



## Hybrid School Bus – Emergency Response Guide

Document Number:  
**SV400003R-**

Revision Letter:  
-

Revision Date:  
**02/08/2007**

*Prepared by:*

*Reviewed/ Approved by:*

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[www.enovsystems.com](http://www.enovsystems.com)

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## FOREWORD

- This guide has been prepared to help emergency responders in the safe handling of IC hybrid school bus following any incident. Emergency response procedures are similar to other vehicles with the exception of the high voltage electrical system. It is important to recognize and understand the high voltage electrical system features, specifications, and disabling procedures as these may not be familiar to emergency responders.
- High voltage electricity powers an electric motor and control electronic unit (CEU). All other conventional automotive electrical devices such as the headlights, radio, and gauges are powered by the standard 12-Volt chassis battery. Numerous safeguards have been designed into the system to help ensure that the high voltage (HV) – approximately 330-Volt, Lithium-ion (Li-ion) hybrid vehicle battery pack is kept safe and secure at all times.
- The HV Lithium-ion battery pack contains sealed batteries that are similar to rechargeable batteries used in laptop computers, cell phones, and other consumer products. The electrolyte is absorbed in the cell plates and will not normally leak out even if the battery is cracked.
- High Voltage cables, identifiable by **orange insulation** are isolated from the metal chassis of the vehicle. These cables are routed underneath the vehicle in areas which would not normally be accessed by emergency responders at the scene of an accident. *See figure 2.2 on page 9.*
- **THE EMERGENCY RESPONDER SHOULD NOT TOUCH OR CUT OR DISCONNECT THE ORANGE COLORED HIGH VOLTAGE CABLES UNDER ANY CIRCUMSTANCES (UNLESS THE EMERGENCY RESPONDER IS TECHNICALLY TRAINED TO HANDLE HIGH VOLTAGE PROCEDURES). THE HIGH VOLTAGE CABLES SHOULD ALWAYS BE HANDLED BY TRAINED TECHNICIANS.**
- **THE EMERGENCY RESPONDER SHOULD NOT TRY TO OPEN / INVESTIGATE ANY OF THE HYBRID COMPONENTS UNDER ANY CIRCUMSTANCES. THE HYBRID COMPONENTS HAVE HIGH VOLTAGE CIRCUITS WHICH ARE VERY DANGEROUS AND CAN CAUSE SERIOUS INJURY OR DEATH DUE TO ELECTRIC SHOCK. HIGH VOLTAGE HYBRID COMPONENTS SHOULD ALWAYS BE HANDLED BY TRAINED TECHNICIANS.**

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## 1.0 OVERVIEW OF THE HYBRID SCHOOL BUS

### 1.1 The hybrid system

The hybrid system combines diesel engine and electric motor power to improve fuel economy and reduce emissions. Depending upon the driving conditions, the hybrid system blends the power output from the engine with the motor to optimize performance and efficiency. The system includes batteries which provide power to the motor on acceleration and recover power during deceleration (power regeneration). In addition the charge depleting strategy employed on this vehicle discharges the battery over the day's driving in a planned manner to further improve efficiency. The batteries must therefore be recharged when the vehicle is not in use, either between shifts or overnight.

### 1.2 The hybrid school bus

Post-transmission parallel hybrid is ideal for vehicles making frequent stops, like school buses. Enova's hybrid system is non invasive & doesn't require any additional certifications to the existing engine.

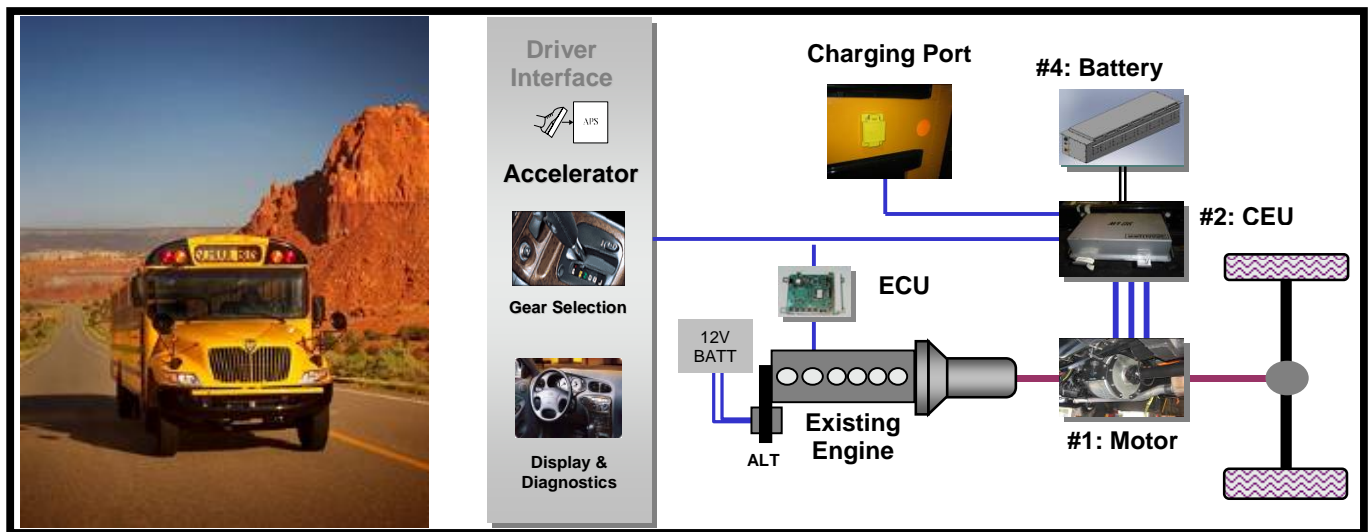


Figure 1.1: The Power systems of hybrid school bus

(# refers to the serial number of the hybrid system component as per Table 1.1 on page 7)



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### 1.3 Hybrid operation status indicators

The hybrid system is virtually transparent to the vehicle operator. The only driver accessible features which are added are:

- 1) Hybrid enable switch (to turn ON/OFF the hybrid system)
- 2) Green light – HYBRID READY (indicates proper operation)
- 3) Red light – HYBRID FAULT (indicates system fault)
- 4) Amber light – BATTERY CHARGING (indicates charge cable is plugged into vehicle)

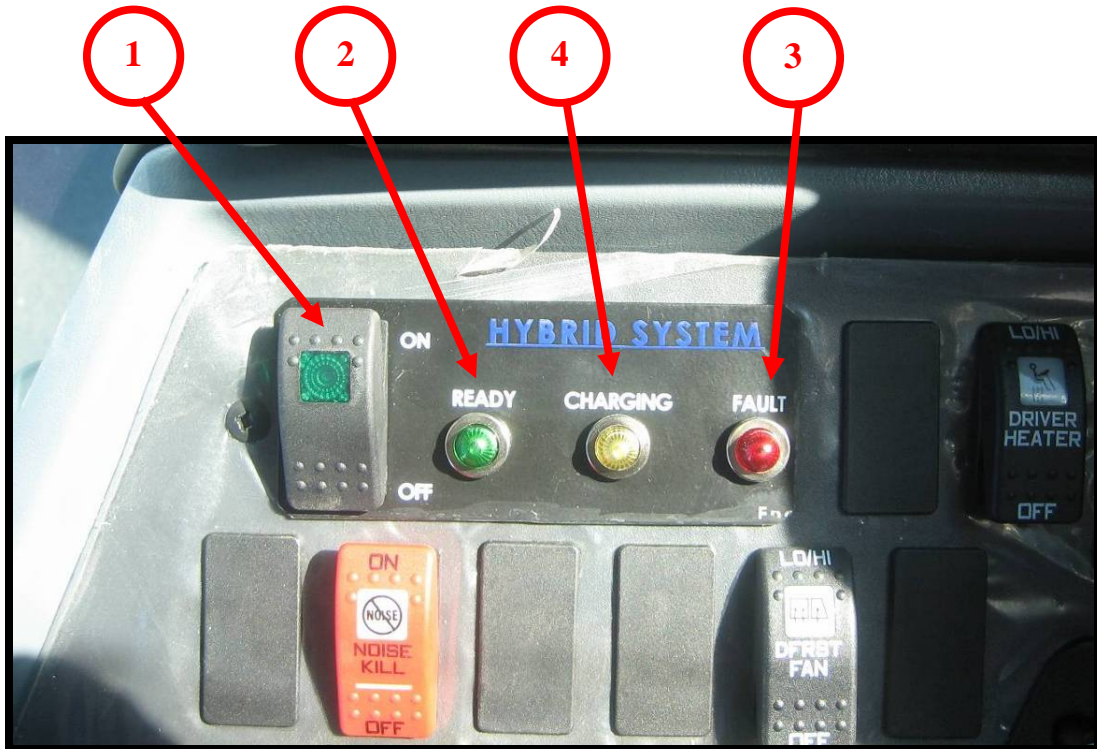


Figure 1.2: Hybrid system interface for the driver

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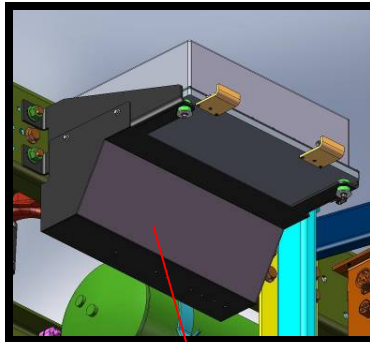
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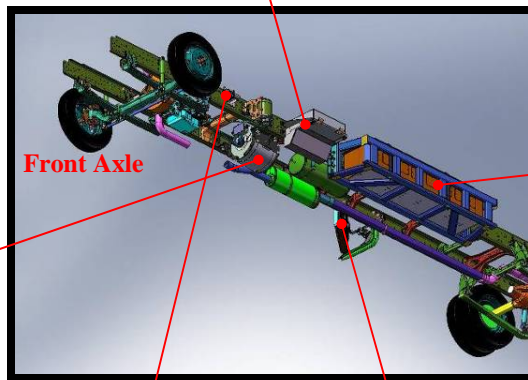
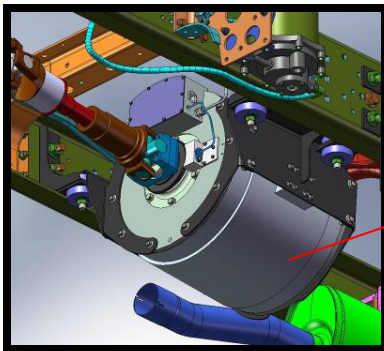
### 1.4 Location and description of hybrid system components

The location and description of hybrid system components is mentioned below:

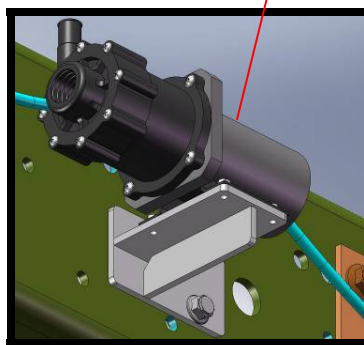
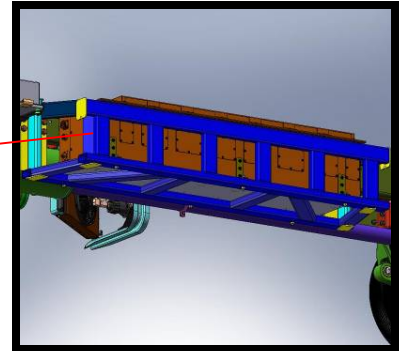
**#2: Control Electronics Unit (CEU)**



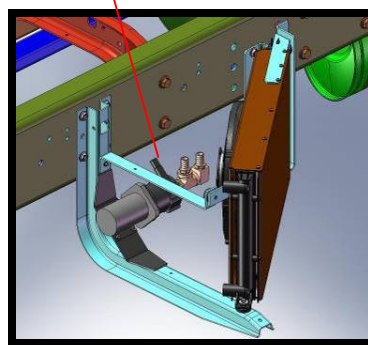
**#1: Electric Motor**



**#4: High Voltage Battery Pack**




**Pump 1**



**Radiator & Pump 2**


**#3: Cooling System**

Figure 1.3: Location of hybrid system components on the vehicle

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S.N.	Component	Location	Description
1	Electric Motor	In Driveline	A 3-phase induction electric motor contained in the trans-axle is used to power the vehicle during acceleration & to slow down the vehicle during regenerative braking.
2	Control Electronics Unit (CEU)	Undercarriage, Driver Side	<p>Converts DC electricity from HV battery pack to AC electricity that drives the electric motor.</p> <p>Converts AC from electric motor to DC that recharges the HV battery pack (regenerative braking).</p> <p>Also contains the charger module for recharging the battery pack (when the charging cable is connected to the vehicle charge port &amp; a power outlet).</p>
3	Cooling System	<p>Radiator &amp; Pump 2 – Undercarriage, Passenger Side.</p> <p>Pump 1 – Undercarriage, Driver Side</p>	<p>The pumps circulate the coolant in the hybrid system to cool its components.</p> <p>The radiator transfers heat from the coolant to the surrounding air, thus preventing the hybrid components from getting over-heated.</p>
4	High Voltage (HV) Battery Pack	Undercarriage, Driver Side	<p>330V Li-ion battery pack consisting of 28 low voltage (12V) modules connected in series.</p> <p>Provides power to the motor during acceleration and stores the power generated during deceleration.</p>

*Table 1.1: Location & description of hybrid system components on the vehicle*

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## 2.0 HIGH VOLTAGE SAFETY SYSTEM

### 2.1 Identifying (HV) hybrid system components

Emergency responders who are not aware about the hybrid system may find it difficult to recognize the hybrid system components. There are two ways in which an emergency responder can identify a hybrid system component and thus avoid any potential high voltage electrical hazards:

- 1) All hybrid system components have warning labels which are visible from the sides and underneath. The labels provide a high voltage hazard warning.

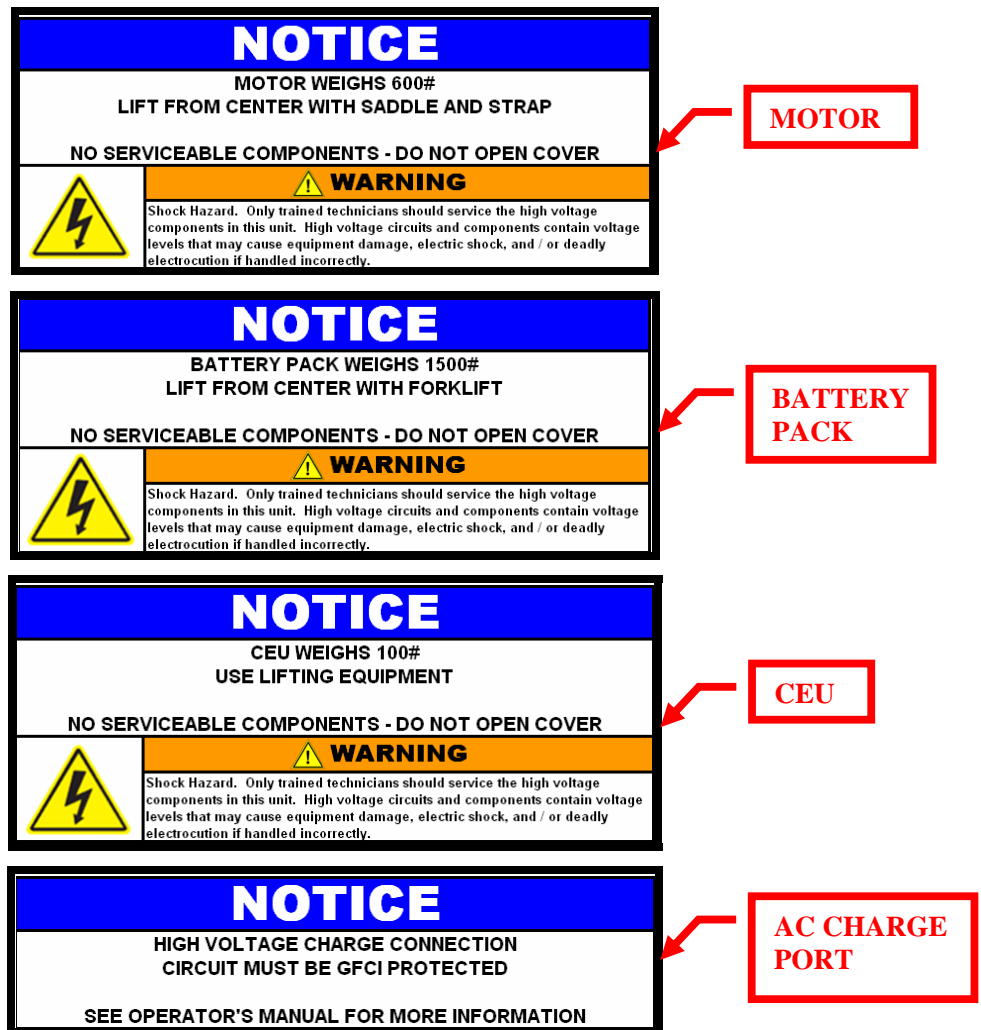


Figure 2.1: Warning labels for high voltage hybrid system components

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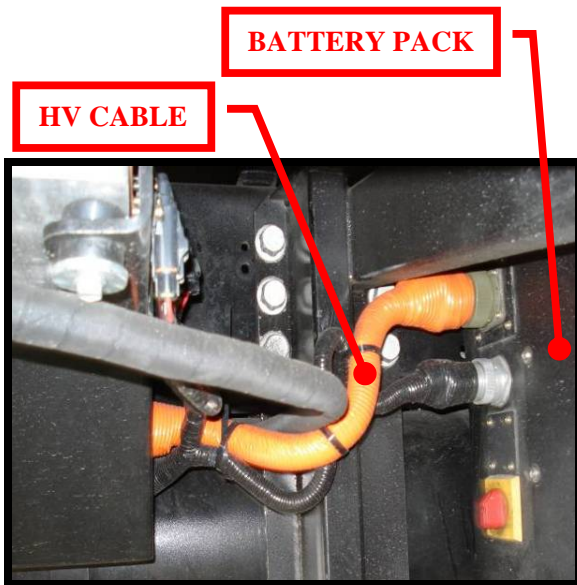
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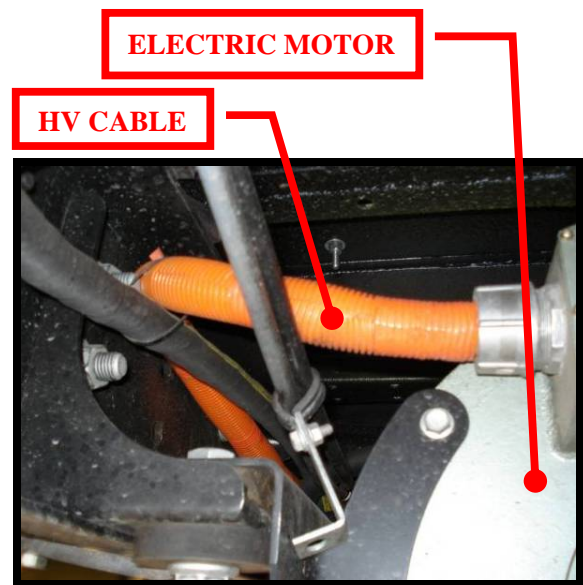
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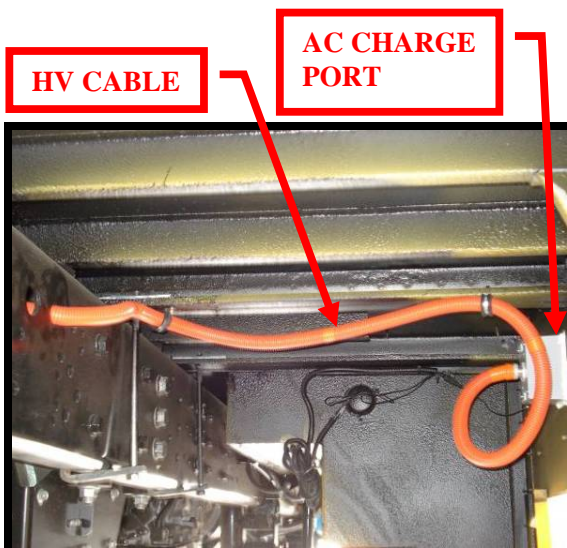
- 2) Any component that has a cable covered in an orange colored loom can be safely assumed to be a hybrid system component. These orange colored cables carry high voltage and should not be touched / cut / disconnected by the emergency responders.



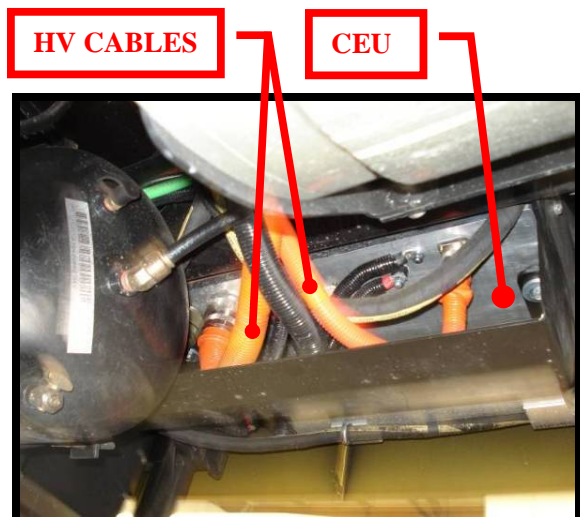
#1: From Battery Pack to CEU



#2: From Electric Motor to CEU



#3: From AC charge port to CEU




#4: HV cables connecting to CEU

Figure 2.2: High voltage cables for hybrid components

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## 2.2 High voltage system safeguards

This system is designed with the following safeguards to avoid any potential HV hazards:

- a. All HV power cables are covered in **orange colored** corrugated loom (*see figure 2.2 on page 9*).
- b. All HV components have **warning labels** for HV electrical hazards (*see figure 2.1 on page 8*).
- c. All HV connectors are fitted with an inter-lock circuit. If the inter-lock circuit is opened at any point the fault (red light) light will illuminate, the system will power down and open the high voltage contactors inside the battery pack.
- d. A fast acting HV fuse provides short circuit protection in the battery pack.
- e. The battery pack is equipped with two contactors that mechanically cut power from exiting the battery pack when the hybrid system is turned off or during system fault conditions.
- f. The battery pack is also equipped with a **service disconnect switch** to cut off battery voltage during service, transport and installation periods (*see figure 4.2 on page 19*).
- g. The HV power cables are isolated from the metal chassis, so there is no possibility of electrical shock by touching the metal chassis. The isolation is achieved by using a corrugated loom to insulate the HV cables.
- h. The CEU actively monitors the battery and the motor voltage potential with respect to the vehicle chassis ground. If the isolation voltage reaches a preset limit, the HV contactors in the battery pack are opened and a fault (red light) is indicated on the dash board.
- i. The Battery Management System (BMS), which is part of the battery pack assembly, continuously monitors the batteries and will report to the CEU any abnormal battery condition such as temperature of batteries during charge/discharge is over the preset limit, supply voltage to the batteries is over the preset limit and supply current to the batteries is over the preset limit.
- j. The AC charge harness and charge port are isolated from the vehicle ground and are designed per UL-2202. Only a GFCI equipped charge cable is recommended for charging the battery pack.
- k. The vehicle AC charge inlet port is water-tight when not in operation & when plugged in.




Figure 2.3: AC charge port


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### 2.3 Safety precautions

 <b>CAUTION</b>
<b>PRECAUTIONS</b>
<p>Precautions for use of HYBRID BUSES. The vehicle has high voltage DC and AC systems as well as a 12 volt DC system. The high voltage circuits are very dangerous and can cause serious injury or death due to electric shock. In order to avoid electric shock do not touch the orange colored high voltage cables or their connectors.</p>

 <b>CAUTION</b>
<b>IF AN ACCIDENT OCCURS</b>
<p>I Pull your vehicle off the road; move the shift lever to PB (if the bus is not equipped with PB, place the transmission in neutral and set the parking brakes), turn the vehicle OFF and remove the ignition key. Turn OFF the service disconnect switch located on the battery pack.</p> <p>II Do not touch any of the high voltage cables or any other hybrid equipment.</p> <p>III If electrical wiring has become exposed do not touch it.</p> <p>IV If a vehicle fire occurs, use only a fire extinguisher rated for use on electrical fires.</p>

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### 3.0 EMERGENCY RESPONSE PROCEDURE

The emergency response personnel should follow standard procedures developed by their own organization for assessing situations and dealing with potential hazards.

Given our knowledge of the hybrid vehicles, the procedures outlined in this section are also recommended.

#### 3.1 Disabling the high voltage hybrid electrical system

- Immobilize Vehicle

Pull your vehicle off the road; chock the wheels and move the shift lever to PB (if the bus is not equipped with PB, place the transmission in neutral and set the parking brakes).

- Disable Vehicle

Turn the hybrid enable switch OFF, turn the ignition key OFF and remove the ignition key. Also turn OFF the service disconnect switch located on the battery pack (*see figure 4.2 on page 19*).

#### 3.2 Hybrid battery pack fire


Approach and extinguish the fire using only proper vehicle fire fighting agent or extinguishers recommended for vehicle fires. Fire extinguishers rated for vehicle use are suitable for use on hybrid vehicles; “Halon Fire Extinguisher Model C354TS” and other similar fire extinguishers for vehicles are recommended to use.

#### 3.3 Submersion or partial submersion

Pull the vehicle out of the water, and then shut down the hybrid system by following the procedure as described in *section 4.2 on page 18*. There is no risk of electric shock from touching the car's body or framework – in or out of the water.

#### 3.4 Spills

The hybrid bus contains the same common automotive fluids used in other vehicles, with the exception of electrolyte used in high voltage battery pack. The electrolyte, however, is absorbed in the cell plates and will not normally spill or leak out even if a battery module is cracked. A catastrophic crash that would breach both the metal battery pack case and the plastic battery module would be a rare occurrence. The emergency and first aid procedure to handle the exposure to the battery electrolyte is described in the next section.

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### 3.5 Emergency and first aid procedures (Exposure to battery electrolyte)

Emergency responders may not be familiar with an electrolyte exposure when rendering aid to a patient. Exposure to electrolyte is unlikely except in a catastrophic crash or through improper handling. Emergency responders should utilize the following guidelines during an electrolytic exposure. Additional information about the Li-ion batteries is available from the MSDS (pages 14 – 17) provided by the battery manufacturer – **Valence Technology, Inc.**

- Wear Personal Protective Equipment (PPE): Use the proper Personal Protective Equipment (PPE) splash shield or safety goggles. Fold down helmet shields are not acceptable for electrolytic fumes or mist. Rubber, latex or nitrile gloves, apron and rubber boots are acceptable PPE for handling electrolytic spills.
- Contact with eyes: In case of contact with eyes, immediately flush eyes with copious amounts of water for at least 15 minutes. Assure adequate flushing of the eyes by separating the eyelids with fingers.
- Contact with skin: In case of contact with skin, flush skin with ample amount of water. Perform gross decontamination by removing affected clothing and properly disposing off the garments. Transport to the nearest emergency medical care facility.
- Inhalation of electrolytic vapor: Under normal conditions, no toxic gases are emitted from the batteries. If the electrolyte leaks and gets exposed to air, electrolytic vapors might arise. In a non-fire situation, the electrolytic vapors are non-toxic and if vapors are inhaled, immediately move to fresh air location. Artificial respiration or oxygen might be required if the person is exposed to electrolytic vapors for a prolonged duration. In case of a fire situation, some irritating and/or toxic fumes may be emitted as a by-product of combustion. All responders should wear NIOSH/MSHA approved self contained breathing apparatus (SCBA) and protective clothing when fighting chemical fires. Remove patient from the hazardous environment to a safe area and administer oxygen. Transport to the nearest emergency medical care facility.
- If swallowed: Rinse mouth with ample amount of water. Call a physician or transport person to nearest emergency medical care facility.



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## Material Safety Data Sheet Valence Battery

Revised Date: 12-16-03  
Preparation Date: 8-9-01

### Section 1 (Product Identification)

Manufacture's Name Valence Technology, Inc.	Emergency Telephone No. CHEMTREC 1-800-424-9300
Address (Number, Street, City, State and ZIP Code) 301 Conestoga Way, Henderson, NV. 89015	
Chemical Name and Synonyms Valence P1a Battery Liquid Cell and Polymer	Chemical Abstract No (CAS). Mixture
Chemical Family N/A	Chemical Formula N/A

### Section 2 (Hazardous Ingredients)

Hazardous Ingredients	CAS	Percent	ACGIH TLV	OSHA PEL
Polyethylene/Polypropylene Film	TS	.5-10	Not Established	Not Established
Graphite	TS	10-20	N/A	15 mg/m <sup>3</sup> (TWA Dust)
Silica	TS	.5-10	10 mg/m <sup>3</sup> (TWA)	10 mg/m <sup>3</sup> (TWA)
Carbon black	TS	10-20	3.5 mg/m <sup>3</sup> (TWA)	3.5 mg/m <sup>3</sup> (TWA)
Lithium Metal Phosphate	TS	30-40	Not Established	Not Established
Fluorinated Polymer	TS	5-15	Not Established	Not Established
Electrolyte Solvent A	TS	1-10	200 ppm (TWA)	200 ppm (TWA)
Electrolyte Solvents B and C	TS	5-15	Not Established	Not Established
Electrolyte Solvent D	TS	1-5	Not Established	Not Established
Electrolytic Fluorinated Lithium Salt	TS	1-10	Not Established	Not Established
Copper	TS	1-10	1 mg/m <sup>3</sup> (TWA dust)	1 mg/m <sup>3</sup> (TWA dust)
Aluminum	TS	1-10	10 mg/m <sup>3</sup> (TWA)	15 mg/m <sup>3</sup> (TWA)
Packaging	Mixture	1-10	Not Established	Not Established

Note: TLV - Threshold Limit Value, TWA - Time weighted average, TS -Trade Secret



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### Section 3 (Physical Data)

Boiling Point	90 °C (Solvent A); 243 °C @ 740mm (Solvent B); 125.8° C (Solvent C); 242.1° C (Solvent D)
Melting Point	3500 °C (Carbon); 3500° C (Graphite); 140°C (Fluorinated Polymer); >1000°C (Lithium Metal Phosphate); 2-4 °C (Solvent A); 37-39 °C (Solvent B)
Density (gm/cc) @ 25°C	1.7-1.9 (Carbon);
Vapor Pressure	97.68mm @ 20 °C (Solvent A)
Vapor Density (Air=1)	Not Established
Specific Gravity	1.9-2.1 (Carbon); 1.78 (Fluorinated polymer); 3.6 (Lithium Metal Phosphate); 2.2 (Silica); 1.069 (Solvent A); 1.321 (Solvent B)
Solubility in Water	Insoluble: Carbons, Silica, Lithium Metal Phosphate; Negligible: Fluorinated polymer; Not Established: All other materials
Appearance and Odor	Appearances vary. Odor negligible

### Section 4 (Fire & Explosion Hazard Data)

Flash Point	Autoignition Temperature	Flammability	LEL	UEL
Not Established	Not Established	Not Established	Not Applicable	Not Applicable
Extinguishing Media Water, Carbon Dioxide, Dry Chemical or appropriate Foam				
Special Fire Fighting Procedures Wear NIOSH/MSHA approved SCBA and protective clothing when fighting chemical fires.				
Unusual Fire and Explosive Hazards Emits irritating and/or toxic fumes under fire conditions.				

### Section 5 (Health Hazard Data)

Toxicity Data Not Established	HMS Hazard Rating Not Established
Routes of Entry Not Applicable	
Effects of Overexposure (acute and chronic) None under normal conditions. In the event of exposure to battery contents the following could occur. Acute Effects: Vapor or mist is irritating to the eyes, mucous membranes and respiratory tract. Causes eye and skin irritation. Exposure can cause: Nausea, Dizziness and headache. Chronic Effects: Overexposure may cause reproductive disorder(s) based on tests with laboratory animals. Target Organs: Kidneys, Central nervous system, eyes, male reproductive system.	
Medical Conditions Generally Aggravated by Exposure Unknown	



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Carcinogenicity	NTP	IARC Monographs	OSHA Regulated
Not tested	N/A	N/A	N/A
Emergency and First Aid Procedures			
In case of contact, immediately flush eyes with copious amounts of water for at least 15 minutes. Assure adequate flushing of the eyes by separating the eyelids with fingers. Flush skin with water. Remove and wash contaminated clothing promptly. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, wash out mouth with water provided person is conscious. Call a physician.			

Section 6 (Reactivity Data)	
Stability	Conditions Contributing to Instability
<input checked="" type="checkbox"/> Stable <input type="checkbox"/> Unstable	N/A
Incompatibility	
Organic Solvents	
Hazardous Decomposition Products - Thermal and Other	
Hydrogen Fluoride, Carbon Monoxide and Carbon Dioxide	
Hazardous Polymerization	Conditions to Avoid
<input type="checkbox"/> May Occur <input checked="" type="checkbox"/> Will Not Occur	Do not open, puncture, or incinerate.

Section 7 (Spill & Disposal Procedures)
Steps to be taken in Case Material is Released or Spilled
Not Established
Waste Disposal Method (Consult federal, state or local authorities for proper disposal procedures).
Consult federal, state, or local authorities for disposal procedures.

Section 8 (Special Protection Information)		
Respiratory Protection		
Where concentration may exceed OSHA/ACGIH permissible limits, use appropriate approved respiratory protection.		
Ventilation (Always maintain exposure below permissible limits)	Local Exhaust	Special
	N/A	N/A
	Mechanical (general)	Other
	N/A	N/A
Protective Gloves	Eye Protection	
Not required during normal handling.	Not required during normal handling.	
Other Protective Equipment/Work Practices		
Handle with care. Do not short positive and negative terminals.		





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### Section 9 (Storage and Handling Precautions)

#### Precautions to be Taken in Handling and Storing

When not being used store in cool dry area. Avoid storing in excessive heat.

#### Precautionary Labeling


All batteries should be appropriately labeled.

### Disclaimer

This information in this Material Safety Data Sheet meets the requirements of the United States Occupational Safety and Health Act and the regulations promulgated thereunder (29 CFR 1910.1200 *et. seq.*). This document is intended only as a guide to the appropriate precautionary handling of this product by a person trained in, or supervised by a person trained in, chemical handling. The user is responsible for determining the precautions and dangers of this product for his or her particular application.

Most of the hazards associated with this product concern the substances used within the seal packaging. To avoid these hazards, the user must insure the integrity of the packaging. Exposure to chemicals present in this product may have serious adverse health effects. Valence Technology cannot warn of all the potential dangers of use or interaction with other chemicals or materials. Valence Technology warrants that the battery laminate components meet the indicated specifications. Valence Technology disclaims any other warranties, expressed or implied with regard to the product supplied hereunder, its merchantability or its fitness for a particular purpose.

Read all precautionary information. As newly documented general safety information becomes available, Valence Technology will periodically revise this Material Safety Data Sheet. If you have any questions, please call Valence Technology (1-702-558-1000) for assistance.

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## 4.0 RESETTING AND SHUTTING DOWN THE HYBRID SYSTEM

At the scene of emergency, the hybrid bus may not be operational; however, if the vehicle is still operational and the emergency responder needs to reset or shut-down the hybrid system, the procedure described in the sections below should be followed.

### 4.1 Resetting the hybrid system

The hybrid system can be manually reset in either of the following two ways:

- 1) Turn the hybrid enable switch on the dash-board to OFF and turn it back ON (*vehicle is ON*).
- 2) Turn OFF the hybrid enable switch and the vehicle ignition key, and then turn ON the vehicle ignition key and the hybrid enable switch.

*The hybrid system should turn back on after resetting, except in case of a Class 0 Fault. If the hybrid system is not back on or the fault light turns on after resetting, the hybrid enable switch should be turned to the OFF position. The vehicle can still be driven with the hybrid system OFF; however a reduction in performance will be observed.*



Figure 4.1: Hybrid System – Driver interface panel

### 4.2 Hybrid shut-down procedure

To shut down the hybrid system completely, the steps mentioned below should be followed:

- 1) Turn OFF the hybrid enable switch on the dash-board.
- 2) Turn OFF the service disconnect switch of the battery pack (*see figure 4.2 on page 19*).
- 3) Turn OFF the vehicle ignition key and remove the key.

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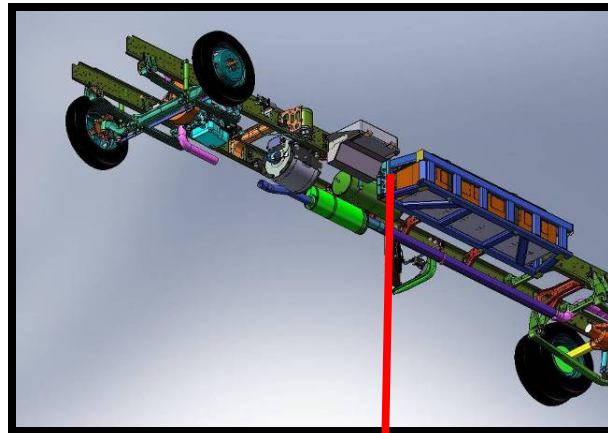
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Turn to OFF position

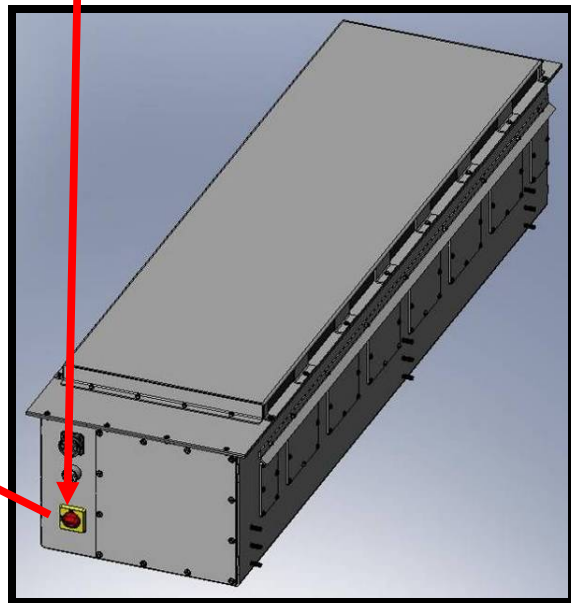
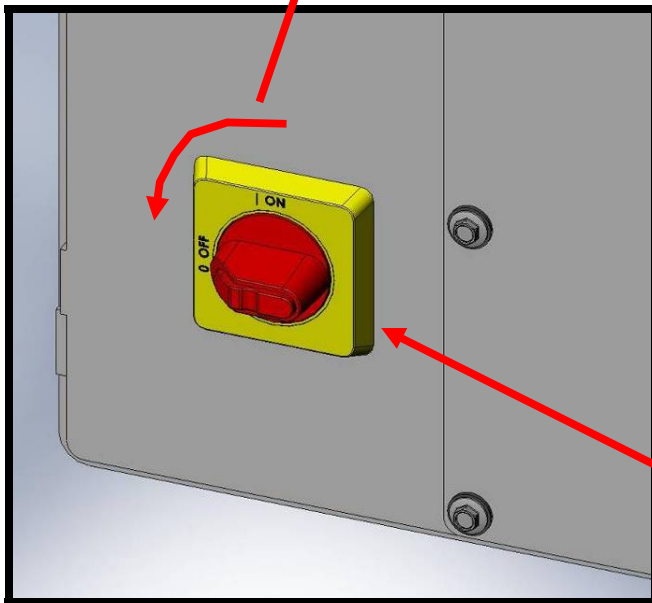



Figure 4.2: Service Disconnect Switch – HV Battery Pack

**UNDER NO CIRCUMSTANCES SHOULD THIS SWITCH BE TREATED AS AN EMERGENCY CUT-OFF SWITCH. This switch is not meant to be used as an over-current interrupter during any situation where the HV cables sustain extensive damage and cause a short in the HV circuit. The only purpose of this switch is to cut-off battery voltage during service, transport and/or installation of the battery pack or HV cables.**

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## 5.0 TOWING & RECOVERY


Since the electric motor will neither get damaged nor cause any damage if it spins while the hybrid system is off, the emergency responders can tow the hybrid school bus by following the standard towing instructions as recommended by International in the “Operator’s Manual”. In case there is an accident or the vehicle breaks down, the emergency responders should make sure that the hybrid system has been shut down completely before the bus gets towed. Upon arrival at the scene, the emergency responders should follow these steps:

### 1) In case of an accident:

- Turn the hybrid enable switch (on the dash-board) to OFF position (*see figure 4.1 on page 18*).
- Turn the service disconnect switch on the battery pack to OFF position (*see figure 4.2 on page 19*).
- Turn the vehicle ignition key to OFF position and remove the key.
- **Do not touch** any high voltage cables (orange colored) or high voltage equipments.
- If the coolant has leaked out, clean it using a dry cloth or towel.
- Follow standard towing procedures as described by International in the “Operator’s Manual”.
- Do not turn the hybrid system on until the vehicle has been thoroughly checked, serviced and repaired by qualified technicians.

### 2) In case the vehicle breaks down:

- Turn the hybrid enable switch (on the dash-board) to OFF position (*see figure 4.1 on page 18*).
- Turn the service disconnect switch on the battery pack to OFF position (*see figure 4.2 on page 19*).
- Turn the vehicle ignition key to OFF position and remove the key.
- Follow standard towing procedures as described by International in the “Operator’s Manual”.
- Do not turn the hybrid system on until the vehicle has been thoroughly checked, serviced and repaired by qualified technicians.

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## 6.0 CONTACT INFORMATION OF ENOVA’S CUSTOMER SERVICE

- **TEL: 310-527-2800**
  
- **WEBSITE: [www.enovasystems.com](http://www.enovasystems.com)**