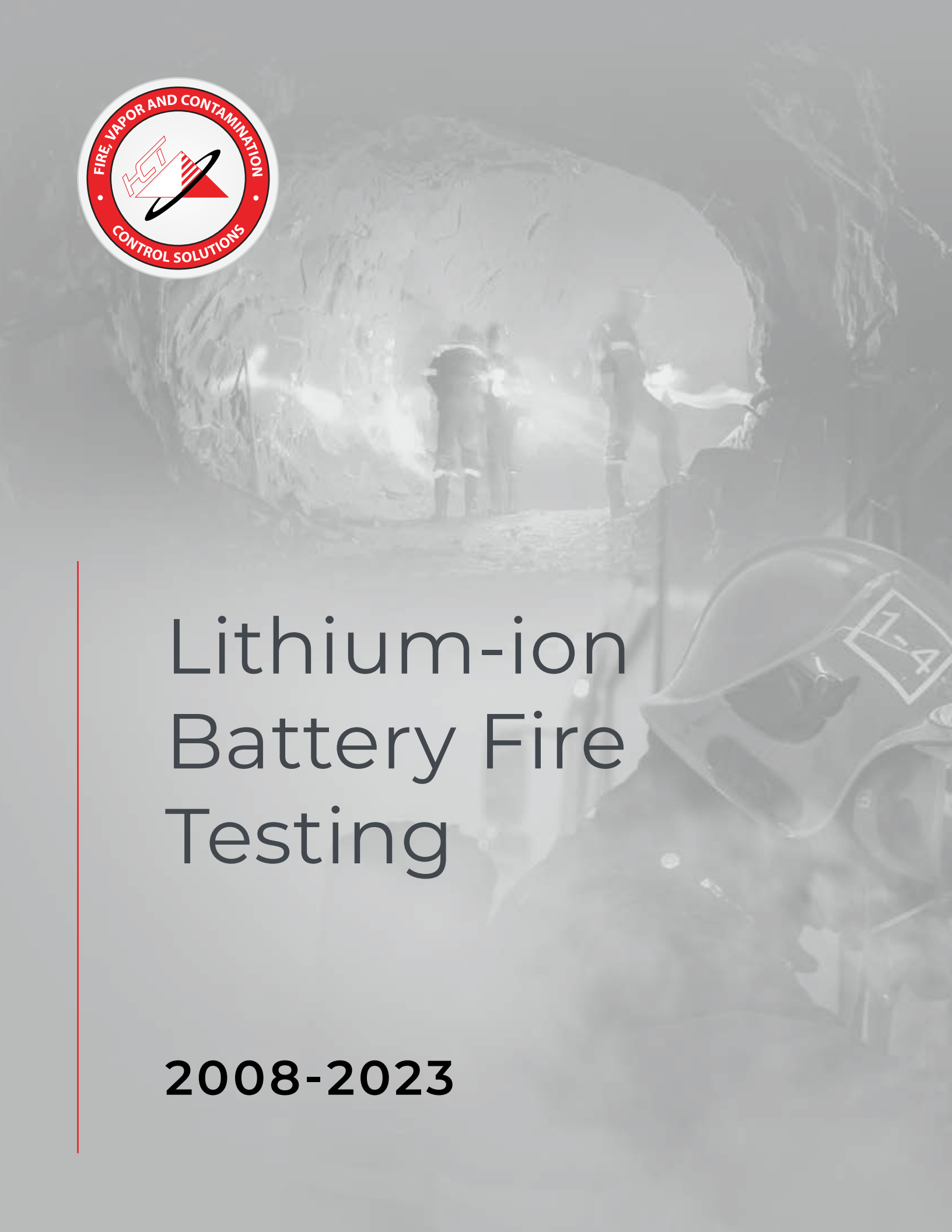

Lithium-ion Battery Fire Testing

2008-2023

1

OVERVIEW

From consumer electronics and electric vehicles to industrial equipment and energy storage systems, lithium-ion batteries can be found everywhere. At the same time, steel is being replaced with lighter alloys, such as aluminum, magnesium and titanium. This trend is creating new challenges for industry professionals and first responders who are faced with new and unique hazards associated with modern manufacturing.

The following events have led to F-500 Encapsulator Agent (F-500 EA) becoming the agent of choice for lithium-ion battery fire suppression and hazard mitigation.

2008

JANUARY

Bosch

Hazard Control Technologies Europe provides Bosch with F-500 EA concentrate to conduct fire suppression testing at their facility on lithium-ion batteries.

2

2009

MARCH

Bosch

Bosch concludes fire suppression comparison testing of water, foam, powder and F-500 EA on lithium-ion and nickel-metal hydride batteries as well as other production parts.

Hazard Control Technologies Europe was invited to Bosch headquarters in Stuttgart, Germany. F-500 EA was chosen as a product of choice by Bosch for extinguishing lithium-ion batteries. Bosch becomes our official reference customer.

3

2009

JULY

VDA

Bosch communicates their findings at VDA. The VDA nationally and internationally promotes the interests of the German automotive industry.

2011

JANUARY

2011 GUIDELINE

Baden-Wurttemberg

After Bosch shares their findings with the Baden-Wurttemberg State Fire School, an application guideline referencing the use of F-500 EA to mitigate lithium-ion battery hazards is published.

4

2011-2012

MARCH

2011 ARTICLE **2012 ARTICLE**

BrandSchutz Magazine

In 2011, an article appears in BrandSchutz Magazine discussing the use of F-500 EA for high-voltage vehicle hazards.

In 2012, another article appears in BrandSchutz Firefighter Magazine reporting that, in addition to lithium-ion batteries, F-500 EA can mitigate other special risks. This includes magnesium, titanium, rubber tires and multiple fuels, such as gasoline, diesel, ethanol and ethanol-blended fuels.

5

2012

OCTOBER

2012 REPORT

DEKRA

DEKRA issues a press release announcing their testing and releases a final report. This is followed up by DEKRA confirming their recommendation of F-500 EA in an opinion letter.

2012

MARCH

2012 ARTICLE

Formula 1

BrandSchutz Magazine describes an incident at the Barcelona Formula 1 Grand Prix that prompted the Hockenheim Circuit to test and accept F-500 EA as their only agent, replacing all foam.

6

2013

FEBRUARY

2013 ARTICLE

BrandSchutz Magazine

BrandSchutz Firefighter Magazine condenses and publishes DEKRA's final report, reiterating F-500 EA's performance for combating modern automotive fire hazards.

2013

APRIL

2013 REPORT

SAE

DEKRA, Daimler and Deutsche present DEKRA's findings in Detroit, MI at the SAE International Conference, receiving attention from NFPA and the United States automotive industry.

7

2015-2016

OCTOBER

2015 SPECIFICATION

General Motors

General Motors invites Hazard Control Technologies Europe to their headquarters to test F-500 EA on lithium-ion battery hazards before specifying F-500 EA for their battery abuse lab.

2016

JANUARY

Tesla

Tesla specifies F-500 EA and installs the first F-500 EA powered fire suppression system engineered and designed for battery charging areas at the Tesla Giga Factory in Sparks, NV.

2016

FEBRUARY

Jaguar

Jaguar invites Hazard Control Technologies Europe to perform lithium-ion battery testing at their United Kingdom facility and standardizes on F-500 EA for lithium-ion battery fires.

2017

JULY

2017 VIDEO **2017 REPORT**

Kiwa

Kiwa Netherlands B.V. testing concludes F-500 EA is the most effective agent on lithium-ion battery fires when tested against foam and dry chemical fire extinguishing agents.

9

2017

MARCH

2017 REPORT

conEdison

conEdison set out to test the return current back through the stream created by a hose line while looking at the variables of voltage, distance to the source and various suppression agents to establish safe standoff distances while manually extinguishing fires within a lithium-ion battery rack system. The results show that F-500 EA is safe to use at both 3% and 6% from a 10 ft distance on a 2 kV source. This 10 ft standoff distance also complies with the OSHA standard for unqualified personnel on a 1 kV source.

10

2017

FEBRUARY

2017 ABSTRACT

Nanjing Tech University

The College of Safety Science and Engineering, Nanjing Tech University, in Nanjing, China, publishes an abstract for the 8th International Conference on Fire Science and Fire Protection Engineering summarizing experimental studies on lithium-ion battery fire suppression using F-500 EA.

2019

MAY

Fraunhofer

Fraunhofer HHI in Goslar, Germany tests the extinguishing power of F-500 EA on lithium-ion battery fires at their battery and sensor testing center.

2020

JULY

2020 REPORT

TU Clausthal

TU Clausthal's testing in Clausthal-Zellerfeld, Germany concludes that using a 2% solution of F-500 EA to extinguish a lithium-ion battery fire is significantly superior to using plain water.

12

2021

OCTOBER

2021 VIDEO **2021 REPORT**

Fraunhofer

Fraunhofer Institute for Telecommunication and Heinrich Hertz Institute, HHI conduct a sprinkler test series on F-500 EA for lithium-ion battery fire suppression.

13

2021

DECEMBER

NEN

The Dutch standard of NTA 8133 is the first of its kind, applying to lithium-ion battery powered electronics such as smartphones, laptops, drones, small appliances and more. Requirements were prepared by a working group in which an inspection body, manufacturers and other experts participated. Numerous tests were performed to determine the correct test procedure.

Fire extinguishers that meet its requirements, such as F-500 EA, may use the NTA 8133 marking. F-500 EA is third-party tested on lithium-ion batteries up to 3,400 Wh, far exceeding the NEN minimum of 600 Wh.

2022

JANUARY

NFPA

For the first time in the history of NFPA standards, the use of water additives, including Encapsulator Agents, can be used for Class A, Class B, Class C, Class D and Class K fire suppression as well as the mitigation of flammable vapors.

18A

Section 7.7.
Spherical Micelle Stability Testing

This section covers the test procedures to evaluate the ability of a water additive solution to form and maintain stable spherical micelles capable of encapsulating combustible and flammable liquids (polar and non-polar), rendering the flammable liquids nonflammable, nonignitable and nonexplosive and maintaining that encapsulation in the presence of high heat over an extended period of time.

15

2022

JANUARY

NFPA

Encapsulator Agents conforming to Section 7.7., such as F-500 EA, are recognized for extensive third-party testing by independent institutions, documenting lithium-ion battery fire suppression as well as the encapsulation of flammable electrolyte, explosive off-gases and toxic off-gases.

18A

Annex 4.3.
Lithium-ion Battery Fire Testing

This testing has been controlled, scientific, and highly instrumented, documenting fire suppression, control and elimination of thermal runaway, and encapsulation of both flammable electrolyte and other explosive off-gases, rendering them nonexplosive. Encapsulator Technology reduces the toxicity of HF gas exposure to humans.

16

2021 - 2022

MARCH

2021 REPORT **2022 REPORT**

Beijing Institute of Technology

The State Key Laboratory of Explosion Science and Technology and Beijing Institute of Technology in Beijing, China publish an experimental study on F-500 EA for lithium-ion phosphate battery fire suppression focusing on rapid heat reduction.

The State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology and the Department of Engineering Physics at Tsinghua University in Beijing, China publish an investigation on the fire suppression mechanics of a spherical micelle as well as the effectiveness of F-500 EA on lithium-ion battery fires.

17

2022

MARCH

2022 REPORT

Sapienza University of Rome

An experimental investigation of Encapsulator Technology for lithium-ion battery fire suppression is published by:

Department of Chemical Engineering, Materials and Environment at Sapienza University of Rome

Systems and Technologies for Mobility and Accumulation Laboratory, ENE DTE-PCU-STMA, CR Casaccia

Central Directorate for Prevention and Technical Safety, National Fire Brigade of Rome, Italy

2022

DECEMBER

2022 VIDEO

Port Authority of New York and New Jersey

Testing is conducted on both a lithium-ion battery pack fire as well as a fully involved hybrid vehicle fire at the Port Authority of New York and New Jersey. A drastic decrease in toxic, flammable and explosive off-gases as well as rapid drop in temperature while extinguishing these fires results in the Port Authority of New York and New Jersey implementing the utilization of F-500 EA for lithium-ion battery fire suppression.

19

2023

MAY

2023 REPORT

NIOSH

A detailed experimental study is conducted at the National Institute for Occupational Safety and Health (NIOSH) Pittsburgh Mining Research Division (PMRD). Water mist with different flow rates, ABC powder, type D dry chemical and water mist with F-500 EA additive are used as the fire suppression agents. Multiple thermocouples are installed on the battery packs to measure the temperature evolution during the tests. The results indicate that the water mist with F-500 EA additive is the most effective suppressant among the agents tested.

HAZARD CONTROL TECHNOLOGIES

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