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THOUGHTS ABOUT THE LIGHTNING PROTECTION OF SOME ELECTRIC VEHICLES

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ABSTRACT

Today, smart devices and technologies, in addition to serving people's individual needs (e.g. smartphones, tablets etc.), are gaining ground in supporting community traffic, healthcare, disaster management as a social public task. As a result of the continuous development of human living communities (villages, towns, settlements), the dominant usage of smart tools and technologies already represents a new quality level (Smart City). Modern logistics support for the public tasks of other settlements or other committed community events takes place through the use of different types of vehicles, in which the use of electric vehicles is also becoming increasingly important. Manufacturers are designing body parts for these vehicles to achieve a smaller weight from various plastic or composite materials in the future, which does not protect the passengers from lightning strikes. From the point of view of life and property protection, the lightning protection of electric vehicles with this technology can be the current area of current research and development.

KEY WORDS

flash hazard, lightning protection, electric vehicles, non-metal framed vehicles

CLASSIFICATION

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INTRODUCTION

Nowadays, infocommunication tools and technologies are used by personal users alike, which affects almost every age group of people. In addition to differentiated personal needs, the Internet-based functional support of family and group needs (eg smart heaters, smart homes, smart farms) is simultaneously occurring and becoming more common. Continuous development of network-based digital technologies based on scientific results nowadays allows not only smaller community communities, condominiums to meet community needs, but also the planning and organization of whole villages, towns, and community-based services and services for citizens through the integrated use of infocommunication tools and technologies, and support for implementation. The exact definition of a smart city – SmartCity – is difficult to formulate precisely, but if the former activities are implemented in practice, then we can usually speak of a smart city, with the same public tasks that can be identified and grouped independently of its size. Without the need for completeness, they can be public transport, emergency public tasks, where several different types of vehicles are used. In the course of technological development, different types of electric vehicles are becoming more common on the roads. Manufacturers of bodywork elements of these vehicles are planned to be produced from different plastics and composite materials in order to achieve lighter weight. These vehicles can unexpectedly or planned exit the lightning-protected area during their traffic routes. Nowadays, natural phenomena suggest that global warming caused by human infrastructure activities increases the number of lightning strikes. As much as 1% of temperature rise will increase the number of lightning strikes by 6% per annum [1]. Parameters of strikes are also increasing (e.g. lightning density, peak value). Therefore, in my opinion, lightning protection not only for buildings, but also for these electric vehicles can be a priority research area about smart cities as well.

EFFECTS OF LIGHTNING

The source of damage is considered to be that point where the lightning may strike. In case of vehicles it may be two different points, strike to vehicle (primary effect) and strike near vehicle (secondary effect). Contrary to popular belief, harmful events may not only occur if lightning strikes directly the automobile, but also when it hits next to it. In the latter case the overvoltage induced in the vehicle's electric systems may cause significant damage.

Figure 1. Direct strike to car.

Property damage is caused by lightning strike's inflammatory effect, which builds up the actual economic damage increased by additional costs. Inflammatory and inductive effects may cause further harmful events, so called explosive incidents, the protection against which is managed by the separate field of overvoltage and explosion protection. In case of primary lightning strikes, lightning hits directly the given object. According to one of the insurance companies' data (2016), 90% of the lightning strike damages was caused by secondary effects of lightning [2]. In the technical jargon there is a well-known saying:

„What did not burn was flooded by the firemen."

This saying is true for automobiles possibly bursting into flames. This saying indicates that lightning strike may directly and indirectly cause very severe damages. In order to avoid these harmful effects, automobiles need to be provided with appropriate protection. In case of direct lightning strikes not only the vehicle may be in danger, but also its electric devices and systems (secondary effect). Metal bodywork gives protection against it. In case of indirect (or secondary) effect damage is not done by lightning strike directly, but overvoltage induced by it. It is very difficult to give protection against it.

ELECTRIC AUTOMOBILES TODAY

Automobiles with alternative drives are becoming more and more popular [3]. Their popularity is well represented by the fact that during the Olympic games in Beijing in 2008 and during the 2018 winter Olympics as well, contestants were transported to different locations by a significant number of electric buses [4].

One of the main reasons behind their popularity and spread is the operating costs and the different tax allowances [5]. From the perspective of utilization, these vehicles are quiet and have zero point emission, therefore result in cleaner air, which will be perceived in major cities when they become widespread. Their disadvantage is the range and charging time. Their maximum range is the fraction of their internal combustion engine equivalents and their "refueling" time is longer by orders of magnitude compared to vehicles running on conventional fuel. There is research and already solutions for rapid charging [6], so probably exceptionally long charging time will not be an obstacle to their spread.

It is important to note that for the charging of these automobiles, electricity is coming from the burning of hydrocarbons, so even if they have zero emission locally, on the places of energy production (power plants) they trigger pollution, but to a smaller extent compared to internal combustion engines. An exception is the charging provided with entirely renewable energy.

LIGHTNING PROTECTION OF NON-METAL BODY AUTOMOBILES

Due to the fact that electric cars are being more and more popular, charging stations are expected to be spreaded around countries. This technical field is new so there is no standards for these type of stations, there are only recommendations like VdS 3471 [7] or DKE/AK EMOBILITY.60 [8]. Standard IEC 61851 is about electric vehicle conductive charging systems, parts of it are under development. These recommendations are drawing attention that lightning strike protection is important for electric charging stations. They have some guideline for protecting the stations (Figure 2.) but there are no guideline for direct lightning strike to cars.

In case of direct lightning strike, the lightning current flows through the car body and partly through the suspension, then finally exits through the wheel disk (rim) and is discharged in air towards the ground. The metal body protects the passengers of the vehicle. In order to increase maximum range, manufacturers are planning to produce the bodywork of electric vehicles out

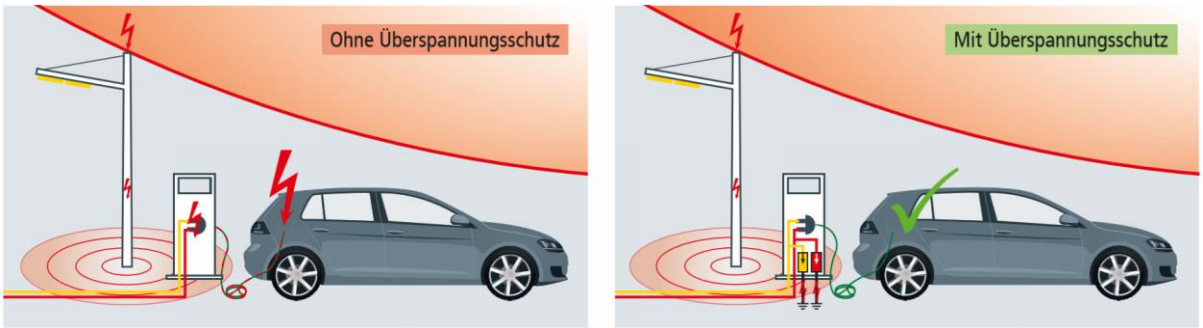

Figure 2. Lightning protection for poles at charging station [9].

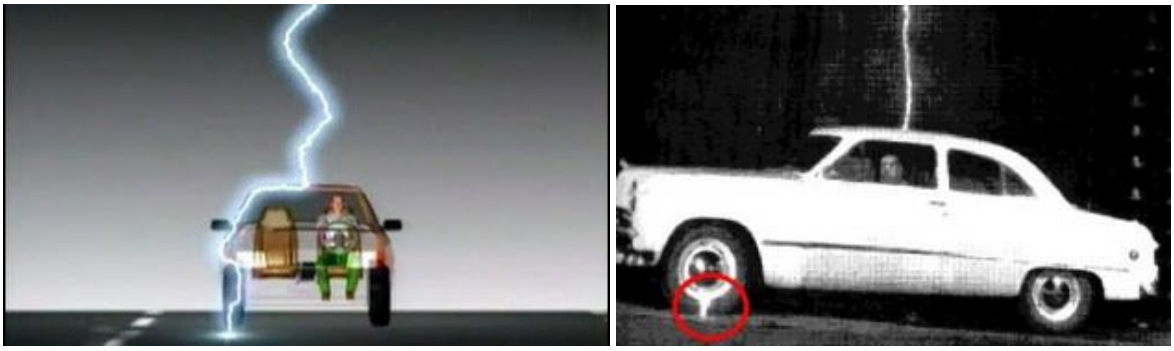

Figure 3. Lightning current route in schematic diagram and in reality.

of non metallic materials (plastics, composite materials). These materials are not conductive, but on the contrary, they have electrically insulating properties. Nowadays, due to the short range, electric vehicles (automobiles, buses) are mostly used in populated areas, and especially in cities.

This gives protection against lightning bolts. Buildings, due to their height, and thanks to lightning arrestors built on them, give safety for the case of lightning strikes.

One might wonder, what happens in case an electric vehicle exits this protected area and what happens in case of s lightning strike? Are passengers in danger? Is there lightning protection?

POSSIBLE SOLUTION

Technically, the aim is to capture the lightning and conduct it towards the ground.

To find the position of the lightning arrestors, we should use the the rolling sphere method. This is a procedure to design the lightning arrestors, according to which the protection is appropriate, if a rolling sphere of given radius can not come in contact from the outside with the protected surface without touching the lightning arrestor. In practice, this means that we are moving a sphere of given radius in the space around the protected object (building, vehicle, etc.) and where the sphere touches an object, that will be the hitpoint of the bolt. With this design method the given object can be protected, because the protected surface will get into the protected space, since the sphere reaches the end point of the protective conductor (better known as lightning arrestor) first. For this design method there are different kinds of 3D software available. As a result, we get a blanket-like surface around the given object, behind which is the protected space (Figure 4).

According to the above mentioned method, lightning is most easily “captured” by a well placed metal body, which therefore is protecting the surfaces. In case of electric vehicles, for

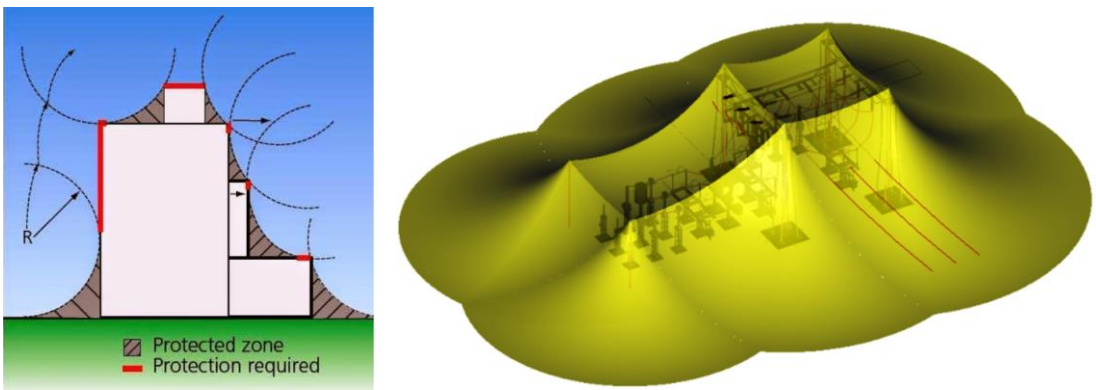

Figure 4. 2D and 3D diagram of the rolling sphere design.

this purpose, a mechanically fixed radio antenna is partially suitable. It is important that the leading wind should not bend the antenna in any direction, since this is protecting a part of the body. For this, adequate mechanical fixing is a must. Moreover, the vehicle must be provided with arrestors on several other points as well.

Figure 5 shows an electric vehicle available on the market, currently manufactured with a metal body. On the left side, the actual, original condition of the vehicle is visible, on the right side the rolling sphere design with the planned arrestors (red markings). We should notice that thanks to the arrestors, the sphere is not contacting the vehicle surfaces, therefore protecting not only the automobile, but the passengers as well. The figure shows one variation of the theoretical design and placement of arrestors. Of course, in case of the vehicle's complete design, the full three dimensional protection of the body should be compiled. For the implementation of lightning protection, not only capturing, but conducting the lightning current is also a problem to solve. When speaking about sizing, the largest stress must be considered, in this case this means a situation when only one arrestor and one conductor would conduct the lightning current. The system should be designed to be capable of conducting even 200 kA of current without damage and warming. For this, a 50 mm^2 cross section conductor is perfect. Lightning current must be conducted to the ground from the body. A solution to this might be a movable conductor that automatically reaches the ground at stops. To avoid excessive and unnecessary requisition (opening of this device at every stop, then closing at start), in practice the movement of this device should be controlled by an electric field strength gauge or by storm warning system. This means that the mobile conductor would be automatically activated when clouds are starting to develop on the sky and therefore the electric field strength measurably changes. A further task is the protection of electric appliances against the induced overvoltage that may appear in such cases. Electric devices in different automobiles are very sensitive to overvoltage. Protection of such appliances can be solved by installing them into metal housings, and electric cables may be threaded through protective tubes or provided with electric shielding.

Figure 5. Rolling sphere design for a commercially available car.

CONCLUSION

Generally I would like to hightlight that the lightning protection of cars and for other vehicles should be designed. This a new area of technical fields and needs a lot of development. The other important technical solution is to pre-create lightning protected routes for vehicles performing public services and make them available for navigation services. It is also advisable to store these data in an integrated database and use it in an interactive way to minimize unintentional passage for the vehicles. To share these data and common experiences (Smart City Connection) in the relationship between smart cities, and to give lectures at conferences or webinars can be also important and useful [10].

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