

January 23, 2002

Mr. Gerald A. Haynes
Department of the Treasury
Bureau of Alcohol, Tobacco & Firearms
Arson & Explosives Programs Division
650 Massachusetts Ave. N.W., Room 7100
Washington, D.C. 20266

Dear Mr. Haynes:

This letter describes a series of ignition experiments, which were designed to characterize the ignition propensity of materials involved in your investigation of the fire at Seton Hall University, January 19th, 2000.

This series was limited to two ignition sources: 1) paper match and 2) smoldering cigarette. The ignition tests were restricted to three types of materials: 1) red craft paper, 2) black craft paper, and 3) seat cushion from sofa. These materials were provided to NIST by the Essex County (NJ) Prosecutor's Office. The experiments included a limited number of ignition scenarios for each material/ignition source combination.

- I) Ignition via match placed on paper with and without a substrate.
- II) Ignition via a cigarette placed between two sheets of paper without substrate
- III) Ignition via a match on a sofa cushion sample
- IV) Ignition via match on foam from the sofa cushion
- V) Ignition via cigarette on the foam cushion sample
- VI) Ignition via cigarette on sofa cushion sample with paper covering the cigarette

Objective: To expose materials, provided by the Essex County Prosecutor's Office, to a flaming match and a burning cigarette to examine the materials' propensity to ignite.

Materials: Three types of materials were provided to NIST.

- 1) Red craft paper, flat finish both sides, approximately 0.127 mm (0.005 in) thick
- 2) Black craft paper, flat finish on one side, glossy finish on other side, approximately 0.127 mm (0.005 in)
- 3) Seat cushion from sofa. The cushion was composed of a wooden frame, springs, wire mesh supports, polyurethane foam, polyester batting, and a woven fabric cover.

Experimental Procedure:

- 1) Materials were cut into test samples. The paper was cut into squares, approximately 100 mm by 100 mm (4 in by 4 in) on a side. The sofa cushion was cut into pieces ranging from approximately 100 mm by 100 mm (4 in by 4 in) on a side to approximately 100 mm by 150 mm (4 in by 6 in) on a side. All of the sample materials were placed in a conditioning room maintained at $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($73\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) and $50\% \pm 5\%$ relative humidity. The samples were conditioned in excess of 10 days prior to testing.
- 2) Just prior to testing the samples were weighed with an electronic balance. The stated uncertainty of the balance by the manufacturer was $\pm 0.05\text{ g}$.
- 3) The laboratory temperature was between $21\text{ }^{\circ}\text{C}$ and $23\text{ }^{\circ}\text{C}$ and between 40 and 60 % relative humidity during the testing.
- 4) The sample material was placed on a laboratory stand for support. The paper samples were tested in two ways: with a substrate and without a substrate. The substrate used was a 152 mm (6 in) diameter, 4.8 mm (0.19 in) thick piece of quartz glass. When tested without a substrate, the sample was placed horizontally on a metal ring stand with a 114 mm (4.5 in) opening. The sofa cushion samples were composed of polyurethane foam covered with a layer of polyester batting, which was covered with the fabric. This simulates how the materials are assembled when used in the sofa. The sample sizes of the sofa materials were not as uniform as the paper samples due to difficulties in cutting the sofa foam.
- 5) A video camera was used to document the experiments. The camera was turned on and recording prior to exposing the sample to the ignition source and continued to record until sample ignition occurred or until the ignition source self extinguished.
- 6) The burning match or cigarette was placed on the sample and observed for ignition. A stopwatch was used to measure the approximate time to ignition. The matches used were paper matches removed from a cardboard matchbook containing 20 matches. The cigarette used as an ignition source was an 83 mm (3.25 in) long unfiltered Pall Mall. * This cigarette type has been used previously in furniture ignition studies.¹
- 7) Water from a small bottle was available to suppress samples if needed.
- 8) Results of the experiment were recorded after ignition of sample or after the ignition source self-extinguished.

* The mention of a particular manufacturer's product is for identification purposes only and does not constitute endorsement by NIST, nor does it indicate that the products are necessarily those best suited for the intended purpose.

¹ Cleary, T.G., Ohlemiller, T.J. & Villa, K., The Influence of Ignition Source on the Flaming Fire Hazard of Upholstered Furniture, Fire Safety Journal Vol. 23, 1994, p 85.

Experimental Results:

I. Paper Match Ignition Source on Paper Samples – with and without substrate

Sample Identification and Weights:

Sample	1	2	3	4	5	6
Sample A Black Paper	0.8 g	0.8 g	0.8 g	0.8 g	0.8 g	0.8 g
Sample B Red Paper	0.9 g	0.9 g	0.8 g	0.9 g	0.8 g	0.8 g

Test Results:

Sample #	Conditions	Results
A-1	Substrate	No paper ignition - Match extinguished in 19 s
A-2	No Substrate	Paper ignited in 5 s / Paper burned out in 30 s
A-3	Substrate	No paper ignition - Match extinguished in 27 s
A-4	Substrate	No paper ignition - Match extinguished in 21 s
A-5	No Substrate	Paper ignited in 6 s / Paper burned out in 26 s
A-6	No Substrate	Paper ignited in 5 s / Paper consumed in 37 s
B-1	Substrate	No paper ignition - Match Extinguished in 12 s
B-2	No Substrate	Paper Ignited in 5 s / Paper burned out in 39 s
B-3	Substrate	No paper ignition - Match Extinguished in 20s
B-4	Substrate	No paper ignition - Match Extinguished in 14s
B-5	No Substrate	Paper ignited in 4 s / Paper burned out in 51 s
B-6	No Substrate	Paper ignited in 5 s / Paper burned out in 44 s

II. Cigarette Ignition Source on Paper Samples –without substrate

Sample weights:

Sample	7	8	9
Sample A Black Paper	0.9 g	0.7 g	0.7 g
Sample B Red Paper	0.8 g	0.8 g	0.8 g

Results:

Sample#	Conditions	Results
A-7	Smoldering cigarette placed on sample paper - no substrate	Cigarette smoldered for 1240 s Paper smoldered and charred No paper ignition
B-7	Smoldering cigarette placed on sample paper - no substrate	Cigarette smoldered for 1140 s Paper smoldered and charred No paper ignition

Sample#	Conditions	Results
A-8/A-9	Smoldering cigarette placed between two sample papers - no substrate	Cigarette smoldered for 1880 s Paper smoldered and charred No paper ignition
B-8/B-9	Smoldering cigarette placed between two sample papers - no substrate	Cigarette smoldered for 1340 s Paper smoldered and charred No paper ignition

III. Paper Match Ignition Source on Sofa Cushion Sample (fabric, batting, foam)

Test #	Sample #	Sample Weight	Results
1	C	34.7 g	Ignition in 27 s
2	B	41.9 g	Ignition in 20 s
3	A	35.7 g	Ignition in 30 s

IV. Paper Match Ignition Source on Sofa Cushion Foam Sample (No fabric or batting)

Test #	Sample #	Sample Weight	Results
4	1	31.5 g	Ignition in 40 s
5	2	29.7 g	Ignition in 40 s
6	3	32.5 g	Ignition in 45 s

V. Cigarette Ignition Source on Sofa Cushion Foam Sample (No fabric or batting)

Test #	Sample #	Sample Weight	Results
7	4	32.0 g	Cigarette smoldered for 960 s No foam ignition
8	5	28.9 g	Cigarette smoldered for 940 s No foam ignition
9	6	24.0 g	Cigarette smoldered for 960 s No foam ignition

VI. Cigarette Ignition Source on Sofa Cushion Sample and Covered with Paper Sample

Sample weights:

Sample	10	11	12
Sample A Black Paper	.8 g	.7 g	.8 g
Sample B Red Paper	.9 g	.9 g	.9 g
Sofa Cushion	na	na	na

Results:

Sample#	Conditions	Results
A-10	Lit cigarette placed on fabric over batting and foam, then covered with a sample paper	Cigarette smoldered for 1350 s Fabric material melted, batting melted discolored, foam material charred, sample paper charred No ignition
A-11	Lit cigarette placed on fabric over foam, then covered with a sample paper	Cigarette smoldered for 2500 s Fabric material melted, foam material charred, sample paper charred No ignition
A-12	Lit cigarette placed on fabric over foam, then covered with a sample paper	Cigarette smoldered for 2930 s Fabric material melted, foam material charred, sample paper charred No ignition
B-10	Lit cigarette placed on fabric over batting and foam, then covered with a sample paper	Cigarette smoldered for 1260 s Fabric material melted, batting melted and discolored, foam material charred, sample paper charred No ignition
B-11	Lit cigarette placed on fabric over foam, then covered with a sample paper	Cigarette smoldered for 1800 s Fabric material melted, foam material charred, sample paper charred No ignition
B-12	Lit cigarette placed on fabric over foam, then covered with a sample paper	Cigarette smoldered for 1640 s Fabric material melted, foam material charred, sample paper charred No ignition

Discussion:

I. Paper Match Ignition Source on Paper Samples – with and without substrate

The first twelve experiments demonstrate the effect that a substrate can have on the ignition of the paper. In the cases where the paper is in contact with the non-combustible substrate, which could represent a tile floor or a concrete block wall, the heat is transferred through the paper, such that the paper does not ignite even though it is in contact with the burning match. In the case with no substrate, i.e. air on both sides of the

paper, the paper loses less heat, due to the insulating value of the air and the burning match can ignite the paper.

II. Cigarette Ignition Source on Paper Samples –Without Substrate

The burning cigarette placed on a single piece of sample paper did not ignite, to flaming, the sample paper. The burning cigarette was also placed in between two pieces of sample paper, to simulate a cigarette that might be lying in a fold of this type of paper. Again no ignition of the sample paper occurred. Given that the energy release rate from a cigarette is significantly lower (approximately 5 W) than that of a burning match (approximately 80 W), this result appears consistent with the first set of experiments².

III & IV. Paper Match Ignition Source on Sofa Cushion and Sofa Foam Samples

The burning match ignited the sofa cushion sample assembly in all six of these experiments. These results appear consistent with previous research examining the ability of a burning match to ignite and sustain ignition of upholstered furnishings¹.

V & VI. Cigarette Ignition Source on Sofa Cushion Foam Sample (No fabric or batting) and on Sofa Cushion Sample Covered with Paper Sample

In this series of experiments the burning cigarette was unable to ignite sofa foam or the complete sofa cushion sample with paper over the top of the cigarette. While fire incident data have shown careless smoking to be the cause of approximately 5 % of all residential fires³, laboratory research has demonstrated that cigarettes are less likely to ignite and sustain burning on a variety of upholstered furniture types, than a small open flame⁴.

It should also be noted that a large number of variables could impact the propensity of a cigarette to ignite a material. This variables would include: the materials and the assembly of the cigarette including tobacco blend, tobacco expansion, cigarette circumference, cigarette paper permeability, and cigarette paper treatment. In addition, environmental factors such as relative humidity and temperature and the condition of the material to be ignited also factor in to the equation for ease of ignition⁵. None of these variables were studied in this limited series of experiments.

² Babrauskas, V. and Krasny, J., Fire Behavior of Upholstered Furniture, NBS Monograph 173, Nat. Bur. Stds (Currently Nat. Inst. of Stds & Tech.), Gaithersburg, MD., Nov. 1985, p57.

³ Fire in the United States, 1989-1998, 12th ed., FEMA, USFA FA216, U.S. Fire Administration, Emmitsburg, MD., Aug. 2001, p 76.

⁴ Cleary, T.G., Ohlemiller, T.J. & Villa, K., The Influence of Ignition Source on the Flaming Fire Hazard of Upholstered Furniture, Fire Safety Journal Vol. 23, 1994, p 86-88.

⁵ Ohlemiller, T.J., Villa, K.M., Braun, E., Eberhardt, K.R., Harris, R.H., Lawson, J.R., and Gann, R.G., Test Methods for Quantifying the Propensity of Cigarettes to Ignite Soft Furnishings, NIST SP 851, Nat. Inst. of Stds & Tech., Gaithersburg, MD., Aug. 1993.

Summary:

In three out of four ignition scenarios, (paper without substrate, sofa cushion, and sofa foam), the burning match ignited the material it was placed on. Ignition occurred between 4 s and 45 s. In the case of paper on a substrate, the burning match did not ignite the paper.

In the three different ignition scenarios conducted with a smoldering cigarette, no ignitions occurred. The cigarette smolder times ranged from 940 s up to 2500 s.

The qualitative results from this limited series of experiments, for the given set of limited conditions, indicate that a small open flame, such as a burning match, is more likely to ignite the given samples, than a burning cigarette. These results appear consistent with previous research findings on the ignition of upholstered furniture.

If you have any questions regarding the material provided, please call me at (301) 975-6677.

Sincerely,

Daniel Madrzykowski, P.E.
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Building and Fire Research Laboratory