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FORENSIC FEATURES

Thermal Imaging: What it Is and How the Infrared (IR) Camera Can Help in Property Damage Investigations

A police chase at night ends safely because a helicopter with a Forward-Looking Infrared (FLIR) imaging system tracks the fleeing vehicle. Military forces use night vision gear to see in the dark. Investigators find evidence of leaky pipes inside a building's walls. All these scenarios are related by the technology of infrared (IR), or thermal imaging. The use of thermal imaging is also called thermography.

Originally developed for night vision and other military uses, thermal imaging technology has recently become available to professionals in other fields, opening the doors to new problem-solving tactics. This article will briefly explain what thermography is, how it works, and how it can benefit Schaefer Engineering's clients.

What is thermography?

To understand the techniques of thermography, it is useful to understand how light and electromagnetic energy travels. The great 17th century physicist, Isaac Newton, used a prism to split a beam of light into a rainbow, demonstrating that light is made up of individual colors (or wavelengths) of energy, known as the spectrum. When you see a rainbow, you see those individual colors – red, orange, yellow, green, blue, indigo, violet. However, there are parts of the spectrum your eyes can't see. The part of the spectrum with wavelengths shorter than violet light is the ultraviolet ("above violet") light that causes sunburns. The part of the spectrum with a wavelength longer than red is the infrared ("below red") light that thermal imaging technology makes use of. Figure 1 shows a representation of the electromagnetic spectrum.

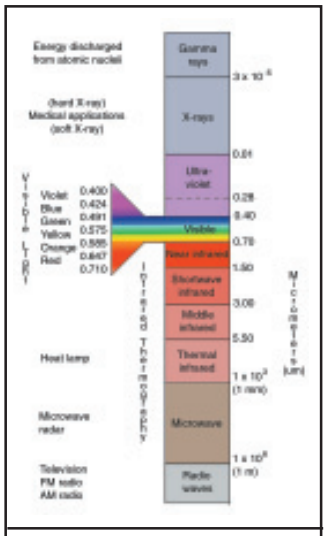

Figure 1: The electro-magnetic spectrum

Every object radiates infrared light in proportion to its temperature. Hot objects radiate more infrared light than cold objects, but humans can't see in those wavelengths. A person in a completely dark room containing a hot frying pan and a glass of ice water couldn't see either item. But with a thermal imaging camera, both objects can be made to stand out from the surroundings.

The engineers at Schaefer Engineering can use an IR camera to "see" temperature differences. This ability allows observation of areas that would otherwise require more invasive and destructive testing.

For example, water intrusion into the walls of a home is often easily detected by the IR camera – without having to remove drywall from the interior walls and without having to make holes in the walls for more traditional moisture probes. Since water is a good conductor of heat, wet areas of walls will be at different temperatures relative to dry areas. For example, Figure 2 on the next page, shows a typical IR image of a ceiling underneath a roof leak. Similarly, areas with inadequate insulation can be detected easily, as shown in Figure 3. Electrical systems that are on the verge of a malfunction can also be detected by the infrared camera. Figure 4 shows heating at an electrical contact caused by a faulty electrical connection. Thermography is one of the few techniques that can be used to examine electrical systems while they are energized and under load.

With proper application, the infrared camera can help pinpoint many diverse property problems that would be difficult or impossible to detect with other methods.

The IR camera helps detect:

- Water intrusion
- Roof leaks
- Pipe leaks
- Improper insulation
- Mold presence
- Electrical malfunctions
- Location of cold and hot water pipe systems
- Nailing patterns

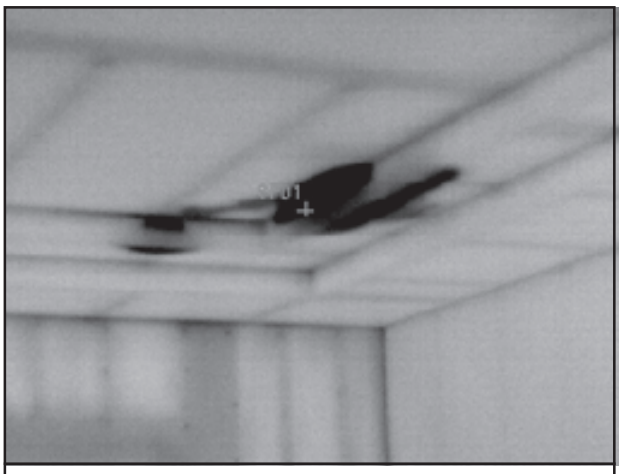

Figure 2: IR image of water damage to a ceiling

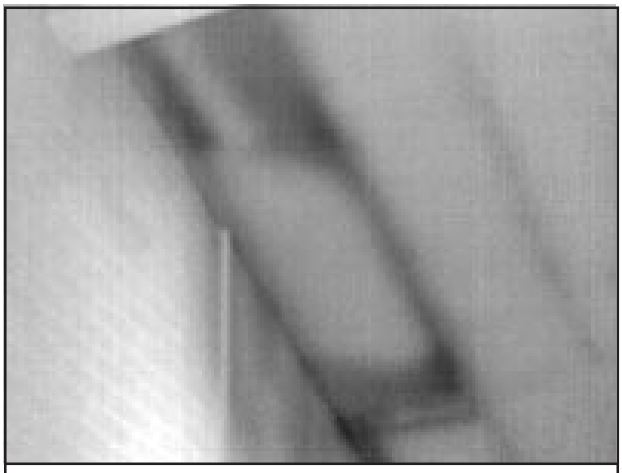

Figure 3: IR image of a ceiling. The dark areas are cooler, and indicate inadequate insulation

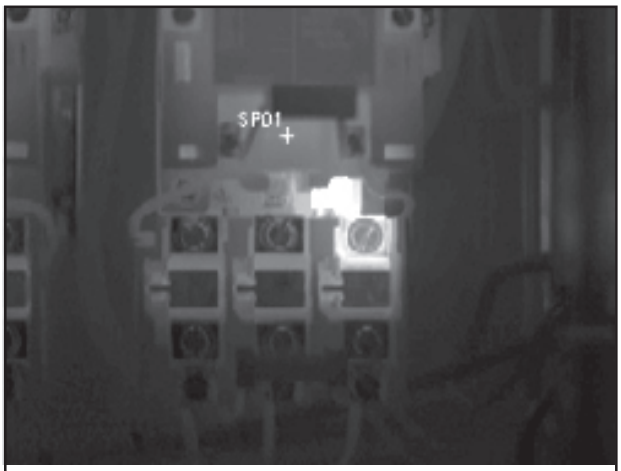

Figure 4: Heating due to poor electrical contact

The ability of the IR camera to detect wet areas in walls is a major help to investigations of EIFS (Exterior Insulation and Finish System) deficiencies. Traditional visual inspections require removing drywall or exterior finish around windows and doors, then visually checking for evidence of water damage. The infrared camera is non-intrusive, and usually requires no demolition of walls or ceilings. The camera is compact and portable, and can record directly to video tape for future reference. Using this tool, we can typically reduce the time and effort necessary to inspect a structure for water and mold damage drastically.

Contact Schaefer Engineering to arrange a thermal imaging demonstration.

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Benefits of the Electronic Total Station: Forensic Mapping of Crash Sites

Prior to 1925, systematic traffic accident investigation was virtually unknown. In the years that followed, automobile collisions became more common. The art and science of investigating automobile crashes became more sophisticated on a number of fronts, namely through the demand for safer vehicles and roadways. Today, collision reconstruction and cause analysis require the use of detailed crash scene maps to allow investigators to examine how the roadway was used. Since the data available to crash reconstructionists is often poor or incomplete, it serves mainly to help identify the location of the crash and to identify weaknesses in the opposing experts work-product. Thorough investigation requires that the investigator collect the best possible scene-data, the accuracy of which correlates closely to the quality of the resultant work-product. The investigator will seek to optimize the amount of data collected in the shortest possible time. The use of *Electronic Total Stations* for collection of scene-data has become increasingly popular.

Although there are several types of electronic survey tools, most operate in the same fashion. The operator places a measuring instrument, or total station, where there is a clear view of the area to be measured. The instrument contains computerized measurement and calculating mechanisms, and emits an invisible infrared beam. The target, or reflectorized prism, reflects the infrared beam back to the total station where its electronic distance meter automatically calculates the distance to the target. Sensors in the total station measure horizontal and vertical angles. A data logger or data collector device, converts the distance and the angles into three rectangular coordinates for north, east and elevation relative to the total station position. The data collector allows the investigator to enter a feature or point description code that describes the point in 3-D space. Some data collectors enable the investigator to see these points on a scene map as the data is being collected. Once this is done the

Data Collector

data is downloaded onto a computer. The data can then be entered as points into AutoCAD, or other drafting software, enabling the investigator to use a connect-the-dots-type of pattern to create a detailed rendering of scaled crash scene drawings, which relay precise dimensions and elevations. Maps can be created to analyze vehicle speeds and other crash-related aspects. These measurements are critical in defining crash case elements.

Accuracy of Field Measurements

The accuracy of crash scene documentation relies on the precision of the scene measurements, which represents nearly a third of all information in any crash. Long gone are the days when "pacing-off" a scene or hand-drawn diagrams are sufficient. The electronic total station is simply the most accurate measurement tool available on the market for use in accident reconstruction.

Although an excellent tool for accident reconstruction, it was not designed specifically for accident investigators. Many applications of the measurement technology have been readily adopted by field users in many industries. From forensic pathology, building construction and architecture to archaeology, the total station is the measurement device of choice. Since its primary use is for measuring large outdoor areas, the tool naturally lends itself to the tasks of measuring crash scenes. Large or complex scenes that often require more than one visit are easy to approach recurrently after monuments are placed.

The degree of accuracy made possible by these electronic measuring devices is far greater than that which can be achieved by manual measuring. Common field conditions can cause a steel tape to lengthen. These variances can be exacerbated when cloth or fiberglass tapes are used, or worse, when measuring wheels are used. Many would argue that two or three inches of accuracy are acceptable for every 100 feet measured. But if considered in the context of a typical urban crash scene, where combined sight and skidding distances often exceed 300 feet, what margin of error would be considered acceptable? Using a total station and the proper technique, an operator can reduce sighting and mapping errors to as little as 1/10 of an inch, out to 1,000 feet.

When attempting to measure a crash site, investigators are tasked with trying to accurately measure critical roadway elements and crash artifacts, often under difficult circumstances. Weather and traffic can contribute to rushed work or difficulty in accomplishing the task. If given the proper treatment, whether fiberglass, steel tapes or rolling measuring wheels are used, the measurements are usually sufficient. However, casual or hurried attention to the measurements and a lack of accuracy can result in misleading analysis, or in the worst cases, lead to incorrect conclusions concerning fault. Given the nature of automobile crashes–often resulting in severe injuries and steep financial costs–consider how inaccurate measurements can affect fault determination

Safety of Hazardous Field Operations

Typically, measurements are made by the first responders to a crash. Since roadway closures are not always possible, one inherent safety concern is the danger posed by continuous street traffic. In certain circumstances the operator may require an assistant to hold a reflectorized prism pole directly atop any point requiring measurement, such as pavement edges, lane markers or debris. The very nature of this work may require the assistant to stand motionless in the traveled portion of the roadway while waiting for the operator to locate and acquire the target each time, shoot the point and then enter the feature codes–all while dealing with street traffic. The operator then relays, via radio or other method, that the point was successfully shot and directs the assistant to the next logical point. If using a reflectorless system, the operator simply focuses the instrument on a target, and presses a button to 'collect' or measure the distance.

A total station with reflectorless technology, such as the tool used by Schaefer Engineering, has several distinct advantages over traditional total stations. Most importantly, it enables an investigator to work ***SINGLE-HANDEDLY***, without moving from behind the total station. Needless to say, the solo operation enables the completion of a survey in a fraction of the time it would take a two person crew, which:

- Decreases the chance of injury to the operator and others involved in the survey due to exposure to normal traffic and environmental hazards.
- Decreases the chances of encounters with interested parties, adversarial parties, police and others. These encounters are routine, but normally take <u>time</u> to deal with.
- Translates to more time available for the investigator to interview witnesses, take photographs, collect evidence and travel.

Robotic stations, along with wireless controllers for data input, are now the state-of-the-art. Using it allows an operator to choose a point, move to the point, acquire the object with the station and enter feature descriptions remotely–all while working alone! The cost of robotic packages remain high, however, the price of reflectorless systems now range from $8,000 - $40,000, with most systems priced around $10,000.

While the popularity of electronic survey equipment continues to increase, competition among manufacturers steadily drives the cost down. These systems will certainly evolve into quicker, safer and more versatile instruments for collecting crash scene data. The speed, accuracy and tremendous safety benefits will continue to make electronic total stations a highly desirable and justifiable tool for use in crash investigations.

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