

# 3M™ Battery

# Enhancement Material

3M Automotive and Aerospace Solutions Division



Extended Driving  
Range



Quicker Charging  
Times



Extended Battery  
Lifespan

**About 3M**

**3M** Science.  
Applied to Life.™

# **Our Vision**

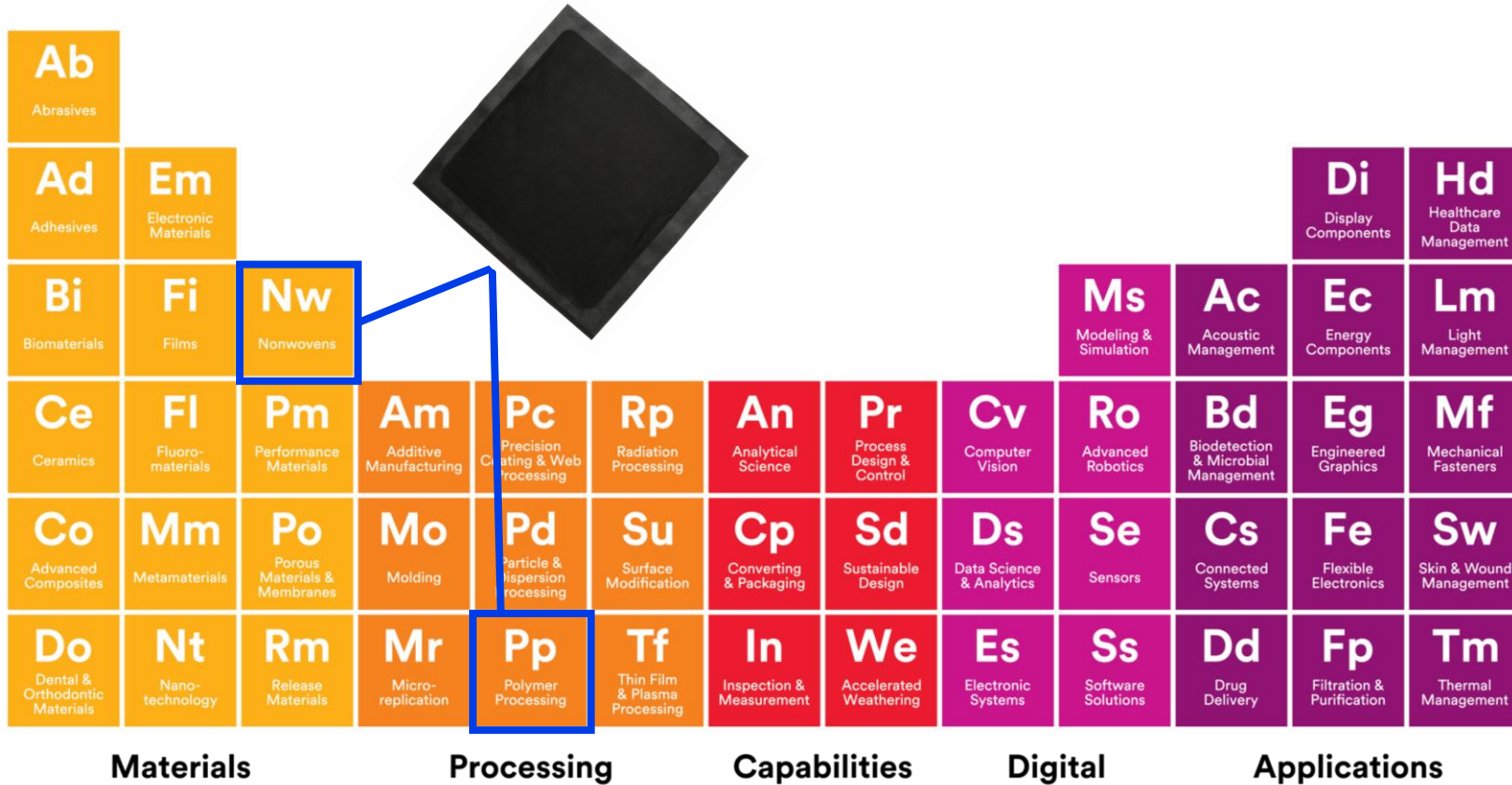
**3M Technology Advancing Every Company**

**3M Products Enhancing Every Home**

**3M Innovation Improving Every Life**



# 3M Technology Platforms



Today we leverage 23 technology platforms to power EV batteries

- Adhesives (Ad)
- Biomaterials (Bi)
- Ceramics (Ce)
- Electronic Materials (Em)
- Films (Fi)
- Fluoromaterials (Fl)
- Metamaterials (Mm)
- Nanotechnology (Nt)
- Nonwoven Materials (Nw)
- Performance Materials (Pm)
- Release Materials (Rm)
- Microreplication (Mr)
- Precision Coating and Web Processing (Pc)
- Particle and Dispersion Processing (Pd)
- Polymer Processing (Pp)
- Analytical Science (An)
- Inspection and Measurement (In)
- Process Design and Control (Pr)
- Sustainable Design (Sd)
- Accelerated Weathering (We)
- Energy Components (Ec)
- Flexible Electronics (Fe)
- Thermal Management (Tm)

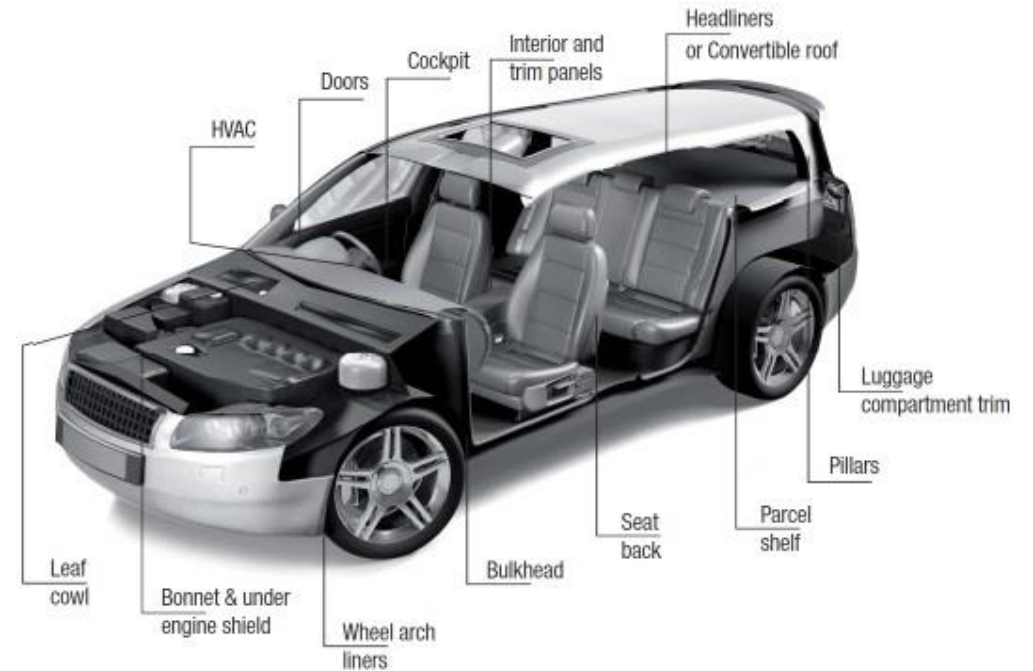
Successful new product growth builds on uncommon connections

# A True Global Supplier

Regional Supply in 5 Continents....



...Same High Quality Products



# Product Overview

# Improving vehicle range: 3M™ Battery Enhancement Material

Battery pack insulation minimizes the effects of outside extreme temperatures on lithium-ion battery cell performance to help maximize battery range and life



Thin



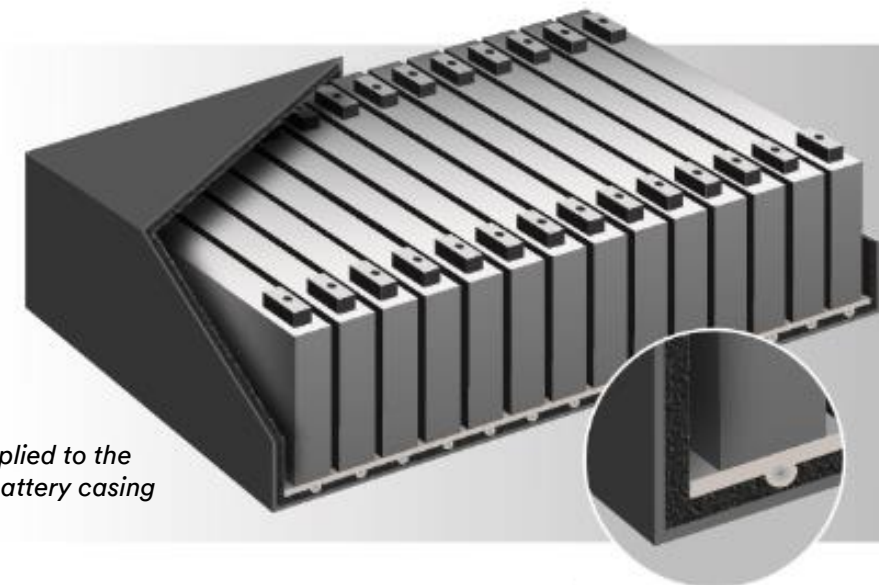
Conformable



Lightweight

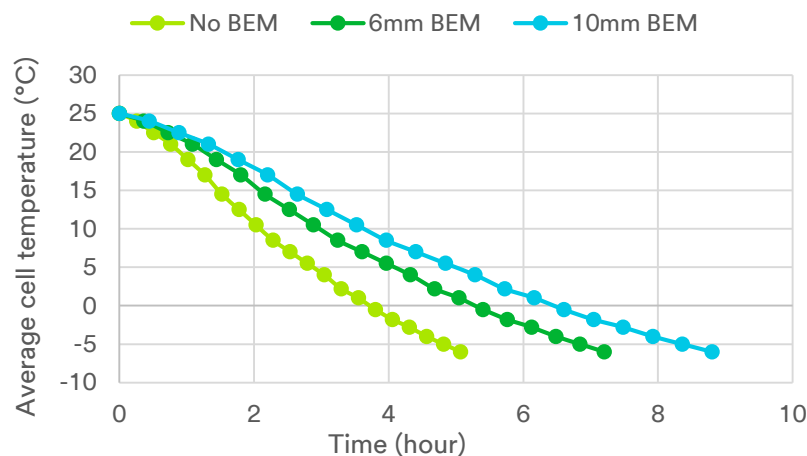


Flame Resistant



3M BEM applied to the inside of a battery casing

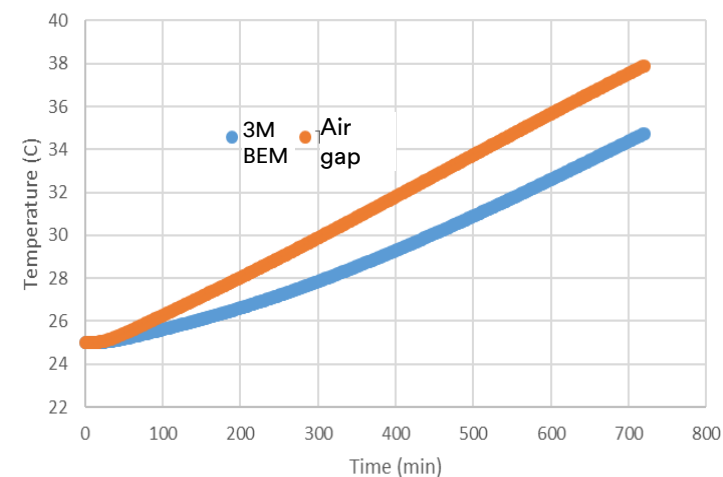
## Parked Car - Patagonia Winter Battery Cell Temp



\*Results from 3M BEV Battery Pack

- Battery placed in -30°C environment
- 3M BEM treatment in 2 thicknesses
- Keeping cell temp above 0°C helps reduce charge time / warm up time
- Insulating slows cell temp degradation

## Parked Car – Brazil Summer Battery Cell Temp



\*Results from Modeling Simulation

- Battery placed in 42°C environment
- 6mm 3M BEM treatment on all 6 sides of battery pack
- Preventing cell temp from reaching high temp can prolong battery capacity
- Insulating reduces cell temp increase

**Key Benefit: Insulating the battery pack reduces energy usage for cooling & heating at high and low temperatures by minimizing battery cell temperature swings**



# Product Overview

## 3M™ Battery Enhancement Material 1807S

- Thin, lightweight, and minimally fiber shedding passive thermal insulation for the battery pack
- Reduces battery usage for cooling, heating, and faster battery warm-up
- Enables extended driving range
- Offers flame resistance (UL 94 V-0)
- Offers high compressibility and recovery properties
- Provides excellent cavity filling
- Performs well in high temperature applications

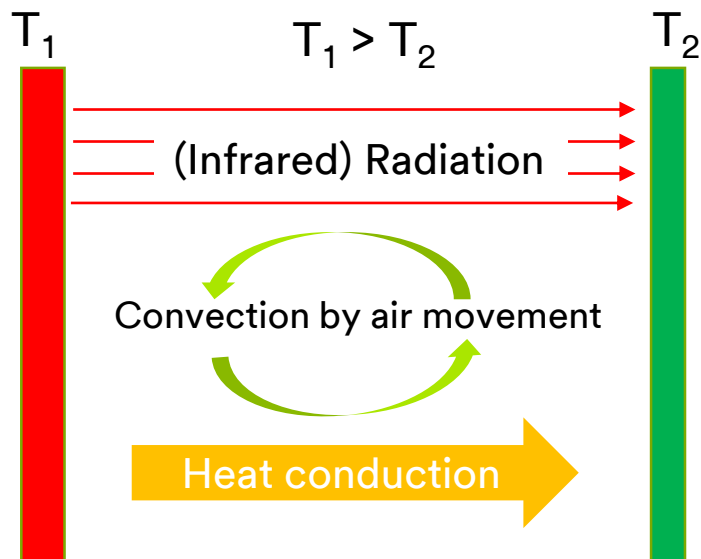


# How Does Our Material Work?

## Standard Materials

Standard materials have three channels of heat leakage from hot surface ( $T_1$ ) to cold surface ( $T_2$ )

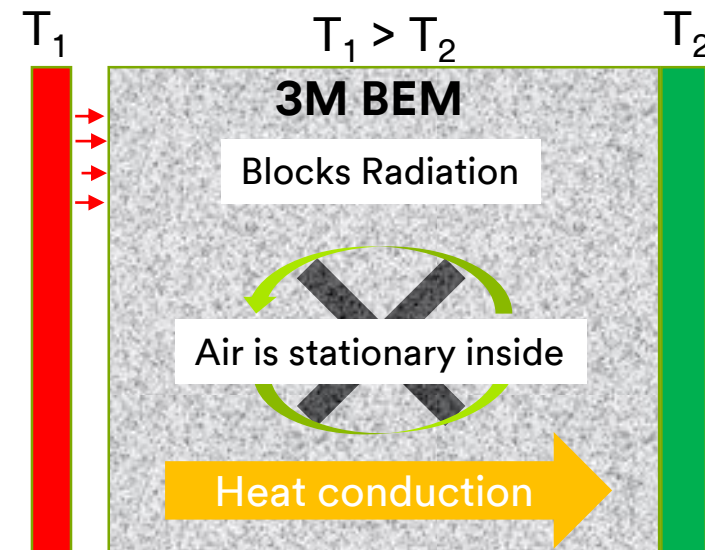
- **Radiation:** infrared light radiate from  $T_1$  to  $T_2$
- **Convection:** air circulation from  $T_2$  to  $T_1$
- **Conduction:** Conduction through air at thermal conductivity coefficient of around 0.026 W/K-m



## 3M™ Battery Enhancement Material 1807S

3M BEM blocks 2 of the 3 channels of heat leakage from hot surface ( $T_1$ ) to cold surface ( $T_2$ )

- **Radiation:** 3M BEM is opaque to block the radiation from  $T_1$  to  $T_2$
- **Convection:** air is stationary inside 3M BEM's microporous structures
- **Conduction:** Conduction through 3M BEM at thermal conductivity coefficient less than 0.35 W/K-m



# Features, Advantages, and Benefits

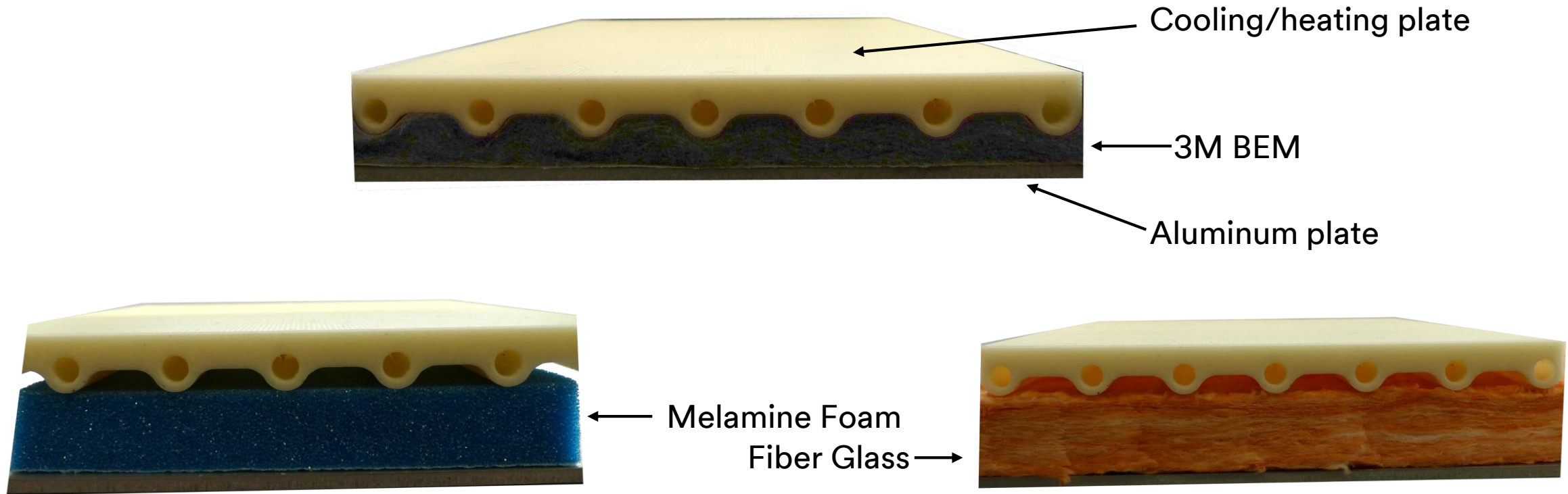
Feature	Advantages	Benefits
<b>Low thermal conductivity</b>	<ul style="list-style-type: none"> <li>• Good thermal insulation</li> </ul>	<ul style="list-style-type: none"> <li>• Helps maintain optimal temperature with the battery pack</li> </ul>
<b>UL 94 V-0 non-flammable</b>	<ul style="list-style-type: none"> <li>• Flame Resistant</li> </ul>	<ul style="list-style-type: none"> <li>• Helps customers design towards improved battery packs</li> </ul>
<b>Compressible and cavity filling</b>	<ul style="list-style-type: none"> <li>• Easy to conform to complex 3D shapes</li> </ul>	<ul style="list-style-type: none"> <li>• Less material required to meet thermal management targets</li> </ul>
	<ul style="list-style-type: none"> <li>• Better workability and ease of handling</li> </ul>	<ul style="list-style-type: none"> <li>• Does not require special handling associated with other solutions</li> </ul>
<b>Permeability</b>	<ul style="list-style-type: none"> <li>• Helps enable moisture control</li> </ul>	<ul style="list-style-type: none"> <li>• Helps reduce moisture within the battery cavity</li> </ul>
<b>Advance fiber technology</b>	<ul style="list-style-type: none"> <li>• Offers high performance, light-weight absorber</li> </ul>	<ul style="list-style-type: none"> <li>• Provides increased thermal management performance and acoustic absorption within the battery</li> </ul>
	<ul style="list-style-type: none"> <li>• High temperature resistant fibers</li> </ul>	<ul style="list-style-type: none"> <li>• Improved aging durability</li> </ul>
<b>Lightweight</b>	<ul style="list-style-type: none"> <li>• Lighter weight product than most current battery thermal management solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Helps OEMs meet weight reduction targets</li> </ul>
<b>Stable roll good</b>	<ul style="list-style-type: none"> <li>• Can be converted into shapes and configurations</li> </ul>	<ul style="list-style-type: none"> <li>• Design flexibility to meet any application needs</li> </ul>

# Key Feature: Light weight, highly compressible and highly conformable

- 3M BEM 1807S is less than 300 grams per square meter (gsm) in surface basic weight
  - Provides excellent cavity filling
- High compressibility and recovery properties allow 3M BEM 1807S to fit into the limited space available in battery packs
- Dust free encapsulation, minimal fiber shedding

Key benefits: weight saving properties help increase driving range

# Compressibility and Recovery Properties



Ease of compression and recovery allows 3M BEM to conform to irregular geometries



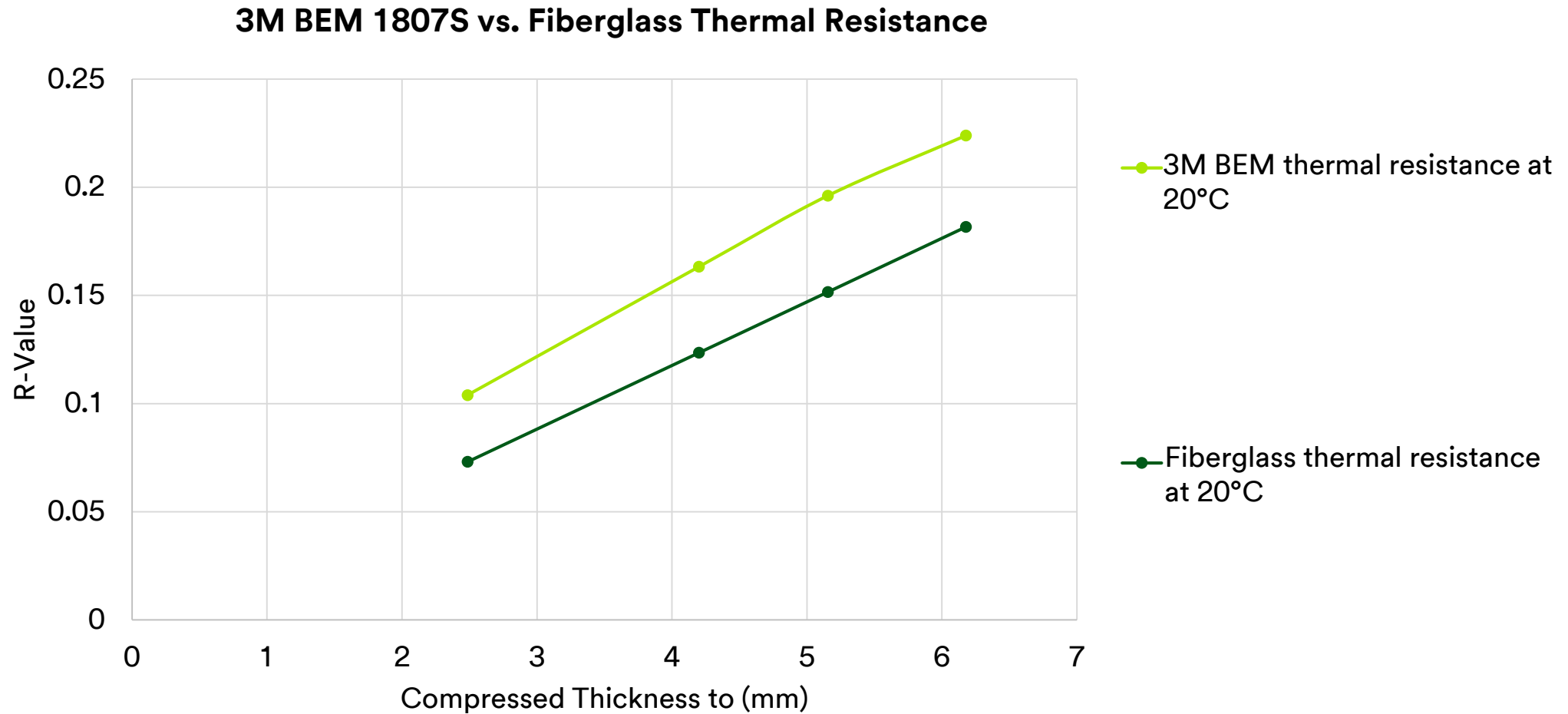
# Key Feature: Excellent thermal insulation performance

- Good performance in high temperature applications
  - Combined thermal conductivity coefficient less than 0.035 W/K-m at 25°C at the original thickness
  - Combined thermal conductivity coefficient 0.028 W/K-m at 25°C when compressed to half the thickness (original thickness is 6 mm)
  - Many battery packs can have an air gap, which can cause higher thermal conductivity when the temperature outside battery pack is different than inside the battery pack
  - 3M BEM thermal conductivity decreases the more it is compressed

Key benefit: better thermal insulation reduces battery usage for cooling, heating and faster battery warm-up

# Thermal Performance

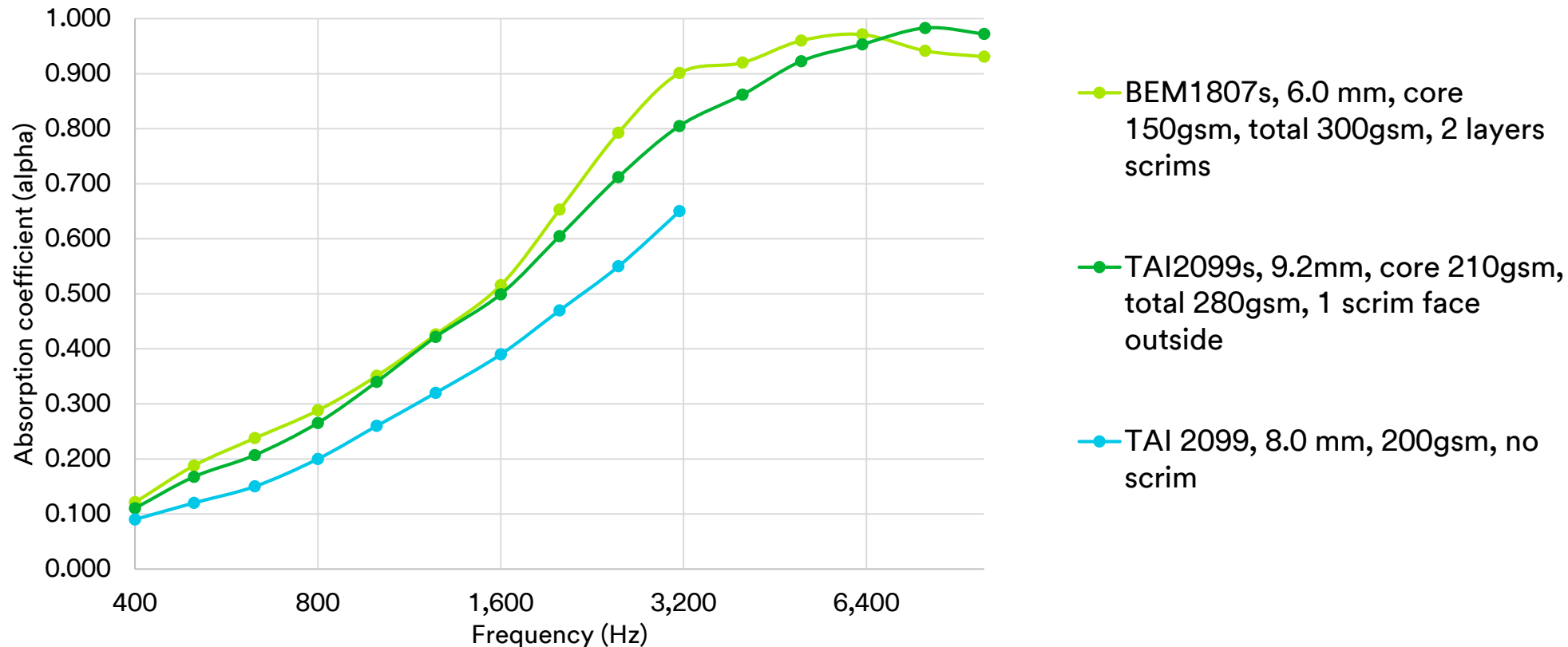
3M BEM vs. fiberglass thermal performance at varying thickness



# Acoustic Absorption of 3M BEM

## Alpha Cabin Test Following SAE J2883 Standard

### Random Incidence Sound Absorption Testing



3M BEM has good acoustic properties compared to Thinsulate™ Acoustic Insulation of similar basis weights and thickness

# 3M BEM for the Battery Thermal Management System

## Background Information and Testing

- Current Thermal Management Systems (TMSs) use dynamic thermal control (i.e. battery energy)
- Battery enhancement materials will make the battery TMS more efficient by controlling the battery optimum temperature range longer without drawing battery power
- This enables:
  - Less battery cooling usage
  - Less battery heater usage
  - Increased driving range
- We continue to push the boundary to provide thin, lightweight insulation
  - Flame resistant – (UL 94 V-0)
  - High temperature performance

# Product Properties

## 3M™ Battery Enhancement Material 1807S

### Typical performance data

	Typical Value <sup>A</sup>	Test Method
<b>Color</b>	Black	Visual
<b>Basis weight</b>	290 gsm	Mass per unit area
<b>Initial Thickness<sup>B</sup></b>	6 mm	SAE J1355
<b>Thermal properties: R-Value<sup>C</sup>   K-Value<sup>D</sup></b>	> 0.17 m <sup>2</sup> K/W   < 0.035 W/mK @ nominal thickness	ASTM C518
<b>Surface Electrical Resistance<sup>E</sup></b>	1.1X10 <sup>9</sup> ohm @ 25°C, 50% RH	ASTM D257, GB/T 1410
<b>Flame resistance</b>	Pass	UL 94 V-0

A: All the property value here are the Typical Value; not a standard value, but test data from 3M lab.

B: Nominal thickness is measured using a 12 in<sup>2</sup> plate with 0.002 psi applied to the sample per SAE J135.

C: R-Value is the thermal resistance of the insulation measured at the corresponding thickness per ASTM C518.

D: k-value is thermal conductivity of the insulation material per ASTM C518

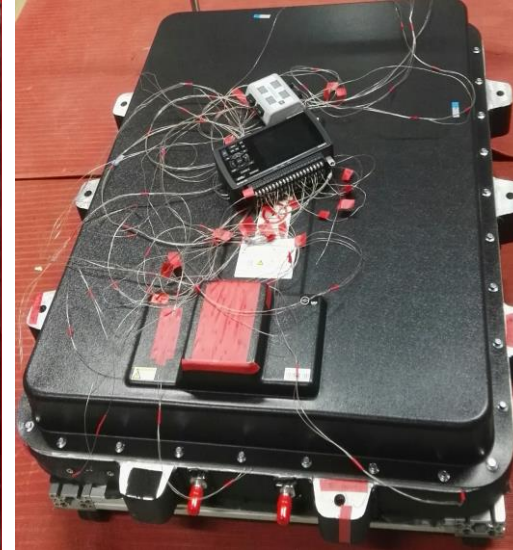
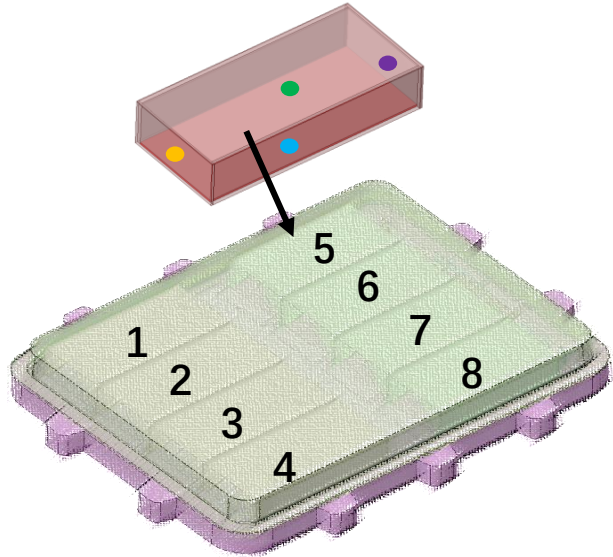
E: The surface Electric resistivity may change under different temperature and humidity condition.





**Test Data**

# Battery Pack Heat Preservation Test

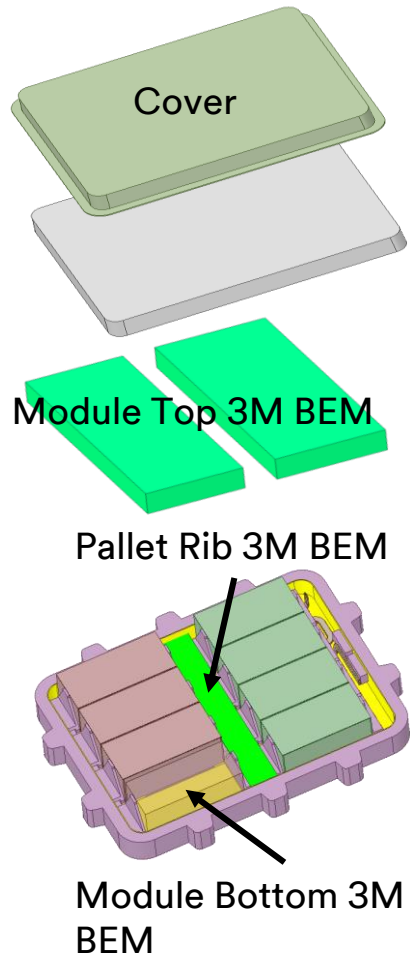


## Testing condition and procedure

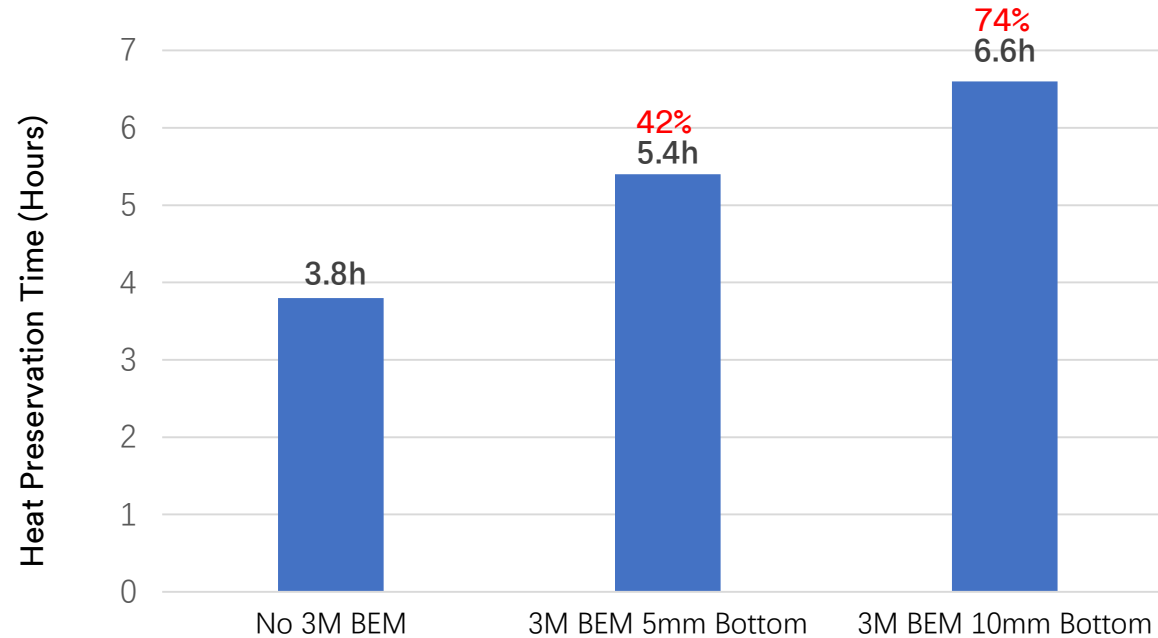
- Chamber temperature is set as  $-30^{\circ}\text{C}$
- Temperature monitoring points are on the busbar of the battery modules
- Battery pack gets stable temperature of  $23^{\circ}\text{C}$  before putting in the chamber
- Put the battery pack in the temperature chamber, then monitor the temperature decreasing curve, record the time when the monitoring points hit  $0^{\circ}\text{C}$ , named “Heat Preservation time”

# Heat Preservation Test Results – Internal 3M Tests

## 3M BEM Solutions



## Heat Preservation Time Testing Results



## Test results

- Original solution **without 3M BEM** is 3.8 hours
- 3M BEM coverage with 5mm bottom thickness prolongs the time to 5.4h, 42% increase
- 3M BEM coverage with 10mm bottom thickness prolongs the time to 6.6h, 74% increase



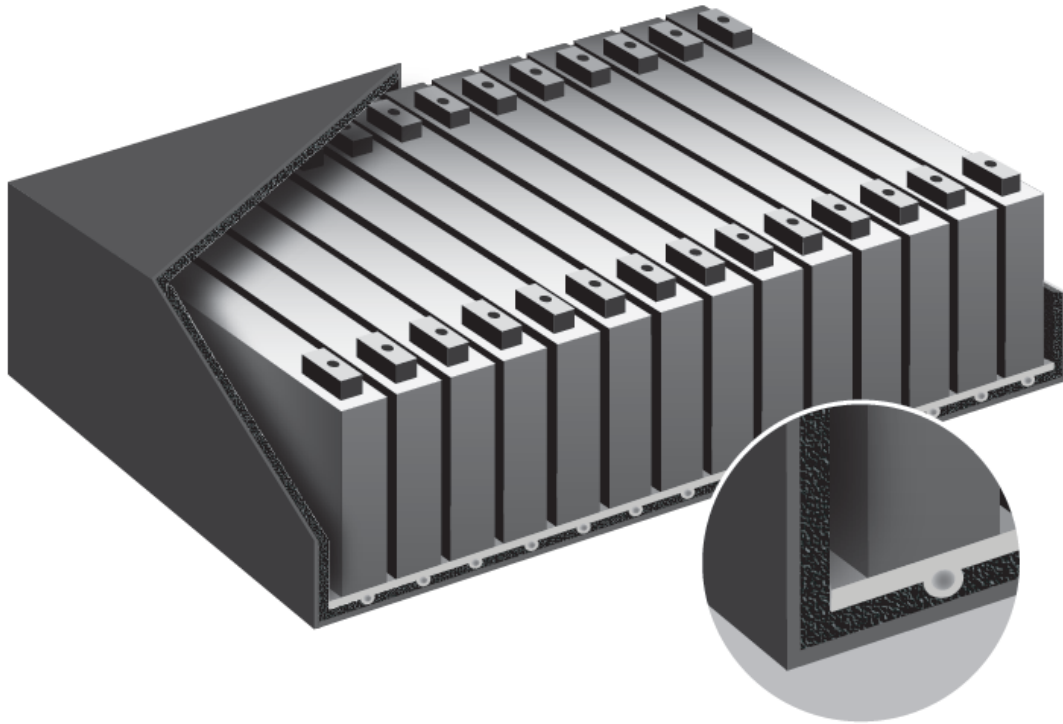
# Additional Test Methods

- **Warm Up Time**
  - In-vehicle test
  - Measure time and amount of energy used for battery to heat up from -20°C to 10°C
  - Compares 3M BEM to Air Gap (no insulation)
  
- **Charging time**
  - In-vehicle test
  - Measuring amount of time to charge from 10% to 90% after being parked outside overnight in winter

# Application Information

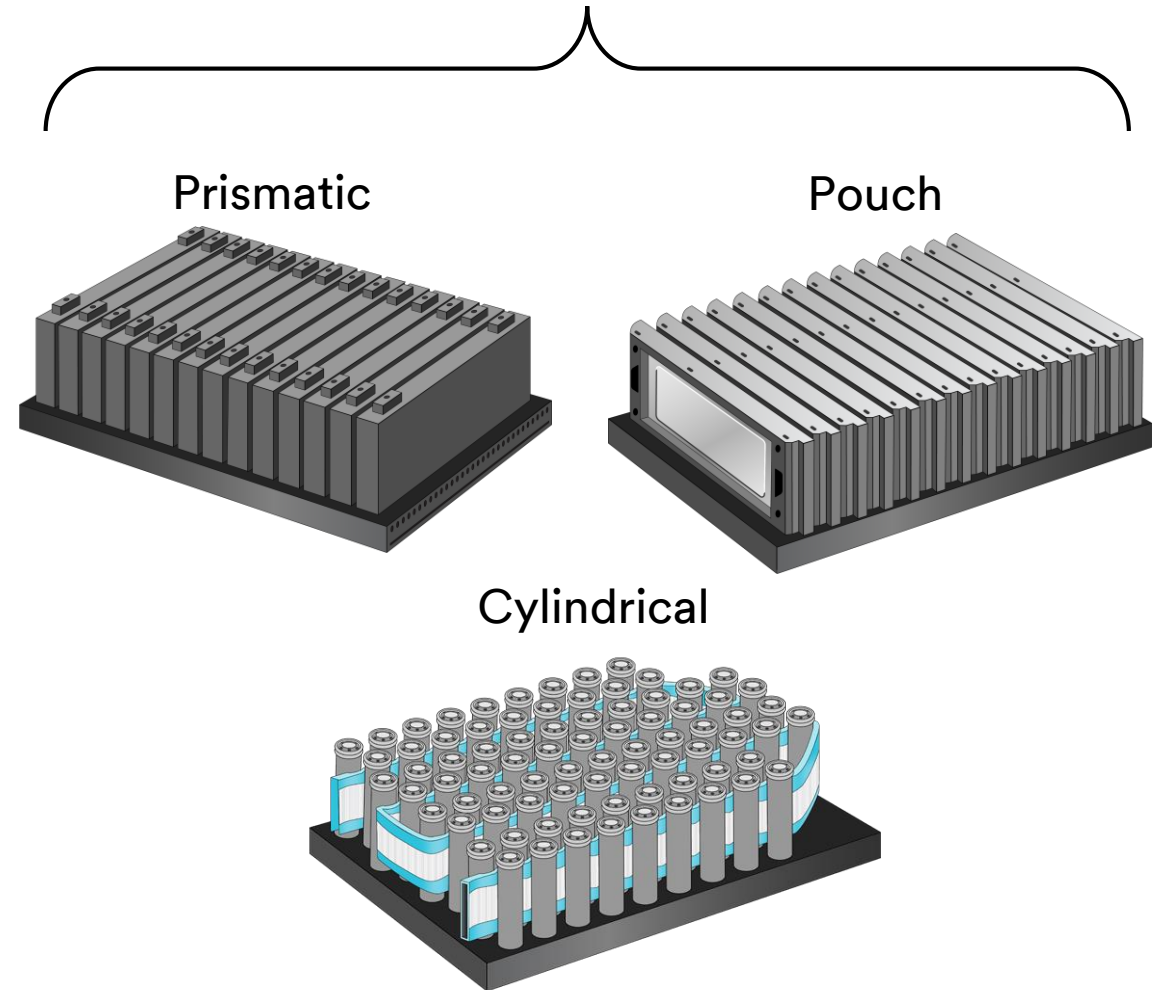


# Potential Applications



3M BEM can be placed on the bottom, top or all around the battery pack.

3M BEM can be used in all of these types battery for thermal insulation



# 3M BEM Application Video



[Click to play](#)

This video shows 3M BEM being applied to the base of the battery pack. It can also be placed in the lid or all around the battery module.

# Where does 3M Battery Enhancement Material go?

## Battery Anatomy

- Full Electric Vehicle pack size = 2 Meters x 1 Meter
- Includes a Heating & Cooling System
- All battery packs have an air gap between pack lid and battery modules



3M Battery Enhancement Material applied during battery pack assembly on to lid or wrapped around module

# Application Guidelines

## How do I use 3M BEM?

3M BEM is wrapped around the battery to thermally insulate the battery from outside environment. It is used in applications where UL 94 V-0 flammability rating is required.

## How much material do I need?

The amount of material required varies based on the battery size and thermal management requirements. Please work with a 3M Application Engineer for specific applications.

## Where do I put 3M BEM?

3M BEM can be placed on the bottom, top or all around the battery pack.

## How much more effective is 3M BEM if I wrap it around the whole battery pack instead of only applying it on top?

If 3M BEM is placed only on top of the battery pack, the preservation time is 5 hours. By adding 3M BEM to the bottom of the battery pack, the preservation time will increase to 7 hours, which is a 40% increase in time.

## What is the temperature range the material can handle?

-40°C - 150°C. Tested at -40°C for 24 hours; at 150°C for 168 hours; and 120°C for 500 hours.

# Application Guidelines

## **Is a special environment required when I apply this material?**

3M BEM should be installed at less than 50% humidity level.

## **What's the minimum amount of space I can have in the battery pack?**

Our 3M BEM can be used in a gap of < 2 mm.

## **What is the mounting method?**

You can use a double-sided adhesive tape on the whole side or a partial area to mount 3M BEM.

## **What is the attachment method?**

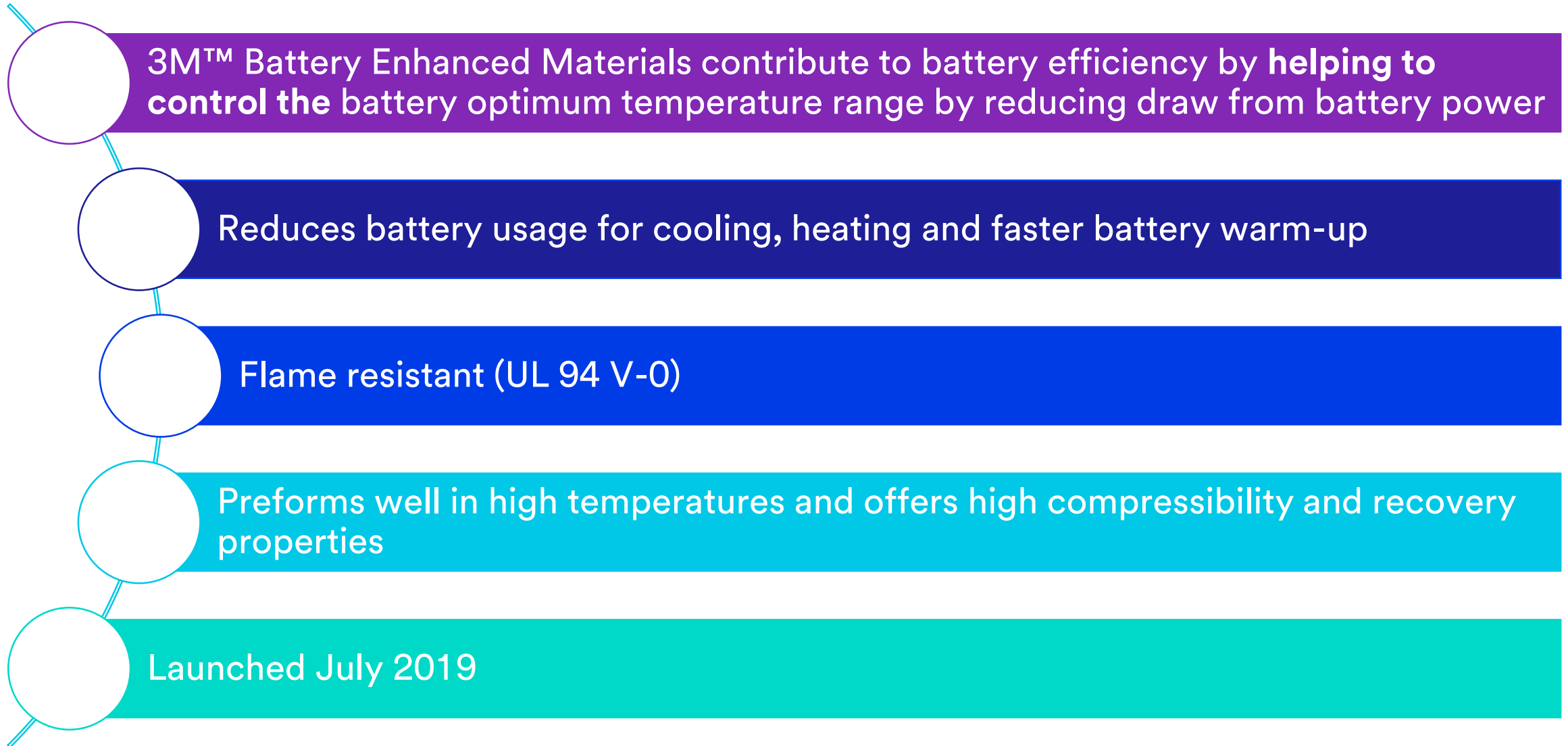
3M BEM can be attached using a double-sided adhesive tape.

## **Does 3M BEM go over or under the cooling plate?**

3M BEM is typical applied under the cooling plate.



# Summary



**Thank you!**

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Automotive and Aerospace Solutions Division  
3M Center  
St. Paul, MN 55144-1000  
Phone: 1-800-328-1684  
Web: [www.3M.com/evbattery](http://www.3M.com/evbattery)

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