Aerial Infrared Roof Moisture Surveys

INTRODUCTION

IR P/PM (infrared predictive/preventive maintenance) is not limited to annual infrared surveys of electrical switchgear. For instance, infrared thermography can be a very effective tool for roof asset management. IR roof moisture surveys are performed on roofs to quantify the extent of roof moisture (water) that is inside the roof system. Infrared thermography is not leak management. 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 located. Extending the life of a roof will save the owner the expense and aggravation of re-roofing or re-covering. Re-roofing means that the roof is taken down to the decking and replaced completely. Re-covering means that the waterproofing layer(s) are removed, the wet insulation is removed and replaced and a new waterproofing layer is put down. The cost of an infrared roof moisture survey is three to five CENTS per square foot. It cost between three and five DOLLARS per square foot to repair/replace roofs, so knowing the exact location of the subsurface water is extremely useful information, since only those areas that are damaged need to be repaired. This information is used to plan budgets and when needed, as a bid document for contracting repairs and/or replacement of the roof.

Keywords: Infrared, Thermography, Roof, Roof Asset Management, Infrared Roof Moisture Survey.

ROOF MAINTENANCE IN GENERAL

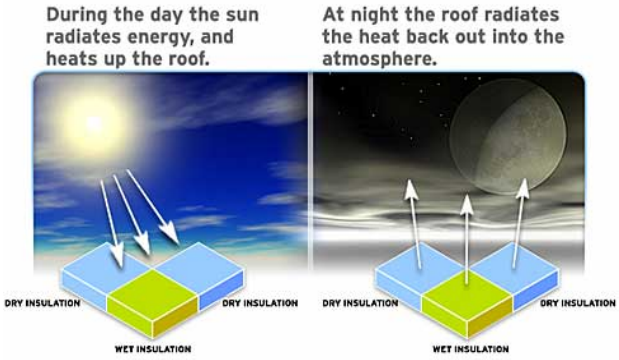
The ravages of sun, wind, rain, snow, chemicals, leakage, rapid changes in temperature and time - will eventually cause every roof to fail. Some roofs last 40-50 years…when they are well maintained. Owners may believe that a roof warranty will somehow protect them from having to do maintenance. Not so, as roof warranties are written by roofing manufacturers for the purpose of protecting themselves from liability. For example, often a warranty is written so that if improperly installed or defective roofing materials are used on a roof and water leaks into the electrical switchgear room causing an explosion, the roofing manufacturer will replace the materials, the roofer will reinstall the materials, but the building owner has to pay for the replacement of the switchgear and any downtime that resulted from the failure. Also, the roofer's and roofing manufacturer's liability, in the case of roof failures are also reduced by vaguely written roof warranties, which do not define words like "regular" or "routine" maintenance. Not accepting the roof warranty is not the answer, since the roof will not be installed unless the owner agrees to the warranty. To eliminate these problems, the building owner should have an agreement with a qualified roofer or roof consultant to inspect and maintain the roof (in accordance with the terms of the warranty) at least once a year.

Waterproofing problems manifest themselves in two ways: Leakage and entrained moisture contamination. Leakage is pretty simple, although the leak inside the building rarely directly relates to the exact spot on the roof, since the water flows down the slope of the roof to a spot that is not sealed and into the building at that point. Most leaks occur where the waterproofing is sealed or where there is a penetration of the roof. Since most types of roof systems absorb some amount of water, it is harder to find the exact spot of water contamination in the insulation because it may not leak into the building until it has absorbed all the water it can hold. There are three types of surveys that are used to find water in a roof. Nuclear gauges-which count neutrons, capacitance meters-which measure resistance, and infrared-which measures heat. Both nuclear gauges and capacitance meters are used to take spot readings on a 10' X 10' or 20' X 20' grid on the roof. These measurements are used to extrapolate where the water is from the readings obtained from the gauge. They are good for types of roofs that do not gain or lose much solar energy and therefore, do not lend themselves to infrared.

BASICS OF INFRARED ROOF MOISTURE SURVEYS

During the day, the sun radiates energy onto the roof and into the roof substrate, and then at night, the roof radiates the heat back into outer space (See Figure 1). This is called radiational cooling. Areas of the roof that are of a higher mass (wet) retain this heat longer than that of the lower mass (dry) areas. Infrared imagers can detect this heat and "see" the warmer, higher mass areas, during the "window" of uneven heat dissipation.

Figure 1) Areas of the roof that are wet retain heat longer than dry areas.

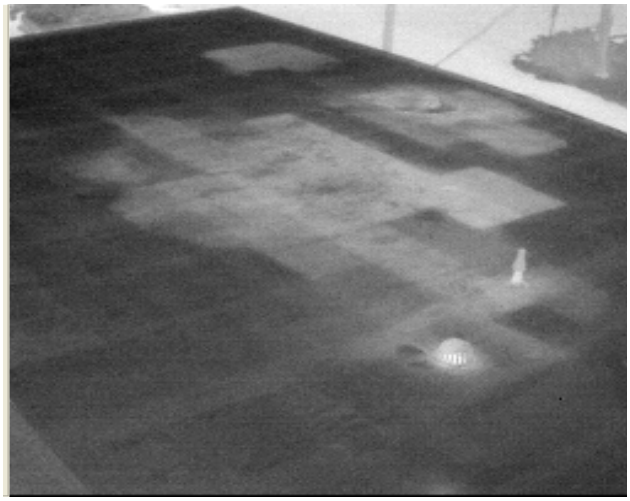


Some roofs and insulation types or combinations do not absorb any water. These roofs leak straight into the building. Even roofs, which have insulation types that do absorb water, some do not exhibit a good infrared signal, primarily for two reasons. 1) The surface is too reflective, and/or 2) the roof's ballast is so thick (or dense), that daylight radiation is not absorbed into the substrate (insulation), therefore it cannot be emitted back into the atmosphere at night. Even with a strong infrared signal, factors on the roof can affect the analysis and interpretation of the data. Some of these factors: water between multiple layers, old patches, heavy flood coats, reflective coatings, heat-producing equipment under the roof –or heat blowing down onto the roof, stains, ponding water on the roof, heavy build-up of ballast at parapet walls and along edges, etc. These roofs should be inspected by other methods as described above.

WALK-ON INFRARED ROOF SURVEYING

To perform a walk-on or on-roof survey properly, a crew of three to four people is needed: an experienced infrared thermographer and helper, an experienced roof consultant or roofer and the building owners' representative for access and security. The crew walks around the roof(s) and when an area of suspect moisture is found, the roof consultant verifies it is wet and then the helper marks the edges of the area directly on the roof with marking paint as instructed by the thermographer. The crew needs authorization and access to all areas and levels of the roof(s) from either ladders or roof hatches and plenty of time to collect data. The infrared images are stored on videotape or digital media and printed (See Figure 2).

Figure 2) On-roof IR image.



The next day, the thermographer goes back on the roof(s) to take matching visual photographs of the marked areas that contain subsurface moisture. The problem with on-roof infrared is that when one is standing on the roof, eye-level is at best six feet over the surface. Even with the best hand-held infrared camera available, there is virtually no way to get large areas (800 sq. ft. blobs or 100' long striations) of moisture contamination on the screen in one infrared shot. Taking multiple shots is labor-intensive and makes the report confusing. When

performing on-roof surveys, many times “you can’t see the forest for the trees.” Marking the roof is fairly easy, but it is very difficult/time-consuming to produce accurate drawings of the wet areas from painted lines on a roof. Often the drawing supplied by the owner is outdated, incorrect or even non-existent.

AERIAL INFRARED ROOF SURVEYING

There is never a time when on-roof imagery is better than aerial imagery. While the best IR imagery of a roof is taken from the air, the same laws of physics apply to both aerial IR and on-roof IR…like a dry roof, low winds and no rain on the night of the survey. Also, the "window" when the roof is radiating heat differently from wet and dry areas is longer with aerial infrared because slight nuances of temperatures over large areas are distinguishable. The high angle of view allows the aerial thermographer to produce more usable imagery and therefore accurate CAD drawings. The cameras that are used for on-roof surveys are not of sufficient spatial resolution to obtain good imagery from flight altitudes of 1,200 – 1,500 feet above the roof, so high-resolution, large format IR cameras (See Figure 3) are required.

Figure 3) Large format infrared imager, fixed-mounted in a light aircraft.

Once the aircraft is over a building, very little time (five minutes per 200,000 square feet, about 25 minutes for two million square feet) is required to fly over making multiple passes. The imagery is recorded on digital videotape. Visual photographs are taken earlier in the day or the next day. After returning to the office, the photos are printed and the thermographs are saved on the computer. The raw video imagery, thermographs and photographs are used to make an edited videotape copy of the passes over the building. Both visual and infrared images are used to do the analysis by overlaying the CAD drawing of the roof ‘over’ the digitized photographs and thermographs. The drawings always need to be corrected, because rooftop equipment has been removed, moved or added since the last update of the drawings. Then, areas of suspected moisture contamination are drawn on the CAD file. The result is a report where visual, infrared and CAD components (printed and video) are well matched and lined-up. The report is given to a roof consultant who verifies the wet insulation during the day, while making other condition notes on the roof.

Fixed-wing aerial infrared imaging provides many advantages over on-roof infrared imaging:

- Access to multiple levels of the roof is not a problem.
- High-angle, straight down infrared images lessen reflection problems.
- High-resolution images capture large areas at once, making report writing easier and less expensive to produce.
- Plan-view imaging allows for infrared images, visual images and AutoCAD drawings to be reconciled closely. As a result, the report is clear, concise and easy to understand (See Figure 4a, 4b, 4c).
- Plan view imaging allows accurate marking of areas of suspect roof moisture contamination.
- The printed CAD drawings can be used on the roof to paint areas of moisture contamination directly on the roof (after verification), if desired.

Figure 4a) Photograph of a roof.

Figure 4b) Thermograph of a roof.

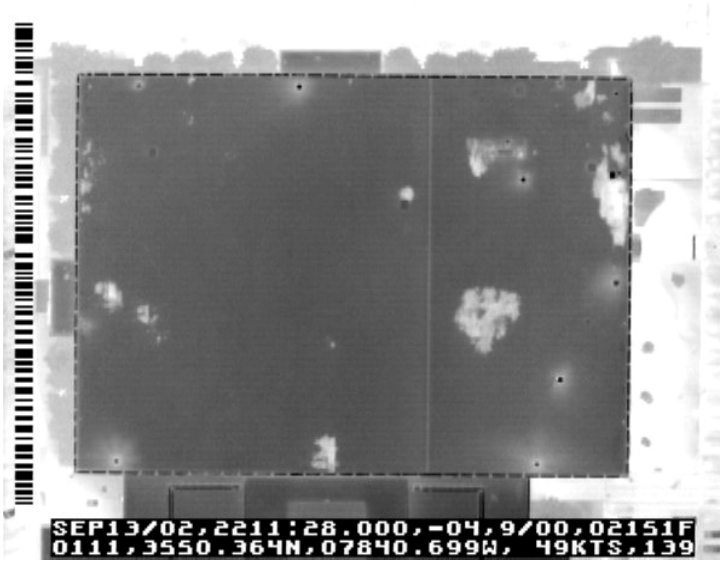
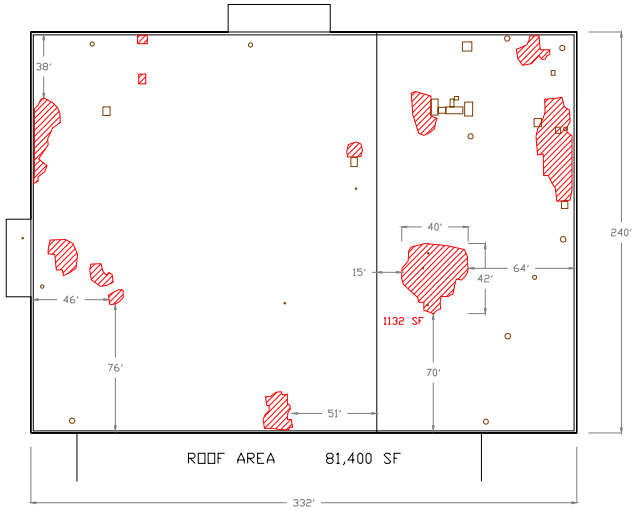


Figure 4c) Scaled CAD drawing of a roof.



- The aerial infrared thermographer can wait for a good night for imaging, surveying many roofs under good conditions.
- The trending of roof moisture becomes possible.
- An aircrew of two can easily survey many millions of square feet in a single night.
- Processing the data is done in the office, not on the roof.
- Report components can be purchased as needed. Aerial IR allows the building owner to buy only the report he needs at that time.

The biggest advantage of aerial infrared is on roofs that are the most difficult to image from any distance or angle. Roofs that, for instance, have a lot of ballast, are covered with reflective coatings or for whatever reason are impossible to image while standing on the roof. With high-resolution, plan view aerial imagery, slight nuances of temperature can be seen from far enough away to actually see the pattern of heat and make a determination of where the problems are.

CONCLUSIONS

Every day millions of square feet of perfectly good roofing materials are disposed of in our landfills. Why? Because roofs are often replaced because know one knows where exactly the roof is damaged until it is too late. If you want your roof to last, it must be regularly maintained by professionals. Infrared roof moisture surveying is the best method of non-destructive testing on roofs, and aerial infrared is the best platform for performing infrared roof moisture surveys. Improvements in IR cameras and flight methodology, aerial infrared thermography and aerial infrared reports are getting better and more useable everyday.

Author Biography
Gregory R. Stockton is President of Stockton Infrared Thermographic Services, Inc. Based near Greensboro, NC; the corporation has six divisions (http://www.stocktoninfrared.com). The aerial division, AITscan, operates ten aircraft, based coast-to-coast (http://www.aitscan.com). Greg has twenty-five years experience in the construction industry, specializing in facilities construction, maintenance and energy-related technologies. He has performed infrared thermography since 1989 and has published fourteen white papers and numerous articles on infrared thermography.