MADE IN THE UK

FIREDRAGON

GREEN & CLEAN FUEL

“Fuel for the Future”
February 2022

Fuel: CN336MOD
DMC: ORP
NSN: 9110-99-426-2694

Stove: RP337A
DMC: ORP
NSN: 7310-99-587-4226

BCB Technical White Paper

For

FIREDRAGON

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Version Control

Version	Date	Author
V2	22/02/18	KG
V3	17/04/18	KG
V4	19/11/18	BH
V5	23/11/18	BH
V6	25/01/19	KK
V7	29/01/19	KK
V8	22/03/19	KK
V9	05/07/19	BH
V10	19/07/2019	KK/BH
V11	30/08/2019	KK

Version	Date	Author
V12	02/10/2019	KK
V13	18/02/2020	BH/KK
V14	09/11/2021	JR
V15	8/2/21	SC

Contents

1. Preamble

Soldiers have for many years been commenting on their need for a fuel that can be used quickly in combat situations; one that is easy to light, safe to carry, and can be used in confined spaces.

Problems with hexamine blocks include variable burning performance, formation of toxic gases when used, harmful if ingested, headaches from breathing in the fumes. Non-environmentally friendly and tainting the taste of food being cooked or stored with it.

FireDragon Solid fuel is the result of collaboration between BCB International and world leading experts at Cardiff University. FireDragon Solid is unique and has been patented (GB patent No. 2500062) worldwide. Designed and made in Britain.

This next generation fuel is a **non-toxic, high-performance**, and **cost-effective product** designed to deliver the professional solider with a fuel that can meet the demands of the modern military arena.

2. Key Features

- High calorific value approximately 28,000 (MJ/Kg)
- Made from **sustainable**, naturally derived bioethanol
- Each block **burns for approximately 7-8 minutes**, with two blocks burning for 12-14 minutes
- **Recyclable packaging -o- Made from renewables -o- High burn output**
- Worldwide patented (GB 2500062)
- Unburnt and exposed FireDragon degrades safely
- **Waterproof, lightweight, easy to light**

Can be packed in with your combat rations or MRE's as it is non-toxic.
Does not give off cyanide or formaldehyde when burnt.

- FireDragon improved heating and boiling compared to Hexamine by 17% to 33%
- Non-toxic, powerful solid cooking fuel
- Solidified ethanol, **environmentally friendly**
- Significant advantages over hexamine, flameless heaters and methyl esters

    ✓ Non-toxic, environmentally friendly
    ✓ Can be packed alongside food
    ✓ Fast boil and long burn – high heat output (better than alternatives)
    ✓ Easy light (spark)
    ✓ **Clean burn** (doesn't dirty cooking equipment)
    ✓ **Very little smoke or soot given off**
    ✓ **Will light and burn even when wet**
    ✓ Air transportable
    ✓ Safe for indoor use
    ✓ Low luminosity flame
    ✓ Odourless burn
    ✓ Also effective as a hand sanitiser and waterless soap

- Can be used in a range of existing cooking systems
- Innovation award 2015.

3. FireDragon Products

3.1 FireDragon Gel Fuel

Our new all-weather gel biofuels are also made from UK sourced ethanol, which can be used in a host of multi fuel cooking stoves, barbecues, and fires.

Cooking rations and boiling drinks quickly. Whilst safeguarding health and protecting the environment. It is **non-toxic, non-drip** and made from **100% natural ingredients**. It is easy to light, burns cleanly, and our research shows that it **boils water faster** than methylated spirits (meths).

FireDragon Gel is supplied in two sizes: 1Litre (right) and 250 ml (left).

3.2 FireDragon Solid Fuel

Comprised of sustainably sourced ethanol, the solid ethanol fuel blocks are **lightweight, easy to light,** and **waterproof**. These features make it suitable for **cooking, fire lighting** and **boiling water** in all weather conditions.

The solid FireDragon removes the possibility of **spillage** accidents since it is not free flowing. Spillage of fluids from their packaging does not solely occur whilst in use but is also possible during storage and transport. FireDragon solid negates these risks as the fuel cannot leach out if the package if it were to be damaged; it will remain in the packaging or at least as a single block, which can be easily contained and cleaned.

Fuel:CN335MOD
DMC: ORP
NSN: 9110-99-426-2694

Cooker/ Stove: RP337A
DMC: ORP
NSN: 7310-99-587-4226

FireDragon is available in the following sizes

Fuel Type	Block Size	Burn Time MM:SS	Cook Time* MM:SS	Pictures
FIreDragon	27 gram (1oz)	10:37	03:15	
	18 gram (0.5oz)	08:03	03:03	
	7 gram + foil tray (0.24 oz + foil tray)	04:24	02:47	
Hexamine	7 gram (0.24 oz)	09:01**	03:52	

*To heat 300cm^3 From 10^{o}C to 55 ^{o}C

**The final 3 minutes of the Hexamine burn were insignificant and did not influence the temperature of the water.

MM:SS = Minutes and seconds

4. Clean Burn – Environmentally Friendly

FireDragon's non-toxic nature means that a soldier's health isn't risked each time they cook a meal, when compared to cooking with hexamine blocks. Its **odourless nature doesn't taint the food or your ration pack.**

FireDragon contains no nitrogen or sulphur atoms which could otherwise produce toxic gases such as hydrogen cyanide or sulphur dioxide along with various nitrogen oxides when burnt.

Hence little smell is given off which can give away your position. Hexamine, when stored and burnt, and methyl esters and flameless when burnt, are all very smelly. Some ration packs still pack hexamine in with rations. The rations stink even before you start cooking. According to the safety data sheet, Hexamine should not be "near food".

FireDragon's bactericidal properties have been well tested, so FireDragon is approved as a hand cleanser product for sanitation purposes. Approved to BS EN 1040:2005 and BS EN 1276:2009 standards. Hence you can use it to clean your hands before preparing and eating your food[2].

FireDragon Solid is sold as **27gram blocks** in packs of 6.
Average pack weight is **178grams.**
Also available in a smaller **14gram block & 7gram foil tray.**



FireDragon Clean Burn: Low Soot

FireDragon – Cup base after burning 1 block of fuel

Methyl Esters competitor – Cup base after burning 1 block of fuel

FireDragon – Soot removed from base of cooker after burning 1 block of fuel.

Methyl Esters competitor – Soot removed from base of cooker after burning 1 block of fuel.

[2] If used to cleanse hands, we strongly advise that the ethanol should be allowed to evaporate and the hands dry fully before attempting to light fires with the fuel. This will be promoted for safe use of the product and avoid burn hazards.

5. Powerful Performance

FireDragon performs in a range of severe conditions including wind and rain. It is reliable to light and burns cleanly whilst producing a **low luminosity flame** - reducing the chances of being detected.

As FireDragon is **easy to light** with a flash point and fire point of 8°C. Hence it can be ignited easily and quickly within 2 seconds. Its auto ignition temperature however is significantly higher at 363°C. It's easy to light nature saves time as well as matches in poor weather. Matches (which are expensive and unreliable especially in the damp) can be replaced by a small flint and steel striker, saving the MoD a considerable sum over a year.

The renewable materials used to produce FireDragon along with its recyclable packaging help to reduce the environmental impact of its use. The fact that it is made in the UK also reduces the transportation carbon footprint.

Quicker boil	**=**	**less fuel needed**
	=	**less time cooking**
	=	**hotter rations**
	=	**better in cold conditions or at altitude**

FireDragon in Action: Fast Boiling Times

Performance varies depending on cooker setup. Tests conducted using 500 ml of water from 20 to 24 °C brought to a boil using the BCB Crusader cooking approximately 8 minutes. Two blocks burn together for about 12 minutes.

6. FireDragon vs The Competition

The use of methyl ester (bio-diesel) based military fuel products for cooking are promoted as an alternative technology to FireDragon. Whilst an improvement over aforementioned and other established fuels, FireDragon still gives superior performance with **quicker boil times by up to 2 minutes** compared to Methyl Esters.

FireDragon solid fuel offers the fastest boil time of any solid fuel we have currently tested. When used with the BCB Crusader II cooking system, 500ml of room temperature water (20-24°C) can be boiled in approximately 5.5 minutes[1], whilst our nearest competitor takes up to 7 minutes.

Flameless ration heaters do not cook food, rehydrate dehydrated combat rations or boil water for a hot drink or sterilise the water. They are also expensive, give off hydrogen and large amounts of fumes which smell and are heavy and bulky even when used.

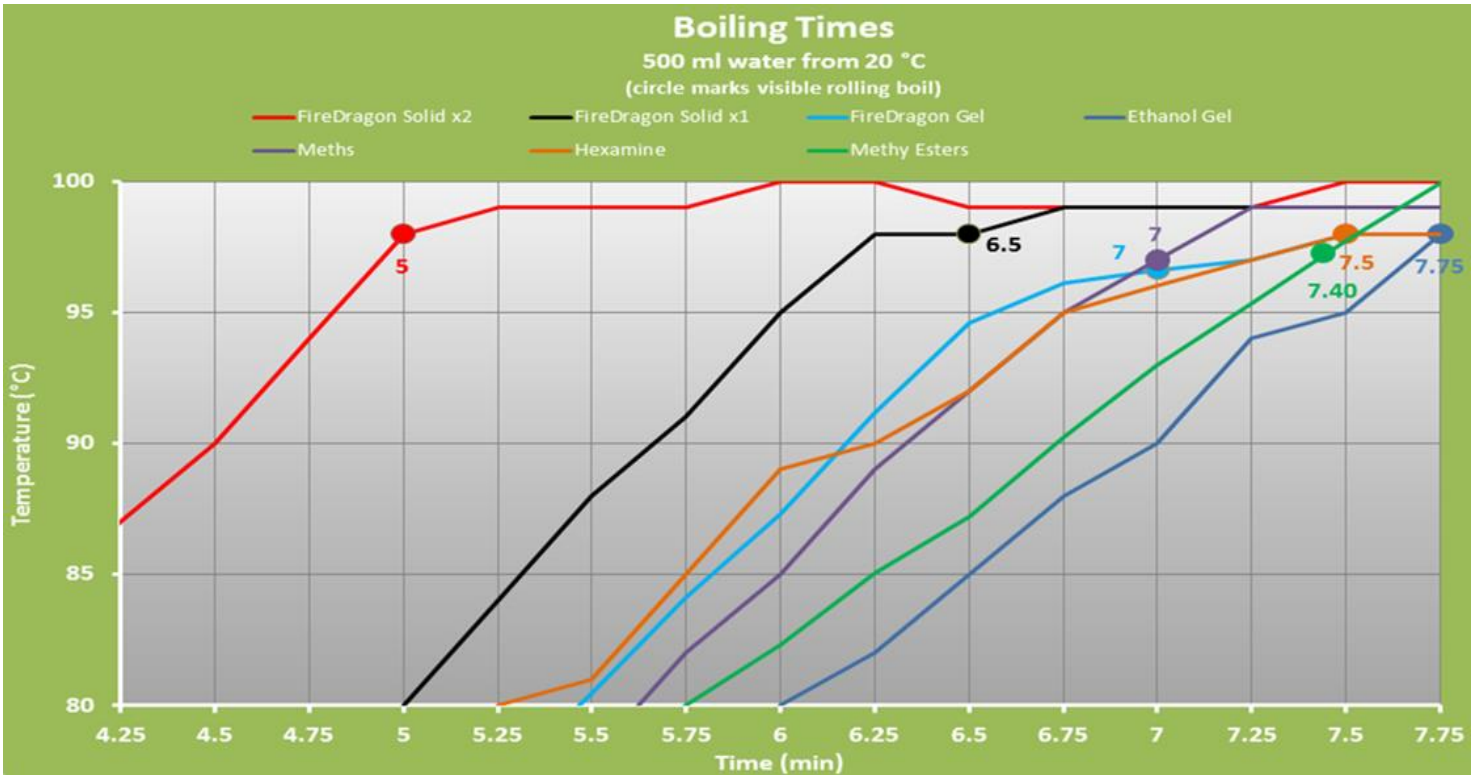
Fuel Type	Characteristics
FRH - Flameless Ration Heater	Does not cook; just warms the food; needs water to activate; gives off hydrogen; very smelly; highly flammable; heavy when wet
Hexamine	Toxic, poison; hydrogen cyanide gas given off during burning; slow burn energy
Trioxane	Toxic, Formaldehyde gas given off during burning
Gas Fuels	Cannot be transported by air, Bulky waste
Meths	Toxic, noxious odour; burn risk
Methyl Esters	High amounts of soot, unpleasant odour Slow burn; Slower energy release = longer time to boil
FireDragon	**Non-toxic** ✓ **High burn output** ✓ **Sustainable** ✓ **Transportable by air** ✓

[1] Boil time varies between 5 and 6 minutes depending on various factors including wind speed and temperature.

	FRH	Hexamine	Trioxane	Butane Gas	Methyl Ester	FireDragon
Non-Toxic	✗	✗	✗	✓	✓	✓
Renewably Sourced	✗	✗	✗	✗	✓	✓
Suitable for Extreme Conditions	✓	✗	✓	✓	✓	✓
Burns Whilst Wet	✓	✗	✗	✓	✗	✓
Easy to Ignite	✗	✗	✗	✓	✗	✓
Odourless	✗	✗	✗	✓	✓	✓
Low Soot	✓	✗	✗	✗	✗	✓
Safe for Wildlife	✗	✗	✗	✓	✓	✓
Long Shelf Life	✗	✓	✓	✓	✓	✓
Air Transportable	✗	✓	✓	✗	✓	✓
Indoor & Outdoor Use (providing suitable airflow)	✗	✗	✗	✓	✓	✓
Low Luminosity Flame	✓	✗	✗	✓	✓	✓

FireDragon also holds the advantage over methyl esters by being **easier to light** in a range of weather conditions; such as heavy rain or wind and can also be **lit when wet.** Methyl ester-based fuels can be susceptible to reduced performance when trying to light/burn in wet conditions. They are also more difficult to ignite without a match or lighter, whereas FireDragon easily and reliably lights even with the simplest of metal and flint strikers and give off a lot of smell, soot and smoke compared to FireDragon.

6.2 FireDragon in action: Performance vs other fuels



All data believed to be correct at the time of writing.

7. Multifuel Cookers

7.1 UN Ration Pack MKI

UN Ration Pack MKI, Heating Kit containing everything required to easily heat and eat food rations while in the field. No tools required.

Contents:

- Metal Mini Cooker
- 6 x FireDragon eco fuel tablets (14g)
- Refuse bag
- Book of 20 matches
- Water purification tablets (6)
- Wet wipes (2)
- Tissue paper - 2 ply (10)
- Spork biodegradable
- Pulp Tray
- Scouring pad

Alternatively the Combat Ration Pack can be made to with ether the folding cooker with wind shield and x3 24gram FireDragon tables or the flat pack cooker and x6 8gram FireDragon tablets.

7.2 MRE Cooker and Fuel System

Compact Ration Heating Kit containing everything required to easily heat food rations while in the field. No tools required.

This kit includes a cooker with 3 x 8gram (0.3oz) FireDragon eco fuel tablets, which are sufficient to heat three meals, plus matches and water purification tablets and a handle for your utensils.

Contents:

- Metal flat folding cooker
- 3 x FireDragon eco fuel tablets (8g)
- Book of 20 matches
- Water purification tablets (4)
- Metal gripper handle
- Packed in waterproof, easy open wrapper

7.3 Patrol Cooker and Fuel System

Compact Ration Heating Kit containing everything required to easily heat food rations while in the field. No tools required. This kit includes a cooker with 3 x 14gram (0.5oz) FireDragon eco fuel tablets, which are sufficient to heat three meals, plus matches and water purification tablets and a handle for your utensils.

Alternatively it can be used with 28gram (1oz) Firedragon, other solid, gel or some liquid fuels.

Contents:

- Metal mini cooker
- 3 x FireDragon eco fuel tablets 14gram (0.5oz)
- Book of 20 matches
- Water purification tablets (4)
- Packed in waterproof, easy open wrapper
- Ration Gripper

7.4 NATO Folding Cooker and Fuel System

BCB's all new folding cooker model has significant advances, this is the perfect companion for our FireDragon fuel range, as well as being suitable for other solid, gel, and liquid fuels.

Designed to deliver exceptional results and meet the stringent requirements of the UK MoD, it is durable with all the operational advantages of being lighter, more compact and more efficient than other small stoves. Shipped with a specially crafted, removable windshield for excellent performance in extreme weather, the cooker has an in-built fuel received designed to channel the heat produced from the fuel right to your mess tin or canteen cup for a quick and efficient cook.

The wind shield when packed **does not rattle**. You can fit it onto either side of the cooker walls as shown below, allowing for simply assembly and use of the cooker. Full instructions are included with the cooker, which can also store 3 x 27gram FireDragon solid blocks within it when closed.

Folded cooker size 115 x 70 x 25mm. Weight 110grams. **NSN:** 7310-99-587-4226

Cooker assembled with wind shield and solid fuel alight in fuel receiver.

3 FireDragon blocks can be neatly packed inside the cooker for transport.

Cooker in use with canteen cup.

Folding Cooker Assembly Leaflet

BCB FOLDING COOKER & FIREDRAGON FUEL INSTRUCTIONS

1. Open cooker (Fig. 1) by pivoting lids ② outwards.

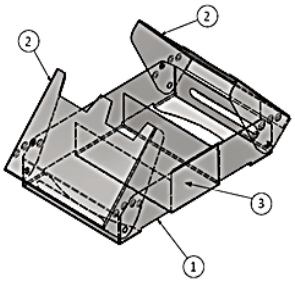


Fig. 1

2. Insert windshield (Fig. 2) by sliding lips ⑤ over cooker sidewall ①, keeping single lip ④ inside fuel receiver ③.

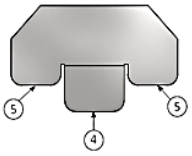


Fig. 2

3. Close lids down onto windshield (Fig. 3).

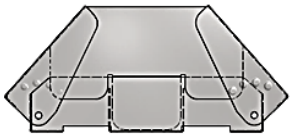


Fig. 3 *(side view)*

4. Peel off foil top from FireDragon fuel pot using corner opening tab ⑥ (Fig. 4).

Fig. 4

5. Empty entire pot contents (including any liquid) into fuel receiver ③ (Fig. 5), and dispose of pot.

6. Light fuel and place canteen cup/mess tin onto cooker.

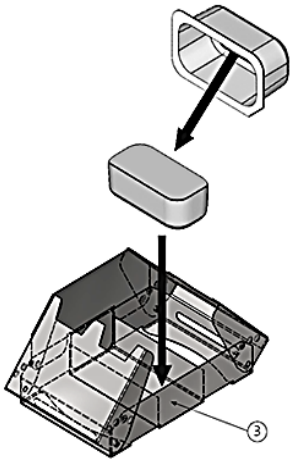


Fig. 5

ⓘ	Windshield can be installed on either sidewall
⚠	CAUTION Cooker will remain hot after use. Allow to cool before handling or storing
⚠	DO NOT burn fuel inside plastic pot

7.5 EU Standard

7.3 Crusader Multifuel Cooker

The 5 piece Dragon System includes:

- **Drinking cup**
- **Canteen 950 ml (3oz) water bottle**
- **Cooking cup**
- **Multi-fuel cooker**
- **Belt-mounted compact carrying pouch**

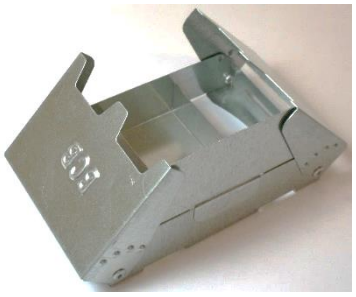
8. FireDragon - Conclusion

8.1 Harnessing the Dragon - The Fuel

We developed the cooker to optimize the performance of our award-winning solid FireDragon Fuel. Both the fuel and the cooker are NATO approved.

The cooker is the perfect companion for solid fuels, gels and some liquid fuels.

- **Non-toxic**, environmentally friendly solid fuel
- Can be packed alongside food
- **Fast boil and long burn** – high heat output (better than alternatives)
- **Easy to light** (spark) even when wet
- **Clean burn** (doesn't dirty cooking equipment)
- **Air transportable**
- Safe for indoor use
- Low luminosity flame
- Also effective as a **hand sanitizer** and waterless soap
- Made from **sustainable natural fuel** ingredients



8.2 Unleashing the Dragon – The Cooker

- **Compact and low cost**
- Easy and quick to use
- **Lightweight (110g)**
- Retractable side walls
- Supplied with a **removable windshield** to enhance extreme weather performance
- The integrated fuel receiver channels the heat produced from your fuel to your mess tin for a quicker cleaner cook
- You can **store three FireDragon solid fuel blocks** within the cooker when closed

FIRE DRAGON SOLID FUEL INSTRUCTIONS v001

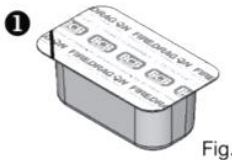


Fig.1

1. Peel off foil top from FireDragon fuel pot using corner opening tab ❶ (Fig. 1).
2. Empty entire pot contents (including any liquid) into fuel receiver ❷ (Fig. 2).
3. Light fuel when safe and ready to use.
4. Use one fuel block at a time in cooker.

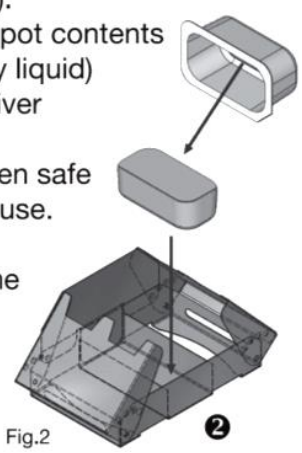


Fig.2

WARNING

- Flammable solid.
- Causes serious eye irritation.
- Keep out of reach of children.
- IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
- Avoid breathing vapours.
- Use only outdoors or in well-ventilated area.
- Dispose of empty top and container appropriately.
- Do not EAT.
- Blocks liquefy when lit.
- Allow all ethanol to evaporate from hands/skin before lighting fuel.
- Can be used as a hand sanitizer as well.

9. Video Link List

1. Lights When Wet
https://www.youtube.com/watch?v=n9V_9jFbrS0
https://www.youtube.com/watch?v=UNKylcQ1KKU

2. Quick Boil Time
https://www.youtube.com/watch?v=wV5YxOnPW-I

3. Clean Burn / Low Soot
https://www.youtube.com/watch?v=iD8TaRcG_d0
https://www.youtube.com/watch?v=Z-plQSMQ2Fo

4. Easy to Light
https://www.youtube.com/watch?v=6FJlWiCxoPY

Appendix 1. Shipping

FireDragon can be easily transported by air, sea, or land. Both can be sent simply as Limited Quantities.

Fuel Blocks: UN1325, Class 4.1, PG III, Flammable solid, organic, n.o.s (Ethanol Fuel).
Fuel Gel: UN1170, Class 3, PG III, Ethanol mixture (ethyl alcohol mixture)
Hazchem/Kemler Code: 1Z/40

Approximately 27 grams of solid FireDragon fuel is packed in a plastic portion pack. Each portion is hermetically sealed with a tri-laminate foil which is printed as seen above. Each pot also includes an easy tear off tab. 6 Portions are flow-wrapped with a cushioned instruction card into an inner pack. This pack contains sufficient fuel for 24 hours (ORP).

10.1 FireDragon Solid

Type	Quantity	Total Portion	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
Portion	1 × 27gram e	1	67.5	40	25.6	0.027
Pack	6 portions	6	115	70	60	0.18
Box	48 Packs	288	590	390	125	9
Pallet	44 cases	2112 packs of 6	1200	880	1100	396

10.2 FireDragon Gel

Type	Quantity	Total Units	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
Bottle	250 ml	1	-	52	153	0.245
Box	13 pouches	13	267	148	162	3.30
Pallet	120 boxes	1560	1200	880	1100	396
Bottle	1 L	1	-	79	246	0.910
Box	10 pouches	10	304	253	263	9.20
Pallet	96 boxes	960	1200	880	1215	883.2

10.3 Folding Cooker

Per Pallet	Cases	Cookers	(11.6) kilo
For Air	42	4200	487
For Road	60	6000	696

Appendix 2. BCB International

BCB International is a long-established company. Founded in 1854 with the invention of Dr Brown's Cough Bottle, a cough medicine of notable success. Since then it has gone from strength to strength.

BCB International has cemented its name as a manufacturer and designer of personal combat equipment and is also a prime contractor to the UK MoD for over 50 years. Our core competencies include:

- Military equipment
- Airborne forces
- Safety and Survival
- Provisions and Rations
- Special Forces operations

BCB International likes to work and develop new unique products, within our core competencies as above. As such, we work closely with Special Forces Units throughout the world; explorers who venture to the extremes, and future soldier programmes.
The solid fuel was developed in conjunction with the Chemistry Department of Cardiff University.
The process has been successfully patented - GB2500062

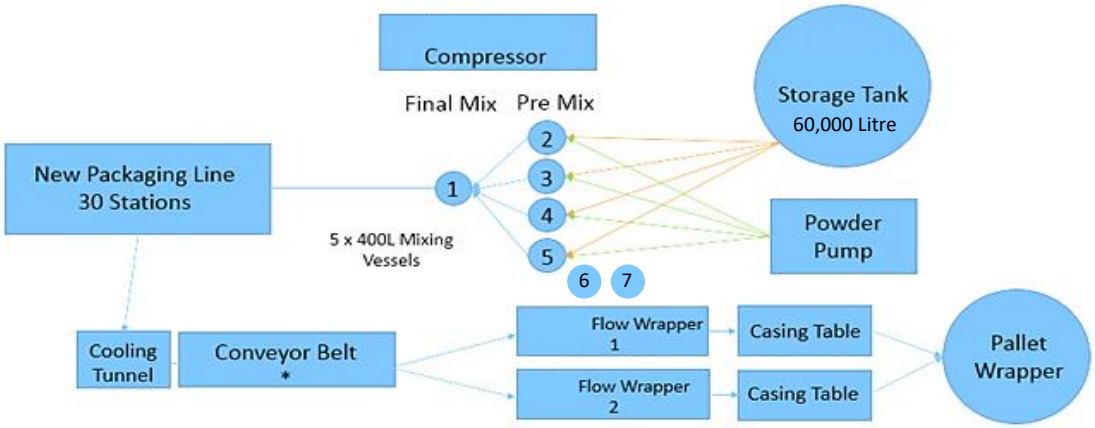
We partner with Universities and Colleges of further education to enhance our design capability.
Design, as long as we believe in the product, we normally undertake free of charge.

Appendix 2.1 Manufacturing Premises

In addition to our Headquarters in Cardiff, South Wales, considerable investment has been made into the FireDragon Programme; resulting in establishing a capable manufacturing base in which both FireDragon Solid and Gel products are made and shipped from.

Appendix 2.2. Production

We have had to, due to high demand, increased production significantly, output is now **18,000 portion packs of 27gram tablets per hour**.



Appendix 3. Quality

We intend to create and maintain the highest quality levels possible. BCB has implemented a quality management system to the new **ISO 9001:2015**.

Each batch of FireDragon fuel is subjected to routine in-house testing performed by skilled staff to ensure our products meet the necessary specifications.

Lloyd's Register

Current issue date: 9 February 2021
Expiry date: 31 January 2023
Certificate identity number: 10334424

Original approval(s):
ISO 14001 - 27 August 2020
ISO 9001 - 13 April 1993

Certificate of Approval

This is to certify that the Management System of:

BCB International Ltd

Lamby Industrial Park, Wentloog Avenue, Cardiff, CF3 2EX, United Kingdom

has been approved by Lloyd's Register to the following standards:

ISO 14001:2015, ISO 9001:2015

Approval number(s): ISO 14001 – 00026723, ISO 9001 – 00015709

The scope of this approval is applicable to:

Manufacture and subcontract manufacture of cosmetic camouflage, protection and fire-lighting products, first aid kits, camping and survival equipment, accessories and ration packs, sewn items, tools and light engineering products for the defence, security, law and order, emergency aid and humanitarian relief, rescue and marine sectors and services. Wholesaling and distribution of clothing, camping, hygiene, protection, survival and first aid equipment to the defence, security, emergency, humanitarian and marine sectors. Distribution, for wholesaling or retailing, of safety, survival and outdoor leisure goods including clean green cooking fuel for use by the general public.

David Derrick

Area Operations Manager UK & Ireland

Issued by: Lloyd's Register Quality Assurance Limited

UKAS MANAGEMENT SYSTEMS 001

Page 1 of 1

Appendix 4. Continuous Innovation

We believe in product innovation by committing a high proportion of resources to Research and Development. By undertaking R&D in this manner we hope to be at the forefront of new product development within our product sector in the UK.

"Saving and protecting lives in hostile environments through innovation"

BCB International holds numerous patents and exclusive design rights to products and is partnered with the local university Centres of Excellence. These partnerships and rights facilitate the development of high quality, innovative products.

Appendix 5. Solid Performance Test Data

All information below is to be used as a guide. Figures are based on laboratory test conditions, so are subject to change when used in varying weather conditions outdoors and/or with cooker setups not listed.

FIREDRAGON SOLID

Cooking System	**Number of Blocks**	**Average Boil Time** (500 ml water at 95 °C)
Crusader 1	1	6:35
BCB Folding Cooker Mk1	1	(Fail) 68 °C
Military Folding Cooker	1	10:42

METHYL ESTER COMPETITOR

Cooking System	**Number of Blocks**	**Average Boil Time** (500 ml water at 95 °C)
Crusader 1	1	8:49
BCB Folding Cooker Mk1	1	(Fail) 95 °C
Military Folding Cooker	1	8:49

Notes:

1) All tests took place using water at a temperature between 17-22 °C and a room temperature between 18-24 °C
2) The average weight of tested Fire Dragon blocks ranged between 25-27gram and methyl ester fuel blocks from 22-24gram
3) BCB Folding Cooker open at position 2, one from fully open. Tests used the Crusader 1 cup and lid.
4) Military Cooker tests used the Crusader 1 cup and lid.

Standard Military Issue cooker (left) BCB Folding Cooker open to position 2 (right)

Appendix 6. Firedragon Solid – Safety Data Sheet

MATERIAL SAFETY DATA SHEET

Date / Revised: 09/03/21

Product Name: FireDragon Green & Clean Solid Fuel

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product Name:	FireDragon Green & Clean Solid Fuel
Product No.	FD336B, CN336, CN336S, CN336PA, CN336PB, CN336MOD
Product Application	Polymerised-alcohol fuel. Intended for use as a firelighter and/or cooking fuel. May be used as a hand cleanser. Use in accordance with product instructions.
Supplier	BCB International LTD, Howell House, Lamby Industrial Park, Cardiff, CF3 2EX, United Kingdom
Emergency Telephone	+44 (0) 29 2043 3700/ +44 (0) 1554 823824 (08:00 – 17:00 Mon-Fri only)

SECTION 2: HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008
One or more of the substances in this product feature the following hazards as a raw material:

Flammable solid (Category 2), H228
Eye irritant (Category 2), H319

For the full text of the H-statements mentioned in this section, see section 16.

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008

Pictogram 

Signal word	Warning
Hazard statement(s)	
H228	Flammable solid.
H302	Harmful if swallowed.
H319	Causes serious eye irritation.
Precautionary statement(s)	
P101	If medical advice is needed, have product container or label at hand.

P103	Read label before use
P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P261	Avoid breathing vapours.
P271	Use only outdoors or in a well-ventilated area.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

For full list of precautionary statements, see section 16.

Supplemental hazard statements

2.3 Other hazards

This product is highly flammable. With container open, explosive vapour/air may be formed even at normal room temperatures.
During combustion/fire, the product becomes molten and exhibits flow.
In high concentrations, vapours and spray mists are narcotic and may cause headache, fatigue, dizziness and nausea.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No.	EC No.	Content (%)	Classification acc. to Regulation (EC) No 1272/2008
Ethanol, denatured	64-17-5	200-578-6	85-95	Flam. Liq. 2 (H225), Eye Irrit. 2 (H319)

Other ingredients are not deemed hazardous.
The full text for all H-statements are given in section 16.

SECTION 4: FIRST-AID MEASURES

4.1 Description of first aid measures

General Advice Rest, warmth and fresh air. Seek medical attention if symptoms persist. Show this safety data sheet to the physician in attendance. Never give an unconscious person anything by mouth.

Inhalation Remove to fresh air and rest. If not breathing, give artificial respiration. If symptoms persist, seek medical attention.

Ingestion Do NOT induce vomiting. Rinse mouth immediately and give plenty of water or milk to drink. If symptoms persist, seek medical attention. Never give an unconscious person anything by mouth.

Skin contact Remove contaminated clothing. Wash affected area with soap and water.

Eye contact Flush with water for at least 15 minutes. Remove contact lenses if present and safe to do. Avoid washing chemical from one eye into the other. Ensure to rinse thoroughly under the eyelid. If symptoms persist, seek medical attention.

4.2 Most important symptoms and effects, both acute and delayed.

Inhalation	May cause respiratory irritation. May cause drowsiness, dizziness and/or headaches.
Ingestion	Gastrointestinal symptoms; nausea, upset stomach, vomiting.
Skin contact	Repeated exposure may cause skin dryness or cracking.
Eye contact	Irritation may occur, causing redness and pain.

4.3 Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: FIRE-FIGHTING MEASURES

5.1 Extinguishing Media

Suitable extinguishing media	Alcohol-resistant foam, dry powder, carbon dioxide, water fog and sand.
Unsuitable extinguishing media	Do not use high-pressure water jets.
5.2 Special hazards arising from the mixture	Carbon oxides, nitrogen oxides (NO_x) and oxides of sodium may be produced during combustion. Product may produce vapour which may be invisible, heavier than air and spread along the ground. During combustion, solid fuel will become molten and exhibit flow. Vapours may form explosive mixtures with air. Flash-back possible over some distance.
5.3 Advice for firefighters	Wear self-contained breathing apparatus. Wear full-protective gear if necessary. Keep containers cool with water spray. Water run-off or discharge should not enter drains.
5.4 Further information	No information available.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures	Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas. For personal protection see section 8.
6.2 Environmental precautions	Ensure waste and contaminated materials are collected and removed from the work area as soon as possible in a suitably labelled container. Do not allow water run-off or discharge to enter drains or environment.

6.3	**Methods and materials for containment and cleaning up**	Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local/national regulations (see section 13). Collect waste absorbent with either an electrically protected vacuum cleaner or by wet-brushing. Wash area thoroughly with water after.
6.4	**Reference to other sections**	See section 1 for emergency contact information. See section 8 for personal protective equipment. See section 13 for waste treatment information.

SECTION 7: HANDLING AND STORAGE

7.1	**Precautions for safe handling**	Avoid skin and eye contact. Avoid spillages. Avoid inhalation of vapour or mist. Keep away from sources of ignition. No smoking. Take measures to prevent the build-up of electrostatic charge. If left exposed, flammable and irritating vapours will be emitted. Ensure adequate ventilation. For precautions see section 2.2.
7.2	**Conditions for safe storage, including any incompatibilities**	Store in a cool, dry place. Keep container closed in a well-ventilated place. Keep away from direct sunlight and sources of heat or ignition. Do not store with oxidising agents.
7.3	**Specific end use(s)**	Apart from the uses mentioned in section 1.2, no other end uses are stipulated.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control Parameters

Components with workplace control parameters

Due to the nature of the product, workplace exposure limits are unlikely to be exceeded. The product has not been tested for workplace exposure limits when used as stipulated in section 1.2.

One or more component exhibits workplace exposure limits as a raw material, as below:

Ethanol	EH40 WEL, TWA – 8h	1,000ppm, 1,920mg/m^3
	ELV (IE), STEL	1,000ppm

8.2 Exposure Controls

Appropriate engineering controls	Provide adequate ventilation to ensure the defined work place exposure limits are not exceeded.

Personal protective equipment

Skin protection	Where possible, wear suitable gloves. As the product is a mixture of several substances, the durability of the glove material cannot be calculated in advance and should be tested before use. Protective gloves should be replaced is damaged or otherwise compromised through wear and tear. Protective gloves should comply with EN 374.
Eye/face protection	Contact lenses should be avoided when working with this product. Safety glasses, when worn, should comply with EN 166.
Body protection	Due to the nature/size of the product, specific clothing is not usually necessary. Impervious clothing, Flame-retardant antistatic protective clothing may be worn when handling large quantities.
Respiratory protection	Due to the nature of the product, no personal respiratory protective equipment is normally required in well ventilated areas. In case of insufficient ventilation, wear suitable respiratory aid equipment. A Type A filter is recommended and mask to EN 143
Control of environmental exposure	Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Solid, colourless. Usually translucent, sometimes opaque
Odour	Alcoholic
pH	8
Melting/freezing point	60-65°C
Initial boiling point	78°C
Flash point	17°C (Cleveland open cup; BS EN ISO 2592:2001)
Upper explosion limit	19% (V)
Lower explosion limit	3.3% (V)
Vapour pressure	5.85kPa (20°C)
Flammability	No data available
Relative density	0.84g/cm^3 (20°C)
Water solubility	Partially soluble (20°C)
Auto-ignition temperature	363°C
Decomposition temperature	No data available
Viscosity	No data available
Oxidising properties	No data available
Explosive properties	Formation of explosive air/vapour mixtures is possible.
Gross calorific value	29MJ/kg (approx.)

SECTION 10: STABILITY AND REACTIVITY

10.1	**Reactivity**	Stable under recommended storage conditions.
10.2	**Chemical stability**	Stable under recommended storage conditions.
10.3	**Possibility of hazardous reactions**	No data available.

10.4	**Conditions to avoid**	Heat, flames, sparks, extremes of temperature and direct sunlight.
10.5	**Incompatible materials**	Alkali metals, ammonia, oxidising reagents, peroxides.
10.6	**Hazardous decomposition products**	Other decomposition products – no data available. In the event of fire, see section 5.

SECTION 11: TOXILOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity	Toxic Dose – LD_{50} >2000 mg/kg (oral rat) Toxic Concentration – LC_{50} >20 mg/l (4hr mouse)
Skin corrosion/irritation	Repeated exposure may cause skin dryness or cracking.
Serious eye damage/irritation	Causes serious eye irritation. May cause redness and pain.
Respiratory damage/irritation	May cause mechanical respiratory irritation. May cause drowsiness, dizziness and/or headaches.
Ingestion	Gastrointestinal symptoms; nausea, upset stomach and/or vomiting.
Respiratory or skin sensitisation	No data available.
Germ cell mutagenicity	No data available.
Carcinogenicity	No data available.
IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probably, possible or confirmed human carcinogen by IARC.
Reproductive toxicity	No data available.
Specific target organ toxicity – single exposure	Ethanol is a CNS depressant. Exposure to vapours may cause dizziness, drowsiness and/or headaches.
Specific target organ toxicity – repeated exposure	No data available. Similar symptoms to STOT – single exposure may occur.
Aspiration hazard	No data available.

The chemical, physical and toxicological properties have not been thoroughly investigated for this product.

Values presented are based on available literature. No testing was carried out for this product.

SECTION 12: ECOLOGICAL INFORMATION

12.1	**Toxicity**	LC_{50}: > 100 mg/l (96 hrs, Fish) EC_{50}: > 100 mg/l (48 hrs, Daphnia) IC_{50}: > 100 mg/l (72 hrs, Algae)
12.2	**Persistence and degradability**	No data available.
12.3	**Bioaccumulative potential**	No data available.
12.4	**Mobility in soil**	No data available.
12.5	**Results of PBT and vPvB assessment**	PBT and vPvB assessment not available as chemical safety assessment not required, not conducted. No component of this product is deemed PBT or vPvB
12.6	**Other adverse effects**	Will dissolve and disperse in an aqueous environment. Do not flush into surface water or sanitary sewer system. Avoid subsoil penetration.

Values presented are based on available literature.

SECTION 13: DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product	Burn in a chemical incinerator equipped with an afterburner and scrubber, but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable product to a licensed hazardous waste disposal company. Any material used to control spillage must be disposed of in the same way. Dispose of in accordance to local and national regulations.
Contaminated packaging	Empty contaminated packaging thoroughly. This can be recycled after thorough and proper cleaning. Packaging that cannot be cleaned is to be disposed of in the same manner as the product.

SECTION 14: TRANSPORT INFORMATION

One or more of this product's components are classified as dangerous good for transportation by ADR/RID, IMDG or IATA. Available information and product testing allows determination of dangerous goods transport class for this product.

14.1 UN number

ADR/RID	1325
IMDG	1325

	IATA	1325

14.2 UN proper shipping name

ADR/RID	Flammable solid, organic, N.O.S, (ethanol mixture)
IMDG	Flammable solid, organic, N.O.S, (ethanol mixture)
IATA	Flammable solid, organic, N.O.S, (ethanol mixture)

14.3 Transport hazard class(es)

ADR/RID	Class 4.1: Flammable solid
IMDG	Class 4.1: Flammable solid
IATA	Class 4.1: Flammable solid

Packing label 

14.4 Packing group

ADR/RID	III
IMDG	III
IATA	III

14.5 Environmental hazard

ADR/RID	No
IMDG	No
IATA	No

14.6 Special precautions for user Tunnel Code (E)

SECTION 15: REGULATORY INFORMATION

This safety data sheet complies with the requirements of Regulation (EC) No. 1907/2006.

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Take note of regulation (EC) 1272/2008 on the classification, labelling and packaging of substances and mixtures.
Take note of the control of substances hazardous to health (COSHH) regulations, 2002.
Take note of directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work.
Take note of directive 92/85/EEC on the protection of the health and safety of pregnant workers.
Take note of directive 94/33/EC on the protection of young people at work
Take note of workplace exposure limits, 2005 (EH40)

15.2 Chemical safety assessment

For this product a chemical safety assessment was not carried out.

SECTION 16: OTHER INFORMATION

Full text of H-statements referred to under sections 2 and 3.

H228	Flammable solid
H302	Harmful if swallowed

H319	Causes serious eye irritation

Full text of P-statements referred to under section 2.

P101	If medical advice is needed, have product container, or label at hand.
P102	Keep out of reach of children.
P103	Read label before use.
P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P261	Avoid breathing vapours.
P271	Use only outdoors or in a well-ventilated area.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Acronyms

STOT	Specific-target organ toxicity.
STEL	Short-term exposure limit.
TWA	Time-weighted average.
LC_{50}	Lethal concentration - concentration at which 50% of the population is killed.
LD_{50}	Lethal dose – dose at which 50% of the population is killed in a given period of time.
IC_{50}	Inhibitor concentration – concentration of an inhibitor where the response/binding is reduced by half.
IARC	International agency for research on cancer.
ADR/RID	European agreement concerning the international carriage of dangerous goods by road and railway.
IMDG	International maritime dangerous goods code.
IATA	International air transport association.
PBT	Persistent, bioaccumulative and toxic.
vPvB	Very persistent, very bioaccumulative.

Further information

The information in this Safety Data Sheet should be provided to all who will use, handle, store, transport or otherwise be exposed to this product. This information has been prepared for the guidance of plant engineering, operations, management and for people working with or handling this product. This information is believed to be reliable and correct at the Revision Date, and represents the best information currently available and known by BCB International Ltd. However, BCB International Ltd makes no guarantee or warranty, express or implied, with respect to such information and we assume no liability and anticipated used and is for the material without chemical additions or alterations. Users should make their own investigations to determine the suitability of the information for their particular purposes. It is the responsibility of the user to undertake a suitable risk assessment/COSHH assessment prior to using the material.

Reason for update: Remove superfluous information.

Appendix 7. FireDragon Gel - Safety Data Sheet

MATERIAL SAFETY DATA SHEET

Date / Revised: 09/03/21

Product Name: FireDragon Green & Clean Gel Fuel

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product Name:	FireDragon Green & Clean Gel Fuel
Product No.	CN336C/CN336D, CN336PC, CN336PD
Product Application	True-gel alcohol fuel. Intended for use as a firelighter and/or cooking fuel. Use in accordance with product instructions.
Supplier	BCB International LTD Howell House, Lamby Way Industrial Park Cardiff, CF3 3EX United Kingdom
Emergency Telephone	+44 (0) 29 2043 3700/ +44 (0) 1554 823824 (08:00 – 17:00 Mon-Fri only)

SECTION 2: HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008
One or more of the substances in this product feature the following hazards as a raw material:

Highly flammable liquid and vapour (Category 2), H225
Eye irritant (Category 2), H319

For the full text of the H-statements mentioned in this section, see section 16.

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008
Pictogram

Signal word	Danger
Hazard statement(s)	
H225	Highly flammable liquid and vapour
H302	Harmful if swallowed
H319	Causes serious eye irritation
Precautionary statement(s)	
P101	If medical advice is needed, have product container or label at hand.

P103	Read label before use
P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P261	Avoid breathing vapours.
P271	Use only outdoors or in a well-ventilated area.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

For full list of precautionary statements, see section 16.

Supplemental hazard statements

2.3 Other hazards

This product is highly flammable. With container open, explosive vapour/air may be formed even at normal room temperatures.
During combustion/fire, the product becomes molten and exhibits flow.
In high concentrations, vapours and spray mists are narcotic and may cause headache, fatigue, dizziness and nausea.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No.	EC No.	Content (%)	Classification acc. to Regulation (EC) No 1272/2008
Ethanol, denatured	64-17-5	200-578-6	80-85	Flam. Liq. 2 (H225), Eye Irrit. 2 (H319)

Product contains other, non-hazardous ingredients.
The full text for all H-statements are given in section 16.

SECTION 4: FIRST-AID MEASURES

4.1 Description of first aid measures

General Advice Rest, warmth and fresh air. Seek medical attention if symptoms persist. Show this safety data sheet to the physician in attendance. Never give an unconscious person anything by mouth.

Inhalation Remove to fresh air and rest. If not breathing, give artificial respiration. If symptoms persist, seek medical attention.

Ingestion Do NOT induce vomiting. Rinse mouth immediately and give plenty of water or milk to drink. If symptoms persist, seek medical attention. Never give an unconscious person anything by mouth.

Skin contact Remove contaminated clothing. Wash affected area with soap and water.

Eye contact Flush with water for at least 15 minutes. Remove contact lenses if present and safe to do. Avoid washing chemical from one eye into the other. Ensure to rinse thoroughly under the eyelid. If symptoms persist, seek medical attention.

4.2 Most important symptoms and effects, both acute and delayed.

Inhalation	May cause respiratory irritation. May cause drowsiness, dizziness and/or headaches.
Ingestion	Gastrointestinal symptoms; nausea, upset stomach, vomiting.
Skin contact	Repeated exposure may cause skin dryness or cracking.
Eye contact	Irritation may occur, causing redness and pain.

4.3 Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: FIRE-FIGHTING MEASURES

5.1 Extinguishing Media

Suitable extinguishing media	Alcohol-resistant foam, dry powder, carbon dioxide, water fog and sand.
Unsuitable extinguishing media	Do not use high-pressure water jets.

5.2 Special hazards arising from the mixture

Carbon oxides, nitrogen oxides (NO_x) and oxides of sodium may be produced during combustion.

Product may produce vapour which may be invisible, heavier than air and spread along the ground. During combustion, solid fuel will become molten and exhibit flow. Vapours may form explosive mixtures with air. Flash-back possible over some distance.

5.3 Advice for firefighters

Wear self-contained breathing apparatus. Wear full-protective gear if necessary. Keep containers cool with water spray. Water run-off or discharge should not enter drains.

5.4 Further information

No information available.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas. For personal protection see section 8.

6.2 Environmental precautions

Ensure waste and contaminated materials are collected and removed from the work area as soon as possible in a suitably labelled container. Do not allow water run-off or discharge to enter drains or environment.

6.3	**Methods and materials for containment and cleaning up**	Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local/national regulations (see section 13). Collect waste absorbent with either an electrically protected vacuum cleaner or by wet-brushing. Wash area thoroughly with water after.
6.4	**Reference to other sections**	See section 1 for emergency contact information. See section 8 for personal protective equipment. See section 13 for waste treatment information.

SECTION 7: HANDLING AND STORAGE

7.1	**Precautions for safe handling**	Avoid skin and eye contact. Avoid spillages. Avoid inhalation of vapour or mist. Keep away from sources of ignition. No smoking. Take measures to prevent the build-up of electrostatic charge. If left exposed, flammable and irritating vapours will be emitted. Ensure adequate ventilation. For precautions see section 2.2.
7.2	**Conditions for safe storage, including any incompatibilities**	Store in a cool, dry place. Keep container closed in a well-ventilated place. Keep away from direct sunlight and sources of heat or ignition. Do not store with oxidising agents.
7.3	**Specific end use(s)**	Apart from the uses mentioned in section 1.2, no other end uses are stipulated.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control Parameters

Components with workplace control parameters

Due to the nature of the product, workplace exposure limits are unlikely to be exceeded. The product has not been tested for workplace exposure limits when used as stipulated in section 1.2.

One or more component exhibits workplace exposure limits as a raw material, as below:

Ethanol	EH40 WEL, TWA – 8h	1,000ppm, 1,920mg/m^3
	ELV (IE), STEL	1,000ppm

8.2 Exposure Controls

Appropriate engineering controls	Provide adequate to ensure the defined work place exposure limits are not exceeded.

Personal protective equipment

Skin protection	Where possible, wear suitable gloves. As the product is a mixture of several substances, the durability of the glove material cannot be calculated in advance and should be tested before use. Protective gloves should be replaced is damaged or otherwise compromised through wear and tear. Protective gloves should comply with EN 374.
Eye/face protection	Contact lenses should be avoided when working with this product. Safety glasses, when worn, should comply with EN 166.
Body protection	Due to the nature/size of the product, specific clothing is not usually necessary. Impervious clothing, Flame-retardant antistatic protective clothing may be worn when handling large quantities.
Respiratory protection	Due to the nature of the product, no personal respiratory protective equipment is normally required in well ventilated areas. In case of insufficient ventilation, wear suitable respiratory aid equipment. A Type A filter is recommended and mask to EN 143
Control of environmental exposure	Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Gel, colourless. Usually translucent, sometimes opaque
Odour	Alcoholic
pH	8
Melting/freezing point	N/A
Initial boiling point	75°C
Flash point	10.5°C (Cleveland open cup; BS EN ISO 2592:2001)
Upper explosion limit	19% (V)
Lower explosion limit	3.3% (V)
Vapour pressure	5.85kPa (20°C)
Flammability	No data available
Relative density	0.84g/cm^3 (20°C)
Water solubility	Soluble in water (20°C)
Auto-ignition temperature	363°C
Decomposition temperature	No data available
Viscosity	No data available
Oxidising properties	No data available
Explosive properties	Formation of explosive air/vapour mixtures is possible.
Gross calorific value	29MJ/kg (approx.)

SECTION 10: STABILITY AND REACTIVITY

10.1	**Reactivity**	Stable under recommended storage conditions.
10.2	**Chemical stability**	Stable under recommended storage conditions.
10.3	**Possibility of hazardous reactions**	No data available.

10.4	**Conditions to avoid**	Heat, flames, sparks, extremes of temperature and direct sunlight.
10.5	**Incompatible materials**	Alkali metals, ammonia, oxidising reagents, peroxides.
10.6	**Hazardous decomposition products**	Other decomposition products – no data available. In the event of fire, see section 5.

SECTION 11: TOXILOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity	Toxic Dose – LD_{50} >2000 mg/kg (oral rat) Toxic Concentration – LC_{50} >20 mg/l (4hr mouse)
Skin corrosion/irritation	Repeated exposure may cause skin dryness or cracking.
Serious eye damage/irritation	Causes serious eye irritation. May cause redness and pain.
Respiratory damage/irritation	May cause mechanical respiratory irritation. May cause drowsiness, dizziness and/or headaches.
Ingestion	Gastrointestinal symptoms; nausea, upset stomach and/or vomiting.
Respiratory or skin sensitisation	No data available.
Germ cell mutagenicity	No data available.
Carcinogenicity	No data available.
IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probably, possible or confirmed human carcinogen by IARC.
Reproductive toxicity	No data available.
Specific target organ toxicity – single exposure	Ethanol is a CNS depressant. Exposure to vapours may cause dizziness, drowsiness and/or headaches.
Specific target organ toxicity – repeated exposure	No data available. Similar symptoms to STOT – single exposure may occur.
Aspiration hazard	No data available.

The chemical, physical and toxicological properties have not been thoroughly investigated for this product.

Values presented are based on available literature. No testing was carried out for this product.

SECTION 12: ECOLOGICAL INFORMATION

12.1	**Toxicity**	LC_{50}: > 100 mg/l (96 hrs, Fish) EC_{50}: > 100 mg/l (48 hrs, Daphnia) IC_{50}: > 100 mg/l (72 hrs, Algae)
12.2	**Persistence and degradability**	No data available.
12.3	**Bioaccumulative potential**	No data available.
12.4	**Mobility in soil**	No data available.
12.5	**Results of PBT and vPvB assessment**	PBT and vPvB assessment not available as chemical safety assessment not required, not conducted. No component of this product is deemed PBT or vPvB
12.6	**Other adverse effects**	Will dissolve and disperse in an aqueous environment. Do not flush into surface water or sanitary sewer system. Avoid subsoil penetration.

Values presented are based on available literature.

SECTION 13: DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product	Burn in a chemical incinerator equipped with an afterburner and scrubber, but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable product to a licensed hazardous waste disposal company. Any material used to control spillage must be disposed of in the same way. Dispose of in accordance to local and national regulations.
Contaminated packaging	Empty contaminated packaging thoroughly. This can be recycled after thorough and proper cleaning. Packaging that cannot be cleaned is to be disposed of in the same manner as the product.

SECTION 14: TRANSPORT INFORMATION

One or more of this product's components are classified as dangerous good for transportation by ADR/RID, IMDG or IATA. Available information and product testing allows determination of dangerous goods transport class for this product.
This product has been classified as Packing Group III following testing in-line with that as described in the UN Model Regulations for Transport of Dangerous Goods, section 2.3.2.2.

14.1 UN number

	ADR/RID	1170
	IMDG	1170
	IATA	1170

14.2 UN proper shipping name

ADR/RID	Ethanol solution (ethyl alcohol)
IMDG	Ethanol solution (ethyl alcohol)
IATA	Ethanol solution (ethyl alcohol)

14.3 Transport hazard class(es)

ADR/RID	Class 3: Flammable liquid
IMDG	Class 3: Flammable liquid
IATA	Class 3: Flammable liquid

Packing label 

14.4 Packing group

ADR/RID	III
IMDG	III
IATA	III

14.5 Environmental hazard

ADR/RID	No
IMDG	No
IATA	No

14.6 Special precautions for user No data available.

SECTION 15: REGULATORY INFORMATION

This safety data sheet complies with the requirements of Regulation (EC) No. 1907/2006.

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Take note of regulation (EC) 1272/2008 on the classification, labelling and packaging of substances and mixtures.
Take note of the control of substances hazardous to health (COSHH) regulations, 2002.
Take note of directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work.
Take note of directive 92/85/EEC on the protection of the health and safety of pregnant workers.
Take note of directive 94/33/EC on the protection of young people at work
Take note of workplace exposure limits, 2005 (EH40)

15.2 Chemical safety assessment

For this product a chemical safety assessment was not carried out.

SECTION 16: OTHER INFORMATION

Full text of H-statements referred to under sections 2 and 3.

H226	Flammable liquid and vapour
H302	Harmful if swallowed
H319	Causes serious eye irritation

Full text of P-statements referred to under section 2.

P101	If medical advice is needed, have product container, or label at hand.
P102	Keep out of reach of children.
P103	Read label before use.
P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P261	Avoid breathing vapours.
P271	Use only outdoors or in a well-ventilated area.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Acronyms

STOT	Specific-target organ toxicity.
STEL	Short-term exposure limit.
TWA	Time-weighted average.
LC_{50}	Lethal concentration - concentration at which 50% of the population is killed.
LD_{50}	Lethal dose – dose at which 50% of the population is killed in a given period of time.
IC_{50}	Inhibitor concentration – concentration of an inhibitor where the response/binding is reduced by half.
IARC	International agency for research on cancer.
ADR/RID	European agreement concerning the international carriage of dangerous goods by road and railway.
IMDG	International maritime dangerous goods code.
IATA	International air transport association.
PBT	Persistent, bioaccumulative and toxic.
vPvB	Very persistent, very bioaccumulative.

Further information

The information in this Safety Data Sheet should be provided to all who will use, handle, store, transport or otherwise be exposed to this product. This information has been prepared for the guidance of plant engineering, operations, management and for people working with or handling this product. This information is believed to be reliable and correct at the Revision Date, and represents the best information currently available and known by BCB International Ltd. However, BCB International Ltd makes no guarantee or warranty, express or implied, with respect to such information and we assume no liability and anticipated used and is for the material without chemical additions or alterations. Users should make their own investigations to determine the suitability of the information for their particular purposes. It is the responsibility of the user to undertake a suitable risk assessment/COSHH assessment prior to using the material.

Appendix 8. Ceram Soot Analysis Report

ceram
INNOVATION | SUSTAINABILITY | QUALITY

Queens Road, Penkhull, Stoke-on-Trent,
Staffordshire, ST4 7LQ, UK

tel: (customer enquiries) +44 (0)1782 764428
tel: (switchboard) +44 (0)1782 764444
fax: +44 (0)1782 412331
email: enquiries@ceram.com
web: www.ceram.com

PHYSICAL TESTING ANALYSIS REPORT

Description:	Soot Content
Test Method:	In House Method
Ceram Reference:	(131676)-8127
Client:	BCB International Unit 21 Stradey Business Park Llangennech Llanelli SY4 8YP
For the Attention of:	Mr Stephen Hughes
Date Logged:	09-Apr-2013
Date of Tests:	16-May-2013 to 20-May-2013
Report Date:	22-May-2013
Purchase Order No.:	0000021034

Please find attached the results for the sample(s) recently submitted for analysis.

Mr Simon Hall
Author

Ceram Reference: (1316756)-8127
Customer Reference: FD
Description: Fire Dragon

ceram

DETERMINATION OF SOOT INDEX
(Ceram In-house Method)

CALIBRATION OF LIGHT BOX

The light box was switched on and left for at least 30 minutes. An illuminance measurement without a glass plate was measured and noted down (E0). This should be at least 750 Lux.

A clean glass plate was placed in the light box and an illuminance measurement with the glass plate was measured and noted down (E1).

A calibration disc was placed on to the glass plate and an illuminance measurement with the glass plate and calibration disc was measured and noted down (E2).

The absorption of the inner surface of the light box (Ai) is calculated from the equation as follows:

$$Ai = E2/E1$$

This should not deviate by more than 10% of Ai value of the light box when new.

METHOD

A porcelain crucible was taken and 30g of the sample was weighed into the crucible. The crucible was placed inside a cage so that the top of the cage was 200mm above the crucible.

The sample was ignited and allowed to burn for a stabilisation period of 5 minutes.

After the stabilisation period a clean glass plate was placed on top of the cage so as to collect any soot from the burning sample and a stop watch started.

The sample was allowed to burn until the flame went out at which point the stop watch was stopped and the measuring time in hours noted down (T m).

The plate when cool was removed from the top of the cage and placed into a light box and the illuminance measured and noted down (E3). The plate was cleaned and the illuminance re-measured and noted down (E1).

The Soot Index (Si) is calculated from the equation below:

$$Si = 1-(E3/E1) \times 100$$

The Hourly Soot Index (Sih) is calculated from the equation below:

$$Sih = Si/Tm$$

Illuminance without a glass plate (E0)	1017 Lux
Illuminance with glass plate (E1)	818 Lux
Illuminance with the glass plate and calibration disc (E2)	760 Lux
Illuminance with the glass plate after burning time (E3)	818 Lux
Burning Time	0.75 Hours (45 minutes)

CALCULATIONS

Ai = E2/E1 = 0.93

Soot Index, Si = 1-(E3/E1) x 100 = 0.00

Hourly Soot Index, Sih = Si/Tm = 0.00

End of Test Report

PHYSICAL TESTING REPORT

UKAS TESTING
0013

BCB International
Unit 21
Stradey Business Park
Llangennech
Llanelli
SY4 8YP

ceram
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fax: +44 (0)1782 412331
email: enquiries@ceram.com
web: www.ceram.com

FAO: Mr Stephen Hughes

Report of Tests on:	Fire Dragon		
Your Reference:	FD		
Ceram Reference:	(131676)-8127		
Date Reported:	22-May-2013	**Order Number:**	0000021034
Date Logged:	09-Apr-2013	**Date(s) of Test(s):**	14-May-2013 **to** 16-May-2013

Determination of Net & Gross Calorific Value of Solid Recovered Fuels

By Bomb Calorimetry BS EN 15400:2011 & PT49

Test Results:

Sample Basis As Received
Gross Calorific Value: 27.8924 MJ/kg
Nitrogen: Default Setting as in E.4 of BS EN 15400:2011

Hydrogen values are used to calculate the net CV at constant volume. If the H content is not determined then the net CV is take n from the linear regression fit of the net CV as a function of gross CV.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

End of Test Report

Mr Simon Hall
Author

Page 1 of 1

PHYSICAL TESTING REPORT

0013

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web: www.ceram.com

FAO: Mr Stephen Hughes

Report of Tests on: Zip Military
Your Reference: ZIP
Ceram Reference: (131676)-8128
Date Reported: 22-May-2013 **Order Number:** 0000021034
Date Logged: 09-Apr-2013 **Date(s) of Test(s):** 14-May-2013 **to** 16-May-2013

Determination of Net & Gross Calorific Value of Solid Recovered Fuels

By Bomb Calorimetry BS EN 15400:2011 & PT49

Test Results:

Sample Basis As Received

Gross Calorific Value: 34.8914 MJ/kg

Nitrogen: Default Setting as in E.4 of BS EN 15400:2011

Hydrogen values are used to calculate the net CV at constant volume. If the H content is not determined then the net CV is take n from the linear regression fit of the net CV as a function of gross CV.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

End of Test Report

Mr Simon Hall
Author

PHYSICAL TESTING REPORT

0013

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web: www.ceram.com

FAO: Mr Stephen Hughes

Report of Tests on: Hexamine
Your Reference: HEX 1
Ceram Reference: (131676)-8129
Date Reported: 22-May-2013
Order Number: 0000021034
Date Logged: 09-Apr-2013
Date(s) of Test(s): 14-May-2013 **to** 16-May-2013

Determination of Net & Gross Calorific Value of Solid Recovered Fuels

By Bomb Calorimetry BS EN 15400:2011 & PT49

Test Results:

Sample Basis As Received
Gross Calorific Value: 29.5395 MJ/kg
Nitrogen: Default Setting as in E.4 of BS EN 15400:2011

Hydrogen values are used to calculate the net CV at constant volume. If the H content is not determined then the net CV is take n from the linear regression fit of the net CV as a function of gross CV.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

End of Test Report

Mr Simon Hall
Author

PHYSICAL TESTING REPORT

0013

BCB International
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email: enquiries@ceram.com
web: www.ceram.com

FAO: Mr Stephen Hughes

Report of Tests on: Utility Flame
Your Reference: UF
Ceram Reference: (131676)-8130
Date Reported: 22-May-2013 **Order Number:** 0000021034
Date Logged: 09-Apr-2013 **Date(s) of Test(s):** 14-May-2013 **to** 16-May-2013

Determination of Net & Gross Calorific Value of Solid Recovered Fuels

By Bomb Calorimetry BS EN 15400:2011 & PT49

Test Results:

Sample Basis As Received

Gross Calorific Value: 21.5478 MJ/kg

Nitrogen: Default Setting as in E.4 of BS EN 15400:2011

Hydrogen values are used to calculate the net CV at constant volume. If the H content is not determined then the net CV is take n from the linear regression fit of the net CV as a function of gross CV.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

End of Test Report

Mr Simon Hall
Author

Appendix 10. Flash & Fire Point Analysis Report

Attn: Benjamin Harrison

Client: BCB International Ltd – Fire Dragon
Unit 21, Stradey Business Park
Llangennech
Llanelli
Carmarthenshire
SA14 8YP

MTD
MINTON TREHARNE & DAVIES LIMITED
Consulting Scientists, Mariners & Engineers
Analytical & Testing Laboratories
Public Analysts

Certificate of Analysis

Lab Ref: **R17-18590**

Client Reference:	RedDragon Fuels	Number of Samples:	2
Client Order Number:		Date Started:	28/04/2017
Sample Source:	As supplied by client	Report Date:	26/05/2017

Plastic bottles of gel-like and solid sample capsule tabs were received at MTD Laboratories on the 26th April 2017 from BCB International Ltd.

All of the samples were analysed in accordance with the testing programme described below.

John Robinson Head of Chemical Laboratories Division

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ALSOOFFICESATLONDON, HOUSTON, SINGAPORE, CARMARTHEN
EMAIL: mtd@minton.co.uk WEB:www.minton.co.uk REGISTRATIONNUMBER:ENGLAND488183

1. **THE TESTING PROGRAMME**

The following tests were conducted on the samples provided:

Gel-like sample (#51261):

- Cleveland Open Cup Flashpoint - Determination of flash and fire points – Cleveland open cup method - by ISO 2592 (Modified)
- Determination of density - Oscillating U-tube method by ISO 12185 (Modified)
- Kinematic Viscosity by EN ISO 3104 (Modified)

Solid Sample (#51262):

- Cleveland Open Cup Flashpoint - Determination of flash and fire points – Cleveland open cup method - by ISO 2592 (Modified)

Signed:
John Robinson, Head of Labs

2. TEST METHODS

2.1 Flashpoint by Cleveland open cup

Due to the low expected flashpoint, the gel-like and solid samples were cooled to 6°C by placing in the fridge together with the sample cup. Heat was applied to the cup using a Bunsen burner at a rate of 1°C a minute. This slow heating rate has been modified into the method due to the low flashpoint expected. The test flame was applied to the sample every 0.5°C.

Using a heating rate of 5-6°C/min, the solid sample (#51262) was frozen down to -16°C prior to commencement of analysis but this gave a different flashpoint in comparison to when a slower heating rate of 1°C/min was applied.

Tests was performed in duplicate and results obtained as per Table 1.

2.2 Kinematic Viscosity

The gel-like sample was initially heated to 60°C in a water bath but it was too viscous to be poured into the viscometer. The temperature of the water bath was increased to 70°C. The sample was poured into a suitable range viscometer and placed in an 80°C water bath but the sample started to boil in the tube after approximately 10mins as bubbles were observed in the tube. The tube was taken out and sample was discarded. A fresh portion of the pre-warmed sample was placed in a 70°C water bath and left for 30mins before commencement of analysis. It was not possible to obtain the kinematic viscosity at 20°C from the viscosity-temperature charts as kinematic viscosity values at two different temperatures could not be obtained. Results for kinematic viscosity @70°C obtained as per Table 1.

2.3 Density by oscillating u-tube method (using a densitometer)

Gel-like sample was pre-warmed to 70°C and density was performed @20°C. Results obtained as per table 1.

Signed: .....
John Robinson, Head of Labs
Page 3 of 4

MTD Minton, Treharne & Davies Ltd R17-18590

3. RESULTS

Sample Number	Sample Description	Cleveland Open Cup (°C) (heating rate: 1°C/min)		Cleveland Open Cup (°C) (heating rate: 5-6°C/min)		Density@20°C (kg/m^3)	Kinematic Viscosity @ 70°C (mm^2/sec)
51261	Gel-like ("Liquid")	11.0	10.5	-		832.5	1188
51262	Solid	17.0	14.5	7.0	9.0	-	-

Table 1

Signed: .....
John Robinson, Head of Labs
Page 4 of 4

Appendix 11. MSL Bactericidal Efficacy Test Results

TEST REPORT
SUSPENSION TEST FOR EVALUATION OF BACTERICIDAL EFFICACY
BS EN 1040:2005

Customer	BCB International ltd.
Contact Name	James Wixey
Address	Clydesmuir Road, Cardiff, CF24 2QS
Email	jw@bcbin.com
PO Number	

Lab Ref	PR-22/15 (lab ref: 9284-1)
Report Date	18/03/2015
Period of Analysis	16/03/15 – 17/03/2015

Name of product	FireDragon solid fuel
Batch number	-
Manufacturer / Supplier	BCB International Ltd.
Storage Conditions	Ambient
Appearance of the Product	Clear solid block
Preservatives/Antimicrobials & Conc.%	Alcohol
Product Diluent recommended by manufacturer for use	Neat as supplied
Method	BS EN 1040:2005
Neutraliser	N3
Product diluent	N/A
Test Concentrations	Neat as supplied
Experimental Conditions	N/A
Interfering substances	N/A
Test Temperature	20^{0}C
Temperature of Incubation	Bacteria - 37°C ±1°C for 24hr to 48hrs
Identification of the Bacterial strains:	*Pseudomonas aeruginosa* ATCC 15442 *Staphylococcus aureus* ATCC 6538
Contact times	Bacteria - 5min ± 10s

Microbiological Solutions Ltd
Gollinrod
Walmersley
Bury, BL9 5NB

Tel: 0844 824 6003
Email: info@microbiologicalsolutions.com
Web: www.microbiologicalsolutions.com

Company Number: 4218514

Introduction

The standard method 1040 describes a suspension test method for establishing the basic bactericidal activity of chemical disinfectants and antiseptic products.

Outline of Test Method

A sample of the test product is diluted and added to a test suspension of bacteria. The mixture is maintained at 20°C for 5mins. At the end of the contact time an aliquot is taken and the bacterial / bacteriostatic activity is immediately neutralised or suppressed by the validated method. The numbers of surviving bacteria in each sample are determined and the reduction is calculated.
The test is performed using *Pseudomonas aeruginosa* and *Staphylococcus aureus* as standard organisms.

Acceptance Criteria

The product when tested as above shall demonstrate at least a 5 $\log_{10}$ reduction in viable bacterial counts.

Conclusion

The product **FIREDRAGON SOLID FUEL** has **PASSED** the test according to the acceptance criteria as outlined in the standard.

See raw data tables below for test results.

The sample will be retained for 1 month unless otherwise requested.

L Boneheyo

Microbiology Technician
Louise Boneheyo

Technical Project Manager
Carolyn Burney

Microbiological Solutions Ltd
Gollinrod
Walmersley
Bury, BL9 5NB

Tel: 0844 824 6003
Email: info@microbiologicalsolutions.com
Web: www.microbiologicalsolutions.com

Company Number: 4218514

Test Results (bactericidal suspension test)

Product Name: Firedragon
Batch Number: -
Lab Ref: 9284

Validation and controls

Validation Suspension (Nv_0)			Experimental Conditions Control (A)			Neutraliser or Filtration Control (B)			Method Validation (C)		
$Vc1$	Ps.116 St.133	Σ = Ps.112.5 St.136	$Vc1$	Ps.111 St.126	Σ = Ps.92 St.134.5	$Vc1$	Ps.87 St.138	Σ = Ps.79 St.120	$Vc1$	Ps.61 St.111	Σ = Ps.62 St.120
$Vc2$	Ps.109 St.139		$Vc2$	Ps.73 St.143		$Vc2$	Ps.71 St.102		$Vc2$	Ps.63 St.129	
$30 \leq x\ of\ Nv_0 \leq 160?$ Yes / ~~No~~			$\bar{x}\ of\ A\ is\ \geq 0.5 \times \bar{x}\ of\ Nv_0?$ Yes / ~~No~~			$\bar{x}\ of\ B\ is\ \geq 0.5 \times \bar{x}\ of\ Nv_0?$ Yes / ~~No~~			$\bar{x}\ of\ C\ is\ \geq 0.5 \times \bar{x}\ of\ Nv_0?$ Yes / ~~No~~		

Pre Test - Sample Sterility check		
AMB	<10cfu/ml	Pass
Y&M	<10cfu/ml	Pass

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Email: info@microbiologicalsolutions.com
Web: www.microbiologicalsolutions.com

Company Number: 4218514

Test Results

Test organism	Σ Inoculum Level	Inoculum Log	Σ V_c	Recovery after Contact Time Log	Log Reduction	Pass / Fail
Pseudomonas aeruginosa ATCC 15442	$6.3x10^8$	7.80	<10	<1.00	>5	Pass
Staphylococcus aureus ATCC 6538	$5.8x10^8$	7.76	<10	<1.00	>5	Pass

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Email: info@microbiologicalsolutions.com
Web: www.microbiologicalsolutions.com

Company Number: 4218514

TEST REPORT
SUSPENSION TEST FOR EVALUATION OF BACTERICIDAL EFFICACY
BS EN 1276:2009

Customer	BCB International ltd.
Contact Name	James Wixey
Address	Clydesmuir Road, Cardiff, CF24 2QS
Email	jw@bcbin.com
PO Number	1040/1276

Lab Ref	PR-22/15 (lab ref: 9284-1)
Report Date	18/03/2015
Period of Analysis	16/03/15 – 17/03/2015

Name of product	FireDragon solid fuel
Batch number	
Manufacturer / Supplier	BCB International Ltd.
Storage Conditions	Ambient
Appearance of the Product	Clear solid block
Preservatives/Antimicrobials & Conc.%	Alcohol
Product Diluent recommended by manufacturer for use	Neat as supplied
Method	BS EN 1276:2009
Neutraliser	N3
Product diluent	N/A
Test Concentrations	Neat as supplied
Experimental Conditions	Dirty
Interfering substances	0.3g/l Bovine Albumin
Test Temperature	20^0C
Temperature of Incubation	Bacteria - 37°C ±1°C for 24hr to 48hrs
Identification of the Bacterial strains:	*Pseudomonas aeruginosa* ATCC 15442 *Staphylococcus aureus* ATCC 6538 *Enterococcus hirae* ATCC 10541 *Escherichia coli* ATCC 10536
Contact times	Bacteria - 5min ± 10s

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Company Number: 4218514

Introduction

The standard method 1276 describes a suspension test method for establishing whether a chemical disinfectant or antiseptic has or does not have bactericidal activity in the fields described in the scope. The test takes into account practical conditions of application of the product, including contact time, temperature, test organisms and interfering substance, i.e. conditions which may influence its action in practical situations.
The conditions are intended to cover general purposes and to allow reference between laboratories and product types. Each utilization concentration of the chemical disinfectant or antiseptic found by this test corresponds to defined experimental conditions. However, for some applications, the recommendations of use of a product may differ and therefore additional test conditions may need to be used.

Outline of Test Method

A sample of the test product is diluted and added to a test suspension of bacteria in a solution of interfering substance. The mixture is maintained at 20°C for 5mins. At the end of the contact time an aliquot is taken and the bacterial / bacteriostatic activity is immediately neutralised or suppressed by the validated method. The numbers of surviving bacteria in each sample are determined and the reduction is calculated.
The test is performed using *Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus* and *Enterococcus hirae* as standard organisms.

Acceptance Criteria

The product when tested as above shall demonstrate at least a 5 $\log_{10}$ reduction in viable bacterial counts.

Conclusion

The product **FIREDRAGON SOLID FUEL** has **PASSED** the test according to the acceptance criteria as outlined in the standard.

See raw data tables below for test results.

The sample will be retained for 1 month unless otherwise requested.

L Boneheyo

Microbiology Technician
Louise Boneheyo

Technical Project Manager
Carolyn Burney

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Email: info@microbiologicalsolutions.com
Web: www.microbiologicalsolutions.com

Company Number: 4218514

Test Results (bactericidal suspension test)

Product Name: Firedragon
Batch Number: -
Lab Ref: 9284

Validation and controls

Validation Suspension (N_{V_0})			Experimental Conditions Control (A)			Neutraliser or Filtration Control (B)			Method Validation (C)		
$Vc1$	Ps.116 St.133 Ec.121 Ent.50	Σ = Ps.112.5 St.136	$Vc1$	Ps.111 St.126 Ec.88 Ent.34	Σ = Ps.92 St.134.5	$Vc1$	Ps.87 St.138 Ec.91 Ent.36	Σ = Ps.79 St.120	$Vc1$	Ps.61 St.111 Ec.72 Ent.31	Σ = Ps.62 St.120
$Vc2$	Ps.109 St.139 Ec.106 Ent.64	Ec.113.5 Ent.57	$Vc2$	Ps.73 St.143 Ec.56 Ent.30	Ec.72 Ent.32	$Vc2$	Ps.71 St.102 Ec.82 Ent.33	Ec.86.5 Ent.34.5	$Vc2$	Ps.63 St.129 Ec.72 Ent.33	Ec.72 Ent.32
$30 \leq \Sigma\ of\ Nv_0 \leq 160$? Yes / ~~No~~			$\Sigma\ of\ A\ is\ \geq 0.5 \times \Sigma\ of\ Nv_0$? Yes / ~~No~~			$\Sigma\ of\ B\ is\ \geq 0.5 \times \Sigma\ of\ Nv_0$? Yes / ~~No~~			$\Sigma\ of\ C\ is\ \geq 0.5 \times \Sigma\ of\ Nv_0$? Yes / ~~No~~		

Pre Test - Sample Sterility check		
AMB	<10cfu/ml	Pass
Y&M	<10cfu/ml	Pass

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Tel: 0844 824 8005
Email: info@microbiologicalsolutions.com
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Company Number: 4218514

Test Results

Test organism	Σ Inoculum Level	Inoculum Log	Σ V_c	Recovery after Contact Time Log	Log Reduction	Pass / Fail
Pseudomonas aeruginosa ATCC 15442	$5.5x10^8$	7.74	<10	<1.00	>5	Pass
Staphylococcus aureus ATCC 6538	$5.3x10^8$	7.72	<10	<1.00	>5	Pass
Escherichia coli ATCC 10536	$9.6x10^8$	7.98	<10	<1.00	>5	Pass
Enterococcus hirae ATCC 10541	$3.6x10^8$	7.56	<10	<1.00	>5	Pass

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Company Number: 4218514

Appendix 12. MSL Shelf-Life Test Results (5 Years)

STABILITY TEST REPORT – SUITE B

Lab Reference	9390/1
Customer	BCB International
Customer PO	
Address	Unit 21 Stradey Business Park Llangennech Llanelli Dyfed SA14 8YP
Contact Name	James Wixey / Ben Harrison
Email	jw@bcbin.com / bh@bcbin.com
Telephone Number	01554 823 824

Product Name	Fire Dragon	Report Date	08/10/15
Batch Code	CN336A	Start Date	28/04/15
Packaging & Volume	Individual wrapped blocks	End Date	05/10/15

	Initial Result	Specification	End of Trial (Summary)*
Appearance	Solid gel	Not Given	No Change
Colour	Translucent	Not Given	No Change
Odour	Alcohol	Not Given	No Change
pH	N/A	Not Given	No Change
Viscosity (cps)	Semi solid	Not Given	No Change
Pack Performance	Foil sealed PET	Not Given	Satisfactory
Weight	23-25g	27g	Within acceptable limits

Opinions and Interpretation

The product has remained unchanged for the 12 week period in the conditions listed and can therefore be allocated a 3 year shelf life. The products have been returned to the conditions in order to predict a 5 year shelf life.

08/10/10 – The product has remained unchanged for a further 8 weeks and so can be allocated a 5 year shelf life, providing the primary packaging is not changed.

Note: The product was not tested as "Opened" as it is a single use sample.

Taking all factors into consideration this product has a probable shelf-life of: **5 Years**

Report Authorised by:

Carolyn Burney

Stability Manager / Technical Project Manager

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Page **1** of **3**

STABILITY TEST REPORT – SUITE B

Raw Data **Lab Reference 9390/1**

SUITE B	Test	Initial	1 week 05/05/15	2 weeks 12/05/15	4 weeks 26/05/15	8 weeks 23/06/15	12 weeks 21/07/15	16 Weeks
22°C Dark (Opened)	Appearance	✓	N/A	N/A	N/A	N/A		
	Colour	✓	N/A	N/A	N/A	N/A		
	Odour	✓	N/A	N/A	N/A	N/A		
	Packaging	✓	N/A	N/A	N/A	N/A		
	pH	✓						
	Viscosity	✓						
	Weight	✓						
22°C Dark (Unopened)	Appearance						0	0
	Colour						0	0
	Odour						0	0
	Packaging						0	0
	pH						-	-
	Viscosity						0	0
	Weight						24.9g	24.3g
Room Temp Light (Opened)	Appearance		0	0	0	0	0	0
	Colour		0	0	0	0	0	0
	Odour		0	0	0	0	0	0
	Packaging		0	0	0	0	0	0
	pH						-	-
	Viscosity						0	0
	Weight							
45°C (Opened)	Appearance		N/A	N/A	N/A	N/A		
	Colour		N/A	N/A	N/A	N/A		
	Odour		N/A	N/A	N/A	N/A		
	Packaging		N/A	N/A	N/A	N/A		
	pH							
	Viscosity							
	Weight							
45°C (Unopened)	Appearance						0	0
	Colour						0	0
	Odour						0	0
	Packaging						0	0
	pH						-	-
	Viscosity						0	0
	Weight						24.4g	24.1g
Freeze Thaw	Appearance		0	0	0	0	0	
	Colour		0	0	0	0	0	
	Odour		0	0	0	0	0	

STABILITY TEST REPORT – SUITE B

* Grading Key:

0	No Change	-No observable change when the test sample and reference standard are held together.
1	Slight Change	-The sample observed in isolation appears unchanged, however when compared to the reference sample there is some difference noted.
2	Moderate Change	–The sample observed in isolation appears to have changed slightly but is still fit for purpose and would not be expected to raise customer complaints.
3	Complete Change	– There is a noticeable change which would risk an unsatisfactory level of complaints.

Stability testing is a predictive procedure based upon data obtained from products stored under conditions which accelerate changes occurring to imitate market conditions. In common with all predictive procedures, results are not absolute but have a certain probability of success; at its lowest where tests are short and with high acceleration. Bearing in mind these limitations, the shelf-life can only be a “probable” shelf-life and not absolute.

Samples will not be retained after the report date unless otherwise requested. The test results on this report refer only to the items tested. This report shall not be reproduced without written permission obtained from Microbiological Solutions Ltd.

Appendix 13. DEKRA Gel Transport Classification Report

DEKRA
www.dekra-process-safety.co.uk

FireDragon Green & Clean Gel Fuel

Vapour Flammability Testing

Client	BCB International Ltd
Client location	Wales, UK
Contact	Benjamin Harrison
Report issue date	22nd November 2018
Report number	S3016004405R1V1/2018

DEKRA

CONTENTS **PAGE NO.**

1. PROJECT DETAILS AND TEST WORK APPROVAL STATEMENT

Quotation Number	3016004405
Job Number	4028003884
DEKRA Process Safety Facility	Chilworth Technology Ltd, Phi House, Southampton Science Park, Southampton, Hampshire, SO16 7NS, UK
Client Facility	BCB International Ltd, Unit 21, Stradey Business Park, Llangennech, Llanelli, SA14 8YP, UK
Contact Details	Phone: +44 (0)23 8076 0722 Email: process-safety-uk@dekra.com Web: www.dekra-process-safety.com
Author / Reviewer	Egle Siusiene Laboratory Technician – Regulatory Testing Laboratory
Peer Reviewer	Shajad Younis Team Leader – Regulatory Testing Laboratory
Study Initiation date*	14/11/2018
Start Date of Experimental Work	19/11/2018
Completion Date of Experimental Work	21/11/2018

* Sample, purchase order or last information receipt date, whichever is the latter.

This report has been issued in digital format. In order to ensure that the integrity of the data is maintained, the signed hard copy (in the DEKRA Process Safety archive) will be considered the source document and digital versions will be considered copies. All original test records are kept in a locked archive for a minimum of 10 years after the date of this report. Any remaining material(s) will be stored for a minimum of 1 month after the issue date of this report. This report was prepared by Christine Simmons.

2. INTRODUCTION

This report contains test data for BCB International Ltd regarding the vapour flammability characteristics of FireDragon Green & Clean Gel Fuel. Specifically, the following work has been undertaken:

- Viscosity Test
- UN Test L.1 Solvent Separation Test

This work is in response to quotation number 3016004405. A formal hazard assessment of the process / plant has not been conducted by DEKRA Process Safety and the consequences of specific process deviations have not been examined[1].

Detailed characterisation of the material tested in this study is provided in Section 3 of this report (with results summarised in the conclusions section)[2].

The materials used in this assessment were supplied by BCB International Ltd.

3. SAMPLE INFORMATION

Product name	FireDragon Green & Clean Gel Fuel
Batch number	170303
CTL sample reference	400012869
Appearance	As received, the sample is observed to be a cloudy, viscous liquid / gel
Preparation	Sample tested as received

[1] Process safety requires that all possible explosion, thermal stability and chemical reaction hazards are evaluated and that a suitable basis for safe operation is determined and implemented. Should the materials or processing conditions change then consideration should be given to re-assessment.
[2] A description of the test procedures together with full test results and information on their interpretation is given in the test sections of this report. DEKRA Process Safety's Laboratories are GLP (Good Laboratory Practice) compliant and this study was carried out to the principles of GLP.

4. VISCOSITY (FLOW-CUP) TEST

Test Objective and Information

The purpose of this test is to determine the flow time of a viscose liquid. The test is conducted in accordance with ISO 2431:2011 for UN Transportation of Dangerous Goods, Manual of Tests and Criteria (6th revised edition).

Apparatus	:	Flow cups (4mm/6mm)	Stopwatch
		Laboratory glassware	Temperature controlled enclosure
		Thermometer	Stand & spirit level

Procedure

The flow-time in seconds is determined at 23°C (± 0.5°C) using the ISO standard cup with a 4 mm jet. Where the flow-time exceeds 100 seconds, a second test is carried out using the ISO standard cup with a 6 mm jet.

With the orifice closed, the cup is filled with sufficient sample to conduct the test. A suitable receiver is located under the flow cup so that the distance between the orifice and the flow cup and the surface of the received sample is never less that 100 mm. The orifice is opened and the timing-device is simultaneously started; stopping as soon as the first break occurs in the stream of sample close to the orifice. The flow time is recorded to the nearest 0.5 s. The test is repeated and the mean of the two determinations is calculated. If the two determinations differ by more than 5 % a third determination is conducted and any test outside 5 % is disregarded.

4.1 Test Results for FireDragon Green & Clean Gel Fuel

Date	:	21/11/2018
Operator	:	E. Siusiene
Preparation	:	Sample tested as received
Temperature	:	23°C
SOP Reference	:	CTL SOP No. 422

Table 4.1

Test	Flow cup orifice size (mm)	Flow time (s)	Comments
1	4	> 100	No flow observed
2	6	> 100	No flow observed

Result = > 100 seconds (4 mm & 6 mm flow cup)

Comments

During the analysis, no flow was observed for up to 3 hours with each of the flow cup sizes, therefore the testing was terminated.

5. UN TEST L.1 SOLVENT SEPARATION TEST

Test Objective and Information

This test is used to determine the extent of solvent separation in viscous liquids, with a flash point of less than 23°C.

The test is conducted in accordance with UN Transportation of Dangerous Goods, Manual of Tests and Criteria (6th revised edition).

Apparatus

A stoppered 100 ml measuring cylinder is required of approximately 25 cm total height and of a uniform internal diameter of approximately 3 cm over the calibrated section.

Procedure

The liquid should be stirred to obtain a uniform consistency and poured in up to the 100 ml mark. The stopper is inserted and the cylinder left standing undisturbed for 24 hours. After 24 hours, the height of the upper separated layer is measured.

Test Criteria and Method of assessing Results

The height of the upper separated layer is expressed as a percentage of the total height of the sample. If less than 3 % of clear solvent separates out then the substance may be considered for inclusion in Packing Group III.

5.1 Test Results for FireDragon Green & Clean Gel Fuel

Date	:	19/11/2018 – 20/11/2018
Operator	:	E. Siusiene
Preparation	:	Sample tested as received
Temperature	:	20°C

The sample was poured into a 100 ml stoppered measuring cylinder up to the 100 ml mark. The cylinder was left standing undisturbed for 24 hours. After 24 hours, no change was observed to the sample condition. The solvent did not separate from the sample.

Result = No separation observed (0%).

5.2 Hazard grouping based on flammability

Classification of FireDragon Green & Clean Gel Fuel has been determined as Class 3 Packing Group III; provided the capacity of the receptacle used does not exceed 450 litres. This classification is based on testing from the UN Manual of Tests & Criteria (6th Revised edition) and assignment of packing groups detailed in section 2.3.2 of the UN Recommendations on the Transport of Dangerous Goods Model Regulations (19th Revised Edition).

Based on section 2.3.2.4 of the above mentioned model regulations:-

Viscous liquids which:

- *have a flash point of 23°C or above and less than or equal to 60°C;*
- *are not toxic, corrosive or environmentally hazardous;*
- *contain not more than 20% nitrocellulose provided the nitrocellulose contains not more than 12.6% nitrogen by dry mass; and*
- *are packed in receptacles of not more than 450 litre capacity;*

are not subject to these Regulations, if:

a. *in the solvent separation test , the height of the separated layer of solvent is less than 3% of the total height;*
   and
b. *the flow time in the viscosity test, with a jet diameter of 6mm is equal to or greater than:*
   - *(i) 60 seconds; or*
   - *(ii) 40 seconds if the viscous substance contains more than 60% of Class 3 substances*

Based on test results FireDragon Green & Clean Gel Fuel does not meet these criteria for exclusion from Class 3 Packing Group III.

6. SUMMARY OF TEST RESULTS AND RECOMMENDATIONS

6.1 Summary of Test Data Obtained

The results of testing completed on FireDragon Green & Clean Gel Fuel are summarised in Table 6.1.

Table 6.1: Summary of Results

Parameter	Test Results
Viscosity Test	> 100 seconds (4 mm & 6 mm flow cup)
UN Test L.1 Solvent Separation Test	No solvent separated (0%)

Classification of FireDragon Green & Clean Gel Fuel has been determined as a Class 3 Packing Group III Flammable Liquid.

The results of testing are highly dependent on the composition and physical nature of the sample. For this reason, any change in manufacturing / handling procedures or composition should be accompanied by a review of the relevant data.

DEKRA Process Safety would be pleased to provide specific advice, including interpretation and application of experimental data. Site visits to discuss operational safety or to perform plant inspections and measurements can be arranged on request.

Appendix 14. MoD (Interscience) Performance Tests

interscience communications

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Haslar Road, Gosport
Hampshire PO12 2AG
United Kingdom
Tel.: +44 (0) 20 8692 5050
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Email:
firetesting@intersciencecomms.co.uk

Test Report: ICL/LR15/08/003

BOIL TIME AND TOXICITY TESTING
MOD Reference: DFFS/5069A DFFS 5069

Sponsored By

Defence Equipment and Support
Defence Fuel & Food Services
Elm 2A, #4224
MOD Abbey Wood
Bristol
BS34 8JH

interscience communications

BOIL TIME AND TOXICITY TESTING
MOD Reference: DFFS/5069A DFFS 5069

Sponsored By

Defence Equipment and Support
Defence Fuel & Food Services
Elm 2A, #4224
MOD Abbey Wood
Bristol
BS34 8JH

1 Objective

DES DFFS had commissioned Interscience to carry out a test programme to assess the properties of a number of Ration Heaters with associated fuel.

The programme of work consisted of:

- Carrying out boiling point test as detailed in the contract document.
- Carry out toxicity test using the apparatus and methodology detailed in AFAP-3.
- Carry out tests on the fuel alone in accordance with the method detailed in ISO 5660-1 at 0 (zero) heat flux.

2 Description Of Test Specimens

The description of the specimens given below has been prepared from information provided by the sponsor of the test. All values quoted are nominal, unless tolerances are given.

Test specimens supplied were marked Fuel A to E and current Fuel.

The sponsor of the test did not supply further details relating to the product tested.

3 Date of receipt of the test specimens

The specimens were delivered on 7th July 2015.

4.0 Water boil time test Procedure

Each fuel was tested by using sufficient fuel for one burn cycle (one sixth of a 24 hours pack). The following parameters were determined.

(i) Measure time taken for each fuel and stove combination to bring 500 ml of water to boiling point.

(ii) Once boiling point has been obtained and whilst remaining on heat, trace the water temperature performance over the following 6 minutes.

4.1 Test results of water boil test

The results of these tests are given in Table 1 below.
Time V temperature chart for each fuel is given in Appendix 1.

Fuel reference	Stove reference	Time to reach boiling point (mins: sec)	Temperature (°C) after 6 mins
Current Run 1	E	9:16	98.8
Current Run 2	E	9:18	98.8
Fuel A Run 1	A	[redacted]	[redacted]
Fuel A Run 2	A	[redacted]	[redacted]
Fuel B Run 1	B	7:55	86.5
Fuel B Run 2	B	7:52	86.5
Fuel C Run 1	C	[redacted]	[redacted]
Fuel C Run 2	C	[redacted]	[redacted]
Fuel D Run 1	D	[redacted]	[redacted]
Fuel D Run 2	D	[redacted]	[redacted]
Fuel E Run 1	E	[redacted]	[redacted]
Fuel e Run 2	E	[redacted]	[redacted]

Notes:

1. Please note t[redacted] recorded was[redacted]
2. The boiling point reported are from visual observation made during the test.

5 Toxicity test

Each fuel was tested for toxic gas emissions using the analytical methodology detailed in AFAP-3.

The furnace was set at 35-40°C. The test specimen (1 ±0.005 grammes) was placed in combustion boat and ignited.

The airflow through the tube furnace was set at 2l/m and maintained at this rate for the 20 minute duration of the test.

5.1 Test results

The gases detected for each fuel tested expressed as C_e (ppm) scaled up for 100grammes combusted in $1m^3$ volume are given in the table below:

Table 1

Gas	Analytical Technique	Average C_0 (ppm)	Average C_a (ppm)	Average C_e (ppm)	Average C_z (ppm)	Average C_g (ppm)	Average C_n (ppm)
		Current Fuel		Fuel B			
Carbon Dioxide	NDIR	48244		37997			
Carbon Monoxide	NDIR	47.95		34.78			
Oxides of Nitrogen	Chemiluminescence	5.13		1.68			
Sulphur Dioxide	IC	ND		ND			
Hydrogen Fluoride	ISE	ND		ND			
Hydrogen Bromide	IC	ND		ND			
Hydrogen Chloride	IC	ND		ND			
Hydrogen Cyanide	Spectrophotometry	0.05		ND			
Phenol	HPLC	ND		ND			
Formaldehyde	Spectrophotometry	ND		ND			
Acrolein	Titration	ND		ND			

ND stands for not detected.

These values were used to calculate Toxicity Index values using references values (Cf value) given in AFAP-3 Annex 1.

A summary table of toxicity Index for each fuel is given below. Individual results for each fuel type are given in Appendix 3.

Table 2

Fuel reference	Toxicity Index
Current Fuel	0.55
Fuel A	[redacted]
Fuel B	0.41
Fuel C	[redacted]
Fuel D	
Fuel E	

Note:

1. Values in the table above are average of two runs

6. Heat release measurement

Tests were carried out using the equipment and methodology detailed in ISO 5660-1 for details of the test procedure reference can be made to this standard.

- Two specimens of each fuel were tested.
- The specimens were ignited using a small gas igniter.
- The furnace of the equipment was at room temperature.
- ISO 5660-1 requires that the test specimen is 100mm x 100mm and the software calculates the heat release values as HRR per m^2.
- The total heat release is also calculated as value per m^2.

6.1 Test Results

The results of the tests are summarised in the table below:

Fuel Reference	pK HRR (kW/m^2)	Time to pK HRR (Sec)	T HR (MJ/m^2)
Current fuel	136.2	225	83.4
Fuel A	[redacted]	[redacted]	[redacted]
Fuel B	148.2	345	60.7
Fuel C			
Fuel D			
Fuel E			

Notes :

1. HR values have been calculated on surface area basis and are reported as kW/ m^2.
2. To get a HRR values for the sample burnt the values in Table above need to be divided by 100.

Time V HRR and Time V THR are given in Appendix 4.
Table of results for each fuel is also given in Appendix 4.

6.2 **Discussion**

- [redacted]
- Fuel B has a faster drop down after reaching the boiling point.
- [redacted]
- [redacted]

The heat release values can be used for:

- As quality control tool to check that the products delivered are identical to one for which order was placed.
- The higher THR value mean that in storage higher fire load is being stored. Experts can use this value to decide the safety precautions needed in storage and transportation.

Prepared by

C. B. Chong
Fire Scientist

Approved by

S. Kumar
Technical Manager

Date of Issue: 21st August 2015

Appendix 3 – Toxicity data

Gas	Analytical Technique	Run 1		Run 2		Average	C_f^* value	TI contribution
		C_1 (ppm)	C_0 (ppm)	C_1 (ppm)	C_0 (ppm)	C_0 (ppm)	(ppm)	C_0 / C_f^*
Carbon Dioxide	NDIR	12250.0000	48926.6101	11900.0000	47561.9504	48244.2803	100000	0.4824
Carbon Monoxide	NDIR	11.9000	47.5287	12.1000	48.3613	47.9450	4000	0.0120
Oxides of Nitrogen	Chemiluminescence	1.2900	5.1523	1.2800	5.1159	5.1341	100	0.0513
Sulphur Dioxide	IC	ND	-	ND	-	-	400	-
Hydrogen Fluoride	ISE	ND	-	ND	-	-	50	-
Hydrogen Bromide	IC	ND	-	ND	-	-	150	-
Hydrogen Chloride	IC	ND	-	ND	-	-	500	-
Hydrogen Cyanide	Spectrophotometry	0.02	0.0639	0.01	0.0440	0.0539	90	0.0006
Phenol	HPLC	N.D	-	ND	-	-	250	-
Formaldehyde	Spectrophotometry	N.D	-	ND	-	-	500	-
Acrolein	Titration	N.D	-	ND	-	-	5	-
							Toxicity Index	0.55

Table 1. Current fuel

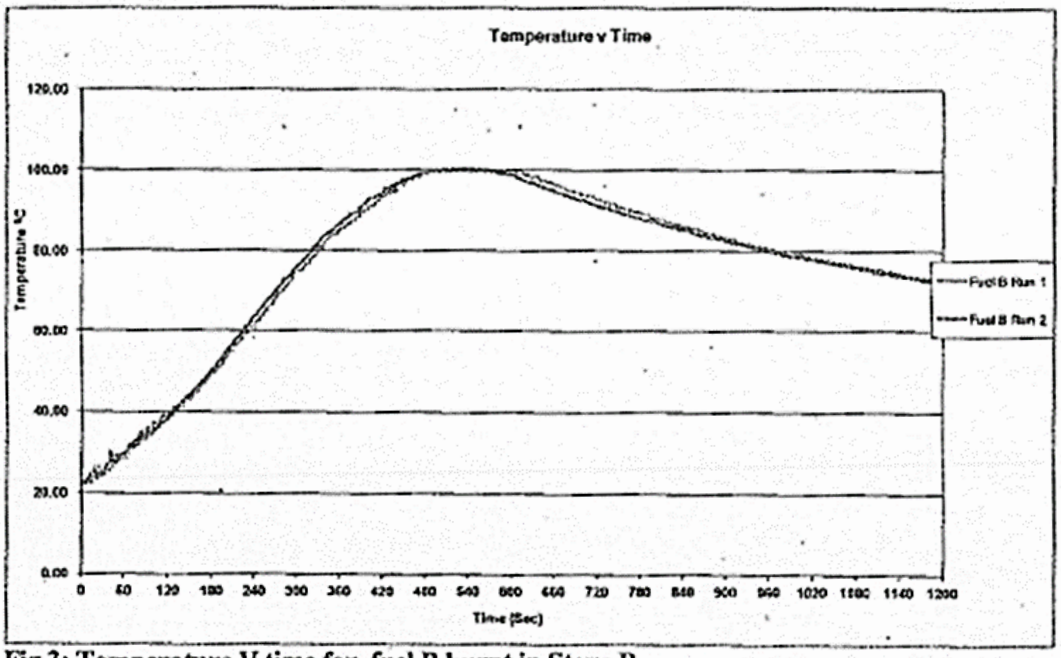

Fig 3: Temperature V time for fuel B burnt in Stove B

interscience communications

Gas	Analytical Technique	Run 1		Run 2		Average	Cf value	TI contribution
		C_1 (ppm)	C_0 (ppm)	C_1 (ppm)	C_0 (ppm)	C_3 (ppm)	(ppm)	C_0 / Cf
Carbon Dioxide	NDIR	9540.0000	38118.0701	9470.0000	37876.2124	37997.1413	100000	0.3800
Carbon Monoxide	NDIR	8.6000	34.3622	8.8000	35.1965	34.7793	4000	0.0087
Oxides of Nitrogen	Chemiluminescence	0.4100	1.6382	0.4300	1.7198	1.6790	100	0.0168
Sulphur Dioxide	IC	ND	-	ND	-	-	400	-
Hydrogen Fluoride	ISE	ND	-	ND	-	-	50	-
Hydrogen Bromide	IC	ND	-	ND	-	-	150	-
Hydrogen Chloride	IC	ND	-	ND	-	-	500	-
Hydrogen Cyanide	Spectrophotometry	N.D	-	ND	-	-	90	-
Phenol	HPLC	N.D	-	ND	-	-	250	-
Formaldehyde	Spectrophotometry	N.D	-	ND	-	-	500	-
Acrolein	Titration	N.D	-	ND	-	-	5	-
							Toxicity Index	0.41

Table 3. Fuel B

Appendix 4 – ISO 5660-1 data

Test on Current Fuel

Parameter	Test 1	Test 2	Average
Specimen Initial mass (g)	28.5	29.09	28.8
Time to ignition (s)	9	10	9.5
Total heat release (MJ/m²)	81.8	84.95	83.4
Mass loss between Ign & Ext (g)	201.0	29.09	115.1
TSR (m²/m²)	7.21	10.99	9.1
pK HRR (kW/m^2)	131.55	140.82	136.2
pk Effective heat of combustion (MJ/kg)	79.53	76.66	78.1
pK Specific ext area (m^2/kg)	2448.94	235.10	1342.0
Average values HRR			
HRR (kW/m^2) over Ign 60 sec from ign	13.74	9.98	11.9
HRR (kW/m^2) over Ign 120 sec from ign	34.96	32.58	33.8
HRR (kW/m^2) over Ign 180 sec from ign	59.77	58.42	59.1
HRR (kW/m^2) over Ign 300 sec from ign	86.57	89.02	87.8
Average values EHC (MJ/kg)			
EHC (MJ/kg) over Ign 60 sec from ign	0.23	8.23	4.2
EHC (MJ/kg) over Ign 120 sec from ign	1.11	15.28	8.2
EHC (MJ/kg) over Ign 180 sec from ign	2.68	19.38	11.0
EHC (MJ/kg) over Ign 300 sec from ign	5.66	24.15	14.9
MARHE (kW/m^2)	95.27	97.17	96.2

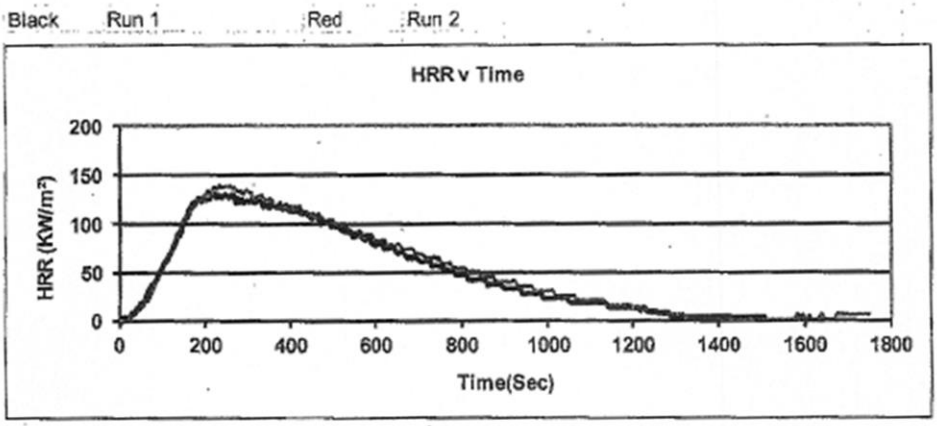

Figure 1 : Time V HRR chart

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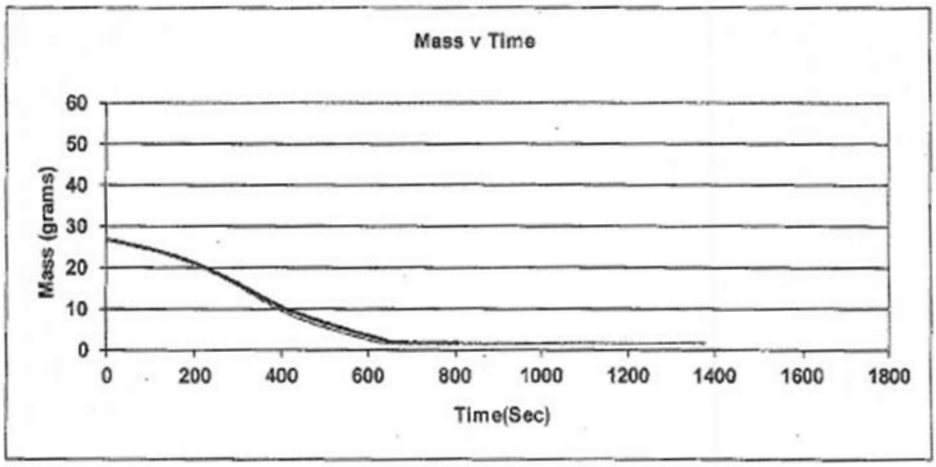

Figure 2 : Time V specimen mass chart

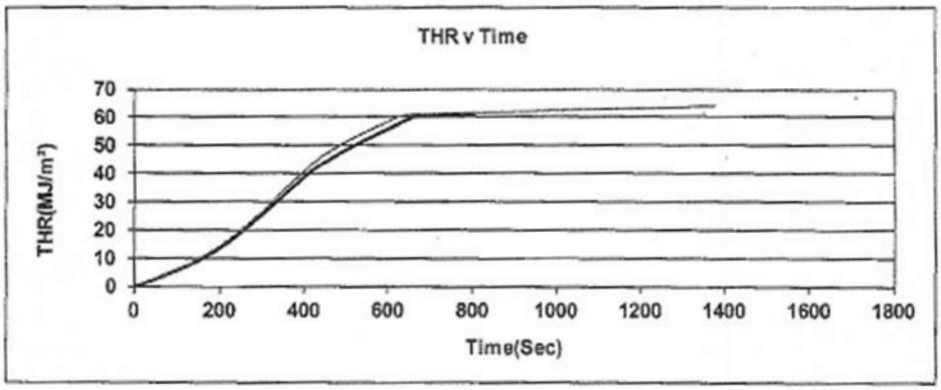

Figure 3 : Time V THR chart

Report No: ICL/LR15/08/003

Test on Fuel B

Parameter	Test 1	Test 2	Average
Specimen Initial mass (g)	26.5	26.64	26.6
Time to ignition (s)	3	1	2.0
Total heat release (MJ/m²)	60.3	61.05	60.7
Mass loss between Ign & Ext (g)	25.0	25.23	25.1
TSR (m²/m²)	0.00	0.00	0.0
pK HRR (kW/m^2)	143.54	152.91	148.2
pk Effective heat of combustion (MJ/kg)	71.39	58.21	64.8
pK Specific ext area (m^2/kg)	0.00	0.00	0.0
Average values HRR			
HRR (kW/m^2) over Ign 60 sec from ign	53.88	59.04	56.5
HRR (kW/m^2) over Ign 120 sec from ign	59.42	64.96	62.2
HRR (kW/m^2) over Ign 180 sec from ign	66.22	72.10	69.2
HRR (kW/m^2) over Ign 300 sec from ign	85.43	90.90	88.2
Average values EHC (MJ/kg)			
EHC (MJ/kg) over Ign 60 sec from ign	23.54	24.08	23.8
EHC (MJ/kg) over Ign 120 sec from ign	23.15	24.15	23.7
EHC (MJ/kg) over Ign 180 sec from ign	22.89	23.71	23.3
EHC (MJ/kg) over Ign 300 sec from ign	23.31	23.96	23.6
MARHE (kW/m^2)	97.34	104.38	100.9

Black Run1 Red Run 2

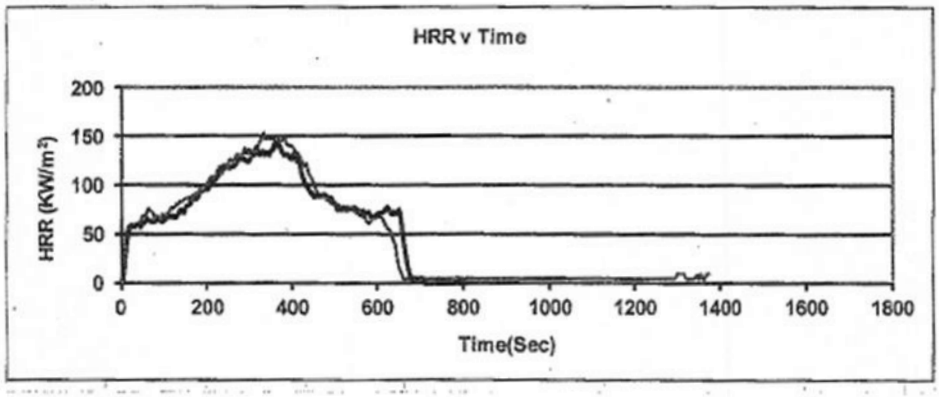

Figure 1 : Time V HRR chart

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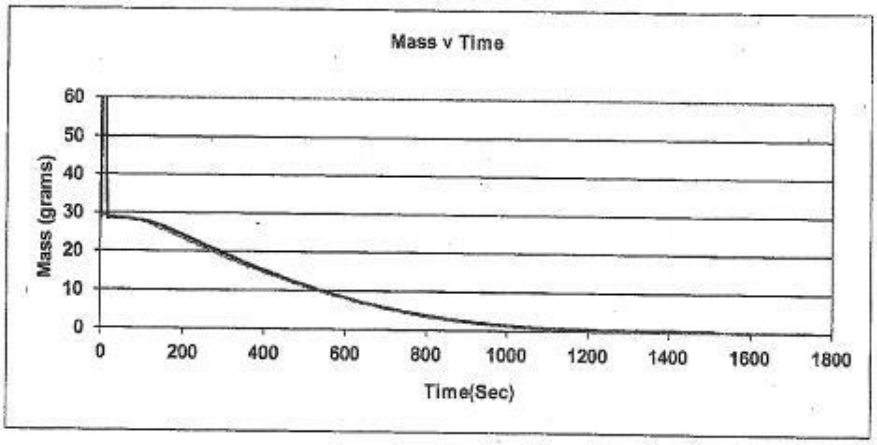

Figure 2 : Time V specimen mass chart

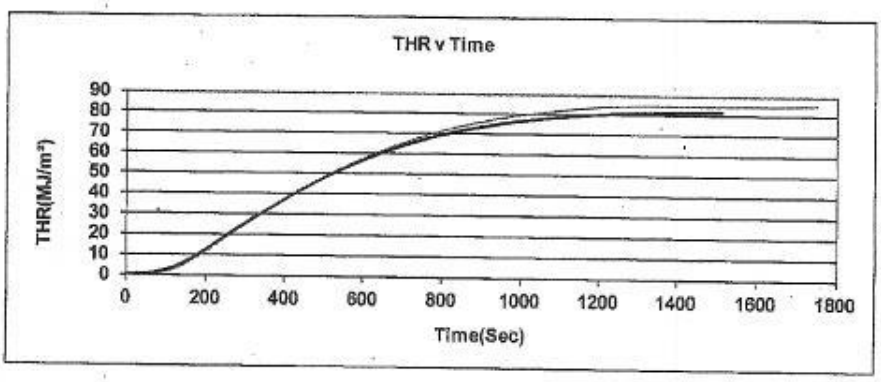

Figure 3 : Time V THR chart

Appendix 15. Report by Taffs TV – Ex 22 SAS, Operational Research (R & D)

TAFFS.TV

Test Report

Test dates between 9th March 19 – 12th March 19

Location: Vannøya, Northern Norway. (70°10'54.88"N 19°42'2.89"E)

Test conditions during the day: Were generally between -2ºC & -4ºC Still air temperature. and up to -11ºC with wind chill. (gusting)

Test conditions during the evening: Were generally between -2ºC & -6ºC Still air temperature, up to -12ºC with wind chill. (gusting)

Wind speed: Up to 30 mph

Wind in MPH	Air temperature in degrees Celsius																
°C--->	10	8	6	4	2	0	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-40
10	8	5	3	0	-2	-5	-7	-10	-12	-15	-17	-19	-22	-24	-27	-29	-54
20	6	4	1	-1	-4	-7	-9	-12	-15	-17	-20	-22	-25	-28	-30	-33	-59
30	6	3	0	-3	-5	-8	-11	-13	-16	-19	-22	-24	-27	-30	-32	-35	-62
40	5	2	-1	-3	-6	-9	-12	-15	-17	-20	-23	-26	-29	-31	-34	-37	-65
50	4	2	-1	-4	-7	-10	-13	-16	-18	-21	-24	-27	-30	-33	-35	-38	-67
60	4	1	-2	-5	-8	-11	-13	-16	-19	-22	-25	-28	-31	-34	-37	-39	-68
70	4	1	-2	-5	-8	-11	-14	-17	-20	-23	-26	-29	-32	-35	-37	-40	-70
80	3	0	-3	-6	-9	-12	-15	-18	-21	-23	-26	-29	-32	-35	-38	-41	-71
90	3	0	-3	-6	-9	-12	-15	-18	-21	-24	-27	-30	-33	-36	-39	-42	-72
100	3	0	-3	-6	-9	-13	-16	-19	-22	-25	-28	-31	-34	-37	-40	-43	-73

Precipitation: Overall approximately 20%

Humidity: Approximately 60%

Weather: Dull overcast most of the time, with some sunny intervals and light to moderate snow, on times creating white out conditions when the snow was wind driven.

Location: The exact test locations were a, located approximately 50 metres from the sea within a secluded bay. 70° 3'14.16"N 19°50'48.86"E and b, on an exposed point 70° 2'47.80"N 19°52'57.01"E

Equipment used: FireDragon solid fuel provided by BCB int, Cardiff.

6 x 27gram blocks of solid fuel.

The outside of the packaging was labelled with an NSN number which was: 9110-99-426-2694

Also, a multifuel cooker – a small folding cooker with a windshield.

The NSN number shown on the packaging was: 7310-99-587-4226

Standard British army 2-part mess tin NSN number 7350-99-973-6265

Test Methodology: Approximately 500ml of water was added to the mess tin from our canteen.

1 block of fuel was opened with thin Marino gloves on.

The block was placed into the central fuel receiver in the stove. This was ignited using windproof/waterproof matches.

The mess tin with water was then placed on top of the cooker and covered by the other mess tin and allowed to cook. This boiled in approximately 9 minutes. The weather conditions at the time were windy with gusts up to 20 mph, and with light to moderate snowfall and the air temperature at the time was -9.8^{o}C. (with wind-chill)

Conclusion: The product lit quickly and easily and burned very well. It was never blown out by the wind. The test was carried out a number of times and building a ‘snow wind break’ around the cooker and mess tins helped with boiling times.

We then went on to use the fuel during the four days of the camp for water heating and cooking. We were overall, very impressed with the performance of the fuel during the four days of trialling. It performed very well, and we used it as our primary fuel source for cooking whilst under test conditions (camping on the water front)

Signed:

Name: A. Wood

Ex 22 SAS, Operational research (R and D).

Expedition and Adventure TV Guide and consultant

Date: 19 March 2019

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BCB International Ltd
TEST REPORT

SCOPE OF WORK
Temperature profile testing of multi-fuel cooker

REPORT NUMBER
103959546MKS-002a

ISSUE DATE
5th June 2019

PAGES
9

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TEST REPORT FOR BCB INTERNATIONAL
Report No 103959546MKS-002a
Issue date: 5th June 2019

SECTION 1

INTRODUCTION

This report gives details of a product evaluation carried out on a single model of multi-fuel cooker. The model was supplied by BCB International Ltd for temperature profile testing using an environmental chamber.

The tests were completed at Intertek Milton Keynes in May 2019.

The tests have been carried out under the limited terms of reference, and as such, the results and opinions given are only applicable to the sample tested and the conditions of the tests. Sample variability and changes in test conditions could influence some results, and the result(s) as stated may not be representative of the mean result if a number of different samples were tested under a variety of test conditions.

This report replaces report '103959546MKS-002' and has been updated with some minor editorial changes.

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TEST REPORT FOR BCB INTERNATIONAL
Report No 103959546MKS-002a
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Summary

As requested by BCB International, all testing was carried out in line with the Leidos/MoD specification as follows:

Temperature profile: Heat 500 ml of water to a temperature of 75°C

a) Within 11 minutes, and sustain the temperature for a period of 5 minutes
b) In an air temperature of -8°C
c) With windspeed of 0 mph
d) Using water with a starting temperature between a min. of +15°C to a max. of +21°C

All specification criteria were successfully achieved during all three of the test runs as shown in the summary table below:

Multi-fuel Cooker test	Test 1	Test 2	Test 3
Time taken to achieve 75°C temperature (mins)	6	6.25	6
Temperature achieved at this point (°C)	77.37	75.77	76.30
Temperature 5 mins after above point (°C)	94.66	87.17	84.10
Time from initially reaching 75°C to falling below 75°C (mins)	8.3	7.0	6.5

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TEST REPORT FOR BCB INTERNATIONAL
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SECTION 2

TEST RESULTS

1. Sample details

Intertek Laboratory Codes BCB1, BCB2 and BCB3

Manufacturer/Distributor – BCB International Ltd
Operation Ration Heater Fuel: FireDragon BCB Part No. CN336MOD*
Mess Tins: Conforming to NSN 7350-99-973-6265**
Operational Ration Heater Stove: BCB Part No. RP337A NSN 7310-99-587-4226*

* Part number has been supplied by BCB International. The parts supplied for testing were not marked as per the information supplied in their entirety.
** Part number has been supplied by BCB International. The parts supplied for testing were unmarked so could not be verified by Intertek

Note: Figure 1 is a photograph showing the products, Figure 2 is a close up of the fuel

Figure 1

Figure 2

The package from which the fuel samples were selected was batch number 190517.

2. Temperature profiles

Testing was performed in an environmentally controlled room set at -8°C ambient.

The product was placed in the environmental chamber with a single fuel block placed in the fuel receiver, after both the foil lid and the plastic tray had been removed.

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A 500ml quantity of water was placed in the larger of the two mess tins and the temperature recorded as being between 20 to 21°C, before the mess tin was placed in the environmental chamber.

The assessor then went into the chamber and lit the firelighter using a butane lighter.

The mess tin and its contents were then carried into the environmental chamber and a calibrated thermocouple was position in the middle of the water, and logging software set running to monitor the temperature of the water, taking a reading every 15 seconds.

During the process of placing the mess tin on the stove, inevitably the environmental chamber loses a proportion of the sub-zero cold air, but this effect was minimised by constructing a barrier between the test room and the door, so that the room was able to maintain -8°C ambient temperature during the test.

The method given above was used to establish the temperature profile of the stove in use.

The product under test is shown in Figure 3.

Figure 3

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Report No 103959546MKS-002a
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The results are given in Table 1 on the following two pages.

Table 1

Multi-fuel Cooker test	Test 1 Temperature (°C)	Test 2 Temperature (°C)	Test 3 Temperature (°C)
Time from when logging started to positioning mess tin over heat source	31 seconds	33 seconds	25 seconds
Time (Seconds)			
0	20.49	20.81	20.58
15	20.50	20.85	20.62
30	20.56	20.92	20.66
45	22.76	20.98	21.14
60	33.88	23.94	23.30
75	37.47	26.61	23.71
90	38.41	27.24	24.30
105	39.96	29.43	25.57
120	40.87	30.69	27.13
135	42.66	31.48	28.70
150	44.76	32.30	30.22
165	47.22	34.13	32.64
180	49.46	36.13	34.89
195	52.08	39.04	37.27
210	54.44	41.43	40.42
225	55.32	43.84	43.35
240	58.06	45.76	45.80
255	60.15	47.37	48.82
270	62.18	49.45	52.10
285	64.73	51.66	55.06
300	67.08	54.40	58.30
315	69.15	58.09	62.50
330	71.23	60.99	65.09
345	74.07	63.83	67.70
360	74.73	66.18	70.59
375	74.85	69.63	73.57
390	77.37	72.91	76.30
405	81.60	75.77	78.17
420	83.63	78.21	79.51
435	85.67	80.94	80.21
450	87.19	83.45	81.39
465	87.62	84.80	81.61
480	87.01	85.62	82.59
495	88.84	86.04	83.75
510	90.58	87.46	83.94

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Table 1 continued

Time continued (Seconds)	Test 1 Temperature (°C)	Test 2 Temperature (°C)	Test 3 Temperature (°C)
525	89.91	88.30	84.80
540	89.65	88.62	85.45
555	89.96	88.81	85.83
570	91.03	89.99	86.83
585	93.28	89.72	87.42
600	93.51	89.74	87.72
615	93.19	89.48	88.00
630	91.95	90.04	88.07
645	92.14	90.36	87.70
660	94.53	89.48	87.13
675	94.07	89.38	85.77
690	94.66	88.44	84.10
705	94.85	87.17	82.39
720	94.31	85.30	80.85
735	94.66	83.60	79.25
750	93.15	82.00	77.68
765	92.62	80.23	76.13
780	90.58	78.72	74.69
795	87.81	77.16	73.30
810	84.38	75.71	71.97
825	81.45	74.20	70.58
840	78.97	72.78	69.24
855	76.81	71.48	68.00
870	75.02	70.21	66.85
885	73.39	68.94	65.72
900	71.89	67.68	64.60
915	70.37	66.53	63.52
930	68.93	65.39	62.51
945	67.63	64.31	61.49
960	66.36	63.20	60.47
975	65.17	62.17	59.46
990	63.96	61.17	58.50
1005	62.76	60.17	57.55
1020	61.67	59.20	56.68
1035	60.58	58.26	55.85
1050	59.53	57.36	55.05

Equipment used: Balance E10030, calibration due 24/9/19; water temperature E10013, calibration due 28/6/19; thermocouple E11063 with MD020, calibration due 18/4/20 and temperature room E10150, calibration due 26/4/20.

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3. Discussion of results

The pass criteria set for the test was to:

Temperature profile: Heat 500 ml of water to a temperature of 75°C

a) Within 11 minutes, and sustain the temperature for a period of 5 minutes
b) In an air temperature of -8°C
c) With windspeed of 0 mph
d) Using water with a starting temperature between a minimum of +15°C to a maximum of +21°C

All specification criteria were successfully achieved during all three of the test runs as shown in the summary table below.

Multi-fuel Cooker test	Test 1	Test 2	Test 3
Time taken to achieve 75°C temperature (mins)	6	6.25	6
Temperature achieved at this point (°C)	77.37	75.77	76.30
Temperature 5 mins after above point (°C)	94.66	87.17	84.10
Time from initially reaching 75°C to falling below 75°C (mins)	8.3	7.0	6.5

Appendix 17. Testimonial Letter Leidos Supply Limited

August 29, 2019

TEAM leidos

BCB International Ltd
Howell House,
Lamby Industrial Park,
Wentloog Avenue,
Cardiff CF3 2EX

SUPPLY OF OPERATIONAL RATION HEATING SYSTEM (ORHS) TO UK MOD

BCB International Limited have supplied the British Military with the Operational Ration Heating System (ORHS) since October 2015.

The ethanol fuel blocks have proved convenient and effective; and the individual cooking system is highly regarded by British troops.

With effect from October 2019, the ORHS contract has been successfully awarded to BCB International for a further 4-year contract period.

We look forward to a continued working relationship with BCB International.

Yours sincerely,

Ian Swann
Head of Commercial, Leidos Supply Limited.

8 Monarch Court / Emersons Green, Bristol BS16 7FH / 0117 332 500 teamleidos.co.uk

Appendix 18. FireDragon v Wood Comparison

		NOT NORMALISED to 13% O_2								
Duration Minutes	Flue Gas Temperature O^c	Organic Gaseous Compounds ppm	Nox ppm	Carbon Monoxide ppm	Carbon Dioxide ppm	Oxygen ppm	Ambient Temperature O^c	Static Pressure Pa		
47.5	70.6	40.8	4.8	269.2	6031.7	204890.4	18.9	11.6	Average T1	1100g Beech logs on open fire
45.0	75.1	29.4	5.0	278.0	6505.3	204638.6	19.3	12.3	Average T2	
45.0	75.1	34.7	5.2	294.2	7645.6	205109.9	21.5	13.1	Average T8	
45.8	73.6	35.0	5.0	280.5	6727.5	204879.6	19.9	12.3	**Average Beech Logs**	
37.5	75.4	1.6	2.0	28.4	4824.9	205623.0	19.6	12.2	Average T3	500g Fire Dragon Fuel in medium (clean container)
38.0	75.0	1.6	2.1	35.8	5035.2	205816.6	19.9	12.1	Average T4	
39.5	72.7	1.5	2.1	42.2	5078.0	206048.3	20.3	12.0	Average T5	
38.3	74.4	1.6	2.0	35.5	4979.4	205829.3	19.9	12.1	**Average Fire Dragon Fuel**	

		NOT NORMALISED to 13% O_2								
Duration Minutes	Flue Gas Temperature O^c	Organic Gaseous Compounds ppm	Nox ppm	Carbon Monoxide ppm	Carbon Dioxide ppm	Oxygen ppm	Ambient Temperature O^c	Static Pressure Pa		
47.5	70.6	40.8	4.8	269.2	6031.7	204890.4	18.9	11.6	Average T1	1100g Beech logs on open fire
45.0	75.1	29.4	5.0	278.0	6505.3	204638.6	19.3	12.3	Average T2	
45.0	75.1	34.7	5.2	294.2	7645.6	205109.9	21.5	13.1	Average T8	
45.8	73.6	35.0	5.0	280.5	6727.5	204879.6	19.9	12.3	**Average Beech Logs**	
37.5	75.4	1.6	2.0	28.4	4824.9	205623.0	19.6	12.2	Average T3	500g Fire Dragon Fuel in medium (clean container)
38.0	75.0	1.6	2.1	35.8	5035.2	205816.6	19.9	12.1	Average T4	
39.5	72.7	1.5	2.1	42.2	5078.0	206048.3	20.3	12.0	Average T5	
48.5	63.9	1.5	2.1	43.8	4758.1	206742.2	20.7	11.2	Average T6	500g (used container)
32.5	80.0	1.2	2.4	50.0	5938.4	205360.0	21.0	12.0	Average T7	460g (used container)
39.2	73.4	1.5	2.1	40.0	5126.9	205918.0	20.3	11.9	**Average FireDragon Fuel**	
Client:	Fire Dragon	Open Fire					Client:	Fire Dragon	**Open Fire**	

Test Fuel:	**Beech wood logs**				
Test Type:	Nominal Heat Output	Test 1	Test 2	Test 8	Mean
Date of Test		23/09/19	23/09/19	23/09/19	
Mean Flue Draught Pa		11.60	12.30	13.10	12.33
Mean Flue Gas Temperature (°C)		70.60	75.10	75.10	73.60
Mean Ambient Temperature (°C)		18.90	19.30	21.50	19.90
Mean CO_2 emissions (%)		0.60	0.65	0.76	0.67
Test Duration (h)		0.79	0.75	0.75	0.76
Measured Heat Output (kW)		2.38	2.51	3.15	2.68
Mean CO at 13% O_2 (%)		0.42	0.41	0.48	0.44
Mean CO at 13% O_2 (mg/m3)		5278	5148	6004	5477
Mean OGC at 13% O_2 (mg/m3)		1035	705	916	885
Mean NO_x at 13% O_2 (mg/m3)		155	153	175	161
Mean PM at 13% O_2 (mg/m3)		65	110	94	94

Test Fuel:	**Fire Dragon fuel**				
Test Type:	Nominal Heat Output	Test 3	Test 4	Test 5	Mean
Date of Test		23/09/19	23/09/19	23/09/19	
Mean Flue Draught Pa		12.20	12.10	12.00	12.10
Mean Flue Gas Temperature (°C)		75.40	75.00	72.70	74.37
Mean Ambient Temperature (°C)		19.60	19.90	20.30	19.93
Mean CO_2 emissions (%)		0.48	0.50	0.51	0.50
Test Duration (h)		0.62	0.63	0.66	0.64
Measured Heat Output (kW)		2.09	2.84	2.86	2.60
Mean CO at 13% O_2 (%)		0.05	0.07	0.08	0.07
Mean CO at 13% O_2 (mg/m3)		645	852	1055	851
Mean OGC at 13% O_2 (mg/m3)		47	49	49	48
Mean NO_x at 13% O_2 (mg/m3)		75	82	87	81
Mean PM at 13% O_2 (mg/m3)		4	1	9	5

Testing conducted by BRSIA Limited on 26th September 2019.

Appendix 19: FireDragon v Flameless Ration Heater

Comparison between masses of FireDragon Solid 27g block and Flameless Ration Heater.

Executive Summary

- FireDragon provides heat at roughly 3x the efficiency of Flameless Ration Heaters.
- FireDragon is roughly 50% lighter when unused, versus Flameless Ration Heaters.
- FireDragon is roughly 23 times lighter when used, versus Flameless Ration Heaters.

Introduction

Flameless ration heaters (FRH) are issued to US DoD soldiers for heating Meal, Ready-to-eat, (MRE) food packs. They offer a means of heating food without using fire but are fundamentally flawed as they require water to trigger the chemical reaction, allowing heat generation. Water is a precious resource in the field, so cannot be used lightly, considering the water used is non-retrievable after use in a FRH.
FireDragon is a novel, globally-patented, solidified ethanol ration heater, developed in the UK, which has already been adopted by the UK MoD as their sole cooking fuel. UK MoD recognised the requirement for change from a dated fuel such as hexamine to a novel, non-toxic fuel such as FireDragon. FireDragon (FD) bested all competition in terms of performance and emissions in independent testing, prior to approval by UK MoD.

Experimental

Tests were performed to calculate the residual waste, including packaging, which a soldier would have to carry after use of FRH and FD, as well as theoretical determinants to determine cooking efficiency of both systems.
Both systems, FD and FRH, were used as per their issued instructions and the resulting waste was calculated in full.
The sealed FRH was weighed. 45cm^3 of cool tap water was added to a HotPack brand FRH, which was then lightly sealed with Sellotape and left laid flat on a heatproof surface. The resulting reaction was allowed to proceed to completion and the resulting system was weighed.
A sealed, production sample of FD was weighed. The lid was then removed, and the FD block was placed in a metal tray, atop a heatproof surface, and ignited with use of a flint and striker. The resulting combustion was allowed to proceed to completion and the metal tray and residue was allowed to cool. The resulting residue was weighed and combined to the mass of the empty packaging to give a total waste mass. The % mass of the residue, versus the FD block, was also measured.
Masses were weighed using a calibrated Ohaus Navigator measuring balance. Volumes were measured using a Academy Grade B Borosilicate 50cm^3 measuring cylinder.

Results

Flameless ration heater;

	1	2	3	Average
Mass before/ g	46.10	44.86	45.41	45.46

1

Mass after/ g	86.45	85.09	85.02	85.52
Change in mass/ g	+40.35	+40.23	+39.61	+40.06
Change in mass/ %	+87.5	+89.7	+87.2	+88.1

FireDragon Solid;

	1	2	3	Average
Mass before/ g	27.56	27.19	27.41	27.39
Mass after/ g	1.32	1.28	1.31	1.30
Change in mass/ g	-26.24	-25.91	-26.10	-26.08
Residue mass/ %	4.79	4.71	4.78	4.76
Packaging mass/ g	2.37	2.39	2.37	2.38
Total waste/ g	3.69	3.67	3.68	3.68

From the above, it was deduced that the total footprint of FireDragon, versus the original mass, was averaged at 12.4%.

Comparison of FRH (unopened) and FD (unopened) was as follows;

$\left(\frac{mass\ of\ FRH}{mass\ of\ FireDragon}\right) = \left(\frac{45.46}{29.77}\right) = 1.52$, i.e. FRH = 1.52x FD, when unopened. This can also be expressed as a 2:3 ratio of masses for the unopened products (2 FRH = 3 FD in mass).

Comparison of FRH (total waste) and FD (total waste) was as follows;

$\left(\frac{used\ mass\ of\ FRH}{used\ mass\ of\ FireDragon}\right) = \left(\frac{85.52}{3.68}\right) = 23.2$, i.e. FRH waste = 23.2x FD waste, after use including packaging. This can also be equivalated to around 70:3 ratio of masses for the used products (3 used FRH = 70 used FD in mass).

Theoretical efficiency;

FRH, produced by Luxfer Magtech, self-report to heat a MRE to 100°F (37°C) within around 10 minutes. The HotPack variety of FRH trialled reached an external temperature, using a DeWalt DCT414 IR thermometer, of around 172°F (78°C). The temperature change of a meal heated by this system cannot be quantified for this report using available methods.

FD are widely reported to take circa 500cm^3 of water from around 62.6°F (17°C) to 212°F (100°C) in around 7 minutes. Oftentimes, internal tests and QC checks have seen instances of rolling boil achieved in less time, closer to 6 minutes.

We may assume change in temperature (herein, ΔT, where Δ also refers to 'a change of') to be approximately from 32°F (0°C) to 100°F (37°C), giving a ΔT of Δ68°F (Δ37°C) over 10 minutes for FRH, as reported by Luxfer Magtech. We may also assume ΔT for FD to be

approximately Δ150°F (Δ83°C) over 7 minutes for FireDragon, given the report of achieving a rolling boil from below room temperature, as stated above.

We can see from the above that there is a distinct difference in the efficiency of the FRH versus FD. To draw a direct comparison, the FRH exhibits a ΔT of Δ68°F (Δ37°C) in 600 seconds (10 minutes) where FD exhibits a ΔT of Δ150°F (Δ83°C) in 420 seconds (7 minutes).

Generally, heating profiles are linear trends, so we can approximate that in 420 seconds (7 minutes) the FRH will reach ΔT of Δ47.6°F (Δ26.4°C), as;
$\left(\frac{68°F}{600s}\right) x\ 420s =$ ΔT in 420s.

From this we can deduce that FD is roughly 3x as efficient as FRH, as;

$$\left(\frac{\Delta T\ of\ FD\ at\ 420s}{\Delta T\ of\ FRH\ at\ 420s}\right) = \frac{\Delta 150°F}{\Delta 47.6°F} = 3.151$$

This value corresponds to the efficiency of FD versus FRH, which can also be expressed as FRH being 32% the efficiency of FD. Given the data regarding masses of FD versus FRH, this efficiency value does not account for differences in weights and relates solely to one unit of heating system (e.g. one FRH and one FD solid block). The above does not account for total heating time. In this respect, Luxfer Magtech report 10 minutes heating where FireDragon will burn for a total of around 10-12 minutes, therefore exceeding FRH's efficiency in this regard, also.

Conclusion

It has been deduced that FireDragon is considerably more efficient than Flameless Ration Heaters, given available data, at a size and weight which should be favourable. At a time when weight savings are crucial, FireDragon should not be left unconsidered given initial weight difference, heating efficiency and used masses where there are significant differences. FireDragon's residue is non-hazardous, non-toxic and non-bioaccumulative so can be emptied out of the cooker anywhere, without issue.
FireDragon's secondary use as an antibacterial hand-cleanser lends itself to further weight savings whereby soap is rendered redundant in cases of FireDragon being issued. As FireDragon possesses the ability to boil water, equipment can be sanitised in this manner which is not possible under any circumstance with FRH. Flames may also be used to sterilise medical equipment, in the case of emergencies, so suture needles (for example) could be quickly sterilised prior to emergency use in the field. This is, again, not a possibility with FRH.

Generated by:
Benjamin Harrison MChem (Hons).
R&D Chemist – BCB International LTD.

Appendix 20: French MoD FireDragon Test Report

LABORATOIRE DU COMMISSARIAT
DES ARMEES

Département de Chimie

RAPPORT D'ESSAI N° V18.2757

Date d'édition : lundi 13 août 2018

Destinataire : 00251

CESCOF / DIVISION ACTIVITÉS
BUREAU SOUTIEN DE L'HOMME

Identification du produit :

Code RAD ... : Code NNO ... :

Désignation . : **COMBUSTIBLE A BASE D'ALCOOL SOLIDIFIE**

Fournisseur .. :

N°commande :

Renseignements relatifs à la demande d'analyse Motif d'analyse ..... : Etude

Prélevé le ..... :

Reçu le ..... : 05/07/2018

Renseignements complémentaires

Date de fabrication ..... : /

DLUO / DDM / DLC ..... : /

Marquage ..... : /

Agrément sanitaire ou EMB.. : /

Emballage/présentation ..... : Blister operculé

Etiquetage *Nature* ..... : FIREDRAGON - Green clean cooking fuel - BCB

Exemplaires

Archives laboratoire (papier)

CESCOF / DIVISION ACTIVITÉS - BUREAU SOUTIEN DE L'HOMME

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Date d'impression : 13/08/2018 *Page 1 sur 2 du rapport d'essai n° V18.2757*

Département de Chimie

Echantillon - (V18.2757.1)

- Essais

Cofrac	Paramètres	Référence	Incertitude	Unité	Résultat	Débuté le
	Aspect de l'échantillon				**Normal**	30/07/2018

Conclusion du département de CHIMIE:

Un sachet contenant 6 blisters de combustible à base d'éthanol solidifié a été utilisé, afin d'étudier le comportement du produit lors de sa conservation à 38°C puis à 55°C.

1) 1er test :

Le produit a été placé 8 jours dans une atmosphère à 38°C et 92% d'humidité relative.

Par la suite, l'échantillon a été examiné, juste après sa sortie d'étuve et après refroidissement.

2) 2ème test :

Le produit a été placé 2 jours à 55°C, avec un examen visuel intermédiaire au bout de 24h et après retour à température ambiante.

3) Un essai de combustion a été réalisé sur un combustible ayant été testé

Résulats (voir annexe pour plus de détails) :

Le combustible se liquéfie partiellement à 37°C et à 55°C, mais se solidie à nouveau après refroidissement.

Aucune fuite n'a été observée, ni pendant ni après les étuvages.

Après les essais de conservation à 38°C et 55°C, le produit s'enflamme facilement et brûle intégralement lors du test de combustion.

Fin du rapport n° V18.2757

TEST D'UN COMBUSTIBLE A BASE D'ALCOOL SOLIDIFIÉ août 2018

V18.2757

Description du produit :
Alcool (éthanol) solidifié conditionné sous forme de 6 blisters operculés (poids unitaire net : 27g), regroupés dans un sachet plastique.

Etude demandée :
Etudier le comportement du produit lorsqu'il est conservé à 38°C et à 55°C (vérification de l'intégrité du produit).

Principe des tests :

- 1 sachet de 6 blisters a été reçu par le LABOCA.

- Un **premier étuvage a été réalisé à 38°C** et 92% d'humidité pendant 8 jours.
NB : Il s'agit d'un étuvage identique à celui réalisé sur les combustibles solides des ensembles de réchauffage actuels (à base de méthanamine).

-Après examen du produit, un **deuxième étuvage a été réalisé à 55°C** pendant 48h.

-Un essai de combustion a été réalisé sur un combustible ayant subi les tests, afin d'observer son aspect et son comportement lors de l'utilisation.

Etiquetage (film de suremballage)

FIREDRAGON
GREEN & CLEAN GEL FUEL

Contract No:
DFFS/5069
DMC: **ORP**
Demand Order No:

D of Q PPQ NSN
EA 1 9110-99-426-2694

Batch Number:
108

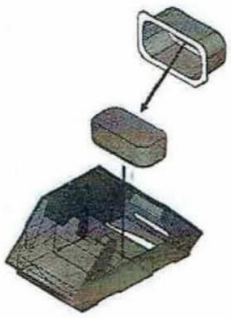
Operational Ration Heater Fuel 24 Hour Fuel Pk
6 × 27g Fuel Blocks
Code: CN336MOD | **Gross Weight:** 176g .
Conforms to BS EN 5660-1
in Great Britain

BCB International Ltd,
Cardiff CF24 2QS UK
www.bcbin.com
Environmentally friendly
"Fuel for the Future"

Instructions:
- Peel off foil top from **FireDragon** fuel pot using bottom left corner opening tab.
- Empty entire pot content including any liquid into the stove fuel receiver.
- Light fuel when safe and ready to use.
- Use one fuel block at a time.
- Block liquefies when lit

Can be used as a hand cleanser. Using it as a waterless soap may affect burn times.

Conforms to BS EN 1276:2009



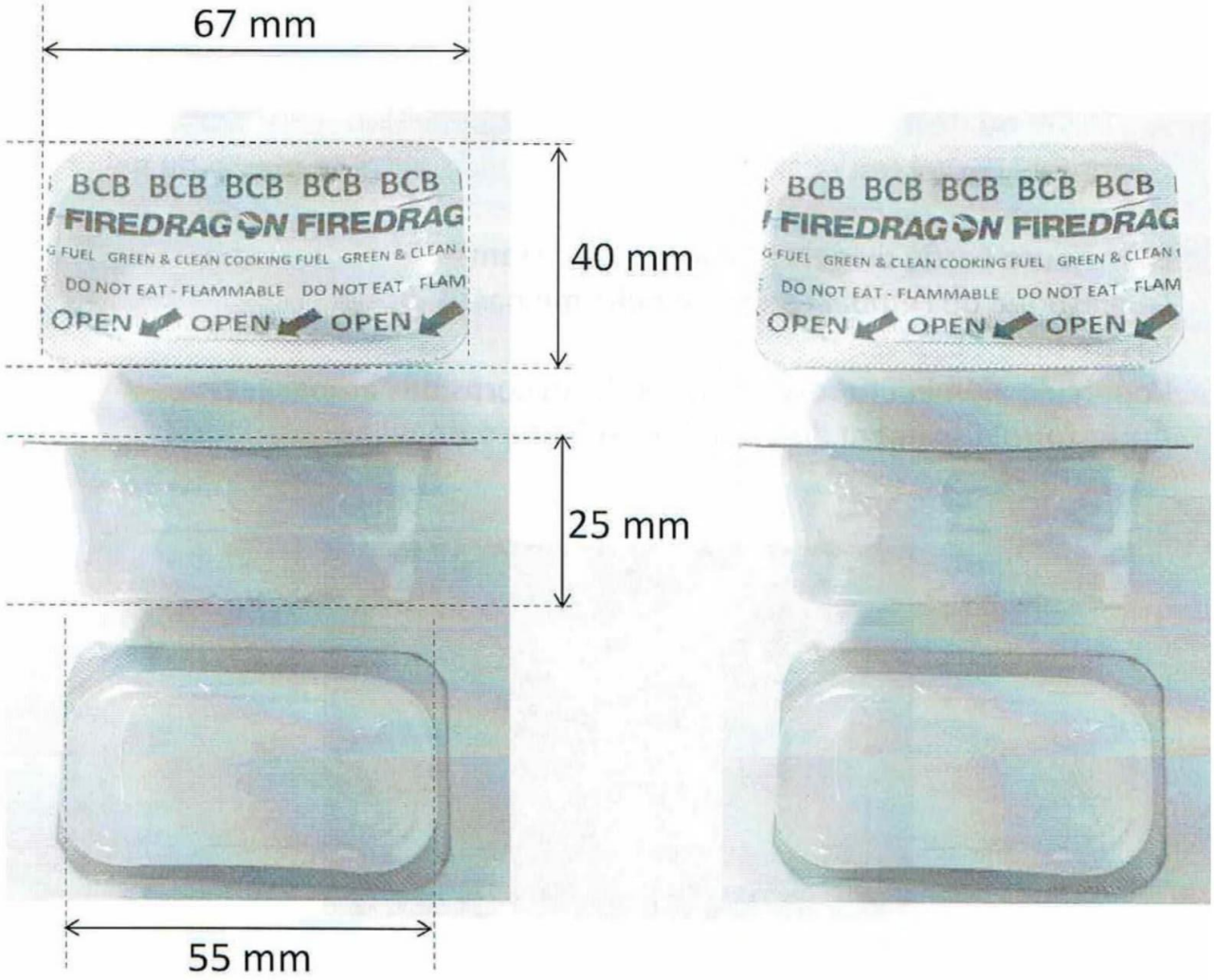
Warning: Flammable Solid. Can cause eye irritation. Do not eat. If medical advice is needed have this packaging at hand. Keep out of reach of children.

Read instructions before use.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if possible.
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources until ready to light. Avoid breathing vapours.
Use outdoors or in well-ventilated area. Dispose of container in a bin.

Contains: Denatured ethanol contains Bitrex taste aversion agent.
Patent granted: GB2500062

TEST D'UN COMBUSTIBLE A BASE D'ALCOOL SOLIDIFIÉ août 2018

Blisters



TEST à 38°C :

Mise en enceinte climatique 38°C 92% RH

- Jo : lundi 30/07/2018
- J2 : mercredi 01/08/2018
- J8 : mercredi 08/08/2018

A l'issue du test (J8), on observe une liquéfaction **très** partielle en périphérie du gel (on observe un peu de liquide entre la masse du gel et la paroi interne de l'emballage translucide).
La majeure partie du gel reste assez consistant.
Le plastique de l'emballage ne se déforme pas.
Pas de fuite observée.
L'opercule aluminium reste bien soudé au corps de l'emballage.
Après refroidissement, le produit se solidifie à nouveau.

NB : Les 6 blisters ont été pesés à chacune de ces étapes, comme pour l'analyse de reprise d'humidité des combustibles habituels. Les résultats obtenus sont conformes aux spécifications des combustibles à base de méthanamine (aucune prise de poids > 0,15%/24h).

TEST D'UN COMBUSTIBLE A BASE D'ALCOOL SOLIDIFIÉ août 2018

TEST à 55°C :

Mise en étuve à 55 °C pendant 48 H (du 08/08/2018 au 10/08/2018), avec remise à température ambiante pendant quelques heures le 09/08/2018 (afin de vérifier l'aspect du produit).

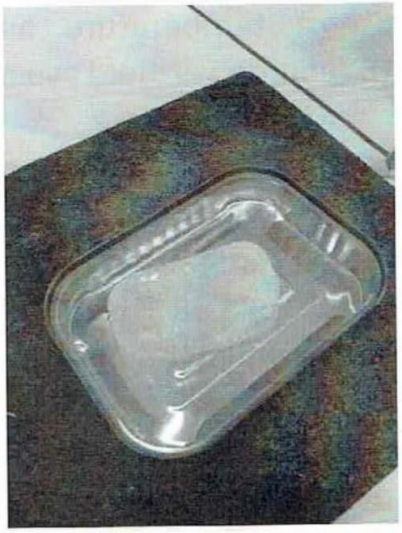
On observe, à l'issue du séjour à 55°C, une liquéfaction partielle en périphérie du gel (on observe un peu de liquide entre la masse du gel et la paroi interne de l'emballage translucide) : la quantité de liquide est un peu plus importante qu'à 38°C.
La partie encore solide du gel à perdu de sa consistance, et le plastique de l'emballage est devenu plus souple.
L'opercule aluminium reste bien soudée au corps de l'emballage.
Le gel se solidifie à nouveau en revenant à la température ambiante.

TEST D'UN COMBUSTIBLE A BASE D'ALCOOL SOLIDIFIÉ août 2018

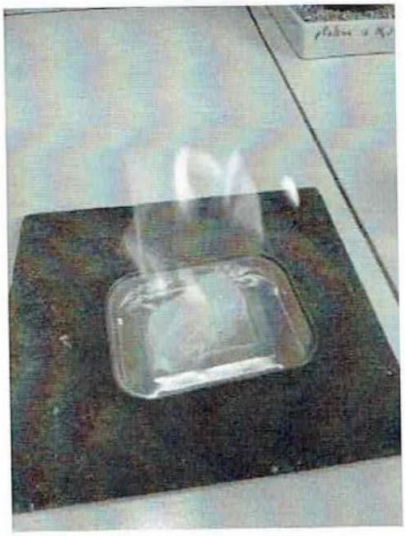
Essai de combustion :

Après refroidissement, un essai de combustion a été réalisé pour un produit qui a été soumis au test d'étuvage à 38°C et 55°C.

Ouverture du blister



Combustible placé dans le réchaud



Début de combustion

Fin de combustion

Résultat : le produit s'enflamme très facilement. En se liquéfiant, il occupe toute la surface du support utilisé comme réchaud.
A noter : le fabricant fournit un réchaud adapté destiné à « canaliser et concentrer la flamme » sur le produit à réchauffer.

Summary of French MoD lab test results on 27g FireDragon tablets are:

- 1st test: 6 FD fuel tablets were stored for 8 days in a 38ºC atmosphere with 92% relative humidity
- 2nd test: the 6 FD fuel tablets were stored for 2 days in a 55ºC atmosphere
- 3rd test: Combustion test

Results: no leaks either before or after the storage tests. After the storage tests the fuel was easy to light and burnt fully.

WOJSKOWY OŚRODEK BADAWCZO-WDROŻENIOWY
SŁUŻBY ŻYWNOŚCIOWEJ
PRACOWNIA TECHNIKI, NORMALIZACJI I KODYFIKACJI

„ZATWIERDZAM"

KOMENDANT
WOJSKOWEGO OŚRODKA
BADAWCZO-WDROŻENIOWEGO
SŁUŻBY ŻYWNOŚCIOWEJ

.....
płk Paweł CZUBKOWSKI

EKSPERTYZA Nr 3/2017

OCENA PRZYDATNOŚCI ZESTAWU FIREDRAGON DO PODGRZEWANIA POSIŁKU Z RACJI ŻYWNOŚCIOWYCH SR-G

WARSZAWA 2017

SPIS TREŚCI

KIEROWNIK PRACOWNI TECHNIKI, NORMALIZACJI I KODYFIKACJI

mjr dr inż. Krzysztof Kosiuczenko

Pieczęć, podpis, data
(kierownik pracowni)

ZASTĘPCA KOMENDANTA
WOJSKOWEGO OŚRODKA BADAWCZO-WDROŻENIOWEGO
SŁUŻBY ŻYWNOŚCIOWEJ

ppłk mgr Adam NOWOSAD
21.08.2017

Pieczęć, podpis, data
(zastępca komendanta)

Streszczenie

W ekspertyzie oceniono funkcjonalność palnika i skuteczność paliwa FIREDRAGON opracowanych przez BCB International Ltd, Clydusmuir Road, Cardiff, CF24 2QS w Wielkiej Brytani. Zestaw obu wyżej wymienionych elementów może stanowić alternatywę ukompletowania racji żywnościowej dla pojedynczego żołnierza wykonującego zadania w oderwaniu od macierzystych oddziałów czy pododdziałów.

1. Cel pracy

Celem pracy jest określenie jakości wyrobów, ze szczególnym uwzględnieniem stopnia i zakresu realizacji oczekiwanych funkcji palnika oraz paliwa żelowego, a także, czy możliwe jest uzyskanie z kostek energii niezbędnej do podgrzania posiłku czy wody.

Podstawa badań:

- Plan zamierzeń WOBWSŻ 2017 - pkt.6 „Opracowanie ekspertyz specjalistycznych z zakresu środków zaopatrzenia żywieniowego i sprzętu polowego służby żywnościowej".

2. Przegląd literatury

Na potrzeby sporządzenia ekspertyzy dokonano przeglądu następującej dokumentacji handlowej i technicznej producenta [1], wojskowej dokumentacji techniczno-technologicznej [4] oraz wyników prac badawczych [2, 3]:

[1] Praca zbiorowa, Katalog produktów BCB, BCB International LTD 2017

[2] Praca zbiorowa, Fuel for the Future-January 2016, BCB International LTD 2016

[3] Bell W., Copeland R., Shulz A., Applications of new chemical heat sources, NATIC 2001

[4] Praca zbiorowa, Dokumentacji WDTT-01 Edycja 3 Załącznik nr 3 (w części dotyczącej wymagań dla zestawu do podgrzewania posiłków), WOBWSŻ 2016

[5] Dzagoev M., Mejl-informacja BCB, BCB International LTD 2016

[6] Caffin R., http://bushwalkingnsw.org.au/clubsites/FAQ/FAQ_Efficiency.htm

[7] Praca zbiorowa, FireDragon Solid - Safety Data Sheet, 2015

3. Metodyka badań

3.1. Zakres przeprowadzonych badań

Badania przeprowadzono dla 3 palników i 3 wybranych losowo zestawów paliwa w wymienionym poniżej zakresie:

- sprawdzenie funkcjonalności (wymagań użytkowych),
- sprawdzenie skuteczności podgrzewania.

Wszystkie badania przeprowadzono w ustabilizowanych warunkach otoczenia:

- w pomieszczeniu pomiarowym o temperaturze otoczenia 20°C i wilgotności względnej: 45%,
- w komorze klimatycznej o temperaturze wewnętrznej 0°C, 5°C, 10 °C, 15°C i wilgotności względnej: 40%.

3.2. Zastosowane metody

Badania przeprowadzono metodą organoleptyczną (poprzez dotyk, ocenę wizualną i zapachu), metodą eksperymentalną (poprzez pomiar parametrów fizycznych), a także metodami analitycznymi. Oceny wyników oraz sformułowania wniosków z badań dokonano na podstawie:

- analizy zmierzonych parametrów fizycznych,
- porównania z już stosowanymi zestawami do podgrzewania posiłku,
- porównania z wymaganiami zawartymi w WDTT [4].

3.3. Miejsce i data przeprowadzenia badań

Badania przeprowadzono w dniach od 24.05.2017 do 08.06.2017 r. w pomieszczeniach badawczych Pracowni Techniki Normalizacji i Kodyfikacji Wojskowego Ośrodka Badawczo-Wdrożeniowego Służby Żywnościowej.

3.4. Zespół badawczy

- pani mgr inż. Anna Staniszewska,
- pan Hubert Szczepański.

3.5. Zabezpieczenie materiałowo-techniczne:

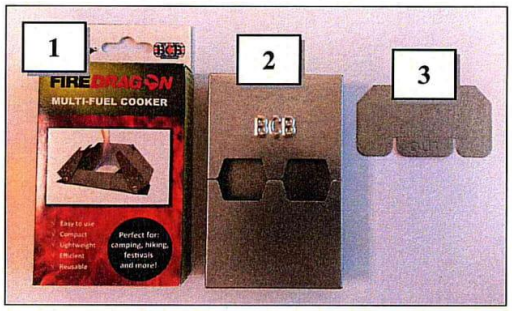
- palnik FireDragon - 3 szt.,
- paliwo FireDragon - 8 kpl.,
- zestaw do podgrzewania posiłków Aidpol (zestaw odniesienia) - 3 szt.,
- wzorcowana waga elektroniczna - 1 szt.,
- wzorcowany cyfrowy miernik temperatury - 1 szt.,
- aparat fotograficzny - 1 szt.,
- puszka aluminiowa - 1 szt.,
- menażka - 1 szt.,
- komora klimatyczna - 1 szt.

4. Przebieg i wyniki badań

4.1. Obiekt badań

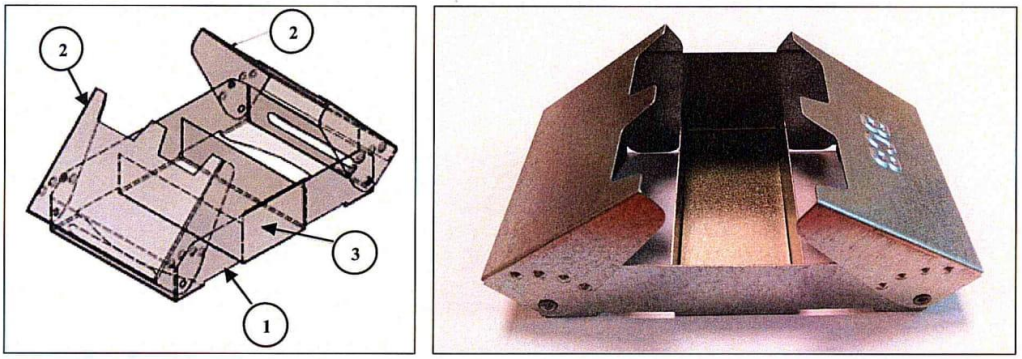
4.1.1. Palnik

Obiektem badań jest palnik FireDragon (stojak) stanowiący podstawę dla podgrzewanej konserwy (Rys.1, 2). Składany, metalowy palnik wykonany jest z galwanizowanej elektrolitycznie stali, o wymiarach w stanie złożonym 114 x 72 x 25 mm i grubości blachy 0,5 mm. Kuchenka jest lekka, o masie nieprzekraczającej 112 g (masa kuchenki wraz z opakowaniem 125,46 g), zapakowana w tekturowe pudełko.



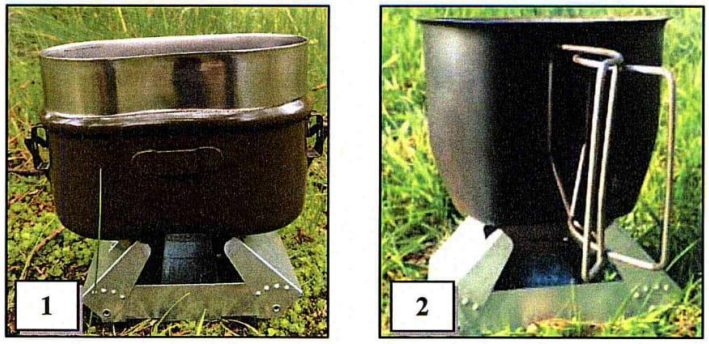
Rys. 1. Widok ogólny palnika w stanie nierozłożonym oraz opakowań z paliwem
1 – opakowanie; 2 – palnik (stojak); 3 – osłona przeciwwietrzna

Konstrukcja palnika umożliwia wielokrotne jego rozkładanie z czterema stopniami otwarcia (Rys. 2). Ściany boczne po rozłożeniu tworzą ruszt pod naczynie i jednocześnie stanowią osłony przeciwwietrzne. Kuchenka wyposażona jest w dodatkową, demontowaną osłonę przeciwwietrzną, której założeniem jest zwiększenie efektywności i stabilności podgrzewania.



Rys. 2. Widok palnika w stanie rozłożonym
1- ścianka boczna, 2- ruchoma pokrywka, 3- miejsce na paliwo

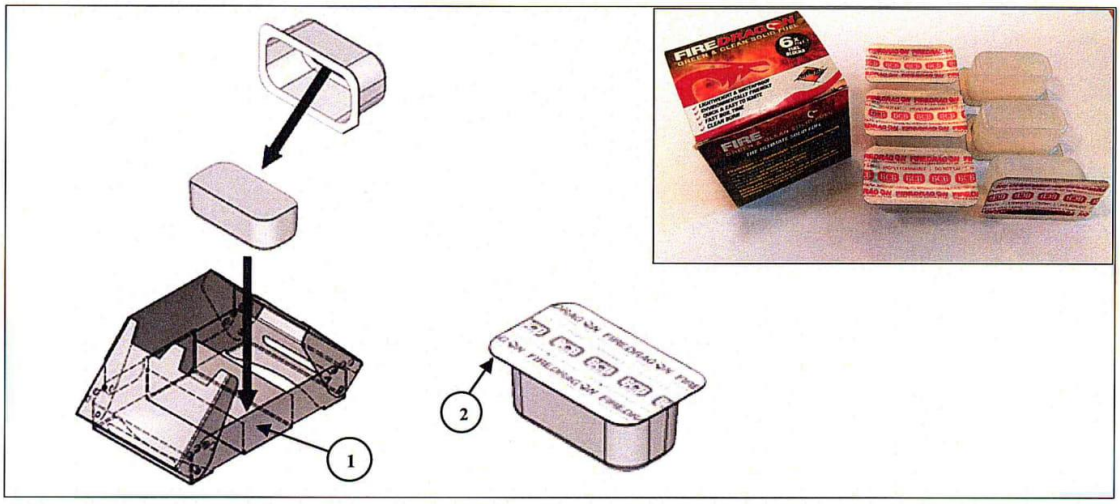
Dzięki mocnej budowie palnik dostosowany jest do podgrzewania zarówno konserw, jak i posiłku w menażce (Rys.3).



Rys. 3. Podgrzewanie menażki umieszczonej na rozłożonym palniku [2]
1 - polska, 2 - brytyjska

4.1.2. Paliwo

Obiektem badań jest również paliwo FireDragon, którego ciepło spalania może być wykorzystane do podgrzania posiłku lub wody na napoje w każdych warunkach klimatycznych (Rys. 4). Jest to zestaw sześciu kostek zapakowanych hermetycznie w plastikowe, pojedyncze kapsułki o wymiarach: 40x67,5x25,6 mm. Każda kapsułka z aluminiową membraną zapewnia łatwy dostęp do paliwa występującego w formie bardzo gęstego, bezbarwnego żelu. Głównym składnikiem kostki żelowej jest etanol a jej masa wynosi 27 g (masa kostki z opakowaniem: 29,4 g; masa opakowania zbiorczego 191,81 g).

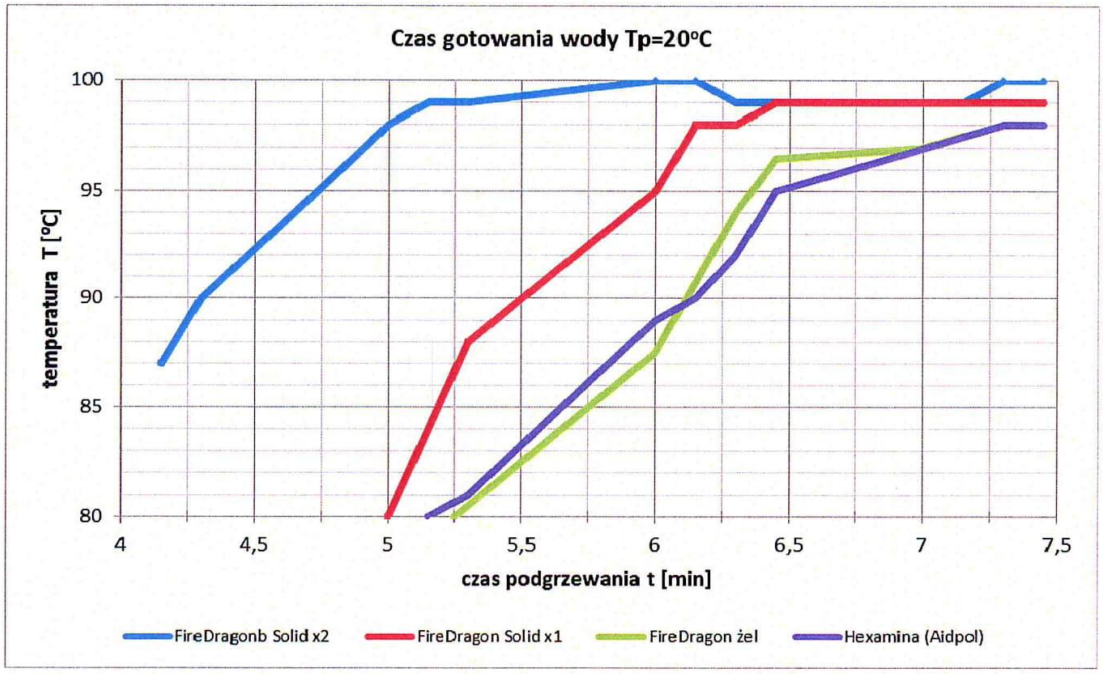


Rys. 4. Sposób wkładania paliwa oraz widok ogólny paliwa:
1 - miejsce na paliwo, 2 - foliowe zamknięcie opakowania paliwa

Zgodnie z deklaracją producenta paliwo Dragon można przewozić transportem lądowym, morskim i powietrznym (materiał niebezpieczny klasy 4.1 wg. UN1325, grupa opakowania PGIII). Jed-

na porcja paliwa to 27g, zapakowane w plastikowe opakowanie (Rys.4). Odpowiada to zapotrzebowaniu żołnierza armii brytyjskiej na 24h w źródło ciepła [2]. W przeciwieństwie do paliwa stosowanego dotychczas w racjach (SR-G) paliwo nie zawiera hexaminy, a zamiast niej metylowany spirytus (denaturat zawierający 95% alkoholu etylowego i 5% metylowego) oraz płynny żel alkoholowy.

Obok różnych zalet tego paliwa takich jak nietoksyczność i trwałość (wynikająca z właściwości chemicznych [7]) oraz dopuszczenie do transportu lotniczego (wynikająca z posiadania odpowiednich certyfikatów), znana jest jego duża efektywność cieplna (energetyczność) [3]. Badania opublikowane w co najmniej dwóch niezależnych źródłach [2, 3] dobrze to potwierdzają (Rys.5). Np. po 6 min ogrzewania 500ml wody paliwem FireDragon temperatura wody wzrosła z 20°C do 95-100°C, natomiast w przypadku paliwa typu Aidpol tylko do 88°C.



Rys. 5 Szybkość podgrzewania wody osiągnięta przy użyciu różnych źródeł energii [2]

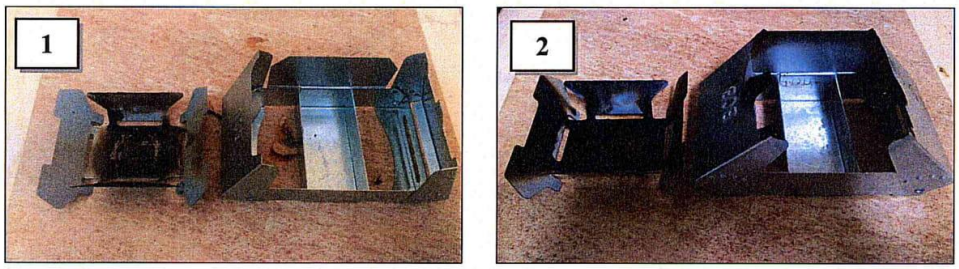
Zgodnie z informacją przesłaną do WOBWSZ przez BCB kaloryczność FireDragon wynosi około 28MJ/kg (0,756/porcję) [5], tyle samo co hexamina z paliwa Aidpol (20-30 MJ/kg) [6]. Różnica wynika z niedokładności pomiaru ciepła metodą kalorymetryczną.

4.2. Przebieg badań

4.2.1. Sprawdzenie jakości wykonania i ergonomii wyrobu

Badania rozpoczęto od dokonania sprawdzenia organoleptycznego jakości wykonania i ergonomii wyrobów (Rys.6). W tym celu poddano ocenie ogólny stan powierzchni (palnika nowego,

palnika po 1 próbie spalania i palnika po 5 próbach spalania paliwa). Następnie sprawdzono użyteczność palnika tj. łatwość rozkładania i trwałość palnika przy wielokrotnym (5-krotnym) rozkładaniu. Na końcu tego etapu badań sprawdzono łatwość wyjmowania kostki żelowej z kapsułki, jej zapach i łatwość rozpalania. Wyniki tej części badań zawarto w Tab.1.



Rys. 6. Badania jakościowe palników
1- widok po 1 próbie spalania, 2 – widok po 5 próbach spalania

4.2.2. Badania porównawcze

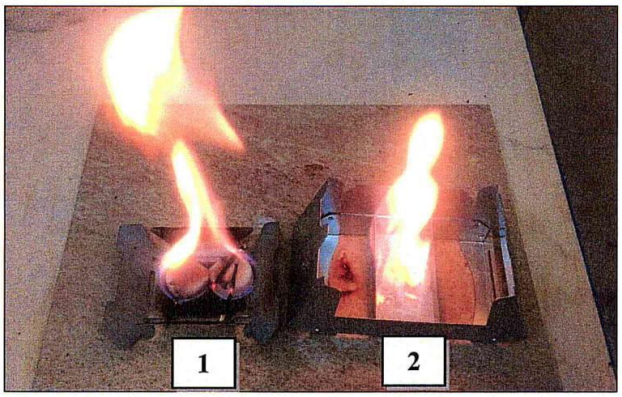
Jedną z najistotniejszych części pracy było porównanie zestawu BCB z już stosowanym zestawem do podgrzewania (zestaw odniesienia-Aidpol). W tym celu zestawiono ze sobą cechy i właściwości obu rozwiązań. Dane porównawcze pochodziły zarówno z badań przeprowadzonych przez autorów, jak i z dokumentacji dostarczonej przez obu producentów.

W pierwszej kolejności porównano oba zestawy pod względem jakości wykonania i ergonomii, a uzyskane wyniki zestawiono w Tab.2.

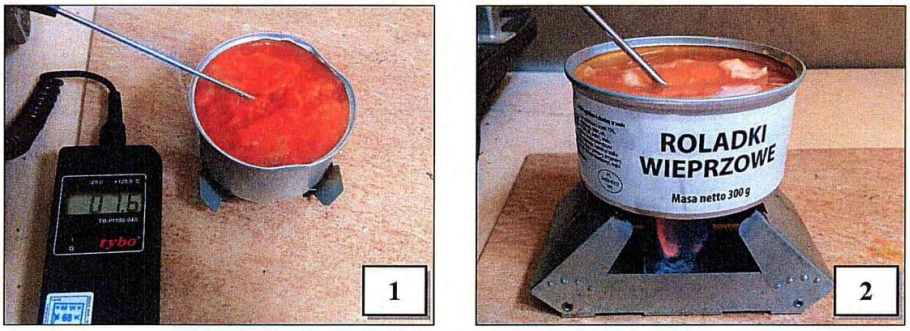
W drugiej części badań porównawczych analizowano skuteczność podgrzewania. Należy pamiętać, że skuteczność podgrzewania nie wynika tylko z kaloryczności paliwa, ale zależy także od innych czynników tj. wpływ wiatru, budowa palnika, prędkość grzania itp. Podgrzewano konserwy 300 g warzywno-mięsne z racji żywnościowej SR-G oraz wodę. W każdym przypadku, dla obu podgrzewaczy, używano tej samej masy paliwa. Ze względu na różny sposób porcjowania (Aidpol-7g tabletki, FireDragon-27g pojemnik), zastosowano zasadę, że 2 tabletki odpowiadają 1/2 pojemnika. Badania skuteczności podgrzewania obejmowały:

- pomiary maksymalnej temperatury podgrzewanej wody/konserwy od temperatury początkowej (0°C, 5°C, 10°C,15°C po zadanym czasie podgrzewania (Tab.3),
- pomiary prędkości podgrzewania (Tab.3, 5, Rys.11),
- pomiary czasu spalania całkowitego (do momentu gdy nie było dymu, palnych substancji w popiele i nie ulatniała się część paliwa w postaci pary) (Tab.4).

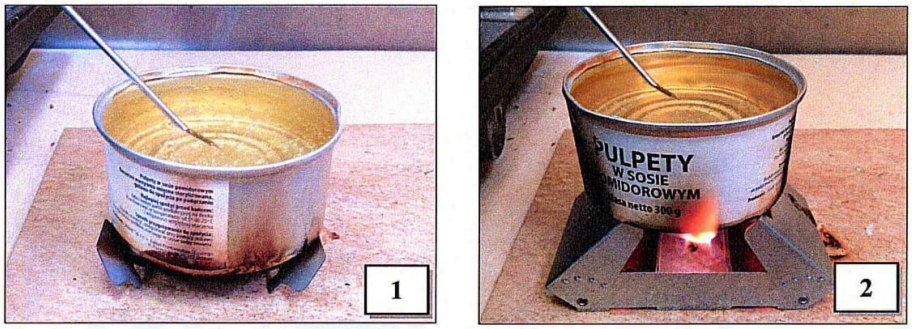
Wyniki badań porównawczych przedstawiono w kolejnym rozdziale. Przebieg badań zobrazowano na kolejnych rysunkach:



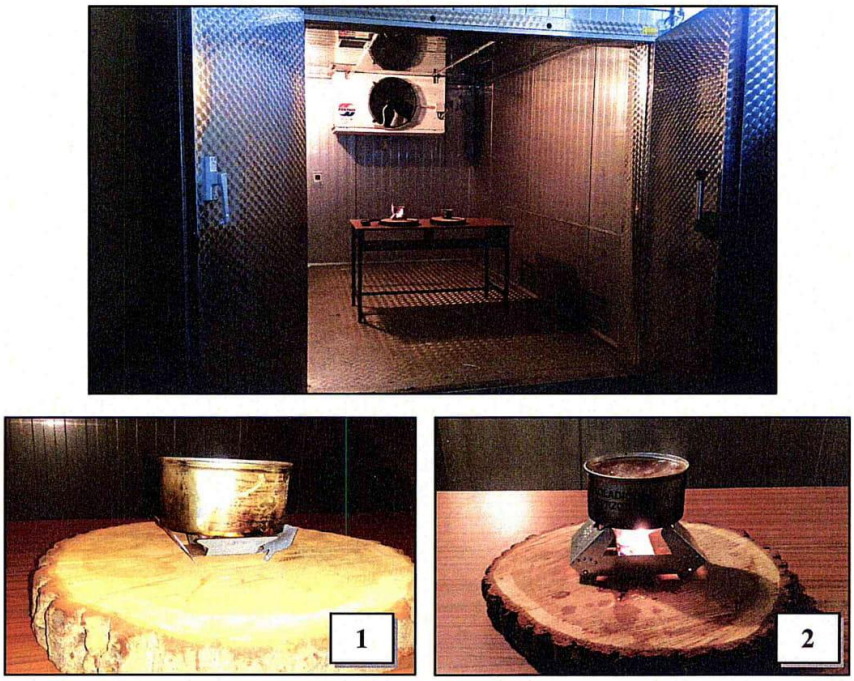
Rys. 7. Badanie czasu spalania paliwa 1- odniesienia, 2 – FireDragon (masa paliw 14 g)



Rys. 8. Badania skuteczności podgrzewania zawartości konserw
1- podgrzewanie zestawem odniesienia, 2 – podgrzewanie zestawem FireDragon



Rys. 9. Badania skuteczności podgrzewania wody
1- podgrzewanie zestawem odniesienia, 2 – podgrzewanie zestawem FireDragon



Rys. 10. Badania skuteczności podgrzewania w komorze klimatycznej
1 – podgrzewanie zestawem odniesienia, 2 – podgrzewanie zestawem FireDragon

4.3. Wyniki badań

Wyniki sprawdzenia jakości wykonania i ergonomii zestawu przedstawiono w poniższej tabeli:

Tab.1 Zestawienie wyników sprawdzenia jakości wykonania i ergonomii zestawu FireDragon

Badany element	Badana cecha	Wynik	Ocena
Palnik FireDragon	Obsługiwalność i praktyczność	Łatwy do rozkładania, z czterostopniowym otwarciem. Wyposażony w demontowalną osłonę przeciwwietrzną.	+
	Trwałość	Konstrukcja lekka i trwała. Umożliwia wielokrotne rozkładanie, Posiada kompaktową budowę. Pod obciążeniem nie deformuje się i nie wykazuje utraty początkowych właściwości.	+
	Ergonomia opakowania	Opakowanie tekturowe w formie pudełka, łatwe do otwarcia, przystosowane kształtem i wymiarami do zawartości. Wymiary gabarytowe nieco większe od wymiarów opakowania palnika odniesienia.	+

Paliwo FireDragon	Cechy fizykochemiczne	Jest konsystencji gęstego żelu. Posiada zapach charakterystyczny dla alkoholu. Łatwo i szybko się zapala. Spalanie paliwa odbywa się szybko, bez kopcenia i bezwonnie. Jest w pełni odporne na wilgoć.	+
	Ergonomia opakowania	Zestaw zapakowany jest w pudełko kartonowe. Kostka żelowa pakowana w hermetyczną kapsułkę zamkniętą aluminiową membraną. Całość wygodna w użyciu.	+

Gdzie:

\+ Spełnienie przewidzianych funkcji

– Nie spełnia przewidzianych funkcji

Tab.2 Zestawienie wyników porównania cech zestawów

Porównywany element	**Cecha**	**FireDragon**	**Aidpol**
Palnik	materiał wykonania	stal galwanizowana	stal
	typ konstrukcji	rozkładana	gięta
	wymiary w stanie złożonym	114 x 72 x 25 mm grubość blachy 0,5 mm	115 x 78 mm grubość blachy 0,6 mm
	opakowanie	tekturowe pudełko	tekturowe pudełko
	wyposażenie dodatkowe	osłona przeciwwietrzna	brak
Paliwo	konsystencja	gęsty żel	twarda
	główny składnik paliwa	etanol	hexamina
	masa 1 porcji	27 g	7 g
	zapach	woń alkoholu	odrażający - „rybi"
	palność	natychmiastowe rozpalenie od chwili zapłonu	kilkusekundowy czas rozpalenia od chwili zapłonu
	spalanie	bez kopcenia, zapach pomijalny	bez kopcenia, zapach mocno wyczuwalny
	odporność na wilgoć	odporny	brak
	opakowanie	pojedyncza kapsułka z aluminiową membraną	zbiorczy blister

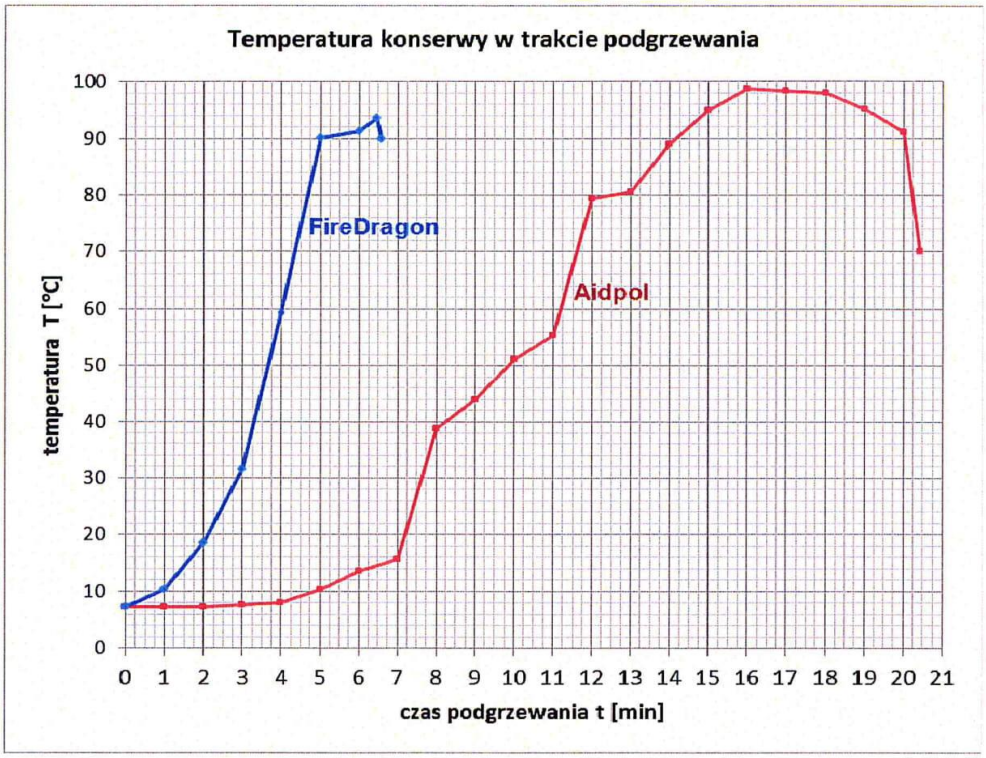
Wyniki badań porównawczych przedstawiono w Tabeli 3. i na Rys. 11.:

Tab.3 Porównanie wyników badań skuteczności podgrzewania konserw o masie 300 g

Czas podgrzewania t [min:s]	**Uzyskana temperatura zawartości konserwy 300 g** T [°C]	
	Zestaw odniesienia (masa paliwa 14g)	**Zestawem FireDragon** (masa paliwa 14g)
00:00	7,2	7,2
01:00	7,2	10,3
02:00	7,2	18,5
03:00	7,7	31,5
04:00	8,0	59,4
05:00	10,3	59,4
06:00	13,5	90,1
06:48	-	T_{max}=93,6
06:58	-	T_k=90,0
07:00	15,7	-
08:00	38,7	-
09:00	44,0	-
10:00	51,2	-
11:00	55,4	-
12:00	79,5	-
13:00	80,6	-
14:00	89,0	-
15:00	94,8	-
16:00	T_{max}=98,6	-
17:00	98,4	-
18:00	98,0	-
19:00	95,0	-
20:00	91,0	-
21:43	T_k=70,0	-

Gdzie:

T_{max} – temperatura maksymalna, T_k – temperatura końcowa (po zakończeniu spalania paliwa)



Rys. 11. Porównanie szybkosci podgrzewania konserw

Porównanie czasu spalania paliwa stanowi Tabela nr 4.

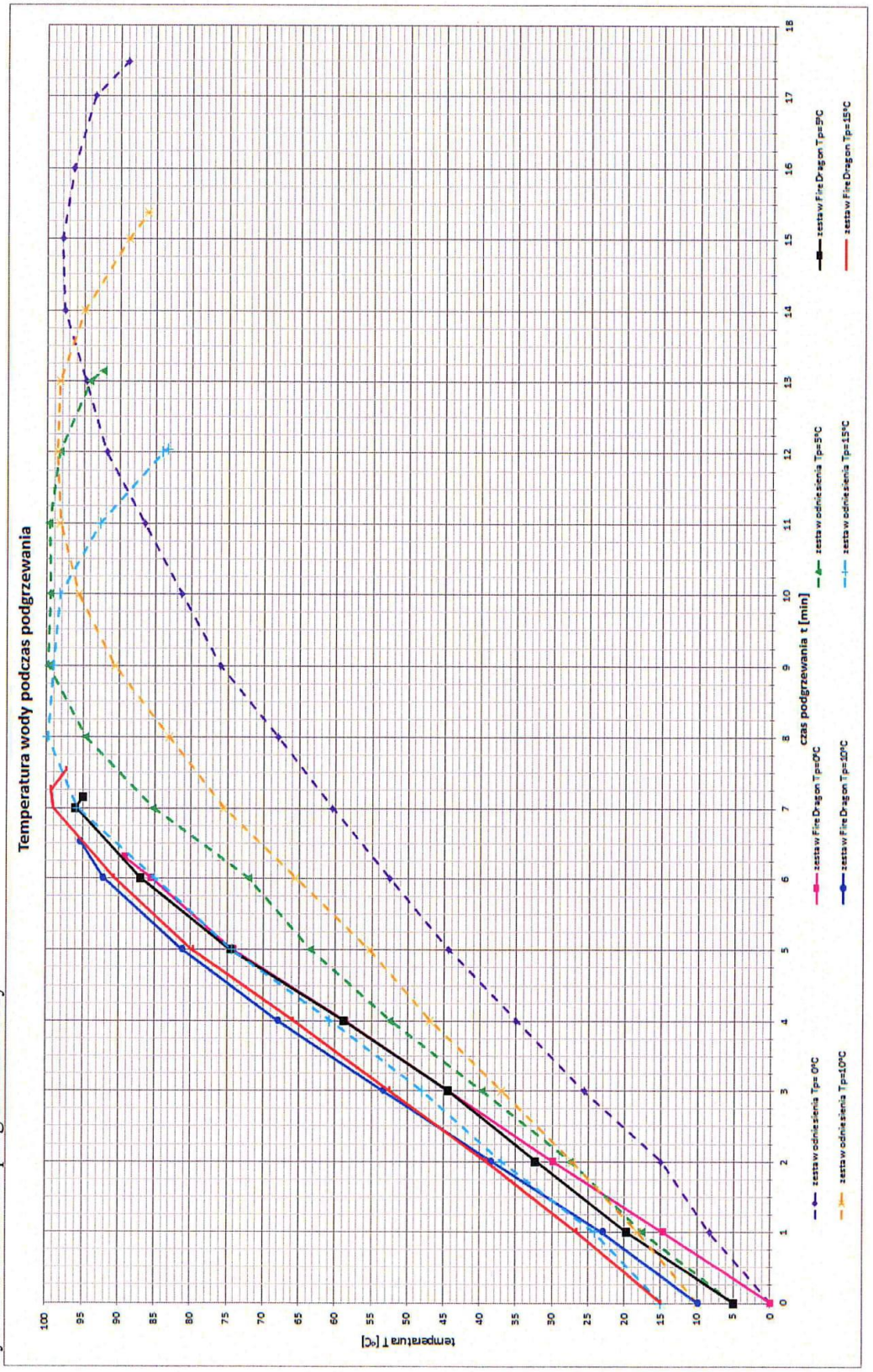
Tab.4 Zestawienie wyników badań czasu całkowitego spalania paliwa

Czas całkowitego spalania t [min:s]		
Paliwo o masie 14g		**Paliwo FireDragon o masa 27g (1 kostka)**
odniesienia	**FireDragon**	
12:04	05:50	12:15

Zestawienie wyników badań skuteczności podgrzewania wody o zadanej temperaturze początkowej zawarto w Tabeli nr 4, ich prezentację graficzną stanowi wykres przedstawiony na rys. 9.

Tab.5 Zestawienie wyników badań skuteczności podgrzewania wody zestawami odniesienia i FireDragon

Czas podgrzewania t [min:s]	Podgrzewanie wody T =0 °C		Podgrzewanie wody T =5 °C		Podgrzewanie wody T =10 °C		Podgrzewanie wody T =15 °C	
	paliwo odniesienia (masa 14g)	paliwo **FireDragon** (masa 14g)	paliwo odniesienia (masa 14g)	paliwo **FireDragon** (masa 14g)	paliwo odniesienia (masa 14g)	paliwo **FireDragon** (masa 14g)	paliwo odniesienia (masa 14g)	paliwo **FireDragon** (masa 14g)
00:00	0	0	5	5	10	10	15	15
01:00	8,3	14,7	17,6	19,7	18,2	23,1	24,1	26,6
02:00	15,0	30,0	27,5	32,3	27,3	38,5	37,1	39,2
03:00	25,6	44,4	39,7	44,4	37	53,4	48	52,5
04:00	35,0	58,7	52,5	58,9	46,9	68,1	60,8	65,9
05:00	44,4	74,2	63,5	74,5	55,3	81,2	74,4	79,8
06:00	52,6	85,6	72,1	87	65,6	92,2	85,1	90,7
06:30	-	89,2	-	-	-	-	-	-
06:52	-		-	-	-	95,4	-	-
07:00	60,5		85,3	96	75,5		95,8	99,1
07:15	-		-	95	-		-	-
07:25	-		-		-		-	99,4
07:52	-		-		-		-	97,4
08:00	68,0		94,6		83		99,9	
09:00	76,0		99,8		90,6		99,1	
10:00	81,4		99,6		95,6		98,2	
11:00	86,6		99,7		98,2		92,7	
12:00	91,8		98,3		98,6		84,1	
12:05	-		-		-		83,4	
13:00	94,7		94,2		98,3			
13:15	-		92,4		-			
14:00	97,7				94,9			
15:00	98,0				88,8			
15:37	-				86,2			
16:00	96,4							
17:00	93,5							
17:48	89,0							



Rys. 12. Skuteczność podgrzewania wody

15/16

5. Wnioski

Wyniki badań pokazały, że zestawy do podgrzewania FireDragon stanowić mogą dobrą alternatywę dla już stosowanych zestawów z racji SR-G. W porównaniu z nimi zestawy FireDragon charakteryzują się m.in. następującymi zaletami:

Paliwo:

- bezwonne spalanie (Tab. 2),
- lepsza skuteczność spalania (Rys. 11, 12),
- odporność na wilgoć (Tab. 2).

Palnik:

- lepsza trwałość i wytrzymałość (Tab. 2),
- możliwość wykorzystania do podgrzewania menażek (Tab. 2).

6. Postanowienia końcowe

- Bez pisemnej zgody WOBWSŻ ekspertyza nie może być powielana inaczej jak tylko w całości i nie może tłumaczona na inne języki. Zgody wymaga również udostępnienie ekspertyzy poza jednostkami organizacyjnymi Ministerstwa Obrony Narodowej.

- Przedstawione wyniki badań odnoszą się wyłącznie do próbek przekazanej do badań.

Appendix 22: French MoD FireDragon vs Esbit for 'Hansa' setup

MoD 2018 Report – FireDragon vs Esbit for 'Hansa' setup

Executive summary

- FireDragon improved heating over hexamine by 17-33%.
- 18g and 27g of FireDragon maintained a rolling boil, where hexamine could not.
- FireDragon is known to be less toxic than hexamine.
- FireDragon can double as an antibacterial hand-cleanser.
- Hexamine was malodorous in use.

Introduction

The French MoD have specified guidelines for their ration-heater fuel, in a view to welcome competition against hexamine-based sources. FireDragon is an innovative fuel, using ethanol as the flammable component. FireDragon has recently been accepted by the UK MoD as their ration-heater fuel of choice, besting the competition including hexamine. FireDragon has been developed to be of low overall toxicity, low soot as well as other properties including, but not limited to, antibacterial properties for use as a hand-cleanser.

Process

Controlled testing of the heating receptacles was performed as below:

- 300cm^3 of cooled water, approximated to 10°C (± 3.0°C).
- A previously unused Hansa tin was used, after emptying the contents.
- The BCB folding cooker was used throughout without use of windshields.
- The BCB folding cooker and Hansa tin were cleaned between tests to ensure residues from previous tests didn't negatively affect results.
- The thermometer probe used was allowed to sit in lukewarm water between tests to allow quick dissipation of heat from previous tests.

Testing required use of a Class B 500cm^3 measuring cylinder to measure 300cm^3 of water per test. Masses of fuel were weighed on a calibrated OHAUS laboratory scales to 2 decimal places. Temperature profile was recorded on a Raspberry pi-based temperature logger. Starting temperature was measured using a calibrated E.T.I LTD Water-Resistant Thermometer. A new, previously unopened, production unit/pot of fuel was used to weigh values per test. Tests were conducted to 8 minutes to directly compare to the French MoD specification. Where starting temperatures were over 10°C, the time over a difference of 45°C was measured.

'Esbit'-brand hexamine tablets were used for these tests.

Conclusion

- 7g FireDragon adequately reaches the 55°C but leaves little scope for external influences.
- 7g FireDragon exceeds the specification, with an improvement of circa 17.3% over hexamine.
- 18g FireDragon exceeds the specification, with an improvement of circa 23.6% over hexamine.
- 27g FireDragon massively exceeds the specification, with an improvement of 32.6% over hexamine.
- FireDragon was largely odourless prior to the burn and during the burn.
- Hexamine was strongly malodorous prior to the burn and during the burn.
- Hexamine left a sticky residue, whereas FireDragon residue was easy to remove from the receptacle.
- FireDragon proved easier to light, with a flint and striker, whereas hexamine required a couple of seconds contact with a match to ignite.
- FireDragon propagated the flame across its surface quicker than hexamine, which appeared to have a definite 'warm-up' time.
- FireDragon self-extinguished quickly with no obvious loss in performance over the last 1 minute of burn. Hexamine lost performance over the last 1 minute 30 seconds with no obvious heating of water over the last 1 minute.

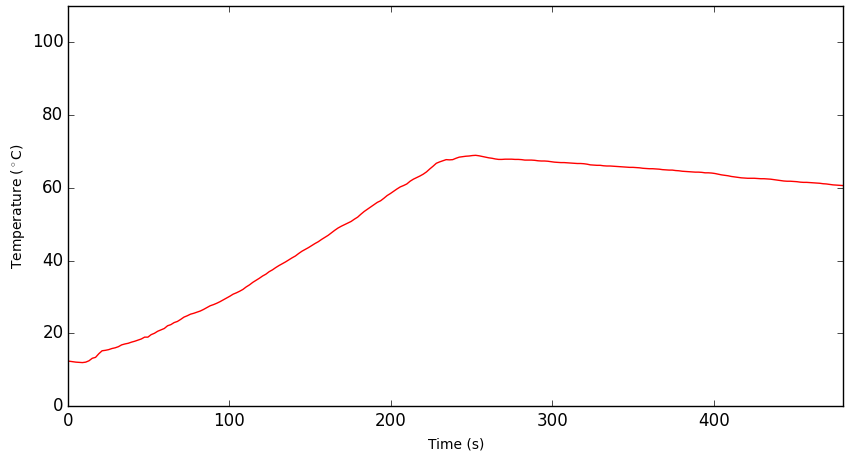
Annex 1

Fuel type	Mass /g	H_2O temperature /°C	Air temperature /°C	Burn time /mm:ss	10-55°C time /mm:ss
FireDragon (7g)	7.05	7.3	24.0	4:24	3:15
FireDragon (18g)	18.02	9.6	24.0	8:03	3:03
FireDragon (27g)	27.10	10.3	24.0	10:37	2:47
Hexamine (7g)	7:05	12.1	24.0	9:01*	3:52

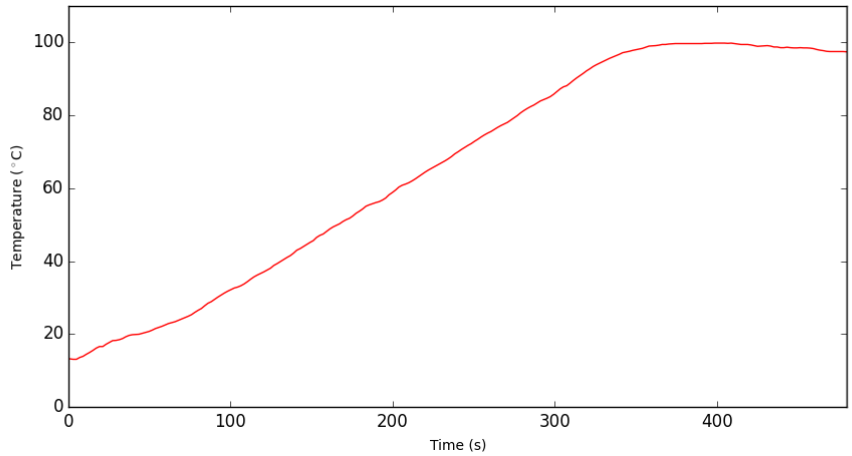
**The final 1:00 (mm:ss) of the burn did not influence the temperature of water. It was an extremely small flame. Conversely, FireDragon self-extinguishes abruptly, so the final burn times correspond to the end of heating period.*

The values listed above are averages of 3 tests per fuel. There were no anomalous results.

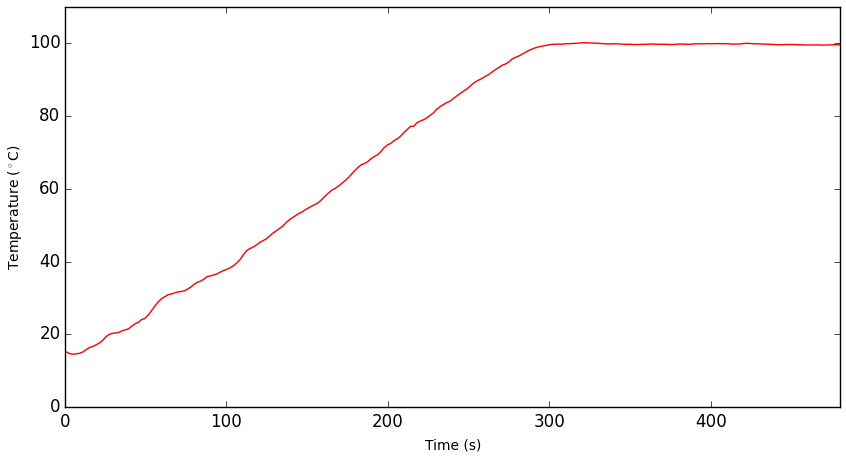
Annex 2



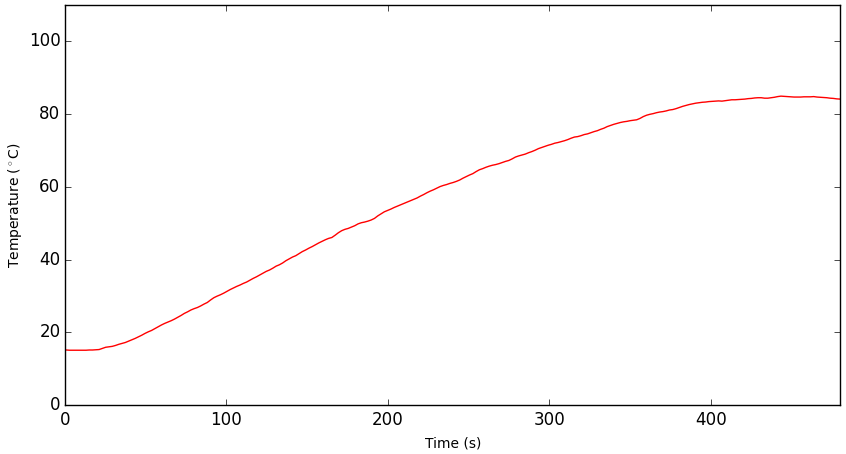
1. *Graph for 7g FireDragon vs time to heat 300cm³ water in 'Hansa' type tin. Maximum temperature reached was 69.0°C.*



2. *Graph for 18g FireDragon vs time to heat 300cm³ water in 'Hansa' type tin. Maximum temperature reached was 100°C, which is visually represented by a rolling boil.*



3. *Graph for 27g FireDragon vs time to heat 300cm^3 water in 'Hansa' type tin. Maximum temperature reached was 100°C, which is visually represented by a rolling boil. The rolling boil was visible for the remainder of the burn up to 10 minutes 37 seconds.*



4. *Graph for 7g Esbit vs time to heat 300cm^3 water in 'Hansa' type tin. Maximum temperature reached was 84°C.*

Annex 3

Above image shows setup of Hansa tray with FireDragon in BCB Folding cooker.

Above Image shows side view of Hansa tray with FireDragon.

Above image shows side view of Hansa tray with Esbit.

Above image shows slow propagation of flame on right hand side of Esbit block.

Above shows packaging solution for 3x full sized (27g) blocks of FireDragon with BCB Folding cooker and windshield. Below image shows expanded setup for ease of viewing.

Above image shows closed cooker with fuel tablets inside to show compact design.

Above shows top profile of 18g FireDragon tablet (left) versus 27g FireDragon tablet (right). Below shows side view of the above fuel tablets.

Above image shows top profile of 18g FireDragon tablet (left) versus 14g Esbit tablet (right). Below shows side view of the above fuel tablets.

Above, the residual soot after 1 burn of FireDragon Solid. The ‘blacking’ on the base of the tin is from successive, high-temperature trials with FireDragon which burnish metals. Below, the shiny residue remaining from one burn of hexamine. This hard-waxy residue was impossible to remove with a damp, or dry, paper towel.

Both hexamine and FireDragon received a soot index of 0.00, relating to the emission of smoke as carried out by Ceram test house, as below;

The Hourly Soot Index (Sih) is calculated from the equation below:

Sih = Si/Tm

Illuminance without a glass plate (E0)	1017 Lux
Illuminance with glass plate (E1)	818 Lux
Illuminance with the glass plate and calibration disc (E2)	760 Lux
Illuminance with the glass plate after burning time (E3)	818 Lux
Burning Time	0.75 Hours (45 minutes)

Ceram Reference: (1316756)-8127
Customer Reference: FD
Description: Fire Dragon

CALCULATIONS

Ai = E2/E1 = 0.93

Soot Index, Si = 1-(E3/E1) x 100 = 0.00

Hourly Soot Index, Sih = Si/Tm = 0.00

Above is result for FireDragon Solid.

The Hourly Soot Index (Sih) is calculated from the equation below:

Sih = Si/Tm

Illuminance without a glass plate (E0)	1016 Lux
Illuminance with glass plate (E1)	813 Lux
Illuminance with the glass plate and calibration disc (E2)	758 Lux
Illuminance with the glass plate after burning time (E3)	813 Lux
Burning Time	0.10 Hours (6 minutes)

Ceram Reference: (1316756)-8129
Customer Reference: HEX 1
Description: Hexamine

CALCULATIONS

Ai = E2/E1 = 0.93

Soot Index, Si = 1-(E3/E1) x 100 = 0.00

Hourly Soot Index, Sih = Si/Tm = 0.00

Above is result for hexamine.

Appendix 23: BCB International FireDragon Military cooker systems presentation

Proudly made in Great Britain

Military Cooker Systems

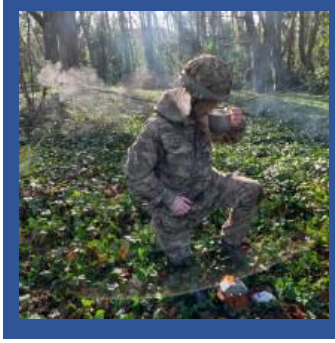
MRE System

Patrol

NATO

Crusader System

Military Multifuel Cooker Systems



- These **compact, lightweight systems** are the modern, **eco-friendly** and fast way to heat and cook your military rations in the field.
- They include FireDragon which can also be used to **sanitise your hands.**
- They all use the patented FireDragon and can also use **other solid or gel fuels.**
- The NATO, patrol and Crusader cookers will also burn some **liquid fuel.**
- All systems can be packed with the other non food items to your specific needs (subject to minimum order quantities.)

3 Innovative Compact Systems



Contents	MRE System	PATROL	NATO
FireDragon Fuel Block	4 x 8gram 0.3oz	3 x 14gram (0.5oz)	3 x 28gram (1oz)
Cooker	Flat fold	Mini	Folding with windshield
Matches and Striker in waterproof bag	20	20	20
Water Purification tablets one per litre	4	4	4
Refuse sack	1	0	0
Tooth picks	3	0	0
Ration Gripper	1	1	1
Packed Size	4x3.5x0.5 inch	2.75 x 2 x 1.5 inch	4.5 x 2.75 x 1 inch
Packed Weight	2.5 oz (70 gram)	3.1 oz (90 gram)	70 oz (200 gram)
Sales Code	CN371	CN370	CN337

MRE Cooker & Fuel System

Compact Ration Heating Kit containing everything required to easily heat food rations while in the field.
No tools required.
This kit includes a cooker with three 9 gram (0.3 oz) FireDragon eco fuel tablets, which are sufficient to heat three meals, plus matches and water purificatio tablets and a handle for your utensils.

Content:

- Metal flat folding cooker
- 4 x FireDragon eco fuel tablets (8g)
- Book of 20 matches
- Water purification tablets (4)
- Metal gripper handle
- Packed in waterproof, easy open wrapper
- Toothpicks (3)

PATROL Cooker & Fuel System

Compact Ration Heating Kit containing everything required to easily heat food rations while in the field. No tools required. This kit includes a cooker with three 14 gram (0.5 oz) FireDragon eco fuel tablets, which are sufficient to heat three meals, plus matches and water purification tablets and a handle for your utensils.
Alternatively it can be used with 28 gram (1 oz) Firedragon, other solid, gel or some liquid fuels

Content:

- Metal mini cooker
- 3 x FireDragon eco fuel tablets 14 gram (0.5 oz)
- Book of 20 matches
- Water purification tablets (4)
- Packed in waterproof, easy open wrapper
- Ration Gripper

NATO Cooker & Fuel Systems

Folding Compact Ration Heating Kit containing everything required to easily heat food rations while in the field. No tools required. This kit includes a cooker with three 28gram (1 oz) FireDragon eco fuel tablets, which are sufficient to heat three meals, plus matches and water purification tablets and a handle for your hot ration.

Content:

- Metal folding cooker with windshield
- 3 x FireDragon eco fuel tablets 28 gram (1 oz)
- Book of 20 matches
- Water purification tablets (4)
- Packed in waterproof, easy open wrapper
- Ration handle

Crusader Cup Cooker & Fuel Systems

Originally designed to meet the changing requirements of the future combat solider.**
An integral folding arm allows the cup to fit securely over a fuel crucible where gel fuel or solid fuel blocks can be lit.

In transit, the cooker nests neatly and compact beneath BCB's Crusader Cup and will fit inside the water bottle.

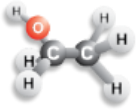
This set consists of: Plastic Mug & NATO Water bottle, Crusader Cup Lid, Crusader Cup, Crusader Cooker, Zulu Belt pouch,, Fireball Flint and Striker.
Innovative solid and gel fuel field cooker.
Boils 500ml (17floz) of water in about 8 minutes.
as used by THE BRITISH MILITARY

Weight: 838 grams (29.6oz)
Product code: CN017

Contents:
1 x Pouch
1 x Flint & Striker
1 x Crusader Cooker II, High quality aluminium
1 x Crusader Cup I (Silver) High quality steel
1 x NATO Canteen & Mug
1 x Lid

FIREDRAGON

"All life on Earth now depends on us..."



C^2H^6O

Based on bioethanol, **Fire*Dragon*** is sustainable and **not a fossil fuel**.
It is a safer fuel for both the user & the environment.
Fire*Dragon* outperforms all other solid fuels.

Fire*Dragon's* bio-ethanol purity is very high at approximately 96%.

This **fuel for the future**:

- ✓ Is sustainable
- ✓ Cooks quickly
- ✓ Burns intensely
- ✓ Is easy to light
- ✓ Safe to carry & transport
- ✓ Gives off a very little soot or nasty smells

Hand Cleanser

All-Weather

Quick & easy Clean burn to light

Fire*Dragon* is more efficient (28MJ/Kg) than kerosene, methyl esters, or paraffin.
Though not as efficient as LPG, which is approx. 50MJ/Kg.

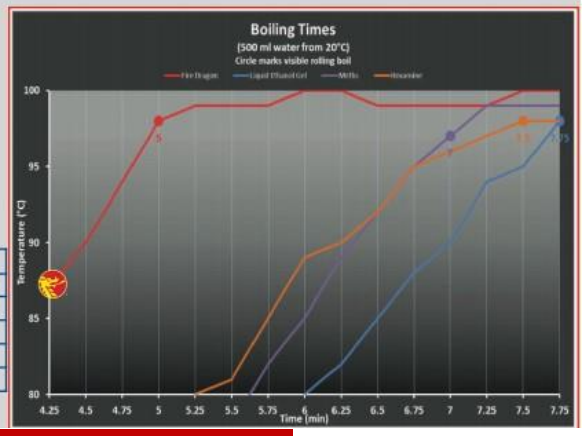
FIREDRAGON

FD compared to FRH — 3 x Faster Cooking — 1/6 Lighter — 2 x Hotter — 4.5 x More Energy

- Ration heater/Cooker/Fire lighter/Hand sanitiser all in one.
- Recyclable , easy and clean to dispose of.
- Safe to use, handle and to pack with rations.
- Efficient to cook/boil water.
  - ✓Boils water from 62°F to 212 °F in 6 minutes
  - ✓Melts snow & ice
- Environment friendly.
- No noxious fumes like hydrogen, cyanide, oxides or magnesium.
- Non toxic. Non explosive .
- Easy to transport and store.
- Patented will work when wet, can extinguish and relight.
- Comparable cost per cook.
- Twice as fast to temperature compare to all other solid fuels.
- NATO#: 9110-99-426-2694/7310-99-587-4226

	FRH	FD
Change in temperature	100 °F (37 °C)	212 °F (100 °C)
Speed from 32 °F (0 °C) to 100 °F (37 °C)	10 minutes	3.15 minutes^
Average Total Weight unused and used per burn*	3 oz (85 g)	0.9 oz (25 g)^
Energy (Kilo joules) per gram	6	29
Shipping/Storage hazardous	Class 4.3	Class 4.1

Includes all necessary components including water, cooker matches per cook, and assumes average over used + unused components. ^ NATO Option.



- **Made from natural ingredients**
- **Non toxic**
- **All weather**
- **Long burn**

Appendix 24: BCB International Defence Presentation

FIREDRAGON Tested and delivers.

Clean Bio Fuel: Fuel for our future

For defence users

Firedragon is;

A. Environmentally friendly
B. Powerful burn
C. Safe and clean to use.

BCB INTERNATIONAL

www.firedragonfuel.com

V1

1

BCB INTERNATIONAL FIREDRAGON Environmentally friendly

Firedragon is made from recycled wasted vegetation and with a 97% purity.

It is therefore an environmentally friendly, green and clean fuel.

As such it will help address some of the UN Sustainable Development Goals, most notably;

Goal 3 Good Health and Well Being
Goal 7 Ensure access to affordable, reliable sustainable modern energy

Goal 13 Climate action

Goal 15 Life on Land

"All life on Earth now depends on us..."

Sir David Attenborough

Green and clean fuel in recyclable packaging.

2

Environmentally friendly

- ✓ **Based on bio - ethanol, FireDragon is sustainable and not a fossil fuel.**
- ✓ **It is a safer fuel for both the user and the environment**
- ✓ **FireDragon also outperforms all other solid fuels**

Fuel for the future is:

- **Sustainable**
- **Cooks quickly**
- **Burns intensely**
- **Is easy to light**
- **Safe to carry and transport**
- **Gives off very little soot or heavily polluting fumes.**

FireDragon is high performance and **All-Weather** Which means it can be lit and used in harsh conditions such as rain or snow.

FireDragon can be safely be used as a natural **Hand Sanitiser** Which can prevent germs and diseases spreading when handling food prior to cooking

FireDragon is **Quick & Easy to light** And doesn't take much to get it going. A spark or a match will suffice to light FireDragon

3

Environmentally friendly

- **Clean burn - doesn't dirty cooking equipment.**
- **Fast boil and long burn – high heat output**
- **Can be used in a range of existing cooking systems**

- **Made from natural ingredients**
- **Non toxic**
- **All weather**
- **Long burn**

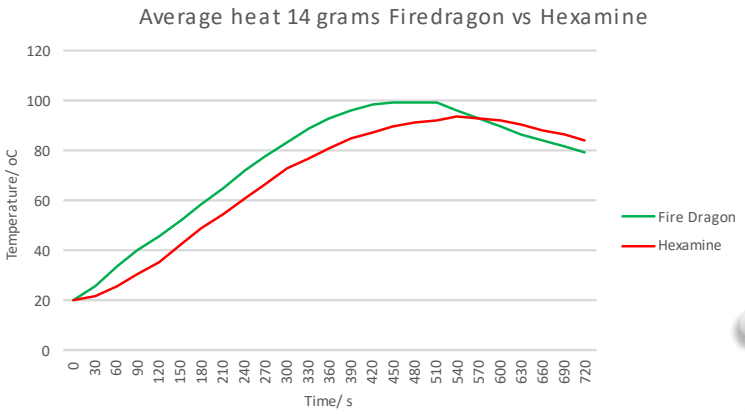
Fire*Dragon's* bio-ethanol purity is very high at approximately 97%.

- **Can be packed with food**
- **Waterproof and lightweight.**
- **Air transportable**
- **Safe for indoor / tent use**

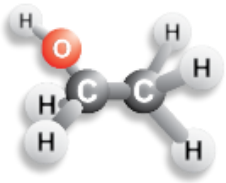
4

FIREDRAGON Powerful high performance

Ethanol not only is very powerful with a high calorific concentration it also delivers its energy quickly, so getting to the boil quicker. Which is important for soldiers.



It is all in the science.
The small molecular chain takes a small amount of energy to release more energy.
Also the Oxygen molecule helps its combustion.



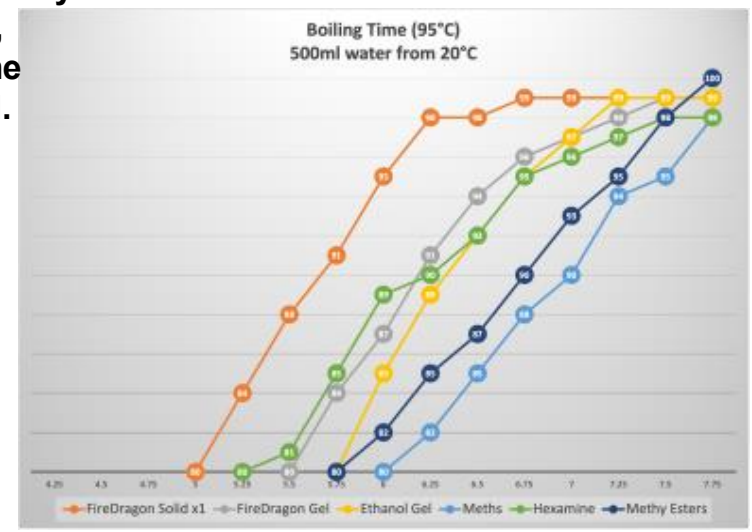
C^2H^6O

FIREDRAGON Powerful high performance

FireDragon has a greater energy density and higher calorific value at **37.344 MJ/Kg** compared to hexamine at **30.0 MJ/Kg.**

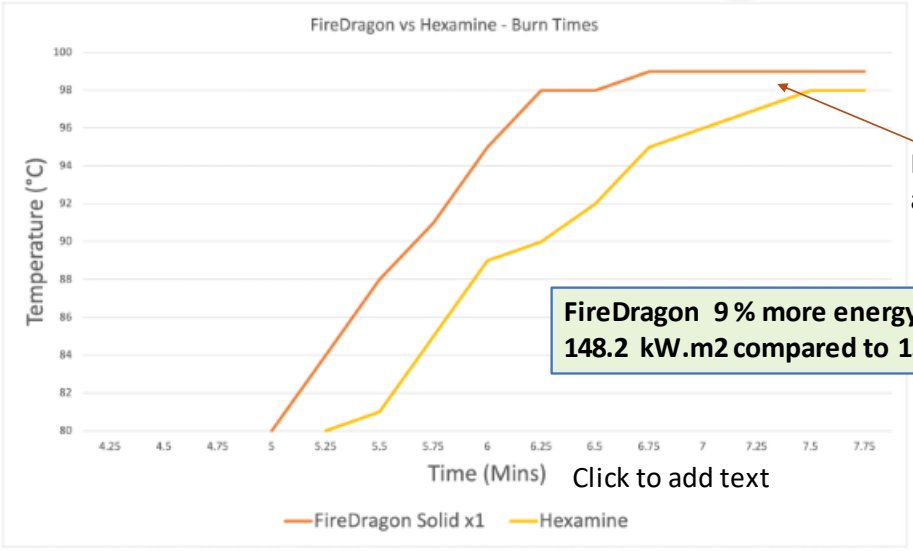
In extensive field and laboratory testing by the British Army, Fire*Dragon* proved to be the best of all solid fuels tested.

The British Army replaced hexamine with FireDragon in 2016.



FIREDRAGON

Powerful high performance



Hexamine doesn't achieve a boil

FireDragon 9 % more energy than Hexamine. 148.2 kW.m2 compared to 136.2 kW.m2

BCB

Click to add text

Test	FireDragon x 1 (Mins)	Hexamine
Time to boil to 80 °C	5:00	5:15
Time to boil to 90 °C	5:30	6:15
Time to boil to 95 °C	6:00	7:00

7

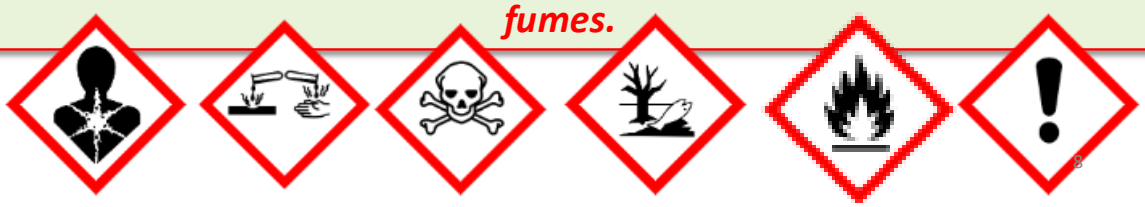
FIREDRAGON

Safe and clean.

Hexamine claims to be:

1) **Odorless.** **It smells acrid which is the ammonia** .
2) **Low smoke.** **High levels of soot are produced.** (Ceram report)
3) **Non – toxic.** In concentrations over 0.16 % ie when used as a fuel, it is highly toxic. Its toxicity index is 0.55 (Interscience report) as its toxicity should be measured when used as intended ie burnt as a fuel it gives off Nitrogen oxides (NOx), Ammonia, Formaldehyde and in some formula's peroxides.
4) **Safe** yet it produces high levels of hydrogen cyanide and particulate matter. As well as high levels of carbon dioxide, methane and carbon monoxide, all bad for your health, our planet and the climate.

Hexamine is made primarily from formaldehyde and ammonia. Two very nasty substances. Accordingly, it gives off some very nasty fumes.



8

FIREDRAGON Is safe and clean.

Hexamine claims to be:

1) Odorless. Yet its safety data sheet advises:

Hazardous Decomposition Products and on burning:

Carbon monoxide (CO), Carbon dioxide (CO2), Nitrogen oxides (NOx), Ammonia, Formaldehyde.

- Avoid breathing dust/fume/gas/mist/vapours/spray
- Wear protective gloves/protective clothing/eye protection/face protection
- Wash contaminated clothing before reuse
- Storage Store in a well-ventilated place.

In Wikipedia hexamine odour is listed as;
"Fishy, ammonia like"
It does contain a high % of ammonia after all.

Protective Equipment and Precautions for Fire

- Wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.
- Should not be released into the environment.
- Wear personal protective equipment. Avoid ingestion and inhalation. Avoid dust formation.
- Do not get in eyes, on skin, or on clothing.

9

FIREDRAGON Is safe and clean.

Hexamine claims to be:

2) Low smoke.

Yet its safety data sheet advises:

- Avoid breathing its dust, fumes, gases, mist, vapours or spray.
- Contaminated work clothing should not be allowed out of the workplace
- Wear protective gloves/protective clothing/eye protection/face protection
- Wash contaminated clothing before reuse
- Storage Store in a well-ventilated place.

Watch for yourself here:

Protective Equipment and Precautions for Fire

Wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

Wear personal protective equipment. Avoid ingestion and inhalation. Avoid dust formation.

10

Is safe and clean.

Hexamine claims to be:

3) Non – toxic. Its safety data sheet advises:

Reproductive Toxicity

Category 2 Specific target organ toxicity (single exposure) Category 3 Target Organs - Respiratory system.

Acute toxicity and immediate effects.

Ingestion, LD50 rat oral (mg/kg): 9200 , (Particulars of main substances contained)

Fishtoxicity: LC50/96h 41g/l Lepomis macrochirus Toxic for aquatic organisms: LC50 /48h 36g/l Daphnia Magna LC 50/ 96h 92,5 g/l Nitroca spinipes EC 50 14d 92,5g/l Pseudokirchnerellasubcapitala

Classification This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard

Warning: May cause an allergic skin reaction

Hexamine is prepared **by the reaction of formaldehyde and ammonia ;** in an acidic environment hexamine is converted to toxic formaldehyde

In 2020, Formaldehyde was one of the 5 confirmed high priority carcinogens selectedfor inclusion under the CMD (Carcinogens and Mutagens Directive) as a substance of high relevance for the protection of workers by the European Commission.

IF ON SKIN: Wash with plenty of soap and water

If skin irritation or rash occurs: Get medical advice/attention

11

Is safe and clean.

Hexamine claims to be:

4) Safe. Yet its cautions and web site state:

- **Symptoms / effects, both acute and delayed Symptoms of allergic reaction may include;**

  rash, itching, swelling, trouble breathing, dizziness, tingling of the hands and feet, light headedness, chest pain, muscle pain and flushing.

- **The toxicological properties have not been fully investigated.**

Explosives risk.
Hexamethylenetetramine is the base component to produce RDX.

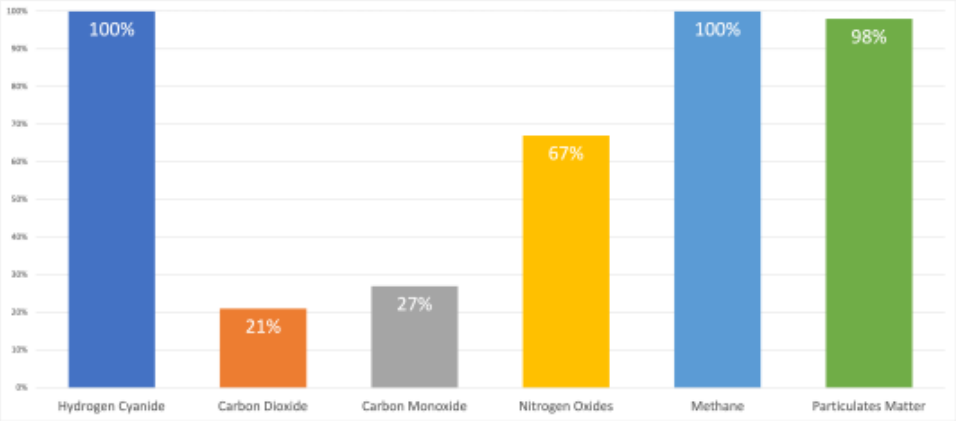
Hexamine is normally mixed with 1,3,5-Trioxane for which the additional hazards statements include;

- **May cause respiratory irritation**
- **Suspected of damaging the unborn child.**
- **Hazardous Decomposition Products and on burning: Carbon monoxide (CO), Carbon dioxide (CO2), Nitrogen oxides (NOx), Ammonia, Formaldehyde, and Peroxides.**
- **Ecotoxicity Do not flush into surface water or sanitary sewer system.**
- **Do not allow material to contaminate ground water system.**
- **Do not empty into drains.**

It should not be released into the environment.

12

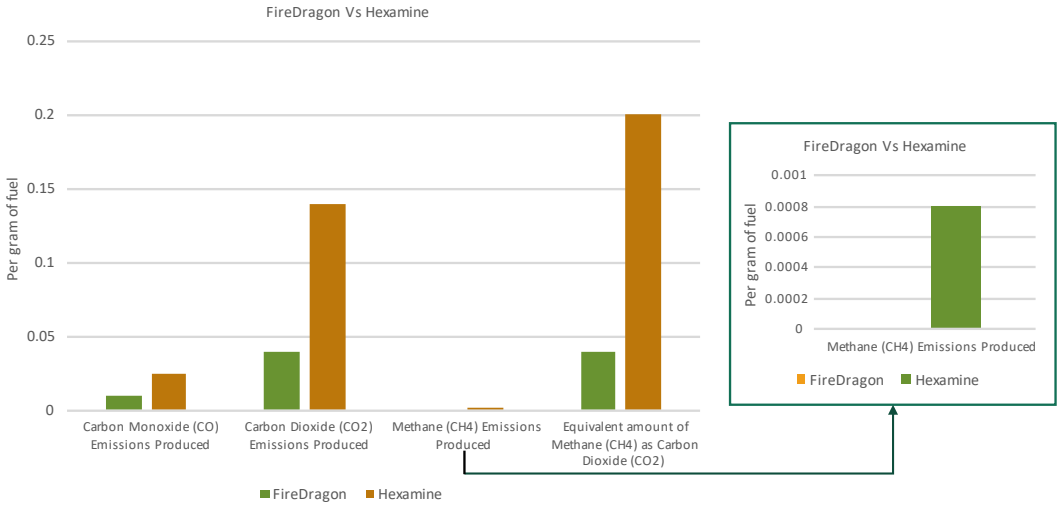
Greenhouse Gas Emissions % of savings of using Fire*Dragon* compared to Hexamine



Test (Gram per gr)	FireDragon	Hexamine	Percentage Difference
Hydrogen Cyanide	0	0.05	+100%
Carbon Dioxide	37997	48244	+21.24%
Carbon Monoxide	34.78	47.95	+27.47
Nitrogen Oxides	1.68	5.13	+67.25
Methane	0	0.0059	+100%
Particulate Matter	0.0032	0.3062	+98.95%

13

FIREDRAGON Is safe and clean.



Reference - Sustainable Energy and Environment. Title: Emissions Reduction from Biomass Cooking Stove. Stephanie James MSc 24-09-2021

14

Previous slide from Cardiff University test 09-2021 quoted:

"However, hexamine produced levels of particulate matter significantly higher than any of the fuels and caused problems (by blocking up the tube furnace) when running the combustion testing. This hexamine is therefore not a viable solution to decreasing emissions and alleviating negativse health effects.

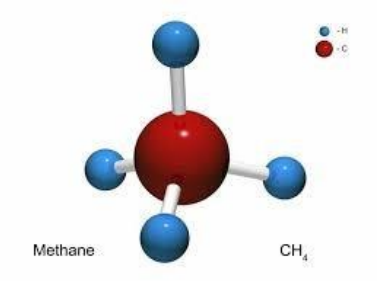
*(During testing) .....**a tar-like substance** was found in the filter, and the highest levels of CO2 and CH4 emissions at a given time were produced by hexamine.*

Of all the alternative fuels examined, the FireDragon... produces the fewest CO and CO2 emissions, with no CH4 emissions and only very small amount of particulate matter."

Hexamine residue left in filter pipe

Burning hexamine releases a very high concentration of the worst level 1 Particulate Matter (PM) carcinogenic compounds. About the same amount of PM`s compounds are given off by 23,500 cigarettes.

Methane has more than 80 times the warming power of carbon dioxide over the first 20 years after it reaches the atmosphere. Approx 60% of today's warming is driven by methane from human actions.



15

FIREDRAGON Is safe and clean.

FEB. 15, 1993

Two Royal Marines die on winter exercises

LONDON -- Two members of an elite Royal Marines commando unit died and a third was found unconscious in a tent Monday during a winter warfare training exercise in Norway, a military spokesman said.

No official cause of death was immediately given, but there was speculation that the men might have been asphyxiated by fumes from a fuel stove in the closed tent while they slept.

It is suspected they died from cyanide poisoning

The British Army replaced hexamine with FireDragon.

FIREDRAGON

Tested and delivers.

FireDragon is safe to handle and is even a proven highly effective hand sanitiser, killing 99.999%in viable bacterial counts.

The findings from the FGD study were;

- ***..supported by user responses from the survey where 100% thought FireDragon was clean or very clean, as well as fast or very fast.***
- ***98% of users thought it was easy to use and cooked most of their dishes.***
- ***85% of respondents thought FireDragon was safe to use.***
- ***87% were very happy with the fuel, while the remaining 13% reported being "quite happy" using FireDragon.***

Ethanol burning with it`s spectrum depicted.

17

FIREDRAGON

Tested and delivers.

FireDragon – Winter Test - 2019

Summary.

- **FireDragon was tested with 500ml of water in snowfall and an air temperature of -9.8°C.**
- **1 block of a fuel was used and placed into the central fuel receiver in the folding cooker. The FireDragon was ignited using matches.**
- **FireDragon lit quickly and burnt well.**
- **It didn't diminish from the high winds or low temperature.**
- **The mess tin was placed on the top of the cooker and allowed to reach the flame.**
- **The water boiled in approximately 9 minutes during wind gusts of 20mph with moderate snowfall.**

18

FireDragon – Ease of Use Trial, 2020

Findings from this FSD user study were:

- **100% of users thought FireDragon was clean or very clean, as well as fast or very fast to burn.**
- **98% of users thought it was easy to use and cooked most of their dishes.**
- **85% of respondents thought FireDragon was safe to use.**
- **Finally, 87% were very happy with FireDragon fuel, while the remaining 13% reported that they were quite happy with the fuel.**

Lightweight Mini Cooker

- **Compact and lightweight cooker.**
- **It can store 3 x14 gram FireDragonsolid blocks inside the stove.**
- **The fuel receiver helps to improve the burn efficiency**
- **which improves your cooking time and reduces the**
- **amount of fuel needed.**
- **Can also be used with most solid fuels, gels and some liquid fuels (not petrol)**

Weight: 40 grams
Size: 7 x 5 x 4cm

NATO Number: 9110-99-426-2694

Other Cookers;

<--- FireDragonFolding Cooker **Weight:** 110 grams **Size:** 11.5 x 7 x 2.5cm

Holds up to 3 x 28 gramor 6 x 14 grams FireDragonblocks inside the folded closed stov

Multi-Fuel & Improved burn times.
Includes wind guard to increase burn times.

FireDragon8 gram Fold Flat Cooker-->

Weight: 26 grams
Size: 10 x 9 x 0.04cm

Holds the 8gram FireDragonpot.

The stove is equipped with adjustable cup support wings and can withstand multiple folds and unfolds

Tested and delivers.

Videos

21

Tested and delivers.

Videos – Lighting when wet

Video – Quick boil time

22

Tested and delivers.

Videos – Clean Burn/Low Soot

Video – Easy to Light

23

Firedragon will light in 1 to 2 seconds with an ordinary match.
Hexamine takes up to 20 seconds and needs expensive long burn wind and waterproof matches to ignite.
This according to UK MoD trials and two independent reports

A burning issue which will not cost the earth.

Ethanol is approx. 25 % higher in calorific density than hexamine.

NATO number 9110-99-126-2694

Safe to pack with food items.

DG Transport classification UN 1325
Class 4.1 Packaging Group III

www.firedragonfuel.com

✓ Air transportable

24

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