1998 Electric Ranger Student Guide

34n07t0

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: Many brake linings contain asbestos fibers. When working on brake components, avoid breathing the dust. Breathing the asbestos dust can cause asbestosis and cancer.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be labeled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.

Produced and Coordinated by
Technical Service Support Operations
Ford Customer Service Division

January, 1998

SERVICE STANDARDS

Mission Statement:

All dealership personnel will treat every customer as a potential lifetime purchaser, communicating a professional image which embraces honesty and concern for customer wants and needs.

Dealer-to-Customer Service Standards:

1. Appointment available within one day of the customer's requested service day.
2. Write-up begins within four minutes of arrival.
3. Service needs courteously identified, accurately recorded on Repair Order, and verified with customer.
4. **Vehicles serviced right on the first visit.**
5. Service status provided within one minute of inquiry.
6. Vehicle ready at agreed upon time.
7. Thorough explanation of work done, coverages and changes.

These seven service standards provide a process and product value that are compelling reasons for owners to purchase and repurchase Ford or Lincoln-Mercury products. These standards also help to attract new owners through favorable testimonials and improved owner satisfaction.

Standard 4

"Fix It Right the First Time, on Time."

The technician is the **most important player** when it comes to Standard #4.

Why

Customers tell us "Fixing It Right the First Time, on Time" is one of the reasons they would decide to return to a dealer to buy a vehicle and get their vehicles serviced.

Technician Training

It is our goal to help the technician acquire all of the skills and knowledge necessary to "Fix it Right the First Time, on Time." We refer to this as "competency."

Technician's Role

Acquire the skills and knowledge for competency in your specialty via

STST
- Self Study
- Ford Multimedia Training (FMT)
- Instructor Led

New Model
- Self Study
- Instructor Led

The Benefits

The successful implementation of standards means
- Satisfied customers
- Repeat vehicle sales
- Repeat service sales
- Recognition that Ford and Lincoln/Mercury technicians are "the Best in the Business"

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TECHNICIAN OBJECTIVES

- Identify major components and systems.
- Describe the operation of major components and systems.

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ELECTRIC VEHICLE (EV) HISTORY

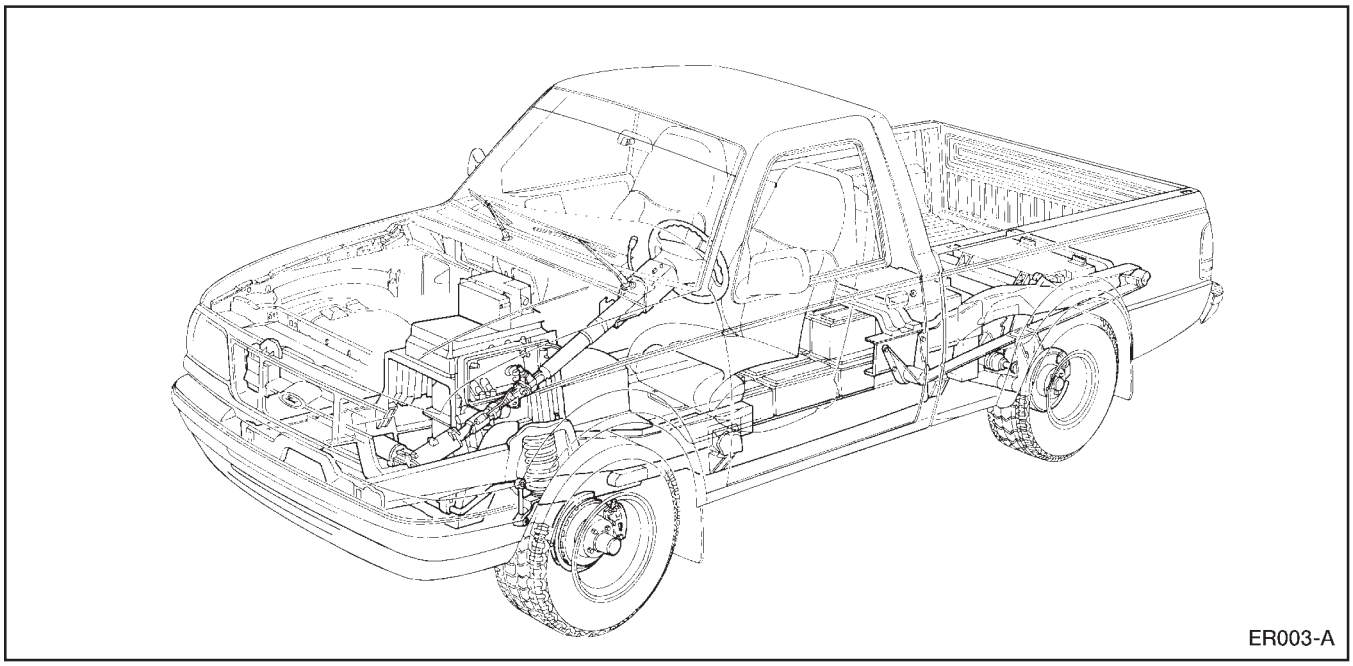
Current legistration requires the development and distribution of zero-emission vehicles. Today, only electric vehicles qualify as zero-emission vehicles. This legislation also states all automobile manufacturers who sell over 5,000 vehicles a year in regulated states must develop and manufacture electric vehicles.

Electric vehicles (EVs) were first developed in the early 1900s. These early EVs traveled at low speeds (24 km/h [15 mph]) and had limited range (48-64 kilometers [30-40 miles]).

Ford Motor Company began its recent EV development in 1982 with the introduction of the ETX 1, a converted Lynx LN7. A lead-acid battery and a 37-kW (50-hp) AC motor powered this experimental vehicle. The ETX 2 followed. The ETX 2 is a converted Aerostar using a refined 53-kW (70-hp) motor; several battery types were used and tested.

In 1993, Ford began a demonstration program to help potential customers gain real-world experience in the use of electric-powered vehicles. With the participation of utility companies and other commercial organizations, this program has now reached the one million-mile mark in vehicle miles driven. The vehicle platform for this demonstration is the Ecostar; a two-passenger electric vehicle based on the European Ford Escort Van. This demonstration program paved the way for production of the Electric Ranger.

ELECTRIC RANGER INTRODUCTION



1998 Electric Ranger

The 1998 Electric Ranger is a low-volume production electric vehicle. The Electric Ranger is built on the 1998 gasoline-powered Ranger platform and is sold and serviced through Ford dealerships.

A traction battery mounted under the vehicle between the frame rails supplies the electric power. The traction battery provides 312 volts direct current (DC), which is converted to three-phase alternating current (AC) that drives the motor/transaxle.

The Electric Ranger is a rear-wheel drive vehicle and operates much like the gasoline-powered models.

The most noticeable difference between the Electric Ranger and the gasoline-powered Ranger is the operating noise is very low. Because of the quiet operation of the vehicle, a motor enabled gauge is provided and is located on the right side of the instrument cluster. The motor enabled gauge indicates ON with the ignition switch in the RUN or START position and indicates OFF with the ignition switch in the OFF position or the powertrain becomes disabled.

SPECIFICATIONS

Vehicle

Model Year	1998
Body Style	Styleside, Regular Cab Pick-Up
Wheelbase	Short Wheelbase of 2,831 mm (111.4 inch)
Payload	315 kg (700 lb)
Dimensions	Similar to 1998 Gasoline-Powered Ranger

Performance

0-50 Mph	12.5 seconds
Top Speed	120 km/h (75 mph)
Range	93 kilometers (58 miles) (without A/C or Heater Operation)

Powertrain

Motor	High-Efficiency, 3-Phase AC Induction
Horsepower	67 kw (90 hp)
Transaxle	Single-Speed Constant-Ratio
Drive Wheels	Rear
Gear Ratio	12.518:1

Equipment

Standard	Dual Air Bags
	Electro-Hydraulic Power Steering
	Regenerative Braking
	4-Wheel ABS
	Aluminum Wheels
	Low Rolling Resistance Tires
Optional	Air Conditioning
	Battery Heater
	Spare Tire and Jack

BATTERY SYSTEM

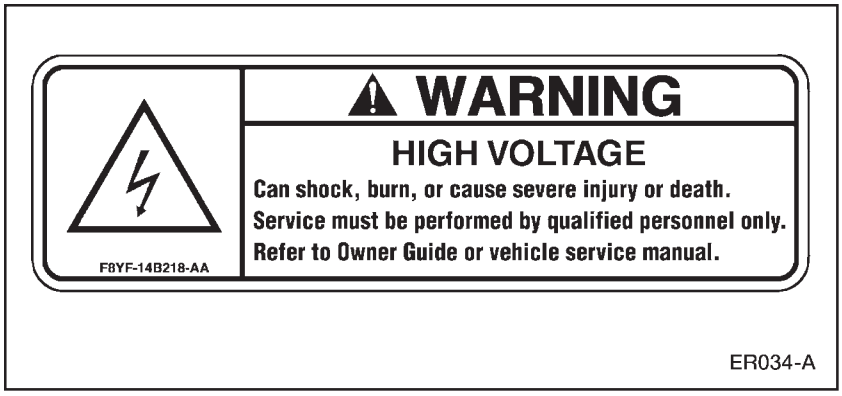
Battery System Warnings

WARNING: THE TRACTION BATTERY CAN DELIVER 312 VOLTS OF DC POWER. IMPROPER HANDLING OF THE TRACTION BATTERY CAN RESULT IN INJURY OR FATALITY. ONLY AUTHORIZED PERSONNEL TRAINED TO WORK WITH TRACTION BATTERY COMPONENTS ARE PERMITTED TO HANDLE THE BATTERIES.

WARNING: BATTERIES NORMALLY PRODUCE EXPLOSIVE GASES WHICH CAN CAUSE PERSONAL INJURY OR DEATH. DO NOT ALLOW FLAMES, SPARKS OR LIGHTED SUBSTANCES TO COME NEAR THE BATTERIES. WHEN CHARGING OR WORKING NEAR THE BATTERIES, ALWAYS SHIELD YOUR FACE AND PROTECT YOUR EYES. ALWAYS PROVIDE VENTILATION.

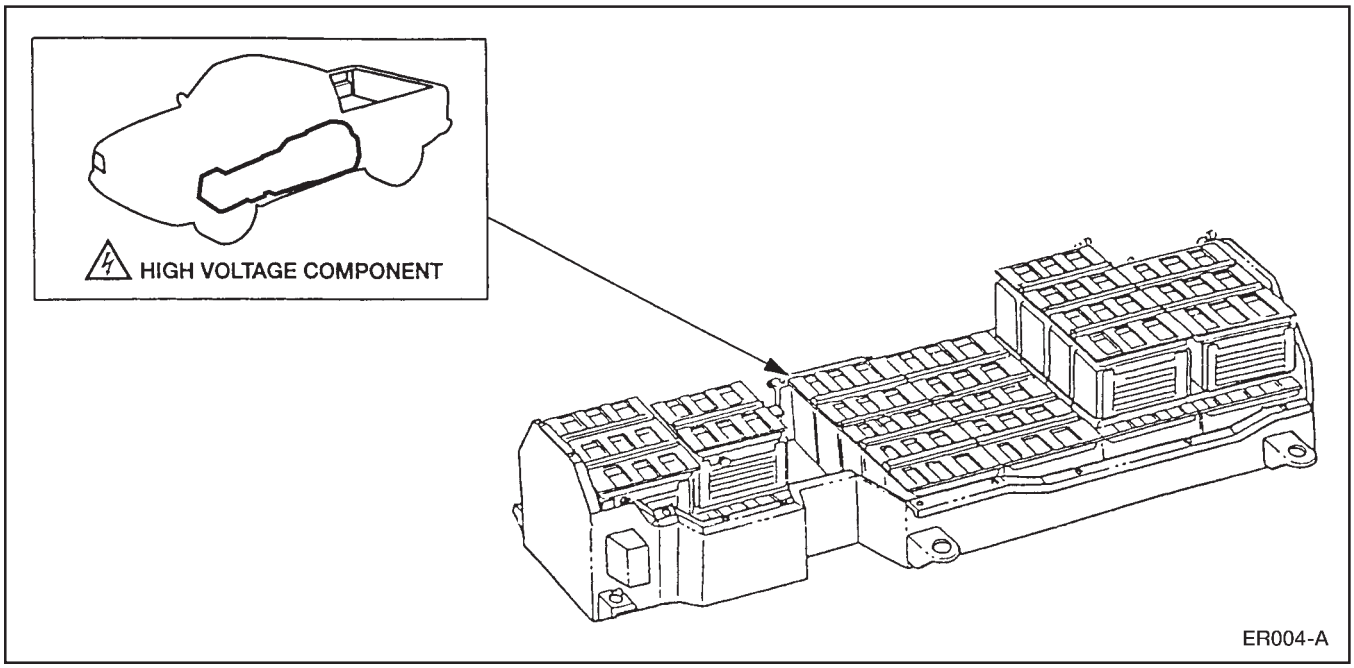
WARNING: LEAD-ACID BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR BATTERIES TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH THE SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF FIFTEEN MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

WARNING: HIGH VOLTAGE COMPONENT SERVICE SHOULD ONLY BE PERFORMED BY TRAINED PERSONNEL. INCORRECTLY PERFORMING SERVICE PROCEDURES MAY RESULT IN INJURY OR DEATH. ALL HIGH VOLTAGE COMPONENTS ON THIS VEHICLE ARE MARKED WITH THE FOLLOWING WARNING LABEL.



High Voltage Warning Label

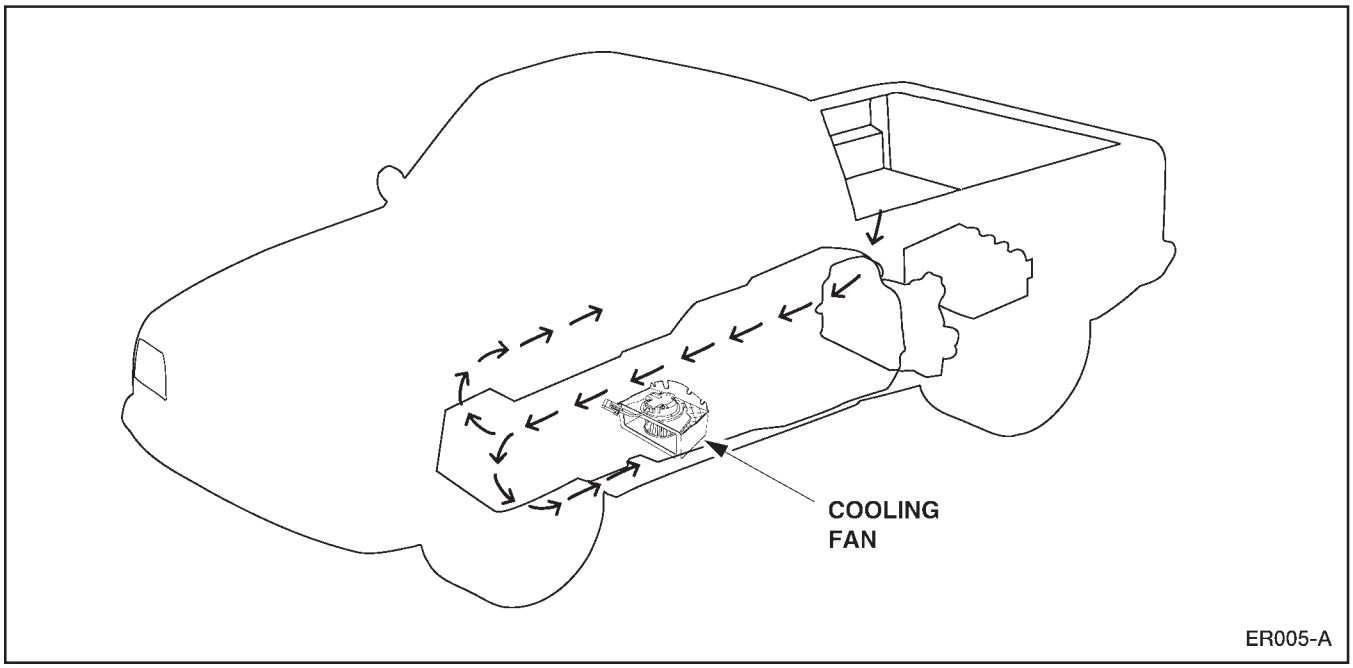
Traction Battery



Traction Battery

- The traction battery is located underneath the vehicle between the frame rails.
- The traction battery consists of 39 8-volt lead-acid battery modules stored in a supporting tray.
- The supporting tray is constructed of an extremely strong non-conductive composite material with bonded metal mounting brackets.
  - The tray is about 8 feet long and weighs almost 900 kg (2000 lb) with battery modules and associated components in place.
  - The supporting tray has a cover which is bolted on. There are individual battery modules and other components contained within the traction battery supporting tray.
- The 39 battery modules are arranged in 2 levels, 12 on the upper level and 27 on the lower level.
- The battery modules are wired in series and produce 312 volts DC.
- A battery control module is located in the upper level at the front of the assembly.
  - The battery control module is secured with Velcro®.
- A contactor box is located in the upper level at the rear of the assembly.
  - The contractor box is secured with Velcro®.
- A cooling system and a (optional) heating system (for cold climate areas) are used to maintain optimal temperature within the traction battery.

Traction Battery Cooling System

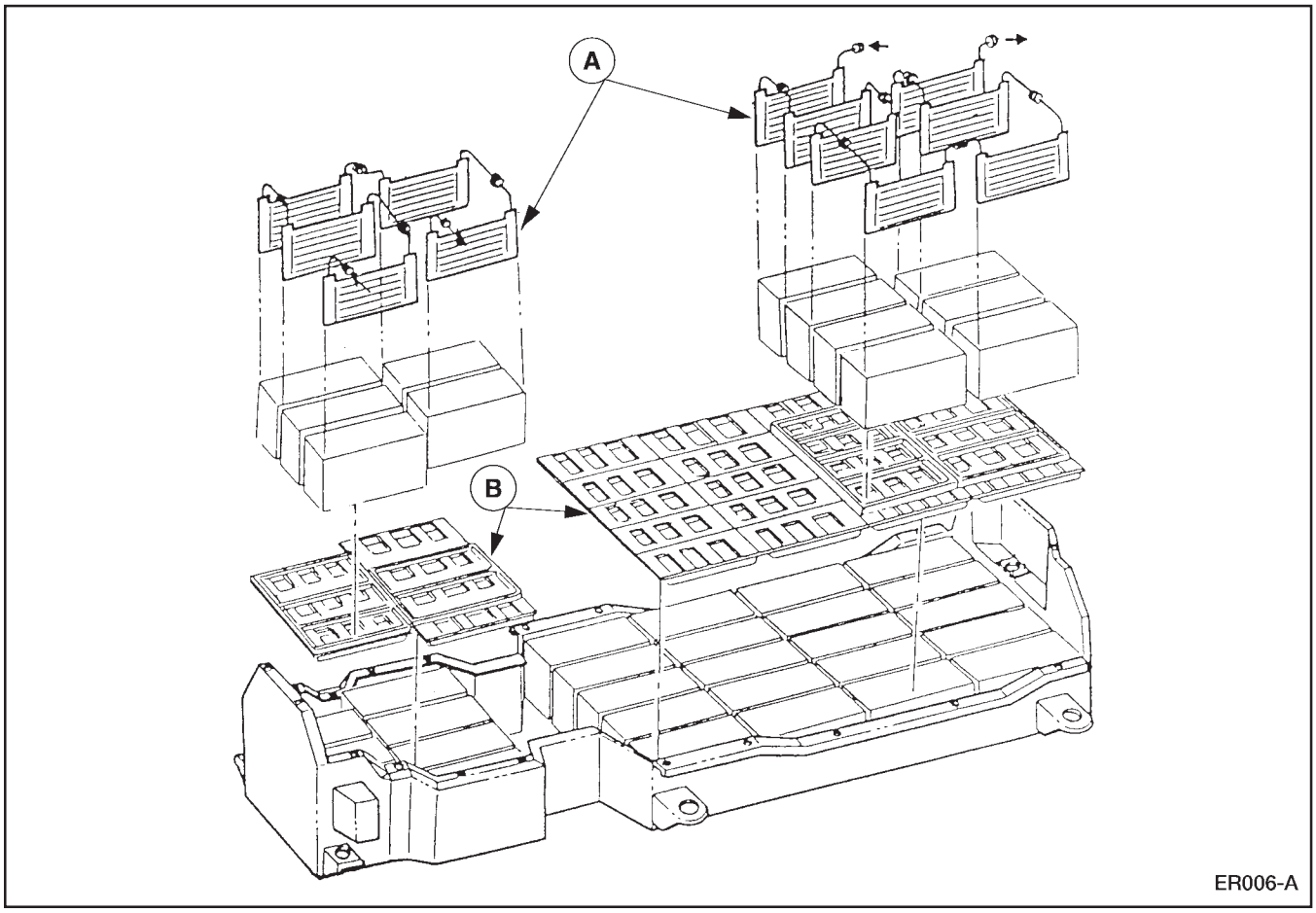


Traction Battery Cooling System

- The traction battery cooling system consists of:
  - four temperature sensors.
  - a two-speed fan.
  - a battery control module.
- The cooling fan is located in the center of the traction battery.
- The cooling function is controlled by the battery control module (BCM).
- During charging, the cooling fan is used for ventilation and cooling of the traction battery:
  - For ventilation, the cooling fan operates at low speed all the time.
  - For cooling, the cooling fan operates at high speed based on the temperature of the traction battery.
  - For ventilation purposes, the cooling fan operates for 10 minutes following the completion of the charge cycle.
- During driving, the cooling fan is used for cooling the traction battery:
  - For cooling, the cooling fan operates at high speed based on the temperature of the traction battery.
  - Air is drawn in from the rear of the traction battery and exits through the front.

NOTE: Be sure vent openings are clear of obstructions before connecting charger.

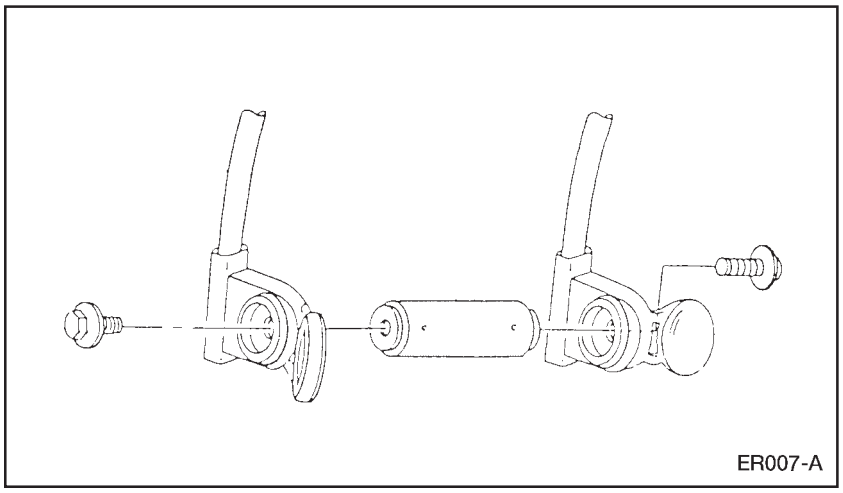
Traction Battery Heating System (Optional)



Optional Traction Battery Heating System

- To maintain proper temperature during charging in cold climates, an optional traction battery-heating system is available.
- The lower level of battery modules is heated using a blanket heater (**B**) to heat the entire lower level.
  - The lower level blanket heater is located underneath the battery modules.
- The upper level uses individual heating elements (**A**) wired in series.
  - The upper level heating elements are mounted directly to the side of each battery module.
- The battery heating function is controlled by the battery control module.
  - The module will activate the battery heating system if the traction battery temperature falls below 15°C (59°F) while connected to an activated charge station.
  - Heating function is deactivated when the traction battery temperature rises above 25°C (77°F). The upper and lower heating elements may function independently based on input from temperature sensors.

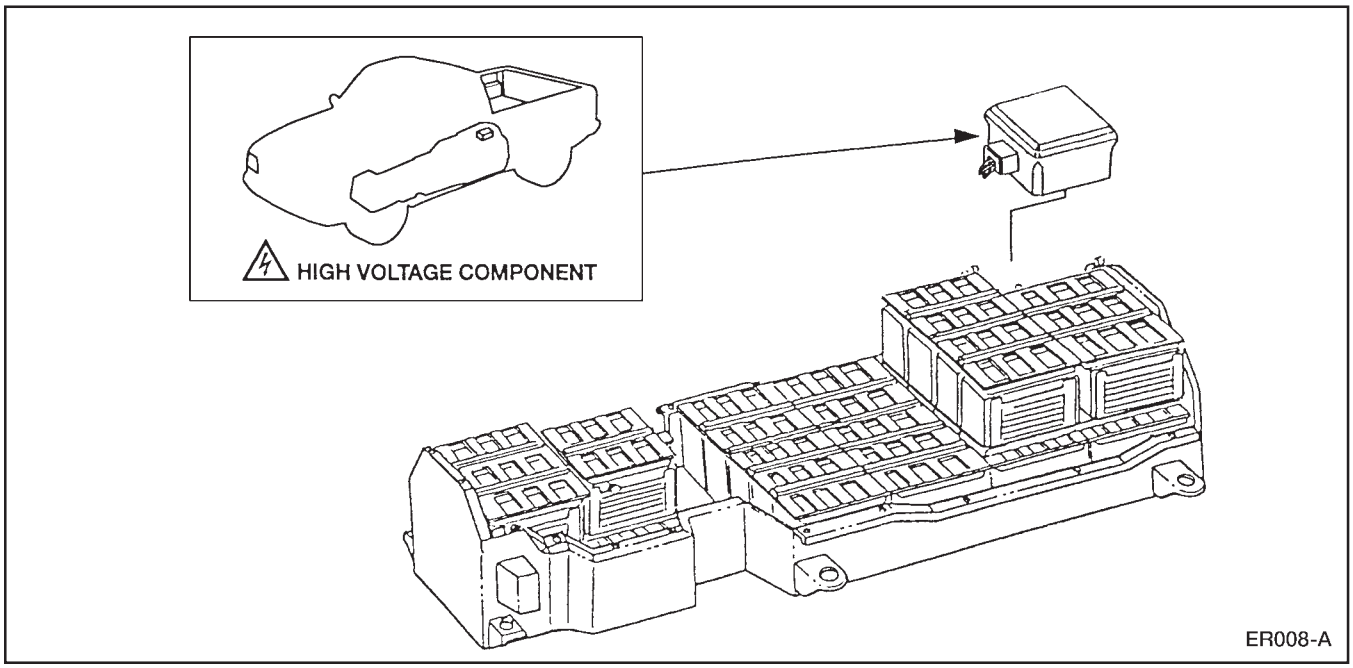
Traction Battery Wiring and Circuit Protection



Traction Battery Circuit Protection

- The traction battery uses low and high voltage wiring.
- The high voltage circuit is protected by a 400-volt 250 amp fuse installed between batteries 20 and 21.
- If the fuse opens or is removed, the high voltage circuit is interrupted.
- Two high voltage connectors connect the traction battery to the vehicle systems.
- The primary power (2-pin) connector is located at the rear of the battery tray and transfers power to the motor/transaxle.
- The auxiliary power (4-pin) connector is located near the front of the battery tray on the passenger side. It transfers high voltage power to the vehicle's auxiliary high voltage circuits.
- Both high voltage circuits are part of the vehicle high voltage interlock circuit (covered later in this lesson).
- The low voltage connector is located near the front of the battery tray on the driver side and transfers low voltage to the vehicle's low voltage circuits.
  - The low voltage connector is a 76-pin connector.

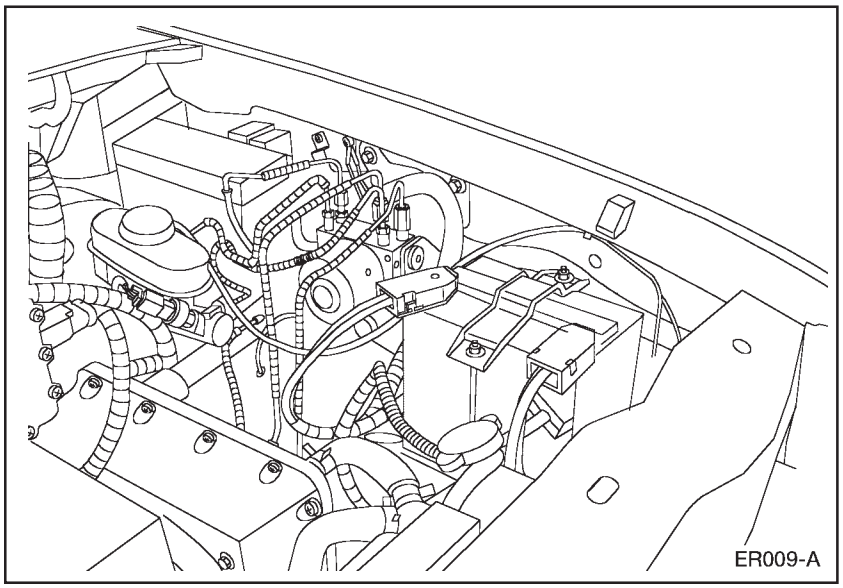
Contactor Box Assembly (CBA)



Contactor Box

- The contactor box assembly (CBA) (arrow) is located in the rear of the traction battery at the upper left side.
- The contactor box serves as the on/off switches for the traction battery.
- Relays are used to interrupt the flow of high voltage when the driver's key is turned to the OFF position, the inertia shutoff switch is activated or the system is in shutdown mode actuated by an electronic control module.
- The contactor box supports these additional functions:
  - high voltage circuit precharging – the high voltage circuits require precharging. Otherwise, the large voltage differential might weld contactors as circuits are switched on. Precharging is accomplished through two relays and two 20-ohm resistors located in the contactor box.
  - traction battery current sensing – the contactor box contains two Hall effect sensors that monitor the current from the traction battery. One sensor monitors the current flow into the traction inverter module (TIM) (power for the motor/transaxle), and the other monitors current flow into the high voltage auxiliary circuits.
  - high voltage circuit protection – the charging, battery heater and high voltage auxiliary circuits are protected by three fuses in the contactor box.

12-Volt Battery

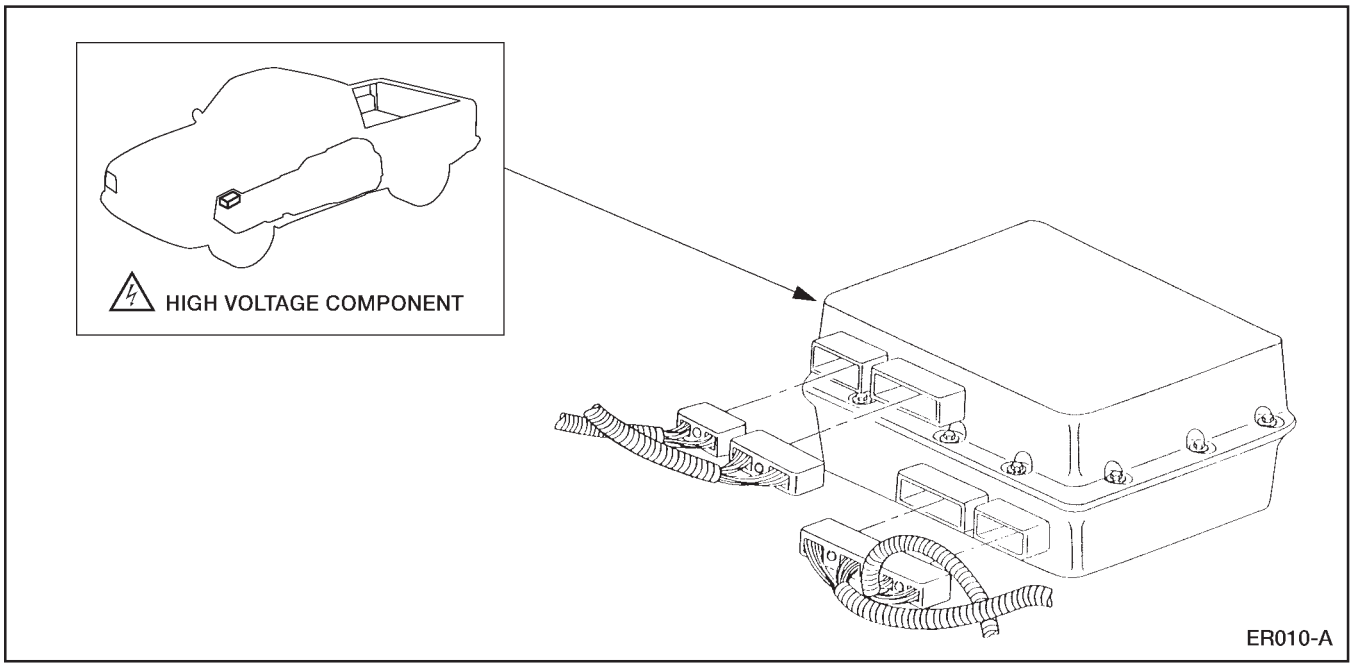


12-Volt Battery Location

- The 12-volt battery is located in the left front corner of the underhood compartment.
- The 12-volt battery is used for lighting and other low-voltage circuits and systems.
- The DC/DC converter acts as an alternator to charge the 12-volt battery.
- The 12-volt battery in the Electric Ranger is different than that used in the gasoline-powered Ranger.
  - The Electric Ranger does not require large 12-volt battery capacity due to the absence of a high current starter circuit.
  - The Electric Ranger battery is a 31 amp-hour deep cycle battery.

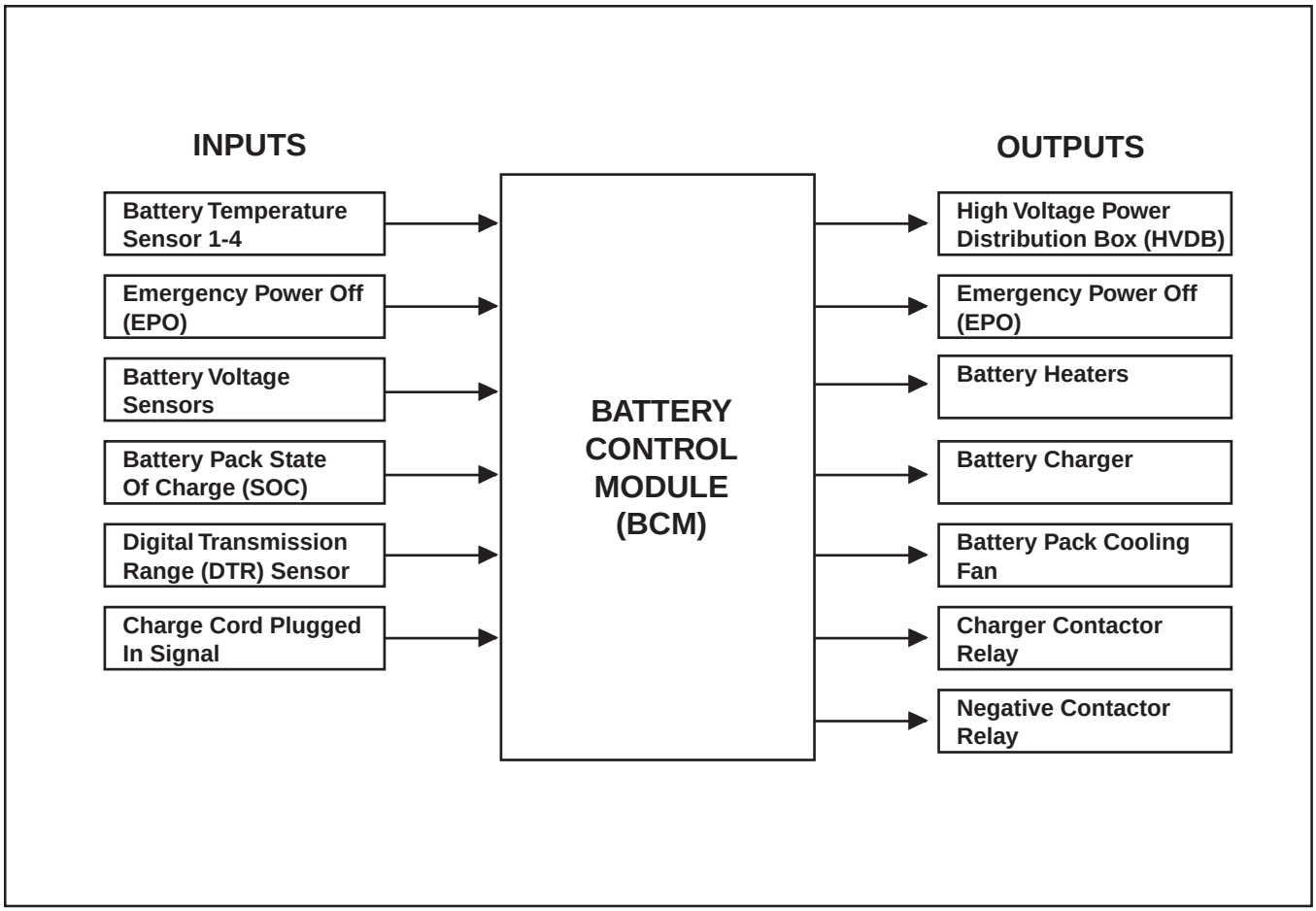
NOTE: Never attempt to jump-start the 12-volt battery.

Battery Control Module (BCM)

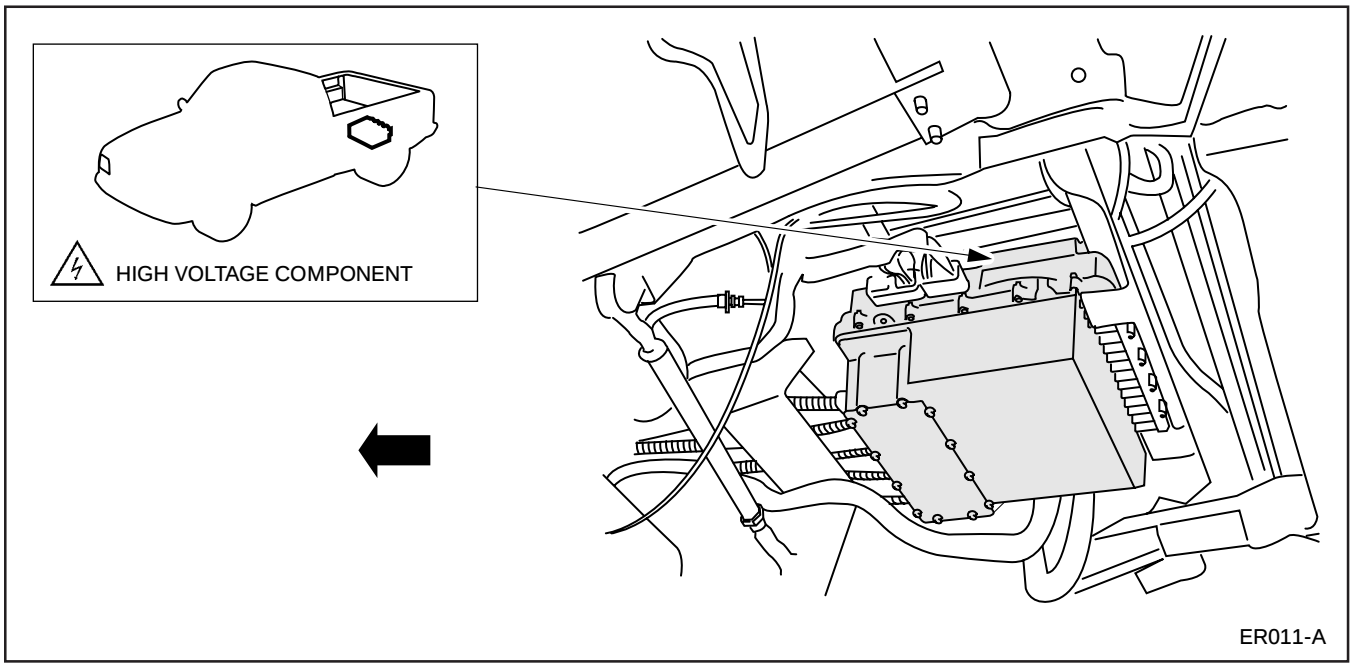


Battery Control Module (BCM)

- The battery control module (BCM) (arrow) is located in the upper front section of the traction battery.
- The BCM is a high and low voltage module that controls all battery system operations.
- The BCM monitors the temperature and state of charge of the 39 battery modules in the traction battery.
- The BCM controls battery charging and cooling.
- The BCM controls the optional battery heating system operation if equipped.


INPUTS
Battery Temperature Sensor 1-4
Emergency Power Off (EPO)
Battery Voltage Sensors
Battery Pack State Of Charge (SOC)
Digital Transmission Range (DTR) Sensor
Charge Cord Plugged In Signal
BATTERY CONTROL MODULE (BCM)
OUTPUTS
High Voltage Power Distribution Box (HVDB)
Emergency Power Off (EPO)
Battery Heaters
Battery Charger
Battery Pack Cooling Fan
Charger Contactor Relay
Negative Contactor Relay

TRACTION INVERTER MODULE (TIM)



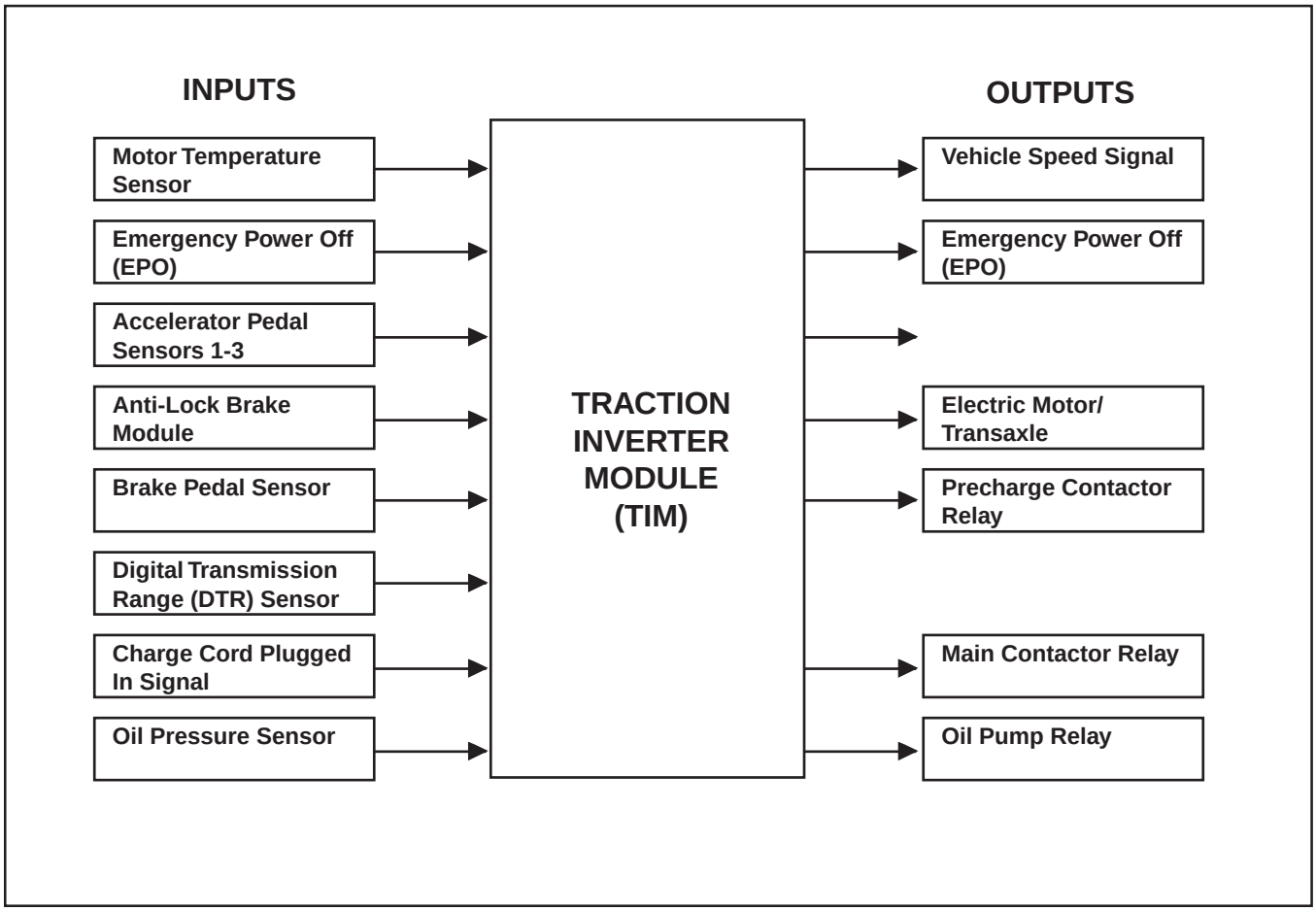
Traction Inverter Module (TIM)

- The traction inverter module (TIM) (arrow) is located underneath the center rear of the vehicle.
- The TIM is a high and low voltage module that performs two functions:
  - vehicle powertrain control
  - electric current conversion for the motor/transaxle
- The TIM controls the vehicle powertrain by processing driver, module, and sensor inputs, and calculating a motor torque command.
- The TIM converts high voltage DC from the traction battery into three phase AC used by the motor/transaxle.
- The TIM consists of:
  - three high power, high-speed insulated gate bipolar transistor modules (IGBTs).
  - four large filter capacitors (used during precharging functions).
  - two-phase current sensors.
  - a high-performance microcontroller.
  - logic circuitry and control circuits.

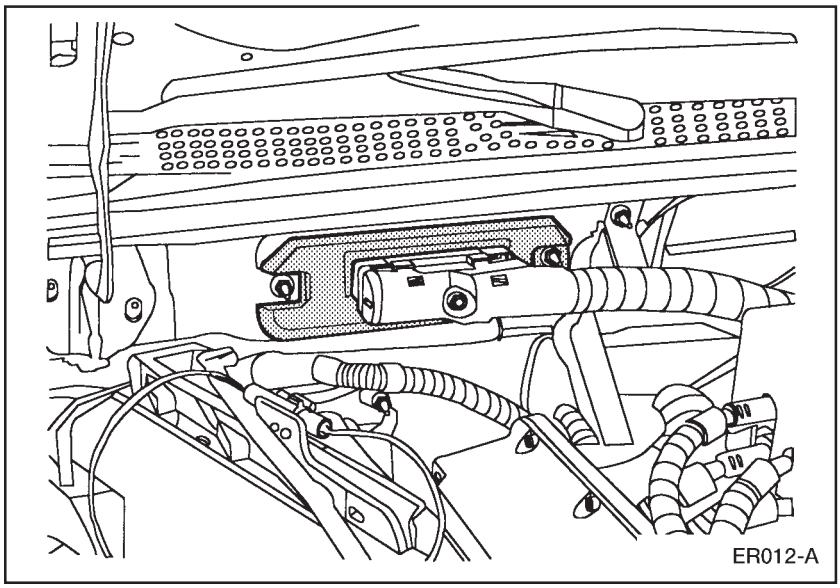
- The IGBTs are used to switch on and off the three motor phases.
  - As they switch on and off, the IGBTs produce voltage spikes that have the potential to damage the TIM.
  - Capacitors are used as a filters to protect the TIM and maintain traction bus voltage during IGBT switching.
  - These capacitors retain traction battery voltage and provide current capability for instantaneous torque.

NOTE: The TIM is equipped with a bleed down system which ensures that the capacitors are discharged to less than 50 volts within two minutes after the driver's key is turned to the OFF position.

- Be sure to allow for capacitor bleed down time before attempting maintenance or repair.

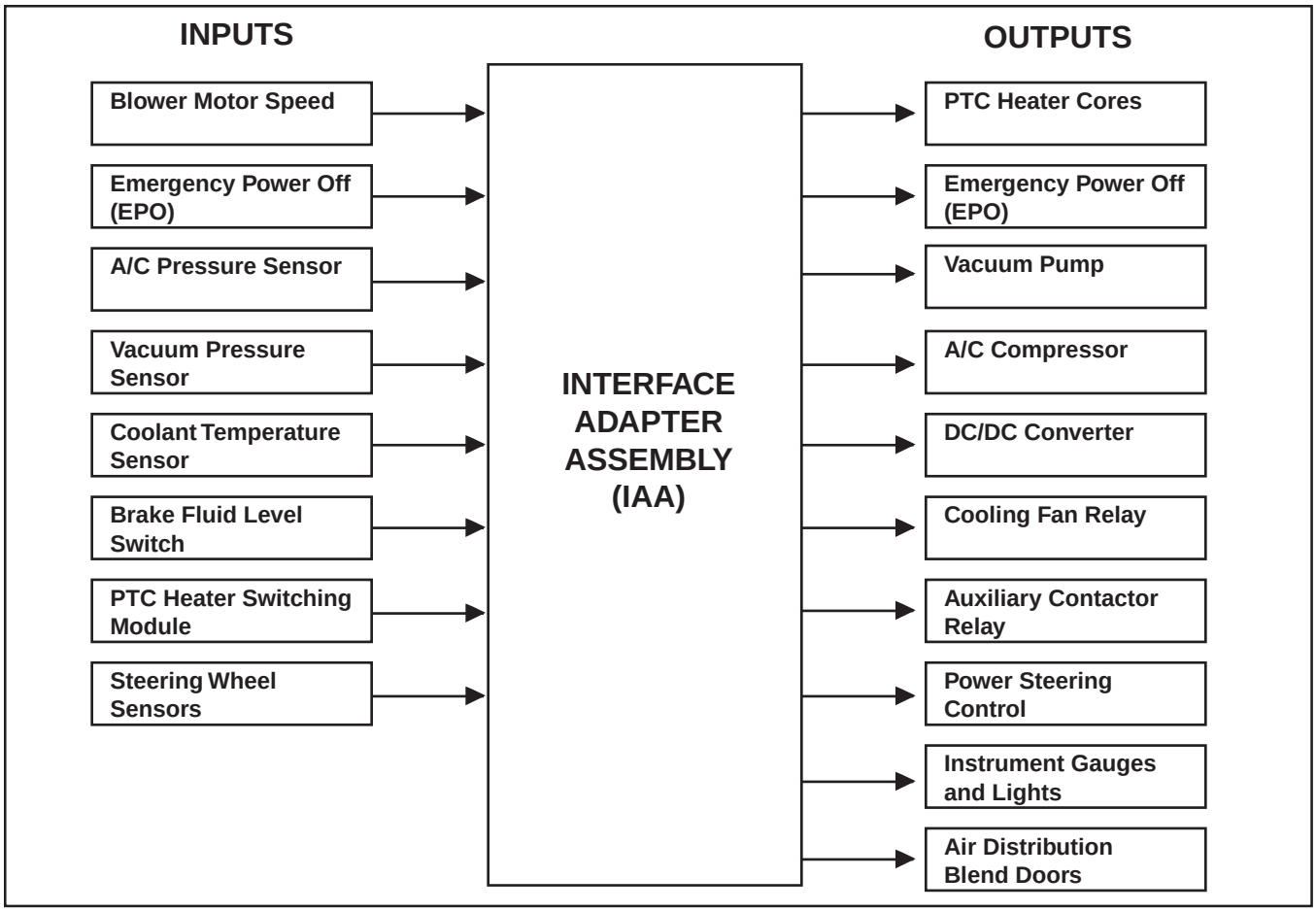


INTERFACE ADAPTER ASSEMBLY (IAA)

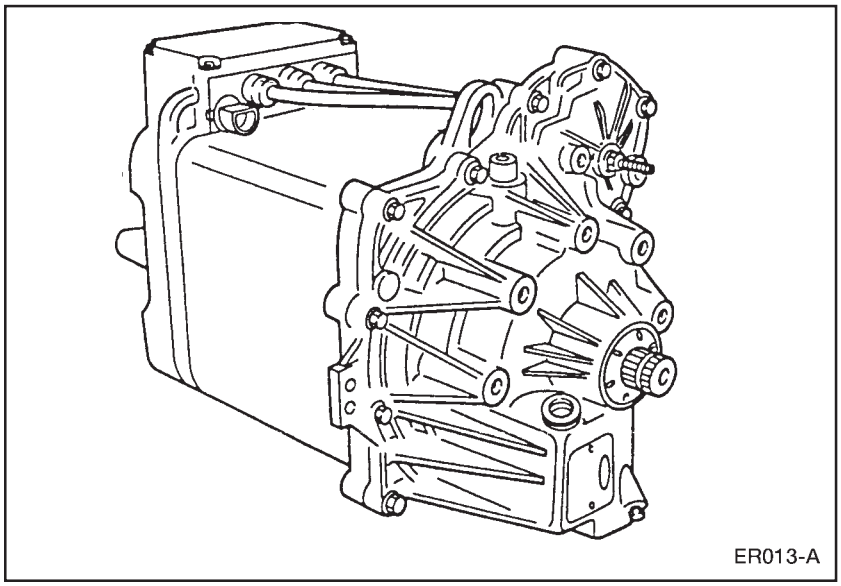


Interface Adapter Assembly (IAA)

- The interface adapter assembly (IAA) is located on the bulkhead under the instrument panel, the same location as the gasoline-powered Ranger EEC-V module.
- The IAA is a low voltage multi-function module that manages the climate control system, the auxiliary systems and most instrument cluster gauges and lamps.
- The IAA is networked with the TIM and the BCM to support instrument cluster functions, contactor box operations, and diagnostics.
- The IAA diagnostics are accessible through the OBD-II diagnostic connector under the instrument panel next to the steering column.
- Diagnostic functions as well as parameter identification (PID) data and active command modes are available.
- Based on operator and vehicle demands, the IAA controls these functions:
  - High voltage A/C compressor (optional).
  - High voltage positive temperature coefficient (PTC) heater.
  - Air distribution blend door and climate control blower fan motor.
  - Power steering.
  - DC/DC converter.
  - Vacuum pump.
  - Liquid cooling system coolant pump and two-speed radiator fan.
  - Instrument cluster operation.


INPUTS
Blower Motor Speed
Emergency Power Off (EPO)
A/C Pressure Sensor
Vacuum Pressure Sensor
Coolant Temperature Sensor
Brake Fluid Level Switch
PTC Heater Switching Module
Steering Wheel Sensors
INTERFACE ADAPTER ASSEMBLY (IAA)
OUTPUTS
PTC Heater Cores
Emergency Power Off (EPO)
Vacuum Pump
A/C Compressor
DC/DC Converter
Cooling Fan Relay
Auxiliary Contactor Relay
Power Steering Control
Instrument Gauges and Lights
Air Distribution Blend Doors

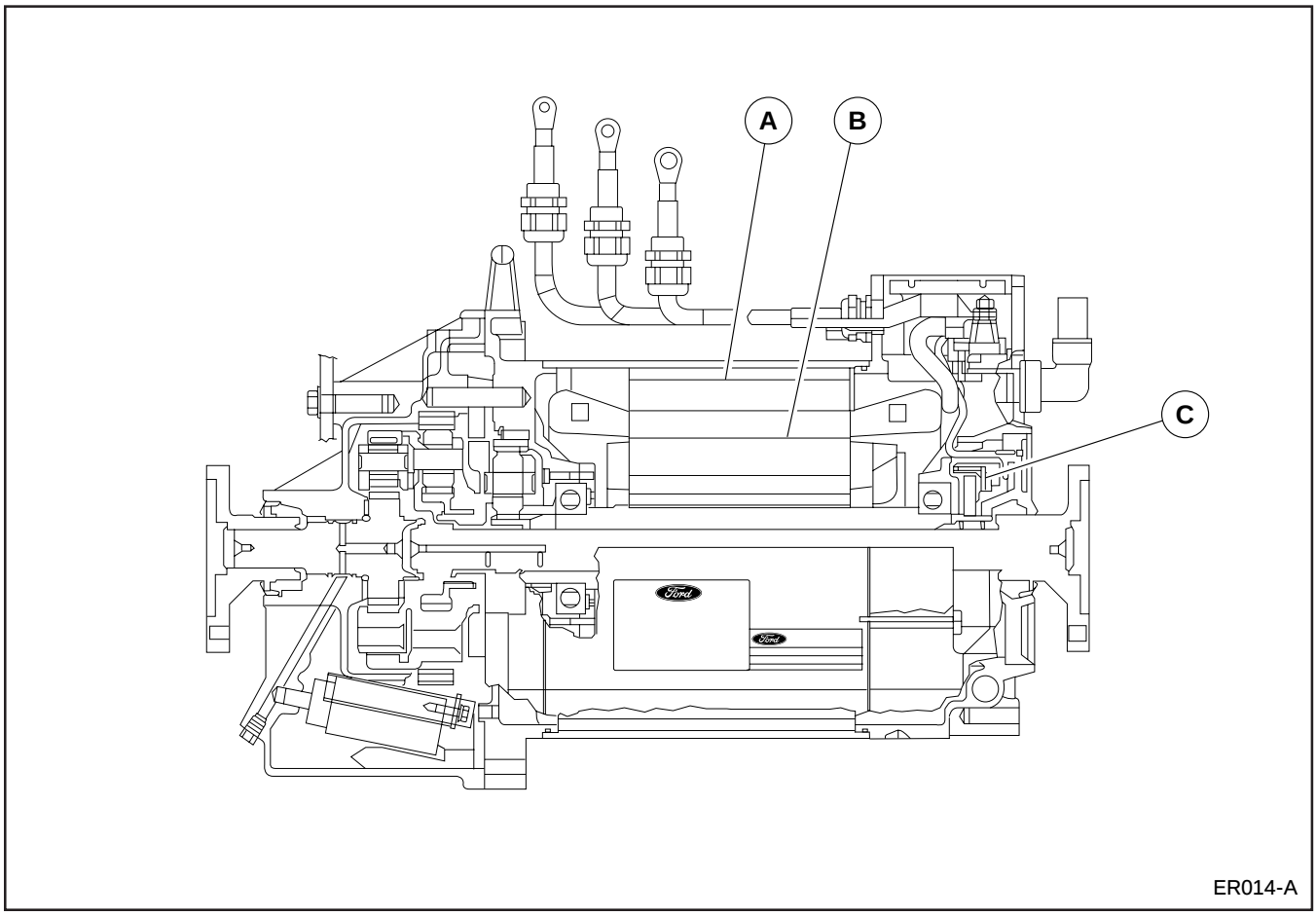
MOTOR/TRANSAXLE



Motor/Transaxle Assembly

- The motor/transaxle is mounted just behind the traction battery.
- The motor/transaxle assembly consists of a:
  - four-pole, three phase AC induction motor.
  - single-speed transaxle with a planetary gearset.
- The motor/transaxle supplies power through halfshafts to the rear wheels.
  - A peak power of 67 kW (90 hp) is produced at 190 Nm (140 lb ft) torque.
- The assembly is packaged in an aluminum case and weighs approximately 91 kg (200 lb).

Motor

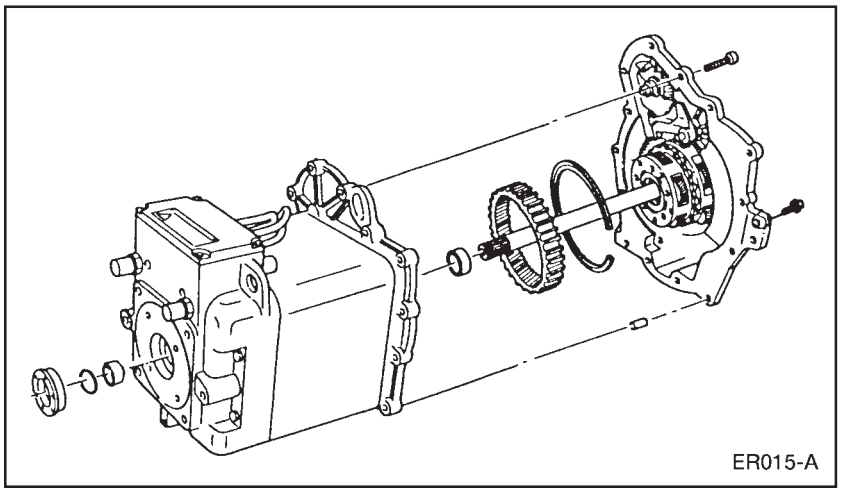


Motor Components

- The AC induction motor consists of a:
  - stator **(A)**.
  - cast aluminum rotor **(B)**.
  - rotor speed sensor **(C)**.
- The motor has a maximum operating speed of 13,000 rpm and maximum current draw of 305 amps.

- Alternating current is supplied from the TIM to the motor through high voltage cables.
  - Current flows through the stator windings generating a magnetic field.
  - The magnetic field causes the rotor to spin.
  - Varying the amount of current controls torque.
  - Varying the AC current frequency controls speed.
  - During deceleration and braking, a negative torque is produced, and the motor acts as a generator and regenerates charge in the traction battery.

Transaxle



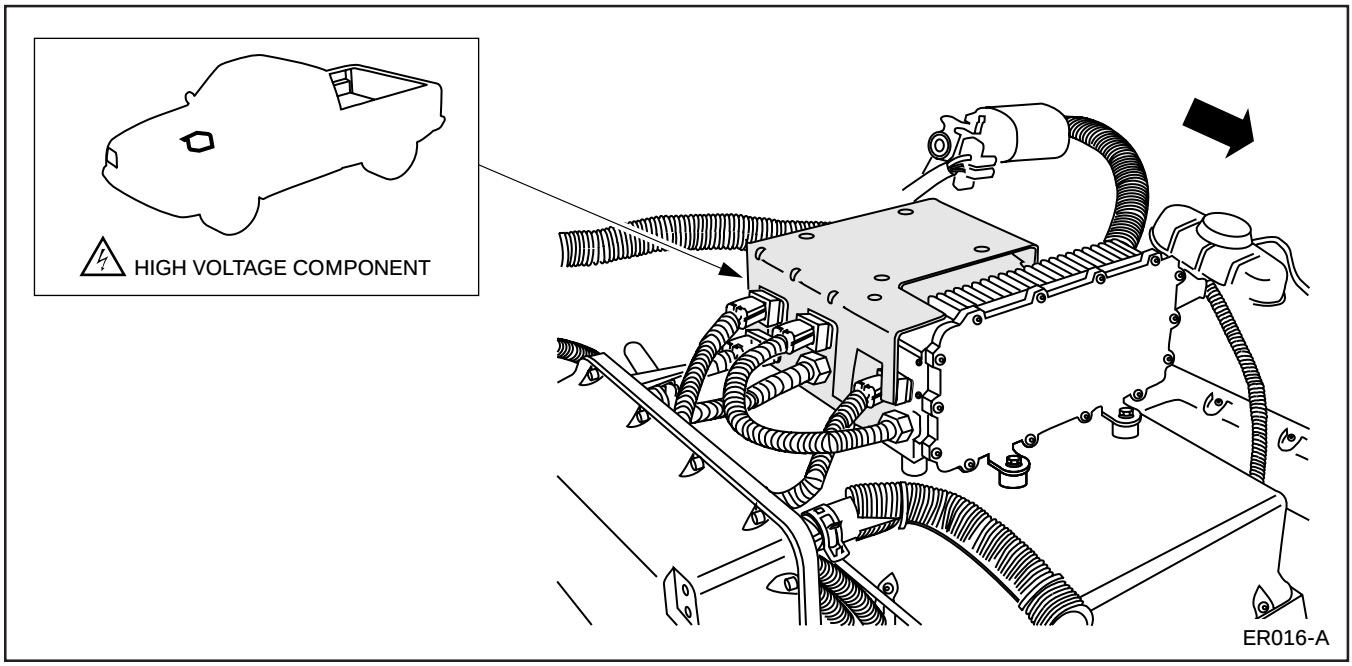
Transaxle Components

- The transaxle consists of a:
  - two-stage direct reduction planetary gear system (similar to other automatic transaxle planetary gear sets).
  - 50/50 planetary differential.
- The transaxle is a constant-ratio (one-speed) unit and uses no apply components.
  - There are no clutches, bands, or valves as in multiple-speed transaxle units.
- A cam-operated parking pawl is operated manually by the gear selector assembly through the shift cable and shift lever.
- The cam has five detent positions:
  - Park (P)
  - Reverse (R)
  - Neutral (N)
  - Drive (D)
  - Economy (E)

- Direction (clockwise or counterclockwise) and speed of the motor are monitored by a speed sensor mounted inside the transaxle case.
  - The speed sensor detects passing teeth on the speed wheel as it rotates.
  - The speed wheel is mounted to the input shaft.
  - The speed (rpm) signal is sent to the TIM.
- The transaxle is lubricated by Tribolube-L6 (Pro Gear 21), a synthetic, low-viscosity oil.
- A 12-volt DC oil pump mounted inside the case supplies oil to lubricate the gears and bearings.
  - The pump is controlled by the TIM.
  - Normal pressure is approximately 103 kPa (15 psi).
  - If pressure drops below 28 kPa (4 psi), the oil pressure switch opens and signals the TIM.
- Motor/transaxle cooling is provided by the vehicle liquid cooling system (covered later in this lesson).

NOTE: Adding transaxle oil is not a standard maintenance item. Change transaxle oil at 3 year intervals.

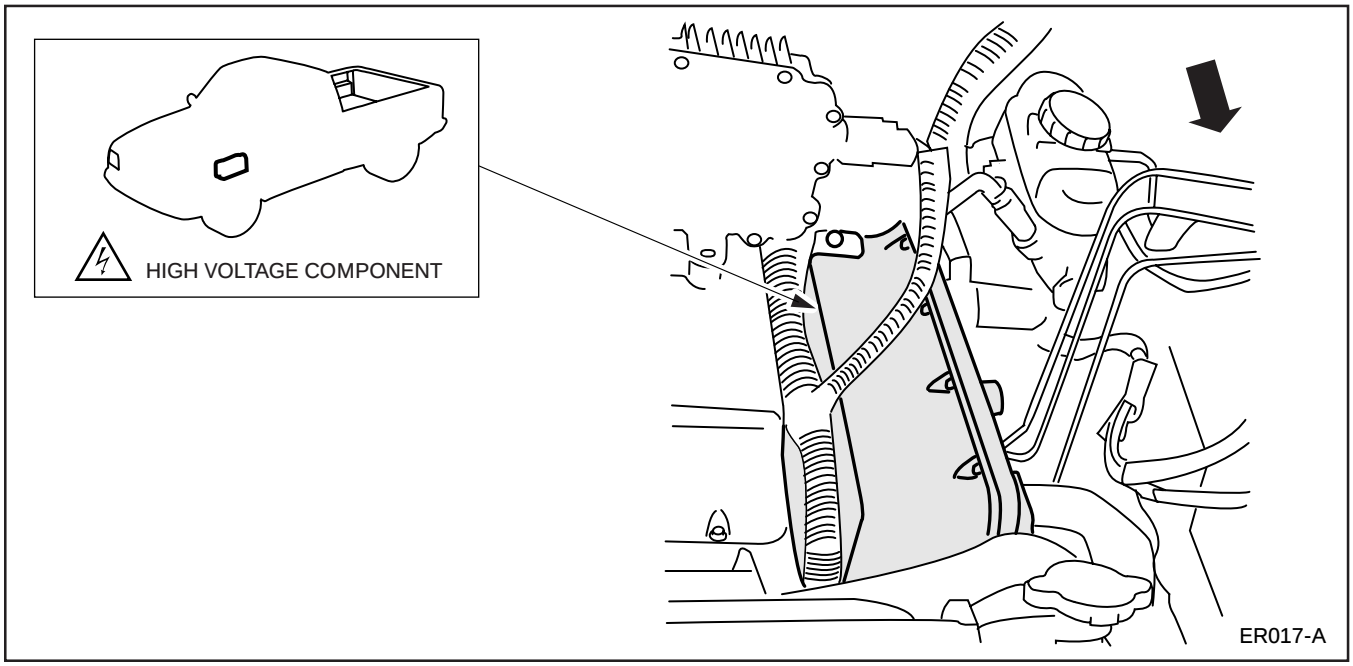
HIGH VOLTAGE POWER DISTRIBUTION BOX



High Voltage Power Distribution Box

- The high voltage power distribution box (arrow) is located in the underhood compartment on top of the battery charger.
- The high voltage power distribution box is similar in function to the fuse box in your home.
  - It distributes high voltage to components and systems.
  - It contains fuses.
- The power distribution box directs fuse protected high voltage to:
  - DC/DC converter.
  - Heating system.
  - Air conditioning system (optional).
  - Power steering system.
  - Battery charger.
- The power distribution box has a protective cover that is part of the high voltage interlock circuit (covered later in this lesson).
  - When the cover is removed, a limit switch will open the relays in the contactor box, which interrupts high voltage to the vehicle systems.

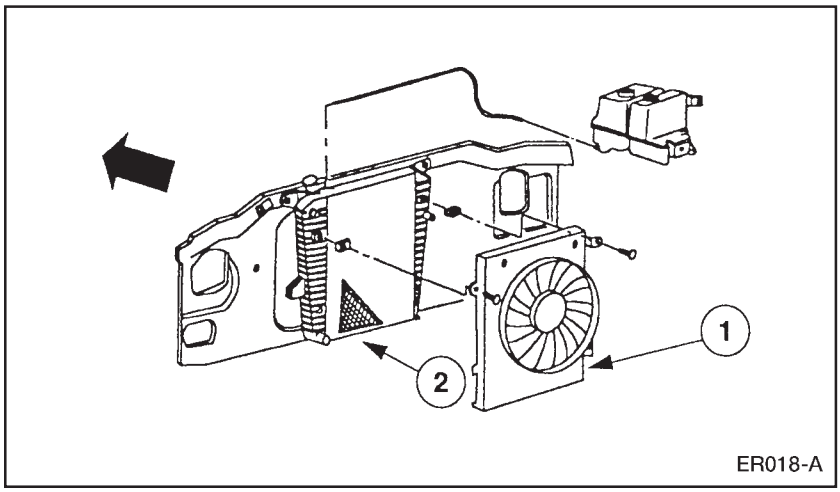
DC/DC CONVERTER



DC/DC Converter

- The DC/DC converter (arrow) is located in the underhood compartment on the driver side of the battery charger.
- The DC/DC converter acts as an electronic alternator, charging the 12-volt battery and supplying power for low voltage components and systems.
- The DC/DC converter steps down traction battery voltage from 312 volts to 12 volts.
- A temperature sensor mounted near the 12-volt battery tray allows the converter to adjust voltage to the 12-volt battery as temperature changes.
- The DC/DC converter is controlled by the IAA.
- The DC/DC converter operates when the key is in the ON position and with the key in the OFF position when the vehicle is connected to the power control station (PCS) for charging.

LIQUID COOLING SYSTEM



Liquid Cooling System Components

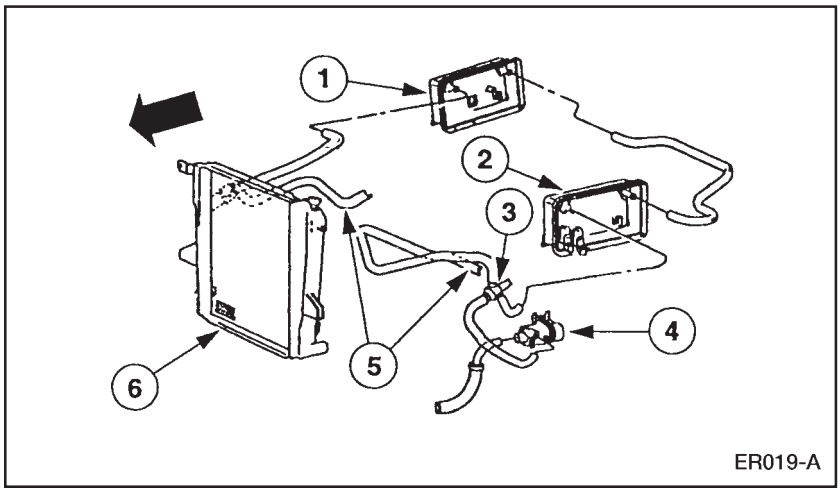
Item	Description
1	Two-Speed Electric Cooling Fan
2	Radiator

- The high voltage electronics used on the Electric Ranger require cooling under normal use.
- Excess heat is removed by a liquid cooling system controlled by the IAA.
- The liquid cooling system cools the:
  - TIM.
  - motor/transaxle.
  - DC/DC converter.
  - A/C inverter motor controller.

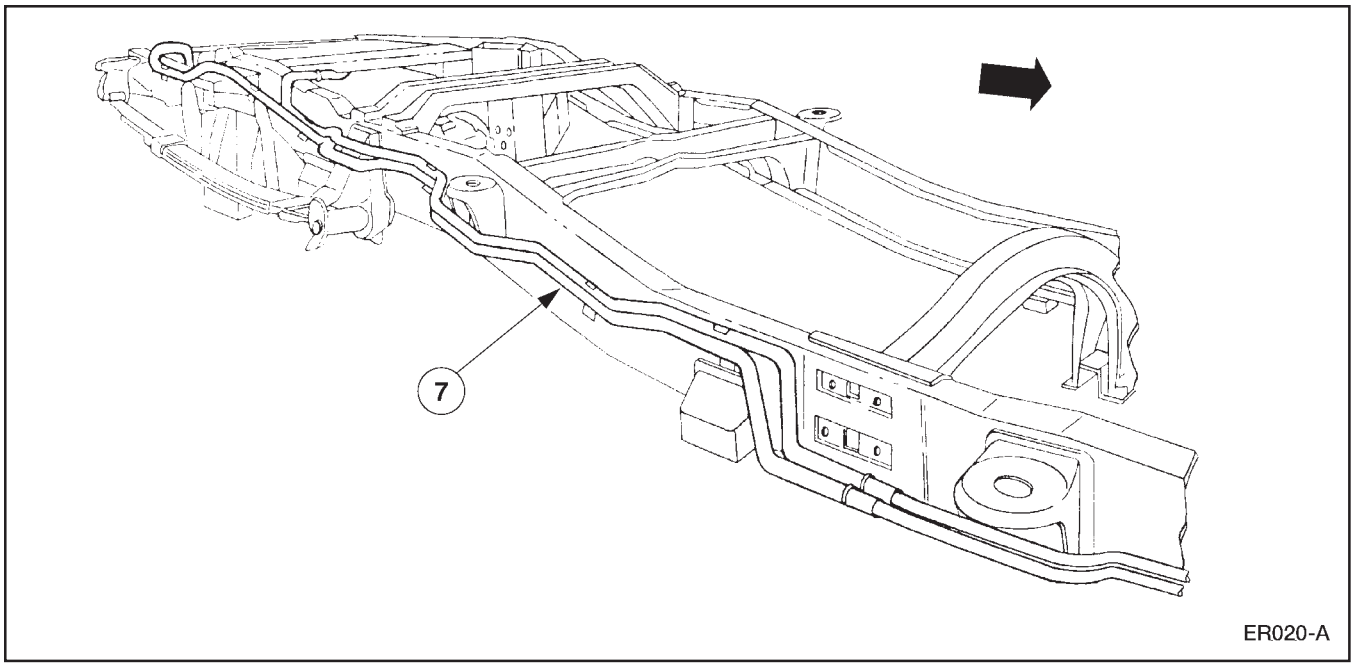
- The liquid cooling system consists of:
  - an Explorer radiator.
  - a two-speed electric cooling fan.
  - a 12-volt electric coolant pump.
  - rubber coolant hoses.
  - metal coolant tubes.
  - a 50/50 mix of water and glycol Ford specification WSS-M97B44-C. (Do not mix with previous specification.)
- The 12-volt coolant pump incorporates a:
  - centrifugal impeller design.
  - 12-volt DC motor.
  - magnetic motor-to-impeller clutch.

NOTE: Adding coolant is not a standard maintenance item. Do not mix the new glycol with the previous specification. Change coolant at 100,000 miles or 5 years whichever comes first.

Coolant Hose Routing



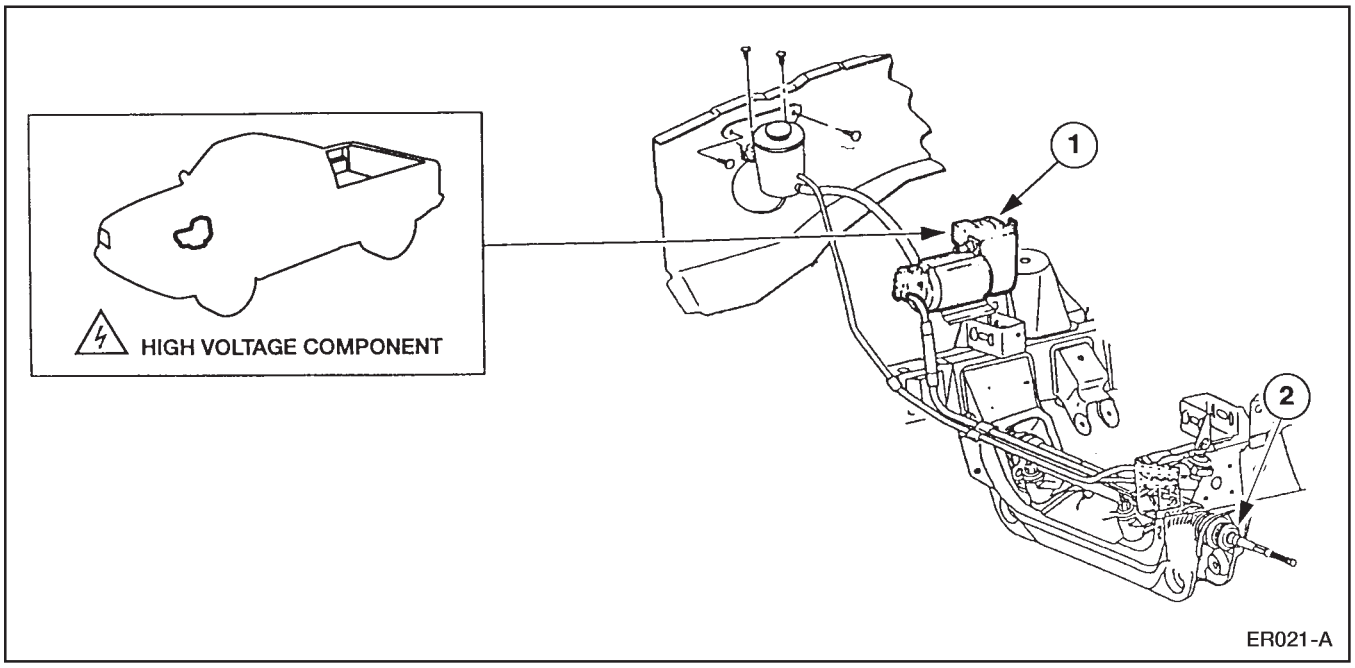
Coolant Hose Routing



Item	Description
1	A/C Inverter Motor Controller
2	DC/DC Converter
3	Coolant Temperature Sensor
4	12-Volt Electric Coolant Pump Motor
5	Rubber Coolant Hoses
6	Electric Cooling Fan Module (not shown)
7	Metal Coolant Tubes

- Coolant is circulated by the electric pump located below the DC/DC converter.
- Rubber hoses carry coolant to the DC/DC converter and the A/C inverter motor controller.
- Rubber hoses and metal tubes carry coolant to the motor/transaxle and TIM.
- An electric cooling fan module is mounted on the lower right section of the radiator.
- The coolant temperature sensor is located in the hose connector above the electric pump.
- The liquid cooling system operates whenever the driver's key in the ON position.
  - It also operates during battery charging if the DC/DC converter is charging the 12-volt battery.

POWER STEERING SYSTEM



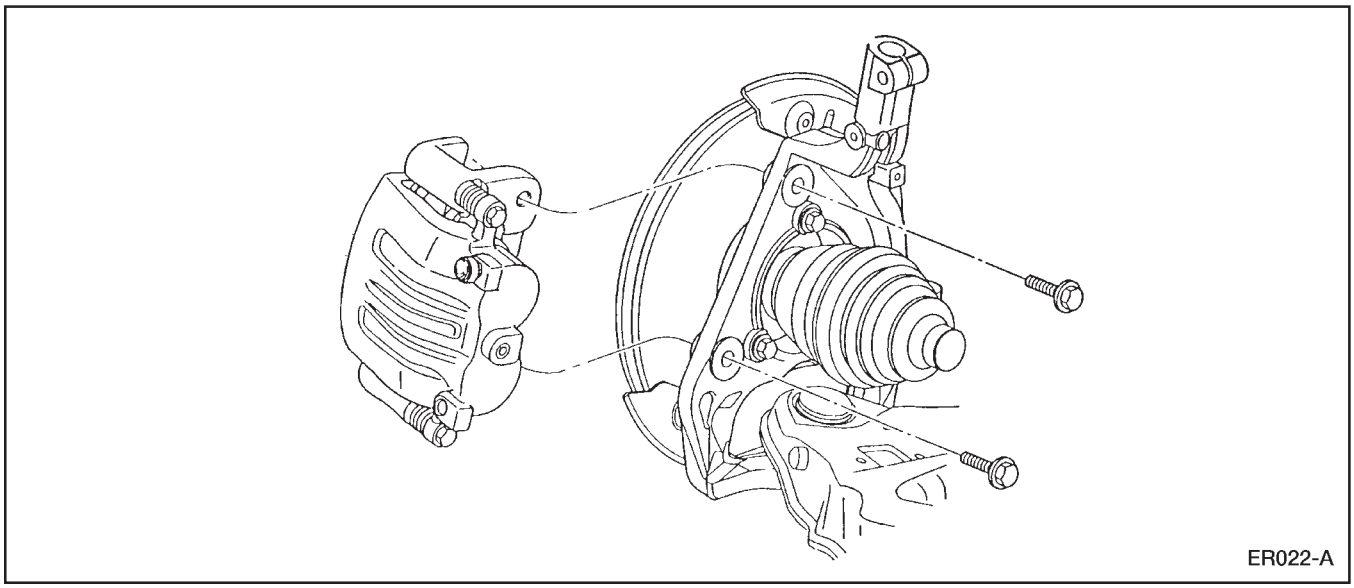
Power Steering System Components

Item	Description
1	Power Steering Controller Assembly
2	Power Steering Gear and Linkage

- The power steering controller assembly is located on the right side of the underhood compartment.
- The power steering controller assembly consists of an electric controller attached to a high voltage AC electric motor and pump.
- The electronic controller has its own inverter to convert DC voltage from the traction battery into the high voltage AC required by the motor.
- The assembly has one high voltage connector and one low voltage connector.
- The steering linkage and power steering gear are carryover from gasoline-powered Ranger.
- The steering column is a Ranger tilt column to accommodate a steering wheel rotation sensor that provides input for additional power assist when the vehicle is at a stop.

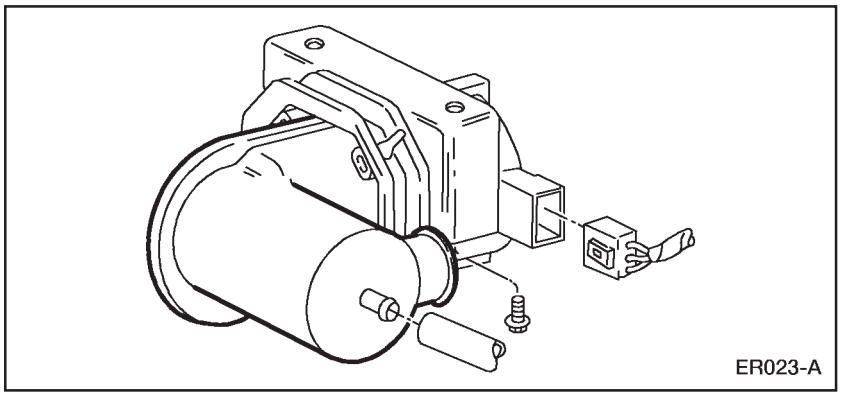
NOTES

BRAKING SYSTEM



Braking System Components

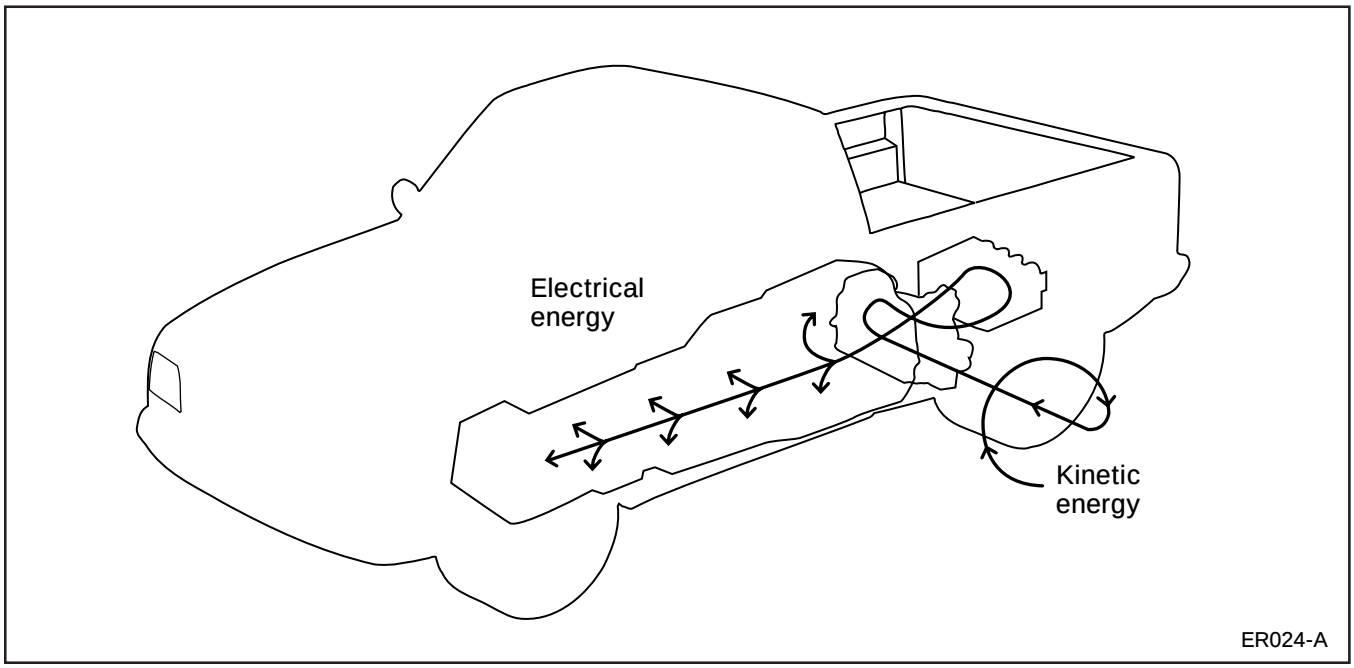
- The base brake system is a conventional hydraulic/friction braking system.
- The brake booster and master cylinder are carryover from the gasoline-powered Ranger.
- The master cylinder includes a modified pressure sensor that provides input for the regenerative braking system.
- The front and rear discs and calipers (above) are carryover Explorer.
  - The hubs are similar to those used on Thunderbird.



Motor Driven Vacuum Pump

- A motor driven vacuum pump is mounted beneath the battery charger.
- The anti-lock braking system (ABS) is a 4-sensor 3-channel system.
- ABS components include:
  - an electronic control unit (ECU).
  - an Explorer hydraulic control unit (HCU).
  - a Ranger mounting bracket.
- The ABS system sends active line output to the TIM for use with the regenerative braking system.
- All of the electric components in the braking system operate off low voltage circuits.

Regenerative Braking System (RBS)



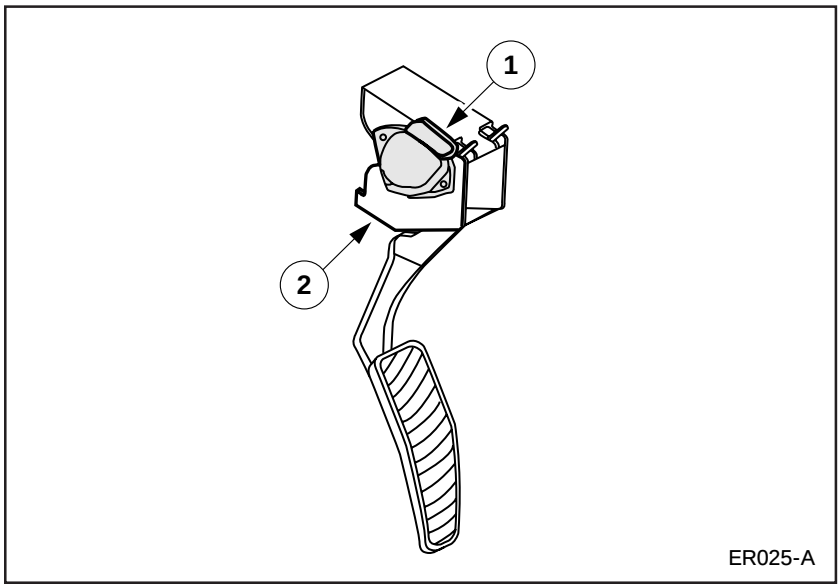
Regenerative Braking System (RBS)

- In a conventional friction braking system, the kinetic energy of deceleration is transformed into heat.
  - This heat is dissipated into the surrounding air.
- The function of the regenerative braking system (RBS) is to recover some of this kinetic energy during deceleration and improve overall vehicle efficiency.
- Regenerative braking is accomplished by using vehicle deceleration to drive the motor/transaxle.
  - This causes the motor to act as a generator and convert vehicle kinetic energy into electrical energy that is stored by the traction battery.

- The accelerator pedal and the brake pedal are inputs of the RBS.
- RBS supplements the hydraulic braking system.
- The RBS operates when the vehicle is moving either forward or backward.
- It is possible for RBS motor torque to cause rear wheel slip in certain circumstances.
  - To prevent excessive wheel slip, the RBS is designed to work with the anti-lock brake system (ABS) module.
  - Whenever an ABS event occurs, the ABS module signals the TIM, which reduces regenerative braking.
  - The RBS is returned to its prior state after the ABS event.

NOTE: The IAA triggers the red BRAKE warning lamp in the instrument cluster if an RBS fault occurs. The vehicle can be safely operated without RBS.

ELECTRONIC THROTTLE CONTROL



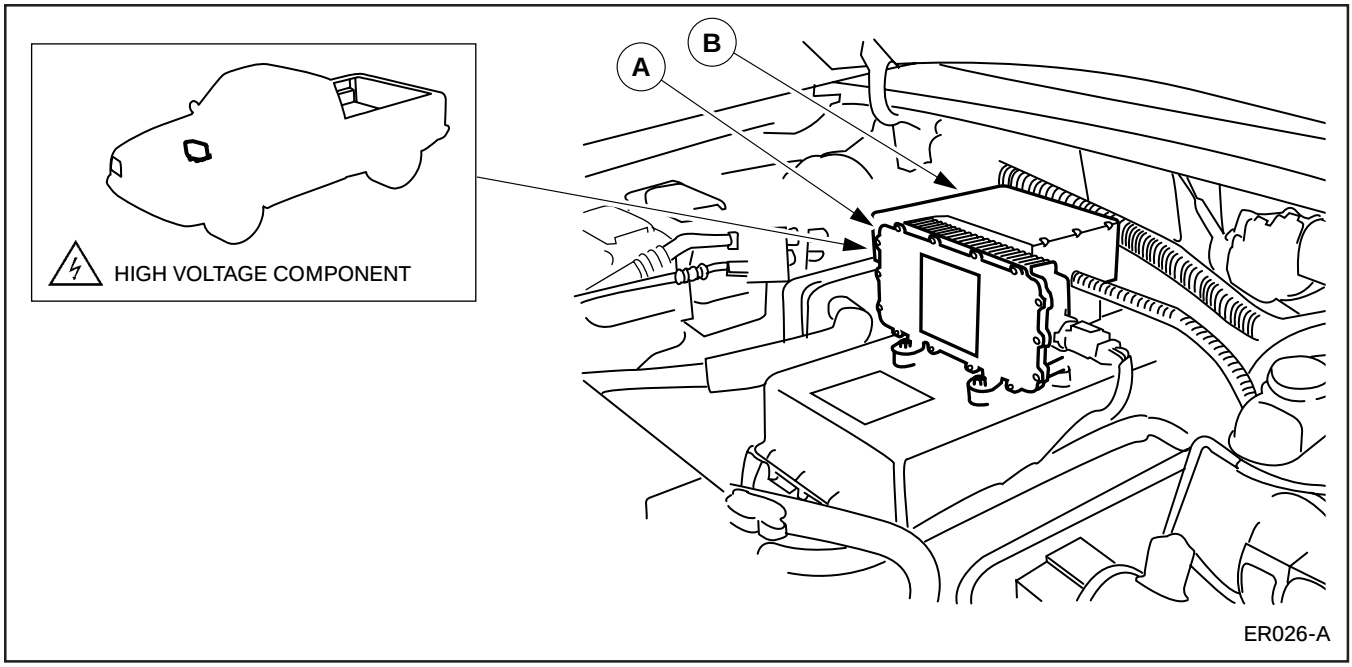
Electronic Throttle Control Components

Item	Description
1	Accelerator Position Sensor (APS)
2	Accelerator Pedal Assembly

- Electronic throttle control is in use on vehicles other than Electric Ranger.
- On the Electric Ranger, electronic throttle control replaces the cable between the accelerator pedal and the powertrain.
- Instead of a mechanical request for power, electronic throttle control uses electrical signals.
- The sensing component of electronic throttle control is an accelerator position sensor (APS) mounted to the accelerator pedal assembly.
  - Three potentiometers in the APS sense the position of the accelerator pedal.
  - The APS sends signals to the TIM, which commands the motor/transaxle to respond accordingly.

CLIMATE CONTROL SYSTEM

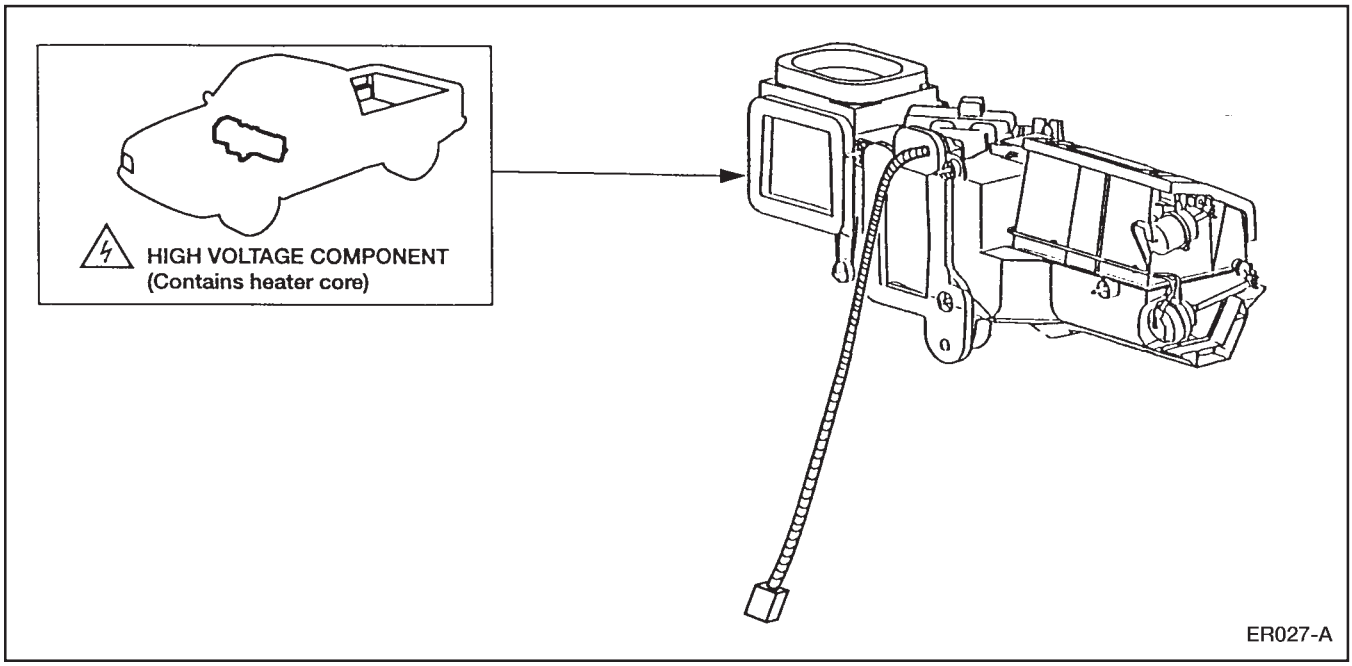
Heating System Description



Heating System

- In place of using engine coolant to heat the passenger compartment, the Electric Ranger uses a positive temperature coefficient (PTC) heater.
- A PTC switching module (**A**) provides high voltage to the PTC heater.
- The PTC switching module is located in the underhood compartment in front of the high voltage power distribution box (**B**).
- The module is controlled by the IAA, and provides fault feedback to the IAA, if any of the following faults occur:
  - A short in the PTC switching module
  - A heater core over-temperature condition
  - A heater core fault
- Feedback is provided on heater core fault conditions (open, short, or over current).

Heating System Operation

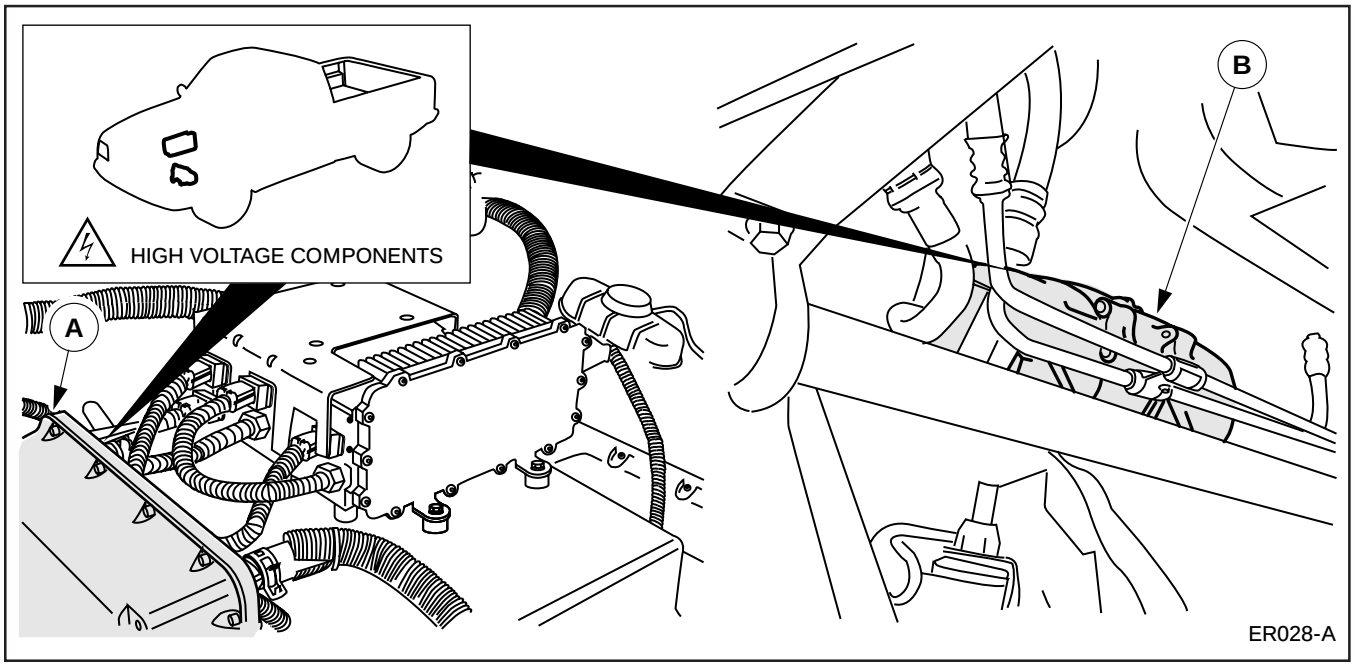


Heater Assembly

- The PTC heater is an electric resistance heater with a two-stage heater core that operates on two separate circuits.
- The heater core uses high voltage DC from the traction battery to defrost the windshield and heat the passenger compartment.
- The heater core is housed in the heater plenum under the instrument panel.
  - The plenum is modified from the gasoline-powered Ranger assembly.
  - The vacuum system, blend door actuator, fresh/recirculation solenoid, over-temperature switch, and wiring harness are new, and the seals are modified.
  - The evaporator assembly is a modified gasoline-powered Ranger assembly.
  - The blower motor and serviceable air filter are new (the air filter is replaced annually). Air filter is located inside the blower motor housing.

- The manual control head is a modified gasoline-powered Ranger design with a:
  - mode switch.
  - blower switch.
  - temperature potentiometer.
- A new recirculation switch allows heat to be recirculated.
- The ambient and in-vehicle temperature sensors are carryover from Explorer.
- Heating temperature in the passenger compartment is limited to 27°C (80°F) to conserve traction battery power.

Air Conditioning System

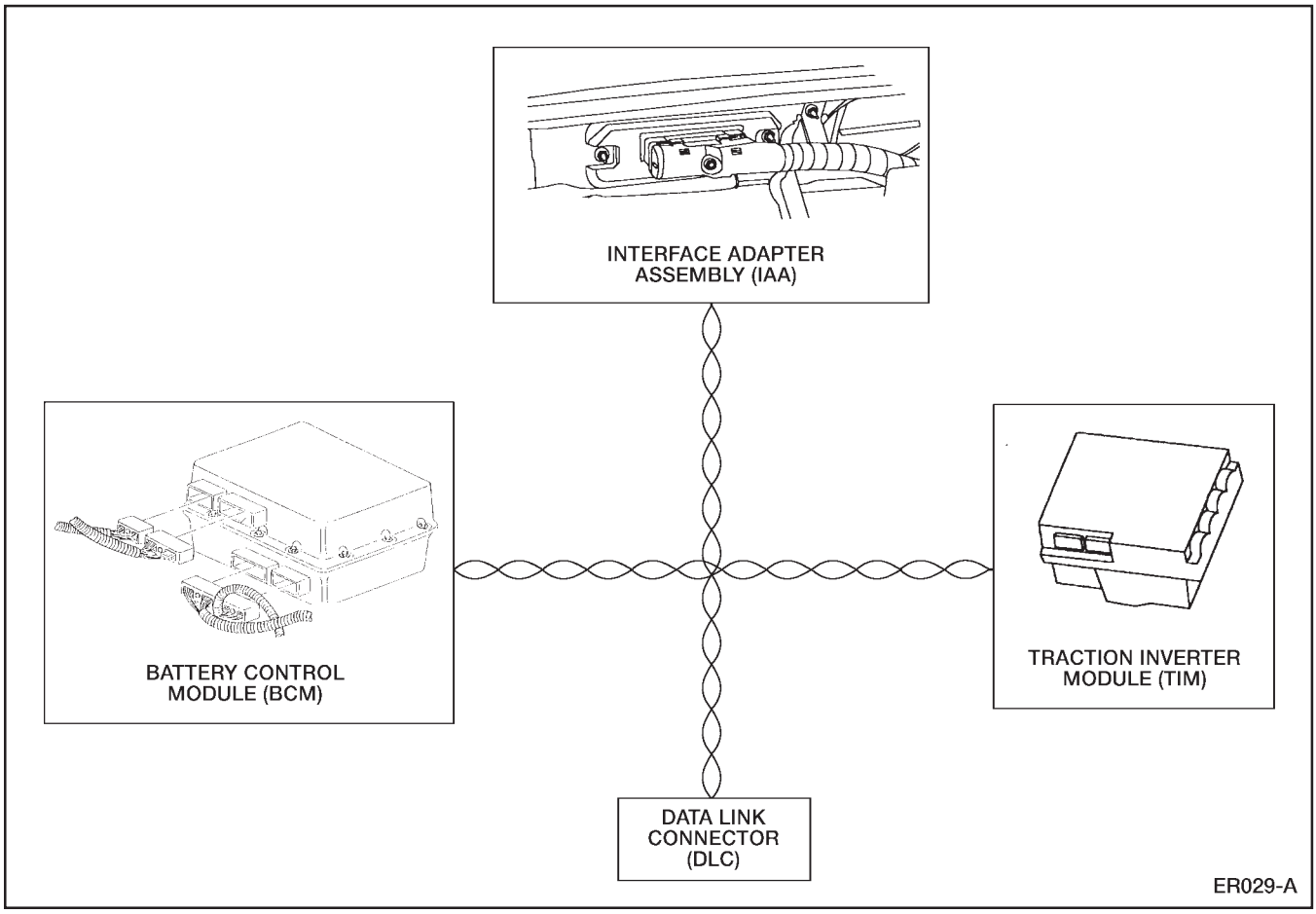


Air Conditioning System Components

- The air conditioning compressor (**B**) is located in the lower center of the under hood compartment.
- The absence of an internal combustion engine means there is no drive belt to power a pulley-driven compressor.
- The Electric Ranger uses an AC high voltage variable-speed compressor.
  - The AC high voltage is supplied by the A/C inverter motor controller (**A**).
  - The A/C inverter motor controller has a case similar to the design of the DC/DC converter and is located next to the battery charger.
  - The controller contains three IGBTs for high speed current switching.

- The compressor is located in the lower center of the underhood compartment and:
  - is a 33 cc scroll design.
  - has an integral 3.5 kW (4.7 hp) motor.
  - has a maximum shaft speed of 7812 rpm.
- The A/C system is a modified Ranger clutch cycling orifice tube (CCOT) system that:
  - requires .8 kg (1.75 lb) of R134a
  - uses a carryover gasoline-powered Ranger condenser unit.
  - has refrigerant lines and evaporator/blower assemblies that are new for Electric Ranger.
- The lower limit of the cooling temperature in the passenger compartment is 18°C (65°F) to conserve traction battery power.

NETWORKS AND MULTIPLEXING

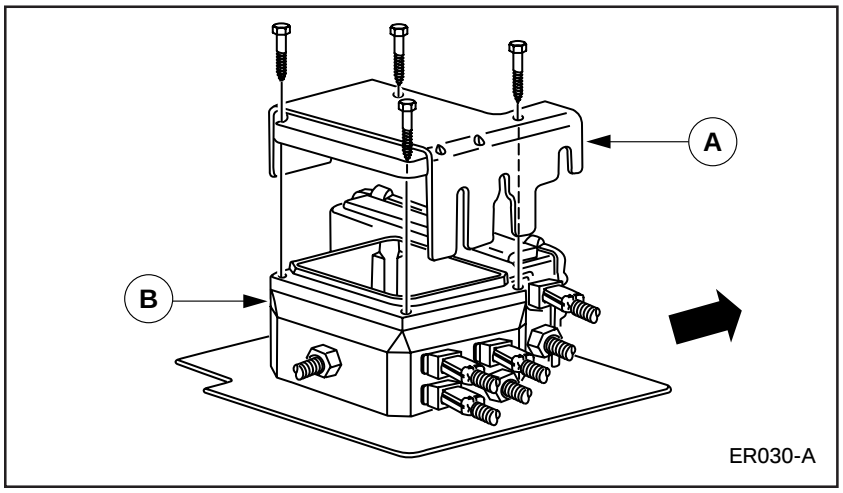


Multiplexing System

- A network is an electronic system composed of control module(s) and/or diagnostic tester (scan tool) that are connected with at least one wire. This hardware allows the modules to communicate with each other.
- The use of networks provides several benefits. These include:
  - Input sensor information can be shared between control modules. This means that they do not have to be hard wired into each module that requires the data they provide.
  - Complex vehicle actions requiring the participation of more than one module can be performed.
  - Improved diagnostic capability is available over the network.

- Multiplexing is an operating strategy where control modules can communicate with each other during normal vehicle operation.
- Multiplexing only occurs over the J1850 network.
- Modules that are multiplexed use the J1850 network and standard corporate protocol (SCP) to communicate (a protocol is a type of computer language).
- The International Standard Organization (ISO) 9141 network is NOT a multiplexed network.
- The ISO 9141 network is only used for diagnostic purposes and is not active during normal vehicle operation.
- In order for the ISO 9141 network to be active, a scan tool must be connected to the network.
- The Electric Ranger has both a J1850 (SCP) and an ISO 9141 network.
- The J1850 (SCP) network consists of:
  - a twisted pair of connecting wires (known as a data bus) in the wiring harness (Circuits 914 and 915).
  - traction inverter module (TIM).
  - battery control module (BCM).
  - interface adapter assembly (IAA).
  - data link connector (DLC) (located next to the steering column).
- The ISO 9141 network consists of:
  - a single wire data bus (circuit 70).
  - anti-lock brake system (ABS) module.
  - central timer module (CTM).
  - electronic crash sensor (ECS) module.
  - DLC.
- Diagnostics for both networks is accessed through the DLC using New Generation STAR (NGS) Tester (covered in Lesson 5).

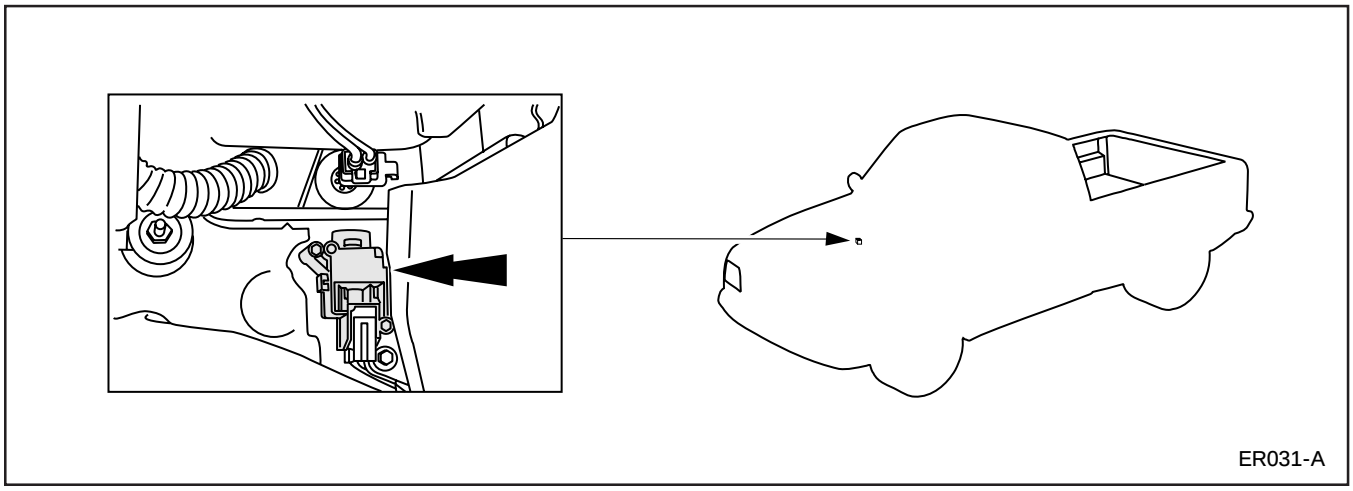
HIGH VOLTAGE INTERLOCKS



High Voltage Interlocks

- High voltage interlocks help prevent electrical accidents by disabling high voltage power when:
  - connectors are disconnected.
  - the top cover (**A**) of the high voltage power distribution box (**B**) is removed.
- The Electric Ranger has interlocks on the following components and wiring:
  - The high voltage power distribution box cover.
  - The high voltage connector from the traction battery to the high voltage power distribution box.
  - The high voltage connector from the traction battery to the TIM.

INERTIA SHUTOFF SWITCH



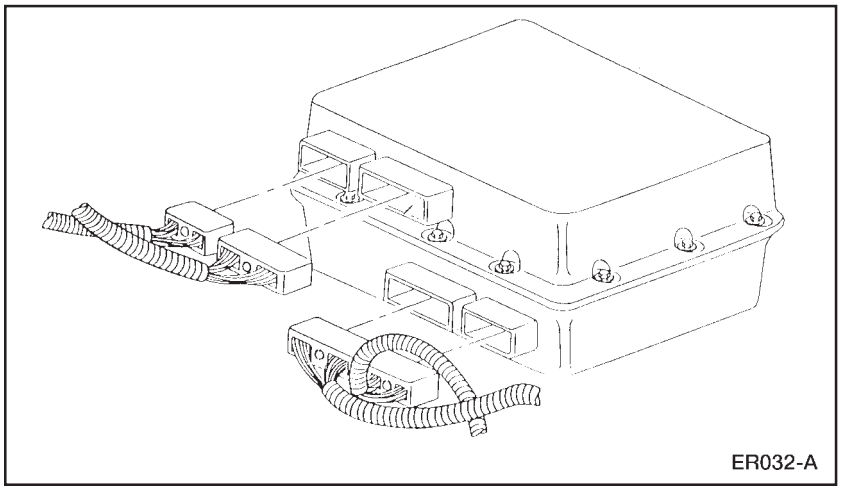
Inertia Shutoff Switch Location

- The inertia shutoff switch (arrow) is located above the carpet line and below the evaporator assembly on the passenger side of the vehicle.
- The inertia shutoff switch on the Electric Ranger performs a similar function as the inertia shutoff switch on the gasoline-powered Ranger.
  - On both vehicles, the inertia shutoff switch disables the vehicle powertrain in the case of an accident.
  - On the gasoline-powered Ranger, the inertia shutoff switch disables the fuel pump.
  - On the Electric Ranger, the inertia shutoff switch interrupts the high voltage power to the vehicle systems.
- The POWER RESET lamp illuminates whenever the inertia shutoff switch is triggered.
  - The reset button is located on top of the inertia shutoff switch.

Emergency Power Off (EPO)

- The EPO is a fail-safe system designed to safeguard against personal injury and prevent vehicle damage.
- EPO is activated when the inertia shutoff switch is triggered or a high voltage interlock is disconnected.
  - An EPO signal is sent to disable all high voltage loads and shut down the vehicle.
  - TIM, BCM, and IAA can initiate an EPO signal.

CURRENT LEAKAGE DETECTION

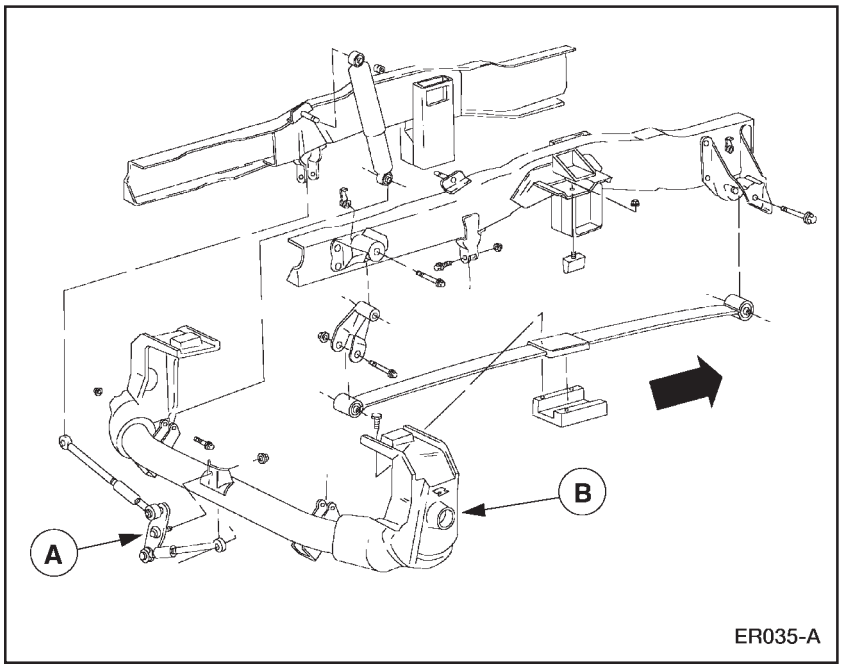


Current Leakage Detection

- The Electric Ranger uses a current leakage detection system to monitor the integrity of the electrical system.
- The BCM monitors the high voltage system for current leakage by checking the DC circuitry for a low impedance path.
- Current leakage detection is performed by relays, leakage current shunts and current limiting resistors within the BCM.
- This internal circuitry interfaces with either terminal of the traction battery to measure impedance path between the terminal and the vehicle chassis.
- If the BCM detects severe leakage, the electric hazard warning lamp in the instrument cluster will illuminate.

NOTE: If the electric hazard warning lamp remains illuminated after lamp prove out, service the vehicle.

SUSPENSION SYSTEM



Rear Suspension Components

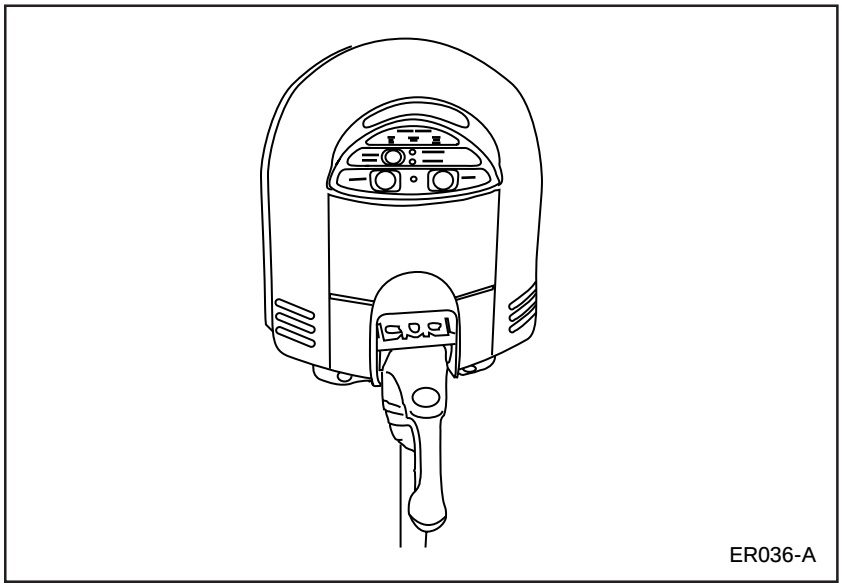
- The rear suspension system is designed specifically for the Electric Ranger.
- The DeDion rear axle (**B**) consists of:
  - a thick-walled aluminum tube.
  - sand-cast aluminum ends with Bearing carriers and spring seats.
  - aluminum ends that are welded to the aluminum tube.
- The rear axle utilizes a Watts linkage (**A**) for handling and control.
- The rear shock absorbers and jounce bumper brackets are unique.
- Composite single-rate leaf springs are used for weight reduction.
- Carryover Ranger spring mounts and shackles are used.

Front Suspension System

- The front suspension consists of Ranger 4x4 control arms and modified Explorer 4x2 steering knuckle and spindle assemblies.
- A unique stabilizer bar is tuned for proper roll stiffness.
- Unique torsion bars and shock absorbers attach to carryover Ranger mounts.

TRACTION BATTERY CHARGING COMPONENTS

Power Control Station (PCS)

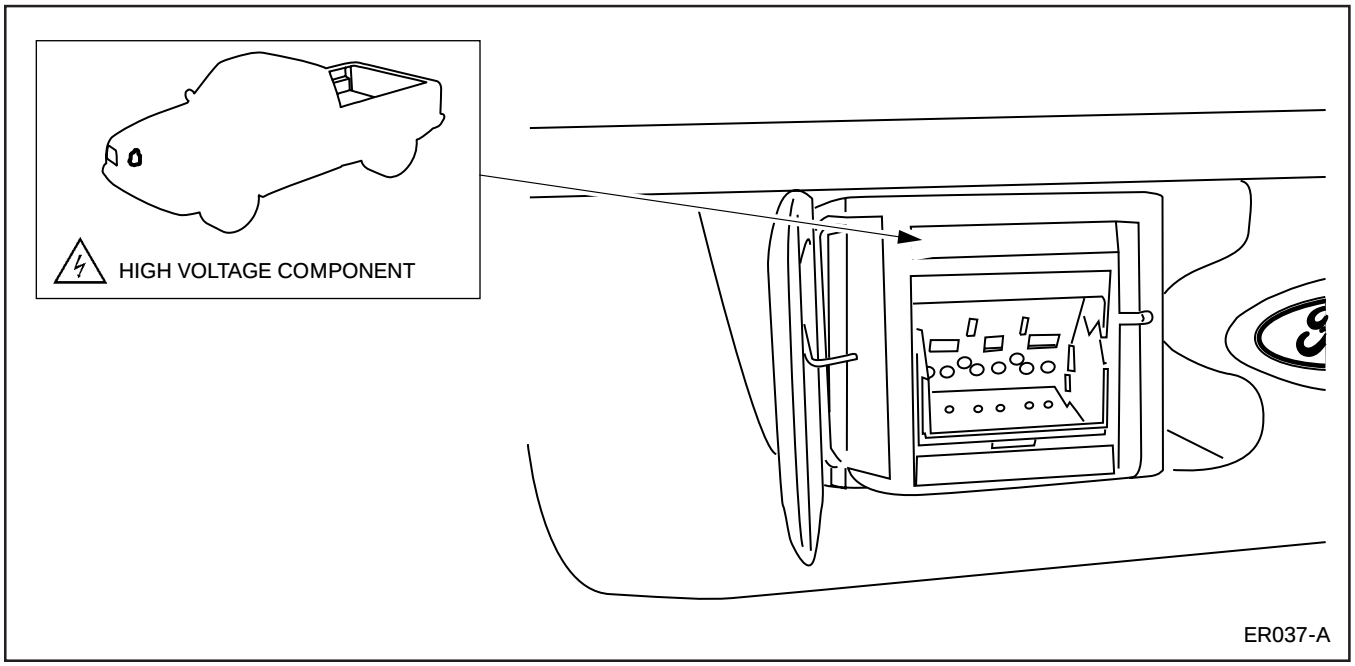


Power Control Station (PCS)

- The Electric Ranger's traction battery is charged by an off-board power control station (PCS).
- The PCS requires 240-volt 40 amp AC service.
- When connection is made from the PCS to the vehicle:
  - self test and vehicle confirmation tests are initiated.
  - if the system is operational, the green charging light will illuminate on the PCS.
  - the green charging light indicates the self test and the vehicle confirmation tests are compete and charging has begun.
  - the charger fans will start cooling the on-vehicle charger approximately four minutes after the charging light illuminates steadily.

- If the green START light goes out and the amber CHARGE INTERRUPT light illuminates:
  - operation has been discontinued by the Class A ground fault detection system.
  - due to the high sensitivity of this system, the charge operation will be shut down if either the charge cord plug or the charge inlet is wet or damp.
- Press the STOP button to reset the system.
  - If further attempts are unsuccessful, it is likely that a ground fault exists.
  - If a ground fault exists, it must be repaired to continue the charging operation.
- Complete charging procedure is covered in Lesson 2.

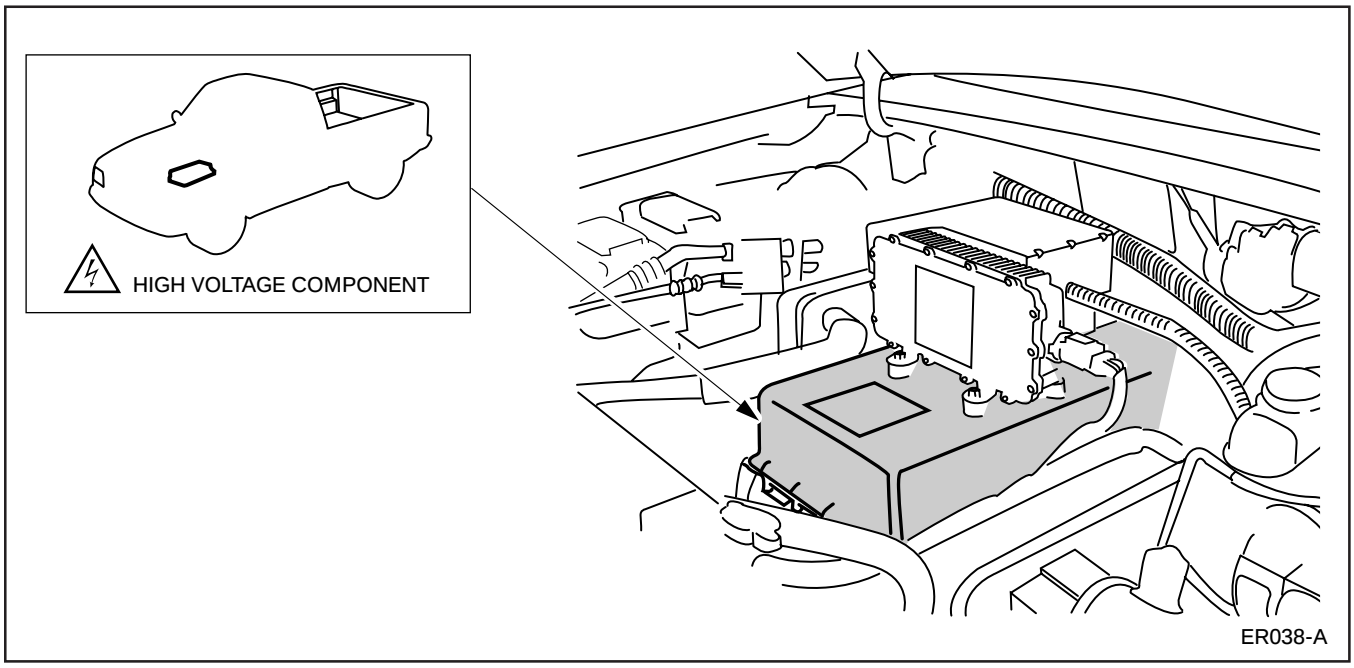
Charge Inlet



Charge Inlet

- The charge inlet is equivalent to the fuel filler port on a gasoline-powered vehicle.
- The Electric Ranger receives power in the form of 240-volt AC current.
- An EV industry standard plug fits into the charge inlet.
  - Located between the headlights behind a grille access door.
- The high voltage wiring that connects the charge inlet to the on board battery charger is energized only during charging.

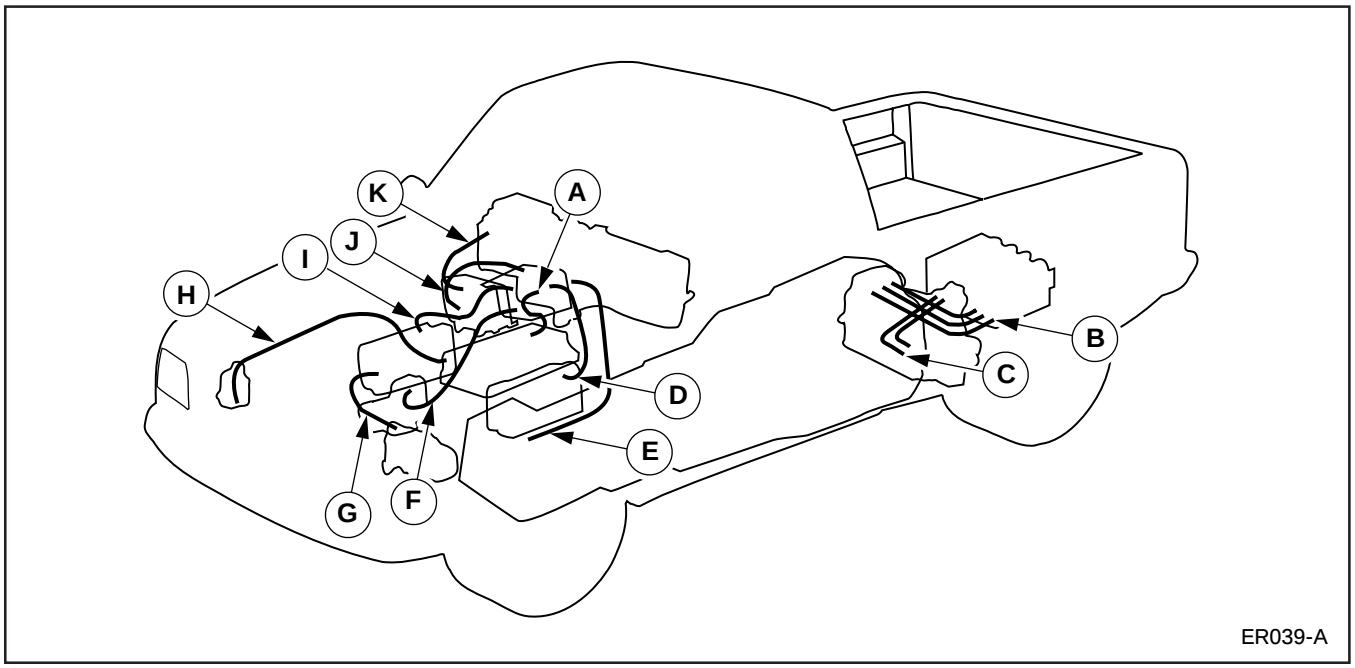
Battery Charger



Battery Charger

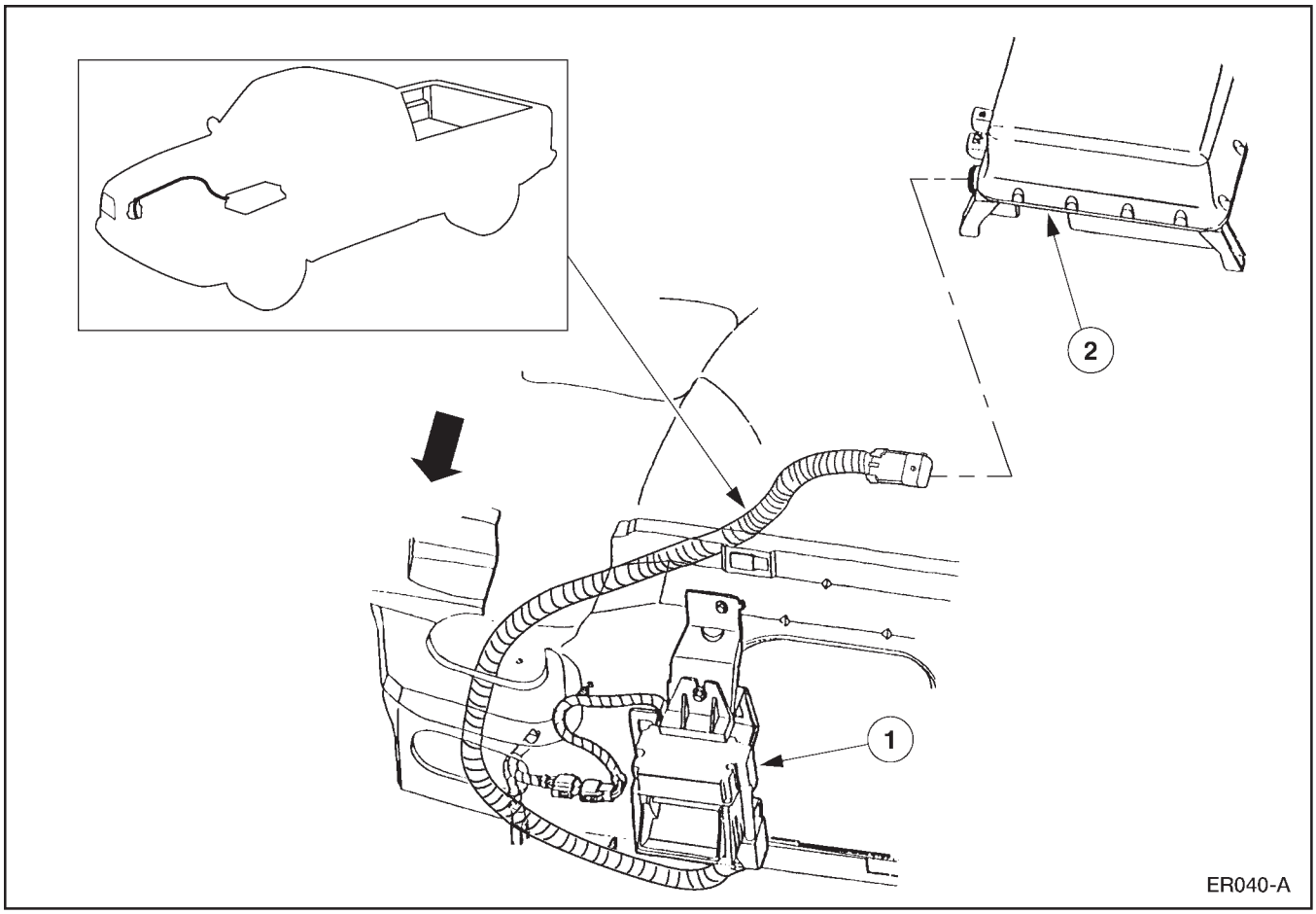
- The on-board battery charger (arrow) is located in the underhood compartment beneath the high voltage power distribution box.
- The on-board battery charger receives 240-volt 40 amp AC current from the power control station (PCS) and converts it into DC current.
- The on-board battery charger operates only with a charger cord plugged into the charge inlet.
  - The vehicle cannot be started or driven with the charger cord attached to the charge inlet.
- Internal fans provide cooling during battery charger operation.

HIGH VOLTAGE WIRING

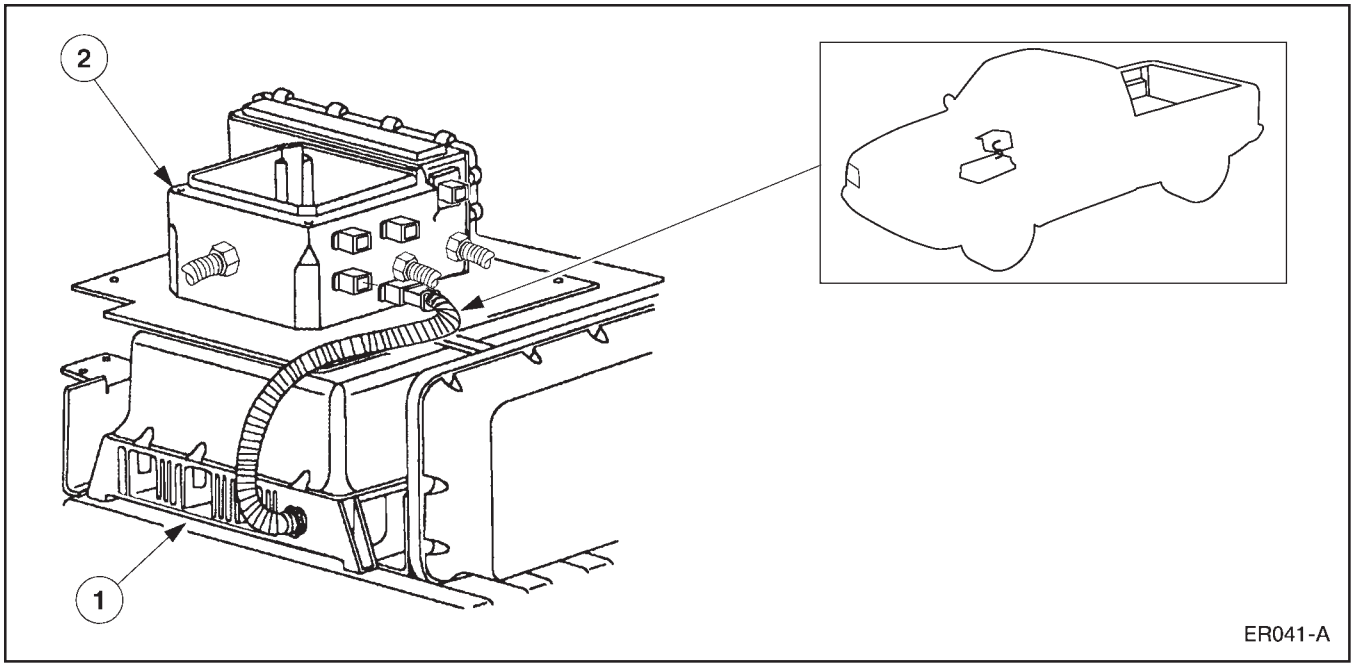


High Voltage Wiring

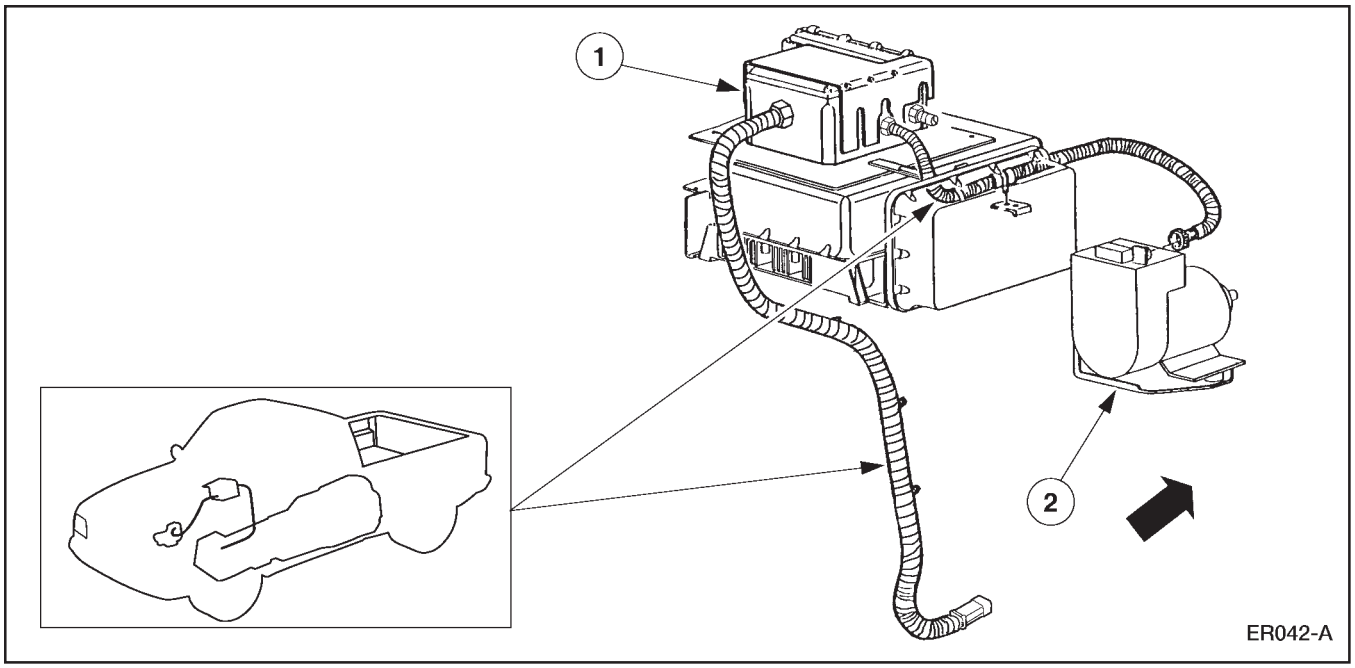
- All high voltage wiring is covered with color-coded with orange convolute.
- High voltage wiring connects the following components:
  - A. From battery charger to high voltage power distribution box
  - B. From TIM to motor/transaxle
  - C. From traction battery to TIM
  - D. From high voltage power distribution box to DC/DC converter
  - E. From traction battery to high voltage power distribution box
  - F. From high voltage power distribution box to power steering controller assembly
  - G. From A/C inverter motor controller to A/C compressor
  - H. From charge inlet to battery charger
  - I. From high voltage power distribution box to A/C inverter motor controller
  - J. From high voltage power distribution box to PTC switching module
  - K. From PTC switching module to PTC heater
- The illustrations on the following pages provide a reference for the high voltage cables on the Electric Ranger.



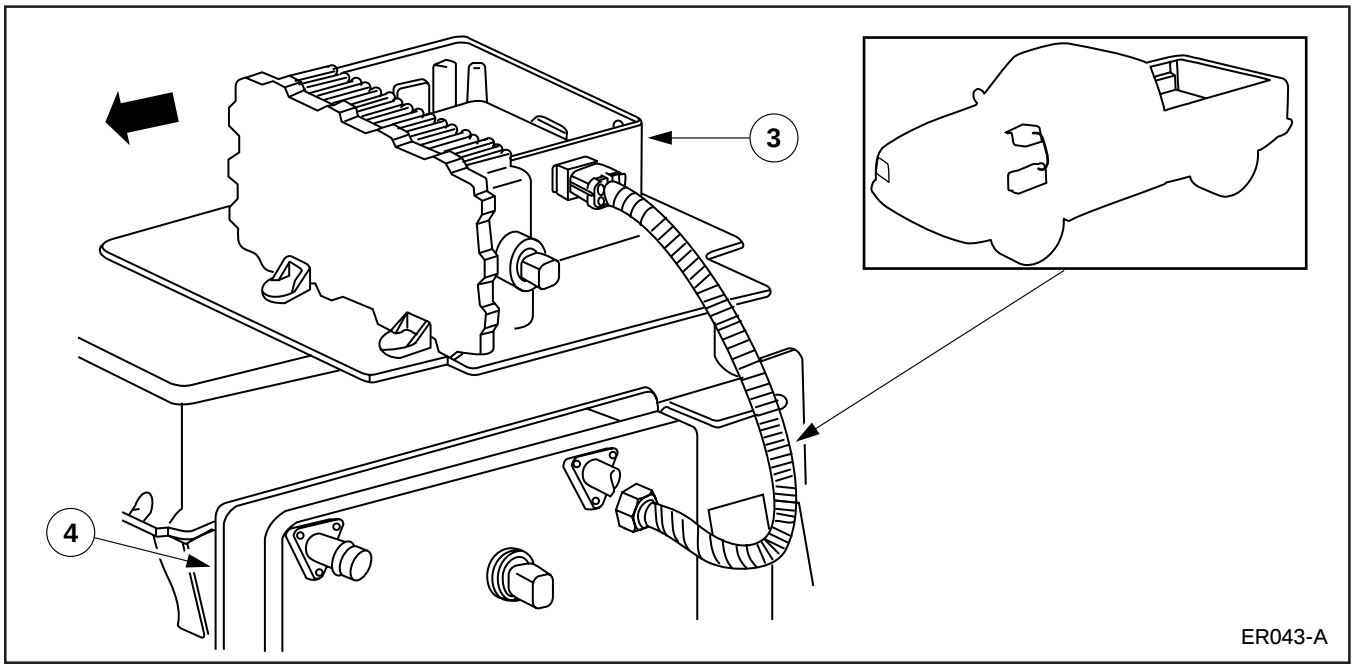
High Voltage Wiring from Charge Inlet (1) to Battery Charger (2)



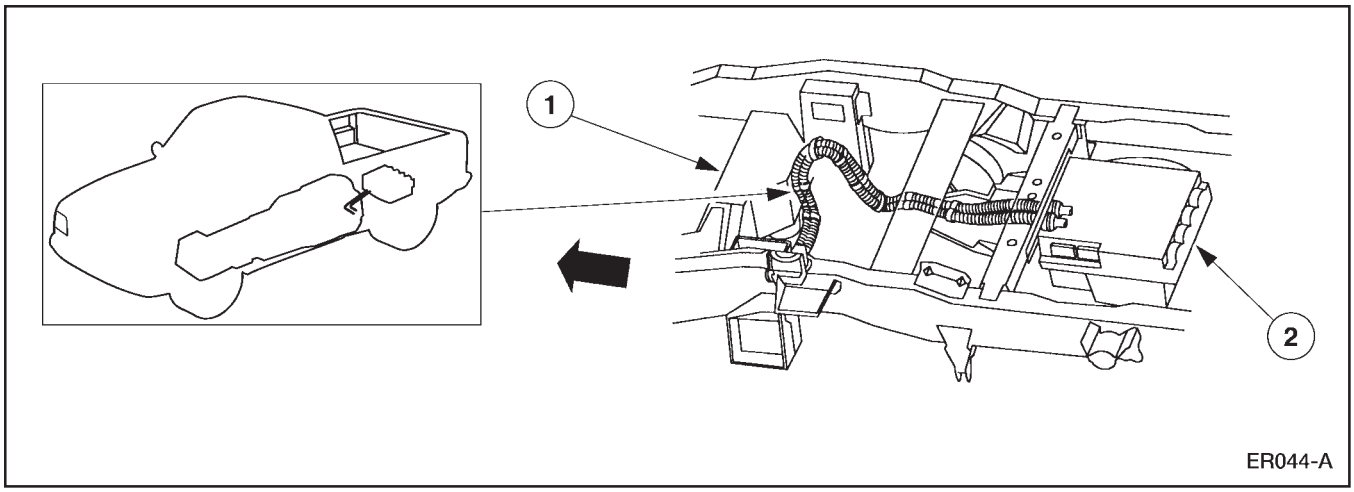
High Voltage Wiring from Battery Charger (1) to High Voltage Power Distribution Box (2)



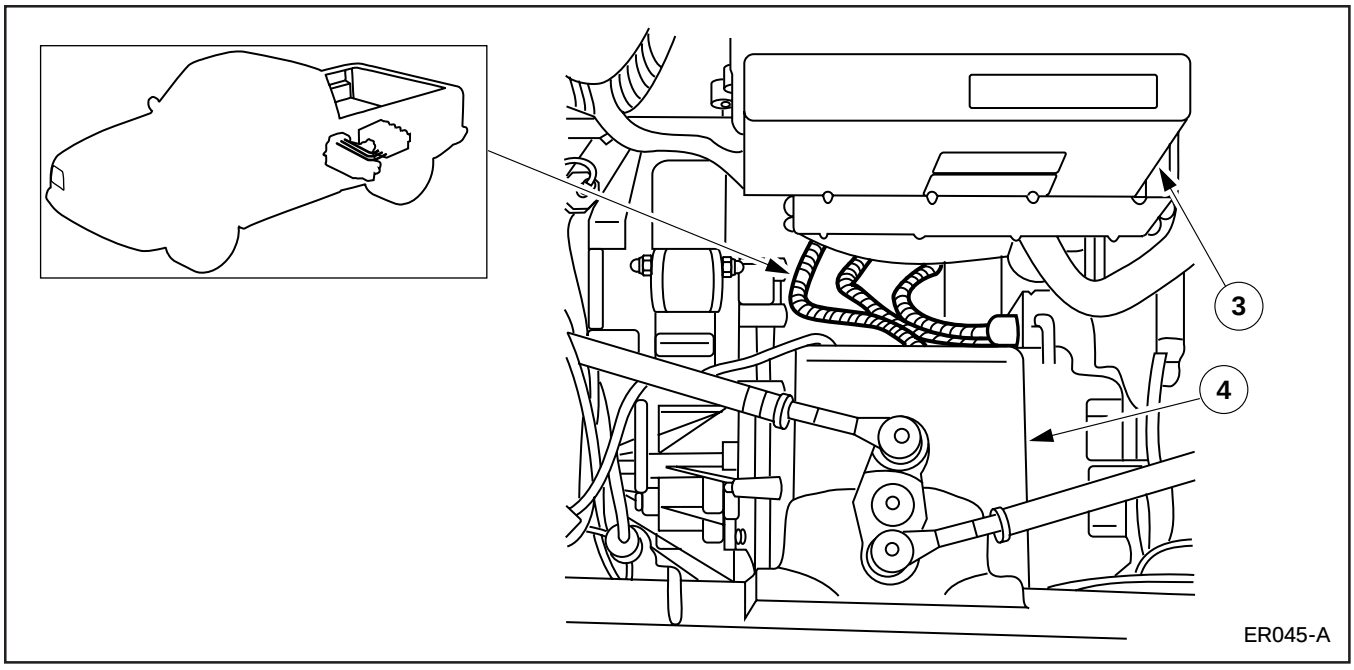
High Voltage Wiring from High Voltage Power Distribution Box (1) to Traction Battery
High Voltage Wiring from High Voltage Power Distribution Box (1) to Power Steering Controller Assembly (2)



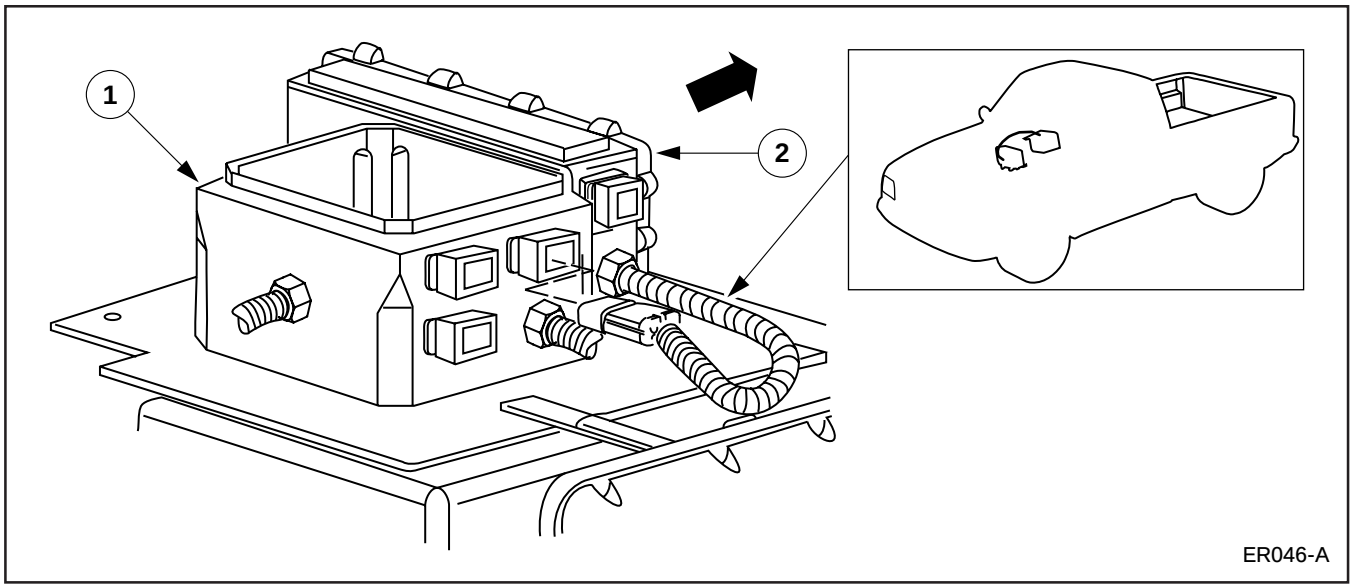
High Voltage Wiring from High Voltage Power Distribution Box (3) to DC/DC Converter (4)



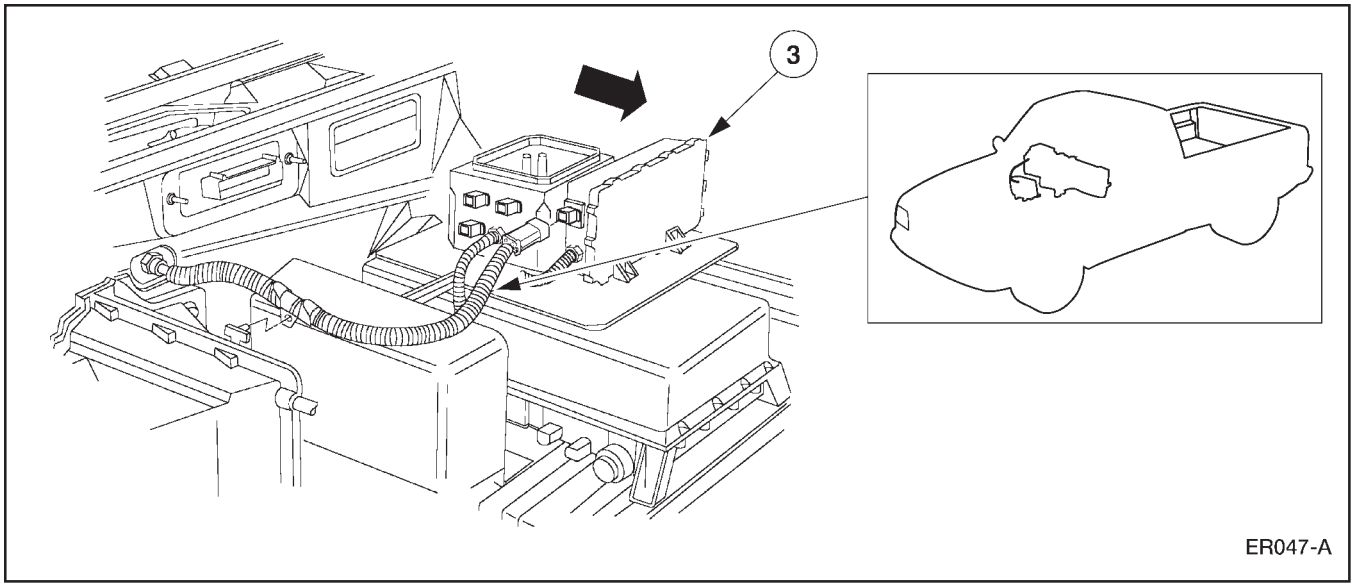
High Voltage Wiring from Traction Battery (1) to TIM (2)



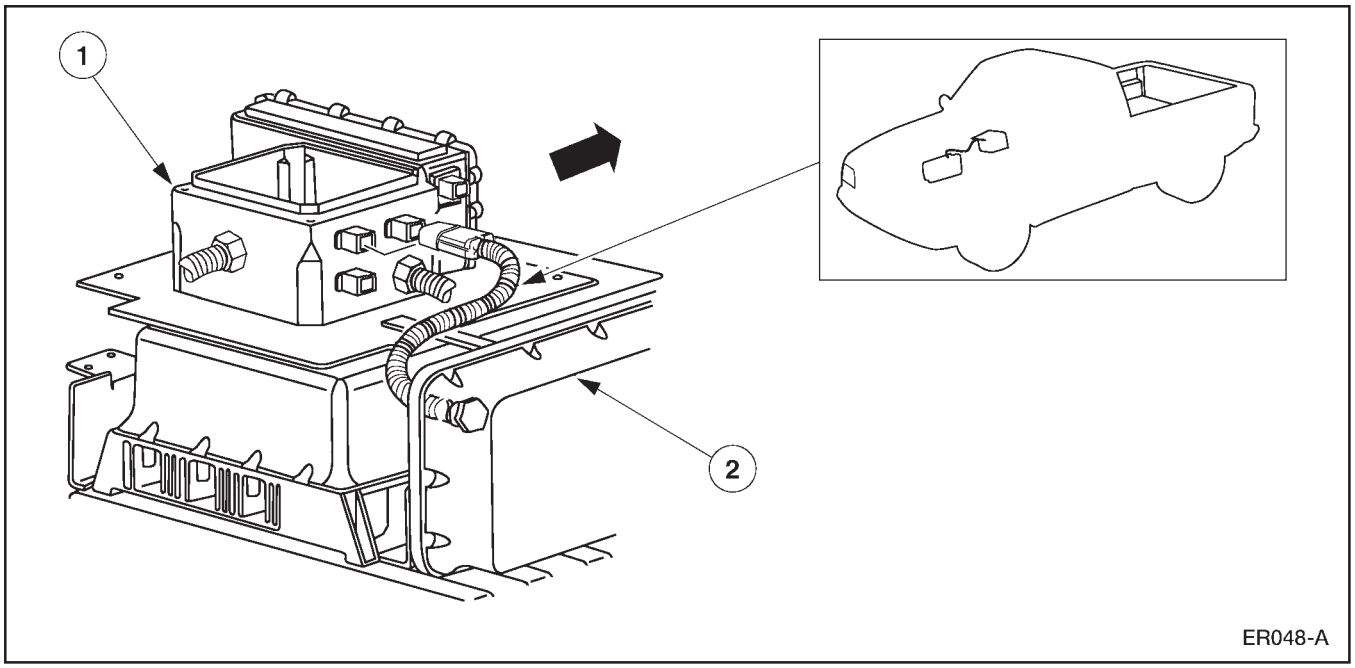
High Voltage Wiring from TIM (3) to Motor/Transaxle (4)



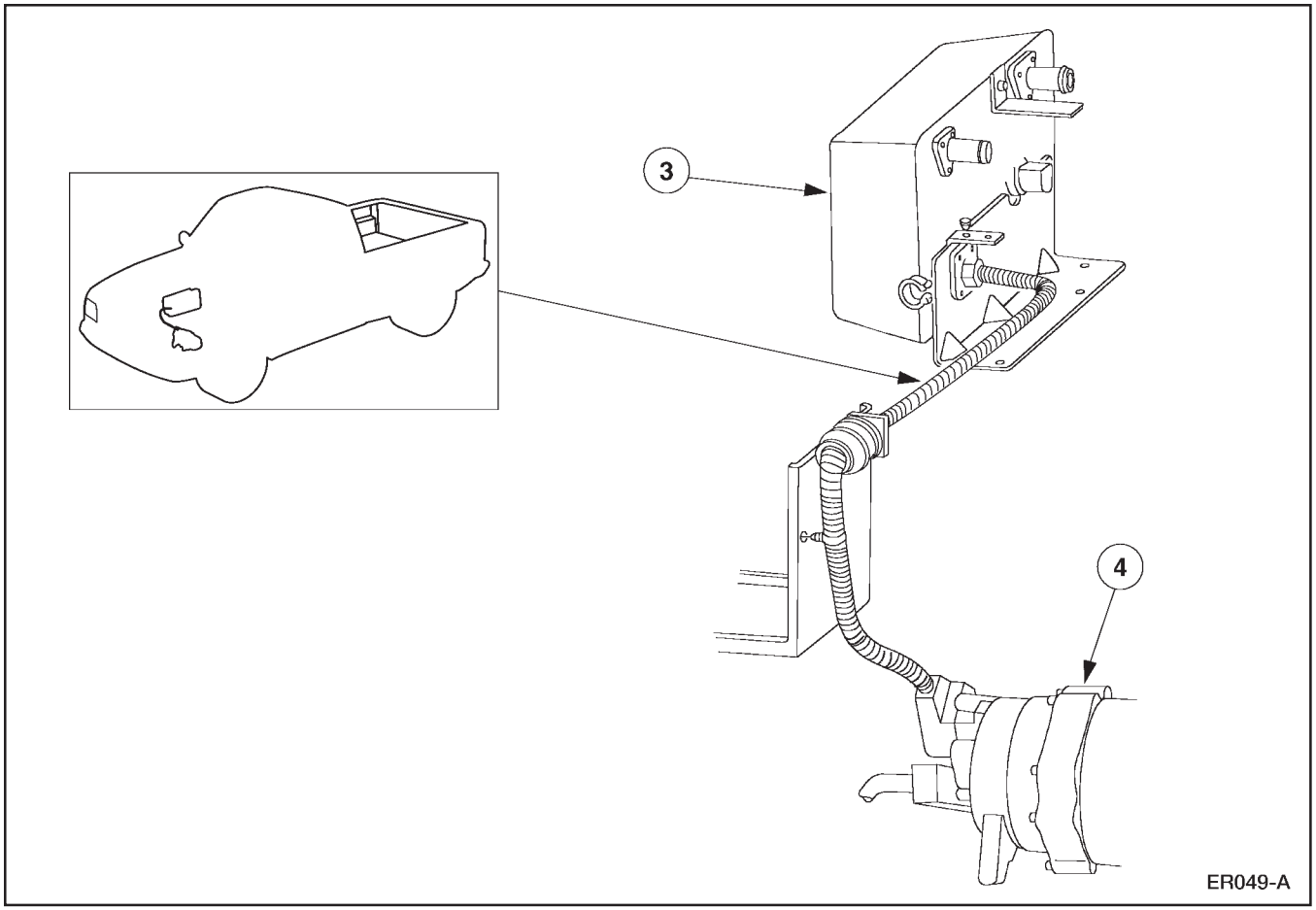
High Voltage Wiring from High Voltage Power Distribution Box (1) to PTC Switching Module (2)



High Voltage Wiring from PTC Switching Module (3) to PTC Heater



High Voltage Wiring from High Voltage Power Distribution Box (1) to A/C Inverter Motor Controller (2)



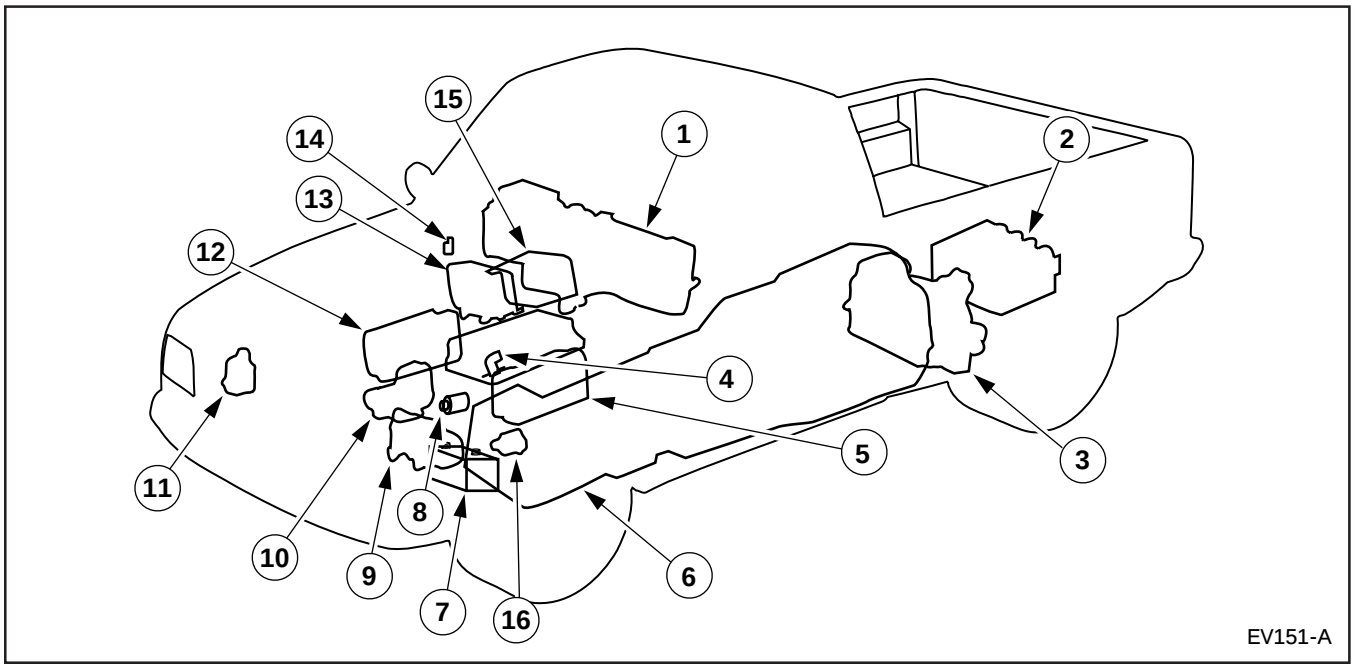
High Voltage Wiring from A/C Inverter Motor Controller (3) to A/C Compressor (4)

NOTES

ACTIVITY 1 – VEHICLE OVERVIEW – WORKSHEET A
COMPONENT LOCATION
STUDENT ANSWER SHEET

OBJECTIVE: To identify the location of EV Ranger components.

DIRECTIONS: Go to the classroom vehicles. You will find the components listed below have tags attached to them. Write the letter/number on the tag that is attached to each of the listed components.



High Voltage Components

_____ A/C Compressor (H)

_____ A/C Inverter Motor Controller

_____ Charge Inlet

_____ DC/DC Converter

_____ Motor/Transaxle (H)

_____ High Voltage Power Distribution Box

_____ Power Steering Controller Assembly

_____ PTC Heater Core (inside of Chamber Assembly-Heater Plenum)

_____ PTC Switching Module

_____ Traction Battery (includes BCM and Contactor Box) (H)

_____ Battery Charger

_____ Traction Inverter Module (TIM) (H)

_____ Vacuum Pump

_____ Coolant Pump

_____ Auxiliary Battery

_____ Inertia Switch

END OF WORKSHEET A

ACTIVITY 1 – VEHICLE OVERVIEW – WORKSHEET B
COMPONENT FUNCTION EXERCISE
STUDENT ANSWER SHEET

OBJECTIVE: To identify the function of the Electric Ranger components and systems.

DIRECTIONS: Match the listed items with the correct definitions:

1. Interface Adapter Assembly (IAA)
2. Regenerative Braking System (RBS)
3. DC/DC Converter
4. Vacuum Pump
5. Contactor Box
6. PTC Switching Module
7. Traction Inverter Module (TIM)
8. Battery Charger
9. Electronic Throttle Control
10. Battery Control Module (BCM)
11. Auxiliary Battery
12. Multiplexing System
13. Inertia Switch

_____ manages all functions of the traction battery.

_____ charges the 12-volt battery.

_____ allows module to module communication during normal vehicle operation.

_____ converts high voltage DC into three-phase AC.

_____ interacts directly with the heating and braking system.

_____ replaces the accelerator cable.

_____ controls the PTC heating system.

_____ is cooled by internal cooling fans.

_____ contains two relays and two resistors for high voltage circuit precharging

_____ converts vehicle kinetic energy into electrical energy.

_____ is located directly in front of the high voltage power distribution box.

_____ powers the lighting system.

_____ interrupts power in the event of a collision.

END OF WORKSHEET B

ACTIVITY 1 – VEHICLE OVERVIEW – WORKSHEET C
SAFETY FEATURE IDENTIFICATION
STUDENT ANSWER SHEET

OBJECTIVES: To describe the safety features found on the Electric Ranger.

DIRECTIONS: Select the correct response for each statement or question.

1. The inertia shutoff switch is located:
   A. Beside the 12-volt battery in the underhood compartment.
   B. Below the evaporator assembly in the passenger compartment.
   C. Next to the diagnostic connector in the underhood compartment.
   D. Above the TIM and close to the left rear fender.
2. When does the electric hazard warning lamp illuminate?
   A. When the driver's key is turned to the ON position (lamp prove-out).
   B. When a high level of current leakage is detected.
   C. When a high voltage interlock is disconnected.
   D. All of the above.
3. What color identifies a high voltage cable?
   A. Red.
   B. Orange.
   C. Yellow.
   D. All of the above.
4. Which of the following is not equipped with a high voltage interlock?
   A. The cover of the high voltage power distribution box.
   B. The connector from the traction battery to the high voltage power distribution box (4-pin connector).
   C. The connector from the traction battery to the TIM (2-pin connector).
   D. The cover of the traction battery.
5. High voltage components are identified by:
   A. Identification tags.
   B. Red color coding.
   C. Warning labels.
   D. Plastic insulation.

END OF WORKSHEET C

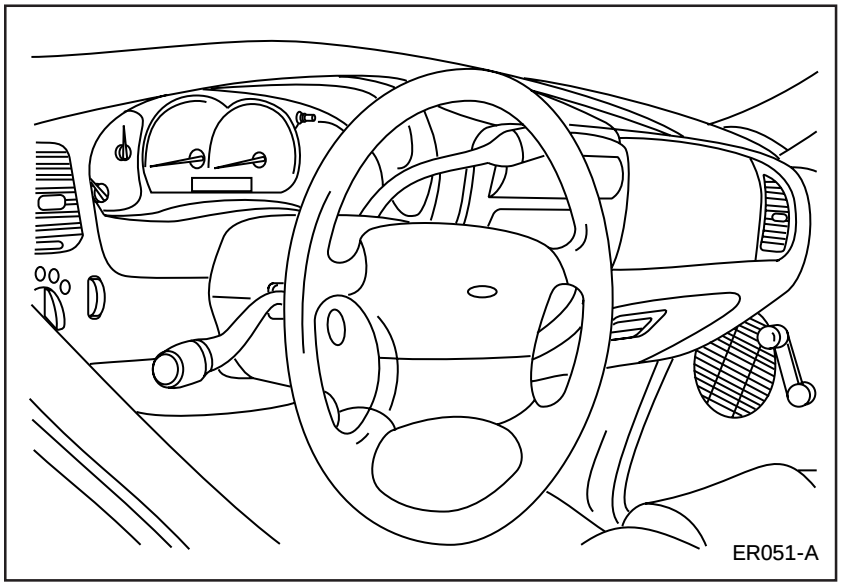
TECHNICIAN OBJECTIVES

- Describe vehicle operation.
- Identify instrument cluster components and functions.
- Describe the economy mode.
- Describe traction battery charging procedures.

CONTENTS

VEHICLE OPERATION

Vehicle Controls



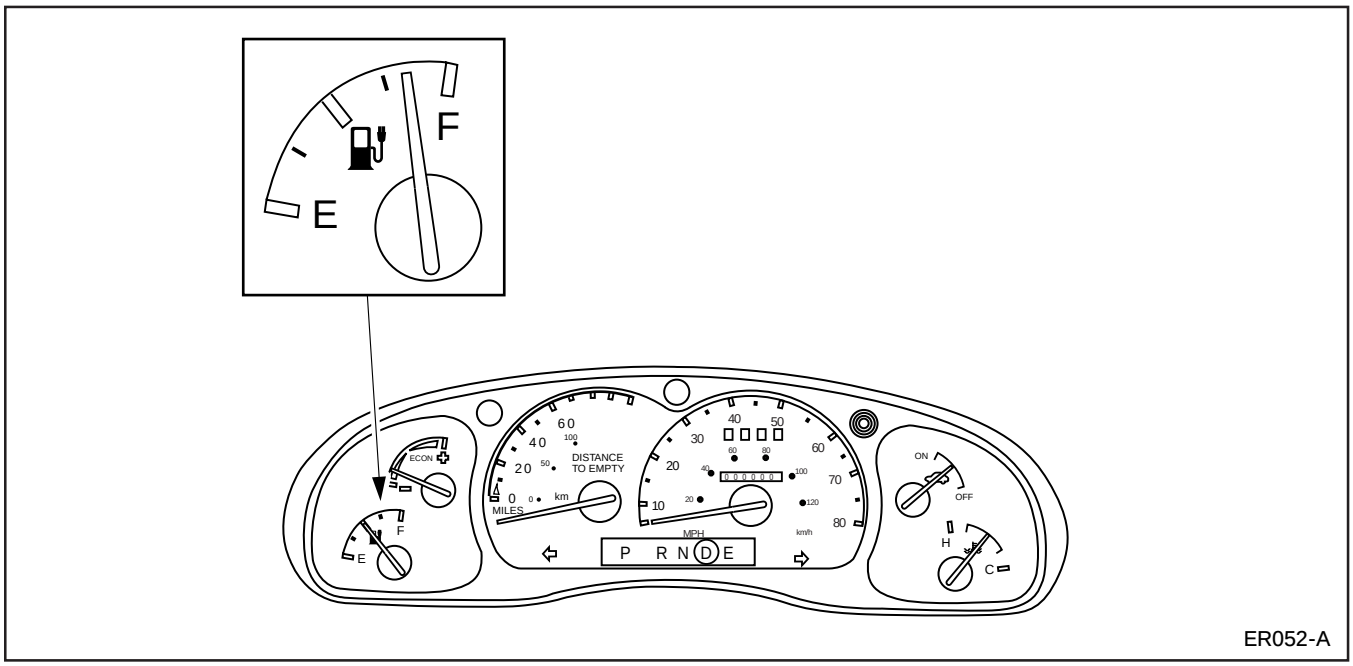
Vehicle Controls

- Driving the Electric Ranger is similar to operating a gasoline-powered vehicle.
- The key positions are the same as other Ford vehicles (positions are listed from full rearward to full forward):
  - ACC
  - LOCK
  - OFF
  - ON
  - START
- The major controls are operated in the same manner as other Ford vehicles.
  - gear selector lever (except for unique economy mode)
  - accelerator pedal
  - brake pedal
  - parking brake

- The instrument cluster has several new gauges and warning lamps (covered later in this lesson).
- When the driver key is turned to the START position, there is no starter motor noise (although the vehicle is activated).
- The Electric Ranger “creeps” forward like a gasoline-powered vehicle with an automatic transmission that is in gear (after the vehicle is “started” and the key remains in the ON position foot off brake).
- During deceleration, a higher drag is felt due to the regenerative braking system (covered later in this lesson).

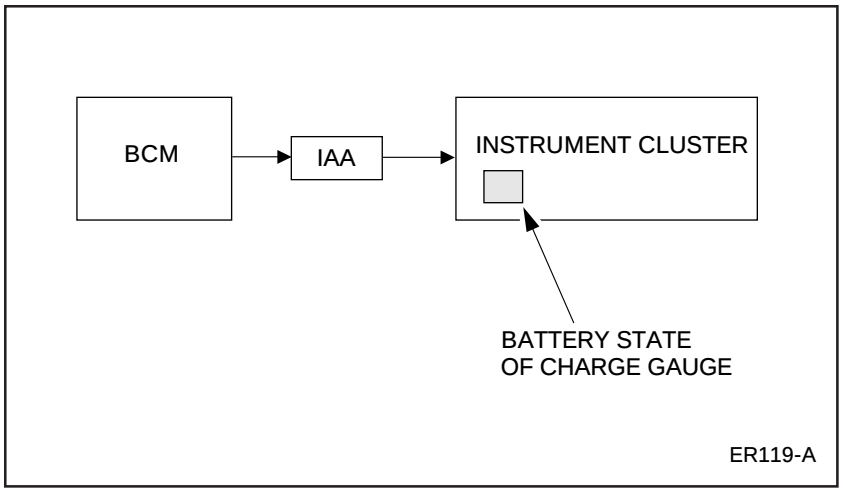
INSTRUMENT CLUSTER GAUGES

Battery State of Charge Gauge



Battery State of Charge Gauge

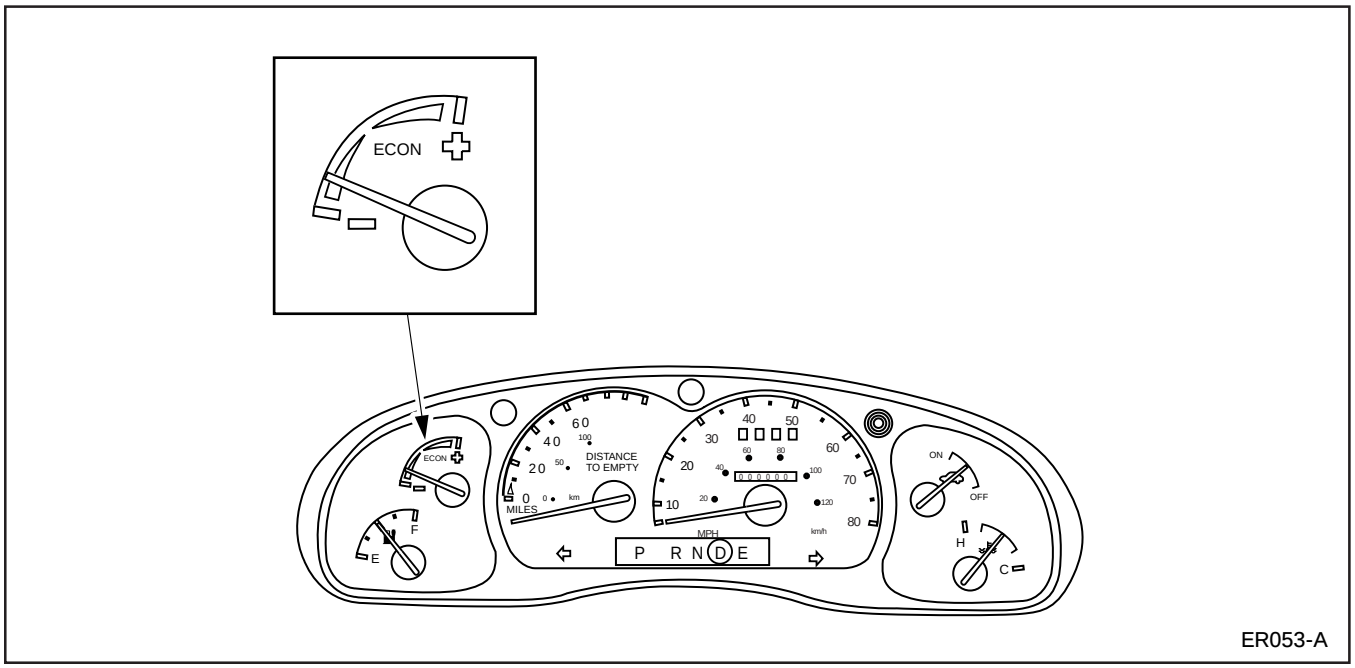
- The Battery State of Charge Gauge is the equivalent of the fuel gauge on a gasoline-powered vehicle.
  - F is indicated when the traction battery is fully charged.
  - E is indicated when the traction battery is discharged to the point where additional operation will reduce traction battery life.
- The BCM monitors the percent of charge of each battery module and calculates the average state of charge of the traction battery.
- The BCM sends battery state of charge information to the IAA through the J1850 (SCP) network.
- The IAA uses the Battery State of Charge Gauge to indicate the traction battery state of charge.



Battery State of Charge Gauge Inputs

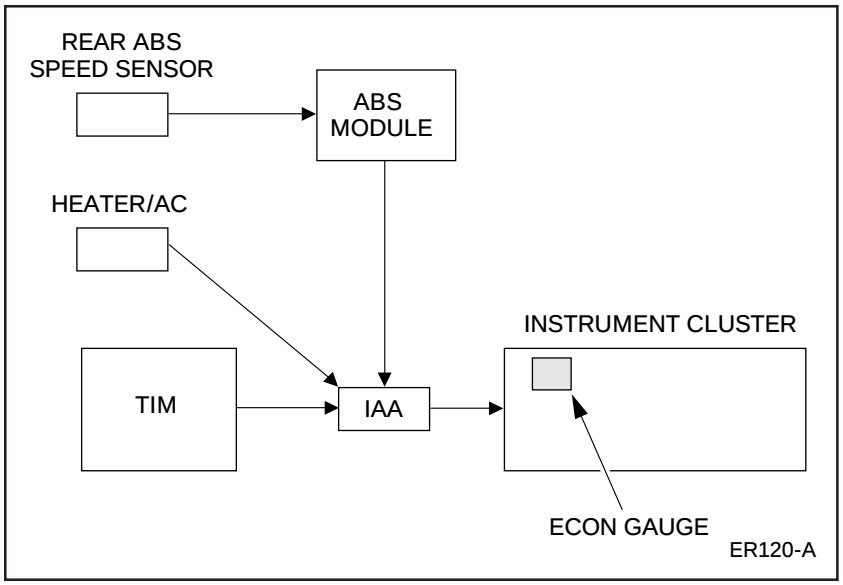
NOTE: The POWER LIMIT and Low Fuel Warning Lamps flash when the gauge reads empty. Vehicle performance will be extremely limited at this point; the driver must pull over off the road (to the shoulder) as quickly and safely as possible.

ECON (Economy) Gauge



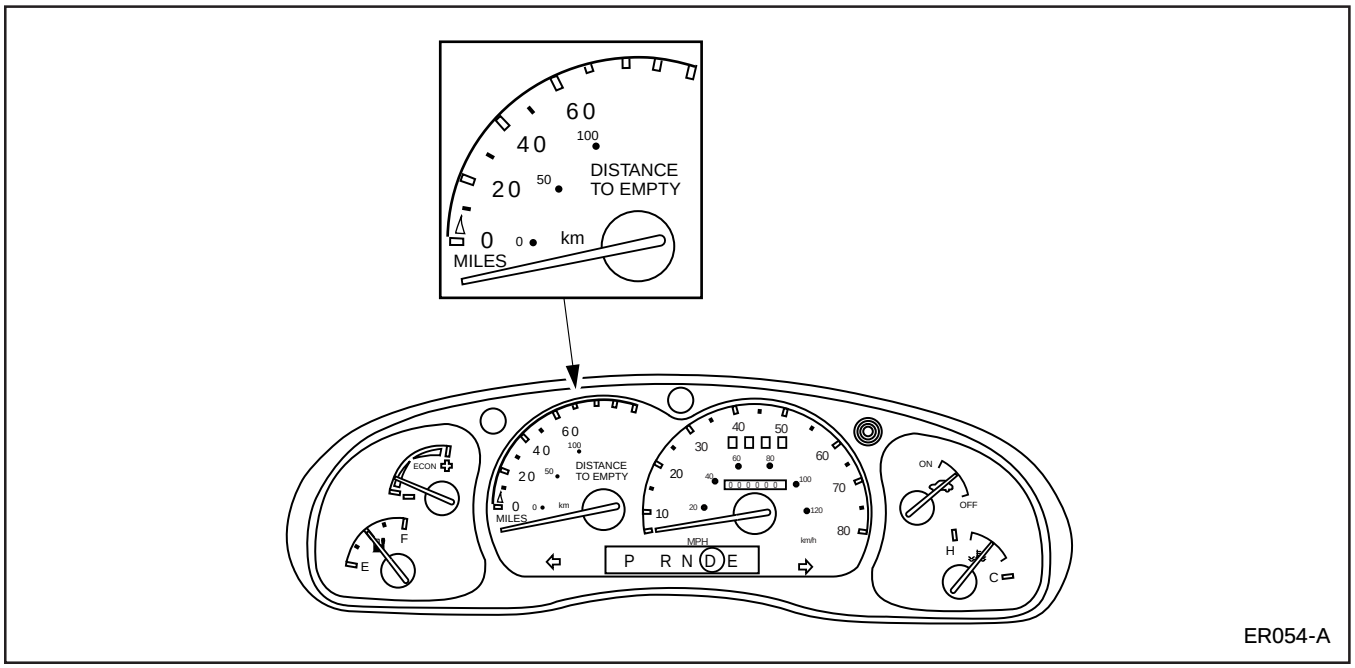
ECON (Economy) Gauge

- The Economy Gauge not only shows the driver that his/her actions affect vehicle range, but that driving more economically can increase the vehicle range.
- The gauge reading reflects:
  - drivetrain power usage.
  - vehicle speed.
  - climate control usage.
  - regeneration effects.
- The needle will move toward the plus (+) sign (green band) when the driver minimizes power usage or puts power back into the vehicle.
- The needle will move toward the minus (-) sign (yellow band) when the driver accelerates quickly or turns on loads that reduce vehicle range.
- The IAA monitors several inputs and uses this information to control the ECON Gauge.



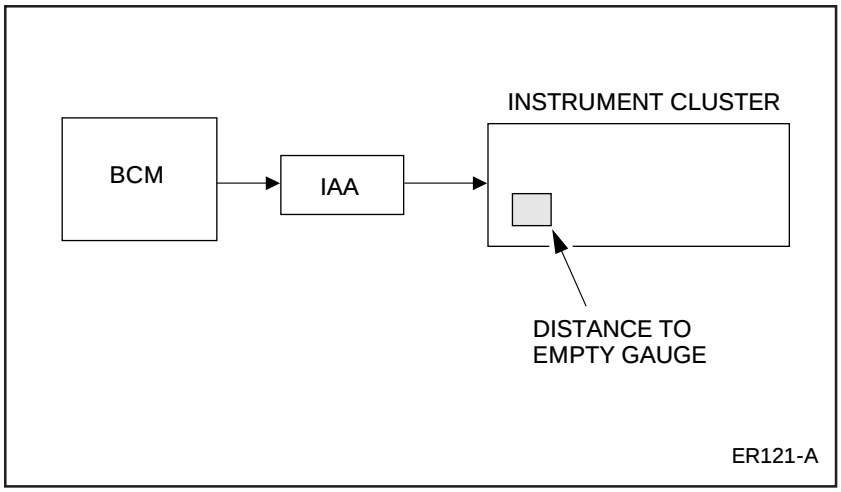
Economy Gauge Inputs

DISTANCE TO EMPTY Gauge



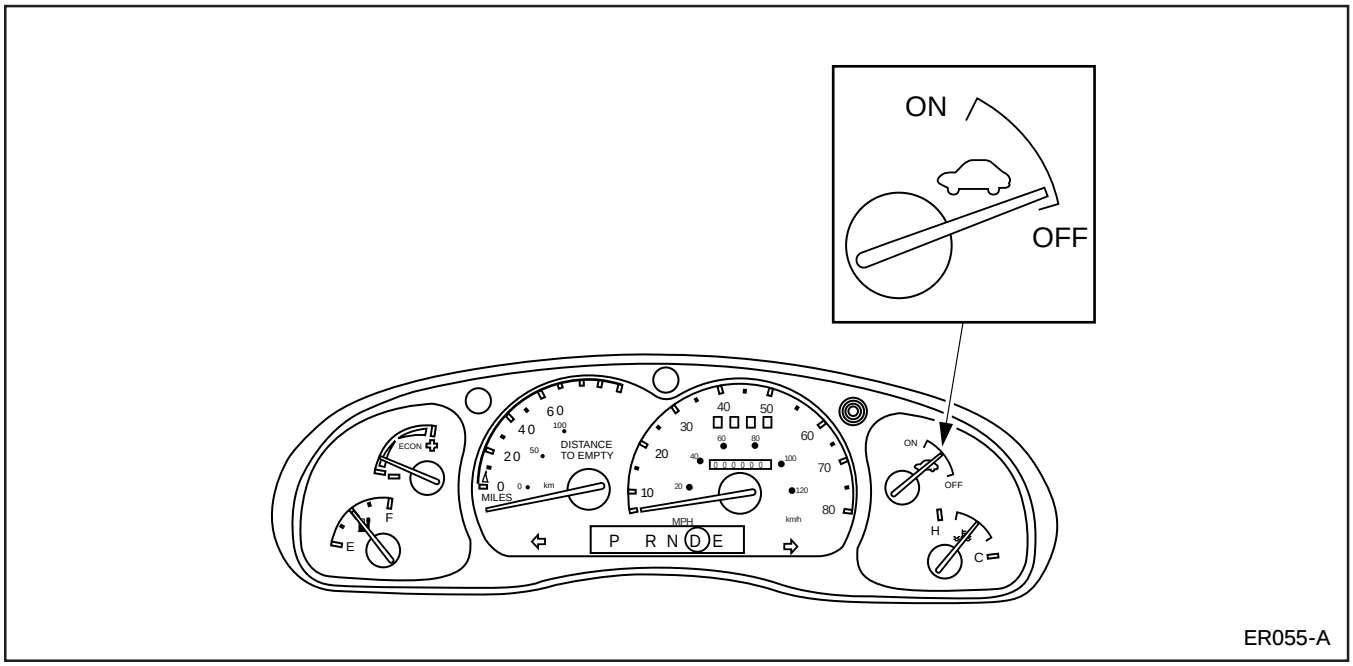
DISTANCE TO EMPTY Gauge

- The DISTANCE TO EMPTY Gauge estimates the remaining distance that can be traveled before the traction battery needs to be recharged.
  - This estimate is calculated by the BCM.
- The DISTANCE TO EMPTY Gauge is controlled by the IAA and varies as driving conditions change.
- Some conditions that affect the DISTANCE TO EMPTY Gauge are:
  - city/highway driving.
  - hilly terrain.
  - climate control usage.
  - driving habits.
- The BCM monitors power consumption and sends this information to the IAA.
- The IAA controls the DISTANCE TO EMPTY Gauge based on this information.



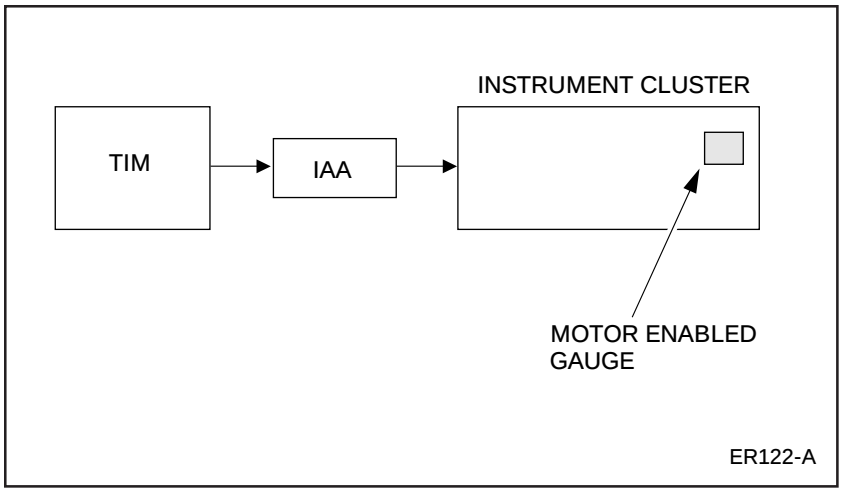
DISTANCE TO EMPTY Gauge Inputs

Motor Enabled Gauge



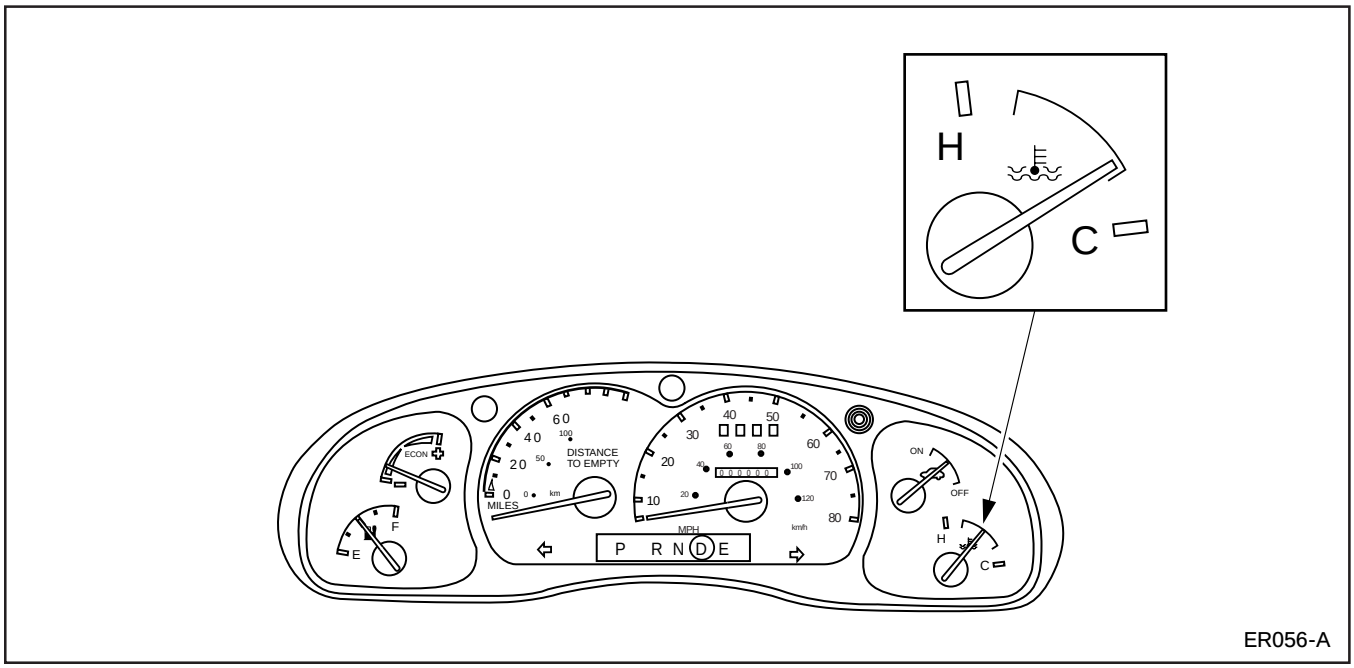
Motor Enabled Gauge

- The Motor Enabled Gauge indicates that the vehicle is ready to be driven.
- The needle will point to ON when the vehicle is enabled.
- The needle will return to OFF if the key is turned to the OFF position or the powertrain becomes disabled.
- The IAA monitors the TIM and uses the Motor Enabled Gauge to indicate the motor state (enabled or disabled).



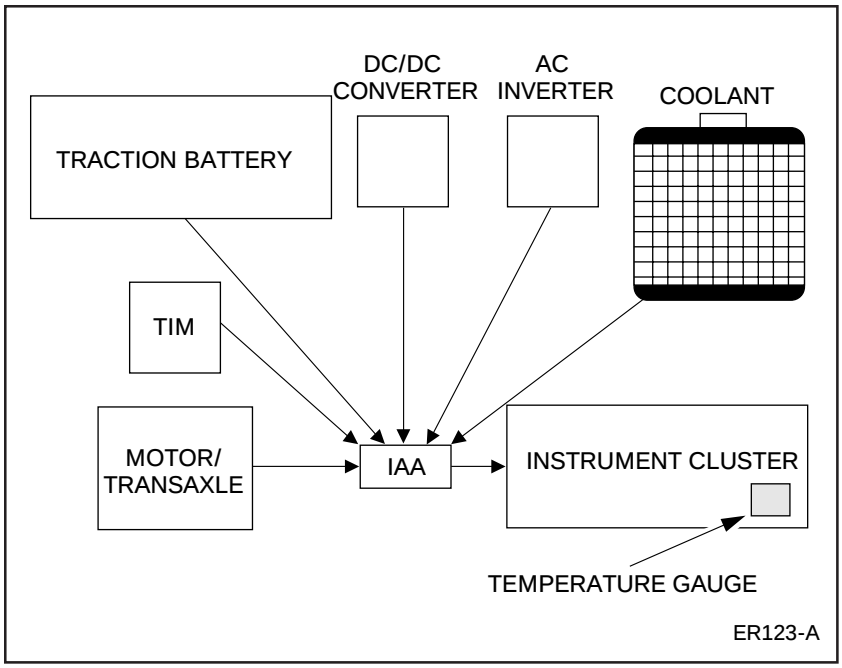
Motor Enabled Gauge Inputs

Temperature Gauge



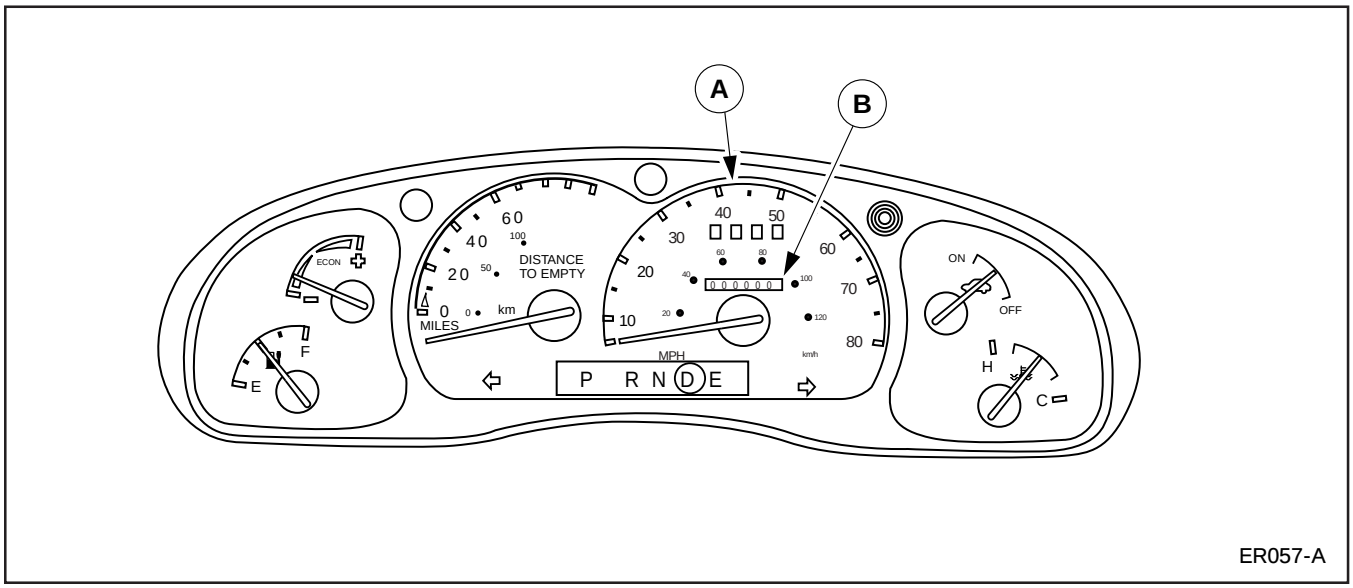
Temperature Gauge

- The Temperature Gauge indicates the extreme temperature of major components:
  - Traction battery
  - TIM
  - Motor/transaxle
  - Coolant
- If the temperature of any of these components is not within desirable limits, the needle will move into the H (hot) or C (cold) areas.
  - The traction battery is the only component that can cause the needle to move into the cold area.
  - If the traction battery is too cold and another component is too hot, the temperature gauge will display the hot condition.
- The IAA monitors systems that produce heat and uses the Temperature Gauge to indicate an overheating condition or a cold condition in the case of the traction battery.



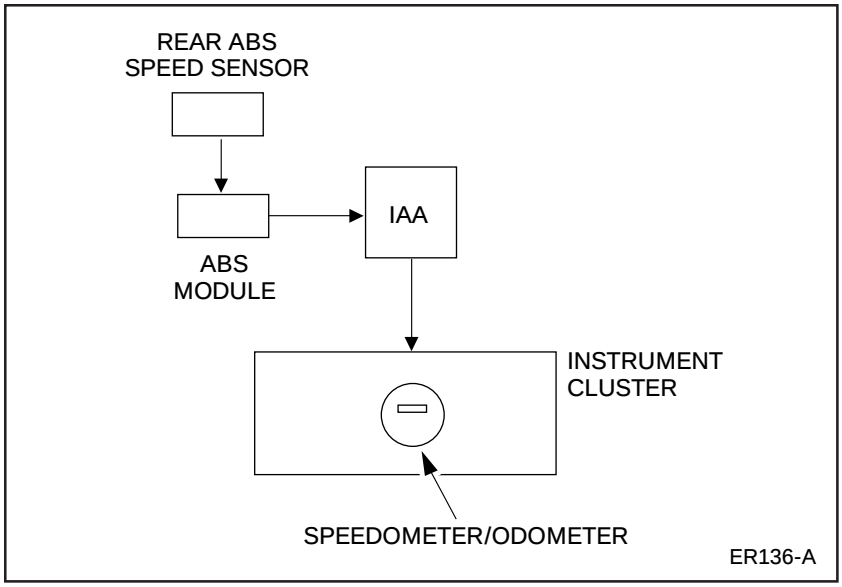
Temperature Gauge Inputs

Speedometer/Odometer/Tripmeter



Speedometer/Odometer/Tripmeter

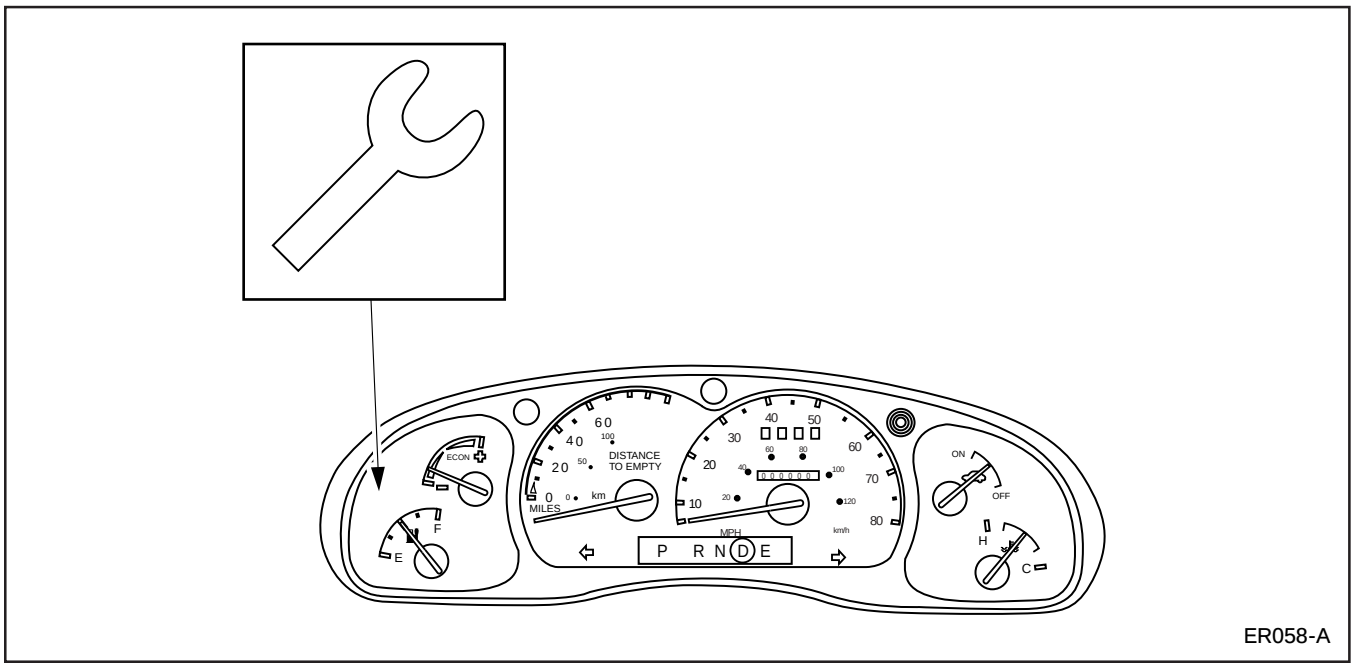
- The speedometer (**A**) is an electronically driven 0-130 km/h (0-80 mph) gauge with a carryover Ranger odometer (**B**) and tripmeter.
- The IAA monitors the ABS module for input from the rear anti-lock brake system speed sensor. This input is used to indicate vehicle speed.



Speedometer/Odometer/Tripmeter Inputs

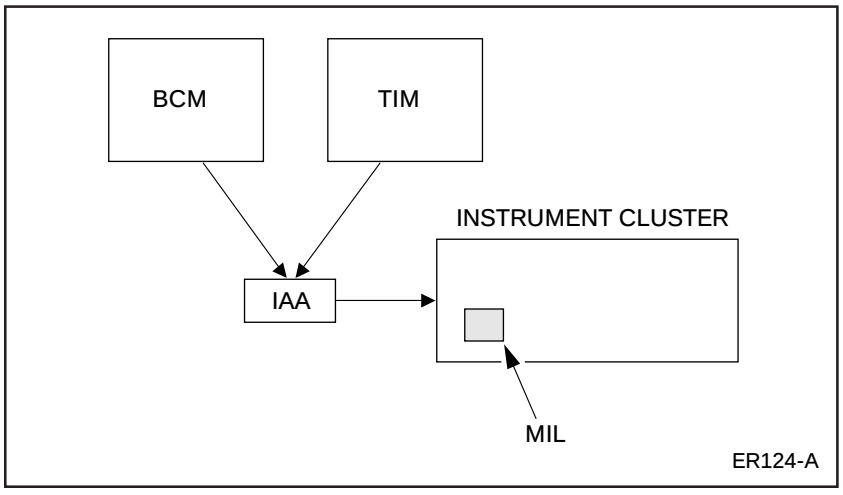
INSTRUMENT CLUSTER WARNING LAMPS

Malfunction Indicator Lamp (MIL)



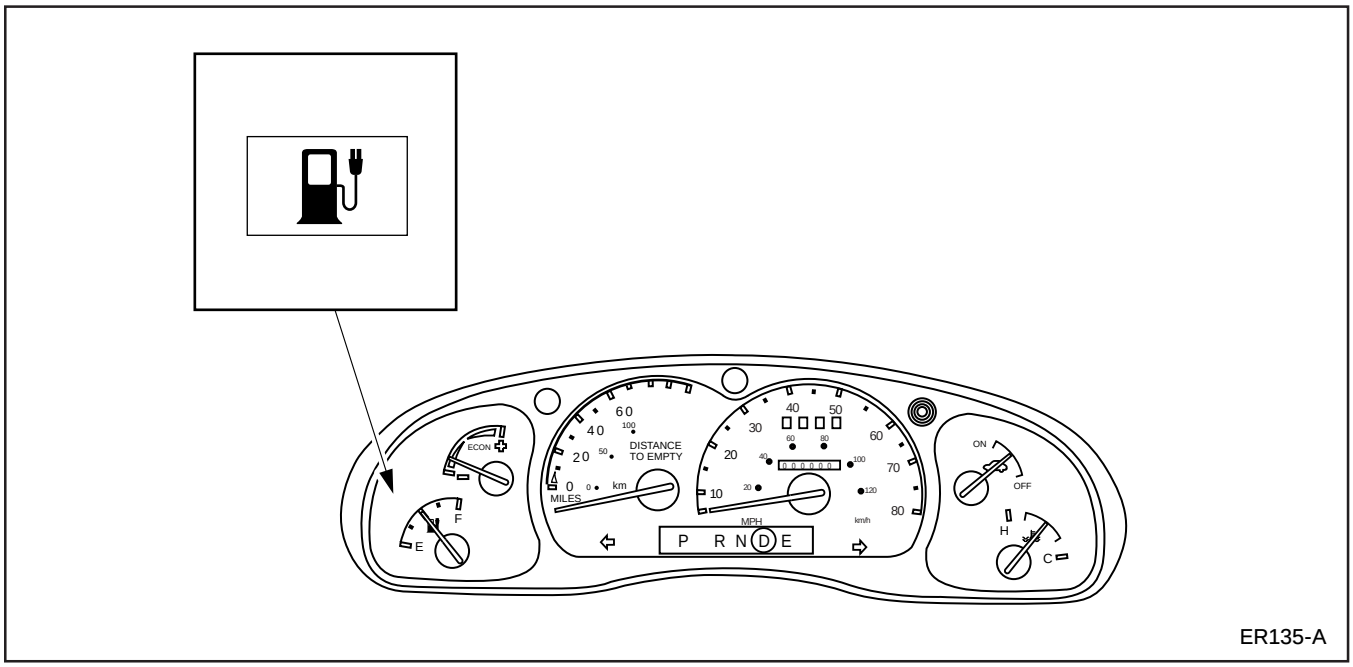
Malfunction Indicator Lamp (MIL)

- The yellow MIL indicates a vehicle malfunction that requires service.
- The MIL will illuminate during these conditions:
  - a concern exists where long-term damage may result
  - when a less serious concern occurs twice within five key cycles
- The IAA monitors the other “smart” modules and uses the MIL to indicate a concern.



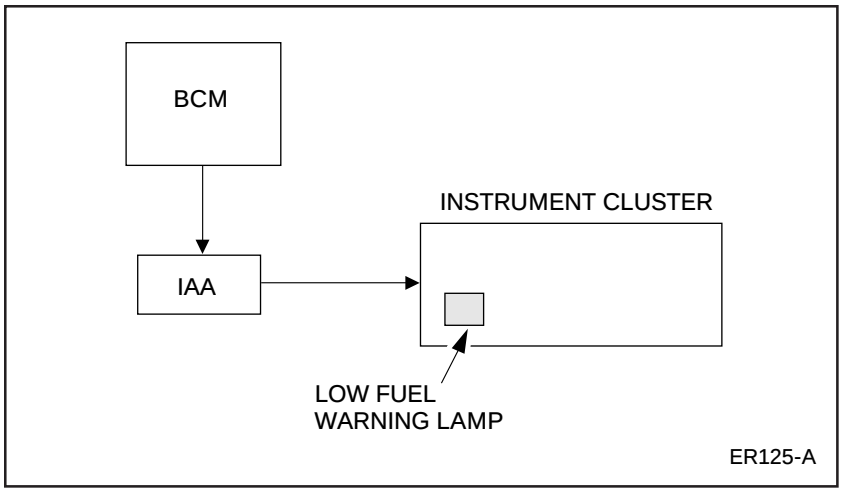
MIL Inputs

Low Fuel Warning Lamp



Low Fuel Warning Lamp

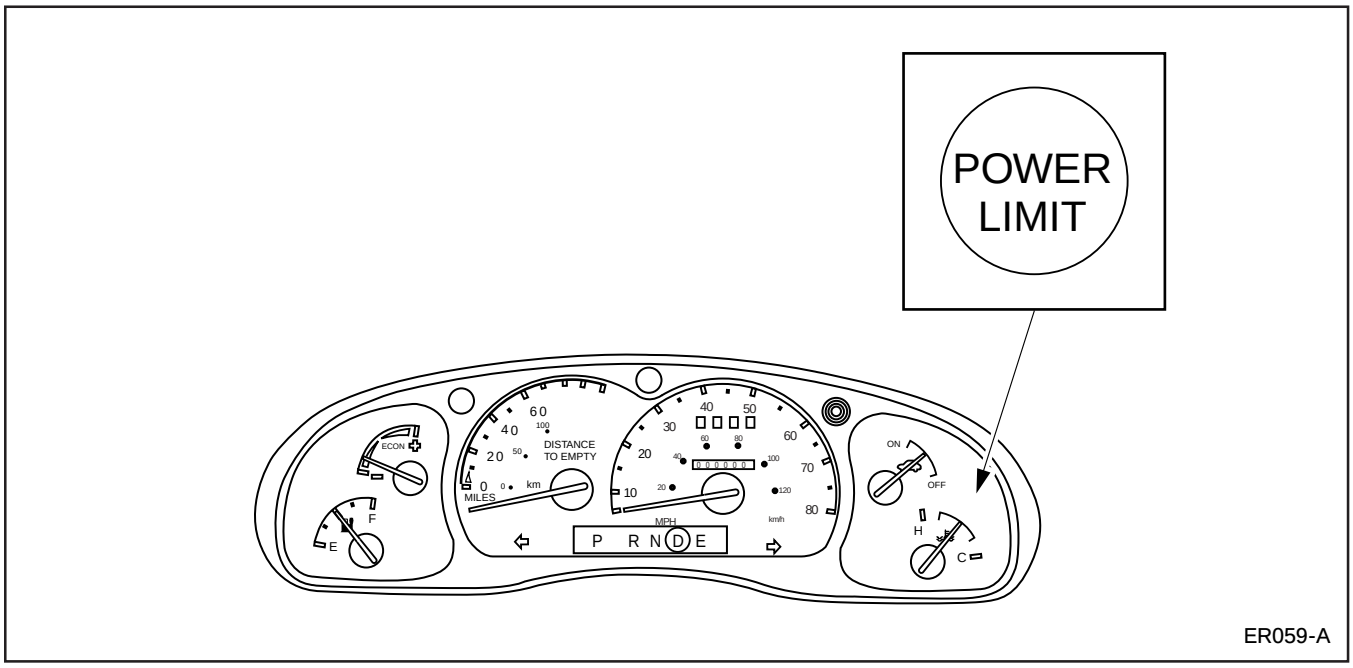
- The Low Fuel Warning Lamp alerts the driver when the state of charge is low.
- This lamp illuminates when the traction battery state of charge reaches 10%.
  - Limited operating strategy is in effect when the lamp is illuminated to conserve remaining power.
- The Low Fuel Warning Lamp will flash when the battery state of charge reaches 0% (the vehicle has very limited range at this point).
  - Speed is limited to 10 km/h (6 mph).



Low Fuel Warning Lamp Inputs

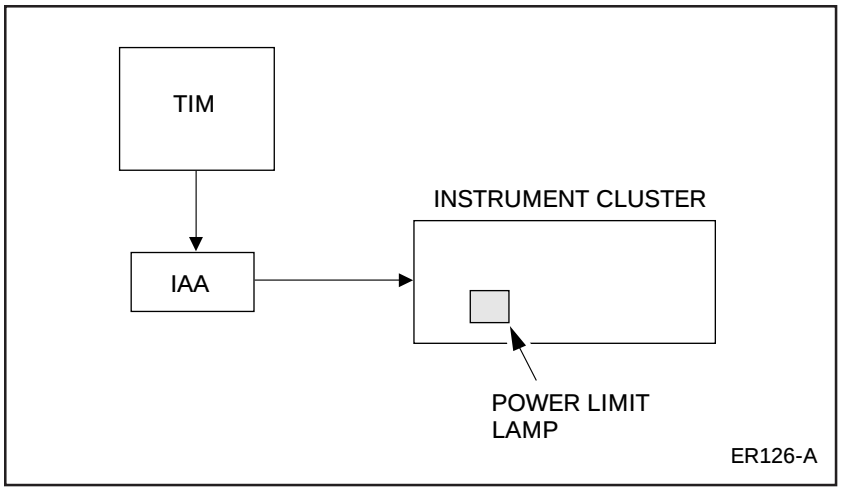
NOTE: When this lamp flashes, range is very limited and the vehicle should be returned to the repair facility. The Low Fuel Warning Lamp will also illuminate or flash if a fault occurs in the system.

POWER LIMIT Warning Lamp



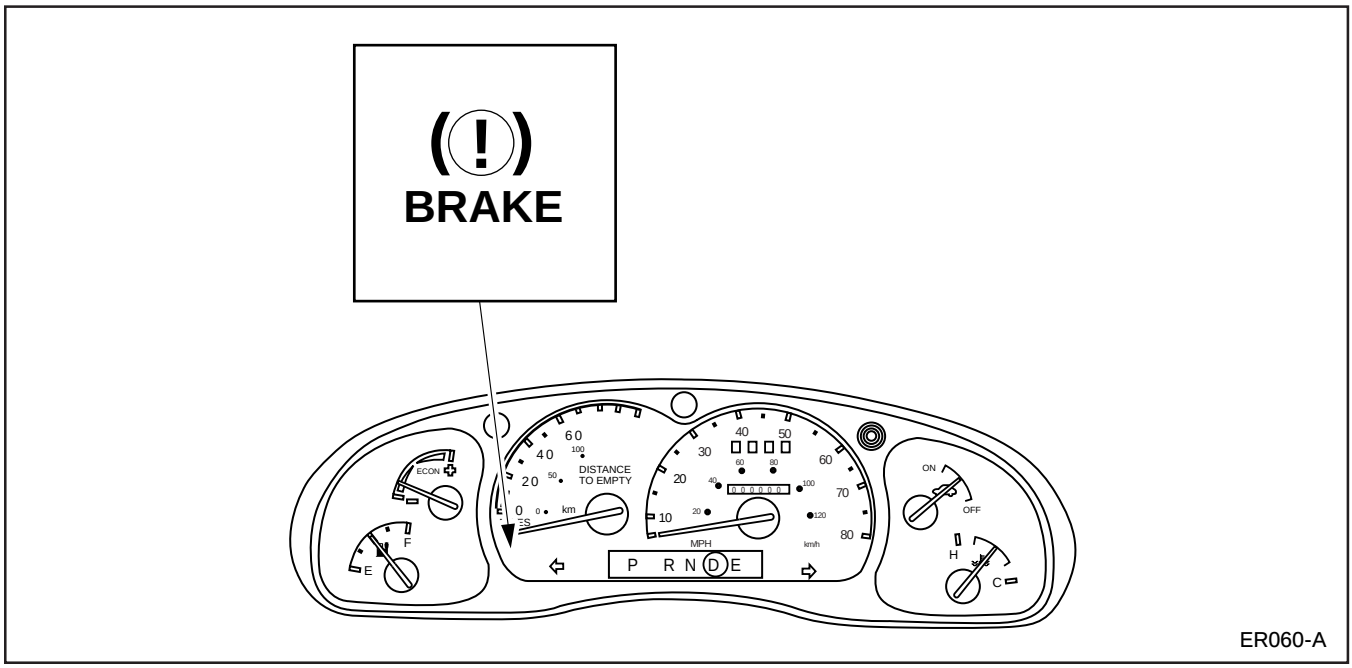
POWER LIMIT Warning Lamp

- The IAA monitors input from the TIM through the J1850 (SCP) network and uses the POWER LIMIT Warning Lamp to indicate the vehicle's performance is limited to conserve remaining battery power (lamp illuminated).
- As the traction battery nears complete discharge, the lamp begins to flash to indicate performance is further limited to allow for safe parking of the vehicle before the battery is completely drained.



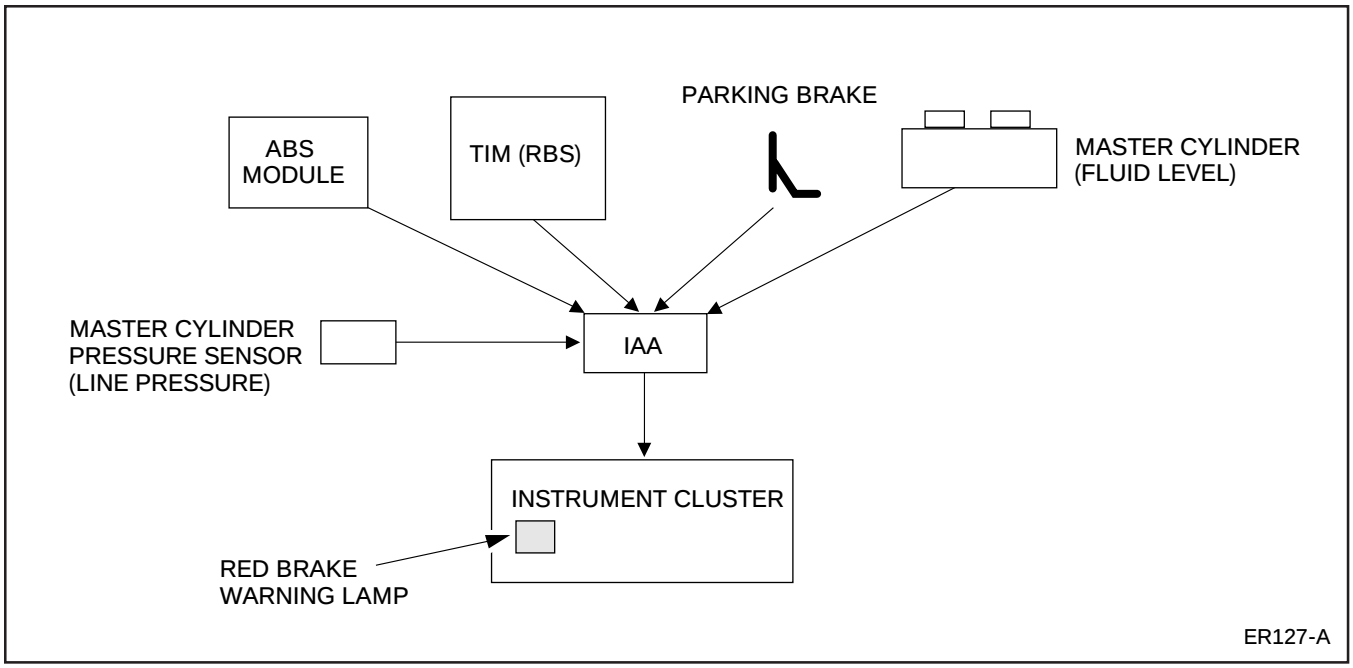
POWER LIMIT Warning Lamp Inputs

BRAKE Warning Lamp



BRAKE Warning Lamp

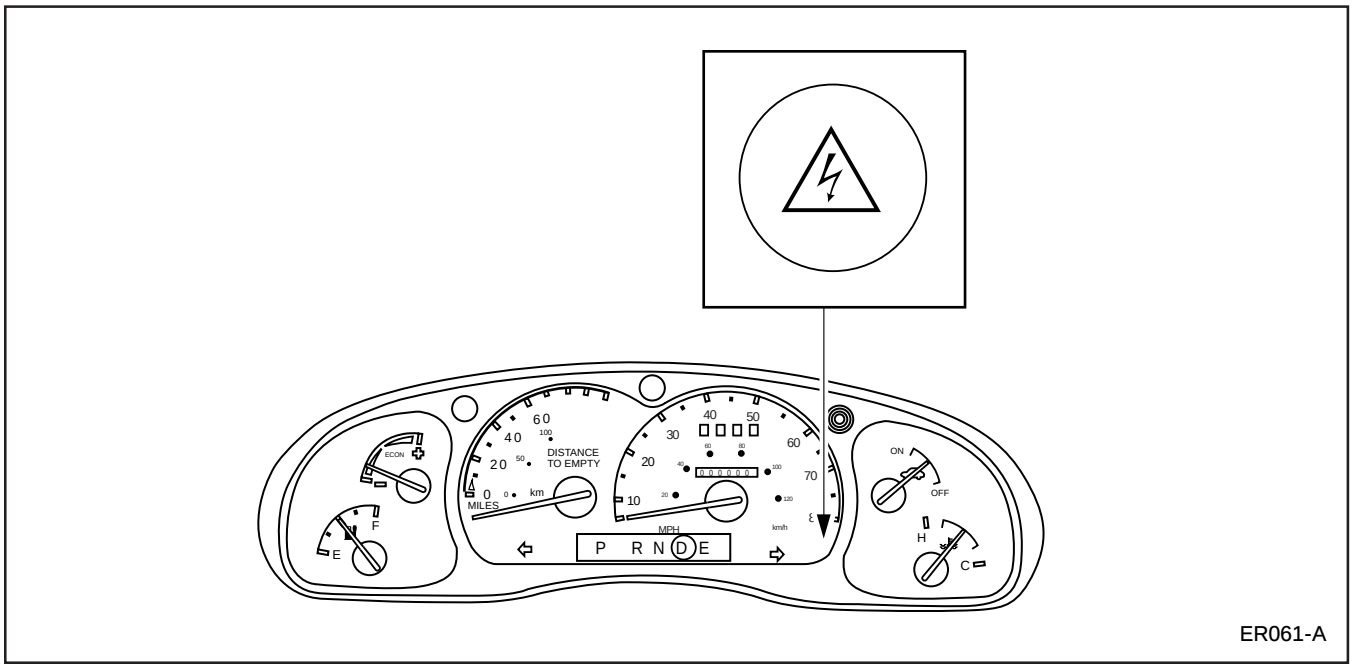
- The red BRAKE Warning Lamp will illuminate during the following conditions:
  - parking brake engaged.
  - low brake fluid level in the master cylinder.
  - regenerative braking system (RBS) malfunction.
  - anti-lock brake system (ABS) malfunction.
- The IAA monitors several inputs and illuminates the red BRAKE Warning Lamp if the parking brake is engaged, there is a RBS failure, or there is a brake system concern.



BRAKE Warning Lamp Inputs

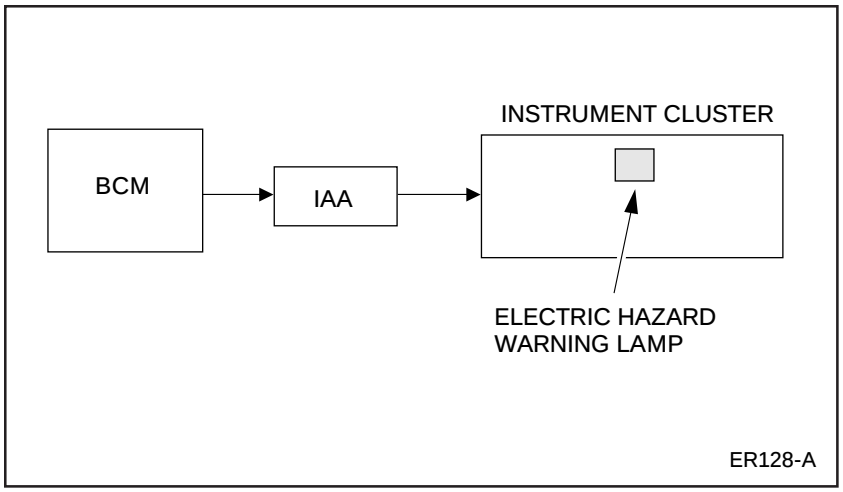
NOTE: If the lamp illuminates, be sure the parking brake is not engaged and the brake fluid level is correct before attempting further diagnosis.

Electric Hazard Warning Lamp



Electric Hazard Warning Lamp

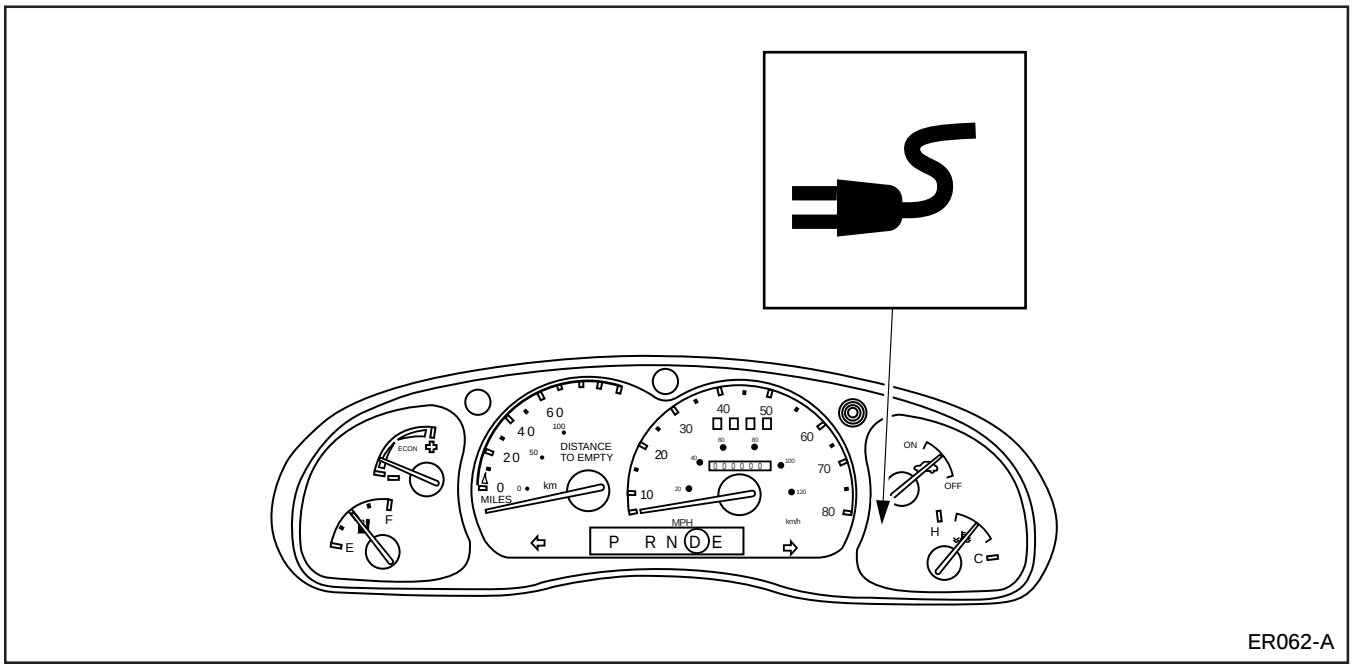
- The red Electric Hazard Warning Lamp will illuminate during the following conditions:
  - severe current leakage is detected.
  - a high voltage interlock is opened.
- If current leakage is detected, the vehicle will continue to operate.
- To prevent possible damage to the vehicle or personal injury, the vehicle must be repaired immediately.
- If a high voltage interlock is opened, the emergency power off (EPO) system will cause all high voltage to be disabled and shut down the vehicle (for more information on EPO see Lesson 1).
- The BCM monitors for current leakage. If current leakage is present or a high voltage interlock is open the BCM will signal the IAA to illuminate the Electric Hazard Warning Lamp.



Electric Hazard Warning Lamp Inputs

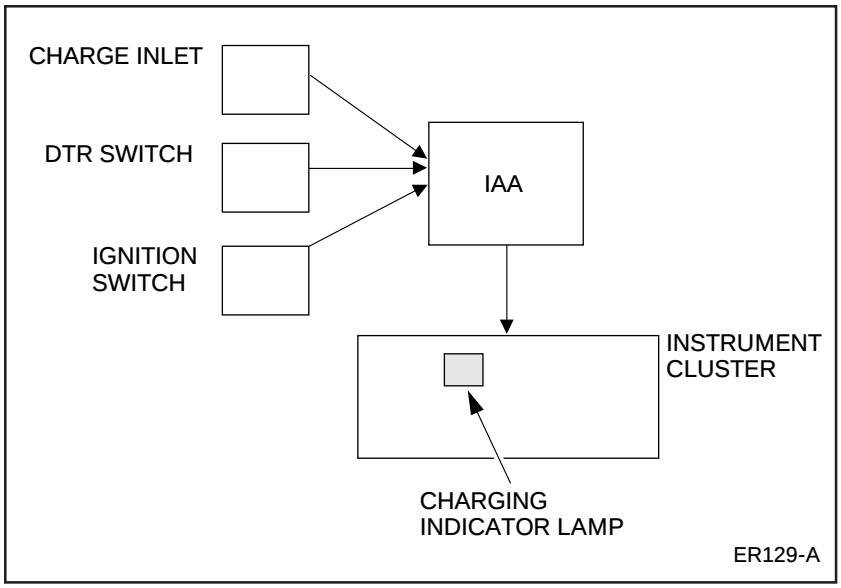
NOTE: If an electrical hazard is present, the electric hazard warning lamp only illuminates with the key in the START or ON position.

Charging Indicator Lamp



Charging Indicator Lamp

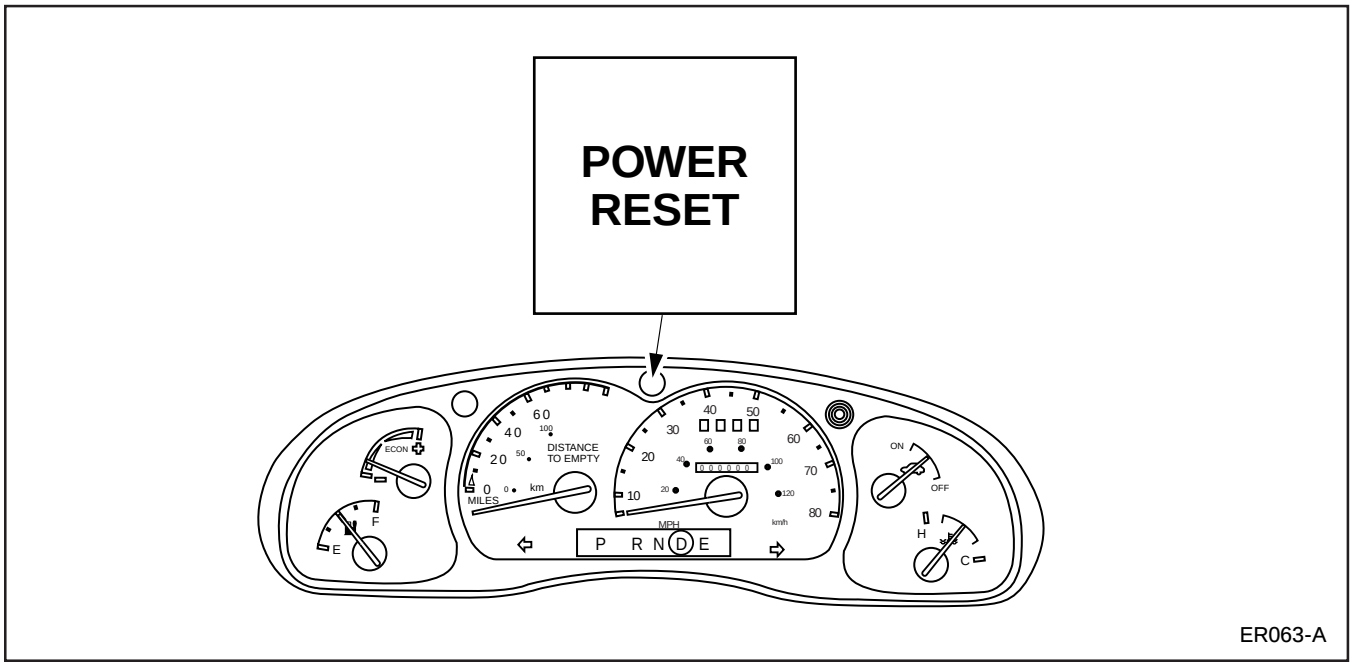
- The red Charging Indicator Lamp will illuminate during charging if the key is turned to the START or ON position.
- The vehicle cannot be “started” and should not be moved while the charging cord is plugged into the charge inlet.
- The IAA monitors several inputs to indicate if it is safe to charge the traction battery.
- If the driver attempted to start the vehicle with the charger connected the lamp will illuminate to indicate it is not possible to operate the vehicle with the charger connected.
- The charging indicator lamp also indicates if it is not safe to charge the battery pack.
  - The lamp will flash if a charging fault exists.



Charging Indicator Lamp Inputs

NOTE: The Charging Indicator Lamp will flash when the key is in the ON position and it is unsafe to charge (vehicle not in PARK [P]), severe current leakage, open interlock or activated inertia shutoff switch).

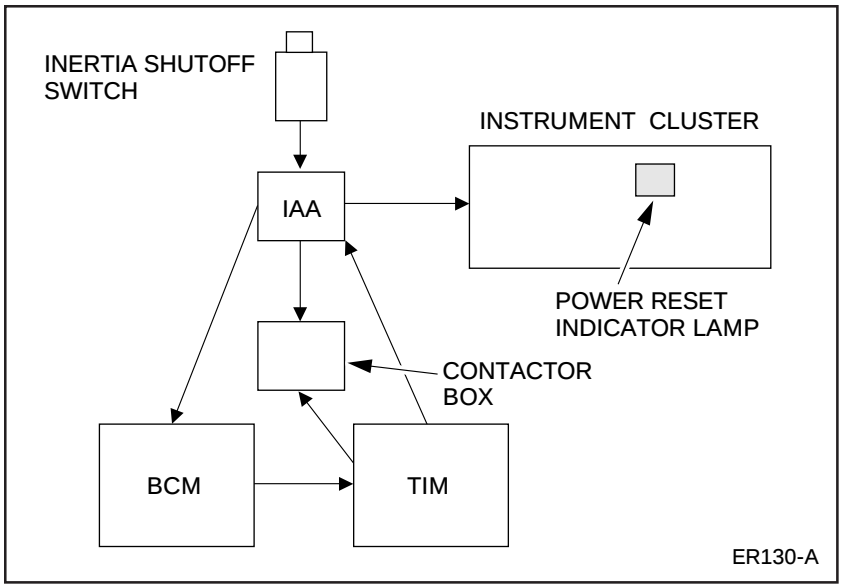
POWER RESET Indicator Lamp



ER063-A

POWER RESET Indicator Lamp

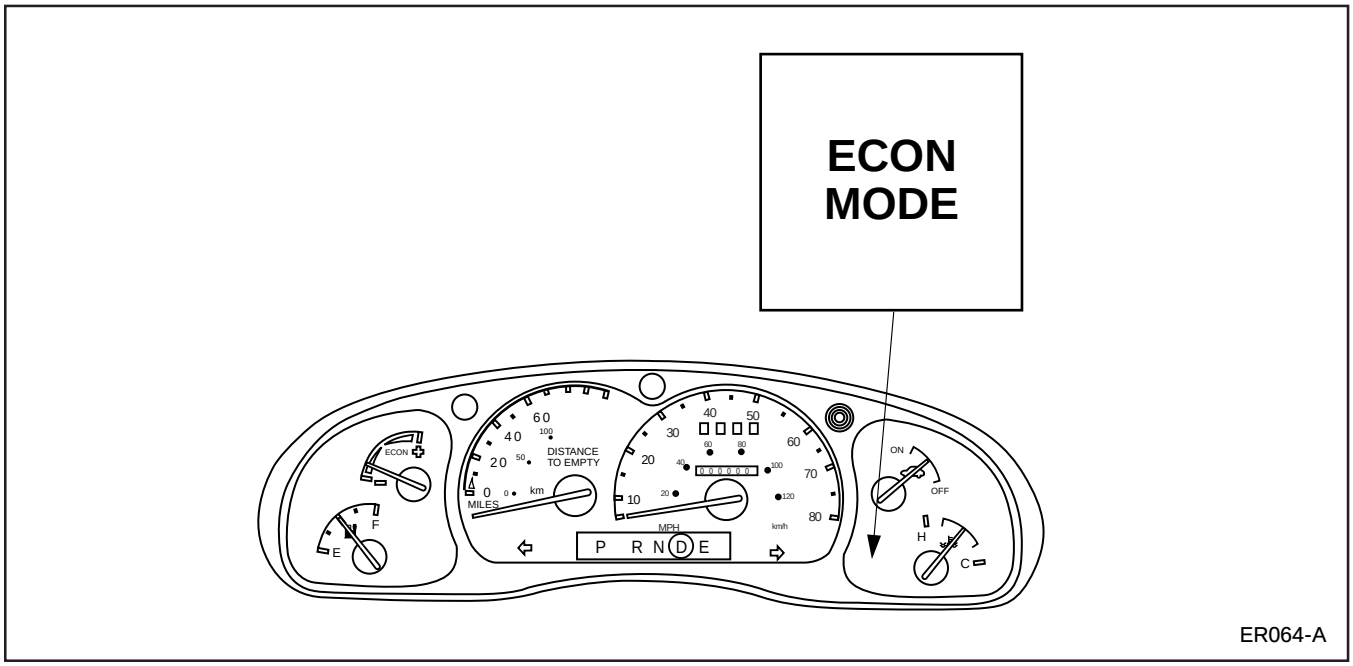
- The yellow POWER RESET Indicator Lamp will illuminate when the inertia shutoff switch has been activated.
- When activated the inertia shutoff switch disables all high voltage power to the vehicle electrical system.
- If no special service is required, pressing the reset button on top of the inertia shutoff switch can restore power to the high voltage circuits.
- The IAA monitors the inertia shutoff switch. If the switch is activated, high voltage circuits are interrupted and the POWER RESET Indicator Lamp is illuminated.
- The IAA opens the negative contactor relay and signals the BCM to command the TIM to open the positive contactor relay.
- The IAA uses the J1850 (SCP) network to communicate these commands to the other control modules.



POWER RESET Indicator Lamp Inputs

NOTE: The inertia shutoff switch is located in the passenger compartment, above the carpet line and below the evaporator assembly.

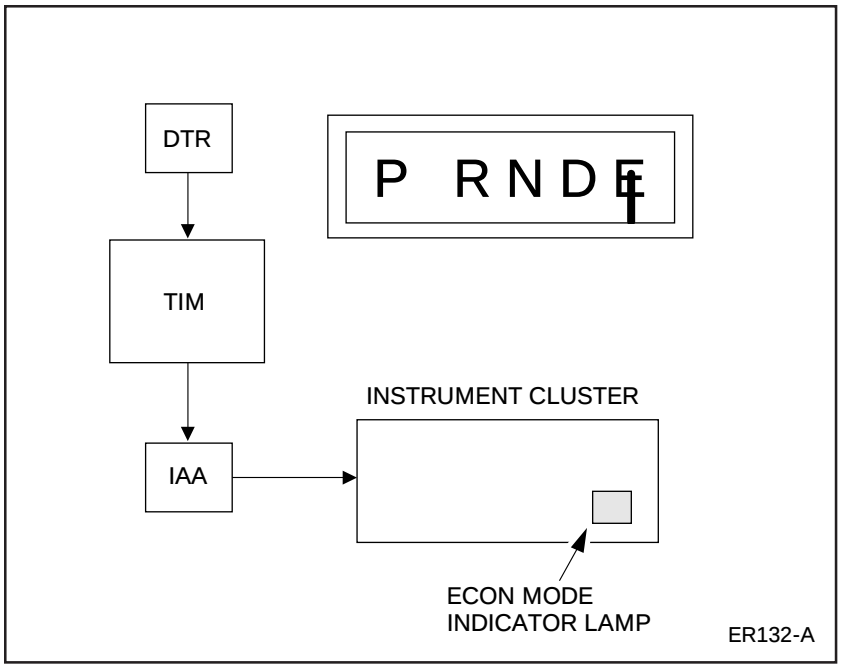
ECON MODE Indicator Lamp



ER064-A

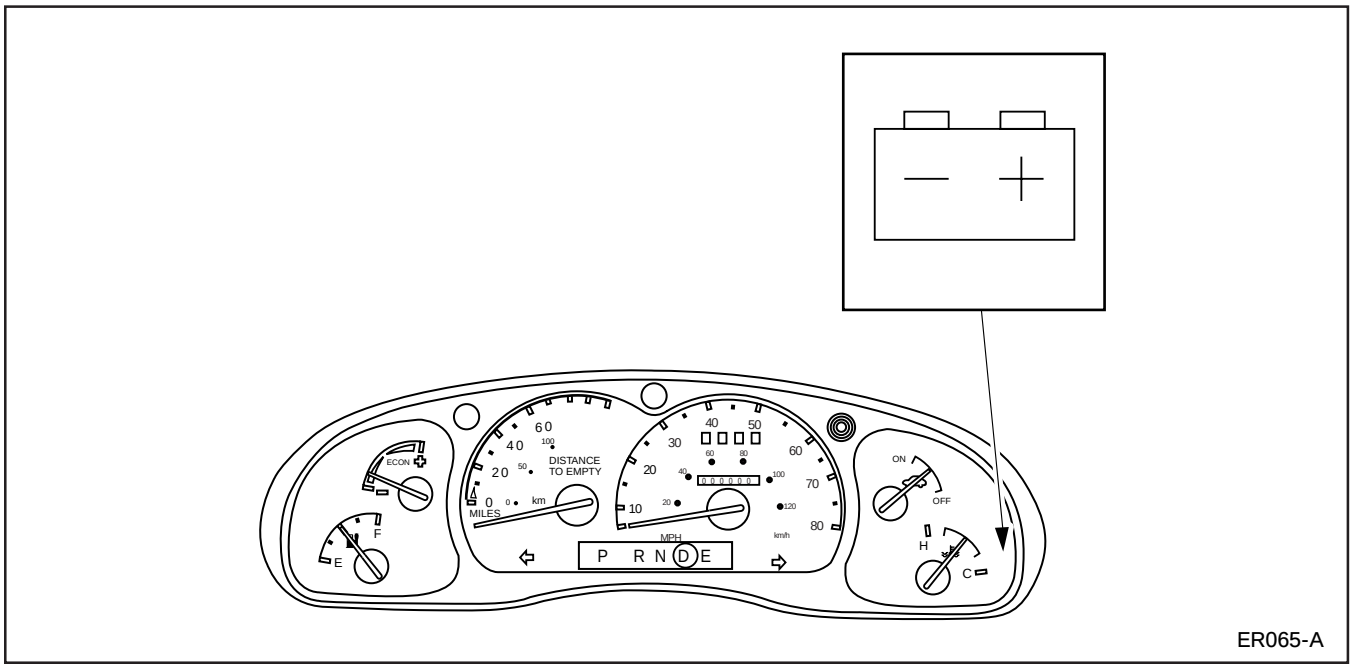
ECON MODE Indicator Lamp

- The green ECON MODE Indicator Lamp will illuminate when the driver has selected the economy driving mode **(E)**.
- The economy mode will increase the level of regenerative braking to improve vehicle range.
- The brightness of this lamp is controlled by the instrument cluster lamp dimmer control.
- The TIM monitors the DTR sensor and relays information to the IAA.
- When the driver selects economy mode, the TIM informs the IAA and the IAA illuminates the ECON MODE Indicator Lamp.



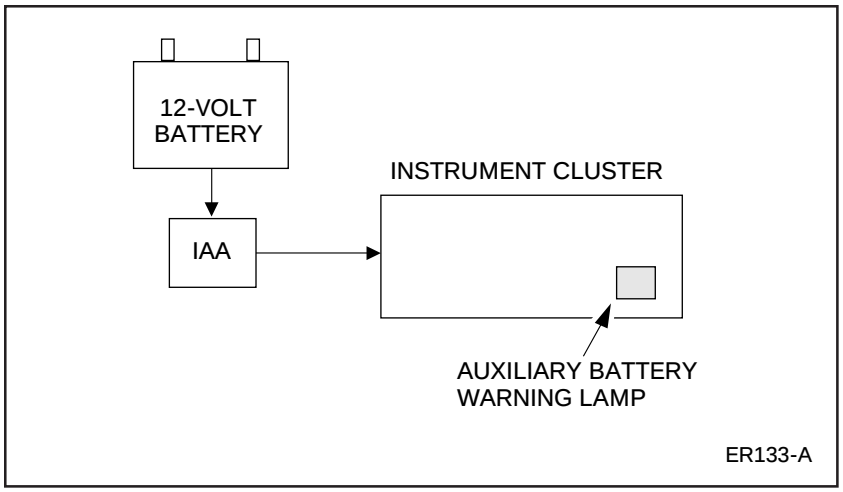
ECON MODE Indicator Lamp Inputs

Auxiliary Battery Warning Lamp



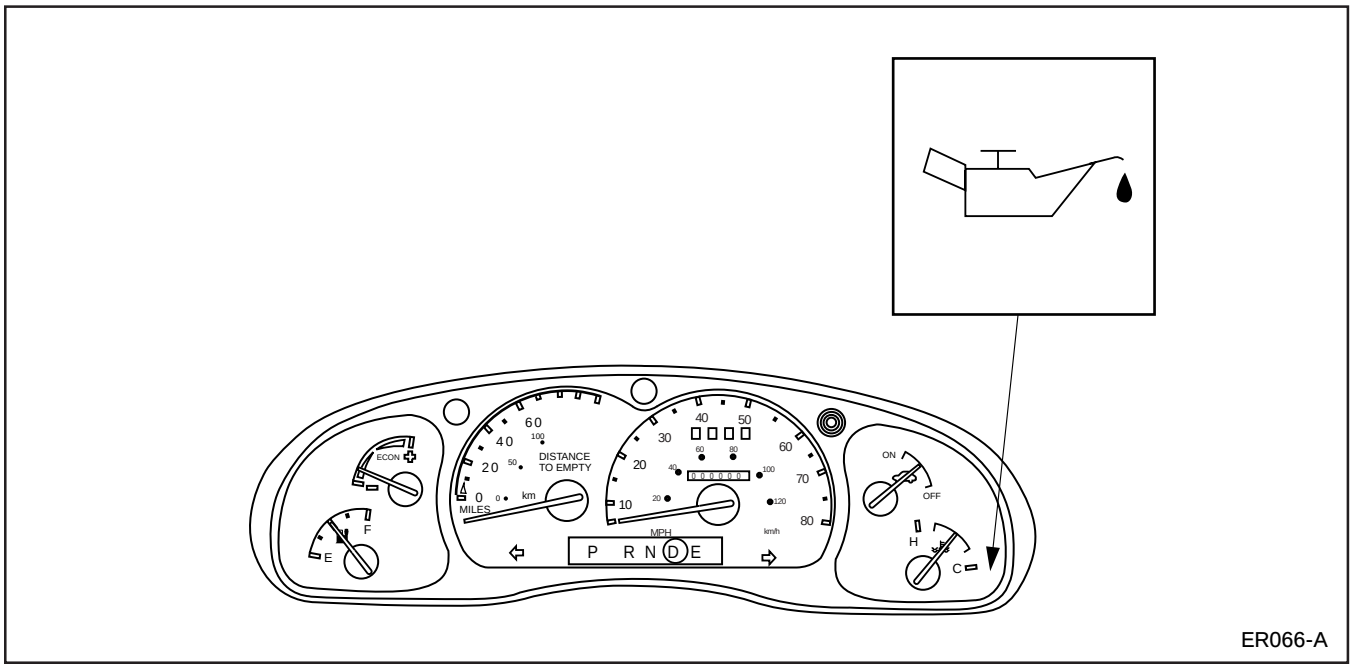
Auxiliary Battery Warning Lamp

- The red Auxiliary Battery Warning Lamp will illuminate during the following conditions:
  - the auxiliary battery voltage exceeds 15.75 volts.
  - the auxiliary battery voltage falls below 11.5 volts.
- If the auxiliary battery voltage warning lamp illuminates, the driver must pull over to a safe area and have the vehicle repaired.
- The IAA monitors the auxiliary battery voltage. If voltage exceeds 15.75 volts or falls below 11.5 volts the IAA illuminates the Auxiliary Battery Warning Lamp.



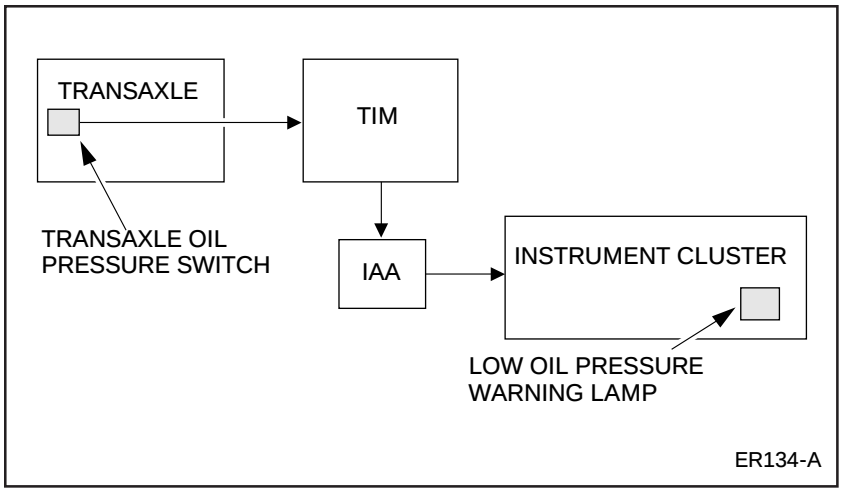
Auxiliary Battery Warning Lamp Inputs

Low Oil Pressure Warning Lamp



Low Oil Pressure Warning Lamp

- The red Low Oil Pressure Warning Lamp will illuminate if the transaxle oil pressure falls below 28 kPa (4 psi).
- If the Low Oil Pressure Warning Lamp illuminates, the driver must pull over to a safe area and have the vehicle repaired.
- The TIM monitors the oil pressure switch mounted to the transaxle.
- The oil pressure switch normally grounds the circuit to the TIM.
- If pressure drops below 29 kPa (4 psi) the switch opens and signals the TIM.
  - The TIM signals the IAA to illuminates the Low Oil Pressure Warning Lamp.

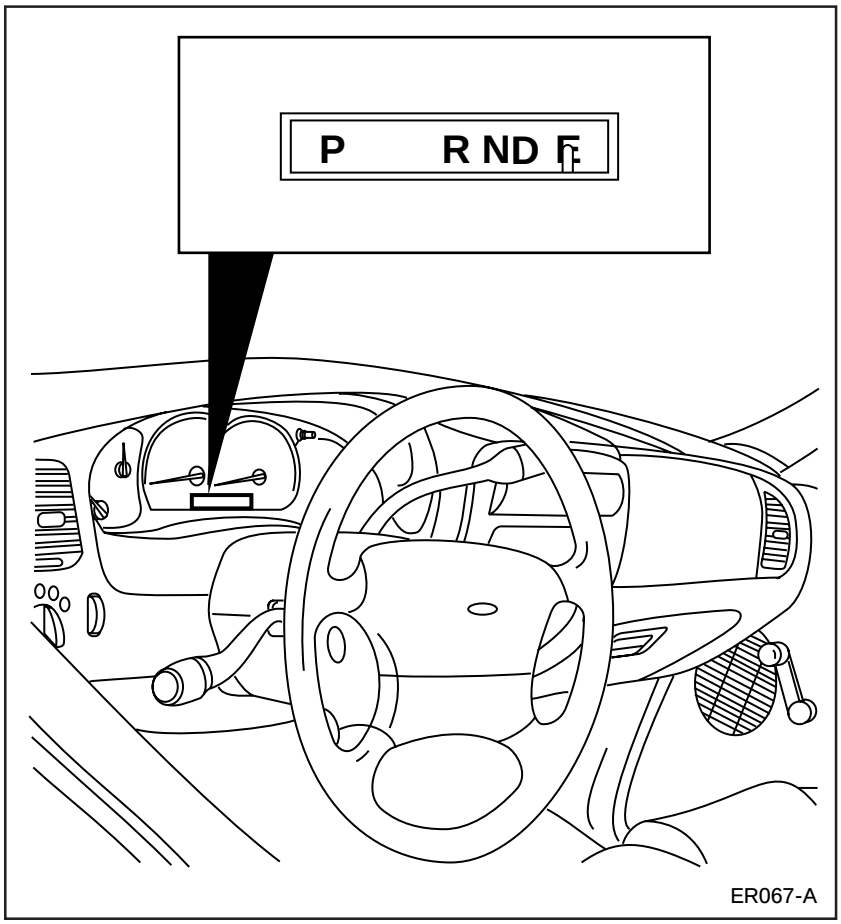


Low Oil Pressure Warning Lamp Inputs

Other Indicator Lamps

- The following indicator lamps operate in the same manner as those used on gasoline-powered vehicles:
  - ABS warning lamp
  - air bag indicator lamp
  - seat belt indicator lamp
  - DOOR AJAR indicator lamp
  - highbeam indicator lamp
  - turn signal indicator lamps

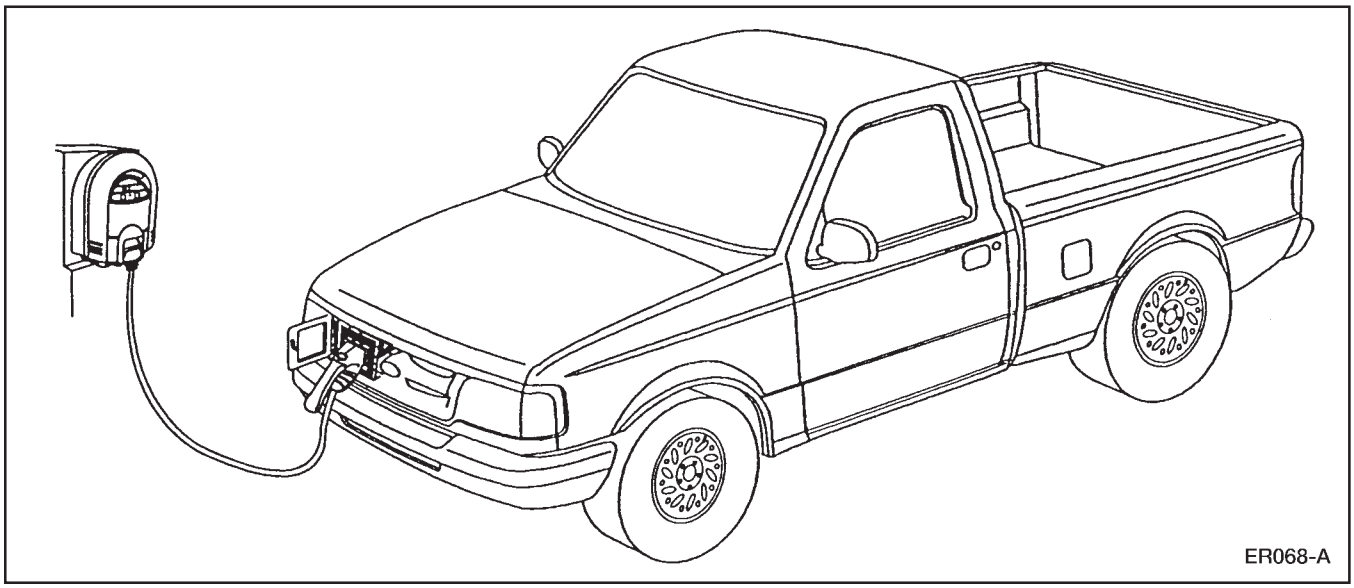
ECONOMY MODE



Economy Mode

- When the driver selects the economy operating mode using the gear selector lever, the regenerative brake function is enhanced to increase vehicle range.
- The economy mode applies a higher regenerative motor torque to the rear wheels, allowing more power to be recovered and stored in the Traction Battery.
- The economy mode also limits the top speed of the vehicle to 104 km/h (65 mph).

TRACTION BATTERY CHARGING



Charge Cord Connection

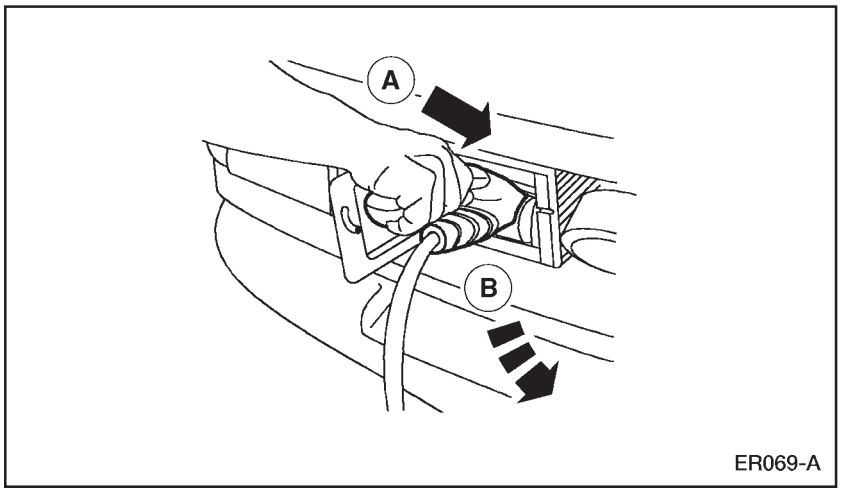
- Traction Battery charging requires 240-volt 40 amp AC service.
- The 7.625-m (25-ft) charge cord plugs directly into the charge inlet on the vehicle.
- Six to eight (6-8) hours are required to charge a fully-discharged Traction Battery at 25°C (77°F).

WARNING: FOLLOW CHARGING PROCEDURES AND DEVICE OPERATING INSTRUCTIONS CAREFULLY. FAILURE TO DO SO MAY RESULT IN INJURY OR DEATH.

WARNING: LEAD-ACID BATTERIES PRODUCE HYDROGEN GAS WHICH, IN LARGE QUANTITIES, IS EXPLOSIVE. AN OVERCHARGED LEAD-ACID BATTERY MAY RELEASE EXCESS HYDROGEN GAS THROUGH VENTS IN THE BATTERY CASE. ALWAYS ENSURE THAT THE LEAD-ACID BATTERIES ARE PROPERLY RECHARGED USING ONLY FORD-SPECIFIED EQUIPMENT AND PROCEDURES.

NOTE: About four hours of equalization charging for the traction battery modules can occur at three-week intervals.

Charging Procedure



Connecting Charging Cord

1. Place the front of the vehicle within 3 m (10 ft) of the charging station.
2. Place the gear selector in Park (P) and set the parking brake.
3. Turn the key to the OFF position and remove the key.
4. Pull open the charge inlet access door.
5. Align the charge cord plug with the charge inlet and fully insert the plug (**A**). Rotate down (**B**).
6. Push the charging station START button. Battery charging will begin when the self tests are completed and the green START light illuminates steadily.

NOTE: If the green charging light goes out and the amber charge interrupt light illuminates, press the STOP button (the light will turn off). Try to initiate the charging procedure again.

To Stop Charging

1. Push the STOP button on the charging station.
2. Depress the thumb button on the plug and disconnect the charge cord plug from the charge inlet.
3. Close the charge inlet access door.

DRIVER RESPONSE TO AN EMERGENCY SITUATION

- If possible, perform the following steps in the event of a collision, fire or some other emergency situation. However, never endanger yourself or others near the vehicle.

  1. Stop and put the gear selector in the Park (P) position.
  2. Turn the key to the OFF position and remove the key.
  3. Set the parking brake.
  4. Exit the vehicle.
  5. Contact crash/fire/rescue emergency personnel and inform them of the type of vehicle (EV) and the nature of the emergency.

NOTES

ACTIVITY 2 – VEHICLE FAMILIARIZATION – WORKSHEET D
OPERATING CHARACTERISTICS OF THE ELECTRIC RANGER
STUDENT ANSWER SHEET

OBJECTIVE: To identify the operating characteristics of the Electric Ranger.

DIRECTIONS: Use your experience driving the Electric Ranger to answer the questions below.

1. When you started the EV, how did you recognize that the vehicle was running? _____

   _____

2. What was your impression of the sound levels of the EV? _____

   _____

3. If you came to a stop and took your foot off the brake, what occurred? _____

   _____

4. When you were coasting in the EV, what impressions did you get, and why? _____

   _____

5. How do you compare the acceleration to that of a conventional vehicle? _____

   _____

6. How do you compare the handling compared to a conventional Ranger? _____

   _____

7. What change in vehicle operation did you notice when operating in the ECON mode? _____

   _____

8. What other differences did you notice between the Electric Ranger and a conventional vehicle? _____

   _____

9. What is your overall impression of the operating characteristics of the Electric Ranger? _____

   _____

10. Run key through all positions. How many positions are there? _____

    _____

11. In what position will the shift lever move without having your foot on the brake? _____

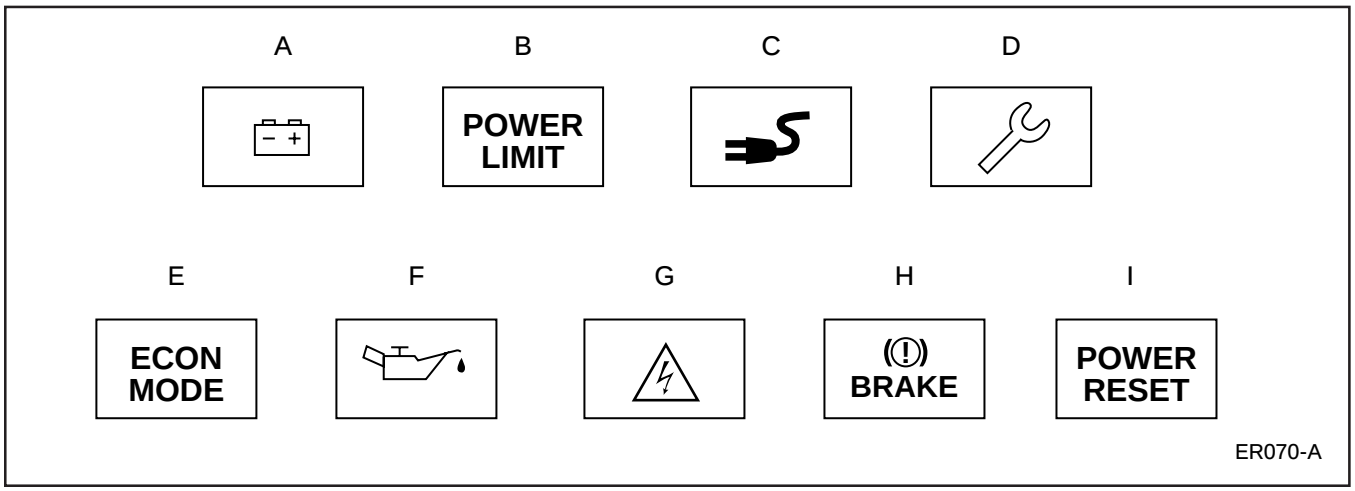
    _____

END OF WORKSHEET D

ACTIVITY 2 – VEHICLE FAMILIARIZATION – WORKSHEET E
WARNING AND INDICATOR LAMPS
STUDENT ANSWER SHEET

OBJECTIVE: To identify the warning and indicator lamp functions.

DIRECTIONS: Match each lamp with its correct definition.



Warning and Indicator Lamps

_____ indicates a general vehicle malfunction that requires service.

_____ flashes when the battery state of charge gauge reaches empty.

_____ is activated when current leakage is detected.

_____ indicates the highest performance level of the regenerative braking system.

_____ illuminates when the vehicle is charging (key in the RUN or START position).

_____ lights to indicate that the inertia shutoff switch has been triggered.

_____ reports a regenerative braking system malfunction.

_____ lights when the 12-volt battery voltage exceeds 15.75 volts or falls below 11.5 volts.

_____ indicates that the transaxle oil pressure has fallen below 28 kPa (4 psi).

END OF WORKSHEET E

ACTIVITY 2 – VEHICLE FAMILIARIZATION – WORKSHEET F
INSTRUMENT GAUGES AND LIGHTS
STUDENT ANSWER SHEET

OBJECTIVE: To describe various functions and indications of the gauges and instrument panel lights on the Electric Ranger.

DIRECTIONS: Select the correct answer for each question.

1. Which of the following is not a step in the battery charging procedure?
   A. Place the gear selector in Park (P) position and set the parking brake.
   B. Turn the driver key to the ON position.
   C. Pull open the charge inlet access door.
   D. Align the charge cord plug with the charge inlet and fully insert the plug.
   E. Push the charging station START button.
2. The needle on the gauge identified by a car icon is pointing towards ON. What does this indicate?
   A. The traction battery is charging.
   B. The driver key in the ACC position.
   C. The 12-volt battery is charging.
   D. The motor is enabled.
3. Which gauge can be overlooked when the CHECK GAUGE Warning Lamp illuminates?
   A. ECON Gauge.
   B. DISTANCE TO EMPTY Gauge.
   C. Battery State of Charge Gauge.
   D. Temperature Gauge.
4. Which component can move the needle of the Temperature Gauge to the “cold” area?
   A. TIM.
   B. DC/DC converter.
   C. Traction battery.
   D. Evaporator core.
5. Which of the following affect(s) the ECON Gauge?
   A. Drivetrain power expenditure.
   B. Climate control usage.
   C. Regenerative braking.
   D. All of the above.

WORKSHEET F CONTINUED ON NEXT PAGE

ACTIVITY 2 – VEHICLE FAMILIARIZATION – WORKSHEET F
INSTRUMENT GAUGES AND LIGHTS
STUDENT ANSWER SHEET (Continued)

6. How many hours of charging are required to replenish a fully discharged Traction Battery at 25°C (77°F)?
   A. 2-4 hours.
   B. 6-8 hours.
   C. 10-12 hours.
   D. 14-16 hours.
7. What would cause the Distance to Empty Gauge reading to increase?
   A. Accelerating to highway speed.
   B. Driving up a steep grade.
   C. Turning the A/C off.
   D. A short to chassis ground in the high voltage power distribution box.
8. The Auxiliary Battery Warning Lamp illuminates:
   A. If voltage exceeds 15.75 volts.
   B. If voltage falls below 11.5 volts.
   C. Either A or B.
   D. None of the above
9. The IAA monitors input from the _____ to control the Battery State of Charge Gauge.
   A. TIM.
   B. 12-volt battery.
   C. BCM.
   D. EEC-V module.

WORKSHEET F CONTINUED ON NEXT PAGE

ACTIVITY 2 – VEHICLE FAMILIARIZATION – WORKSHEET F
INSTRUMENT GAUGES AND LIGHTS
STUDENT ANSWER SHEET (Continued)

10. The ECON Mode Indicator Lamp illuminates:
    A. during braking.
    B. during deceleration.
    C. if the driver selects the Economy Mode.
    D. if Traction Battery state of charge falls below 50%.
11. The Battery State of Charge Gauge is equivalent to the _____ on a standard vehicle.
    A. ammeter.
    B. voltmeter.
    C. fuel gauge.
    D. Battery Warning Lamp.

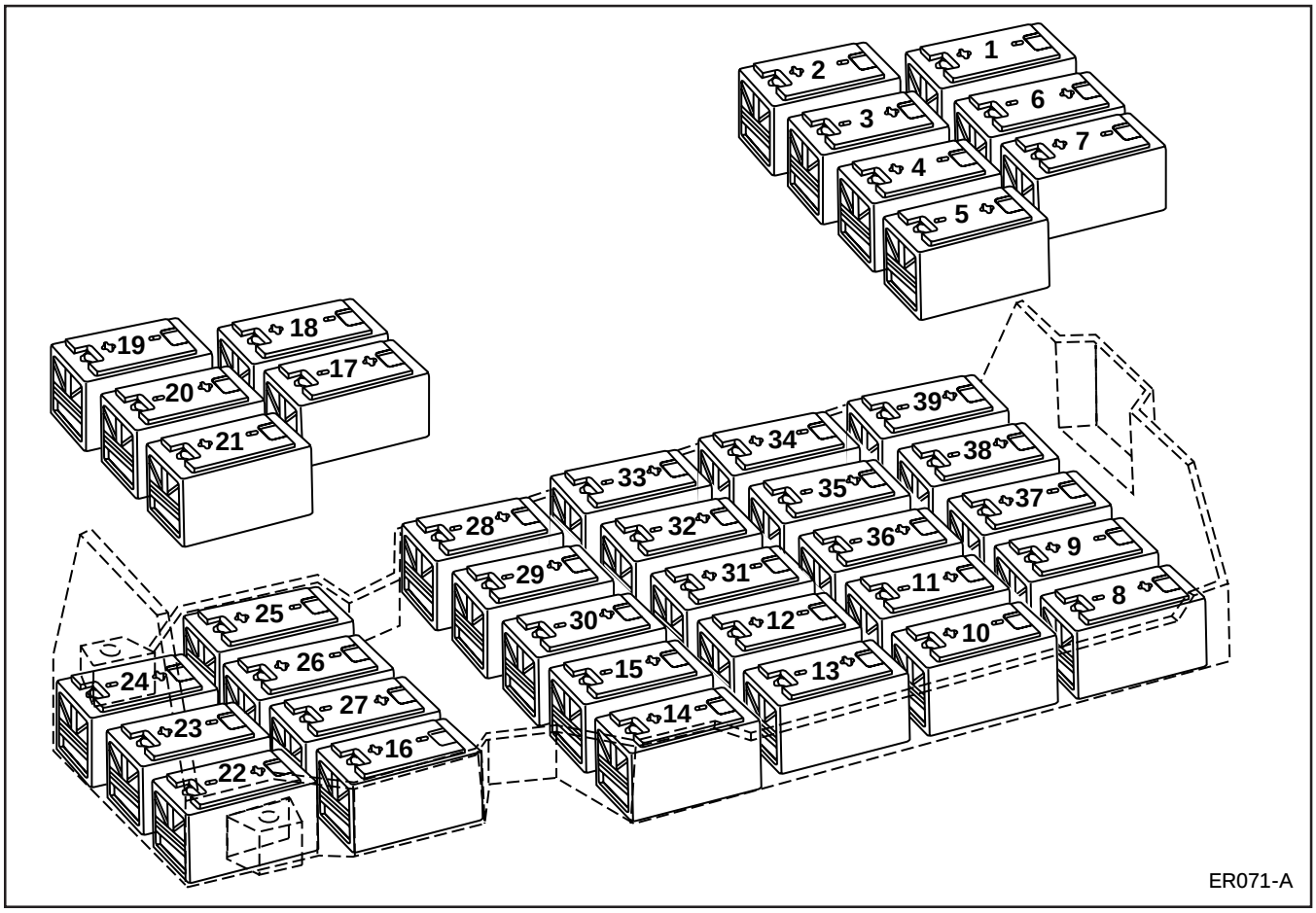
END OF WORKSHEET F

TECHNICIAN OBJECTIVES

- Describe high voltage color coding.
- Recognize high voltage warnings.
- Identify the hazards associated with high voltages.
- Identify the causes of most electrical accidents.
- Identify safety rules that should be followed for accident prevention.
- Describe the first aid procedures to be followed in case of acid contact and/or electric shock.
- Describe what can be done to prevent fires.
- Identify the classes of fire and the types and ratings of fire extinguishers.

CONTENTS

LEAD-ACID BATTERY DESIGN



Lead-Acid Battery Modules

- The Electric Ranger uses advanced technology, valve-regulated, starved electrolyte lead-acid batteries.
- The 39 individual battery modules in the Traction Battery are sealed and maintenance-free.
- Each 8-volt battery is made up of a polypropylene case, stainless steel terminals and sulfuric acid electrolyte.
- The electrolyte inside each battery is soaked in a cotton-like fiber, and only seven or eight drops will drain from each of the four cells in an individual battery.

WARNING: LEAD-ACID BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR BATTERIES TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH THE SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF FIFTEEN MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL, CALL A PHYSICIAN IMMEDIATELY.

WARNING: BATTERIES NORMALLY PRODUCE EXPLOSIVE GASES WHICH CAN CAUSE PERSONAL INJURY OR DEATH. DO NOT ALLOW FLAMES, SPARKS OR LIGHTED SUBSTANCES TO COME NEAR THE BATTERIES. WHEN CHARGING OR WORKING NEAR THE BATTERIES, ALWAYS SHIELD YOUR FACE AND PROTECT YOUR EYES. ALWAYS PROVIDE VENTILATION.

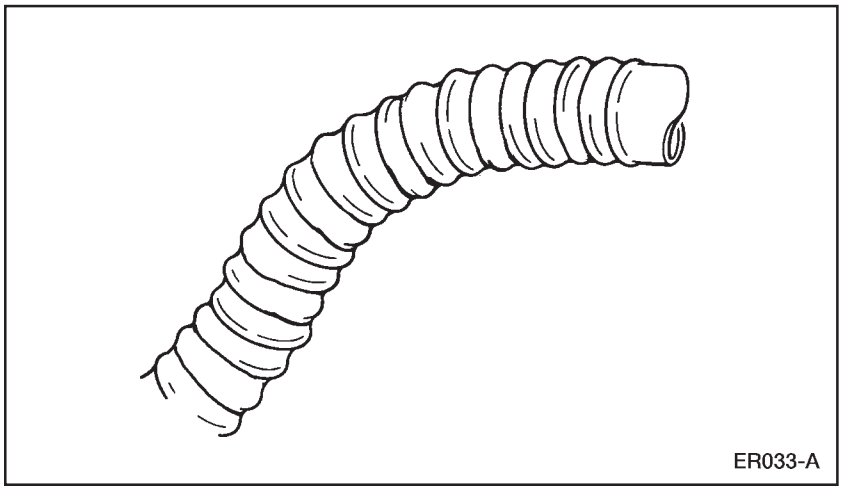
LEAD-ACID MODULE SPECIFICATIONS

Dimensions	Length 399 mm (15.275 in)
	Width 116 mm (5.567 in)
	Height 175 mm (6.890 in)
Weight	19.5 kg (42 lb)
Terminals	Stainless Steel Threads With Lead Contacts
Vent Mechanism	Pressure Relief Valve [Activated at 13.8 kPa (2 psi)]
Contents	Lead/Lead Oxide Plates (Electrodes)
	Glass Mat Separator (Between Electrodes)
	Sulfuric Acid Electrolyte
	(Entrapped/Absorbed in Glass Mat Separator)

⚠ **WARNING: CONCENTRATED SULFURIC ACID CAN CAUSE BURNS TO SKIN AND EYES.**

NOTE: For additional information regarding the electrolyte or any of the other battery components, refer to the Material Safety Data Sheets (MSDS) in your facility.

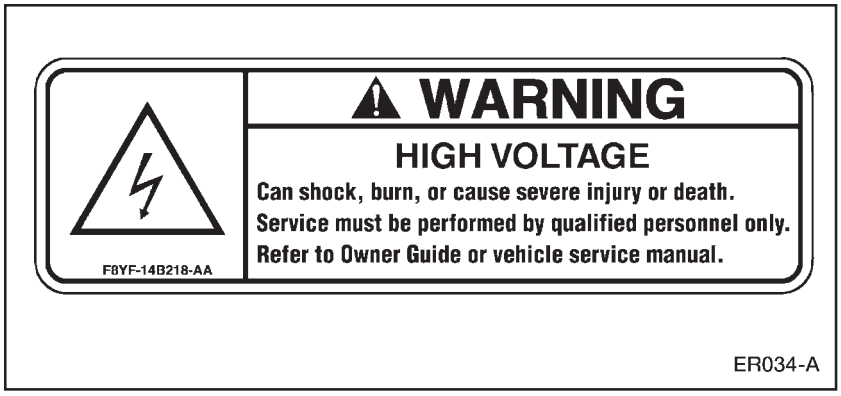
HIGH VOLTAGE COLOR CODING



High Voltage Color Coding

- All high voltage cables on the Electric Ranger are orange-colored by covering the cables with:
  - orange-colored convolute.
  - orange-colored insulation in the battery pack assembly.

HIGH VOLTAGE WARNINGS



High Voltage Warning Labels

- Warning labels identify components that are associated with high voltage.

HIGH VOLTAGE HAZARDS

This portion of the course will examine the three hazards associated with high voltage. Later we'll discuss how to avoid mistakes that can lead to electrical accidents. The three high voltage hazards are ***shock, arcing and blast.***

Hazard One: Electric Shock

People are affected by electric shock in three ways:

1. Muscle Contraction – A 10 ma, 60 hertz current can cause muscles to contract. A hand exposed to sufficient electrical current is unable to release its grip. Chest muscles paralyze and respiration ceases if sufficient current passes through the chest.
2. Fibrillation – Fibrillation is the disruption of a body's normal heartbeat. The heart beats because the brain sends it an electrical signal to do so. Sixty (60) volts are enough to interrupt the electrical signal from the brain and cause the heart to stop pumping. The current must follow a path through the body (hand-to-hand, etc.) in order for fibrillation to occur.
3. Tissue Damage – Tissues within the body and at the current exit point can be damaged by electrical shock when the current exceeds 5 amps. Damage to tissue is caused by heat generated from the current flow. If the energy delivered by the electrical shock is high, the heat cannot be dissipated and body tissue is burned.

- Susceptibility to electric shock varies from person to person, depending on their physical attributes (skin thickness, etc.).
- An open cut can reduce a person's natural resistance, and moist skin will increase the chances of an electric shock taking place. Even a relatively small electric shock can cause serious injury. A person's involuntary muscle reaction to a current as low as 3 ma can result in bruises, bone fractures, and possible death caused by a collision or fall.

Hazard Two: Arcing

An arc is a discharge of electricity across a circuit gap. The primary danger of this hazard is the burn that a person can receive. The heat at each end of an arc reaches up to and beyond 19,427°C (35,000°F), or about 4 times the surface temperature of the sun. Arcing is a significant concern in power plants and other areas of extremely high voltage because arc size and length are proportionate to voltage. Arcing is a potential hazard with lower voltages as well. It can result in insulation damage, the melting of conductors, and vaporization of metal.

Hazard Three: Blast

Electric blast is the pressure expansion caused by an arc. The expansion is actually the rapid heating of the surrounding air and the boiling of a metal, usually copper. Both expand at incredible proportions under the intense heat of an arc. Copper expands by a factor of 67,000 when vaporized.

ELECTRICAL ACCIDENTS

Electrical accidents can usually be attributed to one or more of the following causes:

- Unsafe Equipment or Installation – Serious problems can occur when using improper equipment. Not only must equipment have a safe design, but also it must be installed correctly.
- Unsafe Work Areas – Poor lighting, moisture, flammable liquids, flammable gases, poor labeling and covered labels are all items of concern around high voltage.
- Unsafe Acts by Workers – Failure to follow established procedures can result in an electrical accident.

Personal injury from electricity can vary from trivial burns to complete charring of the skin. Approximately 4,000 people in the United States are injured by electricity each year and about 1,000 are accidentally electrocuted. Five percent of admissions to burn centers are related to electrical injury.

Whether an electric shock will cause injury or death is determined by the amount, duration, and pathway of the current. A relatively large amount of electrical energy may be harmless due to its inability to penetrate dry, callused skin. A shock victim can be thrown back or become paralyzed and remain in contact with the circuit. In either case, extreme care should be taken when treating a person affected by electricity. Symptoms of electric shock are loss of consciousness and skin burns.

ACCIDENT PREVENTION

The Electric Ranger operates on a system that is isolated from the earth ground and its high voltage system is isolated from the vehicle chassis ground. A person must join the positive and the negative to become part of the high voltage circuit. As with any high voltage system, assume nothing when working around an EV.

Safe practices will protect you and those around you. In fact, most EV guidelines are the same as those used in home electrical repairs. Keep in mind the following safety rules and share them with others:

1. Do not work when you are tired or taking medicine that makes you drowsy.
2. Do not work under poor light.
3. Do not work in damp areas.
4. Use approved tools, equipment, and protective devices.
5. Do not work if you or your clothes are wet.
6. Remove all rings, bracelets, and metallic items.
7. Never assume that a circuit is open. Check it with a device or piece of equipment that you are sure is operating properly.
8. Do not tamper with safety devices. Never defeat an interlock switch. Verify that all interlocks operate properly.
9. Keep your tools and equipment in good condition. Use the correct tool for the job.
10. Verify that capacitors have discharged.
11. Do not remove equipment grounds. Verify that all grounds are intact.
12. Do not use adapters that defeat ground connections.
13. Use only an approved fire extinguisher. Water can conduct electrical current and increase the hazards and damage. Carbon dioxide (CO_2) gas extinguishers are preferred for most electrical fires.
14. Follow directions when using solvents and other chemicals. Some may explode, ignite, or damage electrical circuits.
15. Certain electronic components affect the safe performance of equipment. Always use the correct replacement parts.

16. Do not attempt to work on complex equipment or circuits before you're fully trained. There may be hidden dangers.
17. Some of the best safety information for electrical and electric equipment is in the literature prepared by the manufacturer. Find and use it.
18. Always wear protective eyewear.
19. Never touch a shock victim with your bare hands if you suspect that the person is still part of the electric circuit. First deactivate the electricity at its source. If that is not possible, move the victim away from the electrical source with a nonconductive object (a wooden reach pole, a dry board, etc.).
20. Always wear the specified protective clothing and use insulated voltage-rated special service tools and equipment when working with an EV.
21. Always be with another individual when working on or around high voltage components and circuitry. The other person can seek help if an emergency arises.
22. When working around high voltage, wear high voltage gloves and work with ONE HAND INSTEAD OF TWO to prevent your body from becoming a conductor of electricity. Failure to do so may result in personal injury.
23. **Take the time to be safe. Don't rush through a job.**
24. Most electrical accidents are the result of incorrect or careless action, not faulty equipment. Follow procedures exactly.
25. Don't work around energized electrical equipment unless it's necessary. Perform the work only after a written and approved procedure is available.
26. Keeping adequate distance between you and a high voltage circuit will lessen the risk of injury by arc, blast, or flying debris if an accident occurs.
27. Know the emergency procedures for your work area and building. Remember emergency phone numbers in case of an accident.
28. If you don't know what something is, don't touch it.
29. Electrical arcs will melt polyester clothing to the skin. The recommended clothing materials for working around high voltage are natural fabrics like cotton.

30. Welding on an EV requires special procedures. Damage to components can result if improper practices are used. Consult with your supervisor to determine the correct procedure for your specific application.
31. When performing a visual inspection, check for damaged wiring. This includes exposed copper; damaged insulation; pinched, cut, or bare cables, and damaged or crushed connectors.
32. Inspect tools and equipment for cracked, worn, or missing insulation. If you believe that a tool or piece of equipment is improperly insulated, repair or replace it; do not take a chance.
33. Have wooden reach poles situated around the areas where personnel will be working with high voltage equipment. These can be used to move energized electrical wires from harm's way.
34. Know where the fire extinguishers, reach poles, and other safety equipment are located when working on or observing an EV. Be aware of your surroundings.

FIRST AID PROCEDURES

In case of acid contact with the skin, eyes or clothing, flush immediately with a mixture of clean water and baking soda for a minimum of 15 minutes. Know where the first aid station is located.

If acid is accidentally swallowed, drink large quantities of milk or water, followed by milk of magnesia, a beaten egg or vegetable oil. Consult a physician immediately.

First Aid for Electric Shock

The longer a person remains in contact with an electrical current, the less chance he or she has for survival. The victim's breathing may stop and his or her body may appear stiff.

1. Break the electrical connection as quickly as possible without exposing yourself to the current.
2. If the current cannot be turned off, use a wooden reach pole or a dry board to remove the wire or push the person away from the wire. Stand on a dry surface while doing this. Do not touch the person or wire with your bare hands until the electrical connection is broken.
3. Summon medical aid.
4. If the person has stopped breathing or his/her heart has stopped pumping, begin CPR procedures and continue until help arrives.
5. If the person must be moved, take proper precautions.
   Be sure to immobilize injured parts. Pull the person lengthwise (never sideways). If possible, use a stretcher or cot.

Cardio-Pulmonary Resuscitation (CPR)

If a person has received an electric shock, it may be necessary to administer CPR. The goal of CPR is to provide oxygen to the brain, heart, and other vital organs until medical help arrives.

When to Use CPR

CPR should only be administered by a trained individual. Determining the condition of the person is an important step in assessing cardiac and breathing function to determine if CPR is necessary.

Unless it is absolutely necessary, do not move the victim if trauma to the head or neck has been sustained. Emergency personnel properly trained for these types of injuries should be on hand to administer aid to the person.

Where to Get CPR Training

The American Red Cross offers CPR training on a regular basis.

FIRE PREVENTION

General fire precautions should be observed at all times. Shop cleanliness is a good fire preventative. Storage lockers, drawers and partitions should be made of fire-resistant material. Flammable materials should be kept at a safe distance from heating units and open flames. Flammable liquids should be stored in approved safety containers and, when not in use, stored in proper storage areas. Whenever flammable liquids such as cleaning solvents, kerosene or gasoline are used, the work area should be well ventilated and all heating units (particularly open-flame torches) should be removed from the job site.

Classes of Fire

All employees should know the location of fire alarm systems and how to contact the fire department. They should know where the fire extinguishers are located, how to operate them, and for what type of fire they are designed.

Classes of fire are as follows:

Class A	Typical fire: common combustibles, wood, paper, cloth, rubber and most plastics
Class B	Chemical fire: flammable liquids, gasoline, kerosene, oil, grease, solvents and gases.
Class C	Electrical fire: live electrical equipment and wiring.

Types of Fire Extinguishers

Listed below are common types of fire extinguishers:

Water	Class A fires only. Inappropriate for Class B and C fires. Water can conduct electrical current and increase the risk of severe injury.
Regular Dry Chemical	Primarily sodium bicarbonate, effective against Class B and C fires.
Multi-Purpose Dry Chemical	Monoammonium phosphate is effective against Class B and C fires.
Carbon Dioxide Gas (CO_2)	Effective against Class B and C fires, often used in areas where contamination and cleanup time are important.

Ratings of Fire Extinguishers

Fire extinguishers come with UL rating. The higher the rating number, the more capacity for extinguishing the class of fire indicated. The following is a general guide for selecting a fire extinguisher. Minimum extinguisher ratings are listed. Cheek your local fire department codes for detailed information:

Light Hazard (possibility of small fires)	2A, 5B:C or greater
Ordinary Hazard (possibility of moderate fires)	2A, 10B:C or greater
Extra Hazard (possibility of severe fires)	4A, 40B:C or greater

Fire Extinguisher Inspection

Fire extinguishers are pressurized devices. Monthly inspections should be made to verify that all extinguishers have retained their full charge.

NOTES

ACTIVITY 3 – EV SAFETY AND EMERGENCY INFORMATION – WORKSHEET G
SAFETY AND EMERGENCY PROCEDURES
STUDENT ANSWER SHEET

OBJECTIVE: To describe the emergency instructions provided in this section.

DIRECTIONS: Write the correct answers in the blank spaces provided.

1. What should you do if lead-acid electrolyte comes in contact with your skin? _____

   _____

   _____

2. What method is used to identify high voltage cables on the Electric Ranger? _____

   _____

3. What clothing material is recommended for working around high voltage? _____

   _____

4. In what three ways are people affected by electrical shock? _____

   _____

5. Which of the following is a hazard associated with high voltage?
   A. Electric shock.
   B. Blast.
   C. Arcing.
   D. All of the above.

6. When working with high voltage why should you try to work with one hand instead of two? _____

   _____

7. If a person is being shocked and is still in contact with an electric wire, what should you do?
   A. Grab the person and pull them away from the wire.
   B. Push the person away from the wire with a wooden pole.
   C. Wait until a circuit breaker or fuse breaks the electrical circuit.
   D. None of the above.

END OF WORKSHEET G

TECHNICIAN OBJECTIVES

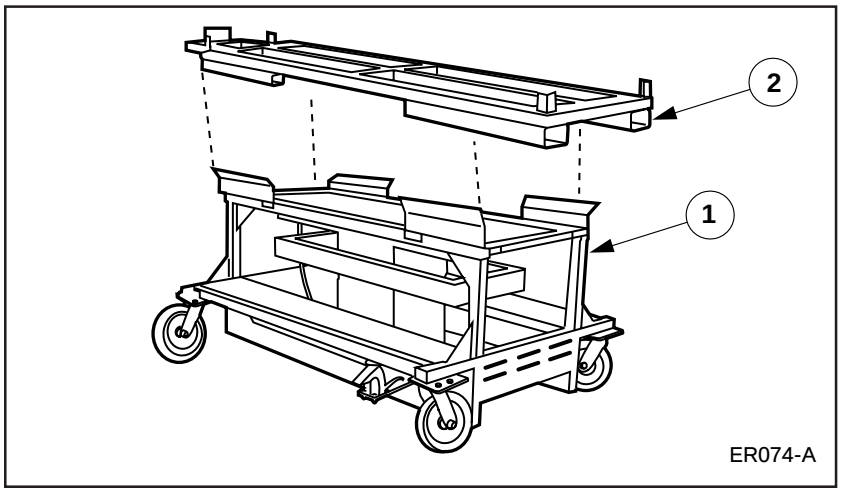
- Identify the special service tools and equipment required for repair on the Ranger EV.
- Identify approved towing methods.
- Describe how to correctly hoist the vehicle.

CONTENTS

SPECIAL SERVICE TOOLS AND EQUIPMENT

Global Tool Number	Description
502-F002	Battery Lift Table
502-F003	Battery Lift Table Pallet
418-F205	Insulated Battery Post Torque Wrench
418-F206	Battery Module Lifting Tool (2 Required)
418-F207	Traction Battery High Voltage (HV) Lockout and Diagnostic Tool
418-F208	Auxiliary Interlock Tool
211-F006	Power Steering Interlock Tool
418-F210	In-Line Bypass Battery Module
418-F211	Electric Motor/Transaxle Test Box
418-F212	BCM/TIM Breakout Box Adapter Cable
418-F213	Capacitor Discharge Tool
418-F214	8-Volt Battery Charger
418-F215	Battery Terminal Cap Opener
418-F220	BCM/TIM Breakout Box Overlay
100-F035	Face Shield
100-F036	High Voltage Insulated Safety Gloves
100-F037	Safety Cones
418-F216	Power Control Station (PCS)
418-F217	NGS Diagnostic Card (Ranger EV)
418-F218	Traction Battery High Voltage Service Cord
418-F219	Traction Battery Low Voltage Service Cord

Traction Battery Lift Table and Pallet



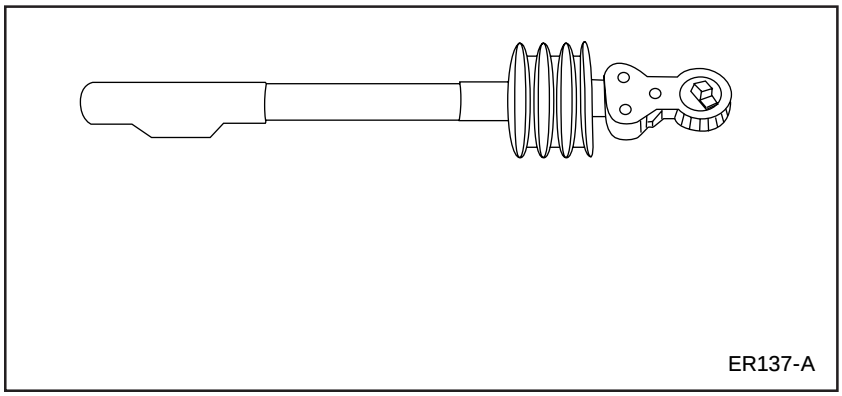
Battery Lift Table

Item	Description
1	Battery Lift Table
2	Battery Lift Table Pallet

- The Battery Lift Table and Battery Lift Table Pallet are specially designed for the Ranger EV.
  - The Battery Lift Table uses pressure from a shop air source to raise and lower the traction battery during removal and installation.
  - A mechanical adjustment screw next to the pressure gauges can be used to adjust the angle of the Battery Lift Table Pallet.

NOTE: When the traction battery is carried on the Battery Lift Table, the weight of the table and battery is more than 2,000 lb. Because of this weight, the Battery Lift Table will roll very easily and will be difficult to stop if it begins to roll. Always maneuver the Battery Lift Table carefully.

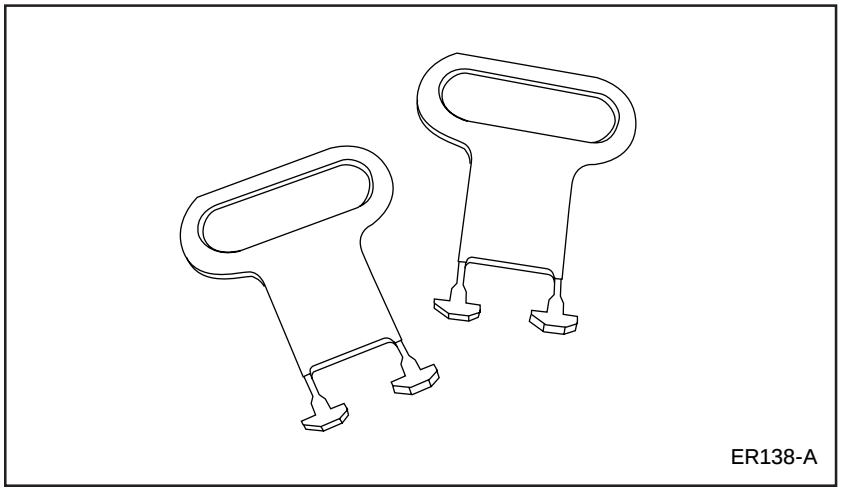
Insulated Battery Post Torque Wrench



Insulated Battery Post Torque Wrench

- The Insulated Battery Post Torque Wrench enables you to safely tighten the battery post connectors.
- The insulation on the wrench prevents arcing in the event of inadvertent contact between a battery positive terminal and ground.

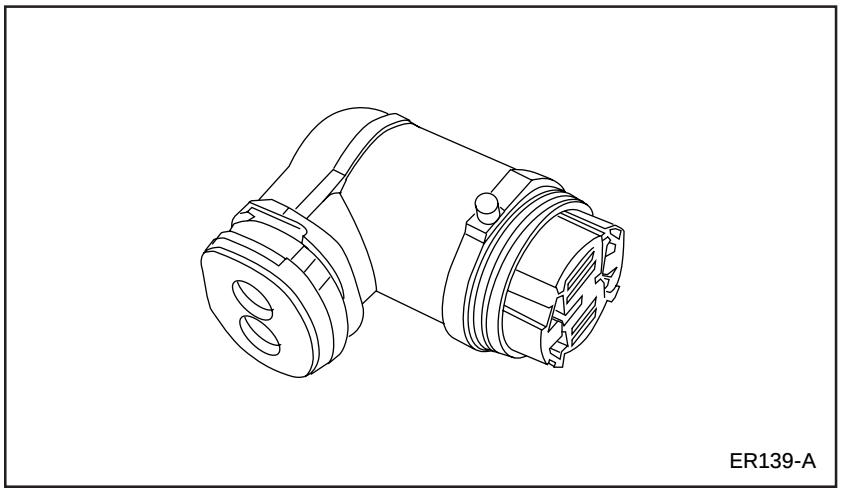
Battery Module Lifting Tools



Battery Module Lifting Tools

- The Battery Module Lifting Tools aid in lifting, carrying and removing the battery module from the traction battery pack.
- Two lifting tools are required for battery lifting, carrying, or removal.

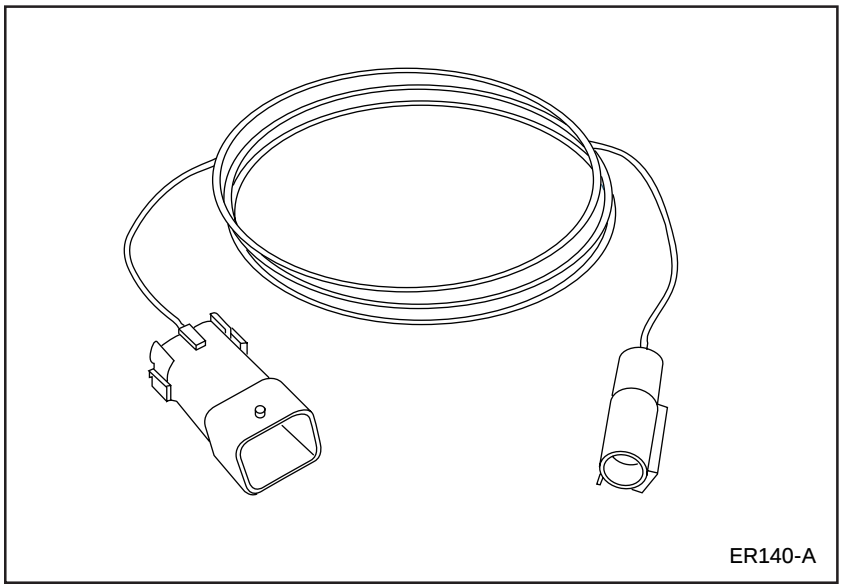
Traction Battery High Voltage (HV) Lockout and Diagnostic Tool



Traction Battery High Voltage (HV) Lockout and Diagnostic Tool

- It is a dual-purpose tool that allows the vehicle to be powered up when performing current leakage diagnostics.
- It is used as a safety device when the Traction Inverter Module (TIM) is disconnected from the traction battery.
- It is connected to the HV two-pin connector located at the rear of the traction battery pack.

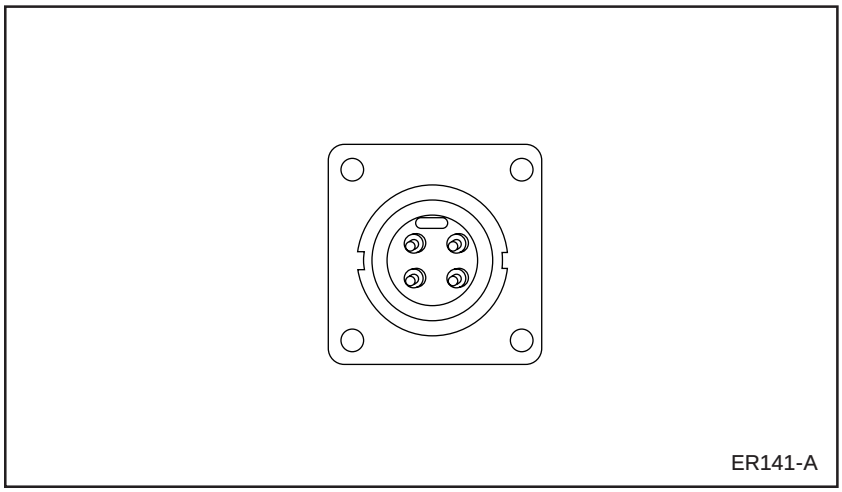
Auxiliary Interlock Tool



Auxiliary Interlock Tool

- It is used to close the interlock loop on the vehicle during diagnostics.
  - After disconnecting the traction battery high-voltage auxiliary load connector at the right front side of the traction battery, connect this tool between the traction battery and in-line interlock connector C1948 located behind the high voltage power distribution box (HVPDB).

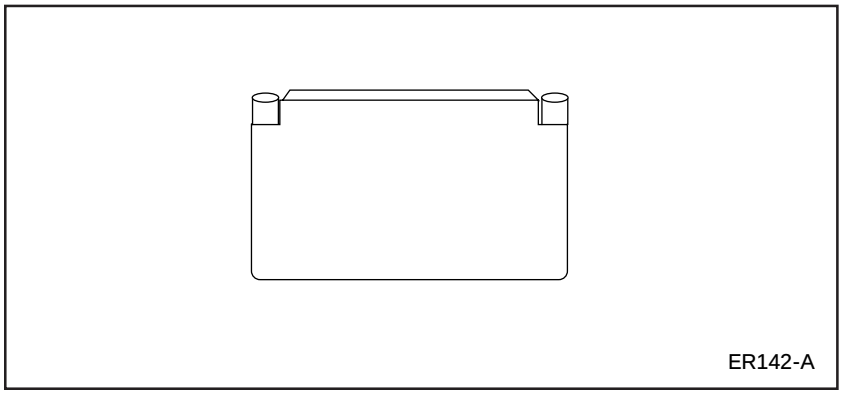
Power Steering Interlock Tool



Power Steering Interlock Tool

- The Power Steering Interlock Tool connects to the power steering connector pigtail from the high voltage power distribution box (HVPDB) to the power steering assembly.
- It is used to close the interlock loop when performing current leakage diagnostics.

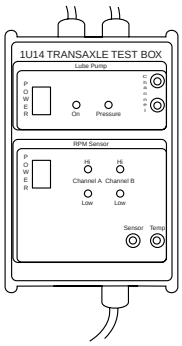
In-Line Bypass Battery Module



In-Line Bypass Battery Module

- The In-Line Bypass Battery Module is used when traction battery module replacement is required.
- It is inserted into the traction battery pack at the location where the replacement module is to be installed.
- The vehicle is then connected to the power control station (PCS), and the traction battery pack is brought up to full charge.
- The In-line Bypass Battery Module tool is then removed and the new, fully charged battery module is installed into the traction battery pack.

Electric Motor/Transaxle Test Box



ER150A-A

Electric Motor/Transaxle Test Box

- The Electric Motor/Transaxle Test Box is used to perform tests that are necessary for diagnosing internal electric motor/transaxle components.
- The Electric Motor/Transaxle Test Box will perform the following component tests on the electric motor/transaxle.

NOTE: If a problem with one of these internal components is identified and confirmed, the entire electric motor/transaxle will require replacement.

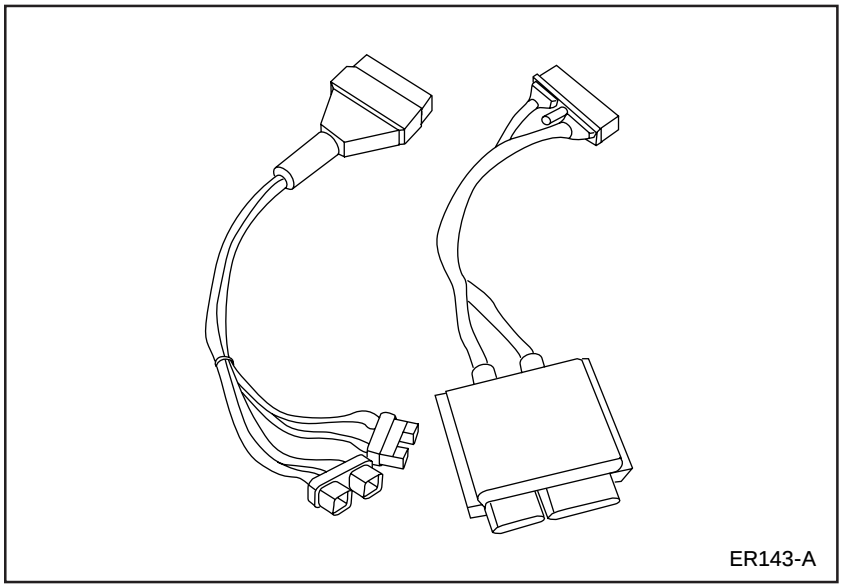
- Motor Speed Sensor Operation – The Electric Motor/Transaxle Test Box will confirm the operation of the speed sensors within the motor assembly. Working through the transaxle connector located on the top of the motor assembly next to the three power leads, the tester directly interfaces with the speed sensors. Spinning the wheels by hand will cause lights to alternately illuminate on the tester. If there is a problem with the sensors, either one or both lights will not illuminate.
- Motor Temperature Sensor – The Electric Motor/Transaxle Test Box provides an interface for a digital voltmeter to directly read the resistance of the temperature sensor. This resistance will correspond with a temperature in degrees Celsius. A resistance value that falls outside of the range specified may indicate that the sensor has either shorted or is an open circuit.

- Oil Pressure Switch Operation – The Electric Motor/Transaxle Test Box interfaces directly with the oil pressure switch. By manually turning on and off the oil pump, the Electric Motor/Transaxle Test Box turns a light on and off respectively.
- Oil Pump Operation – In addition to monitoring the oil pressure switch, the Electric Motor/Transaxle Test Box also provides information on oil pump operation. A manual switch to turn the oil pump on and off is provided on the front of the tester along with an interface for a digital voltmeter. This interface will provide the technician with a voltage that is directly proportional to the current flowing to the oil pump. This current will be checked to verify that it is within a specified range for proper operation.

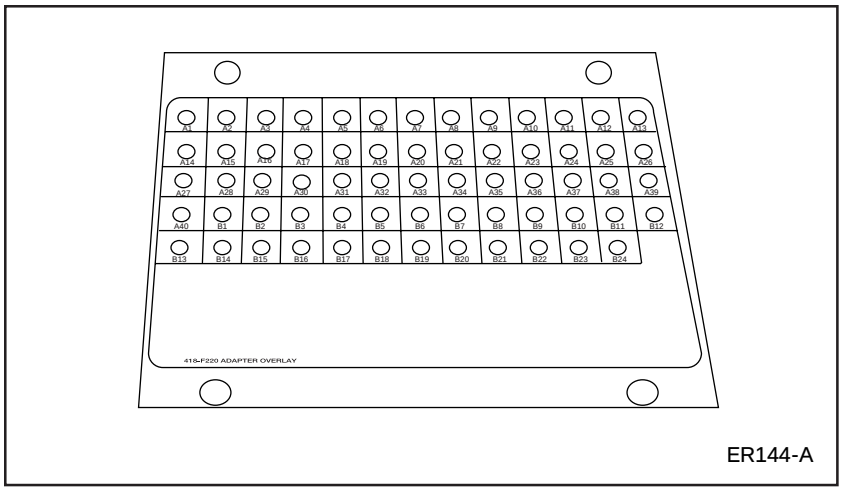
Equipment Hookup

- The Electric Motor/Transaxle Test Box connects to both the transaxle connections and the cigar lighter socket.
  - 9-Pin Transaxle Connector – Located on the top of the motor assembly in front of the three power leads.
  - Oil Pressure Switch Connector – Located on the lower rear of the gear cover.
  - Oil Pump Bulkhead Connector – On the gear cover in front of the driver side halfshaft.

104-Pin Breakout Box (BOB) and BCM/TIM Breakout Box Adapter Cable and Overlay



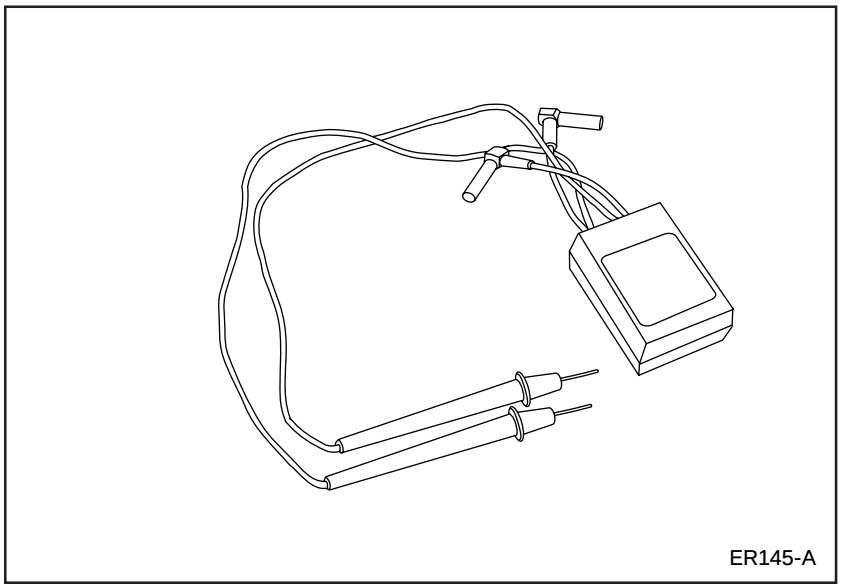
BCM/TIM Breakout Box Adapter Cable



Breakout Box (BOB) Overlay

- The breakout box (BOB) is used in the same manner on the Ranger EV as on conventional vehicles.
- When it is used on the Interface adapter assembly (IAA) module, no adapter cable or overlay is required.
- When using the BOB for battery control module (BCM)/traction inverter module (TIM) diagnostics, the, BCM/TIM Breakout Box Adapter Cable and Overlay are required.
- It is utilized when performing low-voltage diagnostics on the BCM or TIM.

Capacitor Discharge Tool



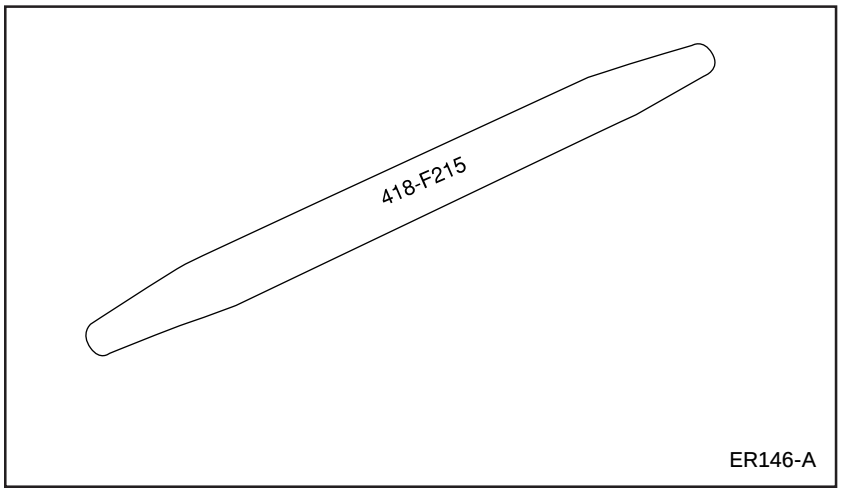
Capacitor Discharge Tool

- The Capacitor Discharge Tool is used to ensure that capacitors have discharged prior to performing vehicle service.
- Connects to a Digital Volt-Ohmmeter (DVOM) to determine when the voltage has completely discharged.

8-Volt Battery Charger

- It is used to charge the 8-volt battery modules of the traction battery pack.
  - It is only used when an individual battery module requires charging prior to being inserted into the traction battery pack.
  - Modules that have sat for more than seven days will require charging before being installed into a battery pack.
  - Charger automatically reduces voltage to a trickle when the battery is fully charged.

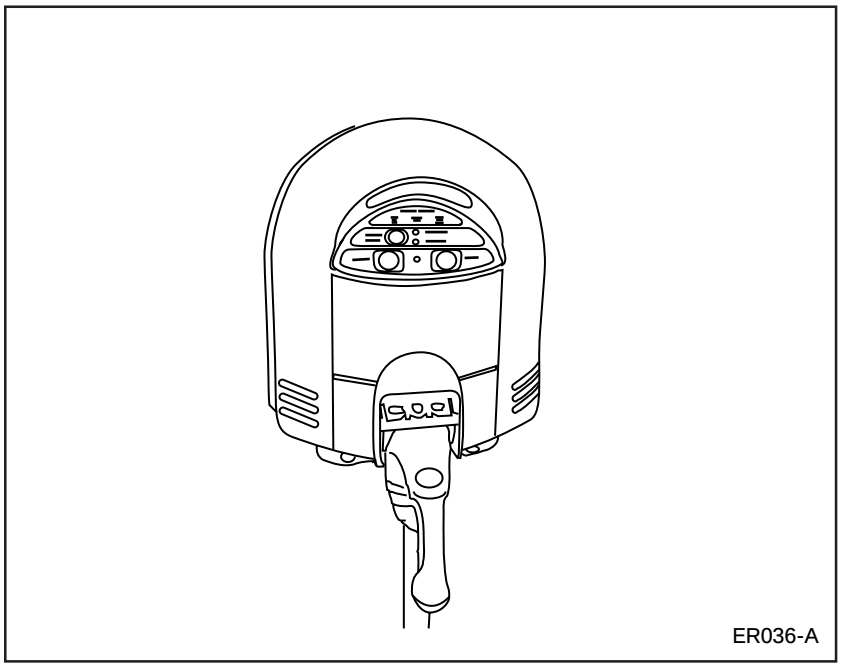
Battery Terminal Cap Opener



Battery Terminal Cap Opener

- The Battery Terminal Cap Opener is a plastic device used to pry open the battery module terminal cap covers to access the terminal retaining nuts.
- The plastic composition of the terminal cap opener is non-conductive.
- Never use metal tools, such as screwdrivers, to remove battery terminal covers.

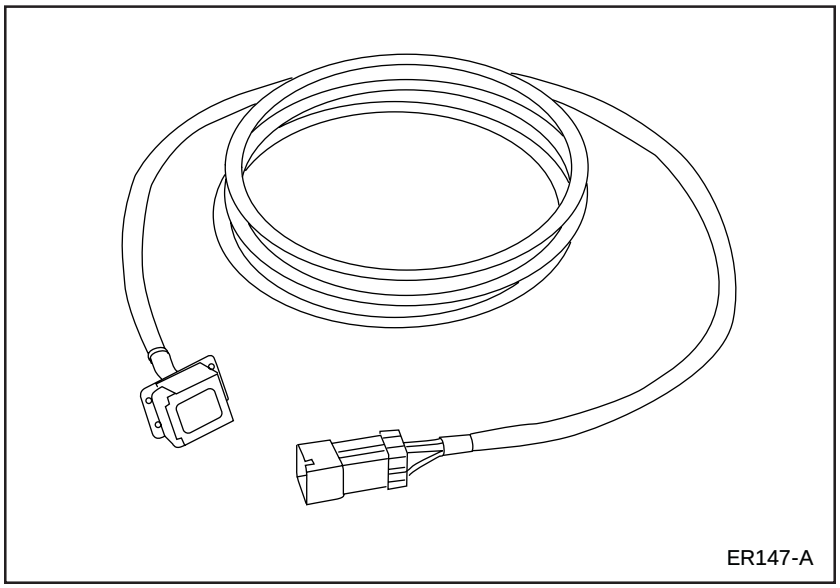
Power Control Station



Power Control Station

- The Power Control Station (PCS) provides 240 volts of AC to the Ranger EV's on-board battery charger.
- The on-board battery charger uses this voltage to charge the traction battery pack.
- There are two types of PCS currently used for the Ranger EV.
- The EVI model provides voice as well as visual indications for PCS operation.
- The SCI model provides only visual indications of PCS operation.

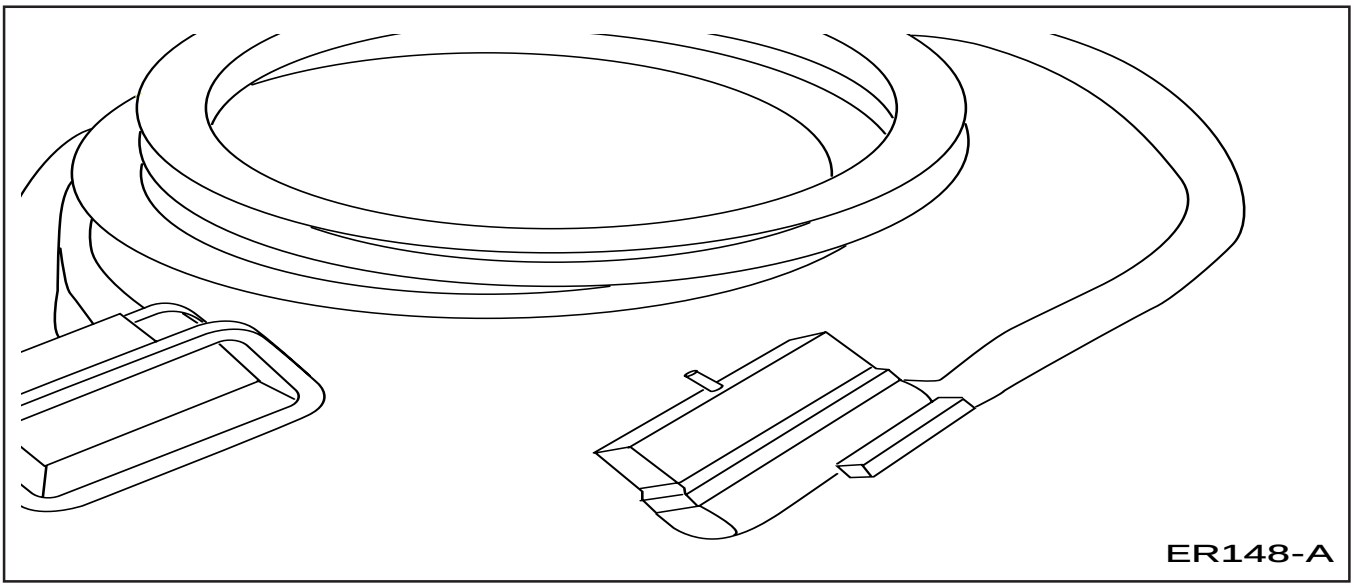
Traction Battery High Voltage Service Cord



Traction Battery High Voltage Service Cord

- It connects between the traction battery high-voltage auxiliary load connector at the right front of the battery tray and the vehicle harness.
- It used when performing diagnostic and service procedures when the battery pack is removed from the vehicle.

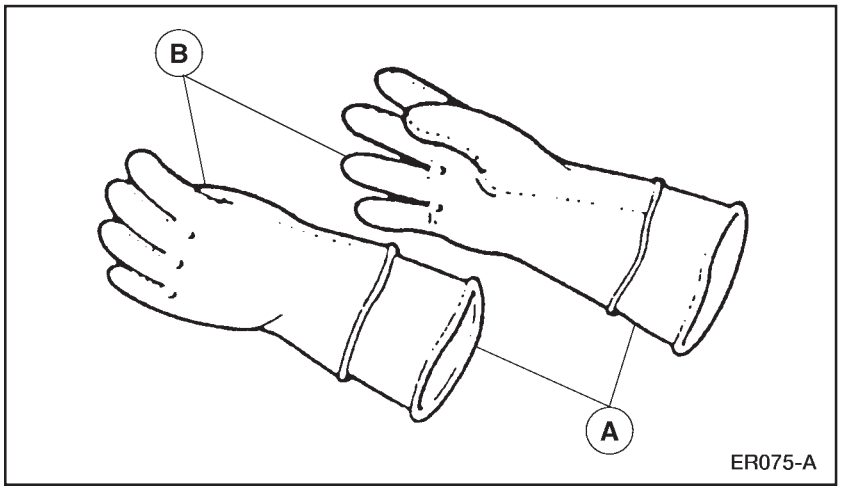
Traction Battery Low Voltage Service Cord



Traction Battery Low Voltage Service Cord

- Connects between the traction battery low-voltage 76-pin connector at the left front of the battery tray and the vehicle harness.
- Used when performing LV low-voltage diagnostic and service procedures when the battery pack is removed from the vehicle.

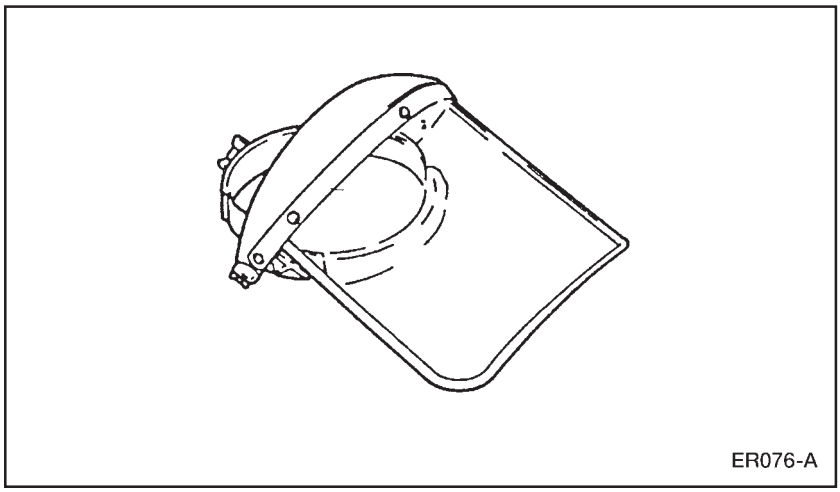
High Voltage Insulated Safety Gloves



High Voltage Insulated Safety Gloves

- When working around high voltage circuits, High-Voltage Insulated Safety Gloves **(A)** must be worn.
- The gloves specified for the Ranger EV are Class “O” rubber gloves.
  - These gloves are designed for working around equipment rated up to 1,000 volts
- Rubber insulated safety gloves are protected by durable leather gloves **(B)** that serve as an outer shell.
- Before putting on High Voltage Insulated Safety Gloves, inspect them to ensure that there are no holes or breakage.
  - Even a pinhole leak is enough to allow current to pass through.
- Inspect the gloves by rolling them up from their open end and making sure that they retain air pressure with no leakage.
- If the gloves show any sign of wear and tear, the gloves should not be used.
  - Replacement gloves must meet all American Safety Testing Materials Standards.
- High Voltage Insulated Safety Gloves must be recertified every six months.
- Protective leather gloves must always be worn over the High Voltage Insulated Safety Gloves.
- Chemicals can break down the rubber of the gloves. Never wash them with chemicals or use them for washing parts.
- Never use the protective leather gloves without the High Voltage Insulated Safety Gloves. Oil that may be on your hands can contaminate the protective leather gloves and then be transferred onto the High Voltage Insulated Safety Gloves.

Face Shield



Face Shield

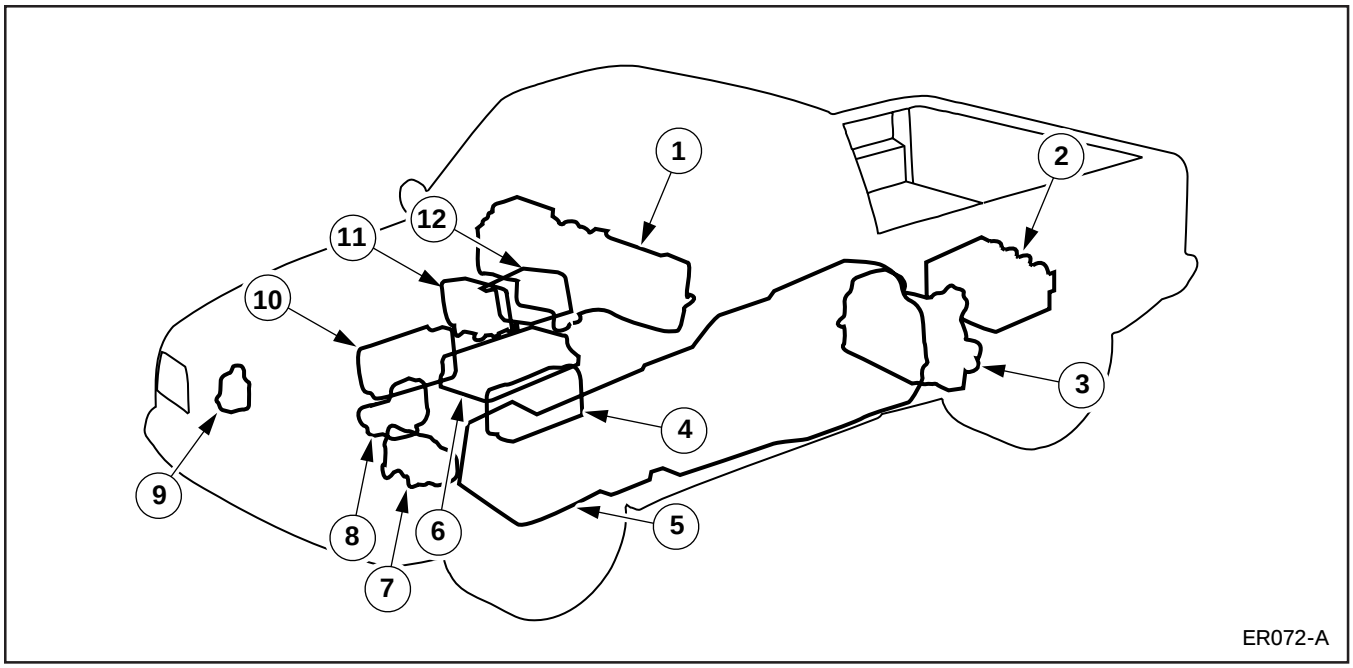
- When working with energized high-voltage equipment, to protect your face and eyes from the possibility of an electrical arc, debris, or spark that could be generated from a short circuit, a non-conductive, OSHA-approved face shield must be worn.

HIGH VOLTAGE DIAGNOSTIC AND SERVICE PROCEDURES

- High voltage diagnostic and service procedures on the Ranger EV require caution and strict adherence to service publication warnings. It is essential that extra care be used when working with high voltage equipment. The following pages provide you with information that will aid you when diagnosing and servicing the Ranger EV.

High Voltage Components

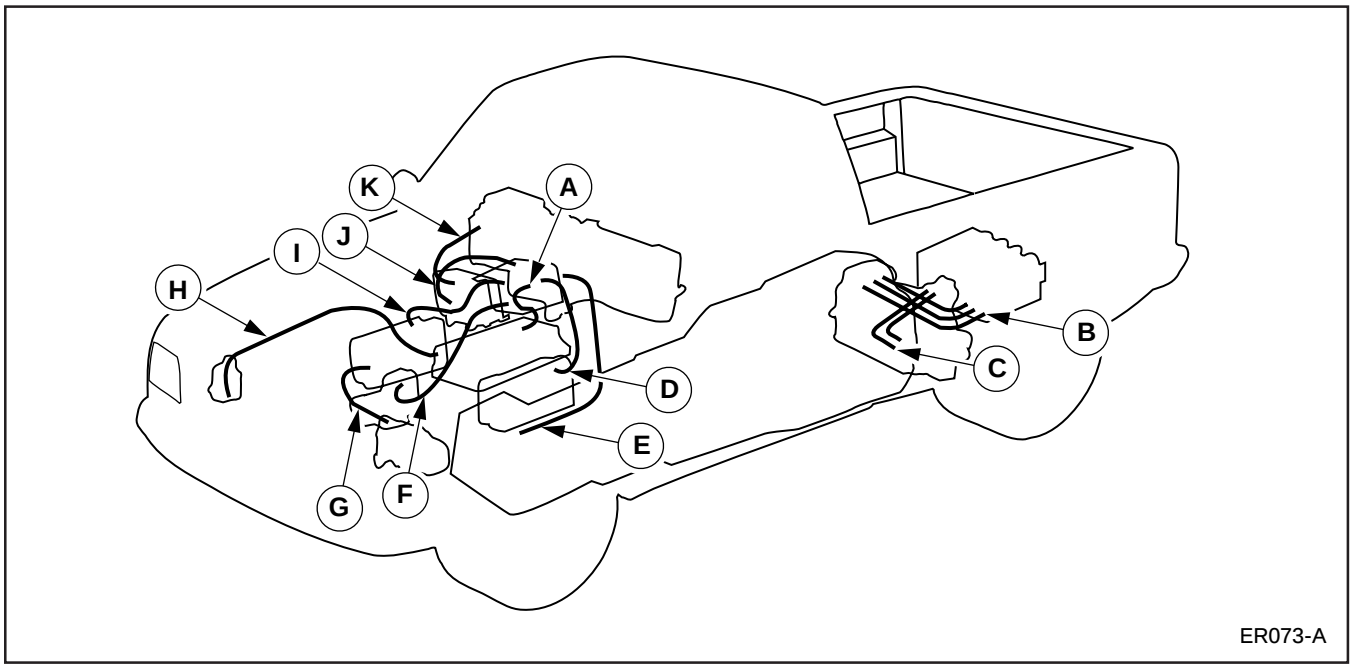
- The components that operate on high voltage are:



High Voltage Components

Item	Description
1	Positive Temperature Coefficient (PTC) heater (inside of chamber assembly-heater plenum)
2	Traction Inverter Module (TIM)
3	Motor/Transaxle
4	DC/DC Converter
5	Battery Pack Assembly
6	Battery Charger
7	A/C Compressor
8	Power Steering Controller Assembly
9	Charge Inlet
10	A/C Inverter Motor Controller
11	PTC Switching Module
12	High Voltage Power Distribution Box (HVPDB)

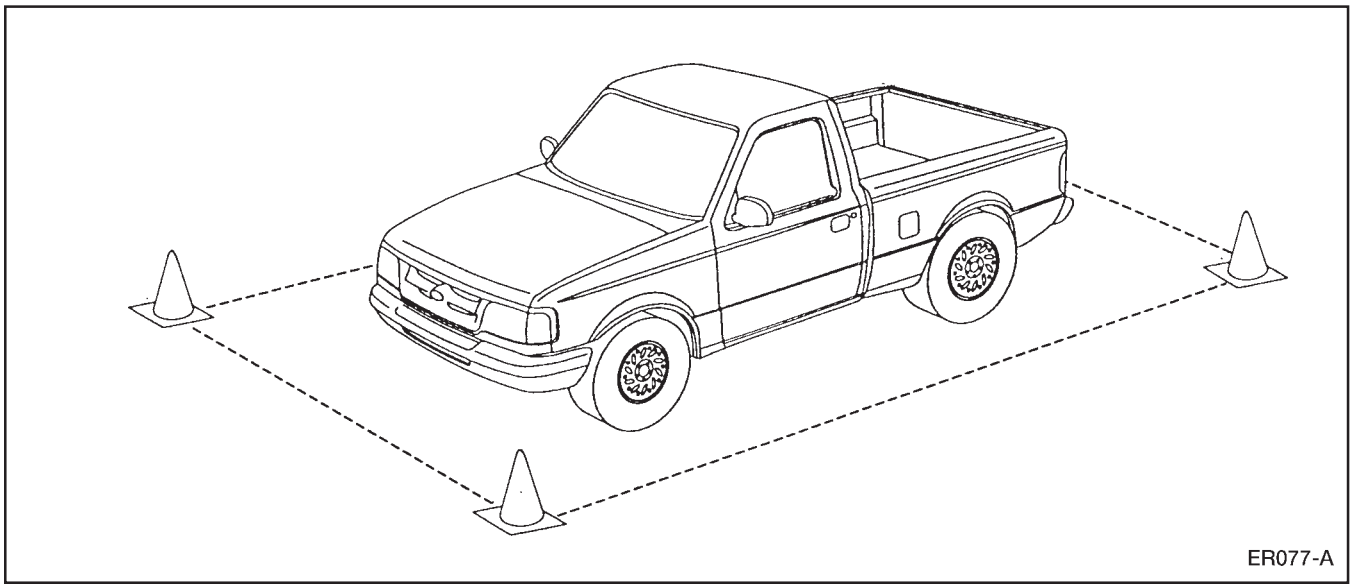
High Voltage Wiring



High Voltage Wiring

- Wiring that distributes high voltage to components that operate on high voltage are connected as follows:
  - A. From the battery charger to the high voltage power distribution box (HVPDB)
  - B. From the TIM to the motor/transaxle
  - C. From the traction battery to the TIM
  - D. From the HVPDB to the DC/DC converter
  - E. From the traction battery to the HVPDB
  - F. From the HVPDB to the power steering assembly
  - G. From the A/C inverter motor controller to the A/C compressor
  - H. From the charge inlet to the traction battery charger
  - I. From the HPVDB to the A/C inverter motor controller
  - J. From the HPVDB to the PTC switching module
  - K. From the PTC switching module to the PTC heater

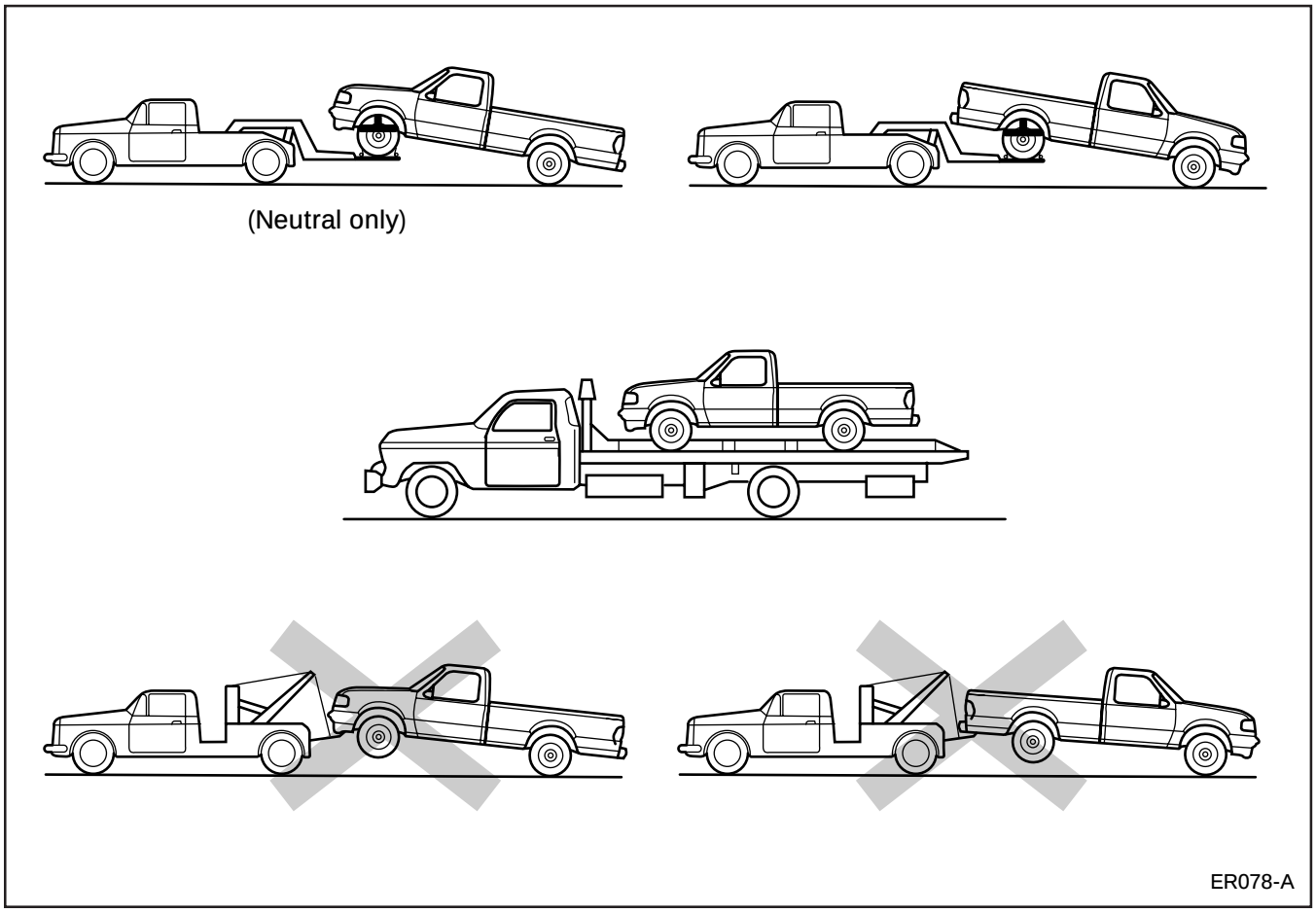
Buffer Zone



Buffer Zone

- When interacting with a high voltage system, unnecessary personnel in the work area pose a safety threat to those directly involved in the repair of an EV.
- The area immediately surrounding the vehicle is designated as a "buffer zone."
  - The boundaries of the buffer zone extend approximately 1 meter (3 feet) from the vehicle.
  - These boundaries must be marked with clearly visible orange cones.
- Only authorized personnel actively involved with high voltage repair are permitted to enter the "buffer zone."
- This "buffer zone" helps to protect technicians and observers from possible personal injury.

TOWING PROCEDURE



Towing Procedure

- The towing procedure specified for the Ranger EV is similar to those of other vehicles.
- Be sure to observe the following warnings and cautions when towing a Ranger EV:

WARNING: TOW TRUCK OPERATORS SHOULD NOT ATTEMPT TO SERVICE, RECHARGE OR OPERATE THE VEHICLE UNDER ANY CIRCUMSTANCE. THIS VEHICLE IS MADE UP OF COMPLEX ELECTRICAL SYSTEMS, AND THESE OPERATIONS MUST BE PERFORMED BY AUTHORIZED PERSONNEL ONLY. IMPROPER HANDLING COULD RESULT IN VEHICLE DAMAGE, PERSONAL INJURY OR DEATH.

WARNING: FAILURE TO TURN THE VEHICLE OFF BEFORE SERVICING MAY RESULT IN PERSONAL INJURY OR DEATH.

CAUTION: Do not disconnect the halfshafts if the motor/transaxle is inoperable. This may cause further damage to the motor/transaxle.

- Because the Ranger EV is made up of complex electrical systems, it is equipped with fail-safe components that can electrically disconnect the traction battery from the vehicle electrical system. A 400-volt, 250-amp fuse in the traction battery also cuts off high voltage to the vehicle electrical system in the event of excessive power output.

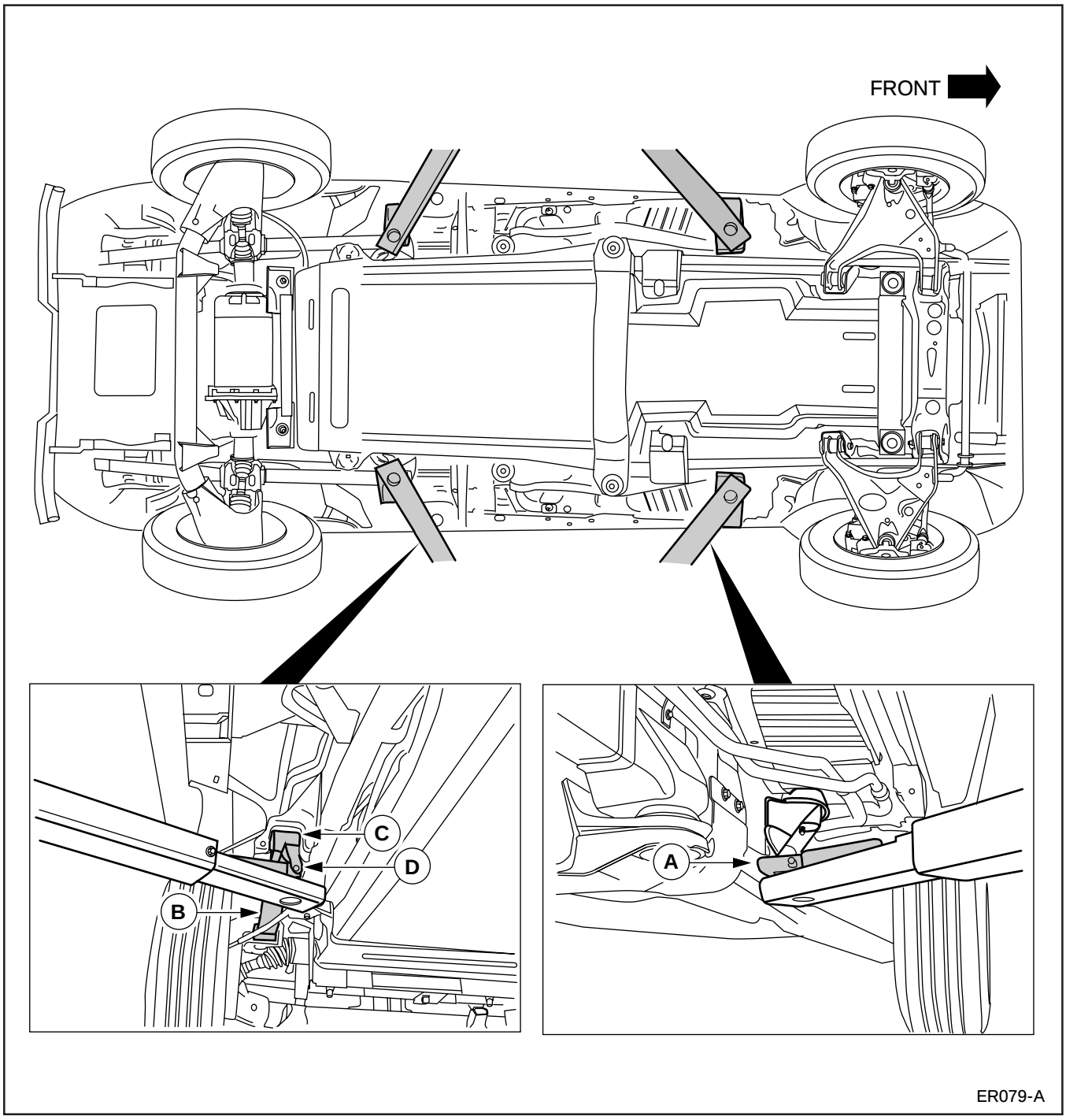
Pre-Towing Instructions

1. The Ranger EV operates very quietly so check to make sure that the key is in the OFF position.
2. Depress the brake pedal and release the parking brake.
3. Lock the steering wheel in the straight-ahead position with a steering wheel locking device designed for towing service use.

Approved Towing Methods

- Three towing methods are approved for the Ranger EV:
  - Front-wheel lift towing (Neutral [N] only)
  - Rear-wheel lift towing
  - Flatbed towing
- Sling towing is not acceptable because damage to the vehicle may occur.
- When towing by front-wheel lift, be sure to place the gearshift lever in the Neutral (N) position. Do not disconnect the halfshafts or damage to the motor/transaxle may occur.
- When towing by rear-wheel lift, do not rely on the steering column lock to lock the wheels in a straight-ahead position. Use a steering wheel locking device. If a locking device is not available, place wheel dollies underneath the front wheels.
- When towing by either front- or rear-wheel lift, be sure to secure the tires to the wheel lifts with nylon straps.
- Limit towing speed to:
  - 88 km/h (55 mph) on normal road surface.
  - 56 km/h (35 mph) on rough road surface.

HOIST LIFT POINTS



Hoist Lift Points

- Front lift point – front cab mount extension **(A)**.
  - Hoist pad in the lowest position.

CAUTION: Position the front hoist pads just outboard of the torsion bars so they do not contact them.

- Rear lift point – rear leaf spring **(B)** at the front hanger eye **(C)**.
  - Hoist pad in the first raised position **(D)**.

WARNING: USE CAUTION WHEN OPERATING THE VEHICLE ON A HOIST. MOVING WHEELS COULD CAUSE SEVERE PERSONAL INJURY OR DEATH.

CAUTION: Hoist the vehicle using only the approved hoisting points. Never hoist the vehicle by unspecified suspension components or the Traction Battery tray. Vehicle damage may result from improper hoisting.

- Use only side-post hoists, which symmetrically locate the hoist arms to the vehicle.
  - Position the hoist pads only at the approved hoisting points.
  - The rear hoist arms should have the pad extension raised to level out the vehicle on the hoist.

SERVICE PUBLICATION NAVIGATION

- The service publications for the Ranger Electric Vehicle (EV) are unique in many ways. When diagnosing and servicing the vehicle, use the following guidelines:
  - Use the Ranger Workshop Manual for diagnosing systems that are not unique to the Ranger EV.
  - Refer to the Ranger Electric Vehicle (EV) Electrical Vacuum Troubleshooting Manual (EVTM) when performing diagnostic procedures to note the differences in systems that are not unique to the Ranger EV.
  - Differences include fuse feeds, fuse ratings, wiring changes, etc.
- The format of the Ranger EV workshop manual supplement has been changed to assist in the diagnosis of vehicle concerns. Note the following differences when using this manual.
- The starting point for all diagnostics is Section 100-07, Electric Vehicle (EV) Diagnostic Direction. Section 100-07 contains the following sub-sections:
  - Diagnostic Preface – This sub-section will spell out several of the specific changes in the Ranger EV manual in contrast to other Ford workshop manuals.
  - Retrieving Diagnostic Trouble Codes (DTCs) – This sub-section will provide directions on the correct procedure to follow when retrieving DTCs. DTC retrieval on EVs is unique, and this sub-section should be studied carefully before retrieving codes. It contains valuable information on the correct sequence used to retrieve DTCs and how to determine if a DTC is valid.
  - Diagnostic Process (DP) series of pinpoint tests – These should be followed whenever initially diagnosing a vehicle concern.
  - Inspection and Verification sub-section – This sub-section provides information on visual inspections and the correct sections of the workshop manual to refer to when diagnosing a unique EV system.
  - DTC Index – The DTC index contains all DTCs that are available on the Ranger EV. The index is divided by the modules that will display them. It will provide information on the test mode that the DTCs will appear in, a brief description of the DTC, and the action to take if a DTC is retrieved.

  - Parameter Identification (PID) Index – These charts will provide a definition of the PIDs available in each module. They also give an expected value for each PID.
  - Miscellaneous Diagnostics – These diagnostics refer to DTCs that are set and relate to the operating condition of the control modules themselves.

- When a DTC is retrieved for a system, the DTC index will send you to the section that pertains to the system that would set that DTC. If no DTC is set, refer to Section 100-09 for symptom-based diagnostic direction.
- If no diagnostics are available in Section 100-09 for a no DTC concern, turn to the individual section for the component that has malfunctioned.
- When in a specific section, you should first look in the symptom chart.
- There is no separate DTC index in each section for the system with the concern. The DTCs have been added to the symptom charts to provide direction to the appropriate pinpoint test.
- A special tool chart precedes the pinpoint tests.

NOTES

ACTIVITY 4 – SPECIAL SERVICE TOOLS AND PROCEDURES – WORKSHEET H
SPECIAL TOOLS AND SERVICE PROCEDURES
STUDENT ANSWER SHEET

OBJECTIVE: To identify special service procedures for the Ranger EV.

DIRECTIONS: Write the correct answers in the blank spaces provided. Note the page number where the information was found.

1. What class of rubber insulating gloves is to be used, how often do the gloves need to be recertified, and when do they need to be tested? _____

   _____

   PAGE # _____

2. What are the methods of towing specified for the Ranger EV? _____

   _____

   _____

   _____

   _____

   PAGE # _____

3. What lift points and hoist pad positions are recommended for the Ranger EV? _____

   _____

   _____

   PAGE # _____

4. What is the correct buffer boundary that should be established around an EV, and how is this boundary marked? _____

   _____

   PAGE # _____

5. What is the tool number for the Power Steering Interlock Tool? _____

   _____

   PAGE # _____

6. What piece of equipment is specially designed for the Ranger EV battery pack removal and installation? __

   _____

   PAGE # _____

END OF WORKSHEET H

ACTIVITY 4 – SPECIAL SERVICE TOOLS AND PROCEDURES – WORKSHEET I
SERVICE PUBLICATION NAVIGATION
STUDENT ANSWER SHEET

OBJECTIVE: Perform service publication navigation using Ranger EV service publications.

DIRECTIONS: Using the Ranger EV service publications and your student reference guide, answer the following questions.

1. On what page of the service manual will you find directions for retrieving diagnostic trouble codes? _____

   _____

2. What information will the Diagnostic Preface provide you? _____

   _____

3. Which pinpoint test should you perform if you retrieve DTC C1184 after cycling the ignition on and off quickly? _____

   _____

4. What procedure does DP1 have you perform? _____

   _____

5. What is the description of TIM DTC C1750? _____

   _____

6. What is the description of BCM PID CCNTBCM? _____

   _____

7. What is the meaning of IAA operation state (OPSTATE) PID 12? _____

   _____

8. If a vehicle comes in that has no DTCs but will not charge, what section of the workshop manual should you refer to for diagnostic direction based upon the symptom? _____

   _____

9. What diagnostic routine are you directed to for the symptom described in question 8? _____

   _____

10. You have retrieved a DTC C1755 from the TIM. In which section and page number can the pinpoint test you will need to perform be found? _____

    _____

END OF WORKSHEET I

ACTIVITY 4 – SPECIAL SERVICE TOOLS AND PROCEDURES – WORKSHEET J
SPECIAL SERVICE TOOLS
STUDENT ANSWER SHEET

OBJECTIVE: To identify special service tools for Ranger EV.

DIRECTIONS: Go to the special service tools on the table. Find the tool that performs the function listed on the right, write in the number/letter of the tag on the tool, and write in the tool's name.

TAG #	TOOL NAME	DESCRIPTION
		Utilized when performing low voltage diagnostics on the BCM or TIM.
		Used when a traction battery module replacement is required.
		Connects between the traction battery LV 76-pin connector at the left front of the battery tray and the vehicle harness.
		Used to ensure that capacitors have discharged prior to performing vehicle service.
		Used to close the interlock loop on the vehicle during diagnostics.
		Confirm the operation of the speed sensors within the motor assembly.
		Aids in lifting, carrying, and removing the battery module from the traction battery pack.
		Uses pressure from a shop air source to raise and lower the traction battery.
		Is used as a safety device when the TIM is disconnected from the traction battery.
		Connects between the traction battery auxiliary load HV connector at the right front of the battery tray and the vehicle harness.
		Allows safe tightening of battery post connectors.
		Used to close interlock loop at power steering connector during diagnostics.

END OF WORKSHEET J

ACTIVITY 4 – SPECIAL SERVICE TOOLS AND PROCEDURES – WORKSHEET J1
ELECTRICAL CONNECTOR IDENTIFICATION
STUDENT ANSWER SHEET

OBJECTIVE: To locate and identify EV Ranger electrical connectors and determine if the circuits of that connector contain high voltage.

DIRECTIONS: Your instructor has labeled several of the vehicle connectors. Locate the correct connector on the vehicle or battery pack, note the tag letter/number, number of pins, and indicate if the connector has any high voltage circuits.

TAG #	CONNECTOR NAME	NUMBER OF PINS	HIGH VOLTAGE CIRCUITS (YES/NO)
	C1865		
	C1866		
	C1895		
	C1914		
	C1917		
	C1920		
	C1923		
	C1935		
	C1939		
	C1945		
	C3994		
	C5000		

END OF WORKSHEET J1

TECHNICIAN OBJECTIVES

- Explain diagnostic strategy (symptom-to-system-to-component-to-cause)
- Accurately and safely perform diagnostic and service procedures on a 1998 Ranger EV.

CONTENTS

INTRODUCTION TO RANGER EV DIAGNOSIS AND SERVICE PROCEDURES

As you have seen, the 1998 Ranger EV is unique in many ways from previous vehicles that you have seen. The differences in this vehicle mean that the diagnosis and service procedures are also unique.

Ford's service goal for all vehicles is to "Fix it Right the First Time, On Time." This goal also applies to the Ranger EV.

Although the 1998 Ranger EV is a completely new vehicle, service procedures for some of its systems are similar to those with which you are familiar. However, many systems on this vehicle are unique. These systems require service procedures that will be completely new to you. This portion of this course will show you the most accurate and efficient methods of performing vehicle diagnosis and service.

SYMPTOM-TO-SYSTEM-TO-COMPONENT-TO-CAUSE DIAGNOSIS

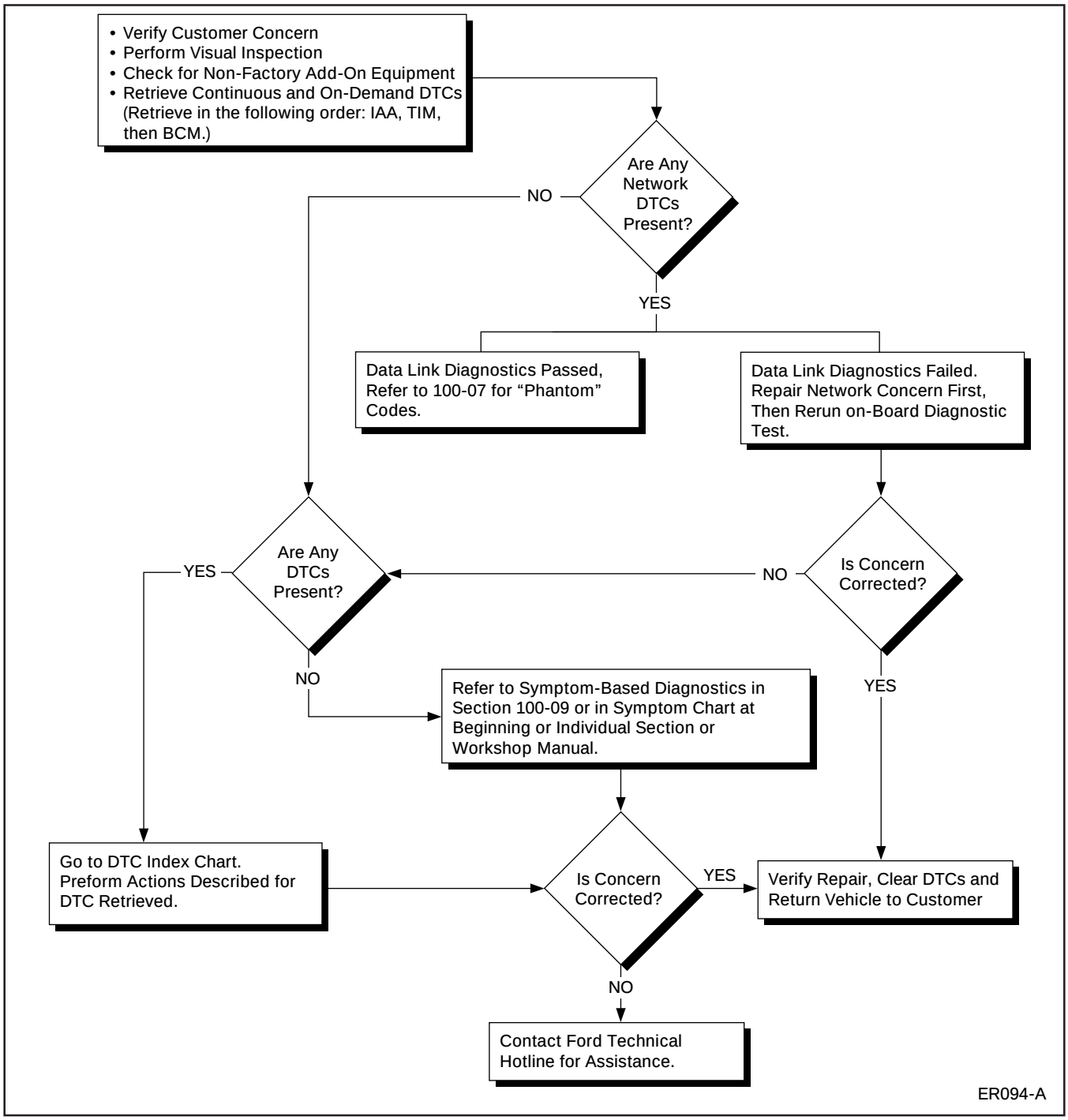
When diagnosing an automotive system, you should always follow standard procedures to locate clues to the cause of a concern. Using these clues, you can then determine what component(s) must be repaired or replaced in order to correct a concern. These clues can usually be found by using a logical, time-effective method. The "Symptom-to-System-to-Component-to-Cause" diagnostic technique is very effective in locating and correcting vehicle concerns.

To use the "Symptom-to-System-to-Component-to-Cause" diagnostic routine, all you have to do is follow the words in the title.

- First, determine the "Symptom" of the customer concern.
  - Ensure you understand the customer concern.
- Next, determine which "System" on the vehicle could be causing the symptom.
  - By eliminating systems that cannot cause the concern, time is saved by testing only systems that could cause the concern.
  - For example, there's not much sense in checking the air pressure of the tires if the vehicle has no power.

- Once you identify the particular system, you then want to determine which “Component(s)” within that system could be the cause for the customer concern.
  - This usually consists of a series of isolation tests.
  - These specific tests and routines can be found in the Workshop Manual or the Electrical and Vacuum Troubleshooting Manual (EVTM).
- Once the failed component is identified, you should always try and determine the “Cause” of the failure.
  - When the faulty or damaged component is located, the cause of the failure or damage must be identified and corrected to prevent repeated component failure.
  - For example, the component causing a system not to get power may be a blown fuse, but if you don’t repair the short that caused the fuse to fail, then the new fuse will fail as well.
- Diagnostic tests are usually isolation tests. The idea behind them is to check the operation of a specific component, without other components in the system affecting the component being tested. On the Ranger EV, this requires product knowledge, skill, and your ability to know how to use and interpret special tools.

RANGER EV DIAGNOSTIC FLOWCHART



Ranger EV Diagnostic Flowchart

The Ranger EV Diagnostic Flowchart will help provide you with a standardized procedure for diagnosing the Ranger EV. In many instances following the steps outlined in the flowchart will help you locate and correct many vehicle concerns.

Preliminary Diagnostic Procedures

As with all vehicles, when a Ranger EV is brought in with a concern certain preliminary diagnostic procedures should always be performed. These steps should include the following actions.

Verify the Concern – This step is critical in the diagnostic process. It is important that you understand exactly what the concern is in order for you to initiate the correct diagnostic steps.

- It is especially important that you determine if the customer concern is actually a vehicle malfunction, or if the concern may arise from the driver's lack of familiarity with the vehicle.
- Since electric vehicles are new to the driving public, it is possible that what the driver feels is a concern is just a normal operating characteristic of the vehicle.
- If this is the case, take the time to explain how the vehicle operates.

Perform a Visual Inspection – The reason for this is self-explanatory. Nothing is more frustrating than performing hours of diagnostics only to find a disconnected wire that was easily visible if a thorough visual inspection had been performed.

- Refer to Inspection and Verification in Section 100-07 of the workshop manual supplement for additional information on areas to focus on and what to look for during the visual inspection.
- During visual inspection check only the low voltage fuses.

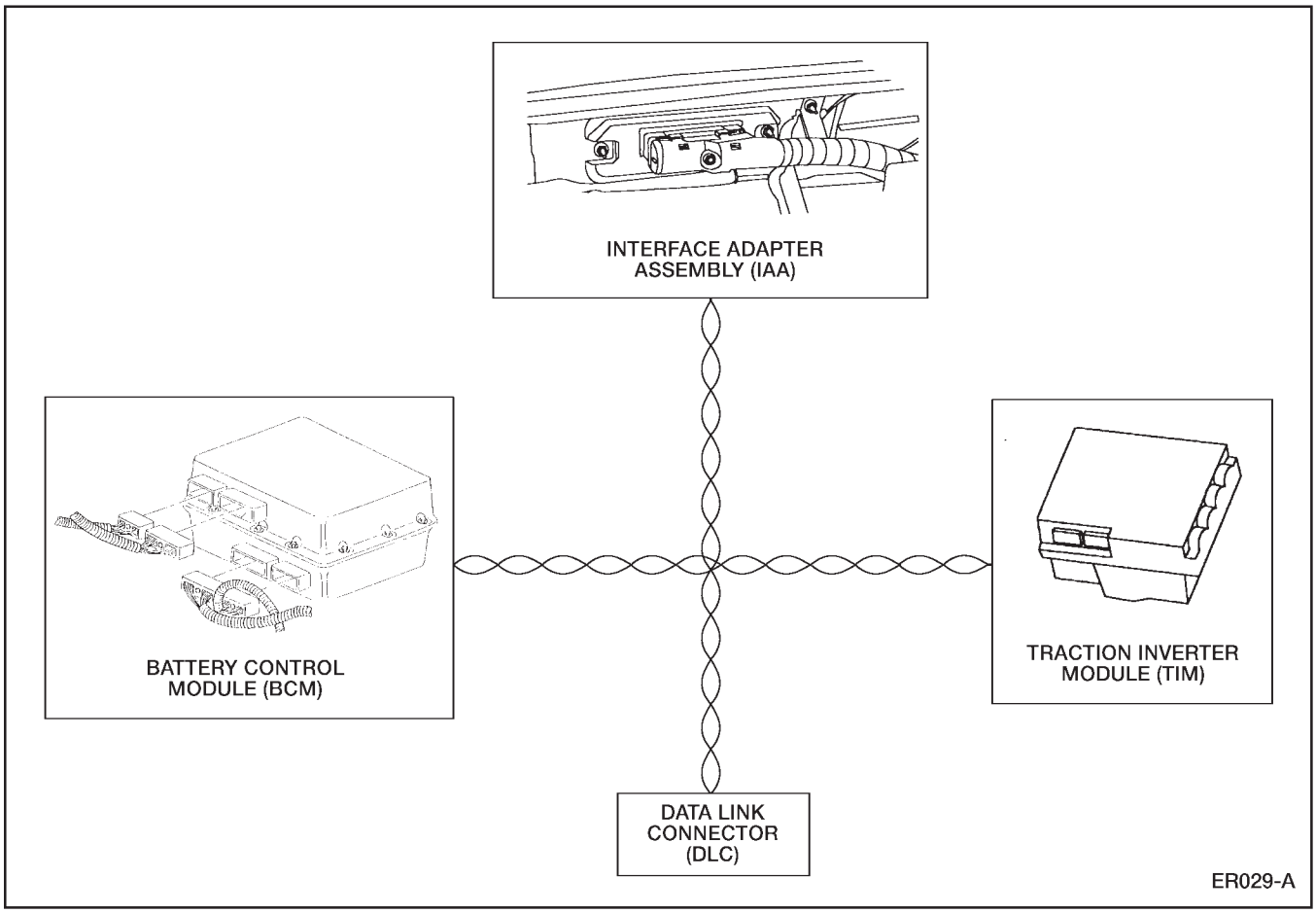
Check for Non-Factory Add-On Equipment – Many calls that come into the Ford Technical Hotline are the result of incorrectly installed add-on equipment.

- Because the Ranger EV will be used in many fleets, add-ons such as radios and light bars may be suspected causes of malfunctions.

Retrieve Diagnostic Trouble Codes (DTCs) – Retrieving DTCs from the control modules of the Ranger EV is unique.

- DTCs must be retrieved from the modules in a specific order (IAA, then TIM, then BCM).
- There are also other important considerations when retrieving DTCs that are unique to the Ranger EV.
- Refer to Retrieving Diagnostic Trouble Codes (DTCs) and the Diagnostic Process (DP Pinpoint Tests) in Section 100-07 of the workshop manual supplement.

MULTIPLEXING SYSTEM DIAGNOSIS



Multiplexing System

Operation

- The Ranger EV uses two module communications networks.
  - J1850 (SCP) network (two-way communication during normal vehicle operation) used by the battery controller module (BCM), interface adapter assembly (IAA) module, and traction inverter module (TIM).
  - International standards organization (ISO) 9141 network communication used by the anti-lock brake system (ABS) module, central timer module (CTM), and electronic crash sensor (ECS) module operates air bag system.
- The SCP network consists of a twisted pair cable data bus.
  - Circuit 914 data bus plus.
  - Circuit 915 data bus minus.

- The SCP network may remain operational even if one of the bus wires is open or shorted (to ground or power). However, all data may be corrupt and the network should be repaired prior to performing diagnostics.
  - The fault will be detected and a DTC will be set in the host module (IAA).
- The ISO 9141 network consists of a single wire, circuit 70.
  - If the wire is open or shorted (to ground or power) diagnostic communication between one or more of the modules will not be possible.

Network Diagnosis

- Before running any NGS diagnostics, perform the data link diagnostic test.
  - If a network concern exists, DTC(s) may be inaccurate.
- To perform the diagnostic Data Link Diagnostic Test routine (System Precheck) refer to the Ranger EV Workshop Manual, Section 418-00.
  - The System Precheck will direct you to the proper pinpoint test or symptom chart, according to test results.
- When network concerns are resolved normal diagnostic routines may be continued if needed.
  - It is possible that a network problem may be the cause of the original concern.
- For an electrical schematic, refer to the Electrical and Vacuum Troubleshooting Manual (EVTM).

NEW GENERATION STAR TESTER

Ranger EV NGS Program Card Main Menu

New Generation STAR (NGS) Tester is essential to Ranger EV diagnosis. While technicians are familiar with NGS tester use on conventional vehicles, the Program Card for the Ranger EV has unique features that will be covered in this lesson.

The Main Menu is similar to the conventional vehicle Program Card Main Menu.

- The Ranger EV Program Card Main Menu selections are:

  - VEHICLE AND ENGINE SELECTION
  - DIAGNOSTIC DATA LINK
  - VIEW RECORDER AREA
  - DIGITAL MEASUREMENT SYSTEM
  - GENERIC OBD II FUNCTIONS
  - SPECIAL FUNCTIONS
  - NEW GENERATION STAR SETUP
  - INTERNAL SYSTEM TESTS

- The most noticeable difference is the Vehicle and Engine Selection Function.
  - The Ranger EV Program Card is dedicated to the Ranger EV and no other selections are available.

Ranger EV Program Card Diagnostic Data Link Menu

To continue diagnostic routines, select DIAGNOSTIC DATA LINK.

- The Ranger EV Program Card Diagnostic Data Link Menu Selections are:

  - ABS-ANTI LOCK BRAKE MODULE
  - BCM-BATTERY CONTROLLER MODULE
  - CTM-CENTRAL TIMER MODULE
  - ECS-ELECTRONIC CRASH SENSOR
  - IAA-INTERFACE ADAPTER ASSEMBLY
  - TIM-TRACTION INVERTER MODULE
  - DATA LINK DIAGNOSTICS

- Before selecting any module test, select DATA LINK DIAGNOSTICS and press the trigger. This will check the network data bus to ensure that all the modules have good network communication.
  - If a module cannot communicate on the network it may be the cause of the concern.
- If network concerns exist, they must be corrected before any other NGS diagnostics can be performed.
  - Circuits 914 and 915 are the data bus circuits for the J1850 (SCP) network.
  - Circuit 70 is the data bus circuit for the ISO 1941 network.

Ranger EV Program Card Module Menu

Once the Data Link Diagnostics are performed and any network concerns are repaired (if present) the suspect module may be selected. The menu for each module is the same.

- Module Menu selections are:

  - DIAGNOSTIC TEST MODES
  - PID/DATA MONITOR AND RECORD
  - ACTIVE COMMAND MODES
  - MODULE IDENTIFICATION
  - DIAGNOSTIC TROUBLE CODE LIBRARY

- The Module Menu selections and functions are similar to other Ford vehicles and should be familiar to technicians.

NOTE: Use of parameter identification data (PID) is critical when diagnosing a Ranger EV. Technicians who are unfamiliar with the operation and utilization of the PID menu should refer to the New Generation STAR Tester Reference Guide.

Parameter Identification Data (PID) Monitor and Record

This menu will allow you to monitor and record the operation of many of the vehicle's components.

- Since there are so many PIDs available, there is also a definition (DEFN) function that will tell you the meaning of the acronym used to identify the component/function.
- Use of PIDs is critical when diagnosing the Ranger EV. If you are unfamiliar with the operation and utilization of the PID menu, refer to the New Generation STAR Tester Reference Guide.
- The PID Indices in Section 100-07 of the workshop manual supplement will provide you with PID descriptions and expected values.

Active Command Mode

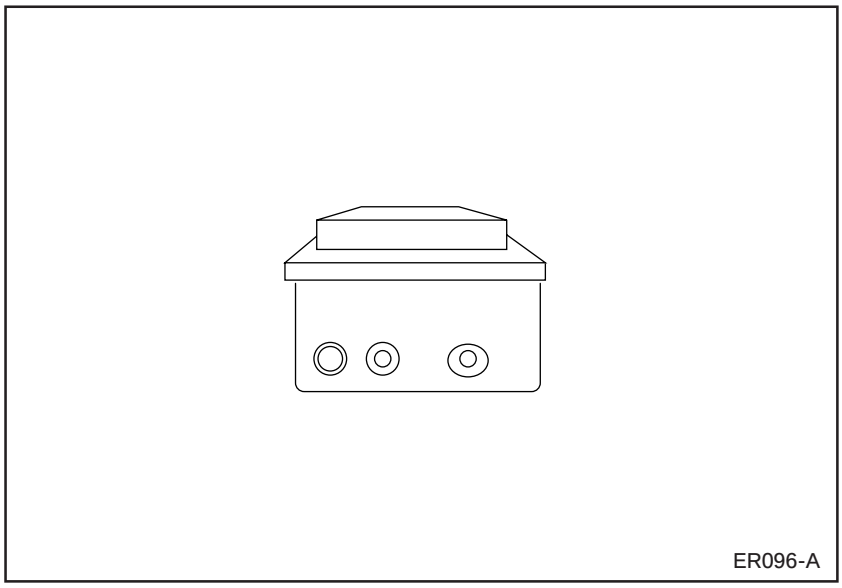
The Active Command Modes menu of the NGS will enable you to activate certain components of a vehicle system using the NGS to test the function. This can save time by determining if the source of the problem is in the component, or in the signaling system that activates it.

- For example, the Central Timing Unit Active Command Menu allows you to command on the windshield wiper.
- If the NGS can activate the wiper, the problem is likely in the wiper switch or circuits. If not, the wiper motor may need repair.
- As with PIDs, each module will have its own list of components that can be commanded in this menu.

There is an active command function for the Ranger EV standard corporate protocol (SCP) networked modules (IAA, BCM, and TIM) called "packeted" commands.

- This function allows the SCP modules to send more than one active command at the same time.
- This allows the NGS to enable multiple high voltage components simultaneously (A/C, IMC, power steering controller assembly, PTC, contactor box relays, etc.)
- In some cases it is required to use a packeted command series in order to activate a component.
  - For example, in order to activate the main contactor using the active command, you must first close the precharge contactor, or the NGS will not be able to perform the operation.

CONTACTOR BOX DIAGNOSIS



Contactor Box

- Diagnostic trouble code (DTC) C1862 is associated with the Contactor Box and its circuits.
- The Contactor Box Assembly (CBA) is basically an on/off switch for the traction battery.
- The CBA contains the high voltage contactor relays, fuses, and resistors.
  - The components of the CBA are controlled by the BCM, TIM, IAA, ignition switch, and Emergency Power Off (EPO) function.
- The only replaceable components inside the CBA are the fuses.
  - If any other component failure occurs the entire unit must be replaced.
- A critical concern in the CBA is the occurrence of an uncommanded contactor relay closure, resulting in high voltage power from the traction battery present outside of the traction battery assembly with the driver key in the OFF position.
  - This condition creates a hazardous situation and must be corrected before further diagnosis or repair is attempted.
- For complete diagnosis of the Contactor Box and circuits, refer to Workshop Manual Supplement, Section 414-03.

NOTES

ACTIVITY 5 – DIAGNOSIS – WORKSHEET K
NGS OPERATION AND IMPROPERLY CLOSED CONTACTOR RELAY DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will be able to navigate and utilize the various functions of the NGS, and be able to verify contactor relay operation.

DIRECTIONS: Go to the assigned classroom vehicles and using the special tools supplied, and the publications provided, perform the tasks and answer the questions below.

1. Once the NGS is booted, what is the first item that must be programmed into the tester? _____

   _____

2. Which menu item must be selected to perform on-board diagnostic tests? _____

   _____

3. Once you have entered this menu, which test should always be performed first? _____

   _____

   Why? _____

   _____

   _____

IRQ: *The SCP network may be able to communicate with the scan tool even if one of the two data bus wires are cut. However, tests are invalid because the information displayed may be inaccurate.*

4. Perform the test indicated in question 3. List the results below. _____

   _____

   _____

5. Do the results of the test performed in question 4 indicate that the system is OK? _____

   _____

6. If this system has a fault, you should:
   A. Ignore the fault and continue on-board diagnostics.
   B. Repair the fault then retest the vehicle to see if the concern is corrected.
   C. Jumper the circuit in question, then repeat the test to see if the fault clears.
   D. Perform an active command to determine if the circuit is actually functional. If it is, continue with on-board diagnostics.

7. Retrieve continuous and on-demand DTCs from the IAA, TIM, and BCM. Will all these modules support these functions? _____

   _____

WORKSHEET K CONTINUED ON NEXT PAGE

ACTIVITY 5 – DIAGNOSIS – WORKSHEET K
NGS OPERATION AND IMPROPERLY CLOSED CONTACTOR RELAY DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

8. List any DTCs retrieved. _____

   _____

9. If any continuous codes are stored in memory, the faults that set these DTCs:
   A. may not be occurring now.
   B. may be occurring now.
   C. have occurred at some time in the last 40 drive cycles (intermittent).
   D. all of the above.

IRQ: *Review continuous DTCs.*

10. Faults that set on-demand DTCs:
    A. may not be occurring now.
    B. are occurring now.
    C. have occurred at some time in the last 40 drive cycles (intermittent).
    D. all of the above.

IRQ: *Review on-demand DTCs.*

11. Return to the Diagnostic Data Link menu.
    – Select IAA module.
    – Select PID Data Monitor and record.
    – KEY ON.
    – Select VACPRES, CM_SPD, SET_TMP, PIDs.
    – Press START.
    – Randomly operate the climate control system by turning the temperature dial and A/C dial for 15 seconds.
    – Press trigger to CAPTURE DATA.
    – Again randomly operate the climate control system by turning the temperature dial and A/C dial for 15 seconds.
    – Press trigger again to STORE DATA.
    – Store data in area 2.
    – Follow the directions on the NGS screen.
    – Once data is stored, press cancel.
    – After saving, return to STORE DATA menu and select VIEW RECORDING.
    – Select all three PIDs to view.

WORKSHEET K CONTINUED ON NEXT PAGE

ACTIVITY 5 – DIAGNOSIS – WORKSHEET K
NGS OPERATION AND IMPROPERLY CLOSED CONTACTOR RELAY DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

12. View the PID activity in the table mode. Press REW. How many seconds before you pressed the trigger is data available? _____

13. Press PLAY. How many seconds after you pressed the trigger is data available? _____

14. Press CANCEL to exit the table mode. Enter the graph mode. How many PIDs can you view at the same time? _____

15. On the right and left sides there are numbers. What do these numbers indicate? _____

16. What NGS button do you press to move the graph forward? _____

    What button do you press to move the graph backward? _____

17. Looking at these PIDs, do these sensors appear to be functioning normally? _____

18. In the workshop manual, refer to Negative Contactor Relay Control Pinpoint Test step A2 in Section 414-03. Perform the test procedure described. What occurs to the voltage displayed? _____

19. What would it indicate if this PID indicated greater than 200 volts? _____

IRQ: *Explain that if voltage is not falling, main and negative contactors are stuck closed. Stuck contactors can cause the vehicle not to recharge. This could cause a safety concern if you are disconnecting the traction battery HV 2-pin connector C3994, because high voltage would be present at the connector. Whenever this connector is open use the traction battery high voltage lockout and diagnostic tool.*

20. While in the TIM active command mode select the following PIDs: BAT_PV, TPCCO, and TPMCO. Press START. Highlight PRECHG IN and command it to close. What occurs to the BAT_PV and TPCCO PID?

ACTIVITY 5 – DIAGNOSIS – WORKSHEET K
NGS OPERATION AND IMPROPERLY CLOSED CONTACTOR RELAY DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

21. Highlight POS MAIN and send a closed command. What occurs? _____

_____

IRQ. Explain that if you try to close the main contactor (POS MAIN) before closing the precharge contactor (PRECHG IN), the NGS will kick you out of the menu. The precharge contactor must close before main.

22. What are the definitions of the following PIDs?

BAT_PV _____

_____

TPCCO _____

_____

TPMCO _____

_____

END OF WORKSHEET K

CHARGING CONCERNS

The Power Control Station (PCS) recharges the traction battery. Under normal conditions all the driver has to do is plug the vehicle into the PCS, and the vehicle batteries will automatically be recharged.

If the PCS is connected to the vehicle and the green start button on the PCS is flashing, the vehicle is not charging.

Certain conditions may result in a failure of the recharging system. Let's look at some of the things that may cause a failure.

Determining the Source of a Charging Concern

The first thing that must be considered when diagnosing a charging concern is to determine if the cause is a failure of the charging system, or if it is the result of a Battery Control Module (BCM) strategy.

The BCM strategy is to prevent charging if:

- The battery is too hot or cold, as determined by signals sent from the four battery pack temperature sensors to the BCM. Each sensor monitors the temperature of the batteries in a certain region of the pack, and transmits this information to the BCM. If the indicated temperature is above 60°C (141ºF) or below -5° C (23ºF), BCM strategy will prevent charging of the battery pack.
- The BCM loses the ability to monitor the voltage of more than five battery modules, it will prevent the battery pack from charging.
- The state of charge of the battery is 99% or above, the BCM prevents charging voltage from reaching the pack.
- There is a difference of 30°C (86ºF) between any of the battery pack temperature sensors, the BCM strategy will prevent charging of the battery pack.

- The BCM strategy is to prevent charging if:
  - There is a failure of the high voltage auxiliary bus current sensor in the contactor box it will also prevent charging of the battery pack.
  - A battery module fails open.
  - A battery module internally shorts, the increased resistance will significantly reduce recharging capability.
  - The inertia switch is tripped, or there is an inertia switch fault.
  - Current leakage exists between the traction battery and chassis ground that reduces resistance to less than 10K ohms.
  - The vent fan is inoperative.
  - More than three battery pack temperature sensors fail.
  - The vehicle is not in Park, or the digital transmission range (DTR) sensor has a fault that indicates that it is not in Park.

If any of the above strategies are implemented, the BCM should store a DTC to indicate the cause of the no charge condition.

No DTC Charging Diagnosis

In some cases a fault in the AC power charging system will not result in a DTC being stored in the BCM memory. In these cases, certain procedures should be followed.

- When diagnosing an “Unable to Charge” concern, (as with all concerns), perform the preliminary diagnostic steps as described in Section 100-07 of the Ranger EV workshop manual supplement.
- As with all concerns where no DTC is present, refer to the symptom-based diagnostic procedures in Section 100-09, or to the symptom chart in the individual section of the workshop manual that pertains to the component that has malfunctioned.

NOTES

ACTIVITY 6 – DIAGNOSIS – WORKSHEET L
CHARGING SYSTEM DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will accurately diagnose the cause of an "unable to charge" concern.

DIRECTIONS: Go to assigned classroom vehicle. Read the repair order, then using the special tools supplied, and the publications provided, perform the tasks and answer the questions below.

1. What customer concern is listed on this repair order? (SYMPTOM) _____

   _____

2. What section of the service publications should you refer to when performing preliminary diagnostic procedures? _____

   _____

3. What SYSTEM(S) is affected by this fault? _____

   _____

4. If a charging system DTC is stored, in which module would you expect to find it? _____

   _____

5. List any DTCs present. _____

   _____

6. If any DTCs are present, do they seem to be valid? _____

IRQ: *Discuss phantom DTCs (especially U prefixed DTCs) and point out that if DATA LINK Diagnostics passes, U DTCs should generally be ignored.*

7. Diagnose the concern. List the steps you perform and their results in the table below. NOTE: The number of rows in the table does not indicate the number of steps in the diagnostic procedure. Use additional paper if required.

DIAGNOSTIC STEP	RESULT

8. What is the cause of this concern? _____

   _____

WORKSHEET L CONTINUED ON NEXT PAGE

ACTIVITY 6 – DIAGNOSIS – WORKSHEET L
CHARGING SYSTEM DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

9. List three possible causes that could cause a strategy to be implemented that will prevent the vehicle from charging. _____

   _____

   _____

10. What are the two types of PCS systems used with the Ranger EV? _____

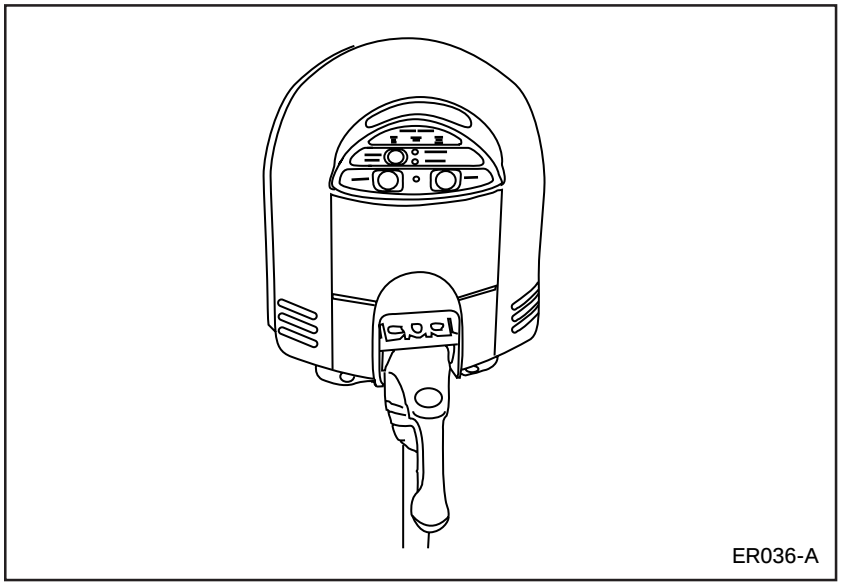
    _____

11. If a no charge condition is found to be caused by an on-vehicle component, what should you try and determine once you've found the component that's at fault? _____

    _____

END OF WORKSHEET L

POWER CONTROL STATION (PCS) DIAGNOSTIC PROCEDURES



Power Control Station (PCS)

In some cases an unable to charge concern may be the result of a fault in the PCS.

- If a vehicle is brought to you with this type of concern and its charging system seems to operate correctly, diagnosis of the customer PCS may be required.
- Be aware that Ford is not responsible for the operation, diagnosis, or repair of customer power control stations.
- It is the responsibility of the customer and the PCS manufacturer to ensure correct operation. However, the following procedures should be used in the event a PCS failure is suspected.
- The following diagnostic procedures are divided by the manufacturer of the PCS. The two PCS systems that are currently used for the Ranger EV are the SCI and EVI systems.

Diagnostic Procedure for SCI Power Control Station

If the vehicle fails to charge, and it is connected to an SCI PCS, use this procedure to determine if it is operating properly.

- Make note of any lights that are flashing or steadily illuminated on the PCS.
- Determine if the charge connector is properly inserted in the vehicle inlet and locked in place.
- If the Charge Interrupted Light is illuminated, the vehicle may have undergone a series of faults which forced the PCS to terminate the charge process.
  - Push the Stop button.
  - To clear the fault, unplug the charge connector from the vehicle inlet.
  - Inspect the charge cable and connector for any signs of possible damage (i.e., cuts, tears, or breaks in the cable insulation).
  - If damage is found, call the PCS manufacturer for repair.
  - If the charge cable /connector are undamaged, reconnect the PCS to the vehicle inlet.
  - If the Charge Interrupted Light is still illuminated or flashing, consult your local dealer to determine a possible vehicle fault.
- If the Service Light is illuminated:
  - Disconnect the charge connector from the vehicle inlet.
  - Turn off the power to your PCS at the service or disconnect panel.
  - Turning off the power may allow the PCS to clear the fault.
  - Turn the power back on and reconnect the PCS to the vehicle inlet.
  - If the Service Light is still illuminated, call the PCS manufacturer for repair or replacement.
- If the Immediate, Economy, or Charging light is illuminated, the PCS is operating correctly and vehicle diagnostics should be performed.
- If turning the PCS power on and off or unplugging and plugging the charge connector in the vehicle inlet does not cause any of the lights to illuminate on the PCS, the PCS has either failed or has a damaged charge cord. Call the PCS manufacturer for repair or replacement.

Diagnostic Procedure EVI Power Control Station

If the vehicle fails to charge, and it is connected to an EVI PCS, use this procedure to determine if it is operating properly.

- Make note of any lights that are illuminated or any messages being issued by your PCS.
- Determine if the charge connector is properly inserted in the vehicle inlet and locked in place.
- If the Protection Light is illuminated, the vehicle may have undergone a series of faults which forced the PCS to terminate the charge process.
  - Push the Stop button.
  - To clear the fault, unplug the charge connector from the vehicle inlet.
  - Inspect the charge cable and connector for any signs of possible damage (i.e., cuts, tears, or breaks in the cable insulation).
  - If damage is found, call the PCS manufacturer for repair.
  - If the charge cable /connector are undamaged, reconnect the PCS to the vehicle inlet.
  - If the Protection Light is still illuminated or flashing, consult your local dealer to determine a possible vehicle fault.
- If the Service Light is illuminated:
  - Disconnect the charge connector from the vehicle inlet.
  - Turn off the power to your PCS at the service or disconnect panel.
  - Turning off the power may allow the PCS to clear the fault.
  - Turn the power back on and reconnect the PCS to the vehicle inlet.
  - If the Service Light is still illuminated, call the PCS manufacturer for repair or replacement.
- If the Ready or Charging light is illuminated the PCS is operating correctly and vehicle diagnostics should be performed.
- If turning the PCS power on and off or unplugging and plugging the charge connector in the vehicle inlet does not cause any of the lights to illuminate on the PCS, the PCS has either failed or has a damaged charge cord. Call the PCS manufacturer for repair or replacement.

TRACTION BATTERY REMOVAL

In the event diagnostic procedures require that the traction battery must be removed from the vehicle for diagnostic and/or service procedures, strict adherence to the service publication procedures must be maintained.

Before removal of a the traction battery, read and follow the service procedures in Section 100-05:

- Rubber insulating gloves testing
- Buffer zone

Follow the procedures specified in Section 414-03 for traction battery removal.

NOTES

ACTIVITY 7 – DIAGNOSIS – WORKSHEET M
TRACTION BATTERY REMOVAL
STUDENT ANSWER SHEET

OBJECTIVE: The student will remove the traction battery.

DIRECTIONS: Go to the assigned classroom vehicle. The instructor will designate students to perform traction battery removal procedures. When not actually working on the vehicle, follow along in the workshop manual supplement and answer the questions on this worksheet.

1. What is the purpose of establishing a buffer zone around the vehicle? _____

   _____

2. What personal safety actions must be performed prior to traction battery removal? _____

   _____

3. What personal safety equipment must be worn during traction battery removal? _____

   _____

4. What is the first component that must be disconnected before removing the traction battery? _____

   _____

5. What must be installed when the HV 2-pin connector is disconnected from the battery pack? _____

   _____

6. What other electrical connectors must be removed prior to removing the traction battery from the vehicle?

   _____

7. Once the table is positioned under the vehicle and it is raised to contact the battery tray, the air controls of the table should be held on until what air pressure is reached? _____
8. How many bolts hold the battery pack in the vehicle? _____
9. What must you watch for when lowering the battery pack? _____

   _____

High Voltage Auxiliary Load System Diagnosis

The high voltage auxiliary load system includes all the high voltage components connected to the high voltage power distribution box (HVPDB).

These components include:

- the DC/DC converter (auxiliary battery charging).
- the A/C inverter motor controller (air conditioning).
- the positive temperature coefficient (PTC) switching module.
- the power steering controller assembly.

The failure of any of these high voltage systems may be caused by a component in the individual system or linked to the HVPDB.

- The HVPDB is a fuse box that provides protection to these systems.
- Always determine if one system connected to the HVPDB has failed or if multiple systems have failed.
- This will help determine the cause of the concern. If more than one system has failed, it may indicate a problem in the wiring or the HVPDB itself.
- If only one system has failed, a failed system component or an HVPDB fuse may be the cause of the failure.

As with all Ranger EV diagnostics, follow the diagnostic procedures in the workshop manual supplement.

- Begin the diagnostic procedure by referring to Section 100-07.
- This section will direct you to the correct procedure for the system you are diagnosing.
- Pinpoint tests must be performed exactly as written; do not skip steps.

WARNING: STRICT ADHERENCE TO SAFETY PROCEDURES IS MANDATORY WHEN PERFORMING THESE TESTS. FAILURE TO DO SO COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

NOTES

NOTES

ACTIVITY 8 – DIAGNOSIS – WORKSHEET N
PTC HEATER DIAGNOSIS DEMONSTRATION
STUDENT ANSWER SHEET

OBJECTIVE: This is a demonstration of the correct safety and diagnostic procedures to follow when diagnosing a vehicle with a PTC heater concern. It will also show correct safety procedures to follow when diagnosing HV components that are connected to the HVPDB.

DIRECTIONS: As the diagnostic procedure is performed, monitor the procedure and answer the questions below. Ask questions of the instructor as he performs this demonstration for any points that you may have questions about.

1. What is the customer concern? _____

   _____

2. What is the first section of the workshop manual that should be referenced to diagnose this system? _____

   _____

3. List the preliminary steps that are performed.

PRELIMINARY DIAGNOSTIC STEPS	RESULTS

4. List the diagnostic steps performed and their results.

IRQ: *PTC Heater Core operation is dependent on ambient temperature. Ambient temperature sensor under hood provides input to determine if one or both cores need to be turned on. Above 40°F, one core on; below 40°F, two cores on. Cores take turns coming on with each key cycle. Turn the key on at least twice with the heater on to ensure that both heaters have been actuated.*

DIAGNOSTIC TEST STEP	RESULT

END OF WORKSHEET N

NOTES

ACTIVITY 9 – DIAGNOSIS – WORKSHEET O
POWER STEERING DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation designated by your instructor. Read the repair order, then using the Ranger EV service publications, perform the tasks and answer the questions below.

1. What is the customer concern listed on the repair order? _____

_____

2. What section of the service publication should you refer to first? _____

_____

3. Can you verify this concern? _____

_____

4. When performing your visual inspection can you see any obvious reason for this concern? _____

_____

5. Are any DTCs present having to do with this concern? _____

_____

6A. If a DTC is present, what service publication section are you directed to? _____

_____

6B. If no DTC is present, what service publication section are you directed to? _____

_____

7. When turning to this section, what chart should you refer to for diagnostic direction? _____

_____

8. What series of pinpoint tests are you directed to perform? _____

_____

WORKSHEET O CONTINUED ON NEXT PAGE

ACTIVITY 9 – DIAGNOSIS – WORKSHEET O
POWER STEERING DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

9. Diagnose this concern using the procedures in the service publications. List the test steps you perform and their results in the table below. (**NOTE:** The number of rows in the table do not indicate the number of steps in the procedure. Use the back of the sheet if required.) FOLLOW ALL WARNINGS IN THE SERVICE PUBLICATION DURING YOUR DIAGNOSIS.

DIAGNOSTIC TEST STEP	RESULTS

END OF WORKSHEET O

ACTIVITY 9 – DIAGNOSIS – WORKSHEET P
AIR CONDITIONING DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation designated by your instructor. Read the repair order, then using the Ranger EV service publications, perform the tasks and answer the questions below.

1. What customer concern is listed on this repair order? _____

   _____

2. List the preliminary diagnostic steps that you performed (NOTE: assume on the road test that the concern is occurring as described by the customer.) _____

   _____

3. Are any DTCs present? _____
4. What SYSTEM(S) is affected by this fault? _____
5. Where does this system receive its high voltage power? _____

   _____

6. What workshop manual section would you refer to for diagnostic direction? _____
7. What is the next workshop manual section to which you are directed? _____

   _____

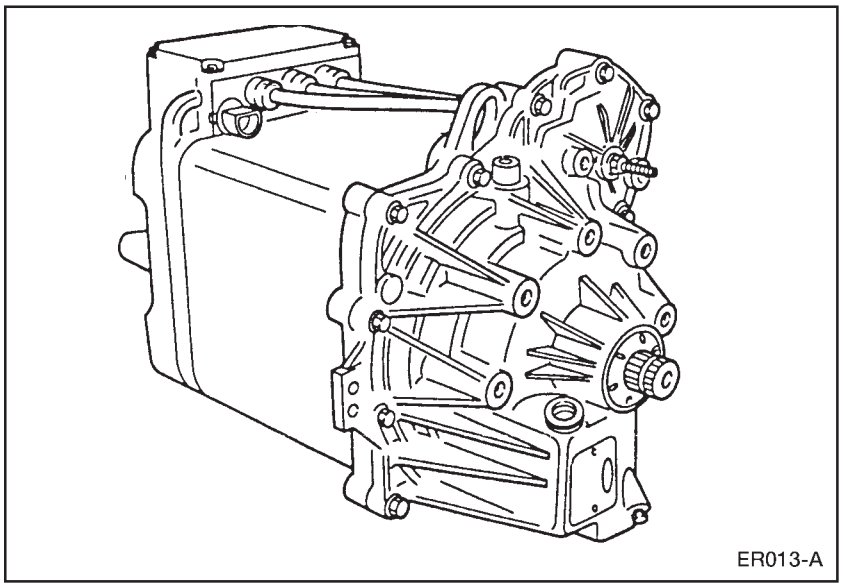
8. While performing diagnostic tests, what personal safety procedures should always be performed? _____

   _____

9. List the test steps that you perform and their results below. (**NOTE:** The number of rows in the table do not indicate the number of steps in the procedure. Use the back of the sheet if required.) Follow all warnings in the service publication during your diagnosis.

DIAGNOSTIC TEST STEP	RESULT

ELECTRIC MOTOR/TRANSAXLE DIAGNOSIS



Electric Motor/Transaxle

The Ranger EV uses a three-phase 90-hp electric motor with an integrated planetary gear transmission. The unit is not field serviceable, and is only serviced as an assembly.

To determine if a component of the motor/transaxle assembly is the source of a concern, Ford has developed the Electric Motor/ Transaxle Test Box.

This tool can test:

- motor speed sensor operation.
- motor temperature sensor operation.
- oil pressure sensor operation.
- oil pump operation.

Refer to the appropriate pinpoint tests for Electric Motor/ Transaxle Test Box diagnostic procedures.

NOTES

TRACTION BATTERY PACK COMPONENTS DEMONSTRATION

The traction battery pack contains many different components. The following is a list of these components. As your instructor points out these components, note the workshop manual section where service information on the components can be found.

- Thirty-nine 8-volt battery modules. SECTION _____
- High voltage wiring that connects the battery modules in a series circuit. SECTION _____
- A 250 amp busman fuse located between batteries 21 and 22. SECTION _____
- The contactor box. SECTION _____
- The battery control module (BCM). SECTION _____
- Battery pack cooling system. SECTION _____
- One sense lead connects between each two battery modules, except for modules 1 and 39, each of which has their own sense lead. SECTION _____
- Four temperature sensors to monitor battery operating temperatures. SECTION _____
- An optional battery heating system to maintain battery temperature in cold climates. SECTION _____
- A low-voltage wiring harness. SECTION _____

NOTES

TRACTION BATTERY DIAGNOSIS

Current Leakage Diagnosis

Current leakage is a condition that occurs if a short develops between the traction battery positive and/or negative bus and chassis ground. If this occurs, resistance is reduced due to the additional current path to ground. This additional path can result in reduction of vehicle range.

Current leakage is monitored by the battery control module (BCM), which monitors the resistance between the traction battery positive and negative bus and chassis ground. Normal resistance is usually greater than 100 K ohms.

The following symptoms may occur if current leakage is present.

- A short that reduces resistance between the traction battery and chassis ground below 50 K ohms but above 10 K ohms will set a DTC and illuminate the Electrical Hazard Warning Lamp.
- A short that reduces resistance between the traction battery and chassis ground below 10 K ohms will set a DTC and illuminate the Electrical Hazard Warning Lamp. If the vehicle is connected, the Power Control Station (PCS) for charging the on-board charger will not activate.

Multiple High Voltage Load Failure

Multiple high voltage load failure will cause the loss of all accessories connected to the high voltage auxiliary circuit. These include:

- the DC/DC converter (auxiliary battery charging).
- the A/C inverter motor controller (air conditioning).
- the positive temperature coefficient (PTC) heater.
- the power steering controller assembly.

This type of failure can be caused by a failure in various vehicle components including:

- the high voltage power distribution box (HVPDB).
- the high voltage wiring harness.
- the auxiliary load 40 amp fuse in the contactor box.
- the contactor box.

If a failure of this type occurs, the IAA module will store a DTC relating to the cause of the failure.

NOTES

NOTES

ACTIVITY 12 – DIAGNOSIS – WORKSHEET Q
CURRENT LEAKAGE AND MULTIPLE AUXILIARY LOAD FAILURE DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by your instructor. Read the repair order on the vehicle and isolate the cause of the concern.

1. What customer concern is listed on this repair order? _____

   _____

2. What section of the workshop manual should you look for diagnostic direction? _____

   _____

3. List the preliminary diagnostic steps that you performed (**NOTE:** assume on the road test that the concern is occurring as described by the customer). _____

   _____

4. Are any DTCs present? _____

   _____

5. Perform the diagnostic test steps required to locate the cause of the concern. List the steps you perform and their results below. **NOTE:** The number of rows in the table does not indicate the number of steps to perform. Use the back of this sheet if required.

DIAGNOSTIC TEST STEPS	RESULT

6. What is the cause of this concern?_____

   _____

7. What is the repair that should be performed? _____

   _____

8. What should be done before the vehicle is returned? _____

   _____

END OF WORKSHEET Q

ACTIVITY 12 – DIAGNOSIS – WORKSHEET R
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by the instructor. Read the repair order on the vehicle and isolate the cause of the concern.

1. What customer concern is listed on this repair order? _____

   _____

2. Perform the diagnostic test steps required to locate the cause of the concern. List the steps you perform and their results below. **NOTE:** The number of rows in the table does not indicate the number of steps to perform. _____

   _____

DIAGNOSTIC TEST STEP	RESULT

3. What was the cause of the concern? _____

   _____

END OF WORKSHEET R

Battery Diagnostic System (BDS) Battery Module and Sense Lead Diagnostics

Diagnosing a battery module or sense lead fault can be of critical importance when a vehicle is brought in for service.

- It is important to note that a single bad module or single sense lead will not usually illuminate any of the warning lights in the instrument cluster.
- However, if signals from five or more modules are lost, an emergency power off (EPO) condition will occur, which will result in a power limit light illumination, no charging, and a vehicle shutdown.

Because all the batteries in the battery pack are wired in series, a bad module may cause a significant loss of range. Because of this series arrangement, one weak module limits the energy output of the whole pack.

However, sometimes the symptoms may not be very apparent. Symptoms of module failure can vary depending on the severity of the failure.

- For example, if a module's capacity is only slightly lower than the other modules in the pack, the vehicle's range may only be decreased slightly.
- If the customer never runs the battery pack below 40 or 50% state of charge (SOC), they may not notice any decrease in vehicle range.
- However, DTC C1671 (BATTERY VOLTAGE OUT OF RANGE) will be stored in the BCM's memory.

If an individual module's capacity is significantly lower than the other modules of the battery pack, its failure can cause a significant decrease in vehicle range that will be readily apparent to most customers.

- It should be noted that weak battery modules tend to occur one at a time.
- A single battery sense lead failure will usually have no symptoms at all. As with a bad module, no warning light in the instrument cluster will illuminate, and the only way you may become aware of the failure is that a DTC 1671 will be stored in the BCM's memory.
- The rule for a sense lead failure is that a bad sense lead will cause a fault to be indicated in two modules.

- This is due to the fact that each sense lead monitors the voltage of two battery modules.
- For example, the sense lead that monitors the voltage for module 15 also monitors module 16's voltage.
- So a failure of the sense lead will cause both modules to indicate bad.
- The only exception is for battery modules 1 and 39, which are monitored by their own individual sense lead.

Manual Method for Diagnosing Battery Modules and Sense Leads

Early production versions of the NGS software may not support the battery diagnostic system (BDS). If this is the case the manual method of diagnosing battery modules and sense leads must be used. Use the Battery Voltage Record Sheet (the next sub-section of this book) and the following steps to locate the cause of a battery module or sense lead concern.

- Enter the BCM PID menu. Review the BAT_FT (battery sense lead fault) PID for each battery module.
- If there is a fault indicated, view the BAT_MV PID for that module in BCM active command mode.
- If that module indicates less than 3-volts, view the voltage indications of the modules around it. If the module voltage directly connected to the module that sets the fault (for example, module 2 set a fault, and module 1 or 3 also has a fault), suspect that a sense lead is bad.
- Operate the vehicle until the state of charge (SOC) PID indicates that the battery pack SOC is 20%.

- Return the vehicle to the repair facility.
- Actuate heater/defroster mode on high fan and leave on headlamps to discharge battery pack.
- When battery pack reaches 10% SOC, view BAT_MV PID for each of the 39 battery modules.
- Using the BAT_MV PID, record the battery voltage on the Battery Voltage Record Sheet. (A copy is provided on the next page. There is also a copy included as part of Worksheet L, and another copy that can be found in the Diagnostic Information Appendix.)
- Select the five lowest voltage battery modules.
- Return to the BAT_MV PID and record the voltages of the five lowest voltage battery modules.
- From these five, compare the voltage readings of the lowest three battery modules.
- If the lowest voltage battery is 0.1 less than the second lowest voltage battery, replace the lowest voltage battery module.
- If the second lowest voltage battery is more than 0.08 volts less than the third lowest voltage battery, replace the second lowest voltage battery.
- Prior to replacing the module, verify the serviceability of the battery's sense lead (measure for resistance of 30.9 K ohms), and verify the module's voltage reading with a DVOM.

Battery Voltage Record Sheet

Directions

1. Enter BCM ACTIVE COMMANDS.
2. Enter BATTERY MODULE SELECT menu.
3. Enter PID menu.
4. Select BAT_MV PID.
5. Press START.
6. Press SETUP button (8).
7. Press AUTO (4).
8. Press CANCEL to return to ACTIVE COMMAND menu.
9. With battery module highlighted, press TRIGGER. This will shrink highlighted (darkened) area to only include the battery module number.
10. Read and record voltage for battery module #1. Record the reading in the table below.
11. Rotate the scroll bar (center knob) and the module number will change. Read the voltage and record it.
12. Continue for each of the 39 battery modules. Record each reading in the table below.

BATTERY VOLTAGE READINGS	BATTERY VOLTAGE READINGS	BATTERY VOLTAGE READINGS
1.	14.	27.
2.	15.	28.
3.	16.	29.
4.	17.	30.
5.	18.	31.
6.	19.	32.
7.	20.	33.
8.	21.	34.
9.	22.	35.
10.	23.	36.
11.	24.	37.
12.	25.	38.
13.	26.	39.

13. Select the lowest five PIDS from above, and again view their voltage readings using the BAT_MV PID. Record their voltage readings.

BATTERY VOLTAGE READINGS	
Battery #	

14. Select the lowest three readings from the modules above.

BATTERY VOLTAGE READINGS	
Battery #	

Module Replacement Criteria

- If the lowest voltage battery is 0.1 less than the second lowest voltage battery, replace the lowest voltage battery module.
- If the second lowest voltage battery is more than 0.08-volts less than the third lowest voltage battery, replace the second lowest voltage battery.
- Prior to replacing the module, verify the serviceability of the battery's sense lead (measure for resistance of 30.9 K ohms), and verify the module's voltage reading with a DVOM.

Sense Lead Criteria

- If two adjoining modules are indicating incorrectly, the sense lead should be suspected and its resistance should be measured.
- Resistance specification is 30.9 K ohms.

Emergency Power Off (EPO)

In the event an unsafe condition occurs that will disable an interlock or if the inertia switch is triggered, an EPO signal will be sent to disable all high voltage loads.

- Can be set by IAA, BCM, or TIM.
- An EPO event will be accompanied by multiple instrument cluster lights illuminating and the vehicle shutting down.
- If an EPO occurs, a DTC will be set that will aid you in locating the source of the concern. Refer to the Ranger EV service publications for EPO diagnostic procedures.

NOTES

ACTIVITY 13 – DIAGNOSIS – WORKSHEET S1 (BDS)
BATTERY AND SENSE LEAD DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by the instructor. Perform the tasks and answer the question below.

1. Retrieve DTCs from the classroom vehicle. In what order should the modules be checked for DTCs? _____

   _____

2. List any DTCs present and in which module you found them? _____

   _____

3. What section of the workshop manual will provide diagnostic direction? _____

   _____

4. What does this DTC indicate? _____

   _____

5. What section of the workshop manual contains the pinpoint tests required to diagnose this fault? _____

   _____

6. Perform the diagnostic steps and list your results in the table below.

DIAGNOSTIC STEP	RESULT

7. According to the service publications, what must be done before installing a new battery module? _____

   _____

END OF WORKSHEET S1

ACTIVITY 13 – DIAGNOSIS – WORKSHEET S2 (NON-BDS)
BATTERY AND SENSE LEAD DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by the instructor. Read the repair order on the vehicle and isolate the cause of the concern.

1. Retrieve DTCs from the classroom vehicle. In what order should the modules be checked for DTCs? _____

   _____

2. List any DTCs present and in which module you found them? _____

   _____

3. What section of the workshop manual will provide diagnostic direction? _____

   _____

4. What does this DTC indicate? _____

   _____

5. What is the next step you should perform? _____

   _____

6. Are there any indications of the source of the concern? _____

   _____

7. Is the vehicle at the correct state of charge to measure the battery voltage to determine if there is a battery module fault? _____

8. Exactly what is the state of charge of this vehicle? _____

   _____

9. While monitoring SOC PID, turn heat on high for three minutes. What is the state of charge at the end of the three minutes? _____

   _____

10. What is the state of charge supposed to be when testing for a bad battery module? _____

    _____

ACTIVITY 13 – DIAGNOSIS – WORKSHEET S2 (NON-BDS)
BATTERY AND SENSE LEAD DIAGNOSIS
STUDENT ANSWER SHEET (Continued)

11. Check the individual voltage of all the battery modules. Use the attached Battery Module Record Sheet found on the next page.
12. If any modules are suspect, list the module number. Module number will vary depending upon where bad module is installed.
13. Does the information on the Battery Module Record Sheet indicate any other concerns are present? _____

    _____

    _____

14. In order to verify your diagnosis of the component(s) that are indicating a fault, what steps should you perform? _____

    _____

    _____

15. Perform the verification tests. Was your diagnosis correct? _____
16. Prior to installing a new battery module what should be done? _____

    _____

END OF WORKSHEET S2 (NON-BDS)

Battery Module Record Sheet

Directions

1. Enter BCM ACTIVE COMMANDS.
2. Enter BATTERY MODULE SELECT menu.
3. Enter PID menu.
4. Select BAT_MV PID.
5. Press START.
6. Press SETUP button (8).
7. Press AUTO (4).
8. Press CANCEL to return to ACTIVE COMMAND menu.
9. With battery module highlighted, press TRIGGER. This will shrink highlighted (darkened) area to only include the battery module number.
10. Read and record the voltage for battery module # 1. Record the reading in the table below.
11. Rotate the scroll bar (center knob) and the module number will change. Read the voltage and record it.
12. Continue for each of the 39 battery modules. Record each reading in the table below.

BATTERY VOLTAGE READINGS	BATTERY VOLTAGE READINGS	BATTERY VOLTAGE READINGS
1.	14.	27.
2.	15.	28.
3.	16.	29.
4.	17.	30.
5.	18.	31.
6.	19.	32.
7.	20.	33.
8.	21.	34.
9.	22.	35.
10.	23.	36.
11.	24.	37.
12.	25.	38.
13.	26.	39.

13. Select the lowest five PIDS from above, and again view their voltage readings using the BAT_MV PID. Record their voltage readings.

BATTERY VOLTAGE READINGS	
Battery #	

14. Select the lowest three readings from the modules above.

BATTERY VOLTAGE READINGS	
Battery #	

Module Replacement Criteria

- If the lowest voltage battery is 0.1 less than the second lowest voltage battery, replace the lowest voltage battery module.
- If the second lowest voltage battery is more than 0.08-volts less than the third lowest voltage battery, replace the second lowest voltage battery.
- Prior to replacing the module, verify the serviceability of the battery's sense lead (measure for resistance of 30.9 K ohms), and verify the module's voltage reading with a DVOM.

Sense Lead Criteria

- If two adjoining modules are indicating incorrectly, the sense lead should be suspected and its resistance should be measured.
- Resistance specification is 30.9 K ohms.

ACTIVITY 13 – DIAGNOSIS – WORKSHEET T
EPO DIAGNOSIS
STUDENT ANSWER SHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by the instructor. Read the repair order on the vehicle and isolate the cause of the concern.

1. What customer concern is listed on this repair order? _____

   _____

2. Can you verify the concern? _____
3. Is there any visual indication of the cause of the fault? _____
4. Are any DTCs present? _____

   _____

5. Perform the diagnostic test steps required to locate the cause of the concern. List the steps you perform and their results below. NOTE: The number of rows in the table does not indicate the number of steps to perform. Use the back of this sheet if required.

DIAGNOSTIC TEST STEPS	RESULT

6. What is the cause of the concern? _____

   _____

END OF WORKSHEET T

RANGER EV ACRONYMS

ABS – Anti-Lock Brake System

AC – Alternating Current

A/C – Air Conditioning

APS – Accelerator Position Sensor

BCM – Battery Controller Module

BOB – Breakout Box

CBA – Contactor Box Assembly

CPR – Cardio-Pulmonary Resuscitation

CTM – Central Timer Module

DC – Direct Current

DC/DC – Direct Current to Direct Current

DEFN – Definition

DTC – Diagnostic Trouble Code

DTE – Distance to Empty

DVOM – Digital Volt Ohmmeter

ECON MODE – Economy Mode

ECS – Electronic Crash Sensor

ECU – Electronic Control Unit

EEC – Electronic Engine Control

EPO – Emergency Power Off

ETC – Electronic Throttle Control

EV – Electric Vehicle

EVTM – Electrical and Vacuum Troubleshooting Manual

GND – Ground (Electrical)

HV – High Voltage

HVPDB – High Voltage Power Distribution Box

IAA – Interface Adapter Assembly

ICE – Internal Combustion Engine

IGBT – Insulated Gate Bipolar Transistor

IMC – Inverter Motor Controller

LOS – Limited Operating Strategy

MCP – Master Cylinder Pressure

MIL – Malfunction Indicator Lamp

MSDS – Material Safety Data Sheets

NGS – New Generation STAR Tester

OBD-II – On Board Diagnostics-Second Generation

PCS – Power Control Station

PID – Parameter Identification

POST – Power On Self Test

PRNDE – Park/Reverse/Neutral/Drive/Economy

P/S – Power Steering

PTC – Positive Temperature Coefficient

RAM – Random Access Memory

RBS – Regenerative Braking System

ROM – Read Only Memory

SCP – Standard Corporate Protocol

SLI – Starting/Lighting/Ignition (12-Volt Battery)

SOC – State of Charge

TIM – Traction Inverter Module

VBC – Variable Blower Control

VSL – Voltage Sense Lead

WRITTEN ACTIVITY SHEET 1
STUDENT ANSWER SHEET

DIRECTIONS: Using the information provided in your Student Reference Guide and the appropriate service publication read and answer the following questions.

1. What fuses inside the contactor box (and its cover) are serviceable? _____

   _____

2. What indication would you see if more than one contactor relay is improperly closed? _____

   _____

3. If a vehicle is brought to you with an "Unable to Charge" concern and no DTC is present, what PID would you select to view?_____

   _____

4. If the PID above displayed a 101, what would it indicate? _____

   _____

5. What type of grease must be applied whenever electrical connectors are disconnected or worked on? _____

   _____

6. Why is the in-line bypass battery module used to charge the battery pack when a new battery module is installed? _____

   _____

7. What control module monitors battery leakage?_____

   _____

8. To disable all the loads on the Ranger EV, where should you remove the ground connections?_____

   _____

9. What does DTC C1862 indicate? _____

   _____

10. What symptoms may occur if a DTC C1750 is set in the TIM? _____

    _____

11. Which diagnostic strategy does Ford recommend be used when diagnosing a vehicle? _____

    _____

12. What personal safety steps should always be performed before working on the Ranger EV? _____

    _____

END OF ACTIVITY SHEET 1

ACTIVITY SHEET 2
STUDENT ANSWER SHEET

DIRECTIONS: Using the information provided in your Student Reference Guide, read and answer the following questions.

1. Which circuits are the data bus for the J1850 (SCP) network? _____

   _____

2. When testing for an improperly closed contactor relay, what PID should you monitor? _____

   _____

3. The battery pack will not charge if the temperature sensors indicate the battery temperature is above _____ or below _____ .

4. What symptom will occur if the auxiliary contactor relay fails open? _____

   _____

5. In order to discharge the high voltage capacitors in the auxiliary components, how long should you wait before probing the connectors? _____

   _____

6. What instrument cluster light will illuminate if a short reduces resistance between the traction battery and ground below 50 K ohms? _____

   _____

7. What connector is between the TIM and the traction contactor relay? _____

   _____

8. Network DTCs should be repaired only if repairing the cause of other DTCs does not correct the concern (circle one). TRUE or FALSE.

9. What symptoms will occur if the traction motor encoder circuit fails below 3 km/h (2 mph)? _____

   _____

   _____

10. What personal safety steps should always be performed before working on the Ranger EV? _____

    _____

11. What is the correct resistance for a battery sense lead? _____

    _____

12. What does DTC B1238 indicate? _____

    _____

END OF ACTIVITY SHEET 2

GENERIC WORKSHEET

OBJECTIVE: The student will safely and accurately diagnose a Ranger EV concern.

DIRECTIONS: Go to the workstation as directed by the instructor. Read the repair order on the vehicle and isolate the cause of the concern.

1. What customer concern is listed on this repair order? _____

2. Perform the diagnostic test steps required to locate the cause of the concern. List the steps you perform and their results below. **NOTE:** The number of rows in the table does not indicate the number of steps to perform. Use the back of this sheet if required.

DIAGNOSTIC TEST STEP	RESULT

3. What was the cause of the concern? _____

END OF WORKSHEET