Research paper

UN classification tests of fireworks and concrete cracker

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Abstract

From Jan. 2004, the confirmation of the package of explosives by the head of the domestic transportation department is needed during the transportation of ships in Japan. Concerning some explosives, a full scale UN test is needed. Concrete cracker and two types of toy fireworks (*hand held torch* and *smoke*) were selected as a UN full scale test sample. We have conducted the 6(a) and 6(c) test which is known as a single package test and a bonfire test, respectively. The UN 6(a) test is a test on a single package to determine if there is mass explosion of the contents. The UN 6(c) test is a test performed on packages of an explosive substance or explosive articles, or unpackaged explosive articles, to determine whether there is a risk of mass explosion or a hazard from dangerous projection, radiant and/or violent burning or any other dangerous effects when involved in a fire. In the UN 6(c) test, the thermal flux effect was evaluated by a radiometer and a burning time. As a result, concrete cracker is assigned to Division 1.4, both of the toy fireworks were assigned to Division 1.4 S.

Keywords: UN classification test, Toy fireworks, Concrete cracker, Single package test, Bonfire test

1. Introduction

At the latter half of 1990 according to the USA proposal; IMDG code provided that the certification of UN classification of explosives, which is classified by the UN classification test and is published by the competent authority, is necessary to acquire. After that, due to the amendment SOLAS (The international convention for the safety of life at sea) agreement in 2000, the application of the IMDG code became mandatory. From Jan. 2004, the confirmation of the package of explosives by the head of the domestic transportation department also became mandatory during the transportation by ships in Japan.

Concerning some explosives, a full scale UN test should be conducted. All of the toy fireworks, except flying-type fireworks are assigned to Division 1.4 S. Flying type fireworks such as rocket fireworks were assigned to Division 1.4 G.

Two types of toy fireworks (*hand held torch* and *smoke*) were selected as full-scale test samples to prove Division 1.4 S. The reason why *hand held torch* was selected is that the radiation of heat is the maximum value in all of the toy fireworks due to the quality and quantity of explosive. The reason why *smoke* was selected is that the smoke contains 10 g of explosives while the smoke type explosives assigned in 1.4 G by DCS (default classification system) contains 5 g or less. Our main objective is to confirm that these toy fireworks are assigned to Division 1.4 S. In both of the toy fireworks, the explosives are packaged by paper, one by one. As there is no probability of mass explosion, UN 6(a), 6(b) test was skipped.

We also focused on the concrete cracker. Concrete cracker is an explosive substance to destroy a concrete structure and the bedrock. In case of concrete cracker, there are some probabilities of mass explosion, we have conducted UN 6(a) test.

To estimate the heat of combustion, the heat of combustion was measured by bomb calorimeter in Air condition and O_2 pressured condition. We also focused on the radiative fraction.

2. Experimental procedure of UN 6(a) test (No.1-1)

2.1 Sample of concrete cracker

One package of concrete cracker is selected as a test sample. One package (L 550 mm × W 295 mm × H 170 mm) of concrete cracker contains 25 concrete crackers (cylindrical main body and igniter) × 2 boxes (total 50 substances) (Fig. 1(a)). Diameter and length of cylindrical main body is 50 mm and 127 mm, respectively. The explosive substance in the concrete cracker is composed of 180 g bromate. The explosive substance in the igniter is composed of 0.5 g barium peroxide. The amount of total explosives in one package was 9.03 kg.

2.2 Experimental method

The experiment followed UN test specification of UN 6(a) [1], and executed. The package was set on the witness plate (900 mm × 900 mm × 3.2 mmt, SS 400) (Fig 2). The surroundings were covered with dry sand of 50 cm or more in thickness. The igniter was installed on one concrete cracker in the vicinity of the center of the package. The igniter was fired by the blasting machine.

2.3 Measurements

It was observed whether there was evidence of the thermal effect, projectiles, detonation and deflagration, and mass explosion. After the experiment, the witness plate was checked. Sample detonation is determined by examining the witness plate. The criteria for detonation is that the witness plate is torn or penetrated. The explosion situation was recorded with the video. DV1 (SONY, DCR-TRV 900) and DV2 (Panasonic, NV-MX 5000) were used as the video cameras. Both of video cameras were set at 41 m from firing point.

3. Experimental procedure of UN 6(c) test (No.1-2, No.2-1, No.2-2)

3.1 Sample of explosives

Concrete cracker and two types of toy fireworks were used in this work. In case of concrete cracker, six packages of concrete cracker were used. The package was same as UN 6(a) test sample, which was written in previous section. In case of toy fire works, one was *hand held torch* and the other was *smoke* (Fig. 1). In the case of *hand held torch*, we enjoy the spouting flame as we hold it in our hand. In the case of *smoke*, we enjoy gush of smoke from it. The amount of explosives a piece was 13.5 g and 10.0 g, respectively. One package (L 680 mm × W 430 mm × H 317 mm) of *hand held torch* contained 20 hand held torches × 21 boxes (total 420 substances). Each package contains 5.67 kg of explosives. Three packages of the sample (total 17.01 kg) were used in this work. One package (L 495 mm × W 316 mm × H 402 mm) of *smoke* contained 30 explosive substances × 30 boxes (total 900 substances). Each package contains 9.00 kg of explosives. Three packages of samples (total 27.00 kg) were used in this work. Table 1 shows the amount of explosives.

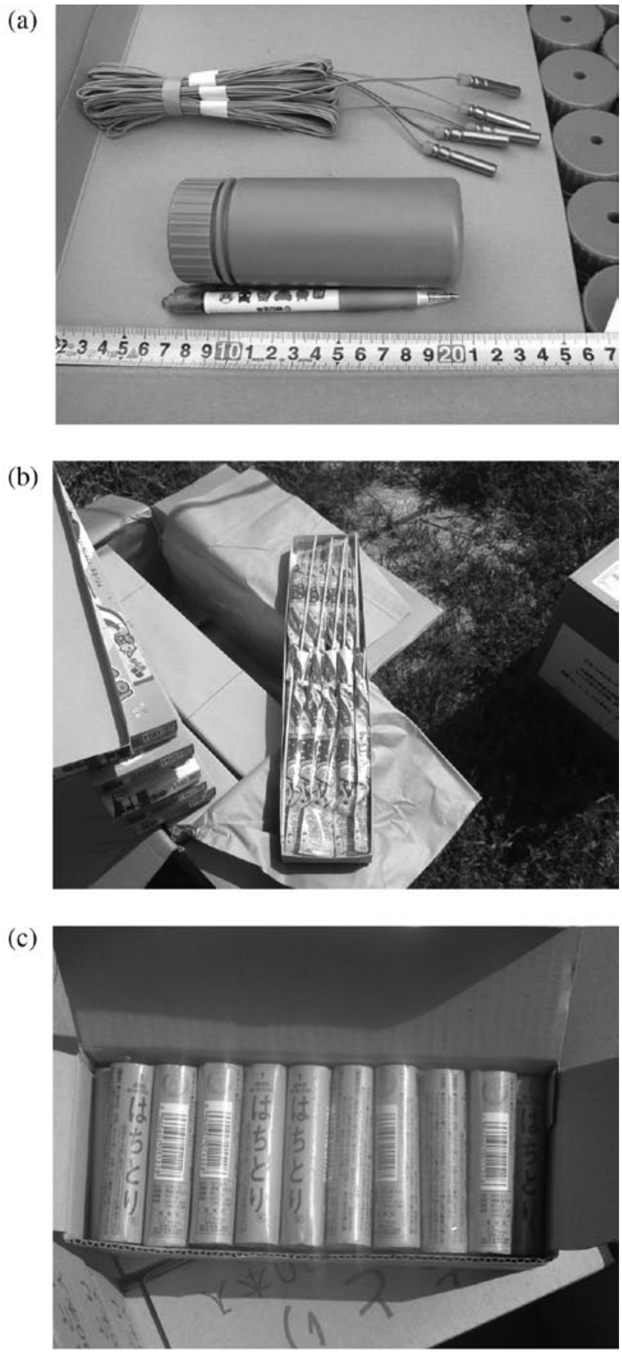

Fig. 1 Photograph of samples, (a) No. 1-2: "concrete cracker", (b) No. 2-1: "*hand held torch*", (c) No. 2-2: "*smoke*".

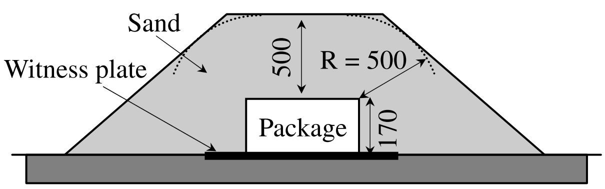

Fig. 2 Experimental setup of UN 6(a) test (No.1-1).

Table 1 Amount of explosives.

Experimental No.	No. 1-2	No. 2-1	No. 2-2
Number of articles	Six boxes 300 pieces	Three boxes 1260 pieces	Three boxes 2700 pieces
Name of explosives	Concrete cracker*1	*Hand held torch**2	*Smoke**2
Explosives	54.00	17.01	27.00
Ignition charge	0.15	0.00	0.00
Total amount of explosives (kg)	54.15	17.01	27.00

*1 Explosives 180 g (mainly consisted of bromic salt), Ignition charge 0.5 g
*2 *Hand held torch* 13.5 g $piece^{-1}$, *smoke* 10.0 g $piece^{-1}$

3.2 Apparatus and materials

The experiment was conducted according to the UN test specification of the UN 6(c) test[1)]. Three packages of the sample were placed on a trestle and fixed with wire. The combustion pan was an SD-type end plate (ID=2000 mm, SS 400, 6 mm^t). The frame of the trestle was 1000 mm square and 500mm in height. A metal grid was used to support the packages above the fuel. 154 ℓ (123 kg) of kerosene (density 0.8 g cm^{-2}) was burned to maintain continuous burning for 30 minutes. The liquid depth of kerosene in center part is 15.5 cm. A witness plate (2000 mm × 2000 mm × 2 mmt, 1100-0) was set at a distance of 4 m from the edge of the packages. The damage to the witness plate was checked after the experiment. Schematic diagram and photograph are shown in Fig. 3 and Fig. 4. The volume of packages should be more than 0.15 m^3 according to the UN test specification. So the appropriate packages were prepared each experiment.

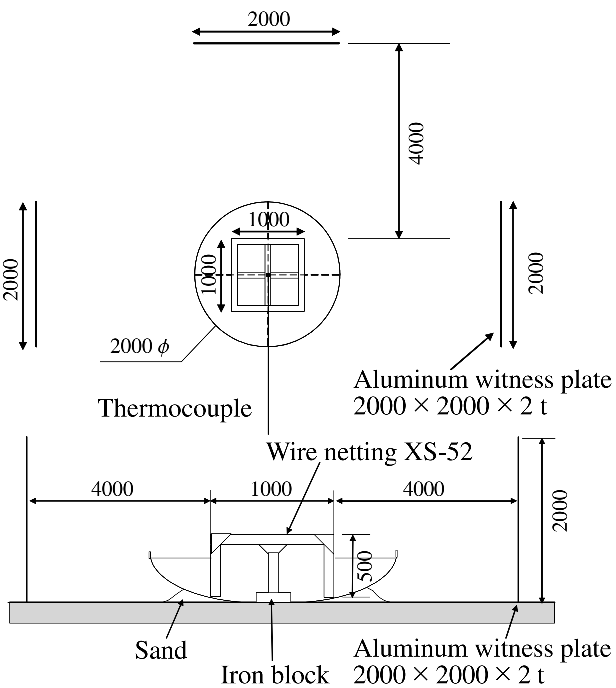

Fig. 3 Setting of a trestle and witness plate.

3.3 Measurements

To observe combustion, flying materials, and jet fire, two sets of video camera systems (DV1, DV2) were used. DV1 (SONY, DCR-TRV 900) and DV2 (Panasonic, NV-MX 5000) were set at a distance of 42 m and 45 m from the firing point, respectively.

K-type sheathed thermocouples (O. D.=1.0 mm, length=1.6 m) were used, flame temperature and center of package temperature were measured. The data was recorded on the data recorder (HIOKI, 8855)

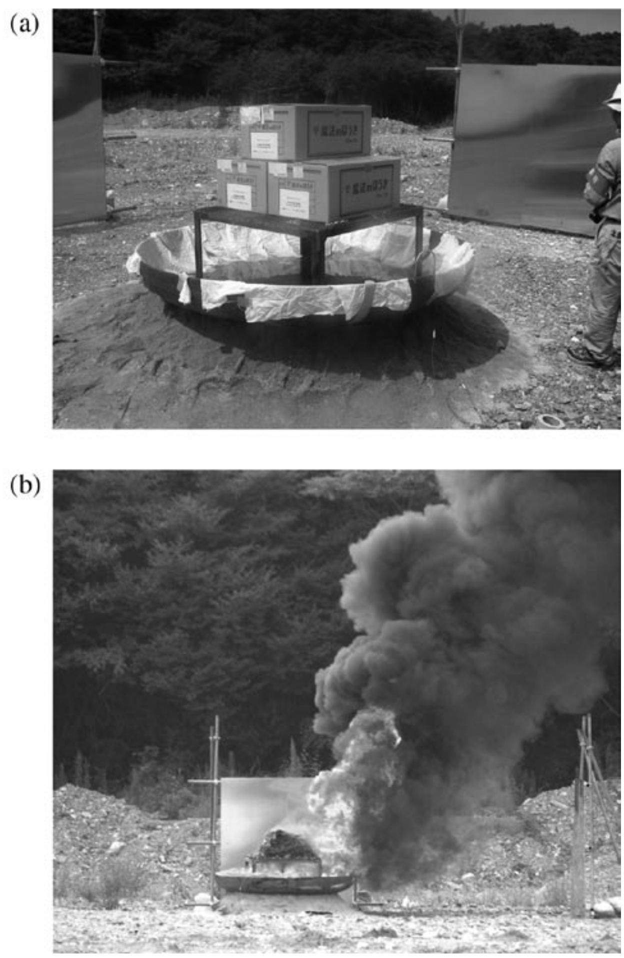

Fig. 4 Photograph of heating system and witness plate (a). Test system when the sample was burning (b).

Table 2 Position of the radiometer and conversion coefficient of irradiance.

Exp. No.	Amount of explosives (Kg)	Distance of radiometer (m)*1		Conversion coefficient of radiometer*2		Conversion coefficient of radiometer*3	
		Ch. 3	Ch. 4	Ch. 3	Ch. 4	Ch. 3	Ch. 4
No.1-2	54.15	15.60	15.20	14.66	13.92	1.63	1.55
No.2-1	17.01	15.55		31.50		3.50	
No.2-2	27.00	15.41		22.73		2.53	

*1 The distance from the edge of article, height is 1.4 m.
*2 In case that the radiometer is set at 5 m distance and the amount of explosives is 100 kg ($(W/100)^{2/3}$)
*3 In case that the radiometer is set at 15 m distance and the amount of explosives is 100 kg ($(W/100)^{2/3}$)

To evaluate the heat of combustion of fuel and explosives, a radiometer (RE-2, Tokyo Seiko Co. Ltd., 1-9 kW m^{-2} range) was used, which was located at 15 m distance from the edge of the package and 1.4 m in height using a tripod (Table 2). The radiometer is thermopile type. The filter (KRS-6, 0.5-27 μm) was attached on the detector front for the prevention of the airflow. The recorded voltage value (mV) was transformed to irradiance (W m^{-2})

In combustion experiments, bomb calorimeter was used. The evaluation of the irradiance of explosives is needed in UN 6(c) test. However, we can only measure the irradiance of explosives with kerosene in UN 6(c) test. To solve this problem, we should conduct the background experiment (pool fire experiment of kerosene). But the time and cost was limited, and the background experiment could not be conducted in this work. As the evaluation of combustion energy of kerosene and explosives is needed to estimate the radiative fraction, the combustion energy was experimentally measured. Two types of combustion experiments were conducted. One is 3 MPa O_2 condition, the other is air condition. To measure complete combustion energy, the experiments under 3 MPa O_2 condition is appropriate. The calorimeter was calibrated by means of calorimetric standard benzoic acid (thermo chemical standard, JCSS). The samples were fired by means of nickel wire (ϕ = 0.1 mm). The volume of bomb calorimeter is 250 cm^3. In O_2 condition experiments, a gelatine capsule 00 (18.56 kJ g^{-1}) was used, because sample scattering was prevented and complete combustion could be established. In air condition experiments, combustion pan was used. Concrete cracker and toy fireworks are normally used under atmospheric air. In case of UN 6(c) test, these explosives are burnt by kerosene, as a result that the combustion energy might be of complete combustion (under O_2 condition). The combustion energy under atmospheric air was measured for the reference.

4. Results and discussion of UN 6(a) test of concrete cracker (No. 1-1)

4.1 Experimental results

There is a lot of smoke from the sample since one minute after the ignition. After a couple of minutes, smoke was almost settled, and extinguished completely in 2.5 minutes. It was confirmed that there were no projectiles by the field investigation and the video. There was completely neither dent nor damage on the witness plate. There was no dispersion thing at all, and the upper part of the covered sand was bored.

4.2 Discussion

The crater was not generated in the vicinity of the examination place, and the witness plate was not damaged. After the experiment, the side part of the sand did not break, and was the state as it had been, and the blast was not generated. It was confirmed that there was no explosion and no dispersion of the sample after the experiment. Since mass explosion did not occur, it was not assigned to Division 1.1 by this UN 6(a) test. UN 6(a) test is followed by UN 6(b) test to conduct further examination of explosives. UN 6(b) test is called as stack test, and aimed at investigating how an explosion in a package influences to the surrounding packages. However, in this UN 6(a) test, the package of concrete cracker was burned only in its corners. The rest of it including top, bottom, and side remained without burning. (Fig. 5) Therefore, no effect of the explosion on other packages is expected. We conclude that it is reasonable to omit UN6 (b) test on concrete cracker.

Fig. 5 Photograph of package of concrete cracker after experiments in UN 6(a) test.

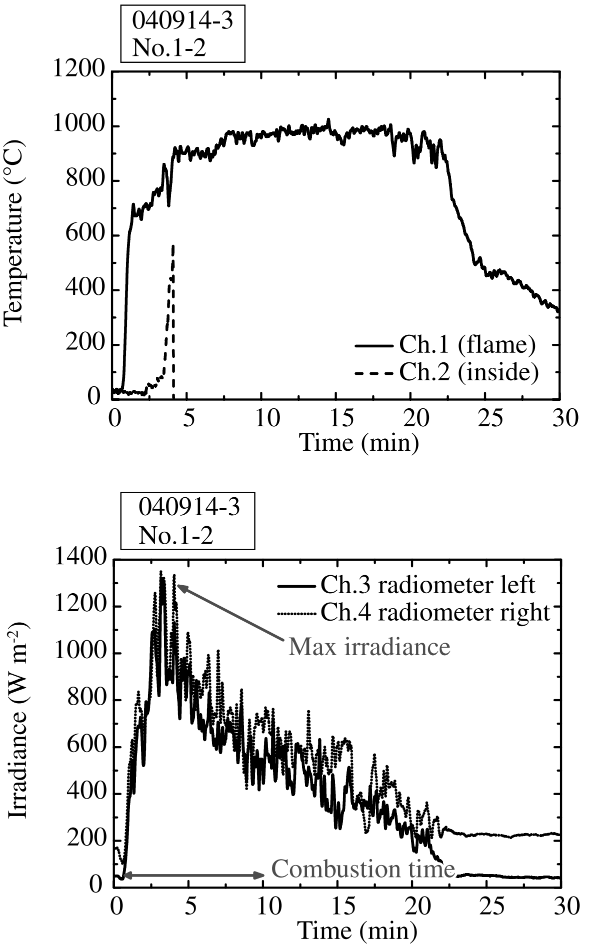

Fig. 6 Temperature and heat of radiation, *concrete cracker* (No. 1-2).

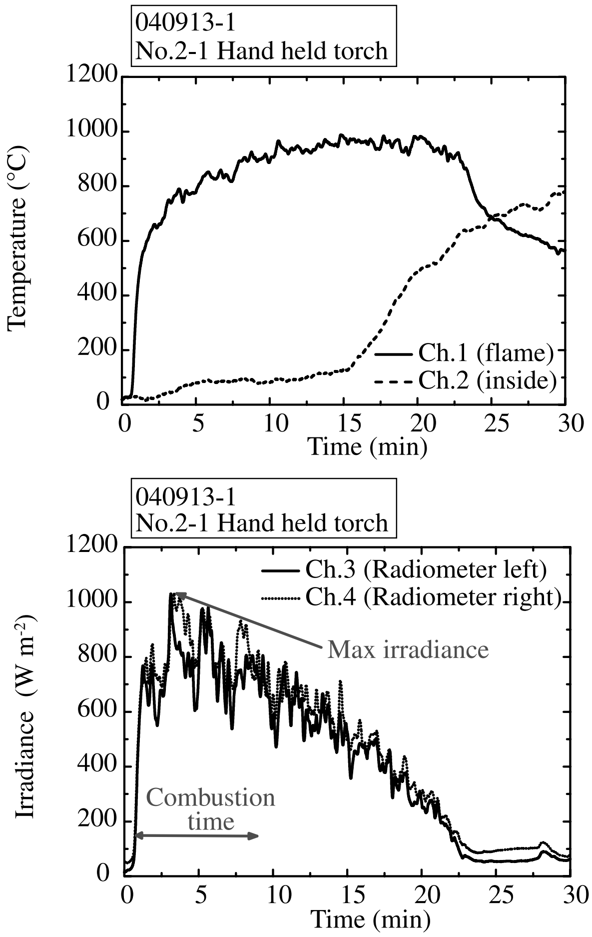

Fig. 7 Temperature and heat of radiation, *hand held torch* (No. 2-1).

5. Results and discussion of UN 6(c) test (No. 1-2, 2-1, 2-2)

5.1 Combustion behaviour, temperature and irradiance

The data obtained from radiometers have been used to plot the variation of irradiance as a function of time (Fig. 6, Fig. 7, and Fig. 8). In every experiment, combustion behaviour was observed for about 22 minutes; the fire was extinguished after 25 minutes.

The UN orange book [1] shows that the heat flux should be evaluated from a distance of 5 m and 15 m using 100 kg of explosives. Conversion coefficients are listed in Table 2. Irradiance of explosives is decided as follows. The irradiance of the kerosene flame is subtracted from the measured radiant heat as a base line. Pan diameter is D =2.0 m and radiometer was set at L =15 m from center of the combustion pan. Koseki et al [2] shows that irradiance of heptane is expressed following equation.

$$q = 35(LD^{-1})^{-2} \tag{1}$$

where q(kW m^{-2}) is irradiance, L (m) is radial distance from the tank center to the radiometer and D (m) is the tank diameter. If the irradiance of kerosene and heptane is nearly same, we can use this equation. In case of $L\ D^{-1}$ = 7.5 (L =15 m, D =2 m), q is equal to 0.62 kW m^{-2}.

Yumoto *et al.* [3] shows that the irradiance from pool fire can be estimated from pan diameter, flame size and shape, and distance. In case of kerosene, the flame height can be approximated to 1.5 D height and drum shape. Radiant emittance of 2 m combustion pan is 70 kW m^{-2} and foam coefficient is calculated as 0.00871. From these results, q could be calculated to 0.61 kW m^{-2}. Therefore in this work, the irradiance of kerosene at $L\ D^{-1}$=7.5 point is estimated as 0.61 kW m^{-2}.

Table 3 Measurement of heat of combustion using bomb calorimetry.

	Air condition (kJ g^{-1})	3MPa O_2 condition (kJ g^{-1})
Black powder	3.93 ± 0.15	5.91 ± 0.10
Hand held torch	5.01 ± 0.20	6.65 ± 0.60
Smoke	2.06 ± 0.05	7.05 ± 0.21
Concrete cracker	3.40 ± 0.31	10.89 ± 0.62

Table 4 Estimated irradiance of explosives using conversion coefficient.

Exp. No.	Irradiance ($kW\ m^{-2}$), 15 m, experimental data	Irradiance ($kW\ m^{-2}$), 5 m, 100 kg	Irradiance ($kW\ m^{-2}$), 15 m, 100 kg
No.1-2	0.64~0.69	9.15~9.86	1.02~1.10
No.2-1	0.34~0.39	10.71~12.29	1.19~1.37
No.2-2	0.19~0.21	4.31~4.77	0.48~0.53

To judge the border of the irradiance according to the UN orange book, the amount of explosives and the distance need to be standardized to 100 kg and 5 m and 15 m, respectively. Table 4 shows the estimated irradiance of explosives using the conversion coefficient, which is listed in Table 2.

5.1.1 Concrete cracker (No. 1-2)

There was a lot of smoke at 4 minutes after the ignition. The combustion period of explosives was about 10 minutes. The weight of concrete cracker's explosives was total 54.15 kg, The threshold period of Division 1.3/1.4 is $330 \times (54.15 \times 100^{-1})^{1/3} = 269$ s and the combustion period was longer than 269 s. The flame temperature increased to 700 °C, 1 minute after ignition. The temperature then reached 1000 °C and the flame temperature drastically decreased after 22 minutes (Fig. 6). The thermocouple of connection part broke because of the intense heat. Maximum value of the irradiance was approximately 1.25-1.30 kW m^{-2} at 3 minutes after ignition. The base line of kerosene was decided as 0.61 kw m^{-2} and the irradiance of explosives is 0.64-0.69 kW m^{-2}. Detail data were shown in Table 4.

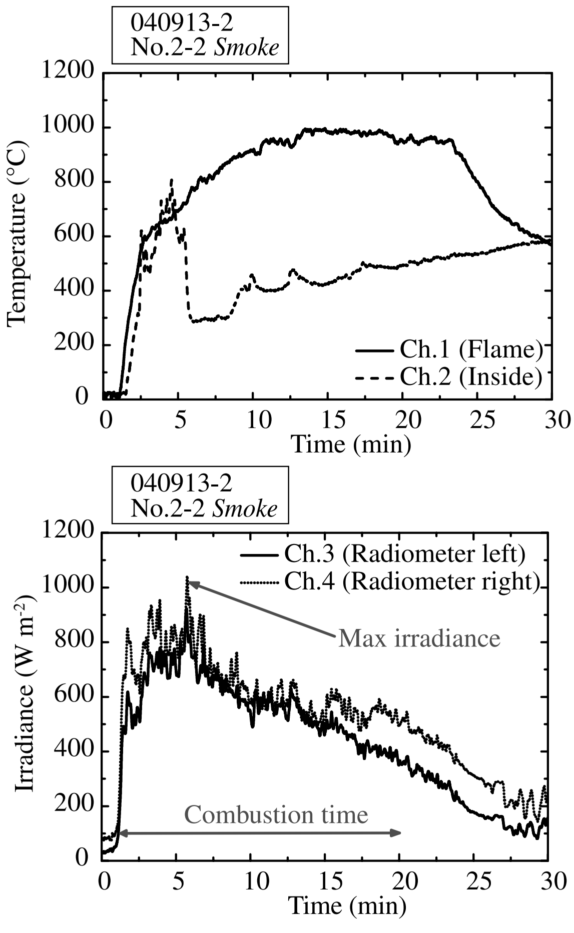

Fig. 8 Temperature and heat of radiation, *smoke* (No. 2-2).

5.1.2 Toy fireworks *hand held torch* (No. 2-1)

There was a lot of flame and smoke at 3-5 minutes after the ignition. The combustion period of explosives was about 7 minutes. The explosive weight of hand held torch was 17.01 kg, the threshold time of Division 1.3/1.4 is $330 \times (17.01 \times 100^{-1})^{1/3} = 183$ s and the combustion period was longer than 183 s. The flame temperature increased to 700 °C, 1 minute after ignition. 15 minutes after ignition, the inside temperature was gradually increased to 800 °C (Fig. 7). 16 minutes after the ignition, the inside temperature was less than 100 °C because the corrugated box was not burned and worked as a thermal insulator. The flame temperature reached 1000 °C and the flame temperature drastically decreased after 22 minutes. Maximum value of the irradiance was approximately 0.95-1.00 kW m^{-2}. As the base line of kerosene was 0.61 kW m^{-2}, the maximum irradiance of the explosives was approximately 0.34-0.39 kW m^{-2}. Detail data was shown in Table 4.

5.1.3 Toy fire works *smoke* (No. 2-2)

There was a lot of flame and smoke at 3-5 minutes after the ignition. The combustion period of toy fireworks is more than 20 minutes. The explosives weight of *smoke* is total 27.0 kg, the threshold period of Division 1.3/1.4 is $330 \times (27.0 \times 100^{-1})^{1/3} = 213$ s and the combustion period is longer than 213 s. The inside temperature increased after the ignition, and reached 700 °C, then drastically decreased to 300 °C, then gradually increased to 600 °C till the end of experiment (Fig. 8). The combustion period of explosives is about 20 minutes from the movie. Continuous and maximum value of irradiance (average of both of radiometer) was about 0.83 kW m^{-2} at 3-4 minutes after ignition. The maximum irradiance of the explosives was 0.19-0.21 kW m^{-2}.

5.2 Heat of radiation

Heat of combustion of toy fireworks and concrete cracker was measured using a commercially available bomb calorimeter. The measured heat of combustion is listed in Table 3. The packages of toy fireworks are mainly composed of paper. The heat of combustion of paper (cellulose) [4] and kerosene [5] are listed in Table 5.

Heat of radiation is calculated by the following procedure. The radiation, which is assumed to be spherical in direction, is calculated from integration of irradiance and time in Fig. 6, Fig. 7, and Fig. 8. Heat of radiation is calculated from the product of the irradiance and the surface area of a 15m spherical body. In every experiment, the radiative fraction (the ratio of heat of radiation to heat of combustion) is approximately 0.4 (Table 6). A combustion experiment using five types of fuels such as LNG and methanol was conducted using a different diameter by Burgess et al [6]. As a result they reported that the radiative fraction ranges from 0.2-0.4. Koseki et al [2] reported that the relation between radiative fraction and pan diameter (0.2-50 m) of liquid fuel such as gasoline, kerosene, heptane, etc. In case the pan diameter is 2 m, radiative fraction is approximately 0.4. The ratio of the radiative fraction is in good agreement with the previous work. (Fig. 9)

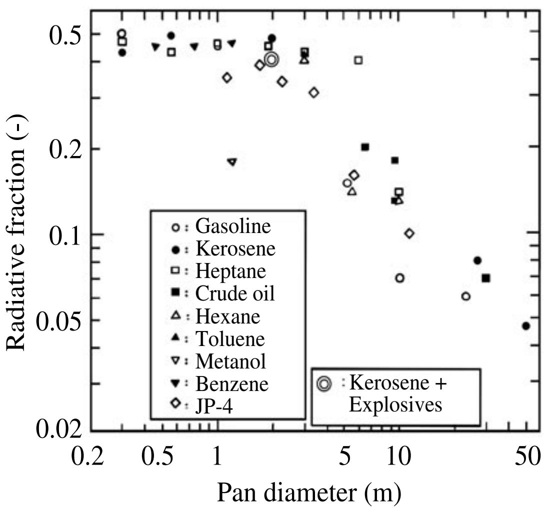

Fig. 9 Relation between radiative fraction and pan diameter of pool fire: about liquid fuel.

5.3 Witness plate and projectiles

The energy of flying objects is estimated by the following equation. This equation was led from the classical mechanics.

$$W = 0.5\ mgl \tag{2}$$

where, m(kg) is the mass of projectiles, g is acceleration of gravity which is 9.8(m s^{-2}) and l(m) is the distance from the combustion pan.

5.3.1 Concrete cracker

On the witness plate, there were six dents of 0.5 mm. The igniters which are collided with witness plate. The collision sound was confirmed. Thirty six pieces of projectiles

Table 5 Heat of combustion of toy fireworks and kerosene.

Exp. No.	Materials	Heat of combustion (kJ g^{-1})	Total amount (kg)	Heat of combustion (MJ)	Ratio (%)	Subtotal of heat of combustion (MJ)
No.1-2	Concrete cracker explosives	10.9	54	589	8.8%	6,698
	Concrete cracker plastic	43.3	8	328	4.9%	
	Kerosene	47.0	123	5,781	86.3%	
No.2-1	Hand held torch explosives	6.7	17	113	1.8%	6,120
	Hand held torch paper	13.2	16	216	3.5%	
	Kerosene	47.0	123	5,790	94.6%	
No.2-2	Smoke explosives	7.0	27	190	2.9%	6,515
	Smoke paper	13.2	41	535	8.2%	
	Kerosene	47.0	123	5,790	88.9%	

Table 6 Comparison between heat of combustion and that of radiation.

Exp. No.	Channel of radiometer	Subtotal of heat of combustion (MJ)	Integral of radiation* (kW m^{-2}s)	Heat of radiation (MJ)	Ratio (%)	Radiative fraction (%)
No.1-2	Right (ch.3)	6,698	696	2,128	31.8%	37.1%
	Left (ch.4)		927	2,835	42.3%	
No.2-1	Right (ch.3)	6,120	761	2,312	37.8%	39.9%
	Left (ch.4)		845	2,568	42.0%	
No.2-2	Right (ch.3)	6,515	771	2,301	35.3%	39.2%
	Left (ch.4)		939	2,802	43.0%	

* Measured radiation intensity at 15 m point

Table 7 Test criteria of this work.

UN classification		Test criteria	Results No. 1-2 Concrete cracker	No. 2-1 *Hand held torch*	No. 2-2 *Smoke*
1.1	a)	A mass explosion.	No	No	No
1.2	b) 1)	Perforation of any of the witness screens.	No	No	No
	b) 2)	Metallic projection with a kinetic energy of 20 J as assessed by the distance.	No	No	No
1.3	c) 1)	A fireball or jet flame which extends beyond any of the witness screens.	No	No	No
	c) 2)	A fiery projection emanating from the product is thrown more than 15 m from the edge of the packages.	No	No	No
	c) 3)	Burning time of the product was measured to be less than 35 sec for 100 kg of net explosive mass.	No	No	No
	c) 4)	Alternatively of c)3), the irradiance of the burning product exceeds that of the fire by more than 4 kW m^{-2} at a distance of 15 m from the edge of the packages.	No	No	No
1.4	d) 1)	A fireball or jet of flame, which extends more than 1 m from the flames of the fire.	No	No	No
	d) 2)	A fiery projection emanating from the product is thrown more than 5 m from the edge of the packages.	No	No	No
	d) 3)	An indentation in any of the witness screens of more than 4 mm	No	No	No
	d) 4)	A metallic projection with a kinetic energy of 8 J as assessed by the distance.	No	No	No
	d) 5)	Burning time of the product measured to be less than 330 sec for 100 kg net explosive mass.	No	No	No
	Ref.	Alternatively of d)5), the irradiance of the burning product exceeds that of the fire by more than 4 kW m^{-2} at a distance of 5 m from the edge of the packages.	(Yes)	(Yes)	(Yes)
1.4 S	e)	The thermal, blast, or projection effects significantly hinder fire-fighting or other emergency response efforts in the immediate vicinity.	Yes	No	No

flew out from the combustion pan. The projectiles are all igniters of concrete cracker. The distance from the combustion pan was range from 35 cm to 1612 cm. The maximum weight of igniters was 2.0 g. As a result the calculated maximum flying energy from *equation (2)* is 0.15 J. These projectiles of igniters will affect significantly hinder fire-fighting in the immediate vicinity.

5.3.2 Toy fireworks *hand held torch*

There was no damage to the witness plate, and no projectiles were observed in the recorded video.

5.3.3 Toy fireworks *smoke*

There was no damage to the witness plate. Four pieces of projectile flew out around the combustion pan. The distance from the combustion pan was 108, 120, 190, and 240 cm, respectively. The maximum weight of projectiles was 9.4 g. As a result the calculated maximum flying energy from *equation (2)* is 0.11 J at most. As the projectiles are 10 g and the flying distance is 2.4 m at most, the projectiles may not disturb fire fighting activities at close range.

5.4 Test criteria of this work

Test criteria of this work are listed in Table 7.

6. Conclusion

Following experiments were conducted to confirm the UN classification of explosives. In case of *hand held torch* and *smoke*, UN 6(c) test was conducted, in case of concrete cracker, UN 6(a) and UN 6(c) test was conducted. The following results were obtained.

1. The irradiance of concrete cracker (9.2-9.9 kW m^{-2}), *hand held torch* (10.7-12.3 kW m^{-2}), and *smoke* (4.3-4.7 k kW m^{-2}) at 5 m/100 kg is beyond 4 kW m^{-2} which is criteria of Division 1.3/1.4. But, the combustion time of every explosive is under the criteria of Division 1.3/1.4.
2. Both toy fireworks; *hand held torch* and *smoke* did not have mass explosion, the thermal, blast, or projection effects nor hinder fire-fighting or other emergency response efforts in the immediate vicinity, so the products are assigned to Division 1.4 Compatibility Group S.
3. Concrete cracker did not have mass explosion in UN 6(c) test, the igniter flew away from combustion pan. This may hinder fire-fighting in the immediate vicinity. Concrete cracker is assigned to Division 1.4.
4. The radiative fraction is approximately 0.4 in all tests.

7. Acknowledgements

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火薬類(がん具煙火およびコンクリート破砕器)の国連分類試験

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2004年1月より，日本国内における火薬類の船舶輸送は地方運輸局長の確認が必要で，いくつかの火薬類について国連分類実証試験が必用となった。そこでコンクリート破砕器およびがん具煙火（すすき，煙幕）を国連分類実証試験の試料として選択し，国連 6（a）試験（単一包装試験）および国連 6（c）試験（外部火災試験）を実施した。国連 6（a）試験は単一包装が大量爆発するか否かを決定する為の試験である。国連 6（c）試験は，火薬類の包装が火災に包まれた場合に，大量爆発，危険な飛散物，激しい燃焼，その他の危険な効果が有るかどうかを決定する為の試験である。国連 6（c）試験では，熱流束を放射熱および燃焼時間で評価した。その結果，コンクリート破砕器は危険区分1.4，がん具煙火（すすき，煙幕）はどちらも 1.4 Sに分類された。

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