

**COMMITTEE OF EXPERTS ON THE TRANSPORT OF
DANGEROUS GOODS AND ON THE GLOBALLY
HARMONIZED SYSTEM OF CLASSIFICATION
AND LABELLING OF CHEMICALS**

**Sub-Committee of Experts on the
Transport of Dangerous Goods**

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Explosives, self-reactive substances and organic peroxides

Classification criteria for fireworks

Transmitted by the expert from the United Kingdom

Introduction

1. During the twentieth session of the Sub-Committee of Experts on the Transport of Dangerous Goods, a discussion was held based on the report of the UN Working Group on the Classification of Fireworks (UN/SCETDG/20/INF.9; ST/SG/AC.10/C.3/2002/1). It was agreed that the default classification system for fireworks should be based on test series 6 results.
2. The United Kingdom have carried out a number of Test Series 6 trials on fireworks and reviewed previous United Kingdom trials work to assist the development of the default fireworks list. Tests have been carried out on a number firework types for which data was not available at the working group meeting in The Hague. The fireworks tested by United Kingdom include:

Report shells with sizes below 75mm (3"),
rockets containing flash as the principle effect,
star shells,
shell in mortar batteries,
"bag mines", and
ground mine.

Tests carried out in the 1980's on Sparklers and 26mm single shot Roman Candle videos were also re-assessed to assign classifications. The resulting data together with information provided by other Experts has been included in a revised default list.

Report shells

3. Four different report shells were included in 6(a) and 6(b) tests, three of which produced mass explosion results. The results are summarised below:

50mm Sunny Titanium salute shells - no mass explosion in 6(b)
50mm flashing salute shells with mortar tube - mass explosion from 6(a) and 6(b)
65mm flashing salute shells - mass explosion from 6(a) and 6(b) (see photo 1 of the 6(b) test)
75mm Igual report shell - mass explosion from 6(a) and 6(b)
75mm Standard Fireworks report shell - mass explosion from 6(a)



Photo 1 – 6(b) test of 65mm flashing salute shells

4. These results were provided at the working group meeting in The Hague and were used to assign all report shells to division 1.1.

Shell in mortar

5. The United Kingdom suggested a classification of 1.1G for these fireworks but the default list agreed at October 2001 working group placed shell in mortar <200mm into division 1.3. The United Kingdom remained concerned about this entry and have tested 25 shot 62mm (2.5"), 75mm (3") and 100mm (4") shell in mortar batteries in a modified 6(c) test. Because of the potential risks involved in recoil of the strapped firework packages on the metal grid in a full 6(c) test it was decided to strap the packages horizontally to a Pendine concrete block facing an aluminium screen and ignite the fireworks.

6. These abbreviated 6(c) tests have shown that the shells ejected from the mortar tubes of the battery had sufficient energy to be projected more than 15m from the package but were unable to perforate the witness screen. Based on UN classification criteria this leads to a 1.3 classification indicating the major hazard to be "radiant heat and/or violent burning but with no dangerous blast or projection hazard". Assignment of a 1.2 classification is not permitted as the witness screens were not perforated and the projectile was not metallic with an energy in excess of 20J.

Data from the tests are presented in table 1 & 2 below and photographs 1, 2 &3 showing the witness screens

Table 1: Witness screen impact data					
Shell calibre (mm)	Depth of dents on witness screens (mm)				
	Maximum	Minimum	No. impacts	Mean	Std. Dev.
65	19.1	6.6	14	11.2	4.00
75	21.3	10.0	6	14.5	5.12
100	26.3	26.3	1	-	-

Table 2: Energy values for shells of different calibres			
Shell calibre (mm)	Mean mass (g)	Velocity range (m.s ⁻¹)	Max. energy (J)
65	76.6	51.8 to 136.2	877
75	141.4	78.4 to 1 01.4	898
100	339.6	101.3 to 130.2	3,555
Comparator shells (100mm)	359.0*	106.2 to 206.9	7,684

* = single shell mass



Photo 2 – 62mm shell in mortar battery



Photo 3 – 75mm shell in mortar battery



Photo 4 – 100mm shell in mortar battery

7. The shells were sufficiently robust to withstand an impact with the aluminium witness screen without breaking open or disrupting the fusing system. The smallest shell produced a kinetic energy of 877J at 4 metres from the end of the mortar tube. During the comparator test (a 100mm shell in a steel mortar tube) the shell hit a 75mm wooden post which had been driven into the ground to act as a marker post. The impact of the shell caused the post to snap about 150mm below the impact point. The velocity of the shell that hit the post was $206.9\text{m}\cdot\text{s}^{-1}$ at a distance of 4m.

8. Because of the extreme danger posed by these fireworks the United Kingdom Expert proposes that, shell in mortar, including batteries and combinations, be classified as 1.1G in the default list or left to competent authorities to classify on the basis of full Series 6 test results.

Rockets containing flash reports as principle effect

9. Two rockets, Bad Boy "Sky Thunder" and WECO "Superblitzknall", were chosen for the study. The "Sky Thunder" was involved in an incident in the United Kingdom when a steel storage unit containing a number of boxes was damaged when the fireworks exploded. The "Sky Thunder" rocket was found to contain a single flash unit (18.6g) and the "Superblitzknall" had 37g loose flash composition charge.

10. In the 6(a) test, the "Sky Thunder" rocket exploded almost instantaneously and 20% of the rockets were recovered from the test. The witness plate was bowed over full length and material used in the test was thrown less than 2 metres. In the 6(b) test the results were similar to the 6(a) but with many recovered fireworks and many separate explosions. These rockets could not be classified as 1.1G fireworks. The 6(a) and 6(b) tests on the "Superblitzknall" rockets produced similar result to the "Sky Thunder" despite the increased amount of flash composition per rocket.

11. The 6(c) test on the smaller "Sky Thunder" rocket was carried out and this produced the following result

- (a) No perforations of the witness screens.
- (b) Table 3 shows recovery distances of the rockets involved in the test. The rocket effect occurred at these distances.

Table 3: No. of rocket motor bodies recovered from stated distances	
Distance (m)	No motor bodies recovered
>15	73
>25	34
>40	12
>50	6
>60	2
Max. distance recorded = 65m	

12. The classification of the "Sky Thunder" rockets was determined to be 1.3G. The 6(c) test was not carried out on the "Superblitzknall" as this larger rocket would be expected to produce a similar throw and effect of the rockets beyond 15m. The United Kingdom Expert proposes that rockets with up to 60g flash composition effects be classified as 1.3G.

Mines containing flash units - designed to be fired in a mortar tube

13. Two sizes of the above mines (which could be classed alongside bag mines) were chosen as suitable candidates for the UN Tests. The sizes chosen were 100mm (4") and 150mm (6") units containing star and whistle effects with two layers of three flash units at the top of the firework. The 6(a) tests for both mines produced an almost instantaneous explosion with the 150mm firework denting the witness plate. The 100mm mine projected debris further and produced greater sound levels than the 150mm mine.

14. The 6(b) test on the 100mm mine produced essentially a single event (see photo 5) which sent out a shock wave. The witness plate was deformed across the whole surface and debris was thrown over 40 metres. The test area was almost cleared of all material used in the test. Noise measurements of 160.5dB(c) at 75m, 143.6dB(c) at 300m and 137.3dB(c) at 750m were recorded indicating overpressures of 2118.5kPa at 75m, 302.7kPa at 300m, and 146.6kPa at 750m.



Photo 5 – 6(b) test of 100mm mines

15. The 6(b) test on the 100mm mine was more energetic than in the 6(a) test. The witness plate was deformed and there was an almost instantaneous explosion. Debris from the test was thrown a few metres and the noise measurements were greater than the 6(a) test. The 150mm mine test results were not as violent as the 100mm mine and debris from the 6(b) test was thrown a few metres from the test site.

16. The two fireworks both contained perchlorate flash report units and the explosive and flash composition densities of the packages were:

100mm Mine	explosive density = 315.3kg/m ³ flash composition density = 122kg/m ³
150mm Mine	explosive density = 164kg/m ³ flash composition = 49kg/m ³

17. On the basis of the 100mm mine the classification of mines containing flash report units designed to be projected from a mortar tube the UNITED KINGDOM Expert proposes these fireworks should be classified as 1.1G.

Ground Mines

18. The United Kingdom have carried out Test Series 6 tests on 90mm ground mines to determine their classification. The mine chosen was Standard Fireworks Red Ruby Mine which contained less than 90g of pyrotechnic composition, mainly lifting composition, whistles, stars and report units and a fountain, as effects being representative of a the more energetic consumer ground mine. The 6(a) test carried out on Red Ruby Mine "exploded" so feebly that it was concluded that this would exclude propagation of the explosive effect from one package to another in the 6(b) test. The fiery projections from the 6(c) test were projected beyond 5m all but two or three stars fell to the ground within 15m. There were no indentations in the witness screen.

19. The United Kingdom's Expert proposes the default classification of ground mines $\leq 100\text{mm}$ and $\leq 100\text{g}$ pyrotechnic composition should be 1.4G, and all other ground mines as 1.3G

Aerial Shells

20. The United Kingdom have carried out tests on 50mm and 125mm aerial shells. 175mm or smaller aerial shells have been shown not to mass explode in the 6(a) and 6(b) tests (TNO test data, UN/SCETDG/21/INF.3). The United Kingdom carried out 6(c) tests on 50mm and 125mm aerial shells and showed that the 125mm shell should be classified as 1.3G. The 50mm aerial shell did not throw fiery projections beyond 15m and most stars, etc, fell beyond 5m. The United Kingdom would suggest the classification of aerial shells $>50\text{mm}$ should be 1.3G, and $\leq 50\text{mm}$ should be 1.4G. The United Kingdom proposes that the largest dimension of cylindrical shells be used when determining the default classification.

21. The United Kingdom Expert supports the conclusions of the Expert from Japan on the classification of "Shell of Shells" (ST/SG/AC.10/C.3/2002/38) but suggests a limit on the number/percentage of small report shells in the 1.3G category.

Fountains

22. The United Kingdom Experts agrees with the TNO's test data (Section 7.3, UN/SCETDG/21/INF.3) on the 1kg Silver Conic Fountain and proposes that fountains, both conical and cylindrical, less than or equal to 1kg pyrotechnic composition should be classified as 1.4G, and all other fountains as 1.3G.

Wheels and Aerial Wheels

23. Fountains are used as the drivers for wheels and aerial wheels and it would be logical to set the default classification for these items on the limit proposed for fountains, ie. 1.3G for wheels with $>1\text{kg}$ of pyrotechnic composition per wheel, 1.4G for wheels with $\leq 1\text{kg}$ of pyrotechnic composition per wheel.

Sparklers

24. The United Kingdom Expert has reviewed tests carried out in the 1980's on Standard Fireworks sparklers. The sparklers had 10g of composition per stick and the 6(c) test resulted in flames extending to 4 metres from the edge of the packaging. This work would support a classification of 1.4G for sparklers with $\leq 10\text{g}$ pyrotechnic composition per stick.

Roman Candles

25. The recent test carried out at Black Cat fireworks was on a 19 shot roman candle combination. The inner diameter of the tube was 29 mm (the maximum allowed by United Kingdom current default list for 1.4G roman candles). The ejected star unit has a mass of 15g (total NEC in each firework was 380g) and there were three firework articles in a package and five packages were used in the test. The 6(c) test on these fireworks produced fiery projections beyond 5 metres but only four projections just beyond 15 metres. The witness screens had impact marks and indentations of approximately 3 to 5mm but there was no penetration. This test would support a default classification of 1.4G for 29mm id.

Selection Boxes

26. The majority of United Kingdom consumer market fireworks are sold in selection boxes which comprise a number of different types of fireworks such as: rockets, Roman Candles, fountains, mines and wheels. These selection boxes are limited to 1.3G and 1.4G fireworks. UNITED KINGDOM Expert proposes that a new category is included in the default list to incorporate this firework package as follows:

Type	Includes: / Synonym:	Definition	Calibre /Weight	HD
Selection Box	Display Selection Box Garden Selection Box Indoor Fireworks	A package, or packages, of fireworks of more than one type each corresponding to one of the types of fireworks listed in this table.	the most hazardous firework type determines the classification but limited to 1.3G, 1.4G and 1.4S	

Test Data

27. The Series 6 results and videos of the tests carried out by the United Kingdom will be available for the working group meeting.

Default Table

27. The default table in the proposed paragraph "2.1.3.5.6" has been amended to include the United Kingdom test data and is attached as Annex 1.

Annex 1				
Type	Includes: / Synonym:	Definition	Calibre /Weight	HD
Shell, spherical or cylindrical	display shell: aerial shell, colour shell, dye shell, multi-break shell, multi-effect shell, nautical shell, parachute shell, smoke shell, star shell; report shell: maroon, salute, sound shell, thunderclap	device with or without propellant charge, with delay fuse and bursting charge, pyrotechnic unit(s) or loose pyrotechnic composition and designed to be projected from a mortar	all report shells	1.1G
			colour shell: ? 200 mm	1.1G
			colour shell: >50mm and < 200 mm	1.3G
			colour shell: = 50 mm	1.4G
	aerial shell kit, preloaded mortar, shell in mortar	assembly comprising a shell inside a mortar from which the shell is designed to be projected from a mortar	all report shells	1.1G
			colour shell: all sizes or assigned by the competent authority on the basis of test data.	1.1G
	Shell of shells (Spherical shells only)	Device with or without propellant charge, with delay fuse and bursting charge, containing individual small shells and designed to be projected from a mortar	Spherical report shell >120mm	1.1G
			Spherical shell = 120mm containing not more than [25%] small individual report shells	1.3G
			Spherical colour shell > 300mm	1.1G
			Spherical colour shell = 300mm	1.3G
Combination/ batteries	barrage, bombardos, cakes, finale box, flowerbed, hybrid, multiple tubes	assembly including several elements either containing the same type or several types each corresponding to one of the types of fireworks listed in this table, with one or two points of ignition	the most hazardous firework type determines the classification	

Annex 1				
Type	Includes: / Synonym:	Definition	Calibre /Weight	HD
Roman candles	exhibition candle, candle, bombettes	tube containing alternate propellant charge(s), pyrotechnic unit(s) and transmitting fuse(s)	= 30 mm and star effect unit =15g	1.4G
			>30 mm and <50mm	1.3G
			? 50 mm, containing no flash composition	1.2G
			? 50 mm containing flash composition	1.1G
Rocket	avalanche rocket, signal rocket, whistling rocket, bottle rocket, sky rocket, missile type rocket, table rocket	tube containing pyrotechnic composition and/or pyrotechnic units, equipped with stick(s) or other means for stabilisation of flight, and designed to be propelled into the air	? 60g flash composition effect	1.1G
			< 60g flash composition effect	1.3G
			[coloured stars effect	1.3G
			coloured stars effect	1.4G]
mine	pot-a-feu, ground mine	tube containing propellant charge and pyrotechnic units and designed to be placed on the ground or fixed in the ground	> 90mm diameter and > 90g pyrotechnic composition	1.3G
			= 90mm diameter and = 90g pyrotechnic composition	1.4G
	bag mine, cylinder mine	bag or cylinder containing propellant charge and pyrotechnic units and designed to be placed in a mortar	report as primary effect	1.1G
			Other	[1.3G 1.4G]
Fountains	volcanoes, gerbs, showers, falls, rains, lances, Bengal fire, flame projectors, flitter sparkle, cylindrical fountains, cone fountains, illuminating torch, tourbillions, strobes, whistle	non-metallic case containing sparks- and flame producing pyrotechnic composition	? 1kg pyrotechnic composition	1.3G
			<1kg pyrotechnic composition	1.4G

Annex 1				
Type	Includes: / Synonym:	Definition	Calibre /Weight	HD
sparklers	handheld sparklers, non-handheld sparklers, wire sparklers, dipped sticks	rigid wire or thin stick partially coated (along one end) with slow burning pyrotechnic composition. with or without an ignition tip	> 10 g pyrotechnic composition per item	1.3G
			= 10 g pyrotechnic composition per item	1.4G
low hazard fireworks and novelties	table bombs, throw downs, crackling granules, smokes, fog, chaser, snakes, glow worm, serpents	device designed to produce very limited visible and/ or audible effect which contains small amounts of pyrotechnic and/ or explosive composition	All	1.4G
spinners	aerial spinners, helicopters, ground spinners	non-metallic tube or tubes containing gas- or spark-producing pyrotechnic composition, with or without noise producing composition, with or without aerofoils attached	pyrotechnic composition per item > 20 g	1.3G
			pyrotechnic composition per item ? 20 g	1.4G
wheels	Catherine wheels, Saxon	assembly including a non-metallic tube or tubes containing pyrotechnic composition and provided with a means of attaching it to a support so that it can rotate	? 1kg pyrotechnic composition	1.3G
			<1kg pyrotechnic composition	1.4G
aerial wheels	flying Saxon, UFO's, rising crown	tubes containing propellant charges and sparks-flame- and/ or noise producing pyrotechnic compositions, the tubes being fixed to a supporting ring	? 1kg pyrotechnic composition	1.3G
			<1kg pyrotechnic composition	1.4G
Selection Box	Display Selection Box, Garden Selection Box, Indoor Selection Box	A package, or packages, of fireworks of more than one type each corresponding to one of the types of fireworks listed in this table.	the most hazardous firework type determines the classification but limited to 1.3G and 1.4G	