PERSPECTIVES

Infrared Testing
2nd Edition

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

OVERVIEW

Infrared Thermography is the process of acquiring and analyzing thermal image information captured by a non-destructive thermal imaging device, often referred to as an infrared camera or an IR camera. These devices detect the heat energy emitted and reflected by objects and present this information as a thermal image, also known as a radiometric jpeg. Once captured, thermal images are then analyzed through specialized software to identify the thermal patterns. By supplementing an investigation or analysis with infrared thermography, additional information can be obtained that would not otherwise be visible to the naked eye or would require significant destructive testing to be performed.

A common and significant misconception in uses for restoration and building sciences is that IR cameras can detect moisture. It is important to note that thermal images depict temperature patterns in substrates; thermal images do not depict moisture or distinguish between wet or dry. Therefore, while irregularities or anomalies detected as thermal patterns may indicate potential locations of moisture, temperature differentials and variations in thermal patterns often occur due to a variety of other factors. For this reason, the analysis of the thermal images should be conducted by a properly trained, experienced, and certified Infrared Thermographer, utilizing additional field instrumentation to evaluate whether temperature anomalies are wet conditions, cold conditions or are related to other conditions.

EXPERT QUALIFICATIONS

The certification process is a program offered by many sources that are typically based on the American Society for Non-Destructive Testing (ASNT) standards. Certification levels consist of Level I, II, and III with education consistent in increasing degrees of difficulty based on that certification level. Currently, there are no mandatory requirements for training or certification in the U.S. on the use of IR cameras or the interpretation of thermal images. As a result of this, an in-depth understanding of infrared science and its application is critical, which also includes conformance with prevailing standards regarding the thermographic inspections. Ideally, forensic professionals performing thermography in an expert capacity should have obtained at least Level I certification. Additionally, expert use of thermography applied to building investigations should be limited to competent thermographers who also possess a background in the study, design and/or construction of buildings, including licensed architects, engineers, building scientists/industrial hygienists, and MEP professionals.

PROPER APPLICATION

It should be understood that the thermal imaging camera is only one of a multitude of tools used when providing thermal imaging investigations, and that a thermal imaging camera's accuracy is dependent upon settings made by the thermographer to the IR camera, as well as the regular calibration of the camera, in order to ensure confidence in the thermal imagery collected. A thermographer's tool chest would include their camera, a moisture meter, an anemometer, a thermohygrometer, and a regular digital image camera, if the IR camera does not include the ability to collect digital and thermal imagery.

The thermographer must assign appropriate values to certain thermal imaging parameters such as emissivity, reflected apparent temperature, and atmospheric conditions among others in order to obtain accurate thermal images. Assuring confidence in thermal imaging measurements relies upon the accuracy of the instrumentation, which can only be confirmed when regular calibration is performed in accordance with each IR camera's manufacturer's requirements occurs. This calibration establishes that the IR camera is operating properly by recording temperature in an accurate range that was verified by comparison against a reliable standard. The calibration certificate for each camera should be maintained with the camera and provided upon request to confirm accuracy.

Proper application of IR cameras occurs when the cameras are used in accordance with the prevailing standards that govern their use. IR cameras have significant limitations to their use as an investigational tool. Thus, adherence to those standards for building enclosures, roofing systems, insulation installation, and the interior of buildings should be complied with. There are European standards in effect, but a variety of American Society of Testing and Materials (ASTM) standards that should be reviewed and utilized where appropriate for each application, in order to ensure the reliability of the IR information obtained.

The thermal image alone should not be relied upon in determining the existence, location or extent of moisture or moisture related damage. Instead, once locations of suspect irregularities or anomalies are identified using thermography, they should then be further investigated using secondary tools such as moisture meters and humidity instrumentation or other appropriate means of assessment. Localized removal of finishes, and or limited deconstruction should only take place when a condition is verified completely.

We have a documented case study that exemplifies this; Fig. 1 is a visual image of the exterior wall of a building which depicts no issues, no visual damage or discoloration of the building finishes. The initial visual image is very important and requires multiple photographs within a closer proximity for detection of moisture entrance points. Fig. 2 is the corresponding thermal image, and each visual image should have the same thermal image framed as close to the same digital image as possible, if the camera does not collect the digital and thermal image as one.

Figure 1 *- Visual image of exterior wall*

Figure 2 *- Thermal anomalies at bottom left corner of window*

The thermal pattern depicted in this single image reveals pattern anomalies at the bottom left corner of the window that could be areas of suspected water intrusion and resultant damage. However, further investigation is necessary to draw this conclusion within a reasonable degree of professional certainty. In this case, the drywall was prematurely removed from the interior face of this wall as depicted in Fig. 3 and limited deconstruction, found that the thermal anomaly was in actuality just a reflection from the adjacent metal roofing and not resultant damage from water intrusion.

Figure 3 *- Destructive Testing performed on interior face of wall*

This limited deconstruction could have been averted if proper methods, protocols and procedures were followed by the investigator that was improperly using the thermal image for this purpose. First and foremost, this image is taken from too far of a distance.

A contrasting example would be Fig. 4, which shows one visual image of the exterior wall of a building and Fig. 5, is the corresponding thermal image of the same view of the building.

Figure 4 *- Visual image of exterior wall*

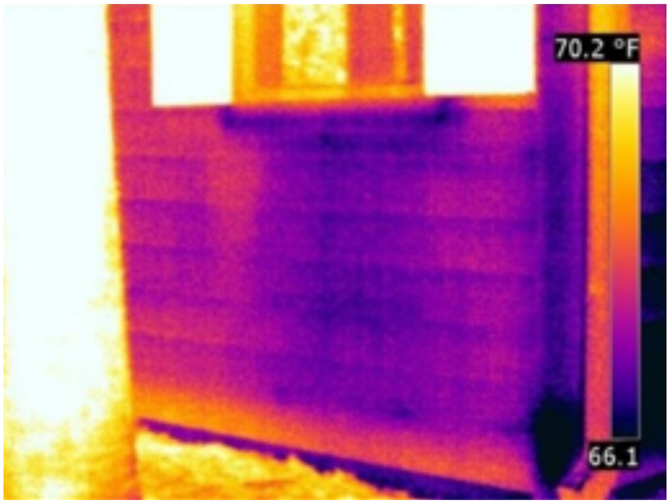

Figure 5 *- Thermal anomalies below window*

This thermal pattern also reveals anomalies located below the bottom corners of a window opening similar to the previous case. However, in this case, moisture meter readings were collected to confirm that the wood had a moisture content level above normal. Then, the exterior siding was removed from below the window opening, and Fig. 6 shows visually, the existence of water intrusion and resultant damage was confirmed. These two examples also serve to emphasize the importance of proper procedural aspects of using all investigative tools and post processing in the application of thermography.

Figure 6 *- Limited deconstruction below window*

POST-PROCESSING CONSIDERATION

Post processing is terminology that describes after-the-investigation analysis of the thermograms, which is typically performed utilizing one of the various software programs available to thermographers. An indication that an expert may be questionable is his or her disregard or dismissal by failure to utilize post processing parameters. As previously noted, the thermographer must assign appropriate values to certain thermal imaging parameters such as emissivity, reflected apparent temperature, and atmospheric conditions among others in order to obtain accurate thermal images. In post processing, thermal tuning can be done to further disseminate and measure the thermal anomaly. Within the post processing software, adjustments can be made to the temperature range or span in which the apparent temperatures are displayed. Adjusting the temperature span of a thermal image essentially adjusts the contrast, as illustrated in Figs. 7 and 8, which are the exact same image shown at different temperature spans. A short span produces a higher contrast image as depicted in Fig. 7, whereas a wide span produces a lower contrast image as depicted in Fig. 8.

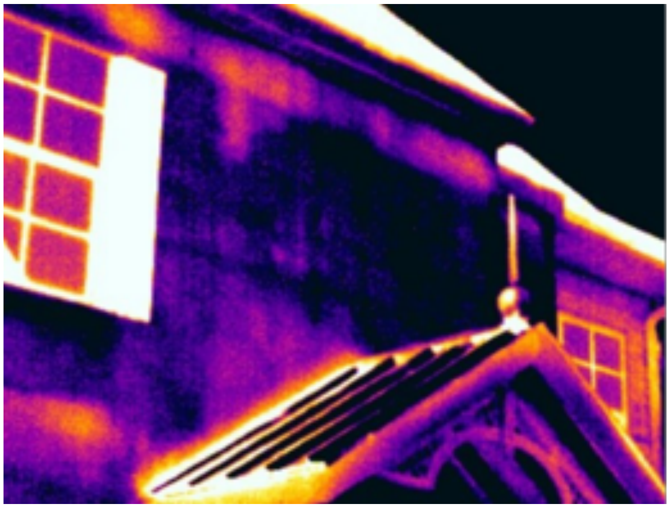

Figure 7 *- High contrast thermal image with short temperature span*

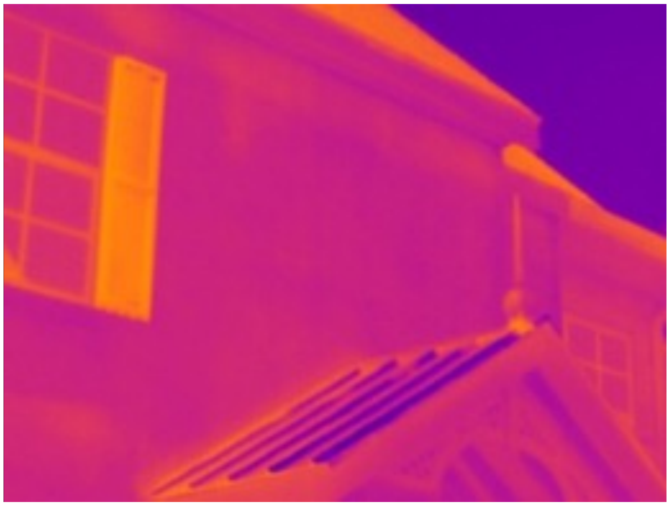

Figure 8 *- Low contrast thermal image with wide temperature span*

Thermal tuning can be abused by misrepresenting or disguising certain conditions. For example, the temperature span can be restricted to produce a higher contrast within a thermal image to intensify or exaggerate temperature differentials or anomalies. Inversely, the temperature span can be widened to reduce the contrast within a thermal image to disguise or understate temperature differentials or anomalies.

IMPROPER APPLICATION

When preparing an expert thermographic report, it is important that the expert include sufficient information to support his or her investigation and analysis. This information should include, at a minimum: the name of the thermographer; their certification level, the camera and lens that were used in obtaining the image, the thermal image and corresponding digital image; the assumed or measured parameter values such as emissivity, reflected temperature, etc.; the atmospheric conditions such as ambient temperature, solar loading conditions, relative humidity, the distance from the object that the image was recorded; the displayed temperature span; and the date, time of day the inspection was performed, and location of the inspection. An omission of critical information within the thermographic report can misrepresent the actual conditions and prevent the findings from being determined to be accurate and reflective of conditions existing.

The thermal image as represented in Fig. 9 is an exterior wall of a building being inspected for possible water intrusion at the window trim. The thermal image by itself could lead an unknowing/untrained person to believe that the anomaly may in fact be damage or some type of a defect.

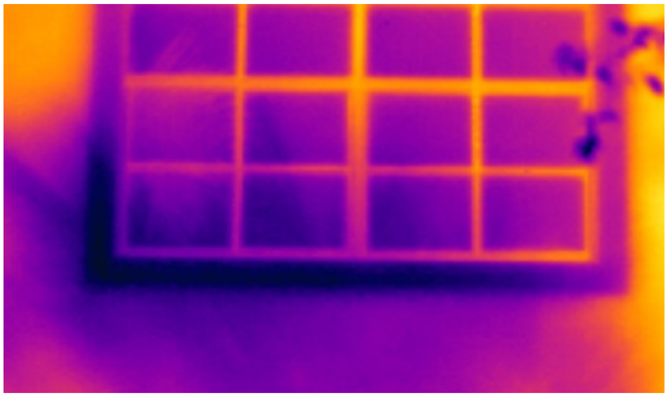

Figure 9 *- Unknown thermal anomaly*

Without the inclusion of the corresponding digital image depicted in Fig. 10, the presence of the adjacent palm tree and its shadow would not have been presented. With this new information, it becomes clearly apparent that the anomaly was resultant of solar loading and the shadow of the palm tree.

Figure 10 *- Corresponding digital image depicting shadow*

Other indications that an IR survey may have been improperly performed or presented in a misleading way include, but are not limited to, the following:

- Disregard of the parameters that are required to make accurate conclusions, often accompanied- by an explanation that the parameters are irrelevant because the survey was only qualitative or drawing relative conclusions.
- Improper or inconsistent parameters (e.g. unreasonable temperatures, emissivity values greater than 0.9, inconsistencies throughout the same survey, etc.).
- Failure to calibrate IR equipment in accordance with manufacturer's requirements that verify accuracy of measurements.
- Lack of certification, qualifications, proper training or experience by the Thermographer.
- Failure to follow peer-reviewed and recognized standards regarding thermographic inspections for buildings and associated substrates.
- Unreasonable and/or unsupported claims without verification (e.g. purple represents wet areas or the thermal image depicts moisture without any substantiating secondary testing records or information).
- No digital images coinciding with the thermal images have been provided.
- Imaging that is blurry, unfocused or unclear that is obtained too closely to the surface being surveyed.
- Imaging taken from too far away from the actual point of interest, without further close-up images.

CONCLUSION

Infrared Technology is utilized in many different aspects of our entire world in the 21st century. The building sciences have a multitude of applications for IR in all trades. The successful use of infrared technology for all of these applications overall is dependent upon on the ability of the thermographer to correctly collect, perform the investigation, process the information gathered, and interpret the infrared data. When collected and processed correctly, following prevailing peer-reviewed standards, the infrared data and its findings can be trusted and depended upon. Conversely, when not collected or processed correctly, whether through negligence or by design, infrared data can obviously be misinterpreted or misrepresented and lead to erroneous conclusions.

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MORE ABOUT J.S. HELD'S CONTRIBUTOR

Michelle Feduccia is a Senior Engineer in J.S. Held's Forensic Architecture & Engineering Practice. Her training and experience include structural, forensic, building envelope, and construction defect investigations. She has performed cause and origin and forensic investigations on a variety of large and small single family and multi-family residential projects.

She has managed several claims evaluating alleged damage to multi-family residential properties. She has also conducted several thermography surveys during the evaluation of building envelope and roof assessments.

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REFERENCES

- Aggelis, D.G., et al. NDT Approach for Characterization of Subsurface Cracks in Concrete. Construction and Building Materials 25 (2011) 3089-3097.
- Bagavathiappan, S., et al. Infrared Thermography for Condition Monitoring – A Review. Infrared Physics & Technology 60 (2013) 35-55.
- Balaras, C.A., et al. Infrared Thermography for Building Diagnostics. Energy and Buildings 34 (2002) 171- 183.
- Clark, M.R., et al. Application of Infrared Thermography to the Non-Destructive Testing of Concrete and Masonry Bridges. NDT&E International 36 (2003) 265-275.
- Grinzato, E., et al. Moisture Map by IR Thermography. Journal of Modern Optics 57 (2010) 1770-1778.
- Infrared Training Center (ITC). Level I Course Manual & Level II Course Manual – An Intermediate Training Course for Thermographers. Pub ITC 120 C2010-01-08, 2010.
- Lanzoni, D. Building Thermography (Including Blower Door and Heat Flux Meter). Davide Lanzoni, 2014.
- Machin G., Simpson R, Brussely M. Cailibration and Validation of Thermal Imagers. 9th International Conference on Quantitative InfraRed Thermography, July 2008.
- Titman, D.J. Applications of Thermography in Non-Destructive Testing of Structures. NDT&E International 34 (2001) 149-154.

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