Thermal Imaging Demonstrations

This document describes low-cost and simple activities that can be used by home energy and weatherization professionals and educators to help illustrate basic building science principles in an engaging way for students who are new to these concepts.

Introduction:

Thermal imaging, more commonly referred to as infrared scanning, is widely used in the weatherization and home performance industry to evaluate a variety of scenarios, including, but not limited to:

- Verifying insulation coverage
- Finding air or duct leaks
- Locating water leaks.

Infrared cameras are not X-ray vision; however, infrared cameras can allow us to "see" building anomalies when surface temperature differences are present within the camera's field of view. These temperature differences within the pixels of the infrared detector are converted into a visual image that we can interpret. The job of the infrared camera operator is to interpret what the image is telling us.

Use these simple classroom activities to learn more about thermography and basic principles of heat transfer and emissivity.[1]

[1] Emissivity: The amount of radiation coming from an object compared to that of a blackbody. Emissivity factor is a number between 0–1. The lower the emissivity, the more reflective the material. A low-emissivity window reflects heat into or out of the building.

Use to:

- Teach students basic building science principles using thermography.

Materials:

- Plastic garbage bag
- Water spritzer
- Scrap piece of insulation
- Scrap piece of wood (1″x4″ or 2″x4″)
- Two plastic cups and one can cooler
- Coins.

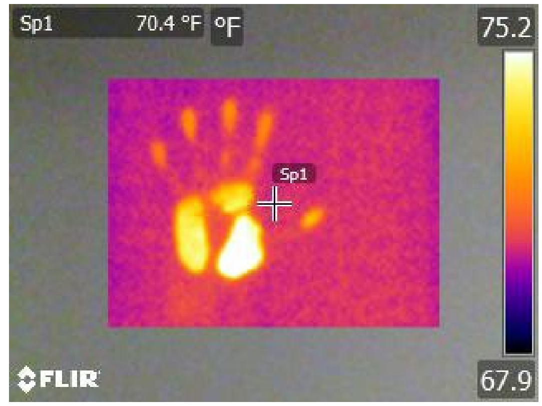
Equipment:

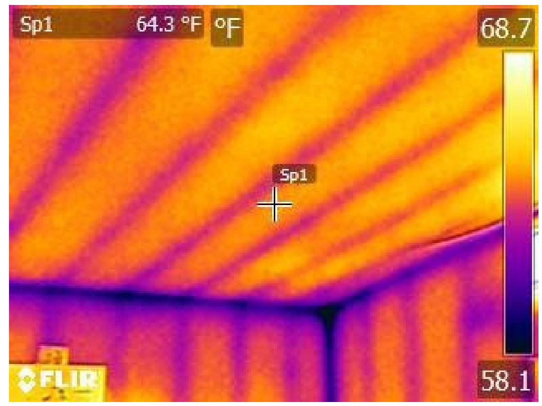
- Infrared camera (AV cord/s or Wi-Fi capable)
- Projection equipment (projector, large screen, laptop, etc.)
- Safety glasses
- Hair dryer.

1 Demonstration #1: Hand on the Wall *(Conduction heat transfer)*:

Ask a student to place their hand on the wall for 3–5 seconds.

Trainer notes: The heat signature of the hand will be visible on the wall surface, demonstrating the basic principle of heat conduction. Body heat from the hand is transferred to the wall surface through direct contact. Remind students that energy or heat moves from warm to cold. In a building scan, wood framing acts as a thermal bridge,[2] and when conditions are right, the framing pattern and any missing insulation will be visible, as shown in the image to the right.





Tips: Use a dynamic color palette; consider asking students what they think they will see; and challenge students to explain why the infrared camera was able to detect the heat signature of the hand and how they think this would be helpful when evaluating building components.

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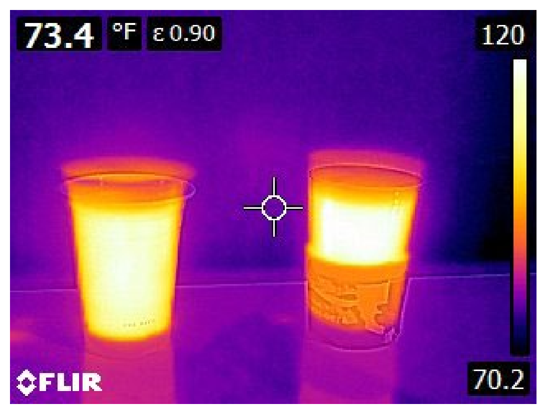
2 Demonstration #2: Hot Beverage in two Plastic Cups *(Temperature difference/insulation)*

Place two identical plastic cups on a table, but place a can cooler over half of one cup.

Fill each cup with a warm or cold fluid; in this example, we used hot tap water.

Trainer notes: The warm fluid will display the same temperature or heat signature, except the bottom of the cup with the can cooler will appear colder, demonstrating the effect insulation materials have by slowing the conductive or radiant losses through the cup. This example can be used to explain the basic concept of insulation R-value and how a home wrapped in a blanket of insulation will retain heat longer than an uninsulated building. Insulation slows heat transfer and is measured in R-value or resistance to heat flow. Remind students that the higher the R-value, the greater the insulation value or longer it will take for buildings to lose heated or cooled air.



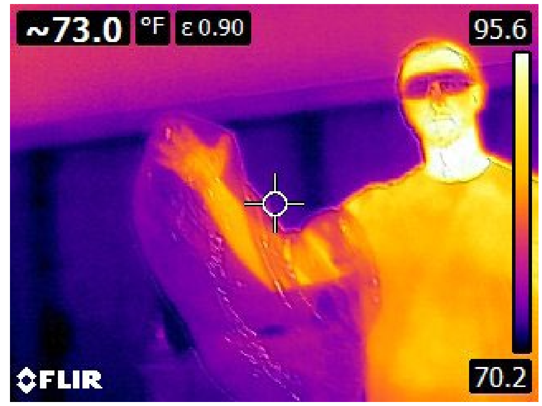
Tips: Use a dynamic color palette; consider asking students what they think they will see; and challenge students to explain why the infrared camera displayed a cooler surface temperature where the can cooler covered the cup and how they think this would be helpful when evaluating building components.

[2] Thermal bridge: A building component or material where rapid heat transfer occurs due to the higher thermal conductivity of the material relative to the surrounding materials. Wood framing of an insulated cavity is an example of thermal bridging.

3 Demonstration #3: Arm in a Bag with Safety Glasses *(Emissivity)*

Ask a student to put on a pair of safety glasses and place their arm into a plastic garbage bag.

Trainer notes: The body heat signature of the arm will be visible through the bag; however, the eyes will appear cooler, demonstrating the basic principle of emissivity or how different materials reflect or absorb heat. Body heat can easily transfer through the garbage bag, as this material has a high emissivity, while the safety glasses have a low emissivity factor. Remind students that all objects absorb or reflect heat energy and that the concept of emissivity is very important, and, depending on the climate location, will be an important consideration when selecting windows (e.g., low-emissivity) or exterior building materials (e.g., color of siding, roof, etc.). If scanning a low-emissivity window, the camera operator will see their own heat signature reflection in the glass, as the radiant body heat is reflected back almost like an image in a mirror.



Tips: Use a dynamic color palette; consider asking students what they think they will see; and challenge students to explain why the infrared camera was able to detect the heat signature of the arm, but not the eyes. Ask students if a high- or low-emissivity roofing material would be beneficial from an energy perspective during the summer in a cooling-dominated climate.

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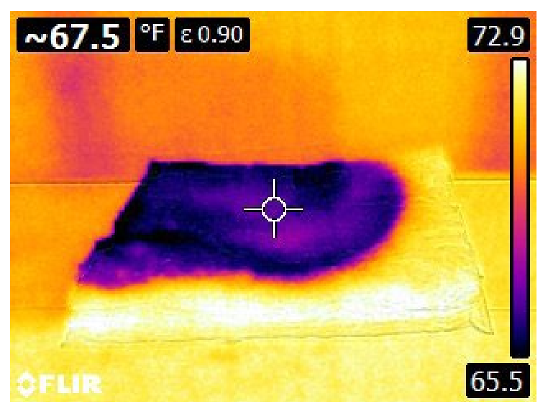
4 Demonstration #4: Wet Insulation *(Temperature difference/evaporation)*

Place a scrap piece of fiberglass or similar-type insulation material on a table.

Spray a portion of the insulation with a water spritzer 3–5 times.

Trainer notes: The wet insulation will display a dynamic cooling pattern, demonstrating the cooling effect that occurs when building materials become wet. The signature will remain for much longer than anticipated, and the insulation could be scanned an hour or two later with the insulation still appearing cool or wet through the eye of the camera. Remind students that there is a cooling effect to evaporation, and wet insulation or building materials are problematic for several reasons, such as degradation of R-value, mold/mildew growth, and eventually building durability, if repeated wetting occurs.



Tips: Use a dynamic color palette; consider asking students what they think they will see; and challenge students to explain why the infrared camera was able to detect the wet insulation and how they think this would be helpful when evaluating building components.

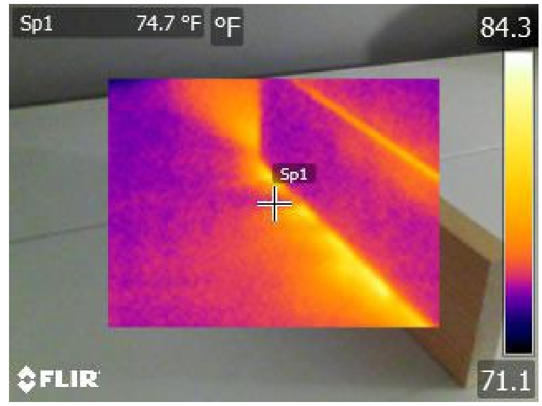
5 Demonstration #5: Hair Dryer

(Temperature difference/ convection/radiation)

Set a scrap piece of wood on a table using a few coins as spacers to create a small gap between the table and the piece of wood.

Move a hair dryer back and forth behind one side of the wood for about 10–15 seconds and turn off the hair dryer.

Trainer notes: The heat signature on the opposite side of the wood will be visible in a flaring pattern, demonstrating the basic principle of convection, more commonly referred to as air leakage. Heat from the hair dryer initially radiates from the coils in the hair dryer, and then a fan moves that heat across the surface. Remind students that convection or air leakage occurs in a building when there is a driving force like stack effect, wind, or fan that creates a pressure difference across a hole. In a building scan, when conditions are right, a similar flaring pattern will be visible where air leaks through gaps and cracks in the building envelope. In this demonstration, students are not seeing heated air but the difference in surface temperature due to warm air blowing across the table.



Tips: Use a dynamic color palette and consider asking students what they think they will see. Challenge students to explain why the infrared camera was able to detect the heat signature from the hair dryer through the crack and along the edge of the wood and how they think this would be helpful when evaluating building components. Additionally, after the hair dryer has been turned off, ask students why they think the temperature signature is still visible.

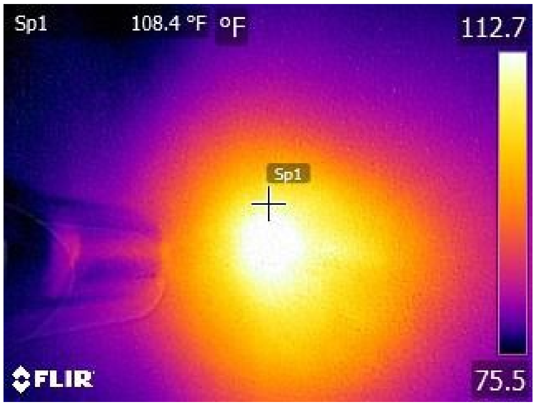
6 Optional Review Activity: Conduction, Convection, and Radiation

Consider adding this three-step final review or introductory activity as a visual representation of the key concepts described in the guide to reenforce or introduce the primary mechanisms of heat transfer. Complete the steps to illustrate conduction, convection, and radiation.

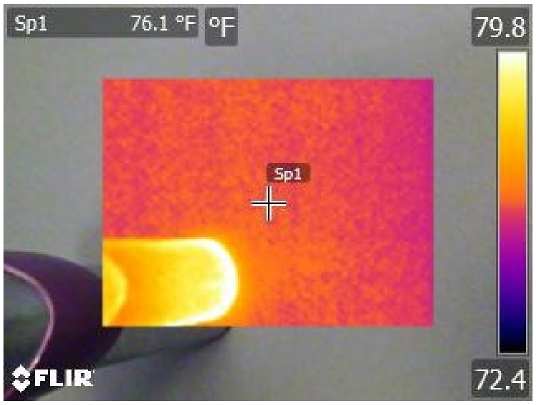
Continued

6 Optional Review Activity: Conduction, Convection, and Radiation *Continued*

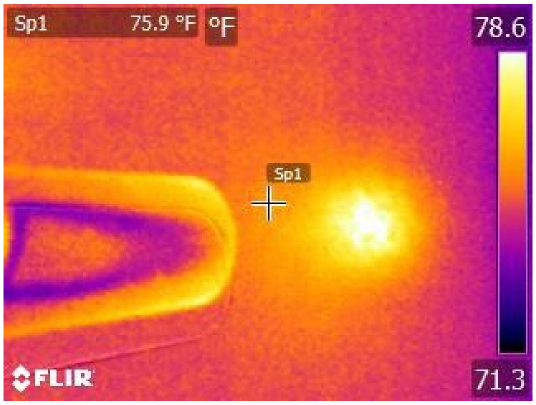
1. Convection (radiation acknowledged): Run the hair dryer for 10–15 seconds, then blow hot air from the hair dryer on the wall for 3–5 seconds.



2. Conduction (radiation acknowledged): Run hair dryer for about 30 seconds, then turn off. Touch hot end of hair dryer to the wall for 3-5 seconds, then remove.



3. Radiation: Run hair dryer for about 30 seconds, then turn off. Hold the hot end of dryer close to wall without touching it.



Trainer notes: Each step correlates to a primary method of heat transfer, so attempt to match each concept to a real world example in your own words. Think of convection as air movement, conduction as heat transfer between objects in contact, and radiation as heat transfer in a straight line where objects are not in contact (e.g., the sun and a window).

To match these concepts to home performance, remind students we air-seal buildings to stop convective losses, we insulate buildings largely to reduce conductive losses or gains (although other heat transfer mechanisms are impacted too), and we choose building materials that either reduce or increase heat transfer through radiation (e.g., cool roofs, or low-emissivity windows, radiant barriers, etc.) based on the climate and orientation building component.

Tips: Use a dynamic color palette and pause between each of the three activities to discuss. A live stream of the camera that all participants can easily see is critical to the success of all demonstrations.

All photos by Cory Chovanec, NREL

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