INFRARED THERMOLOGY– Its use in Forensic Building Science to solve Moisture Intrusion Problems; involving Brick/Stone Veneer, Synthetic Stone & EIFS

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ABSTRACT
This paper will focus discussion on the building envelope, the science behind the inspection, techniques for inspection, and verification of the findings. Because much of our work is pioneering, we will end by addressing the question 'Where do we go from here?'

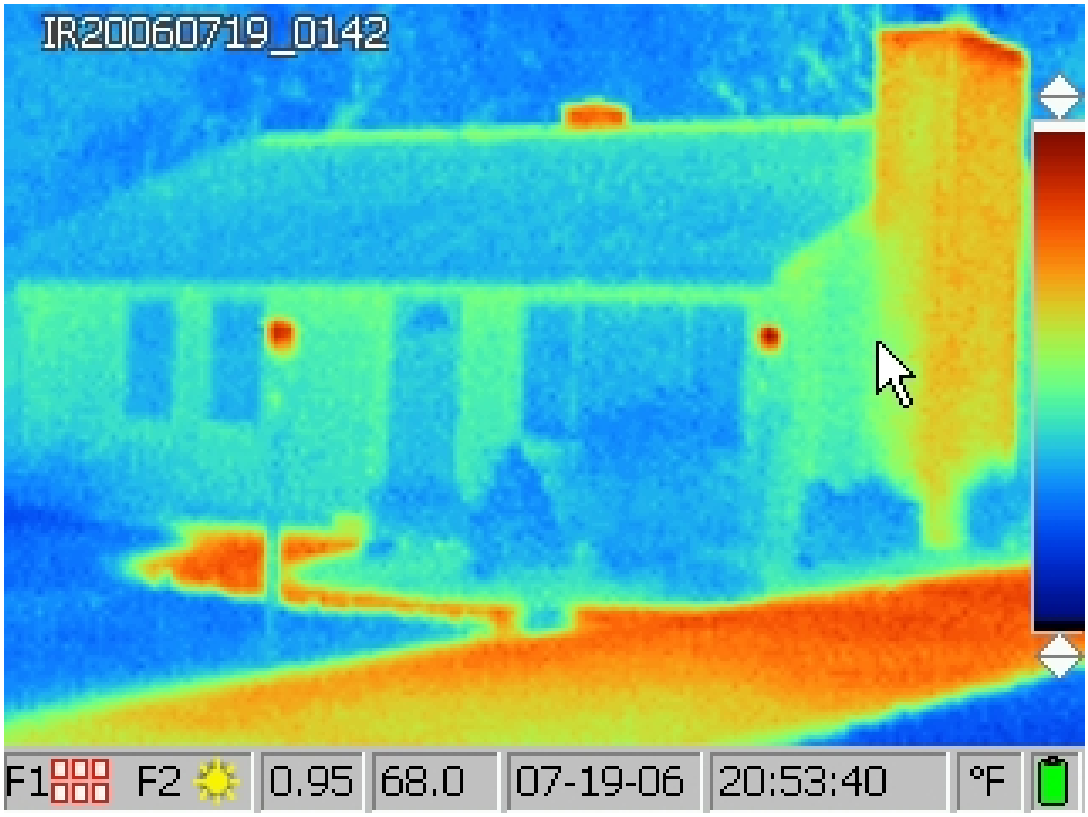

Figure 1. Thermal image of a house

WHY USE INFRARED
A picture says a thousand words; infrared thermography is the only diagnostic technology that lets you instantly visualize and verify thermal performance.

SCHEDULE
"You want it to rain the day before? And you would prefer it to be 92º F outside and 72º F inside?"

This is frequently the way our phone conversations goes with a client; YEP – It is V E R Y Important to have the right temperature difference, that sometime elusive Δ T = 20 º F. This usually breaks the ice, and allows

me to explain the crucial importance of temperature, that the Thermal Imaging is measuring thermal gradients, and NOT moisture! Nor MOLD!

Saturating rains are ideal to challenge the building envelope, with Brick Veneer; it can rain up to and including the time of survey. The most important reason why this is fine is because we can not effectively survey the house from the exterior due to the air space in the wall cladding.

Other important factors are items such as Time of Day, especially if the IR is conducted externally of the building, due to the possible winds and sunshine, as that can cause false readings, not to mention how difficult it is to have the sunshine behind you, and not being able to see the image. An alternative in that instance is to use an umbrella to keep yourself in shade, so that you are actually able to see the image on your own screen. Always remember the emissivity factor and the reflection of the residence, especially if there are copper or other metals for decorative purposes.

When it comes to EIFS Thermal imaging, the time of day is critical, early morning prior to sunrise or in the evening after the sun set eliminates sun reflection and heat absorption problems, particularly with light color surfaces.

Extended dry periods may limit results or findings for bulk water infiltration; however you may be able to distinguish between thermal condensation performance failures from bulk water entry.

Temperature differential between interior space and outside environment is critical. Acquiring a 15-20ºF temperature differential will affect time of day surveying parameters.

When the weather does not fully co-operate there are ways to create artificial controls, such as turning down the AC, by lowering the temp indoors to 60ºF when the outside is only 80º, this still achieves the 20º F differential. We usually ask the client to turn down the thermostat several hours before we arrive, and once we are within 30 minutes of our destination – to have them turn the AC off completely – so you do not get a false “cold” reading above or below air diffuser resulting in wall washing since registers and diffusers are frequently placed under a window. You want a clear view of the underside of the window without the interference of the cold air that has cooled down the drywall and wall cavity just beneath the window.

When the forecast does not call for rain, yes we have used garden hoses, spraying the walls down for 15-30 minutes, without the purchase of a professional “spraying system/rack.” One of us performs the IR on the inside while the other uses the hose, thereby we save time and money for the client, yet we achieve the desired results. The accuracy of wind driven rain is hit or miss without a wall rack and pump system duplicating measured results.

Please remember to ask the owner to turn off any automated sprinkler system the day of IR – that could really throw a curve ball in your imaging, and be an unpleasant surprise upon your arrival.

A cloudy overcast day allows a survey without consideration for solar problems and is often ideal, however we are not sure how to predict or schedule clouds. You can try to work with and watch the long-range weather forecast, but 3-5 days out can be problematic.

Do not force an inspection when conditions are not conducive to scientific finding! Bottom line: this is not a 9:00 a.m. – 5:00 p.m. job!

HISTORY

Part of your investigation prior to survey shots includes an interview with homeowner or client to determine a history of which and how often they understand the problems or symptoms to occur. You should ask for photos, and a physical survey guided by the client.

We usually love the client who has documented repair or construction history. i.e., a window installation with their camera, they might not know what proper “flashing of a window” consists of, but a photo is worth a 1000 words, and it can often explain “WHY” the window leaks. Is it an old home? A newly constructed home, that still might be under warranty?

ORIENTATION OF STRUCTURE

We must understand as thermologists that the orientation of the structure can have a huge impact on performance of the building envelope.

What wall sections see the most solar gain and what wall exposures experience the predominant winds? Where does weather originate, is the structure protected from other buildings, trees, forest, or mountain range? Is there a large body of water affecting conditions?

In our area, the most prevalent weather and winds are from the South West – which leads us to find most of the damage on the South-West side of the building. However, during Hurricane Katrina we had easterly winds, and we were amazed at how many people called that had never experienced moisture intrusion before and said that they had leakage on the north & east side of their homes. Just because there are prevalent winds, do not exclude other possibilities, as Mother Nature can be unpredictable.

METHODOLOGY

Our inspection method has become increasingly important to us, as no matter how long we have been working in the field, it seems like there are a millions of ways to get distracted.

As thermologists, technique is critical; we would highly advise you to determine a technique that works for you and stick to it. Techniques that we have developed and we use are; create a partnership between a building specialist and a thermologist. Start the survey working independently, using science to arrive at the same conclusion. One can document the building conditions that are flawed possibly leading to events or future problems. The thermologist can survey the internal space starting at the top floor and working downward.

Work in a clockwise direction for consistency, mark each area on each floor where there is a suspect problem, and correlate findings from floor to floor. The thermologist confers with the building scientist for possible sources of building envelope failure. The thermologist should repeat survey round two top down, clockwise orientation. Create a site map marking areas of concern needing further evaluation. Round three starts with the repeat survey with both individuals, now we should be confirming moisture intrusions or thermal gradient conditions.

We have learned the hard way to concentrate on a systematic approach. Taking images on the exterior – I walk around the residence to familiarize myself with the layout, and obstacles that might be in my way, such as prickly rose-bushes, steps that needs to be negotiated, or drop-offs, especially if you work at 5:00 a.m. and it is still dark.

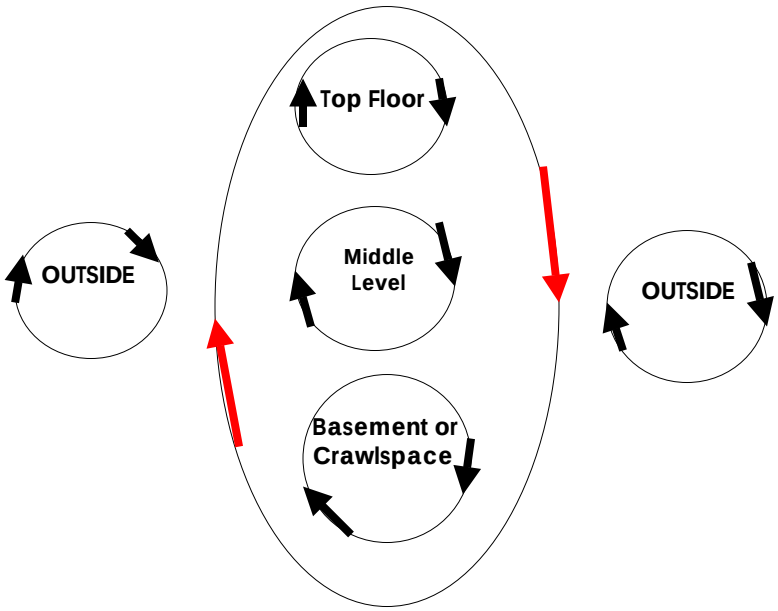

Figure 2. Decide on a consistent inspection methodology, for example inspect in a clockwise direction from the top floor down.

Many of our clients want to "shadow" us during our imaging, for them, this becomes a fantastic learning opportunity. However, if they distract you from your task, and you can not concentrate on the issue at hand, you are not performing your task well. Therefore, I usually start at a distance and survey systematically from the top floor to the bottom – preferable in silence. I have little red dots that I place on areas of concern, and also write down as detailed notes as time and circumstances will allow – I have a digital camera and always try to get a digital image for the final report. I will usually invite the client to survey with us on the 3rd trip, as this allows them to participate and experience and understand our work.

2 PEOPLE VS. 1

The second go-around, I review preliminary findings with my partner, and we review the places of concern, as well as verify the findings. Steve being a Home Inspector having worked in the field for over 30 years has all the Building Science knowledge that I do not have. His experience in Forensic Building science allows me to concentrate on my imaging while he is the "tool-man" using both non-invasive and invasive tools such as moisture meters, inspection gauges, and various probes. All findings are documented and noted, as to percentage of possible moisture content or other verified findings.

INVASIVE & NON-INVASIVE TOOLS

Figure 3 illustrates some of the many tools that we use to verify and document problems with the building.

Figure 3. A sampling of tools used to verify and inspect the building envelope

BUILDING SCIENCE

We must understand the building envelope to be effective with an infrared camera! Remember that an air space is an insulator, and you must learn to recognize all the false positives, air currents, duct work, cavity voids etc. Where is the moisture coming from? Windows? Doors? Wall cladding? The IR camera is only one tool!

The knowledge of building science can not be understated! Synthetic stone is a relatively new building system, and we have learned that the manufacturer's specification on installment has varied since the beginning of this product until today. Our professional experience indicates that synthetic stone does not consistently work as a barrier system; a drainage wall design with proper flashing details is essential.

- Drainage wall systems include cavity walls and anchored veneer walls.
- The basic concept behind the drainage wall assumes a heavy, wind-driven rain may penetrate the exterior wythe of brick. The moisture migrates inward to the cavity or air space.
- Here it flows down the back face of the outer wythe, is collected on the flashing, and is directed out of the wall system through the weepholes.
- Properly designed, detailed, and constructed drainage wall systems are rated excellent with respect to water penetration resistance.

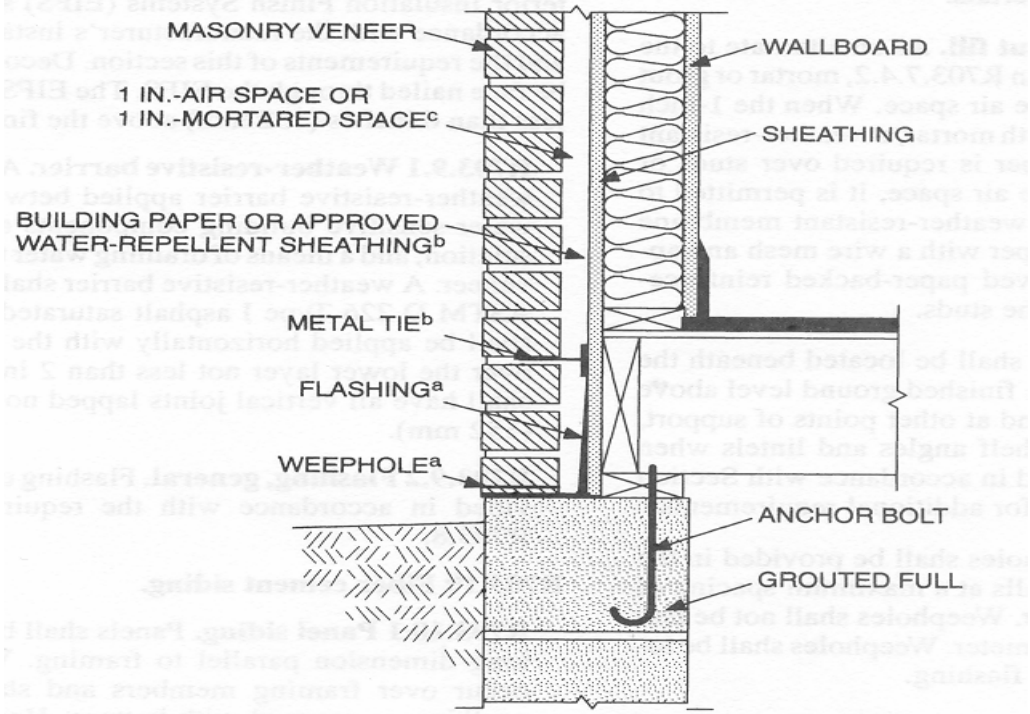

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FIGURE R703.7
MASONRY VENEER WALL DETAILS
(continued)

Figure 4. Masonry veneer wall construction details

We believe that synthetic stone is the new EIFS (Exterior Insulation Finishing System) which caused so many lawsuits and problems in the last 10-15 years. Not because the product necessarily was bad, however, the installation methods lacked redundant protection features; therefore, it failed with expensive and awful consequences to the homeowner. There were homes as new as 1-2 years old, where the water damage and the wood rot on the inside were financially astronomical, and the repair including mold removal, remediation and structural put back often tax the value of the home.

We have found a lot of the same issues to hold true with the Synthetic Stone and Brick Veneer, homes that are 1,2 and 3 years old, with significantly deteriorated wall sheathing and framing with water damage that is horrendous!

MORE INFORMATION

Create a site map to indicate problem areas. Document the IR images in several pallets, indicating conditions and findings. Photo document your work areas, side-by-side with comparisons of digital image to demonstrate findings to client.

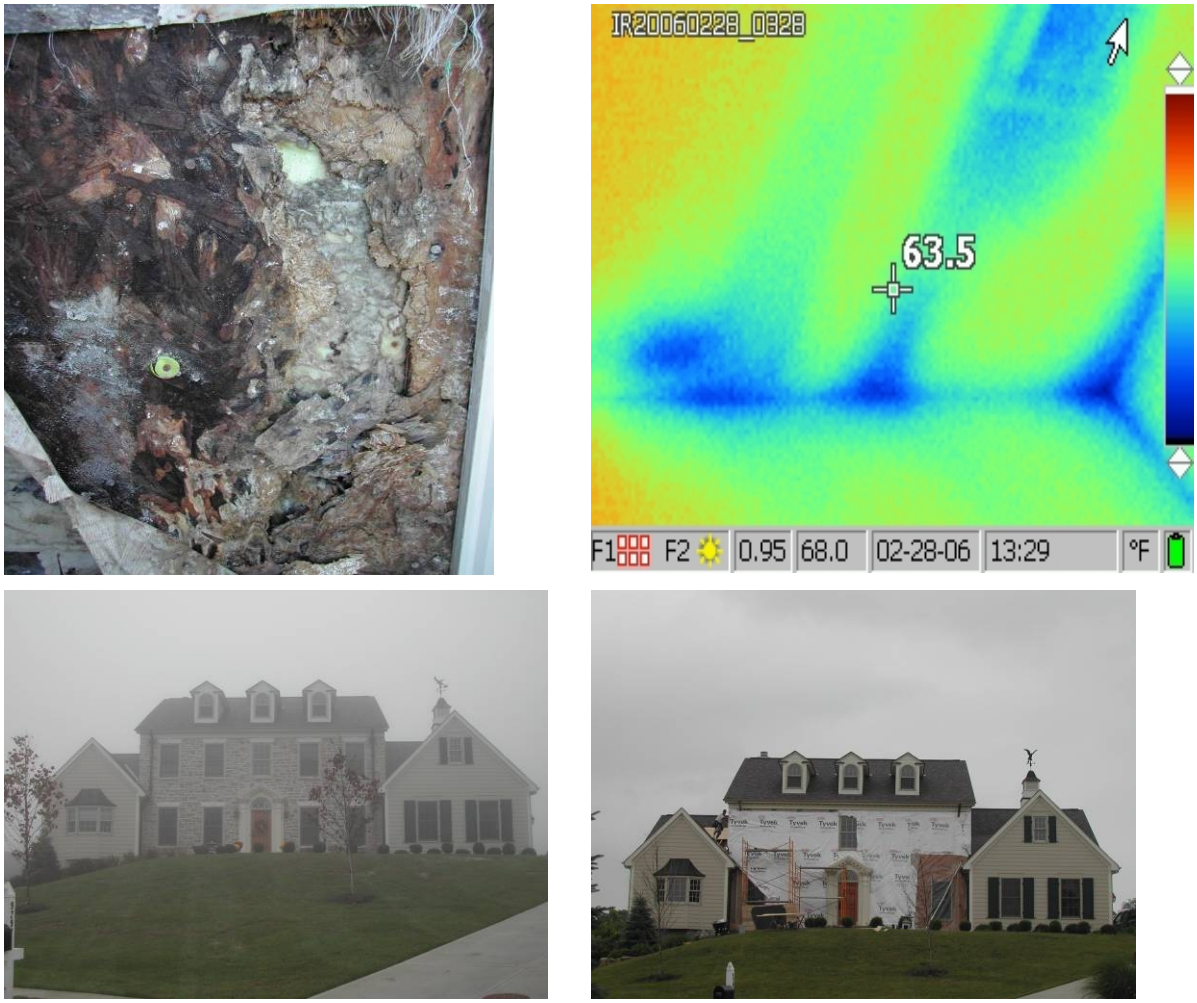

Figure 5. Use visible photographs along with your thermograms to document problems

Figure 6. Destructive testing is necessary to confirm what IR has indicated

Window leakage is very common, assume one in four windows leak, you must determine which ones. Proper window flashing is easy but essential. The industry is just now starting to recognize how important this is. You must recognize there are thousands of improperly flashed windows out there.

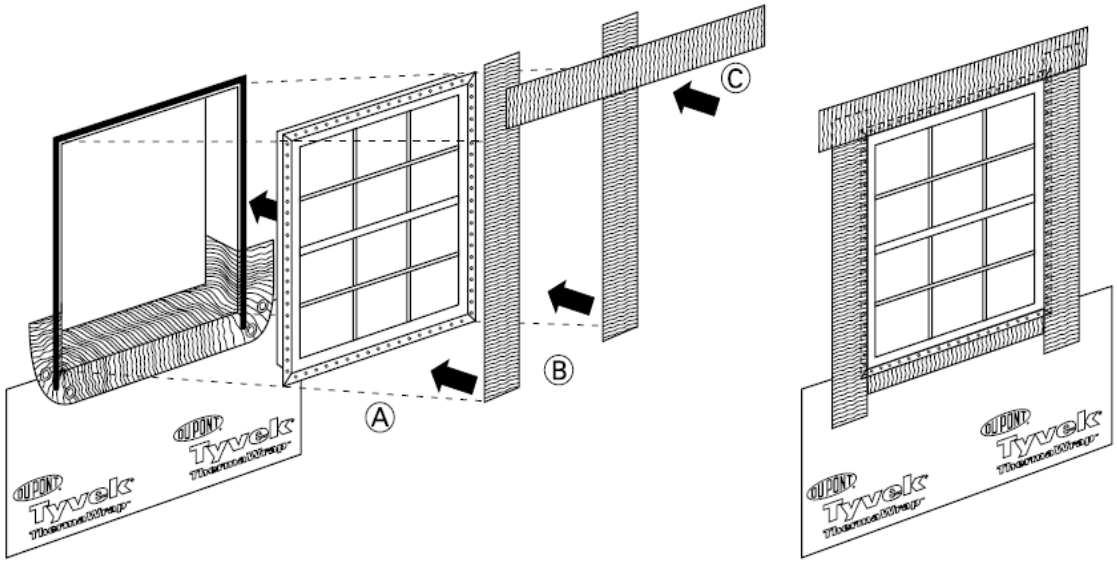

Figure 7. Proper window flashing is essential.

Pay particular attention to all windows and doors. Many houses have lots of openings. Windows and doors have 4 corners subject to leakage and water damage. You should think of the domino effect.

Inside the residence – we usually start at the top and work our way down as water follows gravity. I have learned that a water leak from the second floor often manifests itself on the first floor, ceiling, and wall cavity or even above the window; not to mention the unaccounted surprises that we find such as carpenter ants and other unpleasant surprises.

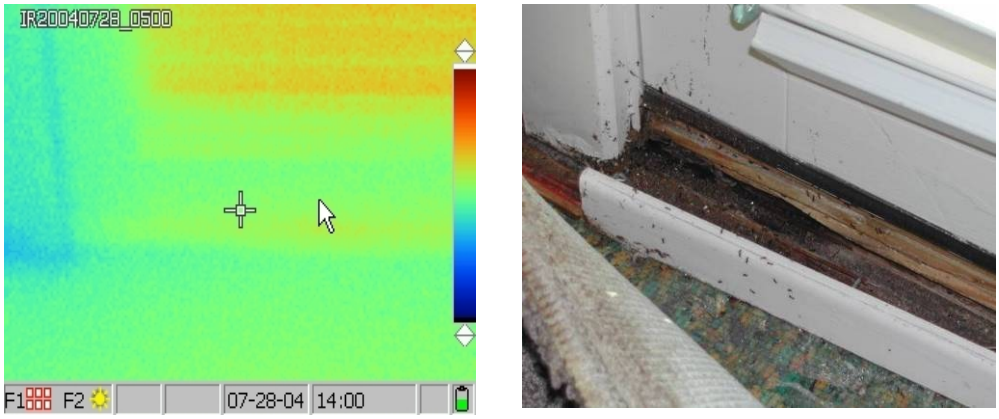

Figure 8. Window corners are often sources of water intrusion

Do not be shy about moving curtains and objects out of your way – be sure that you approach a window that is in question from various angles. We have learned that if you check an area from an angle, it can be deceiving, take the time to go around items, move a dresser or a nightstand, and perform your task with accuracy and diligence!

VERIFY, VERIFY, VERIFY

I would be remiss if I thought I could do all this be myself – as there is no doubt that two sets of eyes and knowledge far supersedes one! Both of us have a Level II cert in thermology, which means we have the time and energy invested in the science. His experience in the building science far exceeds mine, and his knowledge of "how" the building was put together is helpful, such as metal interference, not to mention he is the one who will be recommending solutions and fixes to the problems. After all; finding a problem is relatively easy in comparison to come up with valid recommendations and solutions that are proven and will work. Ultimately that is why a client is willing to pay for 2 people vs. 1; the return on investment has to be of value!

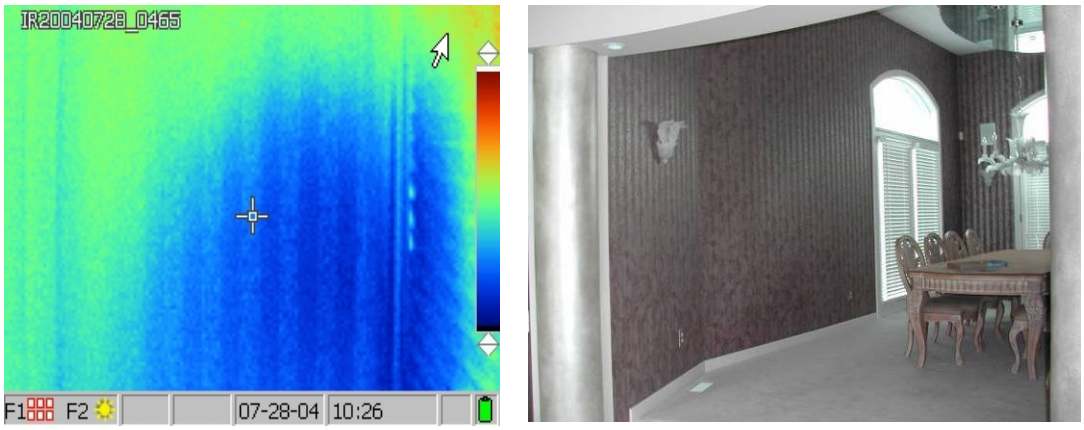

Figure 9. A thermal differential like this on a wall indicates possible moisture in the building materials

DOCUMENTATION

How does your documentation stand up? Does it need to stand up in court? This is something we unfortunately have to keep in the back of our minds in this litigious society, these days. No matter who reads your report, and what the purpose might be, do not ever short change your client!

The report is often a road map for correcting a problem that you found, and only with proper documentation can you hope to be able to find a method of repair.

It is what it is! Do not vacillate, make a decision, and be sure you are right, if you have any doubt, leave it out! Do not second guess yourself, if it is not verified or you can not prove that you have a finding, do not include it in your report. If you suspect a failure, that you can not explain, obtain help and advice from others in the field, but NEVER short-change the client by guessing!

No findings are ok and acceptable!

When you are deposed in litigation – you had better be able to back it up! This might be as important as your thermology findings! After all this is ultimately what your client is paying you for!

Building Science is a vast field, with frequent changes and new technology cropping up. You have to have some basic understanding of how something is designed to be installed, however you do not have to go as far as Steve and I did; we built a Synthetic Stone chimney ourselves, and I have the scars to prove it! It was a great experience, and I learned more than I ever thought possible.

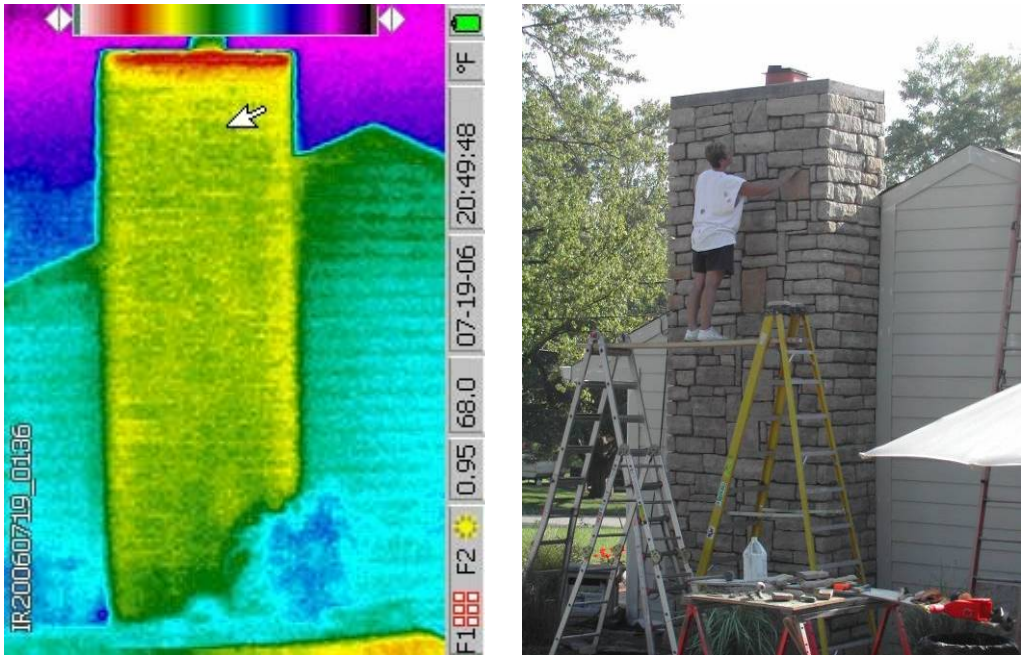

Figure 10. Synthetic stone chimney

Having the “hands-on” experience certainly helps us understand why many building systems fail.

CONCLUSION

This is exciting work – we are helping our clients and the building community to build and maintain a better building envelope. This work requires education, field study, experimentation, and dedication to become the best that you can be.

ABOUT THE AUTHORS

Dr. Száva is the President and Founder of Safety Tech, Inc., and Occupational Health & Safety consulting firm. Dr. Száva holds a Master's Degree in Occupational Safety and Health, from Marshall University, and a Ph.D., from Columbia Southern, in Occupational Health & Safety Engineering. She was the Director of ACGIH's Education Department and Directed and was responsible for the Mold Remediation Symposium. Her industrial background is in Paper and Pulp. Born and raised in Norway, Dr Száva speaks four languages and maintains professional and personal ties in many parts of Europe. She is also an Associate Professor at Marshall University.

Stephen T. Verssen is a degreed Mechanical Engineer of the University of Cincinnati with over 35 years of experience in Construction, including Residential, Commercial and Industrial properties. His industrial background lies within Manufacturing with Paper, Chemicals and Machine tools. He has specialized in the Forensic Building Envelope Failures, with diagnostic skills to interpret and convey findings in a meaningful manner. He is sought after as an expert witness and council in these areas through-out the Midwest.