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Research paper

Energy Saving for the Suburban Rolling Stock

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Abstract

This article is concerned with the problem of energy savings and rise of comfortableness of railway rolling stock. Done analysis has shown the insufficient paying attention to the energy efficiency of suburban rolling stock. In particular, to the problem of heat comfort for passengers. For this purpose, a procedure was carried out for the thermal audit of electric trains, taking into account the prevailing array of required indicators. To determine the sites of local heat losses, there was done the thermal-imaging inspection of the electrical train ER2 series during which it was determined the local sites of heat losses and entry of cold air. Besides the passenger compartment, there were inspected the outer body liner and driver's cabin. As a result of inspection of driver's cabin, it was found the bad quality of a sealing layer for side small windows from one side. On the basis of inspection, the recommendations for elimination of found irregularities were developed.

Keywords: *Energy audit, thermal imaging inspection, multiple unit, energy saving.*

1. Introduction

The main task of multiple unit operation is the provision of timely carriages of passengers in comfortable conditions. The important factor for potential clients during the choice of means of transport with time becomes the quality of service which has to rise permanently and maximally approach to high world norms. For this purpose, the factored package approach to issues of optimal use of production resources of each and all categories, such as labor, temporal, fuel, energy, material, financial etc. should be applied.
Thus, provision of comfortable conditions for carriage of passengers on trains of suburban traffic is the important direction for the rise of competitive capacity in railway as a general principle [1,2].

2. Analysis of Literature Data and Problem Statement

Multiple works are dedicated to an energy audit of railway transport. The most of them are related to the realization of an energy audit of railway facilities [3-5] and audit of lube fuel consumption [3, 5-8]. Herewith, the determination of energy efficiency of rolling equipment in the context of heat saving and creation of comfortable conditions in passenger compartments of suburban and passenger trains was not considered.

3. Purpose and Tasks of Research

The purpose of research consists in determining the sites of heat energy losses while operating the electrical trains.
In the furtherance of this goal it is necessary to solve the next tasks:

- development of the map of thermal-imaging inspection;
- thermal-imaging inspection of external and internal surfaces of electrical train body;
- based on the obtained data of thermal-imaging inspection it is necessary to determine the sites of heat energy losses for their further elimination.

4. Main Material

Implementation of the multiple unit energy audit is the important and promising direction on rises of comfort and energy saving in the rail sector. Thermal-imaging inspection allows to detect the insufficient heat proof of passenger compartments, unsatisfactory installation of windows and others weaknesses in heat saving. Especially it is very important in winter.
The thermal-imaging diagnostics is performed by an infra-red device and auxiliary devices for accurate calibration of temperature fields. As the latter one should use the dot pyrometers.
The important stage of the diagnostic procedure is the development of the map for facility inspection by the infra-red device. The necessity of use of that map is associated with volatility of thermal fields after full stop of the electrical train at the depot during position of it indoors. Herewith different factors begin to influence on the outside of rail-cars which make difficult to determine the sites of heat losses.
In such a way the different level of solar illumination of rail-cars leads to the difference of temperature readings. In addition, the important factor is the difference between the temperature of rail-car surface and room where the audit is carried out. So, the audit procedure begins with outside surface of the body with closed self-closing doors. In case of unequal impingement of sunlight on side faces the inspection begins from the side which more illuminated by direct sunlight.
Using sources [1-10] the procedure of energy audit of multiple unit was developed which is shown in Fig. 1.

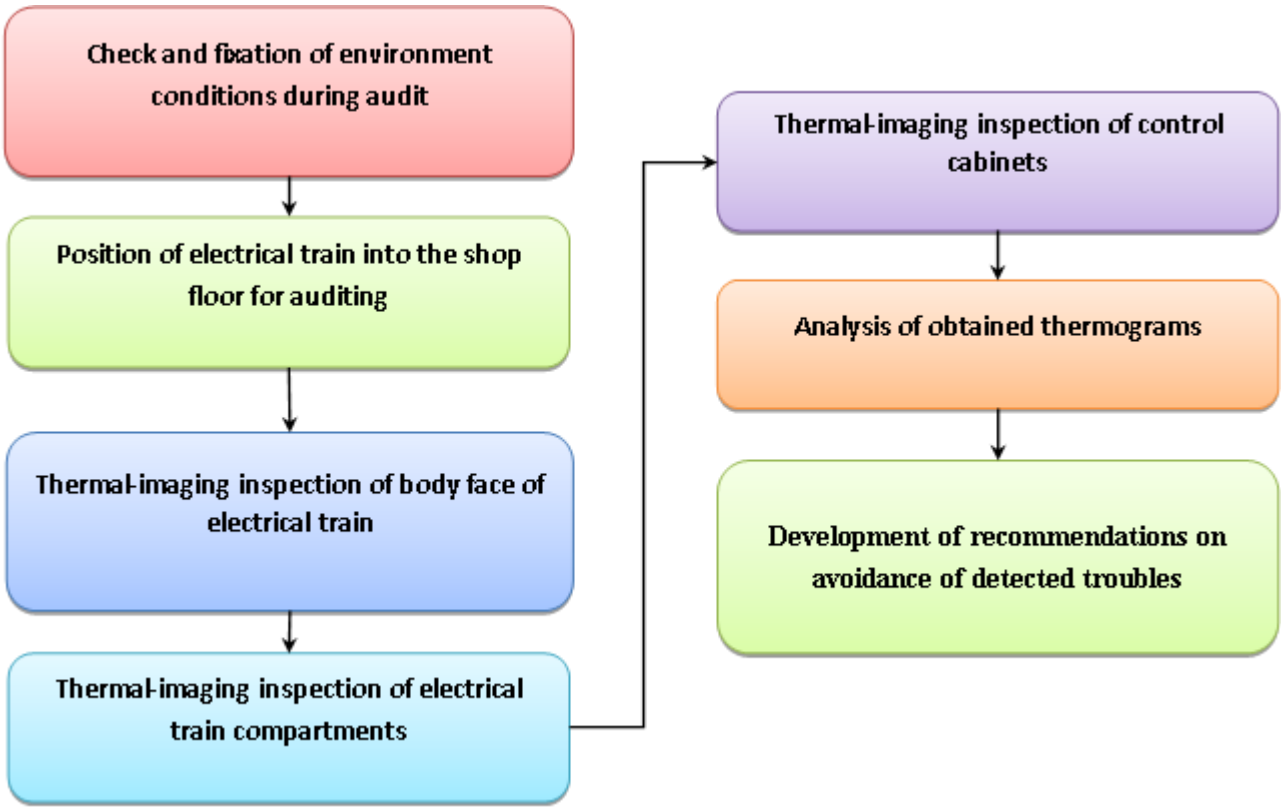


Fig. 1: Procedure of thermal-imaging inspection

Using the expert method, the array of parameters was determined which are defined and the assemblies that need to be energetically evaluated. These parameters and assemblies include: ambient temperature, atmospheric pressure and humidity, room temperature, electrical train's body surface temperature, temperature difference between some parts of the surface, temperature difference between similar parts of different rail cars that run in the same operation conditions.

One of the energy audit stages has been performed for one of the electrical trains ER2R according to the developed procedure. Audit results have shown the following.

Most heat losses in electric trains occur through the doors. So, Figure 2 shows a thermogram of examination of the outer door surface of the electrical train compartment and their usual image.

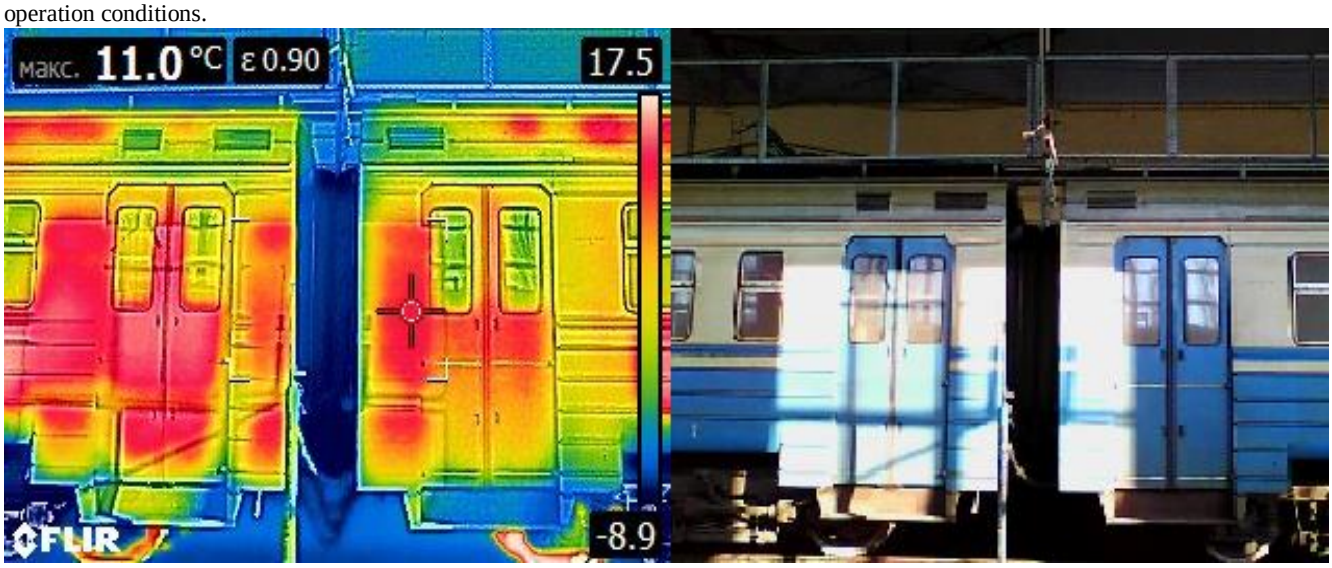


Fig. 2: Thermogram of the electrical train doors

The thermogram clearly demonstrates deficiencies in thermal insulation of the doors. So the surface of the door is in the range from 0°C to 14°C, while the difference between adjacent train cars is almost 5°C. This indicates significant heat losses in the left (on the picture) train car.

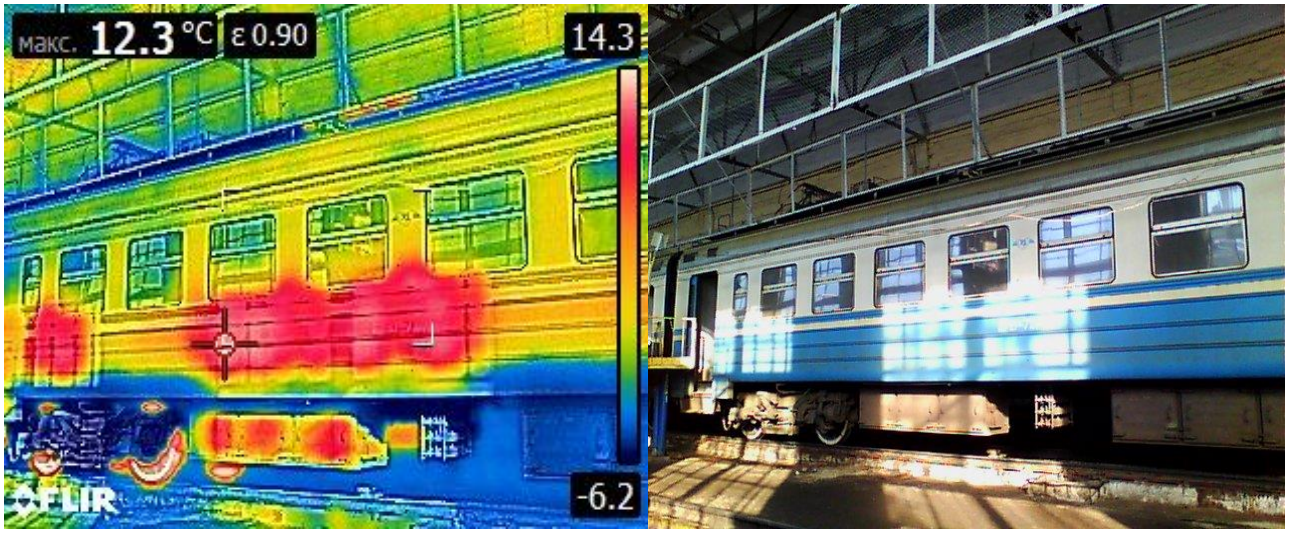
Detailed examination revealed a malfunction of the internal doors between the electrical train compartment and the vestibule as well as poor thermal insulation of train car sheathing.

Figure 3 shows the example of a diagnostics of the outer surface of the train car.

The performed diagnostics revealed a defect of the quality of the insulation sheathing of the train body around the windows. In this case, the operation of windows and their insulation does not need replacing.

Similarly, a survey of the condition of the car internal surfaces (Fig. 4) and the passenger compartment of the car was performed (Fig. 5).

a)



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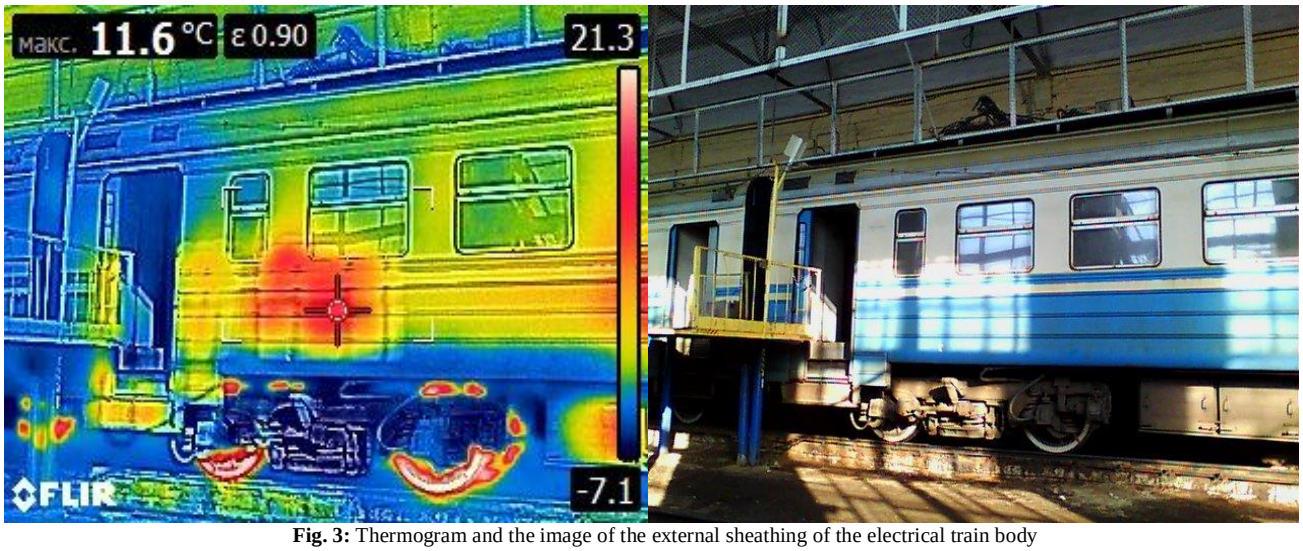


Fig. 3: Thermogram and the image of the external sheathing of the electrical train body

As a result, it was revealed poor fit of the sliding window from the side of train driver (Fig. 4a) in comparison with other parts of the cabin (Fig. 4b), and the same window from the side of the assistant driver (Fig. 4c). Thus, the need to replace was identified of the vent window seal to ensure proper operational conditions for the locomotive crew.

The checking of the status of insulation in the passenger salon has identified the need to increase attention to the insulation in the train body and joints of the windows. So, the audit identified the most vulnerable places – the corners of the windows (Fig. 5a and b).

Figure 5b shows the unsatisfactory performance of window installation. Due to the gap between the window frame and sheathing the cold air in winter and hot air in summer enters in the passenger compartment. Passing through the gap the air flows to the passenger seats and change direction of movement go around the junction of the seat and the skin. It causes the discomfort of passengers and makes worse the work thermal conditions in train car followed by the rise of electrical energy losses for passenger salon heating. Taking into account that the rise of movement speed rises the air quantity that passes through the gap and as a result, it leads to the rising of the losses for the heating. The detected local defect of quality is removed in conditions of the motor-train unit depot.

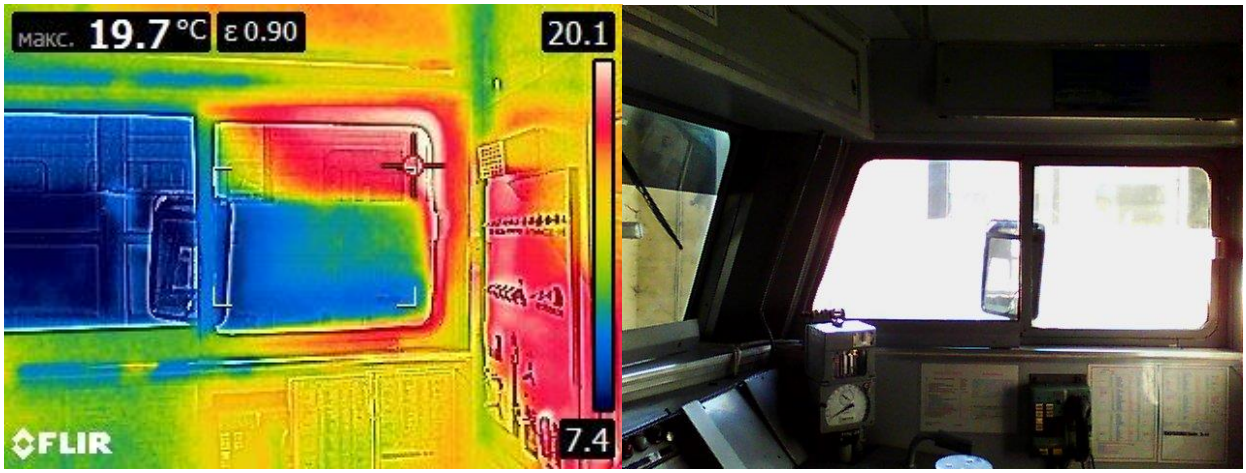
Troubleshooting associated with heat losses will allow reduce the costs of electric energy for the heating of passenger salons of electrical trains. For another thing, it is increasing the comfort of the passenger cabin and the control cabin.

As a result of the performed audit, the recommendations are worked out for recovery of thermal insulation of the body of the electrical train and for replace of the joint sealing.

In addition, complex application of thermal imagers and pyrometers for diagnosing the condition of electrical connections or circuits is a promising direction of increasing the efficiency and reliability of multiple units.

Timely detection of such faults leads to a decrease in specific losses in conductors reduces the possibility of burnout of the contacts of contactors improves the reliability of solder joints and the reliability of electrical insulation of conductors, including conductors of electrical machines.

a)



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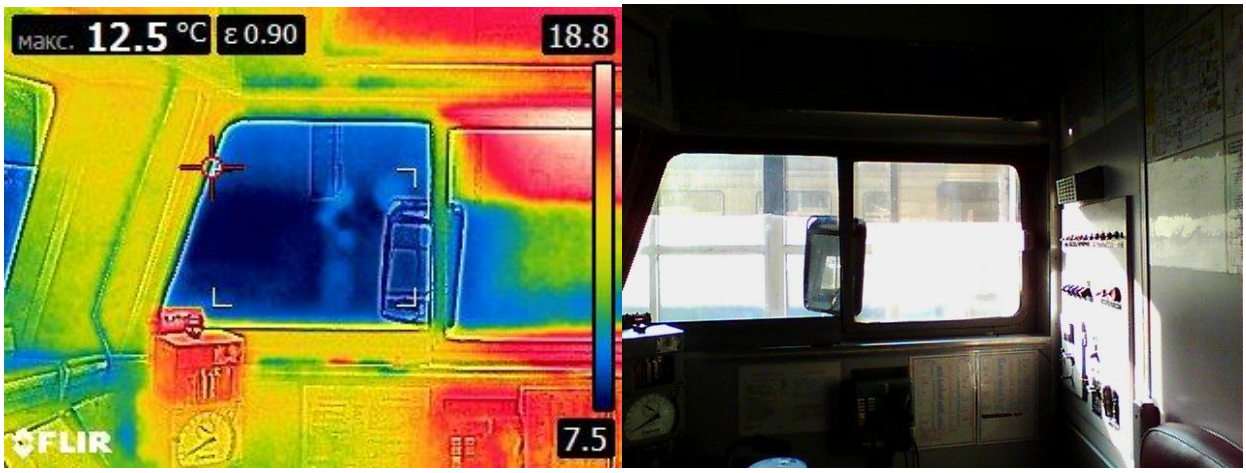

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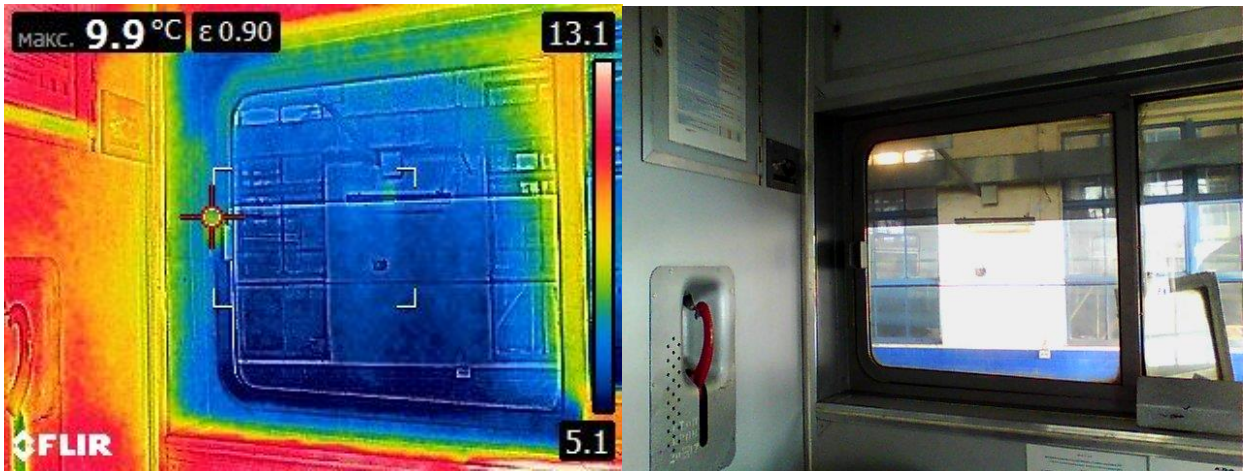


Fig. 4: Thermograms and images of the driver's cabin windows from the driver side (a, b) and from the assistance driver side (c)

5. Conclusions

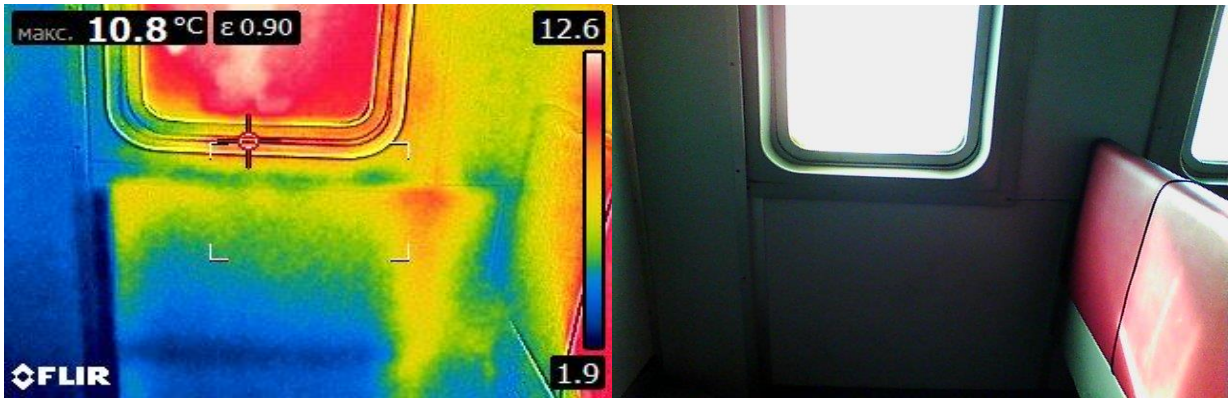
In view of the above, the concepts to improve comfort and energy efficiency of suburban rolling stock should be developed to meet the needs in passenger transport in terms of growing competition between different modes of transport, the introduction of energy management in all spheres of railway transport.

The thermal imaging audit of electric railway cars was developed taking into account the array of required factors.

The thermal imaging audit of electric trains has found out the insulation defect sites. Based on its findings, recommendations for the local elimination of founded defects were offered.

Further development of implementation of electric train energy audit requires the development and implementation of energy passport for each electric train car and electric train in all.

a)



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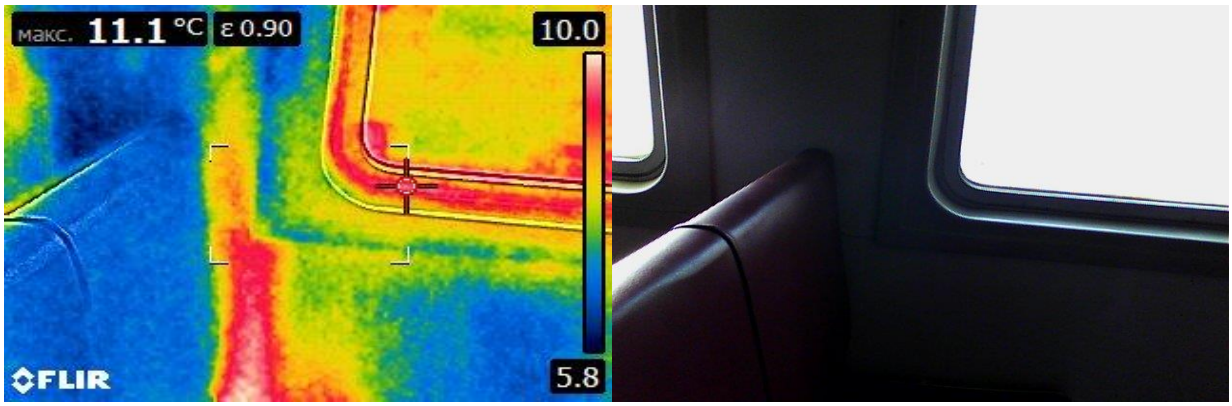

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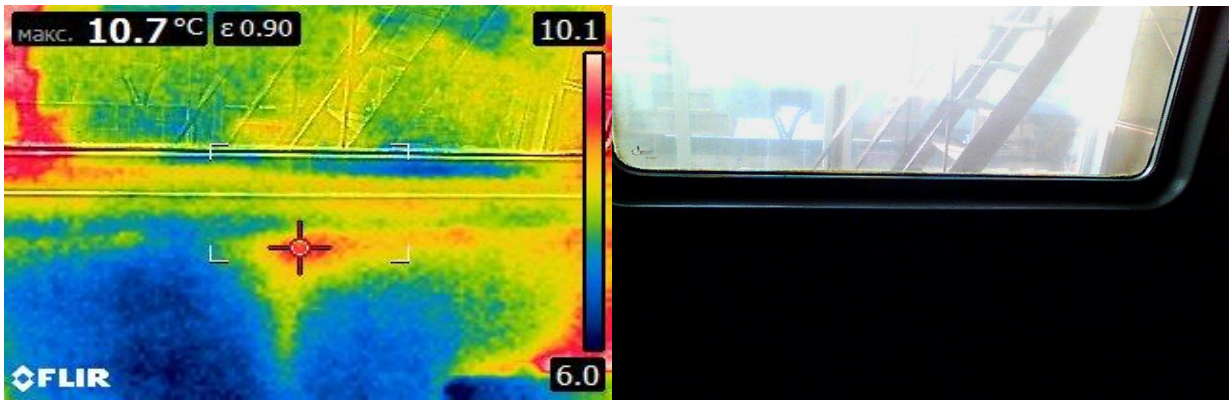

Fig. 5: Thermograms and images of the internal

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