Practical Infrared Thermography for Lift System Maintenance—A CBM Approach to Promote Lift Energy Efficiency

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Abstract: Infrared thermography (IRT) has been one of the most-effective condition-based maintenance (CBM) methods in determining the condition of a component or a system. Using such method in addition to vibration monitoring, chemical monitoring, and other electrical techniques, a set of information can be obtained which is used in predicting the life span of the component or system being tested. CBM provides necessary engineering and procedural recommendations to ensure that the system will not prematurely breakdown. Such tool is very essential in the lift industry since IRT can help maintenance engineers determine the conditions of some of the lift system's components and perform necessary corrective and preventive actions to prevent a potential fault. Furthermore, it is also believed that hot spots found on components in the lift system reduce its efficiency due to energy losses that is why special attention from the maintenance engineer is necessary. Literature on such application is already widespread, but discussions related to lift system maintenance is still something that needs to be considered. With such consideration, we present in this paper components and systems from a generic lift system in which IRT is applicable. Particularly, optical and thermal images are shown and are discussed in brief. This paper is written with the objective of having a simple guide when conducting CBM on lift systems using IRT.

Key Words: predictive maintenance; preventive maintenance; condition monitoring; emergency efficiency

1. CONDITION-BASED MAINTENANCE (CBM), INFRARED THERMOGRAPHY (IRT), ENERGY EFFICIENCY

Condition-based maintenance (CBM) is a discipline in maintenance engineering and technology that deals with the identification of the condition of a system and its subcomponents, with the sole purposes of determining its exact state and predicts its life span (Ahmad & Kamaruddin, 2012; Jardine, Lin & Banjevic, 2006). CBM is executed in conjunction with various maintenance methods such as preventive maintenance (PM) and total productive maintenance (TPM) to name a few. In CBM, it is important to determine the state of a component using various means related to temperature monitoring, chemical monitoring, vibration monitoring, various electrical and mechanical techniques, and signal processing. For temperature monitoring in particular, it is important since it determines the state of those components in which thermal signatures are quantitatively measured using various instrument. Quantitative and qualitative techniques are then being used in assessing and evaluating the condition of the components. These thermal signatures are obtained using various equipment and IRT is one of techniques being employed.

IRT use infrared thermograph which are absolutely expensive due to the technology being used, but are relatively cheap when compared to its return of investment (ROI). Since IRT can be used to find potential faults and prevent failures, there is a big possibility of having a huge amount of savings through its ability in helping prevent premature component failures (Bagavathiappan et al, 2013; Nazmul Huda & Taib, 2013). Another advantage of IRT is its ability in determining if there are components in the system that are not performing efficiently, in which examples are presented in the Chapter 3. Therefore, the authors believe that introducing and practicing IRT in lift maintenance practice promotes efficient use of energy.

2. THE LIFT SYSTEM

The lift system is composed of various mechanical, electrical and electromechanical components. Mechanical components include pulleys, hoisting ropes, overspeed governors, safety gears and buffers to name a few. Electrical components on the other hand include transformers, lift controller, motor drive circuits, etc. Electromechanical components are associated to hoisting motors, hoisting motor brakes and door motors as examples.

Discussion on how a lift system works is presented in (McCain, 2004), while details on codes related to technical compliance in the installation, maintenance and repair of such systems are presented in (European Standard EN 81-1:1998+A3:2009, 2009; European Standard EN 13015:2001+A1:2008, 2008).

3. PRACTICAL IRT APPLICATIONS IN THE LIFT SYSTEM—EXAMPLES

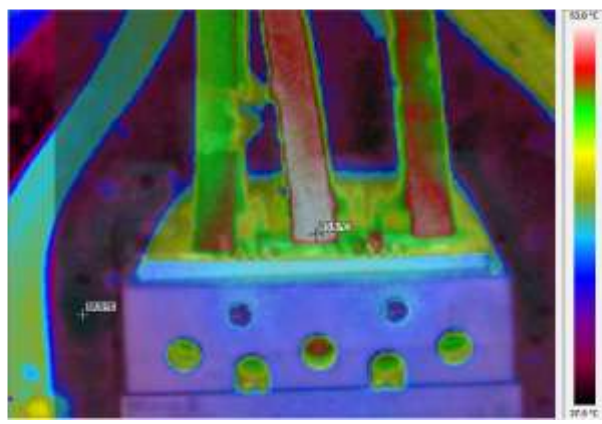

Fig. 1. Three-phase contactors should have balanced load lines. The 2nd and 3rd lines showing red marks seem to have heavier load as compared to the 1st line. For a balance three-phase line, the color differences should not be too different.

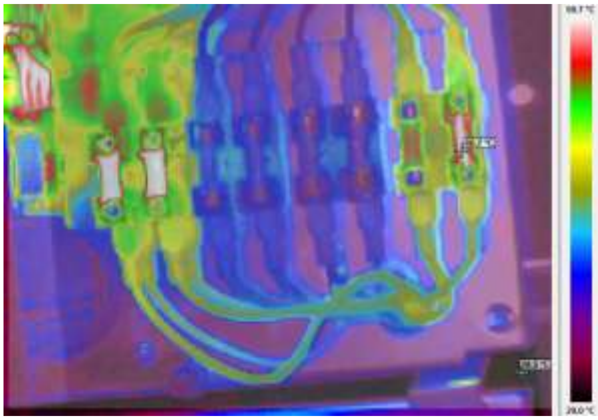

Fig. 2. Fuses should act as "short circuit" to allow the passage of current within its permissible range. However, a fuse that already acts as a resistor will heat up as shown in first two and last two fuses. Excessive heat in fuses corresponds to energy wastage.

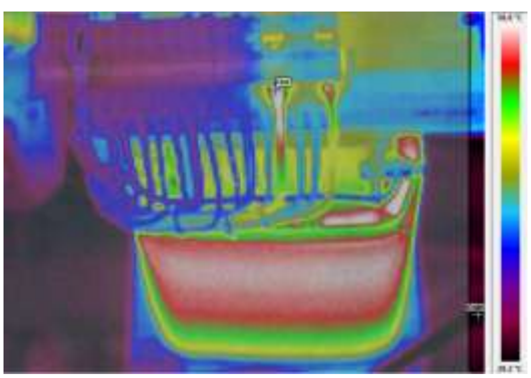

Fig. 3. A multi-tap transformer shows resistive terminals through its terminal hot spots. This may be due to loosen connections which will result in excessive heat.

Fig. 4. Similar to contactors and transformers, relays should have no resistive terminals causing excessive heat. All terminals should be retightened by the maintenance engineer.

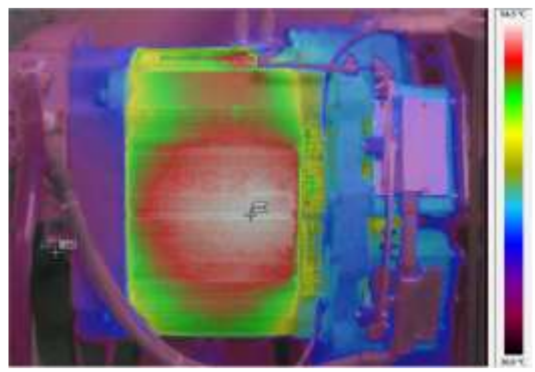

Fig. 5. Electric motor cages should have equal heat distribution due to the symmetrical construction of its stator. Non-symmetrical heat distribution means that some parts of the stator coil is already wearing off due to contamination, old age, or other degradation effects.

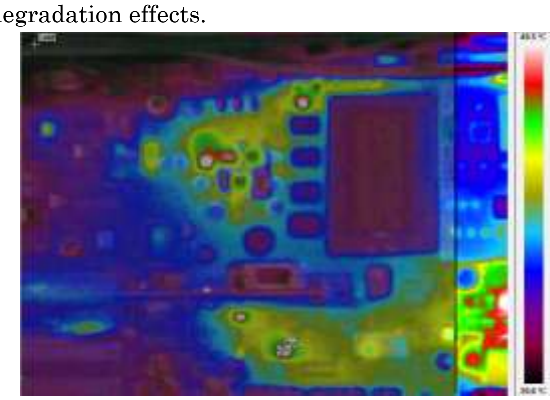

Fig. 6. Normally, printed circuit boards often have hot spots especially in those areas where microprocessors are placed. However, too much heat means that the circuit is heavily utilized.

Fig. 7. The tension of the springs in the guide rollers should be equal to support the lift car movement. This shows that one of its rollers are heavily in contact with the guide rails as compared to the other two.

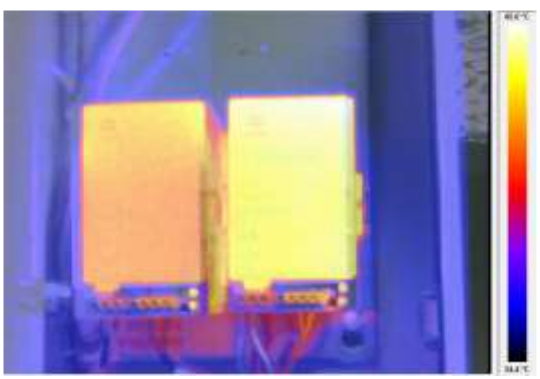

Fig. 8. Power supply modules' temperatures should be checked if they are overutilized.

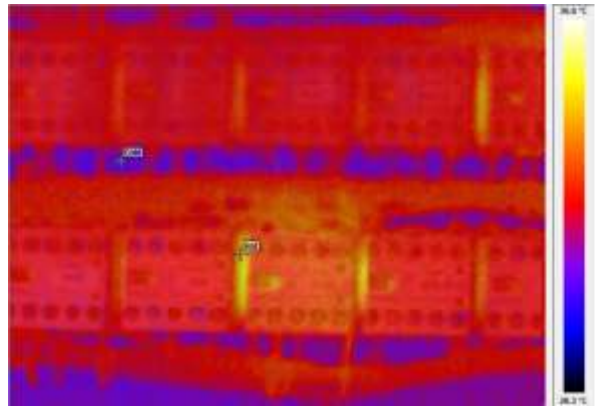

Fig. 9. Hot spots on the sides of the relays show that the internal coils may already be deteriorating. This can be concluded by comparing the thermal signatures of other relays within the vicinity.

Fig. 10. Printed circuit board showing severe operating temperature on a portion composed of transistors.

Fig. 11. Unbalanced lines seen in the contactor similar to Figure 1.

Fig. 12. Circuit breakers show hot spots which could cause potential failure in the future after continuous use. Such hot spots are usually evident on ageing components.

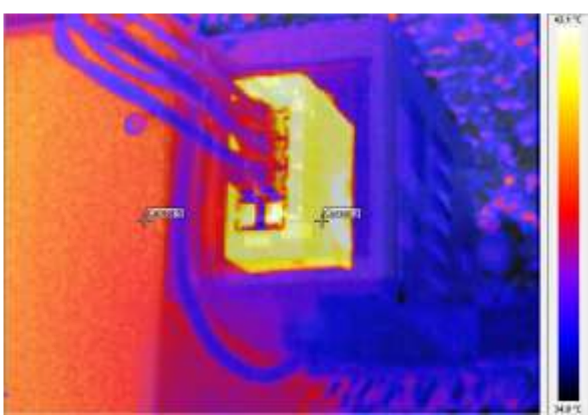

Fig. 13. Ethernet switch operates at around 42 degrees Celsius and could have been improved if the air in the machine room is well-conditioned and ventilated.

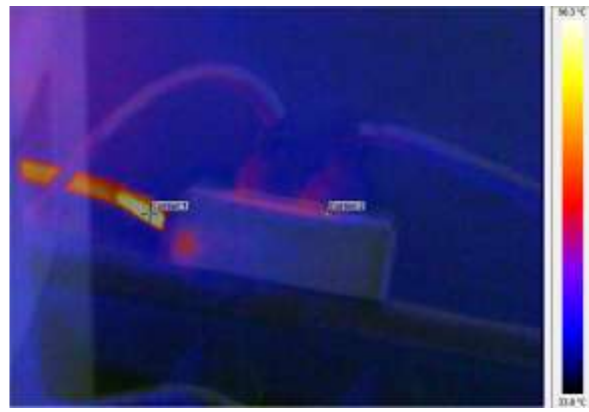

Fig. 14. Extension wire used does not seem to be capable of handling the load requirement.

4. ENERGY EFFICIENCY AND WASTED ENERGY EVALUATION

The computation of wasted energy from thermal images is difficult to obtain and requires extensive image processing algorithms and techniques. Furthermore, component-by-component evaluation of wasted energy is cumbersome and impractical. However, it is possible to determine such parameter, and eventual energy efficiency, by performing the necessary corrective actions such as component replacements, tightening works on electric terminals, motor reconditioning, etc. The difference between the energy needed for the lift to perform its function before and after these corrective actions shall be considered as wasted energy, and that could be used in determining the lift's efficiency.

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