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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. 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. 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. Research Methodology for Thermographic Analysis

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 Rc is defined as follows.

The contact resistance depends on the materials composing the contacts in connection with the total surface area shared between contacts as well as the force applied during contact. Increasing the contact pressure creates a rise in the contact points found between materials. The contact resistance depends simultaneously on the resistance value of thin surface layers that form on contact surfaces. In the working process the contacts wear out while transience resistance keeps increasing. The lines will accumulate through thermal imaging revealing both point density and complete contact area. Factory inspections permit the identification of unreliable contacts so reliable high voltage commutation can be ensured. A thermographic provides data about contact wear and allows for identification of problematic closures during exploitation processes.

III. Electro-mechanical Relay Evaluation

The research studied two electro-mechanical relay types including НМШ1-400 neutral relay devices designed for DC electrical circuit use in railway signaling centralization and interlock systems while НМПШ-900 neutral starter relays were specifically created for railway switching technologies. Multiple thermographic index signatures were recorded through different active load ranges starting from 0.7 A up to 4A and 2A and 8A along with different frequencies of 85 VA, 120 VA and 250 VA.

Thermographic signature data from new carbon metal and metal-metal contact closures and used contact closures served as the basis to measure wear-out degree and remaining resource values in contact closures. The examination method determined both contact closure resource values as well as their remaining functionality. The thermographic research utilizes an IR camera type FLIR P850 equipped with a 480 lens and 70 µm close-up lens. The real-time operational characteristics of relays form the basis of thermography. Different voltages of commutation combined with various repetitive sequences of the image made up the captured sequences. Additional testing was performed to speed up the deterioration process of the relays. Equal commutation voltage determines when the wearing-out criterion occurs through resistance and temperature fluctuations. The heat generation process takes place within a relays structure while thermal insulation fails to protect the surface area visible to the IR camera (indirect measurements). The analysis zone was identified before investigators decided on possible sources of temperature rise and conducted physical disassembly of tested relays to verify conclusions.

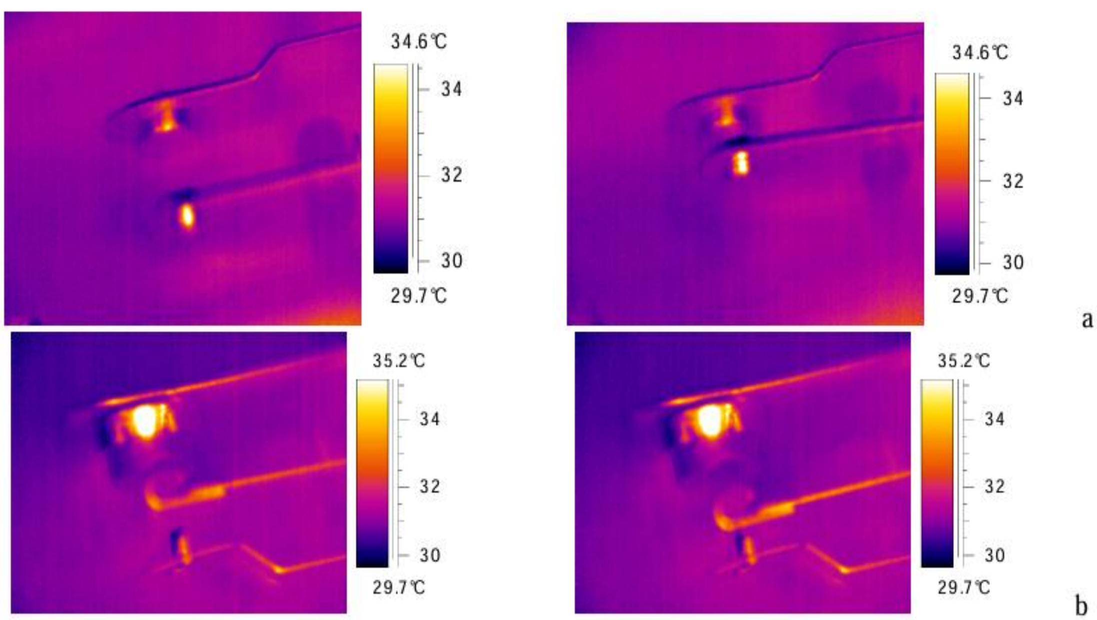

Fig 1: Thermograms: a. contact type metal-metal and b. contact type

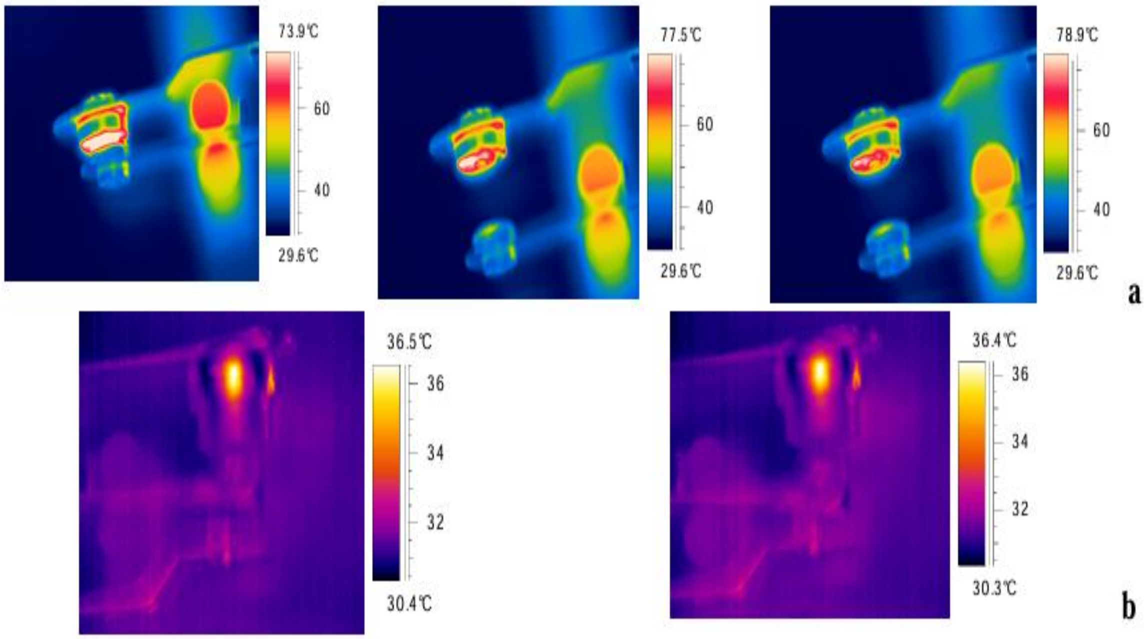

Fig 2 : Thermograms a. An old contact closure type carbon-metal and b. A new contact closure type metal-metal

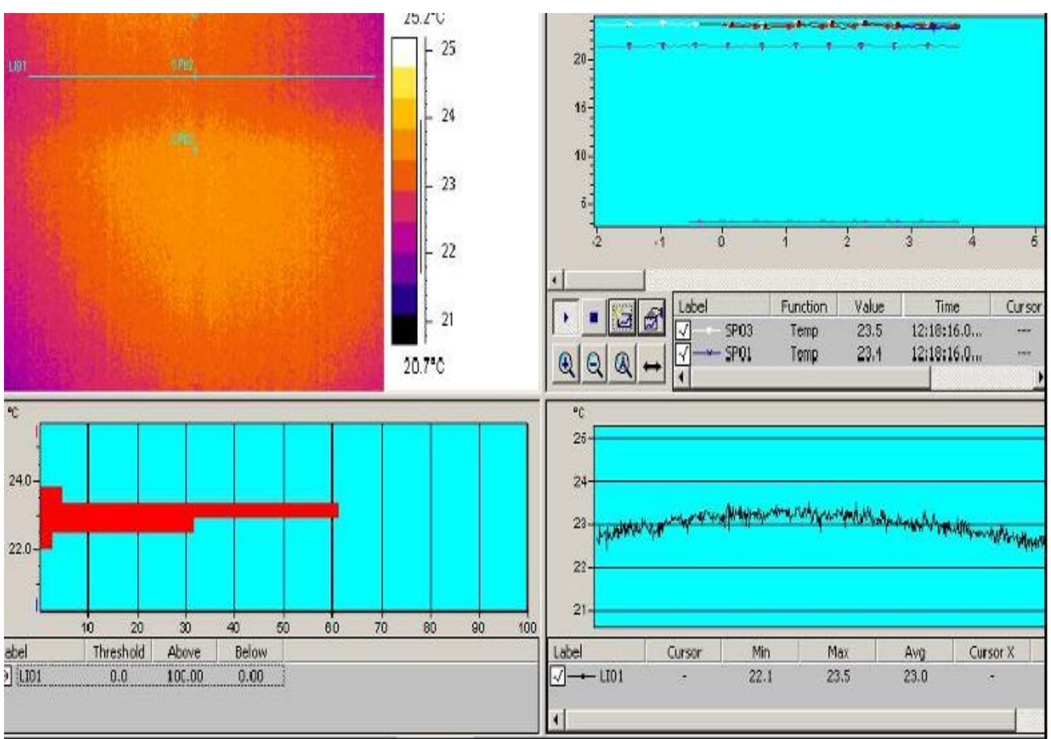

Fig 3: Results of 300 sequences of a new contact closures sealed relay

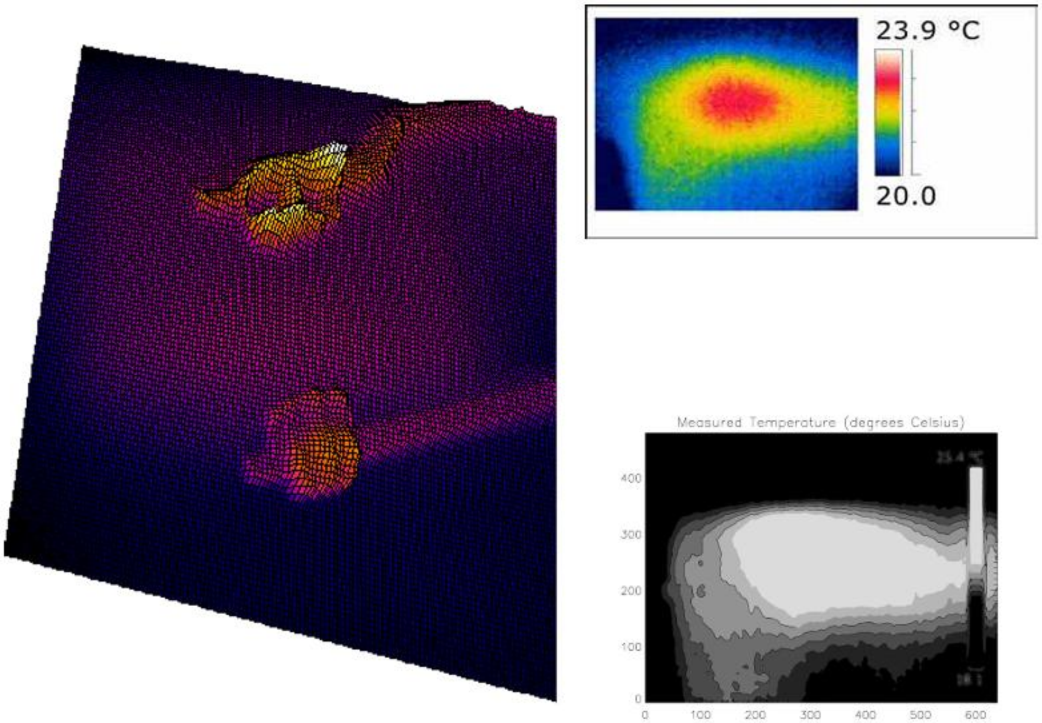

Fig 4: On the left - 3D view of a non-package contact closure. On the right-side top are shown the thermogram and contour picture down of the same packaged relay contact closure.

The method depends on analyzing thermal image histograms from the same object during various stages of loading. According to Fig. 5 the software shows its view while Fig. 6 presents the thermal histograms of the contact closure from 29^0 C to 49.4^0C.

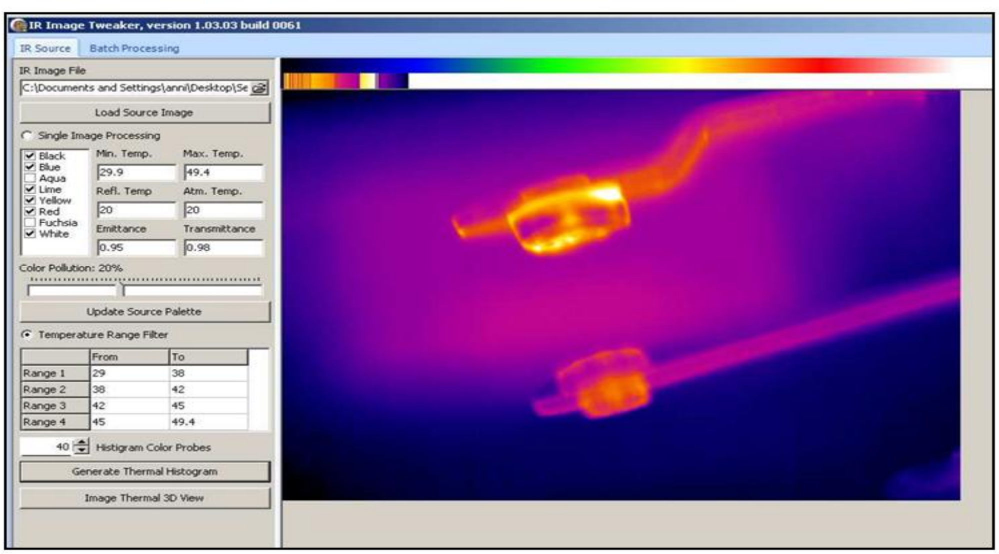

Fig 5: Software relay view

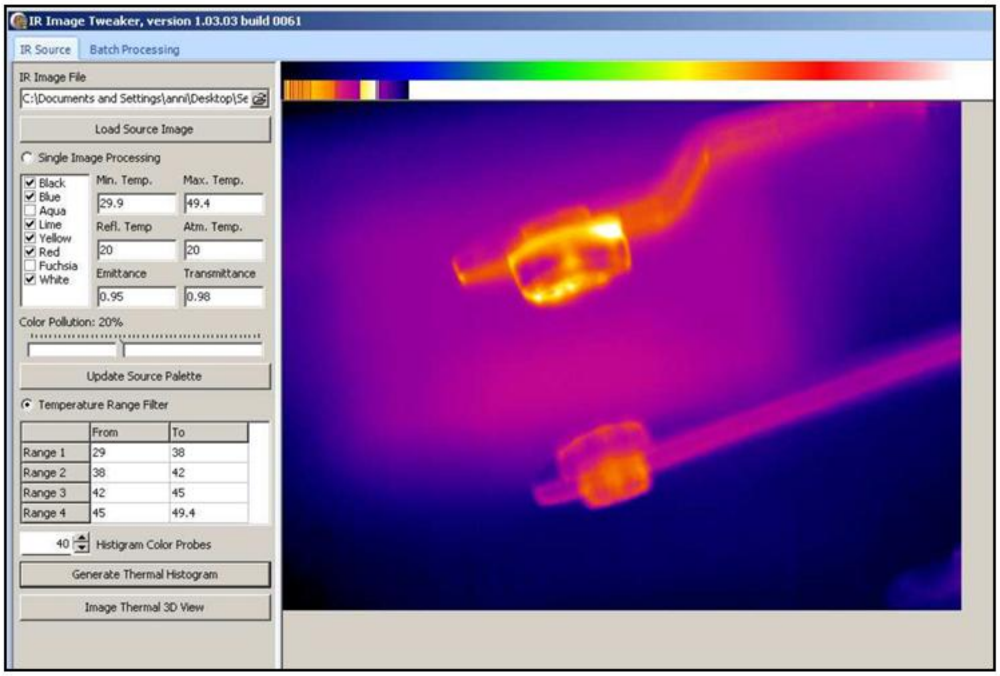

Fig 6: Thermal histograms: a) for a single thermogram and defined temperature ranges and b) batch thermal histograms of a good contact for sequences.

The assessment of thermal histograms happens through comparison stages throughout four arbitrary temperature ranges. Batch processing of series of thermogram images of one object needs different working rates to achieve various surface temperatures. When thermodynamic equilibrium is achieved or with a set frequency between 60 Hz, an individual snapshot can be generated during transitions. Through computer control the camera becomes able to record snapshots at extended intervals above 30 seconds.

IV. Conclusion

This paper demonstrates how thermographic methods when used with IR image processing detect conditions in relay contacts that lead to wearing-out. The solution which determines an optimal replacement schedule demonstrates exceptional importance when it comes to Railway safety equipment. The thermographic image shows locations where resistance increases alongside worn-out contact closures for monitoring. Currency inspections allow detecting faulty relay contact closures to enable either removal or replacement. Development of a methodology with supporting software took place to estimate electro mechanical relays contact closure resources.

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