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## METHOD FOR CALCULATION OF LIGHTNING RISK ASSESSMENT USING MS EXCEL

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**Abstract.** This work considers the method of building a model for calculating the risk of a lightning strike in a building and its implementation in accordance with current regulatory documents using the MS EXCEL computer program.

This technique will be useful for designers who perform a part of lightning protection and during the execution of their projects must calculate the risk of lightning strike. The risk of a lightning strike according to current regulations may consist of the sum of one to four risks: the risk of loss of human life; the risk of losing the ability to provide public services; the risk of loss of cultural heritage and the risk of loss of economic value. This technique is used to calculate the risk of loss of human life as the most important value that can be lost. It provides for the calculation of the risk of lightning strike for public, administrative, industrial or residential buildings, that is, the buildings that the designer most often has to deal with during his work.

This technique is not intended to be used to build risk models for buildings or structures of the following purpose: public communications and objects of cultural purpose, because these buildings involve the calculation of the risk of loss of the ability to provide public services or the risk of loss of cultural heritage, respectively. Also, it does not apply to the calculation of buildings with explosive zones, since the risk calculation for them will be specific. In addition, this technique does not provide for calculations of the risk of loss of economic value, since it is not mandatory according to regulatory documents and is carried out additionally at the request of the customer. At the same time, it can be used as a basis for building more complex models suitable for these types of buildings.

The work considers the methods of solving the main problems faced by the designer during the calculation of the risk assessment: automation of the calculation of similar formulas, and reduction of most of them to several basic types; obtaining a formula that returns a value or a reference to a value from a table or range, and also performs a search for the specified element in the range and returns the relative position of this element; formulation of the risk assessment procedure in accordance with the regulatory document and determination of how certain input data affect the final result.

**Keywords:** computer simulation, lightning protection, functions in MS EXCEL, formulas in MS EXCEL, designing.

## Introduction

As a future member of the European Union, Ukraine has taken on the responsibility of gradually harmonizing its regulatory and technical base with the normative acts of the European community. This became the reason for the adoption of a number of standards (Protection 1-4, 2010, 2011), which replaced the domestic one (Engineering equipment, 2008) in the field of lightning protection. Domestic standards are a translation into the national language of standards developed by the Institute of Electrical and Electronics Engineers (IEEE), which is the largest technical organization in the world and unites specialists in this field from more than 190 countries. These standards (Protection 1-4, 2010, 2011) were published in 2010 and are improved standards published in 2006, based on which the previously active national standard of Ukraine (Engineering equipment, 2008) was developed and associated with it (Rules for arranging, 2017; Rules for the construction, 2001).

Immediately after the publication of the standards (Protection 1-4, 2010, 2011) its innovations began to be discussed at international conferences (Surtees, 2011) and meetings in the participating countries. During the discussions, special attention was paid to the probability of lightning damage and its probability of occurrence. As a result, various protective measures against lightning damage were proposed and their influence on the final result of building and construction protection was investigated (Elliams, 2017; Bao *et al.*, 2021; Araújo *et al.*, 2015) which was discussed in the articles (Souto *et al.*, 2023; Gao *et al.*, 2020; Goh *et al.*, 2017) and in the book (Fernando *et al.*, 2019).

According to the new regulatory documents, in order to assess whether the protection of the building is required, it is necessary to carry out a risk calculation in accordance with the regulatory document (Protection 2, 2010). The calculation algorithm and examples of calculations for the main types of buildings are given in the same document. But due to the large number of such formulas, there is a natural need to automate this process.

After the adoption of European regulatory documents in the field of lightning protection (Protection 1-4, 2010, 2011), software products that facilitate the work of the designer began to appear on the domestic market, allowing to automatically assessing the risk of damage to the building by lightning. You can also find software products in foreign languages that allow you to make online payments. But the disadvantages of all these software products are that they are all paid and do not allow you to issue the results in the form of a document that meets the requirements of the national normative document (Basic requirements, 2009). This, in turn, creates problems during the examination of project documentation and causes comments from experts. A solution option may be to create a model using the MS Excel computer program, followed by exporting the results to a pre-created template in accordance with the regulatory document (Basic requirements, 2009) based on an MS Word document. In addition, one of the advantages of creating a model in MS Excel is the absence of the necessary programming skills, since most designers do not have them.

The use of the MS Excel software complex is widespread in the scientific environment and is used to solve various scientific problems, such as modeling the process of mechanical movement of the body (Horda, & Flehantov, 2015), biological modulation (Tack *et al.*, 1995) and even when teaching science subjects (Ibrahim, 2009). Therefore, the use of MS Excel to create a calculation model for assessing the risk of damage to a building by lightning is fully justified.

The purpose of the work is to build a model for assessing the risk of a lightning strike in a building using MS Excel, which will significantly speed up the work of designers who perform a part of lightning protection and during the implementation of their projects carry out a calculation of the risk assessment of a lightning strike for public, administrative, industrial or residential buildings.

## Materials and methods

To obtain a working model in the MS Excel computer program, the following tasks must be solved:

- solve the formulas used to calculate the risk assessment, which are reduced to several main types or have a specific form:

$$R_Y = N_Y \cdot P_Y \cdot L_Y, \quad (1)$$

where  $R_Y$  is risk component;

$N_Y$  is number of threatening events;

$P_Y$  is probability;

$L_Y$  is loss.

$$N_Y = N_X \cdot A_X \cdot C_X \cdot 10^{-6}, \quad (2)$$

where  $N_Y$  is number of threatening events;

$N_X$  is density of underground lightning flashes;

$A_X$  is area of collection of lightning flashes;

$C_X$  is coefficient.

$$A_X = L \cdot W + 2 \cdot (3 \cdot H) \cdot (L + W) + \pi \cdot (3 \cdot H)^2, \quad (3)$$

where  $A_X$  is area of collection of lightning flashes;

$L$  is length of the building;

$W$  is width of the building;

$H$  is building height.

$$A_X = 2 \cdot 500 \cdot (L + W) + \pi \cdot (500)^2, \quad (4)$$

where  $A_X$  is area of collection of lightning flashes;

$L$  is length of the building;

$W$  is width of the building.

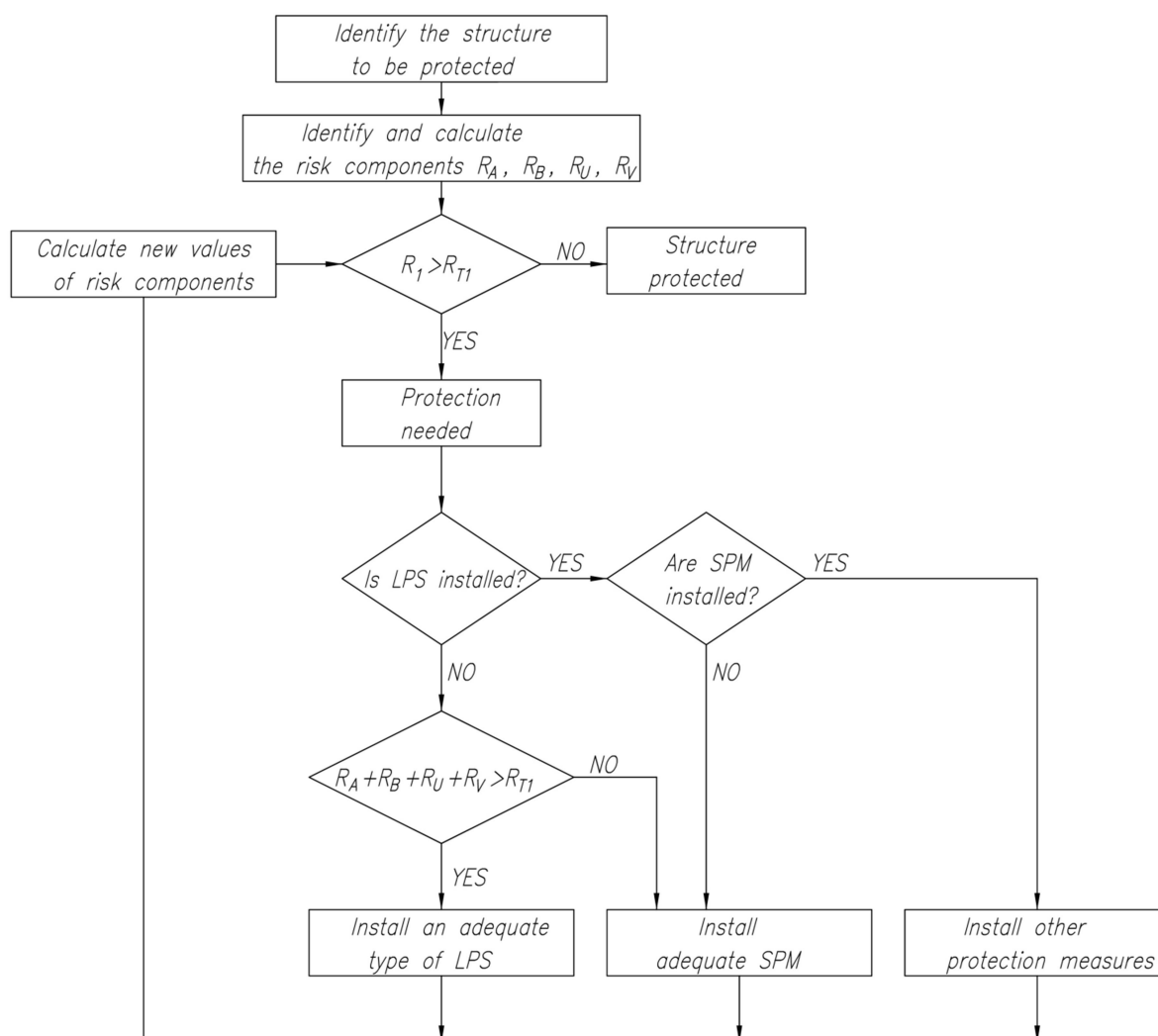
$$R_I = \sum_{i=1}^N R_{Yi}, \quad (5)$$

where  $R_I$  is risk of loss of human life in the building;

$R_Y$  is risk component.

- build a typical formula that returns a value or a reference to a value from a table or range and also performs a search for the specified element in the range and returns the relative position of this element;

- formulate a risk assessment procedure in accordance with the regulatory document (Protection 2, 2010) presented in Fig. 1 and be able to correctly select protective measures to reduce risk (internationally accepted abbreviations in the figure LPS - lightning protection system, SPM - lightning electromagnetic impulse protection measures protection against the electromagnetic pulse of lightning)).



**Figure 1.** Procedure for determining the need for protection and selection of protection measures

## Findings and discussion

To solve the formulas, you first need to get input from the customer of the lightning protection project or the owner of the building for which the lightning strike risk assessment is being performed.

For the optimal distribution of the received data and for convenient use of them in MS Excel, we create two sheets:

- in the first, there will be input data that will have the form of lists, where each block is a separate list – Fig. 2 (1st column - the name of the parameter from the list; 2-nd column - the value of the parameter from the list)

|    | 1                                                                                                                                                                           | 2       |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 1  | Structure surrounded by higher objects                                                                                                                                      | 0,25    |
| 2  | Structure surrounded by objects of the same height or smaller                                                                                                               | 0,5     |
| 3  | Isolated structure: no other objects in the vicinity                                                                                                                        | 1       |
| 4  | Isolated structure on a hilltop or a knoll                                                                                                                                  | 2       |
| 5  |                                                                                                                                                                             |         |
| 6  | Aerial                                                                                                                                                                      | 1       |
| 7  | Buried                                                                                                                                                                      | 0,5     |
| 8  |                                                                                                                                                                             |         |
| 9  | Rural                                                                                                                                                                       | 1       |
| 10 | Suburban                                                                                                                                                                    | 0,5     |
| 11 | Urban                                                                                                                                                                       | 0,1     |
| 12 | Urban with tall buildings                                                                                                                                                   | 0,01    |
| 13 |                                                                                                                                                                             |         |
| 14 | Industrial use equipment                                                                                                                                                    | 4       |
| 15 | Equipment: electrical appliances, etc                                                                                                                                       | 2,5     |
| 16 | Equipment: computers, devices with electronic programming                                                                                                                   | 1,5     |
| 17 |                                                                                                                                                                             |         |
| 18 | Agricultural, concrete                                                                                                                                                      | 0,01    |
| 19 | Marble, ceramic                                                                                                                                                             | 0,001   |
| 20 | Gravel, moquette, carpets                                                                                                                                                   | 0,0001  |
| 21 | Asphalt, linoleum, wood                                                                                                                                                     | 0,00001 |
| 22 |                                                                                                                                                                             |         |
| 23 | High                                                                                                                                                                        | 0,1     |
| 24 | Ordinary                                                                                                                                                                    | 0,01    |
| 25 | Low                                                                                                                                                                         | 0,001   |
| 26 |                                                                                                                                                                             |         |
| 27 | No provisions                                                                                                                                                               | 1       |
| 28 | One of the following provisions: extinguishers; fixed manually operated extinguishing installations; manual alarm installations; hydrants; fire compartments; escape routes | 0,5     |
| 29 | One of the following provisions: fixed automatically operated extinguishing installations; automatic alarm installations                                                    | 0,2     |
| 30 |                                                                                                                                                                             |         |
| 31 | No special hazard                                                                                                                                                           | 1       |
| 32 | Low level of panic                                                                                                                                                          | 2       |
| 33 | Average level of panic                                                                                                                                                      | 5       |
| 34 | High level of panic                                                                                                                                                         | 10      |
| 35 |                                                                                                                                                                             |         |
| 36 | Hospital, hotel, school, civic building                                                                                                                                     | 0,1     |
| 37 | Public entertainment, church, museum                                                                                                                                        | 0,05    |
| 38 | Industrial, commercial                                                                                                                                                      | 0,02    |
| 39 | Others                                                                                                                                                                      | 0,01    |

**Figure 2.** Input data that will be in the form of lists

- in the second sheet, the data will be built on the basis of lists, other input data, intermediate and final calculations - Figs. 3-6 (1st and 2nd columns – the name of the parameter and the value of the parameter from the sides, the number of lightning strikes, the size of the building and the number of people and the time of presence; 4th column – the name of other parameters; 5th – the data is built on the basis lists and formulas; 6th – designation of parameters; 7th – intermediate and final calculations; 8th – references to formulas or tables according to the regulatory document (Protection 2, 2010)).

|    | 1                                   | 2     |
|----|-------------------------------------|-------|
| 1  | <i>Number of lightning strikes</i>  |       |
| 2  | <i>TD</i>                           | 26,00 |
| 3  | <i>NG</i>                           | 2,60  |
| 4  |                                     |       |
| 5  |                                     |       |
| 6  |                                     |       |
| 7  | <i>Dimensions of the structure</i>  |       |
| 8  | <i>L – length</i>                   | 94    |
| 9  | <i>W – width</i>                    | 86    |
| 10 | <i>H - height</i>                   | 15    |
| 11 |                                     |       |
| 12 | <i>Number of people and time of</i> |       |
| 13 | <i>nz</i>                           | 1860  |
| 14 | <i>nt</i>                           | 1860  |
| 15 | <i>tz</i>                           | 8760  |

**Figure 3.** Number of lightning strikes, building dimensions and number of people and presence time

|    | 4                                                                                                                                             | 5                                                                                                                                                                           |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | <b>Table of characteristics of the structure and the surrounding environment</b>                                                              |                                                                                                                                                                             |
| 2  | Location factor                                                                                                                               | Structure surrounded by objects of the same height or smaller                                                                                                               |
| 3  | Probability of physical damage to a structure (flashes to a structure)                                                                        | Structure not protected by LPS                                                                                                                                              |
| 4  | Probability reducing $P_U$ and $P_V$ depending on line characteristics and withstand voltage of equipment when EB is installed                | No SPD                                                                                                                                                                      |
| 5  | Factor relevant to the screening effectiveness of the structure                                                                               | The maximum value (according to NOTE 3)                                                                                                                                     |
| 6  |                                                                                                                                               |                                                                                                                                                                             |
| 7  | <b>Table for power lines</b>                                                                                                                  |                                                                                                                                                                             |
| 8  | Length of line section                                                                                                                        | Up to                                                                                                                                                                       |
| 9  | Installation factor of the line                                                                                                               | Buried                                                                                                                                                                      |
| 10 | Line type factor for a HV/LV transformer on the line                                                                                          | LV power, telecommunication or data line                                                                                                                                    |
| 11 | Environmental factor                                                                                                                          | Urban                                                                                                                                                                       |
| 12 | Factor depending on shielding, grounding and isolation conditions of the line for flashes to a line                                           | Aerial line unshielded                                                                                                                                                      |
| 13 | Factor depending on shielding, grounding and isolation conditions of the line for flashes near a line                                         | Aerial line unshielded                                                                                                                                                      |
| 14 | Rated impulse withstand voltage of a system                                                                                                   | Industrial use equipment                                                                                                                                                    |
| 15 | Factor relevant to the impulse withstand voltage of a system                                                                                  | according to NOTE 4 $K_{S4} = 1/U_W$                                                                                                                                        |
| 16 | Probability reducing $P_U$ , $P_V$ and $P_W$ depending on line characteristics and withstand voltage of equipment (flashes to connected line) | Aerial or buried line, unshielded or shielded whose shield is not bonded to the same bonding bar as equipment                                                               |
| 17 |                                                                                                                                               |                                                                                                                                                                             |
| 18 | <b>Table of reduction factor</b>                                                                                                              |                                                                                                                                                                             |
| 19 | Reduction factor associated with the type of surface                                                                                          | Asphalt, linoleum, wood                                                                                                                                                     |
| 20 | Probability reducing $P_A$ depending on protection measures against touch and step voltages                                                   | No protection measures                                                                                                                                                      |
| 21 | Probability of injury to living beings by electric shock (flashes to a connected line)                                                        | No protection measures                                                                                                                                                      |
| 22 | Factor reducing loss depending on risk of fire                                                                                                | Ordinary                                                                                                                                                                    |
| 23 | Factor reducing the loss due to provisions against fire                                                                                       | One of the following provisions: extinguishers; fixed manually operated extinguishing installations; manual alarm installations; hydrants; fire compartments; escape routes |
| 24 | Factor relevant to the screening effectiveness of shields internal to the structure                                                           | The maximum value (according to NOTE 3)                                                                                                                                     |
| 25 | Number of possible endangered persons (victims or users not served)                                                                           | High level of panic                                                                                                                                                         |
| 26 | Loss due to injury by electric shock                                                                                                          | All types                                                                                                                                                                   |
| 27 | Loss in a structure due to physical damage                                                                                                    | Hospital, hotel, school, civic building                                                                                                                                     |
| 28 | Loss in a structure due to failure of internal systems                                                                                        | It is not standardized                                                                                                                                                      |

**Figure 4.** Parameter names, input data and data built on the basis of lists



|    | 4                                                                                      | 5                                                                                    |
|----|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 29 |                                                                                        |                                                                                      |
| 30 | <b>Table of loss</b>                                                                   |                                                                                      |
| 31 | Loss due to injury to living beings by electric shock (flashes to structure)           | $L_A = r_t \cdot L_T \cdot (n_z / n_t) \cdot (t_z / 8760)$                           |
| 32 | Loss due to injury of living beings by electric shock (flashes to line)                | $L_U = r_t \cdot L_T \cdot (n_z / n_t) \cdot (t_z / 8760)$                           |
| 33 | Loss in a structure related to physical damage (flashes to structure)                  | $L_{B1} = r_p \cdot r_f \cdot h_z \cdot L_{F1} \cdot (n_z / n_t) \cdot (t_z / 8760)$ |
| 34 | Loss in a structure due to physical damage (flashes to line)                           | $L_{V1} = r_p \cdot r_f \cdot h_z \cdot L_{F1} \cdot (n_z / n_t) \cdot (t_z / 8760)$ |
| 35 |                                                                                        |                                                                                      |
| 36 | <b>Structure protection area table and communication lines</b>                         |                                                                                      |
| 37 | Collection area for flashes to an isolated structure                                   | $A_D = L \cdot W + 2 \cdot (3 \cdot H) \cdot (L + W) + \pi \cdot (3 \cdot H)^2$      |
| 38 | Collection area for flashes striking near the structure                                | $A_M = 2 \cdot 500 \cdot (L + W) + \pi \cdot (500)^2$                                |
| 39 | Collection area for flashes to a line                                                  | $A_{LP} = 40 \cdot L_{LP}$                                                           |
| 40 | Collection area for flashes near a line                                                | $A_{LP} = 4000 \cdot L_{LP}$                                                         |
| 41 |                                                                                        |                                                                                      |
| 42 | <b>Table of the expected number of dangerous events due to flashes</b>                 |                                                                                      |
| 43 | Number of dangerous events due to flashes to structure                                 | $N_D = N_G \cdot A_D \cdot C_D \cdot 10^{-6}$                                        |
| 44 | Number of dangerous events due to flashes near a structure                             | $N_M = N_G \cdot A_M \cdot 10^{-6}$                                                  |
| 45 | Number of dangerous events due to flashes to a line                                    | $N_{LP} = N_G \cdot A_{LP} \cdot C_{LP} \cdot C_E \cdot C_{TP} \cdot 10^{-6}$        |
| 46 | Number of dangerous events due to flashes near a line                                  | $N_{LP} = N_G \cdot A_{LP} \cdot C_{LP} \cdot C_E \cdot C_{TP} \cdot 10^{-6}$        |
| 47 |                                                                                        |                                                                                      |
| 48 | <b>Calculation R1</b>                                                                  |                                                                                      |
| 49 | <b>Table of risk components</b>                                                        |                                                                                      |
| 50 | Probability of injury to living beings by electric shock (flashes to a structure)      | $P_A = P_{TA} \cdot P_B$                                                             |
| 51 | Risk component (injury to living beings – flashes to structure)                        | $R_A = N_D \cdot P_A \cdot L_A$                                                      |
| 52 | Risk component (physical damage to a structure – flashes to a structure)               | $R_B = N_D \cdot P_B \cdot L_{B1}$                                                   |
| 53 | Probability of injury to living beings by electric shock (flashes to a connected line) | $P_{U/P} = P_{TU} \cdot P_{EB} \cdot P_{LD/P} \cdot C_{LD/P}$                        |
| 54 | Risk component (injury to living being – flashes to connected line)                    | $R_{U/P} = N_{LP} \cdot P_{U/P} \cdot L_U$                                           |
| 55 | Probability of physical damage to a structure (flashes to a connected line)            | $P_{V/P} = P_{EB} \cdot P_{LD/P} \cdot C_{LD/P}$                                     |
| 56 | Risk component (physical damage to structure – flashes to connected line)              | $R_{V/P} = N_{LP} \cdot P_{V/P} \cdot L_{V1}$                                        |

**Figure 5.** Parameter names and formulas

To facilitate the perception of information, the information is divided into separate blocks, and the cells with numerical values and data built on the basis of lists are marked with the appropriate colors:

- input data is built on the basis of lists from the 1st sheet;
- input data received from the customer;
- intermediate calculations;
- final calculations.



| 6                                                                         | 7       | 8                |
|---------------------------------------------------------------------------|---------|------------------|
| Table of characteristics of the structure and the surrounding environment |         |                  |
| $C_D$                                                                     | 0,5     | Table A.1        |
| $P_B$                                                                     | 1       | Table B.2        |
| $P_{EB}$                                                                  | 1       | Table B.7        |
| $K_{S1}$                                                                  | 1       | Section B.5      |
| Table for power lines                                                     |         |                  |
| $L_{LP}$                                                                  | 50      | Section A.4      |
| $C_{LP}$                                                                  | 0,5     | Table A.2        |
| $C_{TP}$                                                                  | 1       | Table A.3        |
| $C_E$                                                                     | 0,1     | Table A.4        |
| $C_{LDP}$                                                                 | 1       | Table B.4        |
| $C_{LIP}$                                                                 | 1       |                  |
| $U_{WP}$                                                                  | 4       | ПВЕ Table 2.1.17 |
| $K_{S4/P}$                                                                | 0,25    | Section B.5      |
| $P_{LDP}$                                                                 | 1       | Table B.8        |
| Table of reduction factor                                                 |         |                  |
| $r_t$                                                                     | 0,00001 | Table C.3        |
| $P_{TA}$                                                                  | 1       | Table B.1        |
| $P_{TU}$                                                                  | 1       | Table B.6        |
| $r_f$                                                                     | 0,010   | Table C.5        |
| $r_p$                                                                     | 0,5     | Table C.4        |
| $K_{S2}$                                                                  | 1       | Section B.5      |
| $h_z$                                                                     | 10      | Table C.6        |
| $L_T$                                                                     | 0,01000 | Table C.2        |
| $L_{F1}$                                                                  | 0,10000 |                  |
| $L_{O1}$                                                                  |         |                  |

| 6                                                               | 7         | 8             |
|-----------------------------------------------------------------|-----------|---------------|
| Table of loss                                                   |           |               |
| $L_A$                                                           | 0,0000001 | Fomula (C.1)  |
| $L_U$                                                           | 0,0000001 | Fomula (C.2)  |
| $L_{B1}$                                                        | 0,0050000 | Fomula (C.3)  |
| $L_{V1}$                                                        | 0,0050000 | Fomula (C.3)  |
| Structure protection area table and communication lines         |           |               |
| $A_D$                                                           | 30643     | Fomula (A.2)  |
| $A_M$                                                           | 965000    | Fomula (A.7)  |
| $A_{LP}$                                                        | 2000      | Fomula (A.9)  |
| $A_{IP}$                                                        | 200000    | Fomula (A.11) |
| Table of the expected number of dangerous events due to flashes |           |               |
| $N_D$                                                           | 0,040     | Fomula (A.4)  |
| $N_M$                                                           | 2,509     | Fomula (A.6)  |
| $N_{LP}$                                                        | 0,000     | Fomula (A.8)  |
| $N_{IP}$                                                        | 0,026     | Fomula (A.10) |
| Calculation R1                                                  |           |               |
| Table of risk components                                        |           |               |
| $P_A$                                                           | 1,00      | Fomula (B.1)  |
| $R_A$                                                           | 0,0000000 | Fomula (6)    |
| $R_B$                                                           | 0,0001992 | Fomula (7)    |
| $P_{UP}$                                                        | 1,00      | Fomula (B.8)  |
| $R_{UP}$                                                        | 0,0000000 | Fomula (10)   |
| $P_{VP}$                                                        | 1,00      | Fomula (B.9)  |
| $R_{VP}$                                                        | 0,0000013 | Fomula (11)   |
| $R1$                                                            | 0,0002005 |               |

Figure 6. Defining parameters, intermediate and final calculations and references to formulas or tables

In cells marked with color as intermediate and final calculations, the following basic typical or specific formulas are used:

- the solution of the typical formula (1) using MS Excel is used for cell R51C7, R52C7, R54C7, R56C7.
- the solution of the typical formula (2) using MS Excel is used for cell R43C7, R44C7, R45C7, R46C7.
- solving formula (3) using MS Excel is used for cell R37C7
- solving formula (4) using MS Excel is used for cell R37C7
- solving formula (5) using MS Excel is used for cell R58C7

To build a typical formula that returns a value or a reference to a value from a table or range, and also performs a search for the specified element in the range and returns the relative position of this element, you need:

- for cells R2C5, R9C5, R11C5, R14C5, R19C5, R22C5, R23C5, R25C5, R27C5, build the data according to the list of relevant blocks from the 1st sheet;
- for cells R2C7, R9C7, R11C7, R14C7, R19C7, R22C7, R23C7, R25C7, R27C7, you need to use the "INDEX" and "LOOKUP" functions.

According to the risk assessment procedure presented in Fig. 1 if  $R_1$  (value in cell R58C7)  $> R_{T1}$ , measures must be taken to reduce the value of  $R_1$ . According to Fig. 1, these measures are the installation of the appropriate type of LPS, that is, the lightning protection system (change in the value of the R3C7 cell) and the corresponding SPM, that is, the surge protection devices (change in the value of the R4C7 cell). These changes will result in an automatic recalculation of  $R_1$ , again favoring the use of a computer program for calculations. In the case of the necessary further reduction of  $R_1$  according to Fig. 1, it is necessary to take other protective measures, i.e. changing other input parameters and the corresponding automatic recalculation of  $R_1$ .

The obtained model will be especially useful for designers who perform or are going to perform a part of lightning protection and during the execution of their projects perform the calculation of the risk assessment of lightning strikes for public, administrative, industrial or residential buildings.

## Results

The proposed technique allows building an effective model for assessing the risk of a lightning strike in a building using MS Excel, as well as:

- solve the basic and private formulas used to calculate the risk assessment;
- build a typical formula that returns a value or a reference to a value from a table or range, and also searches for the specified element in the range and returns the relative position of this element;
- use it for the procedure of studying the effect of protection measures on the final calculations.

In the future, this technique may form the basis for constructing other models for determining the risk of a lightning strike in buildings related to public communications, cultural facilities and explosive zones, while taking into account the recommendations proposed in the article (Uman, 1994).

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None.

## Conflict of interest

None.

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## МЕТОДИКА РОЗРАХУНКУ ОЦІНКИ РИЗИКУ УДАРУ БЛИСКАВКИ ЗАСОБАМИ MS EXCEL

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**Анотація.** У роботі розглядається методика побудови моделі розрахунку оцінки ризику удару блискавки в будівлю та її реалізація відповідно до чинних нормативних документів комп'ютерною програмою MS EXCEL. Ця методика буде корисна для проєктувальників, які виконують частину блискавкозахисту і під час виконання своїх проєктів повинні проводити розрахунок оцінки ризику удару блискавки. Ризик удару блискавки згідно з чинними нормативними документами може складатися з суми від одного до чотирьох ризиків: ризик втрати людського життя; ризик втрати можливості надання громадських послуг; ризик втрати культурної спадщини та ризик втрати економічної цінності. Пропонована методика поширюється на розрахунок ризику втрати людського життя як найбільш важливої цінності, яку можна втратити. Методика передбачає розрахунок ризику удару блискавки для громадських, адміністративних, виробничих або житлових будівель – тобто будівель, з якими найчастіше доводиться стикатися проєктувальнику під час своєї роботи. Пропонована методика не розрахована на використання для побудови ризикових моделей для будівель чи споруд такого призначення: громадські комунікації й об'єкти культурного призначення, бо зазначені будівлі передбачають розрахунок ризику втрати можливості надання громадських послуг або ризику втрати культурної спадщини відповідно. Також пропонована методика не поширюється на будівлі, що мають вибухонебезпечні зони, оскільки розрахунок ризику для них буде специфічним; а ще ця методика не передбачає розрахунків ризику втрати економічної цінності, оскільки він не є обов'язковим відповідно до нормативних документів та проводиться додатково за бажанням замовника. В той же час вона може бути використана як основа для побудови більш складних моделей, що підходять для таких типів будівель. У роботі розглянуто методи вирішення основних проблем, з якими стикається проєктувальник під час розрахунку оцінки ризику: автоматизація розрахунку схожих формул та зведення більшості з них до кількох основних типів; отримання формули, що повертає значення або посилання на значення з таблиці чи діапазону, а також виконує пошук зазначеного елемента в діапазоні та повертає відносну позицію цього елемента; формулювання процедури оцінки ризиків відповідно до нормативного документа та визначення того, як саме ті чи інші вхідні дані впливають на підсумковий результат.

**Ключові слова:** комп'ютерне моделювання, блискавкозахист, функції в MS EXCEL, формули в MS EXCEL, проєктування.