technical note technical

Flammability of Automotive Child Restraint Seats for Use in Aircraft

November 2001

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16. Abstract

Child restraint seat used in aircraft are based on automotive designs that are required to pass a horizontal burn rate test method. The flammability of child seat materials was gauged against the Federal Aviation Administration (FAA) vertical Bunsen burner tests method. Basically, the vertical test prescribed in Federal Aviation Regulation (FAR) 25.853 (a)(1)(ii) allows a burn length of 8 inches and flame time of 15 seconds after exposure to a Bunsen burner flame for 12 seconds.

Eight child restraint seats were purchased from a retail store. The seats were disassembled in order to cut test specimens from the various seat components. Because of the size of the seat and use of materials, in most cases it was not possible to prepare the required sample size and replicates. However, this did not impact the overall conclusions regarding the flammability of the materials tested.

The test results indicated that the large majority of materials would not meet the FAA vertical fire test criteria. Also, some of the failed materials burned across the entire sample length, and others produced high flames or dense smoke. The findings are consistent with the knowledge that a horizontal burn test is far less severe than a vertical burn test.

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INTRODUCTION

PURPOSE.

The purpose of this technical note is to document the results of flammability tests on automotive child restraint seats approved for use in aircraft. The flammability of the materials was measured with the vertical Bunsen burner test method, prescribed by the Federal Aviation Administration (FAA) in Federal Aviation Regulation (FAR) 25.853 (a)(1)(ii).

BACKGROUND.

The primary purpose of a aircraft child restraint seat is to provide protection to the child against impact forces created in a crash. A secondary consideration is the design of a child restraint seat is the flammability of the seat materials. Since child seats approved for use in aircraft are derivatives of automotive designs, the seat materials meet motor vehicle fire test standards issued by the National Highway Traffic Safety Administration (NHTSA). In particular, the flammability standard specified in FMVSS 571.302 is a horizontal burn test with pass/fail criteria of 4 inches per minute. Conversely, comparable minimum FAA flammability requirements specified in FAR 25.853 (a)(1)(ii) consist of a vertical Bunsen burner test with an allowable burn length of 8 inches and a flaming time of 15 seconds after 12-second burner exposure.

DISCUSSION.

A total of eight car seats of five different brands were purchases at a cost ranging from $49.99 to $199.99. Some of the seats were labeled as certified for aircraft use. The size of the seat and use of materials on each seat varied considerably. Consequently, the quantity of material did not allow for the preparation of three samples per material nor, in some cases, the specified sample size. This necessary departure from the test standard, however, did not impact the overall conclusions regarding the flammability of the materials tested.

TEST PROCEDURE

The tests were conducted in accordance with the vertical Bunsen burner test described in Chapter 1 of the Aircraft Materials Fire Test Handbook*. The following are pertinent test parameters:

- Ignition time is the length of time the burner flame is applied to the specimen. In this case, ignition time is 12 seconds.
- Time to ignition is the time it takes the specimen to ignite once the flame has been added.
- Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from beneath the specimen. Surface burning that results in a glow but not a flame is not included.

*Aircraft Materials Fire Test Handbook, DOT/FAA/AR-00/12, April 2000.

- Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If no material falls from the specimen, the drip flame time is reported to be 0 seconds, or "No Drip." If there is more than one drip, the drip flame time reported is that of the longest flaming drip. If succeeding flaming drips reignite earlier drips that flamed, the drip flame time is the total of all flaming drips.

- Burn length is the distance from the original specimen edge to the farthest evidence of damage to the test specimen due to that area's combustion, including areas of partial consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored, nor areas where material has shrunk or melted away from the heat.

TEST RESULTS

- Century 1000 STE. Four of the six seat materials failed the vertical test criteria (figure 1). The center (checked) material was the most flammable, failing both flame time and burn length criteria (entire sample length was burned). Even those materials that passed had relatively long burn lengths (>5 inches).

- Evenflo Horizon V. Four of the five seat materials failed the vertical test criteria (figure 2). Three of the failed materials exceeded both the allowable flame time and burn length (entire sample length was burned).

- Cosco Eddie Bauer. Seven of the eight materials failed the vertical test criteria (figure 3). All of the samples that failed exhibited very high flames. The center-padded insert foam, which passed, was the only material that did not exhibit high flames. One specimen of fabric material was tested in accordance with the FMVSS test procedure (horizontal orientation). A burn rate of 3.8 inches/minute was measured, just slightly less than the allowable 4.0-inches/minute value.

- Century Encore. Four of the nine seat materials failed the vertical test criteria (figure 4). Some of the materials generated heavy smoke, including two of the samples that passed the test criteria. Again, even those samples that passed had relatively long burn lengths (>5 inches).

- Britax (Total Plaid). Four of the seven seat materials failed the vertical test criteria (figure 5). Some of the materials, including a sample that passed, exhibited heavy smoke and, in one case, fast burning. The two materials that passed had relatively long burn lengths (>5 inches).

- Britax Roundabout. Six of the eight seat materials failed the vertical test criteria (figure 6). Those materials that passed had relatively long burn lengths (7 and 8 inches). Four of the materials burned along the entire sample length.

- Evenflow Medallion. Six of the nine seat materials failed the vertical test criteria (figure 7). The center material and foam produced the heaviest smoke of all seat materials in the

test series. It appeared that the dense smoke inside the test chamber was the cause of flame extinguishment. When it appeared that the flame was out and the door of the test cabinet was slightly opened to evacuate the smoke, the flame reignited apparently due to oxygen entering the cabinet.

- Fisher Price Safe Embrace II. Three of the nine seat materials failed the vertical test criteria (figure 8). The materials that passed had relatively long burn lengths (≥5 inches).

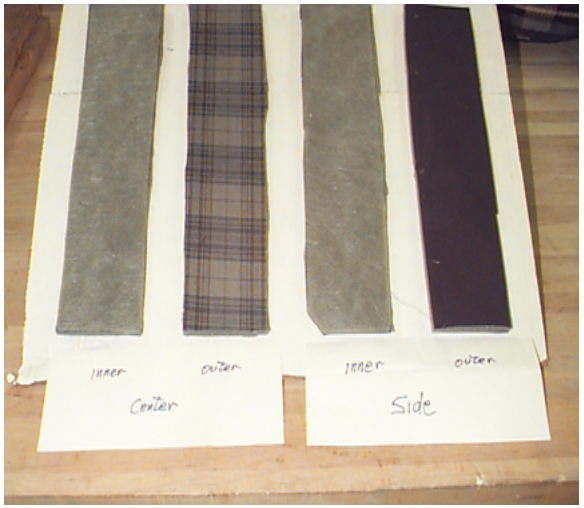
CONCLUSIONS

Flammability tests conducted on eight types of automotive child restraint seats indicated that the large majority of materials would not meet the FAA vertical Bunsen burner test criteria, prescribed in FAR 25.853 (a)(1)(ii). Some of the failed materials burned across the entire sample length, and others exhibited high flames or dense smoke. The seat materials are required to pass a horizontal burn test. It is known that a horizontal burn test is far less severe than a vertical burn test, and the test results are consistent with this behavior.

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Sides (blue)	0:01	0:14	Face: 7.0 Back: 7.8	0:00	Fail
Sides (blue)	0:01	0:30	Face: 7.4 Back: 10.0	0:00	Fail
Sides (blue)	0:01	0:02	Face: 5.6 Back: 6.5	0:00	Fail
Center (checked)	0:01	1:23	12.0+	0:00	Fail
Center (checked)	0:01	1:21	12.0+	0:00	Fail
Cloth Face (no foam)	0:01	0:00	Withdrew 5.8	0:00	Pass
Foam Alone (w/o cloth face)	0:01	0:12	10.0	0:00	Fail
Plastic Structure	0:01	2:18	7.5	0:30	Fail
Foam Backing	0:01	0:04	5.75	0:00	Pass

FIGURE 1. CENTURY 1000 STE: $49.00

Before burning…



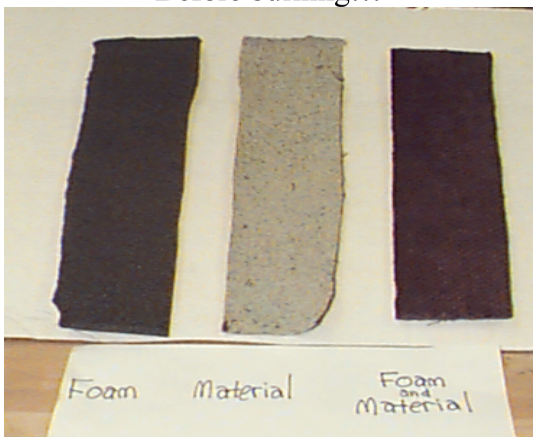
After burning…

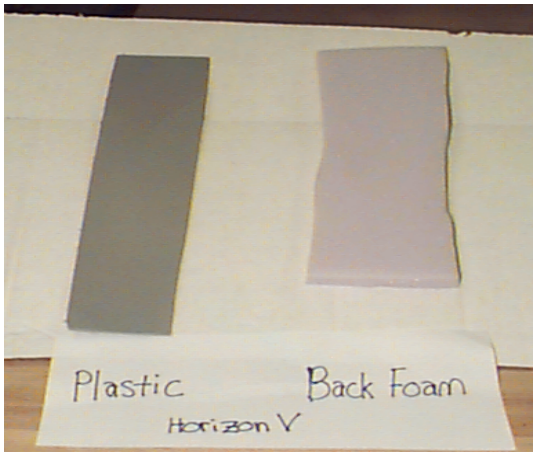
FIGURE 1. CENTURY 1000 STE (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Outer Material (entire seat)	0:01	1:10	12.0+	0:00	Fail
Outer Material (entire seat)	0:01	1:16	12.0+	0:00	Fail
Outer Material (entire seat)	0:01	1:12	12.0+	0:00	Fail
Cloth Face	0:01	0:53	12.0+	0:00	Fail
Plastic Structure	0:01	7:10	12.0	0:00	Fail
Foam Alone (w/o face)	0:01	0:00	9.0	0:00	Fail
Foam Backing	0:01	0:00	6.0+	0:00	Pass

FIGURE 2. EVENFLO HORIZON V: $79.99

Before burning…





After burning…

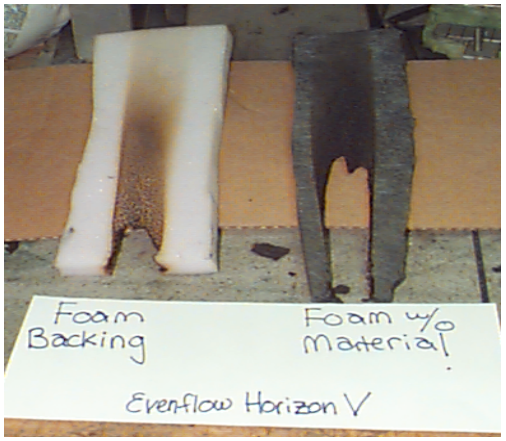
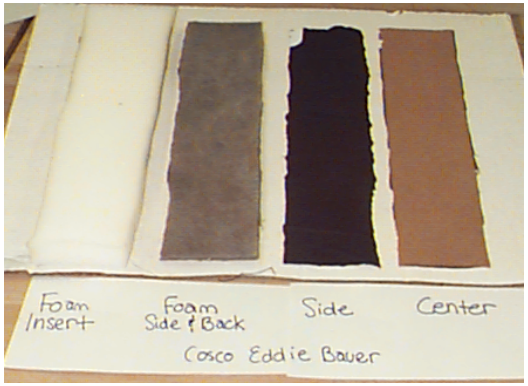


FIGURE 2. EVENFLO HORIZON V (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Foam with Green Material	0:01	1:15	12.0+	0:00	Very High Flames (10-12 in), Fail
Green Material Only	0:01	0:57	12.0+	0:00	Very High Flames, Fail
Foam w/o Green Material	0:01	0:00	Front: 6.0, Back: 6.5	0:00	Pass
Headrest (3-layer)	0:01	1:16	12.0+	0:00	Very High Flames, Fail
Headrest (3-layer)	0:01	1:13	12.0+	0:00	Very High Flames, Fail
Plastic Structure	0:04-0:05	2:18	9.0	1:00	Fail
Center Padded Insert Material (brown)	0:01	0:58	12.0	0:00	Very High Flames, Fail
Center Padded Insert Material (brown)	0:01	0:57	12.0+	0:00	Very High Flames, Fail
Back Material and Foam	0:01	1:50	12.0+	0:00	Very High Flames, Fail
Center Padded Insert Foam Only	0:01	0:01	Front: 5.5, Back: 4.5	0:00	Pass
Chest Protector	0:01	1:08	12.0+	0:00	Very High Flames, Fail

FIGURE 3. COSCO EDDIE BAUER: $99.99

Before burning…

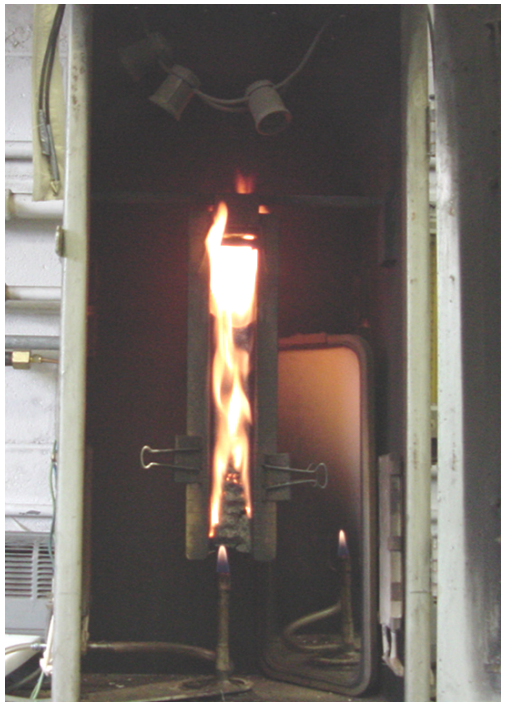


After burning…

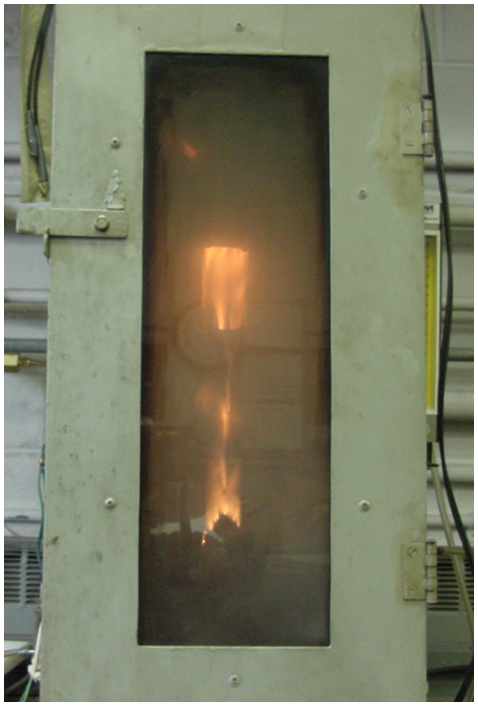
FIGURE 3. COSCO EDDIE BAUER (Continued)

NOTE: The Eddie Bauer seat materials had substantially higher flames than the other seven seats in the test. To show the magnitude of these flames, here are pictures of the Eddie Bauer seat during actual testing.

Green Outer Seat Material



Chest Protector



Headrest

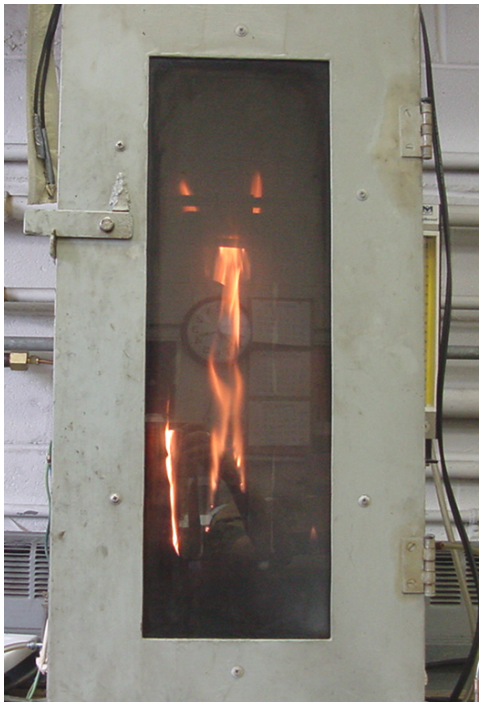
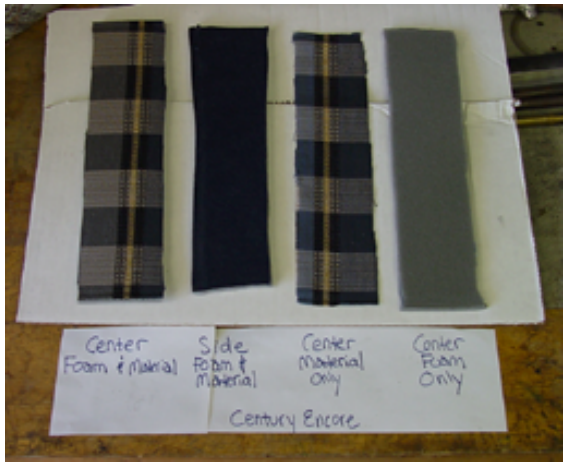


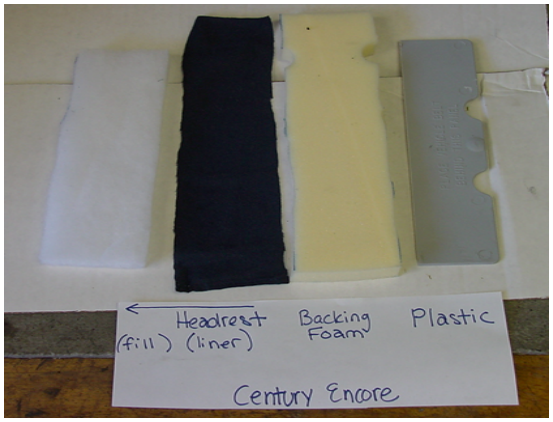
FIGURE 3. COSCO EDDIE BAUER (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Center Foam and Material (plaid)	0:01	1:23	12.0+	0:21	Heavy Smoke, Fail
Side Foam and Material (blue)	0:01	0:05	Front: 7.0 Back: 6.8	0:00	Heavy Smoke, Fail
Side Foam and Material (blue)	0:01	0:12	Front: 8.2 Back: 10.5	0:00	Heavy Smoke, Fail
Center Material Only (plaid)	0:01	1:06	8.5	0:00	Heavy Smoke, Fail
Side Material Only (blue)	0:01	0:05	Withdrew 5.6	0:00	Pass
Center Foam Only	0:01	0:06	8.0	0:00	Pass
Center Foam Only	0:01	0:03	Front: 7.0 Back: 8.0	0:00	Pass
Foam Backing	0:01	0:00	6.5	0:00	Pass
Headrest (3-layer)	0:01	0:08	Front: 4.75 Back:5.2	0:00	Heavy Smoke, Pass
Headrest Liner	0:01	0:05	Withdrew 5.8	0:00	Heavy Smoke, Pass
Headrest Fill	0:01	0:00	Withdrew 9.0	0:00	Withdrew w/no flame, Fail
Plastic Structure	0:01	1:58	5.0	1:30	Fail

FIGURE 4. CENTURY ENCORE: $89.00

Before burning…





After burning…

FIGURE 4. CENTURY ENCORE (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Complete Material (3-layer)	0:01	0:55	12.0+	0:00	Heavy Smoke, Fail
Top Material	0:01	0:14	12.0+	0:00	Fast Burning, Fail
Bottom Material	0:01	0:00	Withdrew 9.0	0:00	Heavy Smoke, Fail
Fill Material	0:01	0:00	Withdrew 5.5	0:00	Heavy Smoke, Pass
Foam Backing	0:01	0:00	6.9	0:00	Pass
Styrofoam	0:01	0:00	Withdrew 8.0	0:00	Pass
Plastic Structure	0:01	2:31	4.7	1:37	Fail

FIGURE 5. BRITAX TOTAL PLAID: $199.99

Before burning…

After burning…

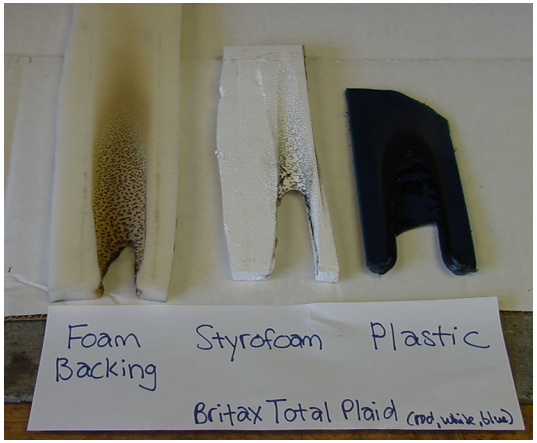


FIGURE 5. BRITAX TOTAL PLAID (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Complete Center Material	0:01	0:48	12.0+	0:00	Fail
Top Material (plaid)	0:01	0:37	12.0+	0:00	Fail
Fill Material	0:01	0:00	8.0	0:00	Pass
Bottom Material	0:01	0:00	9.3	0:00	Fail
Complete Side Material	0:01	1:20	12.0+	0:00	Fail
Top Material (denim)	0:01	1:01	12.0+	0:00	After flame out, material continued to glow – only occurrence of this throughout the test. Fail
Fill Material	Same material as 4 lines above—same material should produce similar results				
Bottom Material	Same material as 5 lines above—same material should produce similar results				
Backing Foam	0:01	0:01	7.0	0:00	Pass
Plastic Structure	0:01	2:35	8.5	0:25	Fail

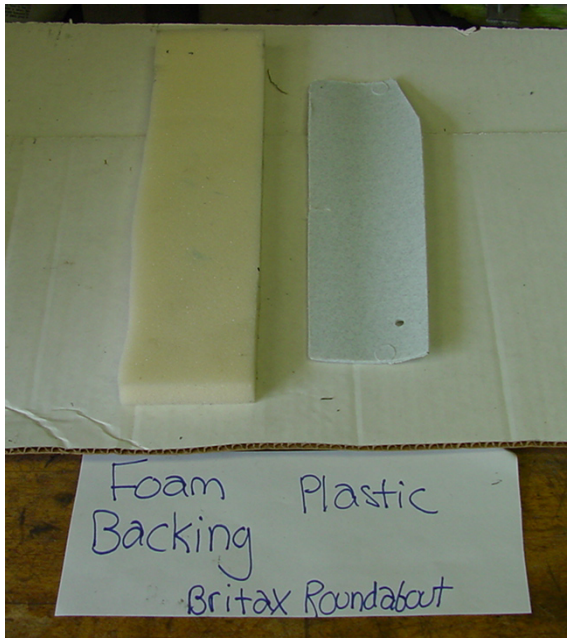
FIGURE 6. BRITAX ROUNDABOUT: $199.00

Before burning…

After burning…

FIGURE 6. BRITAX ROUNDABOUT (Continued)

Before burning…



After burning…

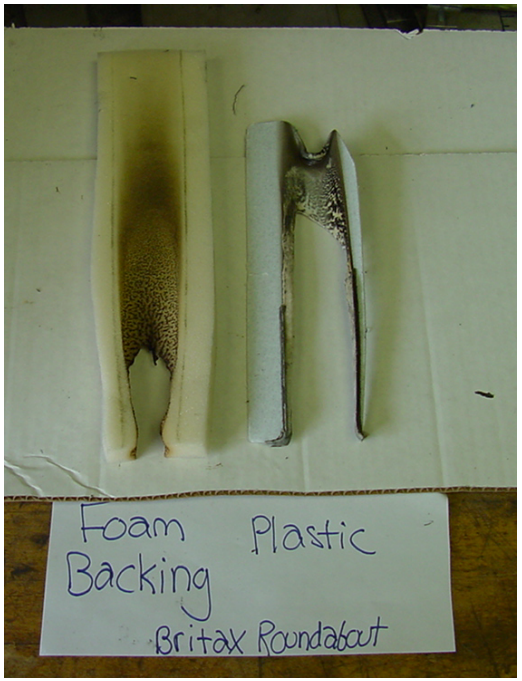


FIGURE 6. BRITAX ROUNDABOUT (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Infant Insert Material (3-layer)	0:01	1:06	4.8	0:00	Fail
Infant Insert Material (3-layer)	0:01	0:01	3.5	0:00	Fail
Top Material	0:01	0:00	6.25	0:00	Pass
Fill Material	0:01	0:14	6.0	0:00	Pass
Foam Fill	0:01	0:00	7.8	0:00	Pass
Center Material and Foam	0:01	1:00	12.0+	0:00	Heaviest Smoke, Fail
Center Material and Foam	0:01	1:04	12.0+	0:00	Heaviest Smoke, Fail
Center Material	0:01	0:11	12.0+	0:00	Fail
Center Foam	0:01	0:17	7.1	0:00	Fail
Side Material and Foam	0:01	0:21	12.0+	0:00	Heaviest Smoke, Fail
Plastic Structure	0:05	3:56	8.5	2:00	Fail
Backing Foam	Same material as Evenflo Horizon V Backing Foam—should produce similar results				

FIGURE 7. EVENFLO MEDALLION V: $139.99

Before burning…

After burning…

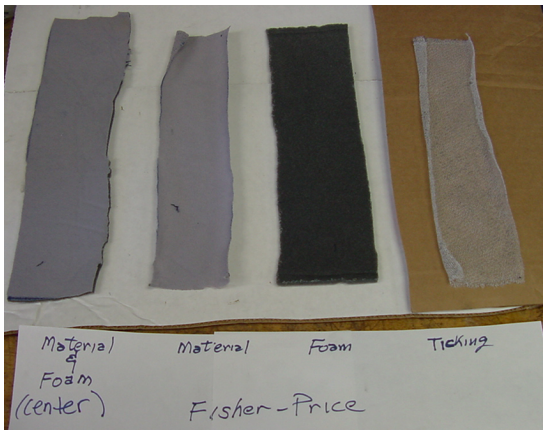
FIGURE 7. EVENFLO MEDALLION V (Continued)

Material Name	Time to Ignition (min:sec)	Flame Time (min:sec)	Burn Length (inches)	Drip Flame Time (min:sec)	Comments
Side Material and Foam	0:01	0:04	6.3	0:00	Pass
Side Material	0:01	0:00	Withdrew 7.0	0:00	Withdrew w/no flame, Pass
Side Foam	0:01	0:00	5.0	0:00	Pass
Bottom Material	0:01	0:00	Withdrew 8.0	0:00	Pass
Center Material and Foam	0:01	0:16	Front: 7.0 Back: 9.0	0:00	Fail
Center Material	0:01	0:00	Withdrew 6.5	0:00	Pass
Center Foam	0:01	0:00	Front: 6.5 Back: 8.0	0:00	Pass
Bottom Material	0:01	0:00	Withdrew 11.0	0:00	Fail
Backing Foam	Same material as Britax Total Plaid Backing Foam—should produce similar results				
Plastic	0:05	2:43	9.0	0:22	Fail

FIGURE 8. FISHER PRICE SAFE EMBRACE II: $149.99

Before burning…

After burning…



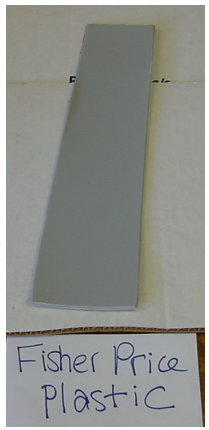


FIGURE 8. FISHER PRICE SAFE EMBRACE II (Continued)