Infrared Thermography
One of the Latest Innovative Tools in Construction

The fast-track nature of today's construction schedules makes installation errors virtually predictable. Some of these errors are covered up before a hard-working project manager, superintendent, foreman or quality assurance third-party assessor can catch the problem.

Construction errors leading to moisture intrusion can be a nightmare for Architects, Building Owners and General Contractors during the construction phase and later in the building's history. One of the more recent innovative tools for detecting moisture intrusion defects in construction is non-destructive Thermographic Wall and Roofing Concealed Moisture Detection Surveys more commonly known as infrared thermography.

Infrared thermography is technology that indicates the radiant heat signature of objects to monitor the object's state or condition. All objects emit heat or energy waves. If an object is cold, its molecules vibrate more slowly and energy of longer wavelengths is emitted. When the temperature of the object rises, its molecules vibrate faster and the wavelength becomes shorter. The definition of this process is Infrared (IR), a term used for radiation in a particular, invisible region of the electromagnetic spectrum, namely, between wavelengths slightly longer than that of visible red light and wavelengths slightly shorter than that of microwave radiation. The name from the Latin word *infra*, meaning "below" means "below red."

In numerical terms, IR radiation spans wavelengths between approximately 750 nanometers (nm) and 1 millimeter (mm). Applications of thermographic scanning techniques include the detection of heat loss in buildings, free air movement in walls, concealed moisture in roofing assemblies monitoring industrial process installations, testing heating and cooling systems, investigating the degree of heating up of engines, electrical components and other machinery in use, as well as medical and biological investigations.

The infrared range of the electromagnetic spectrum lies beyond the red. This portion of the spectrum is invisible to human eyes. Infrared includes all radiations between wavelengths just beyond those of the deepest reds of the visible spectrum (700 nm) and microwaves (100,000+ nm), which are used for cooking in microwave ovens. Although infrared covers a vast part of the spectrum, the portion of it that can be used to expose photographic emulsions is actually quite small. The area extends from about 700 nm to about 1200 nm, but most amateur and commercial infrared films are only sensitized to about 900 nm.

Photographs by infrared radiation are called thermographs and were already made in the nineteenth century, but it was not until the early 1930's that it became possible to carry out infrared thermography with the ease and certainty of ordinary. The earlier infrared sensitive materials were quite low in speed, but with improvements in the methods of making photographic emulsions and the discovery of new dyes, it has been possible to make available for general use infrared films that are sufficiently sensitive that they can be used under average daylight conditions with unsophisticated cameras at fairly small apertures and reasonably fast shutter speeds, such as 1/125 second at f/11 for distant scenes to 1/30 second at f/11 for nearby subjects.

Infrared roof moisture surveys continue to provide vital information for the long-term maintenance of flat roofs. With a national average life of only seven years, flat roofs are the most expensive component of a building. Workmanship problems, such as not sufficiently protecting the roofing membrane during the construction phase and permitting water to migrate under the membrane, lead the list of causes for early failures, followed by poor designs, material failures, and poor maintenance. Once a roof begins to leak, water is absorbed into the roof assembly and especially into the insulation. Once damp, for all practical purposes, insulation never dries. In fact, the trapped moisture can quickly cause further serious degradation to the roof, including the rusting of metal decks and fasteners, reduction in insulating value, and decay of the membrane.

Good workmanship, design, materials, and a long-term maintenance program are key to the longevity of the roof. Twice a year visual inspections using a good checklist are considered essential to head off problems. In addition, an infrared survey is a very good way to quickly and accurately locate and isolate areas of thermal patterns indicating probable wet insulation and trapped water, allowing one to see the true condition of the insulation over the entire roof system. Because the point of water intrusion leak is typically found to be within the boundary of the wet insulation, the wet area is marked for removal and repair; keeping the roof in a dry condition, minimizing roof degradation and extending the life of the roofing system.

When the surface itself is dry, including any gravel or ballast, exposure to the sun on a sunny day will warm the entire roof. Early in the evening, if the sky is clear, the roof will begin to cool down by radiation. Because of its higher thermal capacity, the wet insulation will stay warmer longer than the dry and will be visible in the infrared imager.

The technique is particularly effective on roofs having absorbent insulation such as wood fiber, fiberglass and perlite where thermal patterns correlate almost perfectly with concealed moisture. Infrared inspections of roofs with nonabsorbent insulations, common in many single-ply systems, are more difficult to diagnose because patterns are more diffuse. That's why you must ensure your thermographer is well trained and knows their infrared camera’s capabilities and limitations.

Clearly successful inspections are weather dependent. The ideal conditions are sunny days followed by clear nights with low winds, making spring, summer and fall the best times to inspect. Surveys can be conducted in the winter if the roof surface is dry. Similar thermal patterns are enhanced by the building's interior heating sources. For large roofs, or where there are multiple buildings to inspect, consider hiring an experienced thermographer to conduct an aerial infrared inspection. Using a helicopter or fixed wing aircraft and high-resolution infrared imager, aerial surveys deliver very high quality images of large areas in a short time. MIS overlay’s the infrared image on a visual image of the building to clearly show the areas of probable and possible wet insulation. With the survey data in hand, prioritizing follow up rooftop inspections become a simple matter.

When a roof membrane has finally outlived its useful life, having a dry roof underlayment below the insulation pays further dividends and the deck will be in much better condition. Disposal costs will be reduced because it will probably be possible to salvage some of the dry insulation. Leaving it in place and simply adding a new membrane can easily save $5 per square foot or more.

New roofing systems should be inspected upon acceptance from the contractor as many have wet components from the very beginning. Ideally, roofing systems are also inspected soon after a leak occurs to identify the extent of damage to the insulation. Typically, inspections every 2-3 years will keep up with problems. Of course, if known damage has occurred to the roof, an inspection on an earlier schedule is warranted. The Building Owner deserves a permanent repair that includes replacing components affected by moisture intrusion with new dry components. It is also important to a Building Owner to inspect the roof and indentify probable moisture prior to the expiration of the roofing system warranty.

Moisture intrusion in buildings can destroy the structural integrity of most materials, nurture various types of microbial growth and degrade indoor environmental quality. Contractors and restoration professionals with the aid of a knowledgeable building envelope consultant can rapidly identify those areas of concern so that an in-depth evaluation and cost effective corrective action can be taken quickly.

Moisture intrusion in exterior walls can damage the interior finishes and create problems in the drainage planes. Overloading drainage planes in walls such as in masonry cavities or cavities that are created between the exterior building material and vapor or air barrier can also cause damage. The first step in addressing a moisture intrusion problem is to investigate, locate and identify the source of the intrusion. Professional remediation is required to quickly and accurately remove all sources of damaged material and correct the source of the moisture intrusion.

As continuous air barriers are integrated into building envelopes there will be a steady learning curve until designers and contractors become more experienced and comfortable with the air barrier concept. Energy savings and reduction in HVAC equipment are the goals of having an air barrier system in any building. To achieve these goals a design and construction team must design the walls, roofing and all inserted components within these areas to achieve the reduced air flow.

In the beginning the design team and construction team should employ the services of an air barrier consultant to discuss details, materials and methods of construction. Types of materials used and where they are used also become an important part of reducing the air flow in walls and roofs of a specimen building. After construction of the project, verification of the design is usually recommended by means of Air Barrier Performance Testing. This testing should follow fan pressure testing methods (ASTM E779-03 (standard) and ASTM E-1827-02 (two techniques) on small and large commercial building enclosures. Confirmation of this testing and part of the testing criteria usually includes infrared to verify air loss from the building. These infrared thermographs can be used to verify that the air barrier which was implemented in the building's design and construction is limiting the air flow from the building.

Adequate air exchange is essential for the occupant's health and safety, but most buildings have a far higher rate of air exchange than is necessary. The root cause is often poor design and/or construction which allows air leakage from the inside to outside of the building, or the opposite. The leakage pathway is often complex and, without thermal imaging, extremely difficult to visualize. Thermal imaging also allows the contractors to quickly identify and repair the problem areas to stop the energy loss immediately.

Even though using infrared thermography to examine a building can often pinpoint problems, Owners may have different reasons for wanting to know, or not wanting to know, about the condition of a given building. Here are some examples:

Buildings are often owned by one company and leased to another. If the tenant is paying the utility bills, he/she wants the building to be energy efficient, but the lease may not be long enough for the tenant to enjoy an appreciable return on the investment from reinsulating the building or plugging up the air leaks. The Owner has no financial motivation to make the building more energy efficient unless he/she is paying the heating/cooling bills or can use the fact that the building energy costs are low to his/her advantage in a lease or sales negotiation.

Liability is a real issue for sellers, buyers and insurers. The costs of construction, repairs and renovation are increasing dramatically as Owners bring construction lawsuits against the contractors. "Getting what you paid for" is not a new concept, but prospective Building Owners are increasingly concerned about the costs and about the quality and efficiency of their investments. Infrared thermography can be used as a building quality assurance tool during construction, so that repairs can be made without destroying the building or delaying the building process. Because building materials will absorb, retain and radiate heat energy at a different rate, building components can be checked for the quality of installation using IR. For instance, "cinderblock" or CMU, concrete masonry unit, walls are erected on nearly every street corner in malls, schools, warehouses, retail, convenience stores and more. CMU walls often have rebar and grout-filled cells as a structural component. By allowing the wall to absorb energy during the day and watching the heat energy dissipate at night, the building infrared thermographer can use the "picture" of the heat from the wall, to define exactly where the grouted cells are and where they are missing.

Concealed moisture within a roofing system, in a wall system, or in many other porous building components has never been desirable. The hidden corrosion damage to ferrous framing members from possible concealed moisture has cost building Owners considerably, and detecting and avoiding this problem has been an important engineering endeavor for many centuries.

Concealed moisture can prove damaging to the exterior building envelope, interiors, and below-grade components. Undetected concealed moisture can ruin building components to the point of failure. With current media coverage surrounding the presence and propagation of mold spores, the construction industry and investors are looking to proven non-destructive moisture detection technology.

Thermography can be used as an effective tool to identify problems in new construction. From roofing to the foundation, exterior skins of buildings can be complicated and moisture intrusion or other problems must be identified and remedied. Thermography can be the most innovative tool in today's fast paced construction project.