4µs

(TN060321/D1)




L2
lightning impulse voltage test at ambient temperature
shot 10 of 10
Vpk = -95.2kV ; T1=1.14µs ; T2=47.4µs
(TN060321/D1)
Volts (kV)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
20
40
60
80
100
Time (µs)


L2
lightning impulse voltage test at ambient temperature
shot 1 of 10
Vpk = +94.5kV ; T1=1.14µs ; T2=47.4µs
(TN060321/D2)
Volts (kV)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)

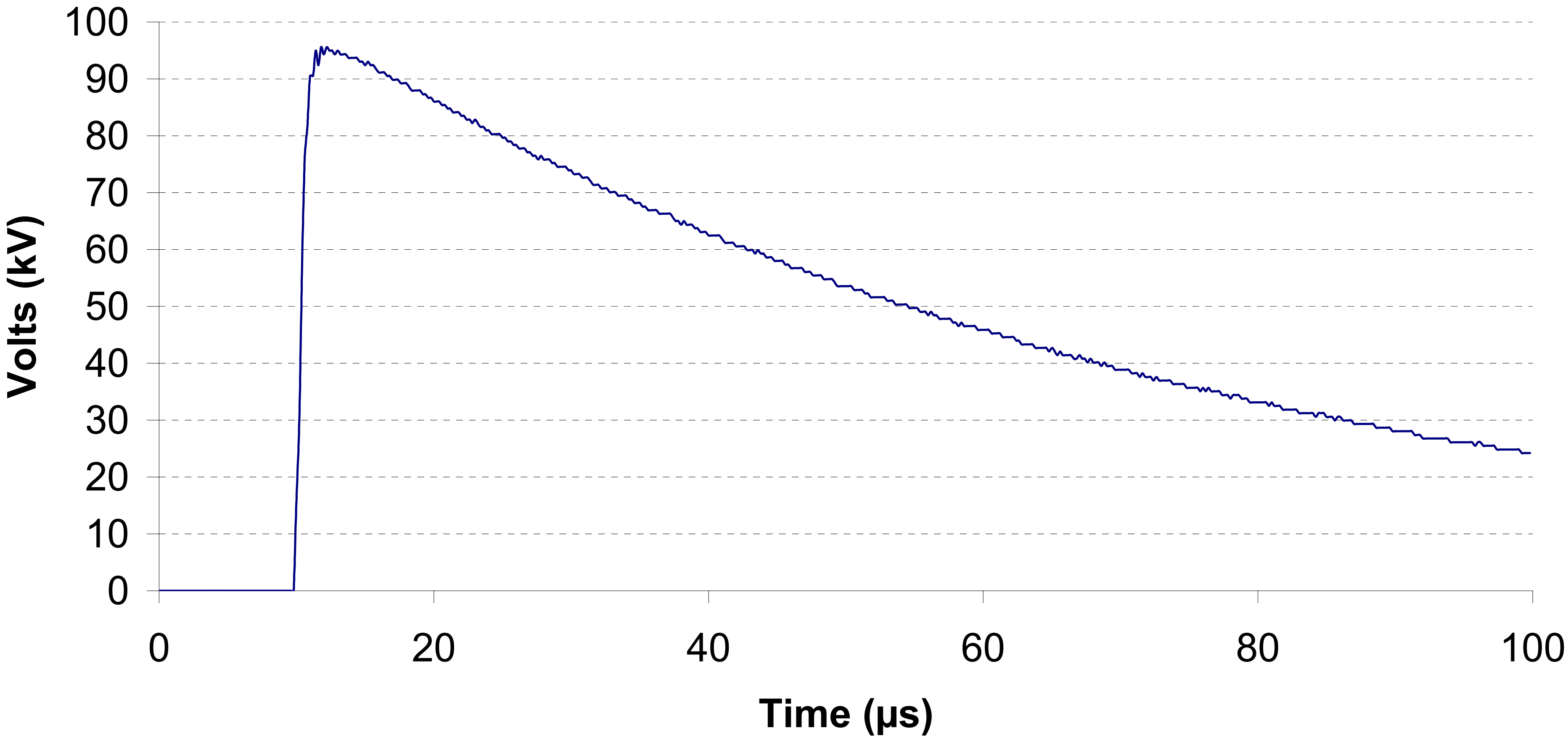
L2

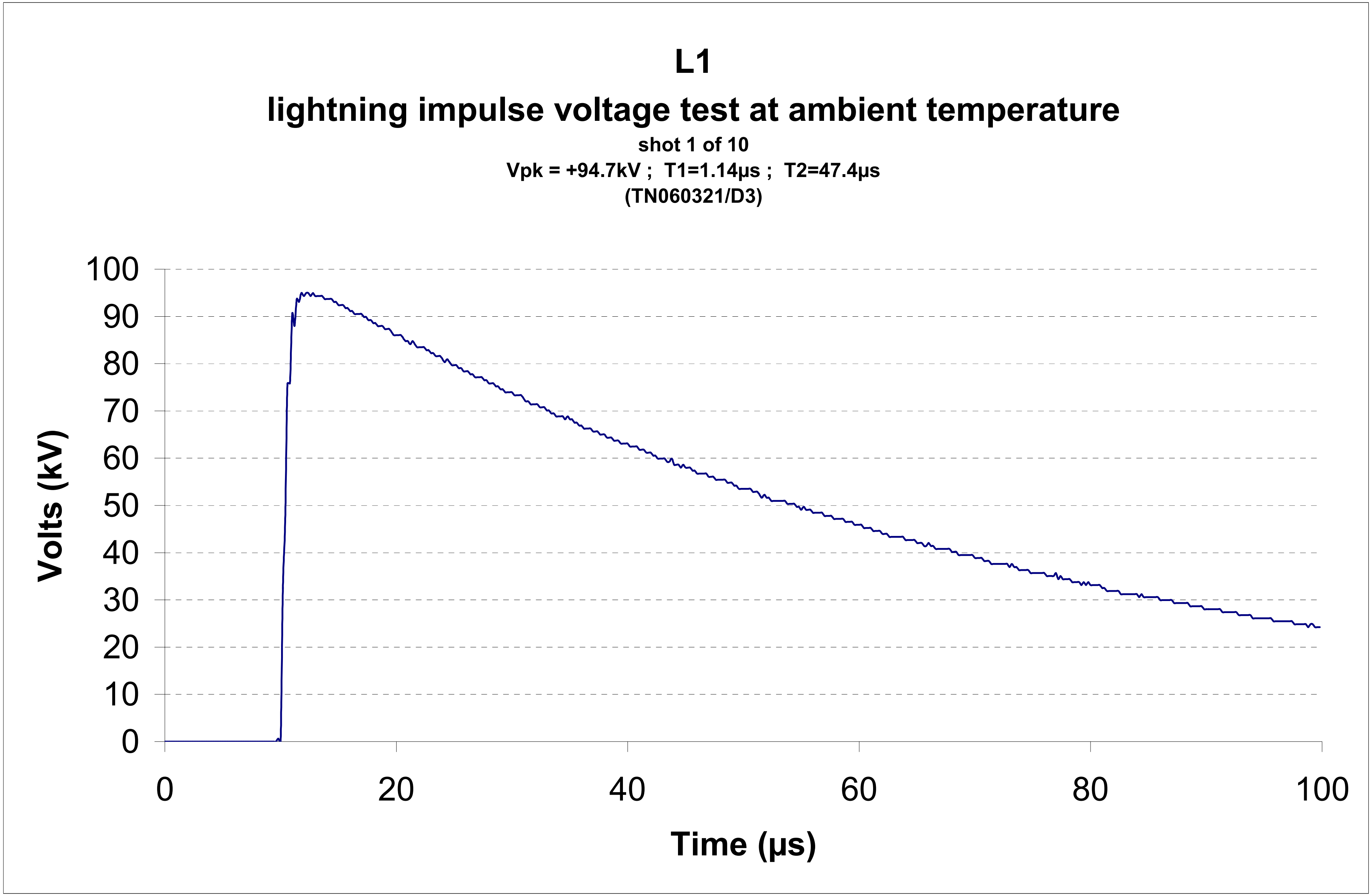
lightning impulse voltage test at ambient temperature

shot 10 of 10

Vpk = +95.1kV ; T1=1.14µs ; T2=47.4µs

(TN060321/D2)





L1
lightning impulse voltage test at ambient temperature
shot 1 of 10
Vpk = +94.7kV ; T1=1.14µs ; T2=47.4µs
(TN060321/D3)
Volts (kV)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (µs)

L1

lightning impulse voltage test at ambient temperature

shot 10 of 10

Vpk = +94.6kV ; T1=1.14μs ; T2=47.4μs

(TN060321/D3)