Articles

Thermography – predictive maintenance technology for HVAC system reliability and safety improvements

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Sai Srikanth Pinisetti currently holds the position of service and parts leader for Trane in Europe. Sai joined Trane in 2000 and has held roles with increasing responsibility since then. Sai is a mechanical engineer with over 20 years of professional experience in heating, ventilation and air-conditioning projects, sales and services in Europe, Middle East and India.

In recent years, there's been a definite shift in how we approach building maintenance – from being reactive to proactive. With budgets under pressure many businesses are increasingly adopting a predictive approach as a means of controlling costs and reducing the likelihood of a heating, ventilation and air conditioning (HVAC) system failure.

Thermography service

Thermography is an easy and proven way to inspect electrical and mechanical components of a chilled water system in a non-invasive manner, without disruption to system operation. Like vibration monitoring, oil analysis and other forms of predictive maintenance, infrared thermography often spares facilities from minor periods of downtime at the least to catastrophic equipment failure at the worst. Early detection of potential, hidden issues improves overall HVAC system performance and also helps lower repair costs.

Infrared thermography uses infrared thermal imaging to detect and diagnose the thermal emissions of different components in the chilled water system. An increase in heat could suggest electrical and mechanical issues that can lead to component failure, unplanned outages and safety issues.

Typical problems that thermography can detect include finding loose electrical connections, cable wear, contactors and switchgear faults, and hot spots on PC boards. On mechanical machinery thermography I can be used to find overheating bearings, gearbox fault and shaft misalignments.

The thermography inspection method is based on the fact that most components in a system show an increase in temperature when malfunctioning. The table below shows thermal problem classification chart with comments and recommended actions depending on identified phase-to-phase temperature rise.

Thermal problem classification chart: problem classification	Phase to phase temperature rise	Comments
Minor	1°C–10°C	Repair during regular, scheduled maintenance. Little probability of physical damage.
Intermediate	10°C–30°C	Repair in the near future (2-4 weeks). During this time watch the load and change accordingly. Inspect for physical damage. Temperature rise indicates probability of damage in the component, but not in the surrounding components.
Serious	30°C–70°C	Repair in immediate future (1–2 days). Replace component and inspect the surrounding components for probable damage.
Critical	Above 70°C	Conduct immediate repair (overtime). Replace component, inspect surrounding components. Repair should be done while IR camera is still available to inspect the component after the procedure.

Figure 1. L1 cable on the connector to the left shows overheating due to a bad connection. This may be the result of a loose corroded connection.

Recommended action: repair and check afterwards if the overheating on the connection and cable has disappeared.

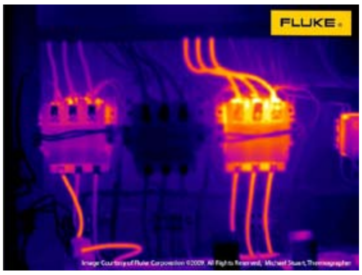


Figure 2. The connector to the right shows a higher temperature in all phases because of a higher electrical load.

Recommended action: verify with a clamp that there is no overload. If the load is under the nominal load, but the temperature is above the recommended (normally 70°C for PVC cables), check with a power quality (PQ) meter the presence of harmonics.

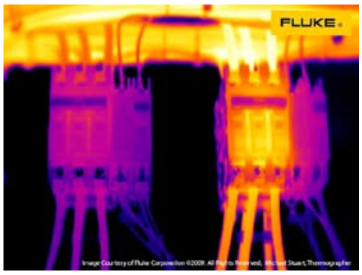


Figure 3. The image shows clearly that the L3 phase on the third connector from the left is overheated due to a bad connection.

Recommended action: guidelines provided by the InterNational Electrical Testing Association (NETA) say that when the difference in temperature (DT) between similar components under similar loading exceeds 15°C immediate repairs should be undertaken.

Figure 4. Fuses in L1 and L3 show overheating and non-uniform temperature.

Recommended action: check the loads for unbalance and if necessary replace fuses.

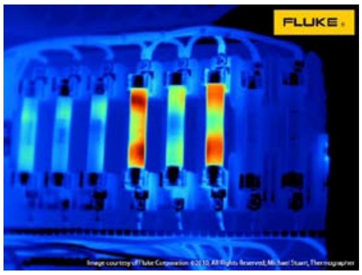


Figure 5. High resistance electrical connection on L3.

Recommended action: check load and difference in temperature (DT) to the other phases to determine severity (slight, moderate, severe or extreme).

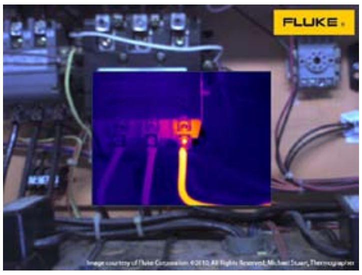


Figure 6. Electrical system inspection to check for loose connections. Load measurement shows 75% and temperature of only 45°C.

Recommended action: repair at the next scheduled maintenance.

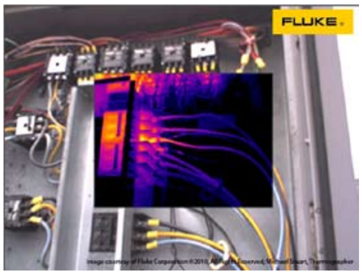


Figure 7. The temperature difference between L3 and L1 is 22.7°C which according to the InterNational Electrical Testing Association (NETA) means an indication of a serious issue. In addition to that, the temperature on the L3 cable is 84.3°C. According to European Committee for Electrotechnical Standarization – CENELEC HD 516 – insulated cable temperatures (PVC) should not exceed 70°C to avoid short circuits, interruptions and fires.
Recommended action: replace L3 cable and check insulation on the other cables.

Figure 8. Possible issue when operating first compressor. The temperatures of the middle and right compressors are 55-67 °C lower than the first compressor on the left.

Recommended action: check working loads and compressor operation to determine the reason for the significant temperature difference.

Figure 9. Loose or high resistance electrical connections on all 3 phases. Measured current is 80% of nominal which is the normal load in this case. Temperature on the upper cables is about 20°C above the ambient temperature of 23°C.This is still less than 35°C above ambient as per IEC 947-1 table 1.
Recommended action: there is no reason to assume the insulation on the cables has been damaged. Repair and conduct another checkup within 3 months.

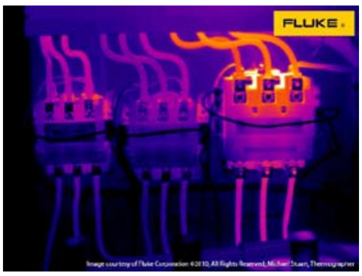
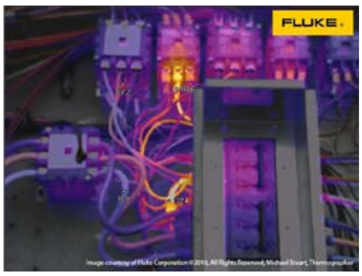


Figure 10. Bad connections caused the temperature of the cables to be above 70°C. This is above the limit recommended by European Committee for Electrotechnical Standarization – CENELEC HD 516 for PVC cables.

Loads at present are low, about 50% of nominal. It is unknown what temperature the cables were exposed to when the loads were at near 100%. According to IEC60724, the short circuit current for a PVC cable with a cross section <300mm2 is maximally 160°C for 5 minutes.
Recommended action: measure cable insulation and replace cables if necessary.



The pictures are real-life examples of the early detection activities that can be done with the thermography service of Trane. [Examples are provided with the courtesy of Fluke]

Predictive maintenance operations

1. Low voltage inspection
Periodical infrared inspections is the best way to diagnose then to overcome the chiller electrical panels problems like:

- Poor electrical connections / contacts
- Loose connections
- Corroded connections
- Current overloading
- Electrical component degradation
- Damaged circuit breakers
- Worn contactors
- Damaged fuses

Thermal imaging cameras are commonly used for electrical inspections. As electrical connections become loose, there is a resistance to the current that can cause an increase in temperature which can then cause components to fail, resulting in unplanned outages and injuries. In addition, the efficiency of an electrical grid becomes low prior to failure, thus energy is spent generating heat, causing unnecessary losses.

2. Mechanical inspections
Periodical mechanical infrared inspections to better prevent or identify mechanical problems of HVAC system's elements can be combined with vibration analysis and oil analysis.

While most commonly used to find "hot spots" in electrical equipment, infrared technology has uses in plenty of other places in and around the plant. Particularly as more plants incorporate comprehensive predictive maintenance programs into their routines. Infrared technology can be used during different maintenance and check-up procedures: to scan conveyor systems, look for hot bearings in the rollers, production-wise or even for checking the buildings themselves.

Thermography reports

A technician takes thermal images of the electrical and mechanical components of the chilled water system while it is up and running. The expert reviews thermal images, both past and new, and produces a detailed report of the current status of the pictured components, including possible reasons for any anomalies. Customers receive a detailed report generated by the computerized infrared scanner detailing the recommended repairs or improvements to avoid system failures and optimize reliability of the system. In detail, the report identifies and indicates:

- All areas photographed with visual and thermal images and their current condition
- Problem areas
- Clear description of expert evaluation of the identified issues
- Recommendations for next steps and solutions
- Repair priority among the identified issues

The Thermography technology is one of the service offerings that support the high performance buildings approach. Through this right approach high performance buildings meet specific standards for energy efficiency, system reliability, environmental sustainability and occupant comfort and safety. ■

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