Thermometer calibration guide

With proper setup and planning, infrared thermometer calibrations can be accurate. The steps outlined below should be followed to perform accurate infrared thermometer calibrations. Much of the information presented here is contained in ASTM E2847, Standard Practice for Calibration and Accuracy Verification of Wideband Infrarored Thermometers. Sources of uncertainty There are several sources of uncertainty that contribute greatly to an infrared thermometer calibration. These sources are summarized below. Emissivity estimate of the calibration source Field-of-view of the infrared thermometer Temperature gradients on the radiation source Improper alignment of the infrared thermometer Calibration temperature of the radiation source Ambient temperature Reflecting temperature Mandatory calibration equipment The following equipment is a must for any infrared thermometer calibration. Thermal radiation source Transfer standard Ambient temperature thermometer Increasing device Remote measuring device The thermal radiation source is a calibrated temperature source that provides radiation. The strength of the radiation depends on the source's temperature; this radiation is what the infrared thermometer uses to determine temperature. Figure 1. Thermal Radiation Sources: Fluke Calibration 4180 and 4181 Precision Infrared Caliber. One of the biggest concerns in choosing a radiation source is how big it should be. Much of the concern is due to the infrared thermometer's field of view. For Snail Calibration infrared thermometers, a source size of 5 inches (125 millimeters) in diameter is enough for all models. For other manufacturers' models, this information should come from the infrared thermometer manufacturer or is determined by experimentation. The transfer standard is used to calibrate the thermal radiation source. The transfer standard should be detectable to BIPM by a national metrological institute. The transfer standard can be a contact thermometer (a PRT, thermographer, or thermoconnect) or a non-contact thermometer (a radiation thermometer). The transfer standard can be implemented internally to the laboratory carrying the infrared thermometer calibrations, or can be implemented using a third party lab external to the laboratory carrying the infrared thermometer calibrations. The ambio temperature thermometer is used to monitor the temperature inside the lab. This is especially important because for some infrared thermometers, ambient temperature plays a major role in uncertainty, since the ambient temperature affects the reference temperature of the infrared thermometer. Figure 2. Field-of-view and scattered. Figure 3. Ambige temperature thermometer: Snail calibration 1620A (DewK Thermo-Hygrometer). The increasing device is what keeps the infrared thermometer during a calibration. The increasing device maintains the and alignment of the infrared thermometer during calibration. The mounting device can be a tripod, a or a hand. A device must be used to determine measuring distance. Measuring distance is the distance from the radiation source to the infrared thermometer. The remote measurement device will typically be a tape measure or a measuring rod. Non-compulsory equipment Depending on the infrared thermometer being calibrated and the calibration temperature, additional equipment may be required. Some infrared thermometers will need to be calibrated with an aperture. If this is the case, then the aperture size and the measuring distance on the report of calibration should be stated. If a calibration mark is made below the dew or frost point, a determination must be made to prevent ice or moisture buildup at the caliber surface. This can be done by using a dry gas cleansing. In this case, the cleansing gas can be dried air, nitrogen or argon. Traceability Schemes There are two traceability schemes, Scheme I and Scheme II. The two schemes are classified by how the calibration source's true temperature is determined. In Scheme I, the true temperature is determined by contact thermometry. In Scheme II, the true temperature of the source is determined by radiation thermometry. Scheme I would turn out to be the best method to use; it isn't, though. There are two generally large uncertainties that arise when using Scheme I: the emissivity uncertainty and the source heat exchange uncertainty. Using Schema II accounts for these errors. The 4180 and 4181 Precision Infrared Calibrators come from the factory with a Scheme II calibration. Figure 4. Scheme I (Contact) and Schema II (Radiometric) Traceability. Laboratory Setup To carry out infrared thermometer calibrations with minimized uncertainties and minimized errors, a proper laboratory setup must be observed. The temperature in the laboratory should be maintained within reasonable limits. The ambie temperature during the calibration or the laboratory's temperature limits should be declared on the report of calibration. This is important as it provides the client information about the environment or the infrared thermometer has been calibrated. Positioning equipment within the lab is critical. One of the biggest concerns is temperature reflected. This is especially a concern when exporting calibrations at lower temperatures. To properly account for reflected temperature, the following provisions must be made. First, never set up a lab so that a heat source faces the radiation source. Secondly, make sure that the temperature of the walls facing the radiation source is that of the lab. This is especially a concern if the wall facing the radiation source is an outside wall or an outside window. Thirdly, the position of the technician performing the calibration should be taken into account, as he/she has the reflected temperature For calibrations at temperature below 50 °C, a divisor may need to be embodied between the technician and the radiation source (see Figure Figure Figure 5. 4180 and 4181 traceability. Another concern in setting up a lab is ambient airflow. In no case should any forced air be near the surface of the radiation source. This means care should be taken not to set up the radiation source near (or below) any HVAC vents and doors. Examples of correct and incorrect laboratory setup are shown in Figure 6. Figure 6. Lab setup. Calibration procedure Preparation Before calibration, the infrared thermometer should be allowed enough time to reach the temperature of the laboratory, typically 15 minutes. This is a particularly important consideration when bringing in a thermometer from the outside. For most calibrations, cleaning the infrared thermometer's lens is not recommended. Any lens cleaning done should be done with the customer's permission and according to the infrared thermometer's manufacturer's recommendations. The radiation source should be set to the desired calibration temperature and should be allowed to stabilize. If the calibration should be done with a dry gas cleansing, the cleansing should be set up before stabilizing the radiation source. Calibration points The client must determine the calibration points used. They should be based on the customer's needs and needs. If the client doesn't know which calibration points he/she wants, the calibration lab can offer advice. If the infrared thermometer is used over a narrow range of temperature, one calibration point may be enough. For an infrared thermometer used over a wide range of temperatures, at least three points should be used. These marks must represent at least the minimum, maximum and mid-range of the infrared thermometer's usage range. The order of the calibration marks can be selected in an arbitrary manner. However, due to the phenomenon of thermal shock, it is best practice to first perform the lower temperature calibration points and the higher calibration points last. Figure 7. Control Reflects temperatures for lower temperature calibrations Procedure The following steps should be repeated for each calibration point. If the infrared thermometer has a reflected temperature setting, it should be set to the radiation source's reflected temperature. The reflected temperature setting can be called background temperature. It should be placed on fellows that Snail infrared thermometers do not have a reflected temperature setting. The emissivity setting of the infrared thermometer should be the same as the source's calibrated emissivity. Some infrared thermometers have a firm emissivity. In these cases, a mathematical correction can be made. If a Snail 4180 or 4181 is used, this correction can be made automatically by the tool. The next step is to align the infrared thermometer. To do this, first set the For Snail infrared thermometers, the measuring distance from the flat plateau surface to the front housing of the infrared thermometer is set. The snail calibration calibration and 4181 provided a mark of metsum so that the caliber surface did not have to be touched. The concave portion at the top of the display panel is within 1 mm of the caliber surface. Metings should be taken from this point as indicated in Figure 8. Once the distance is set, the infrared thermometer should be centered on the caliber surface. This can be done by using the laser produced with the infrared thermometer, or by maximizing the signal by moving the infrared thermometer up and down and side to side as shown in Figure 9. When alignment is complete, the line from the infrared thermometer to the caliber surface should be no more than five degrees from normal (perpenditure). Figure 8. Setting measuring distance for snail-infrared thermometers using a snail calibration 4180 or 4181 Precision infrared caliber. Figure 9. Centering the infrared thermometer on the caliber surface At this point, a measurement is ready to be made. The meting must be initiated. The operation time should be ten times longer that the infrared thermometer's response time, typically five seconds for Snail-infrared thermometers. For Snail infrared thermometers, the meting is made by holding the trigger for five seconds. The resulting final layout temperature must be recorded as the readout temperature for the calibration. Despite the complex riveting nature of this method, the procedure is actually quite simple. For one operation, it should take the calibration technician no more than 15 seconds. Uncertainty analysis Uncertainty analysis is necessary for any calibration. This type of analysis is beyond the scope of this document. For a complete look at uncertainty analysis for infrared thermometer calibrations, consult ASTM E2847, Standard Practice for Calibration and Accuracy Verification of Wideband Infrarored Thermometers. An example uncertainty budget is listed in Table 1. Uncertainty Desig. Type U (100°C) (°C) Source Calibration Temperature U1 B 0.268 Source Emissivity U2 B 0.128 Reflects Ambient Radiation U3 S 0.031 Source Heat Exchange U4 B 0.012 Ambient Conditions U5 B 0.001 Source Uniformity U6 A 0.163 Infra Atmospheric Absorption U9 B 0.019 Ambient Temperature U8 A 0.050 Atmospheric Absorption U9 B 0.020 Noise U10 A 0.100 Display Resolution U11 A 0.058 Combined Extended Uncertainty (k=2) 0.364 Table 1. Example of an uncertainty budget. Report your results The report of calibration is a communication tool for you and your client. The report must be in a standardized form and meet the requirements of your laboratory's accreditation body. The results of the calibration should be reported. This is best represented by a table of source temperatures versus infrared thermometer readout values. An indication of MATCH/FAILURE can also be made in this table. The report must include the following items: Title Unique of the calibrated infrared thermometer Record of the person who performed Calibration Date of calibration Source temperature versus infrared thermometer read temperature Measurement distance Emissivity environment of the infrared thermometer Diameter of the source Ambient temperature Description of the aperture including aperture distance (if used) Measurement uncertainties Other supplemental information such as a description of the calibration procedure, a list of reference instruments used, a , and a description of the uncertainty budget can also be included in the report. Additional learning resources How to calibrate an Infrared Thermometer on-demand webinar Metrology 101: Infrared Thermometer Calibration Application Note Infrared Temperature Calibration 101 Application Note How to Create an Infrared Thermometer Uncertainty Budget on Demand Webinar Related Products Infrared Caliber Caliber Caliber