TEST REPORT

TESTS PERFORMED USING THE EXPERIMENTAL APPARATUS OF THE STANDARD NF C 17-100

Lightning conductor:	**DDCE-100-PLUS**
Manufacturer:	Under License DINNTECO INTERNATIONAL S.L. dinnteco lightning off
On behalf of the Corporation:	*Javier Maldonado Pardo*
Date and location:	4th December 2015 Equipe Génie Electrique Laboratoire SIAME Université de Pau 2, avenue Pierre Angot 64000 PAU
SIAME team :	Antoine de FERRON and Thierry REESS

INTRODUCTION

Tests have been carried out in accordance with the experimental apparatus of the Standard NF C 17-100. Lightning conductors manufactured by "Dinnteco Lightning off" have been tested at the High Voltage Laboratory of Pau (France). A bi-exponential wave, with negative polarity, is applied to a plane electrode, in order to create a discharge on a lightning conductor placed in the vertical axis of the created electric field.

During the duration of the tests, lightning conductors were tested under the same climatic conditions and the same experimental apparatus.

TESTS CONDITIONS

1- Experimental apparatus

A metal plate is located above the tested lightning conductor. The distance between the metal plate and the grounded laboratory floor is **H=2,2m**. The air gap length between the plate and the lightning conductor is **d=1,2m**. The high of the lightning conductor is **h=1m**.

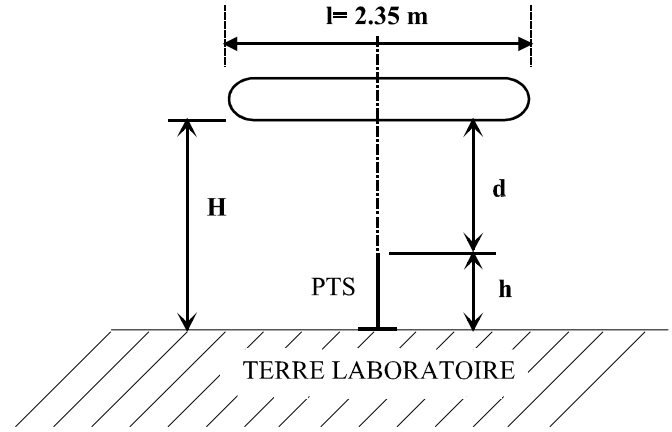


***Figure 1*: the size of the experimental configuration**

This apparatus is energized by the experimental device presented figure 2.

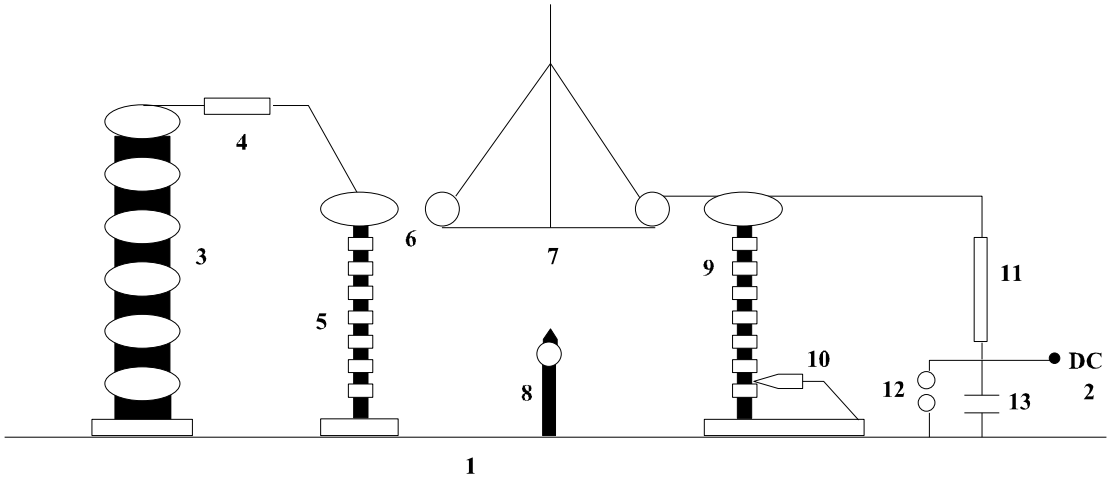


***Figure 2*: Experimental apparatus**

1: Earth plan
2: High voltage DC power supply (100 kV)
3: Marx generator
.amplitude: 650 kV
.rise-time: 400 µs
.load resistor: 700 Ω per stage
4: Resistance of tail of the generator: 70 kΩ
5: Waveform creation capacitor: 666pF, 700kV
6: Insulation gap : insulate up to 50 kV the Marx generator from the continuous polarization (40 kV) from the cloud
7: Cloud
8: Lightning conductor under test
9: Capacitive divider (40pF, 1MV, rapport 1/24500)
10: North Star probe (1/1000)
11: Load resistor (100 MΩ)
12: Security gap (set-up : 50 kV)
13: 1nF capacitor (integrating circuit of the impulse voltage)

All tests are performed without the DC voltage applied to the plane electrode

2- The impulse voltage

Simulation of the impulse field

The air gap is triggered using a 10 stages Marx generator. The time to crest of the impulse is 300µs (figure 3). Using the experimental apparatus presented in figure 2, the maximum applied voltage is about 700kV.

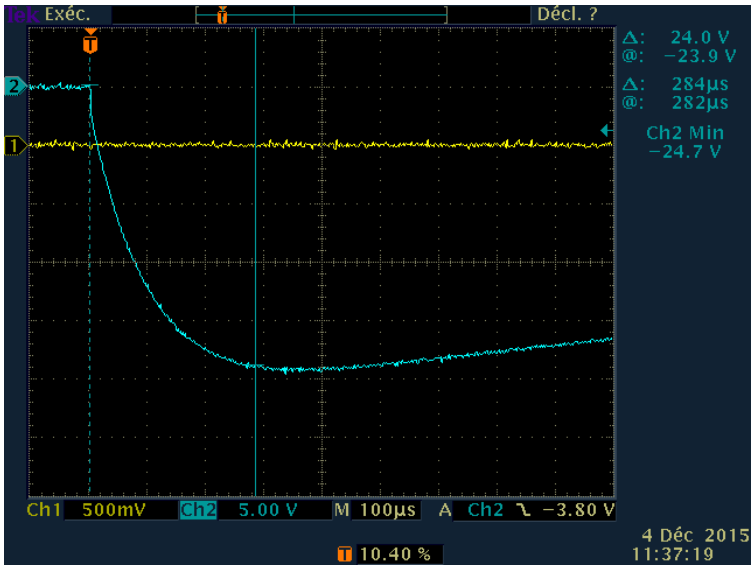


***Figure 3*: Example of applied voltage versus time**

Rise time : T_{cr} = 300µs

Measured voltage : U_{mesure}= 24,7V

Applied voltage : U_{min} = 605kV

($U_{min} = U_{mesure} * 24500$)

3- Measurements

Some diagnostic and measurement devices allow the characterization of the applied voltage and the discharge development:

- The measurement of the voltage delivered by the generator of Marx is carried out by a 40pF - 1MV voltage capacitive divider and a North Star voltage probe. This device of measurement is calibrated by means of another capacitive divider, even calibrated with 1 % precision compared to the national reference EDF Laboratoire de Génie Electrique, les Renardières). The division ratio of the system is 1/24500.

- The light emitted by the discharges at the top of the lightning conductor is analysed by means of a UV photomultiplier.

- The acquisition of the electric signals, such that the voltage waveform and the signals delivered by the photomultiplier, are carried out with the means of a digital oscilloscope Tektronix 744.

- The climatic conditions (temperature, pressure and absolute moisture) are recorded in beginning and end of each configuration: **T = 22°C**, **P = 1035mbar** and **δ = 39%**.

4- Test procedure

First, the tests consisted in characterizing the value of the U_{50} breakdown voltage of the simple Franklin rod. Results presented in page 5 show that:

$$\mathbf{U_{50(PTS)} = 565\ kV}$$

In a second time, the voltage is set to 595kV in order to obtain 100% of breakdown on the simple Franklin rod. For a series of 30 consecutive shocks, we record the number of the shock, the value U_b of the voltage at the breakdown time, and the time to breakdown T_b (page 6).

These results are compared with those obtained using an **inactivated DDCE-100-PLUS** **(short circuit) and an activated DDCE-100-PLUS.**

SIMPLE FRANKLIN ROD

Determination of the U_{50} value

Choc n°	Umesure (V)	Tb (µs)	Choc n°	Umesure (V)	Tb (µs)
1	23,5	402	16	24,2	358
2	23,2		17	22,8	
3	23,4	376	18	23,3	270
4	22,7		19	22,8	
5	23,5	498	20	23,9	324
6	22,3		21	22,7	
7	23,4	456	22	23,3	286
8	22,2		23	22,8	
9	22,3	284	24	22,8	260
10	22,3		25	22,5	
11	23,4	498	26	23,6	314
12	21,9		27	22,6	
13	23,1		28	23,4	288
14	24,1	350	29	22,5	
15	22,9		30	24,1	408

The simple Franklin rod

$< U_{mesure} > = 23,1$ V

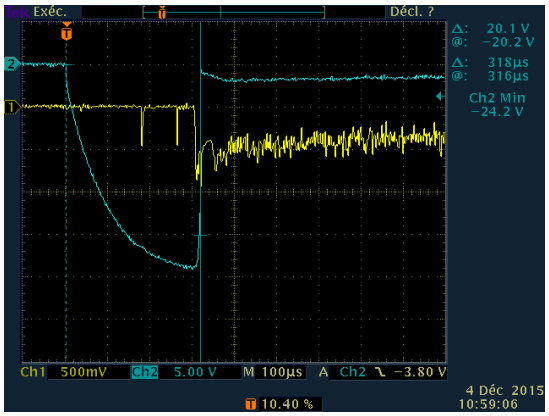
$<U_b> = U_{50} = 565$ kV

<Tb> = 358 µs

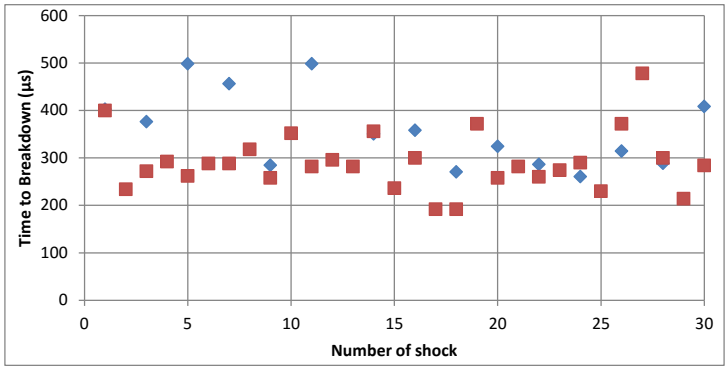
SIMPLE FRANKLIN ROD

Overvoltage tests
U =595 kV

Choc n°	U_{mesure} (V)	Tb (µs)	Choc n°	U_{mesure} (V)	Tb (µs)
1	24,2	400	16	23,8	300
2	23,2	234	17	22,1	192
3	23,4	272	18	22,3	192
4	23,7	292	19	24,2	372
5	23,2	262	20	23,4	258
6	23,8	288	21	24,2	282
7	23,9	288	22	23,6	260
8 (Tek 02)	24,2	318	23	24,1	274
9	23,8	258	24	24,2	290
10	24,5	352	25	22,9	230
11	23,8	282	26	24,6	372
12	24,1	296	27	23,7	478
13	23,8	282	28	23,9	300
14	24,2	356	29	22,7	214
15	23,0	236	30	23,9	284



Records of the shock n°8 (Tek02)
[1] : Applied voltage
[2] : UV light emission



Time to breakdown versus number of the shock

(blue diamond : U_{50} – Red square : overvoltage tests)

< U_{mesure} > = 23,7 V **<U_b> = 580 kV** **<Tb> = 290 µs**	**The use of a simple Franklin rod has given the following results :** **30 shocks : 30 breakdowns and 0 whithstand**

Inactivated DDCE-100-PLUS (short circuit)

Overvoltage tests
U =595 kV

Choc n°	U_{mesure} (V)	Tb (µs)	Choc n°	U_{mesure} (V)	Tb (µs)
1	24,0		16	24,1	362
2	24,1		17	24,2	330
3	24,2		18	24,2	
4	24,2		19	24,2	
5	24,0		20	24,4	
6	24,2		21	24,0	
7	24,1		22	24,0	
8	24,0		23	23,8	
9	24,4		24	24,2	
10	24,2		25	24,4	
11	24,1		26	24,2	
12	24,3		27	24,0	
13	24,2		28	24,4	
14	24,1		29	24,3	
15	24,4		30	24,1	

Inactivated DDCE-100-PLUS (short-circuit)

$< U_{mesure} >$ = 24,2 V **$<U_b>$ = 592 kV** **<Tb> = 346 µs**	**The use of the inactivated DDCE-100-PLUS has given the following results:** **30 shocks : 2 breakdowns - 28 whithstands**

Activated DDCE-100-PLUS

Overvoltage tests
U =595 kV

Choc n°	U_{mesure} (V)	Tb (µs)	Choc n°	U_{mesure} (V)	Tb (µs)
1	24,1		16	23,8	
2	24,3		17	24,1	
3	24,4		18	24,3	
4	24,2		19	23,9	
5	24,7		20	24,1	
6	24,3		21	24,0	
7	24,3		22	24,1	
8	24,3		23	24,2	
9	24,2		24	24,2	
10	24,4		25	23,9	
11	24,0		26	24,3	
12	24,3		27	24,5	
13	24,0		28	23,9	
14	24,2		29	24,0	
15	24,5		30	24,1	

Activated DDCE-100-PLUS

$< U_{mesure} >$ = 24,2V **$<U_b>$ = 593 kV** **<Tb> =**	**The use of the activated DDCE-100-PLUS has given the following results:** **30 shocks : 0 breakdown - 30 whithstands**

Remarque:

At the end of those tests, a maximum applied voltage of about 700kV have been applied to the activated DDCE-100-PLUS. No breakdown has been recorded using 5 shocks.

	Maximum applied voltage (kV)	**Tb (µs)**
1	699	Whithstand
2	698	Whithstand
3	705	Whithstand
4	705	Whithstand
5	703	Whithstand

CONCLUSIONS OF THE TESTS PERFORMED USING THE EXPERIMENTAL APPARATUS OF THE STANDARD NF C 17-100

When a 595kV bi-exponential voltage is applied in accordance with the experimental conditions laid down on this test report, there is a lot of evidence to suggest that:

The use of a simple Franklin rod has given the following results:

30 shocks : 30 breakdowns and 0 whithstand

The use of an inactivated DDCE-100-PLUS has given the following results:

30 shocks : 2 breakdowns - 28 whithstands

The use of an activated DDCE-100-PLUS has given the following results:

30 shocks : 0 breakdown - 30 whithstands

The variations of the electric field generate a leakage current flowing throw the lightning conductor DDCE-100-PLUS