

State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-647

Relating to Exemptions under
Section 27156 of the Vehicle Code

A123Systems, Inc.
L5 Battery Range Extender Modules
Off-Vehicle Charge Capable Conversion System

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-02-003;

IT IS ORDERED AND RESOLVED: That installation of the L5 Battery Range Extender Modules (BREM) off-vehicle charge capable (OVCC) conversion system, manufactured by A123Systems, Inc. of 10 Avenue E, Hopkinton, Massachusetts 01748, has been found not to reduce the effectiveness of the applicable vehicle pollution control system, and therefore, the L5 BREM OVCC conversion system is exempt from the prohibitions in Section 27156 of the Vehicle Code for installation on 2004 through 2008 model-year Toyota Motor Corporation 1.5 liter Prius hybrid-electric vehicles.

This exemption is based on evaluation of the L5 BREM OVCC conversion system under the "Procedures for Exemption of Add-On and Modified Parts" (Procedures), last amended June 1, 1990. Exemption of the L5 BREM OVCC conversion system under these Procedures is limited to sales of five hundred (500) L5 BREM OVCC conversion systems.

The L5 BREM OVCC conversion system includes a lithium ion add-on battery pack, a current sensor, battery temperature sensors, and a controller.

This Executive Order is based on emission testing A123Systems, Inc. conducted with the L5 BREM OVCC conversion system. The Air Resources Board reserves the right to conduct additional emission tests in the future. If such test results demonstrate that the L5 BREM OVCC conversion system adversely affects emissions, this Executive Order shall be effectively rescinded as of the date the test results are validated. Further, if such test results or other evidence provides the Air Resources Board with reasons to suspect that the L5 BREM OVCC conversion system will affect the durability of the emission control system, A123Systems, Inc. shall be required to submit durability data to show that the durability of the vehicle emission control system is not, in fact, affected and/or that the add-on or modified parts demonstrate adequate durability.

This Executive Order is valid provided that installation instructions for the L5 BREM OVCC conversion system do not recommend tuning the vehicles to specifications different from those of the vehicle manufacturer.

Changes made to the design or operating conditions of the L5 BREM OVCC conversion system, as exempt by the Air Resources Board, which adversely affect the performance of the vehicle's emission control system, shall invalidate this Executive Order.

Marketing of the L5 BREM OVCC conversion system using identification other than that shown in this Executive Order or for an application other than that listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board.

Exemption of the L5 BREM OVCC conversion system shall not be construed as exemption to sell, offer for sale, or advertise any component of the system as an individual device.

This Executive Order shall not apply to any L5 BREM OVCC conversion system advertised, offered for sale, sold with, or installed on a motor vehicle prior to or concurrent with transfer to an ultimate purchaser.

This Executive Order does not constitute any opinion as to the effect the use of the L5 BREM OVCC conversion system may have on any warranty either expressed or implied by the vehicle manufacturer.

No claim of any kind, such as "Approved by the Air Resources Board," may be made with respect to the action taken herein in any advertising or other oral or written communication.

In addition to the foregoing, the Air Resources Board reserves the right in the future to review this Executive Order and the exemption provided herein to assure that the exempted add-on or modified part continues to meet the standards and procedures of California Code of Regulations, Title 13, Section 2222, et seq.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF A123SYSTEMS, INC.'S L5 BATTERY RANGE EXTENDER MODULES OFF-VEHICLE CHARGE CAPABLE CONVERSION SYSTEM.

Violation of any of the above conditions shall be grounds for revocation of this Executive Order. The Executive Order may be revoked only after a ten-day written notice of intention to revoke the Executive Order, in which period the holder of the Executive Order may request in writing a hearing to contest the proposed revocation. If a hearing is requested, it shall be held within ten days of receipt of the request, and the Executive Order may not be revoked until a determination is made after the hearing that grounds for revocation exist.

Executed at El Monte, California, this 18 day of September 2008.



Annette Hebert, Chief
Mobile Source Operations Division

EVALUATION SUMMARY

Manufacturer Name: A123Systems, Inc.

Name of Device: L5 Battery Range Extender Modules Off-Vehicle Charge Capable Conversion System

Background:

A123Systems, Inc. of 10 Avenue E, Hopkinton, Massachusetts 01748 has applied for exemption of its L5 Battery Range Extender Modules (BREM) off-vehicle charge capable (OVCC) conversion system from the prohibitions in Section 27156 of the California Vehicle Code. The system is designed for 2004 through 2008 model-year Toyota Motor Corporation 1.5 liter Prius hybrid-electric vehicles (HEV). These vehicles are subject to the following standards:

1. LEV II SULEV Federal Test Procedure (FTP) exhaust emission standards
2. Supplemental Federal Test Procedure exhaust emission standards
3. Zero-fuel evaporative emission standards
4. On-Board Diagnostic II System regulations

Recommendation:

Grant exemption to A123Systems, Inc. as requested and issue Executive Order D-647. This exemption is based on evaluation of the L5 BREM OVCC conversion system under the "Procedures for Exemption of Add-On and Modified Parts" (Procedures), last amended June 1, 1990. Exemption of the L5 BREM OVCC conversion system under these Procedures is limited to sales of five hundred (500) L5 BREM OVCC conversion systems.

Device Description:

The L5 BREM is an OVCC conversion system that provides supplemental electrical energy to the Prius via an add-on battery pack recharged from a standard 110 volt outlet. It allows the Prius to derive the needed propulsive energy from electrical energy rather than from the internal combustion engine (ICE) more of the time than the stock Prius. The L5 battery is connected in parallel to the Prius battery. The battery features are:

Feature	A123Systems L5 BREM	Toyota Prius
Battery	Lithium ion	Nickel-metal hydride
Connection	Parallel	--
Charge time (h)	4.5 @ 110V	--
Weight (kg)	85	45
Energy capacity (kWh)	4.7	1.3
Charge capacity (Ah)	25	6.5
Nominal voltage (V)	185 @ 50% state of charge	201.6
Cell voltage (V)	3.3	1.2
Number of cells	616 (14 sub-modules, 44 cells/sub-module)	168 (28 modules, 6 cells/module)
Charger (kW)	1 on 110V outlet	--

The L5 battery is used in conjunction with a controller that communicates with the Prius hybrid system controller and battery. The L5 controller acts as a gateway for all data required by the Prius hybrid system controller. The L5 controller reads the demand placed on the Prius battery by the Prius hybrid system controller and determines how much electrical power to supply to the electrical drivetrain from the L5 battery in substitution of electrical power from the

Prius battery. The L5 battery provides power up to the L5 DC-DC converter limit of 10kW. Under driving conditions where more than 10 kW is required (e.g. hard acceleration), power is drawn from both L5 and Prius batteries. The L5 controller provides the appropriate signals to the Prius hybrid system controller which then uses them per the original Prius algorithms which are unaltered. A123Systems has presented that the algorithm or logic that determines whether to use the battery, ICE, or a combination of the two remains Toyota's logic. The L5 controller does place an "EV Mode" request to the Prius hybrid system controller which responds to the request based on drive conditions, available electrical energy, and other parameters. A123Systems has presented that the algorithm or logic by which the Prius hybrid system controller either honors or rejects the "EV Mode" request remains Toyota's logic. The same L5 controller calibration/code is used on all the Priuses in this application (production code number PT491009-0010).

Most of the electrical power from the L5 battery is used to drive the vehicle. Some power is transferred to the Prius battery to prevent state of charge (SOC) drift (e.g. to keep the Prius battery at the normal 60 percent SOC, power is transferred from the L5 battery rather than from the ICE).

L5 operation is indicated with a light on the dash with the L5 battery status (e.g. SOC) shown in the user information display. When the L5 battery is fully depleted, the indicator light dims, and the information display shows the Prius battery status. A123Systems has presented that with a fully depleted L5 battery, the vehicle returns to the original Toyota design. In the case where the L5 battery safety or operating parameter limits are exceeded, the L5 battery is taken out of operation. In this case, A123Systems has presented that the vehicle remains fully operational and again returns to the original Toyota design, same as when the L5 battery is fully depleted under normal operation. There is a manual on/off switch for the L5 battery on the dash. Once set to the "on" position, the system is fully automatic.

A123Systems has stated that no modifications to Toyota's On-Board Diagnostics II System are made. A123Systems warrants the L5 BREM OVCC conversion system for defective material or workmanship for 3 years from the date of installation. A123Systems has stated that if Toyota denies its warranty due to a problem caused by the L5 BREM OVCC conversion system, A123Systems will pay for the otherwise warranted repair.

Discussion/Basis for the Recommendation:

This exemption is based on emission testing A123Systems performed with the L5 BREM OVCC conversion system. Results are presented below:

Exhaust Emissions:

	CVS-75 FTP Emissions (grams/mile)			
	NMOG ¹	CO	NOx	HCHO ²
CD ³ Test 1 (7/31/2008)	0.00591	0.0567	0.0065	--
CD ³ Test 2 (8/6/2008)	0.01130	0.0503	0.0063	--
CD Average	0.00861	0.0535	0.0064	--
CD with DF	0.01201	0.1335	0.0074	--
CD Final	0.012	0.13	0.01	--
CS ⁴ Test 1 (7/24/2008)	0.01147	0.0943	0.0049	--
CS ⁴ Test 2 (8/7/2008)	0.01010	0.0740	0.0100	--
CS Average	0.01079	0.0842	0.0075	--
CS with DF	0.01419	0.1642	0.0085	--
CS Final	0.014	0.16	0.01	--
150,000-Mile Toyota DFs	0.0034	0.08	0.001	na
150,000-Mile Standards	0.010	1.0	0.02	0.004
150,000-Mile Toyota Cert.	0.009	0.10	0.01	na

Notes:

- Testing was conducted at Emissions Research and Measurement Division of Environment Canada in Ottawa Ontario, Canada.
- Test vehicle – test group 8TYXV01.5HC3 (LEV II SULEV); evaporative family 8TYXR0030A42 (zero-fuel); odometer reading 10,470 miles
- Test fuel – federal gasoline meeting specifications set forth in 40 CFR 86.113-04(a)(1) (Tier 2)
- 1 NMOG/NMHC ratio of 1.04 was used to calculate NMOG.
- 2 HCHO was not sampled. HCHO conversion ratio, deterioration factor, and Toyota certification level were not available.
- 3 Charge depleting exhaust emission test consisted of a series of UDDS tests following a cold soak. The test began with a fully charged L5 battery and ended when charge sustaining operation was achieved for a pair of UDDS tests. Each UDDS test was separated by a 10-25 minute hot soak period. Emission canister was purged and loaded to 1.5 times its working capacity. Two charge depleting exhaust emission tests were conducted to check the repeatability of the measurements.
- 4 Charge sustaining exhaust emission test consisted of a pair of UDDS tests following a cold soak. This test was conducted with the L5 battery disengaged. Each UDDS test was separated by a 10-25 minute hot soak period. Emission canister was loaded to 2-gram breakthrough.

At the time of A123Systems' testing, test procedures were still being developed for OVCC HEVs. Existing test procedures for HEVs were modified to better assess the emission characteristics of an OVCC converted Prius. A123Systems was required to perform duplicate cold start charge depleting (CD) tests, each CD test consisting of a series of UDDS tests with the L5 battery fully charged until charge sustaining (CS) operation is achieved for a pair of UDDS tests. Duplicate CD tests were required to check the repeatability of the measurements. After adjustment with Toyota's deterioration factors, the average CD CO and NOx emissions were below the certification standards but the average CD NMOG emissions were above the standard. A123Systems also presented results of two cold start CS tests. Each CS test consisted of two UDDS tests with the L5 battery disengaged, where the vehicle is expected to return to the stock Toyota mode. The average CS CO and NOx emissions also met the standards while the average CS NMOG emissions were above the standard. All CS emissions were at or above the CD emissions. For further evaluation, A123Systems presented THC data from additional engineering tests performed on the same vehicle. They are shown below along with the THC data from the tests presented above for comparison:

		THC (g/mi)											
		UDDS 1		UDDS 2		UDDS 3		UDDS 4		UDDS 5		UDDS 6	
		Bag 1	Bag 2	Bag 1	Bag 2	Bag 1	Bag 2	Bag 1	Bag 2	Bag 1	Bag 2	Bag 1	Bag 2
CD	7/22/08 ⁵	0.022	0.000	0.015	0.000	--	--	--	--	--	--	--	--
	7/31/08 ⁵	0.014	0.000	0.011	0.000	0.013	0.001	0.016	0.000	0.000	0.000	0.000	0.000
	8/6/08 ⁵	0.040	0.003	0.013	0.000	0.015	0.000	0.011	0.000	0.000	0.000	0.000	0.000
	8/19/08 ⁶	0.024	0.000	0.000	--	--	--	--	--	--	--	--	--
CS	7/24/08 ^{6*}	0.024	0.003	0.023	0.007	--	--	--	--	--	--	--	--
	8/7/08 ^{6*}	0.051	0.000	0.000	0.000	--	--	--	--	--	--	--	--

Notes:

- 5 Emission canister was purged and loaded to 1.5 times its working capacity.
- 6 Emission canister was loaded to 2-gram breakthrough.
- * L5 battery was disengaged.

The THC levels appeared to vary from test to test.

Evaporative Emissions:

8/19/2008	Hot Soak	2-Day Diurnal		HS + 2D (grams/test)
2-Day Diurnal Test	0.00	na ⁷	0.22	0.22
Emissions with DF	--	--		0.241
Final	--	--		0.24
150,000- Mile ARB ADF ⁸	--	--		0.021
150,000-Mile Standard	--	--		0.35
150,000-Mile Toyota Cert.	--	--		0.14

Notes:

- Testing was conducted at Emissions Research and Measurement Division of Environment Canada in Ottawa Ontario, Canada. Test vehicle – test group 8TYXV01.5HC3 (LEV II SULEV); evaporative family 8TYXR0030A42 (zero-fuel); odometer reading 10,638 miles
 - Test vehicle – test group 8TYXV01.5HC3 (LEV II SULEV); evaporative family 8TYXR0030A42 (zero-fuel); odometer reading 10,470 miles
 - Test fuel – federal gasoline meeting specifications set forth in 40 CFR 86.113-04(a)(1) (Tier 2)
- 7 Environment Canada's system only reports the highest emissions and does not record the lower value.
- 8 Toyota's deterioration factor was not available. ARB assigned deterioration factor of 0.021 for LEV II-evap vehicles (not zero-fuel evap) was applied.

To assess the impact on evaporative emissions, A123Systems performed a 2-day diurnal evaporative emission test. The L5 battery was fully charged for the test. Data showed that the evaporative emission level remained below the certification standard even with the reduced canister purge afforded from a fully charged L5 battery.

Environment Canada reported no diagnostic trouble codes or malfunction indicator lights throughout testing. Based on the above and the limited installation allowed under this Executive Order, the L5 BREM OVCC conversion system is exempted. This evaluation does not address any claims of fuel economy benefits, electric driving range, or charge time.