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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking on the Commission's own motion to consider alternative-fueled vehicle tariffs, infrastructure and policies to support California's greenhouse gas emissions reduction goals.	RULEMAKING 09-08-009 (Filed August 20, 2009) Commissioner Rachelle Chong ALJ Regina DeAngelis

Comments of the Electric Power Research Institute

On codes and standards regarding plug-in electric vehicle charging

/s/ Ellen Petrill

Ellen Petrill

Director

Electric Power Research Institute

3420 Hillview Ave.

Palo Alto, CA 94304-1338

Tel: 650-855-8939

Fax: 650-855-2929

Email: epetrill@epri.com

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17. Please identify current and pending Society of Automotive Engineers vehicle design and interface technical requirements, the Underwriters Laboratory listed components and systems, and the National Electric Code, California Electric Code, and California Building Code Regulations that govern the installation, operation, and maintenance of charging infrastructure at the residential, commercial, and public charging EVSE.

All Plug-In Electric Vehicle (PEV) charging station installations are subject to national and local building and electrical codes[1,2,3]. These codes ensure the safety, accessibility, and equipment maintenance concerns of PEV equipment users, property managers, utilities, and maintenance workers. These rules and regulations fall into two categories: electrical code requirements and building code requirements.

Electrical code requirements cover the safe installation, operation, and long-term maintenance of the electrical equipment at the PEV charging site.

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[1] "The National Electric Code, Article 625," NFPA, 2008

[2] "Electric Vehicle Infrastructure Installation Guide," PG&E, March 1999

[3] EPRI Report, "Plug-in Electric Vehicle Infrastructure Installation Guidelines," Vol. 1: Multi-Family Dwelling, EPRI TR 1017682, Sep 2009

Building code requirements govern the physical construction and placement of the PEV charging station(s) and cover such aspects as accessibility of the equipment, stall dimensions, building materials, and placement on the property. The following sections list the existing and current standards in place and/or being developed.

CODES AND REGULATIONS REGARDING PEV CHARGING

Existing Standards

Table 1 Existing Standards

Vehicle Design & Interface	**Certification**	**Regulations**
Technical Requirements (Vehicle Aspects)	**UL Listed Components & Systems (Off-board Equipment)**	**National Building Codes (Premise Aspects Wiring and Installations)**
SAE	**UL**	**NEC**
J1772™ - SAE Electric Vehicle and Plug In Hybrid Electric Vehicle Conductive Charge Coupler	UL 2202 – Electric Vehicle (EV) Charging System Equipment	Article 625 – Electric Vehicle Charging System I – General II – Wiring Methods III – Equipment Construction IV – Control & Protection V – EV Supply Equipment Locations
J2293 - Energy Transfer System for Electric Vehicles Part 1: Functional Requirements and System Architectures Part 2: Communication Requirements and Network Architecture	UL 2231 – Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits Part 1: General Requirements Part 2: Particular Requirements for Protection Devices for Use in Charging Systems	

SAE J2464 Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing	UL 2251 – Plugs, Receptacles and Couplers for Electric Vehicles	

Updates and New Standards

1. SAE

- **Common EV Supply Equipment / Charging Coupler – SAE J1772™**
  - Updating connector
  - Increasing 120V (level 1) and 240V (level 2) power levels
  - Added diagnosable detection circuit
- **Energy Transfer System for Electric Vehicles – SAE J2293**
  - Retained for existing equipment support
- **Recommended Practice for Communication between Plug-in Vehicles and the Utility Grid – SAE J2847 & SAE 2836™**
  - J2836™ - TIR - General info including Use Cases
  - J2847 – RP – Detail information
    - /1 – Utility programs
    - /2 – DC Energy Transfer (off-board charger in EVSE - Simplified and replaces J2293)
    - /3 – Reverse Energy Flow
    - /4 – Diagnostics
    - /5 – Vehicle Manufacturer Specific

- **Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing – SAE J2464**
  - A major revision of the 10 year old document is intended to update the recommend practice to:
  - Improve test descriptions, procedures and data analysis, incorporating lessons learned from conducting testing.
  - Include other types of electric energy storage devices (e.g., electrochemical capacitors) and new types of electrified vehicular designs.
    - *Previous J2464 title was "Electric Vehicle Battery Abuse Testing"*
  - Make the test results more quantitative

- **Charger Power Quality Requirements – SAE J2894**
  - New standard for on-board chargers

2. **UL**

- **Electric Vehicle (EV) Charging System Equipment – UL 2202**
  - Charging station safety
  - Harmonization with SAE
- **Software in Programmable components – UL 1998**
- **Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits – UL 2231**
- **Plugs, Receptacles, and Couplers for Electric Vehicles – UL 2251**
  - Updates required to include new connector
- **UL 2594**
  - New standard on cordset

- **Inverters, converters, controllers and interconnection System Equipment for use with Distributed Energy Resources – UL 1741**

3. **NEC**
   - **Electric Vehicle Charging System Equipment – NEC Article 625 Code Revision Task Force**
   - **Electrified Truck Parking Spaces – NEC Article 626 Code Revision Task Force**

4. **IEC**
   - **IEC 61851 (IEC TC69/WG4) Electric vehicle conductive charging system**, Part 1, 21, 22, 23
   - **IEC 61851-24 (IEC TC69/WG4) Electric vehicle conductive charging system**-Part 24:Communication between vehicle and charging station
   - **IEC 62196 (IEC TC23/SC23H) - Part 1: Plugs, socket-outlets and vehicle couplers** - Conductive charging of electricity vehicles
   - **IEC 62196 (IEC TC23/SC23H) - Part 2: Dimensional interchangeability requirements for pin and contact-tube vehicle couplers**

5. **ISO**
   - **ISO 12405-1 (ISO/TC22/SC21) Test specification for Lithium-Ion traction battery systems -- Part 1: High power applications**
   - **Joint ISO/TC 22/SC 23 - IEC TC69: Vehicle to grid communication interface**
   - ISO TC22 agreed to establish a joint working group with IEC TC69 to standardize the communication between electric road vehicles and charging stations. ISO TC22 will take the lead in this joint activity with experts from SC3/WG1, SC21 and also IEC/TC69

6. **Smart Energy 2.0 Development and Harmonization**

- Develop and harmonize with SDOs to develop common messaging for PEV Communications
- PEV requirements to be included in SE 2.0

7. **National Institute of Standards and Technology**

- In cooperation with DOE, NEMA, IEEE, GWAC, and other SDOs, NIST is responsible for consolidating the standards associated with the smart grid efforts. PEV is identified as a component of the smart grid in NIST Interoperability Roadmap
    a. Recognize existing consensus standards and develop a roadmap to fill gaps
    b. Provide recommendations for new standards
    c. Harmonize SAE & SE 2.0 activities
    d. Develop testing and certification framework

Electric Vehicle Conductive Charge Coupler Standard

This SAE Recommended Practice covers the general physical, electrical, and performance requirements for the electric vehicle conductive charge system and coupler for use in North America. This recommended practice redefines AC Level 1 and AC Level 2 charge levels and specifies a new conductive charge coupler and electrical interfaces for those levels. Couplers and interfaces for DC and higher AC charge levels are currently being developed and will be added to this document upon completion.

Table 2

Components of PEV Charging System based on SAE J1772™

	US/Japan **IEC 62-196-2 Type I**
Pins	**5 pins** (2xpower, 1 xground, 2x signal)
Maximum voltage	240V
Maximum current	32A (80A in US)
Phases	1
Maximum power	7.2 kW (19.2 kW US)
Interlock	Mechanical latch on connector
Control Pilot	PWM signal
Proximity	Resistor in connector (also used to detect latch status)
Digital communication	PLC

PEV Charging Level

Electric vehicle charging is performed at different voltage levels and using different technologies depending on the model of the PEV and the type of charging situation. Level 1 and level 2 PEV charging are the most common while level 3 charging is most often associated with "fast charge" operations in fueling station or commercial fleet environments.

- AC Level 1 Charging* - 120V AC charging from standard 15 or 20 amp NEMA outlet, on-board vehicle charger (~1.9kw)
- AC Level 2 Charging* - 208 – 240 AC charging up to 80 amps, on-board vehicle charger (~19kw)
- DC Charging (Fast Charging)** - Off-board charger connects directly to vehicle high voltage battery bus

Table 3

Characteristics of Level 1 and Level 2 PEV Charging[4]

	Voltage	**Amps**	**Power (kVA)**	**Phase**	**Outlet**
Level 1	120	12	1.44	single	NEMA 5-15R
Level 2	208/240	12 - 80	6.7/7.7	single	SAE J1772

National Electric Code

The National Fire Protection Association's 2008 National Electric Code (NEC) has established standards for the installation of electric vehicle charging stations. Chapter 6, article 625 of NEC provides details for wiring methods, equipment construction, control and protection, and recommendations for EVSE locations. Section 4 of this report provides more technical requirements for wiring EVSE installations. Below are summaries of key NEC article 625 standards for EVSE installations:

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[4] SAE J1772 draft, "Electric Vehicle Conductive Charge Coupler"

Wiring – EVSE other than cord-and-plug, single phase, 15 or 20 amp must be permanently connected to service and fastened in place with no exposed live parts. Plugs must be non-interchangeable with other electrical devices, and the EVSE should have a means to prevent unintentional disconnection.

Equipment Construction – Equipment must be clearly marked with ventilation, voltage, and intended usage labels. Cables and equipment must provide a means for cable de-energization.

Control and Protection – Overcurrent protection provisions for the EVSE are required, as well as a listed system of personnel protection against shock.

EVSE Locations – Outdoor EVSE equipment must be no less the 600 mm (24 in.) or more than 1.2 m (48 in.) from the ground. Additional requirements for indoor and outdoor installations are detailed in the full NEC article 625.

Note that other NEC articles may apply, including standards for grounding, installation of conduit, and ventilation.

State and Local Electric Codes

While state and local electrical codes usually adhere to NEC safety recommendations, many have additional requirements which must be met to pass planning, permit, and final inspection stages of the PEV charging facility. City and county offices can provide property managers and contractors with the relevant codes for planning and installing EVSE in facilities to adhere to these local code requirements.

Local Building Codes and Ordinances

While electric codes are of primary concern in the installation of EVSE, additional building codes may be applicable. For example, some municipalities may require that outdoor EVSE have minimum vehicle space dimensions for charging stalls, wheelstops, etc. Indoor charging stations may have similar space and material requirements. City and/or county offices can provide detailed information on EVSE building codes, if applicable.

California Electrical Code (CEC)[5]

The 1998 California Electrical Code (CEC), administered by the California Building Standards Commission and the state Fire Marshall's office, mirrors the NEC. Variations with the NEC were reconciled in 1998.

UL Listing and Equipment Certification

All EVSE used at the PEV charging station site should be listed and approved for use in residential multi-unit charging installations by the Underwriters Laboratory (UL). The contractor for the EVSE installation is responsible for certifying that all equipment is UL approved and meets or exceeds all national and local electrical code requirements. Underwriters Laboratory has an online certification verification directory at: http://database.ul.com

Table 4

Codes and Specifications

Codes and Specifications for Supply Equipment (EVSE)	**Codes and Specifications for Receptacle and cord plug**
NEC Article 625	SAE J1772™
SAE J1772™	IEC 62196
SAE J2847 & SAE 2836™	UL 2251
UL 1998	
UL 2202	
UL 2231	
IEC 61851	

[5] "Electric Vehicle Infrastructure Installation Guide," PG&E, March 1999

Communication Standards

While until as recently as 2007, the concept of the PEVs' control and communication system connected to the grid was foreign to the automobile manufacturers, this situation is rapidly evolving and in the span of last few months, a whole host of initiatives have been established to quickly address this gap in automobile's capabilities to communicate with the grid and control its own energy draw from the grid as needed, as well as provide acknowledgement of having done so. These initiatives range from SDOs such as OpenHAN[6] / OpenAMI[7] / ZigBee alliance[8] releasing their specification for Smart Energy Profile v1.0[9] to HomePlug[10] alliance working on their IEEE P1901[11] specification to SAE developing requirements for control and communication between plug-in electric vehicles and the electric grid under the aegis of SAE standards J2847 and J2836.

J2847/1 supports AC or DC energy transfer. J2847/2 supports the additional messages for DC energy transfer and replaces J2293. J2847/3 supports Reverse Power Flow (RPF) and this series is based upon requirements jointly developed by vehicle manufacturers, electric utilities, grid operators, technology suppliers, and other stakeholders. These requirements are reflected in SAE Information Report J2836/1, *Use Cases for Communication between Plug-in Vehicles and the Utility Grid*.

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[6] http://osgug.ucaiug.org/utilityami/openhan/default.aspx

[7] http://osgug.ucaiug.org/utilityami/default.aspx

[8] http://www.zigbee.org/en/index.asp

[9] www.**zigbee**.org/imwp/download.asp?ContentID=12484

[10] www.**homeplug**.org

[11] http://grouper.**ieee**.org/groups/1901/

Whereas J2293 focused on communication between the vehicle and local, off-board electric vehicle supply equipment (EVSE) with optional grid interaction, J2847/1, /2 & /3 focuses on communication between the vehicle and grid, with the EVSE playing the role of local intermediary. Additionally, while J2293 included support for J1773-based inductive charging and J1850-based communication, these are obsolete and hence not supported by J2847. In order to maintain information for existing systems, this task force has reaffirmed J2293, preserving that specification at its last revision level.

This specification addresses major changes that have occurred since 1997 (when J2293 was published) in the technologies of electric vehicles, the grid, and information processing, including:

(1) support for bi-directional energy transfer between vehicle and grid (FPF and RPF, as defined above);
(2) support for new local communications media between vehicle and EVSE (to replace J1850), such as power line communication (PLC) and wireless transports (Zigbee, WiFi, etc.);
(3) synchronizing with a major revision of J1772 which includes new connectors and signals between the vehicle and EVSE, and additional AC and DC power levels;
(4) support for new vehicle architectures such as plug-in hybrid (PHEV) and plug-in fuel cell (PFCV) vehicles;
(5) support for new rechargeable energy storage system (RESS) technologies and packaging methods;
(6) support for vehicle telematic communication transports; and
(7) support for new developments in both utility and customer premises equipment, such as advanced metering infrastructure (AMI) and home-area network (HAN) technologies

The purpose of J2836/1 is to document the set of use cases which must be supported by SAE Recommended Practice J2847/1, *Communication between Plug-in Vehicles and the Utility Grid*. The purpose is to

- To capture requirements associated with PEV infrastructure, core functions and related applications to facilitate successful integration of PEV into the utility enterprise
  - Develop ***Functional*** and ***Non-Functional*** requirements and specifications
  - Evaluate, Distill, Prioritize, and Publish requirements
- Develop and document the set of use cases which must be supported by SAE Recommended Practice J2847, *Communication between Plug-in Vehicles and the Utility Grid.*
- Requirements should support AMI as well as non-AMI environments
- Requirements should be independent of the transport layer
- Extract requirements from the usecases which must be supported by SAE Recommended Practice J2847, *Communication between Plug-in Vehicles and the Utility Grid*

High Level PEV Communications Requirements[12]

[12] EPRI Report, "Smart Charging Development for Plug-in Hybrid and Electric Vehicles – Preliminary usecase Development for SAE Recommended Practice J2847/Jj2836," TR 1015886, Dec 2008

SAE J2847/SAE 2293 and SEP 2.0 will provide the messages and communications application standards for smart charging.

- Standards-based implementation of 'application layer': SAE J1772/J2836 and Smart Energy 2.0
- Supports compatibility and interoperability among alternative message transport protocols – shall not specify the physical layer
- Supports Open, interoperable systems
- Single interface on automotive side, interoperable with diverse 50-state and Canadian utility smart grid infrastructure
- Standards shall apply to AMI and Non AMI communications solutions
- Standards address a specific direction toward the long term
  - Should not divert or interject specifications for short term gap/bridges
- Market/Utilities will develop gap or derivative solutions but should be forward compatible with the long term direction provided in the standard
  - Examples are smart plugs, smart EVSE, and other intermediaries for a Dumb Vehicle
  - Intermediaries are acceptable but should comply to the standard and be compatible with a Smart Vehicle
- Avoid allowing for incompatible alternatives within the standard
- Supports secure two-way communication with the Energy Services Communication Interface (i.e., Utility)
- Supports time- or price-based charging preferences based on current electric rate/tier
- Supports vehicle charging at any voltage
- Support vehicle load correlation (end use metering of the PEV)
- Support Demand Side Management Integration

- Support vehicle charging regardless of utility metering and/or communication availability
- Supports vehicle roaming and unified billing infrastructure
- Supports Customer override/opt-outs
- PEV-to-Utility communications technology based on open standards

How does the timeframe for each code and standard adoption impact current and future vehicle and EVSE products?

Timeline

SAE J1772™

- 1st level ballot September 2009.
- Second level ballot start November 6th 2009 and close December 4th 2009
- Release for publishing by end of 2009

SAE J2847

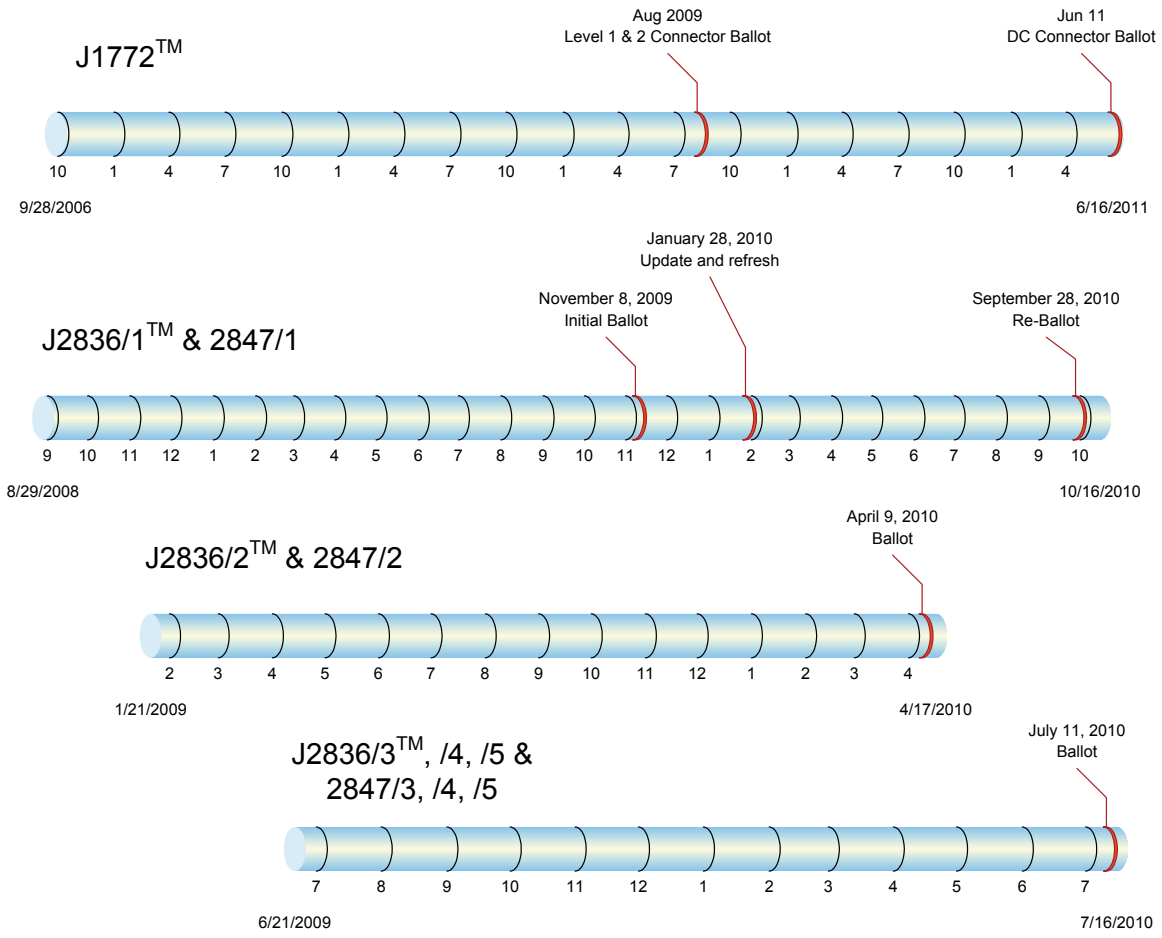

Figure 1

Timeline for SAE Communication Documents[13]

[13] SAE Communication Task Force J2847 & J2836

SE 2.0

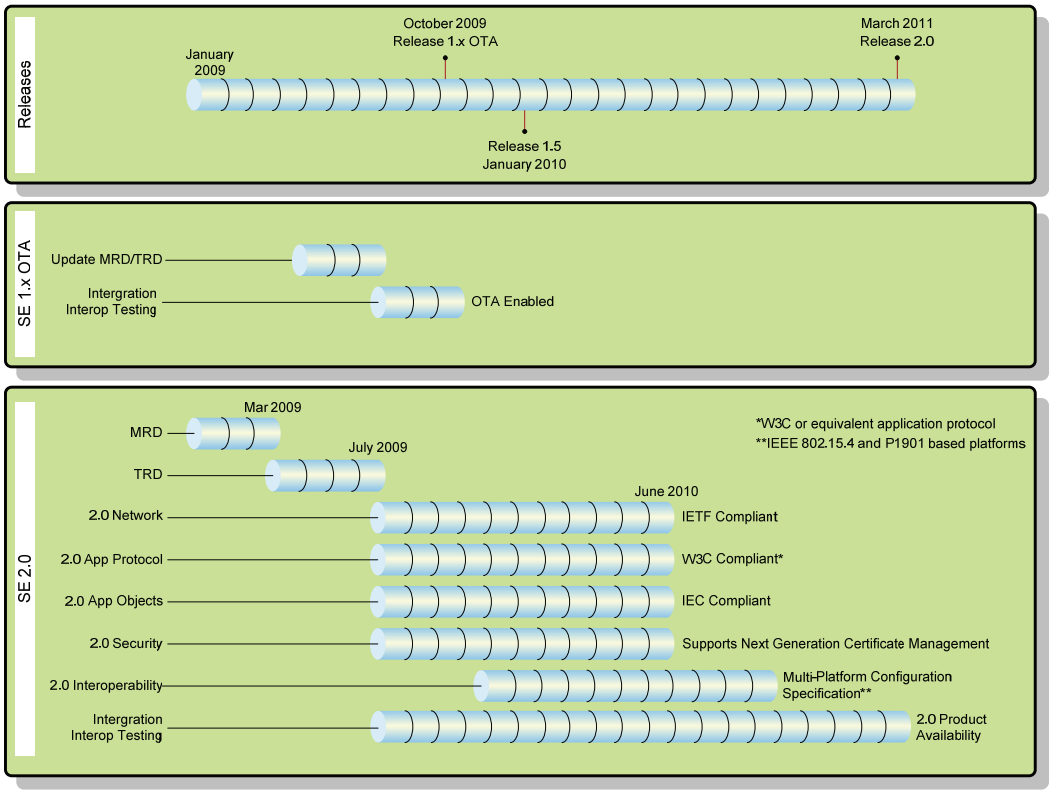

Figure 2

Timeline for SE 2.0[14] (Source: Smart Energy Council Alliance Workgroup)

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[14] SmartGrid Update – SAE and SE 2.0 Working Group Meeting June 2009

/s/ Ellen Petrill

5 October 2009

CERTIFICATE OF SERVICE

Comments of the Electric Power Research Institute **On codes and standards regarding plug-in electric vehicle charging**	

I hereby certify that on October 5, 2009, I served by email or regular US Mail true copies of the original of comments of the Electric Power Research Institute on codes and standards regarding plug in electric vehicle charging.

The Comments were emailed to all parties listed on the service list in Docket No.

R.09-08-009, which is attached, with the exception of those for whom no email

address was known. For parties without an email address, copies were mailed

via regular US Mail to their physical address on the service list.

Dated: October 5, 2009, at Palo Alto, CA..

/s/ Ellen Petrill

5 October 2009