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non-intrusive investigations...

When it comes to assisting our client's needs, **NEW DIRECTIONS IN BUILDING SERVICES®** [NDIBS] **NEW DIRECTIONS IN BUSINESS SAFETY®** **FIRE ASSESS®** is committed to keeping up with the latest technologies. In certain cases it may prove beneficial to utilise an infrared thermography camera for non-intrusive investigation.

This specialised camera can detect infrared energy (heat) and converts it into an electronic signal. This signal is then processed and produces a thermal image on a video monitor. Temperature calculations are derived from the signal, which are crucial for a correct analysis. The temperature calculations performed give the thermographer an understanding of where the problem lies.

Our qualified thermographers use these state-of-the-art infrared cameras to detect a host of problems from structural and building envelope moisture intrusion to circuitry/electronics, mechanical and biological systems. We mainly see these cameras being used for preventative maintenance, R & D testing, and automation/OEM. However, we also see them as an essential analysis tool for a host of applications.

To find out more how infrared technology can benefit your specific needs, please contact: Ian Childs Call him on (02)9594-4477 or 0414-472-042

Moisture Detection

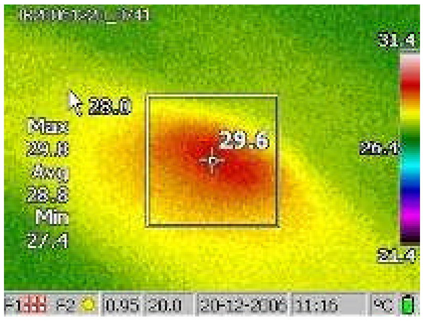
A key to prevention of mould growth.

Mould has existed in our environment long before the recent awareness of its presence in homes and businesses. The impact of mould on health is dependent upon the concentration of spores in the immediate area and the allergic effect on the exposed individual. Potential health problems associated with mould exposure can take the form of allergic reactions or asthma. The problem is not limited to homes. Commercial buildings with moisture accumulation due to condensation or leaks are a candidate for mould growth. In the US, this mould topic has reached such proportions that congress has introduced a bill titled "United States Toxic Mould Safety and Protection Act of 2002" also know as the "Melina bill".

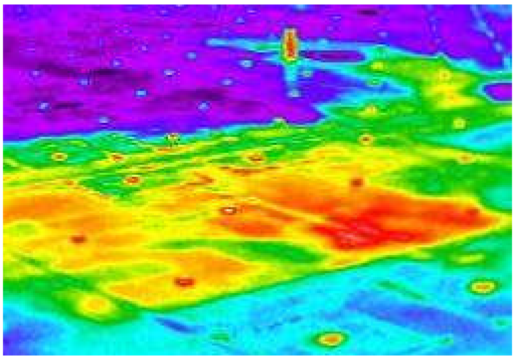
According to the U.S. Environmental Protection Agency, *"there is no practical way to eliminate mould spores in an indoor environment"*. The best way to control mould growth is to control moisture. Mould can begin growth in as little as 24 hours. Roof leaks and water pipe leaks are common sources of water accumulation that may cause mould growth. Mould has closed public schools, accommodation hotels and caused companies to spend millions of dollars on environmental tests and remediation. Clearly, there is more reason to become diligent and aware of conditions which are detrimental to the building fabric as well as the health and wellbeing of building occupants.

In Sydney Australia we have observed mould within Commercial and Educational facilities which has dramatically affected the IAQ and degraded the environmental comfort of the occupants. Eradicating or managing this mould does noticeably elevate the productivity and comfort of the occupants.

Microbial Growth from a spilt softdrink

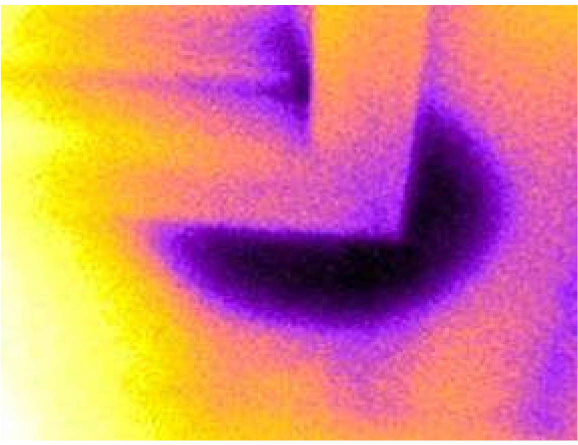


NDIBS can not only identify affected areas, but can work with you or your nominated Engineering Consultants to provide an effective solution.



Moisture present in roofs and walls can be detected with a sensitive infrared camera, under the right conditions. Infrared roof inspections are performed most effectively after sunset, when the roof gives off its heat energy accumulated during the day. The heat capacity of moisture soaked roof insulation is greater than that of dry insulation. As a result, the moisture soaked roof areas appear quite clearly when performing an infrared scan.

Similarly, it is possible to detect moisture located behind interior walls with an infrared camera, under the right conditions. The temperature difference created by the presence of moisture on the inside surface of a wall will appear differently than the surrounding area.

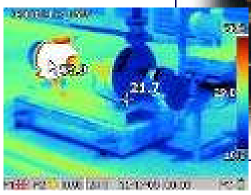


Infrared inspection is a fast, non-invasive method to discover moisture intrusion within the building envelope. Infrared inspection does not directly detect the presence of mould; rather it may be used to find moisture where mould may develop. The limitations to obtaining accurate infrared images pertain to the ability of the surface being scanned to emit heat energy. Gypsum in interior walls emits quite well, whereas highly reflective surfaces do not. Since the temperature difference between the wet and the dry wall are very slight, a sensitive infrared camera such as those used by **NDIBS** must be used.

At the heart of the IR- Flir i7 as wellas the Parrot Drone equipped with Flir IR imaging is an extremely sensitive microbolometer thermal sensor that can distinguish between temperate differences of less than 0.09°C.

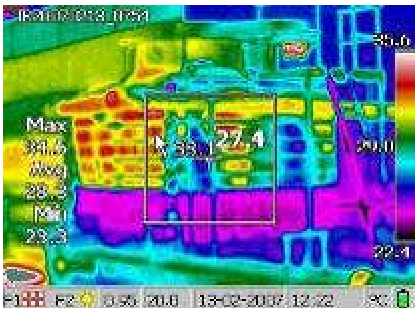
Infrared Inspection of Cooling Water Systems (Cooling Towers)

Dead legs and areas of poor water circulation can be quickly identified, and more importantly recognised by the customer. **NDIBS** can provide this valuable tool when carrying out Risk Management Plans and Audits of these systems and used by engineers with a thorough understanding of these systems.



A recent example of the usefulness of this tool was, when occupants of a large residential complex complained about the noise of the condenser water gurgling through their ceilings, the take-off (swaging) connection tails were identifiable as penetrating into the condenser header pipes to such an extent that they were obstructing the downstream waterflow and creating the noise problems **(defect)**

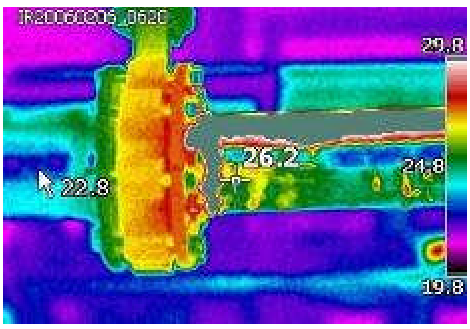
Here Elevated hot deck temperatures are attributable to the operational setpoints for the Screw Chillers in excess of those recommended. Uneven face temperatures suggest "fill" degradation



Such identification is reliant upon the trained thermographer having a real understanding of the operation of the equipment being assessed and intimate knowledge of the applicable Australian Standards eg. AS/NZS 3666.1 and AS 5059 in this instance

NDIBS has that expertise!

Here we have a clearly identified "dead-leg" and as it is part of a condenser water reticulation system, significantly increases the risk of microbial / legionella exposure.



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TIA NEW DIRECTIONS IN BUILDING SERVICES®
NEW DIRECTIONS IN BUSINESS SAFETY®
FIRE ASSESS®
[NDIBS]
PO Box 115 BOOLAROO NSW 2284 Australia
Phone (02) 9594 4477 Mobile Ian 0414-472-042

Infrared Inspection of Roofs

Flat roof membranes are the waterproof barriers between the outside elements and the interior of buildings. They come in a variety of materials and designs. They must be able to expand and contract, resist high winds and the effects of solar radiation and withstand foot traffic. It is easy to see why roofs leak.

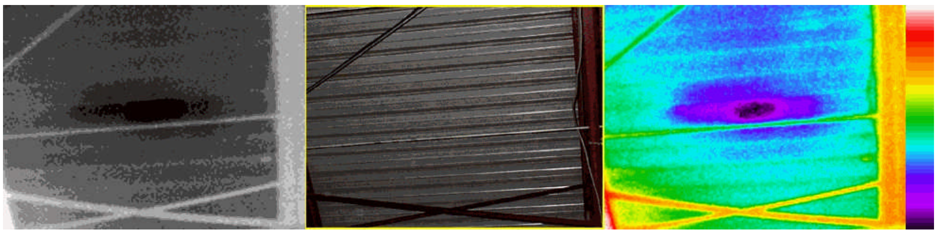
Normally there is little or no water within a flat roof assembly. When a leak develops, water enters the assembly and, depending on the type of insulation system, is either absorbed by the insulation or runs to the cracks between the non-absorbent insulation. When water enters the roof assembly it is there for a long time, sometimes the life of the roof.

Thermal capacitance is the physical property of a material's ability to store heat. The materials in roof assemblies have relatively low thermal capacitance, especially when compared to water. Water requires a lot of energy to raise its temperature and likewise must release a lot of energy to cool.

The physics used for thermal roof inspections is that dry roof insulation heats up and cools down faster than wet roof insulation. Infrared inspection goes beyond simply finding a leak by locating the extent of the moisture invasion of the insulation. To do this we require solar heating of a sunny day. Then at night, after the sun goes down and the roof surface begins to cool, the **dry** roof insulation cools faster than **wet** roof insulation. This temperature difference can be detected by **NDIBS**' Flir i7 or our Parrot Thermal Drone.

Infrared inspections should be done under the right conditions to obtain the best infrared images. We require a different temperature between the day and night. For best results, here are some things to consider:

- Was it a clear sunny day?
- Is it a clear night (for good radiation cooling)?
- Is there little or no wind?
- Is the roof surface dry?
- Is the roof clear of snow, dirt and debris?

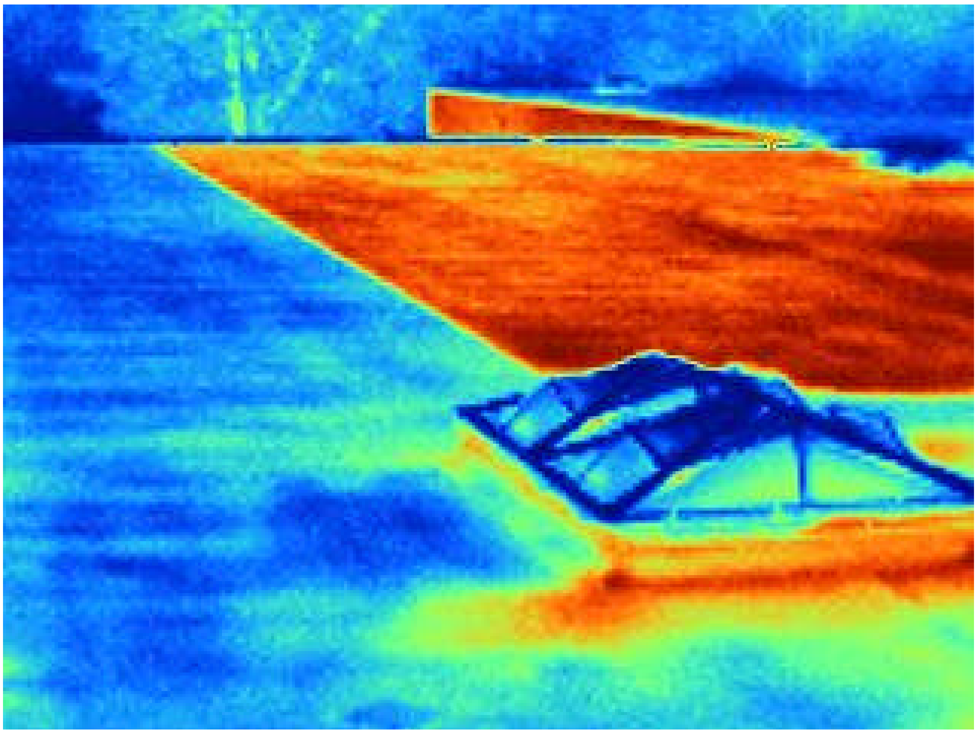


The type of insulation used on a roof will result in an infrared image that is characteristic of how that particular insulation absorbs water. Absorbent roof insulation acts similar to a sponge. The water migrates by capillary action throughout a complete roof board before it jumps to the adjacent board. This results in a checker board thermal pattern.

Non-absorbent roof insulation creates a much different pattern when it becomes wet. The water is not absorbed and runs to the edge of the roof board. The water tends to collect at the edges of the boards resulting in a window frame pattern. Different patterns may result from other less common insulating systems.

There are many conditions that can produce thermal patterns that may look like they were created by wet insulation but are not, and others may mask the true condition of wet insulation. The ASTM specification C-1153 titled "Location of Wet Insulation in Roofing Systems Using Infrared Imaging" suggests performing verification of suspected wet insulation by core methods. The following are some examples of situations that may result in poor infrared inspections:

- Insulation with different R-values or different absorption characteristics which are commonly found in repaired areas
- Different internal building temperatures
- Extra gravel or bituminous left from construction
- Warm or cold air exhausting onto roof
- Re-radiation of heat from south or west facing walls
- Wind
- Internal sources of heat or cold such as lights, heaters, and pipes
- Dirt, vegetation and debris
- Walkway pads and buried steel plates
- Blisters
- Water ponding, steam plumes and water spray

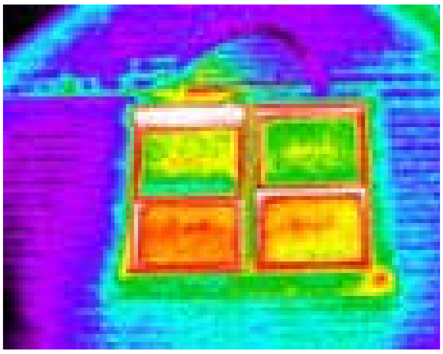


During the winter use the same process; however, winter surveys are more difficult because the temperature differences (ΔT) are usually less than on summer surveys (3°C ΔT in winter vs. 15°C ΔT in summer). If the building is heated, the added heat flow from the building through wet insulation will help enhance the winter thermal patterns.

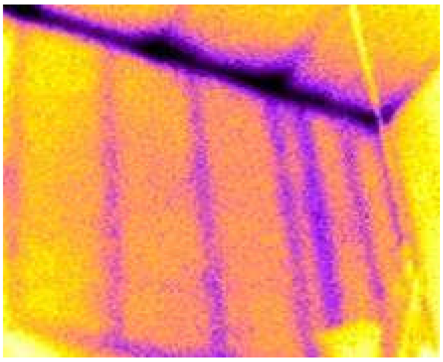
Some safety reminders are:

- Carry out a JSA & prepare a Safe Work Method Statement (SWMS) reflecting operational tasks.
- Don't work on a roof alone.
- Don't walk backwards on a roof.
- **Use** a harness and restraint when working near edges or on slopes.
- **Follow** company and OH&S regulations.

Building Envelope



While the primary concept tool used today to design building efficiency is CADCAM, the primary diagnostic procedure (used internationally) for determining and evaluating the thermal performance of an existing building envelope is infrared thermography. It can be used to identify heating and cooling loss due to poor construction, missing or inadequate insulation and moisture intrusion. Correcting the defects plays a significant role in increasing building efficiency and structural integrity.



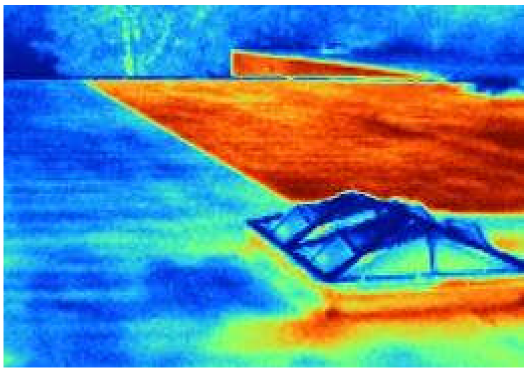
Thermography can identify surface temperature variations of the building envelope, which relates to problems in the structure, thermal bridging, moisture content and air leakage.

Two primary mechanisms for heat loss in buildings are conduction through the walls and air leakage. Both can be identified from the surface of the building with infrared thermography. Early correction of the faults identified can be made before extensive damage occurs.

Conductive Losses

Problems identified as conductive losses are: missing insulation, improperly installed or compressed insulation, shrinkage or settling of various insulating materials; excessive thermal bridging in joints between walls and the top and bottom plates; moisture damage to insulation and building materials; heat loss through multi-pane windows with a broken seal; leaks in water pipes; damaged heat ducts; location of, or leakage in buried water lines or underground sprinkler systems, etc.

Air Leakage



Air leakage is the passage of air through a building envelope, wall, window, joint, etc. Leakage to the interior is referred to as infiltration and leakage to the exterior is referred to as exfiltration. Excessive air movement significantly reduces the thermal integrity and performance of the envelope and is, therefore, a major contributor to energy consumption in a building.

In addition to energy loss caused by excessive air leakage, it can cause condensation to form within and on walls. This can create many problems; reduce insulation R-value, permanently damage insulation, and seriously degrade materials. It can rot wood, corrode metals, stain brick or concrete surfaces, and in extreme cases cause concrete to spall, bricks to separate, mortar to crumble and sections of a wall to fall jeopardizing the safety of occupants. It can corrode structural steel, re-bar, and metal hangars and bolts with very serious safety and maintenance issues. Moisture accumulation in building materials can lead to the formation of mould that may require extensive remediation.

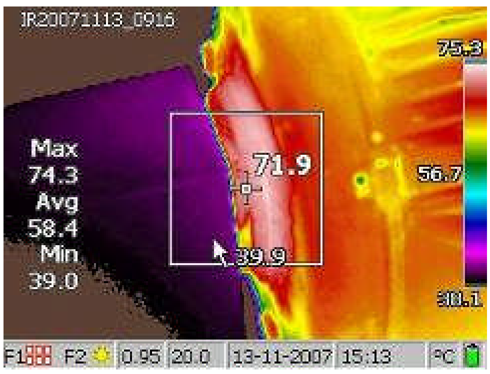
Virtually anywhere in the building envelope where there is a joint, junction or opening, there is potential for air leakage. Using our IR-Flir i7 infrared imagers, we can identify thermal irregularities on the building envelope and the thermal pattern discerning whether the pattern indicates a problem with the insulation, air leakage or the building structure.

The NATIONAL CONSTRUCTION CODE now specifies energy consumption by Class of building for new construction and refurbishment. **NDIBS** can locate and identify areas degrading energy consumption so that performance can be achieved.

NDIBS can arrange for Accredited Performance Audits to reflect the Australian Building Greenhouse Rating (**ABGR**) Scheme and Building Environmental Audits can be provided which reflect National Australian Building Energy Rating Scheme (**NABERS**), *the only recognised building rating schemes effectively auditing the performance of **existing** buildings.*

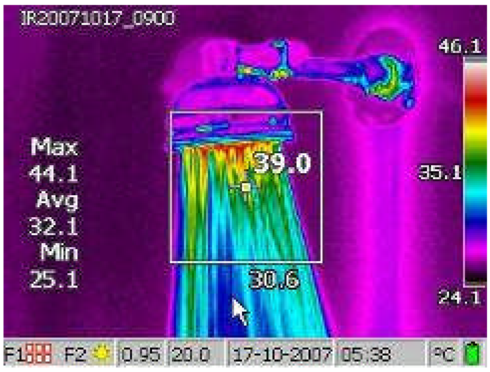
Mechanical Systems

In all plant areas there are diverse collections of equipment that can be successfully inspected using infrared thermography. For most mechanical equipment the techniques used to inspect the equipment are straightforward, but specific knowledge and experience with some equipment is often required.



Bearing worn

NDIBS brings the expertise of their engineers who have been involved in multiple building services engineering disciplines; electrical, hydraulic, mechanical, controls, fire protection, lighting, power generation, microbial control, vertical transportation systems, safety, etc. and are thereby being able to take a holistic approach in our reporting and our recommendations.



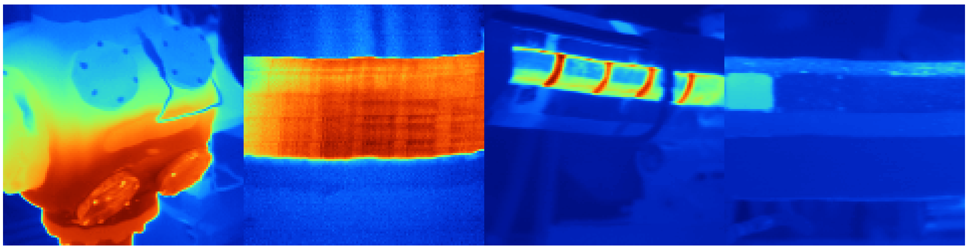
Hot Water in hotel fails to deliver (after 60 secs)
AS3500 requires delivery of 60°C to most disadvantaged outlet or to the supply side of thermostatic mixing valves within 60 secs. or that the system be classified as a warm water system and treated as deemed necessary as specified in AS3500 and AS/NZS3666

We use infrared thermography to assess performance of refrigeration, water chillers, air handlers, hot water systems, etc. and it is only by the broad knowledge of our operators, that this may be properly assessed. eg. The critical temperature of HCFC-R22 refrigerant is 98°C – if we see that at the discharge from a refrigerant compressor – it indicates a significant fault and failure to perform.

An operator without refrigeration knowledge would probably not be able to identify that there was a fault, nor assist in its remediation.

PO Box 115 BOOLAROO NSW 2284 Australia
Phone (02) 9594 4477 Mobile Ian 0414-472-042

Thermogram **T**) is a natural gas compressor where the cylinder head in the lower left of the picture shows signs of a valve problem. Not counting the bolt head parts of the images, this cylinder head shows a 25°C temperature gradient. This gradient was felt to be excessive and it resulted in a tear down and servicing of the compressor. Thermogram **U**) is an image of a rotating 300mm diameter 900mm long pinion gear that drives a 15 metre diameter drum in a molybdenum mining operation. By monitoring the lengthwise temperature gradient, the technician could monitor the gear alignment and its life expectancy. Thermograms **V**) and **W**) are images of pipe with band heaters. **V**) shows the heaters on and functioning and **W**) shows them not working.



T) Compressor U) Pinion Gear V) Band Heater W) Band Heater

Electrical Systems

Most people involved in Asset Management know of and acknowledge the benefits of carrying out Thermographic Inspections of Electrical Distribution Switchboards.

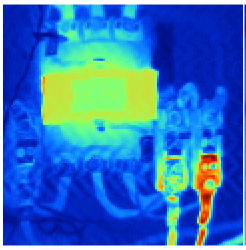
Abnormal heating associated with high resistance or excessive current flow is the main cause of many problems in electrical systems. Infrared thermography allows us to see these invisible thermal signatures of impending damage before the damage occurs. When current flows through an electric circuit, part of the electrical energy is converted into heat energy. This is normal. But, if there is an abnormally high resistance in the circuit or abnormally high current flow, abnormally high heat is generated which is wasteful, potentially damaging and not normal.

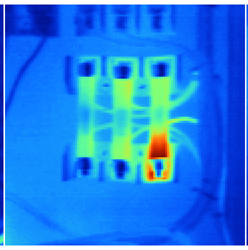
Ohm's law ($P=I^2R$) describes the relationship between current, electrical resistance, and the power or heat energy generated. We use high electrical resistance for positive results like heat in a toaster or light in a light bulb. However sometimes unwanted heat is generated that result in costly damage. Under-sized conductors, loose connections or excessive current flow may cause abnormally high unwanted heating that result in dangerously hot electrical circuits. Components can literally become hot enough to melt.

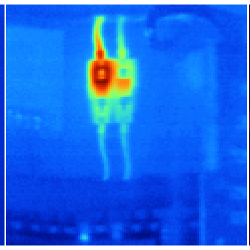
Our IR cameras enable us to see the heat signatures associated with high electrical resistance long before the circuit becomes hot enough to cause an outage or explosion. Be aware of two basic thermal patterns associated with electrical failure: (1) a high resistance caused by poor surface contact and (2) an over loaded circuit or multi-phase imbalance problem.

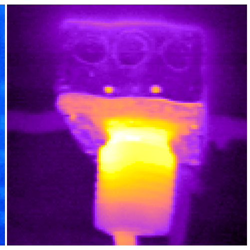
Contact Problems

Heat is produced by current flow through a contact with high electrical resistance. This type of problem is typically associated with switch contacts and connectors. The actual point of heating may often be very small, less than a 1.5mm when it begins. Below are several examples found with the IR SnapShot during customer inspections.


A) Controller


B) 3 Phase Fuse


C) Fuse Clip


D) Plugtop

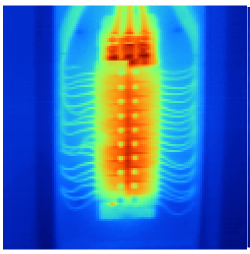
Thermogram **A**) is a motor controller for an elevator in a large hotel. One of the three phase connections was loose, causing increased resistance at the connector. The excess heating produced a temperature rise of 50°C. Thermogram **B**) is a 3-phase fuse installation where one end of one fuse has poor electrical contact with the circuit. The increased contact resistance caused a 45°C hotter temperature at that connection than at the other fuse connections. Thermogram **C**) is a fuse clip where one contact is 55°C hotter than the others. And thermogram **D**) is a plugtop-in which the wire connections were loose causing the terminals to heat 55°C hotter than the ambient.

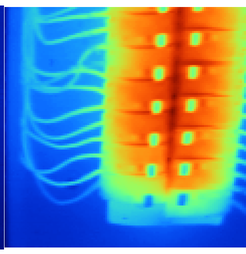
All four of these examples were serious and needed immediate attention. Thermogram **B**) shows an interesting principal used in interpreting thermal patterns of electrical circuit. The fuse is hot at one end only. If the fuse were hot at both ends, the problem would be interpreted differently. An overloaded circuit, phase imbalance, or an undersized fuse would cause both ends of the fuse to overheat. Being hot at one end only suggests that the problem is high contact resistance at the heated end.

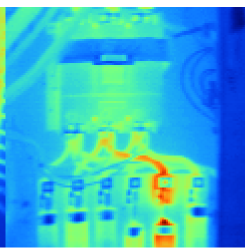
The plugtop in Thermogram **D**) was seriously damaged as seen in the visual picture above the thermographic image, however, it continued to operate until it was identified and due to the associated risks was promptly replaced.

Overloaded Circuit Problems

The following thermograms show overloaded circuits. Thermogram **E**) shows a circuit panel in which the main breaker at the top is over heated 75°C above ambient. This total panel is overloaded and in need of immediate attention. Thermograms **E**) and **F**) show all the standard circuit breakers over heated. Their temperatures were 60°C above ambient. Although in the thermogram the wires are blue in colour they are also hot, 45 to 50°C. This entire electrical system needs to be redone.


E) Circuit Breaker Panel


F) Circuit Breaker Panel


G) Contactor


H) Current Transformer

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Phone (02) 9594 4477 Mobile Ian 0414-472-042

Thermogram **G**) shows one line of a contactor that is about 20°C above the others. This needs further investigation to determine why one wire is that much hotter than the others are and to determine the repair needed. Thermogram **H**) shows a current transformer that is 14°C warmer than the other two transformers in a 3-phase service installation. This indicates a serious imbalance of the service or a faulty current transformer that could seriously impact the customer's utility bill (demand rate time of use tariff).

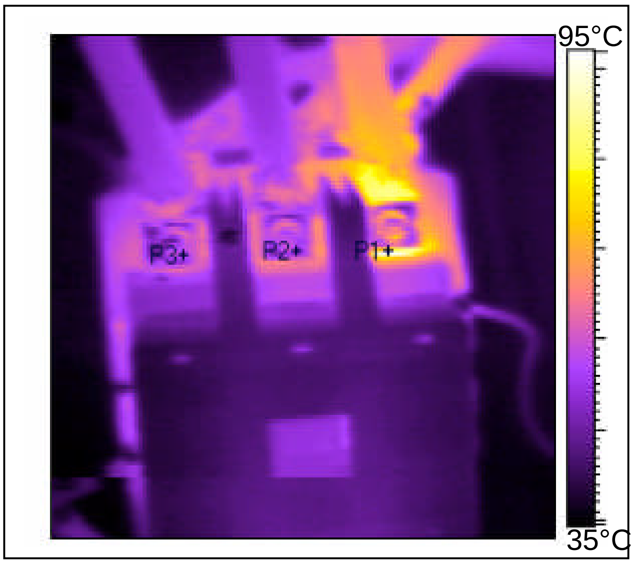
Load Requirements

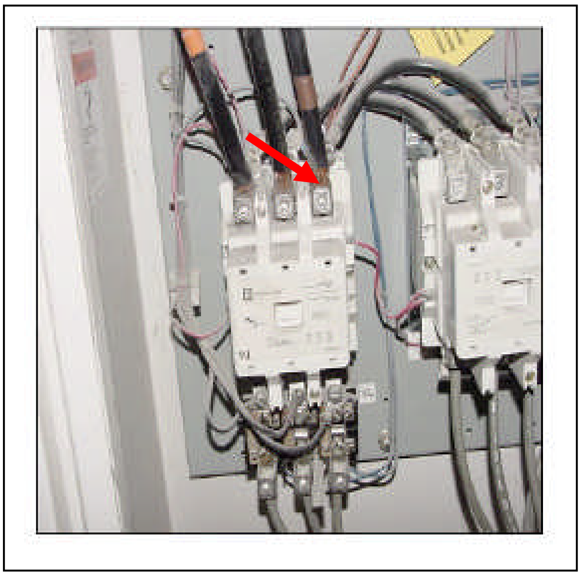
When we are making an inspection it is important that the system is under load. We try to be there with the inspection for "worst case" or peak loads, or when the load is at least 40% (according to NFPA 70B). Heat generated by a loose connection rises as the square of the load; the higher the load, the easier it is to find problems.

In commercial buildings it is suggested that inspections be carried out in the Summer and in the Winter. In this way the Summer Cooling loads and equipment stresses can be assessed as well as the quite different Heating mode loads in Winter.

Surface Temperatures Only

Infrared cameras **cannot see through** cabinets or solid metal bus trays. Whenever possible the open enclosures so the camera can directly see the electrical circuits and components. If you find an abnormally high temperature on the outside surface of an enclosure, rest assured that the temperature is even higher, and usually much higher, inside the enclosure. Following are some thermograms taken of a switchboard cabinet, which identify a serious problem with one phase of the three phase supply connections to the contactor. The hot spot was in the order of 60°C hotter than the ambient and 45~50°C hotter than other parts of the bus enclosure.

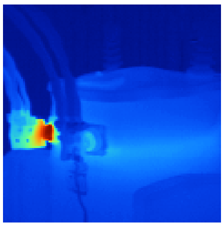


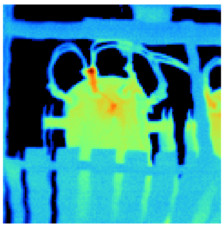


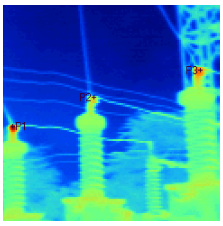
Electrical Distribution

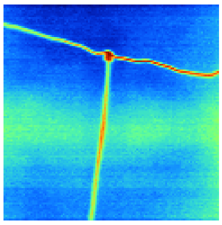
NDIBS can provide our expertise and the Flir-i7 and Parrot Drone thermographic cameras to help with your maintenance.

Thermogram **M**) is a service transformer that had leaked some cooling oil, resulting in dangerously over heated coils near the top. One connection was 160°C above ambient. This transformer needed immediate replacement but the company wanted to delay the repair one month so it could be done during a scheduled total plant shutdown. They used the IR camera to monitor the state of the transformer and successfully delayed the repair. Thermogram **N**) is for a pole mounted service transformer that has a connection 30°C hotter than ambient. Such a condition required maintenance at the next convenient opportunity. Thermogram **O**) shows a hot main connection on an interrupter at a substation. The connection was found to be 14°C hotter than the others. This was believed to be a problem that needed attention. Thermogram **P**) shows an overhead connection in a substation. It was less than 10°C above ambient and not of immediate concern.


M) Transformer

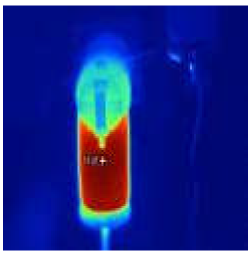

N) Transformer

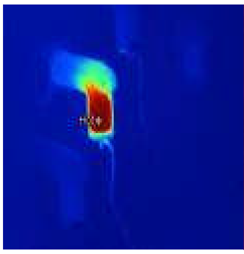

O) Interrupter

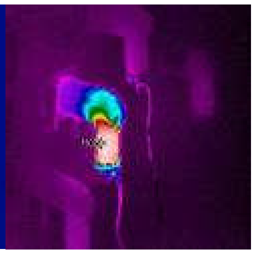

P) Connection

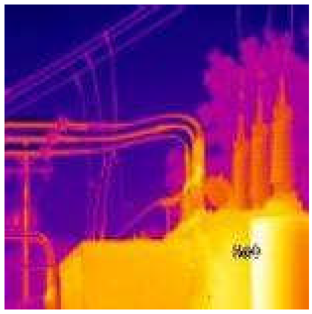
Infrared imaging and temperature analysis are a necessity to efficiently and accurately monitor substations, power connections, and other transmission equipment. With our Flir-i7 and with our Parrot IR drone we can diagnose potential problems before they become catastrophic, saving significant expenses on extensive repairs and downtime. By utilising infrared technology, you will be able to increase reliability, conserve costs, and save money. Below are some sample images of an infrared inspection conducted during a routine predictive maintenance check.

The lower portion of elbow was 46°C above ambient - circuit load was not checked. The warm part is where the elbow is over the bushing, a likely heat source is either the probe and socket or the OCR bushing. This did not appear to be a pin and connector heat source.



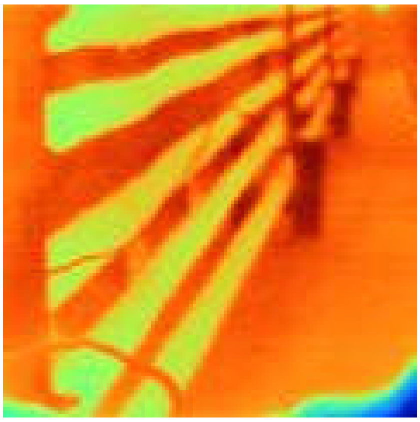






Substation- high side switch- latch appeared warm 12°C above ambient.

PO Box 115 BOOLAROO NSW 2284 Australia
Phone (02) 9594 4477 Mobile Ian 0414-472-042



• **Industrial Process Applications** – Infrared cameras facilitate the inspection of tubes in boilers and condensers for scale build-up. This scaling can easily be detected with suitable high-temperature infrared equipment because areas with scale build-up show up as warmer than other areas of the tube surface.

This example shows coke scale precluding the liquid from uniformly absorbing the tube's heat. Additional disadvantages of coking include higher furnace firing rates and decreased tube life. This provides more incentive to maintenance personnel to perform regular infrared scans to protect against this coking and the efficiency gains provide substantial return on the investment costs associated with these inspections and any remedial works.

Any process involving thermal heat transfer can be accurately assessed by NDIBS and have any faults indicated identified.

Take advantage of this experience and expertise when considering who'll be providing you with engineering support for your buildings.

NDIBS would like support you with Energy Assessments, Maintenance & Capital Works Predictive planning (5-year, 10-year, 20-year projections using the WebFM MPlan™ tool) after building services equipment evaluation, Air Quality assessments, Cooling Water Systems (cooling tower) Risk Management Planning and Assessments, Work Safety Practices and OH&S assessments and Training, Essential (fire safety) Services performance evaluation and endorsement of performing measures (for the Annual Fire Safety Statement), Probable Cause Assessment (Forensic Engineering), Material Hazard Assessment (Asbestos, etc.), Noise assessments, lighting level assessments, close control (Data Centre, LAN rooms, etc.) & environmental (thermal comfort) air conditioning technical support, Building Code – Ordinance & Relevant Australian Standard Compliance Support, Maintenance and Facility Operations Management Advisory.

Check out the **NDIBS** website: www.ndibs.com.au or www.fireassess.com.au