

# THERMOGRAPHY 101 – A SHORT PRIMER

## THERMOGRAPHY 101 – A short primer

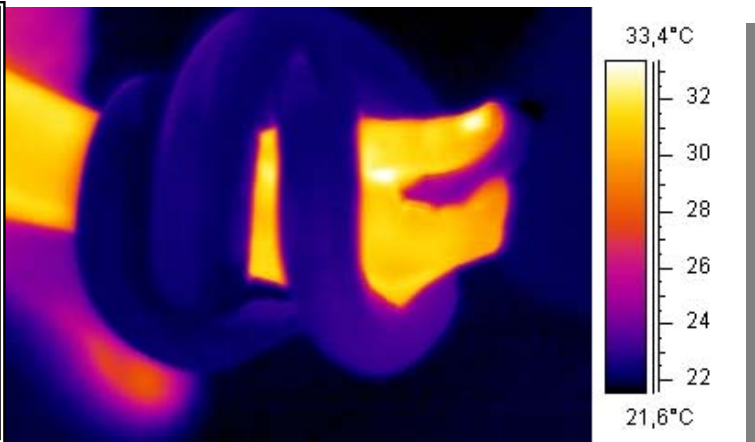
By Daniel S. Amster

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Suppose you wanted to know where insulation, blocking or studs are located behind drywall, or maybe you suspect a water leak in a wall cavity or under a slab. Wouldn't it be great to be like Superman and just use your X-ray vision? How great would it be to gaze into a crystal ball and know in advance if electrical or mechanical components were failing or going to fail shortly? You got roof leaks? Duct leaks? Pipe leaks? Air leaks? These are just a few examples of common problems which in the past may have seemed to building owners, managers and contractors like chasing ghosts; long, frustrating and expensive ordeals. Welcome to the 21<sup>st</sup> century! Thanks to the miracle of modern science, a technology is now available to deploy against these and other vexing building and system issues. Welcome to the world of Thermography.

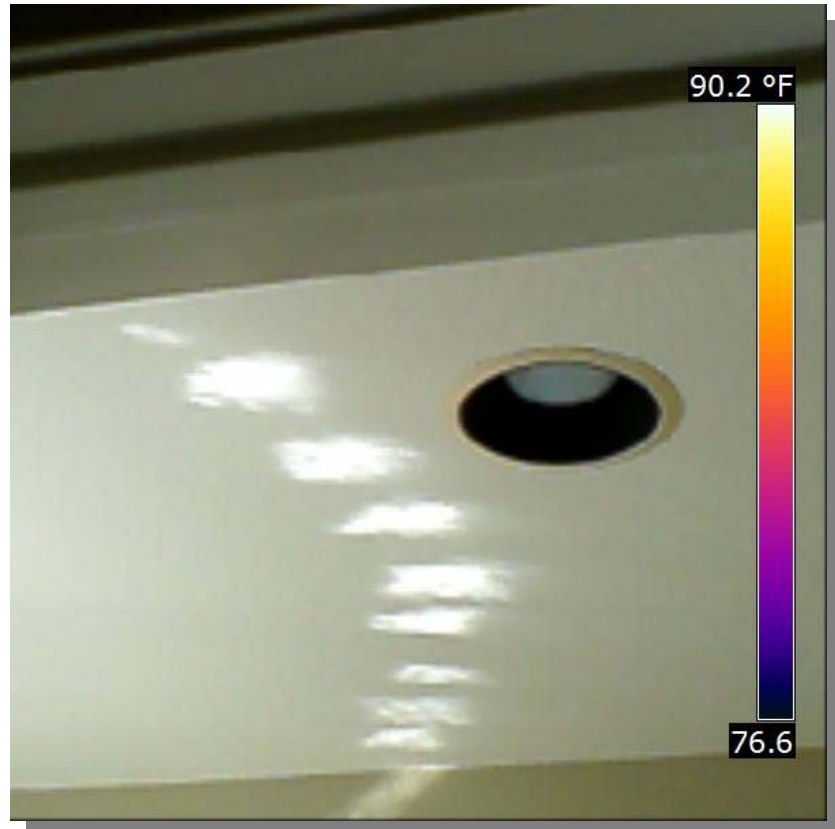
Photography makes images of visible light bouncing off surfaces; thermography makes images of heat energy radiating off of surfaces, a property known as emissivity. Emissivity is a measurement of a material's ability to emit thermal radiation (heat) and is quantified on a scale of 0.0 to 1.0. You know this property from your everyday experience; asphalt has a very high emissivity (.93). Did you ever walk across an asphalt surface during the summer? Did it feel hotter than the surrounding air? The property of emissivity makes working with thermal images different than visible light photography because every material is radiating varying amounts of heat, the images must be "thermally tuned" for maximum usefulness. This tuning works to highlight the actual temperature differences of materials, so the images are useful. Thermal images can be made using a range of colors, black and white, or a composite of photography and thermography; a broad range of options for a broad range of applications.

*The thermographic image on the right is a person holding a snake. The person is radiating heat at approximately 98.6 °F (37°C) while the snake (as a cold blooded animal) is the same temperature as its surroundings and therefore radiates almost no heat. The person's arm appears bright yellow in the picture (hot) while the snake appears dark purple (cool, it's almost the same color as the background).*

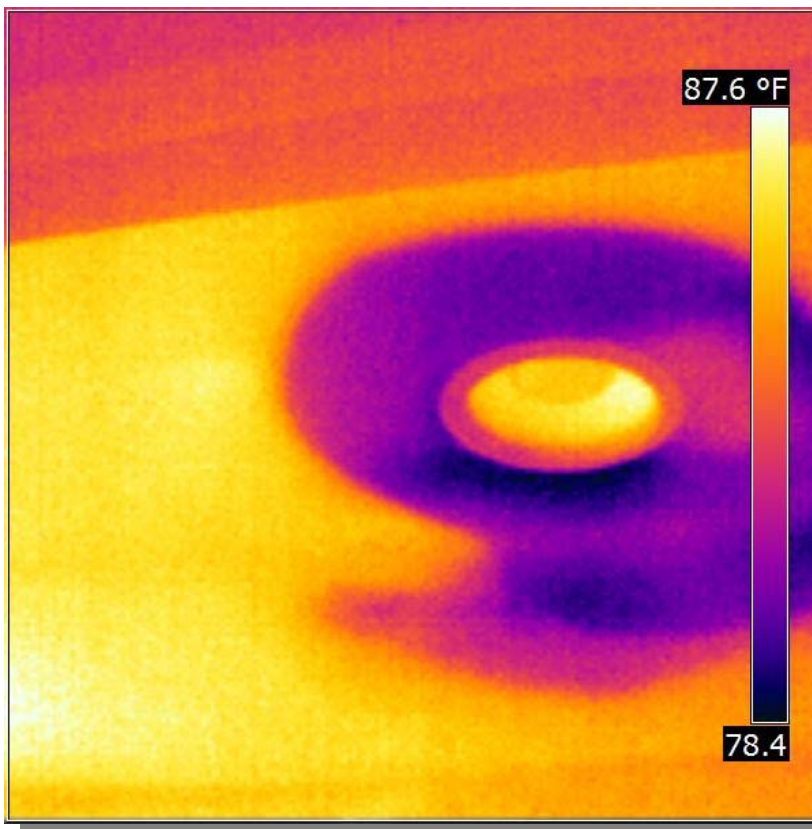


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## Leak detection



*Visible light photograph of a ceiling and a recessed light fixture. Everything looks normal enough, but this ceiling was damaged by a water leak. The extent of the damage is not visible to the naked eye...*



*... but you can't hide the heat signature... On the left is a thermographic image of the same light fixture as above. The extent of the water damage is clearly shown around the fixture. Varying shades of blue/purple indicate the extent of the water damage; the darker purple, the more water intrusion.*

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## Missing insulation



The thermographic image on the left was taken as part of an energy audit of a custom built private residence in Las Vegas. The bright yellow section of wall (center) is a sheerwall that appears to have no insulation. During construction the plywood sheathing was obviously applied before the insulation was installed (a fairly typical problem). When the rest of the house was insulated, this area was covered over, not visible and therefore it was not insulated. Note the sharp contrast between the areas that were insulated and those that are not. This house had many areas of missing insulation.

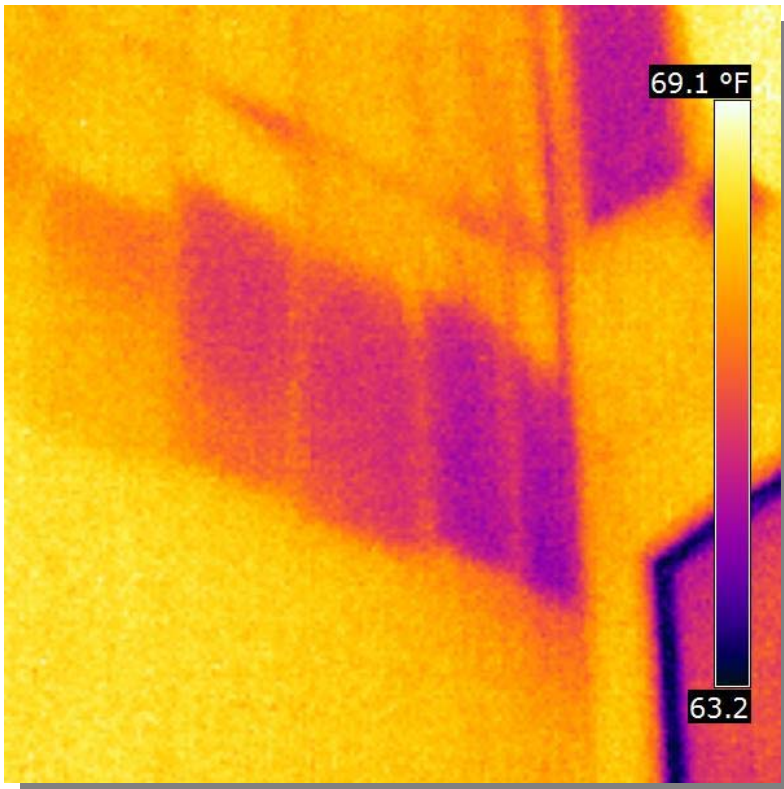
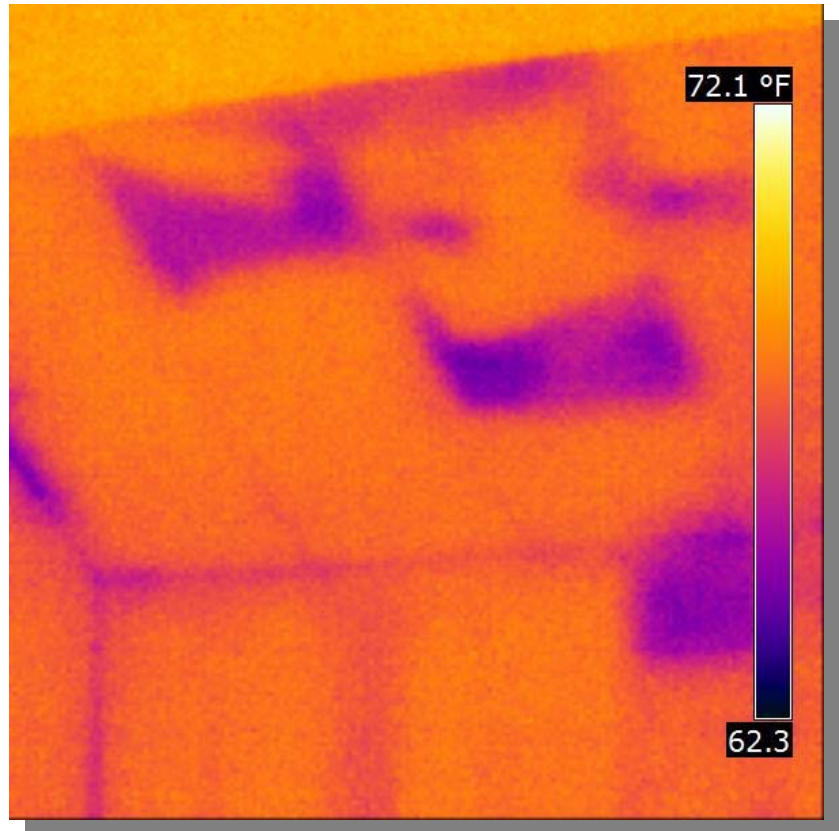
Repairs entailed removing the drywall and the sheerwall panels to expose the un-insulated wall cavity (seen on the left). New insulation was installed (right); the sheerwall panels and drywall were then replaced and finished to match. In this particular residence approximately 20% of the ceilings were not insulated as well as a 320 s.f. section of west-facing exterior wall. Once these problems were corrected, the home owner reports more comfortable living and lower energy bills to match.



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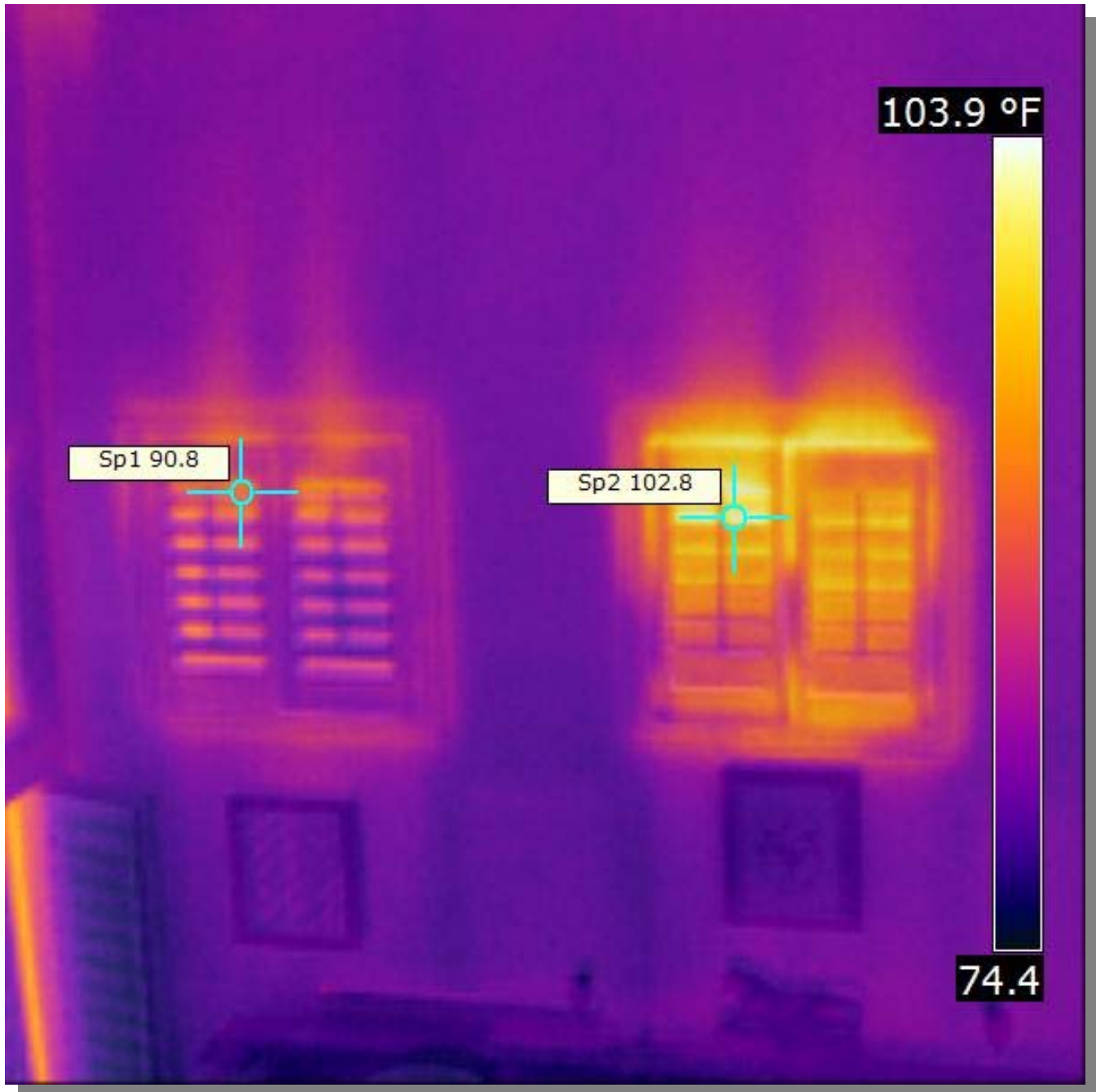
## Missing insulation

The thermographic image on the right shows areas of exterior walls and a vaulted ceiling that are missing insulation (visible as purple in this image). The wood framing also shows up as purple, indicating that it is not as good an insulator as the fiberglass insulation. Repairs to these areas include removing the drywall, installing new insulation and replacing the drywall.



The thermographic image on the left shows areas of exterior walls that are simply missing insulation despite being in plain sight when the insulators were onsite. Perhaps the wind blew the insulation out of the wall before the drywall was installed? The dark area (bottom right) is actually artwork hanging on the wall.

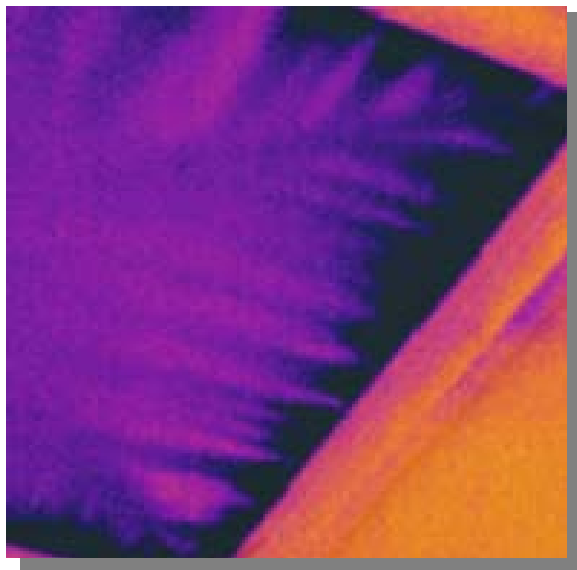
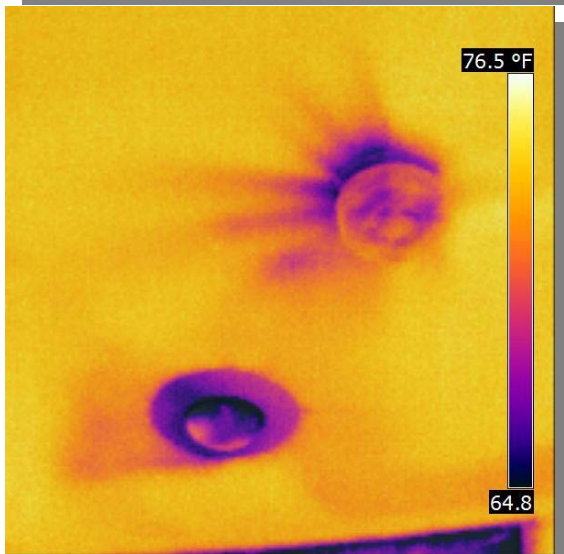
## Solar gain



*Got sun? The thermal image above shows the impact of low emissivity (commonly called low-e) window tint. The two windows shown have full sun exposure and are identical except that the window on the left has a low-e film applied. Due to the nature of emissivity the temperatures shown may not be accurate; what is important is that the low-e film reduces the temperature of the left window 12°F compared to the window on the right.*

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### Air leakage



*Air leakage impacts comfort, energy consumption, and air quality. Besides the obvious hot or cold temperatures associated with outside air infiltration, there's also dust, dirt, and allergens carried into a building along with the outside air. Air infiltration into a building from an insulated attic space or insulated wall cavity can also carry loose fiberglass insulation.*

*Air infiltrates buildings in many ways, around doors and windows, thru electrical outlets in exterior walls, and thru cracks in stucco (to name just a few). The air around us is always on the move. We don't recognize it as wind until it's measurable in miles per hour, but no matter how slight that movement may be it is always moving. This moving air (wind) creates a positive pressure on the side of the house facing the wind and a negative pressure on the side facing away from the house. The pressure differential moves the air in the wall cavities and throughout a building.*

*Hot air is less dense than cold air, so hot air rises relative to cold air and cold air sinks relative to hot air. This is why it always seems to be hotter upstairs than it is downstairs... it probably is. As the warm air rises, cooler air fills in behind it. This cooler air can be the naturally sinking conditioned air from within the building or outside air infiltrating the structure.*

#### Top photo

*Air leakage seen as dark purple under a front door. Insulation also appears to be inadequate in the wall to the lower left of the door.*

#### Middle photo

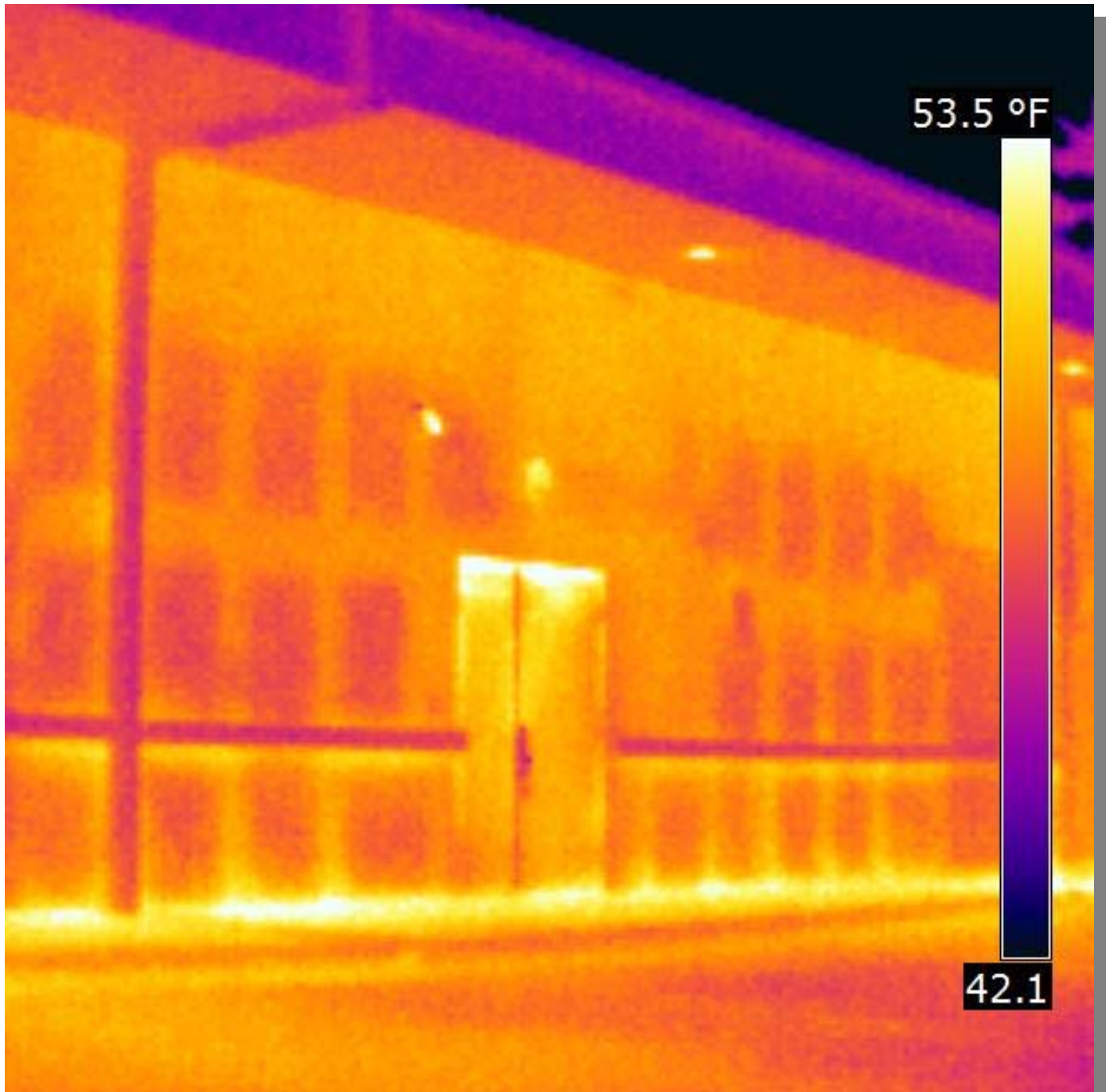
*Air leakage around a smoke detector and recessed can light visible as dark purple on the ceiling.*

#### Bottom photo

*Air leakage of an un-insulated attic access door seen as dark purple in this thermographic image.*

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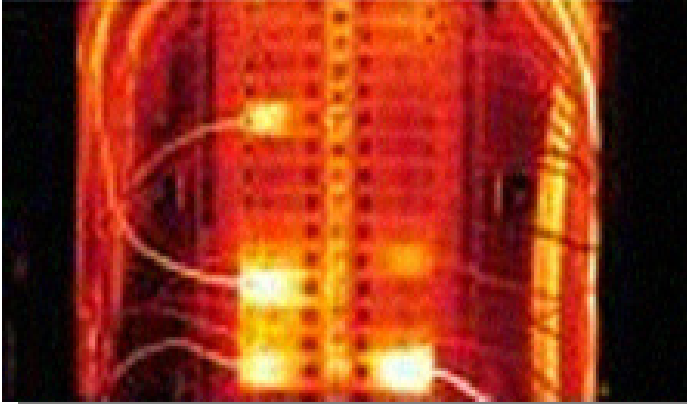
### Structural



*On a recent project, the client needed to analyze an existing masonry structure. The tried and true method is to walk along the wall tapping with a hammer listening for differences in the sound. Using a thermographic image yields more accurate results in a fraction of the time. The lighter shaded areas are grouted solid and contain reinforcing steel – exactly what the client needed to know.*

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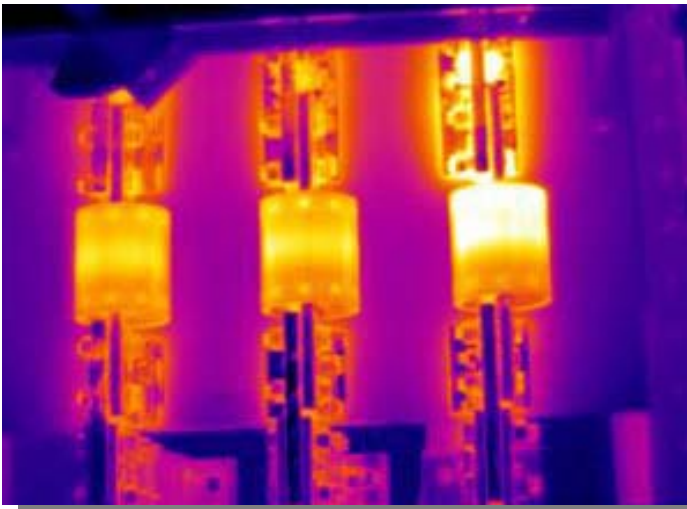
## Electrical



*As electrical components age and wear they draw increasingly larger electrical loads and heat up, further stressing the components. This is an example of a progressive failure.*

*Building electrical services and switchboards can be thermographically imaged without interrupting electrical service to any occupants. In the thermographic image (top left) circuit breakers drawing large loads are shown as bright yellow.*

*In the thermographic image (bottom left) the fuse on the far right is carrying more load and is therefore much hotter than the other two and appears almost white. Catastrophic failure can be averted with timely maintenance by a competent electrician.*

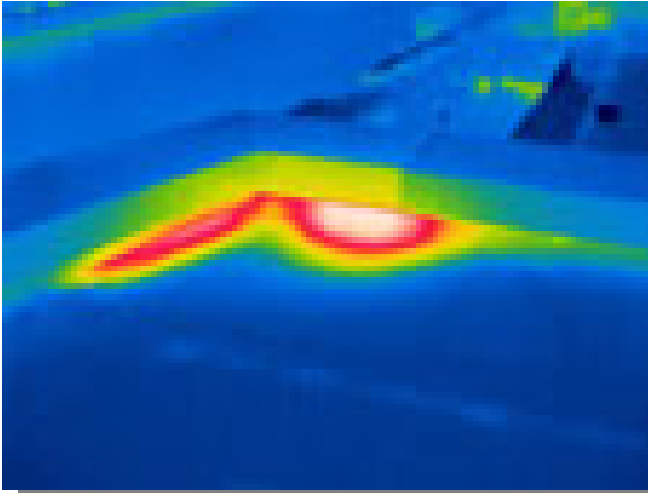


*Some electrical items like printers, photocopiers, and DVRs consume significant amounts of electricity while they sit idle; some 24/7. In the thermograph (right) a DVR and a cable box are seen bright yellow indicating significant phantom power consumption.*



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## Roof leaks

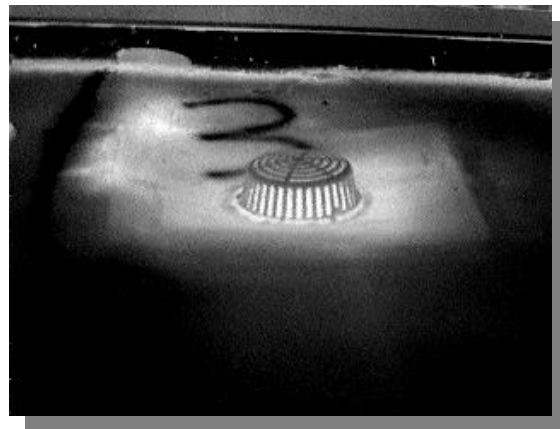


*In the thermographic image (left) water trapped under the roof membrane appears white – warmer than the surrounding roof membrane and insulation. In the image the parapet coping has a seam immediately above the wettest (warmest) part of the affected area and this is the likely source of the leak.*

*In the thermal image (below left) there is an area of relatively cooler temperature in the center. In the photograph (below right, the same view) a roof drain pipe is visible, indicated by the red arrow. Roof drains are a common source of roof leaks.*



*The black and white thermographic image (right) is an example of what a leaky roof drain would look like from above the roof. Leaks found without guesswork of removing the existing roof.*



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### **Summary**

Thermography can be a useful tool when it is not practical, economical or safe to disassemble a system to diagnose or repair. A thorough knowledge of the system being studied as well as the intricacies of the thermal imager is essential to properly using and understanding thermographic images.

A special thank you to Kem Fredrick, principal and founder of LGE Consulting, LLC of Las Vegas for contributing many of the images in this article. Kem is certified as a level II Thermographer. For additional information about thermography or to schedule a thermographic inspection, visit [www.lgeconsultants.com](http://www.lgeconsultants.com), or contact Kem at [kem@lgeconsultants.com](mailto:kem@lgeconsultants.com).