Aerial Infrared Roof Moisture Surveys

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INTRODUCTION

Infrared thermography a very popular means of testing electrical and mechanical systems. Almost everyone in maintenance has seen an article about how infrared (IR) thermography has saved a piece of electrical switchgear from an imminent destruction and the resulting downtime. Infrared thermographers look at the thermal energy that is emitted from an object or group of objects, explain what is normal, see abnormalities and report them so that maintainers can act to repair the problem. This method works well on heat emissions from most objects, including building roofs. A well-prepared, graphic and accurate map of the infrared signatures of a roof can significantly benefit the building owner at all stages of that roof's service life. This type of testing is commonly referred to as an ***infrared roof moisture survey***. Infrared thermography is not leak management, it is predictive maintenance. No matter how the water got into the substrate, the purpose of this type of survey is simply to find and document where the water is so repairs can be accomplished.

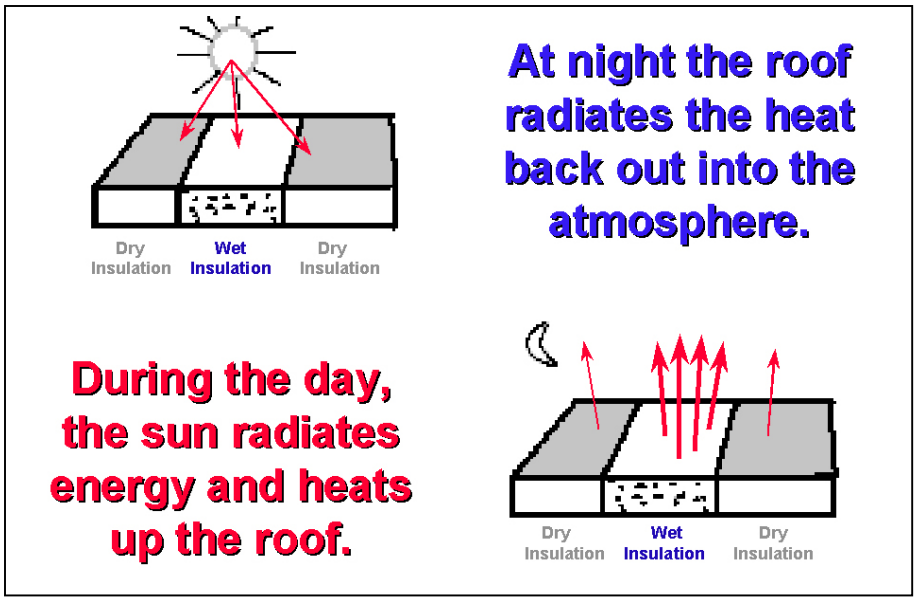
ROOFS AND ROOF MOISTURE SURVEYS

Roof problems can bring economic peril and become safety hazards. Water dripping onto the final product line can damage the end product. Leaks can occur (and according to Murphy's Law *will* occur) in the worst place, like over main switchgear or onto a bus duct. Water on the plant floor is not safe. The roof of a building needs attention, like all other assets.

Everything wears out and roofs are no exception. The ravages of sun, wind, rain, snow, hail, ice, chemicals, leakage and time will eventually cause every roof to fail. Just like electrical switchgear, it must be maintained. To the owner of a building, a roof warranty might seem to be the answer, however roof warranties are written by and for roof manufacturers. They are designed to limit the liability of those writing the warranty, NOT the owner of the roof. Vaguely written roof warranties, which do not define words like "regular" or "routine" or "maintenance" will come back to haunt the owner. All roof owners should have some kind of agreement with their roofer or roofing consultant to inspect the roof at least once a year.

Waterproofing problems manifest themselves in two ways: leakage and entrained water contamination. Leakage is pretty simple, although the leak inside the building rarely directly relates to the exact spot on the roof where there is a hole or tear. Since most types of insulation absorb a certain amount of water, it is harder to find the contamination because the roof may not develop a leak (in the building) until the insulation has absorbed all the water that it can hold. Three non-destructive tools that owners can use to find the subsurface water include nuclear gauges-which count neutrons, capacitance meters-which measure resistance, and infrared-which measures heat. Both nuclear gauges and capacitance meters allow a technician to take a (sample) reading on a 5' X 5' or 10' X 10' grid on the roof. When plotted on a roof plan, these measurements are used to extrapolate where the water is. They work well of roofs that do not gain or lose much solar energy and therefore do not lend themselves to infrared. Some roofs and insulation types or combinations do not even absorb water. For roofs that do absorb water, infrared is the preferred method.

During the day, the Sun radiates energy onto the roof of the building and into the roof substrate, and then at night, the roof radiates the heat back into outer space in a process known as radiational cooling. Wet areas in the roof have a higher mass, retain heat longer than the lower mass, dry areas and therefore radiate heat for a longer period of time, because it takes longer to cool. Infrared cameras can detect the heat and "see" the higher mass (wet areas), during this "window" of uneven heat dissipation *(see Figure 1)*.



ON-ROOF INFRARED SURVEYING

To perform an on-roof survey, typically a crew of at least three people is needed; an experienced infrared thermographer, a helper and a building owners' representative for access and security. It is helpful if he knows the history of the roof. Also, it is a good idea to have a roofer or roof consultant there. If questionable areas are found, he can first use his (non-destructive) nuclear or capacitance meter to verify subsurface moisture or if needed, take core samples and competently repair the test holes. Access to the roof sections and plenty of time is needed to collect data. Depending on how many problems are found, a crew can survey from 50,000-200,000 square feet of building roof in a night. Usually, areas that contain subsurface moisture are outlined with marking paint directly on the roof and marked on a drawing. Infrared images are stored on videotape or other media. The next day, after thermographs (infrared pictures) are printed, at least one of the crew goes back on the roof to take visual photographs of the areas that are considered to contain subsurface moisture. The report includes infrared and visual imagery, the roof plan marked with areas of suspect moisture contamination and a videotape of the entire survey.

AERIAL INFRARED SURVEYING

Performing infrared roof moisture surveys while standing on the roof is not the best method because imagery from a walk-on survey is not as useful as aerial imagery. The IR cameras used for checking switchgear or for performing on-roof surveys are not of sufficient spatial resolution to obtain good imagery from flight altitudes of 1,000-1,500 feet above ground level (AGL). Most modern infrared cameras have no more than 60,000 pixels. This means that one must: a) get closer (say, 500 feet AGL), or b) use a larger lens, or c) have a camera with more pixels. To get as close as 500 feet over a building, a helicopter, giant boom or blimp must be used. These options are dangerous and expensive. Vibrations can also be a problem with helicopter use. A large lens will work, but someone has to mosaic many images in order to make the report easy to understand. The best answer is to use IR cameras with more pixels, typically, at least 260,000 pixels. Large areas of the roof can be imaged at high resolution while maintaining a safe distance from the ground. This allows for the use of the less expensive fixed-wing airplane option.

Very little time is required to obtain the infrared data, once the aircraft is over the building. Usually, a 200,000 square foot building is imaged in less than 10 minutes. This will include multiple passes over the building from varying altitudes, attitudes, speeds and angles. The imagery is recorded on digital videotape and/or captured directly onto a computer. Visual photographs are taken earlier in the day or the next day. When the thermographer returns to his office, the image processing begins. Photographs are processed and

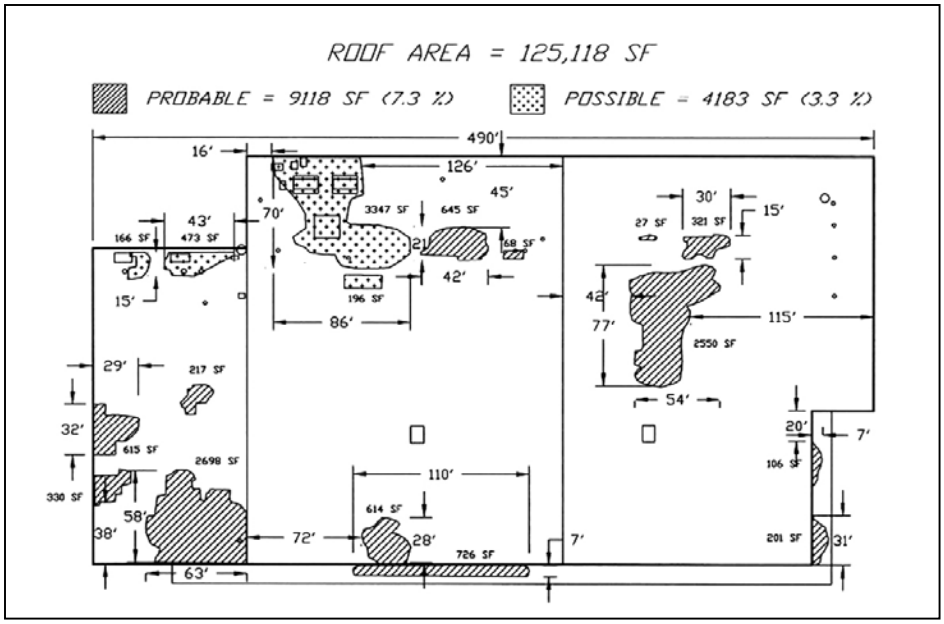
the thermographs are saved on the computer. The infrared images and digital or "scanned-in" photographic images are used to make an edited videotape of the passes over the building. Both visual and infrared images are used to do the analysis by laying the images "over" the CAD drawings, to mark areas of suspected moisture contamination. The result is a report where visual, infrared and CAD components (printed and video) are well matched and lined-up.

COMPARING ON-ROOF TO AERIAL INFRARED ROOF MOISTURE SURVEYS

The same laws of physics apply to both aerial IR and on-roof IR. A dry roof surface, low winds, no rain and few clouds on the night of the survey are desired. The "window" when the roof is radiating heat differently from wet and dry areas, has to be longer in order to do an on-roof survey because slight nuances of temperature differences cannot be seen from the roof. One very big advantage to aerial is angle of view. The closer to a 90-degree angle over a particular area, the better. This helps to avoid reflections and the imaging of a much larger area. Aerial has the advantage of looking straight down over the target, and access to multiple levels is never a problem. The drawing dimensions are close to perfect, which is a big problem with on-roof surveys. The only advantage that on-roof surveys have over aerial is that suspect areas can be marked with paint then and there after the roof consultant verifies a wet area. Aerial infrared has every other advantage over on-roof. Image quality is superior by every standard *(see Figure 2)*.

AERIAL INFRARED SURVEY REPORTS

Report options, in order of costs are: unedited videotape, edited videotape, printed infrared thermographs, aerial photographs (oblique and straight-down) qualitative CAD drawings and/or quantitative CAD drawings *(See Figure 3)*. A complete quantitative infrared roof moisture survey report can include any or all of the above, printed in high resolution or saved to a CD-ROM.



CONCLUSIONS

Maintaining the roof system, thereby extending its service life-perhaps doubling it, will save the owner a great deal of money. Regular aerial infrared surveys should be considered an integral part of the roof asset management program. A quantitative aerial infrared report can be used as a bid document, in the form of verified CAD drawings, for the surgical removal and replacement of wet insulation. *Read more on the subject on the Internet at www.stocktoninfrared.com.*

Author Biography

Gregory R. Stockton is president of Stockton Infrared Thermographic Services, Inc. Based in Randleman, NC; the corporation operates nine complete infrared systems in four divisions. Greg is a Certified Infrared Thermographer (#3583) and has twenty-two years experience in the construction industry, specializing in maintenance and energy-related technologies. He has published eight technical papers at infrared symposiums and numerous articles in trade publications on the subject of infrared thermography.