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Japanese Shell Break Radii

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(Derived from data provided by Dr. T. Shimizu, private communication)

The National Fire Protection Association, Technical Committee on Pyrotechnics is in the process of revising *NFPA-1123, Code for the Outdoor Display of Fireworks* (formerly called *Public Display of Fireworks*). In preparation for considering the appropriate separation distances between spectators and mortar placements and between spectators and fall-out areas, it seemed that it would be helpful to know how great the break radius was for hard-breaking spherical shells. Thus an attempt was made to collect that data. It was also felt that the data would be of general interest to the pyro-community; it was in that belief that this article was prepared.

The assistance of T. Shimizu was sought in the hopes that he had already compiled this information. He graciously responded with a set of unpublished data recorded at the 1965 PL Fireworks Festival, during which shells manufactured by Hosoya, Marutamaya-Ogatsu, Ikebun, Fujiwara, and Aoki were fired. Break radii for approximately 280 shells ranging from 4 to 20 Suns (4.8 to 23.9 inches) were determined photographically, and the results presented graphically. Dr. Shimizu had drawn a curve on the graph indicating the approximate maximum radii as a function of shell size. We added a second curve approximating the typical radii observed for the shells. The table below is a listing of the typical and maximum shell radii (to the nearest 5 feet), which were determined from the Shimizu data.

Table of Typical and Maximum Shell Break Radii.

Nominal Shell Diameter	Shell Break Radius (feet)		Approximate Number of Observations	
	Typical	Maximum		
3	130	215	0	(a)
4	170	270	0	(a)
5	210	330	120	
6	255	380	50	
7	295	430	75	
8	330	470	22	(b)
10	415	540	4	(b)
12	490	595	12	(b)
16	630	690	1	(c)
24	805	820	2	(c)

(a) The smallest shells for which there were data were approximately 5 inch. The results for 3 and 4-inch shells were estimated by extrapolation of the curves through zero.

(b) For shells of approximately 8, 10 and 12 inches all were observed to break with roughly the same radii; however, smooth curves were drawn through the data for all shell sizes.

(c) Because of a very limited number of observations for shells greater than 12 inches, the data must be considered to be of limited reliability.

During discussions with a number of knowledgeable pyrotechnists, concern was expressed that because of the stature of the PL Fireworks Festival in Japan, it was possible that the shells were of a superior quality compared with those exported to this country. Thus the Shimizu data could indicate larger break radii than would be observed for imported Japanese shells. PGI President, C. Hill suggested that some confirmatory tests be performed. He made the offer that the PGI would underwrite the cost of the shells and photo-processing, if we would volunteer the labor to layout the test range and perform the tests. Those tests were performed in October, and the results are reported below.

A test range, consisting of two large supported poles and a number of distance markers, was laid-out on a remote portion of our property. Two 35 mm cameras with standard 55 mm focal-length lenses were set-up perpendicular to the line of markers and at a distance of approximately 1400 feet. To establish the scale of the photographs, each camera was used to photograph the range during daylight. That evening a series of 20 aerial shells were electrically ig-

Data Table for Shell Burst Radii Tests.

Test/ Photo No.	Shell Size (in.)	Shell Description	Shell Weight (lb.)(a)	Break Radius (feet)
1	8	Onda - Brocade Gold	5.3	290
2	8	Onda - Reddish Gamboge to Red, Green and Blue	5.7	400
3	6	Onda - Twinkling Diadem	2.2	265
4	6	Onda - Golden Diadem to Flash w/ Red Pistil	2.2	345
5	5	Onda - Reddish Gam. to Green and Flickering	1.3	215
6	5	Ogatsu - Glittering Silver to Red and Blue	1.5	210
7	5	Ogatsu - 3002 “weak willow effect”	1.1	120
8	5	Onda - Green w/ Encircling Dews	1.4	165
9	5	Onda - Spangled Chrysanthemum	1.7	230
10	4	Onda - Variegated Colored Peony	0.8	215
11	4	Ogatsu - Blue to Silver	0.7	115
12	4	Ogatsu - Blue to Silver	0.7	85
13	4	Ogatsu - Red Chrysanthemum	0.7	160
14	4	Onda - Glittering Silver to Blue	0.9	185
15	3	Onda - Green Peony	0.3	75
16	3	Onda - Brocade Red Chrysanthemum	0.3	110
17	3	Onda - Brocade Red Chrysanthemum	0.3	105
18	3	Onda - Blue Peony	0.3	95
19	3	Onda - Brocade Red Chrysanthemum	0.3	115
20	3	Onda - Brocade Red Chrysanthemum	0.3	100

(a) Weights are for unlifted shells.

nited while being suspended approximately 14 feet above the ground on a cable strung between the two poles. The shells were all of Japanese manufacture (Onda and Ogatsu) and ranged from 3 to 8 inches in size. Each shell was photographed (time exposure) as it burst. The Photo below is and example of the results obtained. It is of an 8 inch Onda-Reddish Gamboge to Red, Green and Blue shell which broke with a radius of 400 feet (total spread of 800 feet). The table below presents the results of the series of tests.

Of the 14 shells larger than 3 inches, 7 broke harder than the typical from the Shimizu data, 1 exactly equaled the typical, and 6 broke weaker. The 3-inch shells all broke weaker than the typical radii suggested by the Shimizu data. However, it should be remembered that the 3 inch data was obtained by extrapolation, since no shells as small as that were actually measured by Shimizu. Finally, even though a couple of shells approached the maximums observed by Shimizu, none exceeded those maximums.

In conclusion, considering the limited number of tests performed, it is felt that the Shimizu data is representative of the typical and maximum break radii for hard breaking spherical shells imported into this country from Japan.

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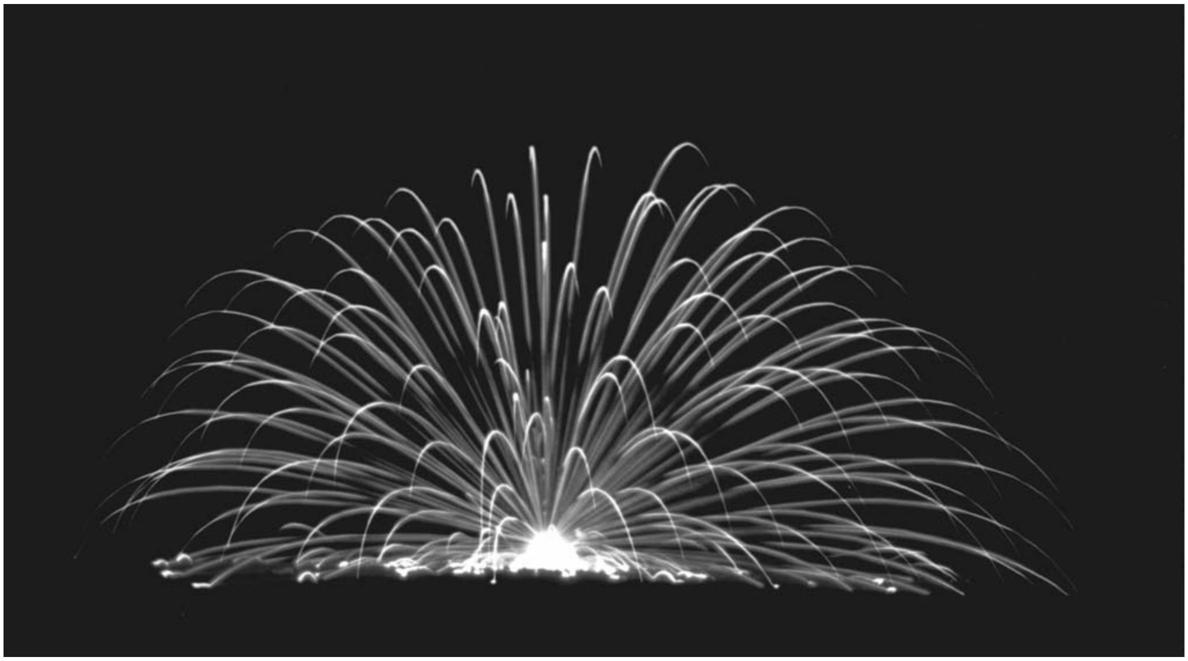

Photo of the burst of an 8" Onda - Reddish Gamboge to Red, Green and Blue shell. Break radius was 400 feet (total spread of 800 feet).

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CMC Its Properties and Uses

Ken Kosanke

CMC, as it is commonly called, is more properly referred to as Sodium Carboxymethylcellulose (carboxy-methyl-cellulose). In the food industry it is also frequently referred to as cellulose gum.

CMC is colorless, odorless, tasteless, and non-toxic. It is somewhat hygroscopic and dissolves readily in water. It is highly thixotropic (That is to say, it is a very effective thickening agent, like corn starch except much more effective. It is used in the food industry to thicken things such as low-cal pancake syrup.) For a good grade of CMC the use of only 1, 2 or 3% will turn water into a slimy liquid, a thick goo or gelatin, respectively. CMC is also an unusually effective adhesive.

In pyrotechnics, CMC has two important uses. Because CMC is so effective as an adhesive even in relatively small amounts (1 to 2%), it makes an excellent binder in situations when the presence of 4 to 6% binder can adversely affect the performance of a composition. For example, in strobe compositions the presence of a high percentage of binder tends to cause the composition to burn continuously as opposed to strobing. The use of CMC in low percentages often improves and makes it easier to control strobe performance. Because CMC is so effective as a thixotropic agent even in relatively small amounts (1 to 2%), it makes an excellent additive when trying to maintain formulations in suspension. For example, in priming or in the manufacture of black match there is always the difficulty of keeping the meal powder ingredients from settling to the bottom of the container during use. The use of CMC in low percentages easily thickens the suspension to the point where essentially no settling occurs.