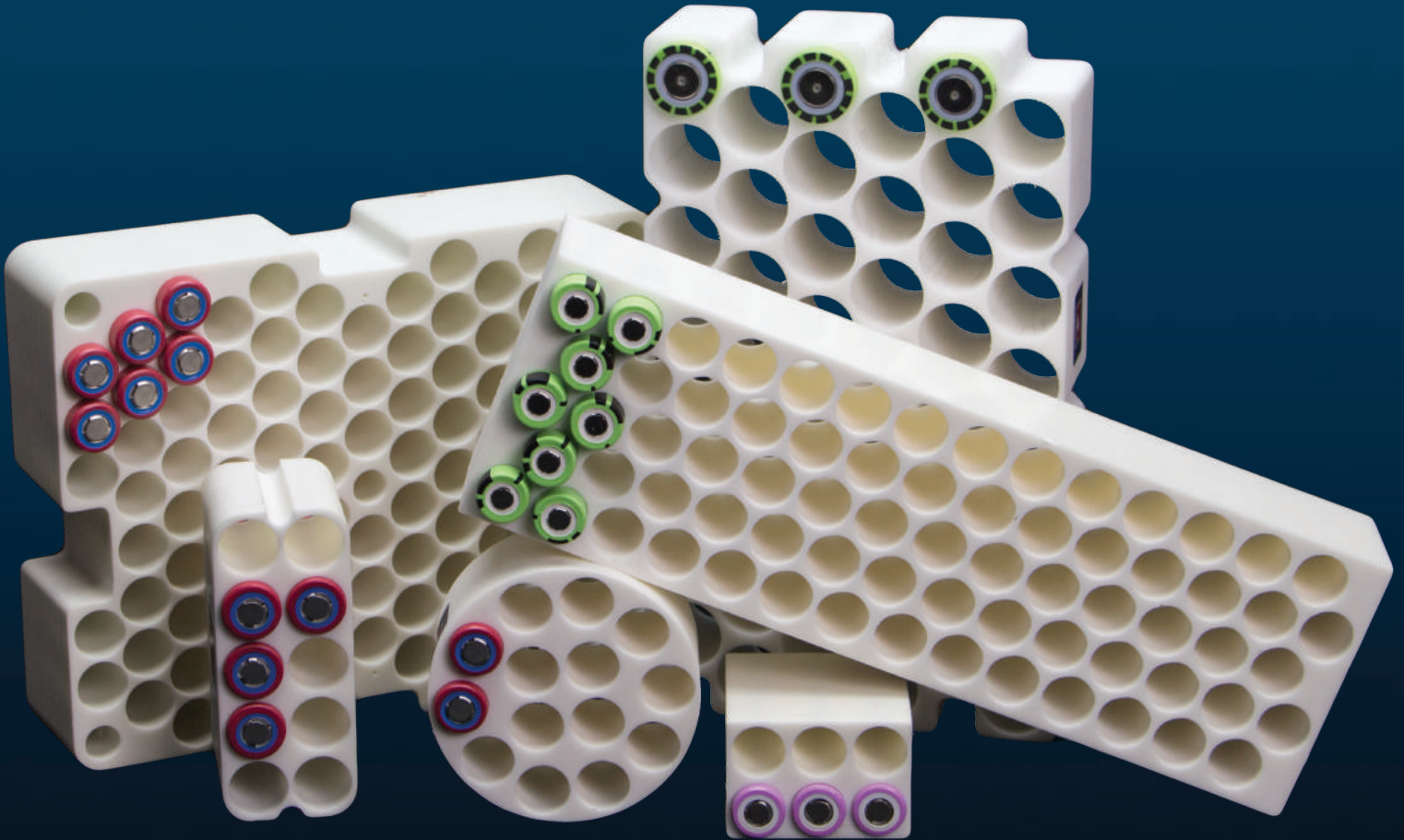




LATENT HEAT SYSTEMS® (LHS®)

FOR IMPROVED BATTERY PERFORMANCE & SAFETY



BATTERY THERMAL MANAGEMENT

Because of their energy density, higher voltage, and negligible memory effects, lithium-ion batteries are the popular choice for a wide range of applications, especially in electric vehicles, energy storage, and portable tools and devices. Larger power demands and increasing cell density of lithium-ion battery packs result in high operating temperatures, especially under peak loads. Because of the susceptibility of most commercial lithium-ion cell chemistries to degrade or age at or above 60°C, this leads to rapid loss of capacity over subsequent charge/-discharge cycles as well as reduced overall power output. Reducing detrimental thermal effects through the use of Latent Heat Systems (LHS) materials that absorb and store thermal energy, has proven highly effective. With their high latent heat, ease of processing, and impressive reliability, LHS materials are becoming the forerunner in effective, simple, and economical thermal management designs for power intensive lithium-ion battery applications.

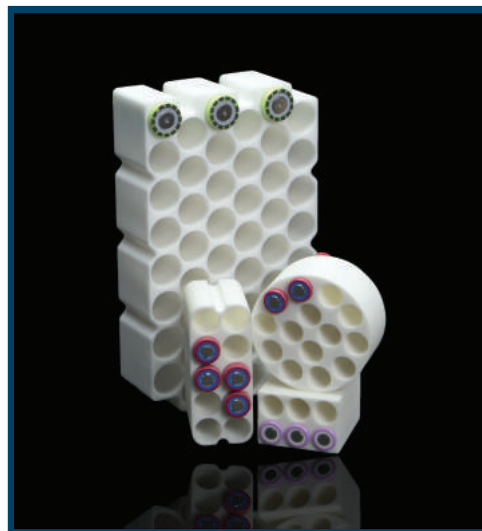
Another impressive feature of LHS Battery Materials is their ability to reduce and even eliminate the potential for Thermal Runaway or Propagation in battery packs. Thermal Runaway and Propagation potential is a growing safety concern in many applications due to the possibility of serious fire in the event the cells are physically damaged or short circuited. The Outlast LHS Battery Materials are highly flame retardant and can eliminate the potential for runaway in a battery pack resulting in a much safer product.

Today, Outlast Technologies is the leader in Latent Heat Systems, for the passive thermal control and protection of your Lithium-Ion battery systems. Outlast is expert at optimizing our numerous available solutions to help you achieve a cost effective, performance and safety solution for your application. Contact our technical team today.

BENEFITS	Battery Matrix	Battery Sheet	LHS FR, Fill & Flow	LHS Fill & Flow	Battery Sleeve / Elastomer	Encapsulant & Potting Compound
Thermal Runaway Protection	+	+	+			+
Increased Battery Life	+	+	+	+	+	+
Cell Surface Thermal Control	+	+	+	+	+	+
Thermal History Reduction	+	+	+	+	+	+
Homogenous Pack Temperatures	+	+	+	+	+	+
Improved Fast Charging Properties	+	+	+	+	+	+
Passive Thermal Management	+	+	+	+	+	+
Electrically Insulative	+	+	+	+	+	+
RoHS Compliant	+	+	+	+	+	+
Shape Stable	+	+			+	+

OUTLAST® LHS® BATTERY MATRIX

Outlast® Latent Heat System (LHS®) thermal management materials provide energy absorption and heat dissipation characteristics for passive thermal control. These materials are designed to prevent thermal runaway, maintain homogenous temperatures across cells and reduce battery overheating due to fast charging/discharging which leads to less battery degradation and an increased battery life.



BATTERY MATRIX BENEFITS



- Eliminates Thermal Runaway
- Passive Thermal Management
- >40% Improved Battery Life
- Significant Reduction in Thermal Degradation
- Electrically Insulative, not Conductive
- Superior Thermal Mitigation during High Charge/Discharge Cycle
- Homogeneous Cell Temperatures Across Battery Pack

OUTLAST® LHS® BATTERY SHEETS

Outlast® LHS® Battery Sheets are a white composite supplied as finished sheets that are molded to finished dimensions or can be supplied in any dimension for further machining or cutting. LHS sheets are designed for layering between pouch batteries for applications requiring good thermal absorption, temperature homogeneity, low shrinkage and low CTE. The LHS composite meets UL94 flammability and RoHs compliance.

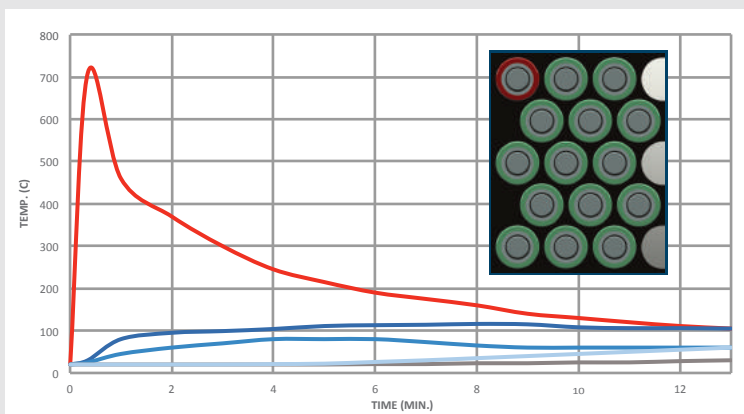


OUTLAST® LHS® BATTERY MATRIX & SHEETS – TYPICAL PROPERTIES

TYPICAL PROPERTIES

	LTX	HTX20
DENSITY:	1.22 g/cm ³	1.27 g/cm ³
HARDNESS, SHORE D:	55D @25°C/15D @ 70°C	60D@25°C/ 45A@70°C
SPECIFIC HEAT:	2.1 J/g°C	2.1 J/g°C
PHASE TRANSITION TEMP.:	40-44°C	56-58°C
HEAT OF FUSION:	65-70 J/g	100-105 J/g
THERMAL CONDUCTIVITY:	<0.4 W/mK	<0.4W/mK
ELECTRICAL BULK RESISTIVITY:	5.89X10 ¹¹ Ω cm	6x10 ¹¹ Ω cm
FLAMMABILITY:	UL94	UL94-V0
ROHS COMPLIANCE:	COMPLIANT	COMPLIANT

THERMAL RUNAWAY PROTECTION



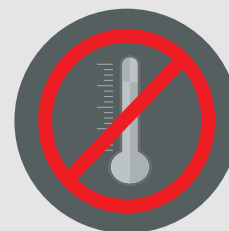
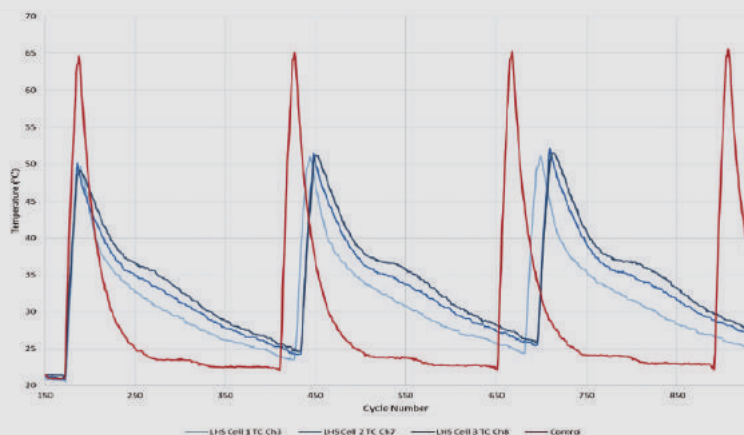
ELIMINATES ADJACENT BATTERY IGNITION FROM SHORT CIRCUITED BURNING CELL

- CELL 1 - Corner Trigger Cell
- CELL 6 - Adjacent Cell
- CELL 2 - Adjacent Cell
- CELL 3
- CELL 5

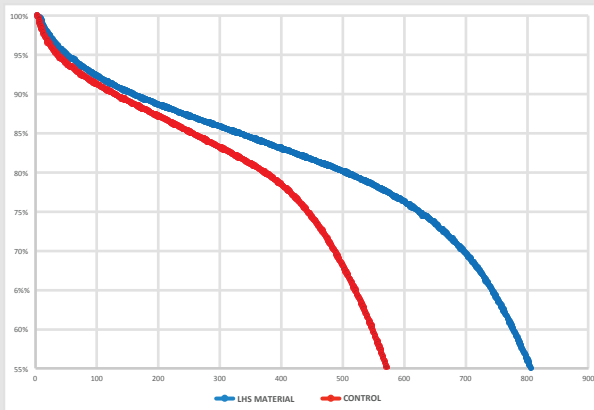


CELL SURFACE TEMPERATURE PROFILE

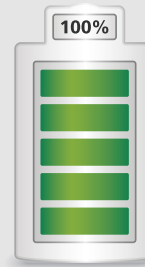
LHS® MATRIX YIELDS LOWER AND HOMOGENOUS CELL TEMPERATURES ACROSS THE BATTERY PACKS



INCREASED BATTERY LIFE



>40% INCREASE IN CYCLE LIFE
ABOVE 75% DISCHARGE CAPACITY



OUTLAST® FILL AND FLOW MATERIALS

Outlast® LHS® materials provide passive energy absorption, thermal mitigation homogeneity, and safety. The LHS Fill & Flow materials may be heated and poured into a sealed environment providing exceptional latent heat and flame retardant properties. These materials are not shape stable.



OUTLAST® LHS® FLOWABLE: TYPICAL PROPERTIES

LHS FR F&F PRODUCT	LHS F&F FR-89	LHS F&F FR-90	LHS F&F FR-91	LHS F&F-89	LHS F&F-90	LHS F&F-91
Phase Transition Temperature*:	35-40°C	44-48°C	55-60°C	36-37°C	42-45°C	49-51°C
Latent Heat:	160-170 kJ/kg	160-170 kJ/kg	160-170 kJ/kg	190-210 kJ/kg	190-210 kJ/kg	200-220 kJ/kg
Specific Gravity @ 22°C:	1.1	1.1	1.1	0.8	0.8	0.8
Viscosity (cps): ¹	20-40	30-60	50-90	25-100	25-100	25-100
Operating Temperature Range:	-10-120°C	-10-120°C	-10-120°C	-10-120°C	-10-120°C	-10-120°C
Thermal Conductivity:	<0.5 W/mK	<0.5 W/mK	<0.5 W/mK	<0.5 W/mK	<0.5 W/mK	<0.5 W/mK
Volume Resistivity:	5.89x10 ⁹ Ω cm	5.89x10 ⁹ Ω cm	5.89x10 ⁹ Ω cm	4.5x10 ¹¹ Ωcm	4.5x10 ¹¹ Ωcm	4.5x10 ¹¹ Ωcm
Dielectric Constant:	4.62	4.62	4.62	3.05	3.05	3.05
RoHS Compliance:	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Flammability	UL94	UL94	UL94	-	-	-

¹ viscosity determined at 20°C above the transition temperature.
*Other phase transition temperatures up to 130°C are available.

PROTECTED BY



LATENT HEAT SYSTEMS® (LHS®)



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