The Role of Standards & Calibration in IR Thermography

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Abstract

Standards play a big role in infrared thermography, but there are several kinds of them. Some are about the thermal imaging instruments themselves, their calibration and performance; and others are about using the instruments. There are still others about the training and qualifications for the people who use thermal imagers. Standards and practices vary in different places in the world. This tutorial describes some of the key ones and how they relate to calibration of imagers and the regular use of infrared imaging equipment.

Introduction

In 2004, I was honored to be asked to deliver the Keynote talk to this meeting. The talk was entitled *A View to Thermal Imaging's Future!* I spoke about the role of lower equipment prices and the increasing number and types of standards in future expansion of thermography applications and opportunities.

It's now seven years later and many of the things discussed then have come true in the intervening years. Some of the changes are way beyond even my optimistic thoughts back then.

Thermal imaging equipment prices especially, have continued to fall faster than the stock market did two years ago. Sub $5,000 products are common and research-grade thermal camera prices have reached the level of ordinary devices less than seven years ago.

Applications have expanded along with many more training companies and specialty business operations. In addition, more guidelines on training and new training methods, like Infraspection's innovative "Distance Learning" (now with 18 online courses) have been developed.

The Standards and Calibration areas also are now more mature with many new standards available to help guide thermographers in their selection and maintenance of equipment. I have mentioned that in subsequent talks to audiences both here and at other conferences.

In this presentation, I'd like to focus on standards that are available for thermographers and the link between certain new key ones and the very critical aspect of thermal imager calibration addressed by some of them.

A few years ago, we had several talks at IR/INFO on calibration and its significance in the continuing use of thermal imagers not just from me, but from Mike Sharlon, too. If you have copies of those papers, I'd suggest that you read them again*.

I think they and the entire topic of calibration is about to become much more significant than ever before. The driving force behind this is a group of relatively new International Standards.

The question is no longer "if" traceable calibration will become mandated, it is "when".

The basic reason is simple: If you report one or more temperature values in your findings to a client, you are performing a measurement, not a guess.

For measurements to be valid legally, engineering-wise and scientifically, they must be able to be reproduced under the same conditions by an unbiased, skilled worker using state-of-the-art equipment and abilities.

In order for that to have some possibility of occurring, the calibration of all equipment used must be traceable to primary standards by an unbroken chain of evidence to fundamental or primary standards.

If there is no such chain of traceability, then untraceable measurements are technically unsupportable and useless.

New international standards not only support such reporting, but they are now coming into use in **Legal Metrology** that governs trade between countries. These standards further specify methods for testing calibration and other properties of thermography equipment that will no doubt, by extension, be selected for use by most industry and national standards organizations.

This seems highly likely, since the standards were developed by groups of scientists and technologists around the world, including staff members from the USA's National Institute for Standards & Technology (NIST).

A **technical standard** is an established norm or requirement about technical systems. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes and practices. In contrast, a custom, convention, company product, corporate standard, etc., which becomes generally accepted and dominant is often called a de facto standard. (http://en.wikipedia.org/wiki/Standard)

A technical standard may be developed privately or unilaterally, for example by a corporation, regulatory body, military, an industry training or educational organization, etc. Standards can also be developed by groups such as trade unions, and trade associations.

Standards organizations often have more diverse input and usually develop voluntary standards: these might become mandatory if adopted by a government, business contract. However, lacking any statutory requirements of local, state or federal government, the principle guidelines in selection and application of standards are in the contractual arrangements, or terms of service, agreed to between a service provider and their customer.

Types of Standards

The primary types of technical standards are:

A ***standard specification*** is an explicit set of requirements for an item, material, component, system or service. It is often used to formalize the technical aspects of a procurement agreement or contract. For example, there may be a specification for a turbine blade for a jet engine which defines the exact material and performance requirements.

A ***standard test method*** describes a definitive procedure which produces a test result. It may involve making a careful personal observation or conducting a highly technical measurement. For example, a physical property of a material is often affected by the precise method of testing: any reference to the property should therefore reference the test method used.

A ***standard practice*** or procedure gives a set of instructions for performing operations or functions. For example, there are detailed standard operating procedures for operation of a nuclear power plant.

A ***standard guide*** is general information or options which do not require a specific course of action.

A ***standard definition*** is formally established terminology.

Standard units**,** in physics and applied mathematics, are commonly accepted measurements of physical quantities.

International Standards Organizations

Broadly, an international standards organization develops international standards. (This does not necessarily restrict the use of other published standards internationally.)

Some organizations

ANSI – American National Standards Institute

ASTM International – based in the USA

BIPM, CGPM, and CIPM – Bureau International des Poids et Mesures and the related organizations established under the Metre Convention of 1875, (France)

DIN – The Deutsches Institut für Normung (Germany)

IEC – International Electrotechnical Commission (Switzerland)

IEEE – Institute of Electrical and Electronics Engineers (USA)

ISA – International Society for Automation (formerly the Instrument Society of America)

ISO – International Organization for Standardization (Switzerland)

OIML –The International Organization of Legal Metrology or Organisation Internationale de Métrologie Légale (France)

National Standards Bodies

In general, each country or economy has a single recognized Standards Body (NSB). Examples include the Brazilian National Standards Organization (ABNT), the American National Standards Institute (ANSI), the British Standards Institution (BSI), the Mexican DirecciónGeneral de Normas (DGN), the Deutsches Institut für Normung (DIN), and so on.

A national standards body is likely the sole member from that economy in ISO.

NSSN – Search Engine for Standards (http://www.nssn.org/) provides users with standards-related information from a wide range of developers, including organizations accredited by the American National Standards Institute, other US private sector standards bodies, government agencies and international organizations.

ANSI – American National Standards Institute, lists industry and regional standards organizations, principally in North America on their website. See the Appendix for a recent list.

There are many other organizations, including specialized training and technical groups that develop standards as well.

Thermography Standards Developing Organizations

ASTM International (ASTM) - (formerly The American Society for Testing and Materials) ASTM has perhaps the largest number of detailed practices and instrument standards related to infrared measuring. Many of these were developed from either older military standards or the many guidelines developed by Infraspection Institute.

ASTM, more than 100 years old, is headquartered in West Conshohocken PA, USA and has Memoranda of Understandings (MOUs) on standards with many countries and sales offices/agents all around the world. It publishes standards, monographs and runs training courses and symposia on a regular basis.

Its Directories of Testing Laboratories and Consultants are available online at no cost and have been some of the most widely used resources in the entire field of materials and testings for decades.

Its standards development process is unique in that it is manned 100% by Committees of volunteers. The approval process of voting approvals are strictly balanced between product/service providers, users and third parties (academia, government, and research). The voting member population is required to be in the minority.

Additionally, any objection to a standard or part of a standard must be settled in a uniform, mandated defined resolution process. Anyone, a member of ASTM or not, is allowed to voice an opinion and objection at any time in the voting process. All standards must be reviewed and reballotted every 5 years. Ballot and reballoting of standards are published online at www.astm.org and in the ASTM's monthly magazine*, "Standardization News*".

ASNT - The American Society for Non Destructive Testing (NDT)
Certifies personnel and provides NDT certification guidelines, educational and related testing services.

IEC - The International Electrotechnical Commission
The IEC is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies.

Infraspection Institute Standards
The independent training organization, the Infraspection Institute of Burlington New Jersey, developed a series of comprehensive guidelines for Thermography Practices as part of their education curricula over the past 25 years. Many of these were provided as initial content for, or served as the foundation for some ASTM standards. In 2008, Infraspection rewrote their guidelines and renamed them "Standards".

ISO - The International Organization for Standardization
The ISO is a worldwide federation of national standards bodies organized to promote the development of standardization and related activities throughout the world.

LETA - The Law Enforcement Thermographers' Association
LETA is a professional law enforcement organization dedicated to promoting the legal and ethical use of thermal imaging in support of law enforcement operations. LETA membership, originally limited to those engaged in or supporting law enforcement, has been expanded to accept all those engaged in providing or supporting public safety.

LETA law enforcement training is recognized across the USA, as well as internationally. The Federal Bureau of Investigation, the Drug Enforcement Administration, the Royal Canadian Mounted Police and a number of state and local agencies currently use LETA for their thermal imaging training.

Bullard and LETA formed the **first thermal imaging training program for the fire service that results in certification by an internationally recognized public safety organization.**

OIML - The International Organization of Legal Metrology (Organisation Internationale de Métrologie Légale)
OIML has developed several standards relating to infrared thermography and temperature measuring equipment. Their standards are used in Legal Metrology, principally in Europe but more and more throughout the world as a means of ensuring that imported products perform to an agreed international standard.

Standards are developed within Secretariats that are composed of delegates from the various member states (nations) that are assigned to it along with members from corresponding members.

> "Legal metrology comprises all activities for which legal requirements are prescribed on measurement, units of measurement, measuring instruments and methods of measurement, these activities being performed by or on behalf of governmental authorities, in order to ensure an appropriate level of credibility of measurement results in the national regulatory environment." [OIML D 1:2004 Elements for a law on metrology]

In other words, Legal Metrology deals with any device that is subject to some governmental rules and/or laws, such as used in Licensed Practices, or is subject to Import Laws, Taxing Authority, Immigration Rules, Public Health Requirements, etc.

OIML currently has 57 Member States (P or participating members) and 55 Corresponding Members (O or other nations), including the USA and most industrialized nations and many under-developed nations as well.

A limited number of OIML Member Counties are involved in developing individual standards for various standards and they are controlled by committees called Secretariats.

If you think these sound like USSR and Soviet-bloc terminologies common during the Cold War, you are correct. Originally OIML was developed among Soviet-bloc countries. Evidently, it worked well in developing trust in technology matters among nations and has been adopted by the majority of industrial nations of the world since the fall of the USSR and the Soviet bloc of nations.

The present OIML Secretariat, TC 11/SC 3: Radiation thermometers, is headquartered in the Russian Federation. Its P-Members (9) are: Czech Republic, Germany, Japan, Korea (R), the Netherlands, Russian Federation, Slovakia, United Kingdom and the USA.

It has only a few Standards, but they include infrared thermographic instruments. After all, thermal imagers are infrared radiation thermometers that provide non-contact temperature measurements over an area, rather than just a single spot.

RESNET
In April 1995, the National Association of State Energy Officials and Energy Rated Homes of America founded the Residential Energy Services Network (RESNET) to develop a national market for home energy rating systems and energy efficient mortgages. (www.resnet.us)

The RESNET standards are recognized for:

- Accreditation of rating providers, rater training providers, and rating software tools
- Verification of energy savings for energy efficient mortgages (EEMs)
- Verification of a home's energy performance for EPA's ENERGY STAR Homes Program
- Performance option for energy code compliance in 16 states
- Verification of energy performance in state utility benefit program funded residential energy efficiency programs in 9 states.

The 2011 RESNET Building Performance Conference will take place on February 28 to March 2, 2011 in Lake Buena Vista, FL. (see: archive.resnet.us/conference/)

Thermography & Related Standards List, by Organization

ASNT - The American Society for Non Destructive Testing
The American Society for Nondestructive Testing, Inc. (ASNT) is a technical society for nondestructive testing professionals. It provides standards & services for the qualification & certification of NDT personnel.

Certification in accordance with the guidelines of the ASNT Recommended Practice No. SNT-TC-1A is an employer-based system, meaning that the employer is responsible for the qualification and certification of their own personnel.

Central certification is administered and maintained by an independent body that provides uniform certification requirements for all certificate holders.

The ASNT Central Certification Program (ACCP) is recognized by Sections I, V, VIII and XI of the ASME Boiler 7 & Pressure Vessel Code. ACCP is incorporated into Recommended Practice No. SNT-TC-1A, any code or specification that references SNT-TC-1A accepts ACCP certification.

Recommended Practice No. SNT-TC-1A

Summary: Personnel Qualification and Certification in Nondestructive Testing (2006) provides guidelines for employers wishing to establish in-house certification programs. SNT-TC-1A establishes the general framework for a qualification and certification program.

In addition, the document provides recommended educational, experience and training requirements for the different test methods.

SNT-TC-1A (2006) is sold as a package with **ANSI/ASNT CP-105**: ***Training Outlines for Qualification of Nondestructive Personnel (2006).***

The ASNT NDT Level II certification program was developed to provide standardized Level II written examinations that employers may use to satisfy the General and Specific examination guidelines of paragraphs 8.3 and 8.4, respectively, of the Recommended Practice No. SNT-TC-1A.

ASNT NDT Level III Certification
Each of the following web site links/documents cover both NDT Level III and PdM Level III certification. (refer to www.asnt.org)

Program Document for the ASNT Level III certification program.

Initial Qualification Requirements for education and experience.

Examinations: A list of all exams with links to topical outlines and references.

Level III Exam Application: The Level III exam application is used for new certifications, to add certifications, to retake failed exams, or to recertify by examination.

Renewal/Recertification Requirements: Details about renewing by points and by examination.

ACCP Professional Level III Certification: The ASNT Central Certification Program (ACCP) Professional Level III certification includes the same exam requirements as the ASNT Level III program above and adds Practical and Procedure Preparation examinations for a more comprehensive certification.

ASTM Standards

ASTM International, formerly known as the American Society for Testing and Materials (ASTM), is a globally recognized leader in the development and delivery of international voluntary consensus standards.

ASTM C1046 -95(2007) ***Standard Practice for In-Situ Measurement of Heat Flux and Temperature on Building Envelope Components***
This practice covers a technique for using heat flux transducers (HFTs) and temperature transducers (TTs) in measurements of the in-situ dynamic or steady-state thermal behavior of opaque components of building envelopes. The applications for such data include determination of thermal resistances or of thermal time constants.

ASTM C1060 -90(2003) ***Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings***
Although infrared imaging systems have the potential to determine many factors concerning the thermal performance of a wall, roof, floor, or ceiling, the emphasis in this practice is on determining whether insulation is missing or whether an insulation installation is malfunctioning. Anomalous thermal images from other apparent causes may also be recorded ...

ASTM D4788 -03(2007) ***Standard Test Method for Detecting Delaminations in Bridge Decks Using Infrared Thermography***
This test method may be used in conjunction with other test methods in determining the general condition of a bridge deck. Areas indicated as delaminated on overlaid bridge decks may be an indication of lack of bond between the overlay and the underlying bridge deck ...

ASTM E1213 -97(2009) ***Standard Test Method for Minimum Resolvable Temperature Difference for Thermal Imaging Systems***
This test relates to a thermal imaging system's effectiveness for discerning details in a scene. MRTD values provide estimates of resolution capability and may be used to compare one system with another ...

ASTM E1256-95(2007) ***Standard Test Methods for Radiation Thermometers (Single Waveband Type)***
The methods described in these tests can be utilized to evaluate the following six basic operational parameters of a radiation thermometer (single waveband type): Section Calibration Accuracy 7 Repeatability 8 Target Size 9 Response Time 10 Warm-Up Time 11 Long-Term Drift

ASTM E1311-89(2004) ***Standard Test Method for Minimum Detectable Temperature Difference for Thermal Imaging Systems***
This test method gives a measure of a thermal imaging system's effectiveness for detecting a small spot within a large background. Thus, it relates to the detection of small material defects such as voids, pits, cracks, inclusions, and occlusions. MDTD values provide estimates of detection capability …

ASTM E1316 -10b ***Standard Terminology for Nondestructive Examinations***
The terms found in this standard are intended to be used uniformly and consistently in all nondestructive testing standards. The purpose of this standard is to promote a clear understanding and interpretation of the NDT standards in which they are used. This standard defines the terminology used in the standards prepared by the E07 Committee

ASTM E1543 -00(2006) ***Standard Test Method for Noise Equivalent Temperature Difference of Thermal Imaging Systems***
This test method gives an objective measure of the temperature sensitivity of a thermal imaging system (relative to a standard reference filter) exclusive of a monitor, with emphasis on the detector(s) and preamplifier. Note 1: Test values obtained under idealized laboratory conditions may or may not correlate directly with service performance. ...

ASTM E1862 -97(2002)e1 ***Standard Test Methods for Measuring and Compensating for Reflected Temperature Using Infrared Imaging Radiometers***
The infrared energy that is reflected by a specimen can cause measurement errors for an infrared thermographer measuring its surface temperature. Two test methods are provided for measuring and compensating for this reflected temperature error source, the Reflector Method and the Direct Method. These test methods can be used in the field or laboratory ...

ASTM E1897 -97(2010) ***Standard Test Methods for Measuring and Compensating for Transmittance of an Attenuating Medium Using Infrared Imaging Radiometers***
The transmittance of an attenuating medium can cause errors for an infrared thermographer using an infrared imaging radiometer to measure the temperature of a specimen through the medium. Three test methods are given for measuring and compensating for this error source. A test method is given for measuring the transmittance of an attenuating medium ...

ASTM E1933 -99a(2005)e1 ***Standard Test Methods for Measuring and Compensating for Emissivity Using Infrared Imaging Radiometers***
The emissivity of a specimen can cause surface temperature measurement errors. Two test methods are provided for measuring and compensating for this error source. These test methods can be used in the field or laboratory, using commonly available materials...

ASTM E1934 -99a(2005)e1 ***Standard Guide for Examining Electrical and Mechanical Equipment with Infrared Thermography***
This guide can be used by an end user to specify infrared examinations of electrical and mechanical equipment and an infrared thermographer to perform them. This guide lists the joint responsibilities of the end user and the infrared thermographer when using infrared thermography.

ASTM E2533 -09 ***Standard Guide for Nondestructive Testing of Polymer Matrix Composites Used in Aerospace Applications***
This guide references requirements that are intended to control the quality of NDT data. The purpose of this guide, therefore, is not to establish acceptance criteria and therefore approve composite materials or components for aerospace service. Certain Practices referenced in the guide are written so they can be specified on the engineering drawing.

ASTM E2582 -07 ***Standard Practice for Infrared Flash Thermography of Composite Panels and Repair Patches Used in Aerospace Applications***
FT is typically used to identify flaws that occur in the manufacture of composite structures, or to track flaw development during service. Flaws detected with FT include delamination, disbonds, voids, inclusions, foreign object debris, porosity or the presence of water that is in contact with the back surface ...

ASTM E2758-10 ***Standard Guide for Selection and Use of Wideband, Low Temperature Infrared Thermometers***
This guide covers electronic instruments intended for measurement of temperature by detecting intensity of thermal radiation exchanged between the subject of measurement and the sensor. The devices covered by this guide are referred to as IR thermometers.

International Electrotechnical Commission (IEC)
The IEC is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies.

IEC/TS 62492-1:2008 applies to radiation thermometry. It defines the technical data, i.e., metrological data to be given in data sheets and operating instructions for radiation thermometers with one wavelength range and one measurement field, to ensure that the data and terminology are used consistently. Its purpose is to facilitate comparability and testability. Therefore, unambiguous definitions are stipulated for stating technical data under standardized measuring conditions.

IEC 80601-2-59
Part 2-59: Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening: This document describes ME equipment that uses infrared technology to detect naturally emitted heat at the skin surface of the face. Such ME equipment can be useful at ports-of- entry or ports-of-exit and the entrances to buildings under indoor environmental

conditions to separate febrile from afebrile individuals to help prevent the spread of communicable diseases. Care can be needed when evaluating individuals under changing environmental conditions, but the inner canthus of the eye has been demonstrated to be a robust measurement site and is supplied by the internal carotid artery.

ISO/TR 13154*, Medical Electrical Equipment* – Deployment, implementation and operational guidelines for identifying febrile humans using a screening thermograph - Laboratory accuracy of a screening thermograph - CALIBRATION SOURCE - Example of relevant uncertainty terms for a screening thermograph, etc.

Infraspection Institute

Infraspection Institute provides training, certification, & support services for thermographers worldwide. They publish software, Standards, & technical articles for thermographers and NDT professionals. Many of the Infraspection Institute Standards were provided as initial content, or served as the foundation for, some ASTM standards. All standards are available in English or Spanish in PDF format.

Standard for Infrared Inspection of Building Envelopes - This 11 page document defines the roles of all persons involved in the inspection including the End User, Thermographer, and Qualified Assistant. It also specifies report content for properly documenting qualitative and quantitative infrared inspections along with requirements for verifying infrared data.

Standard for Measuring Distance/Target Size Values for Infrared Imaging Radiometers - This standard outlines a simple methodology for determining spot measurement size for quantitative thermal imagers. Practicing thermographers need spot size information to determine how close they need to be for accurate temperature measurements. This 7 page document is a must for taking the guesswork out of your quantitative measurements and helping to ensure temperature measurement accuracy.

Standard for Infrared Inspection of Electrical Systems & Rotating Equipment (Basis for ASTM E1394) - This comprehensive document outlines practices and procedures for specifying and safely performing infrared inspections of operating electrical systems and rotating equipment. This 17 page document defines the roles of all persons involved in the inspection including the End User, Thermographer, and Qualified Assistant. The standard also specifies report content for properly documenting qualitative and quantitative infrared inspections. Also covered in the standard are temperature limits for electrical and mechanical equipment along with several proven methodologies for prioritizing exceptions. The standard also includes the IEEE formula for calculating maximum allowable temperature for operating electrical components. This formula is invaluable for establishing pass/fail criteria for components not showing as exceptions.

Standard for Measuring and Compensating for Emittance Using Infrared Imaging (Basis for ASTM E1933) - This 6 page standard outlines simple, proven techniques for measuring and compensating for the emittance of any object. This standard offers simple, step-by-step instructions that are easy to understand and may be applied in laboratory or industrial environments. This document is a must for anyone wishing to get the most from their radiometric imager and make accurate infrared temperature measurements.

Standard for Infrared Inspections to Detect Pests and Pest Related Damage - This 10 page document defines the roles of all persons involved in the inspection including the End User, Thermographer, and Qualified Assistant. It also specifies report content for properly documenting infrared inspections along with requirements for verifying infrared data.

Standard for Measuring and Compensating for Reflected Temperature Using Infrared Imaging Radiometers (Basis for ASTM E1862) - This 6 page standard outlines simple, proven techniques for measuring and compensating for reflected temperature, also known as ambient or background temperature. This standard offers simple, step-by-step instructions that are easy to understand and may be applied in laboratory or industrial environments. This document is a must for anyone wishing to get the most from their radiometric imager and make accurate infrared temperature measurements.

Standard for Infrared Inspection of Insulated Roofs - This application standard outlines practices and procedures for specifying and safely performing infrared inspections of insulated roofing systems. The standard covers procedures for both ground based and aerial inspections. This 11 page document defines the roles of all persons involved in the inspection including the End User, Thermographer, and Qualified Assistant. It also specifies report content for properly documenting infrared inspections along with requirements for verifying infrared data.

Standard for Measuring and Compensating for Transmittance of an Attenuating Medium Using Infrared Imaging Radiometers (Basis for ASTM E1897) - This 6 page standard outlines simple, proven techniques for measuring and compensating for transmittance values of windows, filters or atmospheres. This standard offers simple, step-by-step instructions that are easy to understand and may be applied in laboratory or industrial environments. This document is a must for anyone wishing to get the most from their radiometric imager and make accurate infrared temperature measurements.

ISO - Thermography & Infrared Radiation Thermometry Standards

The ISO is a worldwide federation of national standards bodies organized to promote the development of standardization and related activities in the world.

ISO 13372:2004 - Condition monitoring and diagnostics of machines - Vocabulary
I***SO 13372:2004*** specifies definitions of terms used in condition monitoring and diagnostics of machines. It is intended to provide users and manufacturers of condition monitoring and diagnostics systems with a common vocabulary.

ISO 13374-1:2003 - Condition monitoring and diagnostics of machines - Data processing, communication and presentation - Part 1: General guidelines establishes general guidelines for software specifications related to data processing, communication, and presentation of machine condition monitoring and diagnostic information.

ISO 13374-2:2007 - Condition monitoring and diagnostics of machines - Data processing, communication and presentation - Part 2: Data processing details the requirements for a reference information model and a reference processing model to which an open condition monitoring and diagnostics (CM&D) architecture needs to conform. Software design professionals require both an information model and a processing model to adequately describe all data processing requirements. ISO 13374-2:2007 facilitates the interoperability of CM&D systems.

ISO 13379:2003 - Condition monitoring and diagnostics of machines - General guidelines on data interpretation and diagnostics techniques gives guidance for data interpretation and diagnostics of machines. It is intended to allow the users and manufacturers of condition monitoring and diagnostics systems to share common concepts in the fields of machine diagnostics; to enable users to prepare the necessary technical characteristics that will be used for the further diagnosis of the condition of the machine; and to give an appropriate approach to achieve a diagnosis of machine faults.

Since it gives general guidelines, a list of the machine types addressed is not included. However, the machine sets covered by ISO 13379:2003 will normally include industrial machines such as turbines, compressors, pumps, generators, electrical motors, blowers and fans.

ISO 13380:2002 - *Condition monitoring and diagnostics of machines -- General guidelines on using performance parameters.* This International Standard describes the general conditions and procedures for recording, assessment, evaluation and diagnostics of machine condition by measuring parameters related to machine performance, condition and safety, including thermal, electrical and hydraulic parameters where applicable.

The procedures relate to operational monitoring of machines, and include all components and sub-assemblies necessary to provide the functional operation of the machine.

ISO 13381-1:2004 - *Condition monitoring and diagnostics of machines - Prognostics - Part 1: General guidelines* provides guidance for the development of prognosis processes. It is intended to allow the users and manufacturers of condition monitoring and diagnostics systems to share common concepts in the fields of

machinery fault prognosis; to enable users to determine the necessary data, characteristics and behavior necessary for accurate prognosis; to outline an appropriate approach to prognosis development; and to introduce prognoses concepts in order to facilitate the development of future systems and training.

ISO 17359:2003 - ***Condition monitoring and diagnostics of machines -- General guidelines*** sets out guidelines for the general procedures to be considered when setting up a condition monitoring program for machines, and includes references to associated standards required in this process. It is applicable to all machines.

ISO 18434-1:2008 - ***Condition monitoring and diagnostics of machines -- Thermography -- Part 1: General procedures*** provides an introduction to the application of infrared thermography (IRT) to machinery condition monitoring and diagnostics, where "machinery" includes machine auxiliaries such as valves, fluid and electrically powered machines, and machinery-related heat exchanger equipment. In addition, IR applications pertaining to machinery performance assessment are addressed.

ISO 18434-1:2008: introduces the terminology of IRT as it pertains to condition monitoring and diagnostics of machines; describes the types of IRT procedures and their merits; provides guidance on establishing severity assessment criteria for anomalies identified by IRT; outlines methods and requirements for carrying out IRT of machines, including safety recommendations; provides information on data interpretation, and assessment criteria and reporting requirements; provides procedures for determining and compensating for reflected apparent temperature, emissivity, and attenuating media.

ISO 18434-1:2008 also encompasses testing procedures for determining and compensating for reflected apparent temperature, emissivity, and attenuating media when measuring the surface temperature of a target with a quantitative IRT camera**.**

ISO 18436-1:2004 - ***Condition monitoring and diagnostics of machines - Requirements for training and certification of personnel - Part 1: Requirements for certifying bodies and the certification process*** defines the requirements for bodies operating certification systems for personnel who perform machinery condition monitoring, identify machine faults, and recommend corrective action. Procedures for the certification of condition monitoring and diagnostic personnel are specified.

ISO 18436-3:2008 - ***Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 3: Requirements for training bodies and the training process*** defines the requirements for bodies operating training programs for personnel who perform machinery condition monitoring, identify machine faults, and recommend corrective action. Procedures for training of condition monitoring and diagnostic personnel are specified.

ISO 18436-7:2008 - *Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel-- Part 7: Thermography* specifies the requirements for qualification and assessment of personnel who perform machinery condition monitoring and diagnostics using infrared thermography. A certificate or declaration of conformity to ISO 18436-7:2008 will provide recognition of the qualifications and competence of individuals to perform thermal measurements and analysis for machinery condition monitoring using portable thermal imaging equipment. This procedure may not apply to specialized equipment or other specific situations. ISO 18436-7:2008 specifies a three-category classification program.

ISO 80601-2-56:2009 - Medical electrical equipment - Part 2-56: Particular requirements for basic safety and essential performance of clinical thermometers for body temperature measurement applies to the basic safety and essential performance of a clinical thermometer in combination with its accessories, referred to as ME equipment. ISO 80601-2-56:2009 specifies the general and technical requirements for electrical clinical thermometers. ISO 80601-2-56:2009 applies to all electrical clinical thermometers that are used for measuring the body temperature of patients.

Clinical thermometers can be equipped with interfaces to accommodate secondary indicators, printing equipment, and other auxiliary equipment to create ME systems. ISO 80601-2-56:2009 does not apply to auxiliary equipment.

ME equipment that measures a temperature not as a primary purpose, but as a secondary function, is outside the scope of ISO 80601-2-56:2009.

Requirements for ME equipment intended to be used for non-invasive human febrile temperature screening of groups of individuals under indoor environmental conditions are given in IEC 80601259:2008 and such ME equipment is not covered by ISO 80601-2-56:2009.

ISO 6781: 1983 - Thermal Insulation---Qualitative Detection of Thermal Irregularities in Building Envelopes---Infrared Method. Specifies a qualitative method, by thermographic examination (infrared method), for detecting thermal irregularities in building envelopes. The method is used to identify wide variations in the thermal properties, including air tightness, of the components constituting the external envelopes of buildings. Does not apply to the determination of the degree of thermal insulation and air tightness of a structure.

LETA Certifications

After a qualifying training Basic or Advanced session, students will be offered the opportunity to take a written test. A passing score is 80% or higher. Passing students may complete a certification request at the training site.

OIML Standards

OIML has several standards related to radiation temperature measurements and equipment used to perform them. Of these, the most significant one of Thermographer interest is:

OIML R 141: ***Procedure for calibration and verification of the main characteristics of thermographic instruments- (Confirmed 2008-10-31).*** It is available online as a free downloadable pdf document. (www.oiml.org/publications/R/R141-e08.pdf)

The opening line is significant, I believe. It states:

"This Recommendation applies to general purpose thermographic instruments and specifies the procedure <u>for their calibration, and also for their initial and subsequent verifications.</u>" *(Emphasis added*)

It then goes on to specifically identify what is meant by calibration and verification, stating in Section 3:

"Characteristics of a thermographic instrument to be verified"

"In the process of verification, the following metrological characteristics of a thermographic instrument shall be determined:

- spatial resolution;
- field of view;
- instantaneous field of view;
- accuracy of radiation temperature measurement;
- noise equivalent temperature difference;
- number of damaged sensitive elements;
- sensitivity to non-uniformity in the field;
- influence of environmental conditions on the performance of the instrument; and
- repeatability of the thermographic instrument readings"

In subsequent sections it goes into detail about how each property or instrument characteristic is to be determined and in Section 5.8 states:

"**5.8 Checking the range and estimating the accuracy of the radiation temperature measurement**
5.8.1 Measurements are taken at a distance from the reference radiator and the thermographic instrument that ensures coverage, by the aperture of the radiator, greater than 20% of the field of view of the thermographic instrument. The emitting surface of the standard radiator is matched with the central area of the thermogram.
5.8.2 The accuracy of a thermographic instrument is determined for at least *five points of the working temperature range (the lower, the upper and three points within the range)* for each operation mode (temperature range). When the steady-state conditions of a radiator are set, a minimum of five measurements is taken by the thermographic instrument for each temperature".

The mean value of the radiation temperature of the standard radiator is determined using the thermogram t_{mean} (°C) taking into account its emissivity and the temperature of the background radiation."

The number of standards and their breadth of coverage has grown extensively since 2004. The emphasis on unified terminology and practices for calibration and technical descriptions of equipment is evident.

RESNET

RESNET Interim Guidelines for Thermographic Inspections of Buildings **(September 29, 2010)** provides guidance on the use of infrared thermography for the inspection of low rise, three stories or less, wood or steel frame, residential and light commercial buildings. (Free online as a PDF download at: www.resnet.us/standards/RESNET_IR_interim_guidelines.pdf)

The three-fold purpose of this standard is to:

- Provide for the means by which those wishing to obtain a RESNET advanced certification in infrared thermography will have a means to do so
- Provide inspection guidance in using infrared thermography for air intrusion and insulation inspections
- Provide a possible substitute for an insulation inspection on a new building where viewing of the insulation installation was not accomplished before the drywall was applied

This RESNET Standard also includes information for:

- Using an infrared imaging system to determine radiation differences associated with surface temperature variations of a building enclosure
- Determining whether the areas being viewed meet the specifications in this Standard and in the RESNET 2006 Mortgage Industry National Home Energy Rating System Standards
- Documenting the type and extent of any observed anomalies
- Locating the primary areas needing further physical inspection
- Providing an indication of thermal insulation performance and continuity, and
- Indicating areas affected by air and convection when an infrared imaging system is used in combination with blower door operation.

Certification for Infrared Inspections of Buildings
All individuals applying for IR certification must have attained the RESNET certification of at least a Building Performance Auditor (BPA).

The person applying to RESNET for the Infrared Inspection of Buildings Certification will have two possible courses of action:

Thermographic Imaging Requirements

Infrared Imaging System Performance

The infrared imaging system must have the gain or contrast set so as to be able to distinguish a framing member from the other parts of the envelope cavities under the prevailing thermal conditions with the IR imaging system at a distance, which permits the recognition of thermal anomalies...

Resolution
The Noise Equivalent Temperature Difference (NETD), which is a measurement of thermal resolution or sensitivity, must be less than or equal to 0.10 °C at 30 °C (0.18 °F at 86 °F).

Spectral Range
The infrared imaging system must have an operating spectral range that falls anywhere between 2 and 15 micrometers (μm).

Field of View (FOV)
This is defined as the picture size or total field of view, which is normally expressed in angular degrees or radians per side if rectangular and angular degrees or radians if circular. The FOV should be capable of showing at least two wall-framing cavities across while still being able to resolve an individual framing member. In order to accomplish this prerequisite, a FOV of approximately 20 degrees is suggested.

Recorded Images
The imaging system must have a means of recording images seen on the camera's screen. The images may either be in a video format or in individual still frame images.

Instantaneous Field of View and Detector
The detector and lens combination of the infrared imaging system must have sufficient resolution to resolve framing members and the small void areas or wall cavities. For practical purposes, the camera's detector array must have no less than 120 x 120 pixels.

Infrared Training Providers
The Infrared Training Provider must be a RESNET HERS Rater Provider or a RESNET Training Provider in good standing and have a RESNET Infrared Rater Trainer on staff or under annual contract.

The IR Training Provider will ensure three months experience either before or after the training and will review the first three reports or examples of old reports to ensure compliance with Section 802.8 of the RESNET Standards.

The Provider will also ensure compliance with all CEUs (18 hours in a three year period) necessary to remain a RESNET trained Building Science Thermographer.

RESNET will provide electronic confirmation/recognition upon completing the RESNET Building Science Thermographer certification requirements.

This Standard recognizes that federal or state laws take precedent over this Standard.

This Standard is only an interim one, the question of final standard details will await further developments. But it took from 1995 until 2010 to see the first published, interim, version.

Final Thoughts

Clearly the role of standards is not only here, it is growing quickly as this equipment finds its way into more and more applications in industry, science and commerce. It would be well for thermographers to keep an eye on future developments, especially when bidding jobs with new clients.

Equally clear, to me at least, is that calibration is finally coming into view as a critical component of both selection and maintenance of thermal imagers. Users are getting serious about devices having the fundamental capability of reporting traceable temperatures. To that end, perhaps now we will begin to see manufacturers updating their specifications accordingly.

As a support to this standards collection we are expanding the content on our free access IRWeb.INFO website (also known as: IRApps.com) to provide more information on standards relating to infrared radiation thermography and thermometry. The list provided here, with live web links is already online there.

As a final note, listed below are organizations that already publish infrared standards along with those that have the potential to do so. Some may already have; we don't pretend to know them all.

If you learn of any new, published standards and/or certification requirements, please let me know. The easiest way is to enter a note on www.IRApps.com as a submission or just a comment. Either way, your contribution to the rest of the thermography world will be recognized and certainly appreciated by your fellow infrared thermographers.

Other Potential Thermography Standards Resources

A2LA (American Association for Laboratory Accreditation) (www.a2la.org)
ACI International (www.concrete.org)
Aerospace Industries Association of America (www.aia-aerospace.org)
American Architectural Manufacturers Association (www.aamanet.org)
American Boat and Yacht Council (www.abycinc.org)
American Institute of Steel Construction (www.aisc.org)
American Iron and Steel Institute (www.steel.org)
American National Standards Institute (www.ansi.org)
American Nuclear Society (www.ans.org)
American Petroleum Institute (www.api.org)
American Society of Home Inspectors (ASHI) (www.homeinspectioninstitute.com)
American Society for Quality (www.asq.org)
American Society of Agricultural and Biological Engineers (ASABE) (www.asabe.org)
American Society of Civil Engineers (www.asce.org)
American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (www.ashrae.org)
American Society of Mechanical Engineers (ASME) (www.asme.org)
American Society of Safety Engineers (www.asse.org)
American Society of Sanitary Engineers (www.asse-plumbing.org)
American Water Works Association (www.awwa.org)
American Welding Society (www.aws.org)
Association for the Advancement of Medical Instrumentation (www.aami.org)
Association of Equipment Manufacturers (www.aem.org)
Automotive Industry Action Group (www.aiag.org)
ASTM International (www.astm.org)
Building Industry Consulting Service International, Inc. (www.bicsi.org)
Building Owners and Manufacturers Association (www.boma.org)
Canadian Standards Association (CSA) International (www.csa.ca)
Composite Panel Association (www.pbmdf.com)
Conveyor Equipment Manufacturers Association (www.cemanet.org)
Cooling Technology Institute (www.cti.org)
Ductile Iron Pipe Research Association (www.dipra.org)
Electrical Apparatus Service Association (www.easa.com)
Electrical Generating Systems Association (www.egsa.org)
Environmental Industry Associations (www.envasns.org)

Institute of Industrial Engineers (www.iienet2.org)
Institute of Inspection, Cleaning & RestorationCertification (www.iicrc.org)
Institute of Electrical and Electronics Engineers (IEEE) (www.ieee.org)
International Society of Explosives Engineers (ISEE) (www.isee.org)
International Association of Electrical Inspectors (IAEI) (www.iaei.org)
International Facility Management Association (www.ifma.org/)
ISA - International Society for Automation (www.isa.org)
Masonry Society (www.masonrysociety.org)
Material Handling Institute (www.mhia.org)
NACE International (www.nace.org)
North American Energy Standards Board (www.gisb.org)
North American Reliability Corporation (www.nerc.com)
National Board of Boiler and Pressure Vessel Inspectors www.nationalboard.org)
National Concrete Masonry Association
NCSL International (www.ncsli.org)
Standards Engineering Society (www.ses-standards.org)
And more…

References

A View to Thermal Imaging's Future!, G. Raymond Peacock, IR/INFO 2004, Orlando FL Jan 18-21, 2004

Simplified Calibration of Radiometric Equipment, Michael R. Sharlon, IR/INFO 2004, Orlando FL, Jan 18-21, 2004

Confidence Limits in Temperature Measurements, G. Raymond Peacock, IR/INFO 2003, Orlando, FL, Jan 2003

International Standards Organizations, Wikipedia.org: http://en.wikipedia.org/wiki/Standards_organizations#International_Standards_Organizations

Procedure for calibration and verification of the main characteristics of thermographic instruments (*Confirmed 2008-10-31)* a free downloadable pdf document. (www.oiml.org/publications/R/R141-e08.pdf)

www.StandardsLearn.org an online resource for self-paced e-learning programs that help to raise awareness of standards and conformity assessment activities.