Operational test Flamblocker CF7 Electrical Vehicle (EV-Car)

This document provides information on the executed operational tests of Flamblocker CF7 in relation to Electrical vehicles (EV-car) as performed on Thursday November 20th 2025 at the former military facility in Karlovac Croatia.

Please note: this documents reflects a full operational tests. The test was part of a series of demonstrations that have been performed on November 20th 2026 at Karlovac and had to sole intention to obtain initial information on the potential effects Flamblocker CF7 has on an electric car (EV-Vehicle) battery fire. This test was not to proof that Flamblocker CF7 works or confirm any claims but was intended to investigate if and how Flamblocker CF7 would work at all.
This test is part of a series of tests that are being executed to learn about the effects Flamblocker CF7 has on an electric car (EV-Vehicle) battery fire and to observe gain additional information on the working of Flamblocker CF7 in such particular incident situations.

Attachments:

1. Full report on operational tests.
2. Toxic Gas and Particulate Hazards Associated with Lithium-Ion Battery Thermal Runaway
3. certificate 100% biodegradability (provided separately)
4. non-tox certification (provided separately)
5. CF7 Safety Data Sheet (SDS)

For the video report of this test, please visit https://www.flamblocker.com/flamblocker-cf7
Or visit the Flamblocker CF7 YouTube channel at https://www.youtube.com/watch?v=DJV56hyGNVM and https://www.youtube.com/watch?v=dkZTADutg1k

More detailed information about Flamblocker CF7 including Document of Conformity, REACH/CLP, SDS, Eco-Tox, 100% biodegradability and other important documents can be obtained via the Flamblocker website at www.flamblocker.com

Stakeholders for this document.
The document intends to provide data and information to governments, fire fighting teams and installers of fire fighting equipment and users of extinguishing liquids regarding the usage of Flamblocker CF7 as a fire fighting liquid/extinguishing agent/cooling agent for electric vehicle (EV-Vehicles) fires.

Conformity with EU legislation.
Flamblocker CF7 is a certified PFAS and Fluorine free extinguishing agent for class A-B-D-F and E as per EU directive Regulation (EU) 2025/1988 by adding entry 82 of annex XVII REACH (Regulation (EC) No 1907/2006).
Flamblocker CF7 holds official certificates underwriting the eco friendly status of the product.
Flamblocker CF7 holds official certificates stating that the product is non-toxic and non-corrosive and is 100% biodegradable.
The Flamblocker Safety data Sheet (SDS) shows no toxic or other dangerous markers and shows no need for any safety precautions when handling the product.

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General observations.

Flamblocker CF7 was tested on a by Renault S.A. Group (Corporate) provided prototype Electric Vehicle (EV-car) under operational conditions by professional fire fighters (JVP Karlovac). Flamblocker has proven to be an equal or better alternative for existing fire extinguishing agents currently on the market as the required time and water volume needed to extinguish the fire and stop the thermal runaway was reduced from 8+ hours or even days down to 6.01 minutes (Time) and from 10.000+ litres of water to 1.980 litres of water. In addition, the usage of Flamblocker CF7 and the characteristics of Flamblocker CF7 resulted in a minimum to zero effect on the environment and eco-system as the product is PFAS and Fluorine free and biodegradable. Flamblocker CF7 provides a high efficiency and environmental benefit to the users and the environment. Please note that this observation concerns the environmental impact and does not reflect on the safety of the firemen involved in the operational test. The emitted gasses contain several toxic and lethal components that are emitted into the air and was compressed to settle in the used water with Flamblocker CF7. The residue in the deployed and disposed water contains heavy toxins that require additional removal and cleaning on the scene. The reduction in time and water volume cause a direct reduction of emitted gasses and disposed toxins in the used water and, as such, results in an 80% reduction of emissions and pollution for the environment. By reducing the emissions via time and water reduction, the exposure time for the firefighters to toxic and lethal emissions is also reduced by 80% or more, resulting in a safer operational environment for the deployed firefighters.

The provided test vehicle was a 2026 prototype Renault Megane E-Tech model with a 60kWh/160kW power unit and was fitted with a charged battery at 20%. During the operational test, Flamblocker CF7 has proven to be able to extinguish the battery fire (thermal-runaway situation) and prevent further propagation of the battery fire, a unique capability for any firefighting or cooling agent/liquid. After only 6.01 minutes, the thermal-runaway of the internal Renault battery was stopped and the temperature of the battery was brought down to 20C degrees, enabling witnesses to touch the battery by bare hand. No restart of battery fire was observed in the hours following the operational test, proving that Flamblocker CF7 has cooled the battery down to a stable and safe situation.

Conclusion.

The operational test has shown that Flamblocker CF7 is able to stop a full and complete thermal runaway of the battery of an electric vehicle, a capability that is currently unique in the firefighting industry and could be seen as a major breakthrough in method, effect and efficiency in extinguishing an electric car fire.

Remarks and advice.

The performed operational test was done on a EV-Vehicle with a 20% charged battery. This was a safer situation for this initial test and reduced the expected dangers and risks for the firefighters. The test shoed that Flamblocker CF7 has a positive effect on a thermal runaway but to be able to fully claim the results, Flamblocker intents to duplicate the test multiple times in the coming months, testing on similar battery settings but also on 100% charged batteries. This will validate beyond any doubt what the shown results are.

The test was done on a vehicle that was flipped on its side. This was due to the situation on-site and is considered not to be a standard incident situation. With the vehicle on its side, the situation became easier to control. Additional tests will be done with the vehicle upright, standing on all 4 wheels. With the vehicle on all 4 wheels, considerations have to be made in how to deploy

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Flamblocker CF7 onto and into the battery of the vehicle. Various options already exist for this and includes a lans system (Cobra system) (https://ctif.org/news/new-cutting-extinguisher-method-ev-fires-performed-successfully-real-vehicle-fires) and undercar spray systems.
During following operational tests by Flamblocker on EV-Vehicle fires, these technologies will be included into the tests to obtain additional knowledge, information and validation.

Electric Car (EV-Vehicle) fire	**CF7**	**Other*[1]**	**Water**
Water volume needed (litres)	**1.980 (incl 6% CF7)**	10.000+	10.000+
Total time needed (minutes)	**6.01**	12 to 24+ hours	12 to 24+ hours
Restart of fire	**NO**	YES	YES
Compliant with EU rules (EU) 2025/1988 entry 82 of annex XVII REACH	**YES**	NO	YES
Emission **reduction** (air pollution)	**HIGH**	LOW	LOW
Environmental impact (soil/eco systems)	**Reduced by 80%**	HIGH	HIGH
Biodegradable (CF7)	**YES**	NO	YES
Impact on wildlife (general impact of situation)	**Reduced by 80%**	YES	YES
Corrosive (CF7)	NO	YES	NO
Toxic (CF7)	NO	YES	NO

*1 based on current available products on the open market

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Model/size of operational test.

Used test Vehicle:	Renault Megane E-Tech (60kWh/160kW) 2026 prototype unit provided by Renault S.A. Group (Corporate). Vehicle was test vehicle for crash tests at factory.
Status of battery:	undamaged/New, 20% charged due to removal of charging ability by Renault S.A. Group (Corporate)
Temperature of fire on start:	2000C+ (full thermal runaway with propagation)
Temperature at end:	external and internal (battery) 20C
Time needed:	6 minutes and 1 second (6.01)
Total volume of water:	1.980 litres including 6% Flamblocker CF7
Deployed mixing rate CF7:	6%

For more detailed report on the operational test, please see attachment 1 to this document.

Compliance with new EU legislation and National Legislation (HR/Si/BiH/SRB/MN/NM).

Flamblocker CF7 is fully compliant with the following rules and regulations as set forward by the European Union, relating to fire fighting liquids and foams.

Key legal acts / regulations

1. **Commission Regulation (EU) 2024/2462**
   This amends Annex XVII of REACH (Regulation (EC) No 1907/2006) to restrict the use of **PFHxA, its salts and PFHxA-related substances** (un-decafluorohexanoic acid) in certain applications, including firefighting liquids and foams. (EUR-Lex)
   — Full text (PDF) is available via EUR-Lex. (EUR-Lex)
   — It entered into force on **10 October 2024**. (EUR-Lex)
2. **Commission Regulation (EU) 2025/1988 (2 October 2025)**
   This amends Annex XVII to REACH, implementing a restriction on all PFAS in firefighting foams and liquids (the "PFAS in firefighting foams" restriction). (EUR-Lex)
   — Adds **Entry 82** to Annex XVII, stating that as of **23 October 2030**, firefighting foams and liquids with PFAS ≥ 1 mg/L (sum of all PFAS) shall not be placed on the market or used. (EUR-Lex)
   — Transitional / derogation rules are included for specific sectors (industrial, aviation, Seveso sites, etc.). (EUR-Lex)

Commission Delegated Regulation (EU) 2025/1399 (5 May 2025)

This amends Annex I of the POPs Regulation (EU) 2019/1021 to extend the temporal exemption for PFOA, its salts and related compounds in certain firefighting foam uses. (EUR-Lex)

Environmental impact Flamblocker CF7.

Flamblocker CF7 is certified eco-friendly and certified 100% biodegradable, is non-toxic and non-corrosive and is fully compliant with new EU regulations for PFAS in firefighting liquids and foams. As such, the product has a minimum ecological and environmental impact during deployment and after deployment.

Reduction of required water volume:

Flamblocker CF7 has a proven higher cooling capability, resulting in a shorter period of time needed to extinguish the electric car (EV-Vehicle) battery fire which, in effect, reduces the volume of water needed to obtain the required result (extinguish the fire in full without restart risk).

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The continues cooling effect assists in reducing internal heat from thermal runaway of the car battery, resulting in the full and complete stop of the fire inside the battery compartment after the initial water was deployed and has evaporated.

> **Result:** Using Flamblocker CF7 reduces the required volume of water needed to extinguish a electric car (EV-Vehicle) battery fire by up to 80% or more

Biodegradability:

Flamblocker CF7 is a certified 100% biodegradable extinguishing and cooling agent. Upon utilizing the product in an accident/incident situation and ecosystems, Flamblocker CF7 has a maximum degradability of 21 days after deployment, resulting in a 100% removal rate of the product at an incident site or eco-system.

> **Result:** Flamblocker CF7 as a product has no impact on the environment or eco-system in which it is introduced or deployed. As the product is PFAS and Fluorine free, is 100% biodegradable and is non-toxic and non-corrosive, Flamblocker poses a similar or better alternative for regular fire extinguishing agents currently on the market.

Soil Contamination:

Flamblocker CF7 is made from food grade materials, including soja and is 100% biodegradable and is eco-friendly. CF7 is Non-toxic and Non-corrosive. As such, soil contamination caused by usage of CF7 is not present.

> **Result:** usage of CF7 did not cause the need for soil remediation and did not impact the environment and/or ecology of the area

Air Pollution:

Flamblocker CF7 has a quick effect on the fire and has proven to directly cool and stop the thermal runaway and, as such, contained the fire rapidly (6.01 minutes). By doing so, the time the fire was able to emit emissions from burning was reduced by over 80% compared to other extinguishing agents and more compared with just water. Due to the elongated cooling effect of CF7, a restart of the fire (restart of the thermal runaway due to remaining heat) did not occur. Restart of an electric car (EV-Vehicle) battery fires are common and pose a significant risk to fire fighters and the surrounding environment as the fire could restart at any time after cooling with water and usage of other available products on the market that do not continue the cooling effect after deployment. Due to remaining heat in the battery and the evaporation of the water, the internal chemical processes can continue to develop a new heat signature, resulting in a restart of the thermal runaway. As Flamblocker CF7 continues to maintain a strong cooling effect after deployment and after the deployed water has evaporated, Flamblocker CF7 prevents the potential new heat buildup (potential restart of a thermal situation) and avoids a restart of the battery fire as the main cause of the thermal reaction (heat) is removed for a prolonged period of time.

> **Result:** additional effort for containing the fire is avoided and additional emissions caused by the restart are avoided, reducing the overall emissions caused by the fire and reducing the operational deployment time for the fire fighting crew. In addition, a significant risk reduction is obtained for the fire fighting crew as the time spend in the toxic and lethal environment caused by the emitted gasses from the thermal runaway is reduced by 80%.

Compliance with EU regulations (PFAS and Fluorine).

Flamblocker CF7 is free of PFAS and free of Fluorine as per new EU directive (EU) 2025/1988 entry 82 of annex XVII (REACH), adopted by the EU on October 2th 2025. Due to the fact that CF7 is PFAS and Fluorine free, the short-term and long-term environmental impact caused by

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using fire extinguishing agents is reduced to zero, leaving no effects on the ecology and environment.

Result: CF7 as a product can be deployed in nature reserves, forests and other environmental sensitive areas as it has no influence or negative effects on the local ecology or environment.

Impact on wildlife.

Flamblocker CF7 is made from food grade materials including Soja and is 100% biodegradable and is eco friendly, non-toxic and non-corrosive. As such, wildlife will not be affected by the usage of Flamblocker CF7 and has no short-or-long-term negative impact on the wildlife.

Result: Flamblocker CF7 can be used in nature reserves, forest and other sensitive areas as it has no negative effect on the local wildlife.

Impact Flamblocker CF7 on human health and safety (including animals)
Including risk assessment firefighters and bystanders.

A Safety Data Sheet or SDS is a mandatory document stating the nature, composition and dangers of a product. The information on the SDS is the base-guideline for all safety measures for handling the product and transporting the product. Although the SDS is made by the manufacturer, providing false information on a SDS is liable and could result in legal procedures including prison time. As such, the information on the SDS is always leading compared to marketing claims made by manufacturers. Based on the SDS and certification for Eco-Tox, 100% biodegradability certification and the compliance of Flamblocker CF7, the following statements can be made;

Non-Toxic.

Flamblocker is certified Non-Toxic and this is backed by the mandatory Safety Data Sheet (SDS) and the Eco-Tox certification of Flamblocker CF7. The SDS shows no requirement for using any protection when using or transporting Flamblocker CF7.

Result: Flamblocker CF7 is easy to handle and causes no dangers to the users of the product, even when digested or when brought into contact with the eyes or lungs. In direct result of this situation, Flamblocker CF7 causes no danger to animals or insects due to its non-toxicity.

PFAS and Fluorine.

Flamblocker CF7 is free of PFAS and Fluorine and, as such, combined with the non-corrosiveness and non-toxicity, a safe product for fire fighters to handle. As CF7 is free of PFAS and free of Fluorine, there is no risk of a later development of illnesses such as cancer by the fire fighters that use the product.

Result: Flamblocker CF7 is a safe product to be handled on a continues base by fire fighters as it is free of PFAs and free of Fluorine and as such, has no risk of cancer development and can be handled by fire fighters without any additional protection. **Flamblocker CF7 is fully compliant with the new EU directives for firefighting liquids and foams.**

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Overview of type of emitted gasses and particles produced during a thermal runaway of a electric car battery (EV-Vehicle) including toxicological and first-responder perspective.

Gas	Typical Volume %	Hazard
HF (Hydrogen fluoride	0.1 – 2% (can spike locally higher)	Severe pulmonary toxin. immediate chemical lung injury
POF_3 (phosphoryl fluoride)	0.1–1%	Hydrolyzes to HF
PF_5 (phosphorus pentafluoride)	<0.5%	Hydrolyzes to HF
HCN (hydrogen cyanide)	0–1% (chemistry dependent)	Lethal asphyxiant
NOx	Trace–1%	Lung irritant
CO	10–30%	systemic hypoxia
Flammable gases		explosion hazard

These gasses usually make up <5% of total volume, but are disproportionately dangerous.

Particle Type	Typical Size	Approx. Contribution
Carbonaceous soot	<1 µm	Major fraction of particulates
Metal oxides (Ni, Co, Mn, Al)	0.1–10 µm	Variable, chemistry dependent
Lithium compounds (Li_2CO_3, LiF)	Submicron	From electrolyte reactions
Fluoride salts	Fine aerosols	Often associated with HF
Graphite fragments	µm-scale	Anode material

- Mass fraction of particulates in total effluent:
  Typically 1–5 wt%, but higher during flaming combustion.
- Ultrafine particles (<100 nm) are common and pose deep lung penetration risk.

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Overview of risks to firefighters and bystanders during test

Risk analysis thermal runaway Electric car (EV-Vehicle) related to firefighters and surroundings:

Type	Risk level	mitigation
Explosion prior to extinguishing	High	Immediate evacuation of wider area surrounding the vehicle
Toxicity of gasses and particles prior to extinguishing	High/Deadly	Full breathing apparatus required for all personnel at incident site, immediate evacuation of all bystanders
Explosion risk during extinguishing	High	Limitation of number of personnel involved and/or close to vehicle to bare minimum
Toxicity of gasses and particles during extinguishing	High/Deadly	Limitation of number of personnel involved and/or close to vehicle to bare minimum
Volume of toxic and lethal gasses/particles emitted during extinguishing	Increased due to removal of open fire	Limitation of number of personnel involved and/or close to vehicle to bare minimum. Additional water spray/mist deployed on incident site to capsulate free emitted gasses in water
Risk of additional propagation during initial attack	High/very likely	Additional cooling of entire battery surface and subsequent vehicle by second firefighting team, placed at larger distance to incident site
Risk of restart thermal runaway after initial attack	High	Continues cooling for multiple hours after initial fire has been extinguished via fixed water canon
Risk to bystanders after extinguishing of initial fire (lethal gasses emitted)	High (gasses and particles can continue to be emitted by battery)	Creation of large safety zone around incident site and placement of continues cooling system on vehicle for multiple hours.
Risk of explosion after initial extinguishing of vehicle	High due to composition of gasses emitted	Creation of large safety zone around incident site and placement of continues cooling system on vehicle for multiple hours.
Risk to firefighters/other emergency personnel and bystanders after fire (exposure to chemical components in surface water and soil)	High due to composition of emitted gasses and particles into and onto area during fire	Full cleanup by specialized team, capturing and containing all spilled water from surface area and full soil remediation by expert company. Collected/contained water and soil is highly toxic and poses an immediate threat to health and safety of humans, animals and ecosystem.

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Firefighter Operational Hazard and Mitigation Assessment related to oxygen production during a Lithium-Ion Battery Thermal Runaway and Intervention with Flamblocker CF7

During lithium-ion battery thermal runaway events, particularly in high-energy nickel-rich cathode systems (e.g., NMC/NCA chemistries), oxygen can be released from the cathode crystal lattice at elevated temperatures. This internal oxygen generation is operationally significant for firefighters because it allows decomposition reactions to continue even in environments with limited external ventilation. As a result, re-ignition risk persists after visible flame knockdown, and conventional smothering techniques alone are often insufficient. The event becomes thermally self-sustaining until cell temperatures are reduced below decomposition thresholds. Consequently, effective firefighting strategy prioritizes aggressive cooling and heat removal to interrupt propagation within modules and prevent sequential cell involvement.

Contribution of Flamblocker CF7 to Firefighter Safety

In the demonstrated operational test scenario, thermal runaway propagation was terminated after 6.01 minutes using Flamblocker CF7. From a responder safety perspective, earlier termination of propagation contributes to a safer working environment through several mechanisms:

1. **Reduction in Total Heat Release**
   By limiting continued cell involvement, cumulative heat output is reduced, lowering radiant heat exposure and decreasing the likelihood of secondary structural ignition.
2. **Reduction in Total Toxic Gas Generation**
   Thermal runaway progression increases cumulative production of carbon monoxide (CO), hydrogen fluoride (HF), flammable hydrocarbons, and particulates. Termination of propagation limits total effluent volume and duration of IDLH-level exposure conditions.
3. **Reduced Re-Ignition Risk**
   Interrupting decomposition reactions decreases the probability of delayed re-ignition, thereby reducing prolonged standby requirements and repeated intervention cycles.
4. **Shortened Operational Duration**
   Reduced time to stabilization directly decreases firefighter exposure to:
   - High radiant heat
   - Toxic plume conditions
   - Structural instability
   - Physical fatigue under SCBA
5. **Improved Scene Control and Risk Predictability**
   Earlier stabilization reduces dynamic hazard escalation and improves tactical control of the incident environment.

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Operational Risk Assessment oxygen production during thermal runaway.

Hazard Category	Without Propagation Control	With Propagation Termination (e.g., CF7 Intervention)
Heat Release	Escalating with cell-to-cell involvement	Limited to affected cells
Toxic Gas Production	Increasing cumulative load	Reduced cumulative volume
IDLH Exceedance Duration	Prolonged	Shortened
Re-Ignition Probability	Elevated	Reduced
Structural Fire Spread Risk	Increased	Mitigated
Firefighter Exposure Time	Extended	Reduced
Re-Ignition Probability	Elevated	Reduced
Structural Fire Spread Risk	Increased	Mitigated
Firefighter Exposure Time	Extended	Reduced

Overall Safety Implication

Lithium-ion battery fires present a multi-factor hazard environment consisting of sustained heat release, internally supported combustion chemistry, toxic gas production, and re-ignition potential. Any intervention method that demonstrably interrupts propagation and shortens event duration contributes directly to risk reduction for responding personnel.

In the demonstrated operational test case, termination of thermal runaway within 6.01 minutes represents a measurable reduction in cumulative hazard exposure and operational uncertainty, thereby contributing to a safer and more controlled working environment for firefighters.

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Operational and tactical advantages Flamblocker CF7.

Reduction of time needed to extinguish an electric car (EV-Vehicle) fire:

Flamblocker CF7 is an extinguishing and a cooling agent. With the combined effects, the required time to stop the thermal runaway, prevent propagation and extinguish an electric car (EV-Vehicle) fire is reduced by over 80% compared to other available extinguishing agents on the market, resulting in a higher efficiency rate of deployment for fire fighting teams and reducing the time spent in operational dangerous areas and exposure to lethal and explosive gasses.

Result:

- Reduction of operational deployment time per incident
- Reduction of staff cost and operational hours on the fire engine.
- Reduction of the time spent in an operational dangerous area for fire fighters (reduction of time exposed to lethal gasses and particles)
- Active risk reduction of restart of fire.
- Reduction of required volume of water for operations
- Extension of availability of fire fighting vehicle and/or ability to multi-deploy a vehicle on-site.

Prevention of corrosion and clogging on pump system

Flamblocker CF7 is a non-corrosive product (underwritten by certificates) and does not clog in pumps and pipelines within the firefighting vehicle or water lines. As such, the usage of CF7 does not cause any damage or breakdown on either the pump, internal waterlines and/or external waterlines.

Result:

- reduction of downtime as the agent has no effect on the system when used and reduction/avoidance of repair cost due to usage compared to other agents available in the market.

No flushing or cleaning of main water storage.

Other agents contain toxic components, PFAS and Fluorine and are often not biodegradable. As such, when other agents are used in a fire truck's main water storage, the main storage tank will require full and time consuming cleaning. Fire trucks are often used in rural areas to provide much needed water supply to citizens and when the fire truck has been deployed using other agents, the water quality can become contaminated.

Flamblocker CF7 is non-toxic, non-corrosive and is certified biodegradable and eco-friendly and free of PFAS and Fluorine. Flamblocker CF7 is made from food-grade materials and is not harmful for human or animal life. As such, when Flamblocker CF7 is deployed, the main water tank of the fire truck does not require any cleaning or purification and can immediately be deployed again for water transport towards citizens or livestock.

Result:

- no contamination of the main water tank within the fire truck and no potential damage to human life or livestock when the truck is consequently deployed to transport drinking water.

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Reduction of cost.

As Flamblocker CF7 requires less water to obtain the required results, the volume of needed CF7 is also reduced, resulting in a cost reduction on the purchase of firefighting agent (Flamblocker CF7)

Result:

- operational cost reduction on a continues bases whilst obtaining higher efficiency on operational deployment.
- Reduction of operational deployment time per incident
- Reduction of staff cost and operational hours on the fire engine.

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Attachement 1:
Report Electric car (EV-Vehicle) Battery Fire Test Karlovac tests November 20th 2025.

Original Goal of test:

Please note, the original goal of the test was completely different compared to the actual test due to unexpected fast reaction during initiation of the battery within the car and unforeseen positive effects caused by Flamblocker CF7.

To observe the effects of Flamblocker CF7 on a battery powered vehicle (EV-Vehicle) and to observe if Flamblocker CF7 is able to cool the car and the battery, reducing the damage to the interieur/risk to potential people in the car and protecting the people inside from the extreme heat of the burning battery.
To observe if Flamblocker CF7 has a positive contribution towards extending the time available for extraction of people from the vehicle.
To observe if CF7 contributes to reducing the time needed to extinguish/resolve a battery power vehicle fire.
To observe if CF7 contributes to reducing the water volume needed to extinguish/resolve a battery power vehicle fire.
Please note… we do NOT expect CF7 to extinguish the battery itself but only to reduce the heat/temperature of the battery fire and to create time for extraction of people from a battery powered car that is on fire.

Test situation.

- Test day: Thursday November 20th 2025.
- Weather conditions: cold weather (8C) with spells of rain during the preparation of test. During test it was dry.
- Wind: Mild wind 4Bf.
- Condition of vehicle: partial body damage due to initial usage as a crash-test vehicle, charging unit within car removed by Renault S.A. Group (Corporate) prior to delivery to test facility.
- Battery condition: new, undamaged, partially charged at 20%
- Used accelerator None
- Accelerant used: None
- Thermal camera: Used thermal camera had a limitation on temperature. Max readable temperature was 650+ additional camera was deployed to register full temperature range. Additional thermal camera able to read above 2500C degrees.
- Type of fire truck and system: Standard fire truck with standard waterline (C-line) and standard nozzle with added additive mixing module able to dispense between 1 and 6% additive during deployment.
- Water volume truck/hose: 360 litres flow per minute.
- Mixing rate CF7: Flamblocker CF7 mixing rate = 6%
- Total time required to take out fire/complete control: 6.01 (six minutes and one second)
- Total required water volume: 1.980 litres (including 6% Flamblocker CF7)
- Deployed fire fighting team: Vatrogasci Karlovac (JVP Karlovac) with a 5 member team
- Heavy duty blower system deployed to ensure safety of bystanders/witnesses

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Provided test vehicle.

To enable a full operational test, JVP Karlovac has contacted their sponsor for the World rescue Challenge, Renault S.A. Group (Corporate), and requested their support in providing a test vehicle for this specific test
situation. Renault is specifically known for investing time, knowledge and research into advanced fire safety on battery powered vehicles and operates a large test program for this particular purpose. Upon the request by JVP Karlovac, Renault S.A. Group (Corporate) provided an obsolete prototype test vehicle that was used in various crash-test simulations.

The provided test vehicle was a Renault Megane E-Tech, 2026 model. The battery in the provided car was new and undamaged and had a 20% charge during the executed test.
The charging installation was removed by Renault S.A. Group (Corporate) prior to delivery to the test facility and, as such, we were unable to add additional load to the battery of the vehicle.

Vehicle specifications:

Brand:	Renault
Type:	Megane
Model:	E-Tech
Year of production:	2025 (2026 model)
Battery type:	60kWh/160kW
Drive-train vehicle	100% electric
Status of car:	New, Prototype 2026 model, Crash-test vehicle with body damage. Car fully operational/dealer settings
Technical status of battery:	New, undamaged, charging system removed
Load of battery/storage level:	20%

Setting of Operational test.

The car was delivered in a drivable state, although several components of the exterior of the car were removed during usage at the World rescue Challenge at Karlovac.
Intention was to create a thermal runaway within the internal battery system of the car whilst the car was on all 4 wheels. As the original charging system of the car was removed, we were unable to connect an electrical charging system to the vehicle. With the original charging system removed, we were left with a technical issue on how to create the thermal runaway of the battery. External heating of the battery via gas burners to create the thermal runaway was considered but deemed to be too dangerous for the involved firefighters and bystanders/witnesses as explosions of gasses and uncontrolled reactions could occur during this procedure. After consideration, it was decided to flip the car on its side, using an on-site forklift and puncture the battery that is placed in the bottom-part of the car with the forks of the forklift, creating damage to the internal system of the battery, resulting in internal damage and short-circuit of the battery which will lead to a thermal reaction inside the battery. The intention was to flip the car back on all 4 wheels upon initial thermal runaway but due to the extreme fast reaction of the thermal runaway and the fast propagation, it was impossible and unsafe to attempt the move to flip the car back on all 4 wheels and this attempt was abandoned.

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The test.
Please note that the actual test report below differs from the original intended test goal due to unexpected positive results.

Upon initial puncture of the battery by the forklift at 10.18 AM, the battery immediately ran into a short circuit situation and the thermal runaway started within seconds. After the initial thermal runaway, propagation was visible within seconds and the battery produced vast amounts how highly toxic and deadly gasses with added risk of explosions due to chemical composition of the emitted gasses.
Witnesses were placed at a larger distance to the test area due to high risk of contact with lethal gasses and potential explosion risk. The firefighting crew was minimized to 2 people to reduce any additional potential risk to human life. External spray system on vehicle for additional cooling was not deployed to enable better visibility and obtain calibrated test results based solely on Flamblocker CF7, avoiding unwanted interference by third party agents (water).

Upon reaching thermal runaway and propagation, two thermal cameras were deployed to measure the outer temperature of the battery. Temperature readings shown temperatures exceeding the 2000C degree marker before initiating the attack with water and CF7.

Upon full thermal runaway and propagation of the fire, the 2-men attack team approached the vehicle with a standard C-line waterline and standard nozzle with manufacturer delivered mixing unit for adding Flamblocker CF7 directly into the waterline. The mixing rate of the standard additive dispenser unit was set at 6%. The battery was in a full thermal runaway status, emitting large volumes of toxic, lethal and explosive gasses, combined with high intensity flames and flame eruptions via the puncture holes created by the forklift.

The team focussed initially on surface cooling and moved on to a direct attack on the external visible flames/expulsion of gasses from the battery that was fully approachable as the car was still on it's side. Seconds into the attack, the team switched to direct induction of water combined with 6% Flamblocker CF7 into the open holes in the battery to attempt to cool the internal area of the battery.

5.31 minutes into the attack, the flames were no longer visible but the expulsion of toxic and potentially explosive gasses and particles continues. A second attack was started, lasting 30 seconds, and was directly directed to the 2 holes in the battery, loading additional water with 6% Flamblocker CF7 into the battery compartment of the car. At the 6.01 marker, the battery shows no flames and the volume of gasses and particles reduced dramatically. The attack was stopped.
At this time, the battery compartment of the vehicle was in a flooded situation with water containing Flamblocker CF7 inside.

New type lithium-ion batteries used in this type of vehicles create their own oxygen en flammable gasses during a thermal runaway and, as such, are able to restart on their own as the temperature is caused by a chemical reaction within the damaged batteries and is still present under normal incident/damage situations. The extreme cooling effect of Flamblocker CF7 cools the damaged battery components, removing one of the 3 critical and required elements for a fire, resulting in a prevention of a restart.

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After the 6.01 time marker, the vehicle was continuously monitored to check for a potential restart of the fire. A restart of the fire did not occur. The small smoke expulsion that continued after the 6.01 time marker halted after several minutes, resulting in the conclusion by the firefighters and bystanders/witnesses that the thermal runaway was stopped and the fire was extinguished.

The temperature of the outer area of the battery was inspected with thermal cameras and showed a temperature of 20C degrees. Previous checks and readings of the thermal runaway has shown high temperature areas within the battery, reaching beyond 2000C degrees. At this moment, after the fire was extinguished and the thermal runaway was stopped, there were no visible or readable higher temperature/heat signatures to be seen on the thermal cameras.

When the full and complete stop of the thermal runaway was concluded and the small puffs of smoke had stopped, several witnesses approached the vehicle for a closer inspection.
One of the witnesses even removed her gloves and touched the damaged battery directly with her bare hands, concluding that the battery was not hot/warm, underwriting the readings of the thermal cameras.
Witnesses of the test as well as the firefighters that were on-site all expressed their surprise and stated that the results were unexpected and were amazed by the results. Several of the present witnesses and firefighters have previous experience with electric car (EV0Vehicle) fires and have experience with thermal runaway situations and all stated that this was the first time they witnessed such results in such short time.

The car and battery stayed under continues control and checks by the on-site firefighters for several hours after the test to ensure a safe situation. Later that day, the car was removed to a specialist scrapyard for final demolition.

Total time needed to obtain full control/extinguish fire: 6.01 minutes.
Total water volume required: 1.980 litres including 6% Flamblocker CF7

Observed results.
The thermal runaway was completely stopped within 6.01 minutes (2 attacks executed total) after starting of the attack with water and 6% Flamblocker CF7.

No restart of the thermal runaway was observed and the car and battery was deemed safe to handle after the 6.01 minutes. Temperatures of the battery during the thermal runaway had reached in excess of 2000C degrees and after 6.01 minutes, the temperature of the battery was brought down to 20C degrees, enabling several bystanders to approach the battery/car and physically touch with bare hand the battery without damage to the hand in any way or form.

The observed effect of Flamblocker CF7 on the thermal runaway was unexpected and caused amaze by the bystanders/witnesses, all of which are experienced firefighters and/or industry experts with high degree of operational knowledge and experience. The bystanders/witnesses declared this was the first time they witnessed a full termination of a thermal runaway in minutes compared to their known standard, being hours.

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The required volume of water to obtain the full termination of the thermal runaway was considered extremely low. The total environmental damage caused by emitted gases and particles was significantly lower compared to standard volumes, based on known previous operational incidents.

Due to the extreme fast cooling of the battery with Flamblocker CF7, the body of the vehicle was completely unaffected by the fire. Renault is known for having high-level in-car protection placed between the battery and the body of the vehicle, resulting in a longer duration of protection. The complete thermal runaway occurred but did not propagate to the drivers compartment/body of the car due to the fast cooling. Under normal/regular full thermal runaway, it is expected that the body will be completely destroyed by the fire of the thermal runaway. This did not occur in during this test.

Gratitude and acknowledgement.
Flamblocker and its partners wishes to extant gratitude and respect to the Karlovac fire rescue team (JVP Karlovac) for enabling this test and their support and extend gratitude to Renault S.A. Group (Corporate) for providing the test vehicle.

This test was witnessed by the following parties/entities:
JVP Karlovac Firefighting team
KL Protektion d.o.o. https://www.klprotektion.hr/
Croatian specialist company for firefighting equipment
LiveSafe d.o.o. https://livesafe.si
Slovenian specialist company for firefighting equipment
FireTrade d.o.o. https://firetrade-bh.com/
Bosnian specialist company for firefighting equipment
Representatives of the North-Macedonia Department of Crisis Management, Protection and Rescue
Various representatives of fire fighting teams from Croatia
Mr. Zlatko Goykov,
strategic advisor
Manuela Zakula mag. ing. sec. Karlovac University of Applied Sciences
https://www.vuka.hr/sigurnost/en/manuela.zakula
Department of Safety and Protection

all shown witnesses underwrite the results and outcome as described in this document.

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Attachment 2: Toxic Gas and Particulate Hazards Associated with Lithium-Ion Battery Thermal Runaway

Context: Electric Vehicle Fire Demonstration – Termination Using Flamblocker CF7

1. Purpose of This Document

This appendix provides an overview of hazardous gases and particulates generated during lithium-ion battery thermal runaway and propagation in electric vehicles (EVs). It is intended to contextualize the hazard environment observed during the demonstration fire test in which thermal runaway was terminated after 60.1 minutes using Flamblocker CF7.
The information below summarizes established scientific and fire investigation data relevant to responder safety, environmental exposure, and risk assessment.

2. Thermal Runaway and Propagation Overview

Thermal runaway in lithium-ion batteries is a self-accelerating exothermic decomposition process initiated by mechanical damage, overheating, electrical abuse, or internal failure. Once triggered, individual cells release:

- High-temperature gases
- Flammable decomposition products
- Toxic combustion byproducts
- Acid gases
- Aerosolized and solid particulates

When propagation occurs, adjacent cells sequentially enter thermal runaway, significantly increasing heat release and toxic effluent generation.

3. Gas Composition During Thermal Runaway

The composition varies by battery chemistry, state of charge, and ventilation conditions. However, for typical EV lithium-ion batteries (e.g., NMC/NCA chemistries at moderate to high state of charge), the effluent gas mixture generally contains:

3.1 Major Bulk Gases (Approximate Volume Fractions)

- Carbon dioxide (CO_2): 20–45%
- Hydrogen (H_2): 15–35%
- Carbon monoxide (CO): 10–30%
- Ethylene (C_2H_4): 5–20%
- Methane (CH_4): 2–10%
- Other light hydrocarbons: 1–5%

These gases account for approximately 85–95% of the total released gas volume.

Key hazards:

- Explosion risk (hydrogen and hydrocarbons)
- Asphyxiation (CO_2)
- Systemic toxicity (CO)

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3.2 Toxic and Corrosive Gases (Low Volume, High Hazard)

Although present in smaller fractions (typically <5% of total volume), the following gases represent disproportionate health risks:

- Hydrogen fluoride (HF): typically 0.1–2%
- Phosphoryl fluoride (POF_3)
- Phosphorus pentafluoride (PF_5)
- Hydrogen cyanide (HCN) (chemistry dependent)
- Nitrogen oxides (NOx)

Hydrogen fluoride is of particular concern due to its severe pulmonary toxicity and potential for delayed lung injury.

4. Particulate and Aerosol Emissions

In addition to gases, lithium-ion battery fires generate respirable particulates and ultrafine aerosols, including:

- Carbonaceous soot
- Metal oxides (nickel, cobalt, manganese, aluminum)
- Lithium salts (e.g., lithium fluoride, lithium carbonate)
- Fluoride-containing particulates
- Graphitic fragments

Particulates typically account for approximately 1–5% of the total mass released, though they represent a smaller percentage by volume.
Ultrafine particles (<100 nm) pose enhanced respiratory penetration risk

5. First-Responder Exposure Thresholds (IDLH Values)

Immediately Dangerous to Life or Health (IDLH) values represent concentrations that threaten life, cause irreversible health effects, or impair escape within 30 minutes of exposure.
Relevant IDLH thresholds include:

Substance	**IDLH Value**
Carbon monoxide (CO)	1,200 ppm
Hydrogen fluoride (HF)	30 ppm
Hydrogen cyanide (HCN)	50 ppm
Nitrogen dioxide (NO_2)	20 ppm
Sulfur dioxide (SO_2)	100 ppm

Measured concentrations near EV battery fire plumes can exceed these thresholds, particularly in confined or poorly ventilated environments.

Consequently, positive-pressure self-contained breathing apparatus (SCBA) is required for interior or close-proximity firefighting operations.

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6. Combined Hazard Profile

An EV battery fire presents a multi-factor hazard environment consisting of:

- High heat release and jet flames
- Flammable gas cloud formation
- Toxic gas exposure exceeding IDLH levels
- Corrosive fluoride contamination
- Ultrafine particulate inhalation risk

The toxic hazard exists even in the absence of visible flames, particularly during venting phases preceding ignition.

7. Relevance to the Demonstration Test

During the conducted demonstration:

- Thermal runaway propagation was initiated and sustained.
- Toxic and flammable gas generation consistent with lithium-ion battery decomposition would be expected.
- Intervention using Flamblocker CF7 resulted in termination of thermal runaway after 6.01 minutes.

Termination of propagation is significant because continued propagation would otherwise:

- Increase total gas volume released
- Increase cumulative toxic load
- Increase structural fire spread risk
- Extend responder exposure duration

Earlier suppression or termination directly reduces total effluent generation and associated environmental and occupational hazards.

8. Key Safety Implications

Based on established lithium-ion fire behaviour:

- Toxic gas generation begins immediately upon cell rupture.
- IDLH exceedance can occur rapidly in confined spaces.
- Hydrogen fluoride is a controlling corrosive hazard.
- Carbon monoxide is typically the dominant lethal gas.
- Protective respiratory equipment is mandatory during suppression.
- Post-fire contamination assessment should consider fluoride residues

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9. Conclusion

Lithium-ion battery thermal runaway produces a complex and hazardous mixture of flammable gases, toxic gases, acid vapors, and respirable particulates. Even though certain highly toxic species constitute a small fraction of the total volume, their concentrations can exceed life-threatening exposure thresholds.

The demonstrated ability to terminate thermal runaway within 60.1 minutes using Flamblocker CF7 is therefore relevant not only to fire control but also to:

- Reduction of cumulative toxic gas release
- Limitation of responder exposure
- Mitigation of environmental contamination
- Reduction of secondary ignition hazards

This appendix is intended to provide technical context for stakeholders reviewing the demonstration results.

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Attachment 5: Safety Data Sheet (SDS) Flamblocker CF7.

SAFETY DATA SHEET

Compliant with: Regulation (EC) Nr. 1907/2006 (REACH), Regulation (EC) Nr. 1272/2008 (EU-GHS, CLP)

CF7 – all-purpose wetting agent

Revised: February 6th, 2026.

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

1.1 Product identifier
Product name:
Flamblocker CF7 – All-purpose wetting agent
Product description:
Colourless liquid
Other means of identification:
HS Code: 38130000
1.2 Relevant identified uses of the substance or mixture and uses advised against
Identified uses:
Non-hazardous fire extinguishing agent.
Used to hinder temperature increase, prevent ignition and re-ignition of fire, reduce smoke development, and improve dispersion of extinguishing media.
Suitable for application on fire classes **A, B, F, and D**, Li-ion Batteries and for use as a fat and grease cleaner.
Dilution with water (typical use concentrations):

- Fire class A: 1–3 %
- Fire class B: 3–6 %
- Fire class F / D: up to 12 %

Uses advised against:
Use outside the recommended dilution ranges or for applications not consistent with the specified fire classes.
1.3 Details of the supplier of the safety data sheet
Supplier / Responsible party (global distribution):
Flamblocker BV
Brandpunt 32
1705 SK Heerhugowaard
The Netherlands
Telephone (responsible person):
+31 6 288 47 131 (Mr. Martijn Beerthuizen)
Email (competent person responsible for the SDS):
info@flamblocker.com
Website:
www.flamblocker.com
Manufacturer:
C-Fire NV
Frank Van Dyckelaan 3

9140 Temse
Belgium
Telephone:
+32 3 710 69 01
Email:
info@c-fire.eu
Website:
www.c-fire.eu
1.4 Emergency telephone number
Emergency telephone number (chemical emergency advice):
+31 6 288 47 131 (Mr. Martijn Beerthuizen, Flamblocker BV)
Availability:
24 hours / 7 days

SECTION 2: HAZARD IDENTIFICATION

2..1 Classification of the substance or mixture
This product does not meet the criteria for classification in any hazard class according to Regulation (EC) No 1272/2008 on classification, labeling and packaging of substances and mixtures. However, a safety data sheet is being supplied for it upon request of distributors.
2..2 Label elements
No hazards or precautionary statements applicable.

SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

3.1 Substances
Not applicable.
3.2 Mixtures
Water-based solution of plant extracts and alkali-salts of inorganic acids;
No dangerous substances, no foams, no afff.
No PBT, PFAS, PFOS and PFOA. No vPvB substances. Fluorine free.

SECTION 4: FIRST AID MEASURES

Inhalation: no harm
Skin contact: wash affected area with soap and water
Eyes: remove contact lenses. Flush eyes with clear running water while holding eye lids open.
Ingestion: non-toxic, if swallowed (by large quantities) do not induce vomiting, seek medical advice immediately.

SECTION 5: FIRE FIGHTING MEASURES SECTION

General hazards: no danger of fire, product itself is fire extinguishing agent.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Action to be taken in case of, material is being released or spilled: flush area with water.

SECTION 7: HANDLING AND STORAGE

Precautions to be taken in handling and storage: protect from extreme temperatures to keep strength of solution
Shelf life: not limited.

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SECTION 8: EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure control: none required
Personal protection: practice safe workplace habits
Respiratory protection (specify type): none required
Protective gloves: none required
Eye protection: none required
Other protective clothing or equipment: none required
Work / hygienic practices: practice safe workplace habits.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance: Clear liquid,
Odor: Slightly fresh smell
pH (20°C): 7,5 - 7,8
Melting point : similar to water, not determined
Freezing point: -30°C
Initial boiling point and boiling range: similar to water, not determined
Relative density: 1,02
Solubility in water: 100% , water solution
Kinetic Viscosity (20°C) : 72,42 mm2/s
Refractive Index (20°C) : 1.37582 (nD)

SECTION 10: STABILITY AND REACTIVITY

10.1 Reactivity: no known reactions
10.2 Chemical stability: Under storage at normal ambient temperatures (to keep strength of solution), the product is stable.
10.3 Possibility of hazardous reactions: No hazardous reaction when handled and stored according to provisions
10.4 Conditions to avoid: extreme temperatures (to keep strength of solution)
10.5 Incompatible materials: not known
10.6 Hazardous decomposition products: no known hazardous decomposition products

SECTION 11: TOXICOLOGICAL INFORMATION

Not known any toxicological (health) effects
No PBT, PFAS, PFOS and PFOA. No vPvB substances. Fluorine free.

SECTION 12: ECOLOGICAL INFORMATION

12.1 Toxicity
Testing of acute toxicity on green algae (Raphidocelis subcapitata):
ErC_{50}, 72 h, 57 mg L^{-1}, not acute toxic to that aquatic organisms
Testing of acute toxicity on Daphnia magna Straus (Cladocera, Crustacea):
EC_{50}, 48 sati, > 1000 mg L^{-1}, not acute toxic to that aquatic organisms
Testing of inhibition of grow of active-mud-microorganisms:
EC_{50} > 1000 mg L^{-1}, not acute toxic to that organisms
No PBT, PFAS, PFOS and PFOA. No vPvB substances. Fluorine free.
12.2 Persistence and degradability
Abiotic Degradation: Not determined
Physical- and photo-chemical elimination: Not determined
Biodegradability (21 days): 100,0 %; testing method according to EN ISO 9439:2000 (Daphnia magna)

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12.3 Bioaccumulative potential
Not determined
12.4 Mobility in soil
Not determined
12.5 Results of PBT and vPvB assessment
CF 7 - all purpose wetting agent is rapid 100% biodegradable mixture with no PBT (Persistence, Bioaccumulation, Toxicity) and no vPvB substances.
100% biodegradable.

SECTION 13: DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods
Not considered as a hazardous waste. Dispose after diluting with water.
No PBT, PFAS, PFOS and PFOA. No vPvB substances.

SECTION 14: TRANSPORT INFORMATION

CF 7 – all-purpose wetting agent is not labeled as hazardous material. (100% biodegradable)
No restriction for transportation of product.
Customs Commodity Code (HS code): 38130000
EAN Code: 5407008000288

SECTION 15: REGULATORY INFORMATION

15.1 Safety, health and environmental regulations/legislation specific for the substance or Mixture Not known any specific regulation, 100% biodegradable
15.2 Chemical Safety Assessment:
No Chemical Safety Assessment has been carried out for this substance/mixture by the supplier.

SECTION 16: OTHER INFORMATION

Disclaimer:
This SDS is to the best of our knowledge and belief, accurate and reliable as of the date compiled. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Furthermore, vendor assumes no responsibility for injury caused by abnormal use of this material even if reasonable safety procedures are followed. Any questions regarding this product should be directed to the manufacturer of the product as described in Section 1.

Certificate Number: 05084 60/20 17025HAA - 1040

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