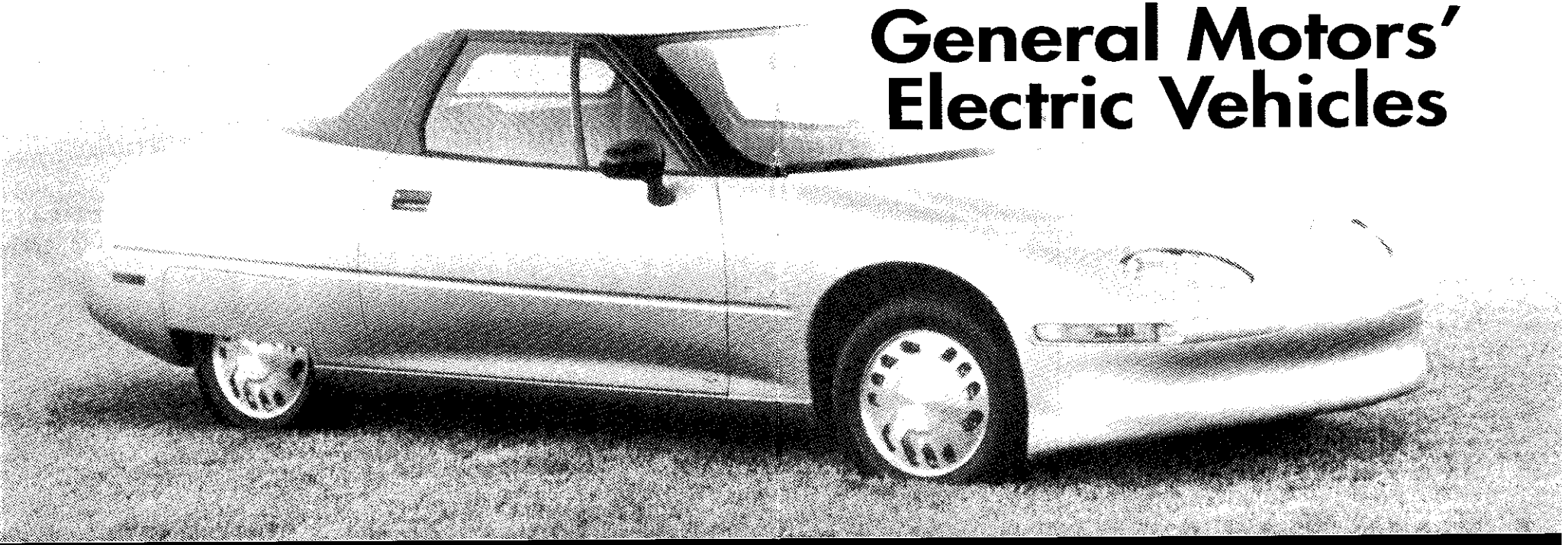
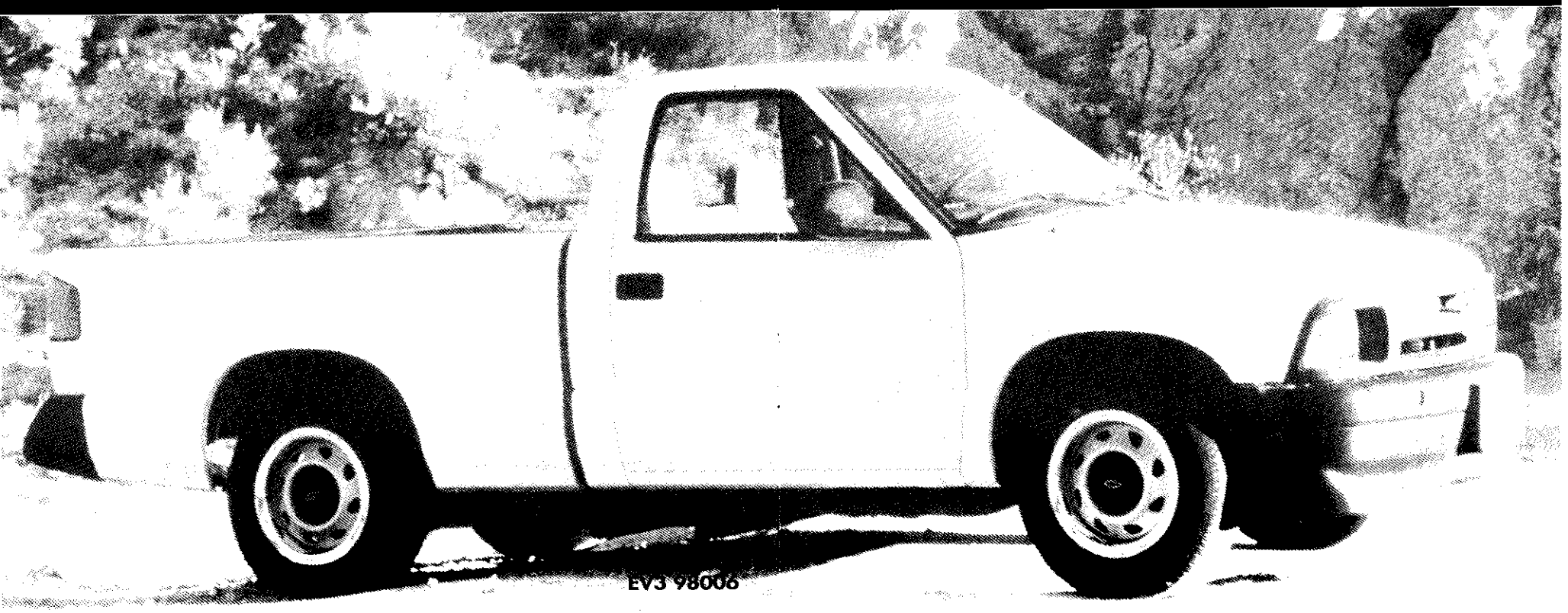
General Motors' Electric Vehicles



Emergency Response Information



EV3 98006

INTRODUCTION

The purpose of this booklet is to provide technical information to emergency response personnel for use in their handling of emergency situations involving General Motors' electric vehicles.

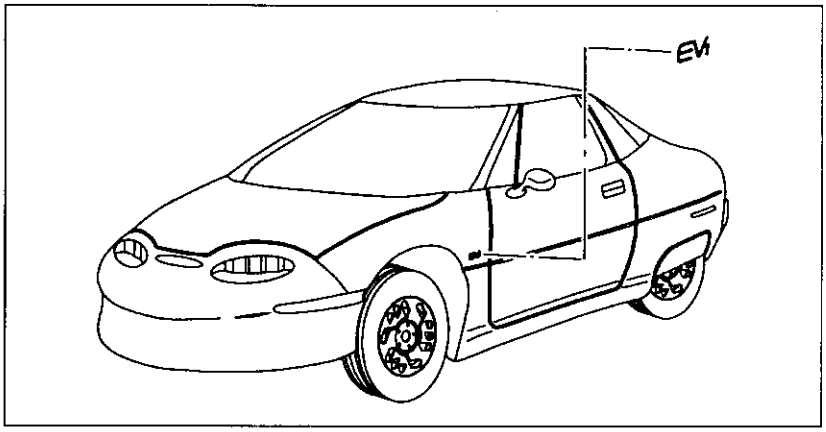
Even though electric vehicles (EVs) are a unique form of automotive transportation, many similarities exist between them and existing GM vehicles. The majority of rescue procedures used with them will be identical to those currently used in emergency situations involving gasoline-powered vehicles. However, noteworthy differences do exist. The remainder of this booklet is devoted to analyzing and describing those features unique to EVs, i.e., components or materials which are not currently used in the production of other GM products offered for sale. In addition, attention is given to unique factors which may affect how a rescue procedure is performed.

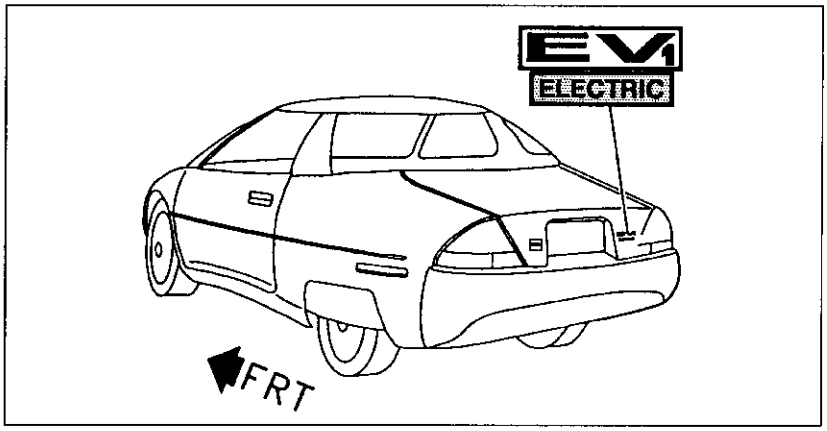
The information provided is, to the best of our knowledge, comprehensive. We have attempted to analyze the entire vehicle from the perspective of emergency responders, and offer the following information.

NOTES

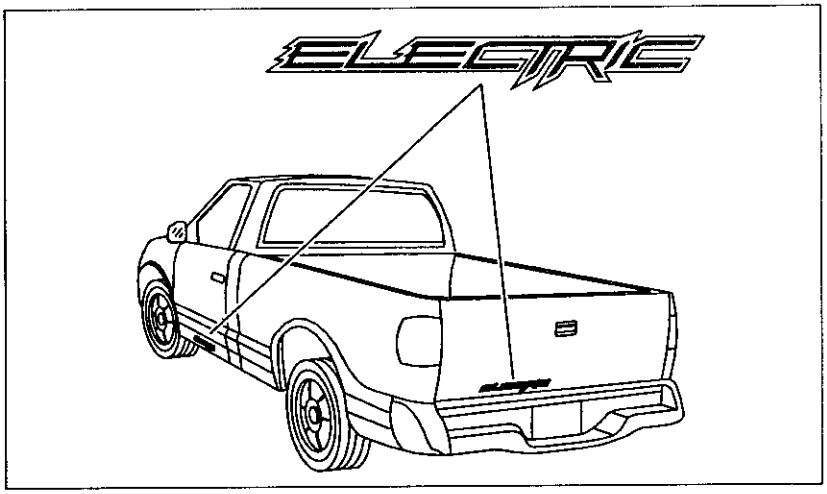
VEHICLE DESIGN OVERVIEW

When emergency response personnel approach a General Motors EV1 or Chevrolet S-10 Electric, they can identify that it is an electric vehicle by the following means:





- **The EV1 badge is located in three places on the EV1: on both right- and left-front fenders as well as in the rear of the vehicle on the right-hand side of the license plate opening.**
- **The word "Electric" is located below the EV1 badge at the license plate location on the EV1.**



- **The word "Electric" is located on both doors of the S-10 Electric, and it is also on the tailgate.**

In a circumstance where vehicle badging is not readily distinguishable, if the vehicle underbody is visible, the EV1 can be distinguished from other gasoline-powered vehicles by its fully enclosed, smooth underbody, i.e., there are no exhaust pipes or gas tanks underneath the vehicle. Instead, the vehicle's underbody is closed off by "belly pans." This design feature makes the EV1 unique among all other GM products currently offered for sale.

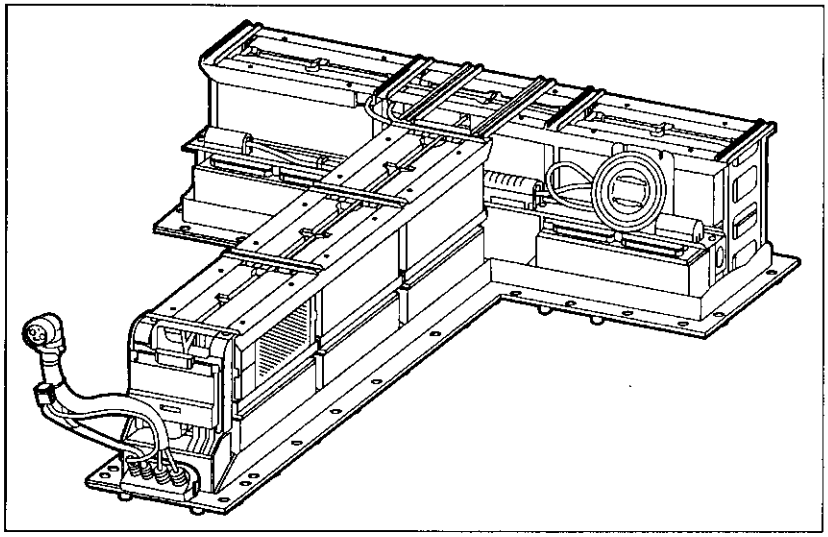
The S-10 Electric also has "belly pans" in the front and center of the vehicle. However, the S-10 Electric underbody is not completely enclosed like the EV1.

Unlike the EV1, the S-10 Electric does have a diesel fuel tank (1.5 gallons) and a small exhaust pipe for the fuel-fired cabin heater.

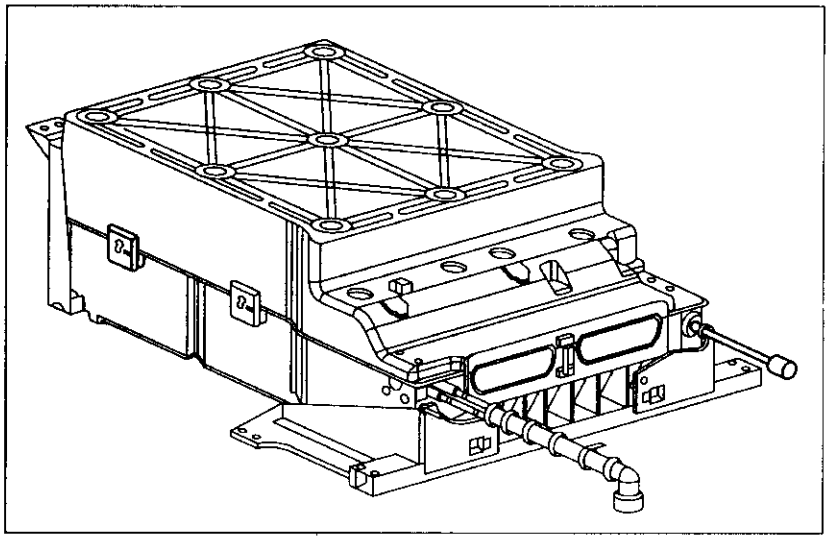
The General Motors electric vehicles are powered by lead-acid battery technology, a chemistry which is prevalent in nearly all automotive applications today. Although the chemistry is not unique, the engineering of the batteries includes several noteworthy features.

The battery packs consist of twenty-six, 12-volt lead-acid battery modules connected in series, for a system total of 312 volts. The modules are gas-recombinant, valve-regulated, and have a higher specific energy (52 amp-hours) than standard batteries found in conventional vehicles. These battery modules are not "flooded" with electrolyte. Instead the electrolyte is trapped in an absorptive glass mat.

Therefore, the amount of free electrolyte contained within each battery module is actually very small. In the unlikely event of a severe puncture of a battery module, the amount of possible electrolyte leakage from the module is about 1 to 2 teaspoons.



EV1 Battery Pack



S-10 Electric Battery Pack

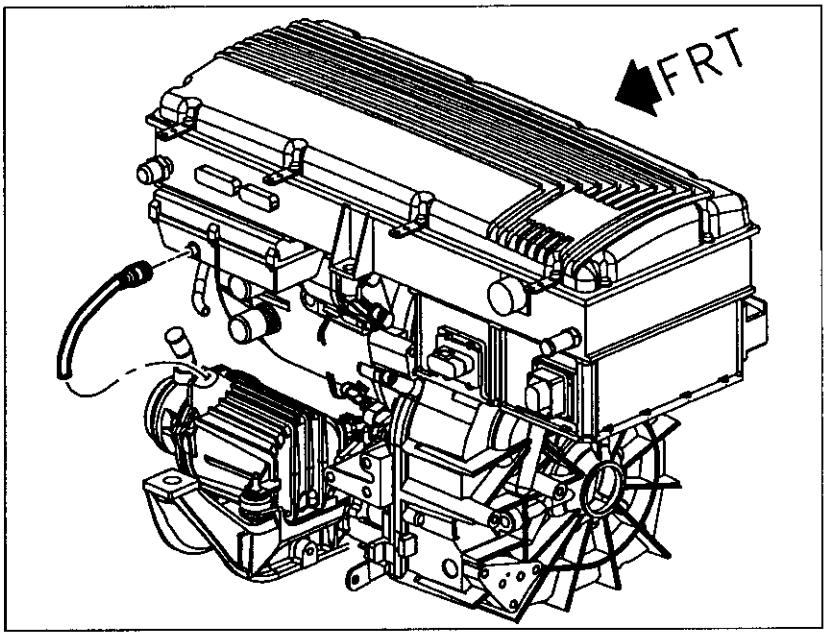
Both the battery modules and the battery pack are vented to allow the removal of trace amounts of hydrogen and oxygen produced during charging or vehicle operation. Using the test procedure developed by Underwriter's Laboratories (UL2202) for measuring gaseous emissions during EV charging, ***the GM EVs have been shown to produce levels of off-gassing that are significantly lower than the specification limit***, which is 25% of the lower flammability limit (LFL). During a normal 3-hour charge cycle, tests have shown off-gassing levels of roughly 1% of the LFL. Measurements taken under a "worst-case scenario" show off-gassing levels that are approximately 4.5% of the LFL.

Both the EV1 and the S-10 Electric are propelled by an alternating current (AC) induction motor with integral gearing. The EV1 is capable of achieving 137 horsepower; the S-10 Electric is capable of achieving slightly less horsepower. The sealed drive unit (motor, gears and differential) contains about 56 oz. of oil which is there for the life of the vehicle. The battery direct current (DC) is converted to three-phase (AC) for the motor by insulated gate bi-polar transistors (IGBTs) in the power inverter module (PIM).

The vehicles are charged using an off-board inductive charging system. The inductive charging system is actually a take-apart transformer with the off-board portion (the charger) acting as the primary, and the on-vehicle portion (the charge receptacle) acting as the secondary coil, of the transformer. Primarily, the vehicles are charged using a 6.6 kW charger hard-wired to a 220-volt/40-amp circuit. In addition, the EV1 comes with a convenience charger which is stowed in the trunk. This operates from a conventional 110-volt wall outlet or plug. The S-10 Electric does not have a convenience charger.

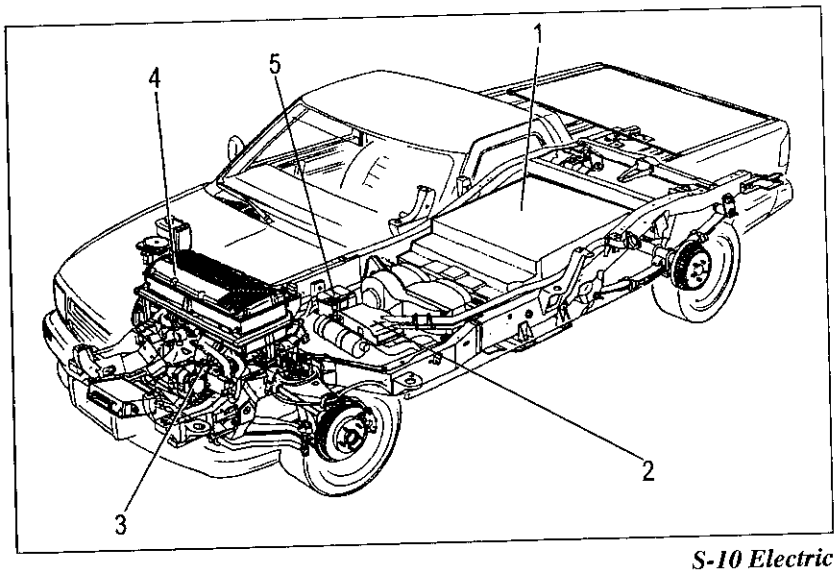
The EV1 braking and steering systems are both somewhat unique in that they are electro-hydraulic systems. The front disk brakes are hydraulically actuated and powered by electrically driven pistons (12-volt power); the rear drums are electrically actuated (12-volt power). The brake components — including brake fluid — are the same as those typically used in other GM vehicles. The S-10 Electric uses a standard vacuum-boosted hydraulic brake system with Kelsey Hayes ABS.

Steering power-assist is provided by an electric motor-driven pump rather than a belt-driven pump. ***The pump motor is a high-voltage (180 AC volts) component and should be approached with caution.*** The high-voltage carrying cables can be quickly identified by their orange color. (See section entitled "Safe Vehicle Handling: Electrical" for more details.)



The other power steering components — hoses, rack and pinion gear and hydraulic lines — are essentially the same as those used in other GM products. The power steering fluid used in the EV1 is not the standard petroleum-based fluid normally used in GM vehicles; rather, it is a synthetic fluid. However, its chemical and physical properties are nearly identical to those of the power steering fluid most commonly used today. The only noteworthy difference is that the flash point for the EV1 power steering fluid is 45°F (25°C) lower than the standard fluid (302°F or 150°C rather than 347°F or 175°C).

The EV1 and S-10 Electric use a heat pump for passenger heating and cooling, rather than a conventional heating and air conditioning system. As a result, some special consideration must be given to these components. ***The compressor motor***, located forward of the left front tire (driver's side) on the EV1 or the right rear of the motor compartment on the S-10 Electric, ***is a high-voltage (180 AC volts) component and should be approached with caution.*** The high-voltage electrical wiring for the compressor is easily identified by its orange color. The refrigerant used for cooling is an industry-standard R-134a refrigerant. However, the system uses a different compressor oil; it is a polyoester oil rather than the typical motor lubricant.



S-10 Electric

1. Battery Pack
2. Fuel Tank
3. Drive Motor
4. Power Inverter Module
5. Fuel-Fired Heater

When the heat pump is in heat mode or A/C (Cool) mode, the heat exchanger is pressurized from 200 to 300 psi. On the EV1, the heat exchanger is located inside the passenger compartment, under the dash, just behind the radio module. The S-10 Electric has two heat exchangers, one located behind the glove box for cabin heating/cooling and an additional heat exchanger located directly in front of the battery pack for heating and cooling of the batteries. To turn off the heat pump on the EV1, press the "OFF" button on the center console. To turn off the heat pump on the S-10 Electric, turn the heat control knob to "OFF."

Once the heat pump is turned off, the pressure bleed-down takes place within 1-2 seconds. However, to add a margin of safety, emergency personnel should wait approximately 10 seconds after turning power off to the heat pump before using any mechanical device in the area of this heat exchanger.

The S-10 Electric has an additional heater which burns diesel fuel to warm the cabin. The fuel-fired heater is located under the vehicle between the drive motor and the battery pack towards the passenger side. The fuel-fired heater draws its fuel from a 1.5 gallon tank which is located about 12 inches to the right of the heater.

The tire and wheel assembly is similar to other GM vehicles on the road today with one exception: the tires are pressurized to 50 psi. The EV1 wheels are ultra-lightweight cast aluminum. The S-10 Electric wheels are steel.

The suspension system design, and materials used, are generally consistent with those used on other GM vehicles. The front suspension is a short-long-arm (SLA) construction. The EV1 rear suspension is unique in its design and composition (it's constructed of aluminum and plastic composites); however, it does not present any special consideration for emergency response personnel. The S-10 Electric rear suspension is a simple tube axle and also presents no special consideration for emergency response personnel.

All EV1 body panels are molded from glass-reinforced plastic composites, similar to the plastic panels used on the Chevrolet Corvette. The door construction is SMC inner and outer panels using a mini-wedge door striker assembly. This design is similar to other General Motors vehicles; door strikers, locks, and handles are identical to existing designs. Therefore, door prying efforts, as well as procedures for defeating the locking mechanisms, will be identical to those used on other GM vehicles of that design. The S-10 Electric body panels are steel, except for the unique grill and front fascia.

The body construction for the EV1 is highly unique, making use of many proprietary materials and manufacturing processes. The EV1 structure, or vehicle frame, is made of aluminum assembled using a combination of welding and epoxy bonding. Many of the aluminum components are treated with a chromate conversion coating before assembly. This coating is typically used on structural construction components used in architecture. It is also currently used on after-market aluminum wheels. This coating does not pose any unique risk to emergency response personnel.

To assemble the EV1 aluminum frame, a structural adhesive is used which is a one-part epoxy. This adhesive is not used in any other GM product, but reportedly has been used on other manufacturers' vehicles sold in the United States. A relatively small amount of this epoxy is used in the construction of the EV1. Once the epoxy is cured, it becomes chemically inert and poses no particular risk.

Because the EV1 body is structurally "glued" together, extrication procedures may have to be revised. Body flanges may not separate the same way welded-steel structures do.

The S-10 Electric structure or vehicle frame is the same steel rail ladder design used on S-10 4x4 trucks. Cab and box construction are identical to conventional S-10 pickups.

The interiors of both vehicles are constructed of materials which are commonly used throughout the General Motors product line. Seat and carpet fabrics, instrumentation plastics, trim vinyls and seat cushions are all constructed of commonly-used automotive materials.

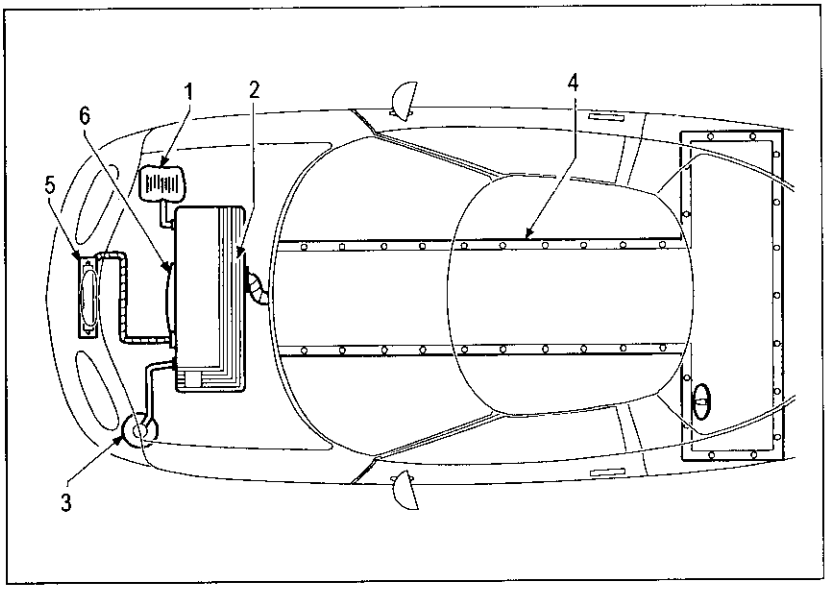
Even the EV1 seat frame, which is constructed of a magnesium alloy, is similar to another magnesium alloy which has been used in General Motors products (such as the Pontiac Grand Prix) since 1988. The magnesium alloy used in the EV1 will not burn below 1060°F. Above this temperature, the material will burn, but it is not considered hazardous. It should be noted that other automotive manufacturers have been using magnesium alloys in their vehicle construction for many years. The use of magnesium is growing in automotive applications because of its engineering properties.

The remainder of this booklet is devoted to a more comprehensive discussion of EV1 and S-10 Electric vehicle features and the implications for emergency response personnel and procedures.

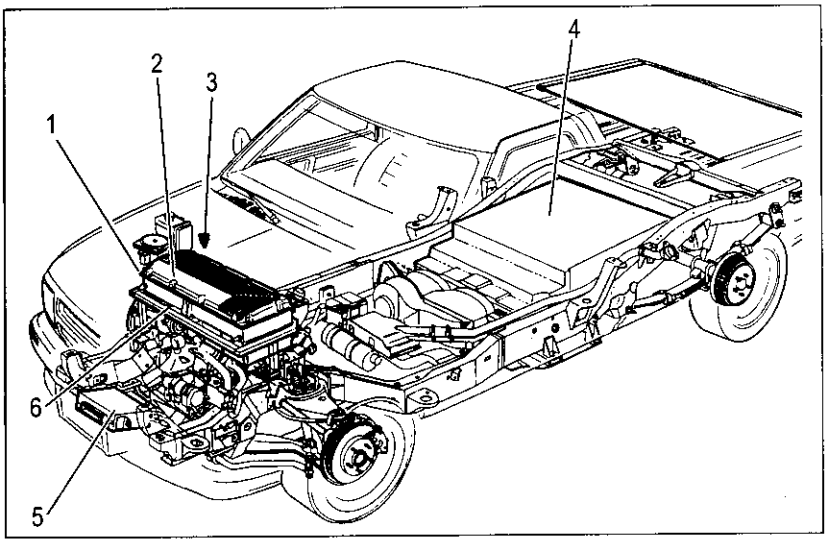
SAFE VEHICLE HANDLING: ELECTRICAL

A. High Voltage in Motor Compartment (Underhood)

There are several high-voltage components in the motor compartment of which emergency rescue personnel need to be aware.



EV1 High-Voltage Components



S-10 Electric High-Voltage Components

1. Power Steering Motor
   - located in the lower right side of motor compartment (passenger side)
   - high-voltage cables are orange in color

2. Power Inverter Module (PIM)
   - the power inverter/motor controller
   - located underhood, in the center of the motor compartment

3. Heat Pump Compressor
   - located forward of left front tire (driver's side) on the EV1
   - located in the right rear motor compartment on the S-10 Electric
   - high-voltage cables are identifiable by their orange color

4. Battery Pack

5. Vehicle Inlet (charge receptacle)
   - located in the "nose" of the vehicle in the front fascia (EV1)
   - located behind the front license plate (S-10 Electric)
   - hinged door at opening
   - high-voltage is available at all times at high voltage cables

6. Drive Motor/Gear Assembly
   - direct attachment to PIM; no high voltage cables or wiring (EV1 Only)
   - cable from PIM to drive motor on S-10 Electric

- **The cables and connections for all of these components should NEVER be cut, punctured or handled, especially if abraded, exposed or damaged in any way.**

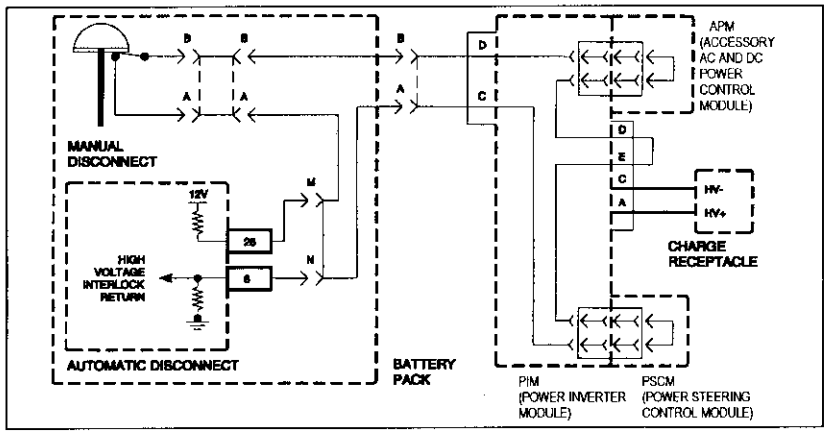
- **These components are electrically-isolated from the vehicle frame and body. Even in the unlikely event of isolation failure, an emergency responder cannot be electrocuted by touching the vehicle frame.**

B. High Voltage in Vehicle "Tunnel"

1. Lead-acid Battery Pack
   - located down center tunnel of vehicle (between driver's and passenger's seats) in T-shaped compartment; length of pack extends from front-of-dash to forward trunk wall (EV1)
   - battery cables are white in color (EV1)
   - located under bed of truck between rear of cab and rear axle tube (S-10 Electric)
   - battery cables are orange in color (S-10 Electric)
   - twenty-six, 12-volt modules are connected in series for 312 volts, total
   - battery modules, cables and connections are securely attached to the battery tray, which is bolted into the vehicle's structure.

- Never cut into the battery tunnel or penetrate the battery pack compartment, in any way, even after disabling the battery service disconnect. (See item "C" for this procedure.) The battery pack and all of its connections (except the service disconnect) are not accessible from any location on the vehicle, without the use of special service tools and equipment. The battery compartment is fully enclosed by underbody "belly pans."
- Mechanical or hydraulic extrication tools may be used to enter the passenger compartment of this vehicle through the door, door frame, front windshield, rear window, or roof. Extrication procedures may include cutting through the roof "pillars" in the areas of the windshields and door frame. However, care must be taken not to cut into the side of the vehicle just forward of each rear wheel-well, since the battery pack is accessible at that location.
- If cutting through the floor on an EV1 is required in an extrication procedure, the procedure must be carried out with care to avoid the battery pack compartment. Cut the floor panels directly under and forward of the driver and passenger seats. Avoid cutting the hard plastic T-shaped battery support tray.
- If cutting through the floor on an S-10 Electric is required in an extrication procedure, the procedure must be carried out with care to avoid the battery pack and high voltage cable along the right (passenger-side) frame rail. The cable is in orange conduit.
- The battery modules, cables and connections are electrically isolated from the vehicle frame and body. Even in the unlikely event of isolation failure, an emergency responder cannot be electrocuted by touching the vehicle frame.

C. Disconnecting the High Voltage System



1. Automatic Disconnect

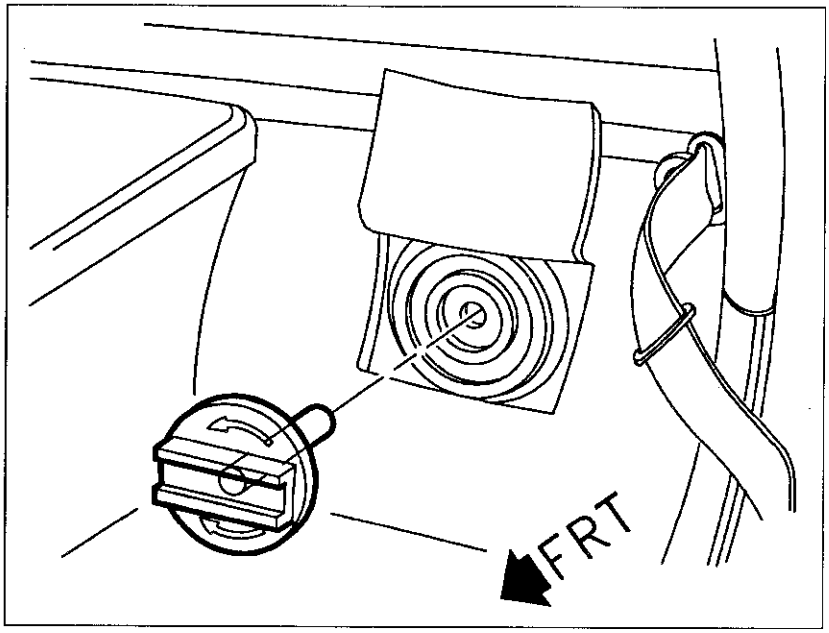
The vehicle has a high voltage interlock loop which passes through all high voltage components: the battery pack, power inverter module, power steering pump motor, heat pump compressor, and charge receptacle. This interlock loop is designed to "open" in the event of a vehicle collision which has caused damage to underhood high voltage components. If the interlock loop is broken, or opened in any way, high voltage is immediately removed from the high voltage bus and the bus is discharged. Malfunctions may cause the bus NOT to discharge. NEVER assume the bus is down. Always check the "RUN" light on the EV1 center console and the battery pack voltage gage on the S-10 Electric instrument cluster. All of these components are disabled within a fraction of a second that the loop is broken and voltage is removed from the connectors and cables along this loop.

- **Even though the automatic disconnect has been tripped, this does not remove the energy stored in the battery pack. High voltage still exists inside the battery compartment.**
- **Rescue personnel can identify that the automatic disconnect has tripped if the "WAIT" tell-tale light is illuminated on the instrument panel. (This can only be done if 12-volt power has not been disabled.)**
- **Accessory power to all 12-volt systems is not disconnected by this feature.**

2. Service Disconnect

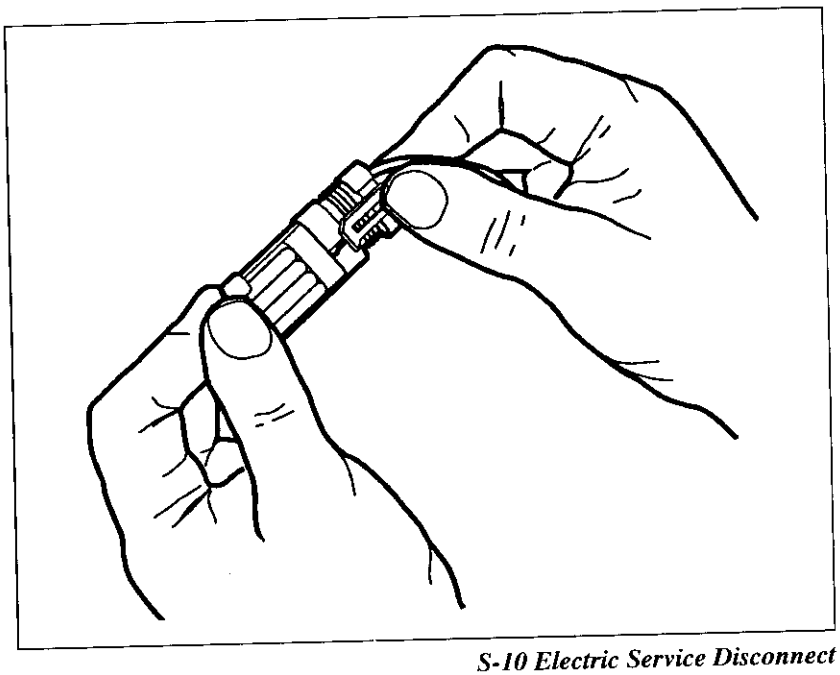
The battery pack may be disconnected manually from all high-voltage components by removing the service disconnect.

However, the primary reason for this service disconnect is to facilitate servicing of the vehicle. Since the automatic disconnect will contain the high voltage in the battery if there is any disruption to the high voltage circuitry, there is no need to use the service disconnect for the purpose of isolating battery voltage, in the event of a crash or vehicle fire. In the case of a minor accident where the vehicle will need to be towed away for service, it is conceivable that the automatic disconnect will not contain the voltage in the pack, in which case it may be advisable to pull the service disconnect prior to towing the vehicle.



EV1 Service Disconnect

The service disconnect in the EV1 is located behind the driver's seat underneath a panel of carpeting. To isolate battery voltage, lift the small carpet panel, rotate the service disconnect handle and remove the pin. Power to all high-voltage components will be contained within a fraction of a second.



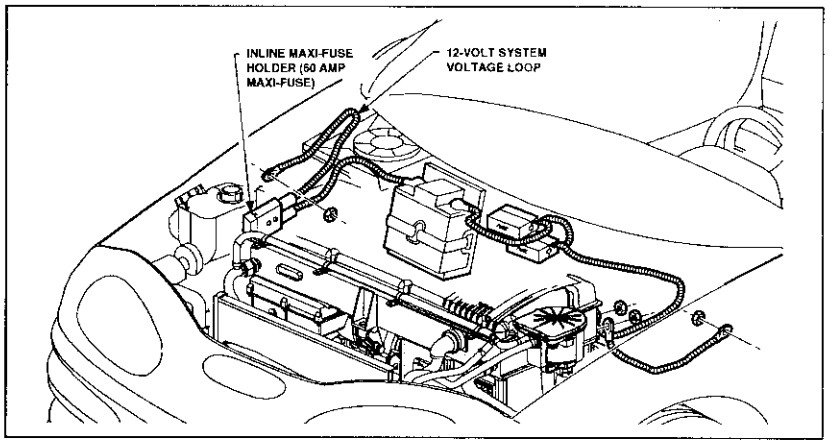
S-10 Electric Service Disconnect

The service disconnect in the S-10 Electric is located near the brake booster and master cylinder assembly under the hood on the left (driver's) side. To remove the manual disconnect, lift the safety locking tab slightly and pull the connector apart. Power to all high-voltage components will be contained within a fraction of a second.

The high-voltage components, with the exception of the power inverter module, do not have any significant "capacitance," i.e., the ability to store an electric charge. The power inverter module contains several large capacitors that have the ability to store a very small portion of the battery pack's power. For an added margin of safety, after pulling the service disconnect, emergency response personnel should wait approximately 60 seconds before they do any work in the motor compartment.

- **The service disconnect is intended for vehicle service use only. It is not necessary to pull the disconnect in the event of a vehicle collision.**
- **The service disconnect does not disable the 12-volt power system.**
- **Even though the service disconnect is pulled, the energy contained within the battery pack is still present.**

D. Disabling the 12-Volt Power System



EV1

The 12-volt power system of the EV1 may be disconnected by removing the 60 amp "Maxi-Fuse" located under the front-of-dash at the passenger's side of the vehicle. Use the voltage loop if the fuse is inaccessible.

The 12-volt power system of the S-10 Electric may be disconnected by cutting the negative auxiliary battery cable near the auxiliary battery. (The auxiliary battery is located in the front of the motor compartment on the passenger's side.)

SAFE VEHICLE HANDLING: MATERIAL

Handling Battery Electrolyte

The batteries are not the typical "flooded" battery variety commonly used in automotive applications. The battery electrolyte is absorbed in a fiberglass separator and retained against the electrodes. This design significantly reduces the amount of electrolyte contained within each module, minimizing the risk of exposure to any human being in the event of battery puncture.

The EV1 battery pack is fully contained within the battery tunnel and sits on a plastic battery tray along the center line of the vehicle. The S-10 Electric battery pack is also fully contained and is under the bed of the truck. In the event that the battery tray or pack is damaged and a battery module is ruptured, the amount of possible electrolyte leakage is minimal, about one to two teaspoons per module. The electrolyte is typical in chemical composition (43% concentration, by weight) to that commonly used in lead-acid automotive batteries and should be handled using the same hazardous material procedures.

- **If battery electrolyte is present, treat according to local hazardous material procedures for containment and handling.**
- **Follow established protective clothing guidelines and procedures for Self-Contained Breathing Apparatus (SCBA) when handling battery electrolyte seepage.**

SECURING THE VEHICLE

If the EV1 is powered-up and running, the instrument cluster will be lit and the "RUN" light (located on the lower left-hand side of the center console) will be illuminated. When the vehicle is off, the instrument cluster will be totally dark.

If the S-10 Electric is powered-up and running, the battery pack voltage gage on the instrument cluster will read the approximate pack voltage (320 volts).

- **NEVER ASSUME THE VEHICLE IS "OFF" SIMPLY BECAUSE IT IS QUIET!**
- **Vehicle noise is virtually undetectable while the vehicle is on. Therefore, care should be taken to ensure that system power is removed through the securing procedure before vehicle handling takes place.**

A. Securing the EV1

1. Place the vehicle in park by moving the shift lever to the "PARK" position. The parking brake will actuate (set) automatically.
2. Shut off vehicle power by depressing the "LOCK" button located on the center console; or by depressing the "OFF/ACC" switch for 2 seconds.
3. If the vehicle cannot be placed into park, shut off the vehicle power by depressing the "OFF/ACC" switch, and hold it for 2 seconds until the vehicle power is turned off.

Note: The park brake can be set manually by pressing the park switch located on the left side of the dash if the vehicle is not able to be placed into park using the shifter (assuming 12-volt power is available).

- **Securing the EV1 ensures that it will not operate inadvertently.**

B. Securing the S-10 Electric

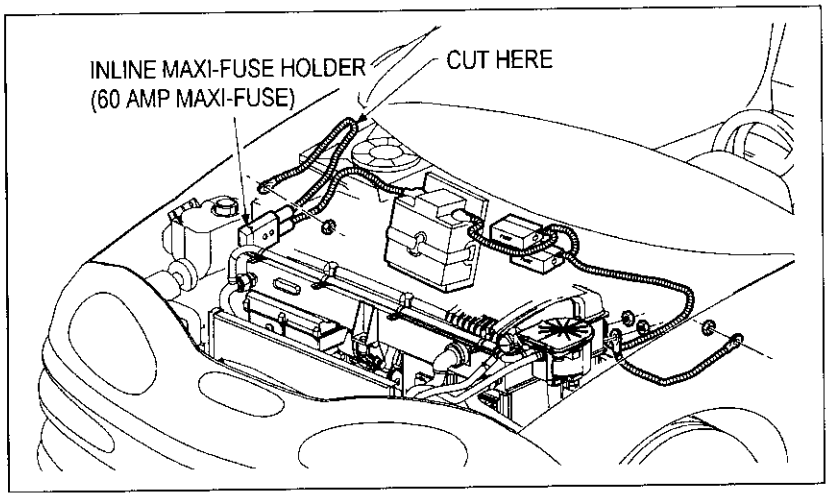
1. Place the vehicle in park by moving the shift lever to the "PARK" position.
2. Shut off vehicle power by turning the ignition key counter clockwise to the "OFF" position.
3. If the vehicle cannot be placed into park, place into neutral and set the parking brake on the left (driver's) side of the passenger compartment.

- **Securing the S-10 Electric ensures that it will not operate inadvertently.**

SAFE HANDLING OF SUPPLEMENTAL INFLATABLE RESTRAINTS (SIRs)

Even though handling vehicles equipped with supplemental inflatable restraints (airbags) in an emergency rescue situation is not unique to electric vehicles, it is worth noting that the EV1 is equipped with both a driver and passenger air bag, while some S-10 Electric trucks have a driver air bag only and others have both a driver and right front passenger air bag.

Generally, in the event that the airbags have deployed, there may be some dust in the air. This dust could cause breathing problems for people with a history of asthma or other breathing trouble. There may also be some powder residue present. Protective gloves and eyewear should be used in these rescue circumstances.



EV1

If the airbags have not deployed, battery power to the airbags may be disconnected by removing the 60 amp "Maxi-Fuse" or cutting the 12-volt cable (all airbag harnesses are distinguishable by their yellow color).

Capacitors in the airbag module (SDM) provide enough energy to deploy the airbags for up to 10 minutes after the loss of power to the SDM. Therefore, it is advised that rescue personnel carry out extrication procedures without delay, but do not place their body or any objects against or in close proximity to either air bag location. The extrication procedure should take place with care not to get in close proximity to the airbag modules.

- **Follow standard airbag handling procedures.**

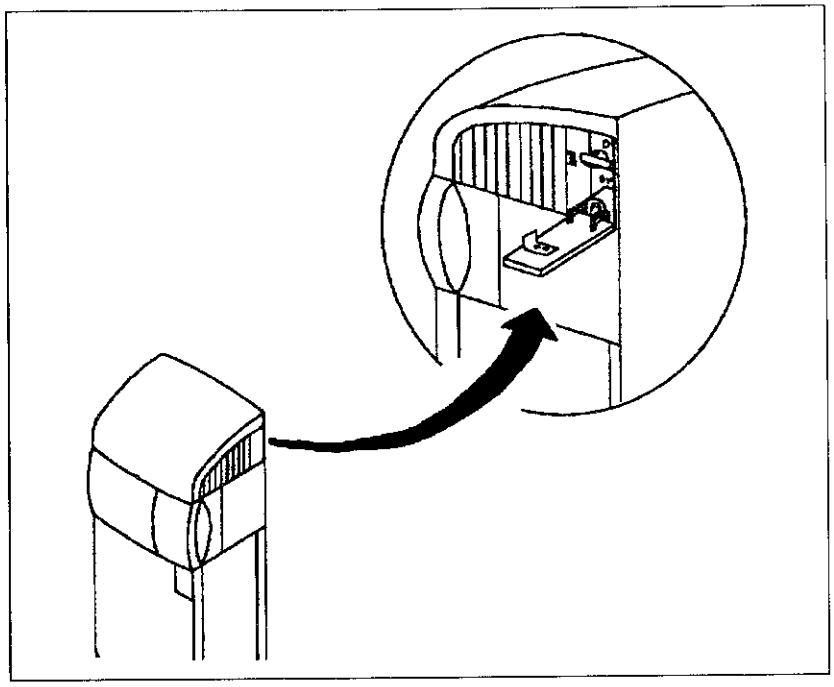
SAFE HANDLING DURING FIRE

A. While Charging

In the event that there is a vehicle fire while charging, the following actions should be taken:

Turn off the charge power, at its source:

- with the convenience charger (EV1 only), simply pull the plug out of the wall outlet



6.6 kW Charger Power Switch

- with the standard 6.6 kW charger, turn off the power switch on the equipment or disconnect the main power source for the circuit.

After the charge power is turned off, treat the fire as any other fire, using extinguishing materials and procedures commonly used to fight vehicle fires.

B. While Parked and Not Charging

Treat the fire as any other fire, using extinguishing materials and procedures commonly used to fight vehicle fires.

SAFE HANDLING DURING IMMERSION

If the vehicle is immersed in water, either partially or completely, there will be no electrical hazard to either vehicle occupant(s) or emergency response personnel. When water enters the battery pack compartment the system quickly "shorts-out;" battery pack voltage is consumed in a rapid discharge process that is contained within the battery pack compartment. Because the battery pack is isolated from earth ground, this discharge process takes place without risk to either vehicle occupants or the rescue workers who may be required to enter the water for an extrication operation. Emergency response personnel should be aware that during this rapid discharge process, the water in the battery compartment undergoes an electrolytic process, producing small amounts of hydrogen and oxygen gasses. There could be some minor popping in the battery compartment as these gas "pockets" come into contact with the dissipating battery voltage. **Emergency response personnel must not attempt to pull the service disconnect in these circumstances.**

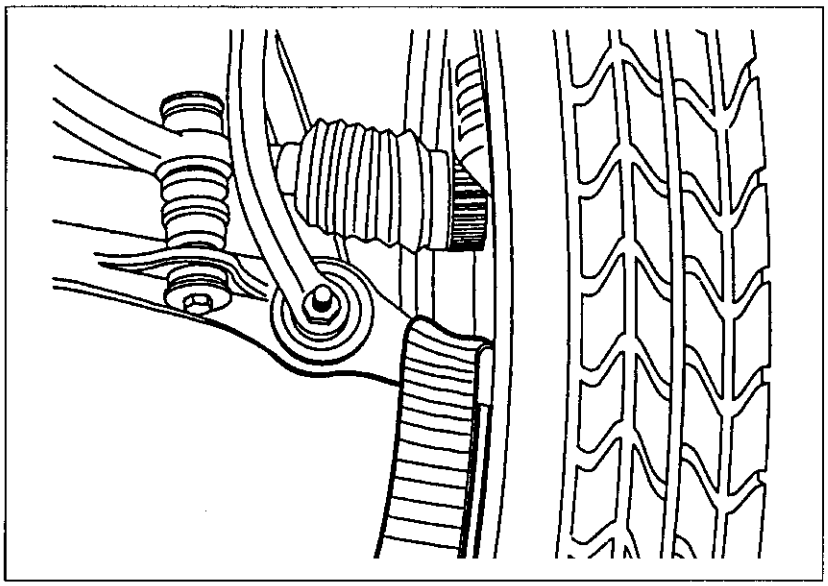
Occupant extrication should take place using normal procedures for vehicle immersion circumstances.

TOWING

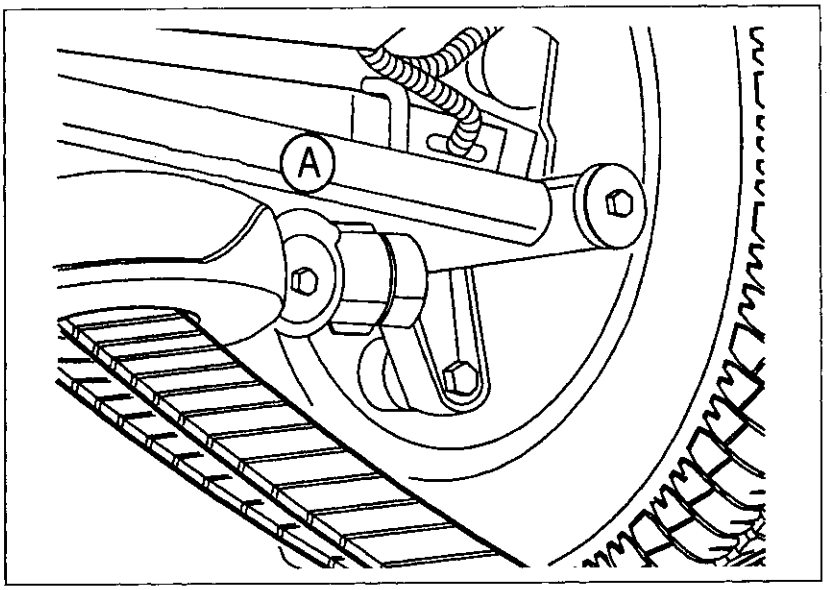
A. Towing the EV1

The EV1 should be hauled on a flat-bed or tilt-bed vehicle carrier.

The vehicle should be secured to the vehicle carrier by attaching straps to the front and rear suspension.



Route the front nylon tie-down straps around the lower control arms near the front tires (on both sides of the vehicle).



Route the rear nylon tie-down straps up through the spring mount holes at the rear axle, then forward through the *lowest* coil spring openings and back around the axle. Don't route the rear tie-down straps around the rear suspension track bar (A).

B. Towing the S-10 Electric

The S-10 Electric should be towed using a wheel-lift tow truck, or flat-bed or tilt-bed vehicle carrier designed for the purposes of towing. The S-10 Electric is front-wheel drive. When a wheel-lift tow truck is used to tow the vehicle with the rear wheels lifted, a towing dolly must be placed under the front wheels.

The vehicle should be secured with T-hooks and nylon tie-down straps.