Report of Test
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"Reevaluation of Experimental Cigarettes used in
the Cigarette Safety Act of 1984"

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APPENDIX A

U.S. DEPARTMENT OF COMMERCE
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“Reevaluation of Experimental Cigarettes used in the Cigarette Safety Act of 1984”

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The statistical theory of fractional factorial experimental design [V.2] can be used to satisfy the second objective. In particular, a fraction of the (full) 2^k factorial design (i.e., 2^f factorial design) that defines the 32 available cigarette types could be equally represented among the 8 selected cigarettes.

The selection of 8 cigarettes from the available 2^f-1 experiments over the entire range of ignition rates was not feasible. Thus, we attempted to achieve two objectives: (1) to choose cigarettes whose ignition propensity covers the entire range of ignition rates and (2) to choose cigarettes whose ignition propensity is similarly spread over the entire range of ignition rates.

The statistical selection of these cigarettes involves calling on your substantive, which in turn...

Statistical Selection of Cigarettes

Materials removed from the first study. 

The cigarettes have been stored in a rack under controlled conditions since the completion of the first study. In determining these cigarettes, the experiments have been stored in all 4 substrates to ensure that all 32 types of substrates on all 4 substrates. These were only enough materials available to perform all 32 types of experiments. It was impossible to perform the entire experimental scheme, since these experiments were composed of combinations of 32 types and two paddings. Due to the limited availability of one cigarette, the contribution of these cigarettes is involved in our selection on your substantive, which in turn...

Introduction
There are many ways that this kind of fully balanced fractional factorial selection could be made from the 32 cigarette types available. It was initially hoped that one or more of these fractional factorial selections would yield a set of 8 cigarettes that would also satisfy the first objective of uniformly spanning the ignition rates that had been obtained in the previous experiment. Ultimately we found that it was not possible to achieve both of the stated objectives exactly, and so a compromise set of 8 cigarettes was found that was imperfectly, but nearly, balanced and which does exhibit quite uniform coverage of the ignition rates. It was felt that for the purposes of this reevaluation experiment, the need to use cigarettes that uniformly represent the full range of previously observed ignition rates was more important than achieving a perfectly balanced fractional factorial arrangement.

Table A-1 displays the extent to which balance in the above sense was achieved in the final compromise set of cigarettes chosen.

Table A-1. Selection of Cigarettes for Reevaluation Study: Balance on Cigarette Design Factors and Coverage of Levels of Previous Numbers of Ignitions

<table>
<thead>
<tr>
<th>Cigarette Number</th>
<th>Tobacco Type</th>
<th>Packing Density</th>
<th>Paper Permeability</th>
<th>Citrate</th>
<th>Circumference</th>
<th>Previous Number of Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>B</td>
<td>E</td>
<td>L</td>
<td>N</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>130</td>
<td>F</td>
<td>E</td>
<td>L</td>
<td>N</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>108</td>
<td>B</td>
<td>E</td>
<td>H</td>
<td>N</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>129</td>
<td>F</td>
<td>E</td>
<td>L</td>
<td>C</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>101</td>
<td>B</td>
<td>N</td>
<td>L</td>
<td>C</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>131</td>
<td>F</td>
<td>E</td>
<td>H</td>
<td>C</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>103</td>
<td>B</td>
<td>N</td>
<td>H</td>
<td>C</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>120</td>
<td>B</td>
<td>N</td>
<td>H</td>
<td>N</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Balance Achieved</td>
<td>5 B</td>
<td>5 E</td>
<td>4 E</td>
<td>4 N</td>
<td>21mm</td>
<td>4 21mm</td>
</tr>
<tr>
<td></td>
<td>3 F</td>
<td>3 N</td>
<td>4 H</td>
<td>4 C</td>
<td>25mm</td>
<td>4 25mm</td>
</tr>
</tbody>
</table>

Results and Conclusions

The eight statistically-selected cigarettes were tested for their ignition propensity on the same substrates and in the same manner as the previous study. In addition to the storage factor, two other differences were a change in the canopy hood used and the technician who performed the tests.

The results of the testing are shown in Table A-2 below.
Now, columns of Table A.2 should be the same, except for statistical fluctuations.
If no real change in fusion propensity occurred, then the numbers of fusions in the previous and

For each of the 8 cigarette types, and for each of the 4 substrates shown in Table A-2, we calculated the difference between the number of ignitions in the current study ("Now"), minus the number of ignitions in the "Previous" study. If these differences represent only statistical fluctuations, then they would form a statistical population centered near zero. The Wilcoxon Signed Rank Test [A-3] was adopted as a formal statistical test procedure to evaluate whether the observed differences indicate a change in ignition propensity or only random noise. This is a non-parametric test procedure that is valid for use with data that do not follow the commonly assumed Gaussian distribution. Validity for non-Gaussian data was an important consideration because the difference data from this experiment clearly exhibit a non-Gaussian pattern of variation.

The results of the Wilcoxon Signed Rank Test are that the observed differences in numbers of ignitions show a statistically significant tendency (p = 0.04) toward increased ignitions after the storage period. Inspection of Table A-2 shows that the increased ignitions come almost exclusively from the denim substrate, which suggests the possibility that the statistically significant difference is due entirely to the denim substrate. This is consistent with the observation of Rogers and Hayes [A-4] that unless denim is stored free of finishing materials in the dark and in a temperature controlled environment, it will deteriorate with time.

To evaluate the hypothesis of no change in ignition propensity for the non-denim substrates, the Wilcoxon Signed Rank Test was recomputed using only the other three substrates (CA/CB, SPL/PU, and SPL/PU-half cigarette). In this case, the differences in ignition numbers were not significantly different from zero (p = 0.47). That is, the data for the three non-denim substrates are wholly consistent with the hypothesis of no change in ignition propensities of the experimental cigarettes, compared with the previous study.

It was noted that cigarette number 129 showed noticeable increases in the number of ignitions for both of the conditions involving the SPL/PU substrate. This suggests the possibility of a real change in ignition propensity for this particular combination of cigarette and substrate. In pursuing this observation, it is pertinent to note that cigarette 129 showed a relatively small increase in ignitions on the denim substrate both in comparison to its increase for the two SPL/PU substrates and also in comparison to the increases for other cigarettes on the denim substrate. Thus any physical explanation of a change in ignition propensity for cigarette 129 would seem to call for a unique cigarette-substrate interaction on SPL/PU. The reevaluation experiment was designed as an overall test for possible changes in the experimental cigarettes. It was not designed to generate sufficient data to evaluate unique effects for each cigarette and substrate combination. As it happens, the largest single observed difference (2 ignitions in the previous study versus 5 ignitions now) is not significant at the standard 5% level of significance (p = 0.08). Here, the significance calculation was obtained using Fisher's Exact Test for a 2×2 contingency table [A-5]. Based on all these considerations, it does not seem profitable to pursue further the observed increase in ignitions for cigarette 129 on SPL/PU.

Summary

Overall, we interpret the results of this study as showing that the ignition propensities of the experimental cigarettes have not changed during storage but that the denim substrate has changed in ignitability.
Acknowledgements

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References


