SAE Certified Vehicle Electrification Professional
Body of Knowledge Overview for the CVEP

First Edition
Introduction

Although, in the United States, Hybrid Electric cars account for a fraction of 2012 auto sales, only 3.3 percent, “analyst firm Mintel estimated... that sales of hybrid, plug-in hybrid and electric cars in the US will exceed 535,000 units in 2013, a sizable increase on the 440,000 sold last year. Sales of hybrids and electric cars rose 73 per cent in 2012, making it the fastest growing segment in the US auto market.”

Http://grist.org/news/green-car-sales-were-up-in-2012-and-should-be-even-more-up-in-2013/

Top-selling Hybrid-electric Vehicles by Model in the United States

1999-2012

As reported by the International Herald Tribune, a separate market analysis by Pike Research estimates that there will be “annual global sales of 3.8 million electric or plug-in hybrid cars by 2020”. It also “estimates that sales of plug-in cars will grow by 40 percent annually.” During that same period, general car sales will grow by 2 percent. Industry growth is always celebrated; however, change brings challenges. SAE is determined to meet those challenges with the development and implementation of the Certified Vehicle Electrification Professional (CVEP) Examination. Those who pass the examination will be awarded an SAE certification.
Notes: (1) Sources: 2011 and 2012 HybridCars.com, all other figures from Alternative Fuels and Advanced Vehicle Data Center (U.S. DoE). (2) CYTD: Calendar year to date, as of September 30, 2012

Who should take the CVEP? CVE-Professional (CVEP): This certification is designed for the individual who will be working in the electrified vehicle industry as a member of a product realization multidisciplinary team, those responsible for product design, manufacturing process, design, and manufacturing implementation.

Benefits of Certification- Certification benefits both the individual and the industry as a whole.

- Certification ensures a certain level of professional standards and eligibility has been attained.
- Credentialing benefits the profession by codifying it and creating standards; it benefits the individual by offering a means to prove value and identify a path for continued professional development; and it provides employers a reference point from which they can evaluate job candidates.
CVEP Examination Structure

Essential Safety Examination
The examinee will first face the 10 essential safety questions chosen by Subject Matter Experts as life and death safety issues. This examination must be passed with a 100% score. To be as fair as possible, the participant may not move from one question to another until he has selected the correct answer. This is a timed examination of 30 minutes.

Second, the examinee will face the Core CVEP examination which is comprised of four sets of questions covering two types of examinations:

Knowledge-based Examination
Two sets of knowledge questions are included, estimated to take a total of 1.5 Hours. Each set is 45 minutes long with a break between sets. The questions in the knowledge-based exam only have one correct answer.

The knowledge-based tier is built upon the axiom that the team-members, including engineers, must have a complete grasp of all of the information necessary to implement the design and be able to evaluate the efficiency and effectiveness of an Electric Vehicle.

Applications-based Examination
Two sets of application questions included, estimated to take a total of 3 hours. Each set is 75 minutes long with a break between sets. The questions in this set have potentially more than one correct answer. You receive points for each correct answer you select and lose points for each incorrect answer you select. Not selecting an answer does not lose nor does it gain points; however, if you do not select enough of the correct answers in these sets of questions you might not achieve the threshold score for the certification.

The applications-based tier is to check the applicant’s ability to apply the knowledge and skills needed for the CVEP level. The ability to be a productive team member applying the knowledge for this level is presented in scenario and case study formats.
The two types of CVEP examinations are graded by topic. The topics and objectives covered in the CVEP exam include but are not limited to the following:

**Vehicle Electrification Fundamentals and Safety**

**Introduction to Electronics and Electricity**
- Explain the history of Electricity and Electronics
- List the types of charges and currents
- Utilize a multi-meter
- Define Voltage, Current and Resistance
- Analyze simple circuits
- Demonstrate use of formulas
- Construct the different types of Circuits
- Illustrate Voltage Drop
- Apply Ohm’s, Kirchhoff’s, Joule’s and Faraday’s Laws
- Relate the EV battery and charger to theory
- Identify Electronic components
- Classify Power devices
- List types of power conversion

**Fundamentals of Electrified Vehicles**
- Define types of electrified vehicles
- Compare micro, mild, and full hybrid
- Differentiate between the pros and cons of micro, mild, and full hybrid
- Describe the layout of micro, mild, and full hybrid
- Identify the major components of micro, mild, and full hybrid
- Classify the different modes of operation of micro, mild, and full hybrid
- Contrast plug-in hybrid to range extended electric vehicle
- Differentiate the pros and cons of plug-in, extended range, BEV, and fuel-cell vehicle
- Describe the layout of plug-in, EREV, BEV and fuel-cell vehicle
- Identify major components of plug-in, EREV, BEV, and fuel-cell vehicle
- Classify the different modes of operation of plug-in hybrid
- List commercially available examples of battery and range extended electric vehicles
- Classify different modes of electric drive trains

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Contrast power-split, parallel and series drive train layout
Identify major components of Parallel, Series, and Power-split drive train configuration
Explain the regenerative braking system
Explain stop/start operation

Safety
Identify the relevant fire and electrical safety codes, standards and specifications which address the safety hazards associated with the widespread implementation of electric vehicles
Apply the emergency procedures upon approaching an EV crash site to include towing
Explain how to store and dispose of an EV battery
Define proper work procedures for High Voltage before working around vehicles
Identify the components used to service the vehicles and determine if the vehicle is safe to work on
Determine safety precautions before working on a system
Identify the appropriate protective gear
Performing and documenting the maintenance of the tools and protective gear used to check the vehicles High Voltage (HV) systems
Demonstrate how to disable the HV system

Energy Storage Systems

Batteries
Explain what an electrochemical cell is
Deconstruct the battery components
Designate the roles of component parts of the electrochemical cell
Differentiate between a cell and battery
Identify type and forms of cells
Define cell chemistry
List different cell chemistries
Describe ingredients of active components of cell
Explain manufacturing process of electrochemical cell including winding, stacking, and Z-folding
Identify CAE model of electrochemical cell
Compare characteristics of different cell chemistries
o Describe the SEI layer
o List failure modes of SEI layers
o Describe the advantages and disadvantages of different type of chemistries
o Describe C-rate of different type of chemistries
o Identify the Redox characteristics of battery material types

Battery Chargers
o Discern the vehicle design and limits of the charging / storage system (Charge Limits)
o Describe the function of the charger when connected to the EVSE to enable safe charge
o Distinguish between the different charging levels and implication on the performance
o Identify the level of the charging system equipment (EVSE)
o Describe the power connection interface between the charger and the HV-Battery
o Describe the communication interface between the charger and the HV-Battery
o Differentiate between the various charge port connectors and impact on the performance
o Explain the OBD (OBD2, E-OBD) requirements for the charge system
o Describe the potential uses of a bi-directional charge system
o Calculate the cost of the charging the vehicle (Based on random electricity prices)
o Describe the charge profiles (Are the cells balanced during the charge cycle?)

Low and High Voltage Systems
o List types of Lead-acid batteries
o Compare and contrast the 12 Volt-SLI battery and the 42 volt battery
o Compare the charge/discharge rate
o Use of the hydrometer
o Determine the type of wiring for both Low and High Voltage

Propulsion and Propulsion Interfaces
o Define Electric motor
o Apply Faraday’s law of Induction
o Differentiate between the pros and cons of the following major electric machine types: Switched Reluctance, Induction, and Permanent Magnet
o Describe the pros and cons of the following flux arrangements: radial flux and axial flux
o Differentiate between the pros and cons of increasing pole count in an electric machine
o Describe the pros and cons of integrated drive electronics within an electric machine

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Differentiate between a brush-type DC machine and a Brushless DC (BLDC) machine

Describe at least one parameter that can be changed on a rare-earth permanent magnet machine to keep its power, torque, or efficiency the same when using less rare-earth material

Determine the pros and cons of the air vs. liquid vs. refrigerant vs. oil cooling

Determine the pros and cons of central (conventional) vs. distributed (per wheel) traction machine approaches

Establish the pros and cons of inboard per-wheel and in-wheel traction machines

Develop a scenario where a traction motor would not require gear reduction

Develop a scenario where a traction motor would require multiple gear ratios

Describe the basic difference between linear and rotary electric machines

### Product Realization Phases and Tools

- Demonstrate a comprehensive understanding of the Product Realization Process
- Examine the key factors that contribute to successful PRP implementation
- Identify the five primary stages of PRP
- Determine the proper tools and techniques for defining production process controls
- Implement customer part and process submission and acceptance requirements
- Direct resources to satisfy customer needs
- Identify early required changes to remove potential failure and avoid late changes
- Exhibit the ability to provide quality products on time at the lowest cost

### Multi-Disciplinary Team Dynamics and Functionality

- Define Team Goals
- Plan as a Leader of a team
- Define Roles and Responsibilities of a team
- Exhibit clear communication skills
- Perform as a beneficial team member in a balanced and consistent manner.
- Define Decision-making Procedures.
- Set and follow Ground Rules and Group Processes.
- Use approved tools and methodology