RESEARCH-DEVELOPMENT AND TESTING NATIONAL
INSTITUTE FOR ELECTRICAL ENGINEERING
ICMET CRAIOVA

HIGH VOLTAGE DIVISION - HVD
HIGH VOLTAGE LABORATORY - HVL

HVD

acreditat pentru
ÎNCERCARE
RENAR
SR EN ISO/CEI 17025:2005
CERTIFICAT DE ACREDITARE
nr. LI 450/2009

200515 Craiova, Calea Bucureşti 144
Certificat de înmatriculare: J 16/312/1999; Cod de înregistrare fiscala RO3871599
Phone: 0351 - 404888, 0351 - 404889, 0351 – 402425; Fax 0251 - 415482, 0351 - 404890

TEST REPORT
No. 42113 / 06.08.2009

1. **CUSTOMER:** **Forend Elk.Malz. ve Dis Tic.A.S.**
19 Mayis Mah. Buyukdere Cd. Basman Han No:4 Kat:4 Sisli –Istanbul TURKEY

2. **MANUFACTURER:** **Forend Elk.Malz. ve Dis Tic.A.S.**
19 Mayis Mah. Buyukdere Cd. Basman Han No:4 Kat:4 Sisli –Istanbul TURKEY

3. **TEST ORDER:** Contract No.1429 / 17.07.2009 (21100 / 17.07.2009)

4. **TESTED PRODUCT:** **Early Streamer Emission Lightning Conductor (ESELC) type Petex – L**

5. **REFERENCE STANDARD:** NFC 17.102 : 1995, Appendix C; UNE 21186 : 1996, Anexo C

6. **TEST PERFORMED:** – Determination of the initiation advance

7. **TEST DATE:** 05.08.2009

8. **TEST RESPONSIBLE:** Eng. I. Badea

9. **TEST RESULTS:** The product passed the tests.

10. Report has 12 pages and it is edited in 4 copies from which 3 copies for customer.

HEAD OF HIGH VOLTAGE DIVISION
Eng. Ion PĂTRU

ICMET DIVIZIA DE ÎNALTĂ TENSIUNE CRAIOVA

HEAD OF LABORATORY
Eng.Aurel UNGUREANU

1. *Results refer to test product only.*
2. *Publication or reproduction of the contents of this report in any other form unless its complete photocopying is not allowed without writing approval of division to which laboratory belong to.*
3. *Accreditation of the laboratory or any of its Test Report issued under accreditation regime do not constitute or do not imply themselves an approval of the product by the accreditation body.*

1. Tested material

Early Streamer Emission Lightning Conductor (ESELC) type Petex – L.
See photo on page 9 and drawing on page 10.
Lightning Conductor supplied by FOREND Elk. Malz. Dis Tic.A.S.

2. Type of tests

A switching impulse wave negative polarity and a DC voltage of negative polarity are applied on the upper metallic plane.

3. Specification

N F C 17 – 102 / 1995 Appendix C; UNE 21186 : 1996, Anexo C

4. Test equipment

Laboratory inner dimensions: 48 m x 32 m x 27 m (height)
Altitude: 100 m above see level
4200 kV High Voltage Impulse Generator 336 kWs, TUR Dresden – Germany, no.5 – 1197.
Capacitive divider of impulse generator 4.2 MV, no. 5 – 1197.
1000 kV Rectifier cascade type GS 1000 / 30; 30 mA; TUR Dresden – Germany, no.3 – 35/11.
Resistive divider of cascade 1MV, 30 mA, no.3 – 35 / 11
1400 kV Damped capacitive divider, ICMET Craiova, Romania, no.3/996.
TR – AS 100–10/4 transient – recorder, no.241, Dr.Strauss System Electronik, GmbH- Germany.
Impulse calibrator type KAL – 1000, 0.84 / 60 μs and 20 / 3000 μs Dr.Strauss System Electronik, GmbH – Germany.
Multimeter Kheithley no. 1070038.

5. Test circuit

See the test circuit diagram on page 11
The measuring system that consists of 1400 kV damped capacitive divider and TR – AS transient recorder was calibrated by Accredited Laboratory DKD – K – 18701, Romania with Calibration Certificate 176 of 29th January 2009, measuring uncertainty for switching impulse voltage is ± 1.4 %; for T_p is 4.3 % , for T_2 is 4.1 % and checked before beginning of measurement with the impulse calibrator KAL 1000, calibrated by PTB – Braunschweig – Germany, calibration certificate 4066 PTB 08 and Fluke 5500 A calibrator calibrated by Metrology National Institute of Romania, order calibration certificate No. 000457 – DKD – K – 39701 / 17.10.2008.

Expanded uncertainty of measurements parameter inside of limits, prescribed by IEC 60060 – 2 / 1994 for SI Approved Measuring Systems (3 % for peak values and 10 % for time parameters).

6. Mounting arrangement

See the test set up on page 12
See photo on the pages 9

The lightning conductor tested is put on a 5 x 5 m grounded metallic plane and connected to ground.
A square metallic plane, dimensions: 4.5 m / 4.5 m / 0.2 m with the edges rounded, is suspended above the lightning conductor and connected the high voltage.

7. Test procedure

The DC polarization of the upper plane is adjusted on the square metallic plane.
The negative impulse wave is adjusted in order to obtain a flashover.
The height of the lightning conductor (h) and the distance between the ground and the square plane (H) are measured at the beginning of each test.
The atmospheric conditions taken before and after each test.
The peak value (Up) of the impulses and the triggering time (T_B) are recorded at each impulse.
One hundred significant impulses are applied on the lightning conductor.
The early streamer emission lightning conductor (ESELC) is to be compared with a simple rod lightning conductor (SRLC).
Tests are performed is the same conditions and configuration for each lightning conductor: ESELC and SRLC.
The test on SRLC (100 significant impulses) was performed in two series and circled by the test on the ESELC.

Height of lightning conductor (h) adjusted to:	1050 mm
Distance between ground / square plane (H) adjusted to:	2195 mm
h / H:	0.478
Polarization voltage:	62.5 kV
Peak time / Rise time of the full wave:	593 µs / 269 µs
Time interval between consecutive impulses:	> 1 min

8. TEST ON SRLC BEFORE AND AFTER TEST OF ESELC type Petex – L

8.1. Reception date: 03.08.2009

8.2. Test date: 05.08.2009

8.3. Atmospheric conditions

	FIRST SERIES	SECOND SERIES
BEFORE TEST	Beginning of the test: 19h30 p = 1000 mb t = 25.6 °C hr = 56.9 %	Beginning of the test: 23h07 p = 1000 mb t = 25.4 °C hr = 57.4 %
AFTER TEST	End of the test: 20h45 p = 1000 mb t = 25.6 °C hr = 57.4 %	End of the test: 00h15 p= 1000 mb t = 25.3 °C hr = 57.9 %

8.4. Results

See tables on page 6

Number of significant impulses: 100

Average of significant T_B:

- calculated from the experimental wave T'_{PTS} = 383.38 µs Stdev: 29.40 %
- transferred on the reference waveform: T_{PTS} = 439.16 µs

See curves on page 8

9. TEST ON ESELC type Petex – L

9.1. Reception date: 03.08.2009

9.2. Test date: 05.08.2009

9.3. Atmospheric conditions

BEFORE TEST	Beginning of the test: 20h55 p = 1000 mb t = 25.6 °C hr = 57.5 %
AFTER TEST	End of the test: 23h00 p= 1000 mb t = 25.4 °C hr = 57.5 %

9.4. Results

See tables on page 7

Number of significant impulses: 100

Average of significant T_B:

- calculated from the experimental wave T'_{PDA}= 339.59 µs Stdev: 19.97 %
- transferred on the reference waveform: T_{PDA} = 375.06 µs

See curves on page 8

Measuring uncertainty for ΔT is 5.7 %.
The uncertainty stated is expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k = 2. The value of measurand lies within the assigned range of values with probability of 95 %.

Triggering advance: $\Delta T = T_{PTS} - T_{PDA} = 439.16 - 375.06 = 64.1\ \mu s \pm 3.65\ \mu s$

Test on SRLC before and after test on ESELC type Petex – L

Impulse no.	T_B µs	Impulse no.	T_B µs	Impulse no.	T_B µs
1	532	41	347	80	315
2	368	42	512	81	320
3	360	43	301	82	252
4	487	44	535	83	628
5	267	45	331	84	296
6	536	46	309	85	421
7	517	47	377	86	500
8	802	48	267	87	533
9	542	49	270	88	371
10	283	50	535	89	398
11	259	Second	series	90	470
12	316	51	254	91	533
13	327	52	540	92	464
14	346	53	348	93	707
15	532	54	535	94	379
16	294	55	497	95	280
17	290	56	335	96	261
18	267	57	298	97	348
19	335	58	330	98	537
20	267	59	414	99	570
21	298	60	541	100	541
22	537	61	297		
23	428	62	263		
24	299	63	278		
25	538	64	347		
26	356	65	299		
27	298	66	295		
28	528	67	250		
29	537	68	339		
30	454	69	541		
31	404	70	320		
32	523	71	219		
33	320	72	262		
34	333	73	272		
35	292	74	317		
36	370	75	350		
37	443	76	383		
38	322	77	332		
39	318	78	499		
40	289	79	534		

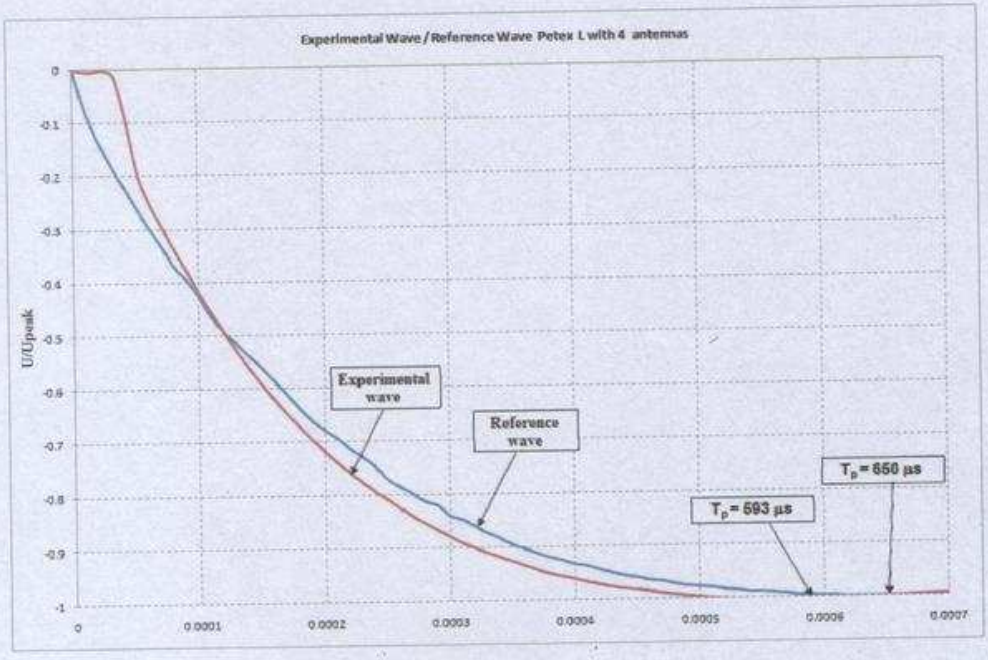
NS: No significant
T_B : Break-down time

HVD

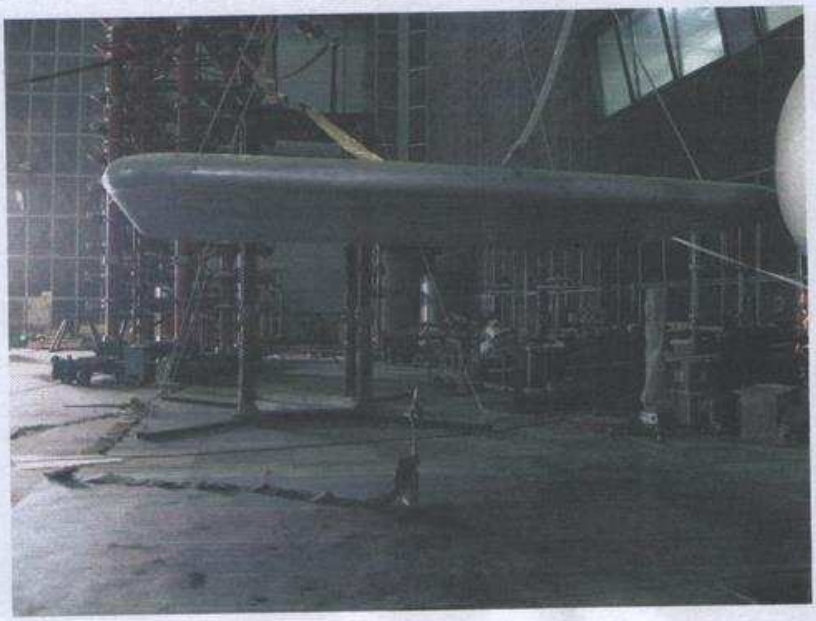
Test on ESELC type Petex – L

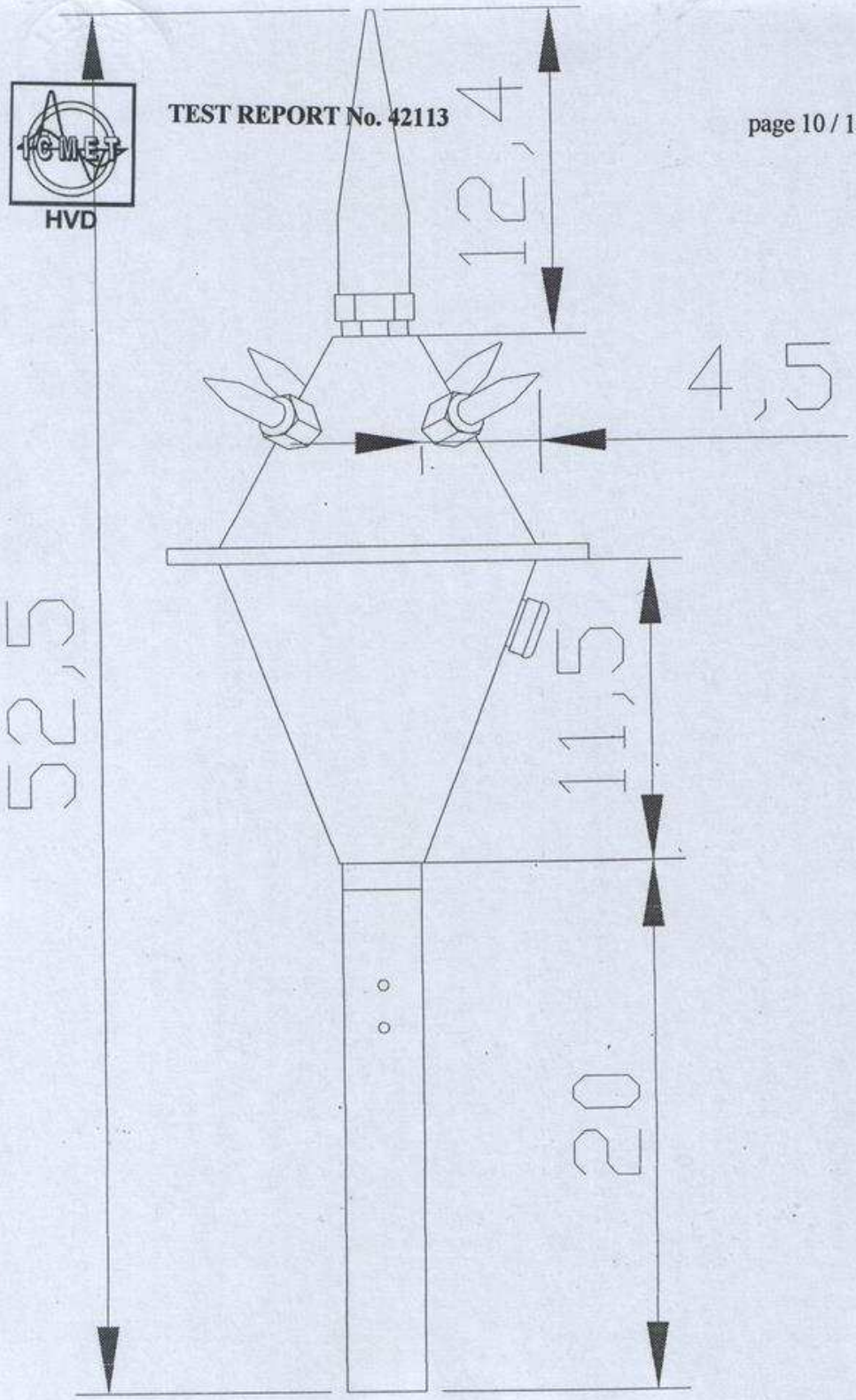
Impulse no.	T_B µs	Impulse no.	T_B µs	Impulse no.	T_B µs
1	259	44	344	87	304
2	277	45	328	88	298
3	301	46	405	89	257
4	294	47	476	90	324
5	274	48	353	91	385
6	291	49	400	92	318
7	489	50	395	93	280
8	465	51	293	94	267
9	343	52	280	95	268
10	400	53	442	96	299
11	338	54	239	97	287
12	263	55	391	98	286
13	343	56	366	99	287
14	418	57	365	100	440
15	231	58	340		
16	295	59	317		
17	298	60	469		
18	255	61	312		
19	373	62	340		
20	382	63	453		
21	439	64	478		
22	314	65	356		
23	306	66	395		
24	305	67	489		
25	328	68	396		
26	296	69	316		
27	396	70	479		
28	327	71	259		
29	386	72	262		
30	278	73	372		
31	252	74	349		
32	469	75	313		
33	305	76	276		
34	396	77	303		
35	245	78	408		
36	326	79	294		
37	264	80	477		
38	336	81	261		
39	279	82	432		
40	316	83	421		
41	274	84	332		
42	346	85	345		
43	288	86	278		

NS: No significant
T_B : Break-down time

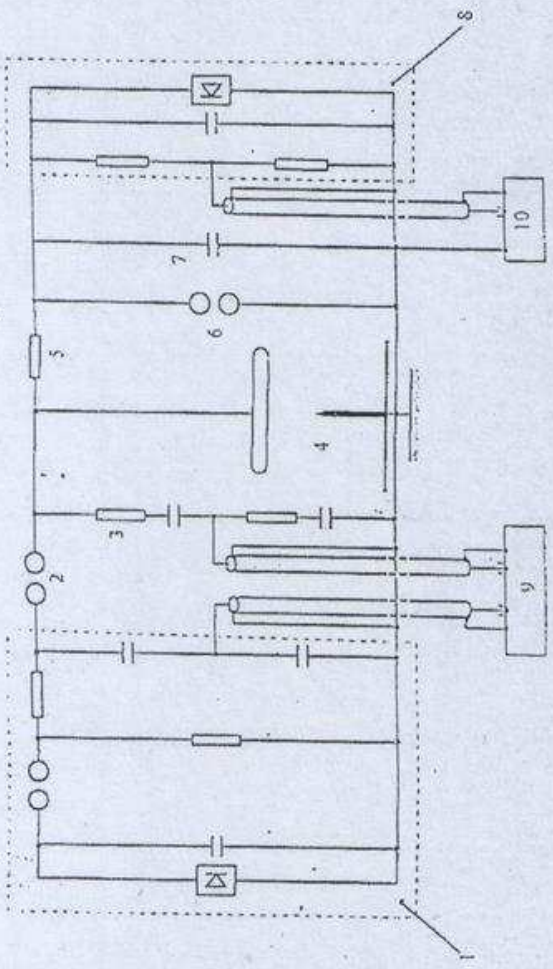


T'_{PTS} = 383.38 µs
T'_{PDA} = 339.59 µs
T_{PTS} = 439.16 µs
T_{PDA} = 375.06 µs
$\Delta T = T_{PTS} - T_{PDA}$ = 64.1 µs




12,4
4,5
52,5
11,5
20

Test circuit diagram on lightning conductor



1 - HV Impulse Generator SPF 340/4200
2 - Serial protective gap, Φ = 250 mm
3 - Damped capacitive divider, 1600 kV
4 - Test configuration
5 - Resistance 2 MΩ
6 - Parallel protective gap, Φ = 500 mm
7 - Capacitor 4,5 nF
8 - Rectifier cascade GS 1000/30
9 - Transient recorder TR - AS 100 - 10
10 - Measurement volimeter

TEST SET UP ON EARLY STREAMER
EMISSION LIGHTNING CONDUCTOR
(ESELC)