An earlier version appeared in *Proceedings of the 4th International Symposium on Fireworks*, 1998.

Sticky Match® and Quick Match: Temperature Dependent Burn Times

K. L. and B. J. Kosanke
PyroLabs, Inc., 1775 Blair Road, Whitewater, CO 81527, USA

ABSTRACT

Sticky Match® is an expedient and reportedly effective type of fuse, especially useful in fusing lance set pieces. However, some users have mentioned an apparent tendency for the fuse to burn noticeably slower at low temperatures. The authors conducted a brief investigation of Sticky Match burn rate as a function of temperature. The study was conducted over a temperature range from approximately –30 to +40 °C (–20 to 100 °F).

In what is likely to be its normal method of application, it was found that at the lowest temperature Sticky Match burn rate fell to as little at 1/3 that at the highest temperature. Using a slightly different method of application, it was found that its burn rate was even more strongly affected at both extremes of temperature. In a third and substantially different method of application, it was found that Sticky Match was essentially unaffected by temperature, but always burned rather slowly.

As a comparison to Sticky Match's temperature performance, the study also characterized the effect of temperature on the burn rate of conventional quick match. In two configurations, similar to those used for Sticky Match, it was found that the burn rate of quick match was virtually unaffected by temperature.

Introduction

Sticky Match®[1] is an expedient and reportedly effective type of fuse, especially useful in fusing lance set pieces. The fuse is made by confining a trail of granular Black Powder between two strips of thin plastic tape that face each other, with one tape being significantly wider than the other. Accordingly, the exposed adhesive on the wider tape is available to secure the fuse in place. (See Figure 1.) Sticky Match has gained considerable acceptance in the USA during the relatively short time it has been available. However, there have been reports of its burn rate being quite temperature dependent. While, even if true, this would generally not be a serious problem, it could produce unexpected results and would be something a user should be aware of. This article reports on an investigation of the temperature dependence of Sticky Match used in three configurations and compares those results with results for quick match. (For results of a more complete study of quick match performance, see reference 2.)

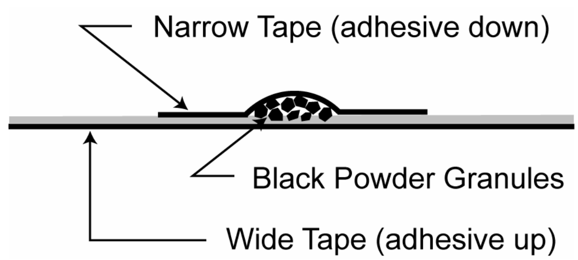

Figure 1. Cross section of Sticky Match.

Measurements

The first configuration studied is illustrated in Figure 2 and, in the test results, is designated "normal", as it represents the way Sticky Match would be used to fuse a lance set piece. For these tests a length of Sticky Match was used to span a row of four wooden dowel pins, spaced 0.15 m (6 in.) apart. The dowel pins were in-

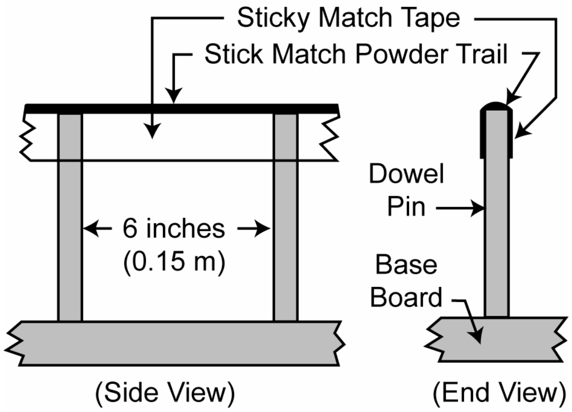

Figure 2. Sticky Match test configuration—"normal" (not to scale).

tended to represent lance tubes on a set piece. The Sticky Match was placed tightly over the top of the dowel pins and held in place by the adhesive of the wider tape. Between the dowel pins, the edges of the Sticky Match tape, with the exposed adhesive were pressed together to help hold it in place on the dowel pins and to produce a potential fire path below the Black Powder trail. It was thought that closing the space below the powder trail in this manner would help retain the heat of burning, passing more thermal energy along to unburned powder, and potentially making its burn rate less temperature sensitive.

For each burn-time test, a 0.46 m (18 in.) length of Sticky Match was used. In each case it was ignited with an electric match[3] installed against the powder trail at the first dowel pin. The progress of the burning was video recorded, and burn times were subsequently determined by playing the videotape field by field. Prior to each test, the assembly was held in a temperature-controlled chamber for at least two hours. The actual measurement was made in the temperature-controlled chamber. Then the door to the chamber was briefly opened, and the Sticky Match quickly ignited before its temperature could change significantly. In this manner, a set of three measurements were made at each of a series of temperatures ranging from about –30 to +40 °C ±1 °C (–20 to +100 °F). The results of these measurements are reported in Table 1; however, discussion of the results is deferred until later in this paper.

Table 1. Sticky Match Burn-Time Test Results.

Test Condition	Temperature (°C)	Temperature (°F)	Burn Time for 18 in. (0.46 m) (1/60 second) Test 1	Test 2	Test 3	Average	Average Burn Time (s)
Normal	–28	–18	75	52	46	58	0.97
	–11	12	44	54	36	45	0.75
	1	34	20	27	24	24	0.40
	14	58	21	23	22	22	0.37
	29	84	21	16	18	18	0.30
	38	100	20	18	22	20	0.33
Side Mounted	–31	–24	149	218	182	183	3.00
	–13	0	74	24	31	43	0.72
	2	35	38	31	41	37	0.62
	13	55	10	15	9	11	0.18
	30	86	18	12	26	17	0.28
	38	100	11	9	9	10	0.17
Pipe Mounted	–31	–24	115	135	174	141	2.35
	–13	0	61	131	65	86	1.43
	2	35	122	208	165	165	2.75
	13	55	64	128	187	126	2.10
	30	86	156	106	163	142	2.37
	38	100	43	168	86	99	1.65

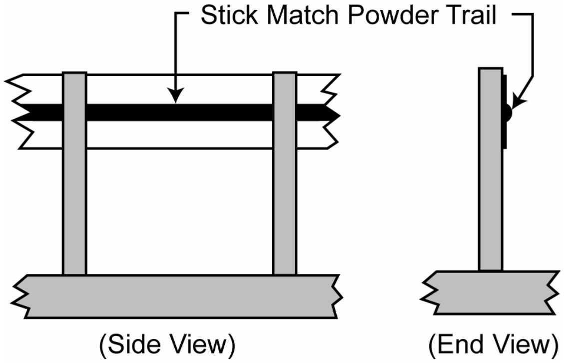

Figure 3. Sticky Match test configuration—"side mounted" (not to scale).

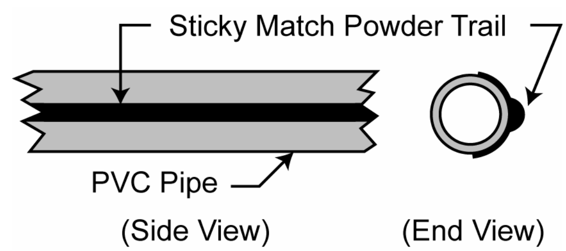

Figure 4. Sticky Match test configuration—"pipe mounted" (not to scale).

In a similar fashion, two other Sticky Match configurations were tested; these are shown in Figures 3 and 4. One is described as "side mounted", where the Sticky Match was just placed against the side of the dowel pins. In this configuration no fire path is formed below the powder trail as in the "normal" configuration (produced when the edges of the tape were pressed together). The other configuration is described as "pipe mounted", where the length of Sticky Match was tightly attached to a length of nominal 1-inch (25.4-mm) schedule 40 PVC pipe. It was thought that the close proximity of the pipe would be fairly effective in absorbing heat from the burning powder and might tend to slow the burning of Sticky Match. The burn-time results as a function of temperature, using these two configurations, are also presented in Table 1.

As a comparison, standard quick match[4] was tested in the "normal" and "pipe mounted" configurations. In the normal configuration, the quick match was held in place using masking tape, as is often the case when it is used to fuse lance set pieces. In the pipe mounted configuration, the quick match was held as tightly as possible to the surface of the pipe using 51 mm (2-in.) wide clear plastic packaging tape. Temperature conditioning of the assemblies and burn-time measurements were conducted just as they were for Sticky Match. The results from these measurements are presented in Table 2.

By comparing the results from the three individual measurements at each temperature in Tables 1 and 2, it is clear that large variations in burn times were often observed. Occasionally the range of burn times exceeded a factor of two. Accordingly, the statistical precision of the average burn times reported in Tables 1 and 2

Table 2. Quick Match Burn-Time Results.

Test Condition	Temperature (°C)	Temperature (°F)	Burn Times for 18 in. (0.46 m) (1/60 second) Test 1	Test 2	Test 3	Average	Average Burn Time (s)
Normal	–29	–21	11	9	15	11	0.18
	–16	4	9	7	15	9	0.15
	0	32	16	9	11	12	0.20
	15	59	9	6	11	10	0.17
	28	82	9	6	16	10	0.17
	38	100	10	10	8	9	0.15
Pipe Mounted	–30	–22	9	5	4	6	0.10
	0	32	7	7	4	6	0.10
	28	82	10	6	8	8	0.13
	38	100	5	6	6	6	0.10

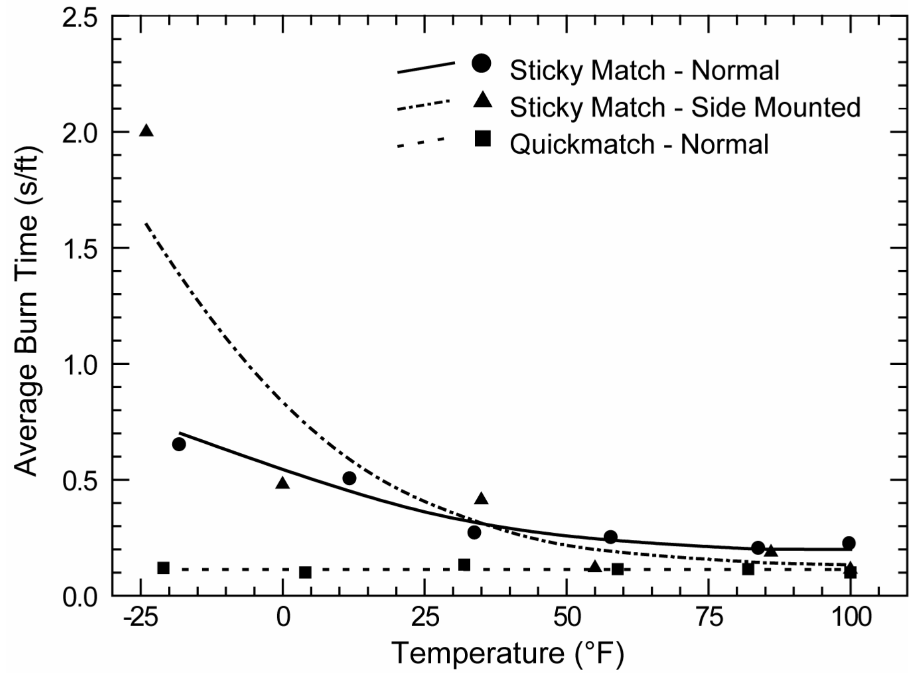

Figure 5. Burn-time results as a function of temperature for the "normal" and "side mounted" test configurations. [To convert s/ft to s/m, divide by 3.28. To convert °F to °C, °C = (°F – 32) × (5/9).]

are not high, and some caution is appropriate in attempting to interpret those results. Average burn-time results for the "normal" and "side mounted" configurations are presented graphically in Figure 5. Note that burn times for quick match seem to be mostly unaffected over the temperature range studied. On the other hand, while the burn times of Sticky Match are not strongly temperature dependent at higher temperatures, at low temperatures Sticky Match was observed to become increasingly slow burning. For the normal configuration, Sticky Match burn times increase by about a factor of three for the lowest temperatures. Note further that the burn times for the side-mounted configuration are even more sensitive to temperature, perhaps increasing by a factor of more than ten at the lowest temperatures studied.

Average burn-time results for the "pipe mounted" configuration are presented graphically in Figure 6. Note that the burn times for Sticky Match are quite variable, but seem to be mostly independent of temperature in this configuration. Again, burn times for quick match are quite constant and independent of temperature in the range studied.

Conclusions

A number of conclusions can be drawn from the reported data regarding the use of Sticky Match:

1) Over the range of temperatures normally expected for fireworks displays in the summer, 21 to 38 °C (70 to 100 °F), Sticky Match burns at a rate of about one half that of the quick match used in this study. This should not be a problem for use on lance set pieces and may allow for a more aesthetically pleasing ignition, along the lines described in reference 5.

2) Over the range of temperatures normally expected for fireworks displays in the summer, 21 to 38 °C (70 to 100 °F), the burn rate of Sticky Match is not noticeably temperature dependent.

3) When Sticky Match is to be used at low temperatures, $\lesssim$ 0 °C (32 °F), it must be anticipated that its burn rate will depend on temperature, and it may burn significantly slower than might be expected. However, its burn rate will be less temperature dependent if an attempt is made to enclose the space

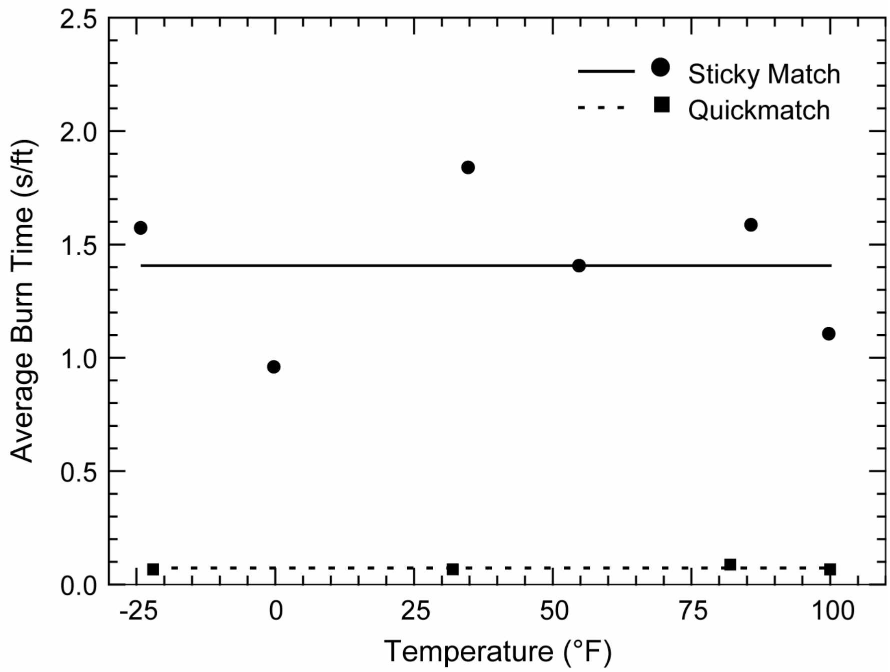

Figure 6. Burn-time results as a function of temperature for the "pipe mounted" test configuration. [To convert s/ft to s/m, divide by 3.28. To convert ºF to ºC, ºC = (ºF – 32) × (5/9).]

under it by pressing the edges of the tape tightly against itself over the span between the individual lance tubes.

4) At any temperature, the burn rate of Sticky Match can be retarded by taping it tightly against a surface. While it would seem that precise time delays might not be possible using this method, it is a method that may occasionally prove to be useful.

Sticky Match is an interesting and useful fusing material. However, for some applications, a better understanding of its properties may be important to use it successfully to accomplish one's purpose.

Acknowledgements

The authors are grateful for the suggestions made by L. Weinman and M. Williams on an early draft of this paper.

References

1) Sticky Match® is a Registered Trademark of Four-D Enterprises, Inc., 10510 El Comal Drive, San Diego, CA 92124 USA. Patent Number 5,662,719. The samples used in this study were supplied in early 1998, courtesy of Ron Dixon, Four-D Enterprises.

2) K. L. & B. J. Kosanke, "Quick Match: A Review and Study", *Proc. 4th Int'l. Symposium on Fireworks* (1998). Also in *Selected Publications of K. L. and B. J. Kosanke, Part 5 (1998 through 2000)*, Journal of Pyrotechnics, 2002.

3) The electric matches used were Daveyfire SA-2000, provided courtesy of Alan Broca, Daveyfire, Inc., 2121 N California Blvd. Ste. 290, Walnut Creek, CA 94596, USA.

4) Supplied in 1997 by Precocious Pyrotechnics, Inc., 4420 27th Ave. NW, Belgrade, MN 56312, USA.

5) B. J. and K. L. Kosanke, "Lancework - Pictures in Fire"; *Pyrotechnica* XV (1993); Also in *Selected Publications of K.L. and B.J. Kosanke, Part 3 (1993 and 1994)*, Journal of Pyrotechnics, 1996, p 28.