APPLICATIONS OF THERMOGRAPHY

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INTRODUCTION

The high technology of infrared (IR) thermography is helping engineers, auditors and inspectors troubleshoot inefficiencies in electrical generation, transmission, and use. The technology utilizes portable IR cameras and recorders to detect overheated objects. Applications generaly fall into one of three categories: Transmission system inspections, quality control uses, and auditor surveys (the body of the report emphasizes this third category).

Utilities find the equipment useful in pinpointing potential malfunctions in transmission and electrical substation equipment. For example, a survey can spot a poor connection, a phase imbalance, or a transformer with a low fluid level. Quality control personnel can find the technology to be a valuable tool. Uses cover a broad spectrum of applications such as motor wear checks, paper moisture measurements and stream trap operations. Similarly the equipment can be useful to auditors and building inspectors. Applications include roof studies, retrofit inspections and blower door surveys.

ROOF INSPECTIONS

Leaky roofs translate to wet insulation which means excellent heat transfer...and therefore poor building energy performance. In other words, no insulation is better than wet insulation. Frequently the IR camera is used to detect roof leaks by taking advantage of natural phenomena.

To understand the IR scanning methodology one needs first to understand how thermal differences arise between roof areas over wet and dry insulation. During the day, the sun heats the entire roof surface. The water in the wet insulation, because of its ability to store vast quantities of energy with little temperature change (high heat capacity), tends to remain cool while storing a large amount of energy. This phenomenum, coupled with the insulation's reduced thermal resistance which in turns permits increased heat flow into the building, causes the roof over the wet insulation to be cooler than that over the dry.

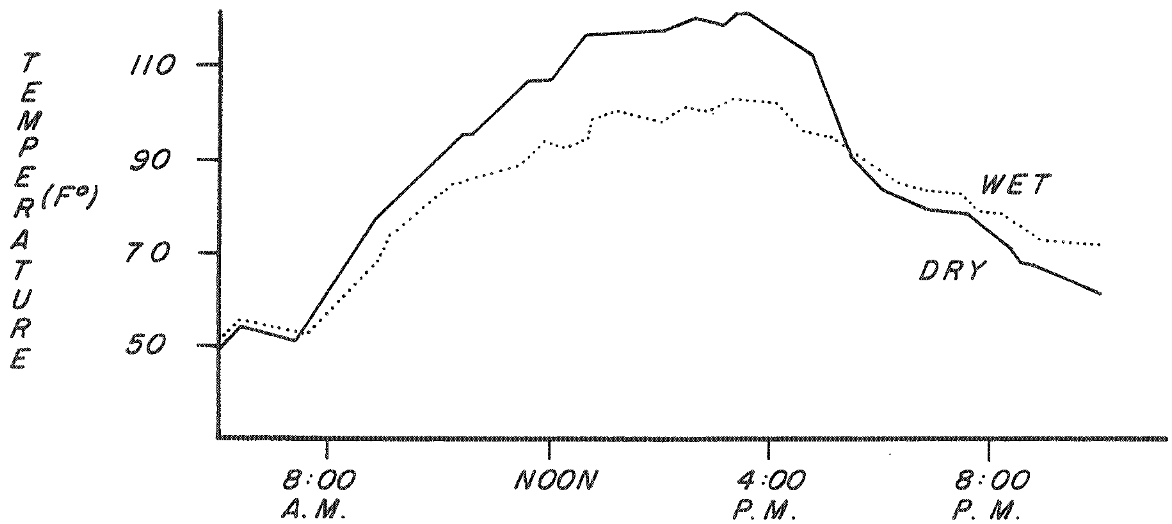
At night the energy stored in the roof system is lost through radiant, convective, and conductive effects. The areas over the dry insulation, though warmer during the day, have less energy stored than the wet insulation areas. Because of this, the dry insulation areas cool more rapidly.

Additionally, at night, the interior building temperature is generally greater than the exterior. This causes a heat flow from inside to outside. The poor thermal resistance of the wet insulation causes a greater energy conductance in the wet areas which keeps the roof surface warmer.

These two effects couple to make the roof over the wet insulation areas warmer at night than those over dry insulation. The diurnal temperature difference between the roof surfaces over wet and dry insulation can be seen in Figure 1.

Figure 1

Roof Surface Temperatures over Areas of Wet/Dry Insulation



During a sunny summer's day the magnitude of the differential may exceed 11°C (20°F). This is far greater than the differential expected at night. However, general application of daytime infrared roof scanning is limited to aerial scanning because of the roof's reflectance of solar energy and the rapid differential cooling rates observed as the roof is shadowed by clouds.

At night, temperature differentials of up to 5°C (9°F) may be normally observed between wet and dry insulation areas. This is more than sufficient for detection using "state of the art" infrared imaging devices which generally have minimum detectable differentials of around 0.1°C or 0.2°C (.2° - .3°F).

Therefore, best results call for a systematic scan of all roof surface areas using a high resolution infrared scanner while walking on the roof at night. The period in which the infrared scanning must be done (scanning window) begins when the wet insulation areas become so much warmer than the dry that they can be sensed using the scanner. As the roof cools throughout the night, the scanning window may close as both the wet and dry insulation areas near the same temperature.

For the interested reader, the Cold Regions Research and Engineering Laboratory (603) 643-3200 has over ten reports covering IR roof scanning methodoligies and results.

BUILDING ENVELOPE

When the auditor is not doing nighttime scans on the roof, how can she or he spend the remaining 16 hours of each day? The answer is scanning the building envelope. Similar phenomena apply in envelope scans, that is, the IR equipment can detect temperature differences due to insulation voids and air leaks.

Because insulation impedes the flow of heat, interior wall surfaces of a heated building are warmer than wall surfaces with less insulation. Conversely, exterior wall surfaces are cooler where more insulation is present. If temperature differences were great enough, one could simply feel the interior wall for cold spots or exterior wall for warm spots and thus locate areas of insulation deficiencies. In most cases, however, such temperature differences are not large enough to enable this simple approach and building size would make such an approach too time consuming.

The IR scanners easily sense and display relative surface temperatures. Objects near normal ambient temperatures radiate energy primarily in the infrared wavelength region of the electro-magnetic spectrum. All objects radiate this energy in a way that depends on their absolute temperature. Thus, a sensor that can readily detect infrared radiation can be calibrated to measure the temperature patterns of a wall surface. These patterns indicate insulation defects and areas of air infiltration/exfiltration.

With thermography, temperature variations on the surface of a building sidewall or roof can be measured quickly from a distance using aerial or motor vehicle surveys. These data can be used to diagnose, with varying degrees of accuracy, the thermal integrity of the building structure. For greater accuracy ground surveys can be performed inside or outside a building. Although exterior ground IR surveys provide greater detail of heat loss locations than aerial surveys and vehicular, interior surveys can provide even more data from which to make specific recommendations.

In general, the closer the sensing equipment is to the source of the energy loss, the more accurate and detailed are the results. Interior surveys also have the advantage of a stable interior environment (i.e., no wind or temperature changes). However, when selecting the type of thermal infrared survey desired, one should evaluate the added costs associated with accuracy versus the intended use of the data. Case histories on building envelope scans are available from Infraspection Institute (802) 985-2500.

CONCLUSION

Using properly trained personnel, IR thermography is a valuable diagnostic tool for applications such as electrical transmission and distribution surveys, roof inspections, and building performance audits. The tool can act as an incentive. For example, a contractor works better knowing his or her insulation retrofit job will be IR scanned. Also, the technology can provide graphic evidence to consumers that their high power bills are not necessarily the fault of the utility but instead are caused by poor building performance - and that weatherization methods represent a sound investment.

Happy Scanning.