



Thermographic Assessment Specification Requirements for Commissioning and Building Condition Applications

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History of Infrared Thermography in Building Applications



- **Late 1970's:**

- Large format LN₂ cooled, non portable equipment
- Laboratory investigations, wood frame construction
- Detection of insulation defects, air leakage

- **1980's:**

- Portable, LN₂ cooled, analogue imagery, 2-6 μ or 7-14 μ
- Late 1980's first digital converters, 100 x 100 resolution
- Field trials, interior & exterior investigations

- **1990's:**

- One or two piece portable,
 - Digital Thermal, (Microbolometers, Ferroelectric)
- Late 1990's Photon, (InSb, PtSi, QWIP) better resolution
- Digital image processing for temperature measurement
 - Implementation in electrical and mechanical applications




History of Infrared Thermography in Building Applications (con't)



- **2000's:**
 - Truly hand held, portable versus laboratory
 - Radiometric versus non-radiometric systems
 - Powerful image processing and data logging, trending
- **Detector Image Size:**
 - 5K, 10K, 20K, 80K or 300K pixels per image
 - (FPA row/columns of: 80 x 60, 100 x 100, 120 x 120, 160 x 120, 320 x 240, or 640 x 480)
- **Wave Length:**
 - Short Waveband; Mid Waveband; or Long Waveband
 - (1.5 – 3 μ ; 2-6 μ ; or 7-14 μ)
- **Detector Type:**
 - Thermal, (Microbolometers, Ferroelectric)
 - Photon, (InSb, PtSi, QWIP)



Technical Spec's vs Optional Features

TECHNICAL SPECIFICATIONS	OPTIONAL FEATURES
Detector Array Size and Type	Weight, size, ergonomics
Lens Field of View and Interchangeability	Batteries
Spatial Resolution (IFOV expressed in mrad)	Display; LCD, Viewfinder, both
Measurement Resolution (Distance to Measurement Spot Ratio)	Visual Imaging and Fusion capabilities
Detectable Temperature Range	Video, flash capture
Calibration range (may be different from Temperature Range)	Supplemental lenses
Radiometrics (Accuracy and repeatability)	Text and Voice Annotation
Operating Temperature Range	Manual vs motorized focus
Thermal Sensitivity (NETD)	Laser Pointer
	Image Storage Capacity and Media
	Onboard Software Features
	Image Analysis and Reporting Software



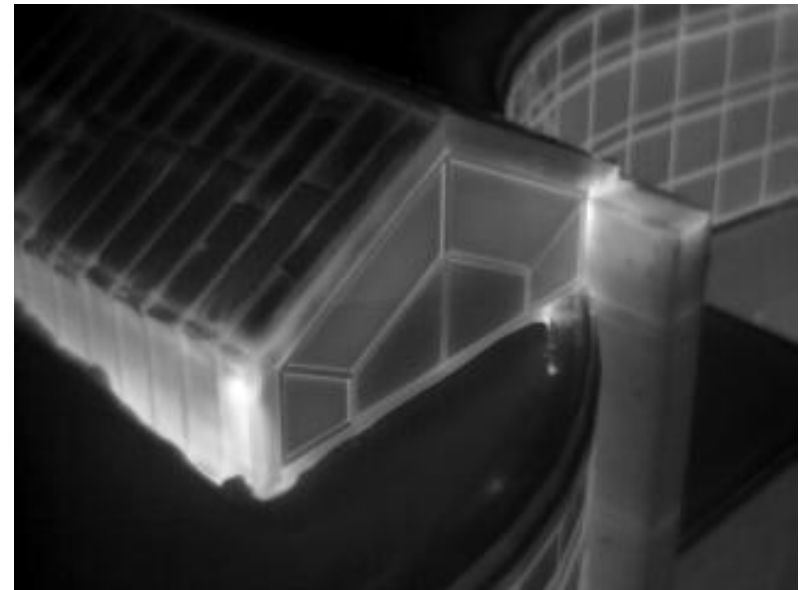
Specifications for IR Assessment Services for Open Bid Projects

- Generic specifications for inspection services have been developed for large buildings based on **professional liability** issues and **technical requirements** for inspections. (NMS Canada)
- Similar specifications can be used for the low-rise residential market but much of the demand for quality control of services may not be implemented in that market sector due to current market service rates.
- Creating a level playing field for all consultants is the only means of **protecting clients** and **ensuring industry survival of services** in this sector.



Intent of Assessment Specifications For Open Bid Projects

- Ensure that suitable equipment is used in each type of assessment application to meet current standards and guidelines.
- Where practices are not defined, suitable procedures are specified related to currently used equipment.

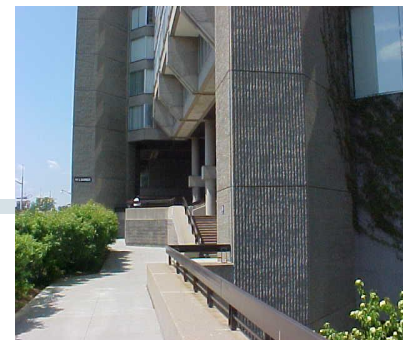


Intent of Assessment Specifications

- Identify varying requirements for each type of application related to:
 - Equipment
 - Minimum thermal and spatial resolution
 - Conformity to safety standards
 - Additional inspection equipment
 - Equipment operators
 - Level of certification and experience in specific discipline
 - Report authors
 - Level of certification and experience in specific discipline
 - Level of liability insurance



Technical and Disciplinary Requirements versus Assessment Applications



Requirements	Large Buildings	Low Rise Residential
Equipment (Technical)	<ul style="list-style-type: none"> •10K, 20K, 80K & 300K pixel imagers c/w telephoto lenses •Spatial, measurement resolutions and distances to objects 	<ul style="list-style-type: none"> •10K & 20K pixel imagers c/w telephoto lenses •Spatial, measurement resolutions and distances to objects
Equipment Operators (Disciplinary)	<ul style="list-style-type: none"> •Electrical •Mechanical •Low slope Roofing •Building Envelope 	<ul style="list-style-type: none"> •Electrical •Mechanical •Building Envelope
Procedure Development, Analysis & Reporting (Disciplinary)	<ul style="list-style-type: none"> •Electrical •Mechanical •Low slope Roofing •Building Envelope 	<ul style="list-style-type: none"> •Electrical •Mechanical •Building Envelope



Standards Governing Infrared Thermography



- In Canada:

- CSA, CGSB and NDT



- In USA:

- ASTM, ASNT through ANSI (American National Standards Institute)



- In Europe:

- ISO



NMS Referenced Standards



- The majority of the 400+ standards referenced in the NMS are from CSA, CGSB and ASTM
- Four types of ASTM standards:
 - Test methods - procedure that produces a specific result with specific precision
 - Specifications - explicit sets of requirements to be satisfied by materials, products, systems or services.
 - Practices - definitive set of instructions for performing specific operations that do not produce a definitive test result
 - Guides - tutorials indicating how something is to be done and provides recommendations on things to consider.



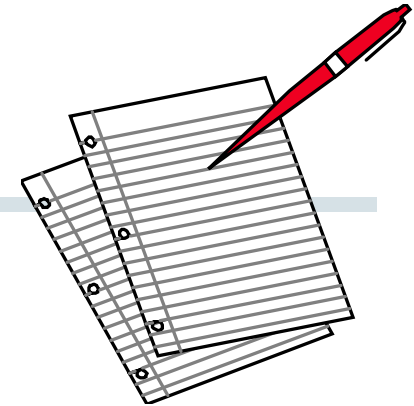
NMS Referenced Standards



- ASNT promotes standards for personnel qualifications and certification in non destructive testing technologies.
- NMS uses them to produce a set of uniform expectations between those wanting work done and those doing the work
- ASNT-CP-189: is an ANSI/ASTM specification
 - A person must comply with all of the requirements within CP-189 plus any additional specific requirements requested by the user.
- ASNT-SNT-TC-1A: is an ANSI/ASTM guide
 - Similar to a specification but intended to be modified by users to meet specific needs. To be compliant is to have a written practice, keep records in accordance with your written practices and do what you say you will do.
- Standards are voluntary unless mandated into law (e.i. NEPA 70E – Standard for Electrical Safety in the Workplace)



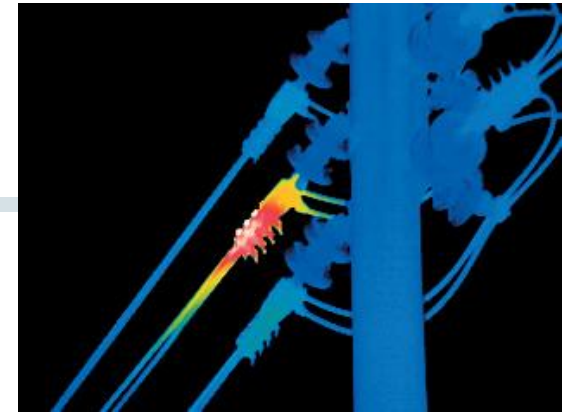
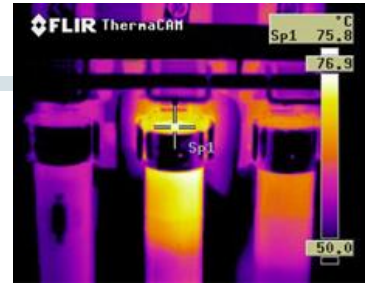
NMS Content Structure



- Reference the appropriate standards
- Define all relevant terms
- State all the submittals being requested;
- Reference qualifications required by equipment operators, analyzers and report authors.
- Itemize the scheduling requirements.
- Itemize specifications for all equipment required.
- State requirements for examinations of relevant as built documents.
- List items to be carried out in preparation of field inspections.
- List all general field inspection requirements.
- List inspection requirements for each type of infrared thermography inspection methodology.
- List all information to be recorded as part of the inspection services.
- List all re-inspection requirements if remediation work.
- State job site status after inspection services



Thermographic Assessment; Electrical Equipment

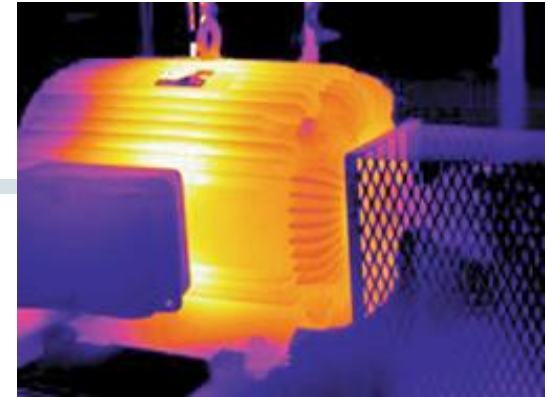


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- **Level II certification is proposed as minimum requirement for both equipment operator and report authors.**
 - **Level I certification is acceptable for low rise residential where existing ASTM inspection standards are available.**
 - **Equipment requirements are noted for infrared equipment AND related equipment required to carry out assessments.**
 - **Places maximum inspection distance restrictions on specific types of infrared equipment.**
 - **Distance limits are not indicated on existing standards**
-
- 3 mrad IFOV equipment; limit distance to object (6 mm) to 2 m
 - 1.5 mrad IFOV equipment; limit distance to object to 4 m
 - Distances greater than 4 m to object require telephoto lenses



Thermographic Assessment: Mechanical Equipment

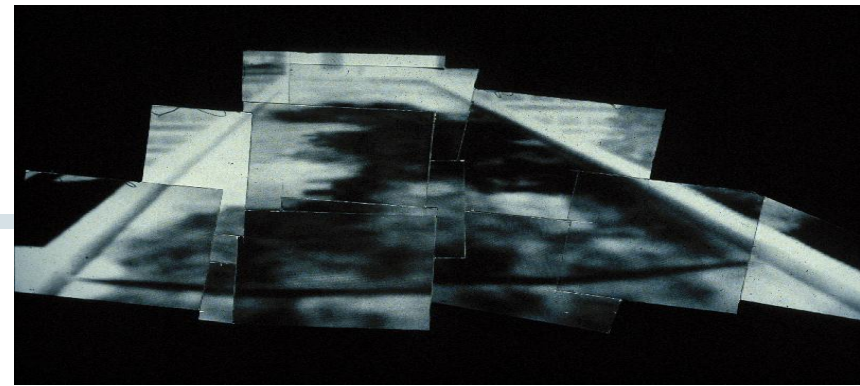


Section 02 27 19

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 - **Equipment requirements are noted for infrared equipment AND related equipment required to carry out assessments.**
 - **Places maximum inspection distance restrictions on specific types of infrared equipment.**
 - **Distance limits are not indicated on existing standards**
-
- 3 mrad IFOV equipment; limit distance to object (**9 m**) to 3 m
 - 1.5 mrad IFOV equipment; limit distance to object to 6 m
 - Distances greater than 6 m to object will require telephoto lenses

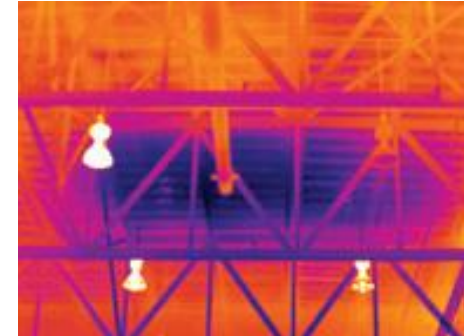


Thermographic Assessment; Roofing



- **Section 02 27 16**

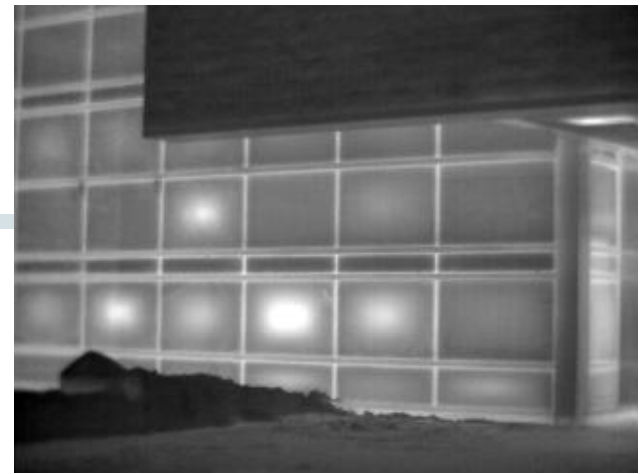
- Roofing assessments focus on qualitative results
- Moisture detection in roof insulation is a transient heat flow procedure therefore results will differ based on inspection conditions
- Spatial resolution is the key equipment specification



- 3 mrad imagers suitable for walk on roof inspections
 - Max. distance to target surface is limited to 10 m for 25 mm spot size
- Where inspections are done from other roof tops or aerial;
 - 1.5 mrad imagers or telephoto lenses will be required
- Level I certification is proposed for equipment operators.
- Level II certification is proposed for report authors dealing with large building low sloped roof assessments with variable assembly configurations



Thermographic Assessment; Building Envelope



- **Section 02 27 13**
 - Most complex of all building applications
 - Most procedures are qualitative due to transient conditions
 - Quantitative procedures can be used for specific applications
 - Severity of fault based on relative imagery of similar assemblies
- 3 mrad imagers limit; distance to object (**12 mm**) of 5 m
 - Fine for interior work and low rise buildings.
 - Telephoto lenses required for buildings larger than 4 stories
 - Detection of small openings and thermal signatures require good spatial resolution
- Thermal resolution of 0.1°C acceptable, 0.05°C preferred
 - Diffuse air leakage patterns
 - Moisture detection by means of phase change



Thermographic Assessment; Building Envelope

- Deals with various related assessment procedures
 - Insulation defects
 - Thermal bridges
 - Surface moisture detection
 - Interstitial moisture detection
 - Air leakage detection
 - Convective heat loss
 - Voids in composite and homogeneous materials
- Methodologies vary for each assessment and type of assembly
 - Minimum environmental conditions are specified to provide guidance where gaps within present standards exist.
 - Minimum times of inspection after sunset and pressurization are provided



Thermographic Assessment; Building Envelope

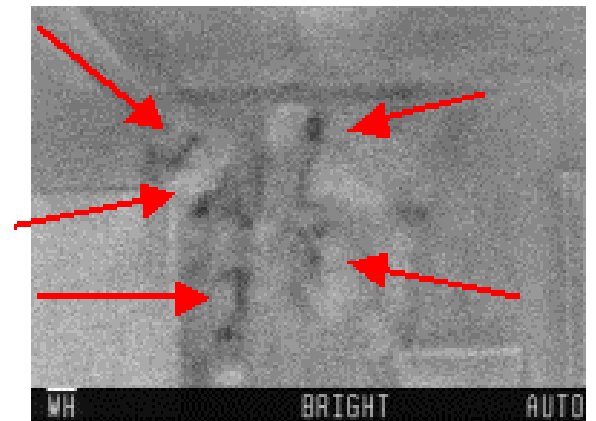


- large building **level of complexity**
 - **Masonry** (solid load bearing, cavity wall, cladding with stud wall back up)
 - **Pre-cast Concrete** (cladding only, composite panels)
 - **Metal and Glass Curtain Walls** (window walls, curtain walls)
 - **Insulated Steel Assemblies** (multiple cladding types with interior metal liners)
- Inspection methodologies are not always defined within the standard infrared inspection protocols
 - Professional building science expertise is required to
 - Develop new inspection procedures
 - Determine severity of fault
 - Provide recommendation for remediation solutions
 - Level II certification is required for both equipment operator and report author



Thermographic Assessments; Future Applications

- Transient heat flow methodologies:
daytime inspections
 - Interstitial moisture (EIFS)
 - Thermal comfort problems
 - Material deterioration
 - Void detection
 - Biological infestation
- Steady state heat flow methodologies:
night time inspections
 - In-situ R value confirmation
 - Insulated Glass Unit seal failures



**Digital and grayscale images
of wall area in house with
termite activity behind wall.**

(courtesy of Jon L. Grossman)



Summary

Small Bldg	Detection	Measure-ment	Field Of View	Thermal Sensitivity	Operator Knowledge	Author Knowledge
Electrical	< 3mrad	>100:1	>20°	<0.3C @ 30C	ASNT L I	ASNT L I
Mechanical	< 3mrad	>100:1	>20°	<0.3C @ 30C	ASNT L I	ASNT L I
Interior	< 3mrad	>100:1	>20°	<0.1C @ 30C	ASNT L I	ASNT L I
Exterior	< 3mrad	>100:1	>20°	<0.1C @ 0C	ASNT L I	ASNT L I
Large Bldg						
Electrical	< 3mrad <1mrad)	>100:1 >300:1	>20°, >60°	<0.3C @ 30C	ASNT L I	ASNT L II
Mechanical	< 3mrad	>100:1	>45°	<0.3C @ 30C	ASNT L I	ASNT L II
Roofing	< 3mrad	N/A	>20°	<0.2C @ 30C	ASNT L I	ASNT L II
Interior	< 3mrad	>100:1	>20°	<0.1C @ 30C	ASNT L II	ASNT L II
Exterior	< .05mrad	N/A	>45°, >10°	<0.1C @ 0C	ASNT L II	ASNT L II



Thank You for your attention.

Thermographers are in the best position to make sure that the architectural community does not give birth to unwanted “water babies” (buildings that wet themselves)

Through non destructive testing, validation and remediation prior to hand over to owners thermographers can easily “potty train” any building.





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Thank You

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