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Electric Matches: Effective Thermal Output

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Introduction

A study of electric match sensitiveness and performance has recently been completed, and a summary of the results is being presented as a series of short articles. This is the ninth article in the series[1] and presents the results of tests to determine the effective thermal output for the same collection of 10 electric match types as in the previous articles.

Effective Thermal Output Test

The ignition of one pyrotechnic composition by another (an electric match in this case) is accomplished by the transfer of energy. This transfer is generally accomplished by some combination of thermally incendive sparks (incandescent solid or liquid particles), high temperature gases, and radiant thermal energy. These three ignition stimuli are listed in decreasing order of their effectiveness for the ignition of typical pyrotechnic compositions. Accordingly, the effectiveness of ignition transfer depends on the relative proportion of these three sources of ignition energy, which in turn depends on the chemical nature of the donor pyrotechnic composition, which is likely to be different for some of the various electric matches being tested.

The effectiveness of ignition transfer also depends on the nature of the material to be ignited. Accordingly, the best measure of an electric match's ability to cause the ignition of pyrotechnic materials would be to conduct a series of ignition tests on various pyrotechnic compositions, under various conditions and in each configuration determining the percentage of times ignition was accomplished. However, for the ten electric matches being evaluated in this study, this could easily run into the many thousands of individual test firings. Clearly such an extensive series of tests was not possible for this brief screening study, and a more general method had to be utilized. This article reports on the first of a short series of tests intended to provide information on the electric matches' ability to produce ignition.

The tests reported in this article are described as "effective thermal output" tests. This is in opposition to "total thermal output" tests, such as would be accomplished by sealing an electric match inside a tiny vessel, causing the ignition of the electric match and measuring the total energy produced, as reflected by the increase in temperature of the vessel. Because of the hierarchy of effectiveness of the three ignition stimuli mentioned above, it was thought that such a total thermal output measurement could produce misleading results. Accordingly, a slightly different approach was taken, as illustrated in Figure 1. In this case, the vessel was not sealed, such that any permanent gases produced by the firing of the electric match would escape without transferring much of their thermal and radiant energy to the walls of the vessel. On the contrary, a fair amount of any temporarily vaporized reaction products (temporary gases) are likely to condense on the walls of the tube, thereby transferring much of their thermal energy. Similarly, much of the thermal energy from incendive sparks is expected to be transferred to the brass tube.

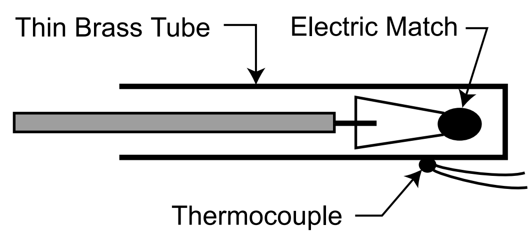

Figure 1. Illustration of the "effective thermal output" test configuration.

During the period of each test firing, the temperature of the thin brass tube was monitored using a thin gauge thermocouple attached to the outer surface of the tube. A typical temperature profile (temperature as a function of time) is shown in Figure 2, demonstrating the rapid rise and relatively slow fall of the temperature. This made it quite easy to accurately record the maximum temperature rise observed during each test firing. In each test, the initial and maximum temperatures were recorded, and the difference (increase) in temperature was calculated. Pairs of test firings were performed for each type electric match, and the average temperature increase calculated. These results are reported in Table 1. Prior to testing each pair of electric matches, a new (clean) brass tube was installed.

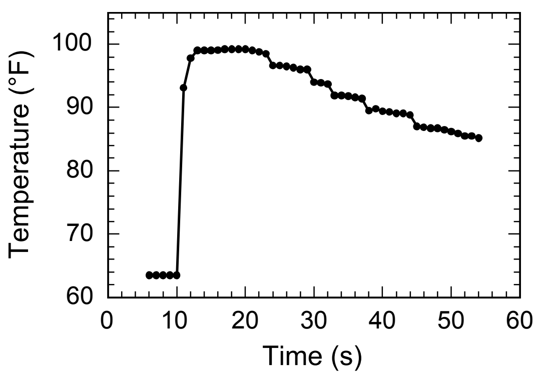

Figure 2. A graph of temperature as a function of time for an effective thermal output test.

If it can be assumed that the temperature rise, as determined in these tests, correlates with the electric matches' ability to produce ignitions of typical pyrotechnic materials, the Daveyfire A/N 28 F electric match is superior, producing a temperature rise of nearly 80 °C. Next are the Luna Tech Flash and Martinez Specialties E-Max electric matches, both producing an approximately 50 °C rise. The remaining seven electric match types then produce temperature increases ranging from approximately 20 to 35 °C.

Reported in the last column of Table 1 is the normalized temperature rise (i.e., the temperature rise in °C divided by the approximate mass of pyrotechnic composition used on that type electric match). While this information is of little practical significance, it was included to satisfy the potential curiosity of a few readers wishing more information on the relative efficiency of the different pyrotechnic compositions used by the various manufacturers.

Table 1. Results of Electric Match Effective Thermal Output Testing.

Supplier	Product Designation	Δ Temp.[a] °F	Δ Temp.[a] °C	Mass mg[b]	Norm. ΔT[c]
Aero Pyro		51	28	80	0.4
Daveyfire	A/N 28 B	35	20	40	0.5
	A/N 28 BR	53	29	80	0.4
	A/N 28 F	142	79	80	1.
Luna Tech	BGZD	56	31	10	3.
	Flash	96	53	20	3.
	OXRAL	41	23	40	0.5
Martinez Spec.	E-Max	85	47	20	2.
	E-Max Mini	39	21	6	4.
	Titan	62	34	20	2.

a) This is the average increase in temperature of the brass tube as a result of firing each of two electric matches inside the brass tube, reported to the nearest degree.

b) This is the approximate mass of pyrotechnic composition in mg used on each type of electric match, reported to only one significant figure, as reported previously, *Fireworks Business*, No. 206, 2001.

c) This is the normalized temperature increase (i.e., the temperature increase in °C divided by the mass of composition in mg) reported to only one significant figure.

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References

1) K. L. and B. J. Kosanke, A series of eight articles appearing in *Fireworks Business*, Nos. 198, 199, 200, 201, 202, and 203, in 2000; Nos. 206, and 207 in 2001; also appearing in this collection of articles.