NATIONAL INSTITUTE FOR RESEARCH, DEVELOPMENT
AND TESTING IN ELECTRICAL ENGINEERING
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accredited for TESTING
SR EN ISO/CEI 17025:2005
ACCREDITATION CERTIFICATE
LI 1036

TEST REPORT
No. 46805 / 23.07.2019

CUSTOMER:	**SCHIRTEC AG** Address: Ignaz-Köck Strasse 10/A-1210 Wien / AUSTRIA
MANUFACTURER:	**SCHIRTEC AG** Address: Ignaz-Köck Strasse 10/A-1210 Wien / AUSTRIA
TESTED PRODUCT:	Early Streamer Emission (ESE) Lightning Conductor type **SCHIRTEC- AS (S-AS)**
REFERENCE STANDARD:	NFC 17-102:2011, Annex C UNE 21186: 2011, Annex C
PERFORMED TESTS:	I. General tests I.1 Documentary information and identification I.2 Marking tests II. Mechanical tests - Inspection of dimensional characteristics III. Environmental tests III.1 Salt mist treatment III.2 Humid sulphurous atmosphere treatment IV. Early streamer emission tests
TEST PERIOD:	09.07.2019 ÷ 22.07.2019
TEST RESULTS:	For test I.1 see page 4, for test I.2 see page 5, for test II see page 5, for test III.1 see page 6, for test III.2 see page 8, for test IV see pages 12, 13 and 15.

The test report contains 20 pages and is edited in 4 copies, copy no.1 remains in laboratory and copies 2, 3, 4 are sent to the customer.

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Warnings:

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b. *Publication and 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 belongs.*
c. *All signatures of the present report are original ones.*

CONTENTS:

1. IDENTIFICATION OF THE TEST PRODUCT

Type:	SCHIRTEC- AS (S-AS)
Serial / year:	Serial number 082124
Technical Specification / Drawing:	Drawing SCH.102 (Annex 2)
Contract / Test order:	No. 705.2 / 1121 / 05.06.2019
Internal test order:	23817 / 18.06.2019
Product receiving date:	01.07.2019
Product condition at receiving:	New

2. TECHNICAL CHARACTERISTICS ESTABLISHED BY MANUFACTURER

See Annex 1 page 19

Early streamer emission efficiency $\Delta T = 30\ \mu s$

3. TESTS PROGRAM

I. General tests	C.3.1
I.1 Documentary information and identification	C.3.1.1
I.2 Marking tests	C.3.1.2
II. Mechanical tests - Inspection of dimensional characteristics	C.3.2
III. Environmental tests	
III.1 Salt mist treatment	C.3.3.1
III.2 Humid sulphurous atmosphere treatment	C.3.3.2
IV. Early streamer emission tests	C.3.5

4. RESPONSIBLE FOR TEST

Eng. Luminiţa TAŞCĂU (I, II)

Tech. Ioana PĂTRU (III)

Eng. Laurenţiu Vlădoi (IV)

5. PRESENT AT THE TEST:

I. GENERAL TESTS

I.1 DOCUMENTARY INFORMATION AND IDENTIFICATION

1. Test date: 09.07.2019

2. Test standard: NFC 17-102:2011, Annex C, clause C.3.1.1

3. Atmospheric conditions: temperature 20,9°C; relative humidity 53,1%

4. Equipment used: –

5. Test procedure: The ESE Lightning Conductor was identified by the following information indicated on the product (marking), Photo 1 and 2:

- Trade mark (and logo) of the manufacturer: **SCHIRTEC®**
- Early streamer emission efficiency: $\Delta T = 30$ μs
- Serial number: 082124

The checking of the identification of marking was carried out by visual inspection.

6. Test results: Identification of marking was according to the requirements of C.2.1.1 of the NFC 17-102.

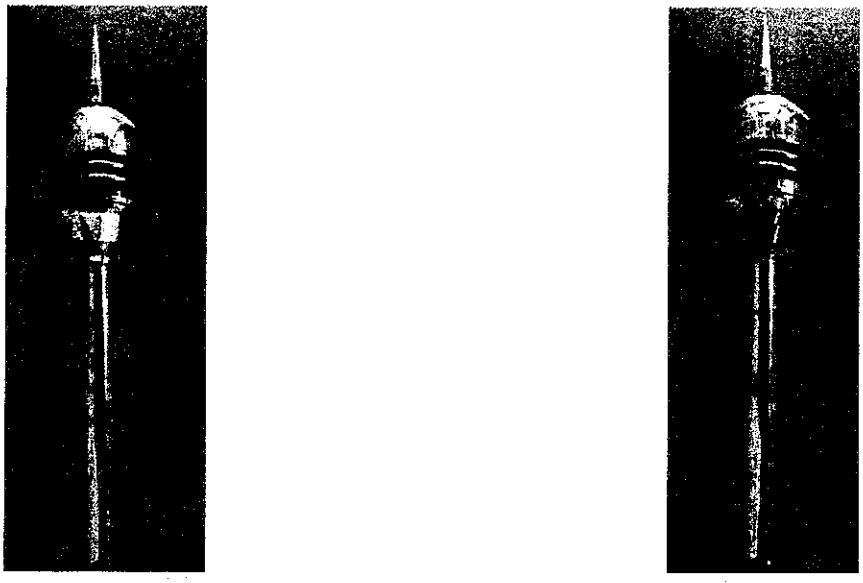


Photo 1 Tested product

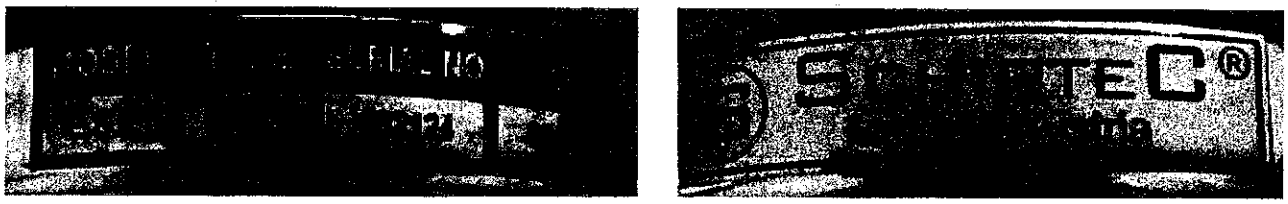


Photo 2 Product labels

I.2 MARKING TESTS

1. Test date: 09.07.2019

2. Test standard: NFC 17-102:2011, Annex C, clause C.3.1.2

3. Atmospheric conditions: temperature 20,9°C; relative humidity 53,1%

4. Equipment used: **Material**: hexane aliphatic defined by a 0.1% maximum content of aromatic carbide in volume (Note 1, clause C.3.1.2)

5. Test procedure: The test was carried out by rubbing the marking by hand for 15 s with a cotton rag dipped in water and for 15 s more with a cotton rag dipped in hexane aliphatic.

6. Test results: After the test the marking was legible (Photo 3).

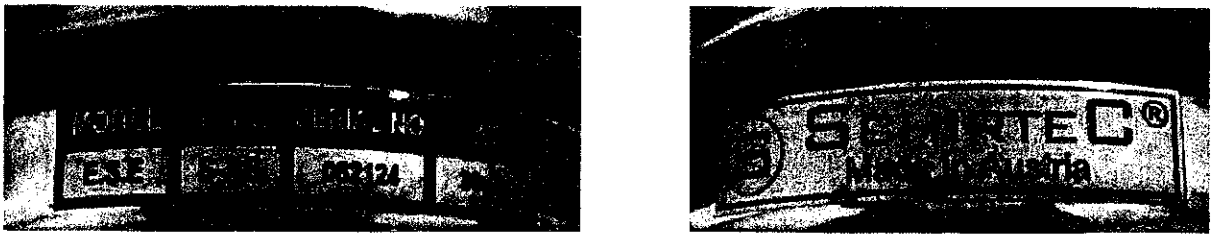


Photo 3 Product labels after the test

II. MECHANICAL TESTS - INSPECTION OF DIMENSIONAL CHARACTERISTICS

1. Test date: 09.07.2019

2. Test standard: NFC 17-102:2011, Annex C, clause C.3.2

3. Atmospheric conditions: temperature 20,9°C; relative humidity 53,1%

4. Equipment used:

- Digital calliper, serial no. 5V0064501, manufacturer TESA Switzerland, CC no. 0906DJ16/01.02.2017, DRML Craiova
- Digital calliper with vernier 1000 mm, type D 10233, serial no. D 18051 manufacturer China, CC no. 01.01-128/2017, INM Bucuresti

5. Test procedure: The checking of the dimensional characteristics with their tolerances was carried out according to manufacturer drawing no. SCH.102 (Annex 2).The tolerance is ±3% for all dimensions.

Dimension (mm)	∅24	20	∅116	∅30	232	8	44
Measured value (mm)	∅24	20	∅116	∅30	232	8.1	45

Dimension (mm)	35	96	10	140	565
Measured value (mm)	35	96.6	10	139.3	566

6. Test results: The difference between the measured values and the rated dimensions has complied with the specified tolerance.

III. ENVIRONMENTAL TESTS

III.1 SALT MIST TREATMENT

1. Test period: 23.07.2019 – 26.07.2019

2. Test standard: NF C 17-102:2011, Annex C, clause C.3.3.1,
UNE 21186: 2011, Annex C, clause C.3.3.1
SR EN 60068-2-52:2002

3. Atmospheric conditions: temperature 25,1°C-26,5°C, relative humidity 62-63%

4. Equipment used:
- Salt mist chamber, tip SC/KWT 1000, manufactured by Weiss Umwelttechnick Germany, serial no 59226175160010, calibration certificate no.07837-06.19
- Climatic chamber, climatic room Votsch Germany ,type VC 40 60, series 59566092700010 calibration certificate no. 07836-06.19
- Portable conductivity meter, type 3210, manufactured by WTW Germany, serial no. 15440615 /2015, calibration certificate no. 132.05/03.03.2016
- pH meter, type SD50, serial no. 0815/49481, calibration certificate Nr. 6134DJ18/18.02.2019
- Thermohygrometer type HD 100, serial 06102402, manufactured by KIMO France, calibration certificates no. 4174Dj17/03.2018 (for thermometer function) and no. 4175Dj17/03.2018 (for hygrometer function)

5. Test procedure:

The test was carried out with level 2 severity.

The product was placed in the salt mist chamber (Photo 4) and it was sprayed for 2 h with a 5% sodium chloride solution at ambient temperature. At the end of the spray period, the product was transferred to the climatic chamber (Photo 5) and stored for 22 h at a temperature of 40°C and a relative humidity of 93%.

A cycle consists in a period of exposure to salt mist and a period of storage to moisture. The product was subjected to 3 (three) such conditioning cycles.

The salt mist treatment diagram is presented in Photo 6.

6. Test result:

The product was conditioned for the humid sulphurous atmosphere test.

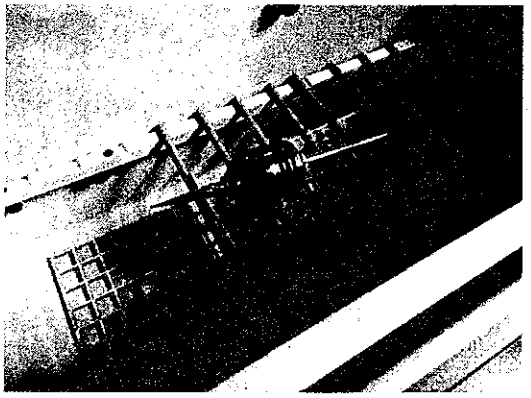


Photo 4
Product inside the salt mist chamber

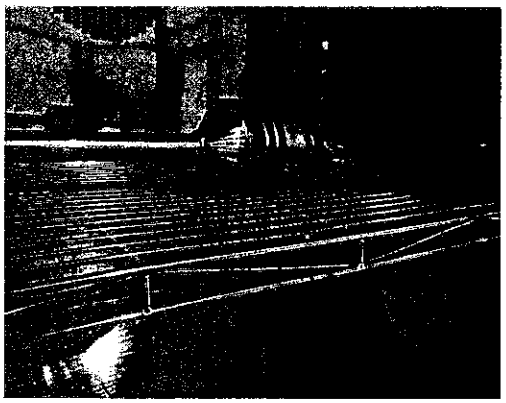


Photo 5
Product inside the climatic chamber

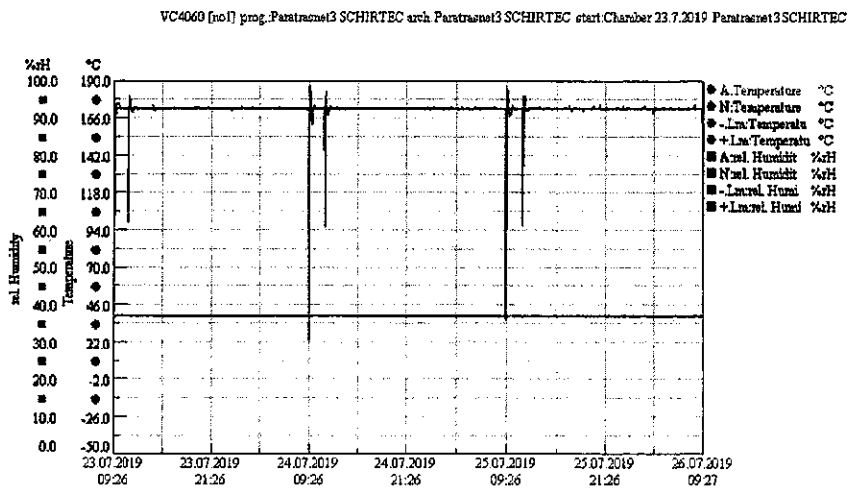


Photo 6
Salt mist treatment diagram

III.2 HUMID SULPHUROUS ATMOSPHERE TREATMENT

1. Test period: 26.07.2019 – 02.08.2019

2. Test standard: NF C 17-102:2011, Annex C, clause C.3.3.2
UNE 21186: 2011, Annex C, clause C.3.3.2
SR EN ISO 6988:1997

3. Atmospheric conditions: temperature 25°C-27°C, relative humidity 62-65%

4. Equipment used:
- Humid sulphurous atmosphere chamber, type V.702.861.101, manufactured by VLM Germany, serial no.1701901, calibration certificates BURKERT Nr.72010935/24.11.2016 and VLM nr. 14609/03.02.2017
- Thermohygrometer type HD 100, serial 06102402, manufactured by KIMO France, calibration certificates no. 4174Dj17/03.2018 (for thermometer function) and no. 4175Dj17/03.2018 (for hygrometer function)

5. Test procedure:

The product was subjected to 7 (seven) conditioning cycles in humid sulphurous atmosphere chamber (Photo 7). Each cycle lasted 24 hours and included an 8-hour heating period at a temperature of 40 °C in a saturated humid environment, followed by a 16-hour standing period. After this standing period, the humid sulphurous atmosphere was restored.

At the beginning of each cycle, 2 dm^3 of distilled water were introduced into the test chamber and 0.2 dm^3 of sulphur dioxide were dosed inside using an electronic mass flow meter. Simultaneously, the heating was started and it was created a humid sulphurous atmosphere at 40 °C. The product was kept in the above conditions for 8 hours, followed by 16 hours aeration inside the test chamber at 23 °C.

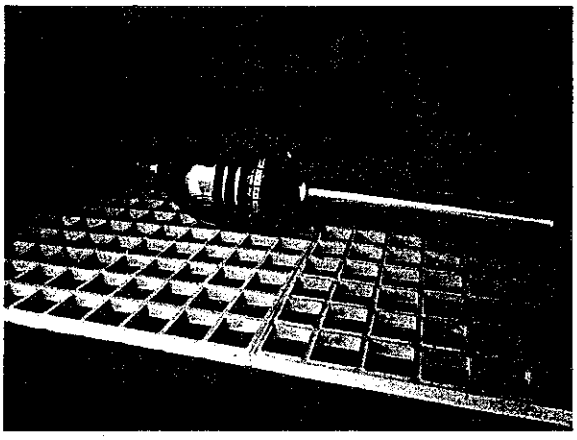


Photo 7
Product inside the humid sulphurous atmosphere chamber

6. Test result:

The product was conditioned for the electrical tests. The product at the end of the test is shown in photo 8, photo 9 and photo 10.

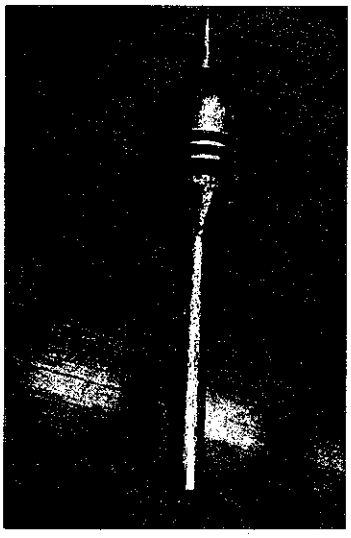


Photo 8

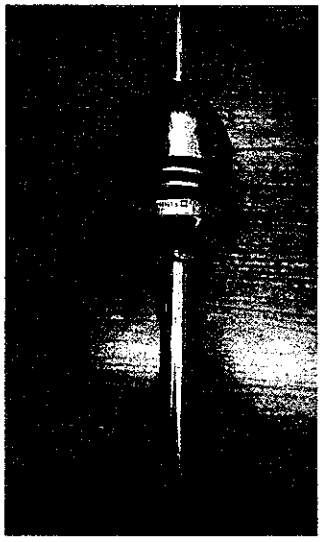


Photo 9

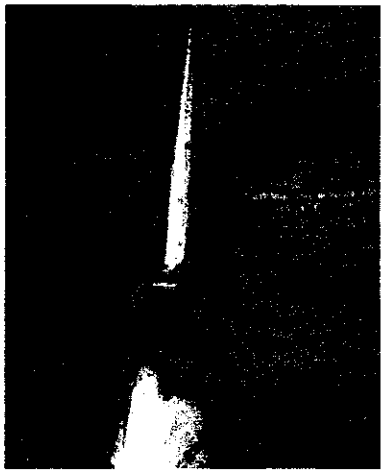


Photo 10

IV. EARLY STREAMER EMISSION TESTS

1. Test date: 22.07.2019
2. Test standard: NFC 17-102:2011, Annex C
UNE 21186: 2011, Annex C
3. Atmospheric conditions:

While testing the S.R.A.T

BEFORE TEST:	p = 1007 mbar t = 24 ^{0}C h_r = 65.5 %
MIDDLE OF THE TEST:	p = 1007 mbar t = 24.1 ^{0}C h_r = 64.2 %
END OF THE TEST:	p = 1007 mbar t = 24 ^{0}C h_r = 64 %

While testing the E.S.E.A.T

BEFORE TEST:	p = 1007 mbar t = 24 ^{0}C h_r = 64 %
MIDDLE OF THE TEST:	p = 1007 mbar t = 23.7 ^{0}C h_r = 63 %
END OF THE TEST:	p = 1007 mbar t = 23.3 ^{0}C h_r = 62 %

4. Equipments and apparatus used:

Laboratory inner dimensions: 48 m x 32 m x 27 m (height); Altitude: 100 m above see level;

4200 kV High Voltage Impulse Generator type SPF 336; 336 kWs, TUR Dresden – Germany;

1000 kV Rectifier cascade type GS 1000 / 30; 30 mA; TUR Dresden – Germany;

1400 kV Damped divider type RC 1400, serial no. 03/1996, ICMET Craiova, Romania; TR – AS Transient – Recorder, Dr.Strauss System Electronik, serial no.228 GmbH – Germany; Digital multimeter Keithley, serial no. 1070037 – USA.

See the test circuit diagram on page 17.

The measuring systems consist of:

- For SI:

- High Voltage Measuring system for switching impulse, 1400 kV that consist of:
  - Divider type RC 1400, serial no.03 / 1996 – manufacturer by ICMET Craiova.
  - Transient Recorder type TR–AS 100–10 / 4, serial no. 228, manufacturer by Dr. Strauss GmbH;
  - Coaxial measuring cable, 75Ω, 40m.

The measuring uncertainty is 1.43% for peak voltage value and 3.86% for peak time parameter according to the Calibration Certificate no.85 / 09.2016.

- For DC:

- 1MV - DC High Voltage Measuring system that consists of:
  - DC resistive divider (serial no.3-35/1),
  - Digital multimeter type Keithley (serial no.1070038)
  - Coaxial measuring cable, 50Ω, 25m

The measuring uncertainty is ±1% according to the Calibration Certificate, no. 44 / 07.2015.

- For climatic parameters:

- Measuring system used for recording the climatic parameters (type ALMEMO 2390-5) consists of:
  - digital thermometer type 2390-5, serial no.H07040351, measuring uncertainty 0.30% according to Calibration Certificate no.04.01-157/2016;
  - digital barometer type 2390-5, serial no.SN 07020126 measuring uncertainty 0.07% according to Calibration Certificate no.02.02-041/2016;
  - digital hygrometer type 2390-5, serial no.H07040351, measuring uncertainty 1.8% according to Calibration Certificate no.05.02-195/2016.

5. Test procedure / test set-up / working mode:

See the test set up on page 18
See photos on the page 16

The tested S.R.A.T. / E.S.E.A.T. were set on a square support with a 0.2m side and connected to ground.

A square metallic plane with dimensions: 4.5 m / 4.5 m / 0.2 m having the edges rounded, was suspended above the lightning conductor.

On the upper metallic plate there were applied at the same time the DC polarization voltage and the switching impulses (250 / 2500 μs), both having negative polarity.

The switching impulse voltage was determined by using a simplified "up and down" procedure in order to obtain the value U100 with a final precision of 1%.

The DC voltage was adjusted in order to create an electric field between the two metallic plates in the range of – 20 to – 25 kV / m (effectively 22.4 kV / m).

Tests were performed in the same conditions and configuration for each lightning conductor: E.S.E.A.T. and S.R.A.T.

The atmospheric conditions were taken at the beginning, at the middle and at the end of each test.

First, there were applied 50 impulses on the S.R.A.T. and after that 50 more impulses were applied on the E.S.E.A.T.

The early streamer emission lightning conductor (E.S.E.A.T.) is compared with a reference single rod lightning conductor (S.R.A.T.).

The peak value (Up) of the impulses and the triggering time (T_B) were recorded for each impulse.

The height of the lightning conductor (h) and the distance between the two metallic plates (H) were measured at the beginning of each test.

Height of lightning conductor (h) adjusted to:	1182 mm
Distance between the upper plate and the ground (H):	2450 mm
h / H:	0.482
Polarization voltage:	54.86 kV
Peak time / Rise time of the full wave:	236 μs / 98.3 μs
Time interval between consecutive impulses:	2 min

6. Test results:

6.1. test results for S.R.A.T.

The average value of significant break-down times (T_B) calculated from the experimental results (table below) is T_{SRAT} = 148.9 μs with a standard deviation σ_{SRAT} = 21 %.

By transferring T_{SRAT} on the reference waveform it was obtained T'_{SRAT} = 395.5 μs (see graphic from page 14).

Impulse no.	T_B [μs]	Impulse no.	T_B [μs]
1	124	41	140
2	130	42	178
3	200	43	111
4	217	44	194
5	114	45	167
6	148	46	134
7	186	47	179
8	112	48	135
9	107	49	194
10	147	50	225
11	129		
12	131		
13	157		
14	131		
15	139		
16	101		
17	171		
18	147		
19	120		
20	165		
21	155		
22	126		
23	135		
24	126		
25	181		
26	179		
27	139		
28	124		
29	175		
30	123		
31	200		
32	126		
33	107		
34	119		
35	199		
36	129		
37	121		
38	156		
39	158		
40	135		

T_B : Break-down time

6.2. Test results for E.S.E.A.T.

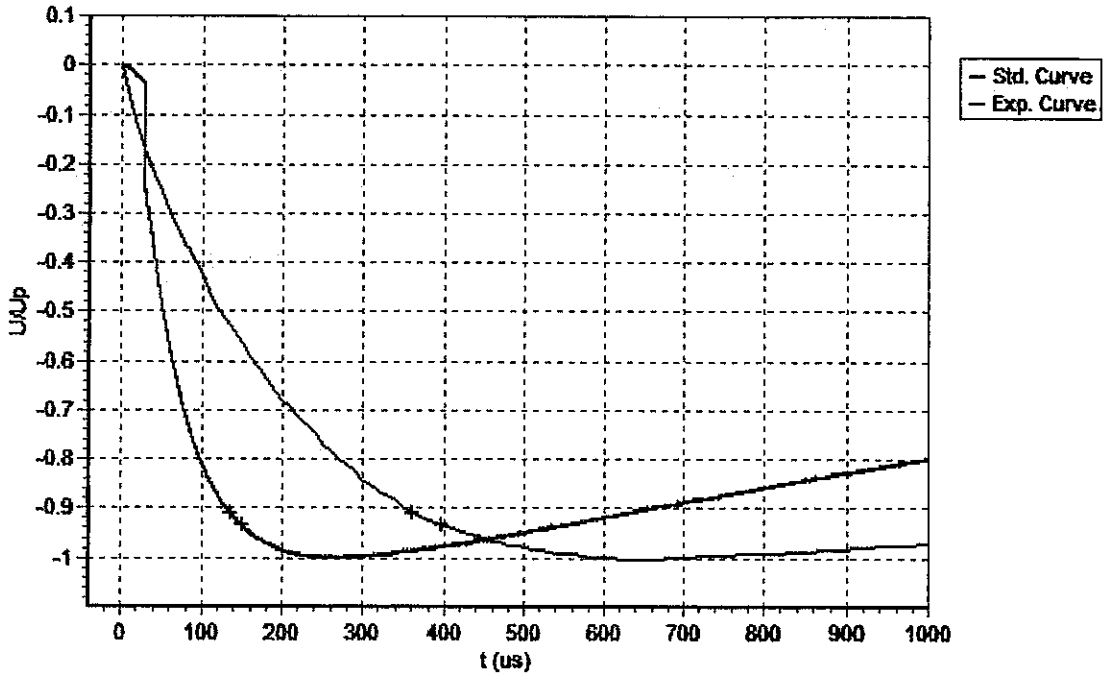
The average value of significant break-down times (T_B) calculated from the experimental results (table below) is T_{ESEAT} = 134.2 μs with a standard deviation σ_{ESEAT} = 15.8 %.

By transferring T_{ESEAT} on the reference waveform it was obtained T'_{ESEAT} = 360.6 μs (see graphic from page 14).

Impulse no.	T_B [μs]	Impulse no.	T_B [μs]
1	165	41	128
2	162	42	133
3	106	43	119
4	124	44	126
5	190	45	165
6	155	46	124
7	163	47	137
8	127	48	150
9	113	49	158
10	124	50	131
11	147		
12	143		
13	143		
14	142		
15	157		
16	131		
17	167		
18	113		
19	107		
20	145		
21	122		
22	162		
23	141		
24	148		
25	110		
26	122		
27	158		
28	148		
29	133		
30	131		
31	141		
32	98		
33	104		
34	132		
35	130		
36	98		
37	109		
38	98		
39	115		
40	116		

T_B : Break-down time

Graphic 1 – Determination of the early streamer emission of the E.S.E.A.T



Where:

- On OX axes there is represented time in μs;
- On OY axes there is represented amplitude U / U_{peak} in relative units;
- Green line is the experimental waveform;
- Red line represents the standard waveform.

6.3. Conclusion:

From all shown so far it can be concluded that the triggering advance is:

$$\Delta T = T'_{SRAT} - T'_{ESEAT} = 395.5 - 360.6 = 34.9\ \mu s \pm 1\ \mu s$$

Measuring uncertainty for ΔT is 3 %.
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 %.

The tested lightning conductor is an E.S.E.A.T. (early streamer emission air terminal) because it fulfils all the conditions stipulated by standard (according to NFC 17-102 :2011, Annex C, clause C.3.5.2.5):

- $T_{ESEAT} < T_{SRAT}$ (134.2 < 148.9)
- $\sigma_{ESEAT} < 0.8\ \sigma_{SRAT}$ (15.8 % < 0.8 · 21 % = 16.8 %)
- $T'_{SRAT} - T'_{ESEAT} > 10\ \mu s$

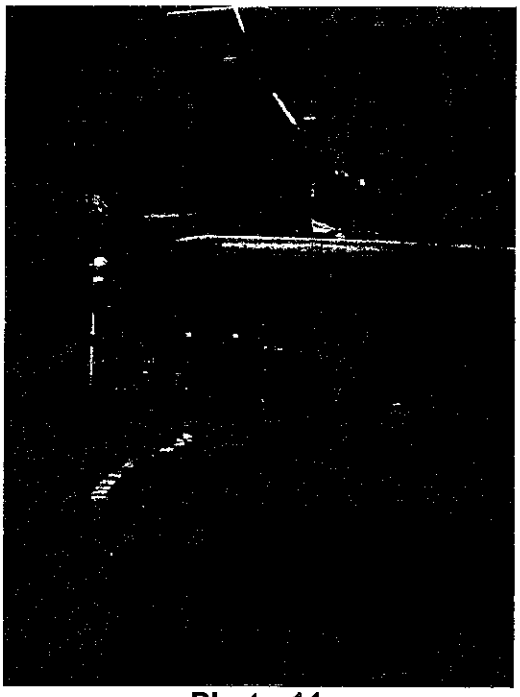


Photo 11

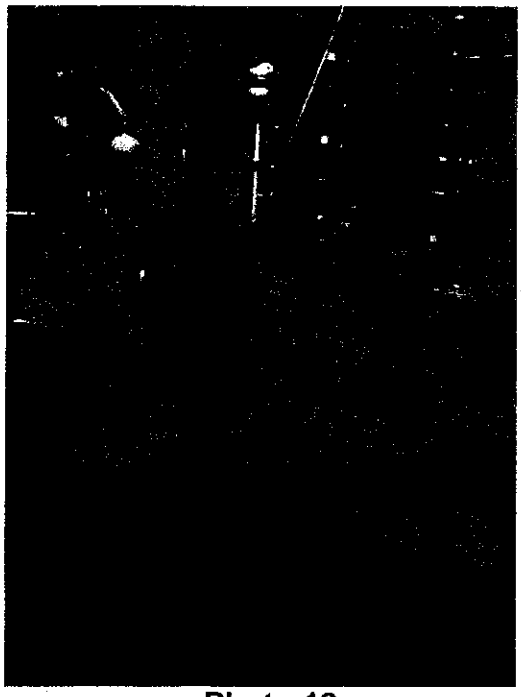
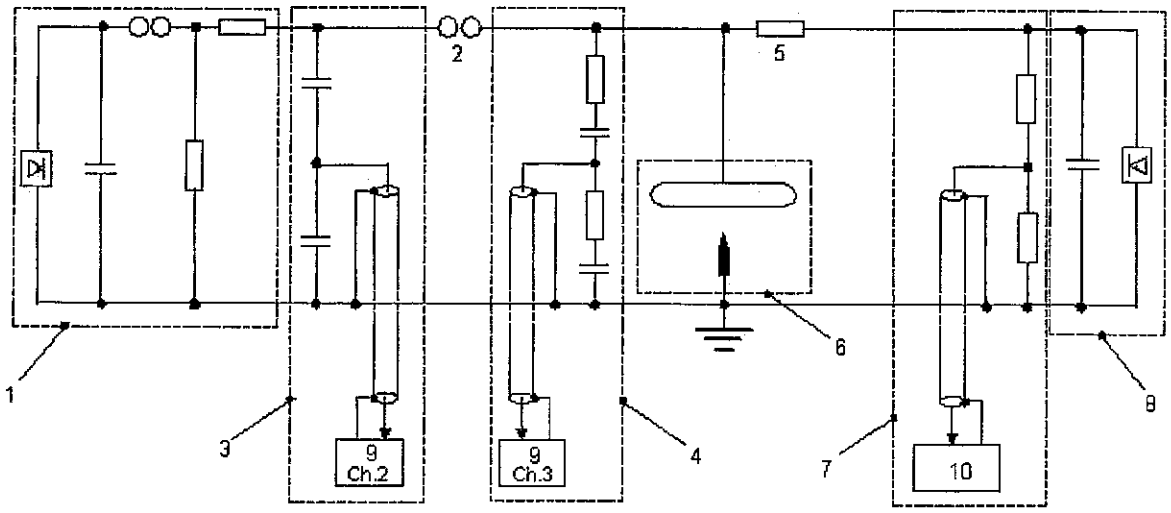


Photo 12

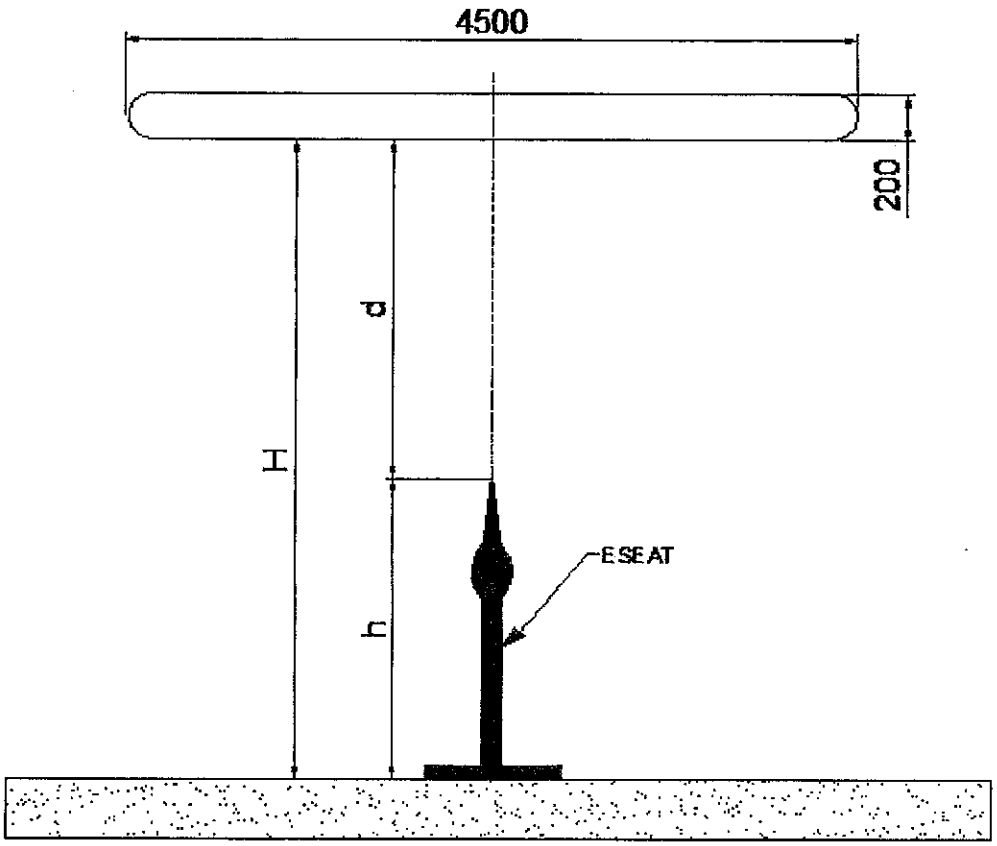
Photo 13

Test circuit diagram for testing E.S.E. conductors



1 - HV Impulse Generator 4.2MV-336kWs;
2 - Serial protective gap Φ = 250 mm;
3 - 4.2 MV measuring system;
4 - 1400 kV measuring system;
5 - Resistance 2MΩ;
6 - E.S.E. test configuration;
7 - 1 MV DC measuring system;
8 - Rectifier DC cascade GS 1000/30;
9 - Transient recorder TR-AS 100-10/4, channels 2 and 3;
10 - Digital multimeter KETHLEY.

TEST SET UP FOR EARLY STREAMER EMISSION AIR TERMINAL



Annex 1

E.S.E. Lightning Conductors

SCHIRTEC

S-AS

The E.S.E. Lightning Conductor S-AS protects from a single point mid-sized buildings and houses.

Specification - 30 µs	
Material:	stainless steel
Size:	55 x 12 cm
Weight:	2,8 kg
Protection Radius:	50 m
Installation Height:	4-5 m

TÜV AUSTRIA BET ICMET

Made in Austria

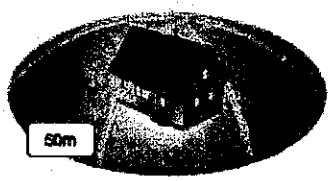
The Austrian company SCHIRTEC AG is certified to ISO 9001:2015 and ISO 14001:2015. The E.S.E. Lightning Conductor S-AS is in accordance to the NFC 17-102: 2011 and the UNE 21186: 2011 Standards. The product is made of stainless steel, which is confirmed by TÜV Austria. The discharge capacity of lightning is confirmed in the laboratory CTI Vienna.

Installation

Installation of S-AS is simple and fast. The lightning arrester is installed on the top of the building and protects not only the building itself but also everything that is within the protective radius.

	Rp(m)			
h	I	II	III	IV
2	19	22	25	28
4	38	44	51	57
5	48	55	63	71
6	48	55	64	72
8	49	56	65	73
10	49	57	66	76
20	50	59	71	81
30	50	60	73	85
60	50	60	75	90

h – Installation height
Rp (m) – Protection Radius
I | II | III | IV – Protection Level



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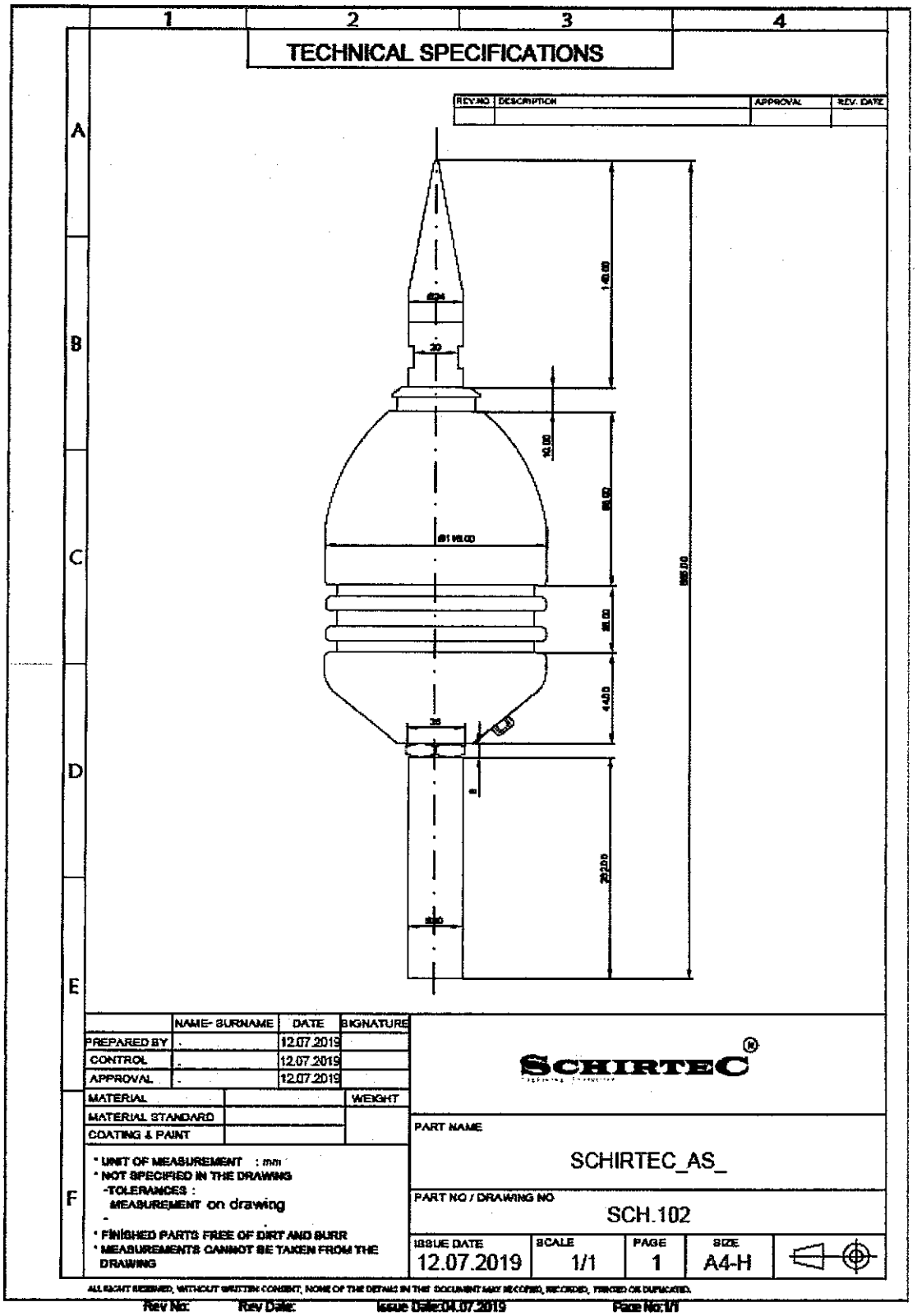
Annex 2



– End of the test report –