USABC Li-Ion Battery Thermal Management System Requirements

The technical specifications provided in Table 1 will be used to guide and evaluate the development of battery thermal management technologies. While conventional approaches (e.g. air or liquid convention) still have room for improvement, emerging solutions requiring additional development – such as direct thermal exchange (i.e. immersion cooling, dielectric coolant systems), integrated two-phase solutions (i.e. heat pipe, vapor chamber, flow boiling), low-cost refrigerant/heater, etc. – are encouraged. Furthermore, the noted metrics are to evaluate pack-level performance; however proposals are required to estimate additional necessary loads to the vehicle system (e.g. electrical power, pumps, condensers, etc.).

Table 1. USABC Li-ion battery thermal management system gap chart

			USABC Goals*				
Program Targets		**Units**	**EV**	**PHEV**			**Program Target**
Key Parameters	**Parameter Details**			**PHEV-20**	**PHEV-40**	**xEV-50**	
Operational Life @30°C		[years]	15				
Operating Environment†		[°C]	-30 to +52				
Pack Temperature Uniformity	ΔT: Cell-to-Cell	[°C]	< 3				
Cell Temperature Uniformity	ΔT: Cell Surface	[°C]	< 3				
System Efficiency	Ambient (unconditioned)	[ratio] Q/P‡	> 15				
	Active		> 4				
Weight	Pack Components	[kg]	< 5.3	< 5.6	< 9.6	< 12	
Volume	Pack Components	[L]	< 13.5	< 11.75	< 20	< 25	
System Cost	@250k units	$	< 112	< 44	< 68	< 85	

* *Developer to select one system application (PHEV or EV) for the proposal and align with existing RFPI battery performance targets as listed on the USABC website, http://www.uscar.org/guest/article_view.php?articles_id=85*

† *Temperature range of normal operation with extended considerations for the system survival temperature range of -46*°C *to +66*°C as noted in the respective system test manual, *http://www.uscar.org/guest/article_view.php?articles_id=86*

‡ *Ratio of heat transfer rate (removed, in Watts) vs. electrical power (Watts)–**see details below***

Definitions:

- **Pack Temperature Uniformity (ΔT: Cell-to-Cell)** – The homogeneity of cell temperatures measured throughout the battery pack [= Max Cell Temp – Min Cell Temp]. The amount and locations of measurements to be further defined in the scope of work phase of the project with dependence on the associated EV or PHEV system selected as well as dependence on the cell type.
- **Cell Temperature Uniformity (ΔT: Cell Surface)** – The homogeneity of the cell's temperature measured in at least three separate locations on the cell's surface (to be further defined in the scope of work phase of the project with dependence on cell type).
- **System Efficiency (Ambient vs. Active)** – The ratio of the heat transferred (Q, in Watts) from the system vs. the electrical power (P, in Watts) used by the vehicle to remove said heat.
  - In an **Ambient (unconditioned) System** no energy is used to thermally manage the cells, modules, or pack except for the energy used in moving the thermal fluids (e.g. by pumps, fans, etc.); thus the electrical power (P) used relates to the fluid flow in the battery thermal management system.
  - In an **Active System** energy is used directly for cell/battery thermal control in addition to the electrical energy for moving fluids; thus the electrical power (P) is the sum of direct thermal control plus the power to move fluids.
- **In Pack Components Only** – Components that are connected and encased within the battery pack housing for the purpose of thermal control (e.g. cold plates, sensors, etc.).
- **Pack + Vehicle Connections** – Components and connections identified in "In Pack Components Only" and any items external to the battery pack housing for thermal control (e.g. fans, pumps, heat exchangers, communications, etc.).

Additional Development Considerations:
As Table 1 details the quantitative rubric in which awarded programs will be evaluated, the following considerations are encouraged to advance the state of the art. These items are less quantifiable in traditional improvements, but highlight technical challenges in battery thermal management technology.

- Development and implementation of thermal interface materials with through-plane thermal conductivity >15 W/m-K (ensuring electrical isolation as necessary) enhancing tradition cell-to-thermal management system heat transfer maintained through system lifetime requirements.
- Development and implementation of viable approaches to high heat transfer convection at the cell, effectively reducing cell-to-thermal management system thermal resistance, while maintaining electrical isolation of the cell(s).
- Development and implementation of embedded, integrated, or scalable interconnected thermal sensing mechanisms for cell-to-battery pack state monitoring.