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# EVALUATION OF "KIMMCO-ISOVER GLASS MINERAL WOOL RIGID PIPE INSULATION" IN ACCORDANCE WITH ASTM C547-19

| | |
|---|---|
| A Report to: | **Kuwait Insulating Materials Manufacturing Co. S.A.K (KIMMCO)**<br>**KIMMCO-ISOVER Brand**<br>Mina Abdullah, Shuaiba Industrial Area<br>Area 1, Block 3, Plot 42, Wafra Road<br>65451 Kuwait. P.O.Box: 10042 Shuaiba |
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| Proposal No.: | 20-006-220631 Rev01 |
| Report No.: | 21-06-P0009 Rev. 1<br>14 pages, 1 Appendix |
| Date: | July 6, 2022 |

## 1.0 INTRODUCTION

At the request of Kuwait Insulating Materials Manufacturing Co. S.A.K (KIMMCO), Element Materials Technology was retained to evaluate a sample of the KIMMCO-ISOVER glass mineral wool rigid pipe insulation in conformance with ASTM C547-19, "Standard Specification for Mineral Fibre Pipe Insulation".

Upon receipt, the materials were assigned the following Element Sample Numbers:

| Client Sample Description | Element Sample No. |
|---|---|
| KIMMCO-ISOVER Glass Mineral Wool Rigid Pipe Insulation Type 1, Nominal: 64 kg/m$^3$ | 21-06-P0009 |

## 2.0 PROCEDURE

The sample was tested in conformance with ASTM C547-19 for the following tests:

| Test Description | Test Methods |
|---|---|
| Maximum Use and Exothermic Temperature | ASTM C411/C447 |
| Thermal Conductivity | ASTM C335 |
| Dimensions and Density | ASTM C302 |
| Linear Shrinkage | ASTM C356 |
| Water Vapour Sorption | ASTM C1104 |
| Surface Burning Characteristics / Smoke Development | ASTM E84 |

## 3.0 RESULTS

### 3.1 HOT SURFACE PERFORMANCE (ASTM C411and C447)

| | | |
|---|---|---|
| Specimen Dimensions: | 1,000 mm × 50 mm thick x 89 mm ID | |
| Equipment: | Exova Guarded Hot Pipe Test Apparatus | MII# A11988 |
| Measurement: | Measuring tape | MII# B12690 |
| | Sartorius digital balance | MII# B12518 |
| Test Conditions: | 454°C | |
| Test Duration: | 96 hours | |
| Sample Orientation: | Horizontal | |
| Test Date: | 2021-01-26 to 2021-01-30 | |

A summary of results are presented below in Table 1 and Figures 1, 2 and 3.

SI units is the primary unit of measure.

**Table No. 1 – Maximum Use and Exothermic Temperature Results**
ASTM C411-17/C447-15
*Element Sample No.: 21-06-P0009*

| Test Criteria | Observed |
|---|---|
| Average hot surface temperature | 453.42°C |
| Average mid-point temperature | 247.70°C |
| Average cold surface temperature | 95.68°C |
| Maximum mid-point temperature | 257.24°C |
| Temperature rise due to combustion | 9.54°C |
| Initial density | 58.63 kg/m$^3$ |

| **Table No. 1 cont'd – Maximum Use and Exothermic Temperature Results**<br>ASTM C411-17/C447-15<br>*Element Sample No.: 21-06-P0009* | |
|---|---|
| Final density | 57.10 kg/m$^3$ |
| Weight loss | 2.61% |
| Sag | 0.35 % (0.2 mm) |
| Linear shrinkage | 0 % |
| Warpage | None |
| Cracking | None |
| Delamination | None |
| Flaming | None |
| Glowing | None |
| Smoldering | None |
| Smoking | None |
| Melting | None |
| Dripping | None |
| Other | Permanent discoloration of the insulation adjacent to the hot surface. |

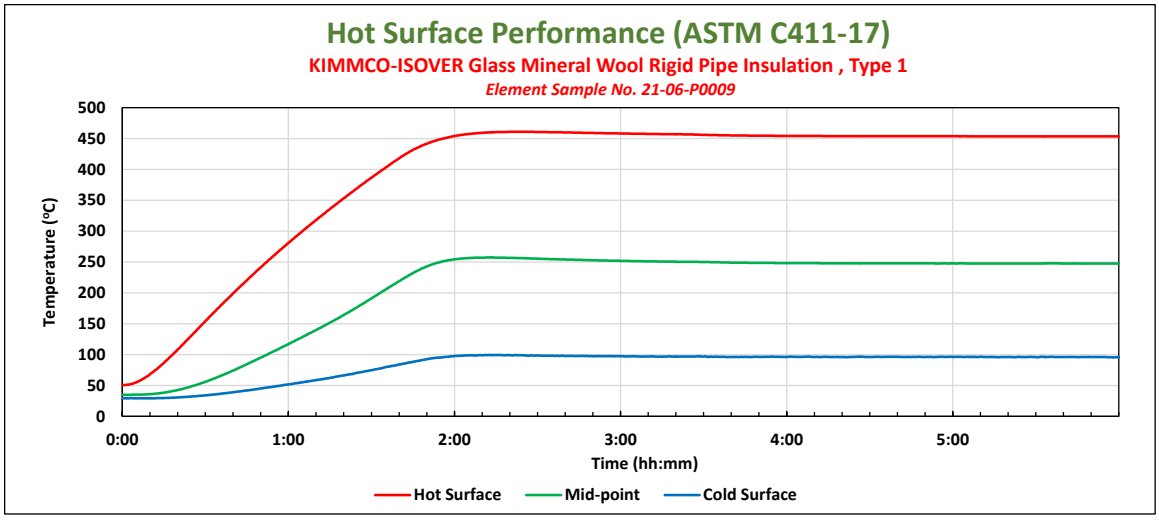



**Figure 1:** Graph of the temperatures recorded during the first 6 hours.

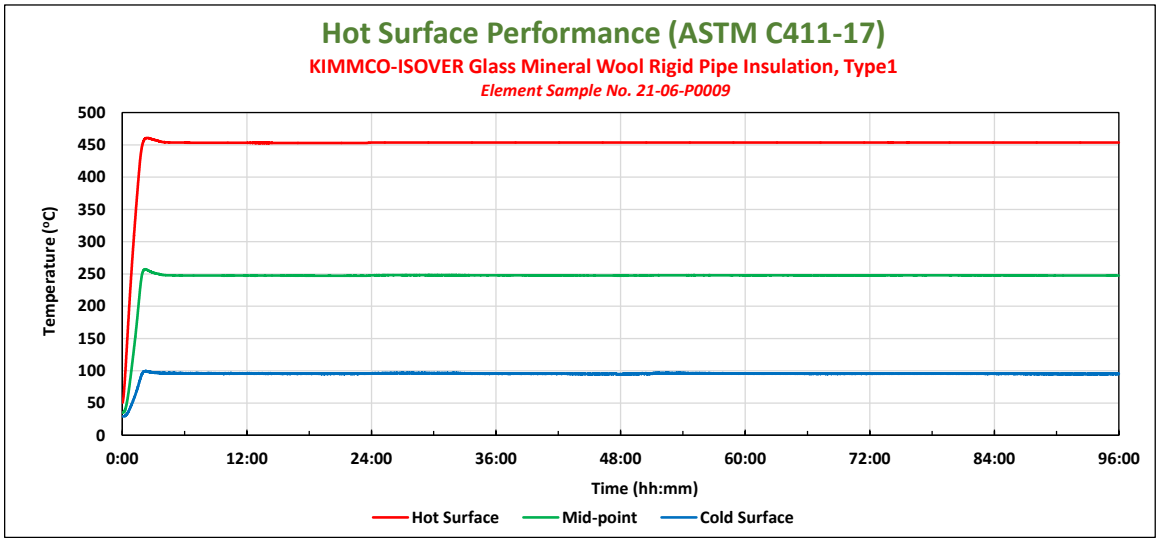



**Figure 2:** Graph of the temperatures recorded during the 96 hour test period.



**Figure 3:** View of the pipe insulation after 96 hours at 454°C

### 3.1.1 CONCLUSION

The sample of the KIMMCO-ISOVER glass mineral wool rigid pipe insulation meets with the requirements of ASTM C547-19 for maximum use temperature of 454°C and obtained a sag of 0.35%.

## 3.2 THERMAL CONDUCTIVITY (ASTM C335 and C1045)

| | | |
|---|---|---|
| Specimen Dimensions: | 1,000 mm long × 89 mm ID × 50 mm thick | |
| Equipment: | Exova Guarded End Hot Pipe Test Apparatus, | MII# A11988 |
| Verification: | Calcium Silicate Transfer Standard | |
| Measurement: | Measuring tape, | MII# B12690 |
| | Sartorius digital balance, | MII# B12518 |
| Test Conditions: | Mean temperatures 38°C, 93°C, 204°C and 280°C<br>Tested from low to high temperature using natural convection. | |
| Sample Orientation: | Horizontal. | |
| Test Date: | 2021-02-02 to 2021-02-11. | |

**Description of Guarded End Test Apparatus**
The test apparatus consists of a 88.9 mm diameter steel pipe subdivided into 3 sections consisting of a 610 mm main test section with 2 guard sections each 200 mm in length. Each section's surface temperature is controlled by an independent process controller. The temperature of the guard sections are maintained within 1°C of the main section.

The main test section's surface temperature is measured by 6 Type K thermocouples imbedded in the surface of the pipe. These are spaced equally along the length and circumference. The test sample's outer surface is measured by 8 Type K thermocouples mounted directly above the test apparatus' main test section at two locations at 45° intervals. The test sample was fastened to the test pipe using 6 mm wide stainless steel straps.

The thermal bridges between the guard heaters are each monitored by 8 Type K thermocouples mounted in the surface of the guard and main sections. There is also 1 surface Type K thermocouple that measures the guard surface temperature at the midpoint.

The thermocouple inputs and voltage inputs are monitored in real time by a Measurement Computing USB-2416 data acquisition module. The test data and results are displayed numerically and graphically using a Labview program.

The verification test results from 38 °C to 371 °C obtained an average precision of -1.6%. This is well within the "Precision and Bias" statement in ASTM C335 that states, "The maximum deviation obtained by seven different laboratories from the average was +10% and -9% over the hot surface temperature range of 46 °C to 670 °C".

A summary of the test results are presented in Tables 1 through 7 and Figures 1, through 3. SI units are the primary units of measure.

**Table 2 – Thermal Transmission Properties at 38ºC**
ASTM C335/335M-17
*Exova Sample No.: 21-06-P0009*

| Description | Results | | | |
|---|---|---|---|---|
| | Value | SI Units | Value | Imperial Units |
| Sample thickness | 52.00 | mm. | 2.047 | in. |
| Sample density, initial | 55.71 | kg/m³ | 3.48 | lb/ft³ |
| Sample density, final | 54.25 | kg/m³ | 3.39 | lb/ft³ |
| Ambient room temperature, ($t_a$) | 25.82 | °C | 78.48 | °F |
| Hot surface temperature, ($t_o$) ($t_1$) | 49.86 | °C | 121.75 | °F |
| Cold surface temperature, ($t_2$) | 27.60 | °C | 81.68 | °F |
| Temperature differential, ($t_o$ - $t_2$) | 22.26 | °C | 40.07 | °F |
| Mean specimen temperature, (($t_o$ + $t_2$)/2) | 38.73 | °C | 101.71 | °F |
| Test section power input, (Q) | 3.944 | W | 13.465 | Btu/h |
| Areal thermal conductance (C) | 0.6893 | W/m².K | 0.121 | Btu/h·ft².°F |
| Areal thermal resistance (R) | 1.4508 | m².K/W | 8.238 | °F.ft².h/Btu.in |
| Areal thermal transference, ($T_r$) | 0.4441 | W/m².K | 0.078 | Btu/h·ft².°F |
| Sample lineal thermal conductance, ($C_L$) | 0.2906 | W/m.K | 2.015 | Btu.in/h.ft².°F |
| Sample lineal thermal resistance, ($R_L$) | 3.4406 | m.K/W | 0.496 | ºF.ft².h/BTU·in |
| Sample lineal thermal transference, ($T_{rp}$) | 0.2691 | W/m.K | 1.866 | Btu.in/h.ft².°F |
| Sample thermal conductivity, (Lambda p) | 0.03584 | W/m.K | 0.248 | Btu.in/h.ft².°F |
| Sample thermal resistivity, ($r_L$) | 27.9018 | m.K/W | 4.024 | °F.ft².h/Btu.in |
| Surface areal heat transfer coefficient, ($h_2$) | 5.9979 | W/m².K | 1.056 | Btu/h·ft².°F |

**Table 3 – Thermal Transmission Properties at 93ºC**
ASTM C335/335M-17
*Exova Sample No.: 21-06-P0009*

| Description | Results | | | |
|---|---|---|---|---|
| | Value | SI Units | Value | Imperial Units |
| Sample thickness | 52.00 | mm. | 2.047 | in. |
| Sample density, initial | 55.71 | kg/m³ | 3.48 | lb/ft³ |
| Sample density, final | 54.25 | kg/m³ | 3.39 | lb/ft³ |
| Ambient room temperature, ($t_a$) | 26.28 | °C | 79.30 | °F |
| Hot surface temperature, ($t_o$) ($t_1$) | 152.33 | °C | 306.19 | °F |
| Cold surface temperature, ($t_2$) | 35.18 | °C | 95.32 | °F |
| Temperature differential, ($t_o$ - $t_2$) | 117.15 | °C | 210.87 | °F |
| Mean specimen temperature, (($t_o$ + $t_2$)/2) | 93.76 | °C | 200.76 | °F |
| Test section power input, (Q) | 23.640 | W | 80.707 | Btu/h |
| Areal thermal conductance (C) | 0.7848 | W/m².K | 0.138 | Btu/h·ft².°F |
| Areal thermal resistance (R) | 1.2741 | m².K/W | 7.235 | °F.ft².h/Btu.in |
| Areal thermal transference, ($T_r$) | 0.5077 | W/m².K | 0.089 | Btu/h·ft².°F |
| Sample lineal thermal conductance, ($C_L$) | 0.3310 | W/m.K | 2.295 | Btu.in/h.ft².°F |
| Sample lineal thermal resistance, ($R_L$) | 3.0209 | m.K/W | 0.436 | ºF.ft².h/BTU·in |
| Sample lineal thermal transference, ($T_{rp}$) | 0.3077 | W/m.K | 2.133 | Btu.in/h.ft².°F |
| Sample thermal conductivity, (Lambda p) | 0.04081 | W/m.K | 0.283 | Btu.in/h.ft².°F |
| Sample thermal resistivity, ($r_L$) | 24.5038 | m.K/W | 3.534 | °F.ft².h/Btu.in |
| Surface areal heat transfer coefficient, ($h_2$) | 7.1902 | W/m².K | 1.266 | Btu/h·ft².°F |

**Table 4 – Thermal Transmission Properties at 204ºC**
ASTM C335/335M-17
*Exova Sample No.: 21-06-P0009*

| Description | Results | | | |
|---|---|---|---|---|
| | Value | SI Units | Value | Imperial Units |
| Sample thickness | 52.00 | mm. | 2.047 | in. |
| Sample density, initial | 55.71 | kg/m³ | 3.48 | lb/ft³ |
| Sample density, final | 54.25 | kg/m³ | 3.39 | lb/ft³ |
| Ambient room temperature, ($t_a$) | 25.69 | °C | 78.24 | °F |
| Hot surface temperature, ($t_o$) ($t_1$) | 353.71 | °C | 668.68 | °F |
| Cold surface temperature, ($t_2$) | 55.32 | °C | 131.58 | °F |
| Temperature differential, ($t_o$ - $t_2$) | 298.39 | °C | 537.10 | °F |
| Mean specimen temperature, (($t_o$ + $t_2$)/2) | 204.52 | °C | 400.13 | °F |
| Test section power input, (Q) | 91.949 | W | 313.914 | Btu/h |
| Areal thermal conductance (C) | 1.1985 | W/m².K | 0.211 | Btu/h·ft².°F |
| Areal thermal resistance (R) | 0.8344 | m².K/W | 4.737 | °F.ft².h/Btu.in |
| Areal thermal transference, ($T_r$) | 0.7588 | W/m².K | 0.134 | Btu/h·ft².°F |
| Sample lineal thermal conductance, ($C_L$) | 0.5055 | W/m.K | 3.505 | Btu.in/h.ft².°F |
| Sample lineal thermal resistance, ($R_L$) | 1.9783 | m.K/W | 0.285 | ºF.ft².h/BTU·in |
| Sample lineal thermal transference, ($T_{rp}$) | 0.4598 | W/m.K | 3.188 | Btu.in/h.ft².°F |
| Sample thermal conductivity, (Lambda p) | 0.06232 | W/m.K | 0.432 | Btu.in/h.ft².°F |
| Sample thermal resistivity, ($r_L$) | 16.0458 | m.K/W | 2.314 | °F.ft².h/Btu.in |
| Surface areal heat transfer coefficient, ($h_2$) | 8.4003 | W/m².K | 1.479 | Btu/h·ft².°F |

**Table 5 – Thermal Transmission Properties at 280°C**
ASTM C335/335M-17
*Exova Sample No.: 21-06-P0009*

| Description | Results | | | |
|---|---|---|---|---|
| | Value | SI Units | Value | Imperial Units |
| Sample thickness | 52.00 | mm. | 2.047 | in. |
| Sample density, initial | 55.71 | kg/m³ | 3.48 | lb/ft³ |
| Sample density, final | 54.25 | kg/m³ | 3.39 | lb/ft³ |
| Ambient room temperature, ($t_a$) | 25.03 | °C | 77.05 | °F |
| Hot surface temperature, ($t_o$) ($t_1$) | 484.40 | °C | 903.92 | °F |
| Cold surface temperature, ($t_2$) | 75.26 | °C | 167.47 | °F |
| Temperature differential, ($t_o$ - $t_2$) | 409.14 | °C | 736.45 | °F |
| Mean specimen temperature, (($t_o$ + $t_2$)/2) | 279.83 | °C | 535.69 | °F |
| Test section power input, (Q) | 172.056 | W | 587.399 | Btu/h |
| Areal thermal conductance (C) | 1.6356 | W/m².K | 0.288 | Btu/h·ft².°F |
| Areal thermal resistance (R) | 0.6114 | m².K/W | 3.471 | °F.ft².h/Btu.in |
| Areal thermal transference, ($T_r$) | 1.0139 | W/m².K | 0.179 | Btu/h·ft².°F |
| Sample lineal thermal conductance, ($C_L$) | 0.6898 | W/m.K | 4.783 | Btu.in/h.ft².°F |
| Sample lineal thermal resistance, ($R_L$) | 1.4496 | m.K/W | 0.209 | °F.ft².h/BTU·in |
| Sample lineal thermal transference, ($T_{rp}$) | 0.6144 | W/m.K | 4.260 | Btu.in/h.ft².°F |
| Sample thermal conductivity, (Lambda p) | 0.08505 | W/m.K | 0.590 | Btu.in/h.ft².°F |
| Sample thermal resistivity, ($r_L$) | 11.7578 | m.K/W | 1.696 | °F.ft².h/Btu.in |
| Surface areal heat transfer coefficient, ($h_2$) | 9.2723 | W/m².K | 1.633 | Btu/h·ft².°F |

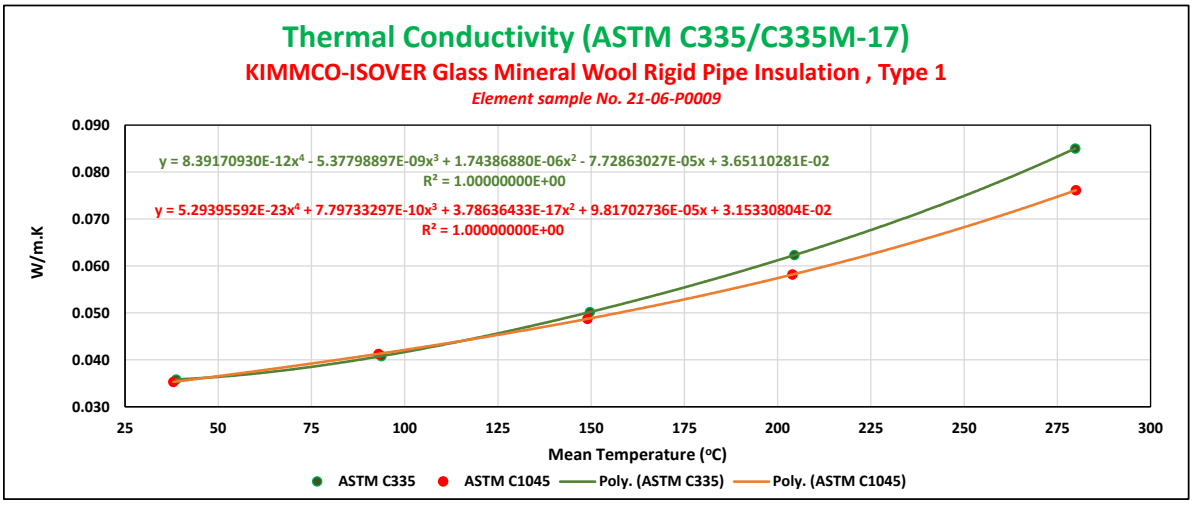



**Figure #4**

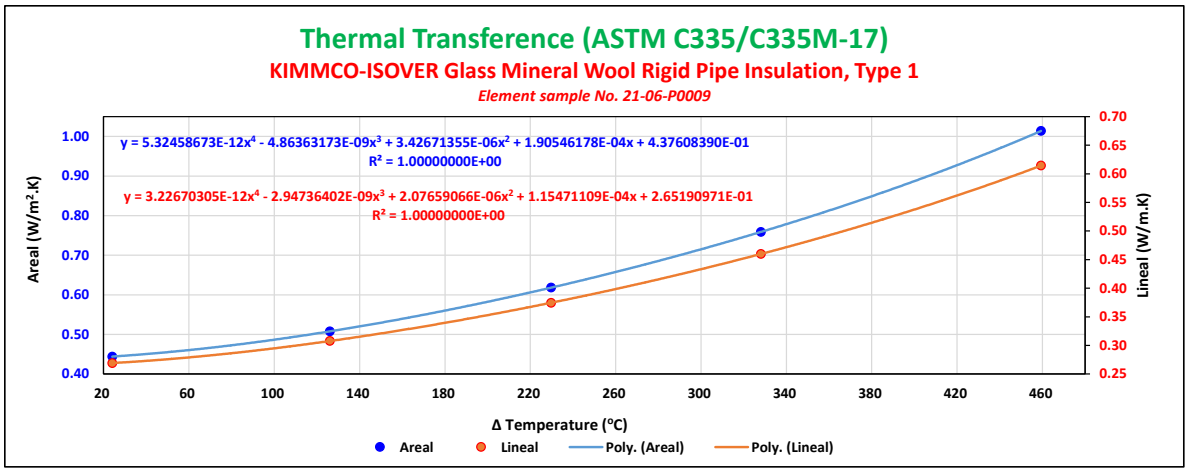



**Figure #5**



**Figure #6:** Test sample mounted on the pipe test apparatus at 280°C

The apparent thermal conductivity test results, for the KIMMCO-ISOVER glass mineral wool rigid pipe insulation, calculated in conformance with ASTM C1045-17 are shown below in Table 6.

**Table 6** Apparent Thermal Conductivity

| Mean Temperature | | Apparent Thermal Conductivity | |
|---|---|---|---|
| (ºC) | (ºF) | (W/m.K) | (Btu.in/h.ft².°F) |
| 38 | 100.4 | 0.0353 | 0.245 |
| 93 | 199.4 | 0.0413 | 0.286 |
| 204 | 399.2 | 0.0582 | 0.404 |
| 280 | 536.0 | 0.0761 | 0.528 |

### 3.2.1 CONCLUSION

The sample of Type 1, KIMMCO-ISOVER glass mineral wool rigid pipe insulation meets with the requirements of ASTM C547-19 for apparent thermal conductivity at the mean temperatures it was evaluated.

## 3.3 DIMENSIONS AND DENSITY (ASTM C302 - 13(2017))

Three specimens, as received, were evaluated in conformance with ASTM C302 - 13(2017).

The test results are summarized below in Table 7. SI units are the primary units of measure.

**Table 7 – Dimensions and Density ASTM C302 - 13(2017)**

| Specimen # | Thickness (mm.) | Length (mm.) | O.D. (mm.) | I.D. (mm.) | Density (kg/m$^3$) |
|---|---|---|---|---|---|
| **1** | 50.97 | 998.5 | 191.53 | 89.64 | 59.18 |
| **2** | 50.80 | 999.7 | 192.49 | 90.81 | 58.93 |
| **3** | 50.43 | 1000.3 | 191.18 | 90.82 | 60.61 |
| **Average** | **50.73** | **999.5** | **191.74** | **90.42** | **59.57** |

### 3.3.1 CONCLUSION

The sample of Type 1, KIMMCO-ISOVER glass mineral wool rigid pipe insulation, having a right annular cylindrical shape with a radially slit on one side, as shown in Figures 3 and 6, meets with the requirements of ASTM C547-19 and ASTM C585-10(2016) for dimensions and has a concentric of less than 5 mm. between the inner and outer bore.

The specimens evaluated obtained an average density of 59.57 kg/m$^3$.

## 3.4 LINEAR SHRINKAGE (ASTM C356-17)

The sample was evaluated in conformance with ASTM C356-17.

| | | |
|---|---|---|
| Pre- Conditioning: | 102°C for 24 hours | |
| | After pre heating >24 hours for 23°C in desiccator for cooling. | |
| Test Conditions: | Heat up | 4.5 hours |
| | Soak at 454°C | 24 hours |
| | Cool to 55.5°C | 5 hours |
| | Carbolite Oven | MII# B10365 |
| | Thermocouple | MII# B13216 |
| | Digital Calipers | MII# B10644 |
| | Weight balance | MII# B12518 |
| | Environ. Controller | MII# B14944 |
| Specimen Size: | 150mm (Length) x 65mm (width) x 33mm (thickness); (nominal) | |
| | Extracted from pipe section | |
| Test Start Date: | 2021-03-15 | |
| Test End Date: | 2021-03-17 | |

A summary of results is presented below in Tables 8 through 11. SI units are the primary units of measure.

**Table 8 – Linear Shrinkage (Length)**
ASTM C356-17
*Element Sample No.: 21-06-P0009*

| Specimen No. | Initial Length, mm | Final Length, mm | Change in Length, % |
|---|---|---|---|
| 1 | 152.35 | 151.30 | 0.69 |
| 2 | 152.41 | 151.22 | 0.78 |
| 3 | 153.15 | 151.89 | 0.83 |
| 4 | 153.76 | 152.31 | 0.95 |
| Average | 152.92 | 151.68 | **0.81** |
| Std. Dev. | 0.67 | 0.51 | 0.11 |

**Table 9 – Linear Shrinkage (Width)**
ASTM C356-17
*Element Sample No.: 21-06-P0009*

| Specimen No. | Initial Width, mm | Final Width, mm | Change in Width, % |
|---|---|---|---|
| 1 | 63.36 | 62.72 | 1.00 |
| 2 | 63.23 | 62.45 | 1.23 |
| 3 | 63.20 | 62.20 | 1.58 |
| 4 | 62.29 | 61.92 | 0.59 |
| Average | 63.02 | 62.32 | **1.10** |
| Std. Dev. | 0.49 | 0.34 | 0.41 |

**Table 10 – Linear Shrinkage (Thickness)**
ASTM C356-17
*Element Sample No.: 21-06-P0009*

| Specimen No. | Initial Thickness, mm | Final Thickness, mm | Change in Thickness, % |
|---|---|---|---|
| 1 | 40.02 | 38.98 | 2.58 |
| 2 | 40.05 | 39.12 | 2.32 |
| 3 | 38.85 | 40.30 | -3.74 |
| 4 | 39.64 | 39.38 | 0.65 |
| Average | 39.64 | 39.45 | **0.45** |
| Std. Dev. | 0.56 | 0.59 | 2.92 |

| **Table 11 – Change in Mass**<br>ASTM C356-17<br>*Element Sample No.: 21-06-P0009* | | | |
|---|---|---|---|
| **Specimen No.** | **Initial Mass,** g | **Final Mass,** g | **Change in Mass,** % |
| 1 | 33.33 | 32.47 | 2.58 |
| 2 | 36.03 | 35.00 | 2.86 |
| 3 | 34.10 | 33.24 | 2.52 |
| 4 | 34.25 | 33.29 | 2.80 |
| Average | 34.43 | 33.50 | **2.69** |
| Std. Dev. | 1.1 | 1.1 | 0.2 |

### 3.4.1 CONCLUSION

The sample of Type 1, KIMMCO-ISOVER glass mineral wool rigid pipe insulation meets with the requirements of ASTM C547-19 for linear shrinkage. A linear shrinkage of 0.81% was obtained after the 24 hour soaking period at 454°C temperature.

## 3.5 WATER VAPOUR SORPTION (ASTM C1104M-19)

The sample was evaluated in conformance with ASTM C1104M-19. SI units are the primary units of measure.

| | | |
|---|---|---|
| Test Start Date: | 2021-03-25 | |
| Test End Date: | 2021-03-29 | |
| Measuring Instruments: | Digital balance | MII# B17286 |
| | Digital calipers | MII# B10644 |
| | Envirotronics Chamber | MII# A11786 |
| | Env. Control room | MII# B11364 |
| Preheat: | 102°C for 24 hours | |
| Test Conditions: | 96 hrs. @ 95% RH & 49°C | |
| Specimen No.: | 4 (four); half sections of the 150 mm diameter pipe. | |
| Sample Size (nominal): | 150 mm (length) | |
| | 189 mm outer diameter (OD) | |
| | 50 mm thickness (T) | |
| | 89 mm inner diameter (ID) | |

Test results are presented in Table 12, below:

**Table 12 – Water Vapor Sorption (ASTM C1104M-19)**
*Element Sample No. 21-06-P0009*

| Specimen No. | Specimen Dimension | | | Volume ($cm^3$) | Dry wt. (gm) | Final wt. (without bag), g | WVS (vol.%) | WVS (wt %) |
|---|---|---|---|---|---|---|---|---|
| | Length (mm) | Width (mm) | Thickness (mm) | | | | | |
| 1 | 154.92 | 151.97 | 53.27 | 12,541 | 114.05 | 114.60 | 0.04 | 0.48 |
| 2 | 154.08 | 156.19 | 51.43 | 12,377 | 112.80 | 113.39 | 0.05 | 0.52 |
| 3 | 154.72 | 151.87 | 51.43 | 12,085 | 120.00 | 120.62 | 0.05 | 0.52 |
| 4 | 154.91 | 154.71 | 51.84 | 12,424 | 122.14 | 122.81 | 0.05 | 0.55 |
| Average | | | | **12,357** | **117.25** | **117.86** | **0.05** | **0.52** |

### 3.5.1 CONCLUSION

The sample of Type 1, KIMMCO-ISOVER glass mineral wool rigid pipe insulation meets with the requirements of ASTM C547-19 for water vapor sorption. A water vapor sorption of 0.52% was obtained.

## 3.6 SURFACE BURNING CHARACTERISTICS (ASTM E84-21)

Please refer to Appendix A for the detailed test results.

### 3.6.1 CONCLUSION

The sample of Type 1, KIMMCO-ISOVER glass mineral wool rigid pipe insulation obtain a FSI of 0 and a SDI of 15 meeting the requirements of ASTM C547-19.

## 4.0 REVISION HISTORY

| **Date:** | **Revision:** | **Comments:** |
|---|---|---|
| 2021-04-20 | 0 | Original Report |
| 2022-07-06 | 1 | Revised section 3.3.1 to include shape and concentricity. |

**Reported by:**

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Engineer, Building Performance Centre
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**Approved by:**

Franz Bauer, B.Eng., Ext 11403
Tech. Mgr., Building Performance Centre
Products Testing Group

***ACCREDITATION: (A2LA)***
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Appendix A
Surface Burning Test Report #: 21-002-107(Revision 1)

(4 pages)

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# ASTM E 84 Surface Burning Characteristics of "KIMMCO-ISOVER Glass Mineral Wool Rigid Pipe Insulation"

| | |
|---|---|
| A Report To: | **Kuwait Insulating Materials Manufacturing Co. S.A.K (KIMMCO)**<br>**KIMMCO-ISOVER Brand**<br>Mina Abdullah, Shuaiba Industrial Area<br>Area 1, Block 3, Plot 42, Wafra Road<br>65451 Kuwait. P.O. Box 10042 Shuaiba |
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| Submitted by: | Element Fire Testing |
| Report No. | 21-002-107(Revision 1)<br>4 Pages |
| Date: | April 20, 2021 |

**1.0 ACCREDITATION** To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

**2.0 SPECIFICATIONS OF ORDER**

Determine the Flame Spread and Smoke Developed Indices based upon a single test conducted in accordance with ASTM E 84-20, as per Element Building Science Project No. 21-06-P0009, Element Work Order No. 543823, and Element Proposal No. 20-006-220631, Rv1.

**2.1 History of Revision**

This report supersedes Element Test Report No. 21-002-107, originally issued on March 11, 2021. It is revised by request, to amend the sponsor name and address, and to change the Sample Identification.

**3.0 SAMPLE IDENTIFICATION** (Element sample identification number 21-06-P0009)

Thermal insulation material, approximately 2 inches (51 mm) in thickness, identified as:
"KIMMCO-ISOVER Glass Mineral Wool Rigid Pipe Insulation"

**4.0 TEST PROCEDURE**

The method, designated as ASTM E 84-20 "*Standard Method of Test for Surface Burning Characteristics of Building Materials*", is designed to determine the relative surface burning characteristics of materials under specific test conditions, where the material under test is mounted so that it forms the ceiling of a horizontal fire tunnel. A specified airflow is introduced through the tunnel and a specified flame is applied to one end. Observations are then made regarding the rate of flame spread along the specimen. Results are expressed in terms of Flame Spread Index (FSI) and Smoke Developed Index (SDI). There is no established relationship between those two values.

*Although the procedure is applicable to materials, products and assemblies used in building construction for development of comparative surface spread of flame data, the test results may not reflect the relative surface burning characteristics of tested materials under all building fire conditions.*

**5.0 SAMPLE PREPARATION**

The test specimen consisted of a total of seven sections of material, each approximately 2 inches (51 mm) in thickness by 23.5 inches (597 mm) in width by 39.5 inches (1003 mm) in length. The sections were butted together to create the specimen length. Prior to testing, the specimen was conditioned to constant weight at a temperature of 73 ± 5°F (23 ± 3°C) and a relative humidity of 50 ± 5%. At the time if test initiation, the specimen was self-supporting.

The testing was performed on: 2021-03-10

**6.0 SUMMARY OF TEST PROCEDURE**

The tunnel is preheated to 150 ± 5°F (66 ± 2.8°C), as measured by the floor-embedded thermocouple located 23.25 feet (7087 mm) downstream of the burner ports, and is allowed to cool to 105 ± 5°F (40.5 ± 2.8°C), as measured by the floor-embedded thermocouple located 13 feet (3962 mm) from the burners. The tunnel lid is then raised and the test specimen is placed along the ledges of the tunnel so as to form a continuous ceiling 24 feet (7315 mm) long, approximately 12 inches (305 mm) above the floor. Three 8 foot (2438 mm) sections of 0.25 inch (6 mm) cement board are then placed on the back side of the specimen and the lid is then lowered into place.

Upon ignition of the gas burners, the flame spread distance is observed and recorded every second. Flame spread distance versus time is plotted. Calculations ignore all flame front recessions and Flame Spread Index (FSI) is determined by calculating the total area under the curve for the test sample. If the area under the curve (A) is less than or equal to 97.5 min·ft, then FSI = 0.515·A; if greater, FSI = 4900/(195-A). FSI is then rounded to the nearest multiple of 5.

Smoke Developed Index (SDI) is determined by dividing the total area under the obscuration curve by that established for liquid heptane, and multiplying by 100. SDI is then rounded to the nearest multiple of 5 if less than 200. SDI values over 200 are rounded to the nearest multiple of 50.

## 7.0 TEST RESULTS

**SAMPLE: "KIMMCO-ISOVER Glass Mineral Wool Rigid Pipe Insulation"**

| Approx. Time to Ignition (s) | Maximum Flame Front Distance | Time to Maximum Flame Front (s) | Flame Spread Index (FSI) | Smoke Developed Index (SDI) |
|---|---|---|---|---|
| - | (ft.): 0.0<br>(m): 0.00 | 0 | **0** | **15** |

### 7.1 Observations of Burning Characteristics

The specimen did not ignite. Discolouration in the area of direct test flame impingement was observed.

## 8.0 INTERPRETATION OF RESULTS

Industry documents such as the International Building Code (IBC) or NFPA 101 Life Safety Code refer to ASTM E 84 (UL 723, NFPA 255) test results using the following material classification categories:

| | Flame-Spread Index (FSI) | Smoke Developed Index (SDI) |
|---|---|---|
| Class 1 or Class A | 0 - 25 | 450 Maximum |
| Class 2 or Class B | 26 - 75 | 450 Maximum |
| Class 3 or Class C | 76 - 200 | 450 Maximum |
| Results Classification (if applicable): | | **Class 1 or Class A** |





Francis Williams,
Technician.

Ian Smith,
Technical Manager.

*Notes: This report is related only to the sample identified and shall not be reproduced, except in full, without approval. It is covered under Element Materials Technology Canada Inc. Standard Terms and Conditions of Contract, which are accessible at www.element.com, or by calling 1-866-263-9268. ASTM E 84 is a well-established test method that reports data in the form of indices. As such, MU cannot be calculated. In the reporting instructions, calculated values are rounded to the nearest multiple of 5 for FSI, and 5 or 50 for SDI, depending on the result. Since the rounding ranges establish precision and include potential uncertainty, by following the reporting instructions, the lab is considered to have satisfied the MU reporting requirements of ISO/IEC 17025 (section 5.4.6.2 (Note 2)).*

**9.0 TEST CHARTS** **ASTM E 84-20**

**Sample: "KIMMCO-ISOVER Glass Mineral Wool Rigid Pipe Insulation"**

**Chart 1. FLAME SPREAD**

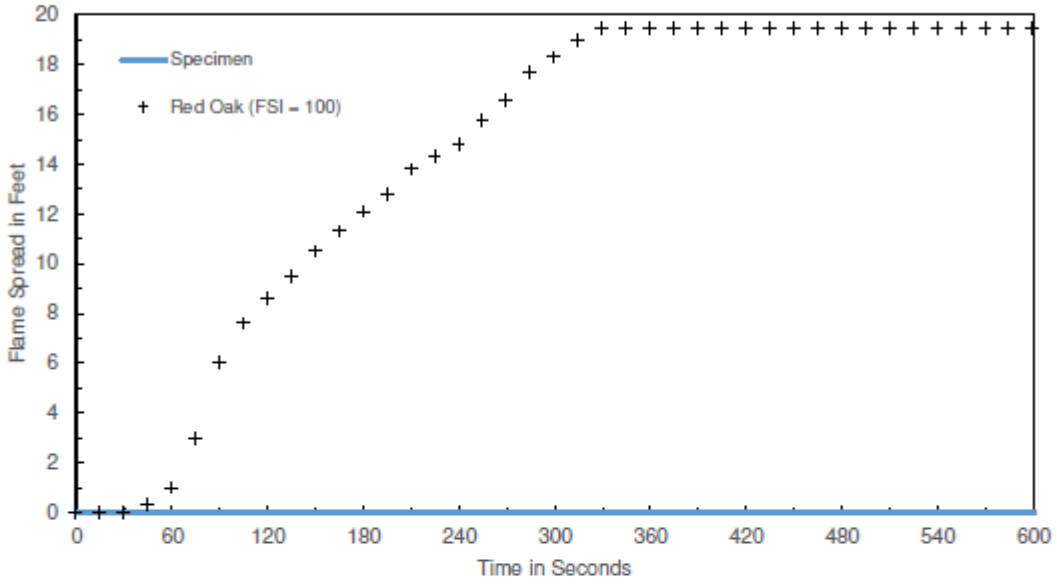
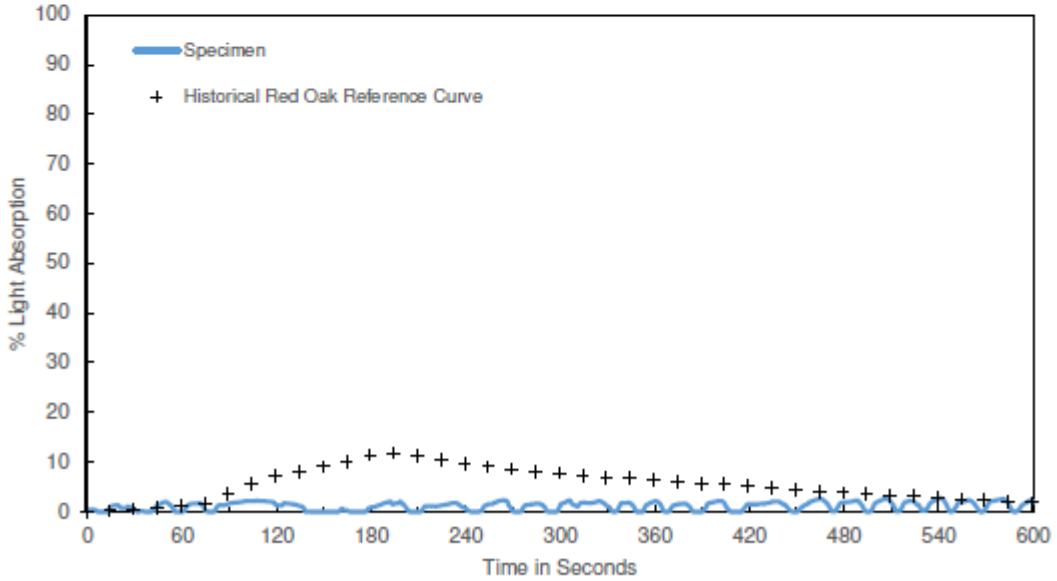



**Chart 2. SMOKE DEVELOPED**




| Calculated Flame Spread (CFS) | Rounded Flame Spread Index (**FSI**) | Calculated Smoke Developed (CSD) | Rounded Smoke Developed Index (**SDI**) | Maximum 23' Air Temperature (°F) |
|---|---|---|---|---|
| 0.0 | **0** | 16.7 | **15** | 538 |