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# Thermographic Assessment of the Quality of Electro-mechanical Relays in Railroad Automation

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***Abstract****: The reliability of the series can be ensured at higher electric current values during the commutation process by employing thermal imaging to assess the quality of an electro-mechanical relay during manufacture. Thermal photography is used during exploitation to help identify which contacts require replacement and to offer information about the extent of contact wear. The length of gas discharge is measured using thermal imaging, and this length serves as a gauge for how quickly the contacts are wearing out. A technique for evaluating the quality of electro-mechanical relays, which are specifically designed for switching strong electrical circuits used in railway automation, is provided in the article.*

***Keywords****: Thermography, quality, NDE, and electromechanical relays*


## I. Introduction

One of the most useful diagnostic techniques for predictive maintenance is thermal imaging. The creation of non-contact infrared, or "heat," images that allow for temperature readings is known as thermal imaging, or thermography. Thermography enables remedial action prior to expensive system failures by identifying irregularities that are frequently imperceptible to the human eye. For quantitative temperature analysis, portable infrared (IR) imaging systems scan structures and equipment, instantaneously converting thermal images into visible photos [1]. Non-contact full-field techniques known as quantitative infrared thermography (NDE) use an infrared camera equipped with digital sensors to identify minute temperature variations caused by various sources [2].

The latter may take the shape of an electromechanical burden that is applied irreversibly. The general objective is to apply thermomechanical deformation to the material or structure in order to generate spatial changes in surface temperatures and enable correlation between the observed infrared field and surface stress or strain. A tiny cyclic load applied to isotropic materials under adiabatic and reversible conditions will cause minor, repeated temperature fluctuations that are proportional to the sum of principle stresses. Currently, completely relay systems are still used by railway automation to manage train traffic.

Relays with certain constructions—that is, components with asymmetrical failure—have been employed. In these components, the likelihood of failure type $0 \rightarrow 1$ (rather than logical 0 in the event that the exit fails to appear logical 1) is marginally lower than the likelihood of transition $1 \rightarrow 0$. On the basis of that, the security systems are combined so that in the event of a system breakdown, the transport process won't develop dangerously. This does not cause the machine to crash; it just causes motion suspension. This type of technology uses more than 100 relays for middle-sized train stops. The wear and tear of the contacts and their ideal replacement schedule are major issues for train traffic.

## II. Preconditions for Research Methods In Thermography

The contacts operate under four different regimes. Wearing out, physical processes, and electrical conditions are the causes of the discrepancy. We are interested in two of these principles: opening contacts and closed contacts. The transience resistance R0 is the primary parameter for closed contact. The contacts' common ground point is not spread across the entire covered area. Regardless of how well-polished the contacts are, there will always be some projecting areas where the contact was created. Electricity lines and currents are accumulating at the points of contact.

The density resistance $R_c$ is defined as follows. It is dependent on the contacts' material, pressure, and total shared surface. The number of contact sites increases in tandem with an increase in contact pressure. The resistance of the thin layers that grow on the contacts' surface also affects the contact resistance. As the connections deteriorate, transience resistance rises during operation. The accumulation of the lines, the count, and the total contact surface can all be seen on a thermograph. To ensure dependable relay operation at high voltage commutation, the defective contacts can be eliminated in this way back at the production stage.

Thermography can be used in the exploitation process to identify which contact closures need to be replaced and to offer information about the degree of contact wear. The resistance changes from R0 to ∞ when the contact is opened. There is tension between them when they open their contacts. Since there isn't much space between the connections at first, discharge phenomena could develop. These phenomena have to do with destroying or moving materials from one point of contact to another. If demolition doesn't take place, the roughness and the closed contact's transience resistance both increase significantly. This is what the term "contacts wearing-out" refers to.

Inductivity, the rate at which the voltage drops, and the active resistance of the circuit are all closely correlated with the magnitude of the stress that occurs. The development of discharge phenomena and contact wear are subservient to the inductive properties. It is impossible to completely prevent those phenomena. The issue is what circumstances should be established to swiftly halt these undesirable occurrences.

## III. Methodology of Thermography

A FLIR P640 infrared camera with 240 and 50 µm close-up lenses is used for thermographic studies [1]. Thermography relies on the real-time operation of relays. Sequences with varying repetition frequencies and commutation voltages have been captured in the photograph. Additionally, an expedited test of the relays' wear-out was conducted. Under equal commutation voltage, the resistance and temperature alternate, which is the wearing-out criteria.

It was discovered during data processing that heat is produced deep within a relay's construction, where thermal insulation between the heat source and the surface the infrared camera observes (indirect measurements) has been lost. The tested relays were disassembled to verify the conclusions drawn after determining the areas with elevated temperatures and outlining potential causes.

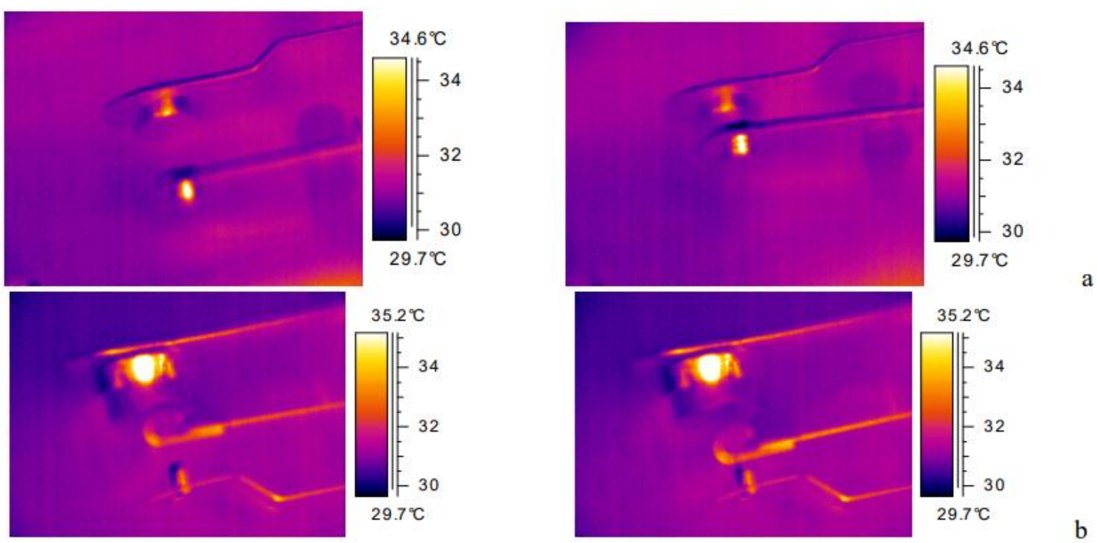


Fig 1: Thermograms of new contact closures commutating at idle: a) contact type metal-metal and b) contact type

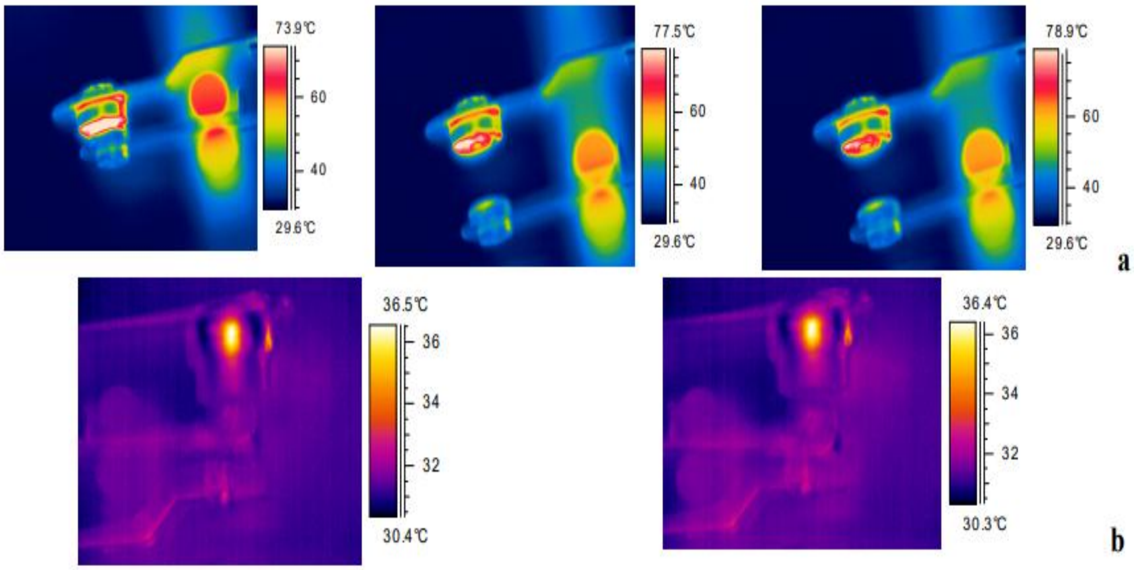


Fig 2: Thermograms showing a) an old contact closure type carbon-metal and b) a new contact closure type metal-metal

Data processing for thermographic images occurred through ThermaCAM Researcher Pro 2.9. ThermaCAM Researcher Pro 2.9 serves as an application for handling thermogram information from hermetically sealed relays with fresh contact operations (Fig. 3). A comprehensive investigation of the carbon-metal worn-out contact uses Figures 4 for its 3D picture and thermogram together with contour analysis data. Studies during the investigation stage revealed that circuit power linked directly to the contact system temperature measurements.

For the research the investigators utilized open and hermetically sealed relays. The research determined the temperature of specific commutating elements during switching circuit commutation by measuring both sealed and unsealed relays with synchronized and unsynchronized frequency frames.

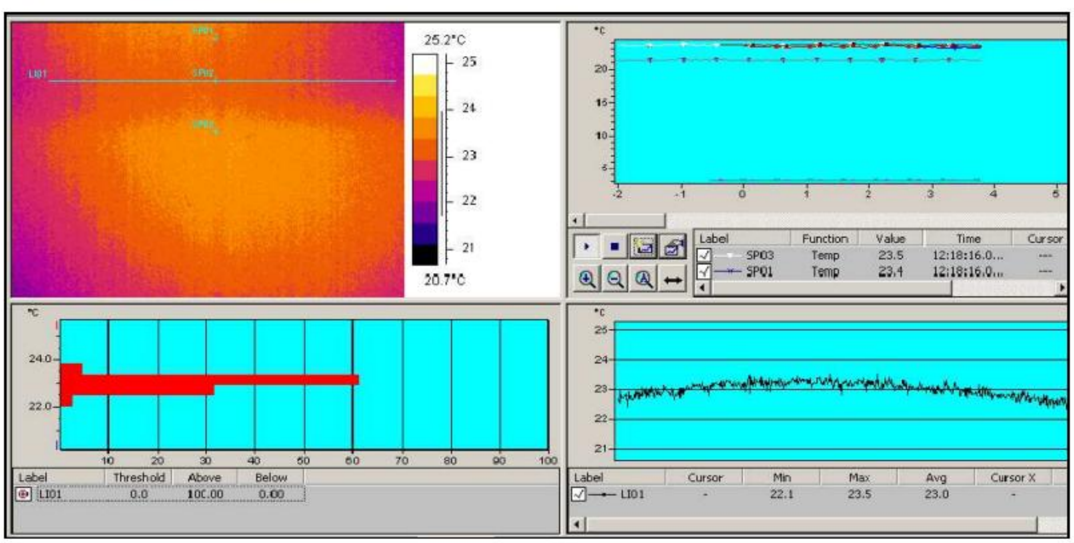


Fig 3: Results of 200 sequences of a new contact closures for hermetically sealed relay.

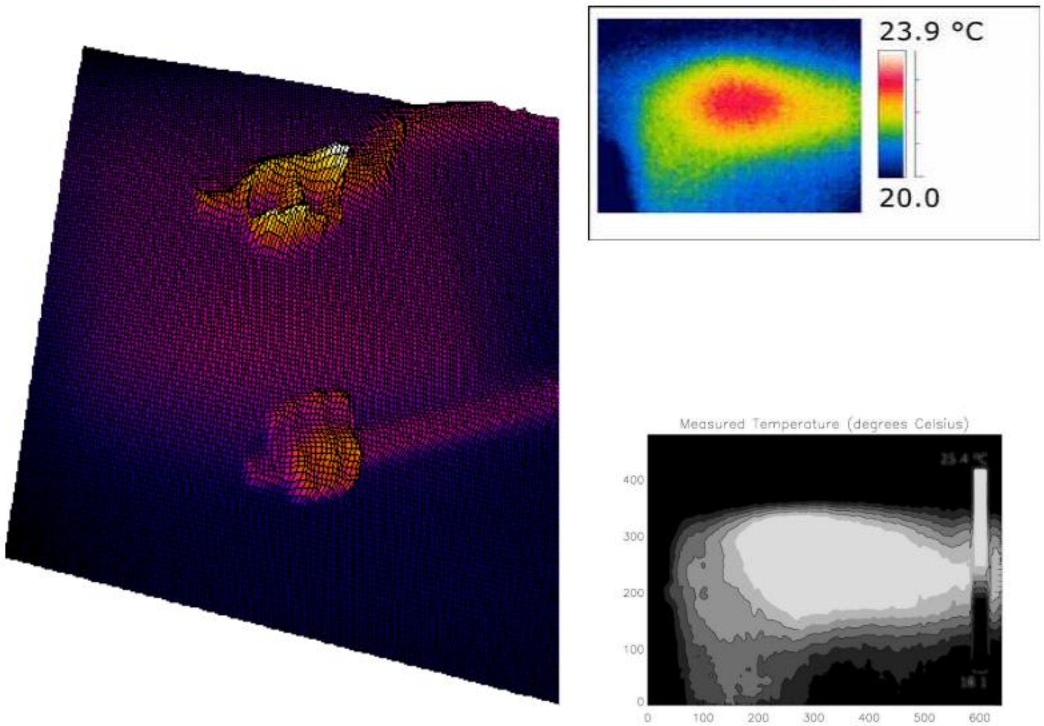


Fig 4: On the left is shown 3D view of a non-package contact closure. On the right (up) are shown the thermogram and contour picture (down) of the same packaged relay contact closure.

The method that was created compares the picture thermal histograms of the same item under various load stages. The software view is displayed in Fig. 5, and the thermal histogram of the same contact closure for the temperature range of $29^0$C and $49.4^0$C is displayed in Fig. 6.

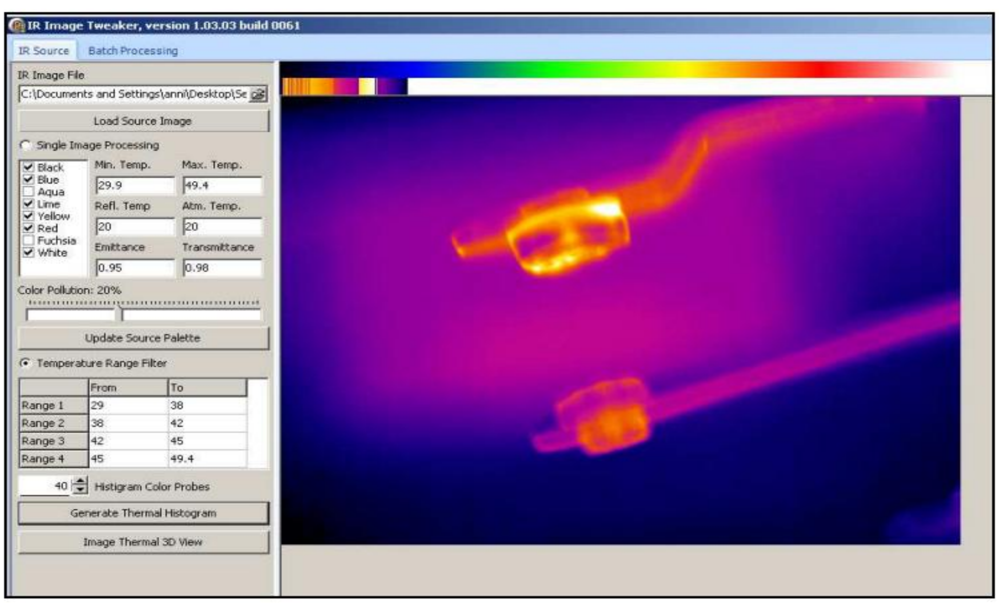


Fig 5: A view of the software of relay contact closures evaluation

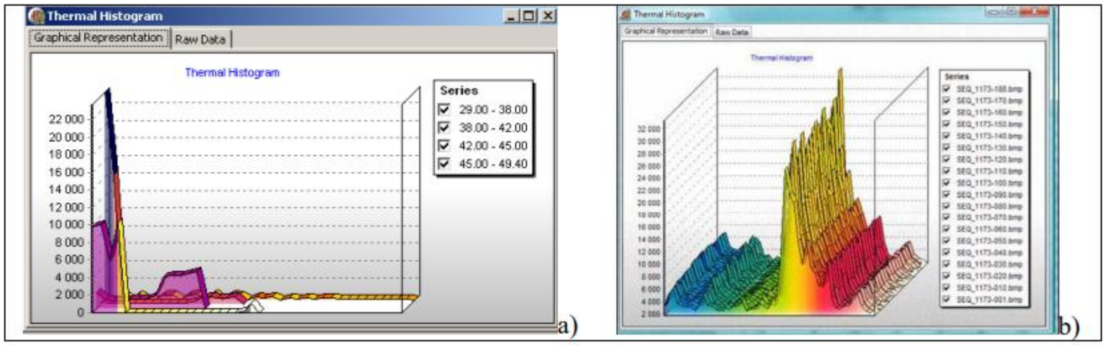


Fig 6: Thermal histograms: a) for a single thermogram and defined temperature ranges and b) batch thermal histograms of a good contact for sequences

Four arbitrary temperature ranges can be used to compare the thermal histograms. When a succession of thermograms of the same object are processed in batches, they are done at varying working rates (corresponding to varying surface temperatures). Depending on how long the transition process takes, a single snapshot can be created either automatically by establishing a time interval between each individual snapshot with a frequency of up to 30 Hz or after thermodynamic equilibrium has occurred.

Snapshots can be taken at intervals longer than 10 seconds when the camera is controlled by a computer. Thus, based on the resultant temperature histograms, a diagnostic and resource evaluation criterion for the tested relays was developed [3]. Locally elevated temperatures emerge on the surface as a result of hot spots forming in the vicinity of the contacts. The fault's severity and hot areas can be determined by online thermal scanning of these surface. Naturally, addressing these fault locations will lessen signal system failures and increase reliability.

## IV. Conclusion

This paper presents the results of thermo-monitoring techniques and infrared image processing when used for relay contact wear-out diagnostics. Railway safety equipment depends greatly on the solution of optimal replacement timing. The thermographic image enables users to track areas with high resistance as well as worn contact closures. Regular examinations allow users to discover faulty relays and find alternatives in order to replace defective contacts. A software program together with operational procedures was developed for determining contact closure lifetime in electromechanical relays.

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