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Product Testing Laboratories
Test Report

JOHNS MANVILLE TECHNICAL CENTER
Thermal Testing Laboratory
February 3, 2010

Subject:

C976/C1363 Hot Box Apparatus Testing of CO Building Systems Inc. Metal Building Wall and Roof Systems

For:

Sealed "N" Safe
320 West 100 North
Ephraim, UT 84627

Submitted by:
Johns Manville Technical Center
PO Box 625005
Littleton, CO 80162-5005

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NVLAP® NATIONAL VOLUNTARY LABORATORY ACCREDITATION PROGRAM FOR SELECTED TEST METHODS FOR THERMAL INSULATIONS

NVLAP LAB CODE 100425-0

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Introduction

Six calibrated hot box tests were conducted from December 16th, 2009 to January 3rd, 2010 to measure the thermal performance of simulated metal building wall and roof assemblies using a Calibrated Hot Box Apparatus (CHBA) located at the Johns Manville Technical Center (JMTC) 10100 West Ute Ave, Littleton, Colorado 80127. These tests were performed for Craig Oberg of Sealed "N" Safe for the purpose of better understanding the heat flows, R-values and thermal performance of standard metal building wall and roof constructions using Sealed "N" Safe's proprietary polyisocyanurate thermal blocks. Two cavity filled systems were tested as roof assemblies (horizontal sample orientation, heat flow up) and two draped (continuous) systems were tested as roof and wall constructions (wall systems tested horizontally) installed in typical metal building configurations with the exception of the thermal blocks. The metal building assemblies were constructed using typical through fastened methods utilizing common metal building components. Two of the samples were first tested in a horizontal orientation (heat flow vertical, up) as a roof assembly and then simply rotated ninety degrees into a vertical position (heat flow horizontal) and tested as a wall assembly. No other changes were made to the samples other than orientation. This report supersedes report T10-003.

Sample Description

The following metal building insulation systems were tested:

Sample 1 - The client provided and installed a system consisting of 16 gage, 10 inch purlins spaced 60" on center. R-25 wide roll metal building insulation was laminated to a white PSK facing with extended tabs attached to the top of the purlin that was used to fill the cavity created by the purlins. Thermal blocks were fastened to the purlins over the extended tabs of the R-25 faced insulation with unfaced R-10 metal building insulation placed over the top of purlins and the 1 inch thickness polyisocyanurate thermal blocks. 26 gage fluted metal panels with corrugations spaced 12" on center were attached to the top of the insulation and thermal blocks. The assembly was further supported by three 2" wide by ½" deep by .020 thick metal channels spaced 30 inches on center screwed to the bottom of the purlins. The entire assembly was installed within a 2" x 10" wood frame with exterior dimensions approximating the interior dimensions of the sample test frame. The product is identified as "Sample 1." See Figures 1 and 10 below.

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Sample Description (continued)

Sample 2 - The client provided and installed a system consisting of 16 gage, 8 inch purlins spaced 60" on center. R-19 wide roll metal building insulation was laminated to a white PSK facing with extended tabs attached to the top of the purlin that was used to fill the cavity created by the purlin. Thermal blocks were fastened to the purlins over the extended tabs of the R-19 faced insulation with unfaced R-10 metal building insulation placed over the top of purlins and the 1 inch thickness polysisocyanurate thermal blocks. 26 gage fluted metal panels with corrugations spaced 12" on center were attached to the top of the insulation and thermal blocks. The assembly was further supported by three 2" wide by ½" deep by .020 thick metal channels spaced 30 inches on center screwed to the bottom of the purlins. The entire assembly was installed within a 2" x 8" wood frame with exterior dimensions approximating the interior dimension of the sample test frame. The product is identified as "Sample 2." See Figures 2 and 11 below.

Sample 3 - The client provided and installed a system consisting of 16 gage, 8 inch purlins spaced 60" on center. R-13 wide roll metal building insulation laminated to a white PSK facing was installed over the purlins layered with 1" thickness polyisocyanurate foam blocks and unfaced R-13 metal building insulation. 26 gage fluted metal panels with corrugations spaced 12" on center were attached to the top of the insulation and thermal blocks. The entire assembly was installed within a 2" x 6" wood frame with exterior dimensions approximating the interior dimension s of the sample test frame. The product is identified as "Sample 3." See Figures 3 and 12 below.

Sample 4 - The client provided and installed a system consisting of 16 gage, 8 inch purlins spaced 60" on center. R-10 wide roll metal building insulation laminated to a white PSK facing was installed over the purlins layered with 1" thickness polyisocyanurate foam blocks and unfaced R-10 metal building insulation. 26 gage fluted metal panels with corrugations spaced 12" on center were attached to the top of the insulation and thermal blocks. The entire assembly was installed within a 2" x 6" wood frame with exterior dimensions approximating the interior dimension s of the sample test frame. The product is identified as "Sample 4." See Figures 4 and 13 below.

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Test Methods

ASTM C976/C1363: Standard Test Method for the Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus. This test method covers the laboratory measurement of heat transfer through a specimen under controlled air temperature, air velocity, and thermal radiation conditions established in a metering chamber on one side and in a climatic chamber on the other side. Under steady state conditions, power inputs and chamber temperatures were measured and then used to calculate the test results.

The test samples were preconditioned at laboratory conditions prior to the testing of the panel assembly. The materials were then assembled within a wood frame that was installed within the Hot Box Apparatus (HBA) frame with a total metering area of 80 ft^2 (10' long by 8' high). The latest calibration check of the system was conducted on 7/25/2009.

The thermal conductivity of the insulation used for full scale testing was determined from samples taken from the full scale test assemblies after they had been tested in the assembly. 24-inch x 24-inch samples were then tested in accordance with ASTM C518 "Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus." Johns Manville is accredited for this test method by the National Voluntary Laboratory Accreditation Program (NVLAP). The thermal conductivity was established for each fiber glass insulation product used in the assemblies. The results are shown below in Appendix 1, Table 1.

Sample Construction

Conditions on the outside surfaces exposed to both the hot metering chamber and cold environmental chamber were each instrumented with 24 thermocouples (TCs) using 32 gauge thermocouple wires attached to both faces of the assembly. There are also 24 thermocouples (TCs) using 32 gauge thermocouple wires that measure the air temperature on each side of the sample. The outside metal surfaces were sealed with silicone caulk and duct tape to prevent any heat loss due to air infiltration. The sealing process was performed on all joints, cracks, and screws. The interior side poly liner sheet was also sealed to the surrounding HBA frame. The roof samples, Sample 1 and Sample 2, were tested in a horizontal orientation as a roof (vertical heat flow, up). Samples 3 and 4 were first tested as a roof (horizontal, heat flow up) and then tilted to a vertical orientation and tested as a wall (horizontal heat flow). See Figures 6 through 9 below.

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Sample Construction (continued)

Sample 1 Test Configuration: Heat flow vertical ("winter" conditions) from the steel panel exterior to the interior laminated PSK faced insulation. See Figure 1 below.

- 50°F (10.0°C, 283K) Cold side air space, 24 TCs across air space.
- 26 gauge corrugated steel panel exterior sheathing, 12-inch screw spacing with 24 TCs applied to outer surface.
- R-10 unfaced fiberglass metal building insulation.
- 1.0 inch thickness polyisocyanurate foam thermal blocks.
- 16 gage steel Z-purlins/girts (10" depth) installed vertically 60" on center in the 96 inch HBA frame height
- Long tab Poly Scrim Kraft (PSK) faced wide roll R-25 fiber glass metal building insulation installed between the Z-purlins/girts. Insulation tabs were attached to the sheet metal side (top) of the purlin.
- 2" wide by ½" deep by .020 thick metal channels spaced 30 inches on center screwed to the bottom of the purlins
- 100°F (37.8°C, 311K) Hot side air space, 24 TCs across air space.

Sample 2 Test Configuration: Heat flow vertical ("winter" conditions) from the steel panel exterior to the interior laminated PSK faced insulation. See Figure 2 below.

- 50°F (10.0°C, 283K) Cold side air space, 24 TCs across air space.
- 26 gauge corrugated steel panel exterior sheathing, 12-inch screw spacing with 24 TCs applied to outer surface.
- R-10 unfaced fiberglass metal building insulation.
- 1.0 inch thickness polyisocyanurate foam thermal blocks.
- 16 gage steel Z-purlins/girts (8" depth) installed vertically 60" on center in the 96 inch HBA frame height
- Long tab Poly Scrim Kraft (PSK) faced wide roll R-19 fiber glass metal building insulation installed between the Z-purlins/girts. Insulation tabs were attached to the sheet metal side (top) of the purlin.
- 2" wide by ½" deep by .020 thick metal channels spaced 30 inches on center screwed to the bottom of the purlins
- 100°F (37.8°C, 311K) Hot side air space, 24 TCs across air space.

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Sample Construction (continued)

__Sample 3__ Test Configuration: Heat flow vertical and horizontal ("winter" conditions) from the steel panel exterior to the interior laminated PSK faced insulation. See Figure 3 below.

- 50°F (10.0°C, 283K) Cold side air space, 24 TCs across air space.
- 26 gauge corrugated steel panel exterior sheathing, 12-inch screw spacing with 24 TCs applied to outer surface.
- R-13 unfaced fiberglass metal building insulation.
- 1.0 inch thickness polyisocyanurate foam thermal blocks.
- PSK faced R-13 fiberglass metal building insulation.
- 16 gage steel Z-purlins/girts (8" depth) installed vertically 60" on center in the 96 inch HBA frame height
- 100°F (37.8°C, 311K) Hot side air space, 24 TCs across air space.

__Sample 4__ Test Configuration: Heat flow vertical and horizontal ("winter" conditions) from the steel panel exterior to the interior laminated PSK faced insulation. See Figure 4 below.

- 50°F (10.0°C, 283K) Cold side air space, 24 TCs across air space.
- 26 gauge corrugated steel panel exterior sheathing, 12-inch screw spacing with 24 TCs applied to outer surface.
- R-10 unfaced fiberglass metal building insulation.
- 1.0 inch thickness polyisocyanurate foam thermal blocks.
- PSK faced R-10 fiberglass metal building insulation.
- 16 gage steel Z-purlins/girts (8" depth) installed vertically 60" on center in the 96 inch HBA frame height
- 100°F (37.8°C, 311K) Hot side air space, 24 TCs across air space.

Sample Construction (continued)

Figure 1: Sample 1 with PSK Faced R-25 and Unfaced R-10

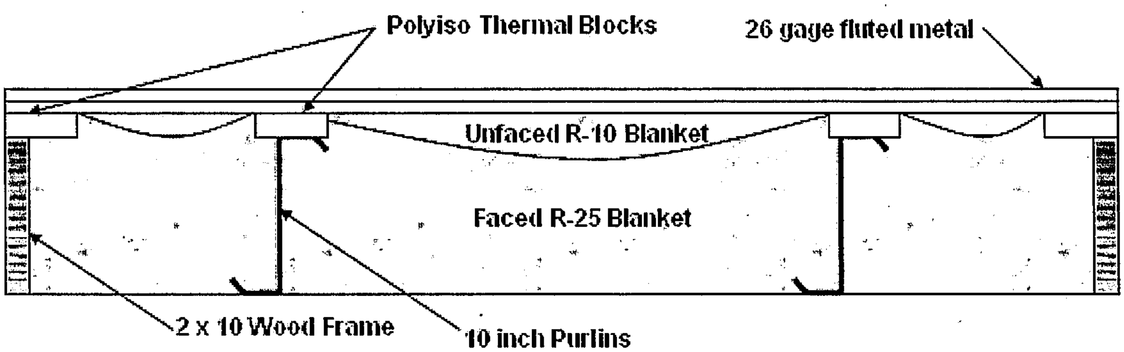
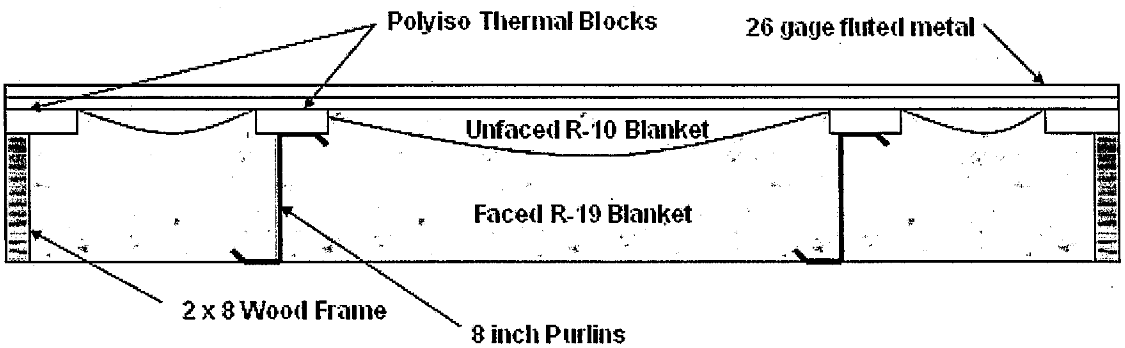


Figure 2: Sample 2 with PSK Faced R-19 and Unfaced R-10



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Sample Construction (continued)

Figure 3: Sample 3 with PSK Faced R-13 and Unfaced R-13

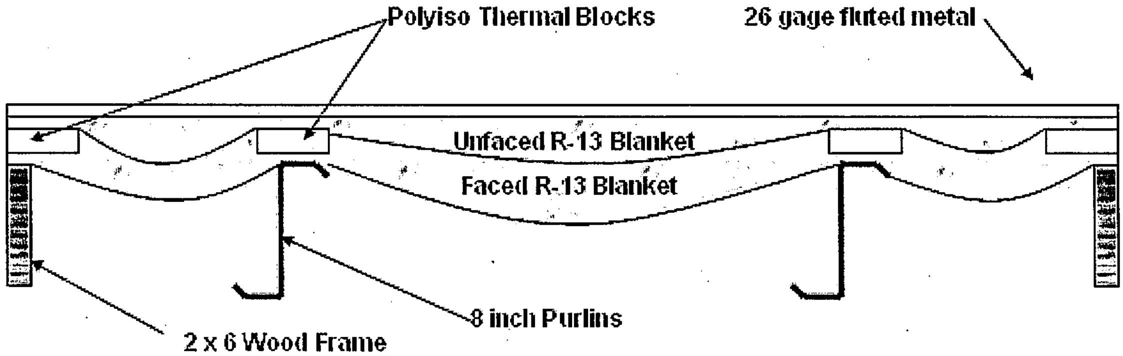
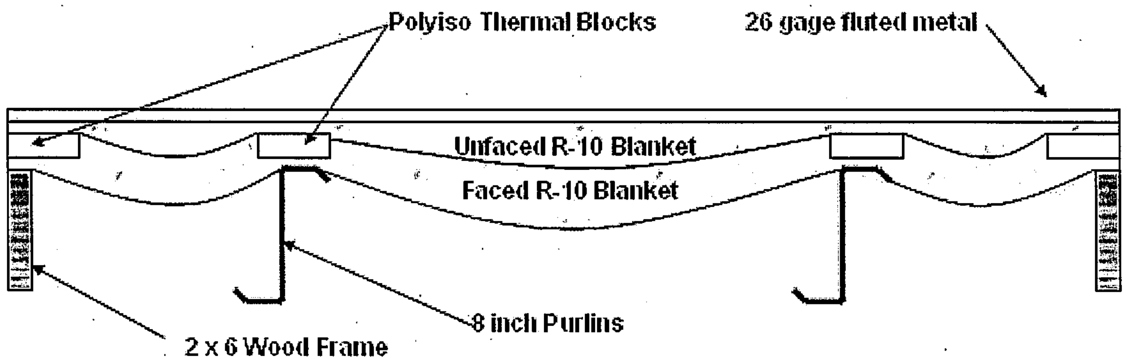


Figure 4: Sample 4 with PSK Faced R-10 and Unfaced R-10



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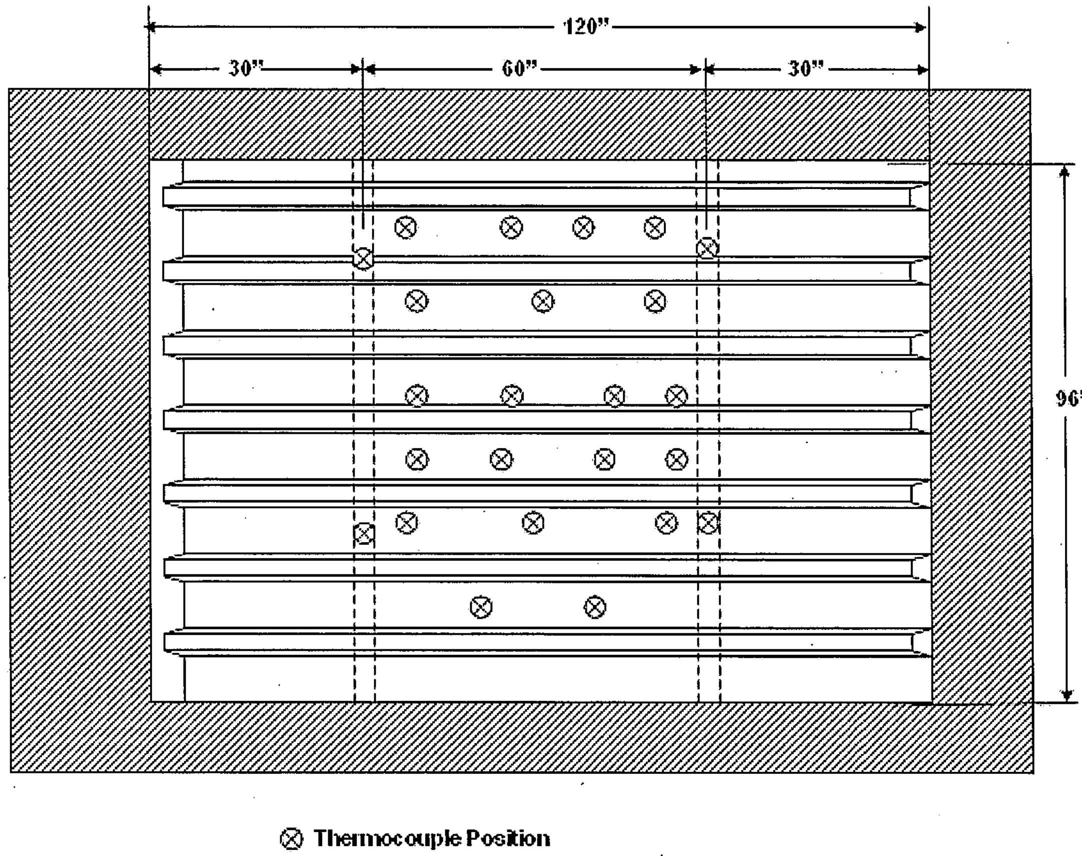
Sample Construction (continued)

Figure 5: Z-purlin Orientation and Spacing Within the Test Frame and Thermocouple Placement.



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Sample Construction (continued)

Figure 6: Blanket and Thermal Blocks

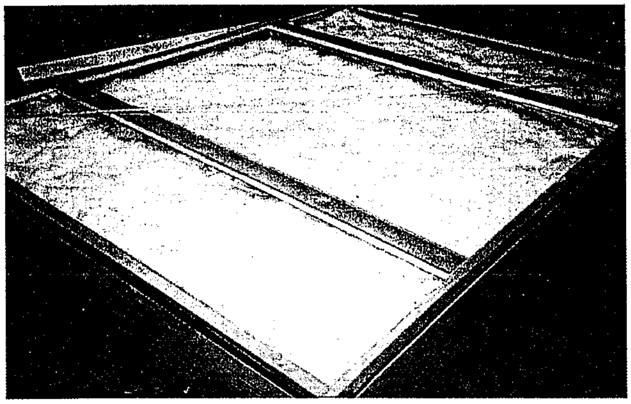


Figure 7: Unfaced Layer Installation

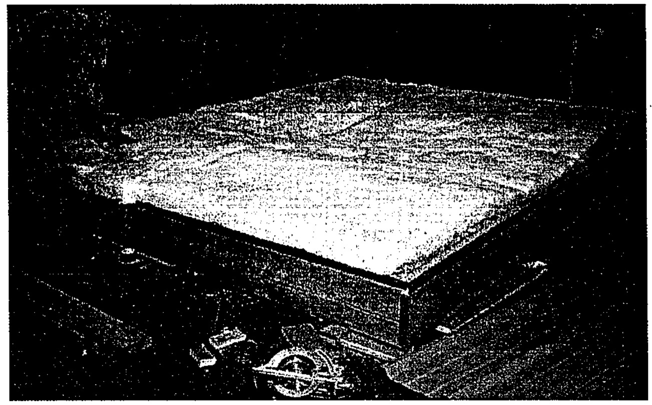


Figure 8: Sheet Metal Installation

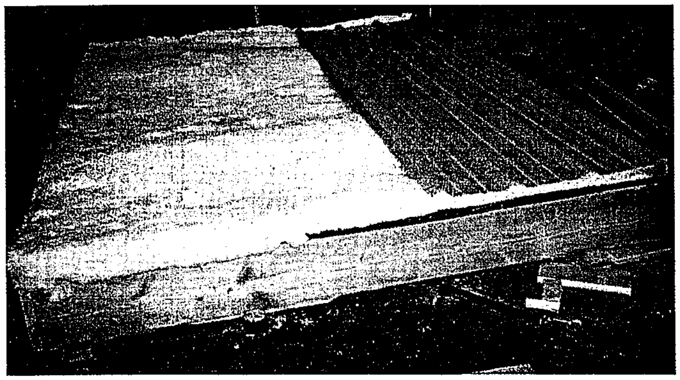
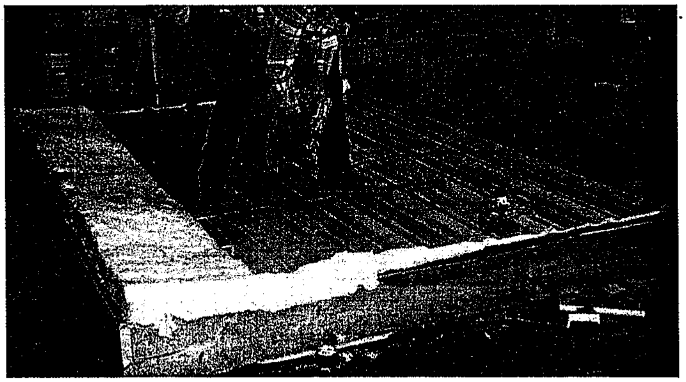


Figure 9: Fastening Exterior to Purlins



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Sample Construction (continued)

Figure 10: Sample 1 Interior Side[1]

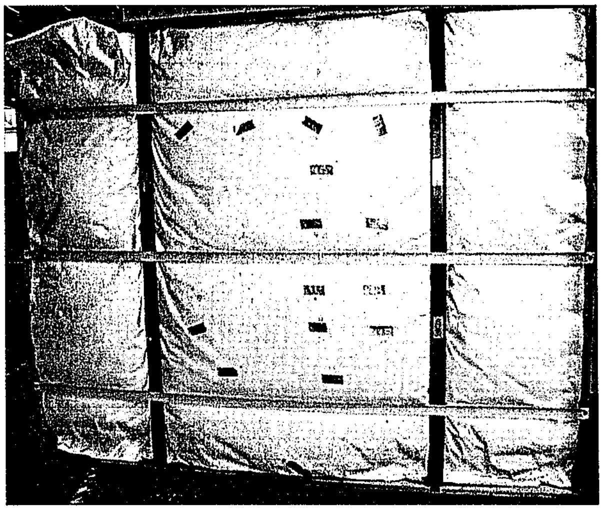


Figure 11: Sample 2 Interior Side

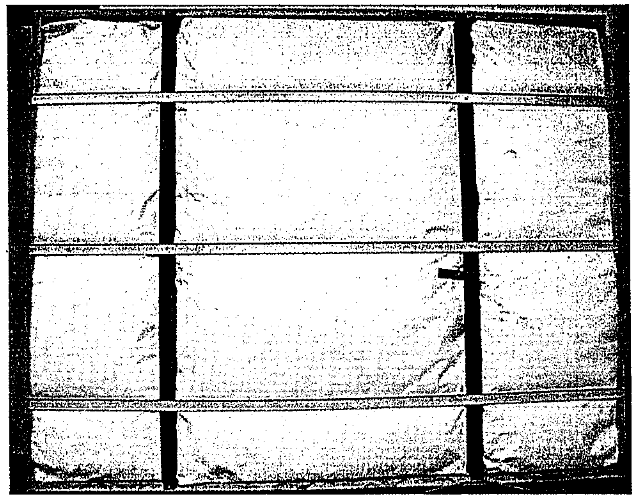


Figure 12: Sample 3 Interior Side

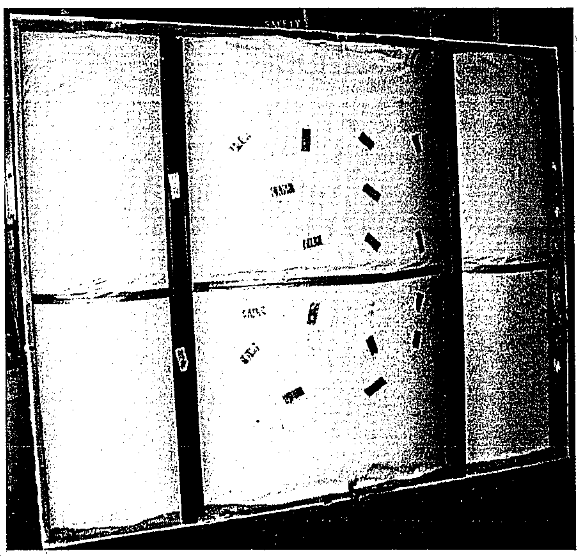
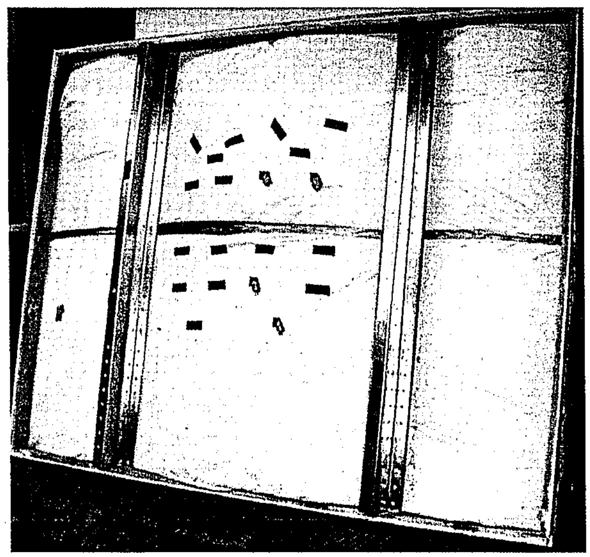


Figure 13: Sample 4 Interior Side



[1] Tape was used to secure thermocouples to the PSK facing of the sample.

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Results

Compiled averaged temperatures for each test are shown in Appendix I. In addition to the averaged temperature data sheets in Appendix I, English unit calculation spreadsheets, using the average surface temperatures, average air temperatures, average heat flow, sample thickness, etc., for each of the tests are used to calculate thermal resistance or R-value of the assemblies. The un-compiled results of this test series are kept on record within the laboratory. The results were corrected for the framing used.[2]

Sample 1- Roof Configuration (vertical heat flow up from PSK facing to the steel panel)
Test Date: December16-18, 2009
Cavity Thickness:10" (25.4 cm)
System Thickness:13.50" (34.29 cm)
Air Mean Temperature, Vertical Heat flow up: 75.6 °F (24.2.1°C, 297.4° K)
Air Temperature Difference, Vertical Heat flow up: 52.7°F (11.5 °C, 284.7° K)

English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block,10" Z-purlin/girt 60" on center, R-25 fiber glass cavity insulation, steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Vertical Heat Flow Up	R-18.36 / U-0.054	R-17.54/ U-0.057

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.8 fiber glass, 25.4 mm thick thermal block, 254 mm Z-purlin/girt 1524 mm on center, R-4.4 fiber glass cavity insulation, steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (m²•K/W) / (W/m²•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m²•K/W) / (W/m²•K)
Vertical Heat Flow Up	R-3.23 / U-0.301	R-3.08 / U-0.324

[2] The value was determined by the following method; U_{ave} = Frame % x U_{Frame} + Sample % x U_{Sample}. Framing percentage was 5.5% with sample percentage equal to 94.5%. Thermal block performance was R-6.15 per inch, wood R-1.25 per inch.

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Results (continued)

Sample 2 - Roof Configuration (vertical heat flow up from PSK facing to the steel panel)
Test Date: December 21-23, 2009
Cavity Thickness: 8.25" (20.96 cm)
System Thickness:11.0" (27.94 cm)
Air Mean Temperature, Vertical Heat flow up: 75.5°F (24.2 ° C, 297.4° K)
Air Temperature Difference, Vertical Heat flow up: 52.6°F (11.4°C, 284.7° K)

English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block, 8.25" Z-purlin/girt 60" on center, PSK faced R-19 fiber glass cavity insulation, steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Vertical Heat Flow	R-18.36/ U-0.054	R-17.32/ U-0.058

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.8 fiber glass, 25.4 mm thermal block, 210 mm Z-purlin/girt 1524 mm on center, PSK faced R-3.3 fiber glass cavity insulation, steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (m²•K/W) / (W/m²•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m²•K/W) / (W/m²•K)
Vertical Heat Flow	R-3.23 / U-0.310	R-3.04/ U-0.329

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Results (continued)

Sample 3- Wall Configuration (Horizontal heat flow from PSK facing to the steel panel)
Test Date: December 25-27, 2009
Cavity Thickness: 8.25" (20.96 cm)
System Thickness: 3.55" (9.02 cm) average insulation thickness.
Air Mean Temperature, Horizontal Heat flow: 75.5° F (24.2°C, 297.3° K)
Air Temperature Difference, Horizontal Heat flow: 52.4° F (11.3°C, 284.5° K)

English Units

Configuration: Corrugated steel panel, unfaced R-13 fiber glass, 1" thick thermal block, PSK faced R-13 fiber glass, 8.25" Z-purlin/girt 60" on center.	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Horizontal Heat Flow	R-13.55 / U-0.074	R-13.04/ U-0.077

Metric Units

Configuration: Corrugated steel panel, unfaced R-2.3 fiber glass, 25.4 mm thermal block, PSK faced R-2.3 fiber glass, 210 mm Z-purlin/girt 1524 mm on center.	C976/C1363 R-Value/U-Value: Air-to-Air (m²•K/W) / (W/m²•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m²•K/W) / (W/m²•K)
Horizontal Heat Flow	R-2.38 / U-0.420	R-2.29/ U-0.436

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Results (continued)

Sample 3- Roof Configuration (Vertical heat flow up from PSK facing to the steel panel)
Test Date: December 23-25, 2009
Cavity Thickness: 8.25" (20.96 cm)
System Thickness: 3.55" (9.02 cm) average insulation thickness.
Air Mean Temperature, Vertical Heat flow up: 75.5° F (24.2°C, 297.3° K)
Air Temperature Difference, Vertical Heat flow up: 52.4° F (11.3°C, 284.5° K)

English Units

Configuration: Corrugated steel panel, unfaced R-13 fiber glass, 1" thick thermal block, PSK faced R-13 fiber glass, 8.25" Z-purlin/girt 60" on center.	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Vertical Heat flow up	R-13.53 / U-0.074	R-13.13/ U-0.076

Metric Units

Configuration: Corrugated steel panel, unfaced R-2.3 fiber glass, 25.4 mm thermal block, PSK faced R-2.3 fiber glass, 210 mm Z-purlin/girt 1524 mm on center.	C976/C1363 R-Value/U-Value: Air-to-Air (m²•K/W) / (W/m²•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m²•K/W) / (W/m²•K)
Vertical Heat flow up	R-2.38 / U-0.421	R-2.31/ U-0.433

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Results (continued)

Sample 4- Wall Configuration (Horizontal heat flow from PSK facing to the steel panel)
Test Date: January 1-3, 2010
Cavity Thickness: 8.25" (20.96 cm)
System Thickness: 3.30" (9.02 cm) average insulation thickness.
Air Mean Temperature, Horizontal Heat flow: 75.5° F (24.2°C, 297.3° K)
Air Temperature Difference, Horizontal Heat flow: 52.5 ° F (11.4°C, 284.5° K)

English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block, PSK faced R-10 fiber glass, 8.25" Z-purlin/girt 60" on center.	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Horizontal Heat Flow	R-13.20 / U-0.076	R-12.74/ U-0.079

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.8 fiber glass, 25.4 mm thermal block, PSK faced R-1.8 fiber glass, 210 mm Z-purlin/girt 2154 mm on center.	C976/C1363 R-Value/U-Value: Air-to-Air (m^2•K/W) / (W/m^2•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m^2•K/W) / (W/m^2•K)
Horizontal Heat Flow	R-2.32 / U-0.431	R-2.24/ U-0.446

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Results (continued)

Sample 4- Roof Configuration (Vertical heat flow up from PSK facing to the steel panel)

Test Date: December 29-31, 2009
Cavity Thickness: 8.25" (20.96 cm)
System Thickness: 3.30" (9.02 cm) average insulation thickness.
Air Mean Temperature, Vertical Heat flow up: 75.5° F (24.2°C, 297.3° K)
Air Temperature Difference, Vertical Heat flow up: 52.1 ° F (11.2°C, 284.3° K)

English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block, PSK faced R-10 fiber glass, 8.25" Z-purlin/girt 60" on center.	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft²•°F/Btu) / (Btu/hr•ft²•°F)
Vertical Heat flow up	R-13.14 / U-0.076	R-12.65 / U-0.079

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.8 fiber glass, 25.4 mm thick thermal block, PSK faced R-1.8 fiber glass, 210 mm Z-purlin/girt 2154 mm on center.	C976/C1363 R-Value/U-Value: Air-to-Air (m²•K/W) / (W/m²•K)	C976/C1363 R-Value/U-Value: Surface-to-Surface (m²•K/W) / (W/m²•K)
Vertical Heat flow up	R-2.31 / U-0.433	R-2.22/ U-0.450

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Appendix I

Table 1: Thermal Performance of Fiberglass Insulation Used in the Constructions

Product	*Thickness*	*Tested R-value*	*Percentage of Label*
NAIMA 202 R-10, PSK faced	2.95	9.70	97%
R-10, Unfaced	3.40	10.20	102%
R-13, PSK Faced	3.85	12.89	99%
R-13, Unfaced	4.40	14.60	112%
R-19, PSK Faced	5.60	18.58	98%
R-25, PSK Faced	8.0	24.38	98%

Table 2: Summarized Data - Calculation Inputs

	Sample 1	Sample 2	Sample 3		Sample 4	
INPUT:	Roof	Roof	Wall	Roof	Wall	Roof
MC Temperatures (F)						
Average MC Air Temperature	101.9	101.8	101.7	101.7	101.6	101.8
Avg. MC Specimen Surface	100.1	99.5	100.2	100.7	100.3	100.4
Average Differential Inside	101.8	99.5	101.6	101.5	101.3	101.6
Average Differential Outside	102.6	101.7	108.2	102.7	102.8	103.5
CC Temperatures (F)						
Avg. CC Specimen Surface	49.8	50.0	49.9	49.9	50.0	49.9
Average CC Air Temperature	49.3	49.2	49.3	49.3	49.4	49.3
MC Power Input						
Fan Voltage (V)	12.8	7.6	12.7	12.8	12.8	12.8
Fan Current (amps converted to volts)	0.1	0.0	0.1	0.1	0.1	0.1
Heater Voltage (V)	17.1	9.7	19.9	20.4	20.8	20.7
Htr. Current (amps converted to volts)	0.4	0.2	0.5	0.5	0.5	0.5
Speciman Area (Sq. Ft.)						
Frame Test Area	80.4	80.5	80.4	80.4	80.5	80.5
Test Specimen Thickness (in)						
Thickness	13.5	11.0	3.55	3.55	3.30	3.30

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Appendix (continued)

Table 3 – Summarized Test Data – Calculated Results

	Sample 1	Sample 2	Sample 3		Sample 4	
	Roof	Roof	Wall	Roof	Wall	Roof
CALCULATIONS:						
Area Weighted Surface Temps. (F)						
MC Surface temperature	100.1	99.5	100.2	100.7	100.3	100.4
CC Surface temperature	49.8	50.0	49.9	49.9	50.0	49.9
Power Input, Qpow						
Fan Power (W)	7.5	3.9	7.5	7.5	7.6	7.6
Heater Power (W)	66.8	31.4	91.0	95.8	100.3	99.1
Total Power (W)	74.4	35.2	98.5	103.3	107.8	106.7
Total Power (Btu/Hr)	253.8	120.2	336.1	352.5	367.9	364.0
MC Wall Heat Flow, Qmcw						
MC/S. Room Temp. Diff. (F)	0.8	2.6	6.6	1.1	1.4	1.9
MC Wall Heat Flow (Btu/Hr)	3.1	9.7	25.2	4.3	5.5	7.1
Infiltration Heat Flow, Qinf						
Infiltration (Btu/Hr)	21.8	7.6	23.0	17.3	26.0	20.1
Flanking Loss Heat Flow, Qfl						
Flanking Loss Thru Frame (Btu/Hr)	6.9	8.2	21.2	21.5	22.4	22.5
Qnet=Qpow+Qmcw-Qinf-Qfl						
Net Heat Flow (Btu/Hr)	228.2	114.3	317.2	318.0	324.9	328.4
Convection Coefficients						
MC Velocity, volts	1.17	0.61	0.41	0.44	0.52	0.52
MC Velocity, sfps	0.78	0.41	0.27	0.29	0.35	0.35
MC Velocity, mph	0.53	0.28	0.19	0.20	0.24	0.24
CC Velocity, volts	3.13	1.70	2.60	2.75	2.45	2.63
CC Velocity, sfps	5.21	2.84	4.33	4.58	4.08	4.39
CC Velocity, mph	3.55	1.93	2.95	3.12	2.78	2.99
hmc	1.54	1.25	2.60	3.97	3.14	2.92
hcc	5.81	4.20	7.43	6.71	7.07	6.88
sqrt. heff	0.82	0.72	1.01	1.13	1.06	1.03
Test Specimen R-value:						
Specimen Temperature Diff. (F)	50.3	49.6	50.3	50.8	50.3	50.5
Mean Specimen Temperature (F)	74.9	74.7	75.0	75.3	75.2	75.1
R Specimen	17.72	17.39	12.76	12.84	12.45	12.38
Air to Air R-value:						
Air Temperature Difference (F)	52.7	52.6	52.4	52.4	52.1	52.5
Mean Air Temperature (F)	75.6	75.5	75.5	75.5	75.5	75.5
Rair/air	18.55	18.43	13.27	13.25	12.91	12.87
U-value	0.054	0.054	0.075	0.075	0.077	0.078
Air Film R-value	**0.82**	**1.04**	**0.52**	**0.40**	**0.46**	**0.49**
Specimen R (Rair to air - Air Film R)	17.72	17.39	12.76	12.84	12.45	12.38
Specimen R-value adjusted for perimenter framing (Air films not included)	**17.54**	**17.32**	**13.04**	**13.13**	**12.74**	**12.65**
Specimen U-values (air films not included)	**0.0570**	**0.0577**	**0.0767**	**0.0761**	**0.0785**	**0.0790**
Specimen R-values including air films	**18.36**	**18.36**	**13.55**	**13.53**	**13.20**	**13.14**
Specimen U-values including air films	**0.054**	**0.054**	**0.074**	**0.074**	**0.076**	**0.076**