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. 47136 / 10.09.2020

CUSTOMER:
TS Lightning Protection Co., Limited
Old Address: No.9 Dongying Street, Dongfeng Road (E), Dongping Village, Baiyun, Guangzhou, Guangdong, CHINA
NEW Address: Hongdiyuan Industrial Park, Wufeng Avenue, Linjiang Town, Jiangdong New District, Heyuan, Guangdong, CHINA

MANUFACTURER:
TS Lightning Protection Co., Limited
Old Address: No.9 Dongying Street, Dongfeng Road (E), Dongping Village, Baiyun, Guangzhou, Guangdong, CHINA
NEW Address: Hongdiyuan Industrial Park, Wufeng Avenue, Linjiang Town, Jiangdong New District, Heyuan, Guangdong, CHINA

TESTED PRODUCT: **Early Streamer Emission (ESE) Lightning Conductor**

REFERENCE STANDARD: NFC 17 – 102 : 2011, Annex C.3.5

TEST PERFORMED: Early streamer emission test

TEST PERIOD: 09.09.2020

TEST RESULTS: Are presented at point 6, pages 6 and 7.

The Test Report has 13 pages and is edited in 4 copies, from which copy no.1 for Laboratory and copies 2 ÷ 4 for Customer.

HEAD OF HVD – TECHNICAL MANAGER,
Eng. Ilie MIHALCEA

HEAD OF ELECTRIC TESTS TEAM
Eng. Laurenţiu VLĂDOI

Warnings:
a. *The results refer only to the tested product.*
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:

Content

1. IDENTIFICATION OF THE TEST PRODUCT

Type:	SMT – ESE60
Serial / year:	TS60001589 / 2020
Photo of the tested product:	Figure 1
Technical Specification / Drawing:	- / see page 13
Contract / Test order:	705.2 / 1233 / 03.09.2020
Internal test order:	23987 / 07.09.2020
Product receiving date:	08.09.2020
Product condition at receiving:	New

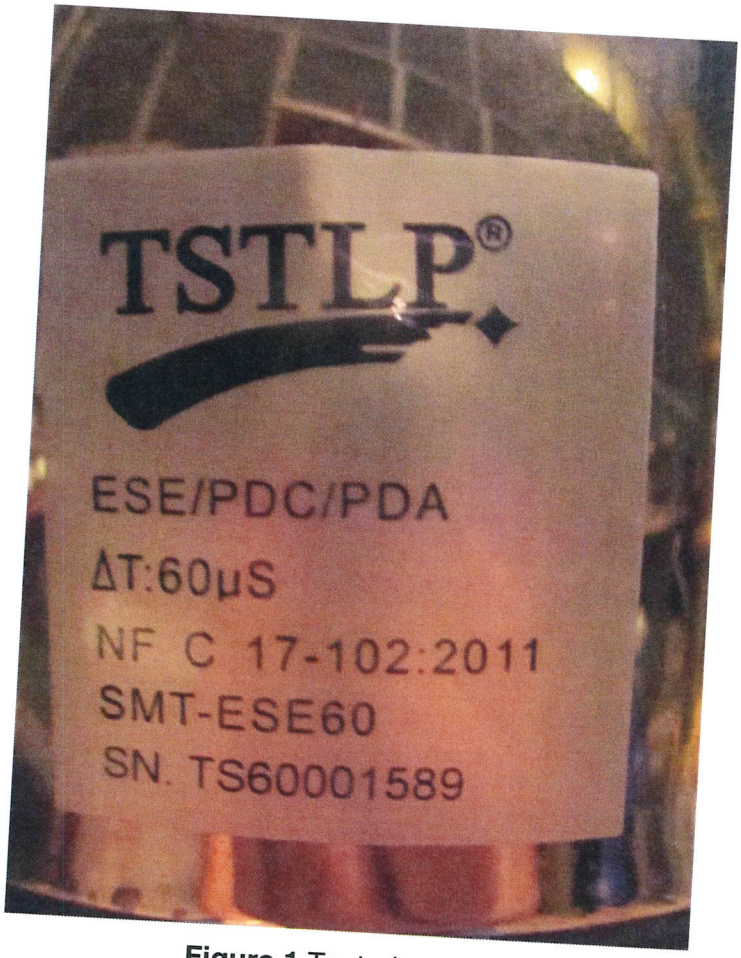


Figure 1 Tested product

Note. In order to performed the test the customer sent:
– E.S.E.A.T. (see drawings from page 13)

2. TEST PROGRAM: Early streamer emission test

3. RESPONSIBLE FOR TEST: Dipl.eng. Tetea Valentin

4. PRESENT AT TEST: -

EARLY STREAMER EMISSION TEST

1. Test date: 09.09.2020

2. Test standard: NFC 17 – 102 : 2011, Annex C.3.5

3. Atmospheric conditions:

While testing the S.R.A.T.

BEFORE TEST:	p = 1012	mbar
	t = 26	^{0}C
	h_r = 48.5	%
MIDDLE OF THE TEST:	p = 1012	mbar
	t = 26.1	^{0}C
	h_r = 48.5	%
END OF THE TEST:	p = 1012	mbar
	t = 26.3	^{0}C
	h_r = 49	%

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

BEFORE TEST:	p = 1012	mbar
	t = 26.3	^{0}C
	h_r = 49	%
MIDDLE OF THE TEST:	p = 1012	mbar
	t = 26.2	^{0}C
	h_r = 49.2	%
END OF THE TEST:	p = 1012	mbar
	t = 26.3	^{0}C
	h_r = 49.3	%

4. Equipments and apparatus used:

Laboratory inner dimensions: 48 m x 32 m x 27 m (height);

Altitude: 100 m above sea 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 11.

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 ±1.62% according to the Calibration Certificate, no.206/06.2020.

- For climatic parameters:

- Measuring system used for recording the climatic parameters (type ALMEMO 3290-8) consists of:
  - digital thermometer type 3290-8, serial no.L9701005M, measuring uncertainty 0.50% according to Calibration Certificate no.04.01 – 721 / 2019;
  - digital barometer type 3290-8, serial no.L9701005M measuring uncertainty 0.6% according to Calibration Certificate no.02.02 – 369 / 2019;
  - digital hygrometer type 3290-8, serial no.L9701005M, measuring uncertainty 1.8% according to Calibration Certificate no.05.02 – 751 / 2019.

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

See the test set up on page 12
See photos on the page 10

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
U100:	554 kV_{peak}
Peak time:	244 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 bellow) is T_{SRAT} = 145.8 μs with a standard deviation σ_{SRAT} = 20.2 %.

By transferring T_{SRAT} on the reference waveform it was obtained T'_{SRAT} = 404.2 μs (see graphic from page 8).

Impulse no.	T_B [μs]	Impulse no.	T_B [μs]
1	139	41	133
2	165	42	192
3	122	43	123
4	132	44	138
5	176	45	182
6	127	46	101
7	146	47	153
8	108	48	132
9	118	49	136
10	214	50	189
11	160		
12	198		
13	179		
14	134		
15	149		
16	127		
17	124		
18	132		
19	135		
20	122		
21	121		
22	141		
23	133		
24	186		
25	141		
26	111		
27	168		
28	112		
29	217		
30	158		
31	140		
32	114		
33	148		
34	116		
35	146		
36	98		
37	177		
38	171		
39	187		
40	119		

T_B : Break-down time

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

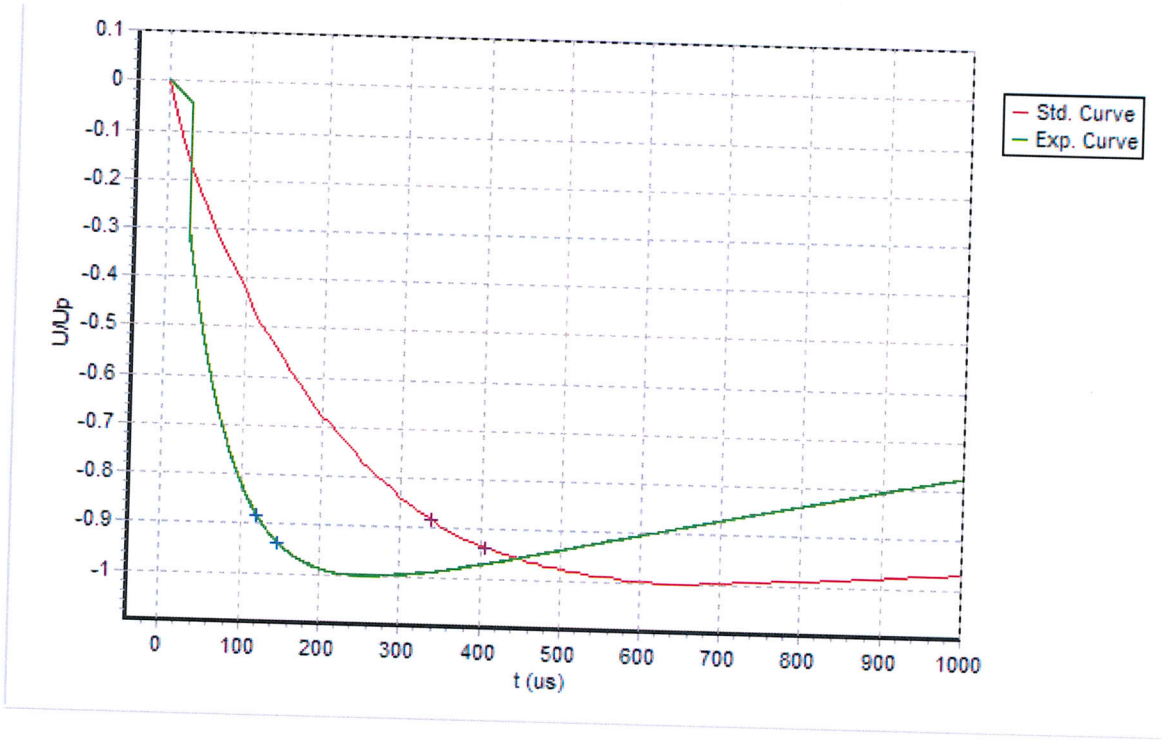
The average value of significant break-down times (T_B) calculated from the experimental results (table bellow) is T_{ESEAT} = 121.2 μs with a standard deviation σ_{ESEAT} = 15 %.

By transferring T_{ESEAT} on the reference waveform it was obtained T'_{ESEAT} = 339.3 μs (see graphic from page 8).

Impulse no.	T_B [μs]	Impulse no.	T_B [μs]
1	118	41	106
2	107	42	145
3	114	43	111
4	104	44	116
5	106	45	148
6	148	46	118
7	141	47	110
8	142	48	105
9	115	49	98
10	131	50	141
11	127		
12	117		
13	112		
14	159		
15	123		
16	131		
17	102		
18	157		
19	111		
20	124		
21	112		
22	108		
23	142		
24	119		
25	100		
26	106		
27	135		
28	180		
29	126		
30	96,6		
31	109		
32	120		
33	140		
34	104		
35	129		
36	106		
37	107		
38	114		
39	110		
40	107		

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:

$$\Delta T = T'_{SRAT} - T'_{ESEAT} = 404.2 - 339.3 = 64.9\ \mu s \pm 4.6 \mu s$$

Measuring uncertainty for ΔT is 7.1 %.
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):

- $T_{ESEAT} < T_{SRAT}$ (121.2 < 145.8)
- $\sigma_{ESEAT} < 0.8\ \sigma_{SRAT}$ (15 % < 0.8 · 20.2 % = 16.2 %)
- $T'_{SRAT} - T'_{ESEAT} > 10\ \mu s$

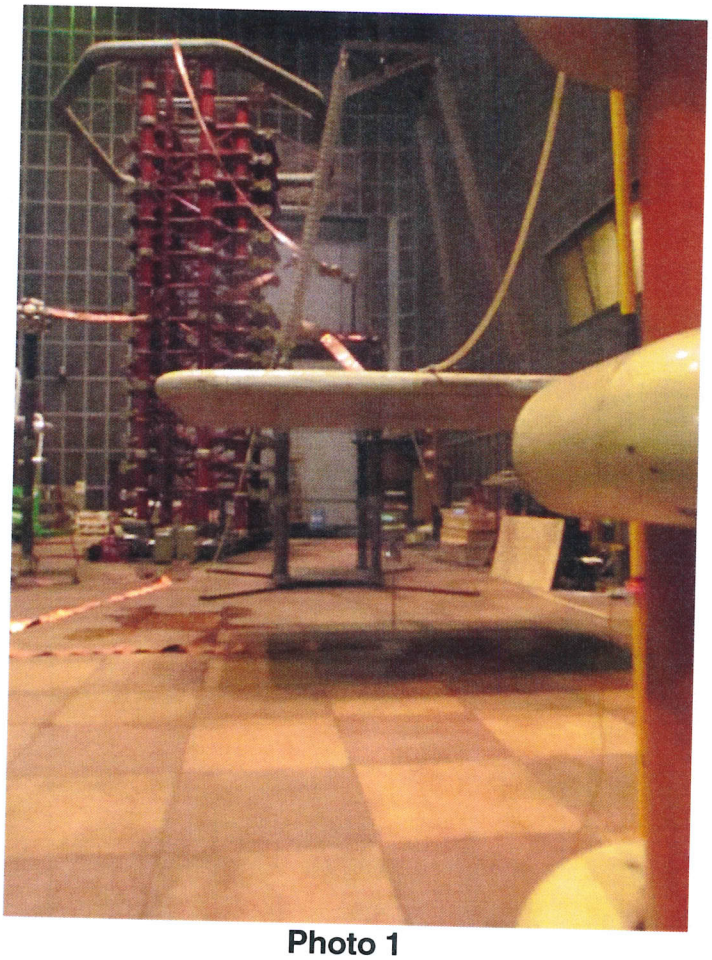


Photo 1

Photo 2

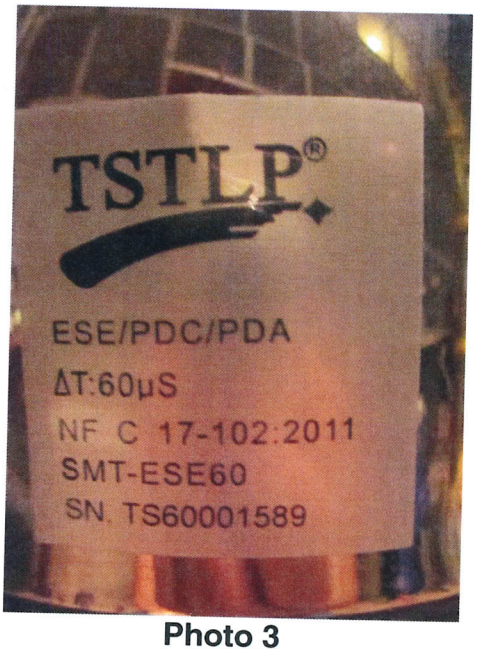
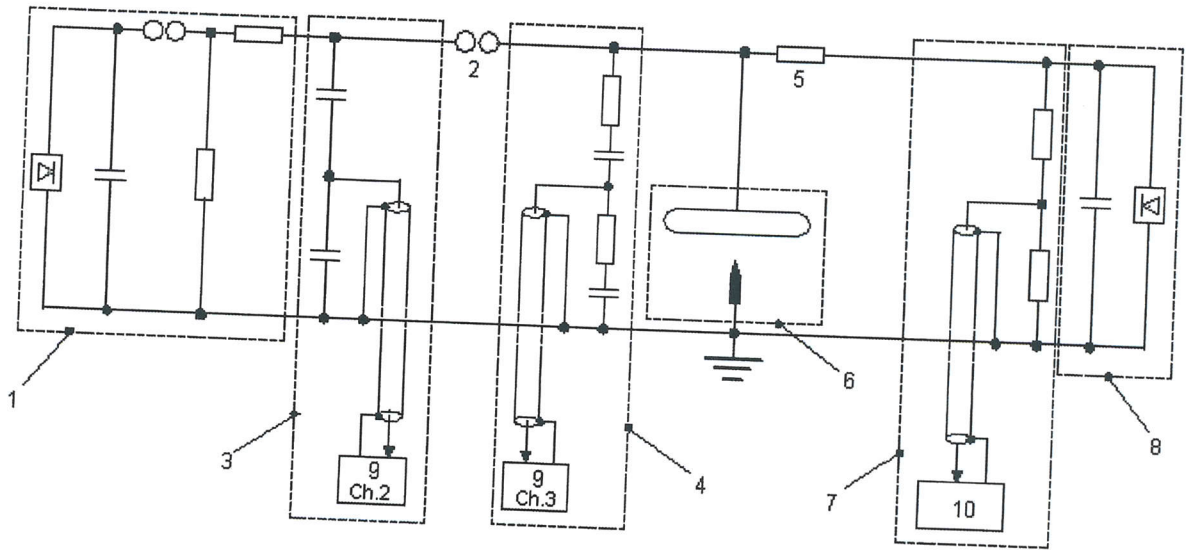


Photo 3

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;

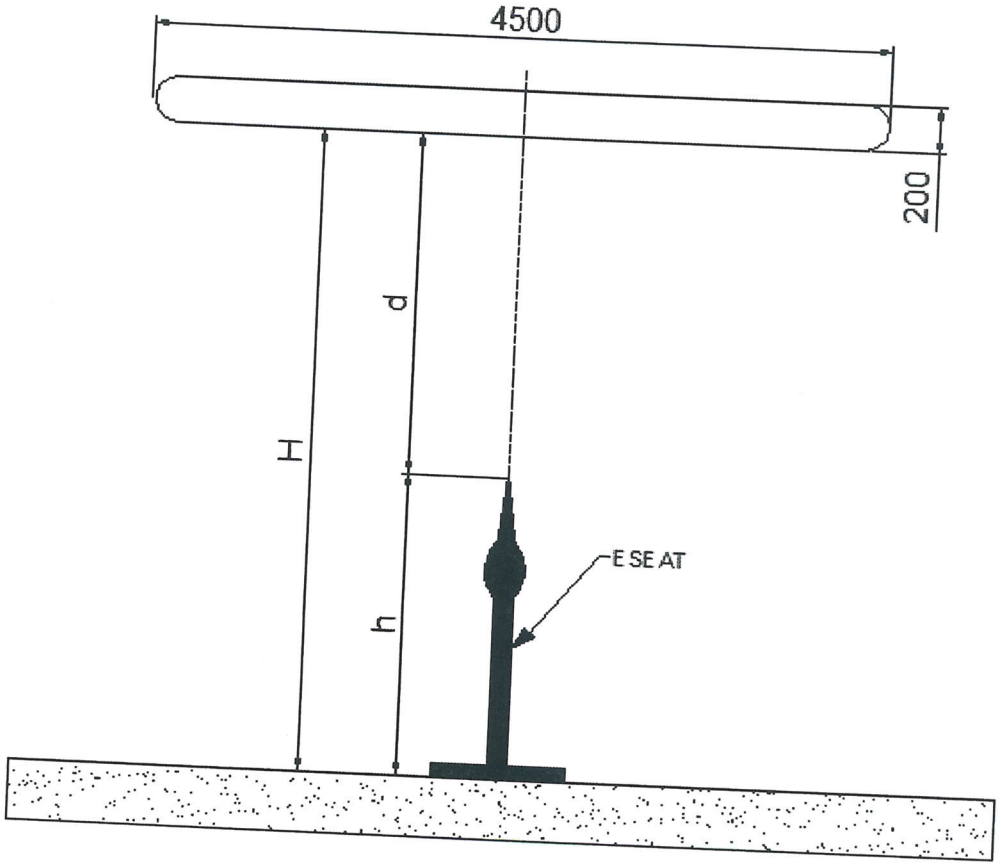
7 - 1 MV DC measuring system;

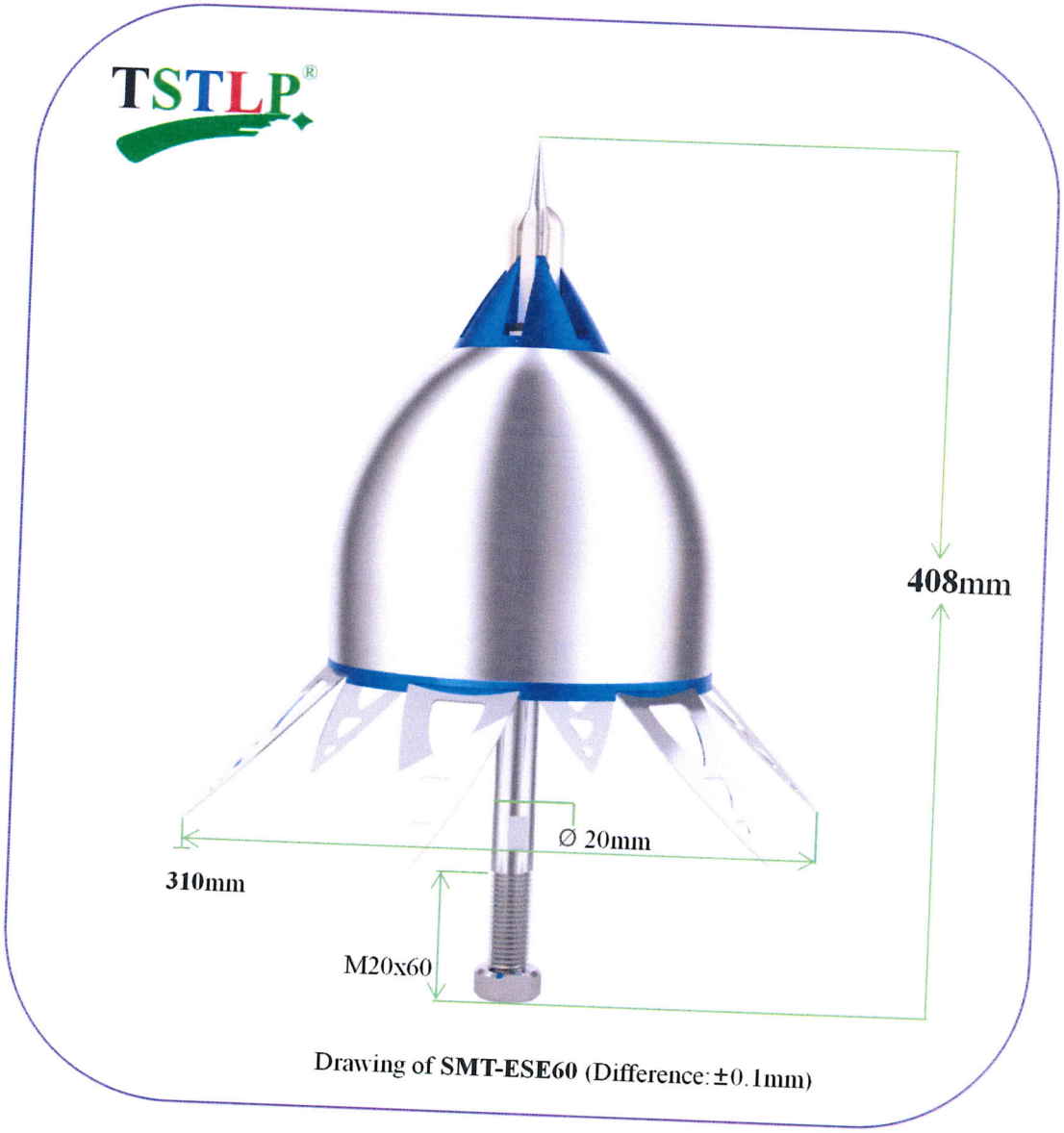
8 - Rectifier DC cascade GS 1000/30;

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





Drawing of **SMT-ESE60** (Difference: ±0.1mm)

– end of test report –