Risk Assessment of Lightning Damages

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Abstract – **Need and economic benefit of introducing lightning protection and choice of protection measures is related to assessment and managing the risk of lightning damages. The article describes a computer program developed to assess the risk of lightning activity based on the European standards for lightning protection system.**

Keywords – **Risk Assessment, Lightning Protection**.

I. Introduction

European standards for lightning protection system EN 62305 introduces the risk associated with the lightning influences, need and economic convenience for lightning protection and the choice of protection measures. The comprehensive and complex risk assessment takes into account the structure to be protected and the services to which the structure is connected.

Assessment and risk management is subject to EN 62305-2 and purposes the choice of appropriate protection level, providing risk reduction to a value less than or equal to the limit.

Tolerable risk R_T [1] is the maximum acceptable value, which varies from 10^{-5} to risk loss of life to 10^{-3} on the risk of loss of public service networks or cultural heritage.

The authors have developed a computer program to determine the risk of lightning [2]. As a final result the program provides the appropriate lightning protection level. The program uses simplified assessment procedure for the following risks: R_1 - loss of human life or cause permanent damage; R_2 - loss of public service networks; R_3 - loss of cultural heritage.

In the present paper the authors offer a developed new computer program taking into account additional risk of loss of economic value R4 and additional components of all types risks R_1 to R_4- injury to living beings due to touch and step voltages as well as component related to physical damage caused by dangerous sparking inside the structure triggering fire or explosion. Those elements are assessed for following cases: lightning flash to a structure or lightning flash near the structure; lightning flash to an incoming service or lightning flash near the service.

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II. Procedure for Risk Assessment

To develop the new computer program methodological guidance for the assessment of damage from lightning [3] based on [4] is used and it includes:

– Identification of the object to be protected and its characteristics;

– Identification of all the types of loss in the object and the relevant corresponding risk R (R_1 to R_4);

– Evaluation of risk R for each type of loss (R_1 to R_4);

– Evaluation of need of protection, by comparison of risk R_1, R_2 and R_3 for a structure with the tolerable risk R_T;

– Evaluation of cost effectiveness of protection by comparison of the costs of total loss with and without protection measures.

Table 1 shows the risk components.

All types of risks are defined as:

$R_1 = R_A + R_B + R_C + R_M + R_U + R_V + R_W + R_Z$

$R_2 = R_B + R_C + R_M + R_V + R_W + R_Z$

$R_3 = R_B + R_V$

$R_4 = R_A + R_B + R_C + R_M + R_U + R_V + R_W + R_Z$

Any risk R is the sum of the components of risk R_D and R_I. R_D is a component of risk relating to physical injuries due to flashes to the structure, leading to fire or total or partial destruction of buildings and external facilities. R_I is a component of risk relating to physical damage (fire or total or partial destruction due to dangerous flashes between the internal fittings, and metal parts, which are usually located at the entry point of the line in buildings and outdoor facilities) arising from currents carried by lightning over or input into the buildings and external facilities for public service networks.

Risk components for a structure due to flashes to the structure are related to:

R_A: injury to living beings caused by touch and step voltages in the zones up to 3 m outside the structure.

R_B: physical damage caused by dangerous sparking inside the structure triggering fire or explosion, which may also endanger the environment.

R_C: failure of internal systems caused by LEMP.

Risk component for a structure due to flashes near the structure are related to:

R_M: Component related to failure of internal systems caused by LEMP.

Risk components for a structure due to flashes to a service connected to the structure are related to:

R_U: Component related to injury to living beings caused by touch voltage inside the structure, due to lightning current injected in a line entering the structure.

R_V: Component related to physical damage (fire or explosion triggered by dangerous sparking between external installation and metallic parts generally at the entrance point

TABLE I

RISK COMPONENTS FOR A STRUCTURE FOR DIFFERENT TYPES OF DAMAGE CAUSED BY DIFFERENT SOURCES

Source of damage Damage	S1 Lightning flash to a structure	S2 Lightning flash near a structure	S3 Lightning flash to an incoming service	S4 Lightning flash near a service	Resulting risk according to type of damage
D1 Injury to living beings	$R_A=N_D.P_A.r_a.L_t$		$R_U=(N_L+N_{Da}).P_U.r_U.L_t$		$R_S=R_A+R_U$
D2 Physical damage	$R_B=N_D.P_B.r_p.h_z.r_f.L_f$		$R_V=(N_L+N_{Da}).P_V.r_p.h_z.r_f.L_f$		$R_F=R_B+R_V$
D3 Failure of electrical and electronic systems	$R_C=N_D.P_c.L_0$	$R_M=N_M.P_M.L_0$	$R_W=(N_L+N_{Da}).P_W.L_0$	$R_Z=(N_I+N_L).P_Z.L_0$	$R_0=R_C+R_M+R_W+R_Z$
Resulting risk according to the source of damage	$R_D=R_A+R_B+R_C$	$R_I=R_M+R_U+R_V+R_W+R_Z$			

Note: N_i, P_i, L_i, r_i, h_i are according the standart [1].

of the line into the structure) due to lightning current transmitted through or along incoming services.

R_W: Component related to failure of internal systems caused by overvoltage induced on incoming lines and transmitted to the structure.

Risk component for a structure due to flashes near a service connected to the structure are related to:

R_Z: Component related to failure of internal systems caused by overvoltage induced on incoming lines and transmitted to the structure.

III. COMPUTER PROGRAM FOR RISK ASSESSMENT

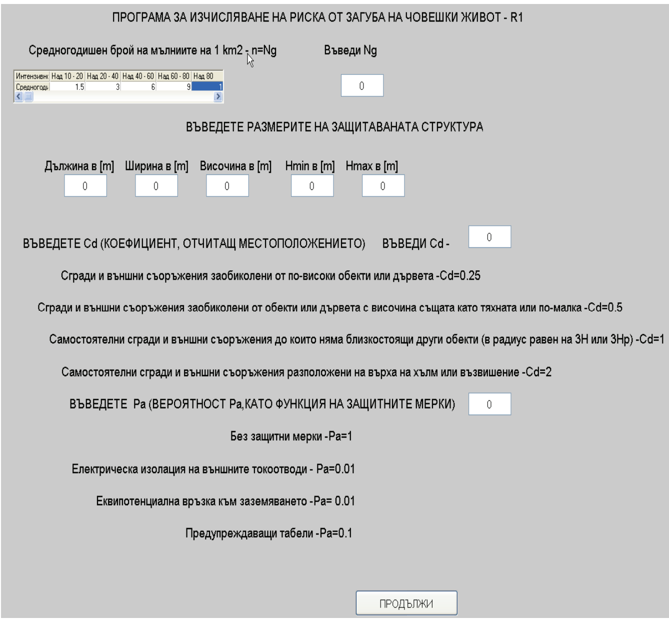

Fig.2. Initial dialog box for input data for risk component R_A related to injury to living beings caused by touch and step voltages.

The authors have developed a computer program based on the procedure [2], Table 1 and [3]. The user can set the calculation of each risk separately - R1 to R4. The program incorporated all the tabular data for determining the risk that the consumer operates in interactive mode, as shown in the sample dialog screens in Fig. 2. The program offers the appropriate level of lightning protection for each risk separately.

At the top of box from fig.2 it is introduced length, width, height and Ng. The coefficient Cd takes into account the location and it is equal to:

Cd =0,25 when the object is surrounded by higher objects or trees;

Cd =0,5 when the object is surrounded by objects or trees of the same heights or smaller;

Cd = 1 at isolated object: no other objects in the vicinity;

Cd = 2 at isolated object on a hilltop or a knoll.

Probability Pa of injury to living beings is:

Pa= 1 when there is not protection measures;

Pa= 0,01 - there is an electrical insulation of exposed down-conductor (e.g. at least 3 mm cross-linked polyethylene);

Pa= 0,01 - there is an effective soil equipotentialization;

Pa= 0,1 - there is the warning notices.

Similarly, the user continues to enter data and / or use the built-in program data. The program assesses risk and provides an appropriate level of protection.

REFERENCES

[1] EN 62305 Protection against lightning.

[2] Йорданова, М., М. Василева, М. Мехмед- Хамза. Компютърна програма за оценка на риска от атмосферни електрически явления, International Scientific and Technical Conference „Electrical Power Engineering 2010”, 2010q Varna, Bulgaria

[3] http://euroengineeringbg.com/

[4] БДС EN 62305-2 **“**Оценка на риска”