RESNET
Residential Energy Services Network

Setting the STANDARD for QUALITY

Infrared Scanning Technology and the RESNET Insulation Quality Installation Inpsection Procedures

Monday 3:30pm – 5:00pm / Nautilus 1

Bruce Harley
Conservation Services Group

Kelly Parker
Guaranteed Watt Saver Systems, Inc. (GWS)

Barb Yankie
Homes +, inc.

RESNET STANDARD FOR THERMOGRAPHIC INSPECTIONS

Purpose

These standards are to set out as a standard for the use and interpretation of infrared thermography of low rise, three stories or less, wood/steel frame, residential and light commercial buildings. This standard shall define a thermographic examination of building components.

Use of a thermographic imaging system to determine surface temperature distribution through part or all of a building envelope,

Viewing the surface temperature variations to determine whether a site is “normal” or “abnormal”

Determining and documenting the type and extent of any observed defects.

RESNET STANDARD FOR THERMOGRAPHIC INSPECTIONS

Relationship to Other Standards

This chapter is provided to compliment the previous chapters of the RESNET Mortgage Industry National Home Energy Rating System Standards. The following are referenced International Standards:

- ASTM C 1060-90 (2003): Standard Practice for Thermographic Inspection of Insulation Installations in envelope Cavities of Frame Buildings.
- ASTM E 1186-03: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems.
- ISO 6781: Thermal Insulation---Qualitative Detection of Thermal Irregularities in Building Envelopes---Infrared Method

Relationship to State Law.

This Standard specifically recognizes that state laws or regulations may have additional requirements to those specified in this document. To the extent that such state laws or regulations differ from these Standards, state law or regulation shall govern.

RESNET STANDARD FOR THERMOGRAPHIC INSPECTIONS

Scope

These standards are set forth to provide a qualitative method for inspecting a building envelope through the use of a thermographic examination, which can be used to detect thermal irregularities caused by defective insulation installations, air leakage, or moisture intrusion. These three building defects can cause thermal irregularities in the components used in the construction of the building envelope. The temperature variations on the surface of the components can then be used to detect defects in the thermal boundary. This standard is limited to framed construction three stories or less. This standard is to set forth the inspection protocols for three specific building defects: defective insulation installations, Air infiltration and exfiltration, and moisture intrusion.

Definitions

Air barrier: Any solid material installed during the construction process of a building that is designed to reduce or stop air leakage either into or out of the building envelope.

Air exfiltration: Air from the conditioned space leaking outside of the thermal boundary of a structure.

Air infiltration: Air from outside the thermal boundary of a structure, which enters the conditioned space.

Air leakage site: A specific location in a structure where the air barrier has irregularities in it allowing both air infiltration and exfiltration depending on the interior pressures of the building.

ANSI: American National Standards Institute

ASTM: ASTM International, originally known as the American Society for Testing and Materials (ASTM)

Definitions

Building envelope: The area of a building's walls and ceilings comprising the thermal boundary, which separates the conditioned space from the unconditioned spaces.

Compression (insulation): This condition occurs primarily when batt insulation is compressed behind plumbing, heat and air, electrical, and other in cavity obstructions that results in the loss of R-value of the installed insulation.

Emissivity: The ability of a surface to emit radiation, measured as the ratio of the energy radiated by a surface to that radiated by a blackbody at the same temperature.

Field-of-view (FOV): The total area of height by width, normally expressed in either degrees or radians, in which an infrared imaging system is capable of displaying and

Framing spacing: The distance from center to center of wall studs, ceiling joists, and roof rafters.

Definitions

Gaps (insulation): A situation where installed insulation does not completely fill the wall cavity, which allows for conductive and convective heat loss and a reduced R-value of the overall building envelope.

Infrared imaging system: An instrument that converts surface temperature variations in infrared radiance into a two dimensional image of the surface being viewed by assigning specific colors or tones to the differing temperatures.

Infrared thermography: The process of using an infrared imaging system to generate thermal images of surfaces or objects, which can be viewed electronically or printed.

ISO: International Organization for Standardization.

Misalignment (insulation): The insulation shall be installed in contact with the air barrier, typically the drywall for walls and the wood flooring over framed floors.

Definitions

Resolution: The minimum temperature difference in either degrees Centigrade or degrees Fahrenheit an infrared imaging system is able to distinguish between two points on a thermal image.

Thermal boundary: Also known as the building envelope, the area of the building, which includes both the air barrier and the thermal barrier and separates the conditioned space from the unconditioned spaces.

Thermal bridging: Heat conduction, most often around installed insulation, resulting from two materials that are very thermally conductive and in contact with each other.

Thermal image or Thermograph: A recorded electronic or printed image provided by an infrared imaging system of the thermal surface variations of an object or a surface.

Definitions

Thermography: The process of generating and interpreting thermal images.

Vapor barrier/retarder: A material used in the construction process to either slow or stop the movement of moisture into or out of the building envelope or the wall structure.

Voids (insulation): Areas where no insulation has been installed but those areas are part of the thermal barrier of the building envelope.

QUALIFICATIONS

The person applying to RESNET for this certification must have the following credentials:

Must be a Level 1 Thermographer or have obtained an equivalent certification. If the Level 1 or equivalent training has not been obtained, an online training course with approved homework is available through RESNET.

HERS rater certification.

Must pass a RESNET Infrared Test-online 20 questions and score an 80 or higher.

Must submit ten reports for review by a RESNET Infrared Certification Committee.

CAMERA REQUIREMENTS

Camera Performance: The camera shall have a minimum resolution of 1ºC (1.8ºF)

Spectral Range: The infrared thermal imaging system shall have an operating spectral range of between 2 and 14 micrometers (µm).

Field of View (FOV): For insulation inspections, the minimum critical dimensions for framed walls shall be two framing spaces wide and one framing space high. For outdoor thermal inspections, the best rule is to be able to view the height of one story width wise and one half that distance high.

TESTING REQUIREMENTS

The thermographer shall have a thorough knowledge of the operation of the particular infrared imaging system being used through training and/or through the manufacturer's owner's manual.

The operator shall have the ability to interpret any obtained data

The operator shall have sufficient building science knowledge to understand heat transfer through the building envelope, building technology, heating, cooling, and ventilation techniques, and measurement techniques.

The interpreter of the data shall understand the effects of stored heat, emissivity, wind effect, and surface moisture.

TESTING REQUIREMENTS

The imaging system shall have the gain or contrast set so as to be able to distinguish a framing member for the other parts of the building envelope and so that any defects or anomalies may not appear in either saturation (maximum brightness or white) or in suppression (minimum brightness or black) on the display or on the thermographic images.

Thermograms shall be taken of selected parts of the building, which are being investigated.

Defects or problems shall be noted on a drawing or with a visible light picture for ease of finding during the process of correction.

Infrared pictures of parts of the building having no defects shall also be obtained to demonstrate the correct functioning of building components.

TESTING REQUIREMENTS

Inspections should be made as close to perpendicular to the surfaces being investigated as possible or at, an angle which still allows for the distinguishing of framing members.

Changing of position and viewing the same area a second time should be done in areas where there is the possibility of reflected radiation.

The specific defect or anomaly shall be identified through the use of calculations, other means of investigations (moisture meters), experience, or by comparing areas of defect with areas of normality or with reference thermographs of known defects.

TESTING REQUIREMENTS

For exterior examinations of buildings, there should be no direct solar radiation on the surfaces to be examined for a period of 3 hours for frame construction and for approximately 8 hours for masonry veneer construction.

Exterior investigations should occur after sunset and before sunrise. Wind speed shall be less than 8 mph for investigations of the exterior façade of a building or for a roof inspection.

The exterior surfaces should be dry during any exterior investigation.

Procedures for Insulation Inspections

This procedure guides the thermographer in conducting qualitative thermal inspections on the insulated wall and floor cavities in frame construction. The procedure will allow the operator of the infrared imaging system to determine areas of improperly installed, missing, or adequate insulation. The emphasis will be on insulation in the building cavities that is either malfunctioning or completely missing. The locations of inadequate or missing insulation shall be designated on a drawing, a video, or visual and thermal images for ease in finding for correction.

The difference of temperature (Delta T or ΔT) across the building envelope, that is, the ΔT between the conditioned space and the unconditioned space, shall be a minimum of 20°F for the insulation inspection. In addition, note the warnings above in 805.1.8 concerning direct solar radiation and wind when performing exterior evaluations of a building envelope.

Procedures for Insulation Inspections

The minimum criterion for satisfactory thermal conditions is to be able to distinguish the framing materials from the wall cavities. Therefore the instruments gain and contrast must be set to make this criterion possible.

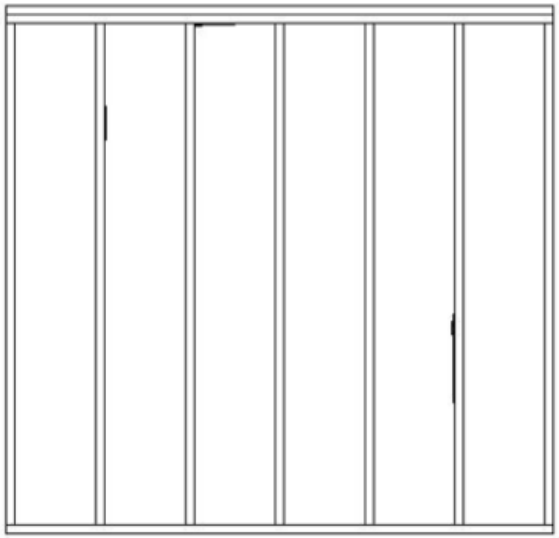
The infrared camera shall also be adjusted in such a way as to prevent any anomalies or areas from being in saturation (maximum brightness or white) or in suppression (minimum brightness or black).

The position selected for obtaining a scan of an area shall have a minimum field of view (FOV) of two framing spaces in width and one framing space in height for all inspections on the interior. Exterior FOV shall be a height of floor to ceiling (one story high) and a width of one half the height.

Different thermal patterns occur as a result of differing wall configurations, which must be accounted for proper interpretation of the thermographic images

Procedures for Insulation Inspections

Intact or Grade 1 Insulation: This type of insulation installation will be seen as dark parallel lines for the framing materials and light areas at the wall cavities on the warm side of the wall. The view of the cool side of the wall will be opposite, that is, light parallel lines for the framing and darker areas at the wall cavities. The wall cavities should be uniform in color. If not then insulation should be modeled as Grade II or Grade III.



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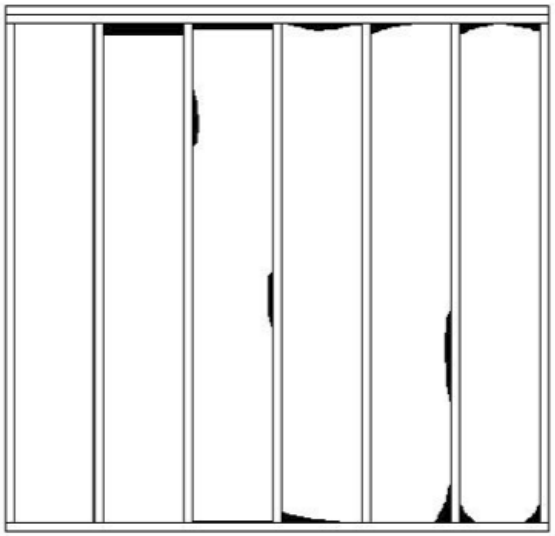

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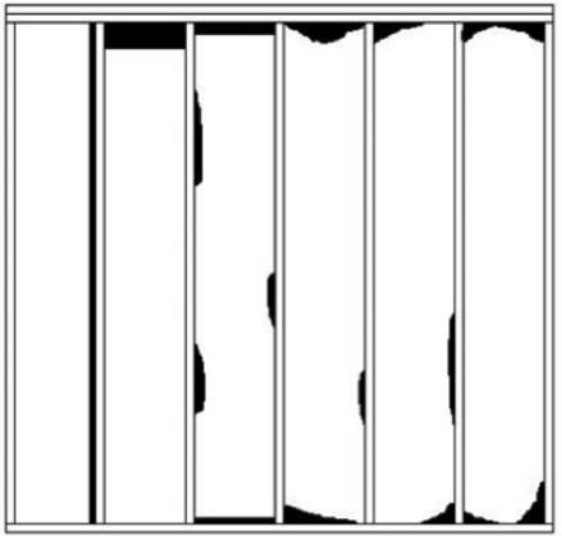
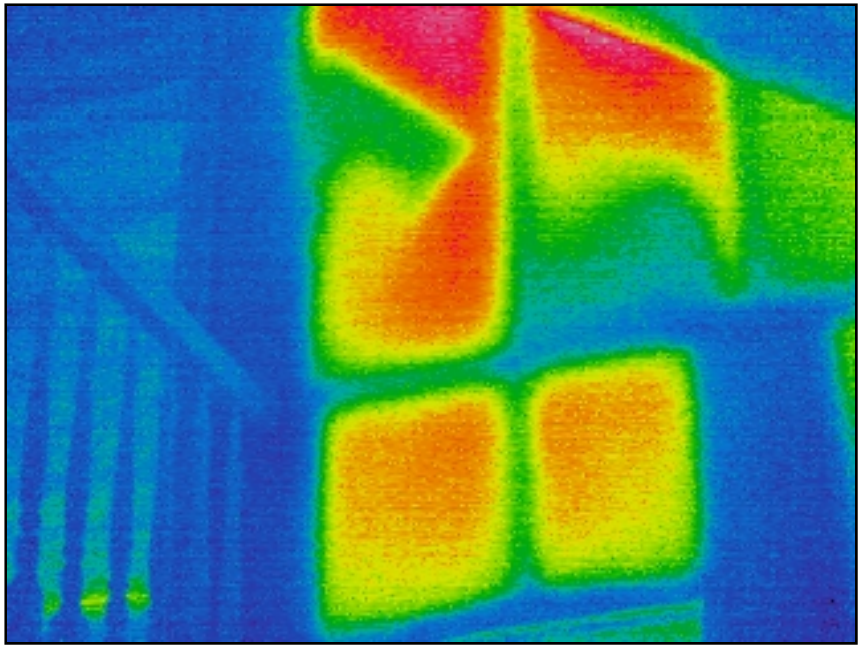


III

Procedures for Insulation Inspections

Completely Missing Insulation: From the warm side of the wall, the framing members will appear as light parallel lines and the cavities will appear as darker. The view from the cool side of the wall will be just the opposite. Convection may be visible in empty wall cavities as a color variation moving from darker at the bottom of the wall to lighter at the top of the wall for both the cool and warm sides of the wall.



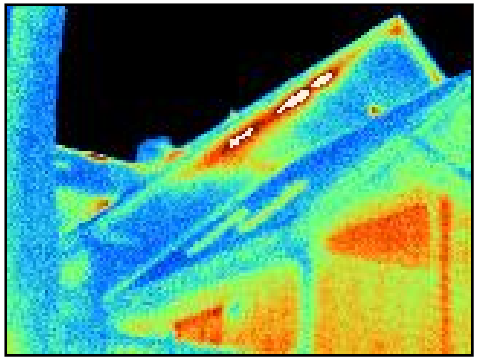
Procedures for Insulation Inspections

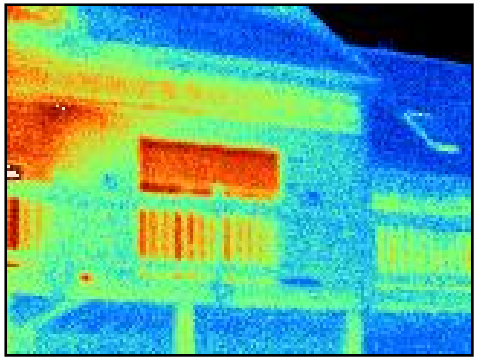
Metal framing will usually appear in greater contrast than wood framing because it is far better in conducting heat.

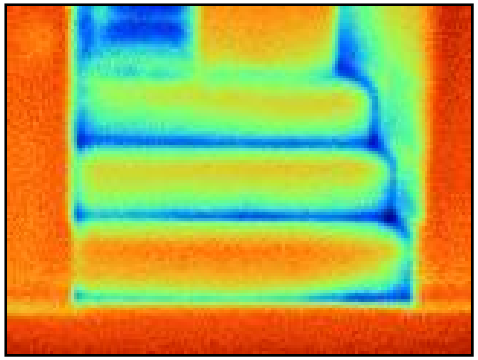
Gaps/Misalignments (partially missing or placed in the wrong place in the wall or floor): These areas where insulation is missing will appear as darker areas on the normally light colored wall cavities as described in 805.6.1. The cool side of the wall will appear as in 805.2.6.1 above but inadequate insulation will be a light area. If a total wall area of 5% of the total wall area falls in this category then the insulation shall be computer modeled as a Grade III.

Procedures for Insulation Inspections

Other Thermal Patterns: There are several possible causes for irregular variations of the thermal patterns found on a wall. These include but are not limited to moisture, convection, air leakage, varying densities of the installed insulation, and thermal bridging.



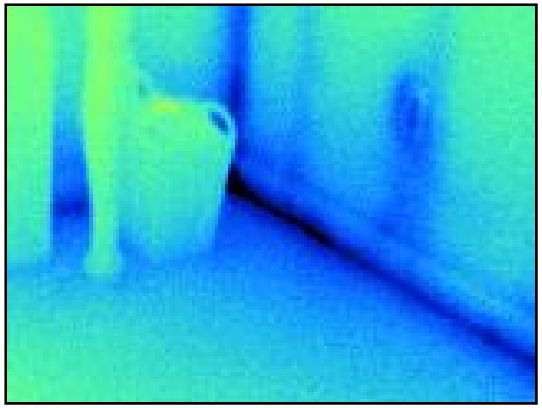




Procedures for Air Leakage Inspections

The following procedures are to aid the thermographer by providing standardized techniques in the inspection of building envelopes or air barrier systems to find air leakage sites. The procedures are qualitative in nature in that it is used in locating leakage sites and not set up to determine quantitative airflow rates for the leakage sites.

This procedure requires a temperature difference between inside the building and the outside of a minimum of 8°F. This temperature difference will allow for rapid surveying of building surfaces to find air leakage sites.



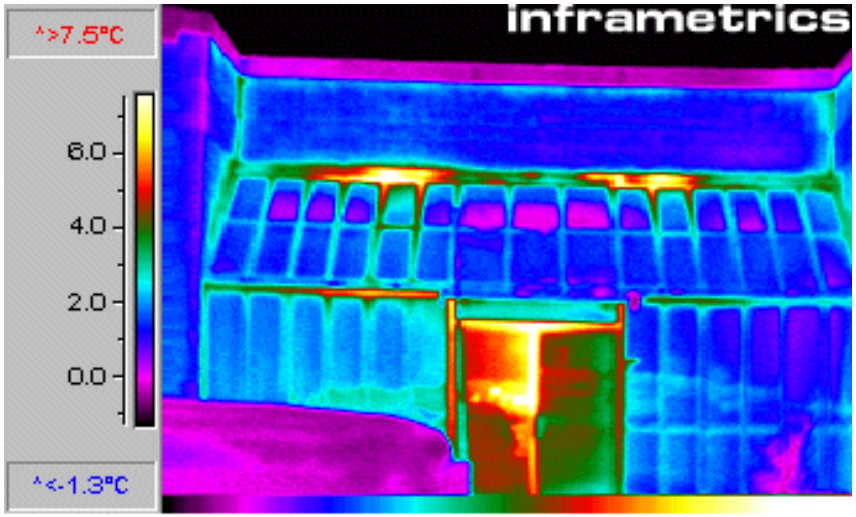
Procedures for Air Leakage Inspections

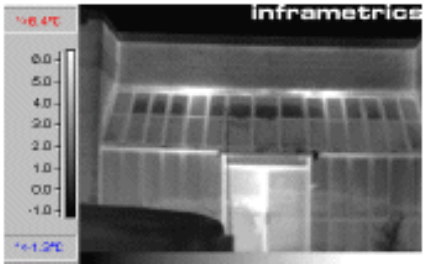
Because air leakage sites are very hard to find by relying on wind or stack pressure, air is artificially forced into or out of the building through the use of a fan, such as a blower door, or by using the mechanical and/or ventilation system(s) in the building. The depressurization technique is preferred because of the lack of interference of solar radiation and wind but the pressurization method will also work when conditions are correct. The premise is that air moving across the building envelope is at a different temperature than the space it is entering and therefore will leave a thermal signature for the infrared imaging system to capture. The thermal image for air leakage is unique when compared to the thermal patterns of inadequate insulation or moisture and will appear as “fingers” or “streaking” beginning as dark when cold air is observed and lighter colors when warm air is viewed.

The tightness of the building air barrier system will account for a large portion of the energy use of the building. It is therefore important as a general note to tighten a building’s envelope as much as possible before an infrared scan..

Procedures for Air Leakage Inspections

When depressurizing a structure, be aware of any combustion appliances in the conditioned space and the possibility of backdrafting. Fireplaces containing ashes should have the damper closed and ashes covered





Procedures for Air Leakage Inspections

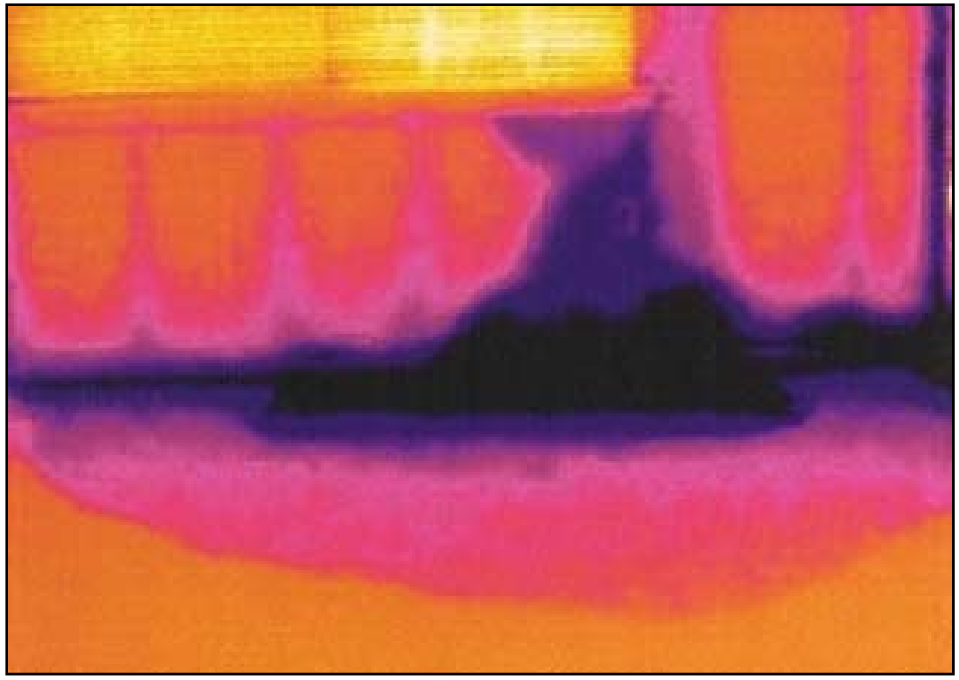
When depressurizing the building, the resultant air leakage shall be allowed to alter the building's surface temperatures for a minimum period of 10 minutes. For the procedure, normal pressure differences across the building envelope shall be between 10 and 50 Pascals. The higher pressure readings will intensify surface temperature differences and further aid in the discovery of air leakage sites.

Although the primary air leakage sites viewed are on the building envelope, interior walls shall also be viewed- air leakage from the attic is also a possibility.

Care must be taken to correctly discern thermal bridging sites from air leakage sites. The signature of the two problem areas will be different when viewed thermally.

Procedures for Moisture Intrusion Inspections

Unlike the procedures for the location and documentation of inadequate insulation and air leakage, there are not special conditions for finding moisture problem areas. The primary premise is that a wet material holds heat at a different rate than surrounding dry materials or areas with no insulation.

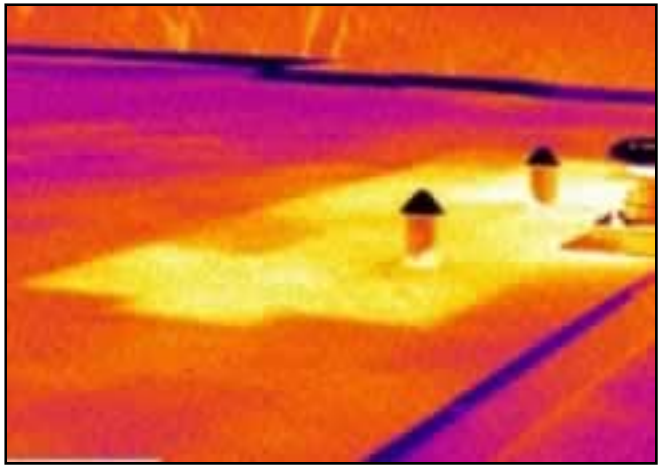


Procedures for Moisture Intrusion Inspections

For indoor investigations, a wet area will normally appear as a darker area on the wall or ceilings unless the water leak is from a hot water line but will appear as lighter areas for a roof inspection. It is critical to understand what is being viewed.

Patterns for moisture within a building will normally appear as a mottled and diffuse pattern and temperature variations are not extreme within the pattern. Other patterns appear as a “puddle”.

Other possible patterns specific to water are as follows. Always keep in the forces due to gravity, vapor diffusion, liquid flow, and capillary seepage when considering water and the possible patterns it may provide.



Procedures for Moisture Intrusion Inspections

A roof leaking on to a ceiling of drywall will normally appear as an expanding circle. If the leak is at the conjunction of the wall and the ceiling, there will be a semicircle on the ceiling and an extended oval on the wall.

Water leaking into the structure at the top of the wall will spread both horizontally by capillary seepage and vertically due to gravity. The vertical dimension of the pattern should be longer than the width with the overall pattern assuming a semicircle at the top and an extended or inverted tall but narrow triangle below the semicircle.

During a flood due to excessive rain or the break of a water line to a washing machine, bulk water will be at the slab level and then come into contact with the walls. The water will then “wick” up the wall due to both capillary seepage and vapor diffusion. The pattern in this case will look like the picture of mountains on the horizon with high and low points across the base of the wall due to the amount of water in each area available for wicking.

Procedures for Moisture Intrusion Inspections

Another area of infrared specialization is to locate leaks on flat roofs. This type of inspection is an in depth study on its own and it is not the intent of this standard to provide all the information for an inspection of this type. The basics of a flat roof inspection are as follows.

Never under any circumstances do a roof inspection alone. This rule ***must*** never be broken. Looking at a camera while walking on a roof is extremely dangerous. ***Never*** walk backwards on a roof.

Be aware of company and government safety regulations for a roof inspection.

It is very important to know the exact components of the roof in order to determine if the roof is one that can be inspected through the use of an infrared imaging system. This problem should be dealt with before the inspection even begins.

Procedures for Moisture Intrusion Inspections

The inspection should begin one to two hours after sunset. You cannot do a roof inspection using the infrared imaging system during the daylight hours, although determining the exact leakage area may best be done during day light hours.

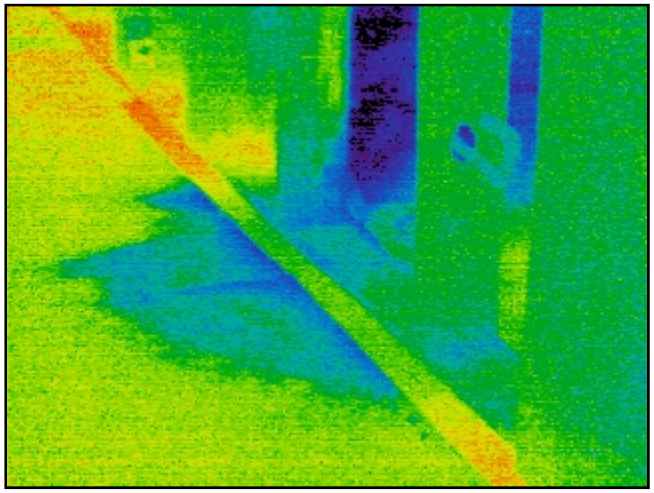
You must have a second party with you whose job is to (1) insure your safety and (2) mark any areas of failure containing wet insulation with paint. Areas marked should also be numbered for the purposes of ease of description on any drawings included with the report.

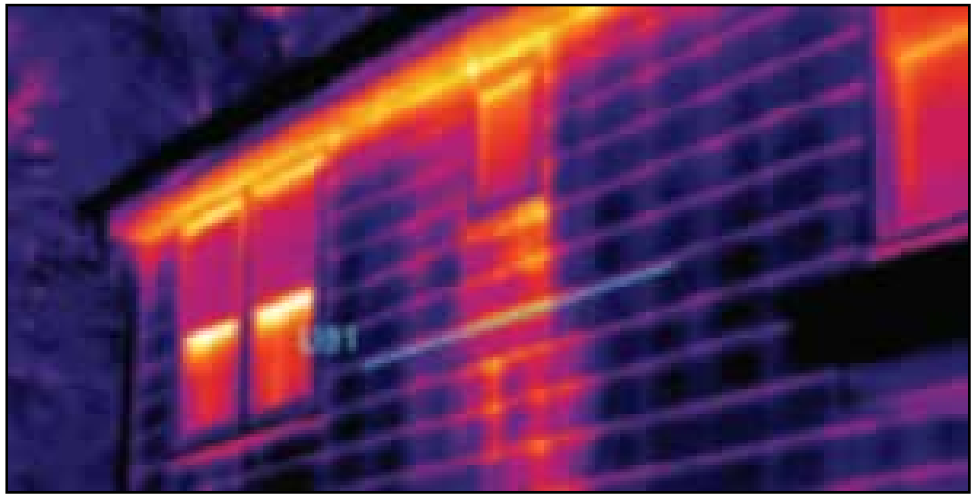
When the inspection begins, there are two primary patterns to look for: (1) a “board pattern” where an entire piece of insulation has become saturated and appears as a four foot by eight foot, a three foot by five foot, or some other square or rectangular shape or (2) a “window pane pattern” where only the edges of the square or rectangular pieces of rigid foam have absorbed water.

Procedures for Moisture Intrusion Inspections

If the insulation is an open cell or absorbent type, the patterns of moisture will remain for a long period of time and actually get better as time goes on. With closed cell foam insulation or light weight concrete, the moisture signatures will disappear quickly and work must be done as fast as possible.

The use of an invasive or noninvasive moisture detector to verify suspected areas of water intrusion is required.





THERMOGRAPH INTERPRETATION

The thermographer should routinely select a color palette with which he/she is comfortable and with which he/she can readily identify hot and cold areas on the infrared image on the display of the camera or on the printed thermo gram. The black and white scale is recommended for on site use because of the ease of interpretation of the images seen. Most software will allow for providing colored images for customers even if the site thermograms are captured in black and white.

Typical building investigations of insulation, air leakage, and moisture intrusion do not require specific temperatures although these readings may be informative as to actual surface wall or ceiling temperatures when compared to the set point on the thermostat.

The thermographer must be aware of the specific Emissivity values of materials or components being viewed and be aware of reflected radiation form any objects having a shiny or reflective surface.

THERMOGRAPH INTERPRETATION

Since differentiating between settled or missing insulation and moisture intrusion can sometimes be complicated, secondary methods of verification are always recommended.

REPORTS: *The infrared report shall contain all of the following information.*

- A brief description of the way the building has been constructed.
- Types of interior and exterior surface materials used in the building.
- The geographical orientation of the building with a description of the exterior surroundings including other buildings, vegetation, landscaping, and surface water drainage.
- Camera brand, model and serial number.
- The name of thermographers and inspectors present.
- Date and hour of tests.
- Ambient air temperature.

REPORTS: *The infrared report shall contain all of the following information.*

- General information for the last 12 hours on the solar radiation conditions in the geographic area where the test is being performed.

- Other ambient conditions such as precipitation and wind direction and speed.

- Inside air temperature.

- Air pressure measurements taken on the leeward and windward sides of the building on each floor when possible.

- Other relevant information, which may have influenced the test results.

- A complete description of the actual test conditions (i.e., the Delta T across the building envelope).

REPORTS: *The infrared report shall contain all of the following information.*

- Drawings, sketches and/or photographs detailing the locations in the building where thermograms were taken detailing possible irregularities in the components being tested.

- Thermograms taken during the inspection with their locations listed along with explanations of the thermal images.

- An identification of the aspects or components of the building being examined.

- Include the results of the analysis that explains the type and the extent of each construction defect observed during the inspection.

- Any results from additional measurements and investigations.

SAFETY CONCERNS

It is not the intent of this standard to address all safety concerns, if any, which may be associated with its use other than what has been stated. It is the sole responsibility of the thermographer or user of this document to provide personal protective equipment and health and safety practices or regulations for all those involved with any of the previous procedures described in this document.

The thermographer is held accountable for all company, state, and federal regulations regarding the various aspects of these inspections and their possible application to the work site.

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THANK YOU