● Indoor Electrical Applications

Electrical inspections are the most commonly known and practised infrared application. The benefits are obvious, since electrical failures can easily cause personnel injury and death, equipment damage, material loss, and downtime.

Unfortunately, this familiarity has made many maintenance personnel and thermographers dangerously casual in their approach. It is too easy to simply pick a camera up and go looking for "hot spots." While it is true that any substantial temperature rise between phases should be treated as a high priority repair, there is a lot more to electrical infrared thermography.

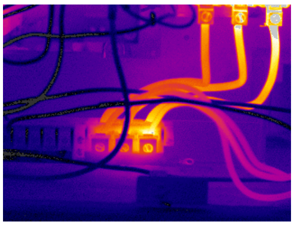
One important factor is the load on a component. The load exponentially affects the power in a circuit and the resulting temperature rise. A small temperature difference under a load of 1A may be critical under a load of 20A. There are still many maintenance personnel and professional thermographers who do not correlate load and temperature rise, and this causes a false sense of confidence when serious problems still exist. The load or temperatures are not always referred to in following samples, but that information was used in determining the criticality of the faults.

It is also important to understand the theories involved in how infrared radiation works and how heat transfer are affecting the objects in a thermal image. Concepts such as emissivity, thermal reflections, thermal conductivity, and indirect temperature measurement are crucial to the identification and diagnosis of electrical problems.

Although infrared electrical inspections are often carried out for insurance purposes, thermograph's true value is as an integral part of a predictive maintenance program. Combined with other technologies and performed conscientiously, thermography will have cost benefits that vastly outweigh the costs.

Anyone performing infrared electrical inspections has to remember what is at stake, and make the effort to do the job properly. The risk of serious injury, death, or huge loss of profit inspired us to pick up the camera in the first place, and the identification of a few "hot spots" will not eliminate that risk.

1. Electrical Survey: MCC



This image shows loose connections on the load side of a contactor (B and C Phases), and loose connections on the terminal block (B and C Phases).

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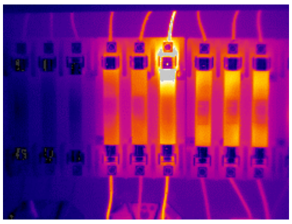
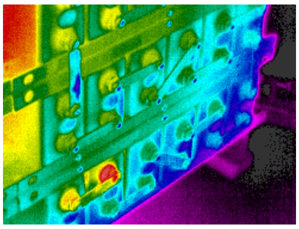
2. Main Electrical Room: Fuse Block

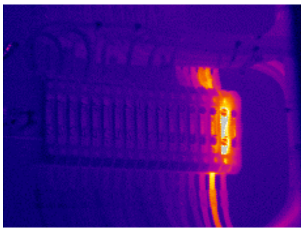


This image shows a loose fuse retaining clip on the fuse block for the power supplies and heat station water system panel in a facility's main electrical room. Amps A phase=20, B phase=20, C phase=20. The temperature rose to 96°C. Manual inspection, cleaning, and tightening of all connections and fuse clips was recommended as well as the replacement of any required components.



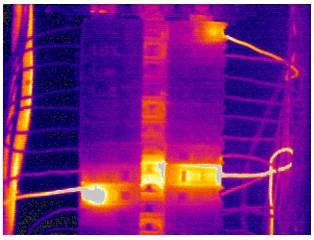
3. Back-up Power Supply Batteries

When batteries are your first line of defense in the case of power loss, it is vital that they perform on demand. This image shows a failing cell on the lower left side (high temperature differential indicated in red). If a problem like this is left unattended, critical systems could be left without power.



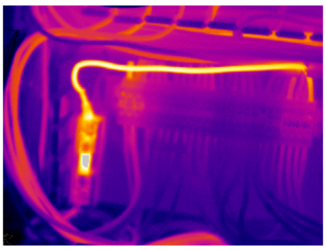
4. Transformer Cabinet Terminal Block Connections

During an infrared survey of a plant substation, Infrared camera can help you to find these loose connections on the terminal block in a transformer cabinet.



5. Lighting Panel

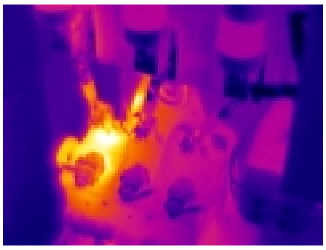
This image identifies loose connections, an overloaded circuit, and a faulty breaker on this common type of electrical panel. As with all electrical problems, the resulting failures could have serious consequences for the equipment, property, and personnel involved.



6. Extruder Control Panel

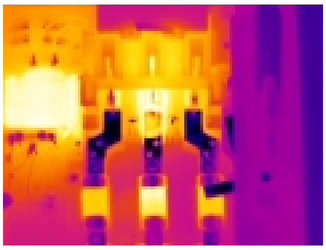
This image shows the main control panel for an extruder. The thermal anomaly noted here is on the fuse block on the right hand side of the lower left fuse block. Temperatures rose to over 100° C in this area. Inspection, cleaning, and tightening of all connections and replacement of any required parts was recommended.

7. Typical Fault Conduction Pattern
This is a typical conduction pattern, showing a thermal tapering along the coated electrical cable from the electrical connection. The connection, likely the source of the fault, does not appear to be as hot because of the emissivity differences between materials. Phase A is under a load of 67.8A, compared to 70.8A and 70.4A for B and C respectively. There is a 30° C temperature rise between phases. This is definitely a critical fault that requires immediate attention.



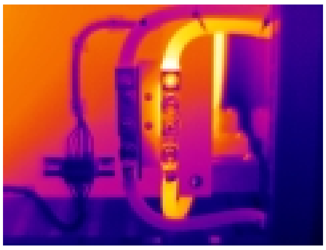
8. Contactor

All three phases are under a load of approximately 61A. There is a very critical temperature rise across the phases of at least 45° C. This temperature measurement is conservative, since it is an indirect temperature. The source of the resistance is likely the electrical contact inside the plastic housing on the A phase.



9. Fuse Disconnect

All phases are under a load of 32A. Between the B and C phases, there is a temperature rise of at least 11° C. There are a lot of apparent temperature differences, such as the cooler reflections off of the shiny surfaces, which have to be disregarded.



10. UPS Inverter

Both sides of this UPS inverter are under a load of approximately 120A. There is, however, a 25° C temperature rise on the neutral side. The temperature measurements were performed on the cable insulation rather than the shiny connections, since the shinier surfaces mostly reflect cooler, background temperatures.

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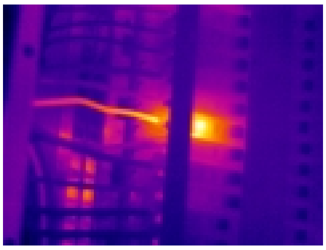
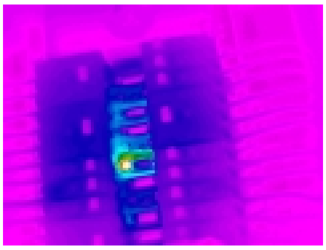


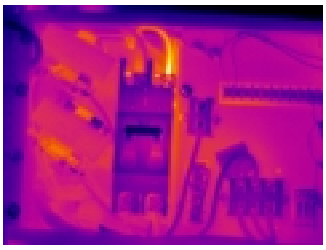
11. Mystery Wire

This wire was on a 15A breaker. It was under a load of 16A. Since the breaker and wire were unlabelled, and no one knew what the circuit powered in the manufacturing facility, there was no way to know if this was the full operating load. Although there was no critical temperature rise or electrical fault, this was still a potentially serious maintenance issue.



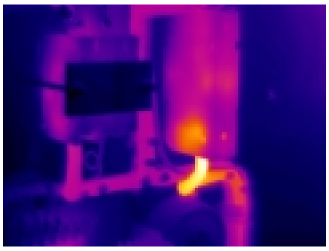
12. Lighting Panel

Three circuits on this lighting panel were not fastened to the panel bus bar. There are electrical faults to be found on lighting panels, however, all of the covers must be taken off to properly identify and diagnose the problems.



13. Rectifier Cabinet

The two wires in this rectifier are under a load of 5A - 6A. The left wire, which appears cooler, is actually under slightly greater load. There is, however, a temperature rise of approximately 11° C between the two. The temperatures were taken from the wire insulation, not from the shiny connections, in order to eliminate errors due to background reflections.



14. Microwave Station Rectifier Breaker

The wire coming out of the bottom of the breaker is over 100° C. This is a very critical fault. The insulation will be breaking down and losing its insulating qualities. The temperature of the actual faulty connection inside the breaker is higher, although there is not as serious of a thermal signature on the plastic breaker housing. This is an example of an indirect infrared diagnosis.

15. Connection on Manufacturing Control Panel

This image shows a small electrical connection that was loose and subject to wide load fluctuations under normal operating conditions.

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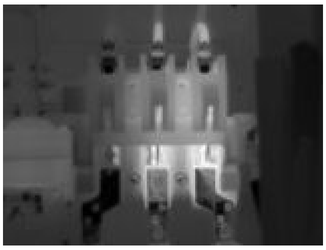
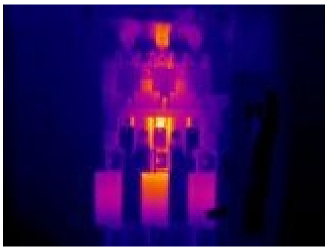


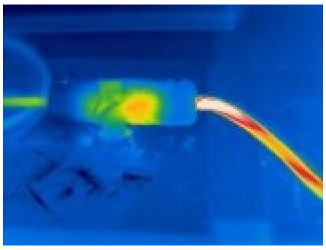
16. C Phase on Disconnect

The C phase of this disconnect was exhibiting a serious temperature rise under normal operating conditions. This electrical equipment was critical in the operation of furnaces on a chemical production facility.



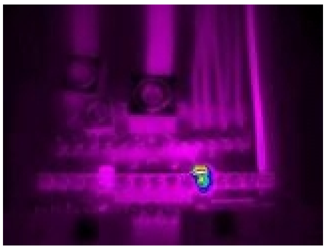
17. Compressor Fuse Disconnect

All three phases of this fuse disconnect had a load of approximately 160A. The center phase had a temperature rise of approximately 75° C. The fuse was replaced and the fuse connections tightened, but this only made the external temperature signature more pronounced. This electrical equipment was connected to a compressor that was critical to the operation of the entire manufacturing line at this stringboard facility.



18. Extension Cord Short

This extension cord was being used to power an air conditioning unit inside of an electrical connection cabinet in the pit of a manufacturing facility. The cord end pictured here was inside the closed cabinet. A short is apparent.



19. Loose Neutral Screw

The neutral screw in this electrical panel was very loose. The threads were stripped, and the connection had to be made elsewhere.

Outdoor Electrical Applications

Two important elements facing a thermographer performing outdoor electrical inspections are environmental factors and safety.

Wind and sun will drastically reduce the effectiveness of an IR survey. Wind is heat transfer by convection, and it doesn't take much of it to remove a serious thermal signature completely. The sun causes two problems. It will thermally load all of the components, removing temperature differences. It will also cause serious reflections, especially for shortwave cameras.

The best way around environmental problems is to avoid them completely. A calm evening or morning when the sun is not shining on the equipment is ideal, especially if it corresponds with high loads on the equipment. If this is not possible, it is vital to understand the effects that the environment will have on your results.

The high levels of energy in much outdoor electrical equipment increases the danger level when inspecting them. Two simple practices will go a long way to reduce the risk of serious injury or death. As part of the hazard identification which must be completed before any work is done, use your infrared equipment to look for hot spots before entering substations or approaching electrical equipment, not just overhead, but all around. You have a unique tool for seeing critical problems that are invisible to the naked eye.

Another very effective means of keeping the thermographer safe is the buddy system. Looking through an eyepiece or at an LCD monitor at the world around you can create tunnel vision. A thermographer may temporarily lose track of the physical dangers such as tripping hazards. Also, it is very difficult to perform CPR or First Aid on yourself in the event of a serious accident.

The high voltages involved in outdoor electrical equipment demand that we treat both the inspection procedure and the safety aspects with respect.

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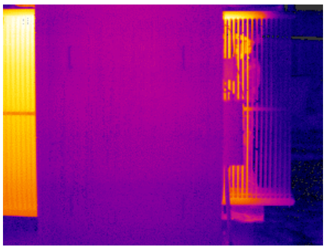
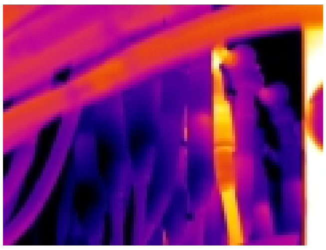


1. 240 KVA Transformer

This image shows approximately half of the North side cooling fins/tubes to be exceptionally cool, indicating possible plugged tubes (right-hand side of image). The image is from an East elevation showing both sides of the transformer.

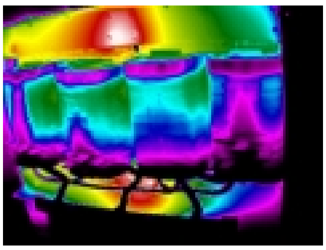
2. Substation

The outdoor electrical equipment providing power to your facilities are often overlooked or ignored during surveys performed by inexperienced technicians. The infrared camera can help you to inspect these support systems while on site to ensure their continued dependability. This image shows a loose pot head connection on the center phase at a substation. Unattended, this problem could lead to a loss of power or fire.



3. Vault Connections

Hot connections in underground distribution vaults are readily apparent with infrared technology. Fortunately, environmental factors are usually not an issue, although one must be careful that the sun is not shining on components from doors or grating. The load on the line, the rating of the component, and the temperature rise must all be taken into account when determining the criticality of the fault.



4. Heat Trace Transformer

All four cells are under a load of 81A - 84A. However, there is a 31V drop in output from circuit A to circuit B, likely due to the failure of cell 1 (far right). This is an example of a "hot spot" being the symptom while a cool area is the actual problem.

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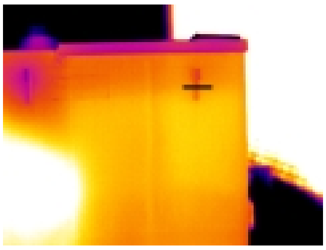
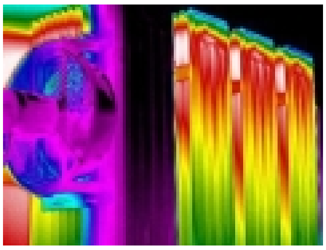


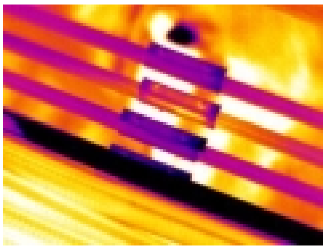
5. Transformer Oil Level

The oil level in this transformer (see the black line) is detectable; however the temperature differences are less than 1° C, so fine adjustments of the level and span are necessary. The areas of solid white in the image are due to the sun shining on the open door and building wall.



6. Transformer Fins

This image shows a portion of the cooling fins on a chemical facility power substation transformer. The fins appear to have poor oil circulation, probably due to pluggage or a low oil level.



7. Gantry Crane Bus

This is a connection on the bus bars for a trolley house on a large gantry crane. Under partial load, the poor connection is apparent as heat transfers through the plastic covering.

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Process Applications

Process applications are some of the least exploited infrared opportunities in industry.

These applications can range from determining internal build-up on components, to evaluating the effectiveness of insulation to finding and analyzing failures of equipment such as flare tips.

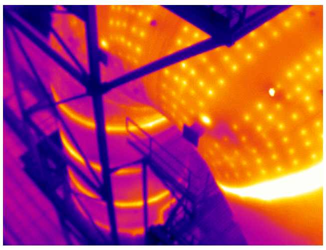
It is important to understand the theory and limitations of infrared thermography for these applications. Process problems are an example of how sharply infrared can deviate from the stereotypical "hot spot" approach. The interpretation of process-related thermo grams involves infrared theory and heat transfer. Many process applications also involve better quality infrared equipment or specialized lenses, filters, and accessories.

Safety is also an issue with process inspections. As with outdoor electrical scenarios, the buddy system is a very effective way to avoid missing hazards while looking through an eye-piece or LCD lens. As with all work, a pre-job hazard assessment should be carried out to ensure that the risks are eliminated.

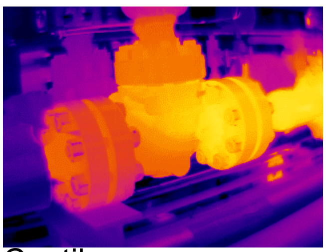
It is also important to remember that the infrared equipment will not be intrinsically safe or explosion proof. Gas monitoring and all of the relevant site safety procedures must be observed where there is the possibility of flammable and explosive materials.

Process applications require knowledge, skills, and imagination, but they can yield some of the greatest benefits.

1. Process Piping

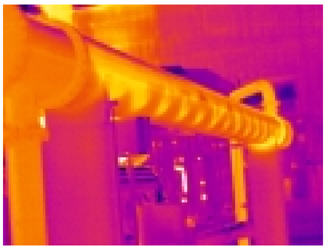


This image shows process material ducting. Internal material build-up is evident on the side walls and two areas show refractory wear. The system is monitored for material build-up to avoid possible blockages. After a few surveys the plant engineer can extrapolate internal material thickness from the external temperature. This survey alone has prevented plant downtime costs of tens of thousands of dollars per hour.



2. Valve Body

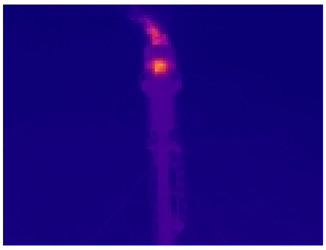
You can not see "through" most objects with infrared. You can, however, often see the different thicknesses of material between you and the source of heat, whether that material is the metal of the equipment, build-up, or fluids.



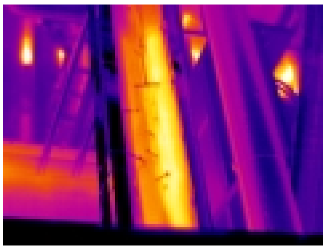
3. Exchanger Shell Side Build-up

Material build-up is evident on the shell side of this exchanger. You are not seeing "through" the metal with the infrared camera. Rather you are seeing how the different rates of heat transfer and thermal masses affect the surface temperatures of the equipment.

4. Flare Tip

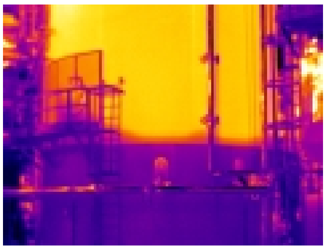


Some flaring conditions would cause a visible glow to appear on this new flare tip. A thermal image showed that the true "hot spot" was likely under the shiny muffler, but even with an infrared camera any temperatures were based on estimated values. The stainless steel material of the flare tip was discolored and oxidized to varying degrees. It would be difficult to give a precise temperature for this indication with the infrared camera since the surface parameters cannot be quantified. Also, the hottest area was likely hidden from view, making any estimation based on the visible signature conservative



5. Sample Lines

This image shows insulated hot water sample lines. There is likely a leak in one of them, or water has penetrated the insulation and is conducting and storing heat from the sample lines.



6. Tower Build-up

Build-up is evident in the bottom of this large tower. You are not seeing "through" the tower with the infrared camera. Instead, the camera is detecting the surface thermal differences due to the different rates of conduction and thermal masses of the build-up and fluids.

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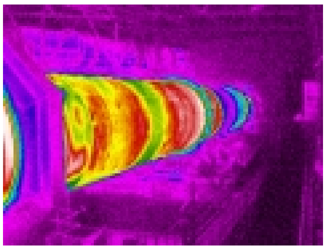
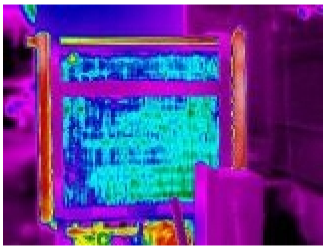


7. Kiln Refractory

Infrared thermography can be used to trend the loss of refractory on the insides of kilns and other plant equipment. The infrared camera can help you to determine refractory thicknesses through the internal material build-up.

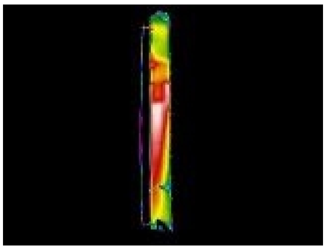


8. Fouled Hydraulic Oil Cooler

The fins of this oil cooler are completely plugged with dust. The vertical inlet and outlet are the same temperature as each other, and relatively no heat is being radiated from the fouled cooling fins.

9. Damaged Glycol Coil

There is a coil in the bottom of this tower. It is connected to the glycol inlet line, coming up from the bottom. The white line is the inlet to the coil. The darker, cooler line is the inlet continuing out through the shell from the coil and up the tower. The coil is either plugged or has failed.



10. Dislodged Tower Trays

The trays in this tower have all come free of the shell and moved together as a unit. Hot glycol is evident flowing down the inside of the tower rather than from tray to tray.

11. Heat Exchanger Flow

The shellside flow pattern and overall heat transfer in a heat exchanger is often readily apparent from the surface heat signature.

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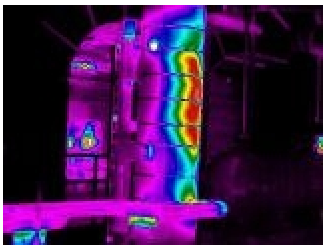
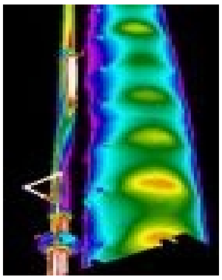


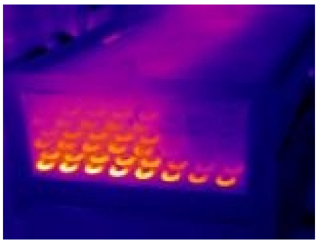
12. Leak Under Cladding

There was an inlet leak at a flange under the cladding of this insulated vessel. The flow of the hot gases under the cladding made a clear surface thermal indication despite the low emissivity of the cladding material.



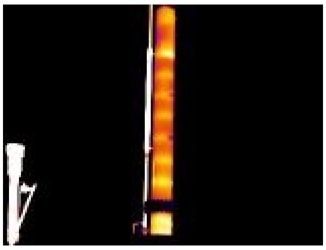
13. Glycol Outlet Heat Exchanger

The shell side of the small exchanger on this tower's glycol outlet is partially fouled, and the flow has channeled its own narrow path.



14. Plugged Glycol Cooler

The passes in the top right of this glycol cooler are plugged. This cooler is attached to a glycol dehydration tower. The tower was cleaned, and the cooler became fouled during the process by materials washed down from the tower. There was no thermal indication of plug gage before the tower cleaning procedure.

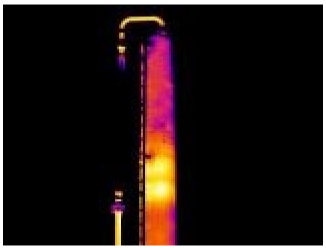


15. Poor Glycol Flow

This image shows a tower with a weak thermal signature of trays. The trays were fouled in this tower, and the glycol was hanging up at the top and flowing down very poorly prior to cleaning. The infrared camera can help you to assists in pre- and post-cleaning tower inspections to gather data used in customizing the cleaning process and to ensure the effectiveness of the cleaning method.

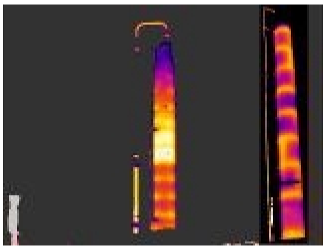
16. Tower Rinse After Cleaning

This tower was chemical cleaned, bottom to top. The rinse cycle is captured in this image. The image shows that the portion below the chimney tray is not included in the circulation of the cool rinse water.



17. Fouled Tower Trays

This image shows a tower under normal operating conditions. The hang-up of the hot glycol on the middle trays is apparent from the surface thermal pattern.



18. Fouled Tower Trays

The tower to the left shows hang-up on some tower trays. The tower to the right shows proper flow from tray-to-tray during chemical cleaning. The infrared camera can assists in pre- and post-cleaning tower inspections to gather data used in customizing the cleaning process and to ensure the effectiveness of the cleaning method.

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Machinery Applications

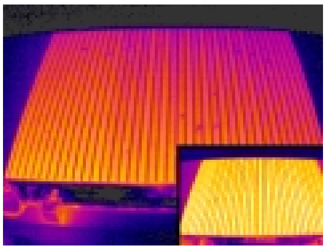
Machinery will usually display thermal signatures of various failures and normal operating conditions.

Cooling systems, rotating components, combustion, vibration, electrical current and other sources of energy will have an effect on the infrared radiation emitted. As with electrical inspections, the load on the equipment and environmental factors such as sun and wind will affect temperature changes.

With both rotating equipment and machinery, infrared thermography is often used to find immediate failures and critical problems. Perhaps an even greater benefit, however, is in trending equipment in conjunction with other maintenance technologies such as vibration analysis, acoustics, and oil analysis. All of these monitoring methods should work together in a comprehensive predictive maintenance program. If the data is gathered and correlated consistently, the cost benefits are phenomenal.

As with all infrared inspections it is also important to understand the theories involved in how infrared radiation works and how heat transfer is affecting the objects in a thermal image. Concepts such as emissivity, thermal reflections, thermal conductivity, and indirect temperature measurement are crucial to the identification and diagnosis of mechanical problems.

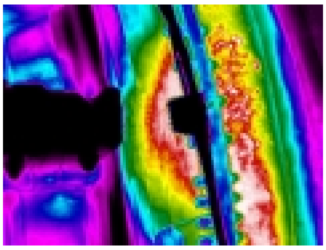
1. Hydraulic Oil Coolers



These two hydraulic oil coolers were side-by-side and fed by the same line. The inset cooler is operating normally, with good flow and heat transfer throughout. The inlet is in the bottom left corner of the coolers and the outlet is at the top. You can see that there is not consistent heat transfer in the cooler pictured in the background. Instead, it is just conducting heat at a slower rate away from the warmer oil at the inlet. There blockage, likely at the inlet to this cooler.

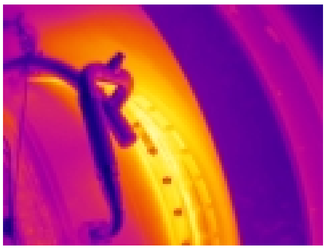
2. Crane Gantry House

This fan motor housing is well in excess of 200° C. The windings would be somewhat higher. This is the cooling fan for the electrical gantry house on a large crane. A GPS cable had fallen into the blades, jamming them. During the several minutes required to find and shut off the power source, this motor housing rose in temperature by at least 14° C.



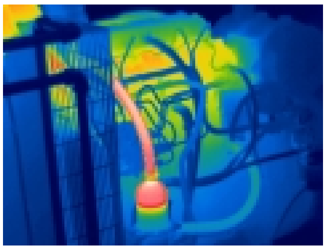
3. Power Turbine Surface Hot Spot

This image shows a hot spot on the surface of a power turbine. With infrared, both quantitative and qualitative data can be collected to identify the thermal signatures of different stages of failure and to calculate the temperatures to determine the criticality.



4. Power Turbine Exhaust Leak

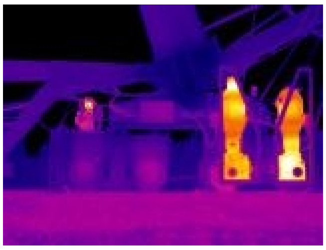
This image shows an exhaust leak on a power turbine near the exhaust cone.



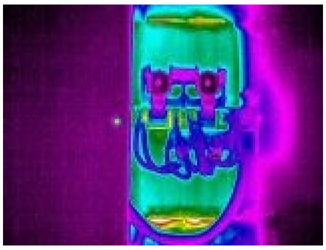
5. Generator Heater

This image does not show a problem. It is, however, clear evidence that the heater in this diesel generator engine is working properly. It is also a good example of both natural convection currents and good thermal focus.

6. Crane Motors and Idler Wheels



Thermography is an excellent trending tool on machinery which can be easily scanned from a distance during normal operation, such as the motors and idler wheels on large gantry cranes.



7. DC Hoist Motor Brushes

The brushes on the lower portion of this image of a DC hoist motor are dirty and worn. The motor cover was removed and the hoist was operated to capture this image.

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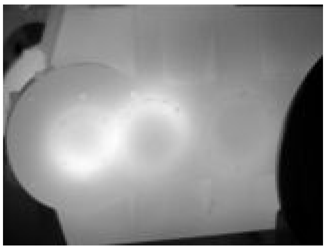
8. Gearbox



Infrared thermography is used in conjunction with technologies such as acoustical testing, oil testing, and vibration analysis for predictive maintenance of equipment such as gear boxes. When these different methods are used together for trending purposes, safety and reliability is vastly improved.

9. Compressor Leak

The heat from this leaking cover on a compressor is transferring to the area of least energy, which is the nearby instrumentation tubing. The tubing is acting as a heat sink in this case.

10. Lube Oil Tank

The levels and flow of fluids such as lube oil can often be monitored using a thermal imaging system.

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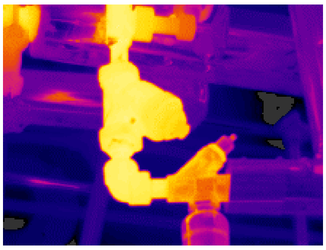
Steam Systems Applications

Steam systems contain a lot of thermal energy by their very nature. The different thermal properties of water vapour vs. steam, of good insulation vs. poor insulation, and other variances allow the thermographer to quickly identify problem areas.

1. Steam Trap Survey



Steam traps hold back water vapour and allow steam to pass through them. The effects of a defective steam trap go beyond the huge financial loss incurred from inefficient steam generation. A failure can increase boiler operating rates, reduce boiler life, impact the environment, raise fuel costs, and influence overall plant integrity.

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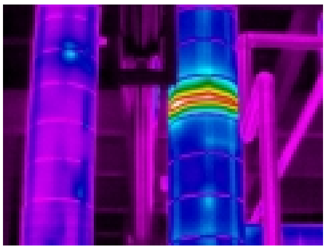
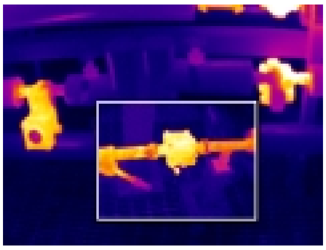
2. Steam Line Insulation



This is a steam line with poorly installed insulation. This image demonstrates two things. First, even shiny cladding will provide a thermal signature of the problem if the temperature rise and differences are adequate and the insulation is poor. Second, energy is lost from steam systems by improperly operating steam traps, insulation, etc. and this wasted energy results in increased operating costs. Maximizing the thermal efficiency of a steam system in a large generation facility will pay for an infrared program many times over.



3. Steam Trap Comparison

The inset image shows a passing steam trap in comparison with the two good steam traps in the larger image. Improperly operating steam traps rob steam system efficiency and increase the erosion in piping and equipment.

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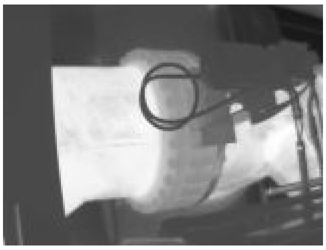
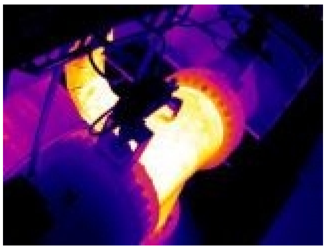
4. Functioning Recovery Valve

This image shows a recovery valve that is properly seated and not passing. The temperature change across the two sides of the valve in this large steam line is very obvious.



5. Passing Recovery Valve

This image shows a recovery valve that is passing. The lack of significant temperature change across the two sides of the valve in this large steam line is very obvious.

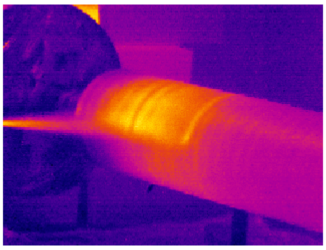


6. Functioning Recovery Valves

This image shows two recovery valves that are properly seated and not passing. The temperature changes across the valves in this large steam line are very obvious.

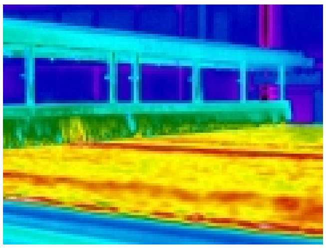
Manufacturing Applications

Real-time, continuous quality control of manufacturing processes is possible with infrared thermography. Periodic scans can be carried out as part of the facility maintenance route, or permanent cameras can be installed to monitor conditions and automatically alarm operators.



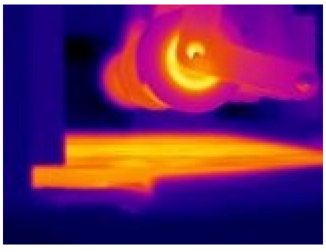
1. Pipe Coating

During manufacturing, infrared thermography can be used to monitor quality, such as in this pipe coating process.



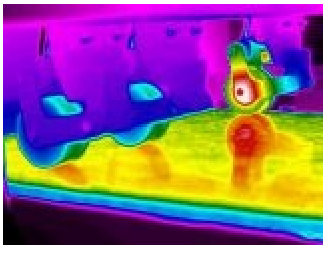
2. Structural Board Manufacturing

This image shows a board manufacturing application. The difference in moisture across the surface is evident with the infrared camera, as are inconsistencies with the brushes.



3. Pinch Roller Failure

This pinch roller has a worn pin and has come loose. Elevated heat from the increase in friction on this continually moving component made this failure immediately obvious with the infrared camera even though it was difficult to detect with the naked eye.

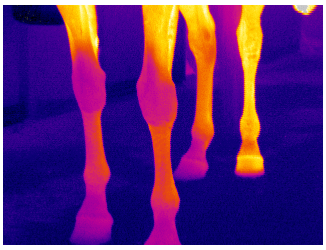


4. Roller Failure

This roller has a worn pin and has come loose. Elevated heat from the increase in friction on this continually moving component made this failure immediately obvious with the infrared camera even though it was difficult to detect with the naked eye.

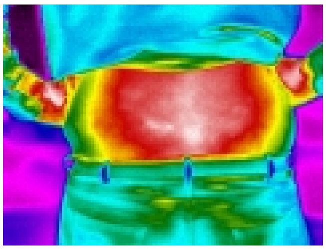
Medical and Veterinarian Applications

As with other systems, human and animal bodies change thermally under different operating conditions or when problems occur. The infrared applications are especially useful for veterinarian applications such as race horse diagnosis when it can be difficult to pinpoint respiratory problems, pinched nerves, improper shoeing and other performance factors.



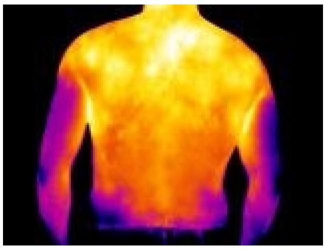
1. Race Horse Left Hind Leg

Infrared thermography can provide valuable information for veterinarians, pinpointing problems such as pinched nerves, strains, pulled muscles, and improper shoeing.



2. Human Lower Back

This image shows a the inflammation of a bad lower back.



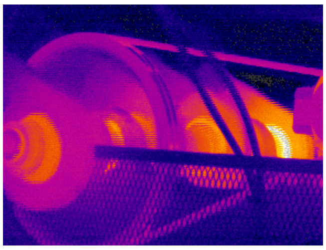
3. Inflamed Shoulder

This image shows shoulder inflammation.

Rotating Equipment Applications

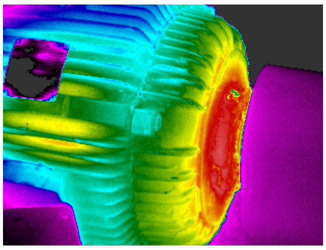
With both rotating equipment and machinery, infrared thermography is often used to find immediate failures and critical problems. Perhaps an even greater benefit, however, is in trending equipment in conjunction with other maintenance technologies such as vibration analysis, acoustics, and oil analysis. All of these monitoring methods should work together in a comprehensive predictive maintenance program. If the data is gathered and correlated consistently, the cost benefits are phenomenal.

As with all infrared inspections it is also important to understand the theories involved in how infrared radiation works and how heat transfer is affecting the objects in a thermal image. Concepts such as emissivity, thermal reflections, thermal conductivity, and indirect temperature measurement are crucial to the identification and diagnosis of mechanical problems.



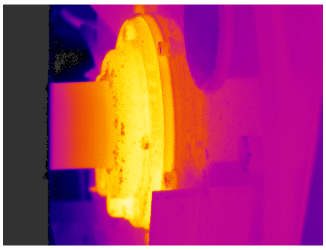
1. Chipper Conveyor Arm Bearing

The hot spot on the right side of the image indicates an overheating bearing. Examination and replacement of the bearing during the next scheduled outtage avoided possible unscheduled down-time and capital loss.



2. Electric Motor Bearing

During a routine electrical survey, this motor was identified as having a damaged inboard bearing. Infrared imaging can quickly identify bearings, motor windings, gears, and other elements of rotating equipment that overheat due to misalignment, wear, under/over lubrication, and misuse.



3. Pump Bearing

During a routine electrical survey, this pump was identified as having a damaged inboard bearing. Infrared imaging can quickly identify bearings, motor windings, gears, and other elements of rotating equipment that overheat due to misalignment, wear, under/over lubrication, and misuse.

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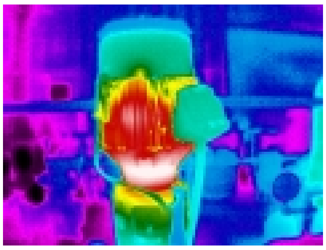
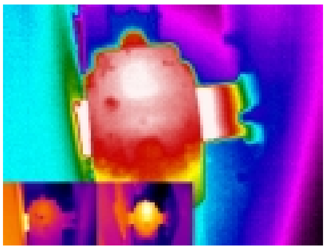


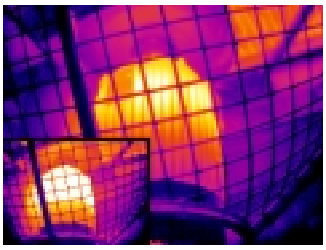
4. Motor Bearing

Bearings can be compared with like equipment under similar load, can be trended over time, or can be flagged for immediate repair if a critical temperature rise is noted.



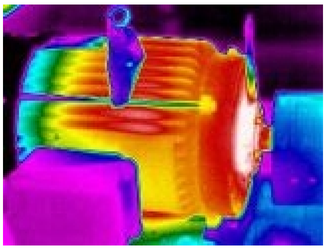
5. Over tightened Cooling Fan Belt

The belt attached to the left side of this bearing is overtightened, causing the top of the bearing to overheat. (This is a lower bearing, therefore the belt pressure is to the top.) The inset image shows a normal bearing (left) where the heat is transferring from the friction of the belt vs. the overheating bearing (right) where the main source of heat is the upward pressure on the bearing itself. Another important thing to note in this comparison, is that the same colors will not necessarily represent the same temperature ranges in different thermograms. The object parameters and image scale and levels will change these representations.



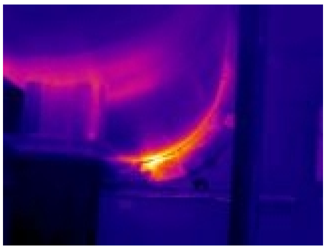
6. Overhead Cooler Fan Motors

The images of these two motors are taken with the same parameters, scale, and level. They should be operating under the same conditions. The inset motor, however, has the wrong pitch of fan blade, at it is operating at least 10° C hotter. This surface temperature on the motor housing is indirect, and the air flow in the area will reduce the thermal signature to some degree, so this calculated temperature rise is conservative.



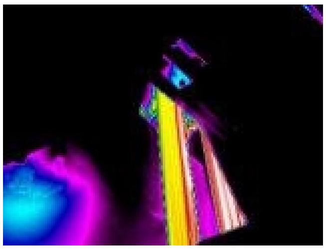
7. Overheating Inboard Bearing

An understanding of heat transfer and the ability to obtain a good thermal focus with an infrared camera allows a thermographer to clearly identify a failing component, such as this motor inboard bearing.



8. Turbine Enclosure

This image shows a leaking seal on a turbine enclusure around a cooling air line.



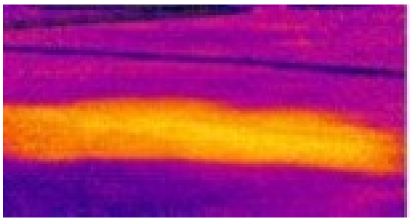
9. Twisted Drive Belt

The far right belt in this belt drive assembly is twisted and appears hotter than the belts to the left. The undersides of all of the belts appear hotter due to friction with the sheave.

Building Applications

Building applications range from the fairly straightforward, such as wet roof insulation, to advanced building science studies. Building envelopes, heating and cooling systems, electrical systems, insulation, pest infestation, structural integrity, and many other aspects can be studied using infrared technology.

As with all infrared inspections it is also important to understand the theories involved in how infrared radiation works and how heat transfer is affecting the objects in a thermal image. Concepts such as emissivity, thermal reflections, thermal conductivity, transient heating and cooling, and environmental effects are crucial to the identification and diagnosis of building problems.

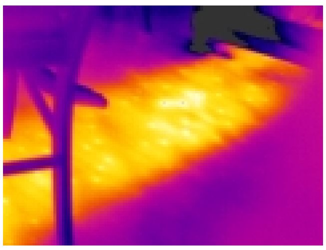


1. Wet Roof Insulation

This image shows wet insulation on a roof. During the day, the sun will warm the roof, and this energy is stored in the thermal mass of the water after the sun's energy is removed. At this point, the wet insulation appears as a hot spot. In the morning, the sun warms the roof again,and wet material takes longer to warm up, appearing as a cold area. At some point during the day and during the night, thermal equilibrium will occur, making the indication disappear.

2. 1948 House Wall from the Inside

This is the North wall in a 1948 house during the winter. The thermal conductivity of the studs, nails, and insulation are very apparent, as is the lack of sealing of the plate at the top of the wall.



3. Heat Duct

This is an image of a hardwood floor in a house. The heating duct between the floor joists had become disconnected, filling the cavity, rather than the room above, with warm air.

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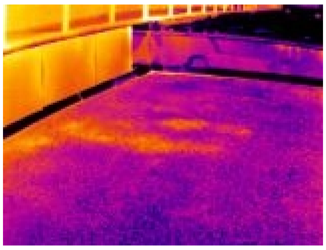


4. Wet Roofing

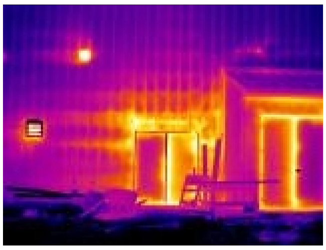
This image shows wet insulation on a roof. During the day, the sun will warm the roof, and this energy is stored in the thermal mass of the water after the sun's energy is removed. At this point, the wet insulation appears as a hot spot. In the morning, the sun warms the roof again,and wet material takes longer to warm up, appearing as a cold area. At some point during the day and during the night, thermal equilibrium will occur, making the indication disappear.

5. Poor Window Seals

Older, aluminum sliding windows typically do not seal as well as the newer style sliding windows. This image shows the exfiltration of warm air around the poor seals on the smaller, sliding portions of these windows on the second story of a house.

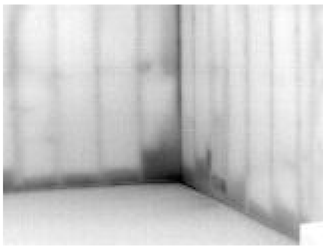
6. Apartment Building Envelope

This image shows air leakage in a wood-framed, multi-story building under positive pressure.



7. Public Building Envelope

The doors and portions of the wall in this image show failures in the building envelope and missing insulation when viewed with a thermal imaging system.



8. Damp House Basement

Wet insulation is apparent in the corner of this basement room.

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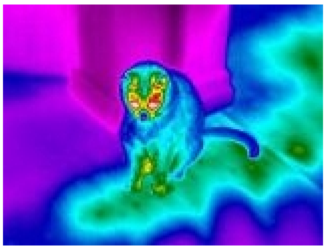
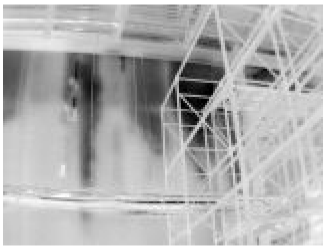


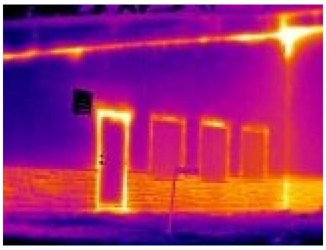
9. Leaking Forced Air Ducts

This portion of the main floor in a residence is over the furnace room. The cat found areas warmed by leaks in the forced air ducting before the infrared camera did.



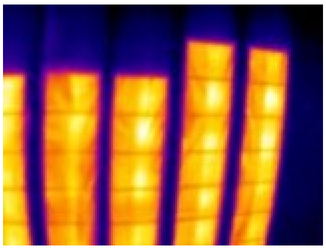
10. Wet Freezer Insulation

A portion of the building caught fire beside this large, industrial freezer. During the attempt to extinguish the fire, water penetrated the freezer insulation from the top down. This image shows the areas of wet insulation.



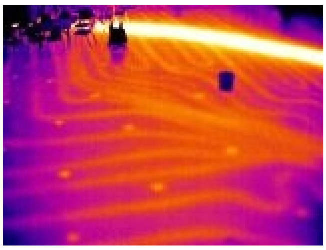
11. Air Exfiltration

This image shows air exhilaration under positive pressure in a sitting area of a public building.



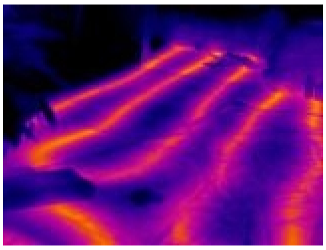
12. In-Ceiling Heat Panels

This image shows electric heating panels installed in the ceiling of an apartment condominium building.



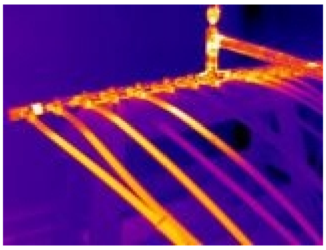
13. In-Floor Heating

This image shows in-floor heating in a large meeting hall. The lines had to be located prior to coring for foam-jacking. The hot spots are where the holes were drilled in the concrete.



14. In-Floor Heating

This image shows in-floor heating in a public pool reception area. The lines had to be located prior to drilling to anchor benches onto the concrete.

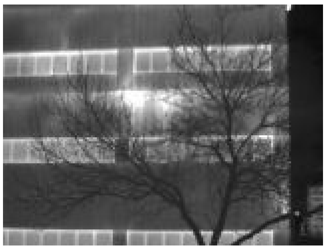


15. Airlocked In-Floor Heating Header

Only four of the eight passes on this side of the header have flow through them. The header was installed on a strange angle, causing airlocks and preventing air from properly bleeding from the valve on the top center of the header. If thermography is used to locate in-floor heating, air-locked lines will not show up since there is no hot fluid flowing through them.

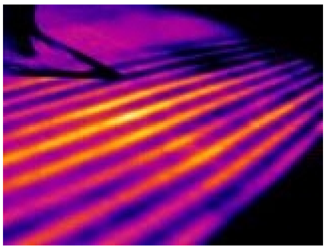
16. Bat Access Under Residence Eaves

This residence has a bat infestation in the roof sections. A thermal imaging system was used to determine where the access areas where so that they could be sealed when the bats left.



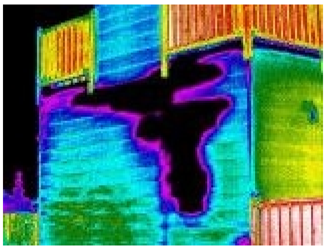
17. Moisture Under Office Complex Siding

There is moisture evident behind the metal siding of this office building.



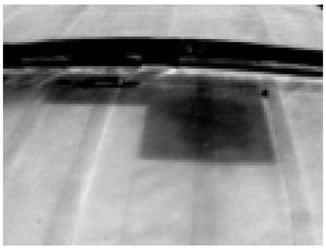
18. Hockey Rink Brine Leak

Leaks in the passes of in-floor refrigeration systems can be detected using infrared thermography, but this technique requires a great deal of care and the proper procedure to be effective.



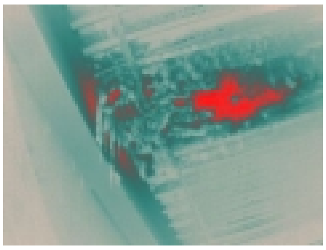
19. Ice Behind Residential Siding

This image shows ice behind the siding of a residence. There is a poor seal around the top of the fireplace chimney.



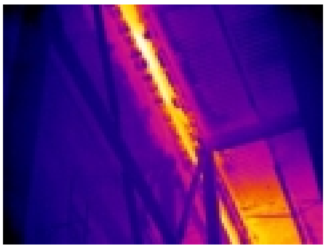
20. Wet Insulation on Freezer Roof

This image shows wet insulation by a roof scupper. The freezer is cold and the day was hot, so the thermal signature is reversed from what you would normally expect from moisture in roofing insulation.



21. Poor Envelope on Freezer Penthouse

This image shows warm air infiltration on the cooling penthouse of an industrial freezer. Moisture from the warm air is condensing and freezing on the cold surfaces around the envelope leak. In some areas, the frost and ice was noted on the floor below the leaks rather than in the immediate area of the air leak.



22. Poor Freezer Envelope Between Old and New Construction

This image shows warm air infiltration between a pre-existing building and a freezer expansion that was added later. Moisture from the warm air is condensing and freezing on the cold surfaces around the envelope leak.

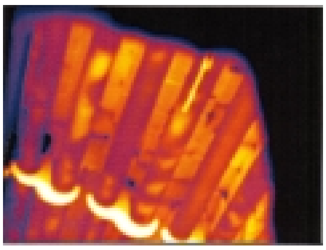
Furnace Applications

Furnaces are an obvious infrared subject since they are a source of a lot of thermal energy. External scans of refractory and piping, doors, and internal furnace tube surveys are all common infrared applications.

For external surveys, a wide angle lens is often useful for the close views of the skin from the narrow decking. A telephoto lens is useful for images taken from grade or adjoining furnaces.

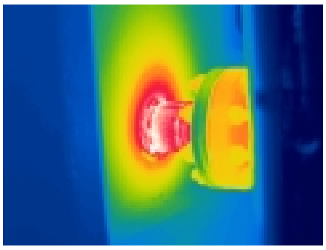
For internal surveys, the right type of camera, filters, and lenses are essential. A solid, repeatable process for collecting the data, including target parameters, is absolutely necessary for reliable temperature data. Remember, there are good reasons why facilities want to know an exact tube surface temperature, and any estimations you make in emissivity or other parametes will result in a greater overall margin of error.

Safety is also very important when working with furnaces. Follow site safety procedures for working around open furnace doors and use the buddy system. Watch for tripping hazards on decking, and make sure you don't still have your infrared camera in your hand when you climb ladders.



1. Furnace Tube Survey

The object of this survey is to identify any possible coking on the inside tube surface. The build-up of coke acts like an insulator reducing the required cooling effect the product has on the tube. Tube life is reduced by deterioration and a rupture is risked. Thermographers can also perform quantitative analysis of tube surfaces to provide temperatures, however this procedure requires careful gathering of object parameters such as emissivity and background reflected temperatures and should not be attempted without a clear knowledge of the possible sources of error.



2. Snuffing Steam Nozzle

This nozzle on a steam snuffing line was noted on the corner of a furnace during a refractory survey. The line had been prematurely blinded in preparation for an up-coming shutdown and temperatures in excess of 600° C resulted.

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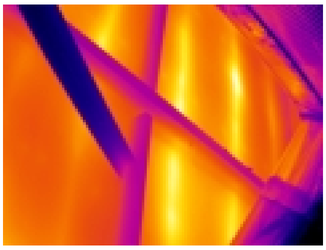
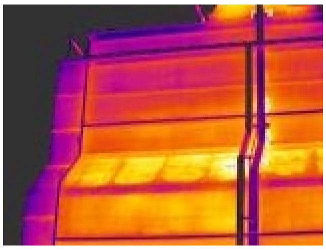
3. Bottom of Furnace

This image shows the bottom of a furnace, including the refractory fastening points and a shallow build-up of ash at the bottom. It is a good example of the fine thermal detail of quality infrared equipment. It also shows the clarity of detail that can be achieved using a black and white palette for some applications.



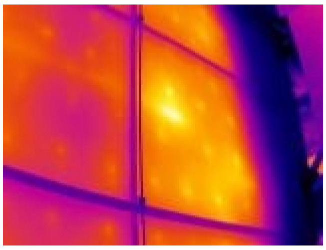
4. Furnace Refractory

Furnace refractory breaks down over time, especially along the joints of the pieces of the insulation. Pre-and-post shutdown scans can determine the extent of repairs required and the effectiveness of those repairs.



5. Asphalt Feed Furnace

Concentrated areas of refractory damage area evident in this image. Trending over time is useful in determining the rate of deterioration of refractory in furnaces.



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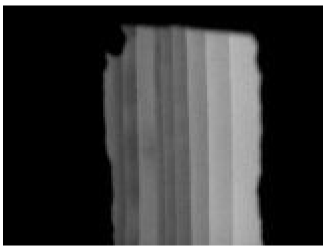

7. Furnace Tubes

This image shows furnace tubes through a small inspection port. The proper thermal imaging equipment with the appropriate filters and correct inspection procedures are required for these types of inspections.

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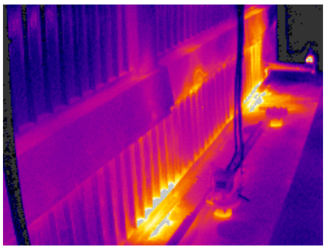
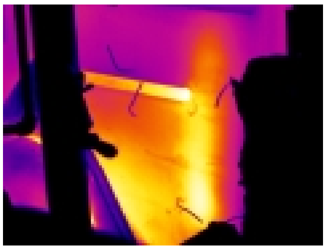
Boiler Applications

1. Boiler Flue Gas Leaks

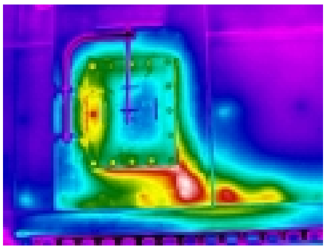


The infrared camera help you scanned for flue gas leaks and to determine the refractory condition. A pre-shutdown infrared survey revealed cracks on the Northwest corner of the boiler on the fifth level. During the shutdown the area was inspected internally and repairs were made as required. Post-shutdown infrared survey confirmed the effectiveness of the repairs.



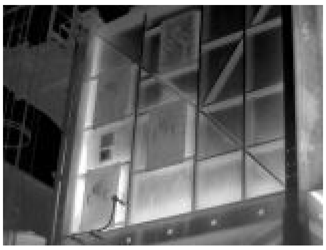
2. Boiler Skin Crack

This image shows an leak on a boiler in a natural gas fueled power generating station. Close examination showed an vertical, linear indication on the wall of the boiler.



3. Boiler Refractory

This is an image of the wall of an new heat recovery steam generator. Poor refractory is evident around the door, as is a poor seal on the left side.



4. Boiler Economizer

This image shows the economizer section of a large boiler. Poor refractory is evident on the left side.

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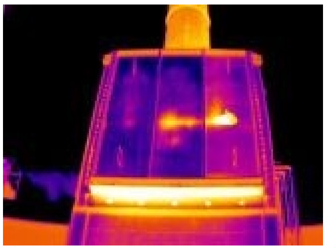
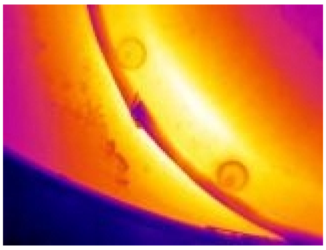


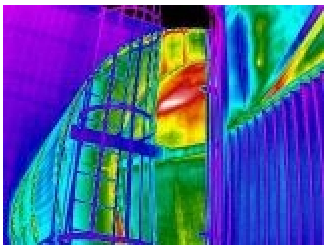
5. Boiler Economizer

This image shows the end of the economizer section of a large boiler. Poor refractory is evident in the center of this panel. The bright, apparently hot indication to the right is merely loss of the reflective paint.



6. Boiler Manway

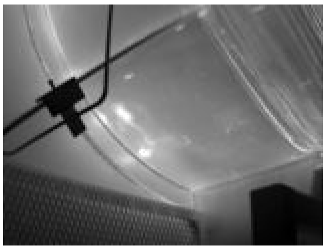
This image shows a boiler manway. A poor seal is evident in the portion captured here.



7. Boiler Outlet

This image shows the outlet section of evident on the top portion of the outlet

a boiler. Poor refractory is to the economizer.



8. Formation Boiler

This image shows poor refractory on the lower portion of a formation boiler.

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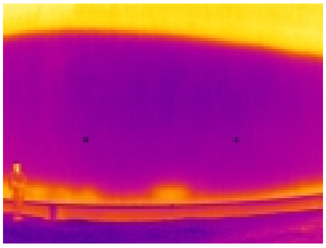
Storage Tank Applications

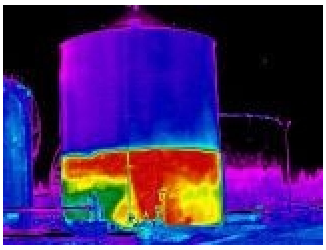
Infrared thermography can be used for various storage tank applications. These include determining tank levels, finding the layers of different liquids and gases, and determining the amount of build-up.

Although these applications can be quite straightforward, there are a lot of factors which can cause errors or make the results inconclusive. It is important to understand the effects of enviromental conditions, curved surfaces of tanks, differing thermal conductivities, and both forced and natural convection in tanks.



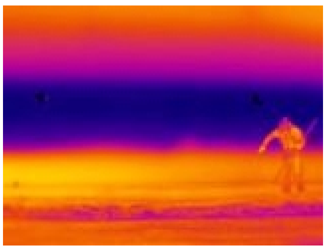
1. Storage Tank Sludge and Bottoms

This image shows measurement of paraffin or sludge levels in a crude storage tank. Paraffin levels appear as a heat differential banding in the tank. The levels are quite high in this image, imaged and confirmed at almost 4 meters. There are also some bottoms (likely water, sand, rust, etc.) apparent in the lower portion of the tank.



2. Disposal Water Tank

The different temperatures of the thermal mass in the tank and the water entering it are evident in this image. In drinking water systems, this phenomenon can reduce the water quality due to mixing and aging problems in distribution system storage facilities.



3. Paraffin Levels

There is usually not just a simple layer of paraffin or other material in the bottom of tanks. Often there are also deposits on the walls of the vessels. These two heights can be confusing, and a good thermal contrast is required to differentiate between them and measure the sludge levels.

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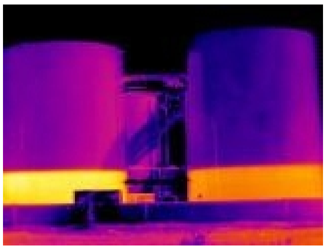


4. Tank Levels

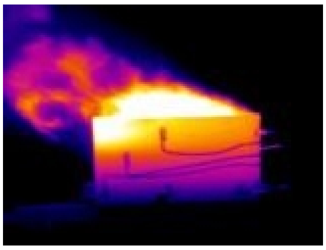
If the conditions are right, tank levels can be very apparent and simple to measure with a thermal imaging system.

5. Water Tank Sludge Build-up

This storage tank required periodic cleaning to remove sludge levels from the bottom. Using infrared imaging technology, the cleaning schedule was easy to determine.

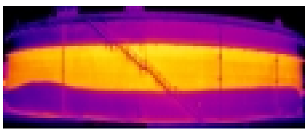
6. Interfaces in Horizontal Vessel

The interfaces between the different layers of product and the gases flashing off are apparent in this image.



7. Tank Fire Simulation

Infrared cameras are excellent tools for monitoring the heat zone moving down a tank during an crude tank fire.



8. Tank Sludge Build-up Overall

The infrared camera can help you to calculate volumes of paraffin and providing cleaning services. Specialized technology is used to measure, calculate, and then remove paraffin if required.

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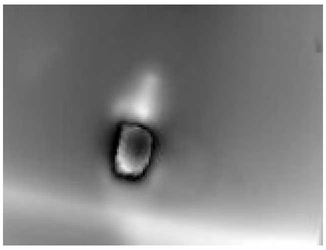
Aircraft Applications

Many of the systems in aircraft are similar to other electrical, mechanical, and hydraulic systems inspected using infrared thermography. The body of the aircraft can also be inspected in a similar fashion to building envelope and moisture studies.

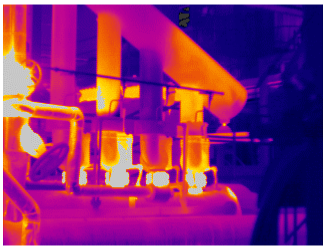


1. Moisture in Aircraft Door

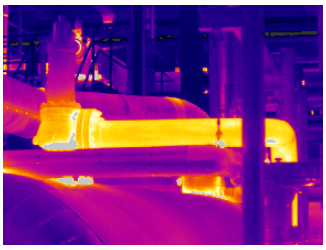
Moisture in composite aircraft components can be detected either as hot spots or cold spots, depending on the procedure used to create the signature.

Pressure Safety Valve Applications

1. Pressure Safety Valves



This image shows 2 powerhouse PSV's passing steam (shown in yellow), and 2 of the valves operating within acceptable parameters. Improving plant operating conditions by reducing fossil fuel consumption resulted in enormous benefits in the areas of plant operating costs and the overall environmental impact.



2. Pressure Safety Valve

This image is of a PSV passing steam on a vessel in a power generation facility. Improving plant operating conditions by reducing fossil fuel consumption resulted in enormous benefits in the areas of plant operating costs and the overall environmental impact.

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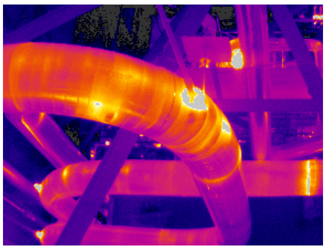
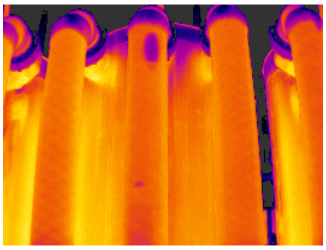
- **Piping Applications**

Piping runs throughout facilities. Although the infrared applications are more limited on insulated and cladded lines, issues such as build-up, delaminations, insulation problems, heat tracing, and other aspects can be evaluated using infrared technology.



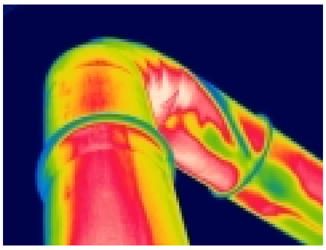
1. Boiler Steam Lines

The infrared camera can help you to scan the steam lines at a large power generation facility. The survey was an integral part of the early implementation of an energy conservation plan. Poorly insulated lines were identified throughout the plant. Heat loss was evident even on lines that had been re-insulated as recently as 2 years prior to inspection. In this image, poor or damaged insulation is apparent on the U-bend of the upper line and on the right-hand portion of the lower line. With the rising costs of fuel, energy efficiency has become a greater priority for industry.



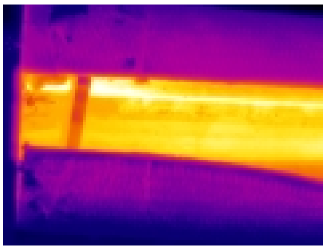
2. Pipe Delamination

During routine scanning at a chemical production facility, delamination of the fibreglass pipe from the teflon liner was revealed. Such delamination could result in diminished production capacity, reduced product quality, and a risk to the welfare of personnel in the event of failure. These lines are scanned when new and monitored on a regular basis.



3. Material Build-up

The internal build-up is visible on the inside diameter of this line, as is the flow pattern. You are not seeing "through" the piping in this image. Rather, there is an evident difference in the rates of heat transfer to the outside of the pipe between the moving fluid vs. the build-up.



4. Heat Tracing

This image was taken to verify that the heat tracing banded to the process line would have adequate heat transfer. The insulation had to be partially removed in order to gather the information desired in this particular application.

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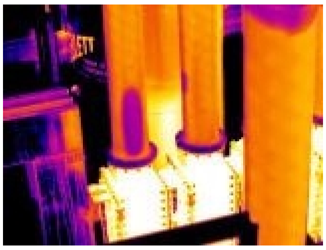
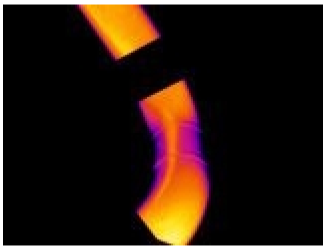
5. Deposits in Piping

The gradual deposit of material over time in this line resulted in restriction. The level of the deposits is evident from grade with a thermal imaging system.



6. Pipe Delaminations

This is another image showing delaminations of the lining from the outer layers of process pipes. A large area is obvious on the front of the pipe to the left. There is a smaller area that has just started on the side of the pipe beside it.



7. Oil Line Build-up

Although it can be difficult to tell what the thickness of build-up is in process lines such as in this sales oil line, the areas of restriction can be located and identified. Trending these areas with periodic thermal scans provides valuable information about the progression of build-up. In this image, there is a clear trough cut through the build-up by the oil as it makes its own path along the underside of the bend.

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