Test Report

Thermal Resistance Measurements According to ASTM C335 on Innovative Energy AstroShield II Duct Insulation

Prepared For:

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Report: RD10381

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Thermal Resistance of External Duct Insulation

R&D Test Number: RD102281DT Date of Test: May 28-31, 2010

Specimen Number: 1021100430-2 Manufacture Date: Unknown

Test Method ASTM C 335, "Standard Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation"

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Description of Test

The resistance of externally applied air-handling duct insulation is determined using a calibrated end apparatus operated in accordance with ASTM C 335 with analysis in accordance with Section 10.8 of ASTM C 1668-09. The calibrated end apparatus is discussed in Section 5.4 of the test method. The test apparatus is a seven-foot long section of 8 by12 inch rectangular steel duct. An electrical resistance heater is mounted horizontally along the center–line of the duct. Fans at each end of the duct provide internal air circulation. Eight Type-E thermocouples are permanently attached to the interior surface of the duct to provide a hot-side temperature. Four thermocouples are attached to the outside surface of installed duct insulation to provide a cold-side temperature. Thermocouples are attached to rectangular end caps of known thermal resistance in order to determine heat loss from the ends of the apparatus. Two thermocouples are placed four inches from the exterior side of the duct insulation to measure the temperature of the air adjacent to the insulated duct. The entire apparatus is located in a conditional space that is maintained at 70 +/- 2 °F and 50 +/- 5% relative humidity. R-value for the duct insulation is obtained from Equation (1) where the heat flow through the insulation is determined from Equation (2). The heat flow through the end caps is calculated from Equation (3) where the R-value for the end caps is obtained as a function of temperature using a heat-flow meter apparatus operated in accordance with ASTM C 518.

$$R = A \cdot \Delta T / Q \qquad (1)$$

A = Surface area of insulated duct in ft^2
ΔT = Average temperature difference in °F
ΔT = T inside Surface – T outside Surface for $R_{sur\text{-}to\text{-}sur}$
ΔT = T inside Surface – T air for $R_{sur\text{-}to\text{-}air}$
Q = Heat flow through the insulation in Btu/hr
R = $ft^2 \cdot h \cdot °F/Btu$

$$Q = Q_{heater} + Q_{fan} - Q_{ends} \qquad (2)$$

$$Q_{ends} = A_{ends} \cdot \Delta T_{ends} / R_{ends} \qquad (3)$$

A_{ends} = Cross sectional area of ends in ft^2
ΔT_{ends} = Average temperature difference in °F
R_{ends} = R Value at the average temperature of the end caps in $ft^2 \cdot h \cdot °F/Btu$

Description of Test Specimen

A layer of AstroShield II bubblepack duct insulation with 7/8 in. thick spacer material was installed around the test duct. The cellular plastic spacer material was installed along the edges of the duct (longitudinal installation). Both sides of the single bubble reflective insulation were faced with low-emittance material. Approximately 48 inches of material was installed around the test section of the duct.

Test Results

The results for the surface-to-surface and surface-to-air thermal resistances and the average insulation temperatures are given in Table 1 along with the corresponding measurement uncertainty. The results are shown graphically below Table 1.

Table 1. Measured Thermal Resistances

Average Temperature (°F)	$R_{sur\text{-}to\text{-}sur}$ ($ft^2 \cdot h \cdot °F/Btu$)	Uncertainty (%)	$R_{sur\text{-}to\text{-}air}$ ($ft^2 \cdot h \cdot °F/Btu$)	Uncertainty (%)
89.1	3.76	11.2	5.05	8.4
92.9	3.80	9.4	5.02	7.5
101.6	3.40	8.8	4.50	6.9
120.3	3.29	7.7	4.35	6.4
133.6	3.00	7.1	3.95	5.4
140.7	3.02	6.4	4.01	5.8

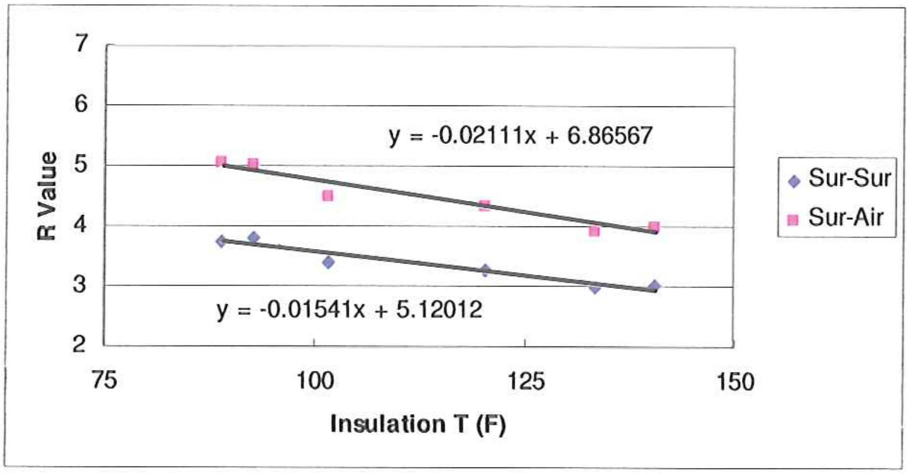

Figure 1. R-value of Duct Insulation Versus the Average Insulation Temperature

The measured thermal resistances contained in Table 1 were used to obtain Equation (4) for the duct surface to outside insulation surface R-value ($R_{sur-to-sur}$). Equation (5) is for the thermal resistance between the duct surface and the air surrounding the insulated duct ($R_{sur-to-air}$). The data and the equations that describe the data are shown in Figure 1.

$$R_{sur-to-sur} = 5.12012 - 0.01541 \cdot T_{ave} \quad (4)$$

$$R_{sur-to-air} = 6.86567 - 0.02111 \cdot T_{ave} \quad (5)$$

T_{avg} is the average temperature (°F) of the insulation assembly.

Equations (4) and (5) were used to obtain the R-Values in Table 2.

Table 2. R-Values at Evenly-Spaced Average Temperature

T (°F)	R ($ft^2 \cdot h \cdot °F/Btu$) Surface-to-Surface	Surface-to-Air
75	3.96	5.28
80	3.89	5.18
85	3.81	5.07
90	3.73	4.97
95	3.66	4.86
100	3.58	4.75
105	3.50	4.65
110	3.43	4.54
115	3.35	4.44
120	3.27	4.33

<u>Conclusion</u>

The thermal resistance between the duct surface and the air surrounding the duct is 5.3 $ft^2 \cdot h \cdot {}^\circ F/Btu$ at an average insulation assembly temperature of 75 °F. The thermal resistance between the duct surface and the exterior insulation surface is 4.0 $ft^2 \cdot h \cdot {}^\circ F/Btu$ at an average insulation assembly temperature of 75 °F.

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7-7-10
Date

The results in this report are limited to the material tested.