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Chlorate Compositions in Quick Match

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After the 1999 PGI convention, the authors were told about a type of quick match that had been sold at the convention and which was suspected of being made using a chlorate oxidizer. The individual's suspicion was based on his perception of its extremely fast burn rate. Subsequently, a sample of that fuse was spot tested and found to contain a nitrate but not a chlorate. Sometime later, the authors were given a sample of quick match thought to be of the same type. The burn rate of the quick match was observed to be most vigorous; however, there was not a sufficient amount for the authors to make a usefully quantitative measurement of its burn rate. Small amounts of the composition were removed from the black match portion of this fast burning quick match, and two tests for the presence of chlorate were performed. The first test was the concentrated hydrochloric acid test, in which a few drops of the acid are placed on the composition. The presence of a chlorate is revealed by a modest rate of chlorine dioxide gas production, with its characteristic color and odor.[1,2] The second test was the aniline-HCl spot test, in which some of the composition is dissolved in a tiny amount of water, the water is decanted and treated with a drop of aniline-HCl test reagent.[1,3] The presence of a chlorate is revealed by the appearance of first a red then blue color. Again, both test results were negative for the presence of a chlorate. Accordingly, another possible explanation for the vigorous burn rate of the quick match was sought.

The design of the quick match was typical of the fuse seen in recent years being used on some higher quality products from China. The fuse had a series of 5 individual strings, each of which was well coated with a pyrotechnic composition that remains noticeably more flexible than that of traditional products. These strands were laid side by side and surrounded with match pipe that was quite flat. This configuration is illustrated in Figure 1 and identified as *Recent Chinese*. This manner of construction is in contrast to the configuration most commonly used in the US (also illustrated in Figure 1 and identified as *Typical US*), in which the collection of strings are coated as a group with a Black Powder slurry and forming a somewhat rounded grouping of the strings.

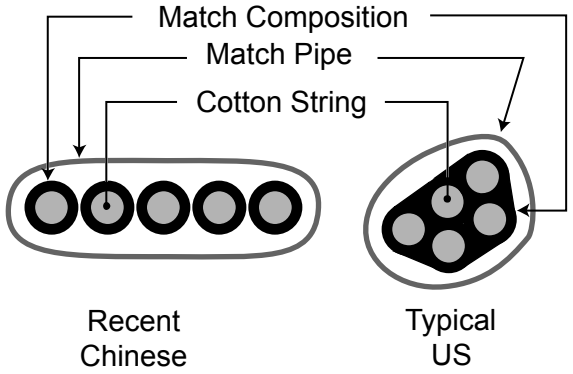

Figure 1. Illustration of the configuration of two types of quick match.

One significant difference between the two configurations is the total amount of surface area of exposed black match composition. For the Recent Chinese fuse, the surface area is proportional to $5\pi D$, where D is the diameter of each individual black match strand. Based on measurements of typical US black match, the overall diameter for the group of threads is typically no more than about $3D$, thus giving a surface area proportional to no more than about $3\pi D$. Accordingly, the Recent Chinese fuse has nearly twice the burning surface area. If it is assumed that the compositions are otherwise effectively the same in their burning characteristics, the Recent Chinese fuse will produce nearly twice the quantity of flame as does Typical US black match. Based on our understanding of the manner of functioning of quick match,[4,5] the greater volume of flame produced will result in a greater *initial* rate of burning for the quick match. (Ultimately, the rate of burning of unobstructed quick match is mostly determined by the strength of its match pipe.)

The Recent Chinese quick match has another property that may cause it to appear to be especially fierce burning. The method generally used

to slow the burning of quick match is to close the fire path between the black match and the match pipe. This is found to work well for the Typical US quick match, where the closure of the match pipe around the central black match can easily be made with a moderately tight wrap of string, and which causes approximately a ¼-second delay.[6] On the other hand, when the same method is attempted with the Recent Chinese style of quick match, it will be most difficult to get a complete closure of the fire paths. This is because small spaces (fire paths) between the individual strands of black match will persist (see Figure 2), unless the composition on the black match strands is sufficiently crushed to completely fill the gaps. Accordingly, this type of quick match will be quite difficult to slow using the normal methods of fire path closure. Accordingly, this also probably suggests to users that its burning is especially fierce.

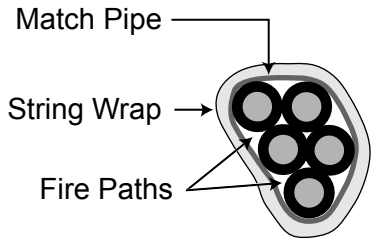

Figure 2. Illustration of the difficulty of closing fire paths to slow the burn rate of the Recent Chinese quick match.

Although it is somewhat understandable that this Recent Chinese quick match was suspected of having been made using a chlorate oxidizer, both its high burn rate and the difficulty with slowing its burn rate can be explained based on its manner of construction. Over the years, the authors have tested many suspect samples of quick match. However, except for a type of quick match used on Horse Brand shells for many years (and possibly still today), none of the others was found to contain chlorates. (Note that is not to say that no quick match ever has been or is being made using a chlorate oxidizer, just that we have not found any except for Horse Brand shell leaders.)

Figure 3 is an illustration of one form of the Horse Brand fuse found to contain a chlorate oxidizer. The quick match shell leader contains two fuse elements. One is a somewhat conventional strand of black match, although it tends to be made of a single thicker strand of fairly coarse cord and to which the powder coating tends to adhere only poorly. This powder coating is found to contain no chlorate, but it is found to contain sulfur and presumably is hand-made Black Powder. (In some cases, especially on larger shells, this quick match has two strands of black match.) The second fuse element is a single (but sometimes double) strand of so-called Chinese fuse, made with a powder core wrapped in tissue paper, which is similar to the type of fuse typically used on small firecrackers. It is in this Chinese fuse that the chlorate oxidizer is found to be present.

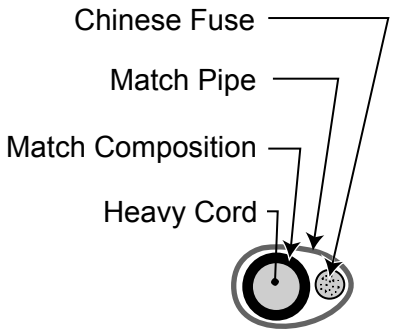

Figure 3. Example of one type of Horse Brand quick match shell leader found to contain a chlorate oxidizer.

The problem with the presence of chlorate in one element of this Horse Brand fuse is exacerbated by the presence of sulfur in the other element. When this fuse is cut or the Chinese fuse becomes sufficiently damaged through handling, there will be a commingling of the chlorate and sulfur compositions, with all the sensitiveness problems that are known to result.[7,8] (For example, in some recent testing of the impact sensitiveness of these Horse Brand fuse compositions, the combination of the two compositions was found to be 2.5 times as sensitive as the rough Black Powder composition alone.) Over the years, there have been a number of serious accidents thought to have been caused by this fuse.

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References

1) R. Winokur, "Some Easy Spot Tests for Qualitative Analysis of Pyrotechnic Compositions", Pyrotechnics Guild International Convention Seminar, 1985, p 1.

2) F. A. Cotton and G. Wilkenson, *Advanced Inorganic Chemistry*, Interscience Publishers, 1966, p 566.

3) W. S. Majdali, "A Selection of Spot Tests for Qualitative Analysis of Pyrotechnic Compositions", *Pyrotechnica XVII*, 1997, p 30.

4) T. Shimizu, *Fireworks, From a Physical Standpoint, Part I*, Pyrotechnics Publications, 1981, pp 11–16.

5) K. L. & B. J. Kosanke, "Quick Match: Its Construction and Manner of Functioning", *American Fireworks News*, No. 221, 2000.

6) K. L. & B. J. Kosanke, "Quick Match: Methods of Slowing its Burning", *American Fireworks News*, No. 222, 2000.

7) C. Jennings-White and K. L. Kosanke, "Hazardous Chemical Combinations", *Journal of Pyrotechnics*, No. 2, 1995, pp 23 and 26; also in *Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 4 (1995 through 1997)*, Journal of Pyrotechnics, 1999..

8) J. A. Conkling, *The Chemistry of Pyrotechnics*, Marcel Dekker, 1985, pp 56, 59 and 109.