

Infrared (IR) Thermography for Building Managers

By: Gregory R. Stockton

Think back to the 1990s. How important was building energy efficiency, building moisture or building quality? Now think about the past 6 months....has your boss asked you to study your energy usage? Thinking "green" has become in vogue. Why is that? Is it because your boss recently downloaded "*An Inconvenient Truth*" and Al Gore convinced him or her that global warming is real and something must be done about it? No "green" thinking is about "green-backs". Building costs and energy costs are on the rise and by inspecting a building with IR and other techniques, the owner can determine what needs to be done to manage the building asset better, use less energy and save money.

There are four types of buildings by use:

- **Residential**--houses and apartments dwellings of all types
- **Commercial**--office buildings, retail stores, malls
- **Industrial**--manufacturing facilities and factories
- **Institutional**--college and universities, hospitals, government buildings

From a building manager's point of view, infrared thermography can be a very useful tool. Some of the many applications are: predictive maintenance of electrical and mechanical systems, manufacturing process quality assurance, product research and development, non-destructive testing and building thermography. This article focuses on building infrared; specifically construction quality assurance, building thermal and moisture envelopes. Building IR survey applications can be divided into categories such as heat loss, moisture intrusion, insulation quality assurance, structural and pest surveys.

Building Thermography...is not all that easy

To be an effective tool, an infrared thermographer must know the limitations of the imager, the way that buildings absorb, retain and radiate heat energy and the best time to perform a given survey. He/she must have an imager capable of finding and documenting problems (or lack thereof) and more importantly, a working knowledge of building physics and an understanding of the thermal dynamics that are in play.

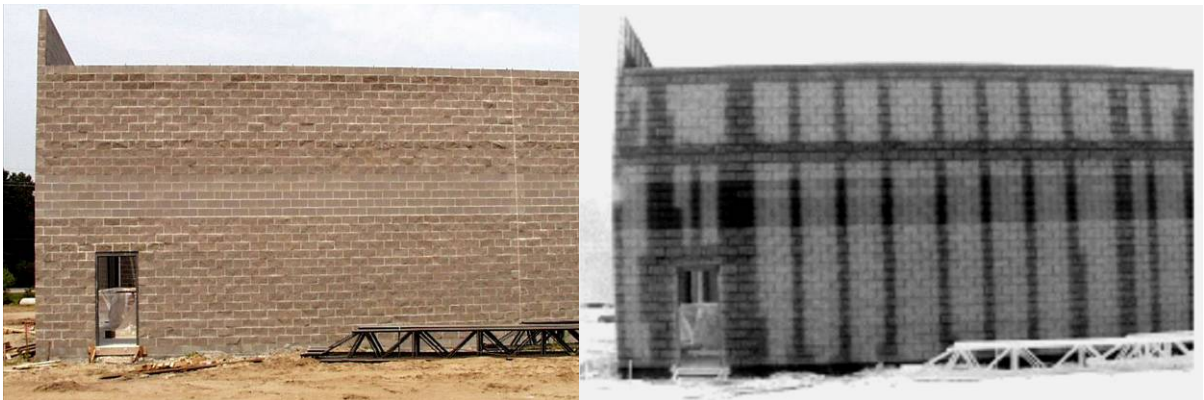
Infrared Imagery in General

Infrared imagery is often a grayscale picture whose scales (or shades of gray) represent the differences in temperature and emissivity (opposite of reflectivity) of objects in the image. As a general rule, objects in the image that are lighter in color are warmer, and darker objects are cooler. No object is detected in visible light wavelengths (400-700nm) rather, it detects infrared wavelengths (3000-5000nm & 8000-14000nm). Lights and other relatively hot objects are evident, but as a result of their heat -not light emissions. When an image is taken with an infrared camera, it is often recorded onto videotape and/or digitally saved to an on-board storage device. The images are downloaded, opened in specialized software and modified in a number of ways to enhance their value to the end user, like coloring the images or adjusting the span and temperature to highlight a particular object in the image.

Building IR applications can actually be some of the most demanding on thermal imager sensitivity and spatial resolution, the two most important factors in an imager's ability to focus in on what can be physically small and/or thermally miniscule problems on a giant object. Coming up with effective techniques and good timing to perform these surveys also presents a challenge. For example, there is a different methodology for surveying the framing, missing insulation, heat loss, air leakage and moisture intrusion in the same building. IR can *only* detect surface temperature differences, but the patterns that these differences leave (IR signatures) can often indicate, what is going on within the building to a very high degree of confidence.

Construction Defects

Liability is a real issue for sellers, buyers and insurers. The costs of construction, repairs and renovation are increasing dramatically as owners bring construction lawsuits against the contractors. "Getting what you paid for" is not a new concept, but perspective building owners are increasingly concerned the costs and about the quality and efficiency of their investments. Infrared thermography can be used as a building quality assurance tool during construction, so that repairs can be made without destroying the building or delaying the building process. Since all building materials will absorb, retain and radiate heat energy at a different rate, building components can be checked for the quality of installation using IR. For instance, "cinderblock" or CMU (concrete masonry unit) walls are erected on nearly every street corner as malls, schools, warehouses, retail, convenience stores and more. CMU walls often have rebar and grout-filled cells as a structural component. By allowing the wall to absorb energy during the day and watching the heat energy dissipate at night, the building infrared thermographer can use the "picture" of the heat from the wall, to define exactly where the grouted cells are and where they are missing (See Figure 1).



Figures 1A & 1B. Visual and infrared image of a CMU wall.

Don't get soaked, or mold is a four-letter word

Design flaws, entrained moisture in roofs and walls and water leaks cause billions of dollars worth of damage to buildings every year. In very hot and very cold climates, poorly installed insulation and vapor barriers can lead to condensation problems and the degradation of the building itself. This can cause rot, mold and mildew and all of these problems lead to the building being devalued. In warm climates, as more "fresh" moist outside air is mechanically introduced into buildings in an attempt to make the building healthier, condensation and its side effects--mold and mildew, become a real threat to the building owner and manager. Mold is a microscopic fungus known to destroy building materials and cause health problems for many individuals (See Figure 2). Occupants are asking for more "healthy" buildings in which



Figure 2. Mold found inside a wall by finding moisture indications with IR.

to work and live. Now, infrared thermography *cannot* be used to detect mold itself, because mold does not exhibit an exothermic reaction strong enough to be seen by an infrared camera walking around a building. But building infrared thermographers can help find moisture and without moisture, mold grow is limited. Roof moisture detection can be accomplished on almost any type of system either by looking up at the roof or down onto the roof. In roofs with attics, the thermographer looks for the evaporative cooling effect of water. In flat or low-sloped roofs (See Figure 3), IR imagery can pinpoint areas that contain moisture. By marking up the CAD drawings with the wet areas, surgical repairs are made, extending the roof's useful life.

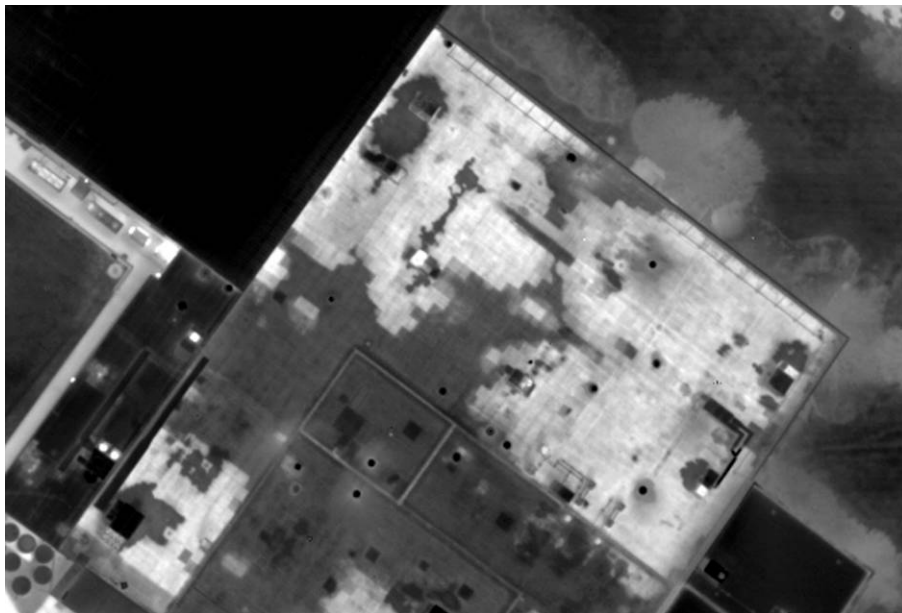


Figure 3. IR image of a flat roof. (Light areas are entrained moisture.)

Building Inspection Motivation Factoids

Even though using infrared thermography to examine a building can often pinpoint problems, owners may have different reasons for wanting to know [or not wanting to know] about the condition of a given building. Here are some examples:

- Buildings are often owned by one company and leased to another. If the tenant is paying the utility bills, he/she wants the building to be energy efficient, but the lease may not be long enough for the tenant to enjoy an appreciable return on the investment from re-insulating the building or plugging up the air leaks. The owner has no financial motivation to make the building more energy efficient unless he/she is paying the heating/cooling bills or can use the fact that the building energy costs are low to his/her advantage in a sales negotiation.

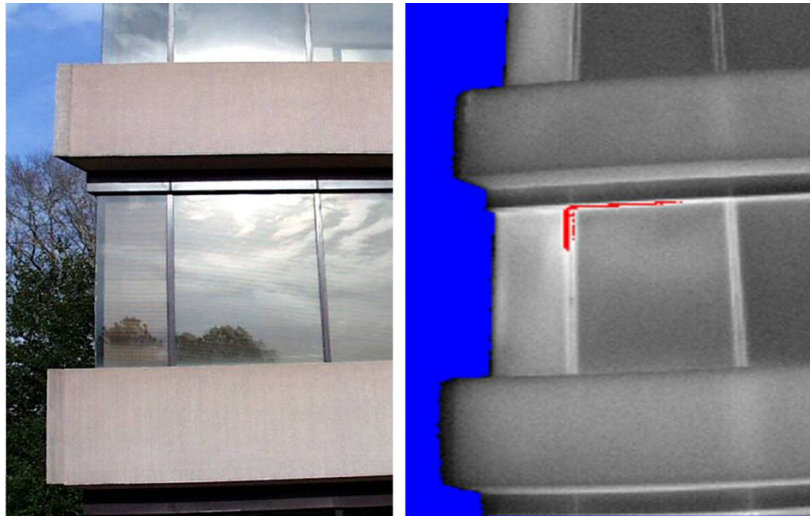


Figure 4. Visual and IR image of an air leak on a window.

- There is nothing remedial about infrared thermography itself, or any other type of testing for that matter. I have been looking at buildings with infrared cameras for 17 years and not once has a building that I scanned ever repaired itself. IR can pinpoint and document problems, but often the repair costs are more than the owner can afford, or the payback is too long.
- Sometimes, finding out that there is a major problem with a building opens a “can of worms” that the owner would rather not have opened. Also, some building owners may not be willing to pay the cost of repairs if they move every few years, because they figure that if they can live with problems for a while, then the problems will become someone else’s.
- Industrial building owners [manufacturers] care about one thing...how many of their widgets go out the loading dock door that day. Unless it affects the bottom line (like a refrigerated warehouse or a building that needs to maintain exact temperature control), most are not concerned about energy loss until it starts to: a) damage the building from condensation, b) affect the operation, or c) make the people inside so uncomfortable that they revolt. In a factory where 85% of the kilowatts are consumed by machinery, the heating/cooling bills are not the issue. But as energy costs go up, the manufacturing companies will be looking for ways to save on heating and cooling costs and reduce energy costs for machines that heat. What a perfect application for infrared!

Going Forward

Inspecting buildings for heat loss was one of the first uses for infrared thermography. As we decide to become less dependent on fossil fuels, IR thermography will again be used as it was in the 1980s to monitor the energy efficiency of buildings. Now with the new IR cameras and more thermographers, more buildings will become energy efficient and better built. Volumes can be written on thermography for buildings and building subsystems. I hope reading this will raise your interest level high enough to go and search for more information.

Gregory R. Stockton is the founder of Stockton Infrared Thermographic Services, Inc. The North Carolina-based corporation operates eight divisions performing many different infrared services in the US, Canada, Central and South America. Mr. Stockton has been an infrared thermographer since 1989 and has published numerous white papers and articles on the uses for infrared thermography over the past 15 years.