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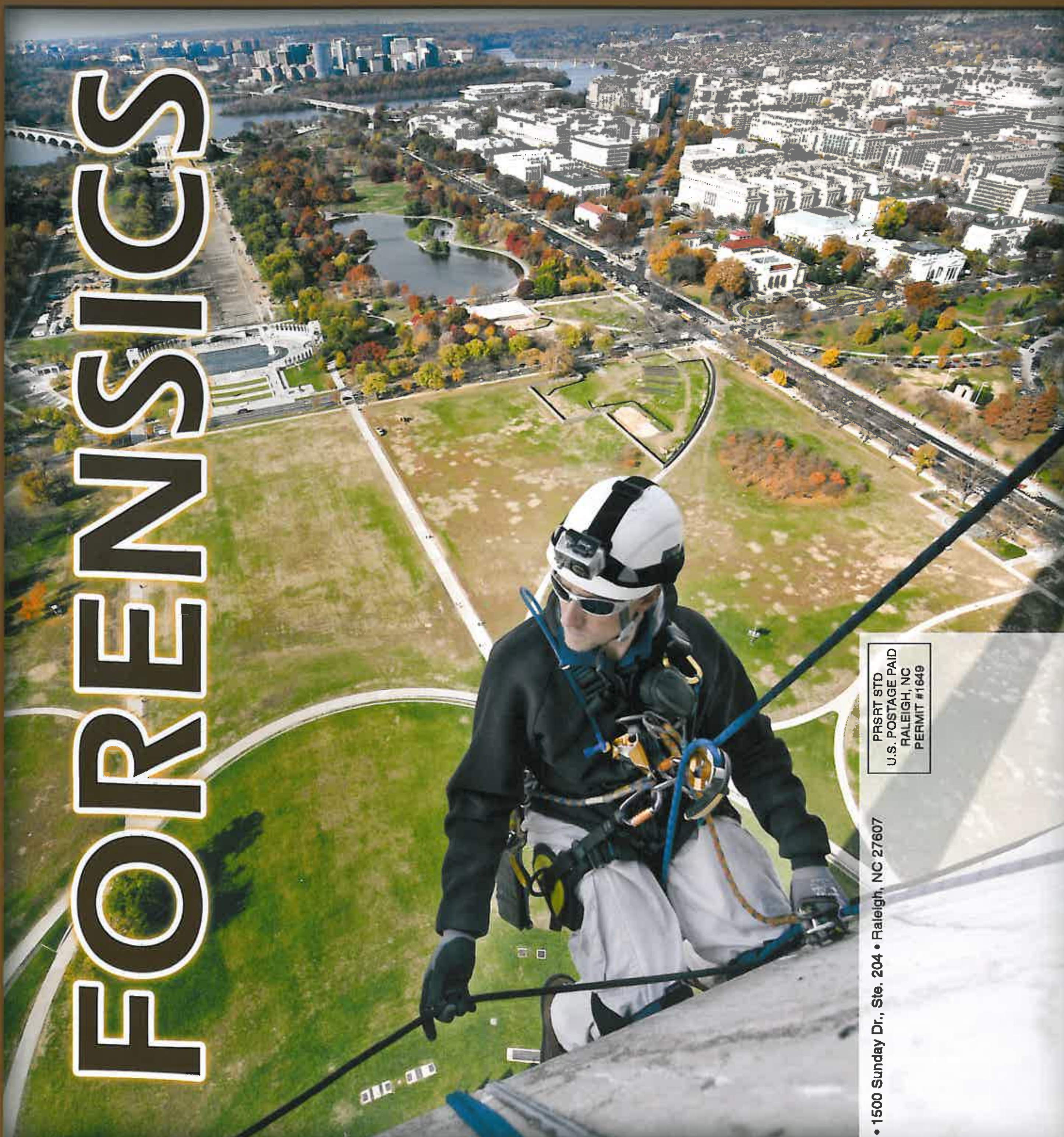

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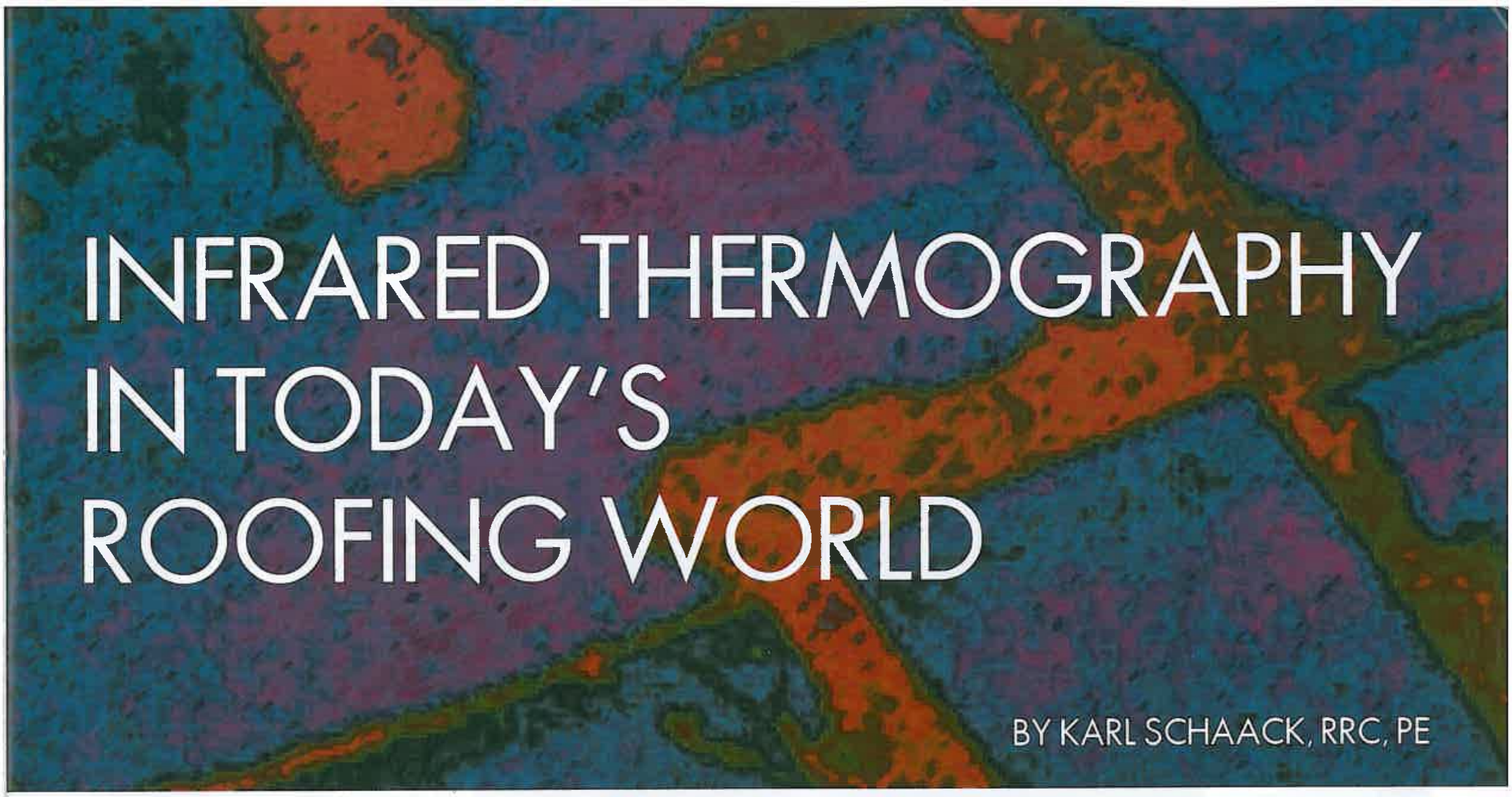


INFRARED THERMOGRAPHY IN TODAY'S ROOFING WORLD

BY KARL SCHAACK, RRC, PE

Infrared thermographic technology has been used effectively for many years for performing moisture surveys to detect entrapped moisture within roof substrate materials. Infrared cameras can be used for detecting moisture within most types of roof construction consisting of various membranes/coverings and insulation types that are in place and currently being constructed. The purpose of this paper is to outline various thermal images or signatures of a wide variety of roof compositions, particularly with newer materials or systems that have been utilized in recent years. The various roof membranes, coverings, insulation, and substrate materials combined have their own thermal signature and offer unique challenges.

ANOMALY TYPES

As presented by others in the past, the effectiveness of the infrared moisture survey relies significantly on the experience of the thermographer. As others have outlined, the common anomalies related to moisture within roofing systems include three basic types: 1) "board-shaped" or "board-stock" anomalies, 2) "amorphous" or "free-forming" anomalies, and 3) "board joint" anomalous areas.

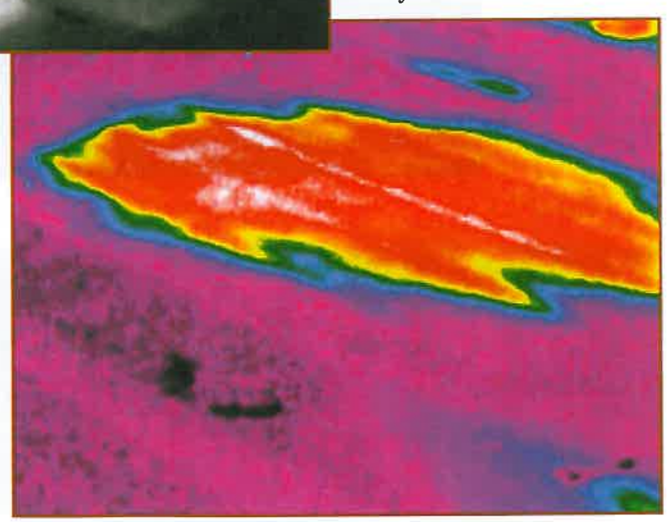
Board-Shaped Anomalies

The board-shaped type of anomaly is the archetypical anomaly that is geometric in nature and typically shaped similarly to the actual insulation board (i.e., 2x4, 4x4, 4x8, etc.). These types of anomalies can also be triangular-shaped when the wetting occurs in tapered edge strips or crickets and saddles. This anomaly is characteristic with the wetting of organic fibrous insulation boards, including perlite and fiberboard. When this type of anomaly is of significant size due to continued moisture infiltration and migration, the area affected by the wetting, when viewed through an infrared camera, will commonly exhibit a stair-stepped or joint-staggered configuration that is used during the original installation of the subject materials (*Photo 1*).

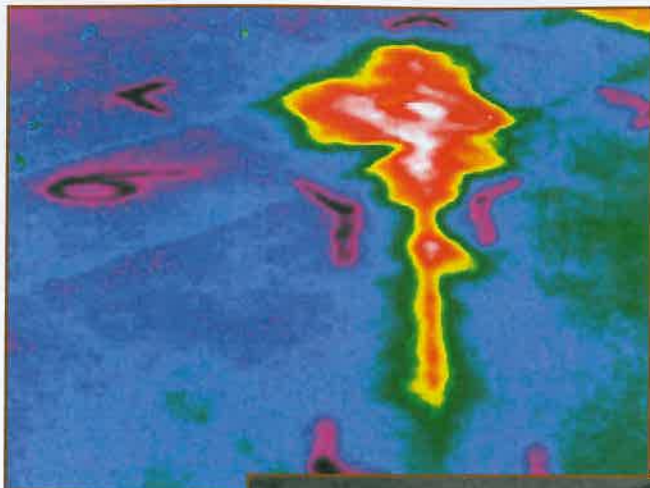
Photograph 1: Board stock anomaly of wet insulation in stair-stepped fashion.

Amorphous-Shaped Anomalies

The amorphous or free-forming anomaly is typically characteristic of the



Photograph 2: Typical amorphous anomaly: wet ISO.



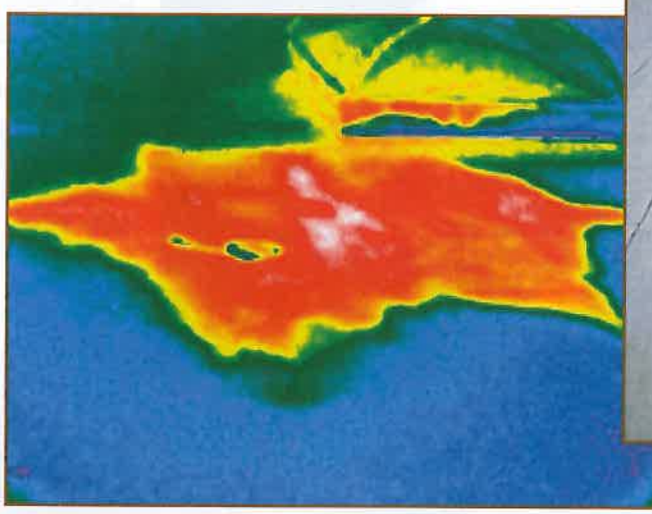
wetting of cellular foam plastic insulation boards such as polyisocyanurate (iso), expanded polystyrene (EPS), extruded polystyrene (XPS), or homogenous materials such as lightweight insulating concrete fill (LWIC) and spray-applied polyurethane foam (SPUF) (*Photo 2*). Due to the relatively low propensity of moisture migration within these types of materials, the anomaly is often localized around the actual defect/breach in the membrane. As moisture intrusion continues, the wetting of these materials occurs outward in an irregular manner, resulting in the amorphous shape. The wetting direction could also be affected by the slope of the substrate. These anomalies are commonly contained within an individual unit when affecting board-stock insulation, as it is much more difficult for the moisture to migrate through a board and travel past joints of adjacent boards due to their relatively low absorption rate. However, if moisture intrusion is significant so that the boards are "sitting in water," these materials can eventually absorb significant amounts of moisture and exhibit thermal evidence as such.

Photograph 3: View of wet insulation occurring along joint between ISO boards (color contrast).

Photograph 4: View of wet insulation occurring along joint between ISO boards (gray contrast).

Board Joint Anomalies

The board joint thermal anomaly can also occur within cellular insulation material such as cellular glass and foamed plastics. This anomaly is observed and typically occurs during the initial wetting as the moisture becomes absorbed along the cut or formed edges of these boards. This type of anomaly, when viewed through an infrared camera, typically appears as irregular-shaped brightened borders around the perimeter edges of the insulation board or joints between adjacent boards (*Photos 3* and *4*).



Photograph 5: Thermogram of wet ISO below modified-bitumen membrane.

Photograph 6: View of anomaly of wet ISO under modified-bitumen membrane.

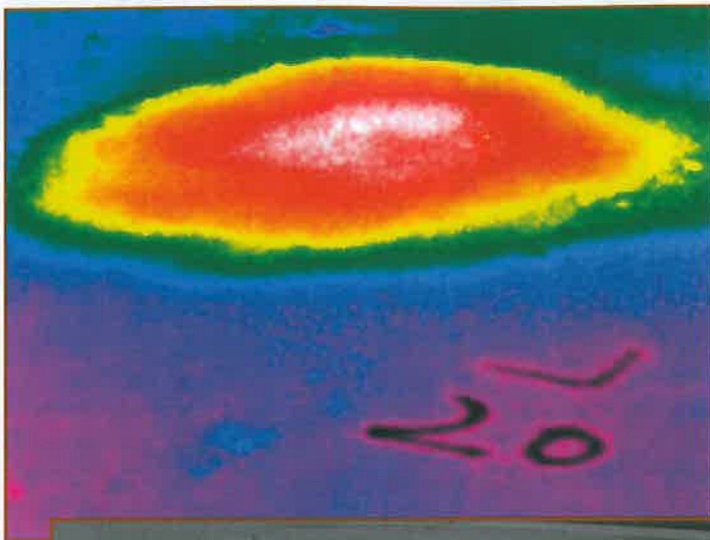


Photo 7 – *Thermogram of wet LWIC under TPO membrane.*

Photo 9 – *Small hole in membrane that was source of water entry.*

Photo 8 – *View of demarcated anomaly.*

Construction Material Issues

In today's roofing market, applications can be composed of a roof membrane—either single-ply or modified-bitumen—installed directly on top of ISO without the use of a cover board (*Photographs 5* and *6*). Single-ply membranes, as well as bituminous membranes, have also been installed directly over LWIC without incorporating any type of rigid board insulation above the surface of the LWIC. Modified-bitumen and single-ply membranes with white-colored surfacing are currently installed in more widespread applications and over various substrates that provide additional challenges for thermographers. If the roof system is applied directly over cellular insulation or LWIC, and moisture intrusion has occurred, entrapped moisture can be detected with infrared thermography (*Photos 7, 8*, and *9*). On white-colored membranes, the images may not be as discernible compared to other darker-colored membranes. On smooth-surfaced, white, single-ply membranes, thermal anomalies may appear as ghost-like images, depending on the weather conditions during the day and survey time.

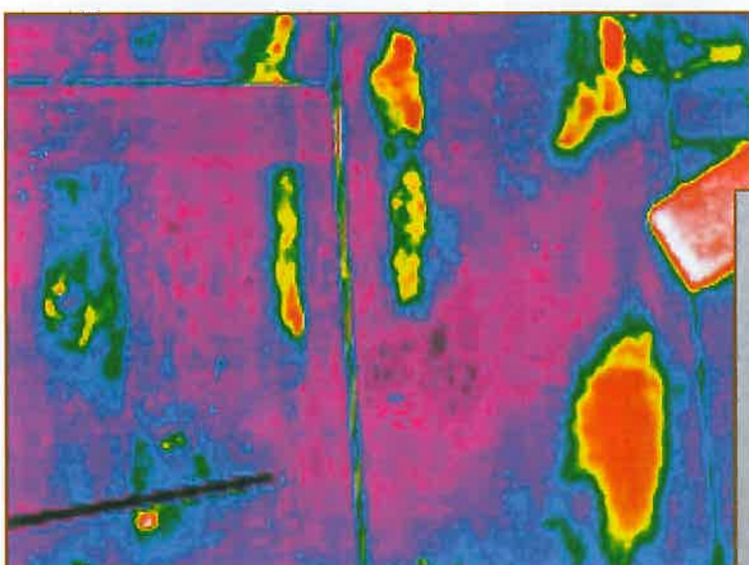


Photo 10 – *View of thermal anomalies caused by soiled areas of white-surfaced modified-bitumen cap sheet.*

Photo 11 – *View of soiled areas of white-surfaced modified-bitumen cap sheet.*

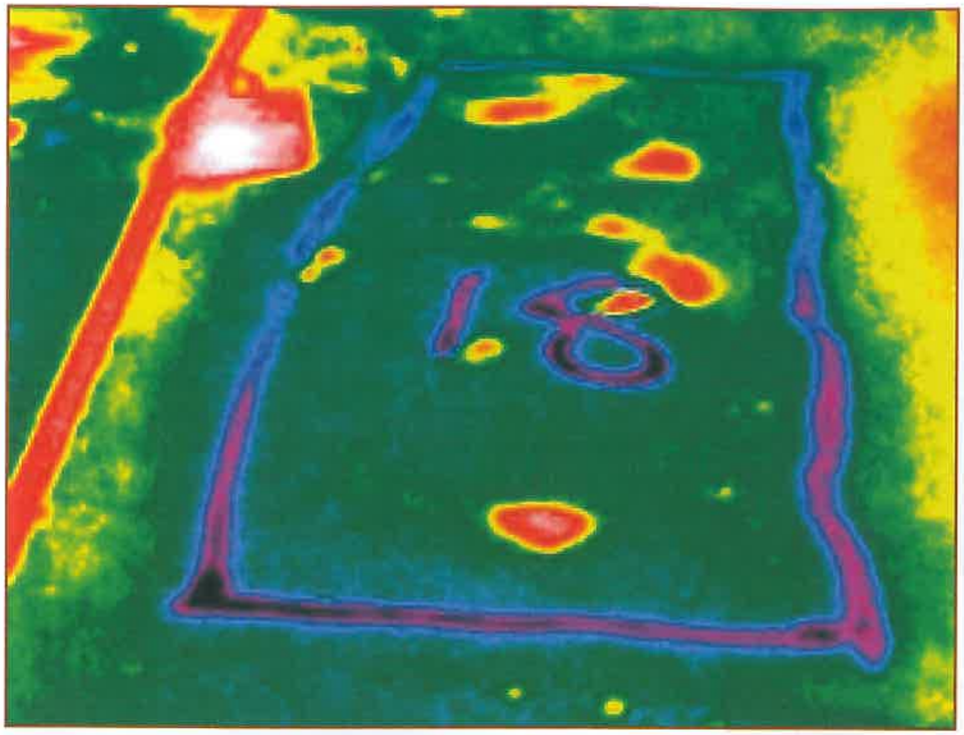
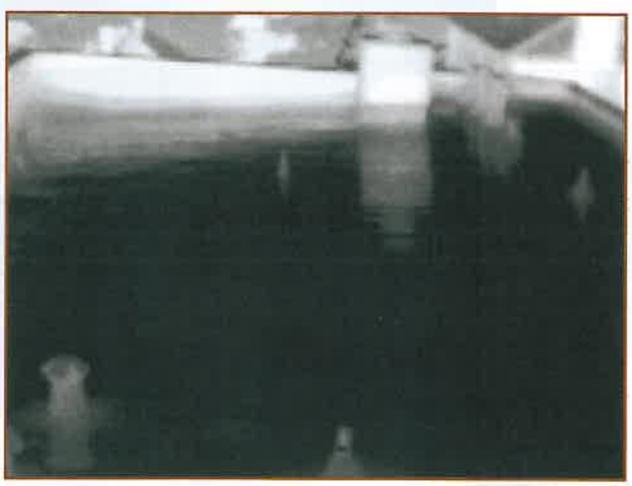
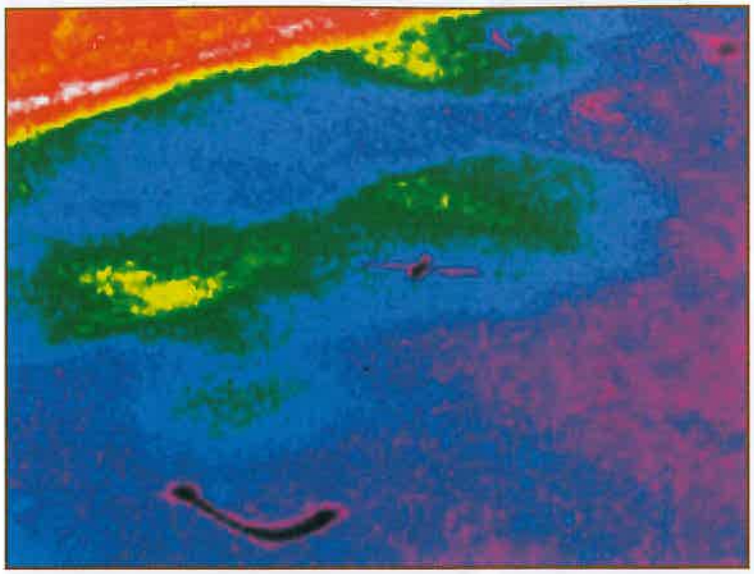


Photo 12 – Small thermal anomalies in SPUF at holes in coating.

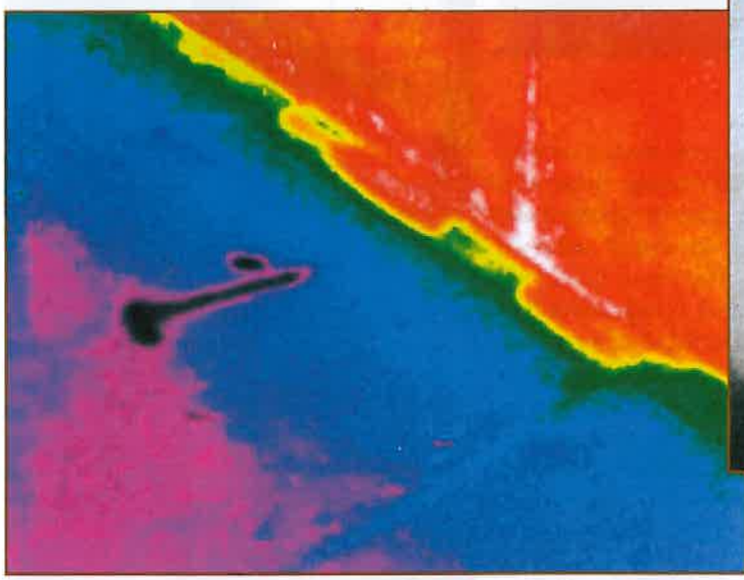
With the reflectivity and physical characteristics of white roofs, the surface temperature of the roof can remain close to the ambient air temperature on the day of the inspection and not become elevated such as typically occurs with bituminous or dark-colored coverings. Therefore, the thermal loading and thermal differential between wet substrate and outside and interior air temperatures may not be as great during the warmer months. The optimum weather conditions for performing an infrared survey would be a relatively warm, sunny day followed by a rapid cool-down after sundown, resulting in a thermal difference of 20° to 30° or greater. Although most commonly used equipment is capable of detecting temperature differentials of less than 1°, the greater the difference in temperatures from daytime to survey time, the better the opportunity for finding thermal anomalies. White-colored surfacings could also have false thermal anomalies associated with isolated areas where the surface has become darkened or stained, such as is associated with ponding water (*Photographs 10* and *11*). Stained or darkened areas on white-colored surfaces that are commonly associated with small "bird baths" of ponding water can have a thermal appearance (amorphous) that is very similar to wetted areas of underlying cellular insulation, LWIC, or SPUF. The staining that commonly occurs on white-colored coated SPUF within undulations of the SPUF also can appear as thermal anomalies. Care must be taken in these areas as well, as the ponding that causes the staining can also be causing the coating to break down or develop pinholes, thereby exposing the SPUF to water intrusion (*Photograph 12*). The utilization of other nondestructive instrumentation would be beneficial in confirming suspect areas of



Photograph 13: Reflection of chimney and penetrations in surface of TPO single-ply.



Photograph 14 – Thermogram of wet area of gypsum roof board under modified-bitumen membrane.



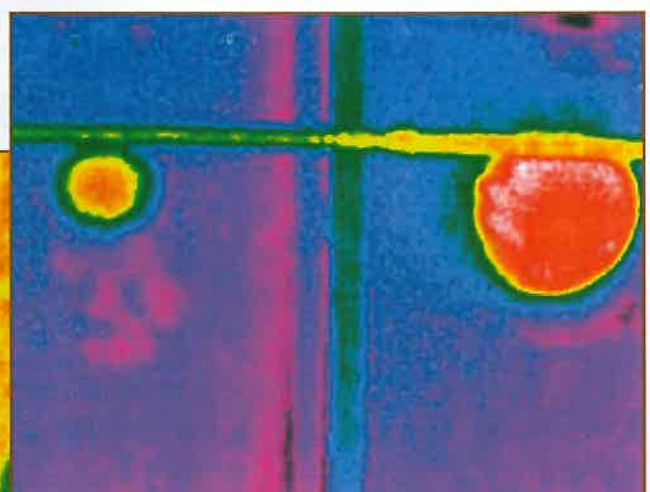
Photograph 15 – Thermogram of water entrapped in TPO base flashing along parapet wall.

thermal anomalies identified under these conditions.

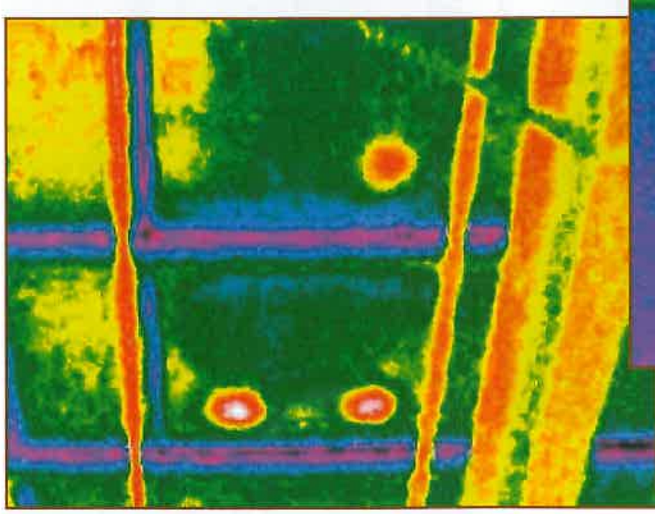
Reflections of equipment, building walls, parapet walls, penetrations, or other items in the background can appear, at first glance, as thermal anomalies on white-colored membranes that have a slick surface finish such as typified by new TPO single-ply or modified-bitumen sheets with film surfacing (*Photo 13*). The author has found that black EPDM membranes installed over fiberboard or perlite insulation (that has become wetted) on a concrete deck can offer the optimum thermal imagery conditions almost any time of the year.

With the advent of new and different inorganic cover boards with higher density and low water-absorption rates (i.e., gypsum roof board, high-density iso, etc.), detecting moisture intrusion in these materials can be challenging. These types of cover boards are relatively thin (5/8 in. or less), and by their nature will not readily "absorb" a significant amount of moisture. Consequently, suspect wet areas (thermal anomalies) can be difficult to discern, most likely will be generally lower in bright-

Photograph 16 – View of anomaly location of water in TPO base flashing.



Photograph 18 – Thermogram of entrapped water pockets in fiberglass insulation located below metal roof (interior view).



Photograph 17 – Thermogram of entrapped water pockets in fiberglass insulation located below metal roof (interior view).

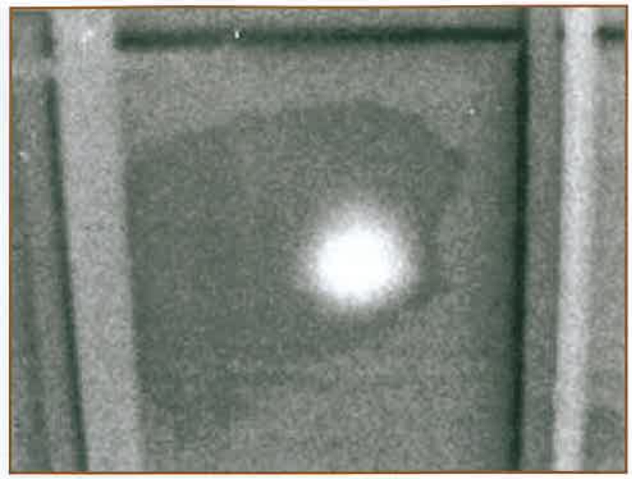
ness (faint image), and will be amorphous in shape (*Photo 14*). In addition, the roof membranes are typically fully adhered to these types of cover boards, which also limits and minimizes the lateral migration of moisture within the material.

On roofs with a single layer of insulation installed over the roof deck, wide joints between adjoining insulation boards and broken and missing corners on boards can have an enhanced thermal image very similar to that associated with "wet" insulation. However, the thermographer should be able to "feel" a void under the subject membrane to determine the true source of the thermal difference.

Water entrapped in base flashings (most likely occurring when the flashing was installed during construction and an adequate tie-in/night seal was not provided) can often be readily detected with infrared imaging.

Water that has migrated through a metal roof that has exposed fiberglass blanket insulation with a facer and taped seams can also accumulate moisture. The water may not be contained within an insulation material or the substrate, but it can be of significant quantity to form a blister or a balloon shape within the flashing material and, therefore, become detectable with infrared technology (*Photos 15* and *16*).

After a good daytime thermal loading of the roof surface, with the lights off in the building interior after sundown and an exposed underside of the insulation, water pockets that have formed within the fiberglass insulation become thermal anomalies that can be readily detected with an infrared camera (*Photos 17* and *18*). Although demarcating the suspect areas via infrared methods is much more difficult than when walking on a roof surface, the use of lifts, scaffolding, or other types of mapping or recording methods of the findings can be achieved. These "bulges" can form in vinyl-face fiberglass insulation and create a permanent deformation that may



Photograph 19: Thermogram depicting stained fiberglass (darker image) with concentrated pocket of water.

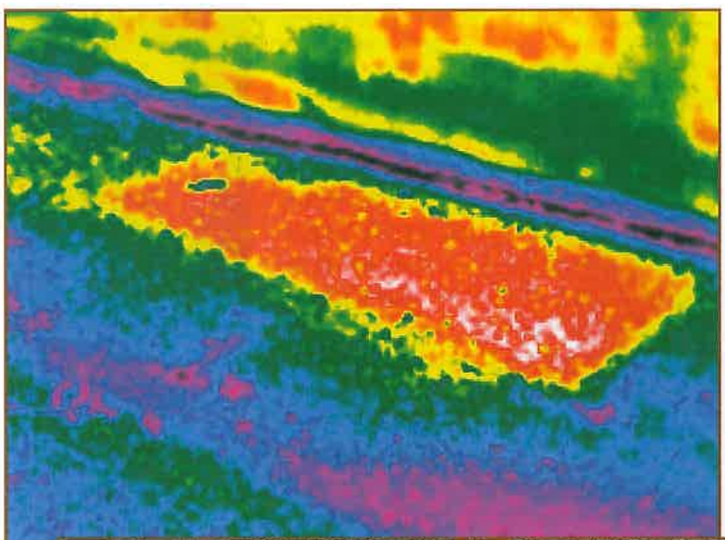


Photo 20 –Thermal anomaly of wet perlite insulation under gravel-surfaced BUR (note "grainy" appearance).

Photo 21 – View of anomaly of wet perlite under BUR.

Photo 22 – Core showing wet upper layer of perlite in BUR.

be visible during the daytime hours, though the actual presence or extent of moisture cannot be confirmed without manually checking each location (*Photos 17,18,* and *19*). Therefore, infrared thermography can be very efficient in assisting with this task.

Gravel-surfaced built-up roof coverings typically can offer the most challenging conditions for gathering accurate results from thermal imaging (*Photos 20, 21,* and *22*). The irregular surfacing from the differing accumulations of bituminous materials or gravel typically creates numerous variations in the thermal appearance of the roof and will most likely involve significantly more time for the thermographer to differentiate between false and actual anomalies associated with wet substrate materials. Asphalt bleed-out at side and end laps or other overlapped sections of sheets, together with embedded metal flashings, provide obstacles such as "false" readings during the survey for detecting thermal anomalies in a roof with a granule-surfaced cap sheet (*Photo 23*). It is prudent to take additional time when viewing these areas, as they are considered to be more vulnerable to moisture intrusion or are most likely sources of moisture penetration if a breach is present.

SUMMARY

With the advent of new materials and roof system combinations, new challenges arise for the individual who is tasked with the detection of moisture within the roof—either during or at the end of the original installation or during its service life. The use of infrared technology still has its merit and is an effective tool when used accurately, but supplemental techniques or equipment may be necessary to properly diagnose the actual conditions.

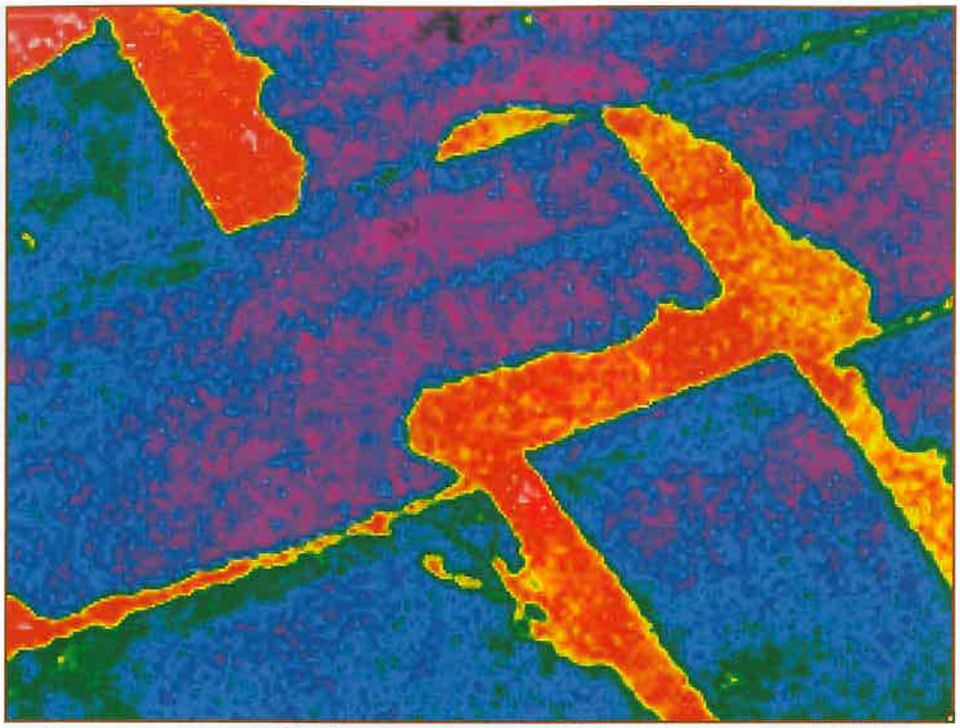


Photo 23 – Thermal anomalies from asphalt bleed-out along side and end laps of a cap sheet.

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Karl A. Schaack is president of Price Consulting, Inc., a professional engineering consulting firm in Houston, TX. Schaack received a BS in civil engineering from Clemson University in 1983 and is a registered professional engineer in Texas and North Carolina. He has been an active Professional member of RCI since 1996 and an RRC since 1997. Mr. Schaack is a member of the panel that authored the RCI Registered Waterproofing Consultant examination, participated in the 2008 RCI 10-Year-Plan Task Force, is a current member of the RCI Technical Advisory Committee, current member of RCI Document Competition Committee, and has authored several articles for *Interface* and other industry publications. In 2007, Schaack was awarded the Richard Horowitz Award for excellence in writing for *Interface*. He is an AWCI Certified Inspector for Exterior Insulation & Finish System (EIFS) and has successfully completed the Tile Roof Institute Certified Tile Installation program.