



# Thermal Resistance Performance Test Results of Reflective Duct Insulation

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## The Importance and Benefits of Duct Wrap Insulation

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Duct wrap insulation plays an essential role in enhancing HVAC system efficiency and building comfort. By providing a thermal barrier around air ducts, duct wrap reduces heat loss, prevents moisture problems, and helps increase occupant comfort.

1. **Energy Savings:** HVAC systems consume a substantial share of building energy,<sup>1</sup> and poorly insulated ducts can waste a significant portion of conditioned air before it reaches living spaces. Properly installed insulation via duct wrap minimizes heat transfer and reduces energy loss. The result is lower utility costs, reduced environmental impact, and greater sustainability.
2. **Condensation Control:** A critical benefit of duct wrap is preventing condensation on the exterior of metal air ducts. When cold air moves through uninsulated ducts in warm or humid spaces, the temperature of the duct surface can drop to the dew point, causing moisture buildup that may lead to mold growth, structural damage, or corrosion. Proper insulation helps maintain the duct surface above the dew point, protecting both ductwork and surrounding building materials.
3. **Comfort Control:** Insulated ducts help maintain consistent indoor temperatures by limiting heat loss or gain as air moves through unconditioned spaces such as attics, basements, or crawl spaces. This improves delivery temperatures, reduces hot and cold spots, stabilizes comfort levels, and reduces strain on HVAC equipment.

Duct wrap insulation is a modest investment with significant returns. By increasing energy efficiency, preventing condensation, and improving comfort control, it helps HVAC systems operate safely, reliably, and cost-effectively — whether installed during new construction or retrofitted later.

<sup>1</sup> U.S. Department of Energy (DOE), "Heating, Ventilation, Air Conditioning, Refrigeration, and Water Heating" (2025).



## Measuring Performance of Duct Insulation: Standard Tests

Duct Assembly as Tested to C335

ASTM C518, a surface-to-surface test, is the standard method used to measure the thermal conductivity or resistance of flat insulation materials, such as fiberglass batts, boards, or blanket insulation. In a controlled lab setting, a flat specimen is sandwiched between heat-flow plates, and the steady-state heat flux is measured. The resulting “R-value” reflects the insulation material’s inherent ability to resist heat flow, independent of how it will be installed.

By contrast, ASTM C335, a surface-to-surface or surface-to-air test, is designed for testing insulation when installed over pipes or ducts. Rather than a flat slab, C335 uses a circular (or otherwise shaped) configuration with insulation wrapped around a pipe. When calculated as surface-to-air, this method accounts for insulation fit, thickness variation, contact at seams and joints, surface effects, air films, convective/radiative heat transfer, and any metallic or reflective layers. As a result, the measured R-value reflects the assembly’s performance as a complete system rather than just the material’s intrinsic thermal resistivity.

Unlike fiberglass or mineral wool, reflective insulation is particularly sensitive to installation geometry and surface properties (metallic jackets, foil layers, air gaps, low-emissivity surfaces). Its thermal performance depends not just on conduction through the bulk insulation, but also on how well it reduces radiant heat transfer after installation and on how it interacts with convective air films or bridging.

Surface-to-surface testing and surface-to-air testing are two methods used to evaluate temperature performance in pipe insulation systems. Surface-to-surface testing measures the temperature difference between two solid surfaces — typically the outer surface of the pipe and the exterior surface of the insulation — to assess the insulation’s ability to resist heat transfer through conduction. In contrast, surface-to-air testing measures the temperature difference between the surface of the insulation and the surrounding ambient air, capturing both conductive and convective heat losses. While surface-to-surface testing focuses on the insulation material’s intrinsic thermal performance, surface-to-air testing includes the thermal resistance of the surrounding air film.



# Performance Testing Approach: Thermal Resistance of Duct Insulation According to ASTM C335 and Thermal Resistance According to ASTM C518

In 2024, the North American Insulation Manufacturers Association (NAIMA) contracted R&D Services to a conduct "Thermal Resistance of Duct Insulation According to ASTM C335" test on three different reflective duct insulation products. All specimens were conditioned for a minimum of 48 hours at  $73 \pm 4$  °F ( $23 \pm 2$  °C) and  $50 \pm 5$  %RH prior to testing. Product A was tested without a spacer. Product B received two tests, one with a spacer and one without. Product C was tested with a spacer.

## Performance Testing Results

| ASTM C335             |                 |                    |                |
|-----------------------|-----------------|--------------------|----------------|
|                       | Labeled R-value | Surface-to-Surface | Surface-to-Air |
| Product A (No Spacer) | 4.2             | 4.2                | 4.2            |
| Product B (No Spacer) | 6.0             | 6.0                | 6.0            |
| Product B (Spacer)    | 8.0             | 8.0                | 8.0            |
| Product C (Spacer)    | 8.0             | 8.0                | 8.0            |

*Systems installed according to manufacturer's recommendation*

In ASTM C335 surface-to-air tests, all reflective insulation products failed to meet their labeled R-value, except for Product A. Surface-to-surface results were all below the labeled R-value, underscoring the need for functioning air films for these products to meet their claims.

Additionally, two of the samples, Product A and Product B, also underwent the "Thermal Resistance According to ASTM C518" test. ASTM C518 tests revealed that the intrinsic R-values of these products at the material level are far below their stated R-values, further underscoring the integral role that functioning air films play in their insulation capacity.

| ASTM C518 |                 |                    |
|-----------|-----------------|--------------------|
|           | Labeled R-value | Surface-to-Surface |
| Product A | 4.2             | 0.76               |
| Product B | 6.0             | 2.79               |

## Conclusion

Designers, engineers, installers, and end users should be aware that reflective insulation products may not meet the labeled R-value, as evidenced by NAIMA's testing. These tests were conducted in laboratory conditions and may not reflect field performance, but they do highlight the necessity to ensure understanding of the performance of any insulation when contributing to the goals of a HVAC system. Air movement within the assembly and dust accumulation on reflective surfaces over time are both possible and would further reduce performance. Designers and engineers should reach out to manufacturers if they have questions about a product's performance.

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NAIMA is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. Its role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials. Through the Insulation Institute™, we leverage the collective insulation expertise of our organization and our members to empower homeowners and professionals to make informed insulation choices. Our mission is to enable a more comfortable, energy-efficient and sustainable future through insulation — and we are constantly working with building professionals, homeowners, government agencies, and public interest, energy and environmental groups to realize that vision.

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