Inspection Standards & Protocols for Building Thermographers: Overview of Standards for Infrared Inspections of Buildings

John Snell
Snell Infrared
PO Box 6
Montpelier, VT 05602
800-636-9820
jsnell@snellinfrared.com

Professional standards have existed for many years to guide thermographers in conducting building inspections in ways that ensure good results. As more and more people employ the technology, especially using lower cost infrared cameras, it has become more important that we consult these standards, and in many cases, follow them to the letter. This session will discuss the primary standards that relate to using thermography for building inspections, discussing similarities and differences.

This overview is intended to cover the major points and concerns for IR thermographers attempting to inspect framed cavities, both to determine if insulation may be insufficient or missing and to determine sites of air leakage using a blower door.

By attending this session, participants will:
1. Become aware of why it is important to conduct an infrared building inspection in compliance with professional standards
2. Learn about the standards that are available to building thermographers
3. Understand the differences and similarities among the various standards.

This overview is *not* intended to be used in lieu of using the actual standards and should only be used as a guide to establishing a building inspection program. It should be noted that the standards assume that in order to perform a successful building inspection the thermographer must have a thorough knowledge of basic heat transfer IR theory and camera operation in addition to a working understanding of frame building construction and the installation techniques and thermal properties of the various insulation types.

• **ASTM C 1060, *Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings*** (available for a fee from www.astm.org)

ASTM C 1060 describes the minimum necessary conditions and techniques for using infrared thermography to inspect both wood and metal framed walls The standard covers the infrared imaging equipment requirements and climatic and indoor conditions that will allow infrared to locate missing, damaged, inadequate or wet insulation in the wall assembly.

ASTM C 1060 is not intended to be a set of instructions rather it is guide for a trained thermographer who has acquired the ability to interpret thermal images based on a thorough understanding of heat transfer, building construction and thermal imaging. The purpose of this standard is not to identify all the possible thermal situations that may occur in a framed building, but focus on the methods, techniques and conditions that are necessary to identify areas of missing or malfunctioning insulation systems.

Section 6, Instrument requirements, spells out the requirements of IR cameras and goes into significant detail about the spectral range of thermal imaging systems as well as the minimum resolvable temperature difference (MRTD) and the spatial resolution required to meet the varied needs of IR inspection of framed walls. C1060 states that a thermal imaging system must operate within the 2 to 14 micron range. The appendix goes into much detail on the recommended MRTD needed to resolve a variety of wall sections that have varying R-values. It is recommended to become familiar with these MRTD recommendations.

Section 7 spells out the level of knowledge required to conduct inspections of framed walls. The level of knowledge is broken out in two areas: use of an infrared camera and interpretation of infrared data. Building inspectors using IR cameras must have a working knowledge of how to use an IR camera as well as knowing when the conditions are suitable for a thermal inspection. The person who interprets the inspection results must have a command of all the factors effecting a thermal inspection including, infrared theory, heat transfer, frame wall construction techniques as well as the understanding the effects of wet surfaces, thermal capacitance of various materials and the effects of wind.

Section 8 of ASTM C 1060 references two appendices. Appendix X2 outlines the basic indoor and environmental conditions for performing an inspection of frame walls. The basic recommendations are a minimum ΔT of 10ºC (18ºF) from interior surface to exterior surface for at least 4 hours prior to the inspection. There should not be any direct solar heating for 3 hours prior to inspecting a wall surface. Winds should be less than 6.7m/s (15mph). It assumes that the inspector(s) have a working knowledge of the design, materials and construction techniques used in the installation of frame walls. Also it is assumed that the thermographer have a working knowledge of the infrared imaging system in order to obtain well adjusted thermal images capable of resolving small temperature surface differences. If the thermographer is also the interpreter of the images they must also have a thorough knowledge of building envelope design and construction as well as understanding heat and mass transfer. The appendix also acknowledges that conditions are not always optimum and that a trained and qualified individual who is aware of the thermal relationships and materials involved may be able to make valid interpretations in less than ideal conditions.

Appendix X1 goes into detail on how to determine the spatial and thermal resolution of infrared imaging systems. Several charts are included that list the minimum thermal resolution needed to

resolve a variety of thermal situations. Of note is that most all modern thermal imagers meet the requirements listed.

Section 9 describes procedures for conducting an inspection. Important considerations are:

- Determining the intent and scope of the report with the building owner/operator
- Gathering background information on the types of construction used in the building including repairs and additions and alterations.
- Locate and evaluate areas that are known problems to the owner/occupant
- Note all surface differences with varying emissivities.
- Note all heat sources such as lights, HVAC ductwork or other equipment that may cause thermal signatures on the surface.
- Know and set your IR imager to sensitivity (span) capable of resolving the subtle temperature differences due to insulation anomalies.
- Perform both exterior as well as interior thermographic inspections. Evaluate surfaces as normal to the wall as possible.
- Thermal images should include at least two framing sections with a description of the location of the anomalies with references to physical components in the room such as windows or doors.

Section 10 describes the various conditions that may exist in frame walls and the associated thermal patterns that are typical of those situations. When inspecting an insulated frame wall with an adequate ΔT from the warm side of the envelope the framing members should appear darker(cooler) and the cavity area lighter (warmer). The opposite is true when inspecting from the colder side of the envelope, the framing will appear lighter while the cavity area will appear darker. In framed walls that are completely void of insulation the patterns will be reversed from above.

It is obviously important to always be aware of the direction of heat movement while moving around a building. For instance solar gain on an elevation can easily reverse the pattern of a frame wall possibly causing a misinterpretation of the thermal image.

Patterns that differ from above may be cause by a variety of situations such as:

- Poor density of blown in insulation resulting in settling at the top of wall cavities
- Bridging caused by structural members, wiring, or structural fasteners creates areas of missing or very low density insulation.
- Wet insulation decreases the thermal resistance of the wall resulting in diffuse mottled type patterns.
- Wet insulation also increases the thermal capacitance of those areas of the framed cavity. Areas with a higher thermal capacitance will tend to heat up and cool down at a different rate than the dry areas
- Air infiltration/exfiltration can be identified when there is a ΔT across the framed building section. Air leakage patterns can vary depending on the temperature difference between the air and the surface temperature as well as the velocity and amount of air leakage occurring.

- Temperature differences can be expected to vary trough out the building requiring the thermographer to be ever aware of the ΔT across the framed building section being inspected.
- Obstructions and wall coverings can cause a lingering thermal pattern after they have been removed from the surface. It is recommended to move objects early to allow their thermal effects to diminish.

Section 11 Reports. Reports are a required element of an IR frame building survey and should include the following data:

- Building name and location
- Contact information for the responsible person
- Date and time of the inspection
- Orientation of the building
- Shading of building
- Make, model and waveband of the thermal imager used for the survey
- Listing and description of the parts of the building that were inspected.
- Notation of all anomalous surface conditions that may be
- Description of the how each wall section is constructed listing specific materials
- Environmental conditions during the survey including air temperature and wind speed and solar insolation for the prior 4 hours.
- Thermal images of all suspected and verified problems found, along with photographs and drawings required to detail problems found.
- Marking of building surfaces with tape or other removable markings to identify potential problem areas
- Results of tests from other technologies such as moisture meters, blower doors etc.

It is important to remember that inspecting framed walls is a qualitative analysis requiring thorough understanding of thermal imaging, heat transfer, the thermal properties of a wide variety of building materials and building construction techniques.

• ASTM E1186 *Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems* (available for a fee at www.astm.org)

• Locating air leakage sites
• Qualitative
• Covers infrared scanning, building and test chamber pressurization and depressurization, smoke generation techniques, sound generation and detection, and tracer gas concentration measurement techniques."
• 4.2.1 *Building Depressurization (or Pressurization) with Infrared Scanning Techniques*
• Indoor–outdoor temperature difference of atleast 5 °C.
• A pressure differential of 10 to 50 Pa
• Depressurizing the building interior with a fan or using the mechanical system in the building for at least 10 minutes
• Produces a unique thermal pattern

• Emphasis is on the interior of the building envelope but other interior surfaces such as partition walls should not be ignored
• This practice can also be performed by pressurizing the building and scanning the exterior but this may be more difficult due to sun and wind
• Same camera specification as is found in ISO 6781
• Familiarity with the building envelope construction and details is required for effective interpretation
• Must distinguish between air leakage and thermal bridging

• ISO 6781, *Thermal insulation - Qualitative detection of thermal irregularities in building envelopes - Infrared method* (available for a fee at www.iso.org)

• The method is used initially to identify wide variations in the thermal properties, including air tightness, of the components constituting the external envelopes of buildings.
• Qualitative but temperature difference measurements are required
• Not just frame buildings
• "The concept in interpretation of the thermal irregularities requires personnel with special knowledge and experience building technology, building physics, heating and Ventilation techniques and measurement techniques."

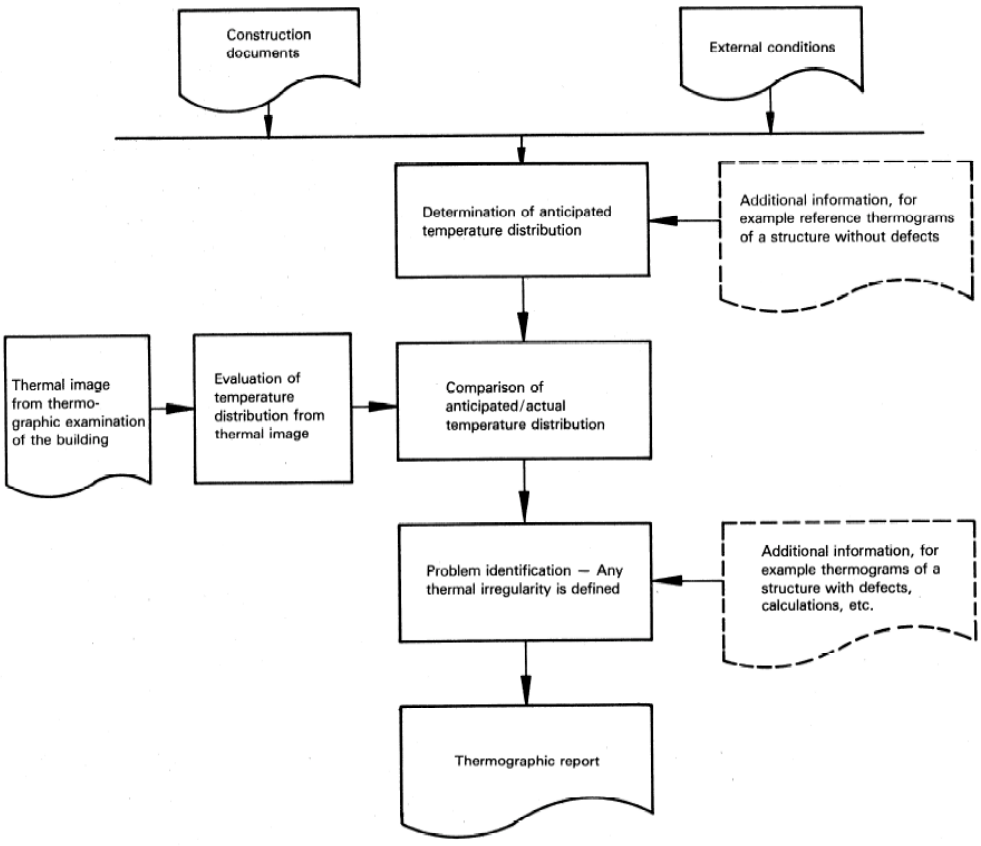

Figure 1 - General procedure for the interpretation of thermal images in thermographic examinations (reprinted from ISO 6781)

• The infrared radiation sensing System shall sense greater than 2 microns, display and record the thermal image and provide a means of establishing the temperature levels on the surface
• MRTD of .3°C at 20C
• The temperature drop across the envelope shall be sufficiently large to permit the detection of thermal irregularities. The following factors need to be considered:
    — the specifications and capabilities of the thermographic equipment
    — the characteristics of the building envelope, i.e. structural elements or insulating layers
    — the radiative properties of the cladding materials
    — climatic factors
    — accessibility for easy inspection
    — influences of the environment
    — other factors of importance
• Shut off HVAC if it interferes and move furniture away from walls
• Determine possible reflections by moving
• If air leakage is suspected in a thermal image, make measurements of air velocity to verify
• Thermal images are compared to "reference" images produced in the field or in a lab; these can represent either normal situations of defects
    — Annex B contains examples of reference thermograms of sections without defects
    — Annex C contains examples of reference thermograms of sections with defects
• The specifics of what should be in the report are given in detail

• Canadian National Master Specifications (NMS), *Section 02 27 13, Thermographic Assessment: Building Envelope*

• Qualitative and quantitative inspections intended for large and commercial buildings
• Qualifications of the personnel: 3 years related experience
    • Thermal Imaging Equipment Operators: ASNT Level I
    • Reporter: ASNT Level II plus building science
    • Report Author: : ASNT Level II plus building science at college level
• IR equipment:
    • 100mK or better at 30C
    • decrease to not more than 500mK or better at outdoor temperatures
    • spatial resolution of 1.3mRad or better
    • array size of 360x240 or better
    • digital and video output
    • calibration certificate required
• Conditions for Air leakage, Thermal performance of insulation, and moisture/water
        • Wind less than 10km/h
        • 10C delta for 10-25 Pascal difference
        • 20C delta for 5-10 Pascal difference
        • Depressurize and pressurize building for 2 hours
• Reinspection after repairs following similar procedure

• **RESNET *Standard For Thermographic Inspections of Buildings*** (the final draft of this standard will be available for public comment this week at www.resnet.us)

• Inspection of low rise, three stories or less, wood or steel frame, residential and light commercial buildings and provides:
    - For a means to achieve RESNET Advanced Certification
    - Guidance in using infrared thermography for air intrusion and insulation inspections
    - Possible substitute for an insulation inspection on a new building where viewing of the insulation installation was not accomplished before the drywall was applied
- SCOPE: These standards are RESNET requirements for inspecting a building enclosure using an infrared imaging system to locate defective insulation installations, framing issues, air leakage, moisture intrusion, or thermal bypasses.
- Certification:
    Method 1:
        - HERS rater certification and building knowledge
        - Level I or Building Science course
        - Report submittal, if necessary
    Method 2:
        - HERS rater certification and building knowledge
        - 32-hour RESNET approved building course with field experience
        - Pass RESNET test
        - One year IR experience and 10 reports
        - Additional reports, if necessary
- IR System:
    - NETD of 100mK at 30C
    - Spectral range greater than 2 microns
    - FOV capable of resolving two or more framing bays at once
    - 120x120 array or greater
    - 3mRad spatial resolution
    - Must record still or video images
- Inspection procedures
    - 18F Delta for at least 4 hours is recommended
    - Interior and exterior
- Insulation inspection (Qualitative)
- Insulation inspection (Quantitative): graded to Grade I, Grade II or Grade III
- Inspections for Thermal Bypasses
- Air leakage inspection

