WARNER ENERGY STORAGE SOLUTIONS

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To Mr. Tim Riley and Pyrophobic Systems,

Following a number of energy storage system (ESS) fires in the nation of South Korea, as well as an ESS explosion in Arizona Public Service territory in the United States, the energy storage industry has begun to question the state of safety as it currently exists. Though many on the safety side of the industry have posed questions and concerns to this end for some time, insufficient fire code requirements, an uncertain regulatory future, and a lack of market and financial pressure to engage in safety otherwise have resulted in an operating fleet whose individual levels of safety vary greatly. Though it is not the intent of this letter to dive into every individual facet of energy storage safety, this letter does aim to examine two facets of this issue and to discuss their relationships to the larger safety picture as well as how the incorporation of Pyrophobic's Lithium Prevent intumescent material may drastically improve the overall system safety in these regards.

The first issue this letter seeks to address is that of propagating or cascading failure. For this purpose, a propagating failure is a scenario whereby a single cell failure spreads to a second cell, which spreads to a third, and so forth. While in many cases a single cell failure is insufficient to cause a significant issue, it is the propagation of this failure through the system which allows a small single cell event to quickly become an unmanageable catastrophe. In this sense as well, propagation may refer to cell to cell propagation but also to module to module propagation and ultimately rack to rack propagation. While there are a number of factors which determine the point in which a battery failure becomes an unmanageable conflagration—or worse—it is generally agreed that containing the failure to the smallest size possible is critical to avoiding such a scenario. It should also be noted that this failure, which can also be thought of as thermal runaway (though whose cause is unimportant) may come in one of two flavors, a high temperature gas release without external combustion, or an even hotter event accompanied by gas release and combustion. Though one event may see higher temperatures, both events generate heat which must be managed conductively and convectively and which could result in explosive gases which may be ignitable long after the event.

To that end, managing this heat generation and transfer is required to avoid cascading of the failure. At the cell level, this may be accomplished in a number of ways, but one which offers a solution to both the conductive and convective aspects is Pyrophobic's intumescent material. This material allows for customizable designs which manage heat conduction through a well understood intumescing process, or the swelling of an ash layer which drastically decreases conduction to safe levels. In limiting heat conduction between cells, as well as providing thermal mass which may absorb heat, this material has proven highly effective at managing heat transfer between small cylindrical cells and should prove equally effective with other sizes and form factors.

This material also offers an avenue for gas management as well by providing exhaust ducts and channels in which offgas from the cells may be directed away from other cells safely and allowed to cool, ideally below easily ignitable limits. While this approach remains in development, early results appear quite promising and similar proofs of concept have shown success at this purpose. Design of the material also encapsulates adjacent cells, limiting heat spread even as the hot gas is channeled away nearby.

While management of single cell failure is critical, those in the safety community have also acknowledged that a number of credible multicell failure modes exist. To that end, larger scale systems are necessary for containing these events. In other cases, the batteries themselves may not be the source of failure but may find themselves exposed to fire from the balance of plant, such as the inverter, wires, or other flammable materials in the container. Regardless of the cause or nature of the event, these larger scale events must also be managed independently of cell to cell propagation concerns.

One way this is accomplished at the macro scale is by the use of clean agent gas fire suppression systems. These systems, which have proven effective at managing class A, B, and C fires, should manage balance of system fires, but concerns abound regarding their ability to directly extinguish, or even suppress, fires from the batteries packed tightly in modules. In some cases, while the agent has proven effective at stopping combustion and flames, limiting the convective heat transfer module to module, the agent has proven entirely ineffective at stopping cell to cell propagation in the module. In many cases, this still results in failure of 100% of cells in a module, but also 100% conversion of electrolyte to flammable or explosive offgas which poses considerable risk in an oxygen depleted atmosphere where dangerously high temperatures remain inside the failed module for several hours. To that end, while these clean agent suppressions systems themselves may not succeed in managing the problem entirely themselves, when coupled with a product which will limit cell to cell propagation within the module, may prove more effective at both stopping greater system propagation as well as minimizing the amount of flammable gas produced. This would ultimately create a more manageable scenario from an emergency operations perspective as well.

Warner ESS believes that large scale test data will show that a system properly comprised of Pyrophobic's material will perform well during internal failure testing with suppression from only clean agent. Current testing and system design favors a two stage approach, with clean agent for initial suppression supported by water if and when that fails. Therefore, any failure of even a small portion of the module may see the destruction of the entire system in trying to prevent an even greater destructive event from system fire or explosion. In this case, the employment of Lithium Prevent may provide an opportunity to save multimillion-dollar investments.

Nick Warner, Founder & Principal Engineer, Warner ESS