

Thermal building inspections bring heating and cooling losses to light

Application Note



Performing a routine roof inspection to search for moisture (leaks and wet areas) in the roofing materials. **Note:** These tests are typically done at night, this photo is for marketing purposes only.

Managers of commercial, industrial and institutional buildings are always on the lookout for ways to reduce their cost of operations, including building-upkeep expenses and heating and cooling bills. One powerful set of tools that has proven helpful in both areas—general upkeep and energy use—is Fluke’s family of handheld thermal imagers, also known as infrared (IR) imagers or IR cameras. Thermal imaging or thermography can capture two-dimensional representations of the surface temperatures of parts of buildings, including roofs, walls, doors, windows and construction joints. Often, those images reveal temperatures or differences in temperatures (Δ ts) that indicate conditions and inefficiencies contributing to the waste of heated or cooled air and needlessly excessive energy costs.

What to check?

While thermography may be used for tasks as diverse as detecting insect or animal infestations and discovering voids in poured concrete structures, here, with an eye toward lowering building-maintenance and energy costs, the discussion is limited to the following:

Roofs. Flat roof structures are the standard in commercial, industrial and institutional buildings in the U.S. In a report published by Infrared Solutions Inc., now a Fluke company, Chaz Nabji writes, “Of the millions of square feet of roof installed each year it has been estimated

that up to 40 % will develop problems within the first year of service. The average life span of these roofs is seven years, but it is estimated that they could last as long as twenty years if correctly installed and maintained. Replacement roofs can cost as much as \$8 to \$10 per square foot when disposal costs of the old roof are included. Billions of dollars are lost every year due to premature roof failure. By simply maintaining the roof, a great deal of money that is being lost could be put to better use. Infrared roof inspection stands above all other methods in prolonging the life of a flat roof structure.*

*Chaz Nanji, “Using an IR-Insight(tm) to do an infrared roof inspection.”



Checking for moisture within the wall surface with a Fluke InSight Thermal Imager.

A flat (actually, low-slope) roof consists of a deck, insulation and a membrane. Usually, the membrane is either built-up layers of roofing felts bonded together, or it is a single sheet of glued-down rubber or plastic further anchored by stone ballast. The membrane's job is to keep out water. When a membrane leaks, water comes into contact with the insulation.

Using methods outlined below, it is relatively easy to isolate moisture in or on insulation during an external inspection using an IR camera. In fact, one thermography expert says that finding water problems on a flat roof, especially finding water-saturated insulation, is so easy it's like "shooting fish in a barrel." Of course, wet insulation loses its R-rating, which means it loses its effectiveness as a barrier against heat and cold and should be replaced.

If a roof leaks but the insulation does not absorb water, then you need more than a passing knowledge of insulation types and of patterns caused by water infiltration to perform meaningful thermography yourself. Still, if you know that the roof construction on your building(s) is built-up felts with absorbent insulation (e.g., perlite, wood fiber, cork or fiberglass), then an investment in an IR camera may be the way to go in guarding against heating or cooling losses and/or expensive roof repairs.

Walls. During an external scan of a building under the right circumstances, a thermal imager can pinpoint moisture in walls in much the same way it can in roofs. Of course, water in walls (or roofs) will lead to mold and mildew, adversely affecting occupants who are allergic to such spores. Also, in walls (as in roofs), wet absorbent insulation will have lost its effectiveness and should be replaced. The latter situation is tantamount to a wall being partially insulated, which also will manifest itself under the right circumstances, even when moisture is not present.

Detecting totally uninsulated walls poses a special problem because there is no insulated section with which to compare uninsulated sections. When thermal readings are uniform for a wall, a physical inspection of the wall's interior may be required to confirm the presence of insulation.

Windows, doors, construction joints, wall and roof penetrations. To monitor for air leakage, which generally translates into cooling losses in summer and heating losses in winter, scan windows, closed doors, construction joints (e.g., soffits and transitions from concrete to frame walls), wall penetrations (e.g., pipes and

electrical entries) and roof penetrations (e.g., vents, hvac ducts and chimneys). Under the right circumstances, an IR camera will detect temperature differences that signal heating or cooling losses.

In double-pane window systems, for example, vacuum seals inevitably erode over time, and moisture collecting between the panes of glass signal that condition. When that happens, an infrared camera scanning a bank of windows from the outside will confirm the seal loss by recording a surface temperature of the suspect window different from the other windows in the bank. The R-value of the window is different because the insulation seal is gone.

While infrared thermography is useful in finding seals that are broken or completely missing on window systems, there is a fairly long payback on repairing windows as compared to other ways of reducing the cost of operations. As one experienced thermographer puts it, "There are usually bigger energy fish to fry somewhere else in the building." That is, a savvy manager is probably going to start with fixes that represent the fastest return on investment. That is, he or she will address roofing problems, for example, before dealing with windows that have lost their seals.

One other often overlooked area of energy loss are doors at shipping and receiving docks. Nearly every commercial, industrial or institutional building, no matter how small an operation it supports, has a loading dock. Except in the rare case when the docks are not heated and cooled for the comfort of workers, the potential for wasting energy when a truck is at a dock is significant. Thermal images will help document the extent of any waste.

When and what to look for?

Roofs. Wet insulation is the primary cause of premature roof failures and high roof maintenance costs. Scan roofs after a hot day. Any detectable moisture will retain the heat of the day while surrounding structures and insulation cool. Nanji notes that different types of insulation result in different thermal patterns. Therefore, knowing what type of insulation is in a roof and the thermal pattern it will create in the presence of water can be very helpful in detecting moisture in a roofing system.

Nanji makes the following observations: At dusk, wet, absorbent insulation will appear thermally as a warm area, but water runs off non-absorbent insulation and collects in insulation joints. In this case, a thermal image will take on a “window frame” pattern. By contrast, foam glass block insulation will only allow water to fill in surface pores. Then, if the water freezes, it will expand and cause the insulation to crack, resulting in a “fractured” pattern.

Water on monolithic insulations (e.g., lightweight concrete, gypsum and foamed-in-place polyurethane) will result in amorphous anomalies that are irregular in shape, while aluminum coated roofs are reflective to solar energy. Reflectivity makes it difficult to detect thermal differences, but inspections of aluminum-coated roofs have been successful after these roofs have accumulated dust or dirt over time.

Note: Because water absorbs heat slower than dry surrounding structures, roof inspections could be carried out at dawn as well as dusk with wet areas appearing as cooler than the dry parts. “However,” Nanji observes, “the industry norm is for the inspections to be carried out around dusk.”

Finally, do not do roof inspections alone. Having a partner on a roof is safer, especially when you are working in the dark. However, it also provides a second pair of hands to mark areas suspected of having moisture or no insulation in them.

Walls. Scan outside walls any time a difference in indoor and outdoor temperatures exists naturally as in winter or summer or when a significant Δt can be created artificially by elevating the output of the heating or air-conditioning system. As with roofs, when screening for moisture in walls, early morning or evening of hot days can create a significant temperature difference that will produce revealing thermal images. Of course, dusk is the best time to monitor west walls, and dawn is best for east walls. Either works for south walls in the Northern Hemisphere, but north walls may not heat up enough naturally to yield revealing thermal images.

In any case, anomalies or variances in surface temperature may indicate problem areas, even when temperature deviations are slight. Unlike doing thermography on production

equipment in an industrial setting, screening building envelopes does not rely on the notion that “a Δt of x degrees between target A and target B indicates a problem.” In other words, a significant Δt on a wall may be very subtle—one or two degrees, depending on the scope of the problem. For that reason, a case can be made for using a highly sensitive thermal camera for building inspections.

Windows, doors construction joints, wall and roof penetrations. Look for thermal anomalies and air flow differences that indicate heat loss or gain through the building envelope. The same strategies used to enhance indoor and outdoor temperature differences for checking walls may be used to help identify heating or cooling losses through windows, doors, construction joints and building envelope penetrations. In addition, for relatively small structures or areas of a building that can be isolated, consider using a blower to pressurize the building or area. This will make more apparent the egress of air of a different temperature.



Facilities manager checks the roof flashing to make sure there is no moisture penetration.



A technician checks the extent of moisture damage.

Most operations with heated or air-conditioned loading docks attempt to stem the loss of conditioned air with dock seals that engage the sides of the cargo compartments of trucks at the docks. Using an infrared camera it is relatively easy to determine the effectiveness of dock seals as a prelude to replacing faulty ones or upgrading to more effective ones. Simply scan the seals when they are engaged and when there is a significant difference between indoor and outdoor temperatures.

Selecting an infrared camera

There are two schools of thought regarding the best thermal imaging method for building diagnostics. One school advocates the use of a basic thermal imager to quickly scan for moisture or other potential problems. This method concentrates on temperature differences without regard to the specific temperatures involved. Then, if and when a potential problem is found, the problem is confirmed using a moisture meter or other standard tool.

The other school of thought is that thermographers inspecting building envelopes must collect fully radiometric images of potential problems, i.e., images that pinpoint the exact temperatures involved. When looking for moisture in a building envelope, for example, a proponent of this school makes the low setting of the camera's calibration range the temperature dew point and scans the structure looking for any areas where the low temperature setting is saturated. This condition indicates the presence of moisture in the structure. Here, the thermal imager becomes more of a diagnostic tool than simply a potential problem

finder. However, a fully radiometric camera is more expensive compared to a pure thermal imager without temperature measurement capabilities.

If you are considering going the fully radiometric route for building inspections, be aware that while there are no protocols for what sensitivities and temperature ranges are needed on the camera, an NETD (noise equivalent temperature difference) of 70mk and a temperature range up to 100 °C should be sufficient. Be aware also that if you are planning to use your camera to perform diagnostics on electrical and mechanical systems inside the building these specifications may not be adequate.

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