Jarosław WIATER

Politechnika Białostocka, Wydział Elektryczny, Katedra Telekomunikacji i Aparatury Elektronicznej

doi:10.15199/48.2017.12.12

Fire hazard in EX Zones caused by lightning protection system tested according to EN 62561-1

Streszczenie. *W artykule przestawiono wyniki badań skutków przepływu prądu piorunowego przez różnego rodzaju złącza odgromowe łączące elementy tworzące kompleksowy system ochrony odgromowej. Badania przeprowadzono celem wykazania, iż prąd według klasyfikacji H opisanej w normie PN-EN 62561-1 dla poziomu ochrony I jest niewystarczający celem właściwej oceny przydatności złącza do stosowania w strefie zagrożonej wybuchem, gdzie może stanowić źródło zapłonu atmosfery wybuchowej.*

Abstract*. The article presents the results of studies on the effects of lightning current through various types of lightning cross connectors forming a comprehensive lightning protection system. The tests were conducted to demonstrate that the H class current described in EN 62561-1 for protection level I is insufficient to adequately assess the suitability of the connector for use in an explosive atmosphere where it may be a source of ignition of the explosive atmosphere. (****Zagrożenie pożarowe powodowane przez system ochrony odgromowej badany zgodnie z normą EN 62561-1****) .*

Słowa kluczowe: wyładowanie piorunowe, pożar, złącze odgromowe, odporność.
Keywords: lightning, fire, cross connector, through connector, immunity.

Introduction

The security level of buildings is directly dependent on naturally occurring storms, lightnings and resulting thereby over-voltages. The current of a cloud-to-earth lightning constitutes a significant threat. The flow of lightning current through the lightning protective device, structural elements of the building or other conductive installations might be accompanied by the following phenomena (See Fig.1).

- thermal erosion of the metal at the point of contact with lightning channel
- glow of metal elements along the flow of the current
- electrodynamic deformation of current paths
- mechanical damage caused by acoustic shock-wave
- sparks produced at interfaces of conductive elements

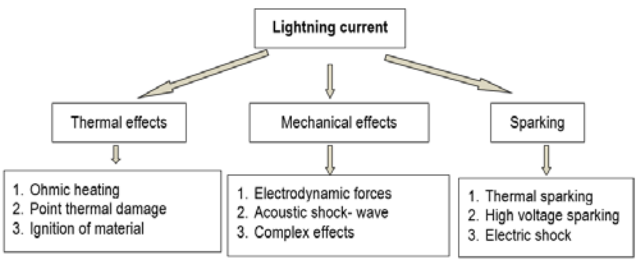


Fig. 1 Consequences of lightning current [1]

Depending on the characteristics of the facility and of the used lightning protective device only some of the mentioned above phenomena are usually dominant.

The basic function of any lightning protective device is to intercept and carry the lightning current in the safety way for the infrastructure and people. It is the proper construction and installation of the lightning protective device that reduces to the acceptable level the risk of damage to the protected facility itself, as well as to the devices installed on the premises. Special consideration should be given to the facilities which comprise zones with potentially explosive atmospheres.

The cables carrying the lightning current themselves, if laid correctly, should not constitute a source of ignition (apart from the spot where the current flows in). The situation is completely different in the case of connecting elements which, if exposed to lightning current, can be a source of ignition through occurring sparks as well as thermal effects of the current. Research has been conducted in cooperation with design and construction company into effects of the flow of lightning current through different types of connectors used to connect cables carrying lightning current.

The following study presents the situation of a direct lightning discharge into an air terminal which carries lightning current to the earthing system. It is a cautionary publication aimed at those who want to "economise" during the construction of a new facility, making use of the so-called lightning protection connectors which fail to comply with the PN-EN 62561-1:2012 standard [2].

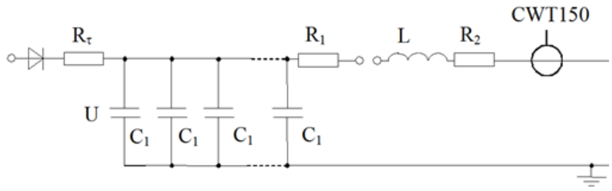
Lightning Test Setup

Different lightning protection connectors were being tested. High voltage generator was used. It produces surge current with different shapes and with a peak value up to 300kA. To implement changes in the parameters of generated surge current, ohmic-inductive component can be replaced. Figure 2 depicts a simplified diagram of the generator used during the tests.

To measure output current of the generator, Rogowski coil from PEM company, of CWT150 o In = 300 kA type and with bandwidth 0,2 Hz to 16 MHz (frequency band 3 dB), and to register output current – digital oscilloscope Tektronix DPO 7254 was used.

Laboratory tests were conducted with the surge current with peak value of 100kA and shape 10/350 μs reflecting the current of actual cloud-to-earth lightning discharge. The subjects of the tests were the popular types of cross and through connectors made of galvanised steel and copper.
During the tests the current surge was supplied to the extreme ends of the samples connected by the tested cross or through connector. The tests were conducted in accordance with the PN-EN 62561-1:2012 standard [2]. Prior to the tests with lightning current the chosen samples were prepared in accordance with the requirements of the above mentioned standard i.e. the fastening elements were tightened with the appropriate torque. What's more, the whole object was subject to ageing according to the requirements. The samples were screwed to a specially prepared board (See Fig.3). According to the standard they were connected with the use of flexible cables to the exit of the high voltage generator.

a)



b)

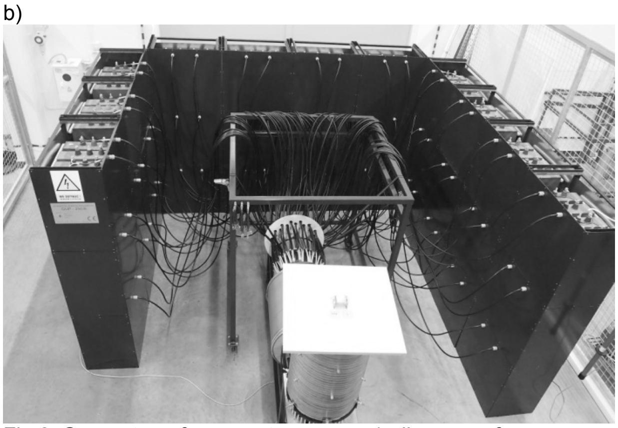


Fig.2 Generator of current surges: a) diagram of measurement system, b) generator view

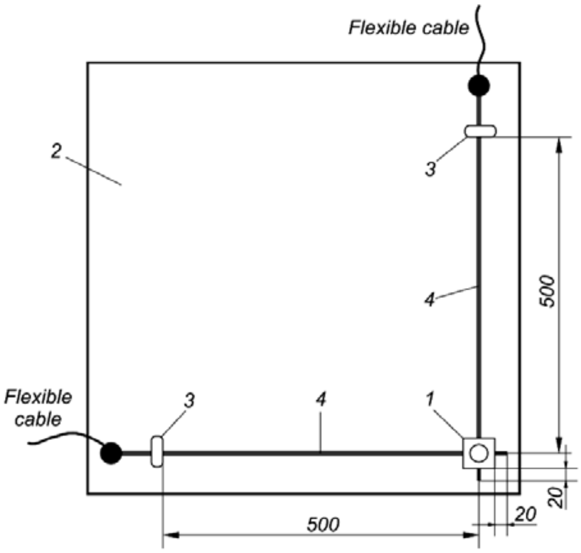


Fig. 3 The way to connect the given sample according to the PN-EN 62561-1:2012 [2] standard where: 1-Cross connection component, 2-Plate made of insulating material, 3-Rigid fastener, 4-Conductor and/or metal installation

Results Of The Laboratory Tests

During the tests the performance of different protective connectors subject to exposure by lightning current at peak value of 100 kA was observed . The test was being recorded by the video camera. Photos 4-9 depict freeze-frames from the film which was shot while conducting the research. The first photo depicts the sample before the test and the second one - afterwards.

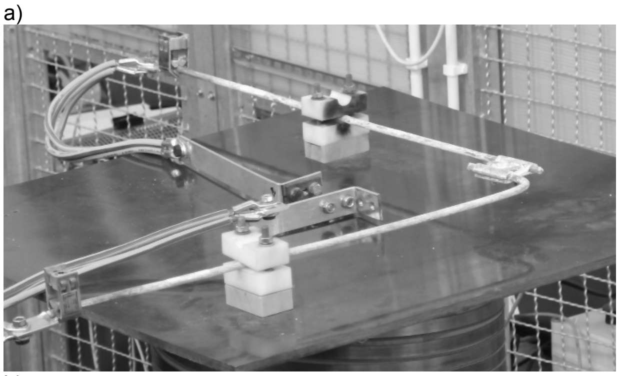
During the research with all types of tested connectors thermal sparking was observed during surge current flow (equivalent to the first lightning discharge) at a peak value of 100 kA and shape 10/350 μs. The scientific test stand was positioned 1.5 m above the ground level. The falling sparks had an impact within the radius of 1.5 m from the connector . Additionally the sparking triggered a significant sooting of the board to which the tested elements were attached. In many instances the protraction of the cable from the connector was also observed.

a)

b)

Fig. 4 Cross connector before the tests (a) and during the test (b) with 100 kA current and shape 10/350 μs

a)



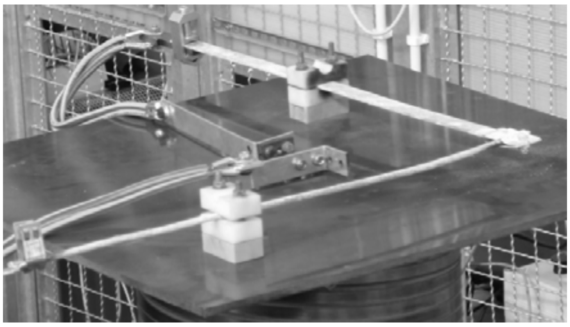
b)

Fig.5 Through connector before the tests (a) and during the tests (b) with 100 kA current and shape of 10/350 μs

Discussion EN 62561-1 and EN 62305 divergences

According to EN 62305-3 [4] all LPS components should be capable of transferring current through them during lightning discharge. In the case of LPL I air termination system, down conductor and other connection components should transfer the full 200kA of the lightning current to the point where the current is divided. The EN 62561-1 [2] standard specifies that the lightning protection system components for class H shall be tested with a current of only 100kA. Divergence in standards increases the risk in potentially explosive areas. Problem is shown on figure 11.

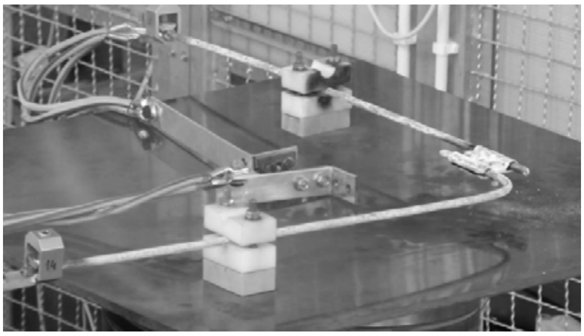
a)



b)

Fig. 6 Cross flat connector before the test (a) and during the test (b) with 100 kA current and shape 10/350 µs

a)



b)

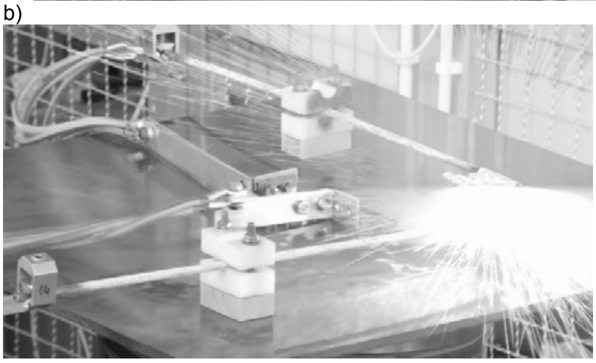


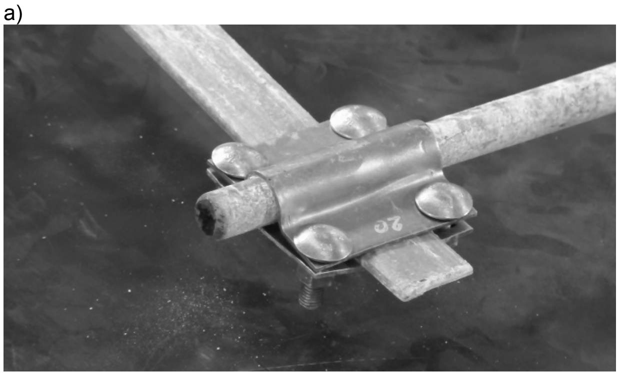
Fig. 7 Through galvanised connector before the test (a) and during the test (b) with 100 kA current and shape 10/350 µs

a)

b)

Fig.8 Through copper connector before the test (a) and during the test (b) with 100 kA current and shape 10/350 µs

a)



b)

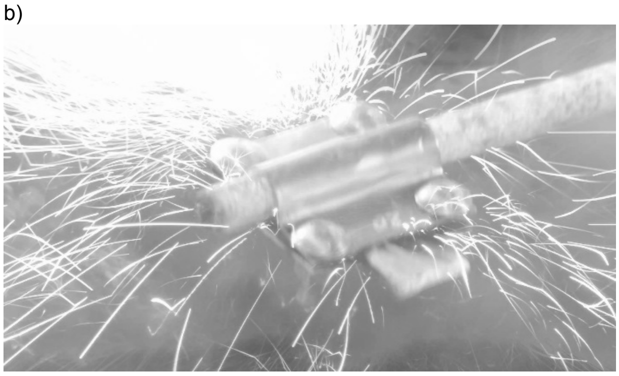


Fig.9 Cross connector assembled before the test (a), during the test (b) with 100 kA current and shape 10/350 µs

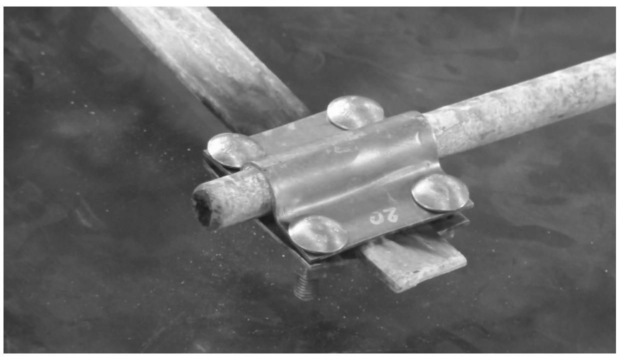


Fig.10 Cross connector assembled after the test with 100 kA current and shape 10/350 µs

Conclusions

During all the tests with the lightning current of 100 kA thermal sparking was observed, as well as ohmic heating, significant electrodynamic forces pulling apart tested connectors as well as point thermal damage. The conducted tests proved that the majority of lightning connectors available on the market are not fully immune to direct lightning discharge. What's more, some solutions can constitute a source of ignition even within 1.5 m radius from the connector. For LPL I standards divergences can cause fire in EX zones.

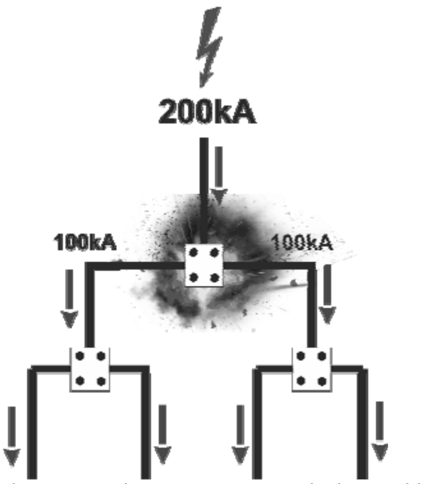


Fig.11 Lightning connection component explosion problem in EX zones because divergences in standards

In our climate conditions there are up to several current strokes during cloud-to-earth lightning discharge [1,2,3]. It is difficult to estimate the actual number of consecutive components of lightning discharge. It is, however, possible to establish that if during laboratory tests thermal sparking was observed therefore in actual conditions every consecutive current of cloud-to-earth lightning discharge will inflict even more damage to connectors, which consequently might lead in extreme cases to the connected elements actually falling apart and consequently being separated from the wall or the building.

***Acknowledgment**: The research was conducted within the project S/WE/1/2015, financially supported by Polish Ministry of Science and Higher Education.*

***Auhtor:** dr inż. Jarosław Wiater, Białystok Technical University, Department of Telecommunications and Electronic Equipment, ul. Wiejska 45d, 15-351 Białystok, Poland*
E-mail: jaroslawwiater@we.pb.edu.pl

REFERENCES

[1] Sowa A.W.: Protection of devices and electronic systems from lightning exposure Rozprawy Naukowe nr 219. Oficyna Wydawnicza Politechniki Białostockiej, Białystok 2011.
[2] EN 62561-1:2012. Elements of the lightning protection device (LPSC) – Part 1: Requirements regarding the connecting elements.
[3] EN 62305-1:2011. Lightning protection - Part 1 : General rules.
[4] EN 62305-3:2010. Protection against lightning - Part 3: Physical damage to structures and life hazard.