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ERRORS PRESENT IN THE DESIGN OF CAR ELECTRICAL INSTALLATIONS

Summary: The article presents a case of bad construction solutions in the design of electrical systems in vehicles. Author presents practical cases of badly designed wire harnesses as well as repair methods and good practices.

Keywords: electrical systems in vehicles, electrical harnesses in vehicles, electric vehicles

BŁĘDY PRZY PROJEKTOWANIU INSTALACJI ELEKTRYCZNYCH W POJAZDACH SAMOCHODOWYCH

Streszczenie. W artykule przedstawiono przypadki złych rozwiązań konstrukcyjnych przy projektowaniu instalacji elektrycznych w pojazdach samochodowych. Autor przedstawił praktyczne przypadki źle zaprojektowanych wiązek elektrycznych wraz z metodami naprawczymi i dobrymi praktykami.

Słowa kluczowe: instalacje elektryczne w pojazdach samochodowych, wiązki elektryczne w pojazdach samochodowych, pojazdy elektryczne

1. INTRODUCTION

Demands set on temperature and current flowing in a given circuit are the main criteria, which are considered in the design of wiring systems in cars. Mechanical aspects are also important since they affect the car performance in the greatest degree. Badly designed wiring system may lead to faults, or even cause a fire.

2. WIRE INSULATION

Insulation of wires is a key issue in design of electrical harnesses for vehicles. Lack of insulation at junctions causes damage to harness and short-circuit may also occur. This error may also result in exposing electrical contact, which may be soiled; this results in increased

contact resistance and possible overheating of the connector. In order to prevent these problems, junctions should be placed vertically, and harness should be laid in a form of a drain trap, so that it might be inaccessible to water and dirt particles (Fig.1).

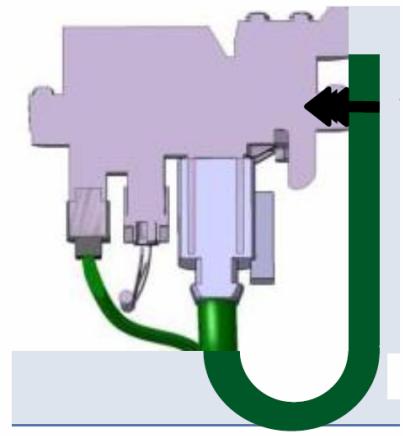

Fig. 1. Electrical harness and junction – correct design

Each vehicle is equipped with ventilation and air-conditioning systems; in these locations we may encounter steam or condensed water droplets. Harnesses laid close to ventilation system are exposed to contact with water. Harnesses running close to heater and compressor of the air-conditioning system are particularly endangered. During winter or in times of abundant rainfall water may get through to ventilation ducts; therefore, harness laid close to these areas should be fitted with additional insulation. This problem may be solved by designing water outlets from ventilation ducts. Part of the air-conditioning system, where servomechanism and harness may be damaged by condensed water from ventilation system is indicated in Fig.2.

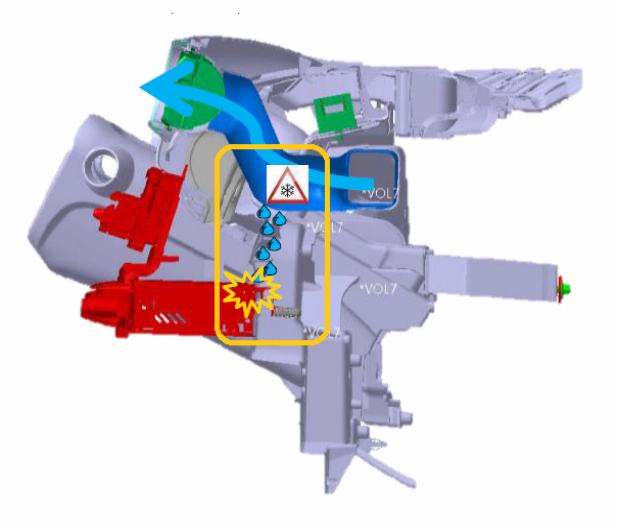

Fig. 2. Air-conditioning system with indicated area of possible steam condensation

3. CAPILLARY ACTION

Capillary effect takes place when water gets first to the internal part of harness and then passes into passenger compartment (Fig.3). This effect is very dangerous since contacts and junction are subjected to damage along the entire length of the harness. Corrosion of contacts occurs and wire resistance is increased, which leads in turn to overheating of harness. In order to avoid these problems, contacts should be attached to the harness very securely and accurately. It is also important to isolate harness placed inside the sealing collar from the external factors (Fig. 4).

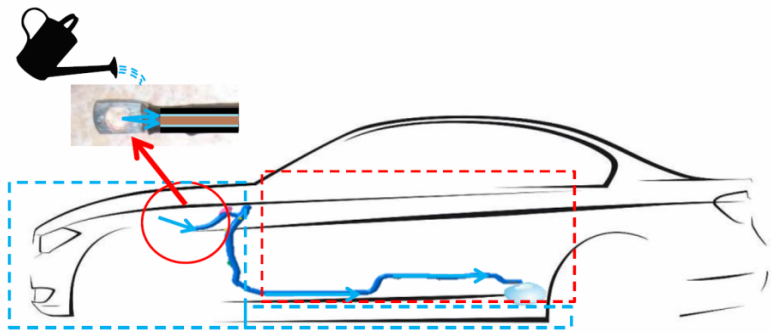

Fig. 3. Capillary action harness damaged by water

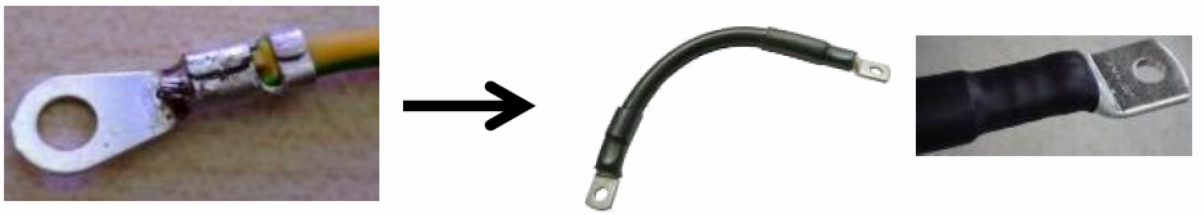

Fig.4. Correct protection of the contact against capillary action

4. PROTECTING HARNESS IN CASE OF COLLISION

Problems described above relate to standard car performance. However, when wiring system is designed, we must also anticipate possible collisions and damage to car body. Harnesses should be laid so that they will not be damaged by excessive extension which might occur during collision. Wires which are in particular exposed to damage are those present in safety system sensors, airbag activators, fuel pumps and central locks. Electrical wiring must not be laid in the immediate neighbourhood of carrying elements such as e.g. solebars, reinforcements and parts dissipating energy during collisions. Example of badly designed harness laid near to the fusebox is shown in Fig.5. Risk of damaging the harness by sharp edges of reflector's fastening elements occurs during head-on collision.

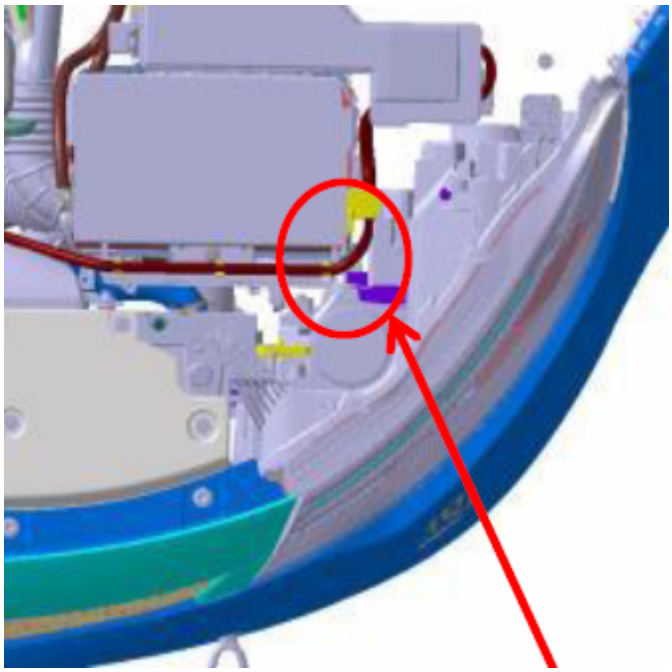

Fig. 5. Incorrect placing of electrical harness (risk of damage in case of collision)

5. USE OF ELECTRICAL HARNESSES LAID CLOSE TO MOVING ELEMENTS

Movable joints and mechanisms can be found in vehicles; electrical harnesses may be located close to these parts. For instance, steering gear is equipped with harnesses supplying electrical motor. Incorrect layout of electrical installation in this area may cause break of the harness and damage the contacts. Wires subjected to frequent stretching may be mechanically injured; damages are accelerated by low temperatures and impact of road salt. Harness kinks in this area may cause short-circuiting between supply and signal wires as well as disconnecting the supply from the loads. In order to prevent such problems, specific methods of attaching the harness are used, so that vibrations are carried along the entire surface and thus eliminating local stresses (Fig.6). It is also recommended by good practice to use initial clamp about 10 cm from the contact, this helps to attach the harness more accurately.

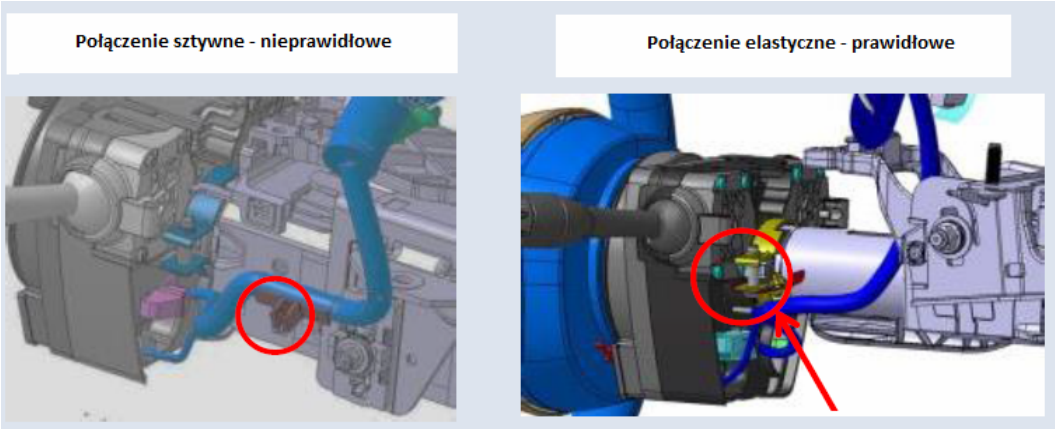

Fig.6. Rigid (left) and elastic (right) attachment of harness

6. ELECTRICAL HARNESSES IN EV

Modern electrical vehicles are equipped with high voltage wires. HV harnesses are fitted with orange insulation to make them easily recognizable. These wires should be fastened with special clamps, which would carry would-be emerging potential to the car body. Electrical harness in EV is shown in Fig.7 together with points, from which possible potential should be transferred to the car body.

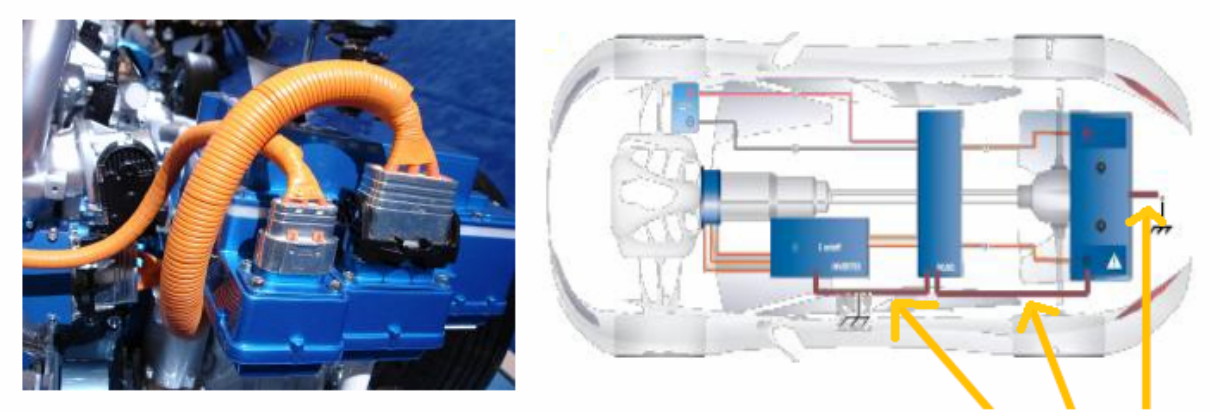

Fig. 7. High voltage wires and locations from which possible wire insulation potential might be carried away

Design of high voltage wires is most important on account of possible EMI in passenger cabin. High voltage wires must be protected with special insulation (and differentiated by orange colour). HV harnesses must not be carried close to ground points and signal wires (buses). Strong electromagnetic interference may be present in the neighbourhood of HV wires, that is why it is so important to separate these wires from other

harnesses. Fig.8 shows the layout of hybrid vehicle with detailed HV installations (the most important requirements as to design of HV wires are also presented in this drawing).

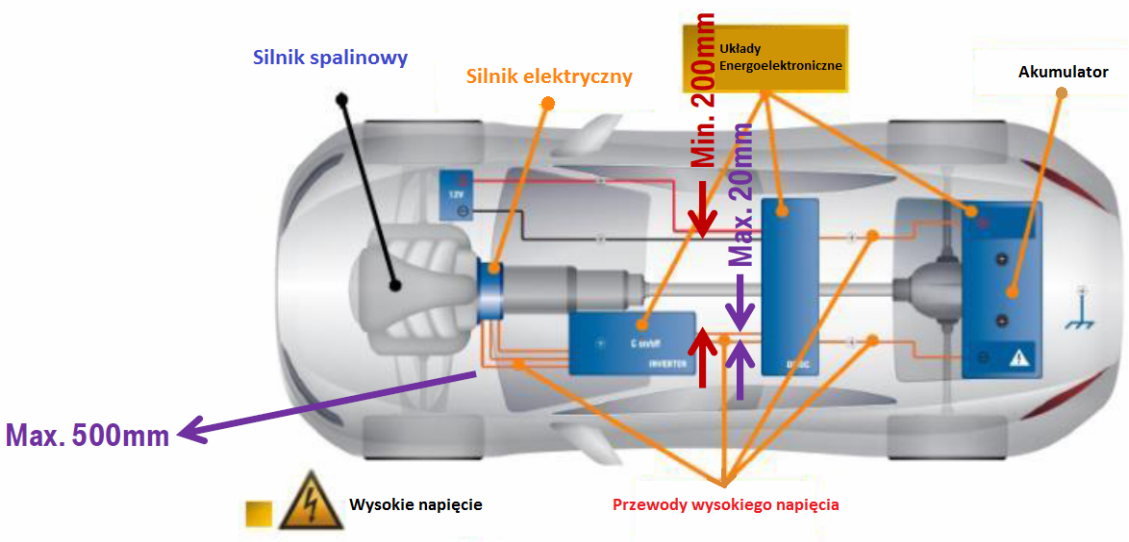

Fig.8. HV installation in hybrid car

7. SHIELDING IN ELECTRIC HARNESSES

Application of shields in car electric harnesses is important on account of possible interference in data transmission systems. Incorrect protection of electric harness may also lead to perturbations in injection system. In order to prevent these problems, shielding of electric harnesses must be used. Method of connecting shields in car electric harnesses is shown in Fig.9.

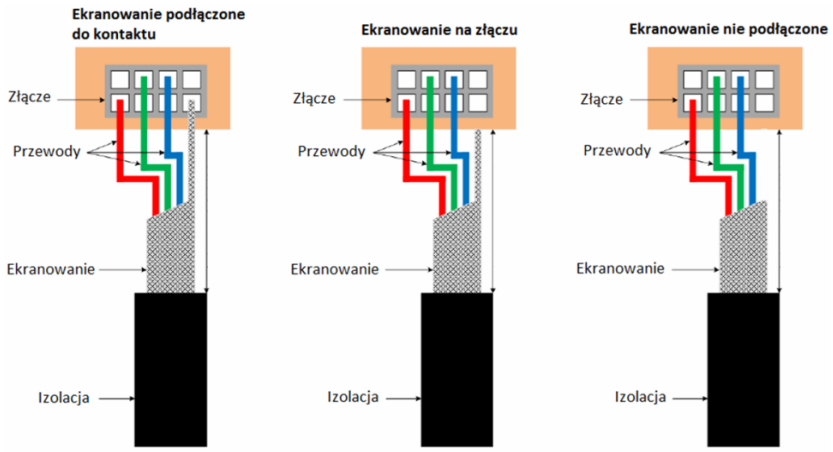

Fig. 9. Shielding in car electric harnesses

8. DEFECTS OF ELECTRICAL CONNECTIONS

Burned out contacts in fusebox (Fig.10) is a popular problem in badly-designed electrical installation. The reason for this lies in incorrect selection of harness cross-section (not suited to electrical circuit load). Insufficient heat removal from electric wires leads to increase of resistance and possible damage of wires and connector. Wire cross-section, contact area and type of plug must be adapted to the loading of electric circuit. It is also important to protect electrical harnesses from vibration (wires must be correctly secured). Vibrations may cause loosening of connectors and this in turn may lead to overheating and burning of contacts.

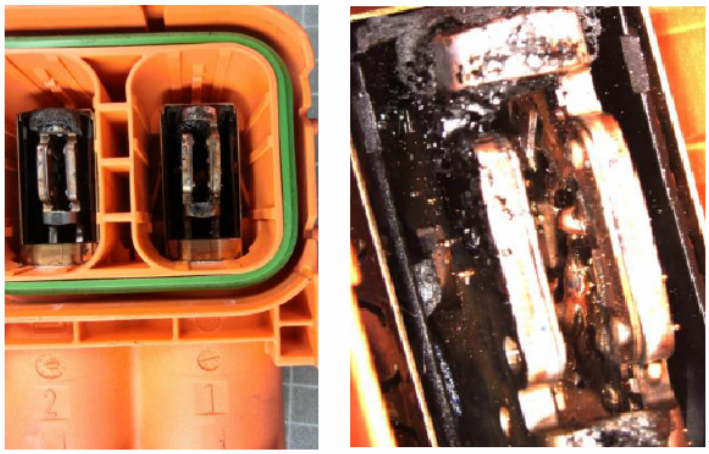

Fig.10. Burned-out contacts in the fusebox

9. CONCLUSIONS

Errors occurring in design of vehicle electrical installations have been presented in this paper. These errors have been identified in the course of tests run during normal car service. Good practice and repair methods make it possible to optimise production process and assembly of electrical installations in cars. This leads to optimisation of manufacturing costs as well as to ensuring better quality of end product, i.e. car. Specific situations such as insulation and connector damage have been identified during ageing and laboratory tests run prior to elaborating this paper.

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