Test Report

Classification According to ASTM C592 on WM 640 Mineral Fiber Wired Mat Insulation Supplied by Knauf Insulation in Novi Marof, Croatia

Prepared For:

Delfina-Bi Baranda Robles
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Report: RD14186-R1

Stuart Ruis
President

April 14, 2014

The test results in this report apply only to the specimens tested. The tests conform to the respective test methods except for the report requirements. The report includes summary data but a full complement of data is available upon request. This report shall not be reproduced, except in full, without written approval of R & D Services, Inc. This report must not be used by the client to claim product endorsement by R & D Services, Inc., IAS or any other organization.

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April 14, 2014

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R & D Services, Inc. has completed tests on "WM 640" Mineral Fiber Wired Mat provided by Knauf Insulation in Novi Marof, Croatia. R & D Services, Inc. received three packages of roll insulation on January 16, 2014. The wired mats were received with galvanized steel mesh and galvanized steel wire. All wire and mesh were removed prior to measurements. Tests have been completed to verify that the product complies with ASTM C592 requirements for Type II insulation. The test results are summarized in Table 1. This is only a summary of tests completed as of today.

Table 1

MATERIAL PROPERTY	TEST STANDARD	RESULT	ASTM C592 REQUITEMENT PASS/FAIL
Density (kg/m^3)	ASTM C167	62.56	PASS
Dimensional Recovery (% of label)	ASTM C167	Length – 101.8 % Width – 100.3 % Thickness – 125.6 %	PASS
Maximum Use Temperature (649 °C)	ASTM C447/C411	No reaction	PASS
Linear Shrinkage (% change)	ASTM C356	0.53	PASS
Water Vapor Sorption (Mass %)	ASTM C1104	0.05	PASS
Odor Emission	ASTM C1304	PASS	PASS
Thermal Conductivity	ASTM C177	See Table 2	See Table 2
Corrosiveness	ASTM C795	PASS	PASS
Corrosiveness	ASTM C665; Section 13.8	Steel – PASS Copper – PASS Aluminum – PASS	PASS PASS PASS
Fungi Resistance	ASTM C1338	No Growth	PASS
Non Fibrous Shot Content (% content)	ASTM C1335	12.9	PASS
Non Combustibility	ASTM E136	PASS	PASS
Surface Burning Characteristics	ASTM E84	FSI – 0 SDI – 0	PASS

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Table 2

MEAN TEMPERATURE (°C)	THERMAL CONDUCTIVITY (W/m·°K)	ASTM C592 REQUIREMENT (W/m·°K)	PASS/FAIL
-4	0.0298	0.030	PASS
24	0.0335	0.036	PASS
38	0.0356	0.039	PASS
93	0.0441	0.049	PASS
149	0.0541	0.060	PASS
204	0.0631	0.076	PASS
260	0.0772	0.092	PASS
316	0.0922	0.108	PASS
371	0.1110	0.124	PASS

Test results on the Knauf Insulation "WM 640" Mineral Fiber Wired Mat show that the product meets the requirements of ASTM C592 for Type II classification.

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Dimensional Tolerance Test Report

Test Number: RD141399DT Date of Test: January 21, 2014

Specimen Number: 1211140116-1,3 Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" Section 11.2; ASTM C 167-09, "Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations."

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Results:

	Minimum Measurement (inch)	Maximum Measurement (inch)	Average Measurement (inch)	Recovery (% of label)
Length	159.88	160.21	160.21	101.8
Width	39.5	39.5	39.5	100.3
Thickness	2.24	2.68	2.47	125.6

Mass per area (lb/ft^2)	0.80
Density at recovered thickness (lb/ft^3)	3.91
Density at nominal thickness (lb/ft^3)	4.91

Mass per area(kg/m^2)	3.93
Density at recovered thickness (kg/m^3)	62.56
Density at nominal thickness (kg/m^3)	78.56

Reviewed By: 4/2/2014 Date:

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Hot Surface Performance of High-Temperature Thermal Insulation

Test Number: RD141592HS Date of Manufacture: Unknown

Specimen Number: 1211140116-1 Date of Test: March 18-22, 2014

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Report Prepared For: Knauf Insulation (Slovenija)

Contact Person: Delfina-Bi Baranda Robles

Test Methods: ASTM C411, "Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation".

ASTM C592, "Standard Specification for Mineral Fiber Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)".

ASTM C447, "Standard Practice for Estimating the Maximum Use Temperature of Thermal Insulations".

Description of Test

ASTM C 411 tests the performance of a thermal insulation intended for high temperature applications when the insulation is in continuous contact with a hot surface at a controlled temperature for a period of 96 hours. Visible signs of flaming, glowing, smoldering, or smoking results in termination of the test. The electrical power to the heater is turned off at the end of 96 hours and the test specimen was allowed to cool to room temperature. After cooling the test specimen was removed from the hot plate for evaluation.

The plate has a heated surface of 610 by 610 mm (24 by 24 inches). The temperature of the plate is recorded in four locations. The temperature of the specimen was measured at 25 mm increments measured from the hot surface through the entire thickness of the test specimen to the surface exposed to the room. The plate was heated to 649°C using a sacrificial piece of insulation. Once the plate was heated to the test temperature, the sacrificial piece of insulation was removed from the plate and four layers of the specimen were placed on the test apparatus and held at a constant temperature for 96 hours.

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Conditions and Observations

1. The product was identified as "WM 640" Mineral Fiber Insulation. The material was supplied by Knauf Insulation in Novi Marof, Croatia.
2. The specimen was cut into four 24 by 24 inch pieces and placed on the plate after the plate was heated to the test temperature.
3. The test temperature was 649 +/- 15 °C. The average plate temperature during the test was 650.9 °C.
4. There was no warpage observed after the 96 hour exposure.
5. There was no flexibility change observed.
6. No cracking or delamination was observed.
7. There was no evidence of flaming, glowing, smoldering or melting during the 96 hour test. There was no evidence of melting or fiber degradation.
8. No smoking was observed during the test.
9. Discoloration was observed in each layer.
10. There was no exothermic reaction observed during the test.
11. Figure 1 is a photograph of layer 1 prior to testing and Figure 2 is a photograph of layer 1 after testing. Figure 3 is a photograph of layer 2 prior to testing and Figure 4 is a photograph of layer 2 after testing. Figure 5 is a photograph of layer 3 prior to testing and Figure 6 is a photograph of layer 3 after testing. Figure 7 is a photograph of layer 4 prior to testing and Figure 8 is a photograph of layer 4 after testing. Figure 9 is the temperature profile for the first 4 hours of the test. Figure 10 is the temperature profile for the duration of the test.
12. Table 1 contains physical characteristics before testing. Table 2 contains the mass change of the material after testing. Table 3 contains temperature and exothermic reaction data of the test specimen during testing.

Conclusion

The "WM 640"mineral fiber insulation manufactured by Knauf Insulation in Novi Marof, Croatia meets the requirements of ASTM C592-13, "Standard Specification for Mineral Fiber Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" when tested according to ASTM C411-11, "Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation" and ASTM C447-10 "Standard Practice for Estimating the Maximum Use Temperature of Thermal Insulations" at a surface temperature of 649°C for a Type II product.

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	Length (mm)	Width (mm)	Thickness (mm)	Mass (g)	Density (kg/m^3)
Layer 1 (exposed to plate)	622.3	628.7	67.0	1440.9	54.9
Layer 2	609.6	622.3	66.0	1407.9	56.2
Layer 3	609.6	628.7	70.0	1572.3	58.6
Layer 4 (exposed to room)	609.6	587.5	67.0	1492.1	62.3

Table 1 – Dimensions and Mass Before Testing

	Mass (g)	Mass Loss (%)
Layer 1 (exposed to plate)	1415.9	1.7
Layer 2	1373.5	2.4
Layer 3	1551.6	1.3
Layer 4 (exposed to room)	1488.2	0.5

Table 2 – Mass Change After Testing

Distance of Temperature Measurement From Hot Surface (mm)	Maximum Temperature (^oC)	Maximum Exotherm Temperature (^oC)	Dwell Temperature (^oC)
25	627.7	-23.4	625.6
50	595.9	-54.8	593.5
75	568.5	-82.2	565.9
100	526.8	-123.9	524.0
125	475.0	-171.5	475.0
150	432.3	-218.7	424.9
175	402.2	-249.0	392.0
200	331.8	-319.4	320.8
Surface	51.2	-599.6	46.2

Table 3 – Exothermic Temperature Data

Note- No exothermic reaction was recorded. The exotherm is the maximum temperature difference between the plate temperature and the measurement location when the measurement location is above the plate temperature. A negative number indicates no exotherm was observed.

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Figure 1. Layer 1 Before Testing

Figure 2. Layer 1 After Testing

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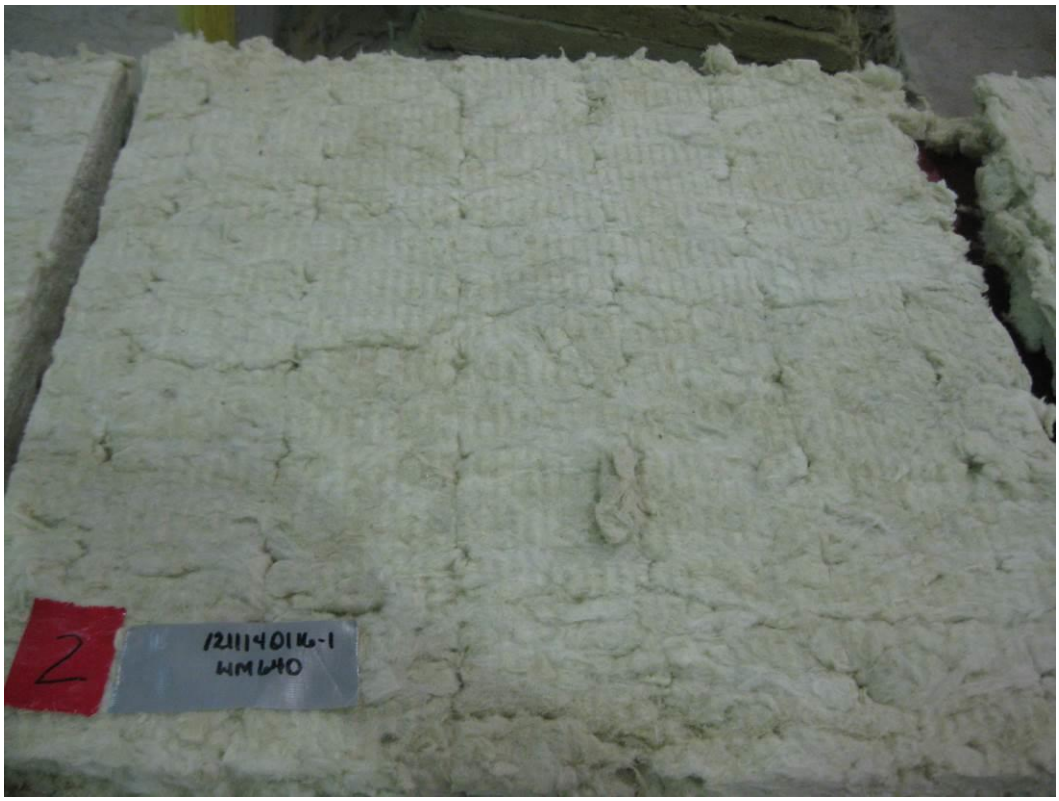

Figure 3. Layer 2 Before Testing

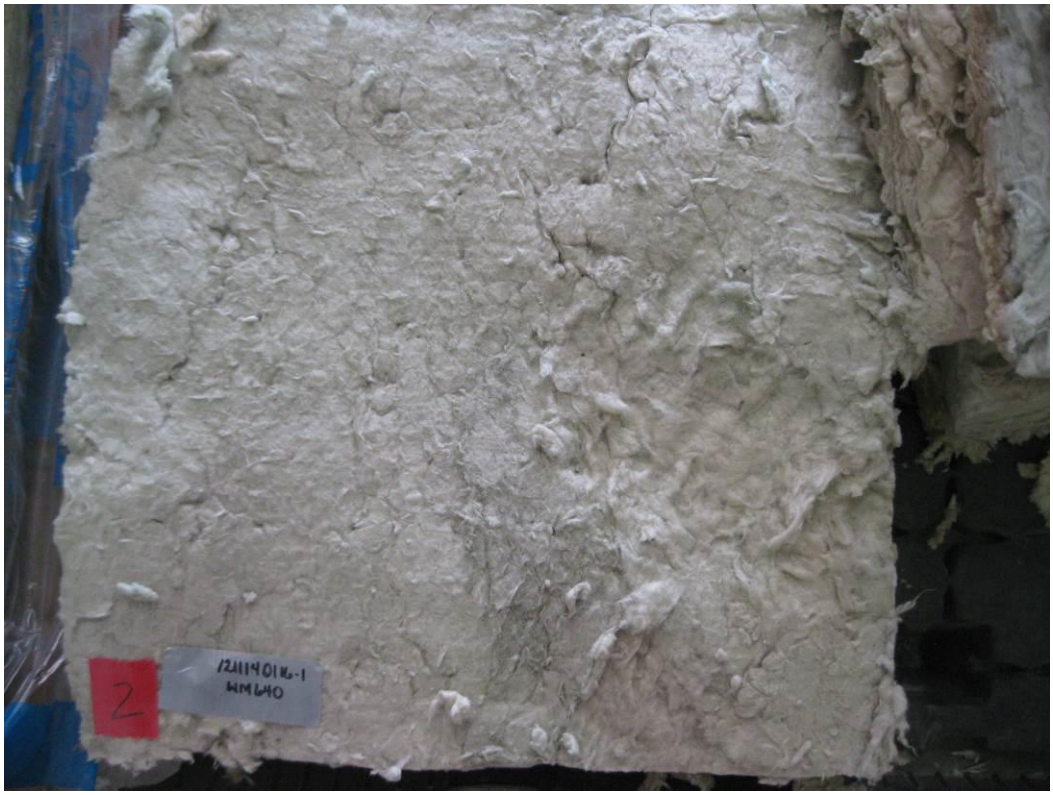

Figure 4. Layer 2 After Testing

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Figure 5. Layer 3 Before Testing

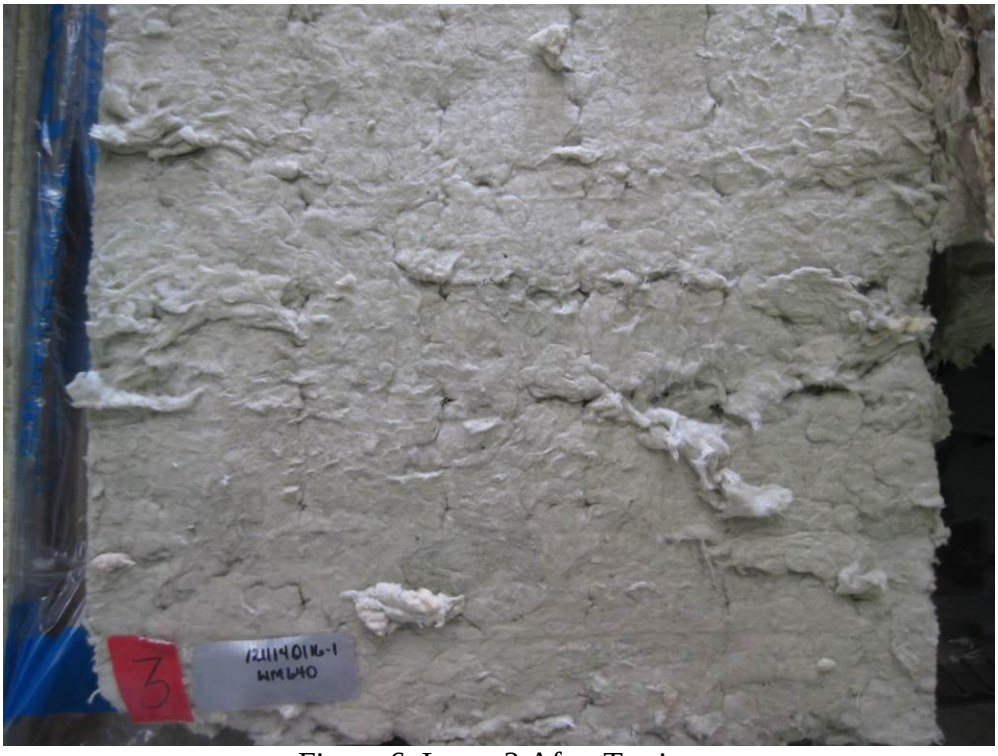

Figure 6. Layer 3 After Testing

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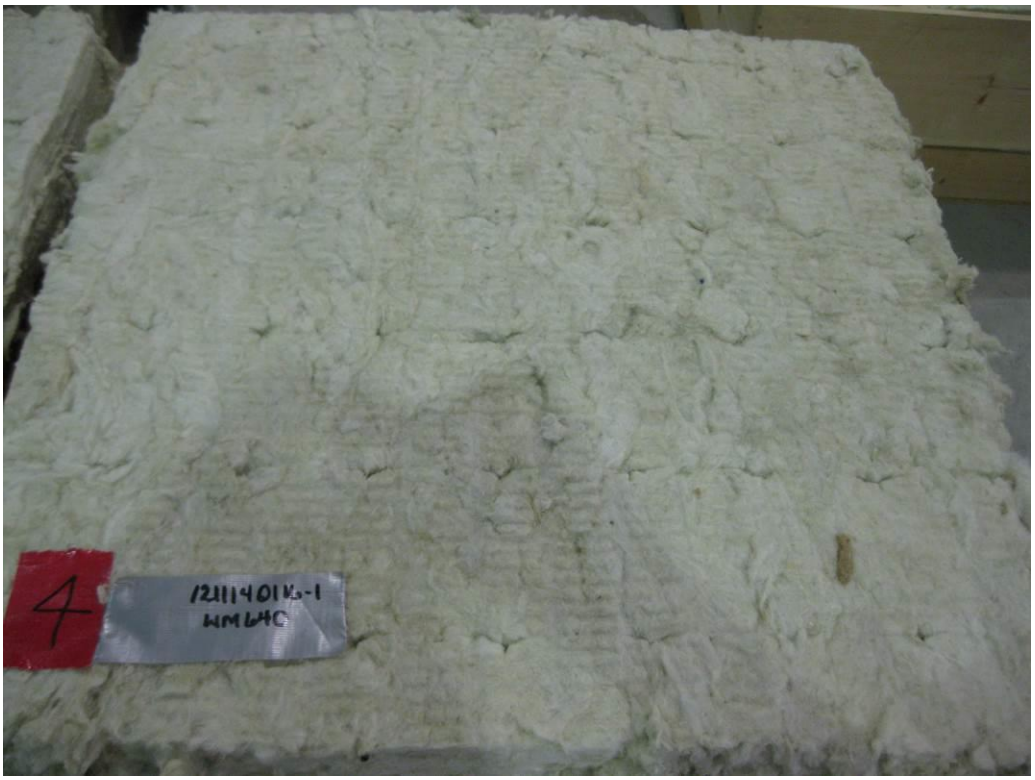

Figure 7. Layer 4 Before Testing

Figure 8. Layer 4 After Testing

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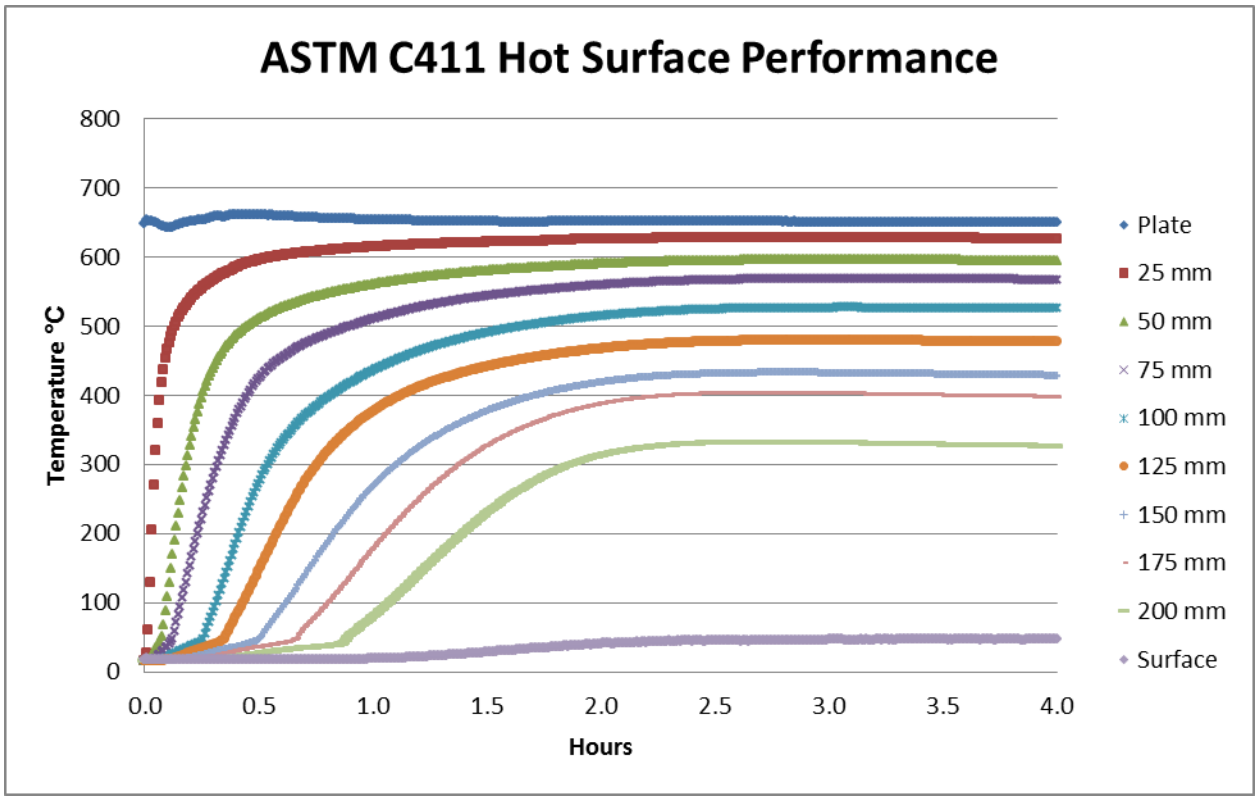

Figure 9- Temperature Profile for the First 4 Hours of Testing

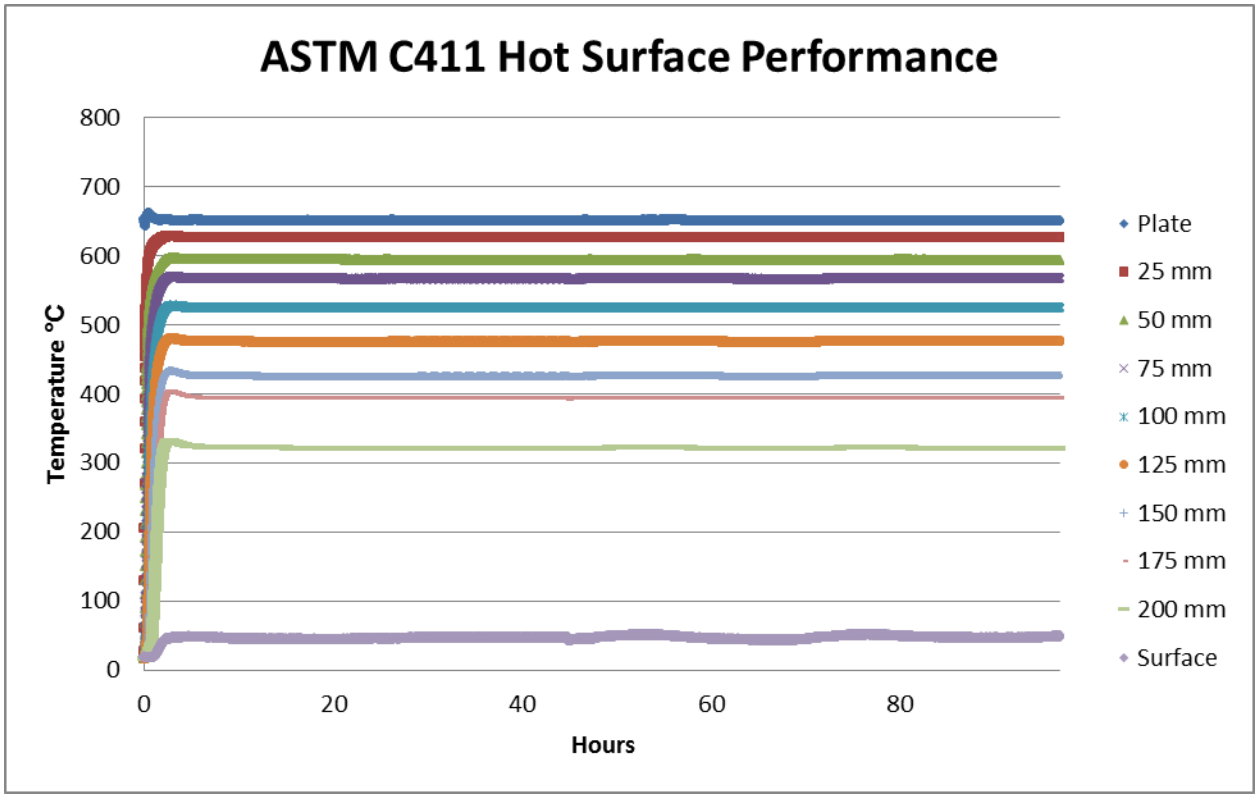

Figure 10- Temperature Profile for the Duration of Testing

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Linear Shrinkage of Thermal Insulation Report

Test Number: RD141397LS

Date of Test: February 19-20, 2014

Specimen Number: 1211140116-1,3

Date of Manufacture: Unknown

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Background

The linear shrinkage of mineral fiber insulation due to exposure to short-term high temperature has been determined in accordance with ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)", Section 11.9 and ASTM C356, "Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat". The specimens are conditioned and exposed to high temperature conditions for 24 hours. The average linear shrinkage of four specimens is measured and used to calculate the linear shrinkage percent of the samples expressed as a percentage of the length measured before exposure.

Description of Test Specimens

The material used in this test was "WM 640" Mineral Fiber Insulation Mat supplied by Knauf Insulation (Slovenija). Four samples approximately 154 by 64 by 65 mm were used. The test was conducted at 649 °C.

Test Results

	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Initial Length (mm)	154.3	158.0	155.7	157.7
Initial Width (mm)	64.0	64.7	65.3	63.0
Initial Thickness (mm)	64.67	62.67	64.67	67.67
Final Length (mm)	154.3	156.7	154.7	156.7
Final Width (mm)	63.0	63.7	64.3	62.0
Final Thickness (mm)	64.67	62.00	64.67	67.67
Change in Length (mm)	0.0	1.3	1.0	1.0
Linear Shrinkage (%)	-0.000	-0.823	-0.642	-0.634

Result:

The average observed linear shrinkage of the test specimens was -0.53 %. This satisfies the physical requirements in Table 1 of ASTM C592.

Reviewed By:

Date: 4/2/2014

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Water Vapor Sorption Test Report

Test Number: RD141402WV

Date of Test: January 30 – February 3, 2014

Specimen Number: 1211140116-1,3

Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" Section 11.8; ASTM C 1104/C 1104M-00 (Reapproved 2006), "Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation".

The procedure used to test blanket, board, or pipe insulation products is contained in Section 8 of ASTM C 1104/C 1104M-00 (2006). The procedure is carried out for three specimens of the product. The volume of each test specimen is determined from measurements of the length, width, and thickness. The dry weight of the test specimens is determined after drying to steady state in a 102 to 121 °C environment. The test specimens are brought to a uniform temperature of 60°C before being transferred to an environmental chamber maintained at 49 ± 2 °C and 95 ± 3 % relative humidity. The test specimens remain in the environmental chamber for 96 ± 4 hours. At the end of the 96 hour exposure the specimens are sealed in a water inpermeable bag and allowed to cool before final weighing. The increase in weight due to the exposure is used to calculate mass % and volume % water sorption relative to the moisture-free material.

Results:

Specimen:	**1**	**2**	**3**
Volume (cm^3):	1438.30	1467.21	1555.69
Moisture-free Mass (g):	76.35	90.93	103.22
Mass after test (g):	76.43	90.94	103.24
Mass % sorbed:	0.10	0.01	0.02
Volume % sorbed:	0.006	0.001	0.001
Average Mass % sorbed:	**0.045**		
Average Volume % sorbed:	**0.003**		

The average observed mass % sorbed of the test specimens was 0.045 %. This satisfies the physical requirements in Table 1 of ASTM C592.

Reviewed By:

4/2/2014
Date:

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Odor Emission Test Report

Test Number: RD141401OE Date of Test: January 31, 2014

Specimen Number: 1211140116-1,3 Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" Section 11.6; ASTM C 1304-08 (Reapproved 2013) "Test Method for Assessing the Odor Emission of Thermal Insulation Materials".

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Judge	1	2	3	4	5
Odor (Yes/No)	No	Yes	Yes	Yes	No
Odor (Objectionable/Pleasant/ Otherwise)		Objectionable	Otherwise	Otherwise	
Odor (Weak/Strong)		Weak	Weak	Weak	

Pass / Fail

Pass

Reviewed By: Date: 4/2/2014

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Apparent Thermal Conductivity of "WM 640" Mineral Fiber Mat Insulation Manufactured by Knauf Insulation – Croatia Thermal Conductivity was Determined According to ASTM C177

Three rolls of nominal 4000 by 1000 by 50 mm "WM 640" mineral fiber mat insulation were received by R&D Services, Inc. on January 16, 2014. The material was manufactured by Knauf Insulation in Novi Marof, Croatia.

Two pieces of each product were sampled from one of the rolls received by R&D Services, Inc. to be measured for thermal conductivity. Two nominal 305 by 305 by 50 mm, specimens were prepared.

Apparent thermal conductivity measurements were performed according to ASTM C177-10, utilizing a Holometrix Model TCFGM guarded hot-plate instrument. The specimen was measured at nine mean temperatures from -4 - 371 °C. A summary of the results is shown in Table 1. A graphical summary of results is shown in Figure 1.

Table 1: Summary of Results

Product	Test Thickness (mm)	Test Density (kg/m^3)	Mean Test Temperature (^oC)	Apparent Thermal Conductivity (W/m·k)	Thermal Resistance (m^2·k/W)
WM 640	50.0	76.5	-4	0.0298	1.68
			24	0.0335	1.49
			38	0.0356	1.40
			93	0.0441	1.13
			149	0.0541	0.924
			204	0.0631	0.792
			260	0.0772	0.648
			316	0.0922	0.543
			371	0.1110	0.451

The tests contained in this report were subcontracted to NETZSCH Instruments North America, LLC. Results are shown in NETZSCH Report Number 621003126-2.

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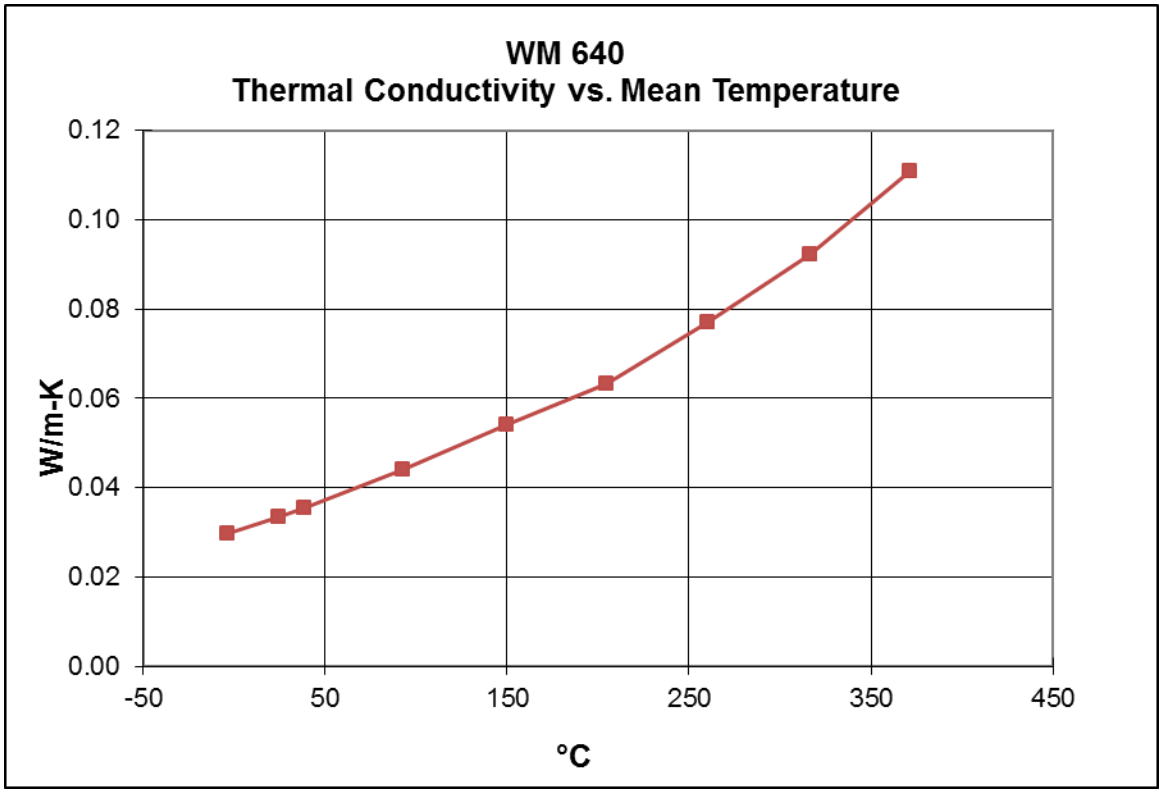
Figure 1: Graphical Summary of Results



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Corrosiveness Test Report

Test Number: RD141400CO

Date of Test: January 29- February 28, 2014

Specimen Number: 1211140116-1,3

Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" Section 11.7; ASTM C 665-12, Section 13.8, "Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing".

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Procedure

Four each of specially cleaned aluminum, copper, steel plates were individually sandwiched between two layers of "WM 640" Mineral Fiber Insulation Mat. Four plates of each were also prepared with sterilized cotton as control specimens.

This report presents the results of tests for corrosiveness conducted on "WM 640" Mineral Fiber Insulation Mat supplied by Knauf Insulation (Croatia). Testing on the steel coupons was completed on February 3, 2014. Testing on the aluminum and copper coupons was completed on February 28, 2014.

The prepared specimens were held by woven metal screens and suspended in an environmental chamber at 49 ± 2 °C and 95 ± 3 % RH. The steel specimens were allowed to remain in the chamber for 96 ± 2 hours. The aluminum and copper specimens were allowed to remain in the chamber for 720 ± 5 hours.

Specimens were removed and post cleaned. The coupons were numbered and a panel of four judges examined the surfaces of each coupon and ranked them based on their best estimate of corrosiveness. Upon completion of the judges' rankings, the arithmetic sum of the rankings for each coupon was calculated. The sums were then ranked from the lowest total to the highest total. The new rankings established were totaled for the controls only. If this sum is greater than or equal to 21 for the controls, then there is no statistical difference between the control and the test plates and the insulation passes.

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Observations:

	Number	Sum	Rank	Total
Steel	1	34	9	37
	2	22	6	
	3	26	8	
	4	18	4	
	5	37	10	

The rankings of the control plates did total 21 or greater, therefore there is deemed to be no statistical difference in the test plates and the controls and the insulation Passes.

	Number	Sum	Rank	Total
Copper	1	19	4.5	34.5
	2	16	3	
	3	32	10	
	4	29	8	
	5	30	9	

The rankings of the control plates did total 21 or greater, therefore there is deemed to be no statistical difference in the test coupons and the controls and the insulation Passes.

	Number	Sum	Rank	Total
Aluminum	1	26	6.5	40
	2	36	10	
	3	34	9	
	4	26	6.5	
	5	33	8	

The rankings of the control plates did total 21 or greater, therefore there is deemed to be no statistical difference in the test coupons and the controls and the insulation Passes.

Reviewed By:

4/2/2014
Date:

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Fungi Resistance Test Report

Test Number: RD141398FR Date of Test: January 23– February 20, 2014

Specimen Number: 1211140116-1,3 Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)" Section 11.12; ASTM C 1338-08, "Standard Test Method for Determining Fungi Resistance of Insulating Materials and Facings.

Report Prepared For: Knauf Insulation (Slovenija)/ Delfina-Bi Baranda Robles

Test specimens and comparative material are exposed to a 28 day inoculation period. After the inoculation period the specimens are removed from test chamber and evaluated under 40X magnification. Each of the test specimens are determined to have no fungal growth, fungal growth no greater than the comparative material, or fungal growth greater than the comparative material.

Specimen	Fungal Growth Comparison
1	No growth.
2	No growth.
3	No growth.

Comparative Material: Birch
The pass/fail result: Pass
Basis for the pass/fail result: Three of three specimens passed.

Carla King

Evaluation: 4/2/2014 Date:

Review: 4/2/2014 Date:

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Non-Fibrous Content Test Report

Test Number: RD141480NF Date of Test: February 19, 2014

Specimen Number: 1211140116-1,3 Date of Manufacture: Unknown

Description of Test Specimen: "WM 640" Mineral Fiber Insulation Mat.

Test Method: ASTM C592-13, "Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)", Section 11.3; ASTM C1335-12, "Standard Test Method for Measuring Non-Fibrous Content of Man-Made Rock and Slag Mineral Fiber Insulation".

Report Prepared For: Knauf Insulation (Slovenija) / Delfina-Bi Baranda Robles

Background

This test procedure determines the non-fibrous content (shot) of man-made rock and slag mineral fiber insulation. The procedure involves a dry sieve analysis method to distinguish between fiberized and non-fiberized (shot) portions of a specimen of man-made rock and slag mineral fiber insulation.

Three 10 gram specimens are prepared. Test specimens are conditioned at high temperature for 15 minutes and allowed to cool to room temperature. The specimens are placed into a nest of three sieves and shaken for 20 minutes using a Tyler model RX-24 portable sieve shaker. The non-fibrous (shot) content remaining in each sieve is weighed. The percentage of non-fibrous content is calculated using the equation in Section 8 of ASTM C1335.

Test Results

Conditioning Temperature: 593 °C
Type of Sieves Used: Number 20, 50 and 100; brass

	Specimen 1	Specimen 2	Specimen 3
Initial Mass of Specimen (g)	10.1312	10.0368	10.1176
Mass of Specimen After Conditioning (g)	10.0480	9.9566	10.0352
Mass of Non-Fibrous Material in No. 20 Sieve (g)	0.0234	0.0092	0.0163
Mass of Non-Fibrous Material in No. 50 Sieve (g)	0.3460	0.3093	0.3311
Mass of Non-Fibrous Material in No. 100 Sieve (g)	0.9973	0.7994	1.0570
Total Mass of Non-Fibrous Material (g)	1.3667	1.1174	1.4044
Non-Fibrous Content (%)	13.6	11.2	14.0

Result:

The average observed non-fibrous content of the test specimens was 12.9 %. This satisfies the physical requirements of Section 7.5 in ASTM C592.

Reviewed By: 4/2/2014 Date: