State of California
Department of Consumer Affairs

BUREAU OF ELECTRONIC & APPLIANCE REPAIR
HOME FURNISHINGS & THERMAL INSULATION
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Summary Report of Barrier Research

August 2018

INTRODUCTION

The Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation (BEARHFTI) adopted the furniture smoldering standard, Technical Bulletin (TB) 117-2013 for California in January 2014. This standard tests the smolder resistance of upholstered furniture components but does not address their resistance to open-flame. According to the TB117-2013 rulemaking documents, the Bureau is required to investigate the open flame component of fire to ensure the safety of upholstered furniture and develop a flammability standard for open flame fires if deemed justified and feasible. In addition, the potential economic impact along with any effects on health and environment must be included in the justification of such a standard.

Upholstered furniture is often one of the largest fuel loads, i.e. contributing source of fires, in a typical residential room. It can be accidently ignited by a small ignition source, which includes but is not limited to matches, candles, lighters and other heating sources in residential areas. Once ignited, the whole room can quickly become engulfed in flames, causing unsustainable conditions such as low oxygen levels and extremely high temperatures in the room. Since the use of a barrier has been regarded as an effective measure to delay the involvement of filling materials in a fire incident, the open flame barrier study is intended to evaluate the effectiveness of a variety of barrier materials which could be used in upholstered furniture.

Due to the tremendous economic burden to conduct a full scale open flammability test, a small scale open-flame method is more feasible. A bench-scale open flame barrier test proposal has been developed by the bureau and a variety of barrier materials provided by the industry have been tested. Full-scale validation tests have been conducted on mock-up furniture which are made by combining various cover fabrics, barrier materials and a polyurethane foam (PUF).

This report is provided to document the Bureau’s research work in accordance with the Bureau’s proposed open flame test for barrier materials. Environmental and economic reviews will be provided in separate documents and will be carefully reviewed.

EXPERIMENTAL STUDY

Materials

In this study, 25 barrier materials were selected and tested in accordance with the proposed small-scale open flammability test standard for barrier materials. The materials are in various forms, i.e. fabric, pad, batting and combinations of two or more materials. The majority of these materials have been widely used in mattresses and/or furniture to meet existing flammability standards, e.g. TB133 and 16 CFR 1633. The barrier materials which were included in this study are listed in Table 1.

Three types of blended heavy weight fabrics were used to construct mock-up furniture which was subject to full-scale flammability tests in later validation tests. The fabric combination and weights are listed in Table 2.

Modern cover fabrics used in upholstered furniture play significant roles in construction of furniture in terms of functional and aesthetic aspects. Usually, the fabrics are made of blends of synthetic, regenerated, and natural fibers in order to provide upholstered furniture with a desirable look, feel and durability which cannot be provided by single type of fiber (Nazare & Davis, 2011). The flammability characteristics of cover fabrics are affected by multiple factors such as their fiber combination, structure patterns, weight, physical processes, chemical treatments and finishing procedures. If ignited, cover fabrics may greatly contribute to the overall flammability performance of the furniture since these fabrics are likely to sustain a flame and spread the flame to underlying components such as batting and polyurethane foam in furniture.

The Standard Polyurethane Foam Substrate (SPFS) has also been used in the mock-up furniture in the validation tests. Their physical properties are listed in Table 3.

Test methods

All materials were used as received. Information for the barrier material was provided by manufacturers.

<u>Small-Scale Open Flame Test</u>

The proposed small scale open flame test method is intended to be used as a bench-scale test measure to distinguish the bad performers from the better performing barriers. The small-scale barrier test system consists of a metal rack, two rigid fire-rated insulation boards and an open-flame ignition source (Figure 1). A barrier specimen of 10” x 10” is placed between the two pre-cut insulation boards supported by the metal rack. A shutter mechanism is installed at the bottom of the horizontal test apparatus to protect the barrier materials before a test starts. The specimen assembly is shown in Figure 2. A piece of 5” x 5” x ½” standard polyurethane foam is fitted snugly on the top of the barrier material in the

opening of the top insulation board. The barrier samples were then tested per draft standard “Proposed Open Flame Test for Barrier Materials - Requirements, Test Procedure and Apparatus for Testing the Open Flame Resistance of Barrier Materials”. The set-up and procedures are prescribed in the proposed testing standard (Appendix A).

Figure 1. Small scale testing apparatus for barrier materials

Figure 2. Test system with a barrier insert

Full-scale Open Flame Test

In order to investigate the impact the use of barrier materials have on the open-flame performance of furniture, five types of barriers have been selected to construct mock-up samples (Table 4). Three types of heavy weight cover fabrics were selected and listed in Table 1. Each mock-up sample consists of a back cushion, a seat cushion, and two arm cushions. For comparison purposes, mock-up cushions made of the same cover fabrics and foam are constructed without barriers as control samples. The detailed material combinations of the full-scale cushions are listed in (Table 5).

The large-scale validation tests were conducted in the full-scale fire facility at the bureau (burn room) under the calorimeter exhaust hood. A burner tube is lit in the crevice of the mockup so that the end of the igniter is at the center of the mockup with equal distance from either edge. The flame remains on the mock-ups for 70 ± 1 seconds, then it is immediately removed from the mockup. The heat release rate and total heat release are measured in these tests. The construction of the mock-up chairs and test procedures are described below (Appendix B).

Results and Observations

Small-Scale Open Flame Test

In this test, a small flame from a Meker-Fisher burner is placed directly underneath a barrier sample. If the standard PUF ignites or a visible flame is observed during the test period, the barrier specimen fails the test. Figures 3-6 shows a barrier material which met the proposed standards while Figures 7-9 demonstrated the burning behavior of a failed barrier sample.

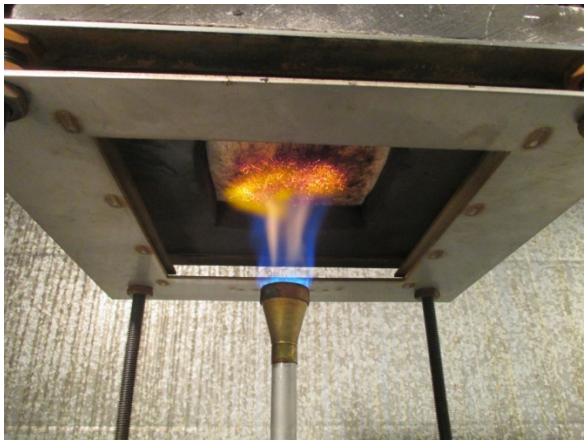


Figure 3. Ignition of a barrier (a passing barrier)

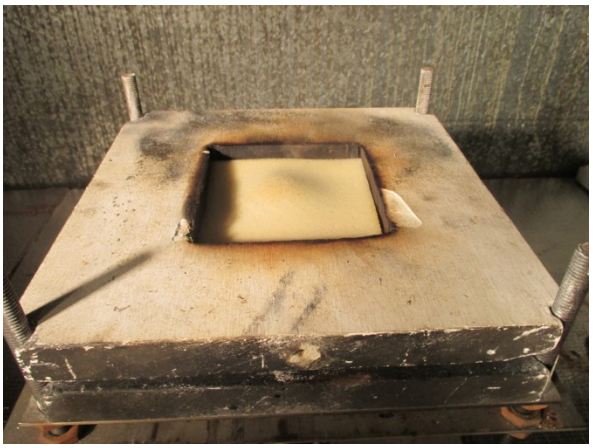


Figure 4. Top shot, 9 seconds after ignition (a passing barrier)

Figure 5 Top shot, 50 seconds ignition (a passing barrier)

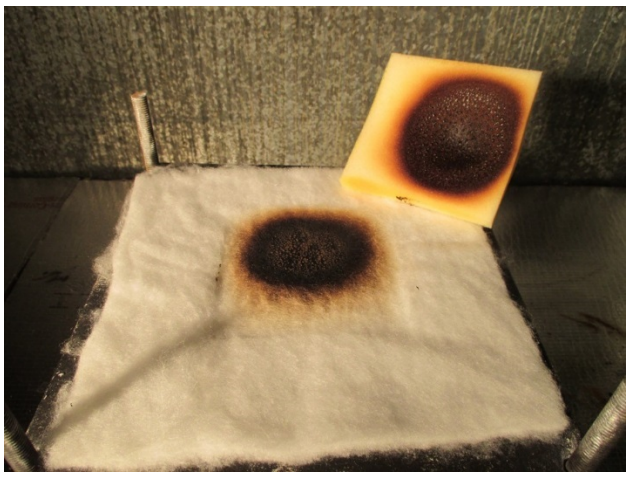


Figure 6. Post-test photo after test is completed (a passing barrier)

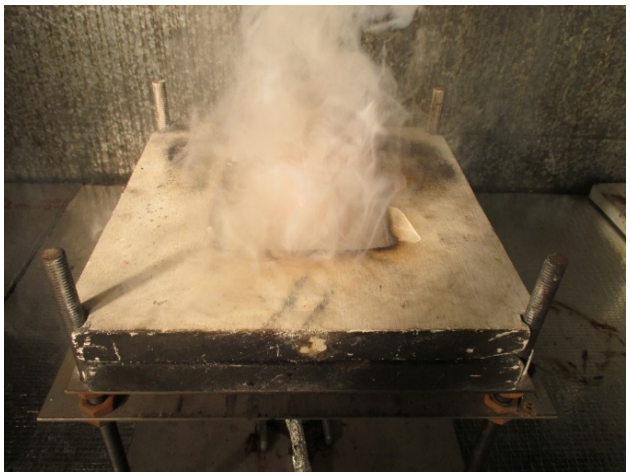


Figure 7. 9 seconds after ignition (a failing barrier)

Figure 8. 12 seconds after ignition (a failing barrier)

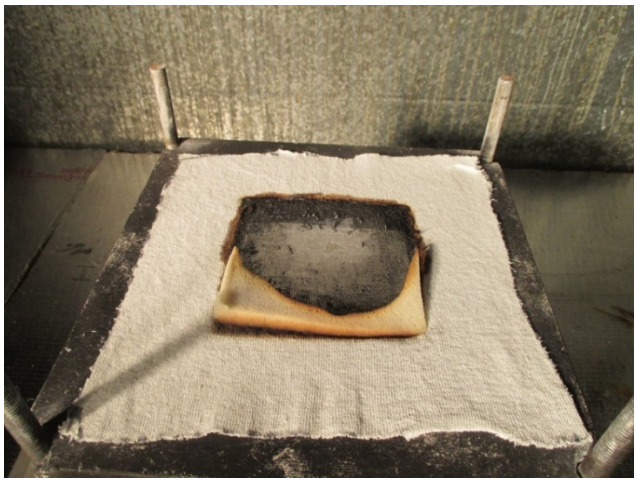


Figure 9. Post-test photo of a failed barrier specimen

The small-scale barrier testing results are listed in Table 6 and more pictures of post-test barriers and foams are shown in Table 7. The effectiveness of a barrier to resist an open flame ignition depends on its structure, weight, fiber combination and many other physical and chemical characteristics. Among the 25 barrier materials currently in the market, two failed the open flame test and both are porous and thin knit fabrics, which might allow thermal penetration and greater rate of air flow through the materials causing quick degradation of the PUF and generation of a large amount of flammable gases leading to ignition (Nazare & Davis, 2011).

The smoldering propensity of the tested barriers was investigated as well. All applicable barrier materials are smolder resistant in accordance with TB117-2013 Section 3, meaning the barrier materials would not impose additional smoldering hazard to furniture if added to the system.

Full-scale Open Flame Test

In this study, the Bureau's lab staff tested various constructed mock-up samples and recorded the Heat Release Rate(HRR) and the total Heat Release (THR). The HRR is a critical measurement to evaluate the severity of a fire. The flammability characteristics of the assemblies depend not only on chemical and physical characteristics of each component, but may also be influenced by synergism or antagonism of the system (Nurbakhsh & Mc Cormack 1998).

Graphs of Peak Heat Release Rate (PHRR) are shown in Figures 10-12. No pass or fail criteria were predetermined before the full-scale tests, but all data were compared to the control samples which were made without barriers. The figures indicate that all samples made with barrier materials show noticeable improvement in fire safety which is demonstrated by significant decrease of PHRR compared to that of their corresponding control samples without barriers.

Mock-up cushion assemblies without barriers, i.e. samples A0, B0 and C0, reached the PHRR over 400 kW or close to 400 kW. The majority of full-scale samples (A1, A2, A3, A4, B1, B3, B5, C1, C2, C3 and C4) show significantly decreased PHRR of less than 200 kW. Barrier 5 failed open flame barrier tests and is presumed to be a weaker barrier according to the small-scale barrier test results. Samples constructed with Barrier 5 showed the second worst and much higher PHRR in their individual groups when fabrics A and C were used, 329.5 kW and 290.6 kW, respectively. However, when Barrier 5 is constructed with fabric B, the mock-up demonstrated enhanced fire protection and yields a much lower PHRR. This phenomenon might be related to the inherent characteristics of the Fabric B, which is mainly composed of cellulosic fibers (Rayon and Cotton) and is over 50% heavier than that of Fabric A and C. After being ignited, Fabric B had a tendency to form char materials and could act as a layer of barrier, which was demonstrated by the noticeable delayed PHRR time of mock-up B0 (4 min 28 sec) compared to that of A0 (2

min 7 sec) and C0 (2 min 30 sec). The charred Fabric B and underneath barrier possibly form a stronger barrier to protect the encased filling materials.

Barrier materials not only lower the PHRR, but also delay the onset of the time to reach the PHRR. Figures 10-12 also demonstrate that control samples had the earliest time to reach their peak of heat release rates in each group.

In addition to the recorded data of the mock-ups, the Bureau's staff also took many pictures at different times to document the progress of the burning articles. Samples without barriers, i.e. A0, B0 and C0, burned much faster and intense compared to furniture with barriers. No materials were left after tests for A0, B0 and C0 assemblies. Some of the pictures of burning mock-ups are shown in Table 8.

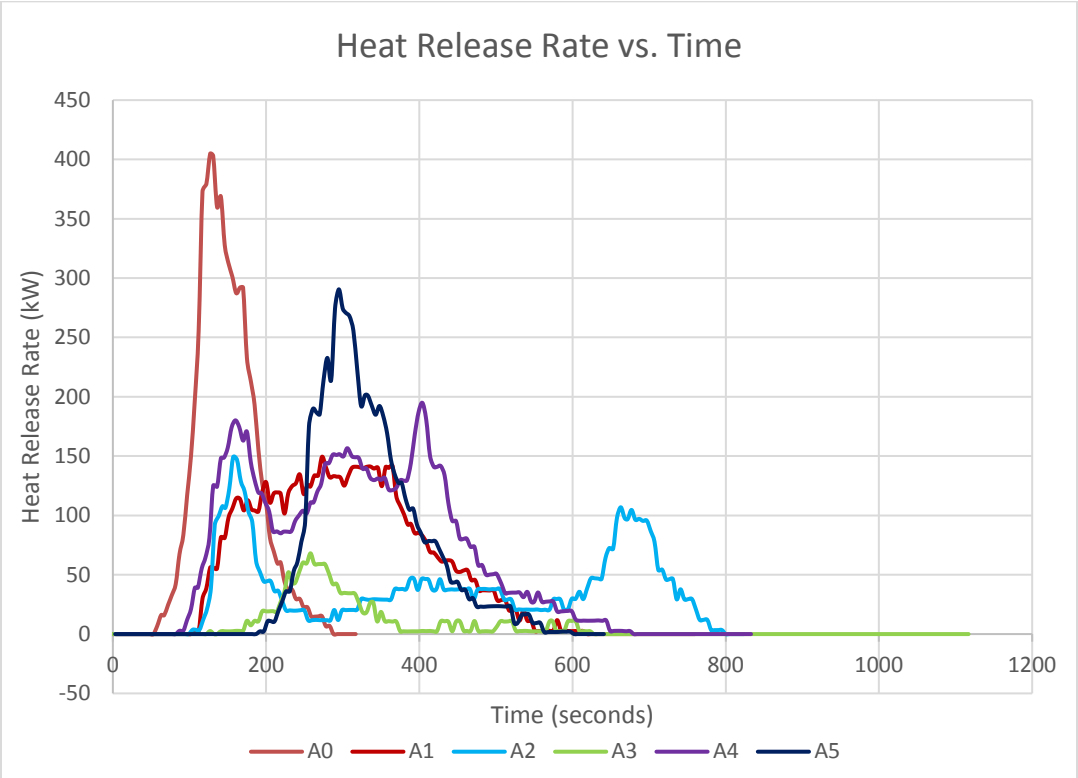


Figure 10. Peak Heat Release Rate of Fabric A with Different Barriers

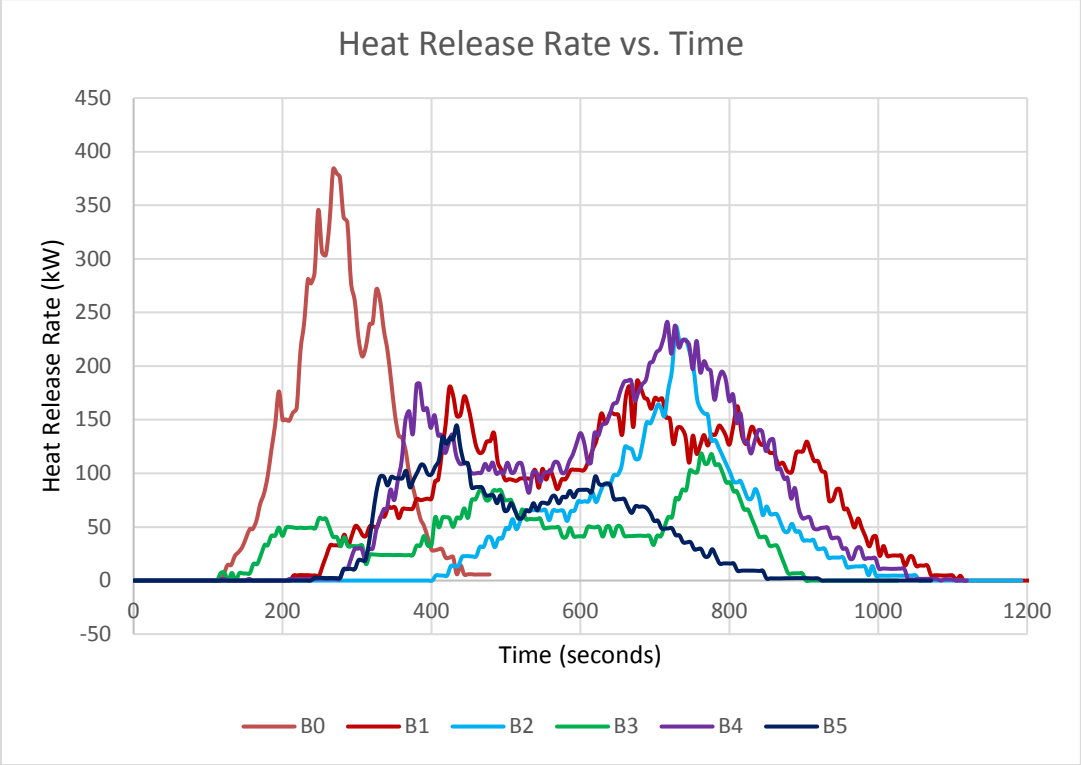


Figure 11. Peak Heat Release Rate of Fabric B with Different Barriers

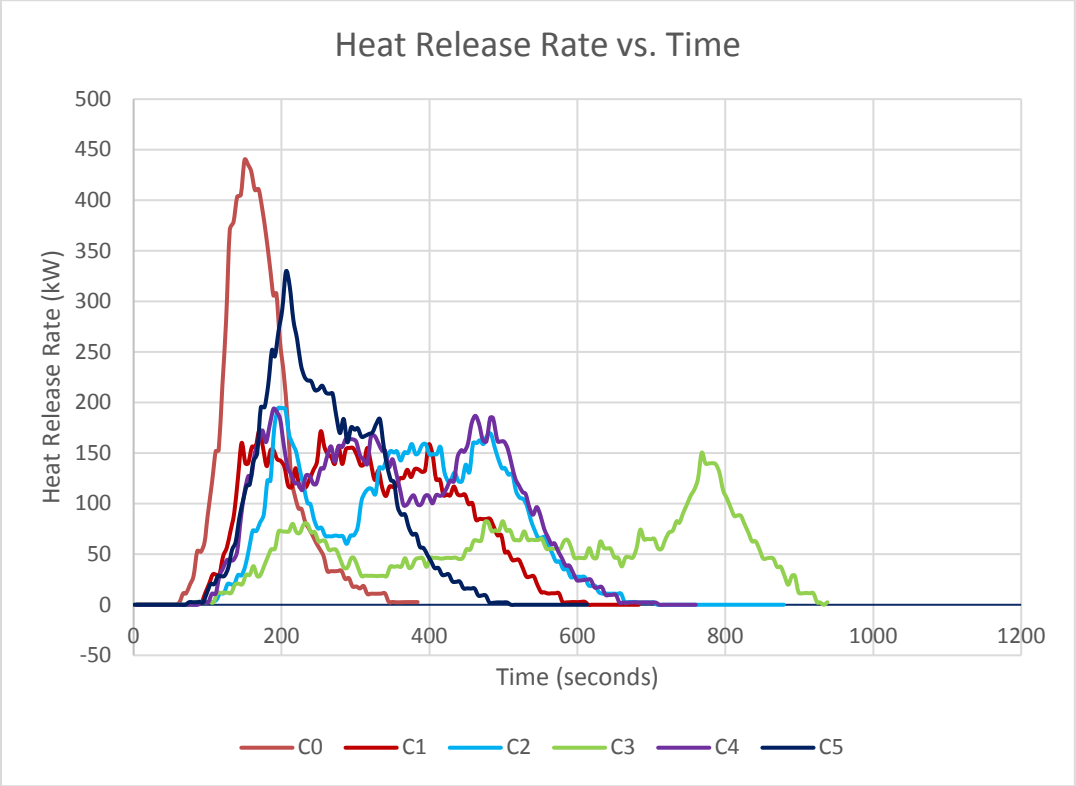


Figure 12. Peak Heat Release Rate of Fabric C with Different Barriers

CONCLUSIONS

Based on the testing data and observation, it is evident that barriers can delay the onset and reduce the peak heat release rate. The proposed open-flame test for barrier materials might be used as a screening test method to determine the effectiveness of a barrier material.

References

Nazare S, Davis R (2011) A review of fire blocking technologies for soft furnishings, NIST TN 1728, National Institute of Standards and Technology, Gaithersburg MD.

Nurbakhsh S, Mc Cormack J (1998) A review of the Technical Bulletin 129 full scale test method for flammability of mattresses for public occupancies. Journal of Fire Sciences 16:105-124

Table 1. Description of barrier materials

	Structure	Weight (oz/yd^2)	Type	Commercially Available?	Market
1	Knit	3.3	Passive	Yes	Mattress
2	Knit	2.7	Passive	Yes	Mattress
3	Knit	3.5	Passive	Yes	Mattress
4	Knit	8.8	Passive	Yes	Mattress
5	Knit	6.6	Active	Yes	TB133
6	Knit	12.0	Active	Yes	TB133
7	Coated knit	10.3	Active	Yes	TB133
8	High loft nonwoven	4.4	Inherent	Yes	Mattress
9	High loft nonwoven	5.3	Inherent	Yes	Mattress
10	High loft nonwoven	8.8	Inherent	Yes	Mattress
11	Knit	4.4	Inherent	Yes	Mattress
12	Knit	3.5	Inherent	Yes	Mattress
13	Knit	4.8	Passive	Yes	Mattress
14	Knit	5.8	Passive	Yes	Mattress
15	Composite nonwoven	7.5	Passive	Yes	TB133
16	Composite nonwoven	5.5	Active	Yes	TB133
17	Thermally bonded high loft nonwoven	7.2	Passive	Yes	Mattress
18	Thermally bonded high loft nonwoven	9.9	Passive	Yes	Mattress
19	High loft nonwoven	9.9	Passive	Yes	Mattress
20	Knit	4.5	Active	Yes	Mattress/ furniture
21	Knit	6.5	Passive	Yes	Mattress/ furniture
22	Knit	4.5	Passive	No	Mattress
23	Knit	9.0	Passive	No	Mattress
24	Knit	5.0	Active	No	Mattress
25	Knit	11.1	Active	Yes	TB133

Table 2. Description of cover fabrics used in validation examination

Fabric	Component	Fabric Weight (oz/yd$^{2)}$
A	75% Polyester/25% Acrylic	12.42
B	54% Rayon/24% Cotton/22% Polyester	18.73
C	36% Cotton/33% Polyester/31% Olefin	12.34

Table 3. Specifications of standard polyurethane foam substrate

Foam	Density (lb/ft^3)	IFD	Airflow (cfm)
Type 1	1.80 +/-0.05	27-30	3.5 – 4.0

Table 4. Selected barrier materials for full-scale validation test

Barrier	Structure	Weight (oz/yd^2)	Type	Market	Open Flame Barrier Test
1	Knit	8.8	Passive	Mattress	PASS
2	High loft nonwoven	4.4	Inherent	Mattress	PASS
3	Composite nonwoven	7.5	Passive	TB133	PASS
4	High loft nonwoven	9.9	Passive	Mattress	PASS
5	Knit	4.5	Active	Mattress / Furniture	FAIL

Table 5. Material combination for full-Scale tests

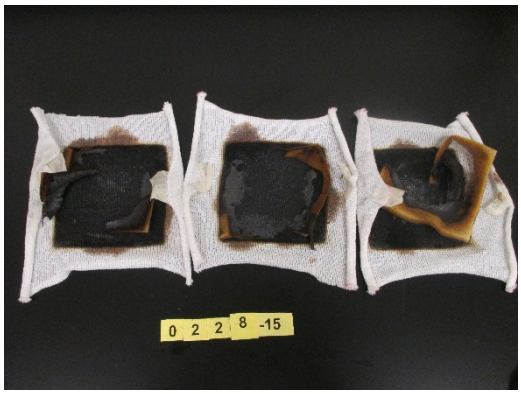
Combination	Cover Fabric	Barrier	Foam
A0	A	None	SPUF*
A1	A	Type 1	SPUF
A2	A	Type 2	SPUF
A3	A	Type 3	SPUF
A4	A	Type 4	SPUF
A5	A	Type 5	SPUF
B0	B	None	SPUF
B1	B	Type 1	SPUF
B2	B	Type 2	SPUF
B3	B	Type 3	SPUF
B4	B	Type 4	SPUF
B5	B	Type 5	SPUF
C0	C	None	SPUF
C1	C	Type 1	SPUF
C2	C	Type 2	SPUF
C3	C	Type 3	SPUF
C4	C	Type 4	SPUF
C5	C	Type 5	SPUF

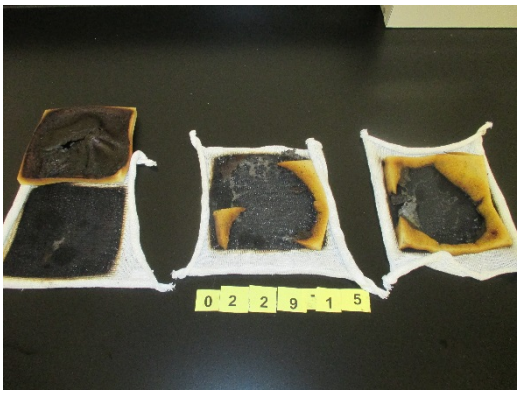
*Standard Polyurethane Foam used in TB117-2013

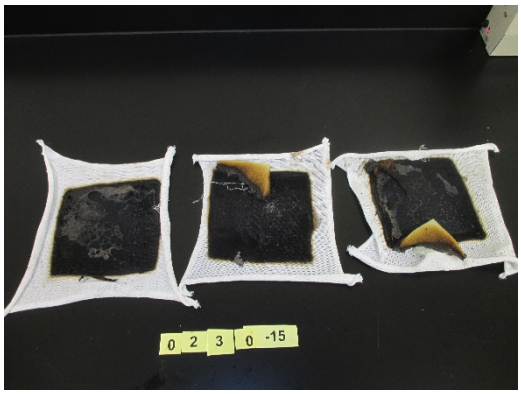
Table 6. TB117-2013 and open flame barrier test results

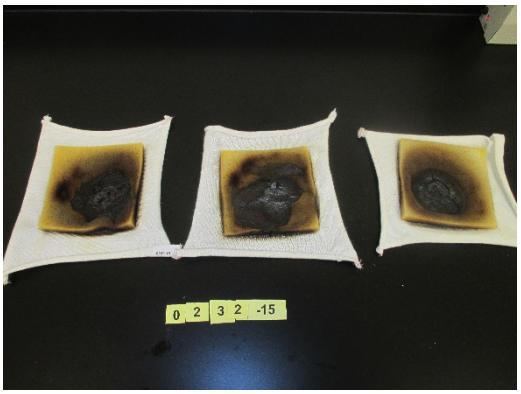
	Structure	Weight (oz/yd^2)	Type	Market	Open Flame Barrier Test	TB117-2013 Sec. 3
1	Knit	3.3	Passive	Mattress	Pass	N/A
2	Knit	2.7	Passive	Mattress	Pass	N/A
3	Knit	3.5	Passive	Mattress	Pass	N/A
4	Knit	8.8	Passive	Mattress	Pass	N/A
5	Knit	6.6	Active	TB133	Pass	N/A
6	Knit	12.0	Active	TB133	Pass	N/A
7	Coated knit	10.3	Active	TB133	Pass	N/A
8	High loft nonwoven	4.4	Inherent	Mattress	Pass	Pass
9	High loft nonwoven	5.3	Inherent	Mattress	Pass	Pass
10	High loft nonwoven	8.8	Inherent	Mattress	Pass	Pass
11	Knit	4.4	Inherent	Mattress	Pass	N/A
12	Knit	3.5	Inherent	Mattress	Pass	N/A
13	Knit	4.8	Passive	Mattress	Pass	N/A
14	Knit	5.8	Passive	Mattress	Pass	N/A
15	Composite nonwoven	7.5	Passive	TB133	Pass	Pass
16	Composite nonwoven	5.5	Active	TB133	Pass	Pass
17	High loft nonwoven	7.2	Passive	Mattress	Pass	Pass
18	High loft nonwoven	9.9	Passive	Mattress	Pass	Pass
19	High loft nonwoven	9.9	Passive	Mattress	Pass	Pass
20	Kinit	4.5	Active	Mattress /Furniture	Fail	N/A
21	Knit	6.5	Passive	Mattress /Furniture	Pass	N/A
22	Knit	4.5	Passive	Mattress	Pass	N/A
23	Knit	9.0	Passive	Mattress	Pass	N/A
24	Knit	5.0	Active	Mattress	Fail	N/A
25	Knit	11.1	Active	TB133	Pass	N/A

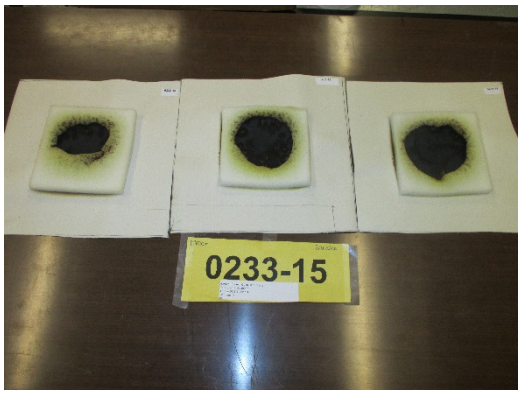
Table 7. Post-test pictures of barrier materials and foams

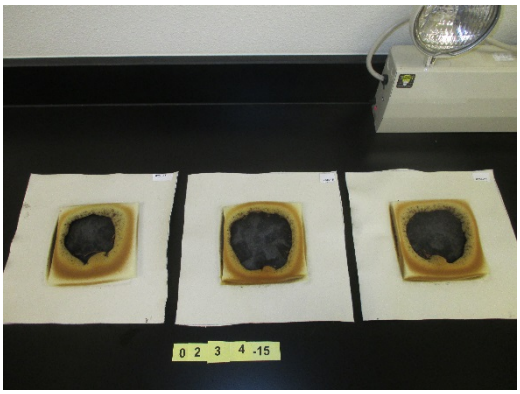


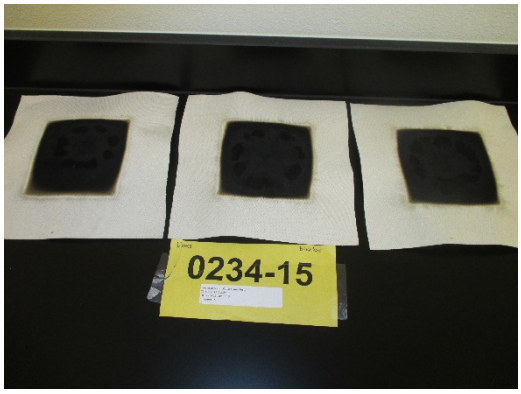


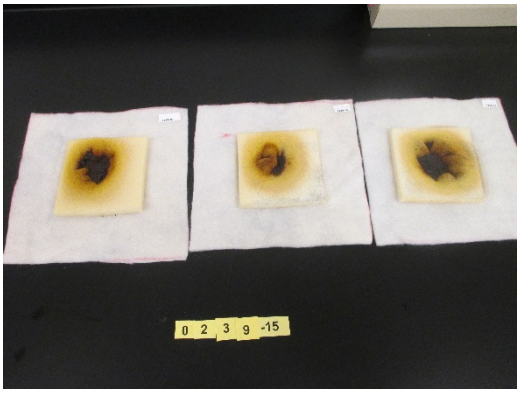


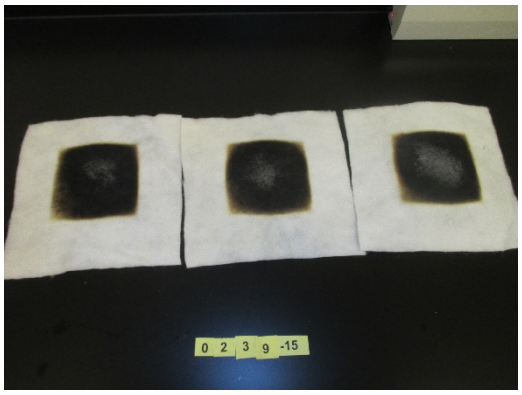








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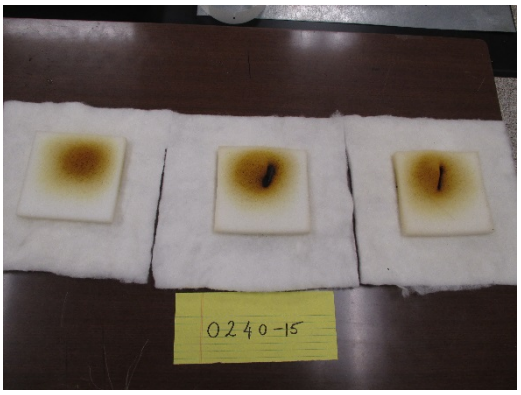
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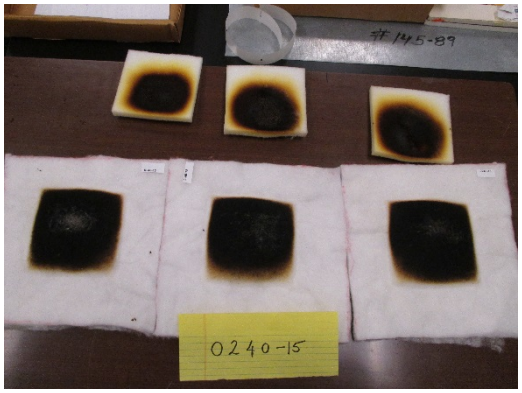
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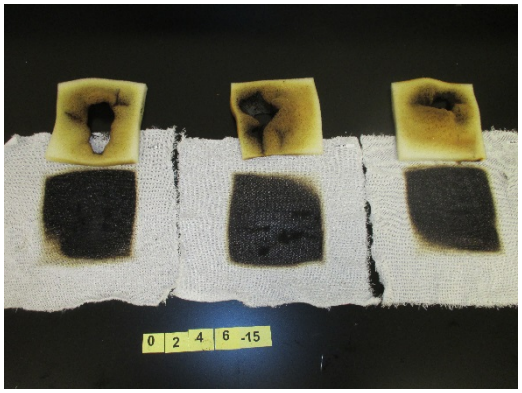
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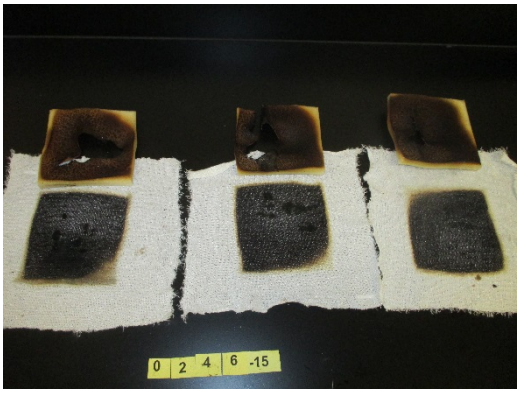
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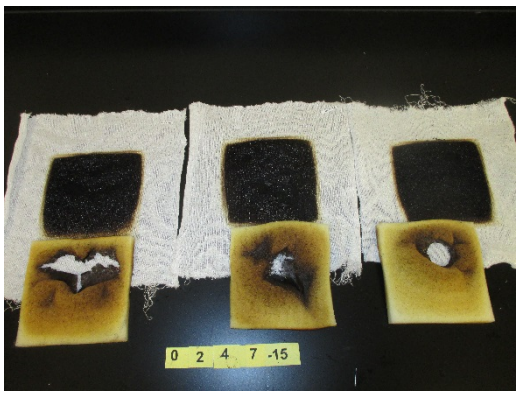
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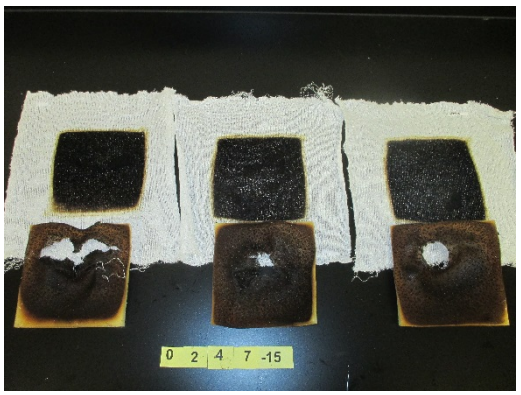
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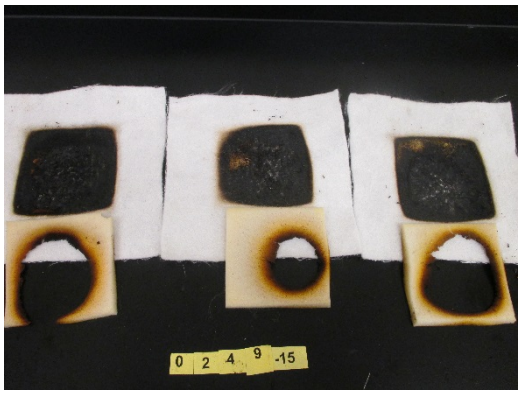
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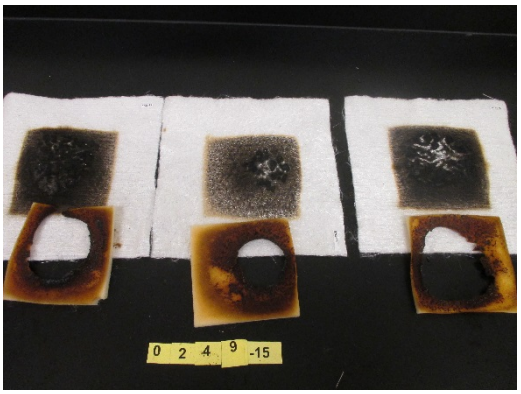
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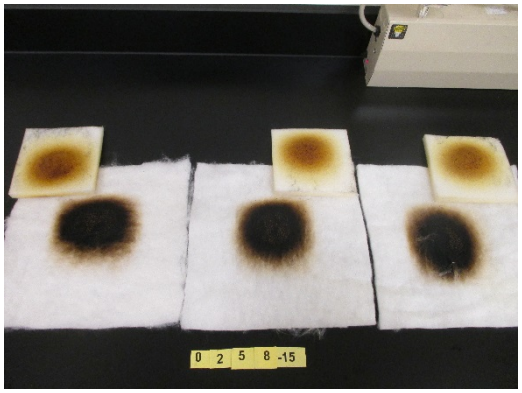
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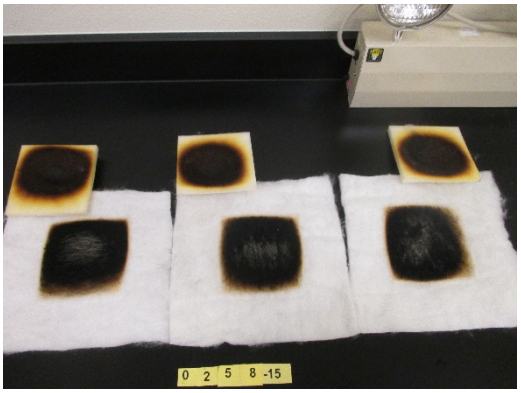
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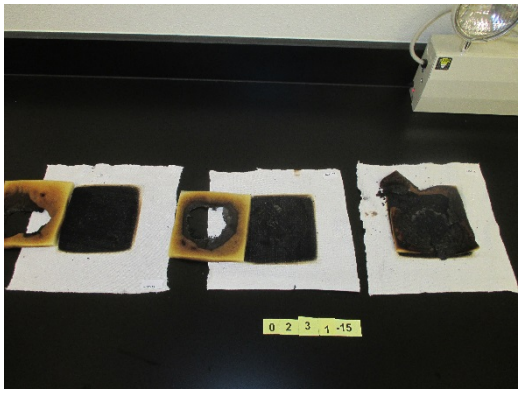
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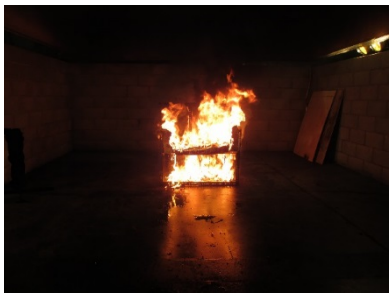
Table 8. Pictures of mock-up test at different times

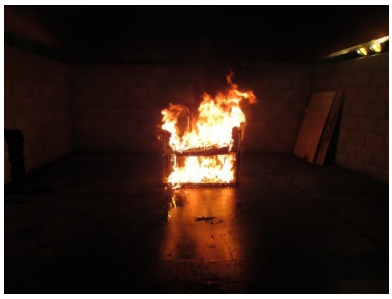
A0 – Fabric A without a barrier

Pre

t = 1 min 30 sec



t = 2 min



t = 2 min 30 sec

t = 3 min 45 sec

Post

A1 – Fabric A with Barrier 1

Pre

t = 3 min

t = 6 min

t = 8 min

t = 10 min

Post

A2 – Fabric A with Barrier 2


Pre


t = 3 min


t = 6 min


t = 8 min


t = 10 min


Post

A3 – Fabric A with Barrier 3

Pre


t = 3 min


t = 8 min


t = 12 min


t = 20 min


t = 25 min

A4 – Fabric A with Barrier 4



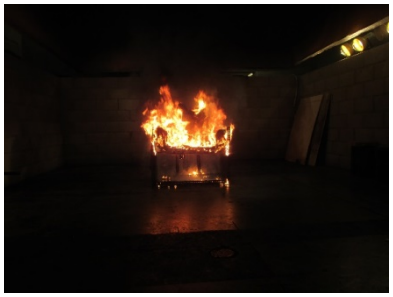
Pre t = 3 min t = 6 min



t = 8 min t = 10 min Post

A5 – Fabric A with Barrier 5





Pre t = 3 min t = 6 min



t = 8 mim t = 10 min Post

B0 – Fabric B without a barrier



Pre | t = 2 min 30 sec | t = 3 min



t = 5 min 30 sec | t = 6 min 30 sec | Post

B1- Fabric B with Barrier 1



Pre | t = 5 min | t = 6 min 30 sec



t = 8 min | t = 10 min | Post

B2 – Fabric B with Barrier 2

Pre

t = 3 min

t = 6 min

t = 8 min

t = 10 min

Post

B3 – Fabric B with Barrier 3

Pre

t = 3 min

t = 6 min

t = 8 min

t = 25 min

Post

B 4 – Fabric B with Barrier 4



t = 5 min t = 8 min t = 10 min



t = 15 min t = 18 min Post

B5 – Fabric B with Barrier 5



Pre t = 3 min t = 6 min



t = 8 min t = 10 min Post

C0 – Fabric C without a barrier


Pre t = 2 min 30 sec t = 3 min



t = 4 min t = 5 min Post

C1 – Fabric C with Barrier 1


Pre t = 3 min t = 6 min



t =9 min t = 10 min Post

C 2 – Fabric C with Barrier 2



Pre t = 3 min t = 6 min



t = 8 min t = 10 min Post

C3 – Fabric C with Barrier 3



Pre t = 5 min t = 9 min



t = 12 min t = 15 min Post

C4 – Fabric 4 with Barrier 4



Pre | t = 3 min | t = 6 min



t = 8 min | t = 10 min | Post

C5 – Fabric C with Barrier 5



Pre | t = 3 min | t = 6 min



t = 8 min | t = 10 min | Post

APPENDIX A

State of California
Department of Consumer Affairs

BUREAU OF ELECTRONIC & APPLIANCE REPAIR
HOME FURNISHINGS & THERMAL INSULATION
4244 SOUTH MARKET COURT, SUITE D
SACRAMENTO, CA 95834-124

Proposed
Open Flame Test for Barrier Materials

Requirements, Test Procedure and Apparatus for Testing the Open Flame Resistance of Barrier Materials

January 2016

Requirements, Test Procedure and Apparatus for Testing the Open Flame Resistance of Barrier Materials

PURPOSE

The intent of this standard is to produce upholstered furniture which is safer from the hazards associated with small open-flame ignition.

Barrier Materials Component Test - Open-Fame Resistance

1. Scope - This standard applies to any material in the form of battings, pads, fabrics, etc. that is used as a barrier in upholstered seating furniture. The test method can also be used for upholstery cover fabrics that are fire resistant and serve as fire barriers as well.

2. Summary of Test Method - The test method consists of the application of an open-flame ignition source, to the bottom side of a horizontally mounted specimen of the barrier material while a layer of standard non-fire retardant polyurethane foam is placed on the top side of the barrier material. The test specimen is situated over an opening and is sandwiched between two rigid fire-rated insulating boards supported by a metal rack. Observations of the burning behavior and patterns are used to assess the performance of the specimen under these test conditions**.**

3. Significance and Use - This test method is designed to assess the response of a barrier material test specimen to an open-flame ignition source. The test provides an indication of the resistance of the barrier material to prevent an external flame reaching the underlayment of standard polyurethane foam and igniting it.

4. Test Apparatus and Materials - The test apparatus, including the horizontal test frame rack and the shutter plate mechanism, is described in Annex A, Figures A1- A8.

The ignition source is a Meker-Fisher Gas Burner. The Meker-Fisher gas burner, the gas train and accessories are described in Annex B.

The Standard Polyurethane Foam (SPUF) – The standard polyurethane foam is described in Annex B of Technical Bulletin 117-2013, June 2013.

5. Test Facility and Hazards - The test facility, exhaust system and hazards are described in Annex C.

6. Conditioning - Condition test specimens and the standard PU foam prior to the test for a minimum of 24 hours at 21° ± 3 °C (70° ± 5 °F) and less than 55% RH. If the sample is taken from a finished article of furniture, conditioning does not begin until the component is removed from the furniture.

If conditions in the test area are not the same as in the conditioning area, tests should begin within 10 minutes of removal from conditioning area.

7. Test Specimen - Representative specimens of barrier materials shall be sampled for testing from various points in the barrier material (batting, pad, flat barrier materials, or combination of materials used as barrier). Three specimens should be prepared from different areas of the material. The specimen shall consist of a swatch of fiber batting, pad, fabric or any other type of barrier material. Cut each specimen to 250 x 250 mm (10 x 10 in) in the thickness of use.

8. Procedure:

8.1. Place the horizontal test rack in a test hood (See Annex C) that provides adequate ventilation to exhaust smoke and gases.

8.2. Before mounting the test specimen on the test rack prepare the gas burner ignition source. Set the gas flow to the Meker-Fisher burner as designated in Annex B. Ignite the Meker-Fisher burner and allow the flame to stabilize. Turn off the gas flow to the Meker-Fisher burner using the toggle on/off switch. Do not make any further adjustments to the gas flow. For the remainder of the test use only the on/off toggle switch. Place the bottom mounting plate on the rectangular metal retaining ring of the test rack. Make sure the plate is firmly positioned.

8.3. Place the barrier material test specimen on the top of the bottom horizontal mounting plate. Center the specimen flat so that the face side of the barrier material which is exposed to the heat source is towards the burner. Ensure barrier material is tight with no sagging or wrinkling.

8.4. Face side of the barrier test specimen is the surface of the material that is in contact with the cover fabric inside the furniture. The bottom side of the barrier is placed in contact with the interior fillings of the furniture. Many barrier materials are reversible and have no identifiable facing.

8.5. Place the top horizontal mounting plate over the barrier material, sandwiching the barrier material between the two mounting plates. Make sure the plate is firmly positioned.

8.6. Insert a piece of 5" X 5" X ½" standard polyurethane foam (SPUF) directly over the barrier material fitting snugly in the upper mounting plate rectangular opening, so that the foam contacts the barrier material at all points.

8.7. Close the shutter mechanism by fully inserting the shutter plate in place.

8.8. Place the Meker-Fisher burner in the center of the bottom plate of the test rack such that the top of the burner is positioned 4 inches (100 mm) below the center of the bottom surface of the test specimen. (Figure A-2).

8.9. Turn on the toggle switch and ignite the Meker-Fisher burner using a butane lighter or a spark striker.

8.10. After a few seconds (less than 10 seconds) pull out the shutter plate and immediately start the timing device.
Note: Do not leave the lit burner underneath the shutter plate for more than a few seconds. Otherwise the test specimen may become preheated before ignition flame impingement.

8.11. Turn off the toggle switch after one minute of ignition flame impingement.
8.12. Remove the burner from underneath the test specimen and set it aside.
8.13. Continue test until all traces of flaming and smoldering have ceased. Make and record observations regarding penetration of the flame through the test specimen and/or decomposition and burning of the standard polyurethane foam.
8.14. When all combustion is ceased carefully remove the mounting plates and the remaining test materials off the metal test rig.
8.15. Thoroughly clean the mounting plates and allow them to reach room temperature before conducting the next test.

9. Pass/Fail Criteria

A single test specimen fails to meet the requirements of this test procedure if the standard polyurethane foam (SPUF) ignites or a visible flame (however brief) is observed above the foam:

9.1. A barrier material passes the test if three initial specimens pass the test.
9.2. If more than one initial specimen fails, the barrier material fails the test.
9.3. If any one of the three initial specimens fails, repeat the test on additional three specimens. If all three additional specimens pass the test, the barrier material passes the test. If any one of the additional three specimens fails, the barrier sample fails the test.

10. Test Report

The test report shall contain, at a minimum, the following information:

10.1. Name and address of the test laboratory.
10.2. Date of the test(s).
10.3. Operator conducting the test.
10.4. Complete description of the test materials.
10.5. Complete description of any procedures different from those described in this test method.
10.6. Observations shall be made, and included in the report, of the behavior of the specimen in response to the application of the burner, specifically noting the following:
  10.6.1. The time of flaming ignition of the foam when applicable.
  10.6.2. Extended smoldering (non-flaming) combustion.
  10.6.3. The condition of the standard polyurethane foam (SPUF) used in the test (e.g. 50% recovered, completely consumed, …)
  10.6.4. The post-test condition of the test material.
  10.6.5. The total test time, i.e., time from start of ignition to the end of all combustion.

10.7. Statement of overall Pass/Fail results.
10.8. Post-test photographs of the test specimens.

ANNEX A

Horizontal Test Apparatus

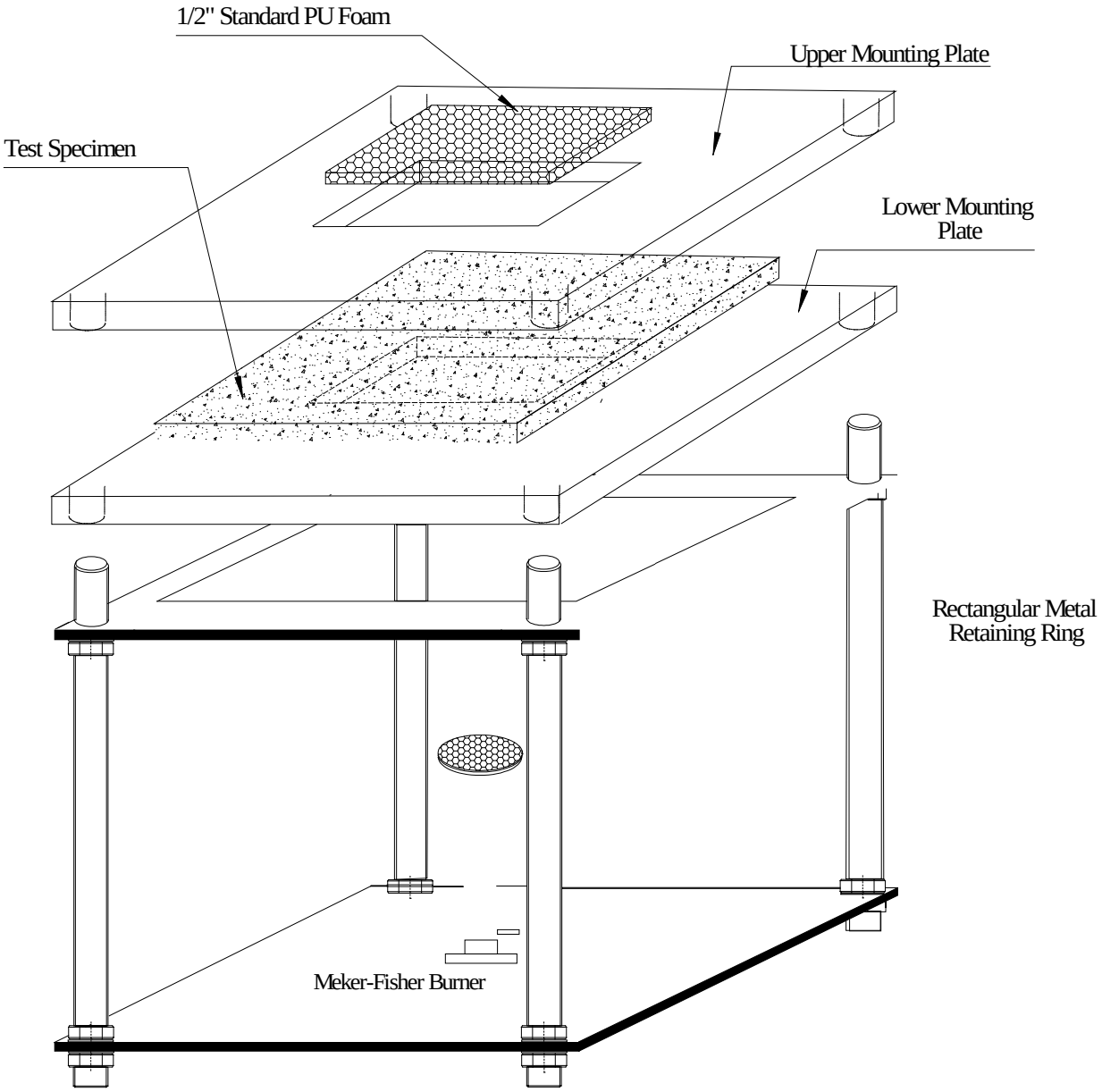
A test rack constructed, as in Figures A-1 to A-4, shall be used to support the sample for testing. The rack shall be constructed with a 356 x 356 mm (14 x 14 in) stainless steel metal (2.4 mm (3/32 in) thick) bottom plate. At each corner of the plate, a 356 mm (14 in) long, 12 mm (1/2 in) O.D. threaded rod shall be mounted vertically to allow adjustment of a horizontal test support to various heights using threaded nuts. The test support shall consist of a fixed rectangular metal retaining ring with inside openings of 254 x 254 mm (10 x 10 in). The metal rectangular retaining ring shall have holes to act as guides for positioning threaded rods through them.

Two 300 X 300 mm (12 X 12 in.) mounting plates, as shown in Figures A1 through A3, are made of 25 mm (1 inch) thick inorganic 740-kg/m^3 (46 lb/ft^3) nominal density calcium silicate boards. A 127 X 127 mm (5 X 5 in) opening is cut at the center of each plate. Four 12 ½ mm (½ inch) holes are made at the four corners of each mounting plate for mounting on through the threaded metal rods. The mounting plates are painted with fire resistant (high temperature) flat black paint.

Note: Other heat resistant insulation materials with physical and thermal properties similar to the calcium silicate board can also be used for the mounting plates.

Shutter Mechanism

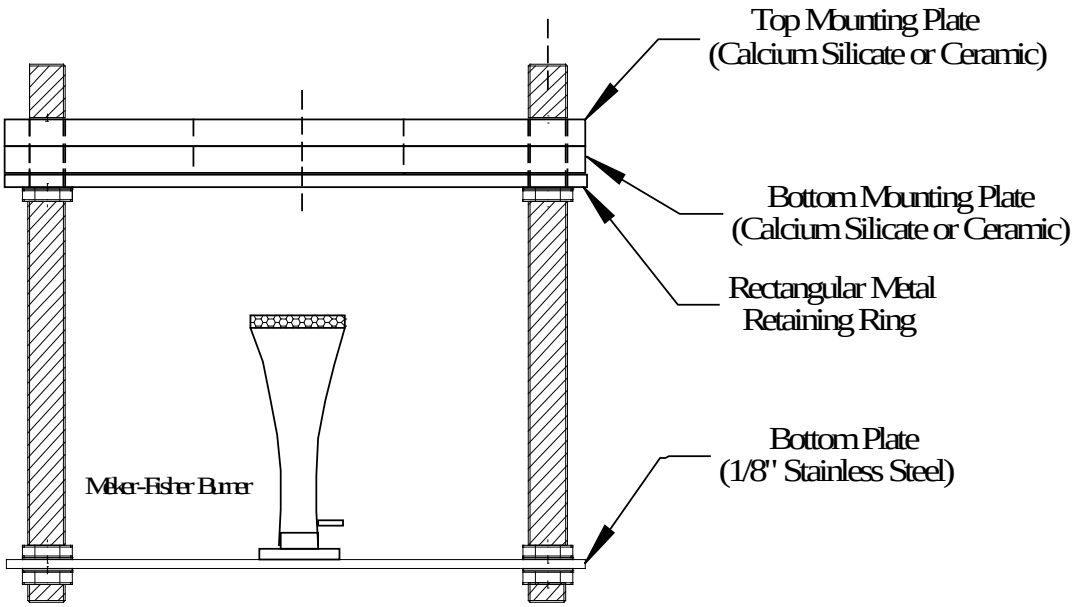
A shutter mechanism consisting of a base shutter plate holder and a shutter plate, as shown in Figure A-5 through A-8, shall be mounted 25 mm (1 inch) below the lower retaining plate of the horizontal test apparatus.



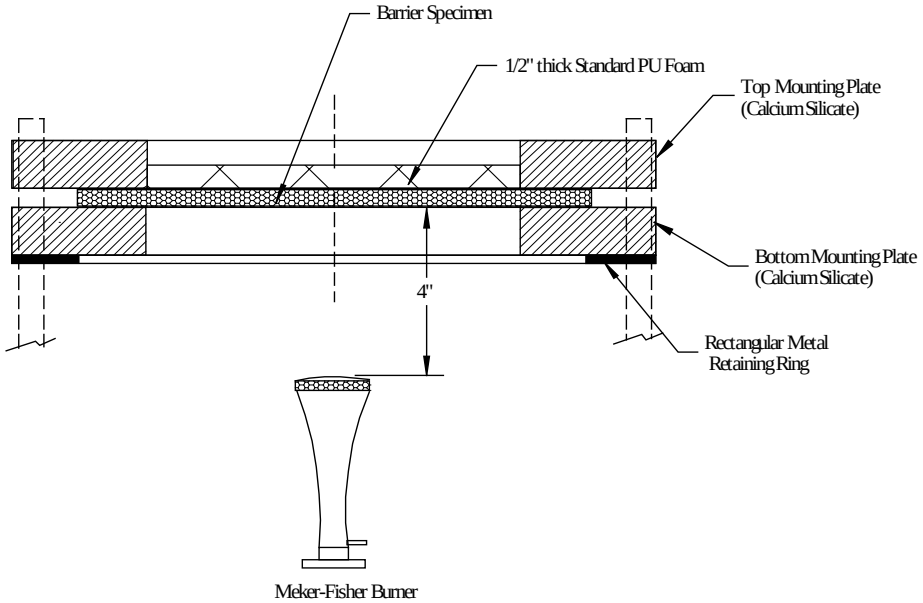
(Drawings Not to Scale)

Figure A-1. Horizontal Test Apparatus Assembly

(Exploded View of Barrier Test Assembly)



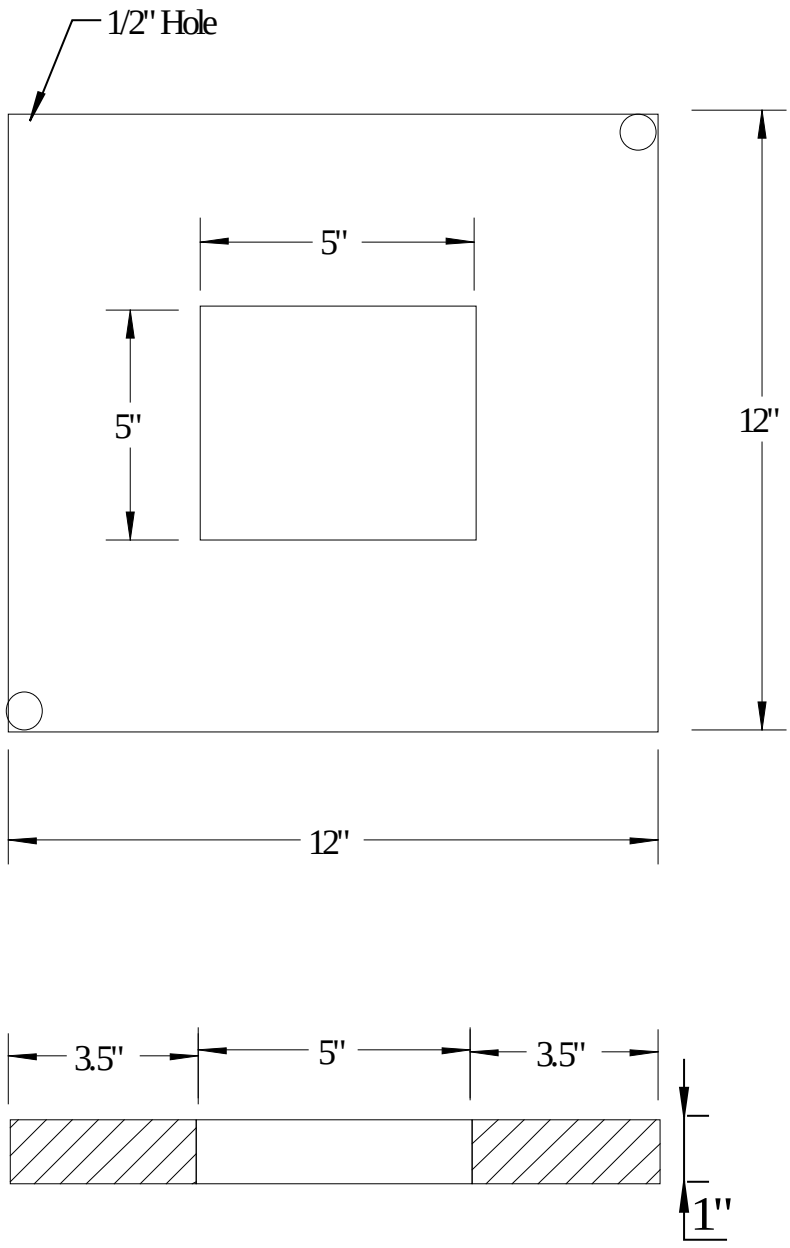
Side view of the horizontal test apparatus



Mounting of the test specimen on the horizontal test apparatus
(Cross Sectional Side View)

(Drawing not to scale)

Figure A-2. Horizontal Test Apparatus Assembly – Side Views



Mounting Plates (Calcium Silicate or Ceramic)

(Drawings not to Scale)

Figure A-3. Horizontal Test Apparatus Assembly – Mounting Plates

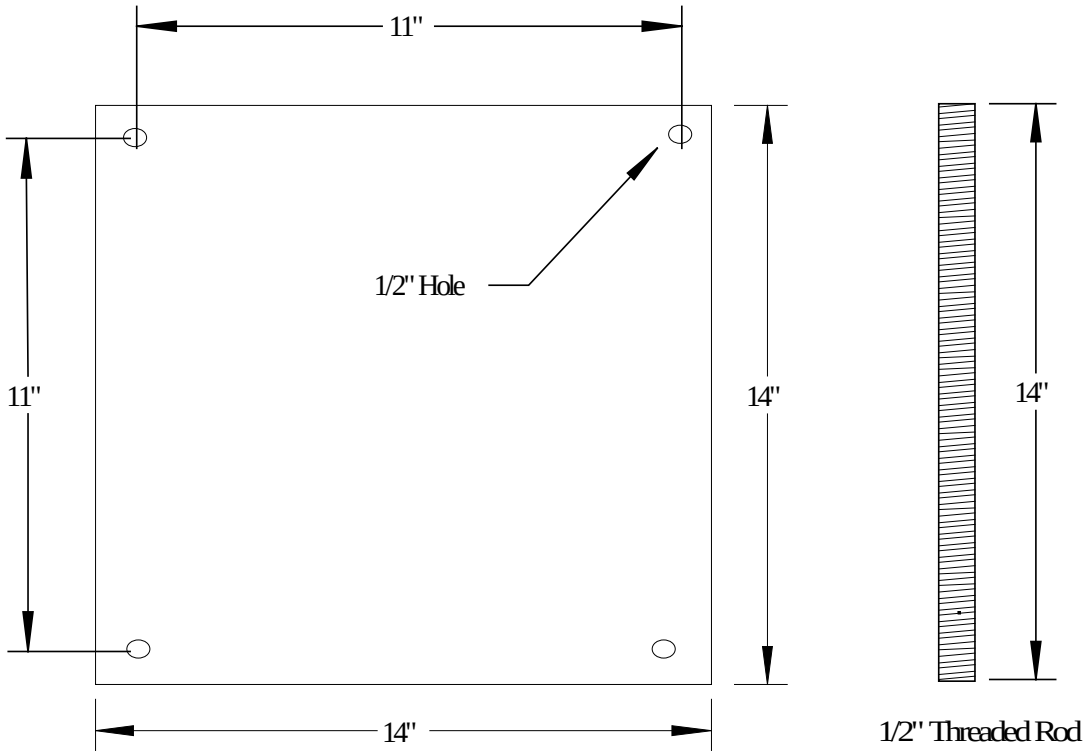


Figure A-4. Horizontal Test Apparatus Assembly – Parts of Test Frame

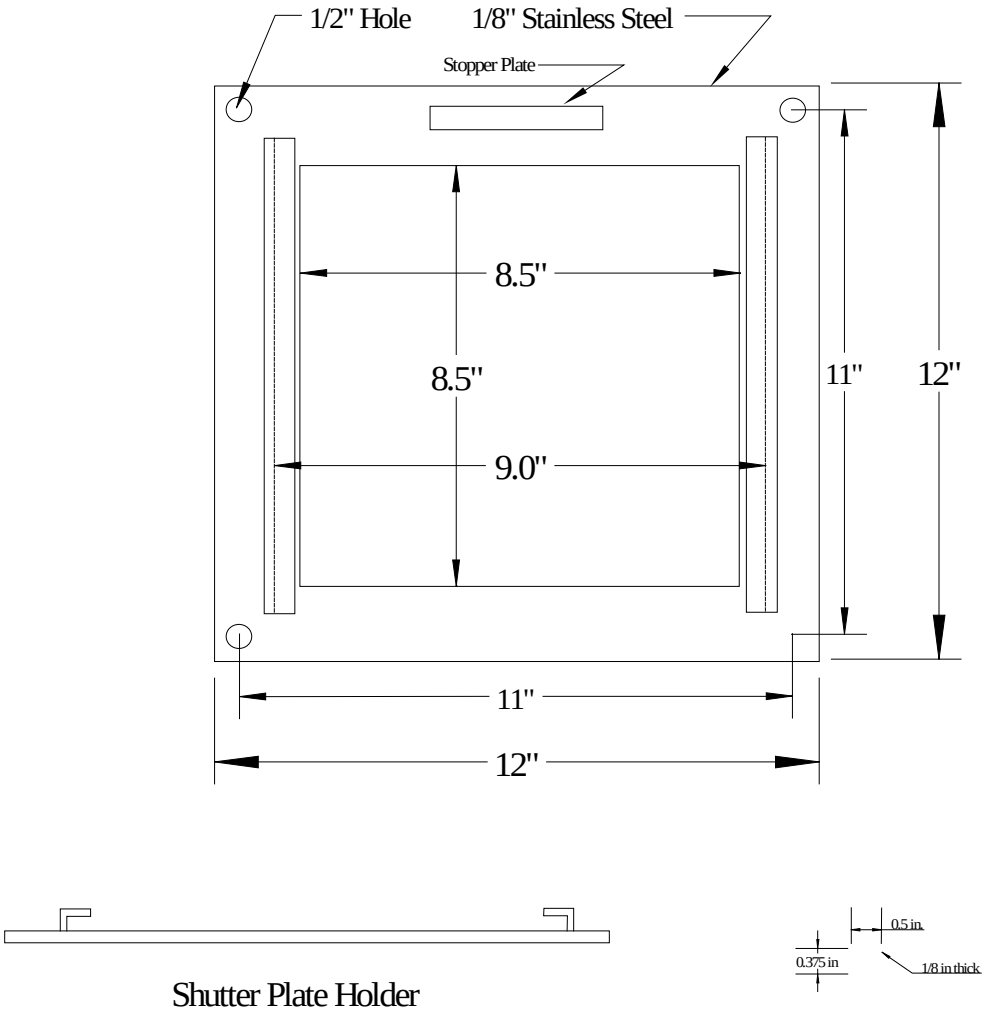


Figure A-5. Shutter Plate Mechanism

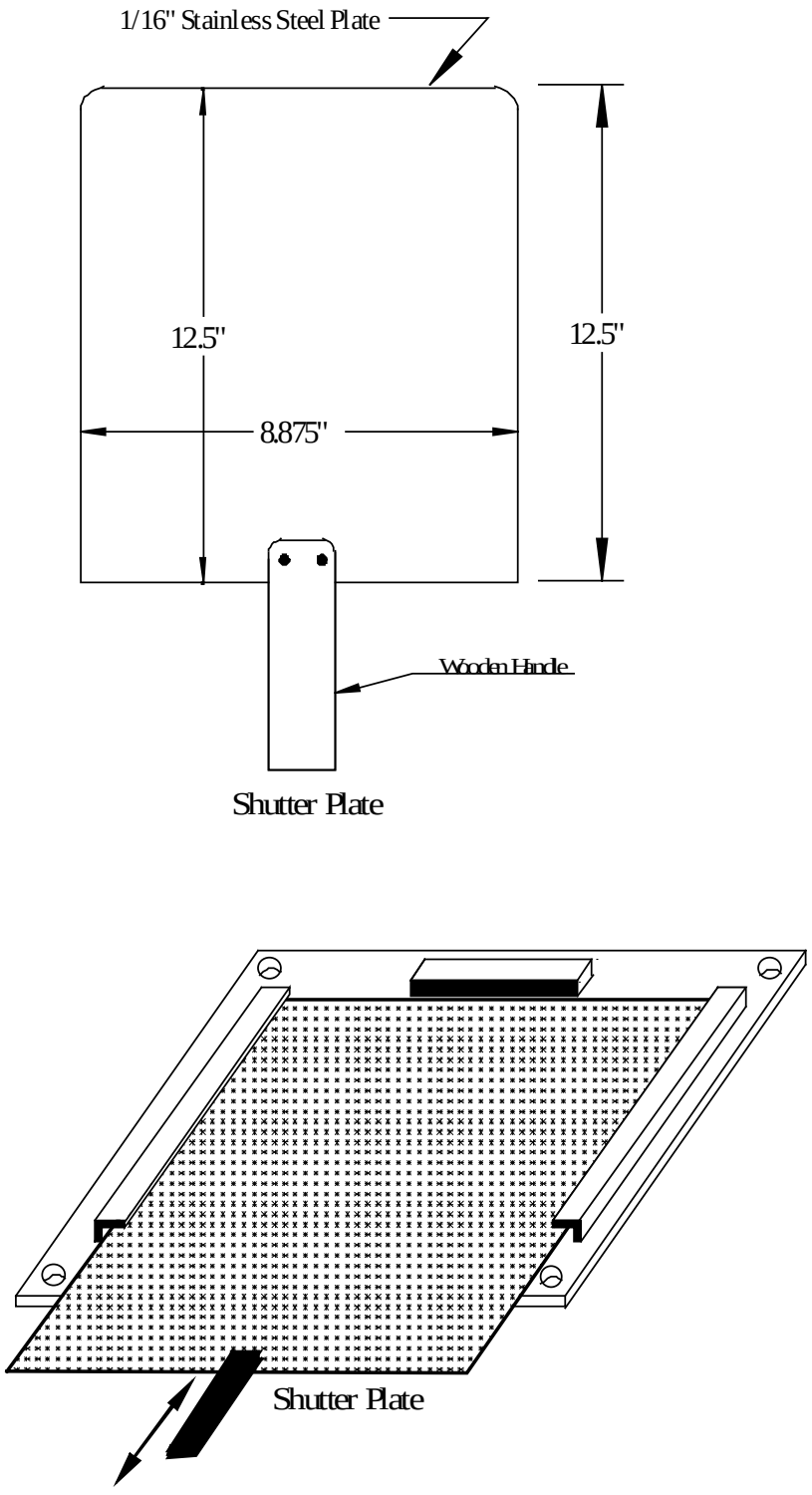


Figure A-6. Shutter Plate Mechanism

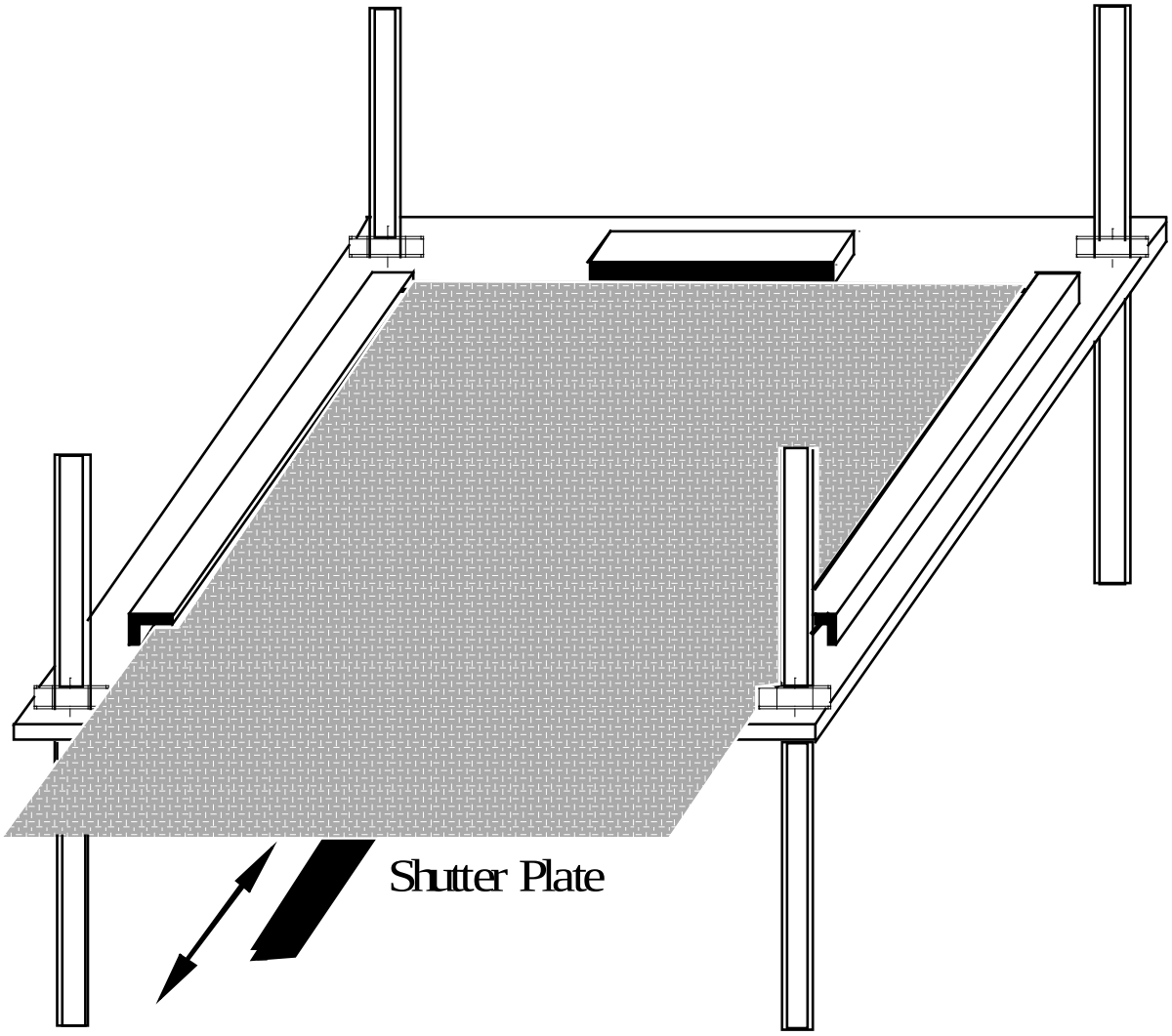


Figure A-7. Shutter Plate Placement

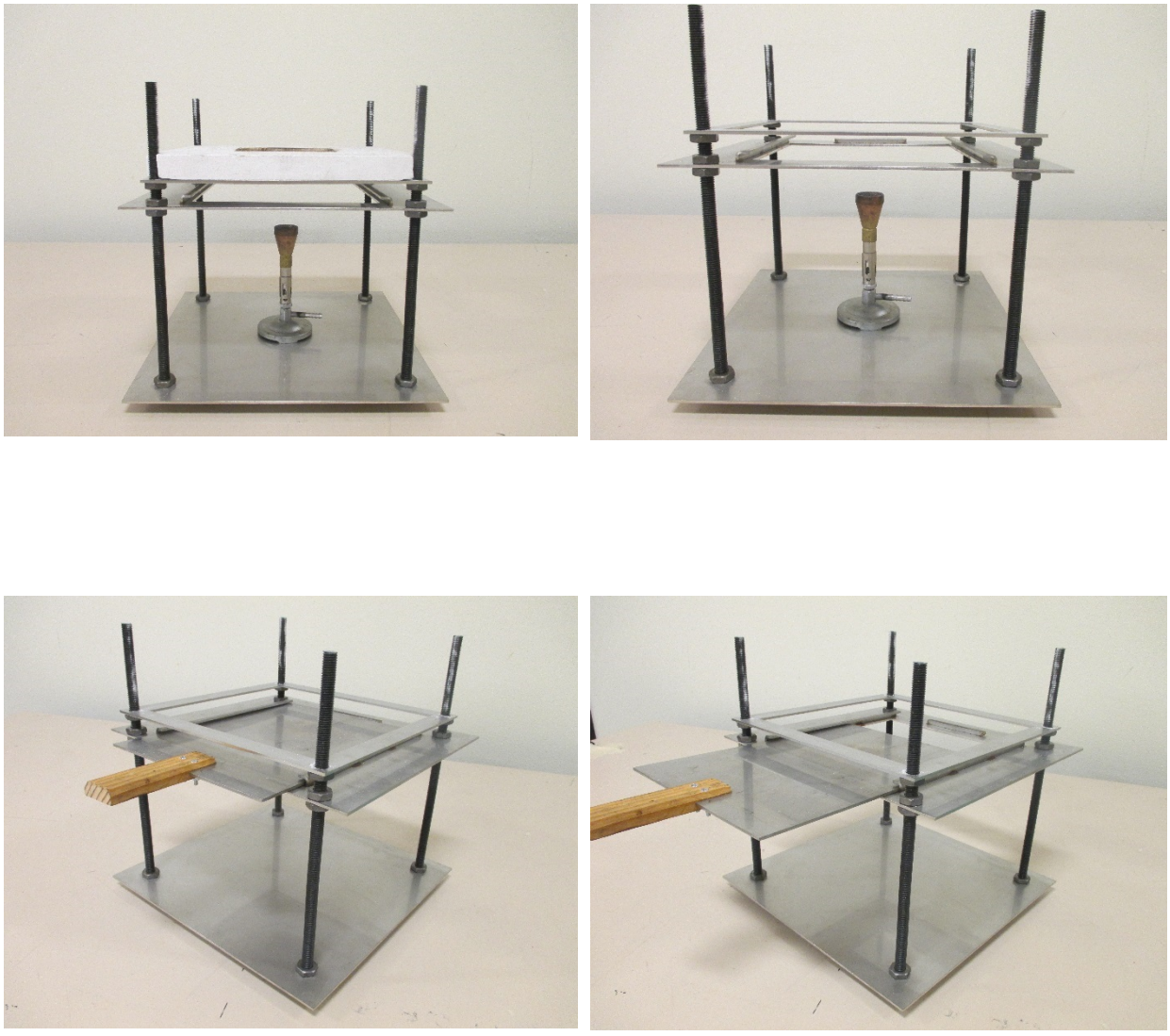


Figure A-8. Horizontal Test Apparatus Assembly with Shutter Plate Mechanism

ANNEX B

Ignition Source

Butane Gas Flame Ignition Source for Barrier Materials

- The ignition source for the barrier open flame test consists of a Meker-Fisher burner with a 32 mm (1.25 in.) diameter top and with orifice size of 1.2 mm (3/64 in.) for Butane gas.
- The flow rate of butane shall be 500 ± 10 ml/min (0.0177 ft^3/min) at 23 °C (73 °F).

The Gas Train

- A gas rotameter with range to provide flow rate of equivalent to 500 ± 10 ml/min (0.0177 ft^3/min) of air at standard conditions.
- Commercial Grade butane, 94% purity with 2-stage regulator shall be provided.
- The following items are required to connect the butane cylinder to the burners: flexible tubing (2.5 to 3.0 m (8 to 10 ft) in length, 7.0 ± 1.0 mm (1/4 ± 0.04 in) I.D.), needle valve, an on-off valve and a cylinder regulator capable of providing a nominal outlet pressure of 2.8 kPa (28 mbar).

NOTE: The following specific items have been found to be satisfactory for the butane gas train: Air Products CP grade, 99.0% purity butane, 20 lb. cylinder; Matheson 2-stage regulator, Model 8-2-510; Matheson 9.0 kPa pressure gauge, P/N 63-3103.

Figure B-1. Meker-Fisher Gas Burner

ANNEX C

Test Facility, Exhaust System and Hazards

Test Facility/Exhaust System

The test area shall be a room with a volume greater than 20 m^3 (in order to contain sufficient oxygen for testing) or a smaller area equipped with inlet and extraction systems permitting the necessary flow of air. All smoldering tests shall be conducted under appropriate test hoods and/or test cabinets equipped with variable speed exhaust fans or other means of controlling the exhaust flow rates, such as dampers. Airflow rates shall be between 0.02 m/s and 0.2 m/s (4 and 40 ft/min), measured in the locality of the test specimen. Position specimen to provide adequate air around the test specimen without disturbing the burning behavior.

Note 1: These rates of airflow have been shown to provide adequate oxygen without physically disturbing the burning behavior of the ignition source or the specimen.

Note 2: A fume hood with air curtains across the face and zero air velocity at the test locations is recommended. Zero air velocity is indicated by an undisturbed vertical smoke plume of 6 inches.

Hazards

- There are potential risks associated with running any fire test. It is essential that suitable precautions be taken, which include the provision of breathing apparatus and proper safety equipment.
- Products of combustion can be irritating and dangerous to test personnel. Test personnel must avoid exposure to smoke and gases produced during testing.
- Suitable means of fire extinguishment shall be at hand. When the termination point of the experiment has been reached, the fire is extinguished, if necessary, with carbon dioxide or water. Presence of a back-up fire extinguisher is recommended. It may be difficult to judge when all combustion in a test specimen has ceased due to potential smoldering or burning deep inside the specimen even after extinguishment. Care should be taken that specimens are disposed of only when completely inert.

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Appendix B

Bureau of Electronic & Appliance Repair, Home Furnishing and Thermal Insulation

Open Flame Barrier Study

Full-Scale Open Flame Validation Mockup Tests

The full-scale validation tests will be conducted in the full-scale fire testing facility (burn room) under the calorimeter exhaust hood. The heat release rate and the total heat release will be measured and determined in these tests. The test duration will not be pre-determined. The test will continue until either the test specimen self-extinguishes, or is fully consumed by the fire. The test duration will not exceed one hour.

Test Facility:

The mockup test specimen consisting of seat/back/arm cushions will be placed on a mock up chair metal test frame.

Conditioning:

Condition all specimens at a temperature of greater than 18 ^{0}C (65 ^{0}F) and less than 25 ^{0}C (77 ^{0}F) and less than 55% RH for at least 48 continuous hours prior to test.

Test Procedure:

The Butane flame ignition source will be applied to the middle of the seat/back crevice for a period of 70 seconds. The heat release rate (kW) and the total heat release (MW) will be recoded continuously during the test.

Lighting the igniter flame: (1) Open the butane tank slowly and light the end of the burner tube. Adjust the gas flow to the appropriate rate to achieve a 240 mm (9 inch) flame. (2) Allow the flame to stabilize for at least 2 minutes.

Starting and performing the test: (1) Place the lit burner tube in the crevice of the mockup so that the end of the igniter is at the center of the mockup equidistant from either edge. (2) Apply the flame for 70 ± 1 seconds, then immediately remove ignition source from the mockup.

Cessation of Test: Allow the specimen to burn out or suppress the fire at any time due to safety concerns.

Reporting the results: The heat release rate shall be recorded during the test. Report the maximum heat release rate and total heat release for the first 10 minutes of the test.

Materials to be used:

Cover Fabrics - Three cover fabrics:

- A 100% synthetic
- A blend, synthetic/natural fibers
- A smolder prone (natural fiber)

Barriers – five selected barrier materials

Foam - A low density non-FR polyurethane foam

All Tests are done in triplicates.

Amount of Materials Needed for Full-scale Evaluation Tests:

Needs 5 yd^2 of the cover fabric for each test run.

Needs 5 yd^2 of the barrier material for each test run.

Needs three 24” X 24” X 4” blocks of foam for each test run.

Cover Fabric Needed:

Total amount of each cover fabric needed (15+15 x N) yd^2 where N is the number of barriers selected for the full-scale tests.

Barrier Materials Needed:

Total amount of each barrier material needed: 50 yd^2 or 50 lineal yards.

Non-FR Foam Needed:

Total number of foam blocks needed: (27+27xN) where N is the number of barriers selected for the full-scale tests.

Butane gas flame ignition source:

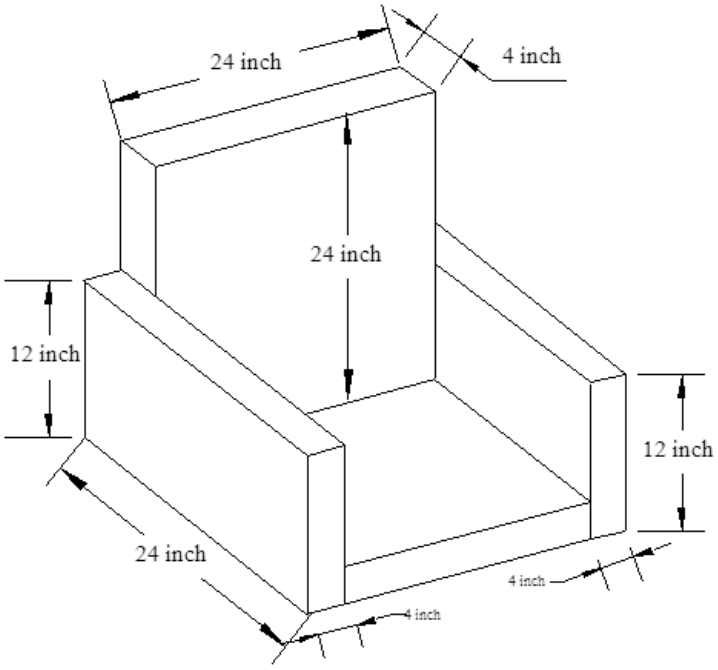
(With flame height and impingement time used by CPSC)

The following ignition source will be used for the full-scale mock up validation tests:

Butane gas burner tube flame ignition source:

- The burner tube will consist of a stainless steel tube, 8.0 ± 0.1 mm (5/16 ± 0.004 inch) outside diameter, 6.5 ± 0.1 mm (0.256 ± 0.004 inch) internal diameter.
- A nominal 240 mm butane flame (10 inch) will be used. The nominal 240 mm butane flame is obtained by establishing a flow rate of butane gas that is 350 ±10 ml/min at 25 C (77 °F) and 101.3 kPa (14.7 psi).
- Flame height is measured from the center end of the burner tube when held horizontally and the flame is allowed to burn freely in air.

Full-Scale Mockup



Photos of a Tube Burner (240 mm flame):