Standard for Infrared Inspection of Building Envelopes

2016 Edition

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Foreword

This standard outlines the procedures and documentation requirements for conducting infrared inspections of building envelopes. This standard covers an application which is both art and science. This document assumes that the reader is generally familiar with the science of infrared thermography. It is not intended to be an absolute step-by-step formula for conducting an infrared inspection.

Infraspection Institute Standards are updated periodically. To ensure that you have the most current version or to obtain a copy of an older version, please visit the standards section of our website, www.infraspection.com.

Vertical lines appearing to the left of text within the body of this document indicate a change from the previous edition.

The use of this standard is not intended to qualify an individual using it to conduct an infrared inspection, or to analyze the resulting infrared data without formal training prior to its use. This document is intended to support infrared thermographers who have been professionally trained and certified. It must be acknowledged and understood that the misinterpretation of data that can occur without proper training and experience cannot be avoided simply by using this standard. In no event shall Infraspection Institute be liable to anyone for special, collateral, incidental, or consequential damages in conjunction with or arising from use of this standard.

Other Infraspection Institute Standards

Infraspection Institute began publishing guidelines for infrared thermography in 1988. Since their initial publication, Infraspection Institute guidelines have been adopted by hundreds of companies worldwide and incorporated into documents published by other recognized standards organizations such as the American Society for Testing and Materials (ASTM). Beginning in 2007, Infraspection Institute guidelines were renamed as standards to reflect their industry-wide acceptance and the best practices they embody.

Several standards are available from Infraspection Institute. These standards cover equipment operation, temperature measurement, and specific applications. A complete list of current Infraspection Institute standards may be found online at www.infraspection.com.

Infraspection Institute standards represent the work of many practicing infrared thermographers and other experts. We thank them for their valuable contributions.

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Table of Contents

1.0 Scope

1.1 This standard covers procedures for conducting infrared inspections of building envelopes for the purpose of detecting thermal patterns caused by excess energy loss, latent moisture, or structural details.

1.2 This standard provides a common document for the end user to specify infrared inspections and for the infrared thermographer to perform them.

1.3 This standard lists the joint responsibilities of the end user and the infrared thermographer that, when carried out, will result in the safest and highest-quality inspection for both.

1.4 This standard outlines specific content for documenting the results of an infrared inspection.

1.5 This standard may involve use of equipment in hazardous or remote locations.

1.6 This standard addresses criteria for infrared imaging equipment, such as spatial resolution and thermal sensitivity.

1.7 This standard addresses meteorological conditions under which infrared inspections should be performed.

1.8 This standard addresses operating procedures and operator qualifications.

1.9 This standard addresses verification of infrared data using invasive test methods.

1.10 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2.0 Referenced Documents

2.1 *Occupational Safety and Health Standards for General Industry 29 CFR, Part 1910.* US Department of Labor. Occupational Safety & Health Administration, Washington, DC.

2.2 *Occupational Safety and Health Standards for the Construction Industry 29 CFR, Part 1926.* US Department of Labor. Occupational Safety & Health Administration, Washington, DC.

2.3 *Level-I Certified Infrared Thermographer® Reference Manual.* Infraspection Institute, Burlington, NJ.

3.0 Terminology

For the purpose of this standard,

3.1 **Building envelope -** those portions of the building that separate conditioned from unconditioned spaces.

3.2 **End user -** the person requesting an infrared thermographic inspection.

3.3 **Exception -** an abnormally warm or cool portion of a building that may be a potential problem for the end user.

3.4 **Imaging radiometer -** see Infrared imaging radiometer.

3.5 **Infrared imaging radiometer (imaging radiometer) -** a thermal imager capable of measuring temperature.

3.6 **Infrared inspection -** the use of infrared imaging equipment to provide specific thermal information and related documentation about a structure, system, object or process.

3.7 **Infrared thermal imager (infrared camera) -** a camera-like device that detects, displays and records the apparent thermal patterns across a given surface.

3.8 **Infrared thermographer -** a person who is trained and qualified to use a thermal imager or an imaging radiometer.

3.9 **Inspection window -** the time period during which infrared inspections of building envelopes can be successfully conducted.

3.10 **Moisture meter probe -** an invasive (electrical resistance or galvanometric type) test that entails the insertion of a meter probe(s) into a material to indicate the presence of moisture.

3.11 **Noise Equivalent Temperature Difference (NETD) -** a measure of the amount of infrared radiation, measured in milliKelvins, required to produce an output signal equivalent to the electronic noise of a particular infrared imaging system. NETD values are often provided by manufacturers of thermal imaging systems as a measure of an imager's thermal sensitivity. Lower values generally indicate better performance.

3.12 **Non-imaging radiometer (infrared thermometer) -** an instrument that measures the average apparent surface temperature of an object based upon the object's radiance.

3.13 **Qualified assistant -** a person provided and authorized by the end user to perform the tasks required to assist the infrared thermographer. He/she is knowledgeable of the operation and history of the building(s) to be inspected and is trained in all the safety practices and rules of the end user.

3.14 **Qualitative infrared thermography -** the practice of gathering information about a structure, system, object or process by observing images of different patterns of infrared radiation, and recording and presenting that information.

3.15 **Quantitative infrared thermography -** the practice of combining qualitative infrared thermography with non-contact temperature measurement. Temperature values may be provided via an imaging radiometer, contact radiometer, or non-contact radiometer.

3.16 **Standard -** a set of specifications that define the purposes, scope and content of a procedure.

3.17 **Thermal imager -** see Infrared thermal imager.

3.18 **Thermal sensitivity -** see Noise Equivalent Temperature Difference.

3.19 **Thermogram -** a recorded visual image that maps the apparent thermal pattern of an object or scene into a corresponding contrast or color pattern.

3.20 **Thermographer -** see Infrared thermographer.

3.21 **Visual infrared thermometer** - an instrument that measures the average apparent surface temperature of an object based upon the object's radiance while providing either a visible light image or low resolution thermal image on the instrument's display screen.

4.0 Significance and Use

4.1 The purpose of an infrared inspection of a building envelope is to locate and document abnormal patterns of infrared radiation (exceptions) from the building envelope that can be potential problems for the end user.

4.1.1 Conductive exceptions are usually caused by insufficient, improperly installed, damaged or water-saturated insulation and/or structural components.

4.1.1.1 Visual inspection is required to confirm insufficient, improperly installed, or physically damaged insulation.

4.1.1.2 Destructive testing is necessary to verify the presence of water within insulation.

4.1.2 Convective exceptions are usually caused by cracks and holes that permit the uncontrolled movement of air across the building envelope.

4.2 Providing opinions about the causes of these exceptions, the integrity of the building envelope, or recommendations for corrective actions requires knowledge and skills beyond those of infrared thermography.

4.2.1 Infrared thermography will be presented as a visual inspection technique to gather and present information about the building at a specific time.

4.2.2 Providing destructive testing of any structures for verification of suspected problems is beyond the scope of infrared thermography.

4.2.3 Data from infrared inspections may be used to assess the condition of a building envelope or for quality assurance inspections of new installations, repairs, or retrofits.

4.3 This standard does not provide methods to determine the cause of latent moisture within a building envelope or its point of entry. It does not address the suitability of any particular material or system to function satisfactorily as waterproofing or insulation.

5.0 Responsibilities of the Infrared Thermographer

5.1 Infrared inspections will be performed when environmental and physical conditions such as solar gain, wind, surface and atmospheric moisture and heat transfer are favorable to gathering accurate data.

5.2 The thermographer will have knowledge of the materials and construction of building envelopes sufficient to understand the observed patterns of infrared radiation.

5.3 The thermographer will be accompanied by a person who is responsible for the thermographer's safety.

5.4 Unless so qualified, the thermographer will not perform any tasks that are normally performed by a construction tradesperson.

5.5 The thermographer will comply with the security and safety rules of the end user and applicable safety standards.

5.6 The thermographer will use thermal imaging and/or measurement equipment with capabilities sufficient to meet the inspection requirements.

5.7 When performing quantitative infrared inspections, the thermographer will assure that all temperature-measuring equipment meets the manufacturer's stated specifications for accuracy.

6.0 Responsibilities of the End User

6.1 Prior to the inspection, the end user will inform the thermographer of any past and current problems with the facility to be inspected and the reasons for conducting the inspection.

6.2 Prior to the inspection, the end user will heat or cool the building to be inspected to a uniform air temperature throughout when requested by the thermographer.

6.3 The end user will provide, during the inspection, a qualified assistant familiar with the construction and history of the facility. This person will be responsible for gaining access to, and maintaining the security of, the subject facilities and premises. When performing air leakage inspections, this person may need to be qualified to operate and control the building's HVAC systems.

6.4 For infrared inspections conducted from the inside of the building, it is the end user's responsibility to remove furniture, wall hangings, and other objects that prevent the thermographer from inspecting the interior wall surfaces prior to the inspection.

6.5 When requested and available, the end user will furnish building drawings and/or blueprints to the thermographer.

6.6 The end user will take full responsibility for consequences resulting from actions taken, or not taken, as a result of information provided by an infrared inspection.

7.0 Instrument Requirements

7.1 General

7.1.1 Infrared thermal imaging systems shall detect emitted radiation and convert detected radiation to a real-time visual signal on a monitor screen. Imagery shall be monochrome or multi-color. Non-imaging radiometers, visual infrared thermometers, and non-imaging line scanners are not sufficient.

7.1.2 Spectral Range: the infrared imaging system shall operate within a spectral range from 2 to 14 µm.

7.1.3 The selected infrared thermal imaging system must have controls that permit the operator to manually adjust level and gain of displayed thermal imagery in real time.

7.1.3.1 Level and gain controls must be able to be adjusted independently by the operator to specific temperature values. Imagers which feature only automatic gain control, commonly referred to as 'Auto Image', are not sufficient.

7.1.4 Infrared equipment may be man portable or vehicle mounted.

7.1.4.1 For vehicle-mounted equipment, care should be taken to ensure that equipment is mounted securely, will not interfere with the safe operation of the vehicle, and meets all applicable regulatory requirements.

7.2 Spatial Resolution

7.2.1 Infrared imaging system must have resolution sufficient to provide clear imagery of inspected components or objects. It is recommended that the infrared thermal imaging system have a detector that has a minimum of 120 x 120 pixels.

7.3 Thermal Sensitivity

7.3.1 The infrared thermal imaging system shall have a thermal sensitivity (NETD) of 0.1 C° (100 mK) or less at 30°C.

8.0 Limitations (Applicability of Constructions)

8.1 Applicable constructions include insulated building sidewalls, exterior insulated finish systems (EIFS), and other building finishes which can absorb moisture.

8.2 Certain construction details can preclude the detection of exceptions. Examples include, but are not limited to: stone or brick facades, walls containing dead air spaces, and low emittance materials such as spandrel glass or metal wall panels.

8.3 Some construction materials can preclude the detection of exceptions. Examples include, but are not limited to, high density materials such as brick, block, stone, spandrel glass, and metal.

8.4 For materials with highly reflective surfaces in the spectral range of the infrared thermal imager, infrared inspections are not practical until the surface is naturally or temporarily dulled.

8.5 The wetting rates of construction materials vary according to the type of material and environmental exposure. Details with insulations that wet slowly, such as EIFS, usually should not be inspected until they are at least three months old.

8.6 Infrared inspections are not intended to identify the source of latent moisture.

9.0 Inspection Procedures

9.1 Prior to conducting an infrared inspection, the end user or the qualified assistant will help the thermographer identify the areas to be inspected.

9.2 Prior to the inspection, the thermographer should perform a walk-through of the areas to be inspected with the end user or the qualified assistant.

9.2.1 In the absence of accurate blueprints or structural drawings, the thermographer will create a graphic representation of the premises showing wall structures and areas included in the inspection.

9.2.1.1 The thermographer should consult any available structural drawings to locate wall cavities and other structural details not readily noticed in a walk-through that could affect observed thermal patterns.

9.2.2 After identifying all the elements of the structure to be inspected, the thermographer should schedule/allow sufficient time for a proper inspection to be made.

9.3 Infrared inspections of buildings are generally performed for one or more of the following reasons: to detect excess energy loss, latent moisture, or the location of structural details. Procedures and requirements for these types of inspections are outlined below.

9.4 Energy Loss

9.4.1 Infrared inspections may be conducted to detect evidence of excess energy loss due to missing, damaged or misapplied insulation or air leakage.

9.4.2 Infrared inspections may be conducted from the exterior and/or the interior of a building; however, inspections performed from the interior are generally more helpful in diagnosing performance issues associated with occupant comfort.

9.4.3 Inspection Procedures

9.4.3.1 With help from the end user or the end user's representative, the thermographer will define the thermal boundaries of the building envelope.

9.4.3.2 When performing infrared inspections to detect energy loss, the temperature differences across the building envelope will be at least 10 C° (18 F°) between:

9.4.3.2.1 The conditioned and unconditioned surfaces for at least three hours before performing conduction inspections.

9.4.3.2.2 The building's inside air temperature and its outside surface temperature when inspecting for air leakage from the outside of a building that is under positive pressure.

9.4.3.2.3 The building's outside air temperature and its inside surface temperature when inspecting for air leakage from the inside of a building that is under negative pressure.

9.4.3.3 These temperature differences for air leakage inspections may be lowered as higher pressure differences are created across the building envelope.

9.4.3.4 If the building is inspected for air leakage under existing pressure conditions, the thermographer will determine which portions of the building envelope are under positive, negative and neutral pressures.

9.4.3.5 The thermographer may use artificial means of creating uniform pressure differences across the building envelope by using a "blower door" or by asking the qualified assistant to temporarily modify operation of the building's HVAC system to create the desired pressures.

9.4.3.5.1 The thermographer should be qualified in the safe use and operation of "blower doors" since heating systems and their exhaust gases can be affected by such equipment.

9.4.3.6 Inspections conducted from the exterior of the building should be performed at night or on overcast days to avoid errors due to solar reflections and solar loading. Inspections conducted from the interior of the building may be performed during daytime hours provided that solar loading of exterior walls is not significant.

9.4.3.7 Infrared inspections should be conducted under normal weather conditions with the HVAC system operating normally.

9.4.3.7.1 When inspecting commercial facilities at night, it may be necessary to override the building's climate controls to duplicate daytime settings.

9.4.3.8 The infrared inspection shall be conducted in an organized fashion to ensure complete coverage of all areas of interest. Items to be inspected shall include walls, windows, and doors. For interior inspections, floors and ceilings should be included as well.

9.4.3.9 Exceptions may appear as hot or cold, depending upon the thermographer's vantage point and weather conditions.

9.4.3.10 Detected exceptions should be documented with a thermogram and daylight photograph. These may be substituted by marking the location and size of exceptions on blueprints or drawings. For large structures, recording thermal imagery to videotape or a digital video file can provide a dynamic record of the infrared inspection.

9.4.3.11 Detected exceptions should be verified by independent means. This may include visual confirmation or the use of invasive testing such as moisture meter probes.

9.5 Latent Moisture

9.5.1 Infrared inspections may be conducted to detect evidence of latent moisture within building materials.

9.5.2 Infrared inspections may be conducted from the exterior and/or the interior of a building. Vantage point should be selected to provide the greatest probability of detection.

9.5.3 Inspection Procedures

9.5.3.1 With help from the end user or the end user's representative, the thermographer will define the areas to be inspected.

9.5.3.2 Latent moisture generally causes a change in the thermal capacitance and/or thermal conductivity of building materials. Moisture evaporating from a surface will generally cause a pronounced cooling in the wet areas.

9.5.3.3 Infrared inspections to detect latent moisture shall be conducted when conditions are most favorable for gathering accurate data.

9.5.3.4 Inspections conducted from the exterior of the building should be performed post sunset following a sunny day with calm wind conditions. Exceptions associated with latent moisture will generally appear warm.

9.5.3.4.1 Inspections conducted from the interior of the building may be performed during daytime hours provided that solar loading of exterior walls is not significant. Exceptions associated with latent moisture may appear as warm or cold, depending upon environmental conditions.

9.5.3.5 The infrared inspection shall be conducted in an organized fashion to ensure complete coverage of all areas of interest. Items to be inspected shall include walls, windows, and doors. For interior inspections, floors and ceilings should be included as well.

9.5.3.6 Detected exceptions should be documented with a thermogram and daylight photograph. These may be substituted by marking the location and size of exceptions on blueprints or drawings. For large structures, recording thermal imagery to videotape or a digital video file can provide a dynamic record of the infrared inspection.

9.5.3.7 Detected exceptions should be verified by independent means. This may include visual confirmation or the use of invasive testing such as moisture meter probes.

9.6 Structural Details

9.6.1 Infrared inspections may be conducted to detect evidence of structural details within building walls, ceilings, roofs, or floors.

9.6.2 Infrared inspections may be conducted from the exterior or the interior of a building. Vantage point should be selected to provide the greatest probability of detection.

9.6.3 Inspection Procedures

9.6.3.1 With help from the end user or the end user's representative, the thermographer will define the areas to be inspected.

9.6.3.2 Structural details generally cause a change in the thermal capacitance and/or thermal conductivity of building materials. Examples include, but are not limited to, studs or framing members within framed walls, fasteners in wall systems, and reinforcing grout details in block walls. Under the correct conditions, these details may be thermographically detected.

9.6.3.3 Infrared inspections to detect structural details shall be conducted when conditions are most favorable for gathering accurate data.

9.6.3.4 The infrared inspection shall be conducted in an organized fashion to ensure complete coverage of all areas of interest.

9.6.3.5 Detected exceptions should be documented with a thermogram and daylight photograph. These may be substituted by marking the location and size of exceptions on blueprints or drawings. For large structures, recording thermal imagery to videotape or a digital video file can provide a dynamic record of the infrared inspection.

9.6.3.6 Detected exceptions should be verified by independent means. This may include visual confirmation or the use of invasive testing as appropriate.

10.0 Significant Environmental Parameters

10.1 Water retained in building materials such as EIFS decreases the thermal resistance and increases the heat storage capacity of such systems. This can lead to thermal anomalies on the surface that can be located using an infrared thermal imager. These thermal anomalies depend upon the type of material, the amount of moisture in the material, and the weather conditions. For a given building envelope, there are four weather related parameters that can cause significant changes in surface temperatures over wet areas compared to dry areas. These are: inside to outside temperature difference, the rate of change of temperature in the hours prior to viewing, the amount of solar loading, and the wind speed.

10.2 Acceptable weather conditions for nighttime infrared imaging inspections will be calm winds with some combination of a large inside to outside temperature difference, a rapid decrease in ambient temperature in the late afternoon and a sunny day prior to the inspection. Typically, an infrared inspection during cold weather relies on a large inside to outside temperature difference. An infrared inspection during warm weather relies on solar loading.

11.0 Required Conditions

11.1 No appreciable precipitation shall have fallen during the 24 hours prior to the infrared survey.

11.2 At the time of the infrared inspection, all surfaces shall be dry.

11.3 For exterior inspections, winds in the area shall be less than 25 km/h (15 mph) at the time of the inspection.

12.0 Data Interpretation

12.1 The interpretation of infrared data is a process of pattern recognition for the purpose of differentiating exceptions from those caused by the following:

12.1.1 Variations in the type, thickness, density, or continuity of insulation.

12.1.2 Variations in wall thickness, moisture content, or continuity.

12.1.3 Variations in the type or thickness of wall surfacing.

12.1.4 Variations within the building walls.

12.1.5 Inconsistencies in walls due to damage, repairs, coatings, or overlays.

12.1.6 Variations in temperature behind walls.

12.1.7 Fasteners, flashings, flanges, or projections from walls or discontinuities within them.

12.1.8 Variations in surface emittance.

12.1.9 Infrared radiation from nearby sources.

12.1.10 Hot or cold air from nearby sources.

12.1.11 Moisture or debris on inspected surfaces.

12.1.12 Variations in shape or geometry of inspected surfaces.

12.2 Accurate interpretation of infrared data requires verification.

13.0 Verification

13.1 In order to determine the cause of exceptions, verification of infrared data must be carried out by the following invasive test methods: visual testing or moisture meter probes.

13.2 Noninvasive testing equipment such as nuclear and capacitance meters may be used to complement, but not replace invasive verification.

14.0 Documentation

14.1 The thermographer will provide documentation for all infrared inspections. The following information will be included in a written report to the end user:

14.1.1 The name and valid certification level(s) and number(s) of the infrared thermographer.

14.1.2 The name and address of the end user.

14.1.3 The name(s) of the assistant(s) accompanying the infrared thermographer during the inspection.

14.1.4 The manufacturer, model and serial number of the infrared equipment used.

14.1.5 A description of the location and construction of the building(s) that were inspected.

14.1.6 When performing air leakage inspections, notations of which parts of the building are under positive, negative or neutral pressures.

14.1.7 The date(s) of the inspection and when the report was prepared.

14.1.8 When performing a qualitative infrared inspection, the thermographer will provide the following information for each exception identified:

14.1.8.1 A description of the exception including its exact location and the direction it faces.

14.1.8.2 The time the exception was documented.

14.1.8.3 The weather conditions surrounding the exception including the inside and outside air temperatures, wind speed and direction, and the sky conditions.

14.1.8.4 Hard copies of a thermal image (thermogram) and corresponding visible-light image of the exception. When approved by the end user, the thermographer may provide sketches or drawings in place of, or in addition to, thermograms and photographs.

14.1.8.5 The field-of-view of the infrared imager lens.

14.1.8.6 Notation of any windows, filters or external optics used.

14.1.8.7 Any other information or special conditions that may affect the results, repeatability or interpretation of the exception.

14.1.9 When performing a quantitative infrared inspection, the thermographer will provide the following additional information for each exception documented:

14.1.9.1 The distance from the infrared imager to the exception.

14.1.9.2 The emissivity, reflected temperature and any transmittance values used to calculate the temperature of the exception.

14.1.9.3 The surface temperature of the exception and of a defined reference, if applicable.

14.1.10 The results of any moisture meter probes or other tests performed for the purpose of verifying infrared data.