



Johns Manville

Johns Manville Technical Center

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Product Testing Laboratories

Test Report

Report Number : T10-029

Date: April 8, 2010

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JOHNS MANVILLE TECHNICAL CENTER

Thermal Testing Laboratory

April 8, 2010

Subject:

**C976/C1363 Hot Box Apparatus Testing of CO Building Systems Inc.
Metal Building 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

Reported By:

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**NATIONAL VOLUNTARY LABORATORY ACCREDITATION
PROGRAM FOR SELECTED TEST METHODS FOR THERMAL
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Introduction

Two calibrated hot box tests were conducted from March 8th to March 10th, 2010 and March 30th to April 1st, 2010 to measure the thermal performance of simulated metal building 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 metal clad polyisocyanurate thermal blocks. The two cavity filled systems were tested as roof assemblies (horizontal sample orientation, heat flow up) 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.

Sample Description

The following metal building insulation systems were tested:

Sample 7 - The client provided a metal building roof system consisting of 16 gage, 8 inch purlins spaced 60" on center, R-10 and R-19 fiber glass metal building insulation with metal clad polyisocyanurate and standard expanded polystyrene thermal blocks on the top and bottom, respectively, of the purlin. A detailed explanation of the assembly is described in the body of this report or in Figure 1.

Sample 8 - The client provided a metal building roof system consisting of 16 gage, 9 inch purlins spaced 60" on center, R-10 and R-25 fiber glass metal building insulation with metal clad polyisocyanurate and standard expanded polystyrene thermal blocks on the top and bottom, respectively, of the purlin. A detailed explanation of the assembly is described in the body of this report or in Figure 2.



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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 ft² (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 and reported in report T10-028. The results are shown below in Appendix 1, Table 1.

Conditions on the sample 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 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 insulation facing was also sealed to the surrounding HBA frame. The roof samples were tested in a horizontal orientation as a roof (vertical heat flow, up).



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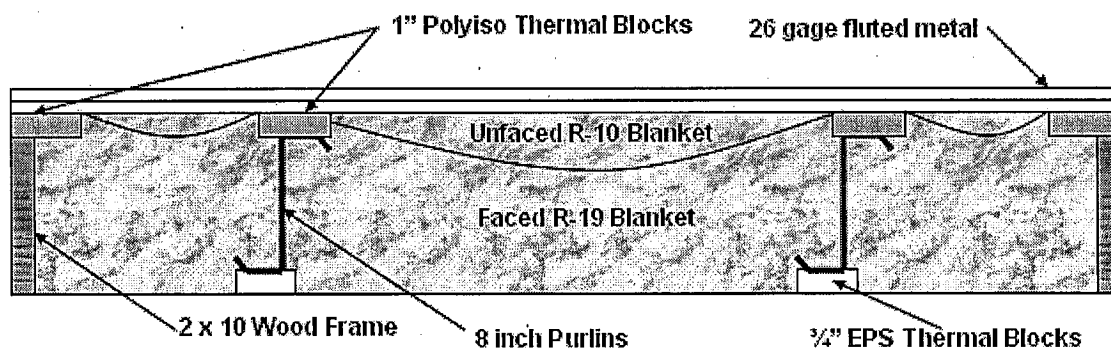
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Sample Construction

Sample 7 Test Configuration: Heat flow vertical ("winter" conditions). Construction elements are listed in order 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 installed continuously over the thermal blocks and purlins.
- 1.0 inch thickness metal clad polyisocyanurate foam thermal blocks attached to the "exterior" purlin flange.
- 16 gage steel Z-purlins/girts (8" depth) installed vertically 60" on center in the 96 inch HBA frame height
- 0.75 inch thickness Expanded Poly Styrene (EPS) thermal blocks installed over the "interior" side of the purlin flange.
- Poly Scrim Kraft (PSK) faced wide roll R-19 fiber glass metal building insulation installed between the Z-purlins/girts. PSK facing tabs were attached to the "interior" side of the purlin between the EPS thermal blocks and metal channels.
- 2" wide by ½" deep by .020 thick metal channels spaced 31 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.

Figure 1: Sample 7 with PSK Faced R-19, Unfaced R-10 and Thermal Blocks



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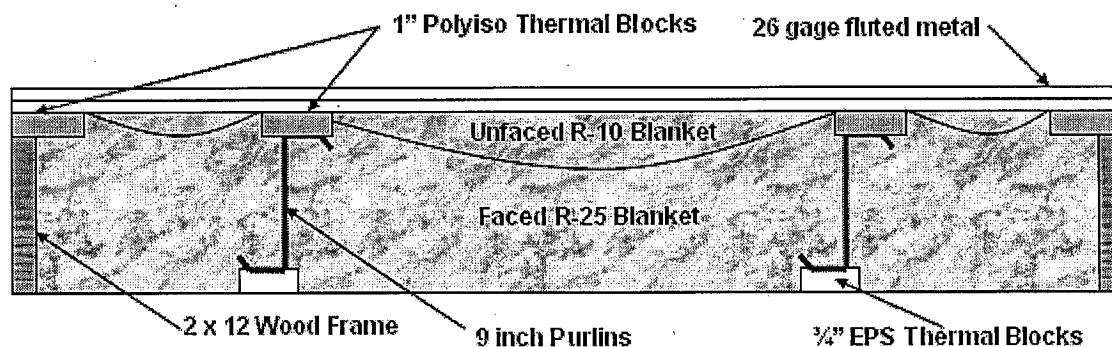
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Sample Construction (continued)

Sample 8 Test Configuration: Heat flow vertical ("winter" conditions). Construction elements are listed in order 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 installed continuously over the thermal blocks and purlins.
- 1.0 inch thickness metal clad polyisocyanurate foam thermal blocks attached to the "exterior" purlin flange.
- 16 gage steel Z-purlins/girts (9" depth) installed vertically 60" on center in the 96 inch HBA frame height
- 0.75 inch thickness Expanded Poly Styrene (EPS) thermal blocks installed over the "interior" side of the purlin flange.
- Poly Scrim Kraft (PSK) faced wide roll R-25 fiber glass metal building insulation installed between the Z-purlins/girts. PSK facing tabs were attached to the "interior" side of the purlin between the EPS thermal blocks and metal channels.
- 2" wide by ½" deep by .020 thick metal channels spaced 31 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.

Figure 2: Sample 8 with PSK Faced R-25, Unfaced R-10 and Thermal Blocks



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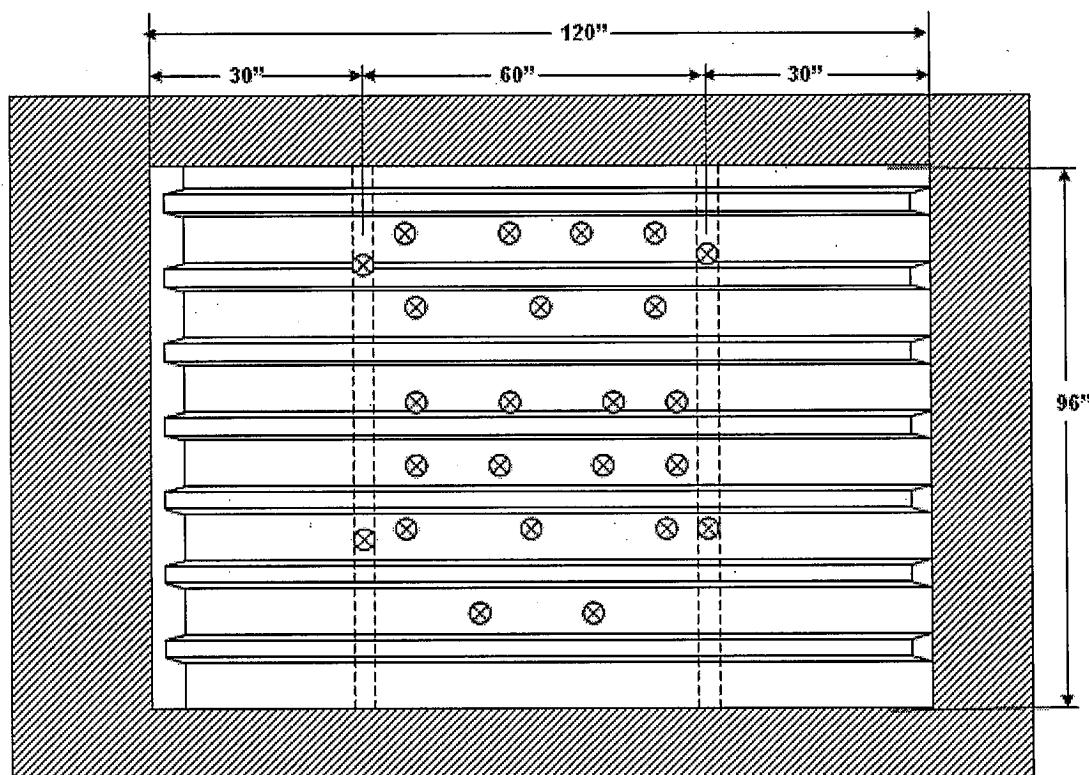
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Sample Construction (continued)

Figure 3: Z-purlin Orientation and Spacing Within the Test Frame and Thermocouple Placement.



⊗ Thermocouple Position



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Sample Construction¹ (continued)

Figure 4: Blanket and Metal Clad Thermal Blocks

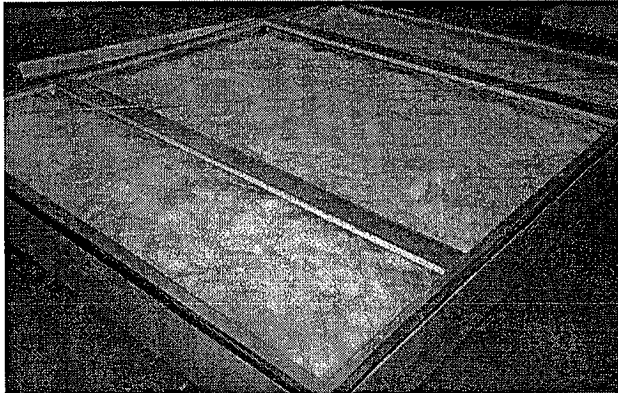


Figure 5: Unfaced Layer Installation

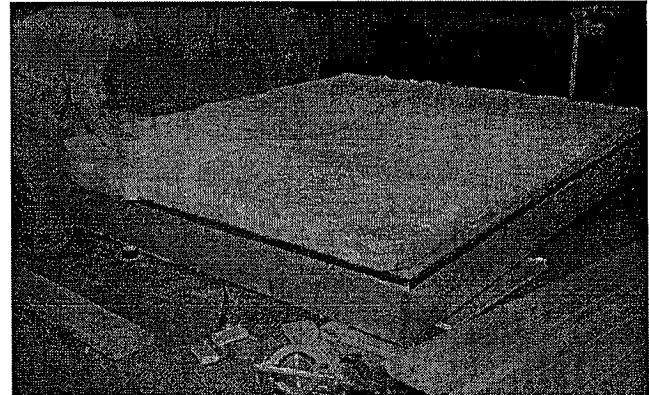


Figure 6: Sheet Metal Installation

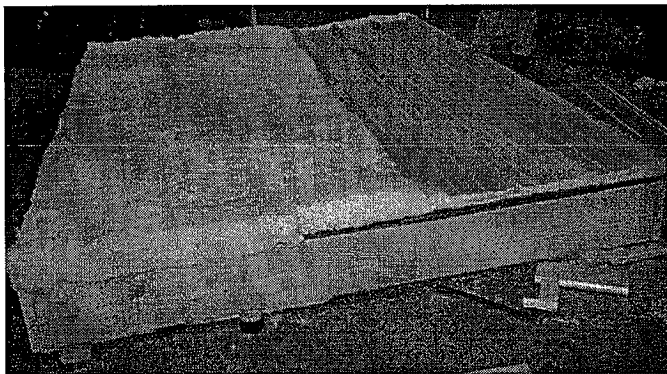


Figure 7: Fastening Exterior to Purlins



¹ These pictures were taken of a prior test assembly, but used in this case to demonstrate how the samples were constructed. It must also be noted that thermal blocks were not used on the perimeter of the wood frame for the test assemblies described in this report.



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Sample Construction (continued)

Figure 8: Sample 7 Interior Side²

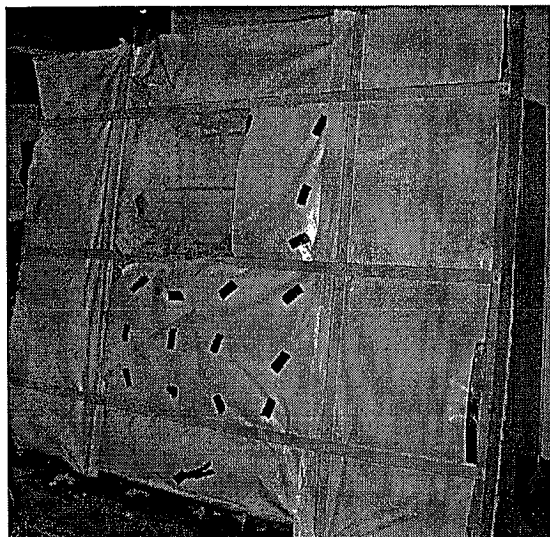


Figure 9: Sample 8 Interior Side

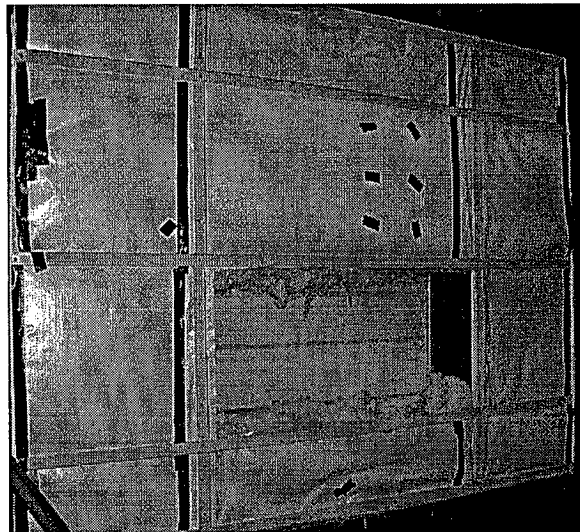


Figure 10: Thermal Block Placement

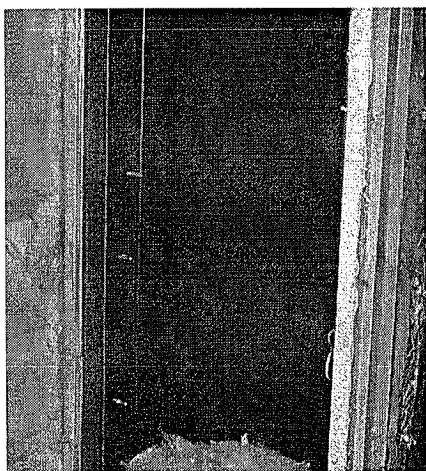
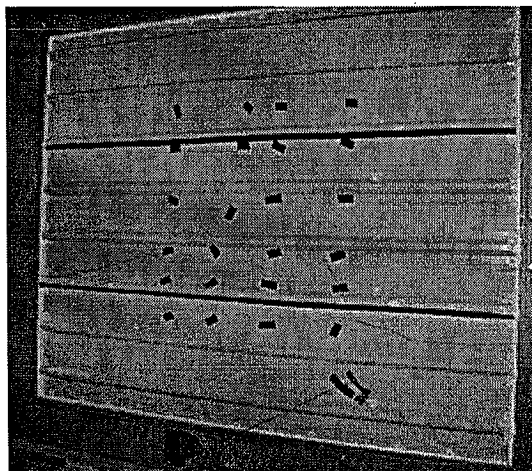


Figure 11: Thermocouple Placement



² Images were taken after samples were removed for small scale testing. 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.³

Sample 7- Roof Configuration (vertical heat flow up from PSK facing to the steel panel)

Test Date: March 8th to 10th 2010

Cavity Thickness: 9.25" (23.5 cm)

System Thickness: 9.80" (24.9 cm)

Air Mean Temperature, Vertical Heat flow up: 75.7 °F (24.3°C, 297.4° K)

Air Temperature Difference, Vertical Heat flow up: 52.1°F (11.2 °C, 284.3° K)

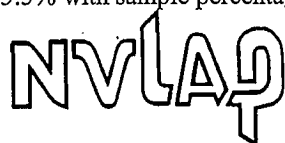
English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block, 9" Z-purlin/girt 60" on center, R-19 fiber glass cavity insulation, 0.75 EPS thermal block steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft ² •°F/Btu) / (Btu/hr•ft ² •°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft ² •°F/Btu) / (Btu/hr•ft ² •°F)
Vertical Heat Flow Up	R-21.35 / U-0.047	R-20.65/ U-0.048

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.74 fiber glass, 1" thick thermal block, 9" Z-purlin/girt 60" on center, R-3.3 fiber glass cavity insulation, 0.75 EPS thermal block steel channels	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)
Vertical Heat Flow Up	R-3.71 / U-0.270	R-3.58 / U-0.279

³The value was determined by the following method; $R_{ave} = \text{Frame \%} \times R_{Frame} + \text{Sample \%} \times R_{Sample}$. Framing percentage was 5.5% with sample percentage equal to 94.5%. Thermal performance of wood is R-1.25 per inch.



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Results (continued)

Sample 8 - Roof Configuration (vertical heat flow up from PSK facing to the steel panel)

Test Date: March 30th to April 1st 2010

Cavity Thickness: 10.25" (26.03cm)

System Thickness: 11.8" (29.97 cm)

Air Mean Temperature, Vertical Heat flow up: 75.0 °F (23.9 ° C, 297.0° K)

Air Temperature Difference, Vertical Heat flow up: 51.6°F (°C, 284.0 ° K)

English Units

Configuration: Corrugated steel panel, unfaced R-10 fiber glass, 1" thick thermal block, 9" Z-purlin/girt 60" on center, R-25 fiber glass cavity insulation, 0.75 EPS thermal block steel channels	C976/C1363 R-Value/U-Value: Air-to-Air (hr•ft ² •°F/Btu) / (Btu/hr•ft ² •°F)	C976/C1363 R-Value/U-Value: Surface-to-Surface (hr•ft ² •°F/Btu) / (Btu/hr•ft ² •°F)
Vertical Heat Flow	R-23.75/ U-0.042	R-23.07/ U-0.043

Metric Units

Configuration: Corrugated steel panel, unfaced R-1.74 fiber glass, 1" thick thermal block, 9" Z-purlin/girt 60" on center, R-4.4 fiber glass cavity insulation, 0.75 EPS thermal block steel channels	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)
Vertical Heat Flow	R-4.13/ U-0.242	R-4.01/ U-0.249



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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
Sample 7 - R-10, Unfaced	3.40	10.93	109%
Sample 7 - R-19, Faced	5.60	18.37	97%
Sample 8 - R-10, Unfaced	3.40	11.02	110%
Sample 8 - R-25, Faced	8.00	21.65	87%

Table 2: Summarized Data - Calculation Inputs

Sample	Sample #7	Sample #8
Orientation	Roof	Roof
Fiber Glass Insulation	R-10/19	R-10/25
MC Temperatures (F)		
Average MC Air Temperature	101.7	100.8
Avg. MC Specimen Surface	100.5	99.9
Average Differential Inside	101.5	100.5
Average Differential Outside	104.3	101.8
CC Temperatures (F)		
Avg. CC Specimen Surface	50.2	49.8
Average CC Air Temperature	49.6	49.2
MC Power Input		
Fan Voltage (V)	12.74	12.82
Fan Current (amps converted to volts)	0.06	0.06
Heater Voltage (V)	16.66	16.98
Htr. Current (amps converted to volts)	0.38	0.39
Speciman Area (Sq. Ft.)		
Frame Test Area	80.49	80.49
Test Specimen Thickness (in)		
Thickness	10.0	11.0



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Appendix (continued)

Table 3 – Summarized Test Data – Calculated Results

CALCULATIONS:		
Area Weighted Surface Temps. (F)		
MC Surface temperature	100.5	99.9
CC Surface temperature	50.2	49.8
Power Input, Q_{pow}		
Fan Power (W)	7.47	7.58
Heater Power (W)	63.48	66.34
Total Power (W)	70.95	73.92
Total Power (Btu/Hr)	242.06	252.22
MC Wall Heat Flow, Q_{mcw}		
MC/S. Room Temp. Diff. (F)	2.73	1.25
MC Wall Heat Flow (Btu/Hr)	10.38	4.73
Infiltration Heat Flow, Q_{inf}		
Infiltration (Btu/Hr)	-39.51	66.75
Flanking Loss Heat Flow, Q_{fl}		
Flanking Loss Thru Frame (Btu/Hr)	8.90	8.11
Q_{net} = Q_{pow} - Q_{mcw} - Q_{inf} - Q_{fl}		
Net Heat Flow (Btu/Hr)	204.08	182.06
Convection Coefficients		
MC Velocity, volts	0.94	0.97
MC Velocity, sfps	0.63	0.64
MC Velocity, mph	0.43	0.44
CC Velocity, volts	2.79	3.05
CC Velocity, sfps	4.66	5.08
CC Velocity, mph	3.18	3.46
h _{mc}	2.14	2.44
h _{cc}	4.64	3.72
sqrt. heff	0.87	0.86
Test Specimen R-value:		
Specimen Temperature Diff. (F)	50.3	50.1
Mean Specimen Temperature (F)	75.4	74.8
R Specimen		
Air to Air R-value:		
Air Temperature Difference (F)	52.1	51.6
Mean Air Temperature (F)	75.7	75.0
R _{air/air}	20.55	22.83
U-value	0.049	0.044
Air Film R-value	0.70	0.68
Specimen R (R _{air to air} - Air Film R)	19.85	22.15
Specimen R-value adjusted for perimeter framing (Air films not included)	20.65	23.07
Specimen U-values (air films not included)	0.048	0.043
Specimen R-values including air films	21.35	23.75
Specimen U-values including air films	0.047	0.042



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