METHODS AND CIRCUITS FOR POWER ARC TEST IN AC CURRENT OF THE SIMPLE AND DOUBLE INSULATOR SETS WITH COMPOSITE MATERIAL FOR AERIAL ELECTRIC LINES

George CURCANU, Constantin IANCU, Corneliu CHICIU

ICMET-Craiova, Calea Bucuresti 144, 200515 Craiova, Romania; e-mail: LMP@icmet.ro

Abstract – **The paper presents methods, circuits, testing parameters for power arc test in AC current of the simple and double insulator sets with composite material for aerial electric lines**

Keywords*: insulator set, power arc test*

1. INTRODUCTION

Ensuring the continuity of electric supply of customers it is the main objective of electric companies. This is dependent of aerial lines networks realised from sustaining pillars and aerial conductors insulated from pillars through ceramic, glass or composite materials insulator set.
The insulators of sustaining the aerial electric line are subjected both to mechanical stress due to atmospheric conditions (wind, rime) and to eventual electric ones due to electric arc appearance by flashover due to pollution or deterioration.
For safety of aerial line operating is necessary that insulator sets to be verified at the action of power arc before mounting within network. These verification at the action of power arc are done on special circuits which reproduce the configuration of aerial electric lines and mechanical and electrical stresses due to short-circuit failure current and perturbing atmospheric factors.
Configuration of testing circuit and technical conditions are specified by IEC 61647 standard. According to it, the test at power arc of insulator sets is mandatory because the exploitation customers took in consideration the failures appeared in aerial electric lines. From these considerations they required to manufactures that insulators to be verified at power arc action.
Following we'll present the regulations regarding testing at power arc for simple and double insulator sets with composite materials.

2. TESTING METHODS AND PARAMETERS

IEC 61647 establishes testing methods, test parameters, number and series, testing circuit, test duties and evaluation criteria of the tests of insulator sets at power electric action.

2.1. Test Duties

Power supply and testing circuit depend of exploitation conditions and of type and geometry of insulator sets. Real cases from exploitation can be simulated on circuits realised in testing laboratories, depending on test series of insulator sets established by test standard [1].
For the analysed case of simple and double insulator sets we considered the test series which simulates the heaviest exploitation conditions [1]. Technical conditions of tests and test duties are presented in Table 1.

Test series	Test circuit	Test current	Test duty	Number and duration of test	Observations
X	A	$I_n = 0.2\ I_{SYS}$	T_{20}	• 2 tests at t = 0.2 s • One test at t = 1s	Test on first sample
X	A	$I_n = 0.5\ I_{SYS}$	T_{50}	• 2 tests at t = 0.2 s • One test at t = 1s	Test on second sample
X	B	$I_n = I_{SYS}$	T_{100}	• 2 tests at t = 0.2 s • One test la t = 0.5s	Test on third sample

Table 1

Table notations:
I_n – rated short-circuit current; I_{SYS} – test duty current; t – short-circuit duration

Time interval between two successive tests is 20 minutes. Number and duration of tests are determinate by real exploitation conditions. In some cases the customers can use other test parameters by a common agreement between customers and manufacturers.

2.2. Test Circuit

2.2.1. Test arrangement of insulator set

The test arrangement shall duplicate the actual configuration of the complete insulator set and as closely as possible that of conductor and of part of the tower nearest to the insulator set.

The actual protective fittings shall be used and their position with respect to the insulator units, clamps and conductor shall be reproduced. The aim of this simulation of actual configuration is to recreate the real electromagnetic field affecting the arc movement.

The distance between the insulator set and ground structure simulating the tower shall be same as for service configuration. In some cases (for example, extra high voltage or special configuration) this can be limited by testing laboratories facilities. To create the real electrodynamic forces which affect arc movement, conductor length on both sides of insulator set shall be minimum 2.5 m [1].

In order to avoid poor electrical contacts and to ensure that the insulator set is correctly positioned, a mechanical load shall be applied to insulator set. In case of vertical insulator set this load can be applied by means of suitable weight suspended from suspension clamp or conductor by means of insulated links. The value of this load is specified by manufacturer.

Test arrangement of simple and double insulator set (V) is presented in fig1 and fig2.

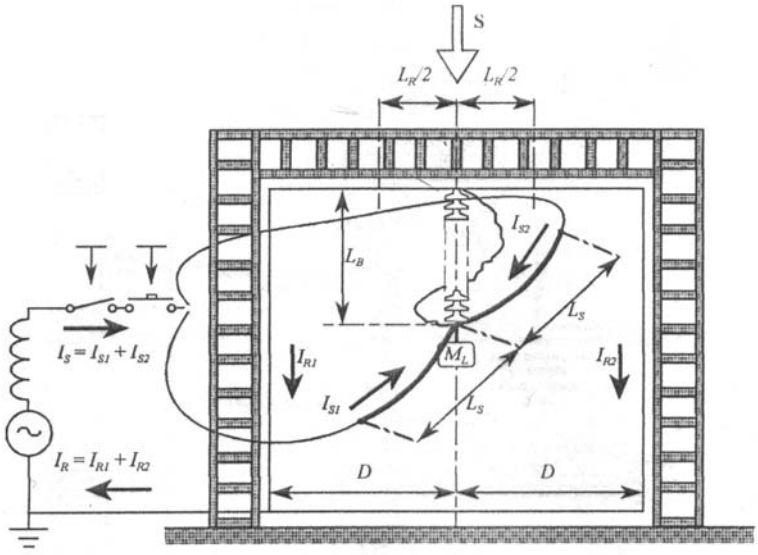

Fig. 1 - Test arrangement of simple insulator set

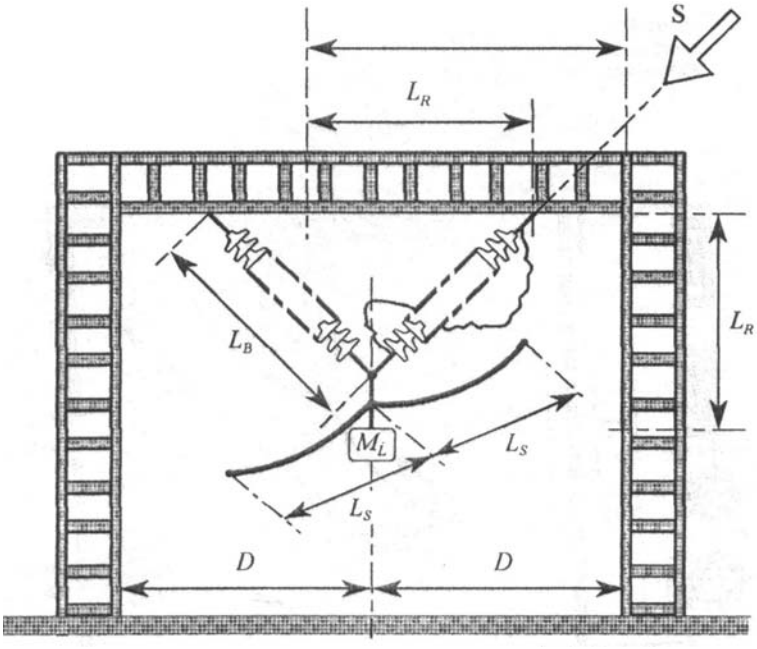

Fig. 2 - Test arrangement of double (V) insulator set

2.2.3. Arc initiation

Arc initiation is made with fusible wire of silver, aluminum or copper with maximum section of 1 mm^2. In some cases can be used two wires twisted in parallel. The fusible wire will be connected between superior and inferior metallic flange of insulator set with a single contact point in the case when insulator has a length of 0.6 – 0.8 m.
The plane where this fusible rest must have a 45° angle with the supply and return conductors.

2.2.4. Ambient conditions

Wind velocity, atmospheric pressure, humidity and temperature of environment shall be recorded because they influence the arc movement on insulator set. For that is recommended to perform the tests within a room or if it is not possible, shall be performed when the weather is calm, with no winds and humidity.

For a power arc of a de short-circuit current less than 10kA is permitted wind velocity of 5m/s.

3. EXPERIMENTS ON FOR SIMPLE AND DOUBLE INSULATOR SETS WITH COMPOSITE MATERIALS FOR MEDIUM VOLTAGE AERIAL ELECTRIC LINES.

3.1. Test Parameters

Power tests for insulator sets were performed according to IEC 61467/1997 and had in aim quality certification for product. Insulator sets were manufactured for aerial electric lines of 24 kV with simple and double (V) sustaining configuration. Rated data of insulator sets, established by manufacturer, are:
[Rated voltage: U_n= 24 kV

- short-circuit current for 1s: I_{SYS} = 20 kA.
- specific mechanical load (SMS) : F = 70 kN

Corresponding test duties parameters are presented in table 2

Test series	Test circuit	Test duty	Test voltage	Test current	Number and duration of test
X	A	T_{20}	10kV	I_n = 4 kA	• 2 tests at t = 0.2 s • One test at t = 1s
	A	T_{50}	10kV	I_n = 10 kA	• 2 tests at t = 0.2 s • One test at t = 1s
	B	T_{100}	10kV	I_n = 20 kA	• 2 tests at t = 0.2 s • One test at t = 0.5s

Table 2

3.2. Test Circuit

Electric scheme of test and measuring circuit executed in High Power Laboratory of ICMET_Craiova is presented in figure 3.

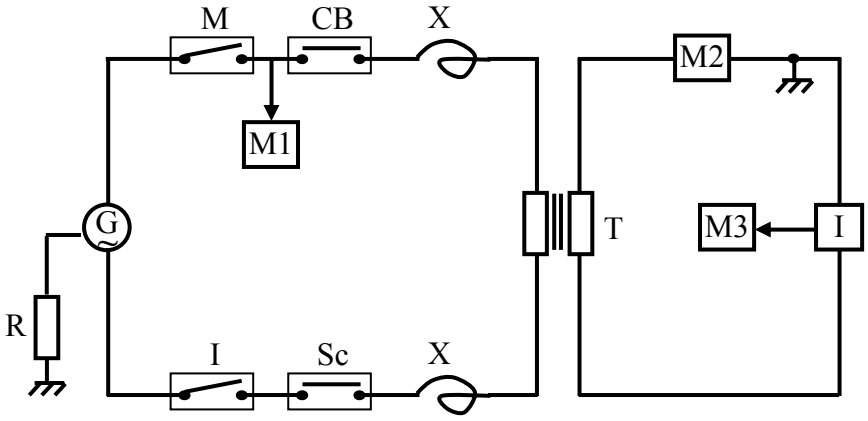

Fig. 3. Scheme of test and measuring circuit.

Notation from scheme:
G- short-circuit generator 12kV/2500 MVA
M – short-circuit maker 12 kV/330 kA max.
CB –protection circuit-breaker for generator 12 kV/125kA
X – reactor 0.1 Ω - 18 Ω; 12 kV / 10 kA
T – step up transformer 12kV/12.86 kV/25.72 kV/51.04 kV, 80 MVA
M_1, M_2, M_3 – measuring points for voltages and currents
I – insulator set to be tested

3.3. Experimental Results

Data resulted from test by processing the oscillogram from figure 4 are presented in table 3:

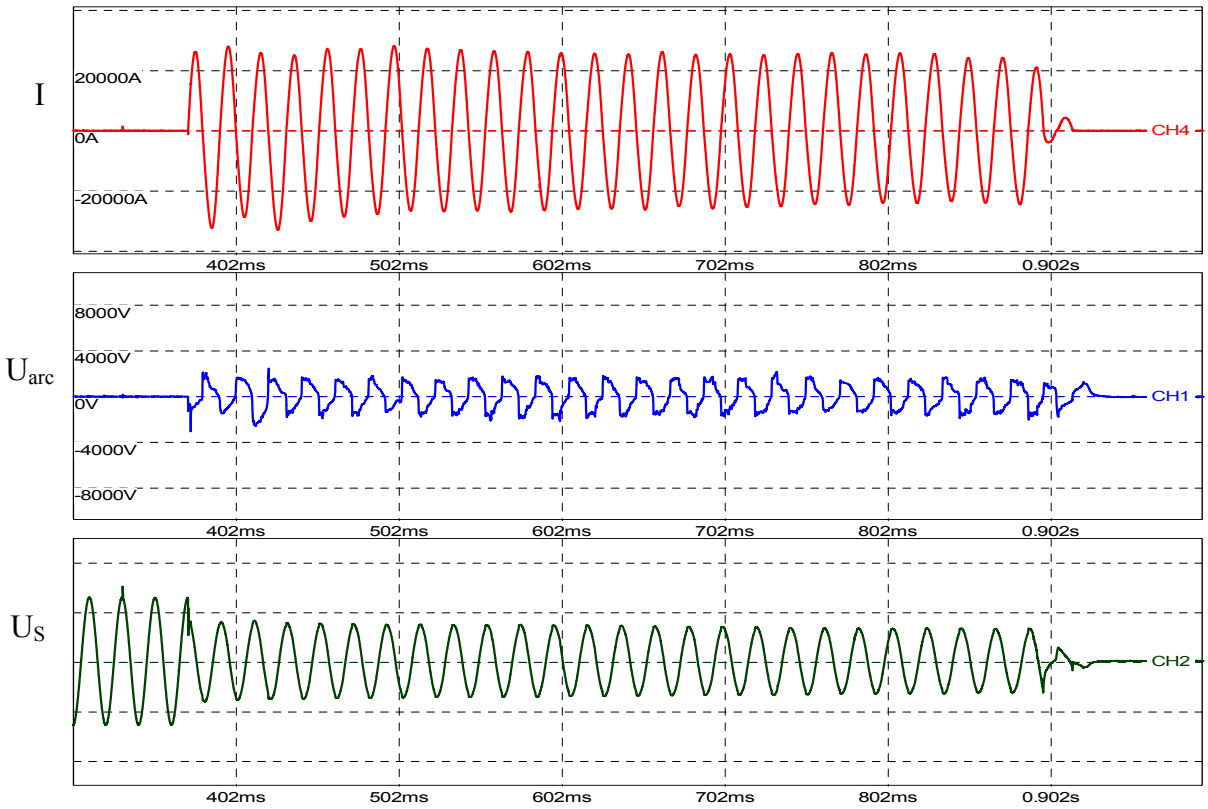

Fig. 4. Oscillogram obtained at test T_{100}

Test duty	U_s [kV]	U_{ap} [kV]	I_{SYS} [kA]	I [kA]	t_{sc} [sec]	I x t_{sc} [kAs]	Observations
T_{20}	5.8	6.22	-	3.7	0.2	0.74	Current calibration
	6.9	7.4	6.2	4.2	0.2	0.84	Test on sample 1
	6.9	7.4	6.2	4.2	0.2	0.84	
	6.9	7.4	7.3	4.2	1	4.2	
T_{50}	7.5	8	-	9.7	0.2	1.94	Current calibration
	7.5	8	15.5	9.7	0.2	1.94	Test on sample 2
	7.5	8	15.5	9.6	0.2	1.92	
	7.5	8	15.5	9.5	1	9.5	
T_{100}	7.7	8.23	-	20.3	0.2	4.06	Current calibration
	7.8	8.3	30	19.8	0.2	3.96	Test on sample 3
	7.8	8.3	30	19.8	0.2	3.96	
	7.8	8.3	31.6	19.8	0.5	9.9	

Measurement were performed with uncertainty of: 1.5% for voltage; 1.1% for current; 0.5 % for time and confidence level P = 95%.

Table 3

Symbols used tables and oscillograms.

I_s = test current – peak value
I_{SYS} = test current– r.m.s. value
t_{sc} = short-circuit duration
U_{ap} = voltage on apparatus
U_s = supply voltage
U_{arc} = arc voltage

Test date	13.05.2004 (4kA)	14.05.2005 (10 kA and 20 kA)
Humidity	41%	56%
Atmospheric pressure	743 mm Hg	748.5 mm Hg
Wind velocity	2 m/s	1 m/s
Ambient temperature	19.5 ° C	17 ° C

Table 4: Atmospheric conditions during the tests

Criteria or test	**Result**
Insulator dislocation during test	Did not occurred
Burning or breaking of grooves, melting of galvanized surfaces	Little burning, little melting of gaps
Baring of core fiber core	Did not occurred
Flashover at industrial frequency in dry air to verify the breakdown	External flashover (Test Report No. 40069/28.05.2004)
Mechanical load test (SML)	It is not the case
Tests on fittings and conductors	Did not occurred faults

Table 5: Evaluation of test results

4. CONCLUSIONS

- Insulator sets tested at short-circuit currents established by manufacturer were not affected by power arc. Evaluation criteria of tests were fulfilled according to IEC 61467.
- Dielectric tests with voltage applied between flanges shown that are produced external flashover on insulator sheds but there are not internal breakdowns.
- Test were performed in corresponding atmospheric conditions: dry weather and wind velocity less than sub 5m/s.

Reference

[1] xxx - IEC 616467 Ed2 / Insulators for overhead lines with a nominal voltage above 1000 V – AC power arc test

[2] xxx - Test reports on simple and double insulator sets for 24 kV aerial electric lines in LMP – ICMET-Craiova