Daytime Infrared Roof Inspections

(You CAN Get a Good Night's Sleep!)

By Ronald D. Lucier

Introduction

Infrared thermography is a proven technology used to help locate wet insulation in roofing systems. As an application, roofing is second only to electrical inspections in popularity. The technology has been applied to roofing since the early 1970s, though the equipment available back then was expensive, suffered from poor resolution, and was very heavy. The modern thermal imagers available on the marketplace today offer an inexpensive, lightweight, and high resolution solution to many of today's inspection missions.

Unfortunately, while the imagers have improved dramatically, the approaches to roof inspections have not. The default standard practice used by most infrared thermographers is ASTM C-1153, "Standard Practice for Locating Wet Insulation Using Infrared Imaging," which addresses only night-time surveys. It is clear from many years of experience that the laws and principles of heat transfer and physics apply during the day, too!

Radiation Physics and Heat Transfer

Every object above absolute zero (0 Kelvins, -459.72˚F) emits infrared radiation, according to the laws described by Planck, Stefan-Boltzman, and Kirchhoff. Infrared imagers sense this radiation and display the results as a live video image. The intensity of the radiation, coupled with the physics model inside the camera, can yield temperature patterns on the surface of the inspected object.

The current infrared imagers have sensitivity in the neighborhood of +/- 0.2˚F. Typical wet insulation areas can yield temperature differences between 0.5˚F and as high as 30˚F or more (depending on latitude and time of year). Therefore, there is adequate infrared camera sensitivity to see some of the smallest temperature indications on roofs.

So why do wet roof areas even exhibit temperature differences? It is due to a material property called "heat capacity." The technical definition is, "the amount of heat required to raise a unit mass one degree in temperature." The accompanying chart (*Figure 1*) provides a graphical representation of heat capacity of various materials. It is evident that water has the highest heat capacity (also known as "specific heat").

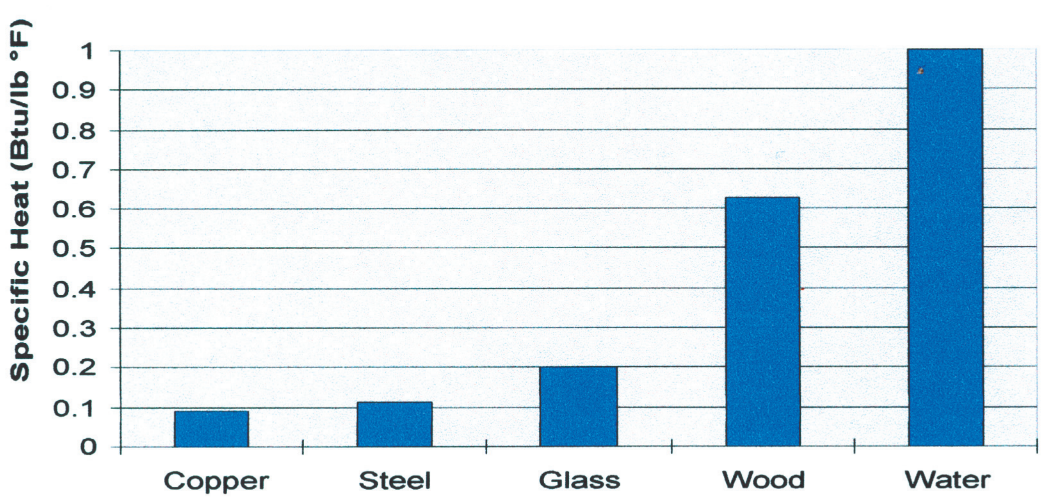


Figure 1

A careful interpretation of these data reveals that it takes over ten times as much heat to raise the temperature of water one degree as it does copper. Also, once the water has been heated, it remains warmer longer!

When it comes to roofing materials, the data are much

Specific Heat - Roof Materials

Material	Specific Heat Cp (BTU/lb-°F)
Bitumen	0.59
"Rubber" Membranes	0.48
Fiberboard	0.32
Gypsum	0.26
Stone	0.20
Fiberglass	0.16
Concrete	0.16

Table 1

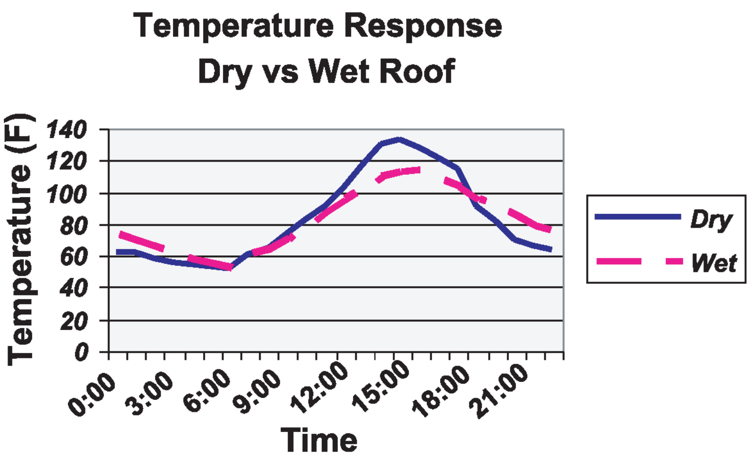


Figure 2

harder to obtain. An exhaustive search of the Internet, manufacturer's product sheets, and quite a few phone calls yielded a very small list of the specific heat values for roofing materials.

It is clear from these data that it takes 6.25 times (1.0 divided by 0.16) as much heat to raise the temperature of water as it does fiberglass. In fact, experience tells us that those roofs constructed with fiberglass insulation exhibit the characteristic thermal signature much sooner (but for a shorter duration) than those of other insulating materials. Also, from these data, the difference in heat capacity between the bitumen and "rubber" materials (an average of several sources) shows that the temperature change necessary to cause a discernible thermal pattern favors the "rubber" over the bitumen.

The net result of this is that when the sun radiates and warms the roof, the wet areas and dry areas heat at different rates. Similarly, at night, the wet and dry areas cool at different rates – graphically. See *Figure 2.*

It is evident from this representative graph that at two points during a day, the wet and dry roof areas are at the same temperature; the infrared inspections would not be worth it. This may occur for two or three hours, depending on the weather and amount of solar insulation. However, for a significant part of the day, there exist significant temperature differences. These are the windows of opportunity in which to conduct the infrared inspections.

In the morning, the roof can be inspected from the underside if the deck is:

- Visible, and
- Painted, coated, and/or fireproofed.

Also, in the morning, the roof may be inspected from the top if:

- There is an unballasted cap sheet.
- The tester can stand the heat.

ASTM C-1153[1]

Most roof thermographers are familiar with this standard. ASTM C-1153 was developed in the 1980s to provide guidelines and recommendations for conducting infrared roof surveys. It addresses the walk-over method and the fly-over method. The entire procedure is focused on night-time surveys, the state of the art at the time it was developed.

Over the past 20 years of infrared thermography experience, this author has been able easily to provide complete inspections during the day using the basic principles of physics and heat transfer. But it is evident, though not noted in ASTM C1153, that these basic laws and principles apply 24 hours a day, not just at night!

Daytime Rooftop and Underdeck Inspections

The daytime inspection process is very similar to one at night. On the rooftop, if it is inspectable (typically limited to adhered, unballasted membranes), the inspector systematically walks the roof looking for cooler areas typical of wet insulation (refer to the time vs. temperature chart). The two images in *Photo 1* and *Photo 2* present results the author located during the night and then during the day.

Photo 1: 9:54 PM

Photo 2: 10:31 AM

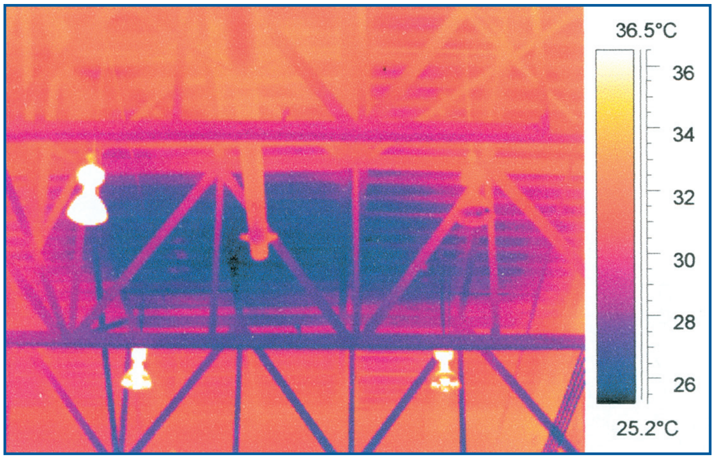


Photo 3

The images were taken at an electronics manufacturing facility from different perspectives, but the results are clear and easy to interpret. The temperature difference observed at night was 19˚F, and 14˚F during the day – very similar! Both were taken with a FLIR[2] P60 thermal imager on subsequent days. A follow-up core cut verified wet insulation.

One image looks like the negative of the other. During the night, the wet insulation was warmer than the dry insulation. This causes a temperature difference on the cap sheet (fully adhered). During the day, the wet insulation is heating up slower than the cap sheet, thus it looks (and really is!) cooler.

An underneath survey at a different facility (large paper mill) yielded different, though dramatic, results (See *Photo 3*).

This is a modified bitumen, built-up roof. The area was marked on a plan view of the section (impractical to mark from the floor; 75-foot-long paint sticks are hard to handle). As in the previous picture, the wet area is darker because it is cooler than the dry area.

Environmental Parameters

The ASTM C-1153 standard is well written, though a bit dated. The environmental parameters apply when inspecting roofs during the day as well. These are:

- No appreciable precipitation for the previous 48 hours.
- Wind less than 15 miles per hour.
- Air temperature above 50˚F.
- Roof free of standing water.
- Direct sunshine on the roof during the day.
- At least 18˚F between the inside and outside of the roof if there is little sun.

Through experience, several other physical parameters may be considered:

- Underneath daytime surveys require direct viewing of the roof underdeck.
- Best results are obtained if the underdeck is coated, painted, or fireproofed.
- Worst results occur if the underdeck is bare steel (low emissivity)
- Heavy ballast or pavers probably prohibit successful inspection.
- There is no advantage to choosing a short-wave vs. a long-wave infrared imager.

Conclusion

You *can* get a good night's sleep! Not every roof will be inspectable from the inside. However, for those roofs in plain sight, give it a try.

Editor's Note: This article is republished from the Proceedings of the 19th RCI International Convention & Trade Show, *Reno, Nevada, March 31-April 6, 2004.*

References

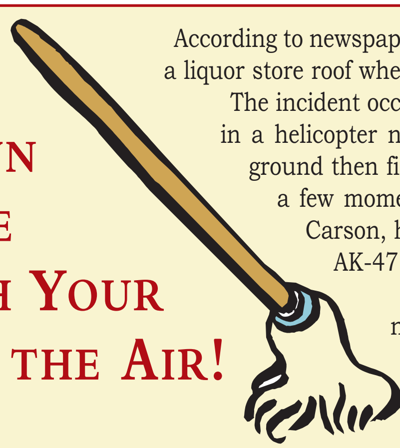
1 ASTM C-1153, "Standard Practice for the Location of Wet Insulation in Roofing Systems Using Infrared Imaging," American Society for Testing Materials, www.astm.org.

2 FLIR Systems, Inc., 16 Esquire Rd., N. Billerica, MA 01862, www.flirthermography.com.

About the Author

Ronald Lucier of FLIR Systems, N. Bellerica, Massachusetts, is a mechanical engineer with over 20 years of experience in the development and application of infrared thermography. He conducts over 30 one-week training courses each year throughout North America and has lectured in Europe and China. He is a member of RCI.

Put the Mop Down and Come Out With Your Hands in the Air!



According to newspaper reports, sheriff's deputies shot an unarmed roofer spreading tar on a liquor store roof when they mistook him for a gunman.

The incident occurred on Normandie Avenue in Los Angeles in March, when deputies in a helicopter near the site of a disturbance saw men on a roof. Deputies on the ground then fired toward the men, striking one in the arm. A few blocks away and a few moments earlier, the suspect in question, Salvador Andres Mosqueda of Carson, had been pursued by police and was killed by them when he drew an AK-47.

Sheriff's spokesman Capt. Ray Peavy called the incident an "unfortunate accident." Civil rights activist Royce Esters said, "They were just shooting like they were in Vietnam. Don't they have a policy of public safety?"

— NC Times.com and *Western Roofing*