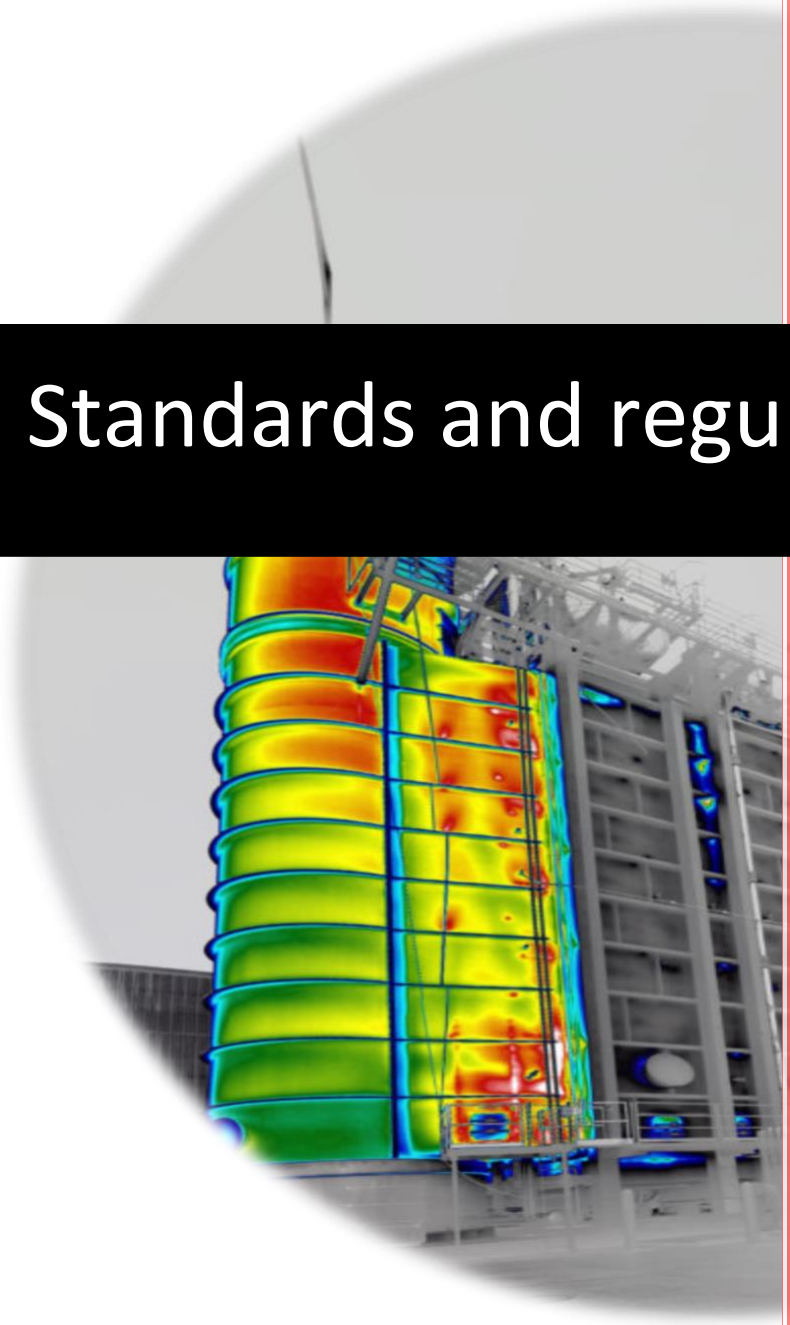
Standards and regulations



Colbert
Infrared Services

1. Standards and regulations covering the conduction of Infrared electromechanically inspections

Training and qualification of who can perform these inspections.

- ASTM - American Society for Testing and Materials (ASTM E1934 - 07)
- ASNT - American Society of Nondestructive Testing (ASNT-TC-1A)
- ISO - International Organization for Standardization (18436-7)

Inspection procedures and documentation requirements.

- ASTM - American Society for Testing and Materials (ASTM E1934 - 07)

Selection of proper Infrared imaging equipment for the appropriate type of inspection.

- ASTM - American Society for Testing and Materials (ASTM E1934 - 07)

Safety of personal who are involved in these types of surveys.

- OSHA - Occupational Safety & Health Administration (29 CFR 1910.132 (d)(1), 29 CFR 1910.269 (l)(6)(iii), 29 CFR 1910.335 (a)(1)(i), (iv), (v))
- NFPA - National Fire and Protection Agency (NPFA 70E)

Electrical Maintenance

- NFPA - National Fire and Protection Agency (NPFA 70B)

Many of these standards and requirements reference each other so that it is essential to understand that you cannot pick and choose what you wish to follow since they are inter-dependent on each other. It is crucial to make sure that you are using a professional infrared thermographic company that is fully compliant with all of the standards and requirements.

Colbert Infrared Services, Inc. not only complies with, but exceeds these requirements and standards, but has also played a key role in their development over the years. It is only in adherence to them that ensures that any Infrared Consulting company that you hire can provide you with the quality that you deserve. It would help if you took it upon yourself to become familiar with these requirements and standards to ensure that you are getting the real value from your IR program. We are sure that if you do, you will understand the reason that we are so adamant about the quality of our services and why we feel uniquely qualified to provide you with truly, World Class Service. We will be glad to provide you with a copy of our Written Practice that defines our unique training and certification requirements for all of our thermographers.

The following information is a list of the key points, and a brief discussion so that you can be aware of them as they pertain to your inspection and how Colbert Infrared Services, Inc. has complied and exceeded them.

We have tried to condense the highlights for you so that you can have a solid understanding of the significant concerns that these requirements and standards address.

Please remember that if you have any further questions that it is best that you thoroughly review the entire standards and requirements yourself.

If you need any assistance in obtaining a copy of them or have any questions as to how they apply to your situation, *please feel free to ask as for assistance, and we will be glad to help you better understand these documents.*

1. Qualifications and Expertise

Who is qualified to perform your inspection?

OSHA, ASTM, ASNT, and ISO clearly define who is qualified to perform your infrared thermographic inspections. It is based on extensive training, written examinations, practical testing, and field experience. These requirements are based on three levels of certification, depending on the type of inspection/IR program requirements that are needed. A solid foundation in physics, thermal dynamics, heat transfer, camera operation, data collection, image analysis, and applications are at the core of these requirements.

A person performing these inspections must be certified to be able to perform these inspections and be able to present a written practice that outlines and details their level of certification.

Colbert Infrared Services, Inc. has selected The Professional Thermographers Association as the training and certification organization for all of our employees.

The training curriculum topics cover Physics, Heat transfer, Thermodynamics, IR camera operation, data collection, and analysis as well as in-depth specific application training.

The training that Colbert Infrared Services, Inc. receives by The Professional Thermographers Association far exceeds the minimum requirements as outlined below.

ASTM - American Society for Testing and Materials (ASTM E1934 - 07)

6.2 The infrared thermographer shall:

6.2.1 Possess certification of adequate knowledge and training in the practice of infrared thermography, as defined in ASNT SNT-TC-1A, for the duties they are assigned:
6.2.1.1 Level I thermographers may perform examinations, collect data, and, as appropriate, make evaluations based on specific, written “pass/fail” criteria.
6.2.1.2 Level II thermographers may perform examinations, collect data, analyze data and prepare reports. Level II competency is recommended for determination of emissivity and most radiometric temperature measurements.
6.2.2 Possess certification of adequate knowledge and training in safety practices associated with working on energized electrical equipment (NFPA 70E), and adequate knowledge and training as required by the owner for necessary familiarity with their facility, operations and equipment.

American Society for Nondestructive Testing (ASNT) standard ASNT-TC-1A

The American Society for Nondestructive Testing (ASNT) standard ASNT-TC-1A provides specific and recommended guidance for minimum qualifications and training of personnel involved in infrared thermography.

It requires the Thermographic company to define in its “Written Practice”, the scope of the training and qualifications of infrared thermographers, as well as the capabilities of personal that are to be performing infrared inspections. This Written Practice shall be made available upon request to any company that is going to be hiring the Thermographic Company for their services.

ANST-TC-1A defines the qualified thermographer as someone that has passed the following:

Testing Requirements:	**Qualification Requirements**
Vision	
Near Vision Acuity Test	Annual Test
Color Contrast Differentiation	Upon Initial Certification and every 3 years there after
Course Training	
Hours Required for Level I, II, and III	32 Hours
Written Examination	
General Examination	40 Questions (Min. 80% to Pass)
Specific Examination	20 Questions (Min. 80% to Pass)
Practical Examination	Minimum 1 Specimen (10 performance Checkpoints)

Initial Experience Levels	
Level I Minimum Required Work Experience	210 Hrs (26.25 days, 5.25 Weeks, 1.3 Months)
Level II Minimum Required Work Experience	1,260 Hrs (157.5 days, 31.5 Weeks, 7.8 Months)

International Organization for Standardization defines in the Standard ISO 18436-7

The International Organization for Standardization defines in the Standard ISO 18436-*7*

Condition monitoring and diagnostics of machines, the requirements for qualification and assessment of personnel involved in conduction Infrared thermography inspections

Testing Requirements:	Qualification Requirements
Minimum duration of cumulative training (hours)	
Level I	32 Hrs
Level II	64 Hrs
Level III	96 Hrs
Minimum examination content	
Level I	50 Questions in 2 Hrs (Min. 75% to Pass)
Level II	60 Questions in 2 Hrs (Min. 75% to Pass)
Level III	60 Questions in 2 Hrs (Min. 75% to Pass)
Supplementary Exam	30 Questions in 1 Hrs (Min. 75% to Pass)
Minimum cumulative practical, interpretation and program management experience requirements (months and hours)	
Level I	12 Months (400 Hrs of actual thermography experience = 50 days)
Level III	48 Months (1,920 Hrs of actual thermography experience = 240 days)
Level III	48 Months (1,920 Hrs of actual thermography experience = 240 days)

2. Regulations and Procedures

What regulations, procedures and documentation requirements are needed?

Inspection procedures and documentation requirements for Infrared Thermography.

Colbert Infrared Services, Inc. is on the steering comity for the development of ASTM standards.
We have been directly involved with the development of the ASTM E1934-07 Standard. It is very important that this standard is utilized when performing Infrared Inspections as to the fact that it is OHSA uses it in its references to work place safety. The following is a brief exert that defines the Significance and Use as well as the responsibilities for both the owner and the thermographer.

ASTM E1934 - 07 is the Standard Guide for Examining Electrical Power Distribution Equipment with Infrared Thermography.

The scope of this document lists the testing procedures and responsibilities of the owner and the infrared thermographer when examining electrical power distribution equipment. Section 5 outlines the use of the document in an IR program and Section 6 defines the responsibilities of personnel.

Significance and Use

5.1 This guide can be used by an owner to specify how an infrared examination of electrical equipment shall be conducted and who is qualified as an infrared thermographer (ref 1.3.2) to perform such examinations.

5.2 The purpose of infrared examinations of electrical equipment is to document the "as-found" condition of the equipment. When this involves the identification of anomalous components or systems, further measures or testing are generally required to fully understand the root cause of the anomaly, or to correct problems before failures occur, or when appropriate to "run to failure," to minimize consequences.

5.3 Anomalies in electrical components can be generally grouped in one of two categories:

5.3.1 Abnormal electrical resistance at points of electrical contact, such as connectors and switch mechanisms, which is typically caused by loose or deteriorated connections, improperly installed components, corrosion, and metal fatigue.

5.3.1.1 Thermal signatures for these types of anomalies will typically be warmer than normal at the high-resistance contact point with diminished temperatures as distance increases from that point.

5.3.2 Overloads on undersized conductors or circuits and abnormal load imbalances.

5.3.2.1 Thermal signatures for these types of anomalies will typically be equally warmer (or occasionally equally cooler) than normal throughout the entire circuit, phases or portion of the system affected by the anomalous condition.

5.3.3 In addition, equipment may be located that is anomalous but cooler than normal as a result of failed or inoperable components.

5.4 Mechanical failures, such as misalignment, unbalanced loads, improper lubrication, corrosion or excessive wear of parts and components, may also have an impact on the electrical systems associated with them.

5.5 System or component failures often result in substantially higher repair costs compared to identifying the anomaly prior to failure and remedying the condition on scheduled downtime rather than incurring unexpected breakdowns.

5.6 These failures can also result in increased risk of substantially greater loss of plant equipment and production capabilities as well as putting personnel at risk.

6. Personnel Responsibilities

6.1 The Owner shall

6.1.1 Establish an inventory list of the equipment to be examined.

6.1.2 Provide a qualified escort to accompany the thermographer, for the purpose of, among other duties:

6.1.2.1 Locating equipment and ensuring its safe examination

6.1.2.2 Opening/Closing electrical panels

6.1.2.3 Removing/replacing protective covers

6.1.2.4 Measuring electrical loads

6.1.2.5 Assisting in assessing the presence and criticality of anomalies and recommended remedial actions

6.1.3 Meet with the thermographer and the qualified escort assigned to the thermographer, to review the equipment scheduled for examination and ensure that all required safety practices have been met and required personal protective equipment is provided.

6.1.4 Shall issue an "Energized Electrical Work Permit" in accordance with the recommendations of NFPA 70E when working on energized electrical equipment.

6.1.5 The owner shall assume full responsibility for consequences resulting from actions taken, or not taken, as a result of data provided by an infrared examination.

6.2 The infrared thermographer shall:

6.2.2 Possess certification of adequate knowledge and training in safety practices associated with working on energized electrical equipment (NFPA 70E), and adequate knowledge and training as required by the owner for necessary familiarity with their facility, operations and equipment.

6.2.3 Verify the owner's designation of the flash protection boundary and if the boundary is to be crossed, use appropriate personal protective equipment.

6.3 Unless the thermographer is qualified, the thermographer shall not:

6.3.1 Cross the restricted approach boundary

6.3.2 Remove or replace panel covers or open or close electrical cabinets containing energized electrical components

6.3.3 Measure electrical loads

Inspection data management – Database and reports

As per ASTM and ISO regulations and standards, Colbert Infrared Services, Inc. utilizes a Microsoft SQL Relational Database Management System called Thermal Trend – Lean DB®, that has been specifically designed for conduction Infrared Thermographic inspections and managing IR PdM programs.

Thermal Trend – Lean DB provides for lies complete historical tracking and trending and advanced analysis of thermal abnormalities that are found on equipment. Below are exerts from the specification requirements for documentation and data management from ASTM and ISO:

ASTM E1934 - 07 is the Standard Guide for Examining Electrical Power Distribution Equipment with Infrared Thermography

8. Report

8.1.3 When relevant, the history of any previously found anomalies associated with the particular component or system (NFPA 70B). Trending of an anomaly over time.

NFPA 70B

4-4.3 Wherever practical, a history of each electrical system should be developed for all equipment or parts of a system vital to a plant's operation, production, or process.

The record should include all pertinent information for proper operation and maintenance. This information is useful in developing repair cost trends, items replaced, design changes or modifications, significant trouble or failure patterns, and replacement parts or devices that should be stocked. System and equipment information should include the following:

- Types of electrical equipment, such as motors, starters, contactors, heaters, relays
- Types of mechanical equipment, such as valves, controls, and so on, and driven equipment, such as pumps, compressors, fans—and whether they are direct, geared, or belt driven.
- Nameplate data
- Equipment use
- Installation date
- Available replacement parts
- Maintenance test and inspection date type and frequency of lubrication; electrical inspections, test, and repair; mechanical inspections, test, and repair; replacement parts list with manufacturer's identification; electrical and mechanical drawings for assembly, repair, and operation.

ISO 18436-7, ISO 13374, ISO 13372, ISO 13379

11. Condition monitoring program management Database management

Individuals classified as Category I are qualified to perform infrared thermography according to established and recognized procedures. Personnel classified as Category I shall be able to:

f) Maintain a database of results and trends

3. Select your Infrared Equipment

ASTM specifically addresses the need for using the correct "infrared imaging system" to insure that it is within the correct limits of both spatial and measurement resolution of the application.

Not all IR imaging equipment are the same, and that different applications will place different requirements on the resolution of the camera, the Field of View (FOV) of the lens and the Instantaneous Field Of View (IFOV) of a single detector. These requirements need to be carefully considered when selecting the correct IR imaged system and lens configuration, or the results of the inspection will be severely compromised. Also please note that the uses of "Spot Radiometers" are not recommended for electrical inspections. These devices typically do not have the required measurement field of view that is needed to be able to correctly identify a problem, and should not be used for conducting infrared inspections.

Colbert Infrared Services, Inc. used only state-of-art infrared imaging systems from in both Short/Mid Wave 3-5, and Long/Far 7.5-14 micron wavelengths, from the following manufactures: FLUKE, Mikron / NEC, Jenoptik-IR, and FLIR.

We also have a large selection of additional lenses that we used depending on the imaging requirements for correct temperature measurements and IR windows.

ASTM E1934 – 07 Standard Guide for Examining Electrical Power Distribution Equipment with Infrared Thermography

7. Procedure

7.6 Thermographic examinations shall be made using an **infrared imaging system**, producing a thermogram for documenting, ideally, any components or systems that are not opera

ting normally.

7.6.1 Every effort shall be made to ensure the thermal image is in sharp focus; failure to do so can render further analysis difficult and may mean radiometric temperatures, if measured, are inaccurate.

7.6.2 Thermal images shall be stored, preferably at bit depths of 12-bit or greater, on electronic media.

7.8 **Spot radiometers are not recommended** for locating anomalies but, when properly used, they may sometimes be employed to measure radiometric temperatures.

7.9.3.4 Care should be taken to work within the limits of both spatial and measurement resolution for the infrared system being used. Supplemental telephoto lenses may be required for some kinds of work, such as outdoor substations or overhead lines.

4. Safety requirements

Personal Protection Equipment (PPE) for safety of personal who **conduct infrared Thermography.**

Colbert Infrared Services, Inc. strictly adheres to the Standards for Electrical Safety in the workplace and follows the specific requirements set forth in NPFA 70E.

ASTM E1934 – 07

6. Personnel Responsibilities

6.2.2 Possess certification of adequate knowledge and training in safety practices associated with working on energized electrical equipment

(NFPA 70E), and adequate knowledge and training as required by the owner for necessary familiarity with their facility, operations and equipment.

Arc Flash:

NFPA 70E - The National Fire Protection Association (NFPA) 70E "Standard for Electrical Safety in the Workplace", provides specific requirements and guidance regarding electrical risk hazard assessment and personal protective equipment requirements when working inside arc flash protection boundaries.

Table 130.7 defines the appropriate PPE (Personal Protection Equipment) for performing infrared thermography on electrical equipment when the thermographer is outside the restricted approach boundary. The table below outlines the Hazard / Risk Category vs. equipment.

Energized Equipment Description / Restricted Approach Boundary Distance Arc Clothing Requirements	Hazard /Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Panelboards or Other Equipment Rated 240 V and Below / Avoid contact	0	N	N
Protective Clothing, Nonmelting (according to ASTM F 1506-00) or Untreated Natural Fiber of equal to [J/cm2(cal/cm2)] = N/A FR Protective Equipment, Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves		Nonmelting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd2	
Panelboards or Switchboards Rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) / 304.8 mm (1 ft 0 in.)	1	N	N
FR Clothing, Minimum Arc Rating of 4 of equal to [J/cm2(cal/cm2)] = 16.74 FR Protective Equipment, Hard hat, Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves, Leather work shoes		Arc-rated FR shirt and FR pants or FR coverall	
600 V Class Motor Control Centers (MCCs) / 304.8 mm (1 ft 0 in.)	1	N	N
FR Clothing, Minimum Arc Rating of 4 of equal to [J/cm2(cal/cm2)] = 16.74 FR Protective Equipment, Hard hat, Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves, Leather work shoes		Arc-rated FR shirt and FR pants or FR coverall	
600 V Class Switchgear (with power circuit breakers or fused switches) / 304.8 mm (1 ft 0 in.)	2	N	N
FR Clothing, Minimum Arc Rating of 8 of equal to [J/cm2(cal/cm2)] = 33.47 FR Protective Equipment, Hard hat, Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves, Leather work shoes		Arc-rated FR shirt and FR pants or FR coverall	
NEMA E2 (fused contactor) Motor Starters, 2.3 kV Through 7.2 kV / 660.4 mm (2 ft 2 in.)	3	N	N
FR Clothing, Minimum Arc Rating of 25 of equal to [J/cm2(cal/cm2)] = 104.6 FR Protective Equipment, Hard hat, FR hard hat liner (AR), Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves, Leather work shoes		Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	
Metal Clad Switchgear, 1 kV Through 38 kV / 838.2 mm (2 ft 9 in.)	3	N	N
FR Clothing, Minimum Arc Rating of 25 of equal to [J/cm2(cal/cm2)] = 104.6 FR Protective Equipment, Hard hat, FR hard hat liner (AR), Safety glasses or safety goggles (SR), Hearing protection (ear canal inserts), Leather gloves, Leather work shoes		Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	

5. Frequency of Infrared Electrical inspection

A solid Infrared Predictive Maintenance Program is based on have a consistence schedule for the routine inspections of your equipment. NFPA 70B states that electrical equipment should be tested annually.

NFPA 70B - The National Fire Protection Association (NFPA) 70B ”Recommended Practice for Electrical Equipment Maintenance” provides useful guidance on the maintenance of electrical systems, including the use of infrared examinations (18-17) for the maintenance process.

18-17.5 defines the frequency of inspection:

Inspection Frequency and Procedures. Routine infrared inspections of energized electrical systems should be performed annually prior to shut down.

More frequent infrared inspections, for example, quarterly or semiannually, should be performed where warranted by loss experience, installation of new electrical equipment, or changes in environmental, operational, or load conditions.