Suppression of Lithium-Ion Battery Fires

Prepared for:

GelTech Solutions
1460 Park Lane South, Suite 1
Jupiter, Florida 33458

Prepared by:

Fire Risk Alliance, LLC
4410 N Ravenswood Ave.
Chicago, IL 60640

October 26, 2015

TABLE OF CONTENTS

1.0 INTRODUCTION

The Fire Risk Alliance (FRA), per the request of GelTech Solutions, conducted a series of tests to determine the efficacy of the suppression agent FireIce in extinguishing lithium-ion battery fires. The first goal of the test series was to compare the suppression performance of a 2.5-liter FireIce extinguisher on a lithium-ion battery fire to that of a 2.5-pound Halon 1211 fire extinguisher. This extinguisher was selected as it is typical to the type of extinguisher found on a commercial passenger airplane. The second goal of the test series was to compare the suppression performance of immersing burning lithium-ion batteries into a bucket of FireIce gel to that of a bucket of water. Submerging burning lithium-ion batteries in a bucket of water is an FAA suggested suppression method. The testing was conducted at the University of Maryland's (UMD) fire lab in College Park, MD.

During the testing, sets of lithium-ion batteries were brought to thermal runaway, cell-to-cell fire propagation, by exposing the batteries to the heat and flame produced from a 20 mL (2/3 oz) methanol cup fire. Mass loss and temperature data were collected to determine the extent of damage and fire spread respectively. For repeatability purposes three tests each, consisting of eight lithium-ion batteries arranged in two rows of four, were allowed to burn with no suppression efforts (free burn) to establish a baseline worst-case exposure. Three additional sets of batteries were ignited and FireIce, an NFPA 18 water additive suppression agent, was applied with a 2.5-liter fire extinguisher. The results were compared to similar tests with three sets of batteries that were subjected to Halon 1211 from a 2.5-pound extinguisher.

In the next phase, tests were conducted to compare the suppression results of submerging the ignited sets of batteries in a steel pail of FireIce (3 tests) compared to those submerged in a pail of water (3 tests). The FireIce extinguisher proved superior in its ability to arrest cell-to-cell fire spread when compared to the Halon extinguisher. The Halon extinguisher temporarily delayed the progression of the fire but failed to stop the continued cell-to-cell thermal runaway. The immersion tests showed that both water and FireIce extinguished the lithium-ion battery fire.

2.0 TEST SETUP

Fire testing was conducted at the University of Maryland's fire lab over a four-week period. The following sub sections describe the test equipment used, fuel source (battery), test procedure and extinguishers.

2.1 Equipment

The test setup included a hood to collect products of combustion and a Mettler Toledo model XP64001L scale to monitor mass loss. The capacity of the scale was 64.1 kg with a readability of 0.1 g. Three type K thermocouples were used to collect temperature data. The scale and thermocouples were attached to a Fluke, model 2640A, data acquisition system with NetDaq software. The thermocouples were used to monitor the fire spread though the batteries while the scale measured mass loss, which indicated the extent of damage due to burning. The mass loss was used as the primary metric of the success of an agent to extinguish the battery fire. Videos of the tests, as well as photos of the batteries after testing, were taken for each sample.

2.2 Fuel Source (Battery)

Figure 1 – 18650 Li-Ion Batteries Used in Battery Array

The battery selected for testing was a Panasonic model CGR18650CG, Figure 1. The battery has a capacity of 2250 mAh and a nominal voltage of 3.6 volts. The battery specification sheet can be found in Appendix A. The batteries were fully charged prior to testing as it has been shown that the State of Charge (SOC) affects the Heat Release Rate (HRR)[1] and a fully charged battery represents a worst-case scenario, Figure 2. The fire source (battery) was not changed during the course of testing. Fifteen total tests were conducted as shown in the test matrix below, Table 1. The cell type selected (18650 cylindrical cell) is used in many laptop computer batteries, the Tesla Roadster, and LED flashlights.

[1] An Investigation of Thermally-Induced Failure of Lithium Ion Batteries, Xuan Liu UMD.

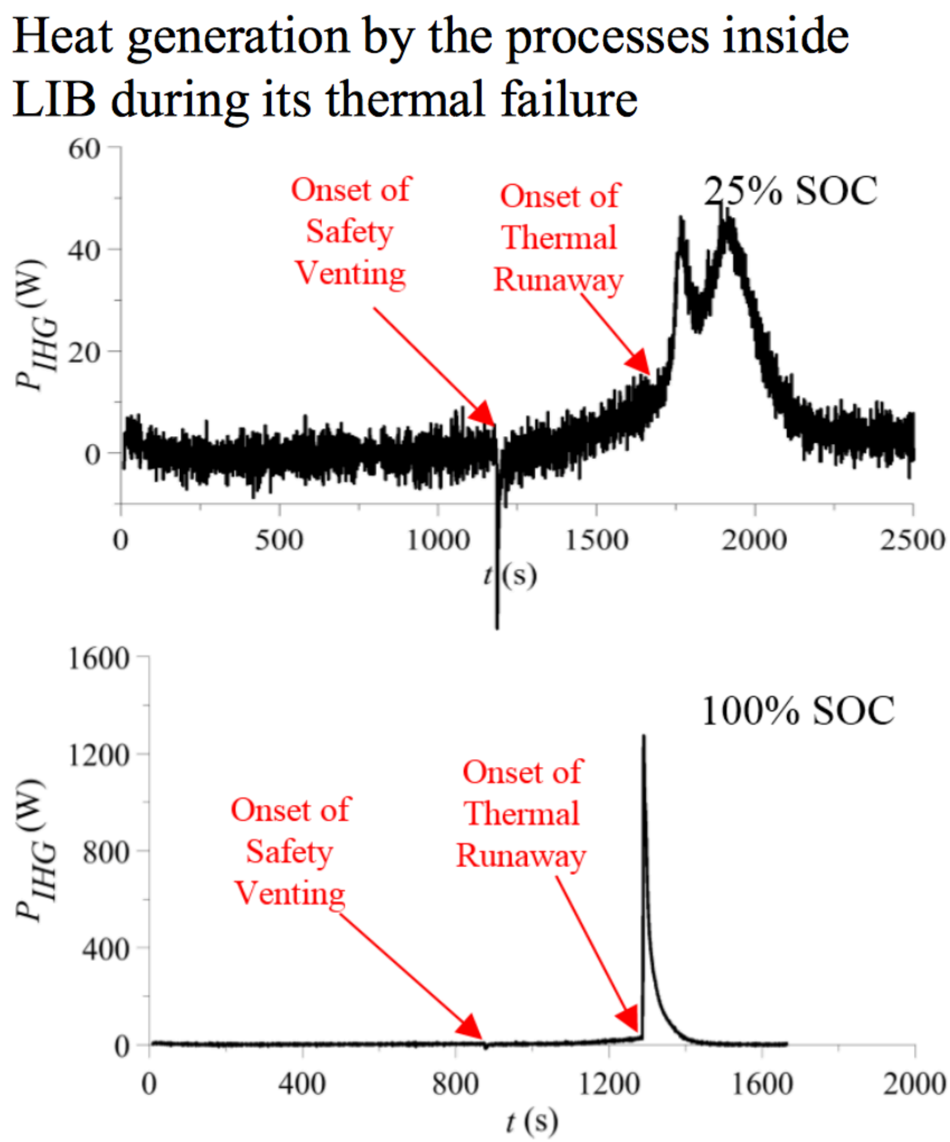


Figure 2 – Heat Generation (Watts) for a Given State of Charge (SOC)

Table 1 – Test Matrix

Test Number	Description
1	No Suppression Effort
2	No Suppression Effort
3	No Suppression Effort
4	Immersion in Water
5	Immersion in Water
6	Immersion in Water
7	Immersion in FireIce
8	Immersion in FireIce
9	Immersion in FireIce
10	Halon Extinguisher
11	Halon Extinguisher
12	Halon Extinguisher
13	FireIce Extinguisher
14	FireIce Extinguisher
15	FireIce Extinguisher

2.3 Test Procedure

The batteries were arranged in two rows of four with the batteries standing vertically on the test stand, Figure 3. The batteries were wired together using 20-gauge wire incorporating the thermocouples (TC) to place one TC at each four-battery intersection of the eight battery set, Figure 4. The batteries were then wired to the screen that was placed on the test stand to prevent them from falling during the test. The batteries were exposed to a 20 mL (2/3 oz) methanol fire from a cup located three inches below the bottom surface of the batteries. During the “free burn” baseline tests, the 20mL of methanol was ignited and the batteries were left to burn until they self extinguished. During the immersion tests, the batteries were forced into the agent contained in a metal pail by a remote controlled actuator that would pull the batteries off the test stand and into the agent, Figure 5. The metal pail was filled with either 1.5 gallons of water or 1.5 gallons of FireIce gel mixture at a concentration of 1%. The actuator was initiated once secondary venting was observed in any one of the cells, as described below. During the extinguisher testing, the methanol was ignited and, once secondary venting was observed in any one of the cells, the agent was applied until all contents of the extinguisher were expelled. The extinguisher was located five feet from the source.

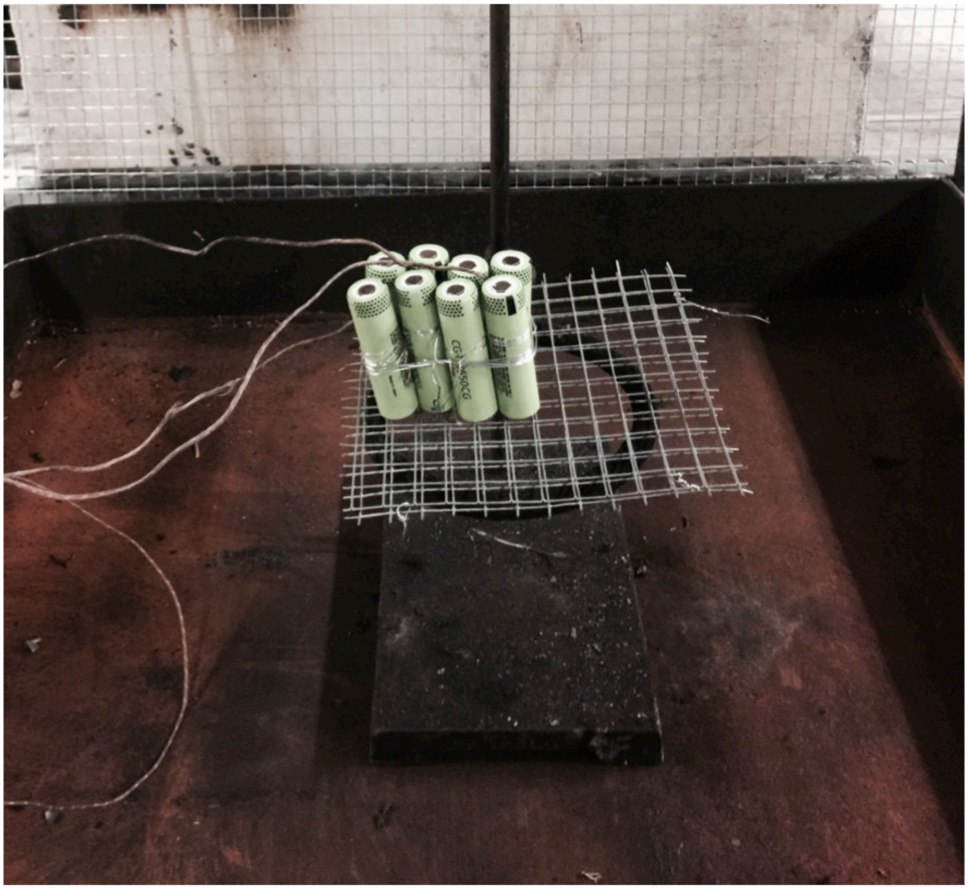


Figure 3 – Batteries on Stand Above Cup of Methanol for Exposure During Free Burn

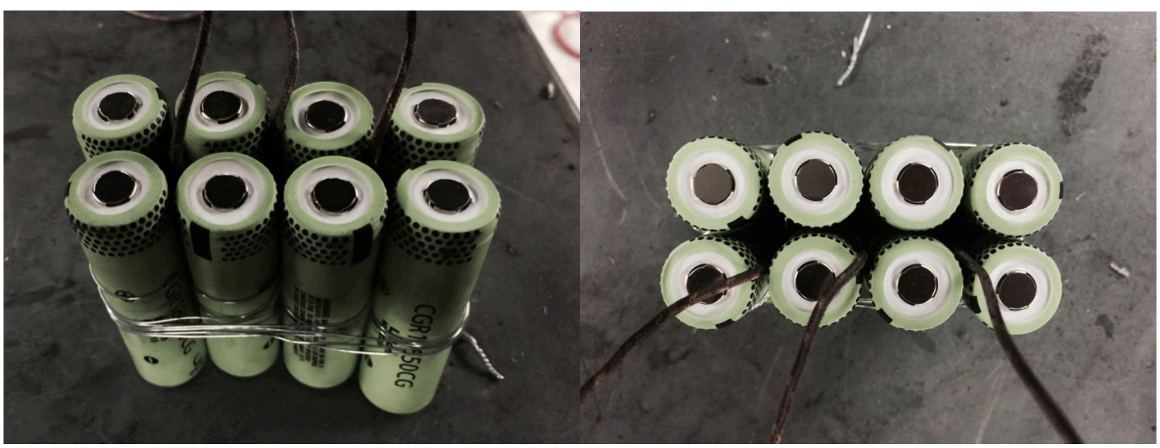


Figure 4 – Li-Ion Battery Array Consisting of Two Rows of Four 18650 Batteries With TCs

Figure 5 – Setup for Immersion Testing

2.4 Extinguishers

The 2.5-liter FireIce extinguisher was filled with two liters of water mixed with 20 grams of FireIce for a 1% concentration, Figure 6. FireIce is a polymer-based powder that when mixed with water creates a gel. The MSDS can be found in Appendix B. The stainless steel FireIce extinguisher was pressurized to 150 psi for this test series.

Figure 6 – FireIce Water Additive (Powder)

Figure 7 – FireIce 2.5-Liter Extinguisher

The Amerex C352TS Halon 1211 extinguisher contains Halon as a liquefied gas, pressurized with nitrogen, which discharges as a vapor, Figure 7. A specification sheet for the extinguisher can be found in Appendix C.

Figure 8 – 2.5-Pound Amerex Halon Extinguisher

3.0 TEST RESULTS

3.1 Free Burn Testing

When exposed to the 20 mL methanol fire, the first signs of battery failure were a short soft pop or crackle sound. This may have been the start of gaseous venting or the plastic cover of the battery cell beginning to burn. A louder pop and the venting of flammable gasses, Figure 9, would follow. The fire produced from this first vent of the cell would diminish and in some cases extinguish. In some instances, other battery cells followed the first cell and also vented flammable gasses. At a certain point, the heat in the initial cell would cause a second more significant vent to occur. During this second venting stage the cell ejects sparks and burning gasses similar to a firework, Figure 10. The heat generated during this stage causes the casing of the battery to glow red hot and TC temperatures reached over 900°C (1650°F), Figure 11. These temperatures were sufficiently elevated to melt the TCs. The heat from the secondary venting would cause adjacent batteries to trigger the primary venting process, if they had not already done so, or cause secondary venting leading to a cascading event. This cascading effect would continue until all 8 cells were consumed. Figure 12, Figure 13, and Figure 14 are images taken after one of the free burn baseline test. It was observed that select batteries would completely expel their internal components, while others would split open. The majority showed signs of venting and were able to contain the remnants of the burnt material inside the battery casing. The green plastic external covering, in all cases, was burned off completely.

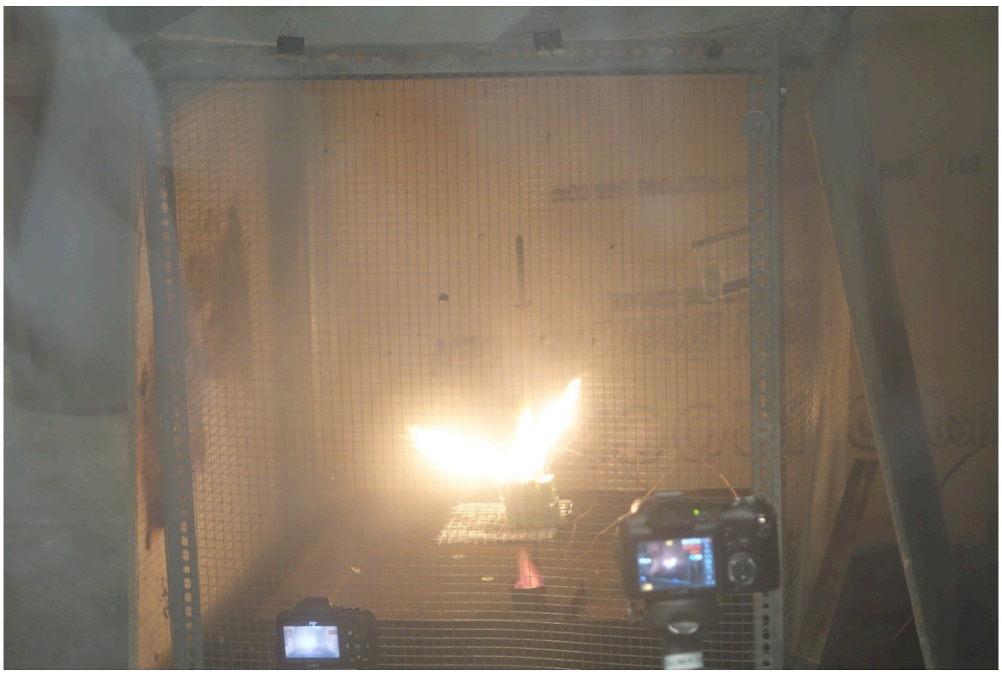


Figure 9 – Initial Venting of Flammable Gasses from Battery

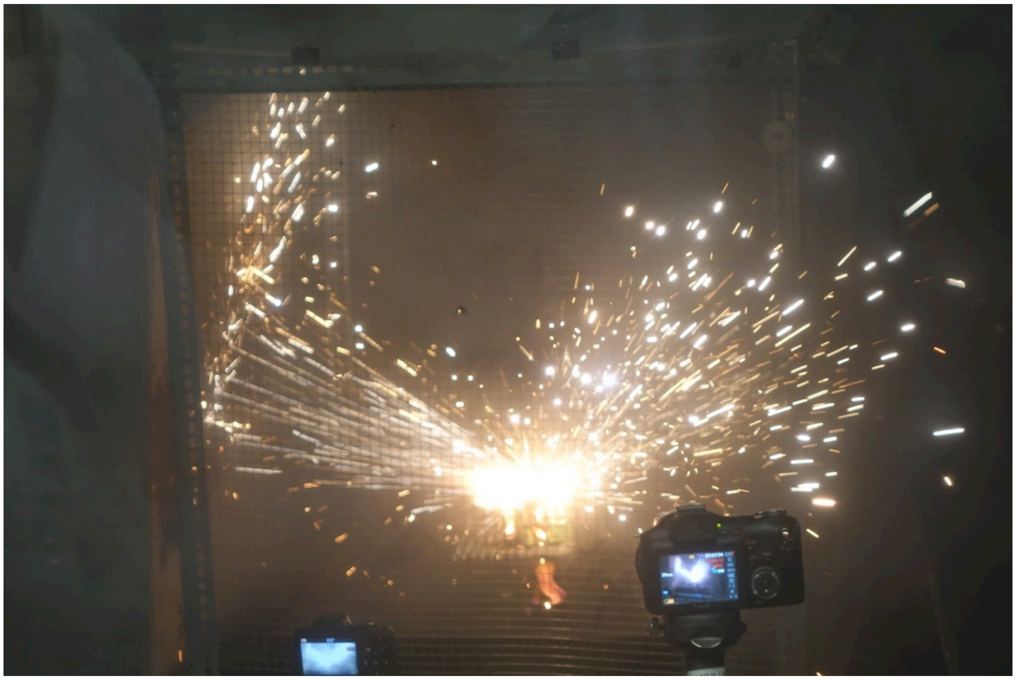


Figure 10 – Secondary Venting of Molten Material from Battery

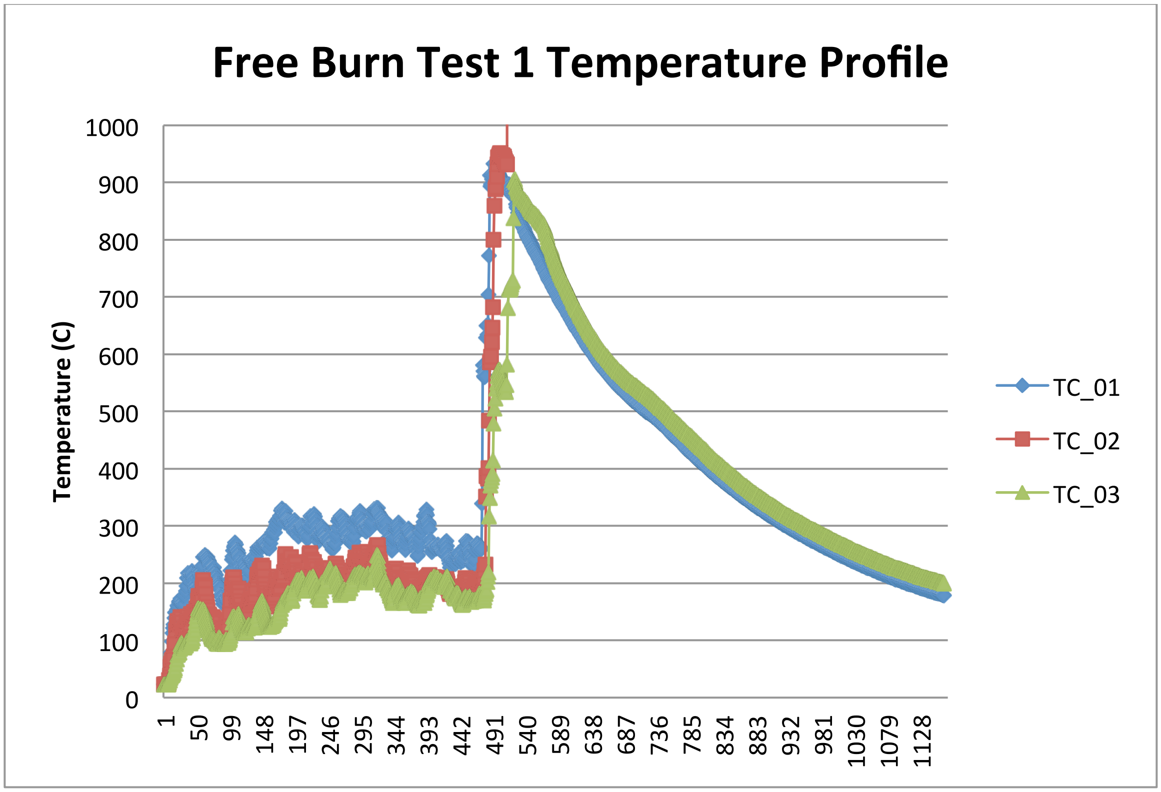


Figure 11 – Free Burn Temperature Profile

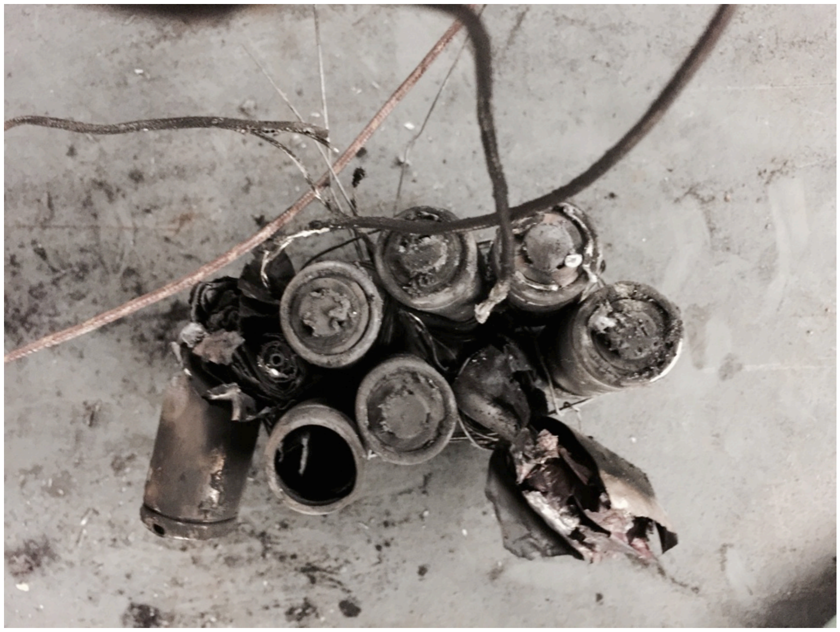


Figure 12 – Top of Batteries After Free Burn

Figure 13 – Side of Batteries After Free Burn

Figure 14 – Bottom of Batteries After Free Burn

Figure 15 is a graph depicting the mass loss data collected during the three free burn tests. The mass includes the stand and flammable liquid used for ignition. The spikes in the graph represent batteries venting causing the readings to fluctuate due to the force and violence of the venting process. The eight batteries weighed 342 grams prior to testing. Upon completion of the testing, the average weight of the batteries was 200 grams. Therefore, it can be deduced that 142 grams of material was lost due to the combustion process.

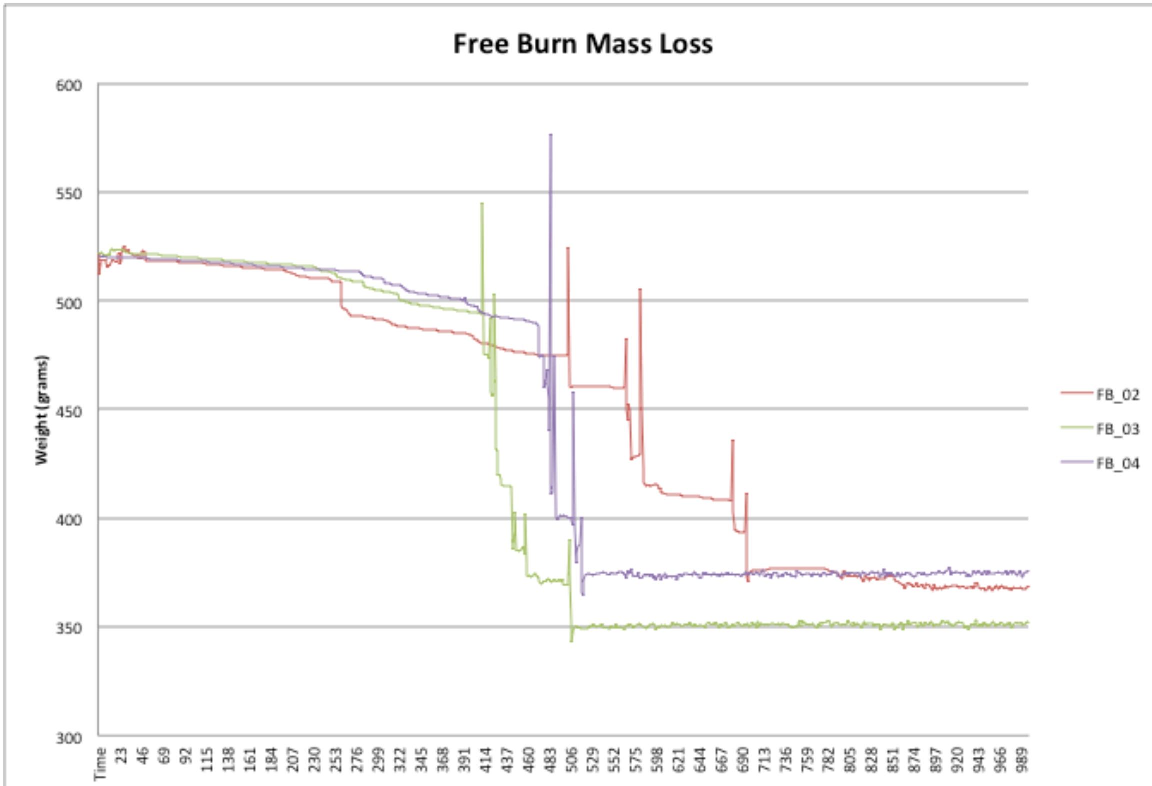


Figure 15 – Mass Loss (Grams) of Batteries During Free Burn Fire Tests

3.2 Immersion Suppression Testing

The immersion testing indicated that both water and FireIce demonstrated the ability to suppress and stop the thermal runaway of the battery fire. Figure 16 through Figure 21 show the temperature data collected during each of the immersion tests. As seen in the graph, after the initial spike in TC temperature due to secondary venting, the temperatures decline and stabilize representing the immersion of the batteries in the pail of water or FireIce. The batteries were immersed in the agent for a duration of approximately 10 minutes and then removed. No re-ignition was observed in any of the immersion tests. Bubbles were observed emanating from the batteries upon immersion in both cases (water and FireIce). It could not be confirmed whether the bubbles being expelled were flammable gasses or were due to the agent filling voids in the battery and pushing out air pockets. In one test, venting of a second battery occurred as the set was entering into the agent (FireIce). It was noted that the agent captured the gasses expelled, turning the contents of the pail black, Figure 22.

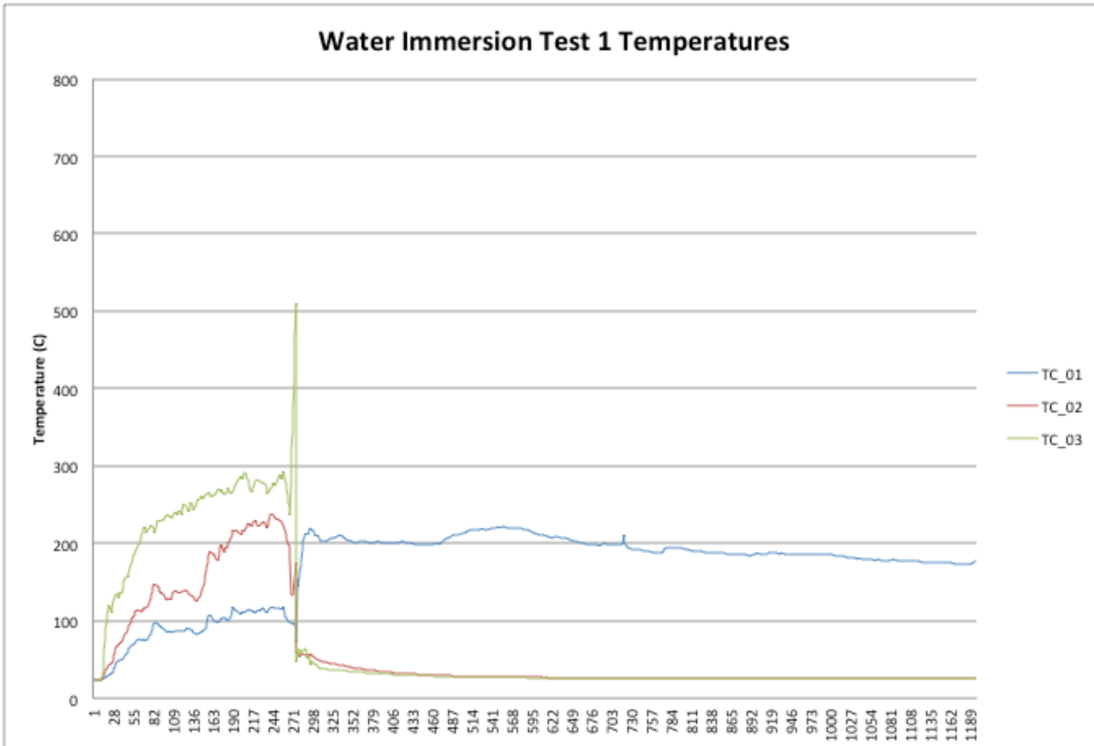


Figure 16 – Temperatures Collected During Water Immersion Test

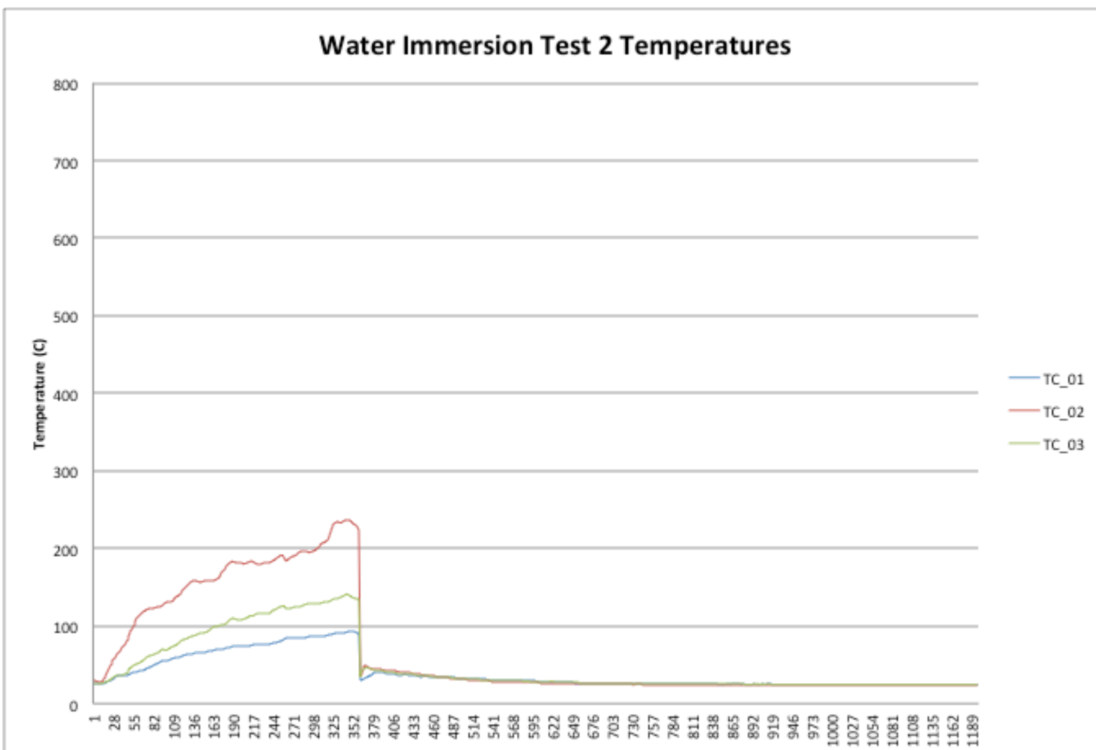


Figure 17 – Temperatures Collected During Second Water Immersion Test

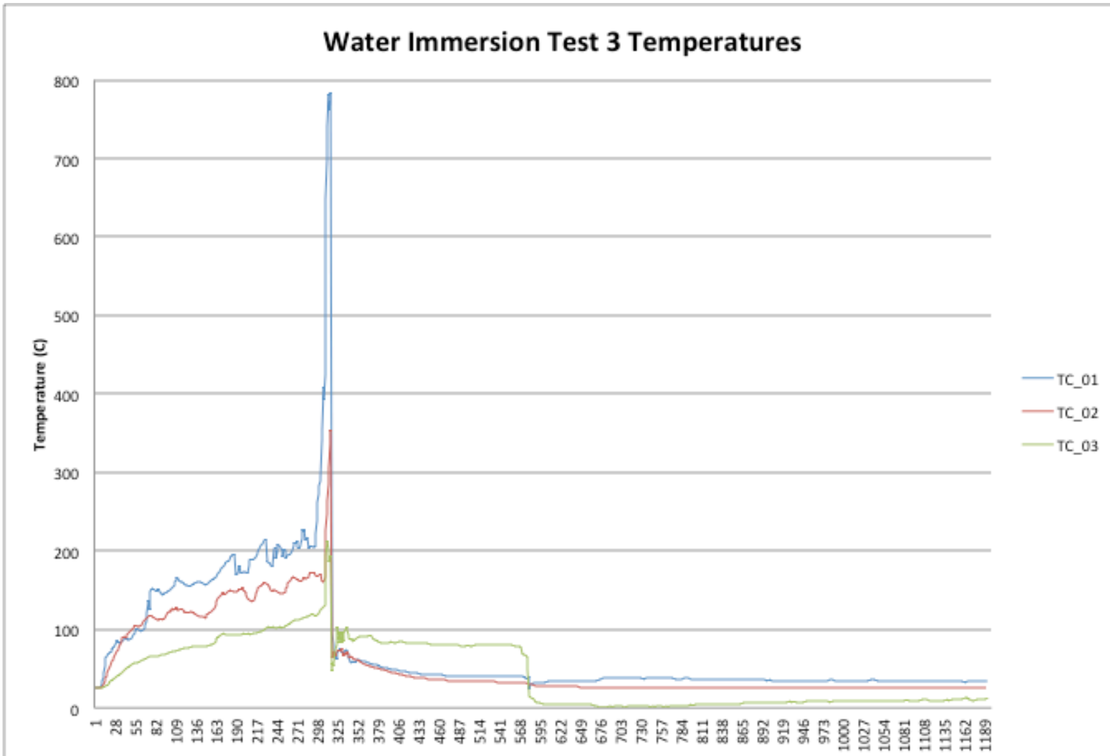


Figure 18 – Temperatures Collected During Third Water Immersion Test

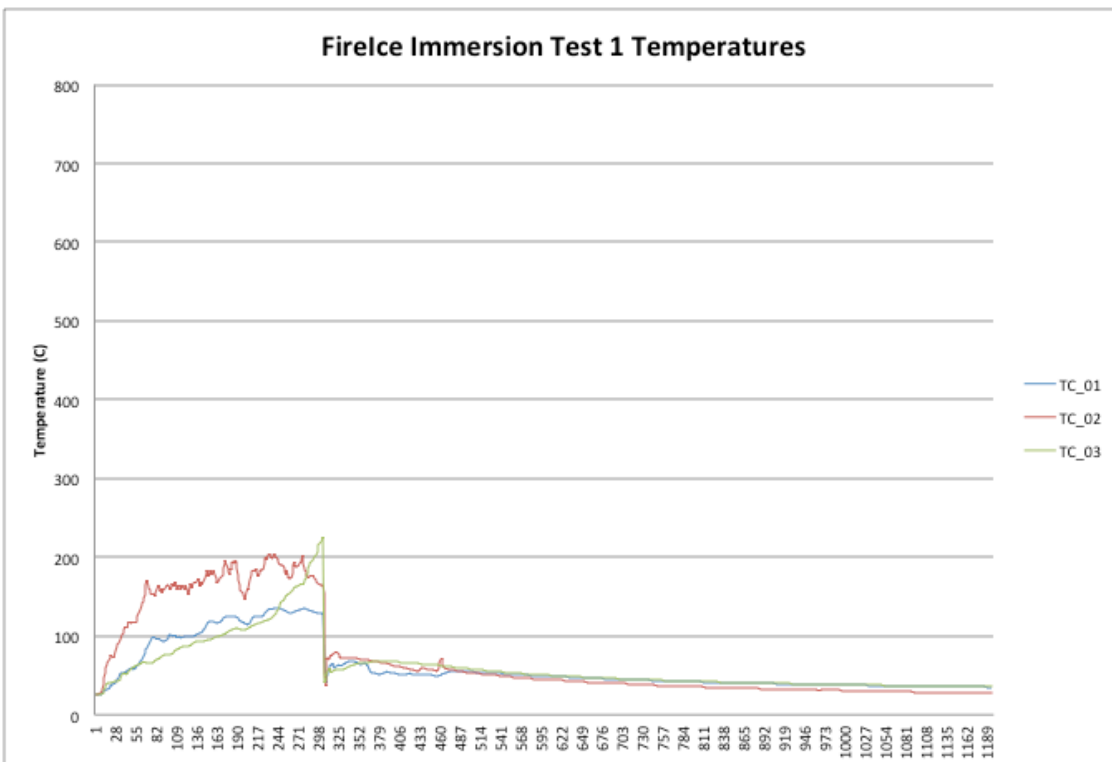


Figure 19 – Temperatures Collected During FireIce Immersion Test

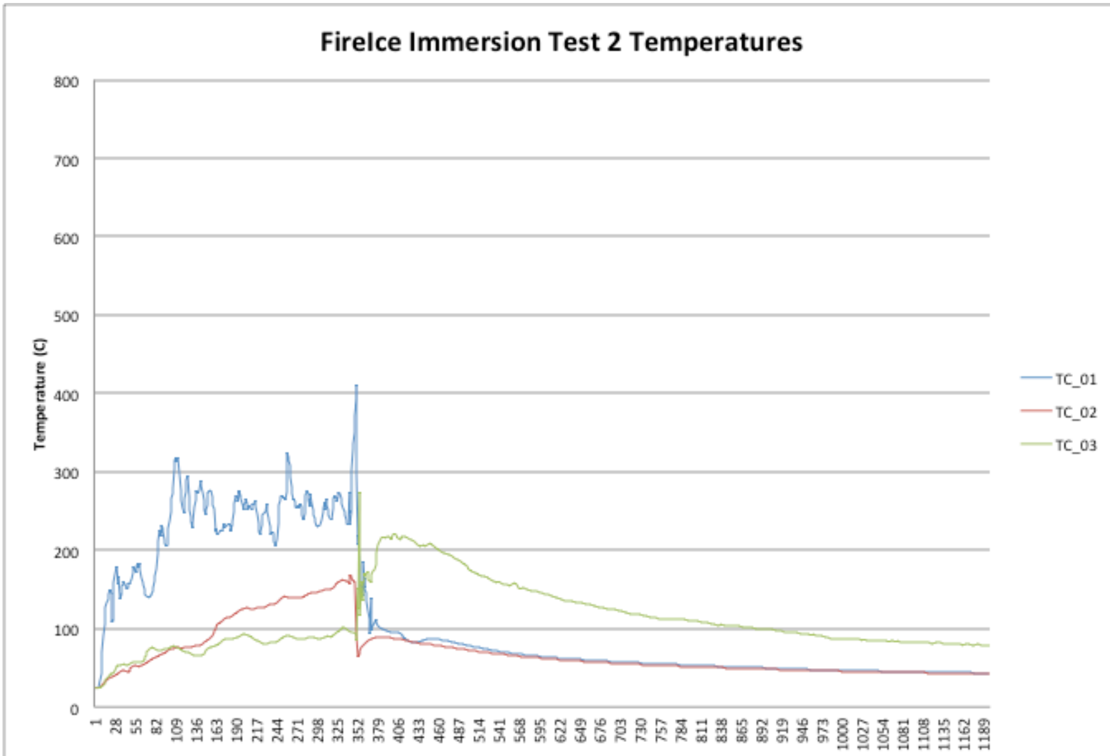


Figure 20 – Temperatures Collected During Second FireIce Immersion Test

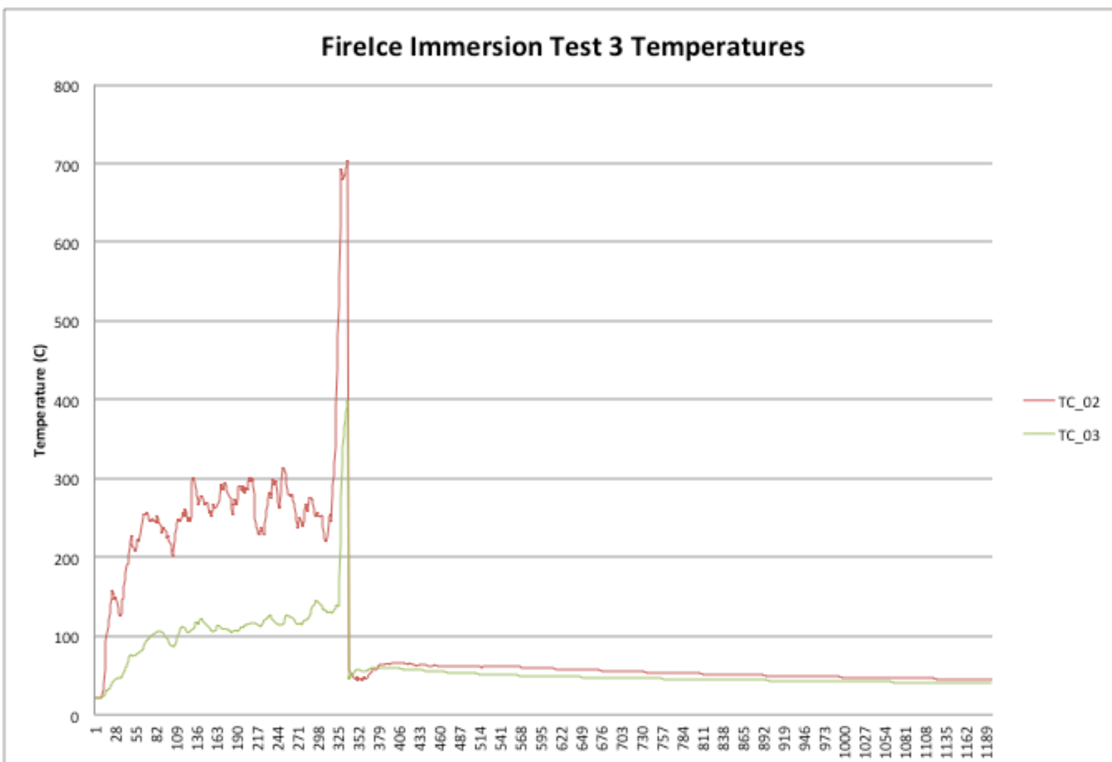


Figure 21 – Temperatures Collected During Third FireIce Immersion Test

Figure 22 – FireIce After Battery Venting During Immersion

Figure 23 through Figure 26 are images taken after one of the immersion tests and are typical of the damage observed during this part of the testing. Figure 23 shows the exposed side of the batteries where the initial and secondary venting took place prior to insertion into the agent. Figure 24 is an image of the top of the batteries. Oxidation was observed on the top of the batteries due to exposure to the agent. White disks were also observed on the top of many of the batteries, which indicated that the battery did not go through the initial stage of venting and releasing of the flammable gasses. The white disk will pop off during the first venting stage. Figure 25 and Figure 26 show the non-exposed side and bottom of the batteries where very little damage was evident.

Figure 23 – Side of Batteries After Immersion Testing

Figure 24 – Top of Batteries After Immersion Testing

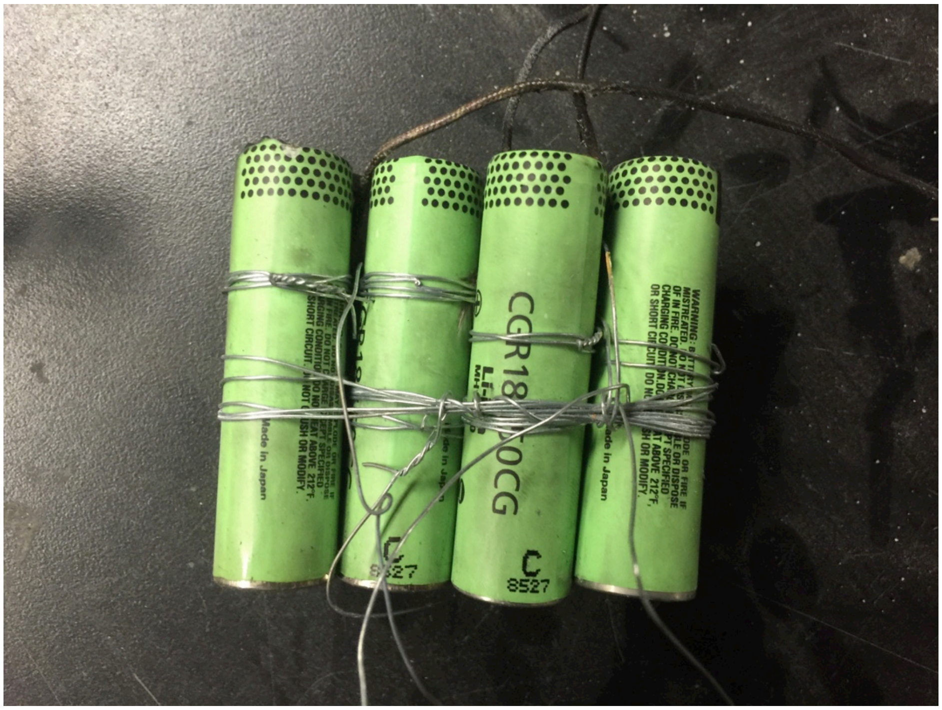


Figure 25 – Back side of Batteries After Immersion Testing

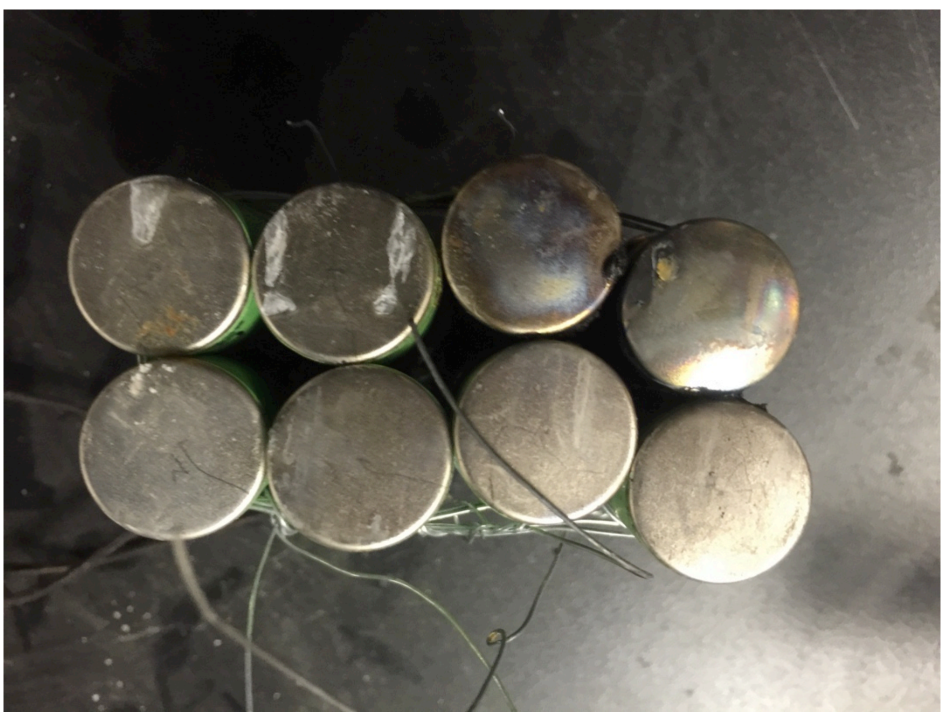


Figure 26 – Bottom of Batteries After immersion Testing

3.3 Extinguisher Suppression Testing

The extinguisher suppression testing began with the Halon extinguisher. Figure 27, Figure 28, and Figure 29 show the temperature profiles collected during the Halon extinguisher testing.

Similar to the immersion tests, the batteries were exposed to a Methanol fire until one of the batteries reached the secondary venting stage. Upon reaching the secondary venting stage the Halon extinguisher was activated until the entirety of the agent was released (approximately 20 seconds). In all three tests the Halon initially appeared to extinguish the battery fire. All signs of fire (flame, smoke, and sparks) stopped and frost was observed on the exterior casing of the batteries. In the graphs below, the release of the Halon agent appears as a dip in the temperature profile. With the Halon extinguisher emptied, the methanol fire extinguished, and no signs of fire, the batteries would re-ignite after a short period of time. The amount of Halon and length of discharge from the 2.5-pound extinguisher were not sufficient to lower the internal temperature of the cells to properly extinguish the batteries. The frost that collected on the batteries melted as the internal temperature rose in the batteries and the batteries would then begin to vent, progressing to secondary venting and eventually causing thermal runaway until all the batteries were consumed.

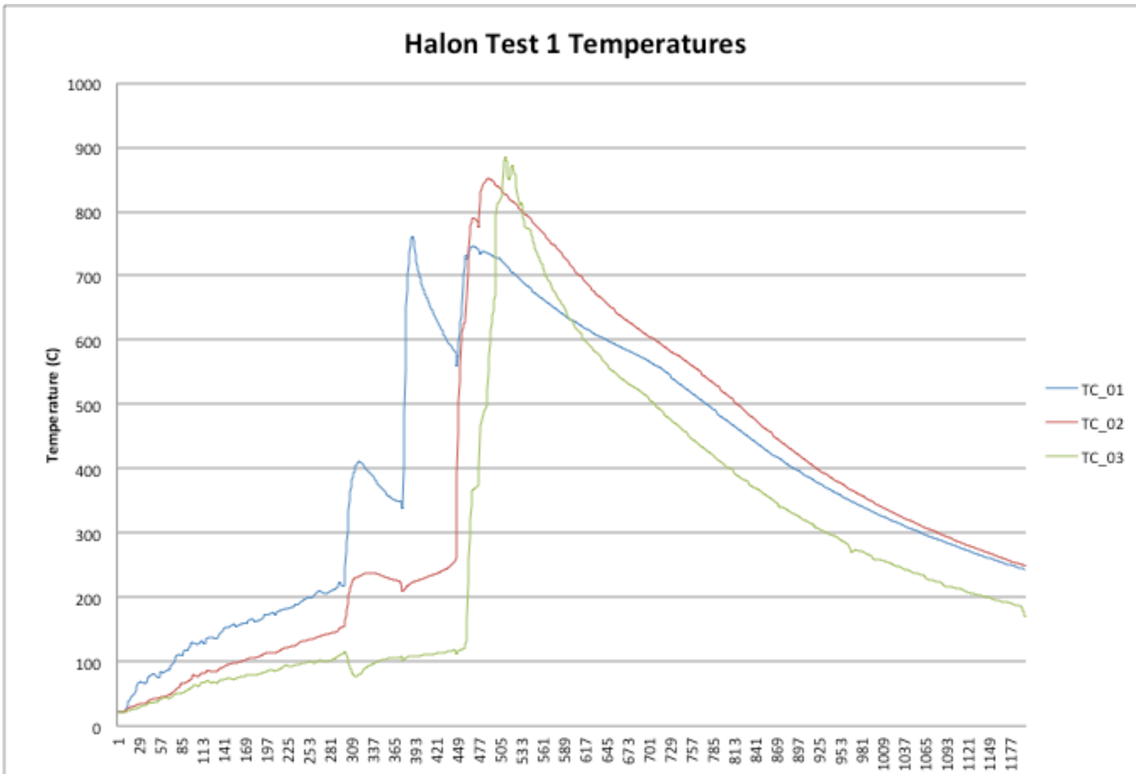


Figure 27 – Temperatures Collected During Halon Discharge

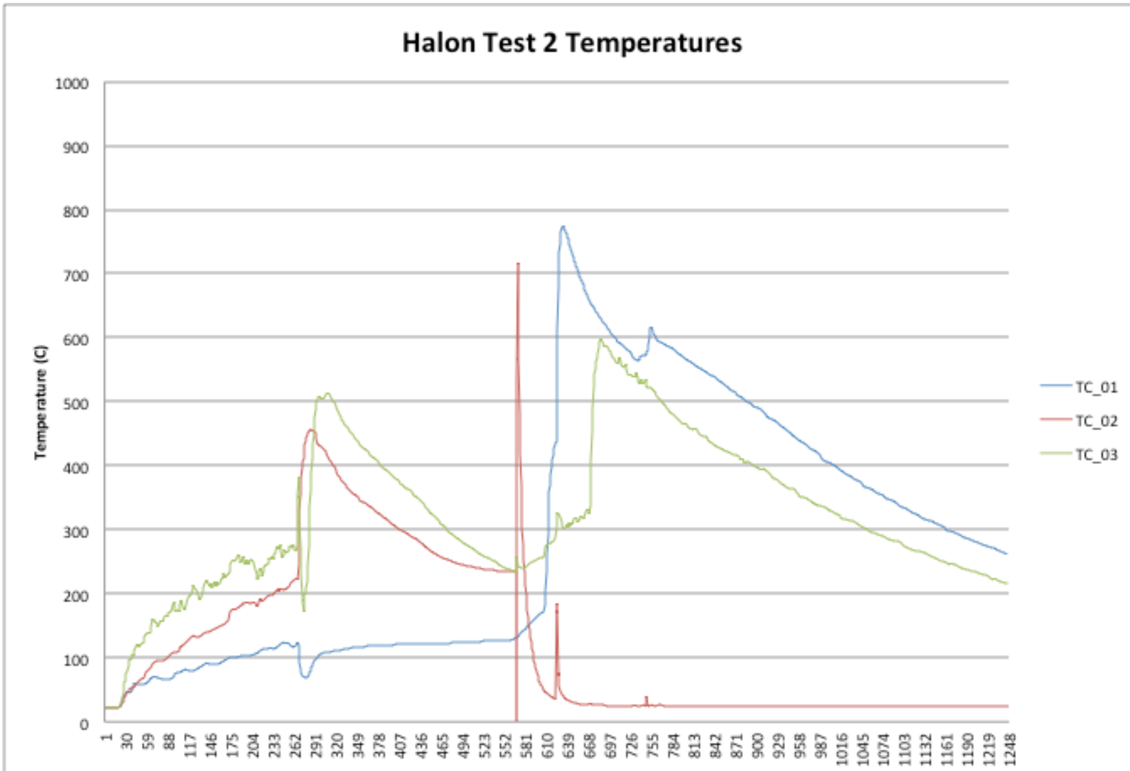


Figure 28 – Temperatures Collected During Second Halon Discharge

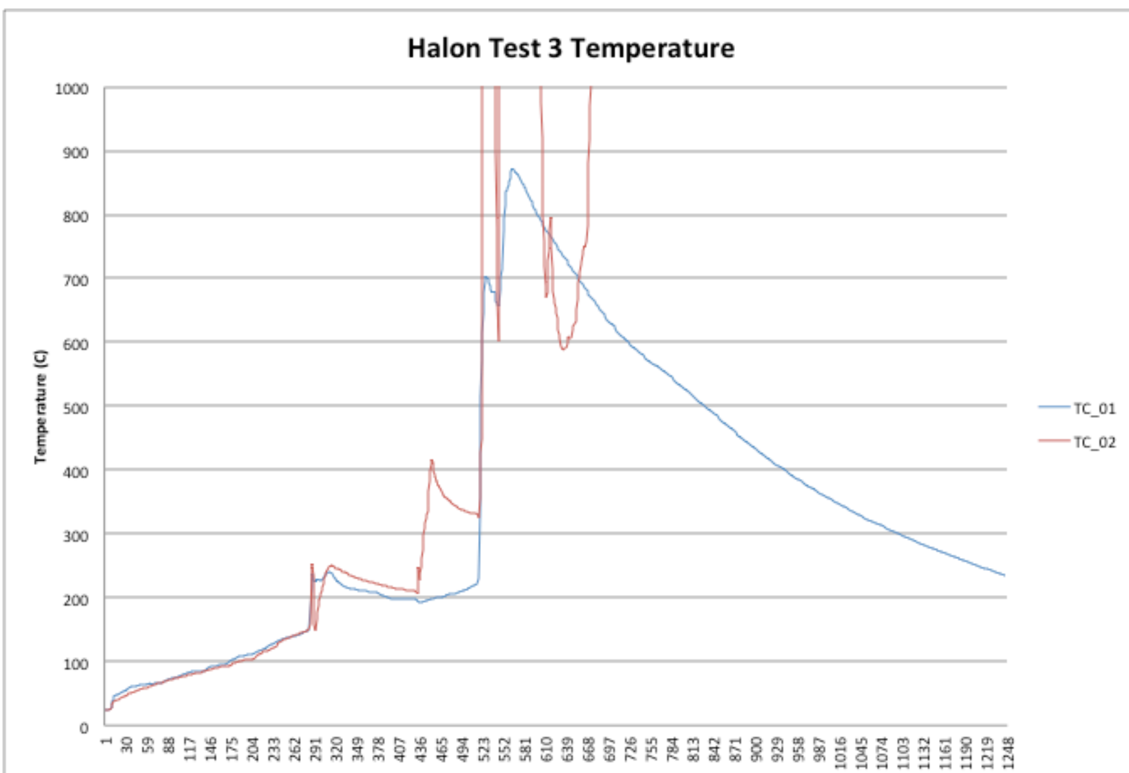


Figure 29 – Temperatures Collected During Third and Final Halon Discharge

Figure 30 through Figure 32 are images taken after the Halon extinguisher testing. The damage is similar in nature to the free burn: the exterior casing burned off, batteries expelled internal workings, some casings split open, and the majority showed signs of venting with the remnants of the burnt material inside the battery casing.

Figure 30 – Exploded Battery After Halon Extinguisher Test

Figure 31 – Side of Batteries After Halon Extinguisher Test

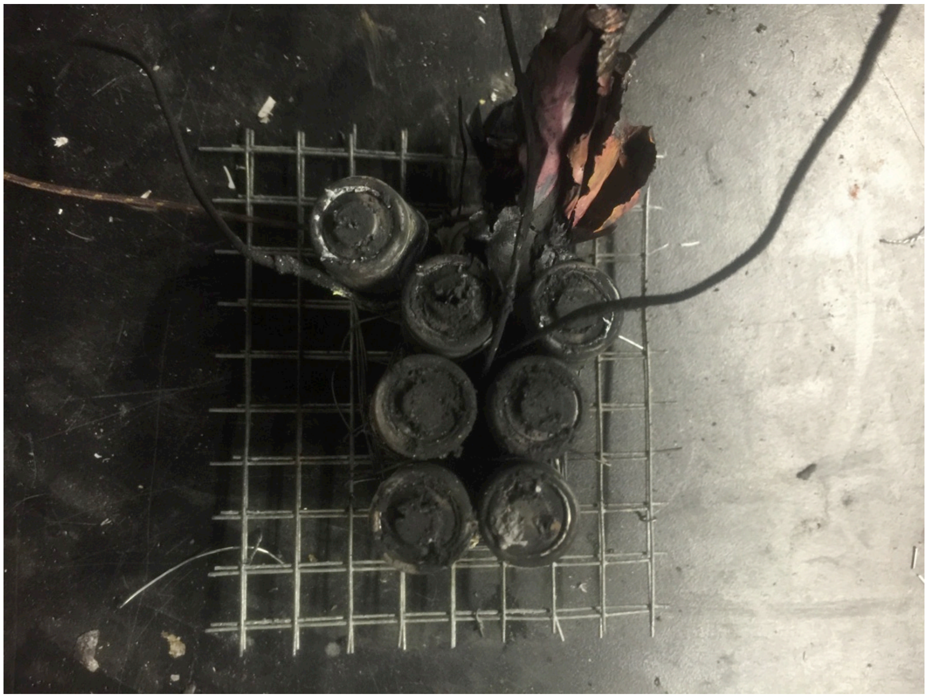


Figure 32 – Top of Batteries After Halon Extinguisher Test

Figure 33 through Figure 35 are the temperature profiles collected during the FireIce extinguisher tests. The profiles are similar to the immersion tests in that the temperature rose until secondary venting when the extinguisher was engaged. In all three tests, the FireIce extinguished the battery fires, which is indicated in the graphs by the decrease and stabilization of the temperatures. In no case did the batteries re-ignite. The FireIce was able to coat the batteries creating a thermal barrier around the casing, stopping the heat transfer, Figure 36.

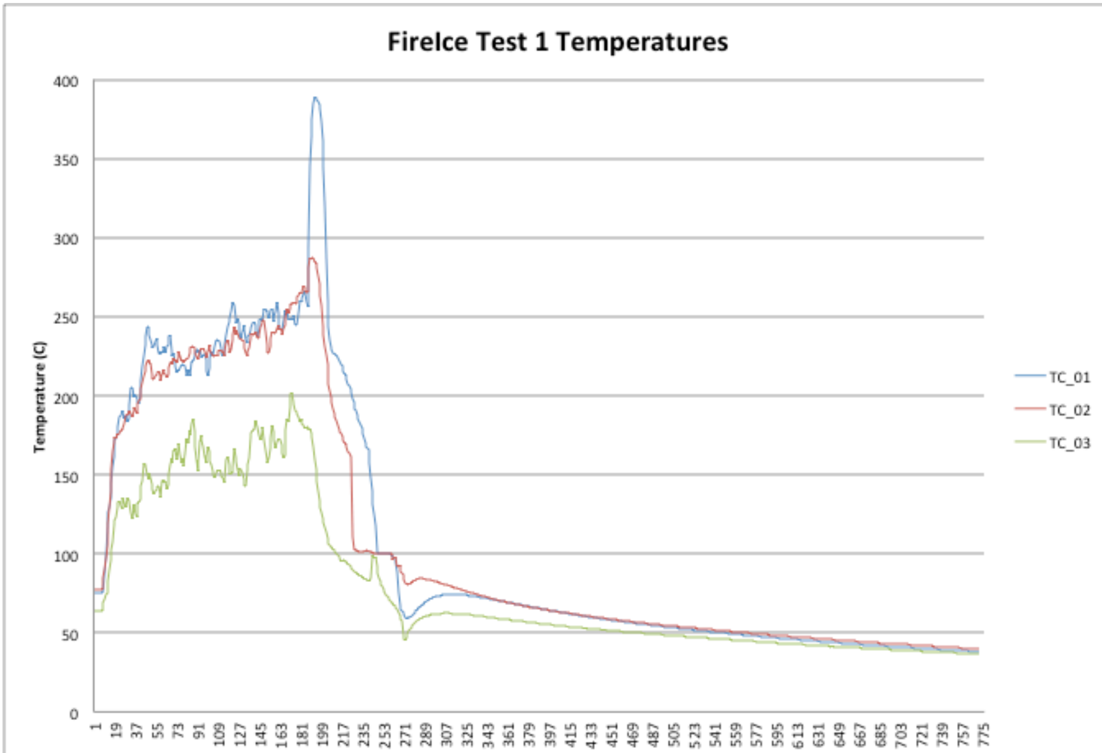


Figure 33 – Temperatures Collected During FireIce Discharge

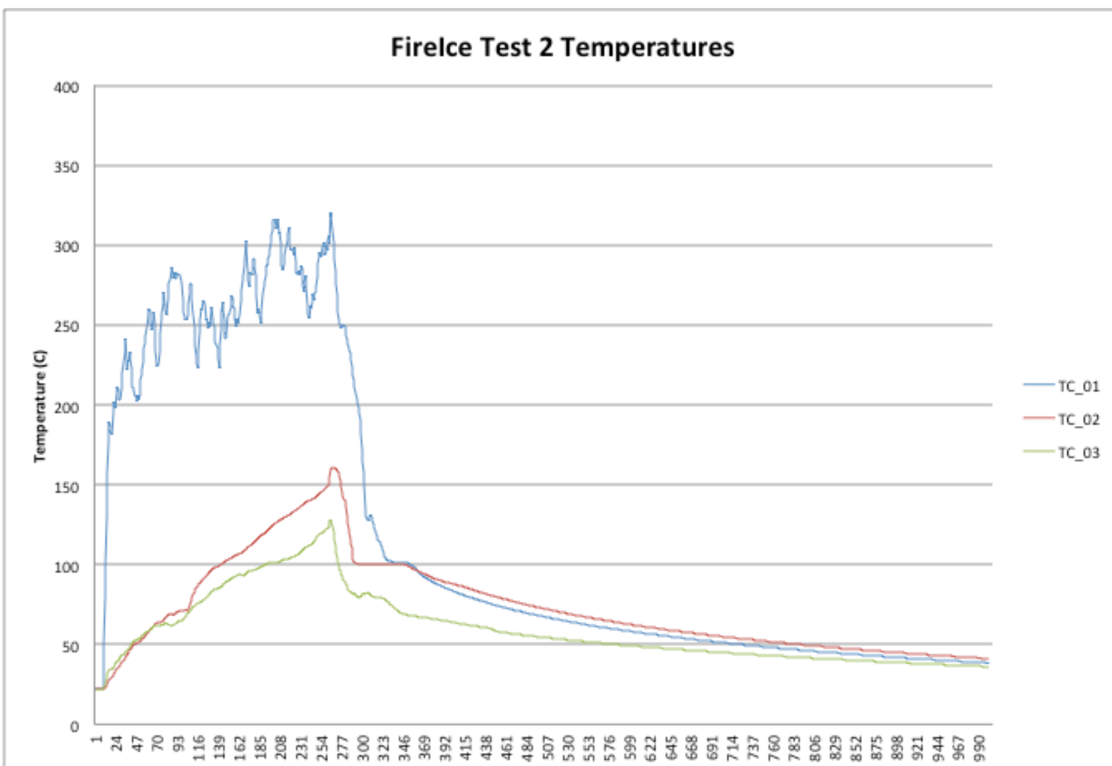


Figure 34 – Temperatures Collected During Second FireIce Discharge

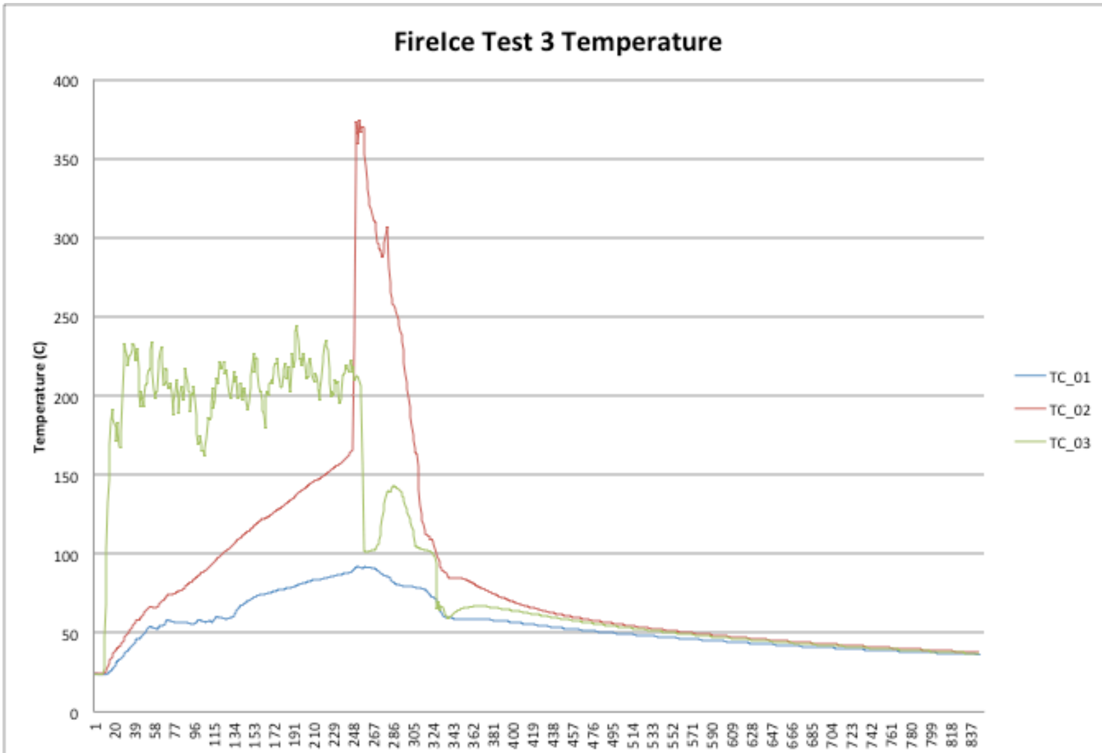


Figure 35 – Temperatures Collected During Third and Final FireIce Discharge

Figure 36 – FireIce Gel From Extinguisher Covering Batteries

Figure 37 through Figure 39 are images taken after the FireIce extinguisher testing. Figure 37 shows the exposed side of the batteries with the vented battery while Figure 38 shows the non-exposed side. Very little damage was observed on the batteries adjacent to the vented battery.

Figure 39 shows the top side of the batteries where some thermal damage was observed due to the initial venting stage.

Figure 37 – Side of Batteries After FireIce Extinguisher Test

Figure 38 – Back Side of Batteries After FireIce Extinguisher Test

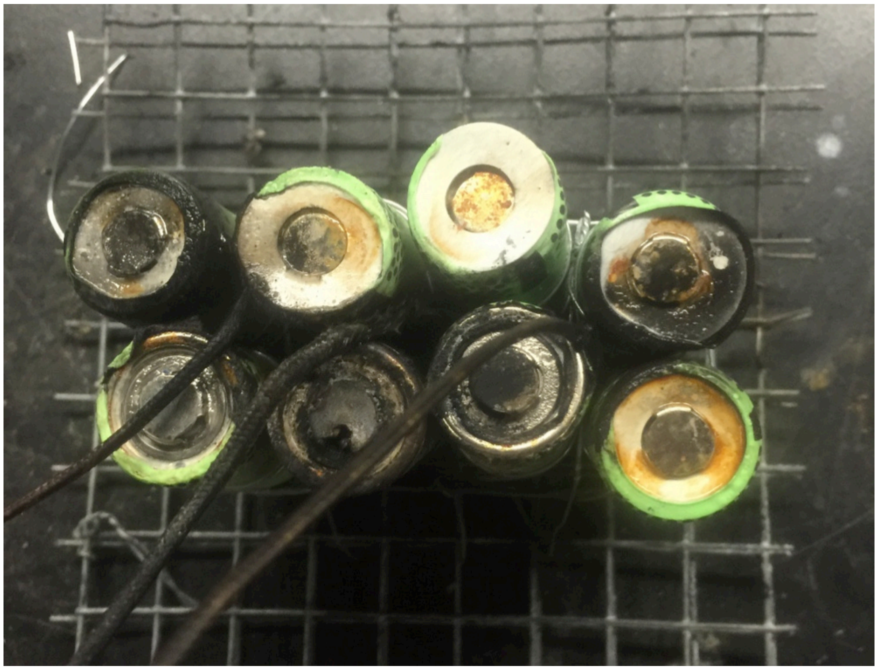


Figure 39 – Top of Batteries After FireIce Extinguisher Test

Figure 40 is a bar graph that depicts the initial average battery weight (blue bar), the average final battery weight (red bar), and the standard deviation (black line) in grams for the five different types of tests conducted. The largest loss of weight, as expected, occurred during the free burn where no suppression attempt was made. An average loss of 141 grams was recorded during the free burns. During the Halon extinguisher testing, an average loss of 128 grams was recorded, representing the second worst damage of all tests recorded. In the immersion testing with water and FireIce, as well as the FireIce extinguisher testing, the least amount of damage, or weight lost, was recorded with 24, 33, and 18 grams lost, respectively.

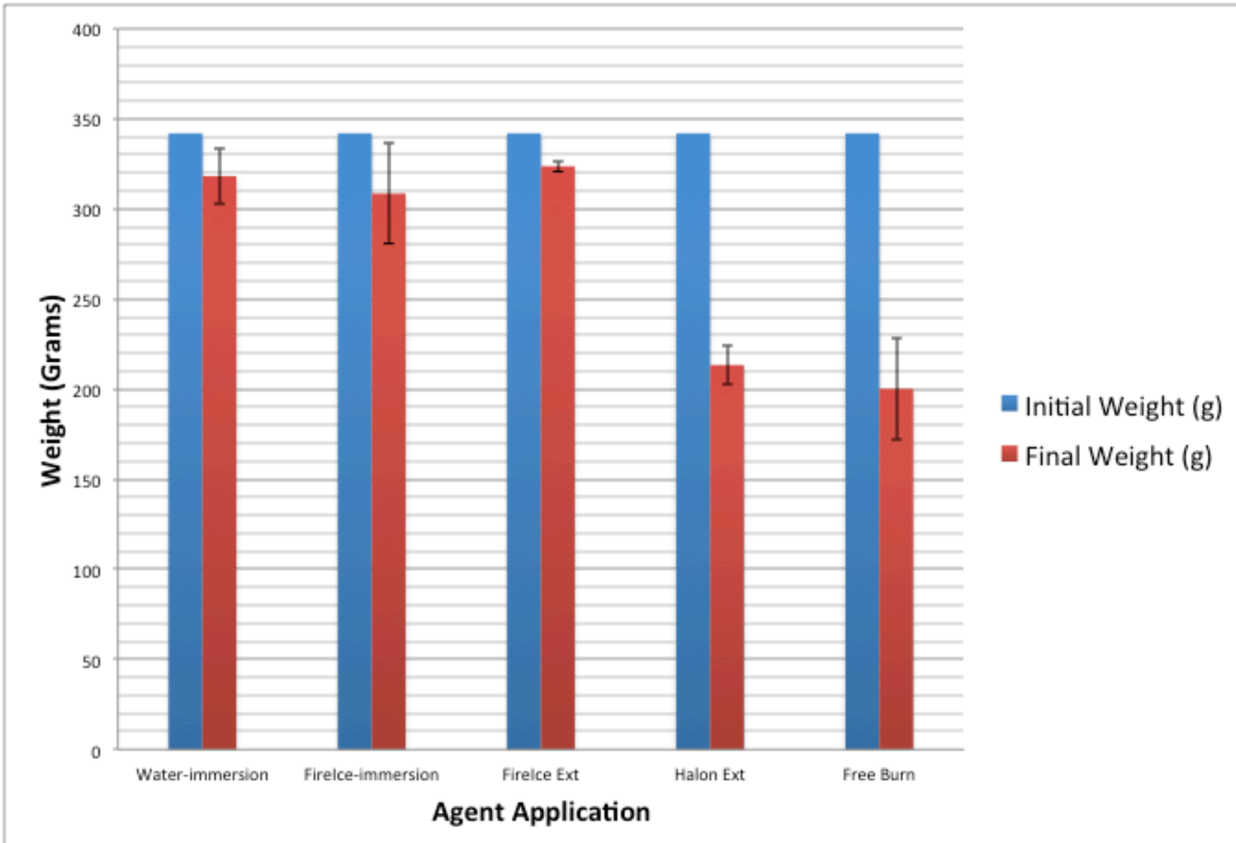


Figure 40 – Average Mass Loss (Grams) for All Test Scenarios

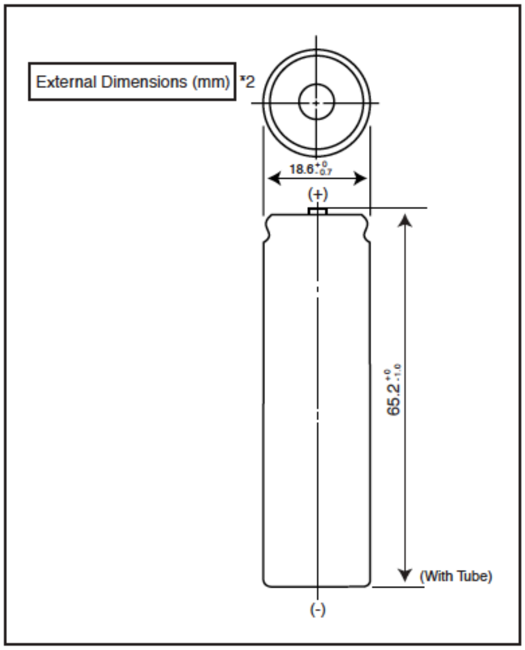
4.0 CONCLUSIONS

Lithium–ion battery fires present a challenging fire suppression scenario. The venting of off-gasses, molten material, and extreme heat make suppression dangerous and fire propagation rapid. The testing showed that venting and subsequent cell-to-cell thermal runaway can be arrested if the battery cells are cooled thoroughly and a thermal barrier is created between the cells. Immersion of the batteries in water or FireIce demonstrated the ability to cool and create the thermal barrier necessary for extinguishment. Of the two extinguishers tested, only the FireIce extinguisher was able to cool and prevent cell-to-cell fire spread extinguishing the battery fire. The Halon extinguisher was able to delay the fire spread temporarily, but eventually the batteries continued to burn.

A. APPENDIX A – BATTERY SPECIFICATION SHEET

LITHIUM ION BATTERIES: INDIVIDUAL DATA SHEET CGR18650CG

CGR18650CG: Cylindrical Model



To ensure safety, the referenced Li-ion cell is not sold as a bare cell. Li-ion cells must be integrated with the appropriate safety circuitry via an authorized Panasonic Li-ion pack assembler.

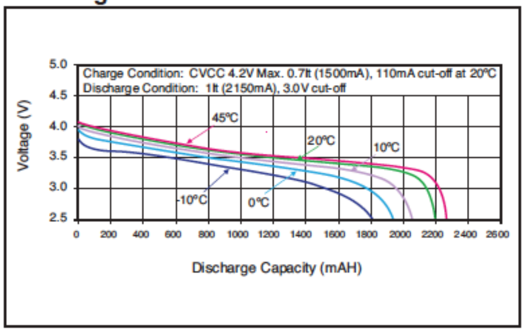
Specifications

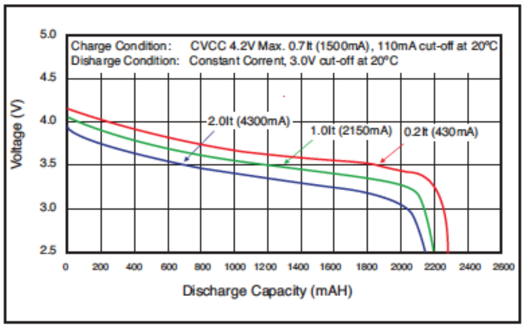
Nominal Voltage		3.6 V
Standard Capacity*1		2250mAh
Dimensions*2	Diameter	18.6 + 0/-0.7mm
	Height	65.2 + 0/-1.0mm
	Weight	Approx. 45g

*1 After a fresh battery has been charged at constant voltage/constant current (4.2 V, 1500mA (max), 2 hours, 20°C), the average of the capacity (ending voltage of 3 V at 20°C) that is discharged at a standard current (430mA).

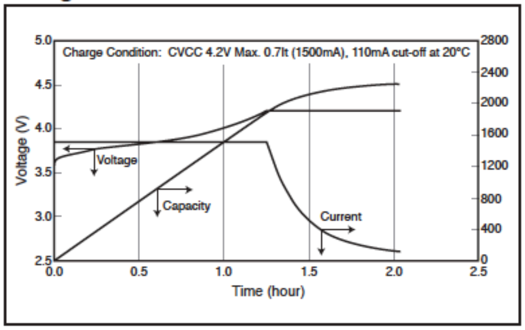
*2 Dimensions of a fresh battery

Discharge Characteristics

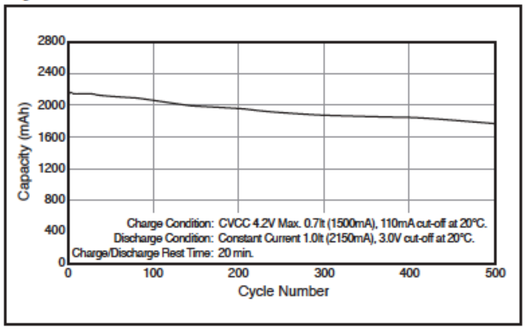




Charge Characteristics



Cycle Life Characteristics



LITHIUM ION DECEMBER 2008

This information is generally descriptive and is not intended to make or imply any representation, guarantee or warranty with respect to any cells and batteries. Cell and battery designs/specifications are subject to modification without notice. Contact Panasonic for the latest information

B. APPENDIX B – FIREICE MSDS

GELTECH® SOLUTIONS

FireIce
Safety Data Sheet

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product name : FireIce

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture : Fire Chemical (Gel)

1.3. Details of the supplier of the safety data sheet

GelTech Solutions
1460 Park Lane S, Suite 1
Jupiter, FL 33458
T 561-427-6144 - F 561-427-6182

1.4. Emergency telephone number

T 561-427-6144 - F 561-427-6182

Toll Free: 1-800-924-4874

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification (GHS-US)

Eye Irrit. 2B H320

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) : None

Signal word (GHS-US) : Warning

Hazard statements (GHS-US) : H320 - Causes eye irritation

Precautionary statements (GHS-US) : P264 - Wash thoroughly after handling
P305 + P351 + P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention

2.3. Other hazards

No additional information available

2.4. Unknown acute toxicity (GHS-US)

No data available

SECTION 3: Composition/information on ingredients

3.1. Substance

Not applicable

3.2. Mixture

Name	Product identifier	Classification (GHS-US)
Polyacrylate Polymer	(CAS No) Trade Secret	Eye Irrit. 2B, H320
Water	(CAS No) 7732-18-5	Not classified

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures after inhalation : Remove to fresh air and remove material from affected areas. Seek medical advice or attention in the event of any adverse symptoms or irritation.

First-aid measures after skin contact : Wash with water. Seek medical advice if skin irritation develops or persists.

First-aid measures after eye contact : Flush with plenty of water for at least 15 minutes. Seek medical advice if irritation develops or persists.

First-aid measures after ingestion : Immediate first aid is not likely to be required. Seek medical advice or attention in the event of any adverse symptoms.

FireIce
Safety Data Sheet

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

Symptoms/injuries after inhalation	: Exposure to respirable dust may cause respiratory tract and lung irritation and may aggravate existing respiratory conditions.
Symptoms/injuries after skin contact	: Exposure to the dust, such as in manufacturing, may aggravate existing skin conditions due to drying effect.
Symptoms/injuries after eye contact	: Dust may cause burning, drying, itching and other discomfort, resulting in reddening of the eyes.
Symptoms/injuries after ingestion	: Although not a likely route of entry, tests have shown that polyacrylate absorbents are non-toxic if ingested. However, as in any instance of non-food consumption, seek medical attention in the event of any adverse symptoms.

4.3. Indication of any immediate medical attention and special treatment needed

No additional information available

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media	: Water. Water spray. Foam. Carbon dioxide (CO_2). Dry powder.
Unsuitable extinguishing media	: None.

5.2. Special hazards arising from the substance or mixture

Fire hazard	: None known.
Explosion hazard	: None known.

5.3. Advice for firefighters

Protection during firefighting	: Firefighters should wear full protective gear.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

No additional information available

6.1.2. For emergency responders

No additional information available

6.2. Environmental precautions

Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

For containment	: Stop the flow of material, if this is without risk. Use caution after contact of product with water as slippery conditions may result.
Methods for cleaning up	: Sweep or vacuum material when possible and shovel into a waste container. Dispose of waste in accordance with local, state and federal regulations.

6.4. Reference to other sections

No additional information available

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling	: Avoid contact with eyes.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions	: Store in a dry, closed container.

7.3. Specific end use(s)

No additional information available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

No additional information available

8.2. Exposure controls

Appropriate engineering controls	: Local exhaust and general ventilation must be adequate to meet exposure standards.
Hand protection	: None required under normal product handling conditions.
Eye protection	: Safety glasses.

FireIce
Safety Data Sheet

Skin and body protection	:	Wear suitable working clothes.
Respiratory protection	:	If working in a well-ventilated area, none required. If airborne concentrations are above the applicable exposure limits, use NIOSH approved respiratory protection.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Solid
Appearance	:	Powder
Color	:	White
Odor	:	None
Odor threshold	:	No data available
pH	:	5.5 - 6.5 (1% in water)
Relative evaporation rate (butyl acetate=1)	:	No data available
Relative evaporation rate (ether=1)	:	< 1
Melting point	:	390 °F
Freezing point	:	No data available
Boiling point	:	No data available
Flash point	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Flammability (solid, gas)	:	No data available
Vapor pressure	:	< 10 mm Hg
Relative vapor density at 20 °C	:	No data available
Specific gravity	:	0.4 - 0.7 g/l
Solubility	:	Insoluble.
Log Pow	:	No data available
Log Kow	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available
Explosive limits	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

No additional information available

10.2. Chemical stability

The product is stable at normal handling and storage conditions.

10.3. Possibility of hazardous reactions

Will not occur.

10.4. Conditions to avoid

None

10.5. Incompatible materials

None

10.6. Hazardous decomposition products

None known

FireIce
Safety Data Sheet

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity	:	Not classified
Skin corrosion/irritation	:	Not classified
Serious eye damage/irritation	:	Causes eye irritation.
Respiratory or skin sensitization	:	Not classified
Germ cell mutagenicity	:	Polyacrylate Polymer had no effect in mutagenicity tests.
Carcinogenicity	:	Not classified
Reproductive toxicity	:	Not classified
Specific target organ toxicity (single exposure)	:	Not classified
Specific target organ toxicity (repeated exposure)	:	Not classified
Aspiration hazard	:	Not classified

SECTION 12: Ecological information

12.1. Toxicity

No negative or toxic effects on the environment are anticipated when released in dilution for terrestrial and aquatic ecosystems; based on government testing. Composted polyacrylate polymers are nontoxic to aquatic or terrestrial organisms at predicted exposure levels from current application rates.

12.2. Persistence and degradability

Decomposes over time or in the presence of natural sunlight when applied to terrestrial substrate or vegetation. Polyacrylate polymers are relatively inert in aerobic and anaerobic conditions. They are immobile in landfills and soil systems (>90% retention), with the mobile fraction showing biodegradability. They are also compatible with incineration of municipal solid waste. Incidental down-the-drain disposal of small quantities of polyacrylic polymers will not affect the performance of wastewater treatment systems.

12.3. Bioaccumulative potential

No additional information available

12.4. Mobility in soil

Polyacrylate polymers are immobile in landfills and soil systems (>90% retention), with the mobile fraction showing biodegradability.

12.5. Other adverse effects

Effect on ozone layer	:	No additional information available
Effect on the global warming	:	No known ecological damage caused by this product.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste disposal recommendations	:	In concentrate form, this product is a non-hazardous waste material suitable for approved solid waste landfills. Diluted product is non-soluble and can be disposed of in suitable effluent treatment plants. Dispose of contents/container in accordance with local/regional/national/international regulations.

SECTION 14: Transport information

In accordance with DOT

Not a dangerous good as defined in transport regulations

SECTION 15: Regulatory information

15.1. US Federal regulations

No additional information available

15.2. US State regulations

No additional information available

SECTION 16: Other information

Full text of H-phrases:

Eye Irrit. 2B	Eye damage/eye irritation Category 2B

FireIce
Safety Data Sheet

H320	Causes eye irritation

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product

C. APPENDIX C – HALON EXTINGUISHER SPECIFICATION SHEET

HALON 1211

Amerex Corporation

Aluminum Valve
A344T
C352TS
B355T

C354TS

RUGGED
- 1 Year Manufacturer's Warranty
- Stored Pressure Design
- Dependable Drawn Steel Cylinders
- Durable High Gloss Polyester Powder Paint
- All Metal Valve Construction
- Temperature Range -40°F to 120°F

CLEAN
- Leaves no residue
- Reclaimed Halon 1211 is Restored to Original Military Specification
- Uses All Recycled Gas in Accordance With The Montreal Protocol

Brass Valve
B369
B371
361

USER FRIENDLY
- Maximum Visibility During Discharge
- Large Loop Pull Pin
- No Electrical Conductivity Back to the Operator
- No Thermal or Static Shock
- Bar Coded and Bi-lingual Labels

OPTION
- USCG Approved with Bracket Listed on UL Label (except model A344T)

HALON 1211 is a liquified gas, pressurized with nitrogen, which discharges as a vapor causing no cold or static shock and no impairment of the operator's vision. This "CLEAN" agent quickly penetrates difficult to see and hard to reach areas and leaves no residue. It is recommended for protection of delicate, sensitive and expensive computers, electrical equipment, tapes and film, automotive and aircraft engines, laboratory chemicals and equipment.

Quality industrial grade hardware, "CLEAN" agent, light weight, good discharge range and excellent fire extinguishing ability.

Recycled gaseous agent certified to meet military specifications

AGENT TYPE	HALON 1211						
VALVE TYPE	ANODIZED ALUMINUM				CHROME PLATED BRASS		
DESIGN	NOZZLE		HOSE	NOZZLE	HOSE		
MODEL NUMBER	A344T	* C352TS	* C354TS	B355T	B369	B371	361
UL & ULC RATING	2B:C	5B:C	5B:C	10B:C	1A:10B:C	2A:40B:C	4A:80B:C
CAPACITY (LBS.)	1.25	2.5	3	5	9	13	17
SHIPPING WT. (LBS.)	2.75	5.5	6	9.75	16.75	22	36.25
HEIGHT (IN.)	10	14.38	14.38	15.25	16.25	20.25	24
WIDTH (IN.)	3.63	4.5	6	5.75	8.5	8.5	9.75
DEPTH (IN.)	2.63	3	3	4.25	5	5	7
RANGE (INITIAL- FT)	9-12	9-15	9-15	9-15	12-18	12-18	12-18
DISCHARGE TIME (SEC.)	10	10	12	10	9	14	22
OPTIONAL CHROME CYLINDER	YES	YES	YES	YES	YES	YES	
MINIMUM SPACE REQUIREMENTS (CU. FT.)	156	312	375	624	1123	1622	2120
INCLUDED BRACKET	VEHICLE	AIRCRAFT	AIRCRAFT	VEHICLE	WALL	WALL	WALL

* SPECIAL VALVE DESIGN FOR AIRCRAFT INSTALLATIONS

Manufactured and Tested to ANSI/UL Standards
Complies with NFPA 10 Standard
ISO-9001/ ISO-14001 Certified
UL LISTED

CONFORMS TO TEST STANDARDS:

UL-1093 - ANSI/UL711

MADE IN U.S.A.

7