Monday, July 03, 2017

Final report

Kiwa 161200045

Report of fire tests on Li-ion batteries based on a hand fire extinguisher with F-500 Encapsulator Agent

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Content

1 Preface

Kiwa Nederland BV has been asked by Westheart International BV to witness and report on the possibility of extinguishing tests on Li-ion batteries on fire. Well-known fact is that, once started, a li-ion battery on fire is practically unstoppable and therefore difficult to extinguish.

This report contains the description of the tests and the results of the tests, see chapter 3.

The tests were performed at Bon Holding BV, Oefencentrum Noord BV, located at Weegbrugweg 2, 9418 TS Wijster, The Netherlands

In the firefighting industry, the following definitions are used:
- Extinguishing mode, putting out a fire, with no re-ignition;
- Suppression mode, sharply reducing the heat release by a fire and preventing a regrowth of a fire;
- Control mode, decrease the heat release of a fire.

Primary goal of the test
The goal is to determine if a trained person is able to achieve the modes Suppression and Control with a handheld, EN3-7 portable, fire extinguisher unit. Although the extinguishing mode can be possible, this is not a part of this report or of the conclusion. This is because of the many variables involved while using a handheld or portable fire extinguisher unit.

Note that “F-500 Encapsulator Agent” is further referred to as “F-500” in this report.

Parties involved are:
- Kiwa Nederland BV
- Fastechnologie
- Westheart International BV

Contact persons are:
- Kiwa Nederland BV, Erik Teubler
- Fastechnologie, Jan Knegt
- Westheart International BV, Willem Westerhof

2 Overview of test

Overview by Kiwa on December 14th and 22th 2016

Hand fire extinguisher units, tests will be conducted outside

Standard EN3-7 certified powder unit (6 KG)

Standard EN3-7 certified foam unit (6 L)

Standard EN3-7 certified F-500 unit (9 L)

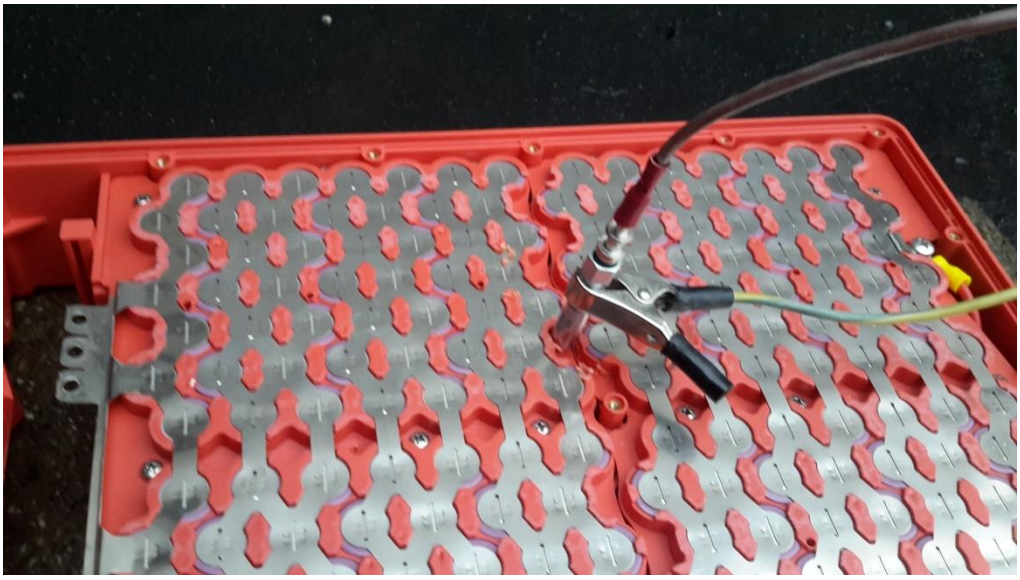
Standard EN3-7 certified F-500 unit (9 L) and 20 l F-500 canister

F-500 canister (20 L)
Product information
Note: F-500 Handheld fire extinguisher units are filled from another badge.

Object under test, Li-ion battery pack
Battery manufacturer Cleantron, capacity is 1.890 kWh and fully charged

Battery before activation and prepared with glow plug (Beru GE 10)
Note:
Preparation by a drilled hole in the same position, the tip of the glow plug will touch 2 cells.
Cells are all from standard 18650 type.

Glow plug (Beru GE 10)


The tip of the glow plug shall touch 2 cells.

Battery for the activation of the glow plug

3 Tests performed

3.1 Tests, requirements and observations

The following tests shall be performed:

- Testing on a minimum of 9 identical battery packs
- Testing of 3 identical EN3-7 certified hand fire extinguisher unit types:
  - Powder extinguisher
  - Foam extinguisher
  - F-500 extinguisher

The outcome will be 3 tests per extinguisher type.

3.1.1 Description of test steps

1. Connecting of electrical leading to the glow plug
2. Activation of the glow plug
3. Ignition of the battery to achieve a thermal reaction and the burning of the battery
4. After ignition of the battery, the operator will try to extinguish the battery by operating the handheld fire extinguisher according EN3-7:
   I.2.3 and I.3.3 Test procedure
   The operator shall bring the extinguisher into use, and direct the jet onto the test fire while moving round the test fire at his own discretion in order to obtain the best result.
   The entire contents of the extinguisher may be discharged either continuously or in successive bursts.
5. After an extinguisher discharge a appropriate period of time is reserved for the observation of the behavior of the battery (no effects or re ignition)
6. Taking temperature samples
7. Visual overview

3.1.2 Requirements

Three (successive) tests for each extinguishant type.

Pass / fail criteria are:

- no flaming or
- re-ignition

directly after the end of extinguishant discharge.

3.1.3 Observations

During the tests on October 14th and 22th, 2016 the following phenomena or events has been generally observed:

- The start of a thermal reaction and burning of the battery is achieved after approx. 360 to 480 seconds after activation of the glow plug.
  - In a few cases, other longer times were observed but with the same result
- After the start of the thermal reaction and burning of the battery, the battery starts to disintegrate because of the chain reaction by the cells. This also causes individual cells to rocket throughout the test facility. This phenomena was only observed after a positive start of the thermal reaction and burning of the battery.
- After the start of the thermal reaction and burning of the battery an attempt is undertaken to extinguish the battery by different types of extinguishant.
  - See 3.1.1. test step 4.
- Only after the discharge of the F-500 extinguishant the temperature drops to 200°C and below to approximately 150°C.

3.1.4 Equipement for data collection during tests

Equipment used for data collection is as follows:

- Digital temperature meter:
    - Type Fluke

All equipment used are for general indication purposes only.

3.1.5 Test results

Type	Result*			Remark
	Number 1	Number 2	Number 3	
Powder extinguisher	Poor	Poor	Poor	Do not apply on Li ion battery fire
Foam extinguisher	Moderate	Poor/Moderate	Moderate	Not recommended to apply on Li ion battery fire
F-500 extinguisher	Sufficient	Sufficient	Sufficient	Can be recommended to apply on Li ion battery fire

* the results as displayed are to be interpreted as follows:

In the firefighting industry, the following definitions are used:

- Extinguishing mode; put out a fire, no re-ignition;
- Suppression mode; sharply reducing the heat release and preventing a regrowth of a fire;
- Control mode; decrease the heat release of a fire.

These are translated to:

- Sufficient; a great effect is observed, suppression and/or control, re ignition is still possible and observed after a few minutes during test 3.
    - Therefor extinguishment is not applicable.
- Moderate; an effect is observed, control but no extinguishment or suppression, re ignition can be expected
- Poor; (almost) no effect

4 Conclusion

Based on the tests and the findings, as described in this test report of Li-ion batteries based on tests with the handheld fire extinguisher unit, the conclusion is:

A hand fire extinguisher unit with F-500 Encapsulator Agent as an additive is significantly better able to achieve suppression mode directly after ignition of a single 1,9 kWh Cleantron battery than a hand fire extinguisher unit with standard powder or foam.

The F-500 hand fire extinguisher can be recommended to apply on a Li ion battery fire taking into account that the attempt to achieve suppression of a Li-ion battery is not without any danger because of the possible explosive behavior of a Li-ion battery.

During the test the temperature will drop to approx. 150°C in a short period, which is regarded to be the temperature, when reached and below, a thermal reaction in a lithium ion battery will stop.

4.1 Note

By drafting this report, the conclusion is no value judgment about any other component(s) and part(s) as present in or at the facility.

The conclusion does not provide in any information about placement, handling, storage or maintenance of a battery pack. The provisions given by the manufacturer must be followed at all times.

The conclusion only applies to the products as mentioned in this report.
This report does not provide in other findings, procedures or requirements than stated in this report.