Celotex Corporation
Testing Services

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THERMAL TESTING LABORATORY REPORT

December 11, 1997

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

MTS Job No.: 258218C-4

Metro Dade Notification No.: CAE 97273

Project: Thermal Performance of an Astro-Foil Reflective Insulation Floor/Ceiling Assembly per ASTM C 1224 using the Guarded Hot Box Test Method

Introduction:

This report presents the results of thermal tests conducted on material submitted to our laboratory on August 26, 1997. Testing was completed on November 6, 1997.

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. The manufacture of the product was witnessed by J. Bridenstine on July 21, 1997 and documented in a P.E. sealed letter to R & D Services, Incorporated, dated July 23, 1997.

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 4 inch wood frame was constructed using 1.5 by 3.5 inch studs fastened together with wood screws. Six (6) framing members were placed 16 inches on center beginning 8 inches off the center line in the 8 by 8 foot test section opening. The reflective insulation was installed at the midpoint of the 3.5 inch stud dimension with staples and tightly draped between the framing members to form two (2) equal 1.75 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.

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Instrumentation:

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 1124-93, "Standard Specification for Reflective Insulation for Building Applications"

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"

Vertical heat flow down was used to simulate insulated floor/ceiling cavity assemblies, respectively. The testing was performed at a cavity mean temperature of 75 $\pm$ 4 °F with a temperature difference across the insulated cavity of 30 $\pm$ 2°F.

A calibration procedure was performed to calculate the framing member, heat flow correction used in determining the thermal performance of the reflective insulation panel assembly.

Initially, the assembly was tested in the horizontal heat flow position with fiberglass insulation installed in the frame cavities. The fiberglass insulation and 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. The two fiberglass insulation thermal resistance results were compared and determined to have a less than 5 percent difference. This procedure, detailed in Section 9.1.5 of ASTM C 1224-93, was used to determine the steady-state heat flow through the reflective insulation cavity.

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Summary of Results:

The thermal resistance of the fiberglass batt insulation was determined to be 12.6 h ft^2 °F/Btu. The calculated thermal resistance of the framing members was determined to be 4.2 h ft^2 °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 vertical heat flow down 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 Calibration	Heat Flow Down Test
Hot Surface Temperature (Cavity), °F	89.4	92.0
Cold Surface Temperature (Cavity), °F	59.7	59.8
Hot Surface Temperature (Frame), °F	87.3	90.5
Cold Surface Temperature (Frame), °F	61.0	60.7
Mean Temperature (Cavity), °F	74.6	75.9
Surface Temperature Difference (Cavity), °F	29.7	32.2
Average Power, Watts	27.55	35.51

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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 ft² °F/Btu
Down	121.1	21.3	99.8	10.6

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

12/19/97

A P P E N D I X

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Reflective Insulation Calculations Procedure

Calculation Constants

R_{BATT} = 12.6 $\frac{h\ ft^2\ ^oF}{Btu}$ (Results from ASTM C518 test)
INSUL
(3.5")

Metering Area = 36 ft^2

A_{STUDS} = (4)(1.5" x 72") = 432 in^2 = 3.00 ft^2

A_{BATT} = A_{RI} = $A_{METERING}$ - A_{STUDS} = 36 ft^2 - 3.00 ft^2
INSUL

A_{BATT} = A_{RI} = 33.00 ft^2
INSUL

R_{STUDS} = 4.2 $\frac{h\ ft^2\ ^oF}{Btu}$ (Results from ASTM C518 test)
(3.5")

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Horizontal Calibration Calculation

Q_{TOT} = 27.55 W/(0.2931 W/Btu/h)

Q_{TOT} = 94.00 Btu/h

$$Q_{STUDS} = \frac{(A\Delta T)_{STUDS}}{(R)} = \frac{(3.00\ ft^2)(87.3 - 61.0)°F}{4.2\ \frac{h\ ft^2\ °F}{Btu}}$$

Q_{STUDS} = 18.79 Btu/h

$Q_{BATT}_{INSUL} = Q_{TOT} - Q_{STUDS} = (94.00 - 18.79)$ Btu/h

Q_{BATT}_{INSUL} = 75.21 Btu/h

$$R_{BATT}_{INSUL} = \frac{(A\Delta T)}{(Q)_{BATT\ INSUL}} = \frac{(33.00\ ft^2)(89.4 - 59.7)°F}{75.21\ Btu/h}$$

R_{BATT}_{INSUL} = 13.03 $\frac{h\ ft^2\ °F}{Btu}$

The percent difference between the ASTM C518 and ASTM C236 test results was 3.4% for the fiberglass insulation.

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Vertical Heat Flow Down Calculation

Q_{TOT} = 35.51 W/(0.2931 W/Btu/h)

Q_{TOT} = 121.1 Btu/h

$$Q_{STUD} = \frac{(A\Delta T)}{(R)_{STUDS}} = \frac{(3.00\ ft^2)(90.5 - 60.7)\ °F}{4.2\ \frac{h\ ft^2\ °F}{Btu}}$$

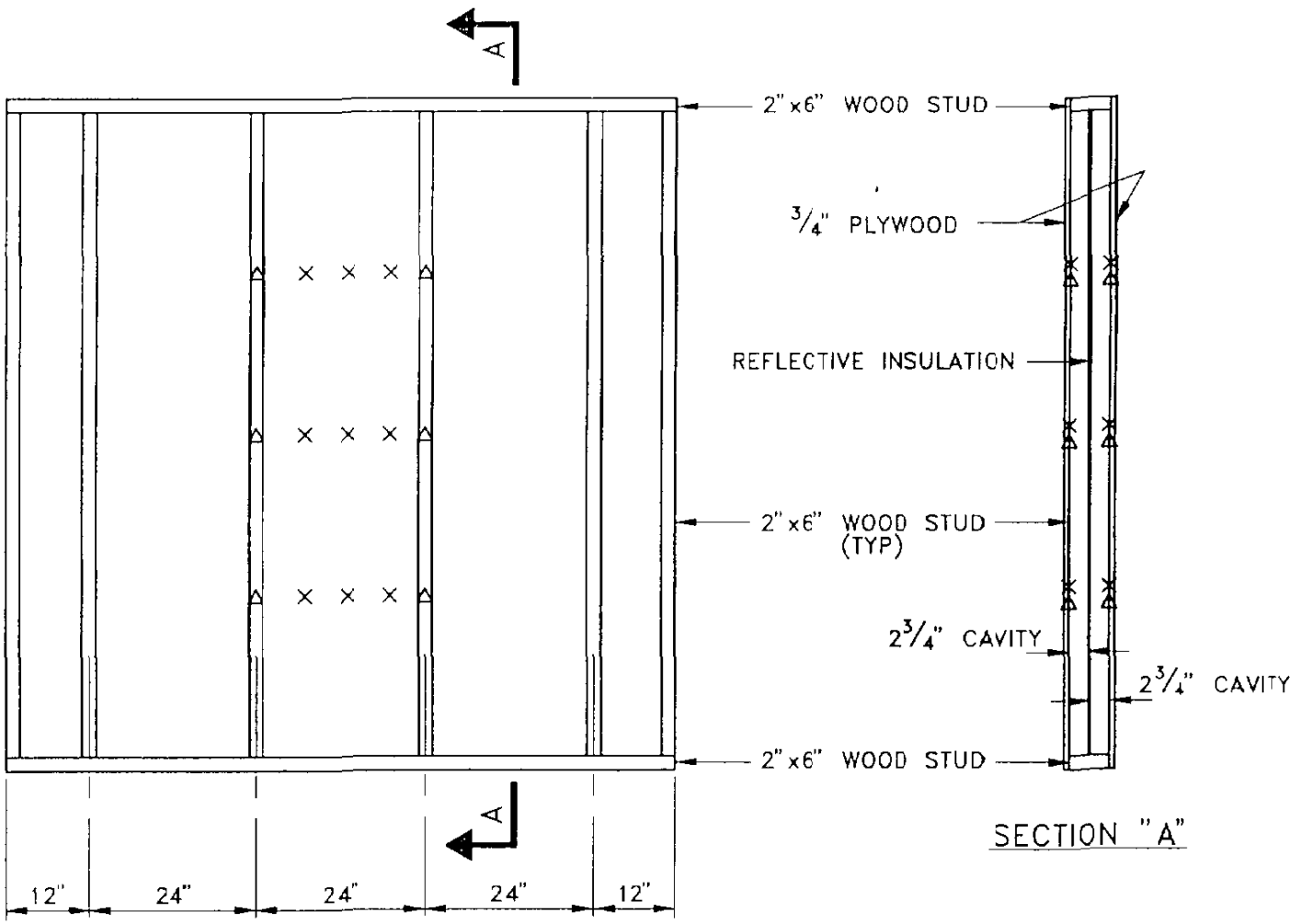
Q_{STUDS} = 21.3 Btu/h

$Q_{RI} = Q_{TOT} - Q_{STUDS} = (121.1 - 21.3)$ Btu/h

Q_{RI} = 99.8 Btu/h

$$R_{RI} = \frac{(A\Delta T)}{(Q)_{RI}} = \frac{(33.00\ ft^2)(92.0 - 59.8)\ °F}{99.8\ Btu/h}$$

R_{RI} = 10.6 $\frac{h\ ft^2\ °F}{Btu}$
HORIZONTAL



SECTION "A"

△ WOOD STUD THERMOCOUPLE

× INSIDE SURFACE THERMOCOUPLE

Celotex Technical Center
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