INFRARED THERMOGRAPHY

For Metal Roof Inspections

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By helping roofing and building maintenance professionals pinpoint wet, failed areas of roofs, infrared thermography inspections can save building owners costs and time through repair rather than replacement. Generally, if problem areas cover less than 30% of the total roof area, the entire roofing system does not require tear-off and replacement.

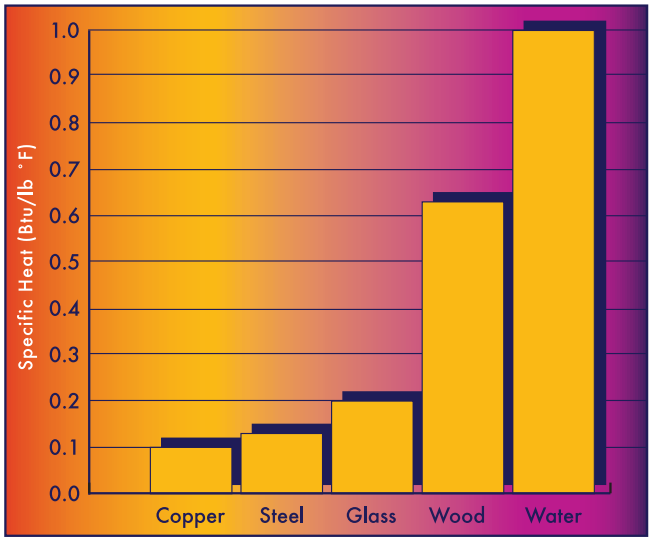

Table 1. Specific heat of various substances. The greater a material's specific heat, the more energy required to heat or cool the material. Water has a much higher specific heat than wood and subsequently cools down or heats up much more slowly than wood under similar conditions. This difference in temperature can be imaged and measured using an IR camera.

Infrared (IR) inspections also enable manufacturers and roofing contractors to create a post-installation inspection record showing the as-built condition of a new roofing system. Some contractors offer periodic IR inspection services to their clients in order to identify problems early, before they become serious. Other contractors and consultants use speculative fly-over surveys to locate problem roofs and then use the evidence to sell their services to building owners.

The practice of infrared roof inspections is addressed in ASTM C 1153, "Location of Wet Insulation in Roofing Systems Using Infrared Imaging" (available at www.astm.org). This standard is well accepted for single-ply and built-up roofing systems. But the rules change when metal roofing is involved.

Instant Analysis is Key

When a roof fails, the most common problem is the introduction of water into the roof system, primarily into the insulation. From here, it can flow onto the structural deck and into the building, where it can cause myriad problems such as leaks, mold, electrical problems, and the destruction of expensive equipment. Over time, persistent leaks can even compromise the structural strength of metal and wood decks.

Infrared thermography is the only technology available that can instantly pinpoint wet areas on roofs invisible to the human eye. An IR camera can quickly assess and image the surface temperatures of many building materials.

When conducted at the right time of day, IR inspections can determine which materials are wet or in contact with wet materials and which are dry. This is possible because water has a high specific heat, which means that it stores heat well and cools down more slowly than common building materials (see Table 1).

After sunset, dry materials cool faster than wet materials,

E2 Camera

so the areas where the camera sees warm temperatures are the ones to check for the presence of water (and leaks) using standard moisture testing methods.

How IR Works with Metal

IR inspections performed from on top of the roof, or a walk-over inspection, can pinpoint leaks in many single-ply elastomeric and built-up roofing systems, but the laws of nature prevent the procedure from working well with metal roofs.

Metal is a poor emitter of infrared radiation and a good reflector. This means that a thermographer aiming an IR camera at the surface of a metal roof will probably get only an accurate reading of the temperature of the sky reflecting off the metal and into the camera lens.

However, metal roofing systems can be evaluated by an IR inspection from inside the building if the underside of the roof deck is accessible. Although ASTM C 1153 does not address this walk-under method, it is fast becoming a favorite technique of roofing thermographers because it can be used to image where a leak is entering a building.

Here's how it works. Just as wet materials cool down more slowly than dry materials, they also warm up more slowly. So after sunrise, the dry portions of the roof heat up faster than the wet areas. Seen from underneath a metal or wood deck, wet areas will appear colder in the infrared (see Figures 1 and 2).

Seen from below, leaks often can be traced to their source, since water can sometimes be seen running through the deck channels. Walk-unders can be performed in virtually any weather conditions, but should be conducted during the morning, when the sunshine on the dry roof causes it to heat faster than the wet sections—just the opposite of walk-over inspection conditions. The acquired thermal images can then be transferred to a structural drawing to help locate likely leak sources topside.

How to Conduct an IR Inspection

To make inspections easier, compact, lightweight infrared cameras are now available that allow inspectors to simply point and scan the roof for an instant, recordable IR image that shows wet areas (see Figures 3 and 4). Conduct a wide-area scan first to confirm that the inspection window is open and good-quality images can be obtained. Then systematically scan the roof and the underside of the deck where possible. Leaks can occur near seams, penetrations, drains, and punctures. Photo document everything in infrared as well as in visible-light photography.

If you locate an anomaly—an unusually warm or cold area—be sure that it is not caused by HVAC units, hot or cold water pipes, electric lights or heaters, or air vents. A sampling of the insulation may be necessary to determine exactly what you have, especially if the records for the last roof construction are lost or unattainable. Highly absorptive insulation will stay wet for a long time. Insulation that drains freely may yield a thermal indication only for a few hours after precipitation.

You may be asked to verify wet areas by destructive or non-destructive test methods, such as cores or the use of moisture instrumentation. A moisture probe requires drilling one or two small holes through the built-up roof surface. After inserting the probe, take and record the moisture reading and then fill the holes with approved sealant.

Outline all confirmed anomalies with paint, and number them sequentially. Take good notes describing the location

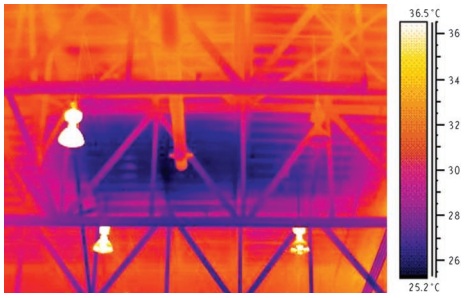

Figure 1. Thermogram during the morning from under a standing-seam metal roof, looking up at the underside of the deck. The sun has warmed up the dry areas of the roof, which appear red and orange. A wet section, not yet as warm as the dry areas, appears purple.

Figure 2. Thermogram of a leaky corner of a large electrical utility building, looking up at the underside of its standing-seam metal roof. The infrared emissivity of the wet materials is 0.98, compared with the emissivity of the metal roof itself, which is only about 0.01. Water has soaked the building walls as well as the underlying roof substrate.

Figure 3. The ThermaCAM RoofCAM from FLIR Systems is a small, lightweight infrared camera designed specifically for roofing and building envelope professionals. The size of a flashlight, it weighs only 1 1/2 pounds with batteries and can store up to 100 images in standard JPEG format and download them to a PC for report generation. A bright red-dot laser designator makes it easy to outline wet areas.

Figure 4. This heads-up display from FLIR Systems projects the infrared image onto a pair of safety glasses. This enhances worker safety by enabling the thermographer to see the image without having to look into an eyepiece or LCD screen.

and nature of each finding. It is also wise to take photographs of marked wet areas from several angles. If a post-repair inspection is contracted, locating the exact spots of the repair without photos may be difficult.

A written formal report may also be necessary. Contents for such a report can vary, but generally include both IR and visible images to document findings and details on leak verification methods. Each wet area should be clearly marked, and locations and results of verification clearly identified. You may be asked to locate findings on a structural drawing of the building, which may require structural engineering input.

Training Requirements and Pricing

By using thermography as a proactive maintenance tool, it is possible to increase the service life of a metal roofing system while reducing overall maintenance costs. However, the effectiveness of any thermographic inspection program will depend upon the quality of the data obtained. There is no substitute for good training and extensive field experience using the IR camera. Inspectors should maintain a Level I or II certification in infrared thermography. Excellent courses in thermography are offered by camera manufacturers.

The most common pricing for roof thermography services is per square foot, subject to a minimum. Typical per-square-foot price ranges are 3 to 6 cents for up to 100,000 square feet, 2 to 4 cents for 100,000 to 1 million square feet, and 0.75 to 1.5 cents for over a million square feet.

The ultimate value and goal of the inspection program is to minimize the cost of repairs, and its success will depend largely upon the condition of the roof when the program is launched. To maximize their value, IR inspections should be implemented before the roof begins to leak—ideally soon after installation and at least annually thereafter.

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