JM
Johns Manville
Johns Manville Technical Center
P.O. Box 625005
Littleton, CO 80162-5005
(303) 978-5200 FAX (303) 978-3123

JOHNS MANVILLE TECHNICAL CENTER
Thermal Testing Laboratory
June 18, 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:

Doug Fast
Research Engineer
Product Testing Laboratories
JMTC Material Performance Technology

Approved By:

Diana Fisler
Section Manager
Product Testing Laboratories
Corporate Research and Development

Approved By:

Rick Packard
Analytical Technology Platform Leader
JMTC Material Performance Technology
Corporate Research and Development

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Introduction

A calibrated hot box test was conducted from June 9^{th} to June 11^{th}, 2010 to measure the thermal performance of a simulated metal building roof assembly using a Calibrated Hot Box Apparatus (CHBA) located at the Johns Manville Technical Center (JMTC) 10100 West Ute Ave, Littleton, Colorado 80127. This test was performed for Craig Oberg of Sealed "N" Safe for the purpose of better understanding the heat flows, R-values and thermal performance of a standard metal building roof construction using Sealed "N" Safe's proprietary metal clad polyisocyanurate thermal blocks. The cavity filled system was tested as a roof assembly (horizontal sample orientation, heat flow up) installed in typical metal building configurations with the exception of the thermal blocks. The metal building assembly was constructed using typical through fastened methods utilizing common metal building components.

Sample Description

The following metal building insulation system was tested:

Sample 8 - The client provided a metal building roof system consisting of 16 gage, 10 inch purlins spaced 60" on center, R-10 and R-25 fiber glass metal building insulation with metal clad polyisocyanurate thermal blocks on the top of the purlin. A detailed explanation of the assembly is described in the body of this report and is shown in Figure 1.

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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 sample was 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 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.

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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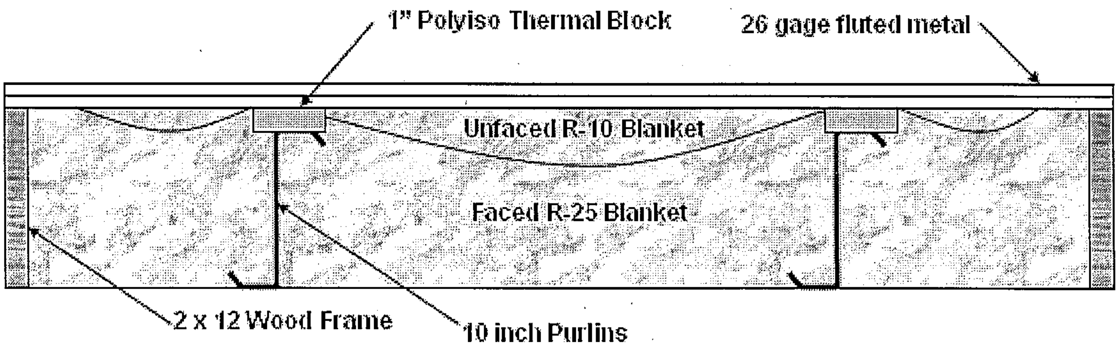
Sample Construction

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 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 (10" depth) installed vertically 60" on center in the 96 inch HBA frame height
- 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 purlins 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 8 with 10" Purlins, PSK Faced R-25, Unfaced R-10 and Thermal Blocks



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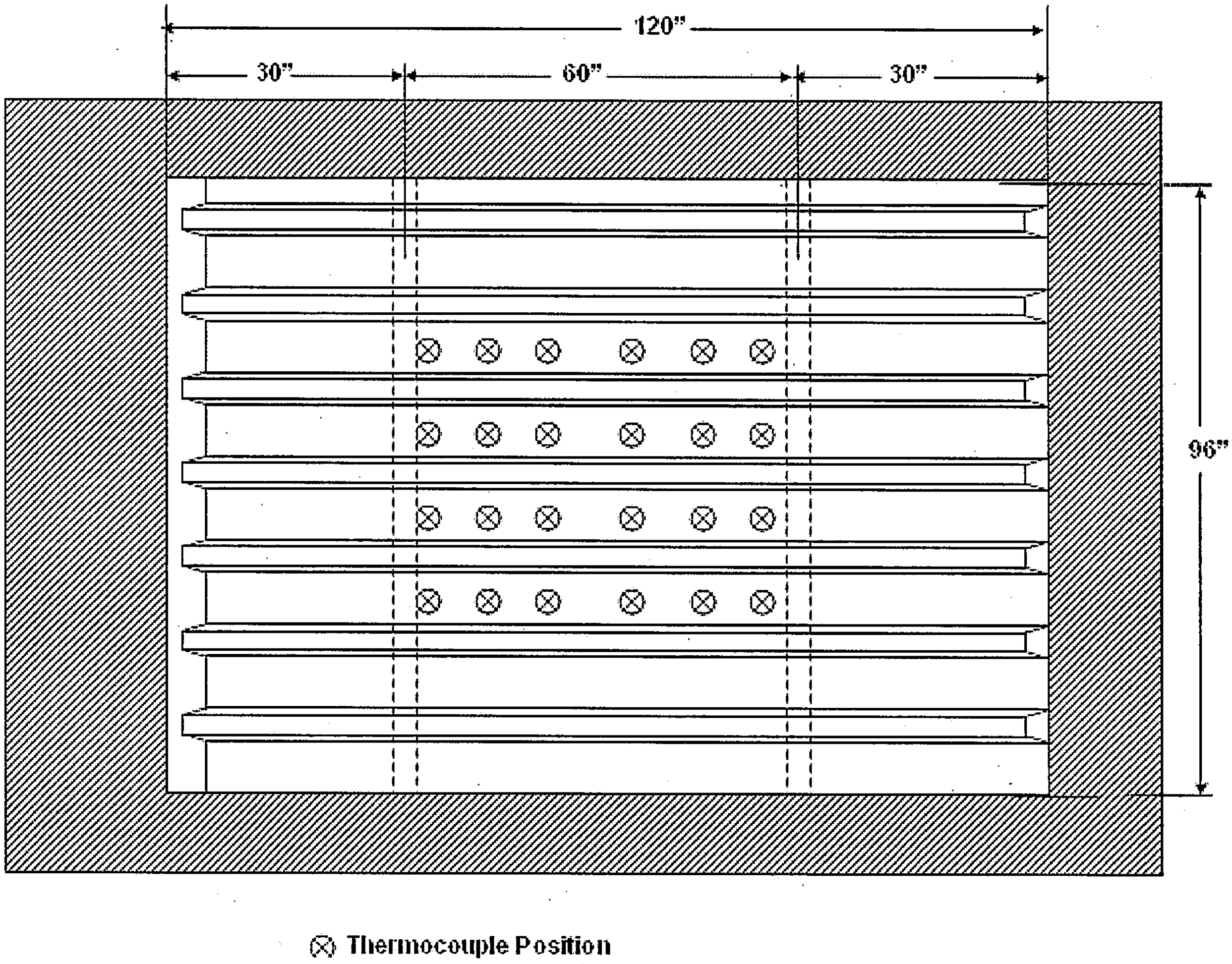
Sample Construction (continued)

Figure 2: Z-purlin Orientation and Spacing Within the Test Frame and Thermocouple Placement.



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Sample Construction (continued)

Figure 3: Blanket and Metal Clad Thermal Blocks

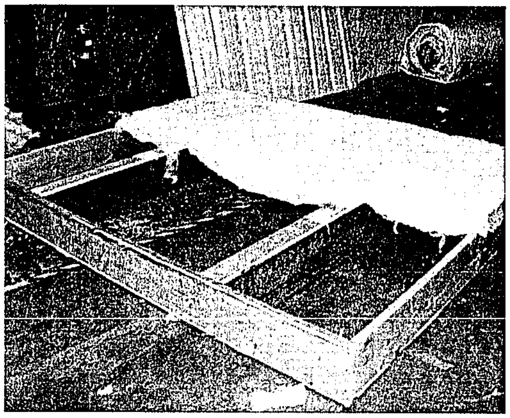


Figure 4: Unfaced Layer Installation

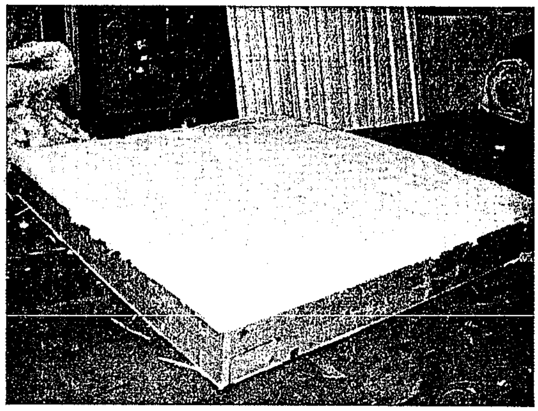


Figure 5: Sheet Metal Installation

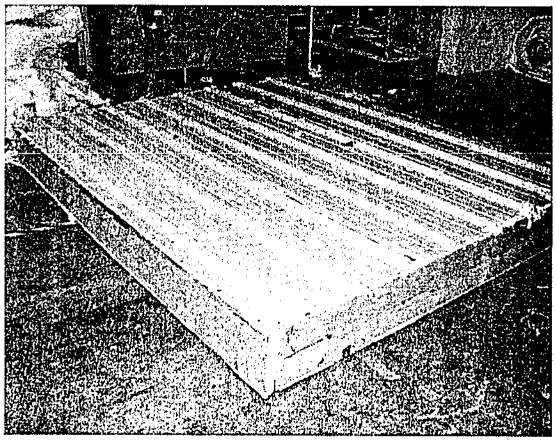
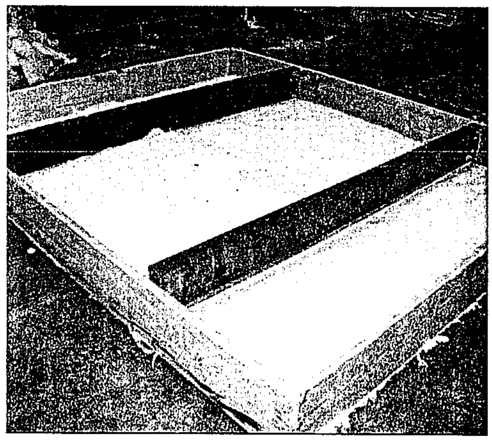


Figure 6: "Interior" Before R-25



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Sample Construction (continued)

Figure 7: Interior Side After R-25 Installation

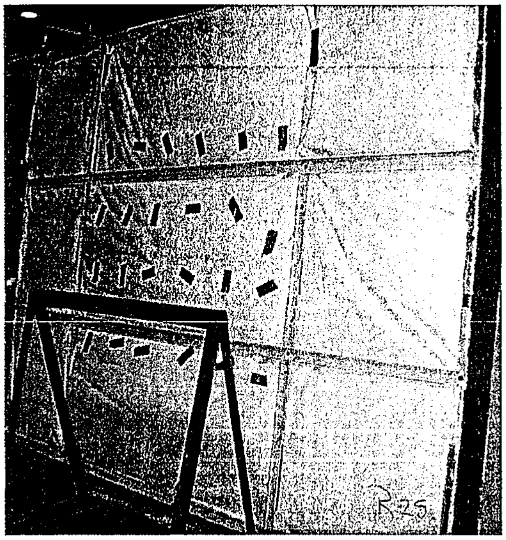
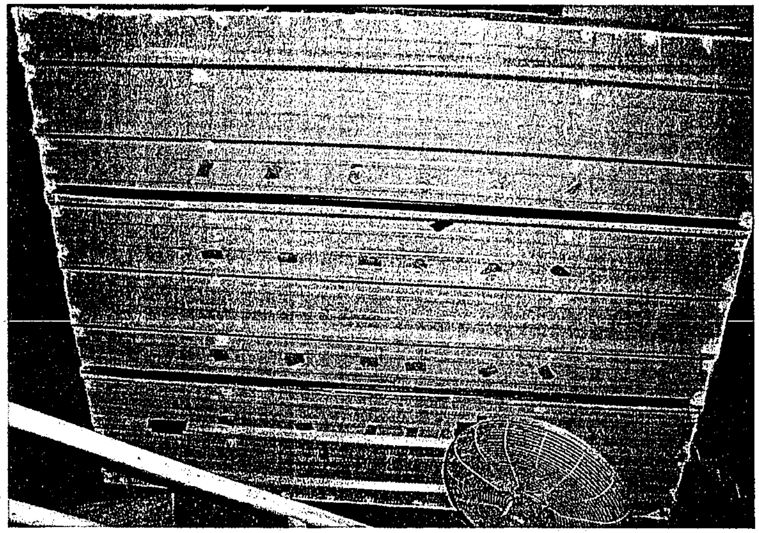


Figure 8: Thermocouple Placement (Exterior)



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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.[1]

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

Test Date: June 9th to June 11th, 2010
Cavity Thickness: 11.0" (27.94 cm)
System Thickness: 12.0" (30.48 cm)
Air Mean Temperature, Vertical Heat flow up: 75.2 °F (24.0 ° C, 297.2 ° K)
Air Temperature Difference, Vertical Heat flow up: 50.7°F (10.4°C, 283.6 ° 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 with 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-23.29 / U-0.043	R-22.59/ U-0.044

Metric 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 with 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-4.05 / U-0.247	R-3.93/ U-0.255

[1] The value was determined by the following method; R_{ave} = Frame % x R_{Frame} + Sample % x R_{Sample}. Framing percentage was 5.5% with sample percentage equal to 94.5%. Thermal performance of wood is approximately R-1.25 per inch.

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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 202-96 R-10, Unfaced	3.40	11.02	110%
NAIMA 202-96 R-25, Faced	7.50	26.34	105%

Table 2: Summarized Data - Calculation Inputs

INPUT:	
MC Temperatures (F)	
Average MC Air Temperature	100.59
Avg. MC Specimen Surface	99.69
Average Differential Inside	100.48
Average Differential Outside	100.98
CC Temperatures (F)	
Avg. CC Specimen Surface	50.32
Average CC Air Temperature	49.85
MC Power Input	
Fan Voltage (V)	12.81
Fan Current (amps converted to volts)	0.06
Heater Voltage (V)	14.97
Htr. Current (amps converted to volts)	0.34
Speciman Area (Sq. Ft.)	
Frame Test Area	80.49
Test Specimen Thickness (in)	
Thickness	12.0

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Appendix (continued)

Table 3 – Summarized Test Data – Calculated Results

CALCULATIONS:	
Area Weighted Surface Temps. (F)	
MC Surface temperature	99.69
CC Surface temperature	50.32
Power Input, Qpow	
Fan Power (W)	7.59
Heater Power (W)	51.00
Total Power (W)	58.59
Total Power (Btu/Hr)	199.90
MC Wall Heat Flow, Qmcw	
MC/S. Room Temp. Diff. (F)	0.50
MC Wall Heat Flow (Btu/Hr)	1.91
Infiltration Heat Flow, Qinf	
Infiltration (Btu/Hr)	12.30
Flanking Loss Heat Flow, Qfl	
Flanking Loss Thru Frame (Btu/Hr)	7.39
Qnet=Qpow+Qmcw-Qinf-Qfl	
Net Heat Flow (Btu/Hr)	182.1
R Specimen	
Air to Air R-value:	
Air Temperature Difference (F)	50.74
Mean Air Temperature (F)	75.22
Rair/air	22.43
U-value	0.04
Air Film R-value	0.60
Specimen R (Rair to air - Air Film R)	21.82
Specimen R-value adjusted for perimeter framing (air films not included)	22.59
Specimen U-values (Air films not included)	0.044
Specimen R values including Air Films	23.29
Specimen U-values including air films	0.043