



UNITED STATES ADVANCED BATTERY CONSORTIUM LLC

**DEVELOPMENT OF AN ADVANCED MICROPOROUS SEPARATOR
FOR LITHIUM ION BATTERIES USED IN VEHICLE APPLICATIONS**

REQUEST FOR PROPOSAL INFORMATION (RFPI)

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1.0 Statement of Purpose/Objectives

The United States Advanced Battery Consortium (USABC) was formed in 1991 to sponsor development of advanced high-performance batteries for Electric Vehicle (EV) applications. USABC has carried out a number of battery development programs, focusing on low-cost, long-life, high-energy, high-power technologies, including several programs in which the development of improved electrolytes was critical to the successful outcome of the program. The USABC, in recognition of the importance of the separator to advanced battery systems, intends to further extend development of this critical component.

The purpose of this RFPI is to identify developers having Li-ion battery separator technologies which have the capability of meeting the USABC goals for Li-ion battery separators, as listed in the attached Appendix, as well as meeting USABC cell performance targets when employed in an appropriate battery cell. The USABC expects that this work will be partially funded by the US Department of Energy through a cooperative agreement awarded to the USABC. The USABC is currently working under a cooperative agreement with the United States Department of Energy (USDOE) for the development of high performance batteries. The USABC has concluded that it is now appropriate to solicit proposals from separator developers who have the potential of meeting the criteria noted in the Appendix.

The USABC intends to capitalize on the knowledge it has gained through the HEV, PHEV, and EV research and development activities it has been engaged in. We expect developers to bring past experiences and lessons learned from their high power and/or high-energy work to bear on developing energy storage technologies for this application.

2.0 Business Objectives

This USABC RFPI represents a unique opportunity for developers to leverage their resources in combination with those of the automotive industry and the federal government. For the auto makers, this type of pre-competitive cooperation minimizes duplication of effort and risk of failure, and maximizes the benefits to the public of the government funds.

Beyond the efficient and timely usage of resources, the auto makers recognize that successful commercialization of these technologies will only be completed when a supplier base has been established for the selected components and subsystems. It is, therefore, a major business objective of USABC to enhance a supplier base as the development progresses. All developers submitting proposals will be requested to demonstrate that they have the potential to develop a commercially viable business, which can produce sufficient volumes to meet automotive requirements, and provide engineering and testing support to meet automotive implementation

requirements. Research and other organizations with current, direct affiliations with businesses that derive a majority of their income from related product sales, will also be considered. At the time of submittal, all developers will be required to have demonstration hardware and test results available for USABC inspection. Testing performed in accordance with the USABC battery test procedures is preferred, however not mandatory. Inspection and testing of samples by the USABC may be included in the selection process. Developers who do not have test results available for examination by USABC at the time of submittal need not respond. Proposals should be meaningfully different from other proposals previously offered to USABC.

3.0 Developmental Timing

The proposals must be accompanied by a development time chart specifying the following:

1. Length of time the technology has been under development by the developer;
2. Projected length of time remaining to full scale availability; and
3. Projected time line for commercialization, including any preproduction phases that may be planned.

4.0 Business Case

The submittal must be accompanied by a business case, divided into two sections. The first section shall state the cost assumptions used that will lead to the cost targets listed in the Appendices. These assumptions should be in general terms, broken down by major components, including material cost, processing cost and other costs. These costs should be presented in sufficient detail such that they can be used by the USABC to build confidence that its cost targets can be met by the proposed technology.

The second portion of the business case should address the anticipated capital investment required to support this initial program investment, including anticipated non-EV markets for the technology, sources of capital, etc. A copy of the USABC cost model, which is a multi-stage spreadsheet, is available on the USABC website:

http://www.uscar.org/guest/article_view.php?articles_id=143.

Please note that USABC will not provide funding for capital expenses.

5.0 Technical Challenges

Proposals must be accompanied by a clear description of the remaining technical and other challenges that the developer still needs to meet in order to commercialize the proposed technology and meet USABC's long-term criteria. A narration of the technical challenges that have already been met in order to reach the present state of development will also be useful. Any testing, by USABC, of pre-contract demonstration hardware will be done in accordance with the USABC battery test procedures. These procedures can be found on the USABC website, http://www.uscar.org/guest/article_view.php?articles_id=86.php?articles_id=86.

6.0 Information Requested

The information USABC is requesting from interested parties is specified in the following subsections. It includes: (1) a brief description of your company(s) background; (2) a description of the advanced separator technology being proposed; (3) the development plan for the technology; (4) the proposed program deliverables, timing, and cost-share; (5) any formal or informal teaming/partnership arrangements planned, and (6) acknowledgement of export control compliance. Note that the ultimate testing and technology demonstration of the novel separator technology must occur in cell formats and sizes of automotive interest (12 V, 48 V, PHEV or EV). Relevant information regarding USABC performance targets can be found on the USCAR website, at

<http://www.uscar.org/guest/teams/12/U-S-Advanced-Battery-Consortium-LLC>.

Therefore, a partnership between the separator developer and a cell fabricator with a proven track record (of the developer's choice) is a necessary condition for separator program approval.

USABC does not expect to award contracts on the sole basis of responses to this RFPI. All responses will be considered by representatives of the partners and other participants, and will be ranked according to their merit. The submitters of the most promising proposals will be contacted by USABC to enter into negotiations that may lead to firm contractual arrangements. If the government and other funding become available, as now expected, USABC intends to award one or more development contracts. However, nothing herein should be interpreted as a commitment to award a contract.

The information requested below should be answered as thoroughly as possible within a maximum of twenty-five pages, in total, for the response to the RFPI. Your submission package should be sent via electronic mail and shall contain a cover letter, a complete copy of your proposal and, a signed copy of the RFPI Agreement. All technical and financial material submitted to the USABC must be in the English language. If you have any questions concerning the RFPI, please contact Ion Halalay @ (586) 533-0483 or Maureen LaHote @ (313) 910-3720.

NOTWITHSTANDING PROPOSER'S MARKINGS TO THE CONTRARY, ALL INFORMATION SUBMITTED IN RESPONSE TO THIS USABC RFPI SHALL BE TREATED ON A NON-CONFIDENTIAL BASIS.

ALL PROPOSALS ARE TO BE SUBMITTED TO THE CONSORTIUM IN ACCORDANCE WITH THE ATTACHED RFPI AGREEMENT WHICH MUST BE EXECUTED WITHOUT MODIFICATION AND ACCOMPANY THE PROPOSAL. NO PROPOSAL SHALL BE EVALUATED BY THE CONSORTIUM WITHOUT PRIOR EXECUTION OF SUCH RFPI AGREEMENT.

SEND, VIA ELECTRONIC MAIL, YOUR PROPOSAL (including signed RFPI Agreement) TO:

Maureen LaHote
Business Manager
United States Advanced Battery Consortium E-mail:
mlahote@uscar.org

6.1 Company Background

In order to become fully familiar with your company(s), the USABC needs information about your business. If your proposal is for a team, furnish the requested information for each company that makes up your team. Please answer/furnish the following information:

- Describe your company's structure, ownership, product lines, and customer base, including domestic and foreign facilities for research and production.
- Please describe how previous R&D successes (especially with USABC or DOE) have been incorporated into the current proposal.
- Please describe the company's experience (if any) in the high volume manufacture of Li-ion battery separators.
- If publicly owned, include the last 3 years of Annual, 10k, and 10Q Reports. If privately held, include the last 3 years of Balance Sheets, Income Statements, and a Sources & Uses of Funds Statement.
- Enclose a copy of your company's Business Plan for areas related to electrochemical energy storage technology.
- Describe the resources (headcount, expenses, and facilities) devoted to electrochemical energy storage technology development for the previous three years, currently, and forecasted through 2016.
- Describe the modeling methods your company uses to estimate costs at sales volumes of 10M m²/year and greater.
- Do you currently hold any licenses and/or patents or pending patent applications for advanced electrochemical energy storage technology and manufacturing processes? If so, please describe. Are there any restrictions on licensing this technology to the Consortium?
- Provide any projections on potential production for the proposed technology. Also, describe key technical innovations that could lead to high performance and cost effective electrochemical energy storage subsystems.
- Provide a brief resume on key personnel to be dedicated to the project.

6.2 Proposed Separator Technology

The proposed separator technology should provide a significant improvement over current separators for lithium-ion batteries in one or more of the following areas: (1) cell cycle life, calendar life, and power; (2) cell abuse tolerance; (4) high-voltage (5.0 V) stability; (4) cost (<\$0.60/m²). These improvements must be demonstrated while maintaining or exceeding current state-of-the art separator parameters in the other areas.

A thorough technical review of each proposed technology is required prior to the award of any contract for development. In preparing a reply to the RFPI please provide a response to each of the following points.

Provide a brief technical description of the proposed technology that will meet the separator goals and characteristics listed in the Appendix.

Summarize the present status of the proposed technology, with experimental data and test methods used to acquire the data, including:

- Physical, performance, and life characteristics of all relevant formulations developed and tested at your facilities, or at independent test facilities.
- Any environmental and safety issues relating to manufacturing, recycling, use and disposal of the proposed technology.
- Dominant failure mechanisms that limit the operating life of lithium-ion batteries using this technology, and use restrictions desired/required to maximize the life of the subsystem.
- Summarize the characteristics of the current technology by using Table 1 provided in the Appendix.
- Provide any relevant quality-related metrics.

6.3 Proposed Technology Development Plan

Propose how the technology would be developed to meet the USABC technical criteria including:

- Barriers that must be overcome (should be closely based on the objectives listed in the Appendix);
- Task objectives needed to overcome the barriers, approaches, success criteria, and demonstration tests (A work breakdown structure is helpful but not required.);
- Feasibility and scale-up issues that must be resolved; and

- Transition from feasibility demonstration to prototype hardware.

Separately propose how the technology could be produced in high volume. Define the raw materials, processes, capital equipment, and labor required at the desired production levels. Discuss the overall timing required to achieve initial production, including prove-out. Define any intermediate steps required to reach initial rated production including pilot plants, technical challenges regarding the manufacturing process, and their time frame.

Define any additional technical issues, and their possible resolution, concerning the proposed technology relevant to vehicle applications. Propose a warranty structure for the subsystem corresponding to the initial commercial production level.

Provide a projected cost breakdown of the proposed technology, including costs projected for the desired production volumes. Costs related to warranty and/or replacement, and recycling should be clearly indicated. The manner in which the projected costs, volumes and time schedules are expected to be achieved should also be provided.

6.4 Proposed Program Schedule, Deliverables, Cost, and Cost Sharing

Developers must clearly identify their milestone objectives. The setting of major milestones and timing will be reviewed and agreed upon between each USABC Work Group and the corresponding subsystem developer/supplier team. It is anticipated that there will be intensive interaction between both parties in setting program milestones. The involvement of all team member organizations in the setting of program milestones is strongly encouraged.

The delivery of separator material and/or battery samples for testing and evaluation will be established with the selected developer(s) and the USABC Work Group. The evaluation of deliverable separator material samples will be undertaken at several testing facilities, such as the various National Laboratories and other USABC partners. The cell test schedule will be agreed upon by the USABC Work Group, the separator developer, and the test facilities.

It is expected that an initial separator sample, of sufficient quantity for testing, will be delivered within the first month of the program and, subsequently, at six months intervals over the program's duration. Additionally, material hardware deliverables will be used to demonstrate and evaluate the performance of the separator in a viable cell (preferably in pouch cell format of 2 Ah size or larger for electrochemical performance; and 10 Ah or larger for thermal abuse tolerance testing). Developers who do not have the experience or capability to make the agreed upon number of viable cells are required to find partners with a proven track record of producing commercial Li-ion batteries. The USABC can, upon request, recommend experienced cell manufacturers.

The USABC is interested in advancing the development of commercially viable energy storage products, and prefers to focus on technologies, including cell chemistries, that are most likely to achieve commercial success in the near term. The current cell chemistry of particular interest is a NMC cathode paired with a graphite anode, although other chemistries may be proposed and/or selected. The preferred positive electrode for high-voltage cells is LNMO spinel, paired

with a graphite negative electrode. The developer should be able to clearly explain the rationale behind the selection of battery couples other than NMC/graphite or LNMO/graphite. The developer must clearly identify the cell to be delivered. The details should include the intended electrodes, separator, electrolyte package, the size and format of the cell, and where they will be built. The goals listed in the Appendix represent the minimum required values that every program must achieve, unless specifically stated otherwise. In addition, it is also expected that successful programs will significantly advance the state of the art in Li-ion battery separators cost and/or battery cell performance.

All Developers are expected to contribute or cost share in the developmental costs. The Developer should submit proposals indicating cost sharing as a percentage of the total proposed program development amount. The extent of cost sharing may be negotiated between USABC and the development team, taking into consideration whether the company is domestic, foreign, or foreign controlled, rights to license background and foreground technology, benefits to US economy, and other factors. However, a minimum of 50 percent developer cost share is contractually required. The Developer will agree that at least 75% of the direct labor billed to the USABC for this project will be incurred within the United States.

The proposer shall provide cost breakdown between labor, materials, indirect costs, etc. and a separate analysis of total costs for each major task. The tasks that each subcontractor will complete and the funding they will receive should be clearly indicated in the cost breakdown.

Contractors will provide written quarterly reports to USABC, including test data and development progress. Additional reporting (i.e., oral) will be scheduled with the USABC work Group. A final written report will be submitted to USABC at the end of the contract period.

6.5 Cooperative Relationships

The proposal should indicate any additional resources that may be required beyond those of the contractor to achieve program goals. This would include the development of cooperative relationships between component developers, component manufacturers, and subsystem integrators. Other cooperative relationships could involve National Laboratories or Universities for materials research, test facility development, test and analytical procedures, or other techniques available only at specialized locations.

6.6 Export Control Compliance

The proposer will be required to acknowledge that export control rules limit or prohibit the transfer of covered technology to foreign nationals and agrees to establish and maintain internal controls and procedures adequate to insure accurate determination by the proposer of whether and when its technology falls within the ranges and definitions of the currently effective export control regime.

RFPI AGREEMENT

NOTWITHSTANDING PROPOSER'S MARKINGS TO THE CONTRARY, ALL INFORMATION SUBMITTED IN RESPONSE TO A UNITED STATES ADVANCED BATTERY CONSORTIUM (USABC) REQUEST FOR PROPOSAL INFORMATION (RFPI) SHALL BE TREATED ON A NON-CONFIDENTIAL BASIS.

AGREED:

BY _____

TITLE _____

PROPOSER _____

DATE _____

APPENDIX - USABC Li-Ion Battery Separator Requirements

Table 1. USABC Li-ion battery separator gap chart.^{1,2}

Parameter		Units	USABC Goal		Program Target
Thickness		μm	< 25 ± 1		
Permeability	Gurley #	s /10 cm ³	< 11 (power)	25 (energy)	
	MacMullin #	non-dimensional	< 4 (power)	8 (energy)	
Wettability		non-dimensional	wet-out in electrolytes ¹		
Functional Life		years	capable of supporting cell performance for 15 years ²		
Average Pore size		μm	< 0.2		
Shear Strength ³		gf / 25.4 μm film	300		
Thermal Stability ⁴		% shrinkage/90°C ⁵	< 5		
Uniformity (Defects) ⁶		pinholes/roll	zero throughout roll length		
Tensile Strength		N/A	<2% offset at 1000 psi		
Cost		\$/m ²	0.60 @ 25M sqm/yr		
Shutdown Temperature (See Section 6.2)		°C	(105 ± 5) °C		
High Voltage Resistance (See Section 6.2)		V	5.0 V		

Notes:

1. The items highlighted in yellow represent stretch goals.
2. The USABC goals in the gap chart for the cell type (12 V, 48 V, PHEV or EV) chosen as test platform for the separator performance must also be met.

Table 2. USABC Li-ion battery separator goals and recommended test methods.

Parameter		Units	USABC Goal		Test Method
Thickness		μm	< 25 ± 1		ASTM D5947-96, D2103
Permeability	Gurley #	s /10 cm ³	< 11 (power)	25 (energy)	Pat. US 4,464,238
	MacMullin #	non-dimensional	< 4 (power)	8 (energy)	electrolyte resistance ratio
Wettability		non-dimensional	wet-out in electrolytes ¹		relative wicking speed
Functional Life		years	capable of supporting cell performance for 15 years ²		long-term cell testing
Average Pore size		μm	< 0.2		ASTM E128-99
Shear Strength ³		gf / 25.4 μm film	300		ASTM F1306-90
Thermal Stability ⁴		% shrinkage/90°C (1 h) ⁵	< 5		ASTM D1204
Uniformity (Defects) ⁶		pinholes/roll	zero throughout roll length		cell manufacturer confirmation
Tensile Strength		N/A	<2% offset at 1000 psi		ASTM D882-00
Cost		\$/m ²	0.60 @ 10M sqm/yr		N/A
Shutdown Temperature (See Section 6.2)		°C	(105 ± 5) °C		hot ER
High Voltage Resistance (See Section 6.2)		V	5.0 V		glassy carbon electrode & cell performance

Notes:

¹ **Wettability:** Determined by a test based on wicking of separator sheet with electrolyte. USABC will use this parameter in a comparative fashion relative to state-of-the-art separators, and/or track any improvement/change.

² **Functional Life:** Verification should be done through calendar and cycle life tests at cell level. It is expected that USABC performance goals for the cell design used in the testing will be met or exceeded.

³ **Shear Strength:** Determined by ASTM test for puncture of packaging films; to be complemented by mix penetration tests, after its validation by National Labs.

⁴ **Thermal Stability:** An additional HTMI test suite (hot tip, TMA, hi-pot test, and high temperature shrinkage under constrained conditions after 1 hour stand at 150 °C) will be added to the recommended test procedures after the proposed test methods are validated by National Labs and publicly disclosed.

⁵ **Hi-T Shrinkage:** Determined for an unconstrained film after 1 hour stand. 90 °C is standard test adopted by the Li-ion battery industry, for manufacturing purposes.

⁶ **Uniformity (defects):** Quality is not extensively listed in the gap chart, but is certainly a requirement. The separator must be free of defects. Defects include pinholes, gels, wrinkles, contaminants, etc.; all are unacceptable. The process for producing separator should include controls that guarantee high quality.