



## Topic VIII: Lightning Deleterious Effects Moderator's Report

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### I. INTRODUCTION

The present session is devoted to the problems of lightning hazard, statistics of lightning-related injuries and damages, risk evaluation in accordance with its acceptable level and protection of humans and systems.

In this short report, these issues are briefly addressed making reference to the state of the art. Moreover, an overview of the papers presented in this session is presented.

### II. PRELIMINARY REMARK ON THE PROBLEM OF LIGHTNING DELETERIOUS EFFECTS

Lightning deleterious effects are considered first of all both in terms of hazard for human beings and livestock, as well as in terms of risk of damage for structures and their apparatus, involving sensitive equipment to lightning electromagnetic impulses (LEMP).

As far as the hazard for human beings and livestock is considered, it should be emphasized that the conditions for electric shock or injury due to lightning current are different from those appearing due to the current from electrical systems. The latter (current) may be DC or low frequency AC, whereas the lightning current can consist of several uni-polar and/or bi-polar fast impulses with different peak values and durations. The interaction of a lightning stroke with human and animal bodies is quite different from the usual experience with electric shock derived from electrical systems. This is a reason for which different Technical Reports have been formulated (compare Part 4 with Parts 1, 2 and 3 of [1]).

It is well known and formally established [1] that in

lightning accidents the pathway often includes the head. This implies a probable inclusion of the brain stem, which includes the respiratory centre, in contrast with pathways of the shock current arising from electrical systems. In particular, it has been pointed out that differences exist between accidents caused by a direct flash compared with those interactions, which are caused by step voltages. Even very short single impulses of lightning can cause cardiopulmonary arrest [3], [5], [6].

Moreover, it can be stated that intense electric interactions with living organisms are very dangerous but, surprisingly in many cases, not always lethal. It is confirmed that 70% or more lightning accidents involving humans are not fatal [2], [4], whereas a corresponding reliable data for livestock is not available. There is a large variation in outcome due to different environments, different activities of people and knowledge of first aid and quality of medical care [2], [3]. In order to standardize the singular effects of lightning strokes, an effort has been made to create a special Technical Report (see [1] Part 4). In [1], the physics of lightning is presented as a basis and the interaction with living bodies is then described, followed by consequences for the life of the victim.

As far as the risk of lightning damages of structures and their equipment is considered, two approaches to the problem should be distinguished:

- the traditional one, which has been known for more than 20 years and which is based on the probabilistic approach involving the Poisson's distribution, and,
- a new approach based on the principles of fuzzy logic.

It should be noted that the first approach to the methods of risk assessment is already quite developed and has been described in a large number of different papers (e.g. [7-12]). It is also standardized. The first version of the standard [13] has been revised and issued as the common standard by IEC [14] and CENELEC [15].

The application of fuzzy logic to the lightning risk assessment is under development and some preliminary studies have been presented [16], [17] and [18].

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### III. BRIEF OVERVIEW OF PAPERS SELECTED FOR TOPIC VIII

#### A. General

One oral session and one poster session are devoted to the problem of lightning deleterious effects. A total of 13 papers (from Austria, Bangladesh, China, Colombia, France, Germany, Hungary, Japan, Poland, and South Africa) were selected for presentation at these sessions. For this aim they have been divided into groups according to different aspects of lightning deleterious effects. The following groups have been distinguished:

- Group 1: Risk assessment (Papers VIII-1, VIII-2, VIII-3, VIII-4, VIII-8, and VIII-9).
- Group 2: Safety measures and protection (Papers VIII-5 and VIII-7).
- Group 3: Lightning accidents and human injuries (Papers VIII-6, VIII-10, VIII-11, VIII-12, and VIII-13)

The papers of the oral session, organized in these 3 groups, are specified in Table I. Similarly the papers of the poster session, which have been organized in the same groups, are specified in Table II.

It should be noted that 6 papers of the session are the result of collaborations involving at least two different institutes. Two papers are the result of an international collaboration.

TABLE I  
PAPERS OF ORAL SESSION

No	Title and authors	Group
VIII-1	Evaluation of the Risk of Damage and its Application for Standardization of Lightning Protection. <i>T. Horvath (Hungary)</i>	1
VIII-2	Development of a complete risk analysis calculator based on the IEC 62305-2 risk management document. <i>A. S. Dickson, J.M Van Coller, I. R. Jandrell (South Africa)</i>	
VIII-3	Comparison of Lightning Risk Calculation Results Using Different Software Based on New Standard IEC 62305-2. <i>M. Loboda M. Szewczyk, Z. Flisowski (Poland)</i>	
VIII-4	On lightning risk management. <i>T. Shindo, T. Suda (Japan)</i>	
VIII-5	Application of Preventive Measures in Lightning Protection <i>A. Gulyás, B. Németh, S. Szonda, I. Berta (Hungary)</i>	2
VIII-7	Perforation of metal sheets due to lightning arcs. <i>D. González, F. Noack, F. Berger, M. Rock (Germany)</i>	
VIII-6	Examples of direct lightning hazards and their scientific analysis. <i>M. Kompacher, S. Pack, G. Kindermann (Austria)</i>	3

#### B. Papers of Group 1: Risk Assessment

In paper VIII-1, the author presents general procedures for the evaluation of risk of damage associated with lightning. It is shown how the approach can be simplified and applied to practical problems.

Papers VIII-2 and VIII-3 describe newly developed

computer codes for the evaluation of risk according to the new IEC Standard 62305-2. In Paper VIII-2, the authors apply their developed risk calculator code to three different structure types in South Africa and present some discussion on the IEC document. In paper VIII-3, Loboda et al. compare their results with those obtained using the IEC Risk Assessment Calculator and provide discussion on the observed differences.

Paper VIII-4 presents a new concept of lightning management. The proposed approach is applied to evaluate lightning risk of wind turbines, taking into account the specificity of winter lightning in Japan.

In paper VIII-8, Duquerroy et al. present a comparison between IEC 61662 and the new document IEC 62305-2, both applied to the lightning risk analysis of French nuclear power plants. The differences between the two Standards are discussed. Further, the authors make suggestions in view of simplifying the new Standard.

In paper VIII-9, the authors present the application of the risk management method based on IEC 62305-2 to various plants. Based on this experience, tools used to facilitate application of the method in France are also presented.

TABLE II  
PAPERS OF POSTER SESSION

No	Title and authors	Group
VIII-8	Lightning risk analysis on French nuclear power plants. <i>P. Duquerroy, P. Baraton, F. Audran (France)</i>	1
VIII-9	Application of IEC 62305-2 in France on various plants Proposals for improvements <i>A. Rousseau, P. Gruet (France)</i>	
VIII-10	Lightning accidents and awareness in South Asia: Experience in Sri Lanka and Bangladesh. <i>C. Gomes (Sri Lanka), M. Ahmed, F. Hussain (Bangladesh), K. R. Abeysinghe (Sri Lanka)</i>	3
VIII-11	Developing a Lightning Awareness Program Model for Third World Based on American-South Asian Experience. <i>C. Gomes (Sri Lanka), R. Kithil (USA), M. Ahmed (Bangladesh)</i>	
VIII-12	Analysis of a Lightning Accident Considering Modified Human Body Model. <i>F. Santamaría, A. Alarcón, F. Roman (Colombia)</i>	
VIII-13	Characteristics of Lightning hazards in Guangdong Province China. <i>Z. Huang, S. Yang, L. Chen, X. Huang (China)</i>	

#### C. Papers of Group 2: Safety Measures and Protection

Paper VIII-5 proposes and discusses preventive measures in lightning protection. The method is illustrated using practical examples.

Paper VIII-7 presents an analysis of metal sheet perforations due to lightning continuing currents. The authors propose new values for the minimum thickness of metal sheets to prevent perforations, determine taking into account both thermal and mechanical effects.

#### D. Papers of Group 3: Lightning Accidents and Human Injuries

In paper VIII-6, the authors present a detailed analysis of three examples of direct lightning strikes and associated injuries, occurred in Austria. The events are correlated with data from the Austrian Lightning Location System (ALDIS).

Paper VIII-10 presents an analysis of human injuries and deaths associated with lightning in Sri Lanka and Bangladesh. The study emphasizes the absence of awareness and knowledge of first-aid principles. In the accompanying paper VIII-11, the authors propose an awareness program for third world countries, based on American (USA) and South Asian (Sri Lanka and Bangladesh) Experience.

Paper VIII-12, the authors apply an enhanced human electrical model and apply it to analyze a lightning accident occurred in Sweden. Simulations are complemented with laboratory experiment.

In paper VIII-13, authors present statistical data of lightning hazards in Guangdong Province of China. This province is characterized by a special geographic location, complex topography and severe thunderstorm conditions.

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