

FCL-X

INNOVATIVE LITHIUM-ION BATTERY
FIRE EXTINGUISHING AGENT



FULL CIRCLE LITHIUM | FCL-X TECHNICAL OVERVIEW | MAY 2025

INTRODUCTION

It is a pleasure to introduce Full Circle Lithium's innovative lithium-ion battery fire extinguishing agent, FCL-X. We developed FCL-X to tackle the growing challenge of extinguishing hazardous lithium-ion battery (LIB) fires. FCL-X has undergone rigorous internal and external testing, demonstrating exceptional cooling capabilities, reduced off-gassing, and prevention of reignition in LIB fires.

The FCL-X team brings significant firefighting expertise, with close to 100 years of combined experience in the State of Georgia (Web Marshall and Shane Bentley, each with nearly 25 years of firefighting experience, and Michael Carver with over 40 years including Fire Chief).

This document will highlight key characteristics that make FCL-X an ideal solution for LIB fires, as well as structural Class A fires. While not a comprehensive technical deep dive, this report aims to provide valuable technical insights for professionals and end users. Due to intellectual property considerations, some confidential details will not be disclosed.

WHAT IS FCL-X AND HOW DOES IT WORK?

FCL-X is an aqueous solution, primarily water, enhanced with a crucial active ingredient measured in parts per million (ppm), making it uniquely effective for LIB fires. Its high water content allows for superior penetration of the LIB compared to non-water-based agents. Unlike foam and vermiculite, which act as temporary barriers on the surface of the ongoing chemical reaction, FCL-X penetrates and halts the reaction at the cell level. Critically, any LIB on fire and experiencing thermal runaway will have an open vent. This vent is essential, as it allows FCL-X to be introduced directly to the source of the fire, stopping or minimizing the chemical reaction and managing the emitted off-gas.

During the extinguishing process, the initial water in FCL-X evaporates, cooling the LIB. Simultaneously, the active ingredient resolidifies and continues to absorb heat. This cycle repeats as FCL-X is applied, ensuring sustained cooling. This cooling phase is vital, enabling the aqueous solution to penetrate the LIB. Once inside, FCL-X initiates several critical actions:

- **Neutralizing Battery Charge / Thermal Absorption:** In a battery already in thermal runaway, FCL-X neutralizes the charge and immediately reduces thermal output by 20%. Neither water alone nor other agents achieve this.
- **Mitigation of HF:** Beyond the fire itself, the release of gaseous hydrogen fluoride (HF) poses a significant threat in LIB fires. HF forms when lithiated hexafluorophosphate, a common electrolyte in LIBs, decomposes at high temperatures and reacts with water. This highly corrosive gas is potentially lethal upon inhalation. FCL-X effectively mitigates most or all HF by reacting with it to form a non-hazardous salt. Again, this is a capability unique to FCL-X compared to water or other agents.
- **Prevention of Hydrogen Explosion:** LIB anodes typically consist of lithiated graphite. Under extreme heat, lithium separates from the graphite and reacts with water, often exacerbating the fire and creating dangerously high levels of explosive hydrogen gas. FCL-X counteracts this. Its initial thermal absorption reduces heat, and the active ingredient forms a protective layer on the lithiated graphite. The continued application of the FCL-X solution then smothers any remaining hydrogen gas production. This multi-faceted approach is not offered by water or other extinguishing agents.

- **Dilution of Internal LIB Solution:** The most critical aspect of extinguishing a LIB fire is diluting the burning solutions within the battery. This requires penetrating the cell, cooling the internal solution, and diluting it. FCL-X's enhanced cooling and the active ingredient's ability to remain effective under heat allow it to penetrate the cell more effectively before evaporation, thus facilitating this crucial dilution process. This level of internal action is not provided by water or other agents.

While FCL-X exhibits exceptional and enhanced cooling capabilities compared to water and other current agents, direct penetration of the LIB is essential for complete effectiveness against LIB fires. A breach or opening in the LIB, often identifiable with thermal imaging cameras or by visual smoke localization, is necessary for FCL-X to reach the source of the chemical reaction. Just as applying water to the exterior of a structural fire won't extinguish the flames inside, addressing a LIB fire requires targeting the breach in the LIB and the individual cells.

ENVIRONMENTAL AND TOXICITY

FCL-X is PFAS-free ("no forever chemicals"). In third-party testing, the total fluorine concentration was below 1 PPM. Typically, 100 μ g/g (PPM) which is 100,000 ng/g (PPB), total fluorine level is an indication of intentionally added PFAS. FCL-X has also demonstrated extremely low toxicity to animals and humans in LC50 third-party laboratory testing. These factors underscore FCL-X safety profile.

Both reports are available upon request.

REAL LIFE APPLICATIONS

FCL-X's effectiveness has been proven in real-world LIB fire incidents:

- Over a dozen EV demonstrations have shown complete extinguishment with less than 400 gallons of FCL-X in under 7 minutes, with several instances using only 100 gallons in under 3 minutes.
- Numerous smaller battery demonstrations (e-bikes, scooters, etc.) have yielded consistent positive results, both in internal testing and verified by third-party laboratories.
- During a large industrial lithium-ion recycling facility fire in Missouri, where millions of gallons of water proved ineffective and environmentally detrimental, our team, in collaboration with a partner, extinguished all fires and mitigated electrolyte decomposition and HF issues using approximately 10,000 gallons of FCL-X within 24 hours of being called.
- FCL-X has undergone testing by professionals and third-party experts. Additionally, we anticipate receiving UL Class A certification in the coming weeks. Due to its superior capabilities, FCL-X can effectively extinguish any fire that can be tackled with water.

CONCLUSION

In conclusion, FCL-X is an effective, efficient, and environmentally safe solution, prioritizing user safety. Extensive internal and external verification, supported by substantial data and real-life LIB fire applications and demonstrations, validates the analysis presented above.