Project:	4787671596	File:	MH61932	TestCode:	12171603
Tested by:	ABRAN GARCIA	Engineer:	JAMILA SHAWON	Date:	2016-12-17

TEST METHOD: The test was conducted in accordance with UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	1	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Face

FLAME SPREAD RESULTS

Flame Spread Data

Distance (Feet)		Time (Sec)
Ignition		10
0.5		12
1		16
1.5		20

Calculated Flame Spread (CFS): 7.54
Flame Spread Index (FSI): 10

Time to Ignition (sec): 10
Maximum Flame Spread (ft): 1.5
Area Under the Flame Spread Curve (ft.-min): 14.6

SMOKE RESULTS

Calculated Smoke Developed (CSD): 7.5
Smoke Developed Index (SDI): 10

Area Under the Smoke Curve (Obs-min.): 6.13
Area Under Red Oak Curve (Obs-min.): 81.64

Post-Test Observations

Discoloration (Feet From Burner): 10

UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	1	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation Face

Test Parameters and Supplemental Information

Test Room Conditions

Ambient Temperature(°F)	72
Ambient Humidity(%)	53

Sample Conditioning

Incoming Sample Weight (g):	N/A
Conditioned Weight prior to test (g):	N/A
Percent Change	N/A

Average Differential Pressures

Burner Orifice (inches water)	0.352
Air Inlet Draft Plate (inches water)	0.095

Historical Smoke Area

Area Under Red Oak Curve (sq. in.):	4.10
Area Under the Smoke Curve (sq. in.):	0.31

Other Information

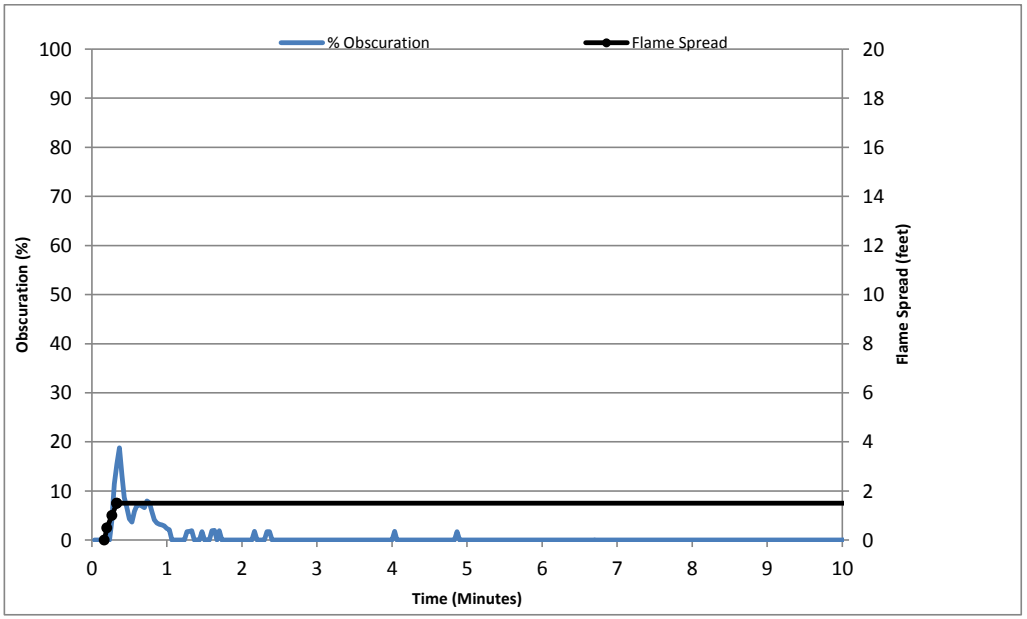
Test Location:	North Tunnel
Test Start Time:	8:45 AM
Average Methane Volumetric Flow Rate (CFM):	5.0
Average Gas Meter Pressure (PSI):	11.4
Average Velocity (m/s):	1.9
Maintenance Calibration Date:	2016-12-09

Test Notes

None

Flame Spread / Smoke Results

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



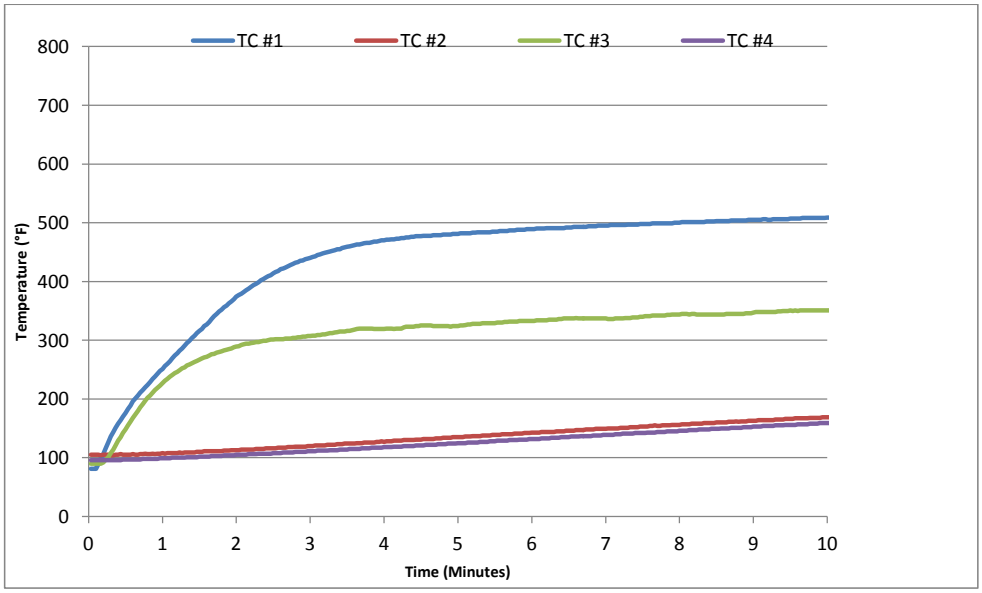
Test Num.: 1
MH61932 /
4787671596
12171603

Flame Spread Index: 10
Smoke Developed Index: 10

Max. Flame Spread (ft.): 1.5

Temperatures

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



Test Num.: 1
MH61932 /
4787671596
12171603

TC1 (Exposed-23 feet from burner) Max. Value (°F): 509
TC2 (Embedded-13 feet from burner) Max. Value (°F): 170

TC3 (Exposed-Exhaust Duct) Max. Value (°F): 351
TC4 (Embedded-23-1/4 feet from burner) Max. Value (°F): 160

Project: 4787671596 File: MH61932 TestCode: 12171604

Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17

TEST METHOD: The test was conducted in accordance with UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	2	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

FLAME SPREAD RESULTS

Flame Spread Data

Distance (Feet)		Time (Sec)
Ignition		8
1		12
2		16
3		26
3.5		28
4		32
5		38
5.5		42

Calculated Flame Spread (CFS): 27.22
Flame Spread Index (FSI): 25

Time to Ignition (sec): 8
Maximum Flame Spread (ft): 5.5
Area Under the Flame Spread Curve (ft.-min): 52.9

SMOKE RESULTS

Calculated Smoke Developed (CSD): 14.4
Smoke Developed Index (SDI): 15

Area Under the Smoke Curve (Obs-min.): 11.78
Area Under Red Oak Curve (Obs-min.): 81.64

Post-Test Observations

Discoloration (Feet From Burner): 12
Char (Feet From Burner): 6

Project: 4787671596 File: MH61932 TestCode: 12171604
Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17
Page 2

UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	2	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

Test Parameters and Supplemental Information

Test Room Conditions

Ambient Temperature(°F)	70
Ambient Humidity(%)	53

Sample Conditioning

Incoming Sample Weight (g):	N/A
Conditioned Weight prior to test (g):	N/A
Percent Change	N/A

Average Differential Pressures

Burner Orifice (inches water)	0.352
Air Inlet Draft Plate (inches water)	0.095

Historical Smoke Area

Area Under Red Oak Curve (sq. in.):	4.10
Area Under the Smoke Curve (sq. in.):	0.59

Other Information

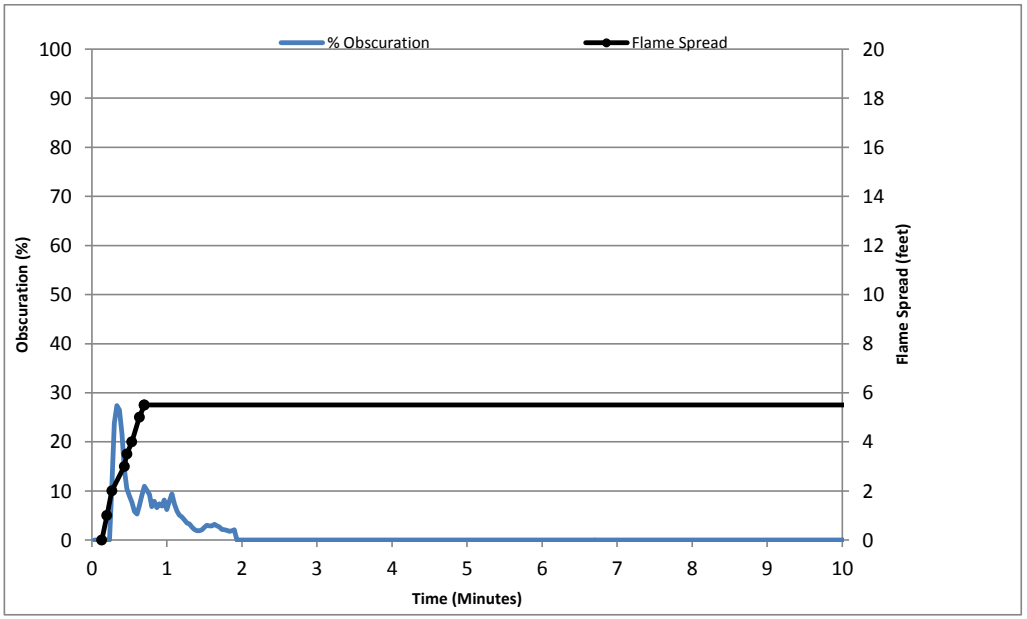
Test Location:	North Tunnel
Test Start Time:	9:43 AM
Average Methane Volumetric Flow Rate (CFM):	5.0
Average Gas Meter Pressure (PSI):	11.5
Average Velocity (m/s):	1.8
Maintenance Calibration Date:	2016-12-09

Test Notes

None

Flame Spread / Smoke Results

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



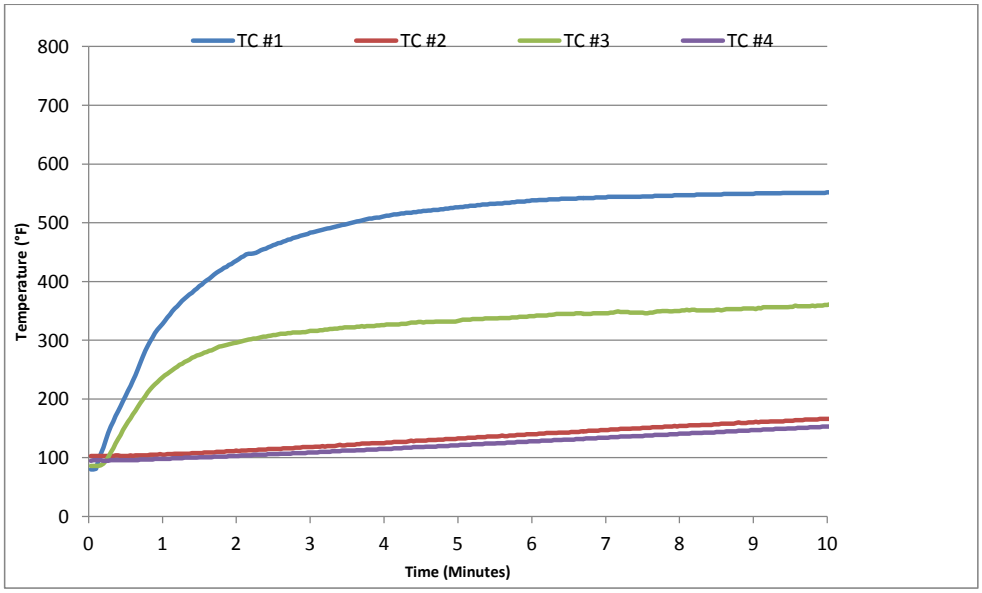
Test Num.: 2
MH61932 /
4787671596
12171604

Flame Spread Index: 25
Smoke Developed Index: 15

Max. Flame Spread (ft.): 5.5

Temperatures

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



Test Num.: 2
MH61932 /
4787671596
12171604

TC1 (Exposed-23 feet from burner) Max. Value (°F): 552
TC2 (Embedded-13 feet from burner) Max. Value (°F): 167

TC3 (Exposed-Exhaust Duct) Max. Value (°F): 361
TC4 (Embedded-23-1/4 feet from burner) Max. Value (°F): 154

Project: 4787671596 File: MH61932 TestCode: 12171605

Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17

TEST METHOD: The test was conducted in accordance with UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	3	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

FLAME SPREAD RESULTS

Flame Spread Data

Distance (Feet)		Time (Sec)
Ignition		8
1.5		18
3		22
3.5		24
4		32
4.5		36
5		38

Calculated Flame Spread (CFS): 24.80
Flame Spread Index (FSI): 25

Time to Ignition (sec): 8
Maximum Flame Spread (ft): 5.0
Area Under the Flame Spread Curve (ft.-min): 48.2

SMOKE RESULTS

Calculated Smoke Developed (CSD): 11.6
Smoke Developed Index (SDI): 10

Area Under the Smoke Curve (Obs-min.): 9.49
Area Under Red Oak Curve (Obs-min.): 81.64

Post-Test Observations

Discoloration (Feet From Burner): 24
Char (Feet From Burner): 10

Project: 4787671596 File: MH61932 TestCode: 12171605
Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17
Page 2

UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	3	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

Test Parameters and Supplemental Information

Test Room Conditions

Ambient Temperature(°F)	69
Ambient Humidity(%)	51

Sample Conditioning

Incoming Sample Weight (g):	N/A
Conditioned Weight prior to test (g):	N/A
Percent Change	N/A

Average Differential Pressures

Burner Orifice (inches water)	0.351
Air Inlet Draft Plate (inches water)	0.095

Historical Smoke Area

Area Under Red Oak Curve (sq. in.):	4.10
Area Under the Smoke Curve (sq. in.):	0.48

Other Information

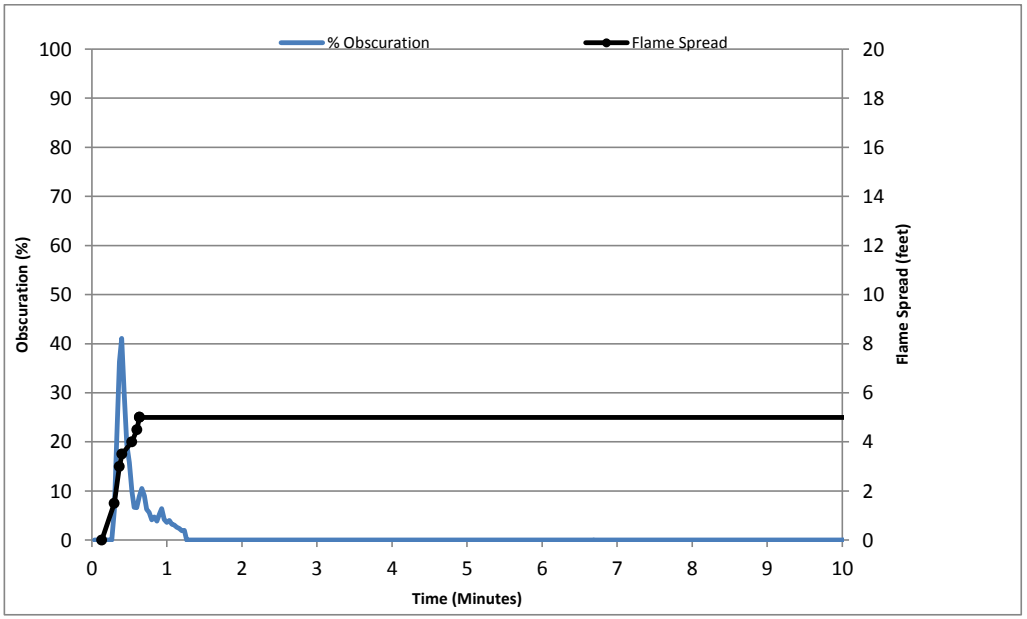
Test Location:	North Tunnel
Test Start Time:	10:34 AM
Average Methane Volumetric Flow Rate (CFM):	5.0
Average Gas Meter Pressure (PSI):	11.5
Average Velocity (m/s):	1.8
Maintenance Calibration Date:	2016-12-09

Test Notes

None

Flame Spread / Smoke Results

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



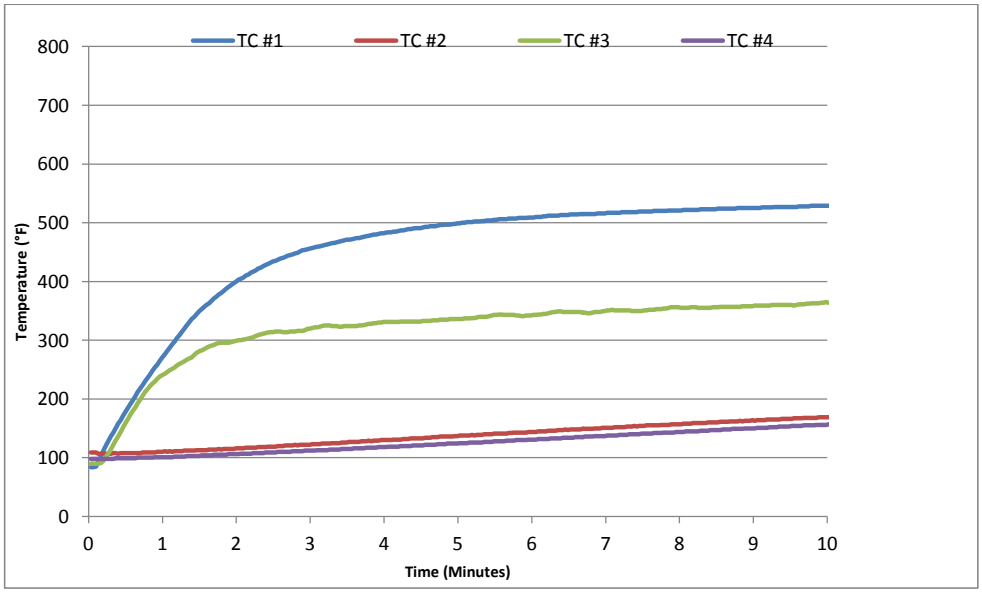
Test Num.: 3
MH61932 /
4787671596
12171605

Flame Spread Index: 25
Smoke Developed Index: 10

Max. Flame Spread (ft.): 5.0

Temperatures

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



Test Num.: 3
MH61932 /
4787671596
12171605

TC1 (Exposed-23 feet from burner) Max. Value (°F): 529
TC2 (Embedded-13 feet from burner) Max. Value (°F): 170

TC3 (Exposed-Exhaust Duct) Max. Value (°F): 365
TC4 (Embedded-23-1/4 feet from burner) Max. Value (°F): 157

Project: 4787671596 File: MH61932 TestCode: 12171606

Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17

TEST METHOD: The test was conducted in accordance with UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	4	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

FLAME SPREAD RESULTS

Flame Spread Data

Distance (Feet)		Time (Sec)		Distance (Feet)		Time (Sec)
Ignition		10		4.5		22
1		12		5		32
2.5		14		5.5		34
3		16		6		39
4		18		6.5		45

Calculated Flame Spread (CFS): 32.35
Flame Spread Index (FSI): 30

Time to Ignition (sec): 10
Maximum Flame Spread (ft): 6.5
Area Under the Flame Spread Curve (ft.-min): 62.8

SMOKE RESULTS

Calculated Smoke Developed (CSD): 18.8
Smoke Developed Index (SDI): 20

Area Under the Smoke Curve (Obs-min.): 15.32
Area Under Red Oak Curve (Obs-min.): 81.64

Post-Test Observations

Discoloration (Feet From Burner): 19
Char (Feet From Burner): 12

Project: 4787671596 File: MH61932 TestCode: 12171606
Tested by: ABRAN GARCIA Engineer: JAMILA SHAWON Date: 2016-12-17
Page 2

UL 723, Tenth Edition.

Client Name:	AFS BORU SANAYI A S				
Test Duration	10 minutes	Test No.:	4	Hot Test:	No
Mounting:	Rods	Test Type:	Classification	Burn-Out Required:	No

Test Sample: Duct# Wire helix duct with Knauf Insulation
Back side

Test Parameters and Supplemental Information

Test Room Conditions

Ambient Temperature(°F)	71
Ambient Humidity(%)	51

Sample Conditioning

Incoming Sample Weight (g):	N/A
Conditioned Weight prior to test (g):	N/A
Percent Change	N/A

Average Differential Pressures

Burner Orifice (inches water)	0.350
Air Inlet Draft Plate (inches water)	0.095

Historical Smoke Area

Area Under Red Oak Curve (sq. in.):	4.10
Area Under the Smoke Curve (sq. in.):	0.77

Other Information

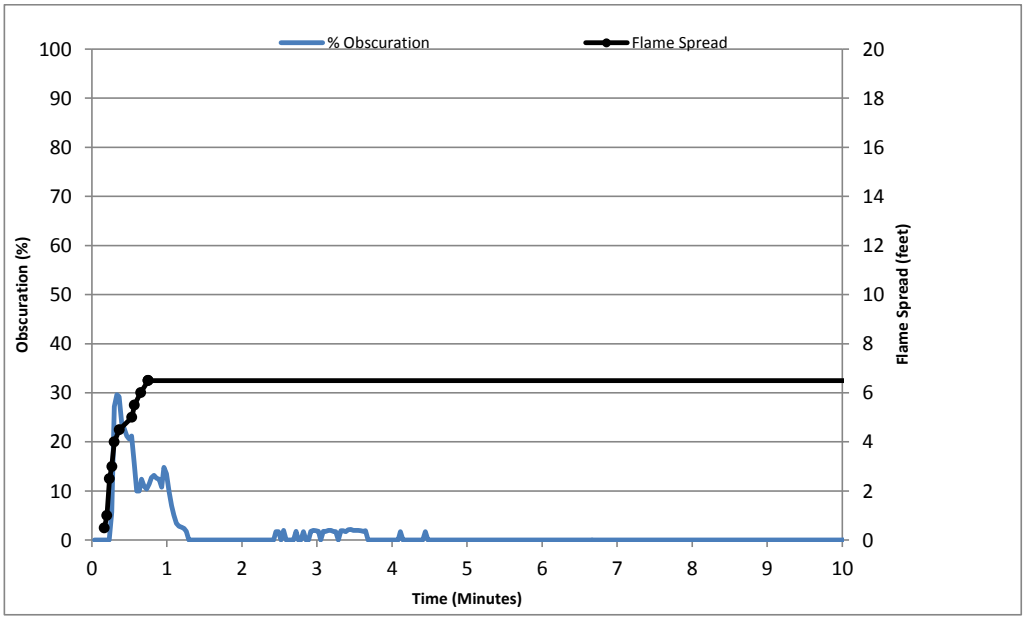
Test Location:	North Tunnel
Test Start Time:	11:20 AM
Average Methane Volumetric Flow Rate (CFM):	5.1
Average Gas Meter Pressure (PSI):	11.5
Average Velocity (m/s):	1.7
Maintenance Calibration Date:	2016-12-09

Test Notes

None

Flame Spread / Smoke Results

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



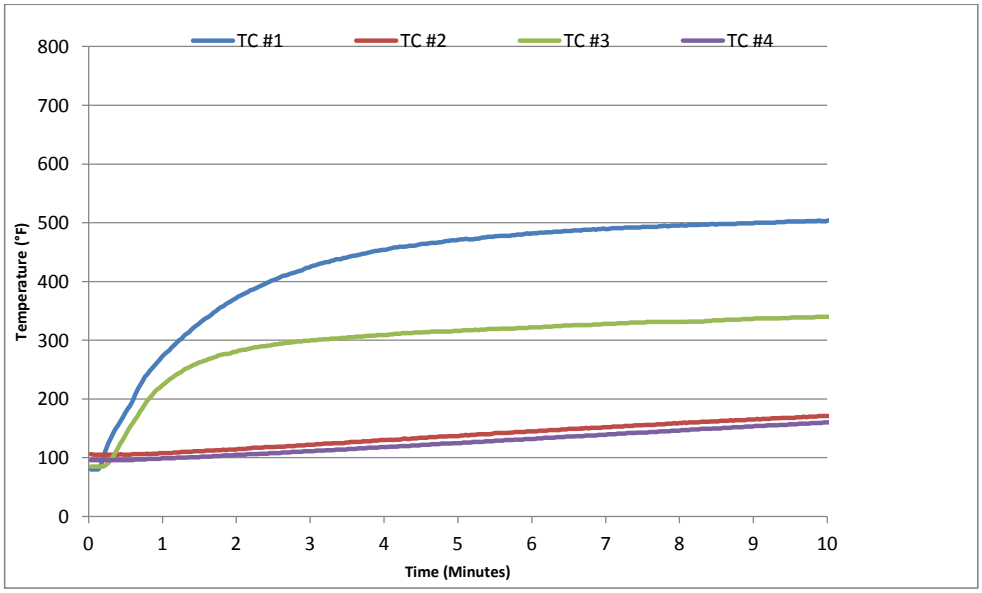
Test Num.: 4
MH61932 /
4787671596
12171606

Flame Spread Index: 30
Smoke Developed Index: 20

Max. Flame Spread (ft.): 6.5

Temperatures

AFS BORU SANAYI A S
Duct# Wire helix duct with Knauf Insulation



Test Num.: 4
MH61932 /
4787671596
12171606

TC1 (Exposed-23 feet from burner) Max. Value (°F): 504
TC2 (Embedded-13 feet from burner) Max. Value (°F): 172

TC3 (Exposed-Exhaust Duct) Max. Value (°F): 340
TC4 (Embedded-23-1/4 feet from burner) Max. Value (°F): 161

FLAME PENETRATION TEST UL181, Eleventh Edition

REQUIREMENT

Through opening, sample is to withstand the Flame Penetration Test without evidence of perforation to an extent, which allows the direct passage of flame or gases, and without ignition occurring on the surface of the sample exterior to the combustion zone of the test furnace.

SAMPLE PREPARATION

1. Cut a 24-in by 24-in section of air duct by slitting the outer jacket down the length of the sample. Allow the insulation and scrim to separate at the overlaps. Cut through the length of the core, being careful to avoid tearing the film material.

2. Mark the jacket and the insulation with an arrow indicating the lengthwise direction of the sample.

3. Weigh fiberglass and determine the Weight Per Area of each sample as follows:

$$\frac{\text{weight (grams)}}{\text{area (in}^2\text{)}} \times 144 = \_\_\_\_\_ \text{ g/ft}^2$$

4. Mount sample in 2-ft by 2-ft frame such that the core wires run from one set of bolts to the other. The insulation, scrim, and vapor barrier should be mounted such that the directional arrow (indicating the sample length) is perpendicular to the core wires.

TEST SET-UP

A. Gas Flow and Pressure

1. Pressure should be 3.5± 0.05 in. W.C.

To Adjust Gas Pressure: Use screwdriver to adjust gas pressure regulator. To increase flow, turn valve clockwise; to decrease flow, turn valve counter-clockwise. Check Water Column after each adjustment.

To Adjust Gas Flow: Turn the fine-tune valve using very slight adjustments. Adjust gas flow to achieve specified furnace temperature. Check Water Column after each adjustment.

FLAME PENETRATION TEST (CONT'D): UL181, Eleventh Edition

PRE-HEAT

1. The furnace is to be fired for at least two (2) hours using natural gas.
2. A 1-inch thick, 18 lb./ft^3, calcium silicate board shall be in place on the top of the furnace for the stabilization period.
3. The calcium silicate board shall contact nine (9) thermocouples in distributed grid. The thermocouple tips shall extend 1 ± 1/16 inch below the bottom of the board's surface. During the pre-heat period, the temperature shall be maintained in the range of 1425°F ± 70°F.
4. The center, individual ring, average ring, and quadrant temperatures are to be measured by an automatic recording device every ten (1-) seconds and averaged each minute until the following conditions are met:
   a) Furnace center temperature shall be a nominal 1425°F ± 35°F for fifteen (15) minutes before removal of the silicate board and placement of the sample on top of the furnace.
   b) The average ring temperature shall be at least 90% of, but not greater than, the center temperature for fifteen (15) minutes before removal of the silicate board and placement of the sample on top of the furnace.
   c) Individual quadrant temperatures shall be at least 90% of, but not greater than, the center temperature for fifteen (15) minutes before removal of the silicate board and placement of the sample on top of the furnace.
   d) No individual ring temperature shall exceed 100°F (38°C) less than or greater than the average ring temperature.
5. Minor adjustments in the gas flow are allowed during this and subsequent stabilization period. The gas flow is not to be disturbed during the test periods.
6. For each succeeding test, the thermocouples grid board is to be replaced on the furnace until the stabilization conditions are met.

FLAME PENETRATION TEST (CONT'D): UL181, Eleventh Edition

TEST METHOD
In Accordance with UL181, Eleventh Edition

1. At the end of the stabilization period, the silicate board is to be removed and the air duct test sample is to be placed on top of the furnace within ten (10) seconds.

2. The test sample is to be subjected to a static load of 2 lb-mass per square inch (0.13 kg/cm^2) over a bearing surface on the sample of 1-inch by 4-inches (25.4 mm by 102 mm), located at the geometric center and rotated to any position determined to be most critical for the penetration on the upper surface of that part of the sample exposed to the flame.
3. The static load is to be placed on the test sample three (3) to five (5) seconds after the test sample is in place.
4. The test is to be continued for a period of thirty (30) minutes. The test period is to be measured from the time the static load is applied to the test sample.

FLAME PENETRATION TEST (CONT'D): UL181, Eleventh Edition

RESULTS

Furnace Start Time: 8:51 AM Test Start Time: 3:40 PM

TEST No.: 1

Sample Designation 1

Insulation Supplier/Designation 642224

Weight Per Area of Insulation: Sample Weight 159.8 (grams) = 40.0 g/ft^2

Input Values	Time	Height
	0:11	17.5"
	1:51	16.75"
Gas Inlet Press. 3.52" in. H_2O	9:47	16.5"
	14:02	16.5"
	21:06	16.5"
	25:11	16.5"
	29:10	16.5"

Observations

Was the Weight Supported? [Yes] ~~[No]~~

If No, Time of Collapse _____ min. _____ sec.

Was there ignition of the exterior surface? ~~[Yes]~~ [No]

If Yes, time of ignition _____ min. _____ sec.

Was there Flame Penetration? ~~[Yes]~~ [No]

If Yes, time of penetration _____ min. _____ sec.

Additional comments regarding the activity of the samples during the test, or any unusual occurrences:

[Pass] ~~[Fail]~~

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough

FLAME PENETRATION TEST (CONT'D): UL181, Eleventh Edition

RESULTS

Furnace Start Time: 8:51 AM Test Start Time: 4:41 PM

TEST No.: 2

Sample Designation 2

Insulation Supplier/Designation 642224

Weight Per Area of Insulation: Sample Weight 156.6 (grams) = 39.2 g/ft^2

Input Values	Time	Height
	0:13	17.5"
	2:11	16.75"
Gas Inlet Press. 3.52 in. H_2O	9:29	16.5"
	15:19	16.5"
	19:22	16.5"
	24:01	16.5"

Observations

Was the Weight Supported? [Yes] ~~[No]~~

If No, Time of Collapse _____ min. _____ sec.

Was there ignition of the exterior surface? ~~[Yes]~~ [No]

If Yes, time of ignition _____ min. _____ sec.

Was there Flame Penetration? ~~[Yes]~~ [No]

If Yes, time of penetration _____ min. _____ sec.

Additional comments regarding the activity of the samples during the test, or any unusual occurrences:

[Pass] ~~[Fail]~~

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough

FLAME PENETRATION TEST (CONT'D): UL181, Eleventh Edition

RESULTS

Furnace Start Time: 9:20 AM Test Start Time: 3:29 PM

TEST No.: 3

Sample Designation 3

Insulation Supplier/Designation 642224

Weight Per Area of Insulation: Sample Weight 162.4 (grams) = 40.6 g/ft^2

Input Values	Time	Height
	0:15	17.5"
	2:19	16.75"
Gas Inlet Press. 3.52 in. H_2O	4:38	16.75"
	12:29	16.75"
	16:02	16.5"
	21:07	16.5"
	25:33	16.5"

Observations

Was the Weight Supported? [Yes] ~~[No]~~

If No, Time of Collapse _____ min. _____ sec.

Was there ignition of the exterior surface? ~~[Yes]~~ [No]

If Yes, time of ignition _____ min. _____ sec.

Was there Flame Penetration? ~~[Yes]~~ [No]

If Yes, time of penetration _____ min. _____ sec.

Additional comments regarding the activity of the samples during the test, or any unusual occurrences:

[Pass] ~~[Fail]~~

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough

Formatted: Strikethrough