



Celotex Corporation
Testing Services

10301 Ninth Street North
St. Petersburg, Florida 33716
(813) 578-4316
Fax (813) 578-4280

THERMAL TESTING LABORATORY REPORT

June 17, 1998

Client: Tenneco Packaging - AVI
1411 Pidco Drive
Plymouth, IN 46563

MTS Job No.: 258481B

Project: Thermal Performance of an Astro-Foil Reflective Insulation Wall Assembly

Introduction:

This report presents the results of thermal tests conducted on material submitted to our laboratory on April 6, 1998. Testing was completed on June 2, 1998.

Sample Identification:

Two (2) 48 inch wide rolls of reflective insulation material were supplied by the client and identified as Astro-Foil foil/bubble/bubble/foil (FBBF) reflective insulation.

Sample Preparation:

An 8 by 8 ft wall test assembly was fabricated using 5/16 inch thick Astro-Foil reflective insulation as per the client's request. A nominal 2 by 6 inch wood frame was constructed using 1.5 by 5.5 inch studs fastened together with wood screws. Four (4) framing members were placed 24 inches on center beginning 12 inches off the center line in the 8 by 8 foot test section opening. The reflective insulation was installed at the midpoint of the 5.5 inch stud dimension with staples and tightly draped between the framing members to form two (2) equal 2.75 inch air cavities between the reflective insulation and the 0.75 inch thick plywood sheathing to be placed on each side. A polystyrene baffle was installed to isolate the 6 by 6 foot metering area. All joints were sealed with caulk to prevent any air infiltration.

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.

Client: Tenneco Packaging - AVI

MTS Job No.: 258481B

Instrumentation:

The system was instrumented in accordance with ASTM C1224-93, "Standard Specification for Reflective Insulation for Building Applications".

Fifteen (15) type T, 30 gauge, thermocouples were used to measure the internal reflective air cavity, stud and plywood, surface temperatures for each side. Six (6) pairs of thermocouples were attached to the inside surface of the plywood with non-reflective aluminum tape and symmetrically positioned with the centerline of the inner most wood studs to determine temperature difference across the studs. Nine (9) pairs of thermocouples were attached to the inside surface of the plywood with non-reflective aluminum tape and symmetrically positioned with respect to the inner most reflective air cavity area to determine the temperature difference across the insulated cavity.

Test Method:

The thermal transmission properties were determined in accordance with the following American Society for Testing and Materials standard test methods at controlled laboratory conditions of 70°F and 50% relative humidity.

ASTM C 236-89 (Reapproved 1993), "Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box"

ASTM C 518-91, "Standard Test Method for Steady-State Heat Flux Measurements by Means of the Heat Flow Meter Apparatus"

Horizontal heat flow was used to simulate the insulated wall cavity assembly. The testing was performed at a cavity mean temperature of 75 ± 4 °F with a temperature difference across the insulated cavity of 30 ± 2 °F.

The frame's wood studs were thermally characterized in an ASTM C518, heat flow meter apparatus. The insulation's thermal resistance was calculated using the guarded hot box measurements and the wood stud test information.

Client: Tenneco Packaging - AVI

MTS Job No.: 258481B

Summary of Results:

The calculated thermal resistance of the framing members was determined to be 7.2 h ft² °F/Btu. ASTM C518 test results are located in the Appendix. All calculations are detailed in the Appendix.

The reflective insulation thermal performance results for horizontal heat flow are presented in Tables 1 and 2. All calculations are detailed in the Appendix of this report.

Table 1: ASTM C 236, Guarded Hot Box Test Results

Average Measured Data	Horizontal Test
Hot Surface Temperature (Cavity), °F	91.2
Cold Surface Temperature (Cavity), °F	60.9
Hot Surface Temperature (Frame), °F	91.4
Cold Surface Temperature (Frame), °F	60.7
Mean Temperature (Cavity), °F	76.1
Surface Temperature Difference (Cavity), °F	30.3
Average Power, Watts	49.89

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.

Client: Tenneco Packaging - AVI

MTS Job No.: 258481B

Summary of Results (Continued):**Table 2:** Reflective Insulation Thermal Performance Results

Heat Flow Direction	Q_{TOTAL} Btu/h	Q_{FRAME} Btu/h	Q_{RI} Btu/h	R_{RI} h ft ² °F/Btu
Horizontal	170.20	6.50	163.70	6.4

- Notes. 1. Q_{TOTAL} denotes the total measured heat flow through the test assembly.
 2. Q_{FRAME} denotes the calculated heat flow through the framing members.
 3. Q_{RI} denotes the calculated heat flow through the reflective insulation cavity.
 4. R_{RI} denotes the calculated thermal resistance of the reflective insulation and the accompanying air cavities as tested at the Celotex Corporation Technical Center

Tested by:

Russell Woltemar
 Russell W. Woltemar
 Research Technologist

Approved by:

Stanley D. Gatland II
 Stanley D. Gatland II
 Research Engineer

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.

A P P E N D I X

MTS Job No.: 258481B

Client: Tenneco Packaging - AVI

MTS Job No.: 258481B

Reflective Insulation Calculations Procedure

Calculation Constants

$$\text{Metering Area} = 36 \text{ ft}^2$$

$$A_{\text{STUDS}} = (2)(1.5" \times 72") = 216 \text{ in}^2 = 1.50 \text{ ft}^2$$

$$A_{\text{RI}} = A_{\text{METERING}} - A_{\text{STUDS}} = 36 \text{ ft}^2 - 1.50 \text{ ft}^2$$

$$A_{\text{RI}} = 34.50 \text{ ft}^2$$

$$R_{\text{STUDS}} = \frac{7.2 \text{ h ft}^2 \text{ } ^\circ\text{F}}{\text{Btu}} \quad (\text{Results from ASTM C518 test})$$

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.

Client: Tenneco Packaging - AVI

MTS Job No.: 258481B

Horizontal Heat Flow Calculation

$$Q_{TOT} = 49.89 \text{ W} / (0.2931 \text{ W/Btu/h})$$

$$Q_{TOT} = 170.20 \text{ Btu/h}$$

$$Q_{STUDS} = \frac{(A\Delta T)}{(R)_{STUDS}} = \frac{(1.50 \text{ ft}^2)(91.4 - 60.2) \text{ }^\circ\text{F}}{7.2 \frac{\text{h ft}^2 \text{ F}}{\text{Btu}}}$$

$$Q_{STUDS} = 6.50 \text{ Btu/h}$$

$$Q_{RI} = Q_{TOT} - Q_{STUDS} = (170.20 - 6.50) \text{ Btu/h}$$

$$Q_{RI} = 163.70 \text{ Btu/h}$$

$$R_{RI} = \frac{(A\Delta T)}{(Q)_{RI}} = \frac{(34.50 \text{ ft}^2)(91.2 - 60.9) \text{ }^\circ\text{F}}{163.70 \text{ Btu/h}}$$

$$R_{RI} = 6.4 \frac{\text{h ft}^2 \text{ }^\circ\text{F}}{\text{HORIZONTAL Btu}}$$

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.

CELOTEX TECHNICAL CENTER TESTING SERVICES

STEADY--STATE THERMAL TRANSMISSION PROPERTIES BY MEANS OF THE HEAT FLOW METER APPARATUS PER ASTM C-518

MTS Job No.: 258481
Project No.: 258481
Sample Description: Spruce-Pine-Fir
Sample I.D.: 2 by 6 Wood Stud

Specimen Orientation: Horizontal
Heat Flow Meter Location: Upper & Lower Plate surfaces
Instrument Used: LaserComp Modified Holometrix R-Matic

Duration of Measurement = -- Minutes
Average Heat Flux = 5.79 Btu/(h sq. ft.)
Average Lower (Hot) Plate Temperature, T_h = 96.7 F
Average Upper (Cold) Plate Temperature, T_c = 55.0 F
Average Temperature Difference = 41.7 F
Mean Specimen Temperature, T_m = 75.8 F
Average Thermal Resistance, R = 7.2 (h sq. ft. F)/Btu
Average Thermal Conductance, C = 0.139 Btu/(h sq. ft. F)

Calculations Based on Thickness Measured in Apparatus

Thickness = 5.498 inch
Average Temperature Gradient = 7.582 F/inch
Average Apparent Thermal Conductivity, k = 0.764 (Btu in.)/(h sq. ft. F)

Operator: R. Woltemar
Date: 05-26-98

Comments:
Density = 28.39 lbs/cu. ft.
5 Point Thickness Measurements: 0.000 0.000 0.000 0.000 0.000 inches
Average thickness = 0.000 inches

This report is for the information of the client. It may be used in its entirety for the purpose of securing product acceptance from duly constituted approval authorities; however, this report or the name of Celotex Corporation shall not be used in publicity or advertising.