A New Hotel "Protected" by Air-Termination System ESE Goes Up In Flames

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A strike of lightning, with a lightning current peak value of 111 kA, into a rod or air-termination system ESE, situated on the roof of a hotel, was followed by its flashover from a down-conductor system into the object's inner installation. The hotel's roof construction went up in flames immediately afterwards. The fire was extinguished thanks to early arrival of the units of professional and voluntary firemen. It was extremely fortunate that the hotel was shortly before its opening and, therefore, unoccupied by any guests. The overall damage totalled approximately 300,000 CZK. The hotel's lightning conductor had a valid inspection report.

1. Introduction

The issue of protecting people and property against direct lightning impact has been discussed ever more intensely since the last decade of the 20th century. Viewed on a long–term basis, the Czech Republic has figured among the countries providing lightning conductor protection, particularly in the private sector (while these efforts have been quite vibrant since the 1990s). This tradition coupled with people's willingness to invest money into the protection of their own objects are being abused by lobbying methods used by sellers of this equipment, by inadequate adult education and lack of professional conduct on the part of competent organizations. As a result, unhomologated systems, which currently contravene the basic standards ČSN EN 62305 (Czech standard, European standard 62305), have been used in the Czech Republic. Part of the responsibility for the deteriorating situation is borne by this country's state administration authorities whose primary duty should be to supervise the implementation of the principles of the safety of individuals and property against lightning. In response to a growing number of ESE installations in the Czech Republic it is vital to inform the broader professional as well as lay public of cases involving the failure of this particular technical variant of the lightning conductor. One of the many such cases occurred in 2007 when a roof of a hotel went up in flames after a lightning strike.

Fig. 1 Fire of the Odry hotel caused by lightning strike into ESE

Fig. 2 Burning-in of the hotel's attic

2. Valid Legislation in Lightning Protection in the Czech Republic

The valid laws and regulations should be observed in any law-abiding state. As regards lightning protection in the Czech Republic, this country has its valid Regulation of the Ministry for Regional Development (in Czech: Ministerstvo pro místní rozvoj, hereinafter referred to as MRD) No. 268/2009 Coll. on the technical requirements for buildings [1] (prior to 2009 it was Regulation No. 137/1998 Coll. [2]). Section § 36 lists the types of buildings in which a risk analysis has to be carried out in the light of the normative background aspects:

a) threat to life or health of persons, especially in a housing unit, building with an inner assembly space, building destined for commerce, health care and education, building serving as an accommodation facility or building designed to house a greater number of animals,
b) breakdown with a wide-ranging impact on public services, especially in a power station, gasworks, waterworks, building housing communication equipment, and railway station,

c) explosion especially in a facility producing or storing explosive and inflammable materials, liquids and gases,
d) damage to cultural heritage, eventually other values, particularly in a picture gallery, library, archive, museum, building which is a cultural monument itself.
e) transfer of fire in a building to neighbouring structures which must be protected against lightning pursuant to letters a) to d),

According to the position of the Ministry of Industry and Trade (in Czech: Ministerstvo průmyslu a obchodu, hereinafter MPO) pursuant to Regulation No. 73/2010 Coll. § 2 [7] lightning conductors are selected technical devices not covered by the Act No. 102/2001 Coll. on the general safety of products [8] and Act No. 22/97 Coll. on the technical requirements for products and changes and amendments of some laws [9].

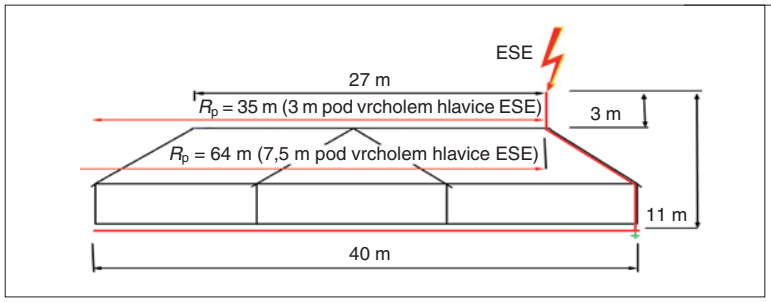

Fig. 3 Design of the protected area of ESE pursuant to NF C 17-102 [10]

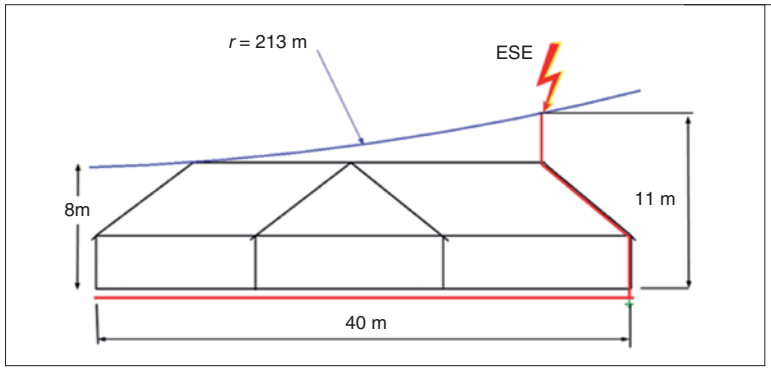

Fig. 4 Checking protected area of ESE pursuant to the ČSN EN 62305-3 (rolling sphere radius r = 213 m)

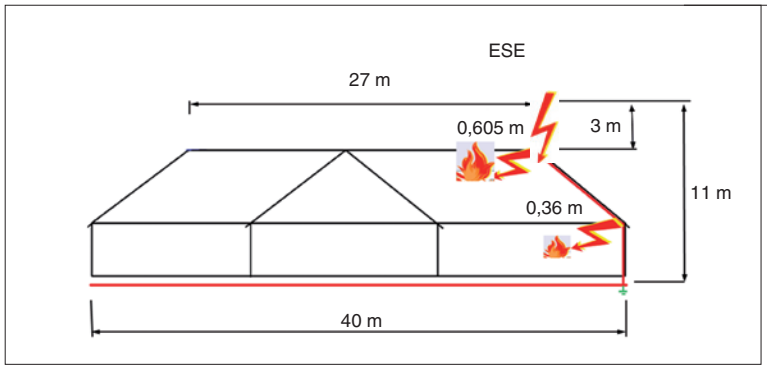

Fig. 5 Checking separation distance of ESE pursuant to the NF C 17-102 [10]

f) threat to a building with an enhanced danger of the strike of lightning as a result of its location on a hill or due to rising above the surrounding terrain, especially in case of factory stacks, towers, lookout towers and broadcasting towers."

An interpretation of the relevant legal regulation prepared by the MRD makes it evident that buildings of public nature, such as, e.g., hotels, fall within the scope of this legislation and it is, therefore, necessary to proceed pursuant to §3 of this Regulation in keeping with the package of the Czech technical standards (ČSN EN 62305-1, 2, 3 and 4) [3 to 6].

According to the position taken by the Office for Technical Standardization, Metrology and State Assaying (in Czech: Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, hereinafter ÚNMZ) the national French NF C 17-102 [10] (French standard) and the Slovak standard STN 34 1391 [11] have not been incorporated into the ČSN system and are not even regarded as harmonized standards, and – according to the legal opinion of the ÚNMZ – cannot be used for the purposes of the Regulation No. 268 / /2009 Coll. [1], as a point of reference to the valid norms introduced in the Czech Republic.

3. Firemen's Press Release

On June 21, 2007 a lightning discharge set fire to the roof of a newly built hotel at Odry, situated in the "protected area" of an ESE. The fire of the roof of the T-shaped object with two aboveground floors was reported by its owner to the firemen's operating centre after half past eight p.m. Five units of the Fire Rescue Corps of the Moravian-Silesian Region set out to the locality. The firemen got the fire under control within 30 minutes. During less than an hour they had to take the roof apart from the outside, taking out even plasterboards from the inside and hosing them down. Worst affected was primarily the roof structure on an area measuring 4 x 2 metres. After extinguishing the fire, local firemen stayed on the site to check the seat of fire.

4. Installation of ESE pursuant to the French national standard NF C 17-102 [10]

The ESE was dismantled immediately after the fire had been extinguished. The assembly company "allegedly" sent the top of the lightning conductor back to the manufacturer in France for further investigation. The installation of the lightning conductor pursuant to the national French standard NF C 17-102 [10] had a "valid" inspection report.

The new hotel building is situated at the foot of a hill, hence in an area with enhanced occurrence of thunderstorms.

Lightning protection was provided pursuant to the French national standard NF C 17-102 [10]:

– **Lightning conductor system** – one ESE, which was absolutely inadequate for the protection of the given objects pursuant to the valid package of standards ČSN EN 62 305 (Figs. 3 and 4);

Pursuant to the standard ČSN EN 62305-1, supplement A.4 radius is calculated by means of the rolling sphere method for lightning current 111 kA as follows:

$$r = 10.I^{0,65} = 10.\ 111^{\ 0,65} = 213 \text{ m}$$

where:
r is rolling sphere radius (m);
I is lightning current peak value (kA).

– **Down-conductor system** – provided by means of one down-conductor, which failed to guarantee safe insulation of lightning current from the hotel's inner installations (primarily metal plasterboard profiles). Separation distance *s:* for one down-conductor = 0.96 m (Fig. 5);

According to available literature [12], separation distance s is calculated as follows:

$$s = \frac{M'}{600} \cdot \frac{1}{1+T_1} \cdot \frac{k_c}{k_m} \cdot l \cdot i_{max} =$$

$$= \frac{1,5}{600} \cdot \frac{1}{1+10} \cdot \frac{1}{0,5} \cdot 12 \cdot 111 = \mathbf{0,605\ m}$$

where (in case of a hotel):
M' is mutual inductance (1,5 μH/m);
T_1 front time of impulse current (10 μs);
k_c coefficient of lightning current distribution (for one down-conductor ≈ 1);
k_m coefficient of material (brick ≈ 0,5);
l length of down-conductor (12 m);
i_{max} lightning current peak value (111 kA).

– Earthing system – foundation earthing.

5. Reviewing lightning protection pursuant to the ČSN EN 62305-3 [3 to 6], EN 62305-1 to 4 [13 to 16] and the IEC international organization 62305-1 to 4 [17 to 20]:

– **System of lightning conductors** – sloped roof (Figs. 7 and 8) is captured on the crest of the roof in a way to meet the requirements of the standard ČSN EN 62305-3, article 5.2.

– **Down-conductor system** – seven down-conductors (Figs. 7 and 8). Originally a single down-conductor was supplemented with another six down-conductors, located – as a priority measure – in the corners of the object and attached to the eaves. This has resulted in reducing the separation distance s according to available literature [12]:

For height level: 0 to 7 m meshed down-conductor system

$$s_1 = \frac{M'}{600} \cdot \frac{1}{1+T_1} \cdot \frac{k_c}{k_m} \cdot l \cdot i_{max} =$$

$$= \frac{1,5}{600} \cdot \frac{1}{1+10} \cdot \frac{0,44}{0,5} \cdot 7 \cdot 111 = \mathbf{0,16\ m}$$

For height level: 7 to 12 m (sloped roof)

$$s_2 = \frac{1,5}{600} \cdot \frac{1}{1+10} \cdot \frac{0,36}{0,5} \cdot 5 \cdot 111$$

$$s_2 = \quad 5\ 111 = \mathbf{0,12\ m}$$

$$s = s_1 + s_2 = 0,16 + 0,12 = \mathbf{0,28\ m}$$

where (in case of a hotel):
M´ is mutual inductance (1,5 μH/m);
T_1 front time of impulse current (10 μs);
k_c coefficient of lightning current distribution (for a three-dimensional system ≈ 0,44,
in case of a sloped roof ≈ 0,36; Fig. C.3 pursuant to the ČSN EN 62305-3 ed.2);
k_m coefficient of material (brick ≈ 0,5);
l length of down-conductor (7 and 5 m);
i_{max} lightning current peak value (111 kA).

An increase in the number of down-conductors has led to a substantial reduction of the risk of flashover from the system of down-conductors to the object's inner installations.

With the greatest probability, the main reason of the outbreak of fire in the hotel was the failure to maintain sufficient separation distance s between one down-conductor and the building's inner electric and metal installation.

6. Summary

– It is both necessary and useful to keep the technical and lay public informed of the inadequate protection of objects by means of ESE lightning conductors which, after failing, behave as classical metallic lightning rods, contravening – through their inadequate number – the prescribed values of down-conductors and lightning rods of the ČSN EN 62305.
– As corroborated by a number of emergencies in the past, for instance:
– hotel at Odry (2007) [21] – a higher value of lightning current of 111 kA, which passed through one down-conductor, caused its flashover and subsequent fire of the building.
– biogas station at Malšice (2011) – a lower value of lightning current of 18 kA caused lightning impact into the protected area of ESE which, in turn, caused an explosion and outbreak of fire of the station.
– To prevent such emergencies it is vital to adhere to the package of the Czech technical safety standards ČSN EN 62305-1 to 4 [3 to 6], eventually to the EN 62305-1 to 4 [13 to 16], and the IEC 62305-1 to 4 [17 to 20]. These standards are known to contain age-old expertise accumulated by experts in lightning protection from all over the world.

Fig. 6 Situation after extinguishing fire

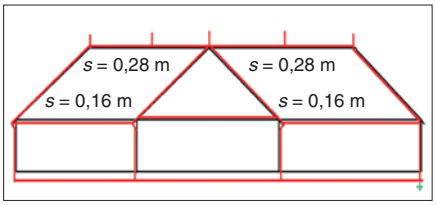

Fig. 7 Design of lightning conductors, down-conductors and check of separation distance s pursuant to the ČSN EN 62305-3 [5]

– The personnel of the State Specialized Supervision (in Czech: Státní odborný dozor, hereinafter SOD) should realize that their primary duty is to enforce the principles of the safety of individuals and buildings and thus to reduce general threat to the public. However, this is, quite frequently, not the case in practical life and, unfortunately, the SOD personnel's priority is to find, at any costs, a solution aimed at meeting

Fig. 8 Current status of the lightning conductor pursuant to the ČSN EN 62305-3 [5]

the requirements of the importers of such devices.

– Pursuant to the Czech Criminal Code No. 40/2009 Coll. [22] criminally liable shall be not only the designer, inspection technician, forensic expert, but personal criminal responsibility shall also be borne by SOD inspector.

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Ing. Jiří Kutáč, was born on 8. 11. 1964. In 1983 he graduated at electrical engineering second school of SPSE in Frenstat p. R. and in 1988 he graduated at the department of electrical drives and power electronics of the Faculty of Electrical Engineering at University of VUT in Brno. Since 2001 he has worked for the company Dehn + Söhne. In 2009 he was appointed District Court in Ostrava in field of electrical engineering and in 2011 in field of electroenergetics. He is guarantor of international cooperation of technical committee CZ by IEC TC 81, CLC TC 81X and is president of Sub-Commission *Protection against lightning* at technical standards committee TNK 97 and also member of technical standards committee TNK 97 Electrical Power and member of technical standards committee TNK 22 Electrical regulations. Since 2011 he is chairman at Union of Court's Expert.

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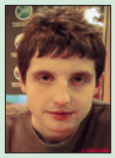

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He has A-level of the secondary school – electrical technologies, in Prague. At Czech Technical University in Prague (CVUT), he graduated in electrical energy engineering in 2006. His thesis is called: *The outdoor protection against the overvoltage effects in atmosphere*. Nowadays, he is post-gradual student at the same university and his work is aimed to the high voltage technology. He engages the high voltage phenomenon, lightning discharge influence of lightning discharge on the technical equipment, and over-voltage effects. Simultaneously, he offers consultation for the commercial subjects.

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