An earlier version appeared in *Fireworks Business*, No. 237, 2003.

Further Report on the Testing of Suspect Tiger-Tail Comets

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In the hope of avoiding a serious accident, earlier issues of *Fireworks Business* carried a report of the powerfully explosive malfunctions of some tiger-tail comets,[1] and then a brief report of an examination and initial testing of a number of the suspect comets.[2] Since that time, samples from one of the suspect comet shells were provided for laboratory analysis. This article reports on the results of that analysis.

Based on a semi-quantitative chemical analysis of the comet composition, the approximate formulation of the problematic comets was as reported in Table 1:

Table 1. Approximate Composition of the Problematic Comets.

Ingredient	Percent
Potassium perchlorate	40
Aluminum (coarse)	30
Magnalium (fine)	25
Binder (unidentified)	5

The binder was water soluble but not otherwise identified, and it was assumed to be present in an amount equaling 5%. The aluminum had the appearance of being the type that is sometimes referred to as *blown* aluminum, which is an irregularly-shaped type of coarse atomized aluminum. The magnalium was granular and had the approximate ratio of 50:50 of magnesium to aluminum. (As determined from electron micrographs, the magnalium was seen to exhibit fracture characteristics consistent with being approximately 50:50 magnalium.) The approximate (rounded to the nearest 10%) mesh fractions of the two metal powders were as reported in Table 2:

Table 2. Approximate Mesh Fractions of the Comets' Metal Powders Reported in Table 1.

Mesh Range (US Standard)	Mass Percent	
	Aluminum	Magnalium
+ 60	65	10
60 – 100	25	10
100 – 200	10	30
200 – 400	0	20
– 400	0	20

Since 90% of the aluminum was coarser than 100 mesh, that suggests that the primary purpose of the aluminum is to produce the comet's spark trail. Also since 80% of the magnalium had a particle size smaller than 100 mesh, combined with the lack of another fuel, that suggests that the primary purpose of the magnalium is the primary fuel for the composition. Normally an atomized aluminum, with particles as large as was used in this case, would not be particularly effective as a source of white sparks. This is because of the difficulty in achieving ignition of such large size aluminum particles with the relatively low burning temperature of Black Powder-based compositions. This perhaps explains the reason for the manufacturer resorting to the use of the potassium perchlorate and small particle size magnalium as a high flame temperature composition.

Calculated from the size and mass of the comet, its bulk density was approximately 1.5 g/cm^3. Based on its apparent formulation, the maximum theoretical density of the comet composition is approximately 2.5 g/cm^3. This difference corresponds to a porosity of approximately 40%, whereas a porosity of roughly 20% is more typical for well-compacted pyrotechnic compositions. The particularly high porosity was confirmed through a microscopic examination, which suggested that gas permeability would also be high. Figure 1 contains two electron micrographs of the comet composition. The upper micrograph demonstrates the extent to which there tends to be void spaces between individual particles in the comet, which themselves appear somewhat like a collection of boulders in a loose pile. The lower micrograph (taken at lower magnification) is similar in appearance but also documents the occurrence of larger more cavernous voids in the composition.

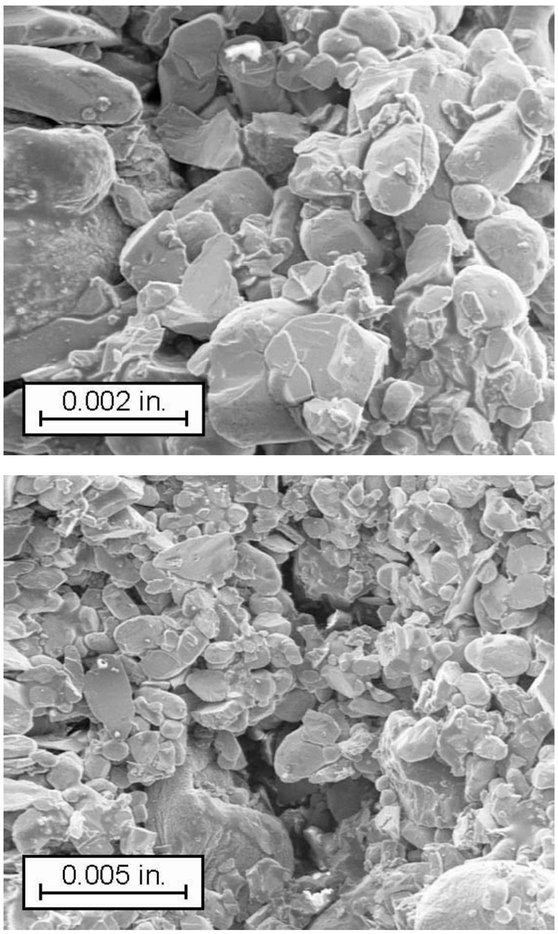

Figure 1. Electron micrographs of the problematic comets.

Although there are differences in construction between these malfunctioning comets and those producing the powerful explosions of comet Roman candles occurring previously in Australia,[3] they share characteristics that are thought to have been the cause of the malfunctions. Both types of comets combine a high energy oxidizer (potassium perchlorate) with small particle size magnalium (in effect constituting somewhat compacted and bound flash powder). Both types of comets have internal structures thought to produce a relatively high degree of gas permeability (fire paths that allow the rapid spread of combustion). The combination of these characteristics is thought to allow the near instantaneous release of large amounts of pyrotechnic energy, occasionally manifesting itself as a powerful explosion. What makes these malfunctions especially problematic is that they are occurring in items generally thought not to be capable of exploding at all.

References

1) K. L. Kosanke, "Warning: Serious Product Malfunction", *Fireworks Business*, No. 232, 2003; also in *Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 7 (2003 and 2004)*, Journal of Pyrotechnics, 2005.

2) K. L. Kosanke, "Report on the Initial Testing of Suspect Tiger Tail Comets", *Fireworks Business*, No. 233, 2003; also in *Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 7 (2003 and 2004)*, Journal of Pyrotechnics, 2005.

3) K. L. & B. J. Kosanke, G. Downs and J. Harradine, "Roman Candle Accident: Comet Characteristics", *Fireworks Business*, No. 228, 2003; also in *Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 7 (2003 and 2004)*, Journal of Pyrotechnics, 2005.