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VERTICAL FLAME TESTS USING VARIED FUELS AND DRAFT CONDITIONS

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ABSTRACT

Using two fabrics supplied by the Army Natick Laboratories, tests were made by the vertical flame test, Method 5902 of Federal Specification CCC-T-191b, to investigate the effect on the test results of variations in fuel for the igniting flame and draft conditions in the cabinet. Three fuels -- Matheson B manufactured gas, propane, and natural gas -- and two different cabinet ventilation arrangements were used.

1. Materials

The two test fabrics received from the U.S. Army Natick Laboratories carried no identification and were therefore arbitrarily designated A and B. Judged from the burning behavior, Fabric A appeared to be a treated cotton material and Fabric B a synthetic material.

2. Test Methods

The test cabinet conformed to the description in Method 5902 of Federal Specification CCC-T-191b. The burner, with igniting flame in continuous adjustment, was moved into test position by means of a bar operated from outside the cabinet; no pilot light was used.

For the 65% RH, 70 ^{o}F conditioning suggested in Method 5902, the specimens were hung in the conditioning room for about 16-20 hours and then transferred to the test laboratory in a closed container, ten specimens at a time. Tests were also made with the specimens oven-dried for 4 hours at 60 ^{o}C, as prescribed in Method 5906 of the Federal Specification.

Three different fuels were used in the test series, -- Matheson B manufactured gas, propane, and the natural gas (essentially methane) in our city lines. In a first group of tests, 5 warp and 5 fill specimens of each fabric were ignited by use of each of the fuels after each type of conditioning. Later, the remaining test materials were used in a repetition of this group of tests, so far as material permitted. Thus, a total of 18 or 19 specimens (10 warp and 8 or 9 fill) of each fabric were tested in each situation.

3. Test Results

The char length results are summarized in Table 1. None of the specimens showed afterglow, and afterflaming occurred only with occasional specimens of Fabric B. In those instances where it appeared it was confined to the edges of the burned-out area and did not extend the length of char or damage, although it sometimes continued for 20 seconds or more. This afterflaming appeared to have no relation to any of the factors in the test procedure under investigation.

Fabric A conditioned at 65% RH appeared to have slightly longer char lengths on the warp-direction specimens than on the fill-direction specimens. Possibly significant differences between warp and fill specimens did not appear with the oven conditioning however, or for Fabric B with either type of conditioning. Hence, there seems no reason for separating the restuls for warp and fill specimens in considering the effects of the different fuels. To facilitate comparison of these combined averages, they are presented alone in Table 2.

Table 2. Average Char Lengths Using Different Fuels

		FABRIC A		FABRIC B	
Conditioning	Fuel	No. of spec.	Avg Char length in.	No. of spec.	Avg Char length in.
65% RH	Matheson B	19	5.0	19	6.0
	Propane	18	4.0	19	5.0
	Natural gas	18	4.2	18	5.2
Oven dried at 60 °C	Matheson B	19	5.2	19	5.9
	Propane	18	4.8	19	5.5
	Natural gas	18	5.1	18	5.7

Referring to Table 2, the results suggest two possible generalizations. First, if Matheson B gas is used as the fuel, the type of conditioning does not significantly affect the char length, and second, if the specimens are oven dried at 60 °C, the type of fuel used does not significantly affect the char length. When the specimens were conditioned at 65% RH however, the char lengths produced by the Matheson B gas flame were definitely longer than those produced by the hydrocarbon flames. Since the Matheson B gas presumably burns faster than the others, it probably produced a somewhat higher temperature which may have driven the moisture out of the specimens more quickly. But with the specimens already dried out in the oven, the length of char was more completely dependent on the height of the flame, or the distance it reached up the specimen, and not much affected by a difference in temperature. While it is not difficult to develop a plausible explanation of the results in this way, any verification would require actual measurement of some of the factors involved.

A technical point noted during conduct of the tests might also have some bearing on the difference between results with the Matheson B gas and those with the hydrocarbon flames. As the Matheson B gas

does not burn with a truly luminous flame, the outline of the flame is not so clearly defined and easily observed as is that of the hydrocarbon fuels. It seemed likely that, even with care in adjusting the flame, the operator might have the reaction zone a bit higher in the Matheson B flame than in the hydrocarbon flames.

Some effort was made to study the effect of a difference in draft conditions on the test results, although our test cabinet did not permit using the 4-inch open space at the bottom of the door shown in the proposed revision of the standard. One set of specimens was tested with the cabinet placed in the open laboratory with all vent holes at the top taped over, and another set was tested with the cabinet placed under a hood with the draft on and all vent holes open. In both series the cabinet door was completely closed during the tests. Natural gas was used for the igniting flame in both sets of tests and the specimens were conditioned in the oven at 60 °C. Ten specimens of each fabric (5 warp and 5 fill) were used in each set of tests. The results are summarized in Table 3.

Table 3. Results with Different Draft Conditions

Fabric	Cabinet with top holes taped		Cabinet in hood, draft on	
	Afterflame, Avg.	Char, Avg.	Afterflame, Avg.	Char, Avg.
	sec.	in.	sec.	in.
A warp	--	5.3	--	5.0
fill	--	5.4	--	4.6
B warp	--	5.0	6.2	6.0
fill	2.4	5.5	2.4	5.8

Considering the effect on the char length, the increased draft seemed to extend the char length for Fabric B slightly and possibly reduce that for Fabric A a bit. Perhaps the most noticeable effect was the greater tendency toward afterflaming exhibited by Fabric B under the increased draft. Only two of the ten specimens showed afterflaming in the cabinet with the holes taped over, while all except one of the ten specimens tested under the hood showed some afterflaming.

Table 1. Summary of Char Length Results Using Different Fuels

FABRIC		Matheson B (540 BTU/ft^3) No. of spec.	Char length max in.	min in.	avg in.	Propane (2590 BTU/ft^3) No. of spec.	Char length max in.	min in.	avg in.	Natural gas (1000 BTU/ft^3) No. of spec.	Char length max in.	min in.	avg in.
Conditioned at 65% RH and 70 °F													
A	warp	10	5.7	4.1	5.1	10	4.9	3.9	4.2	10	5.6	3.7	4.4
	fill	9	5.2	4.4	4.8	8	4.2	3.1	3.8	8	4.8	3.6	4.0
	combined	19	5.7	4.1	5.0	18	4.9	3.1	4.0	18	5.6	3.6	4.2
B	warp	10	7.2	5.3	6.0	10	6.4	4.0	4.9	10	6.2	4.1	5.1
	fill	9	6.9	5.4	6.1	9	6.1	4.2	5.1	8	5.9	4.8	5.4
	combined	19	7.2	5.3	6.0	19	6.4	4.0	5.0	18	6.2	4.1	5.2
Conditioned in oven at 60 °C (140 °F)													
A	warp	10	6.5	4.4	5.2	10	5.5	4.4	4.9	10	5.7	4.3	5.1
	fill	9	5.5	4.5	5.1	8	5.9	3.9	4.8	8	5.7	4.3	5.1
	combined	19	6.5	4.4	5.2	18	5.9	3.9	4.8	18	5.7	4.3	5.1
B	warp	10	6.9	4.4	5.9	10	6.3	5.1	5.6	10	7.0	4.6	5.5
	fill	9	6.9	4.6	5.9	9	6.5	4.0	5.4	8	6.5	5.1	6.0
	combined	19	6.9	4.4	5.9	19	6.5	4.0	5.5	18	7.0	4.6	5.7