Contents

•CAUTION

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

Proper service and repair are important to the safety of the service technician and the safe, reliable operation of all Lithium Ion Battery Packs. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality.

To gain additional knowledge in the use and handling of Green Cubes Battery Packs, please refer to Green Cubes Publication: USE AND CARE SAFETY GUIDELINES

The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specifically designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure, or tool which is not recommended by the manufacturer, must first determine that neither his safety nor the safe operation of the unit will be jeopardized by the replacement part, service procedure or tool selected.

It is important to note that this manual contains various Cautions and Notices that must be carefully observed in order to reduce the risk of personal injury during service or repair, or the possibility that improper service or repair may damage the unit or render it unsafe. It is also important to understand that these “Cautions” and “Notices” are not exhaustive, because it is impossible to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

Common Abbreviations

Ah	AMPERE HOUR (AMP-HOUR)
A	AMPS
APP	PHONE APPLICATION
BARO -	BAROMETRIC PRESSURE
BAT -	BATTERY, BATTERY POSITIVE TERMINAL, BATTERY OR SYSTEM VOLTAGE
B+ -	BATTERY POSITIVE
B-	BATTERY NEGATIVE (B-)
BDI	BATTERY DISPLAY INDICATOR
BMS	BATTERY MANAGEMENT SYSTEM (Module)
BRET	BATTERY RETURN (B-)
CAN -	CONTROLLER AREA NETWORK
CKT -	CIRCUIT
CONN -	CONNECTOR
CTR	CONTACTOR
DEG -	DEGREES
.dfi	FILE EXTENSION FOR DISPLAY GAGE
DFU	DEVICE FIRMWARE UPDATE MODE
DIAG -	DIAGNOSTIC
DICH	DISCHARGE
DLC -	DATA LINK CONNECTOR
DTC -	DIAGNOSTIC TROUBLE CODE
DVOM -	DIGITAL VOLT OHMMETER
E-STOP-	EMERGENCY STOP
FMI -	FAILURE MODE INDICATOR
GO	GENERAL OUTPUT
GND -	GROUND
INSTR	INSTRUMENTATION
I/O -	INPUT/OUTPUT
LI	LITHIUM ION
LED	LIGHT EMITTING DIODE (INDICATOR LAMP)
MSEC -	MILLISECOND
MPR -	MAIN POWER RELAY
NO CHG	NO CHARGE (NOT CHARGING)
N/C -	NORMALLY CLOSED
N/O -	NORMALLY OPEN
OBD -	ON-BOARD DIAGNOSTIC
OPT -	OPTIONAL
PC	PERSONAL COMPUTER
PWM -	PULSE WIDTH MODULATION
RAM -	RANDOM ACCESS MEMORY
REF HI -	REFERENCE HIGH
REF LO-	REFERENCE LOW
ROM -	READ ONLY MEMORY
RLY	RELAY
SPN -	SUSPECT PARAMETER NUMBER
SW -	SWITCH
TENP	TEMPERATURE
TERM -	TERMINAL
V -	VOLTS

Wire Color Abbreviations

ABBREVIATION		MAIN COLOR		TRACER COLOR
BLK	-	BLACK		–
BLK/WHT	-	BLACK	/	WHITE
BLK/RED	-	BLACK	/	RED
BLU	-	BLUE		–
BLU/BRN	-	BLUE	/	BROWN
BLU/YEL	-	BLUE	/	YELLOW
BRN	-	BROWN		–
GRN	-	GREEN		–
GRN/WHT	-	GREEN	/	WHITE
GRY	-	GREY		–
GRY/BLK	-	GREY	/	BLK
LT.BLU	-	LIGHT BLUE		–
LT.BLU/BLK	-	LIGHT BLUE	/	BLACK
LT.BLU/WHT	-	LIGHT BLUE	/	WHITE
LT.GRN	-	LIGHT GREEN		–
GRN/YEL	-	GREEN	/	YELLOW
GRN/ORG	-	GREEN	/	ORANGE
ORG	-	ORANGE		–
ORG/BLK	-	ORANGE	/	BLACK
ORG/WHT	-	ORANGE	/	WHITE
PNK	-	PINK		–
PNK/BLK	-	PINK	/	BLACK
PUR/GRN	-	PURPLE	/	GREEN
PUR/BLU	-	PURPLE	/	BLUE
RED	-	RED		–
RED/WHT	-	RED	/	WHITE
RED/BLACK	-	RED	/	BLACK
RED/BLU	-	RED	/	BLUE
TAN	-	TAN		–
TAN/BLK	-	TAN	/	BLACK
VIO	-	VIOLET		–
VIO/BLK	-	VIOLET	/	BLACK
VIO/WHT	-	VIOLET	/	WHITE
WHT	-	WHITE		–
WHT/BLK	-	WHITE	/	BLACK
WHT/BRN	-	WHITE	/	BROWN
WHT/GRN	-	WHITE	/	GRN
WHT/PUR	-	WHITE	/	PURPLE
WHT/RED	-	WHITE	/	RED
WHT/YEL	-	WHITE	/	YELLOW
YEL	-	YELLOW		–

General Diagnostic Aids

BATTERY MANAGEMENT SYSTEM (BMS)

Self- Diagnostics

The BATTERY MANAGEMENT SYSTEM (BMS) performs a continuous self diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The BMS's language for communicating the source of a malfunction is a system of Diagnostic Trouble Codes (DTC's). When a malfunction is detected by the BMS, a DTC is set and the Malfunction Indicator Lamp (MIL) is illuminated.

Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) is designed to alert the operator that a problem has occurred and that the equipment should be taken for service as soon as reasonably possible. If the problem goes away, the light will go out in most cases after 10 seconds, but a DTC will remain stored in the BMS. When the light remains "ON" with the pack switched "ON" or when a malfunction is suspected due to an operational problem, the "On-Board Diagnostic (OBD) System Check" must be performed as the first step. These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

Diagnostic Trouble Codes DTC's

The Battery Management System (BMS) monitors all battery pack operations against preset calibrated limits. When a component goes outside of its calibrated limits the BMS sets a DTC. The DTC will be stored in the BMS and the Malfunction Indicator Lamp (MIL) will illuminate. If the component goes back into it's normal operation window the MIL will shut off but the DTC will still be stored in the BMS under DTC history until it is cleared. If the MIL stays illuminated it indicates a current malfunction in the battery pack should be serviced immediately.

Reading Diagnostic Trouble Codes

The provision for communicating with the BMS is the Data Link Connector (DLC). refer to figure 1-2. It is part of the battery pack wiring harness, and is a USB connector, which electrically connects to the BMS. The DTC's stored in the BMS's memory can be retrieved with a cable plugged into the DLC, or a PC based software program designed to interface with the BMS data stream.

On-Board Diagnostic (OBD) System Check

After the visual/physical inspection, the "On-Board Diagnostic (OBD) System Check" is the starting point for all diagnostic procedures. The correct procedure to diagnose a problem is to follow two basic steps:

1. Are the on-board diagnostics working? This is determined by performing the "On-Board Diagnostic (OBD) System Check." This is the starting point for the diagnostic procedures. The OBD system check will lead to a diagnostic table in the Diagnosis section to correct the problem.
2. Is there a DTC stored? If a DTC is stored, go directly to that DTC table number in the Diagnosis section.

Using the PC to read DTC's

Connect the USB cable to your PC. Turn on your PC and select the BMS tool. Once connected turn the Main switch "ON" It is helpful to write down each DTC as it is shown to help with further diagnostics when they are needed.

BMS Tool Diagnostic Software

The BMS can communicate a variety of information through the DLC. This data is transmitted at a high frequency which requires a scan tool for interpretation. With an understanding of the data which the BMS Tool Diagnostic Software displays, and knowledge of the circuits involved, the scan tool can be very useful in obtaining information which would be more difficult or impossible to obtain with other equipment. The BMS Tool Diagnostic Software does not make the use of diagnostic tables unnecessary, nor do they indicate exactly where the problem is in a particular circuit.

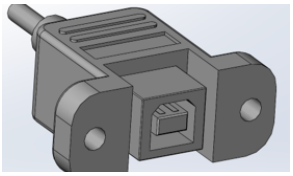


Figure 1-2 Data Link Connector (DLC)

BMS Tool Diagnostic Software With Intermittents

Intermittents are problems that occur in irregular intervals. The system may function normally most of the time then occasionally have problems that seem to fix themselves. This a good example of an intermittent problem.

The BMS Tool Diagnostic Software provides the ability to perform a "wiggle test" on wiring harnesses or components with main switch on, while observing the display.

The BMS Tool Diagnostic Software can be plugged in and observed while operating under the condition when the MIL turns "ON" or the system operation is poor. If the problem seems to be related to certain parameters that can be checked on the BMS Tool Diagnostic Software, they should be checked during operation with system on. If there does not seem to be any correlation between the problem and any specific circuit, the BMS Tool Diagnostic Software can be checked on each position, watching for a period of time to see if there is any change in the readings that indicates an intermittent operation.

The BMS Tool Diagnostic Software is also an easy way to compare the operating parameters of a poorly operating system with those of a known good one. For example, a sensor may shift in value but not set a DTC. Comparing the sensor's readings with those of a known good identical PACK may uncover the problem.

The BMS Tool Diagnostic Software has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the BMS Tool Diagnostic Software successfully for diagnosis lies in the technician's ability to understand the system they are trying to diagnose, as well as an understanding of the BMS Tool Diagnostic Software operation and limitations. The

technician should read the tool manufacturer's operating manual to become familiar with the tool's operation.

How Diagnostic Trouble Codes (DTC) Are Set

The BMS is programmed to receive calibrated voltage signals from individual cells and sensors. The voltage signal from the sensor may range from as low as 0.1 volt to as high as 4.9 volts. The sensor voltage signal is calibrated for each PACK application. This would be the sensor's operating parameter or "window."

If a sensor is within its operating or acceptable parameters, the BMS does not detect a problem. When a sensor voltage signal falls out of this "window," the BMS no longer receives a signal voltage within the operating "window." When the BMS does not receive the "window" voltage for a calibratable length of time, a DTC will be stored. The MIL will be illuminated and a calibrated default value may replace the sensor value to restore system performance. If the fault may result in a condition that constitutes a safety concern, the system will shut down and become inoperative.

Clearing Diagnostic Trouble Codes

The following procedure will instruct you on the method for clearing codes from the BCS's fault code memory.

Before you clear codes it is advisable to record the codes by writing them on a piece of paper or in your service notebook. Since you may want to remember which codes were set at a later time.

1. Connect your PC to the USB diagnostic link connector (DLC) located on the device. You may need to remove the cap from this connector to access the connector.
2. Turn the operating switch to the on position.
3. Select the "clear codes" or the "clear DTC's" function
4. Clear DTC's
5. Turn Operating switch OFF (key off) for at least 20 seconds.
6. Turn operating switch ON and reread DTC's. If DTC's are still present, check "Notice" below and repeat procedure following from step 2.

NOTICE: When clearing DTC's with the use of a code reader, the operating switch must be cycled to the OFF position or the DTC's will NOT clear.

Non-Scan Diagnosis of operating concerns (No DTC's Set)

If Operating concerns still exist after following the OBD system check and reviewing the Symptoms tables, an out of range sensor may be suspected. Because of the unique design of the BCS, the BMS will occasionally replace sensed values with calibrated default values in the case of a sensor or circuit malfunction. By allowing this to occur, limited system performance is restored until the system is repaired. A basic understanding of sensor operation is necessary to be able to diagnose an out of range sensor.

If the sensor is out of range, but still within the operating "window" of the BCS, the problem may go undetected by the BCS and may result in an operation concern.

To identify a sensor that is out of range, you could unplug the sensors electrical connector while the system is functional. After a short period of time, the DTC for that sensor will set, illuminate the MIL, and replace the sensed value with a calibrated default value. If at that point, a noticeable performance variation may be observed, the DTC table for that particular sensor should be followed to correct the problem.

NOTICE: Be sure to clear each DTC after disconnecting and reconnecting each sensor. Failure to do so may result in a misdiagnosis of the operation concern.

Battery Disconnect Caution

•Caution: Before servicing any electrical component, the system operating switch-key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in the procedures. As a further precaution, you may want to

disconnect the battery cables from the battery fork truck or device. This will help ensure that there will not be any accidental short-to-ground connections. Failure to follow these precautions may cause personal injury and/or damage to the equipment or its components.

Documentation

Green Cubes battery packs are made in several voltages. At this time packs are offered from 12V to 80V with some packs able to be set up for variable voltages.

Additionally, upon customer request, custom packs are made.

Due to the large number of offerings and the possibility of custom packs, this manual can only address common or representative builds and is not all inclusive. Therefore, we suggest that one of the first activities a technician engages in, during the visual inspection process, is to document the pack being worked on. Make notes and take pictures of the system before beginning diagnostics, or any component installations.

Special Tools and Equipment

Digital Volt Ohm Meter (DVOM)- Essential

A Digital Volt-Ohm Meter (DVOM) is an essential tool for a number of diagnostic procedures associated with the battery pack. A Fluke 77 or equivalent DVOM is recommended.

Fig. 1-3 Digital Volt Ohm Meter (DVOM)

USB Cable- Essential

A USB-A to USB-B cable will be required to connect the battery pack Diagnostic Link Port to a laptop or desktop PC. These can be sourced on line or at any computer store or department.

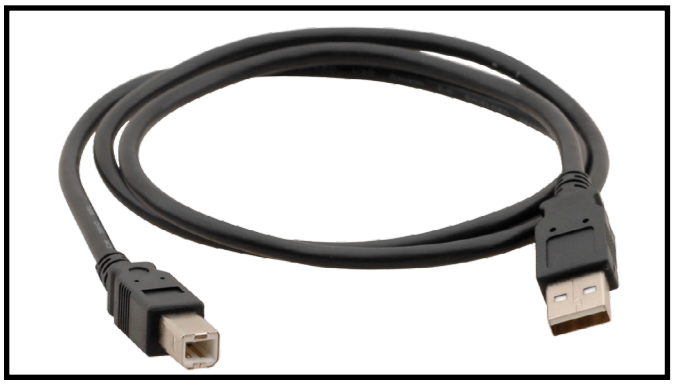


Fig. 1-4 USB Cable

Amp Meter

There may be times when a technician may want to determine the amperage draw of a circuit or device. An “amp-probe” type device is the easiest way to determine amperage draw or load.

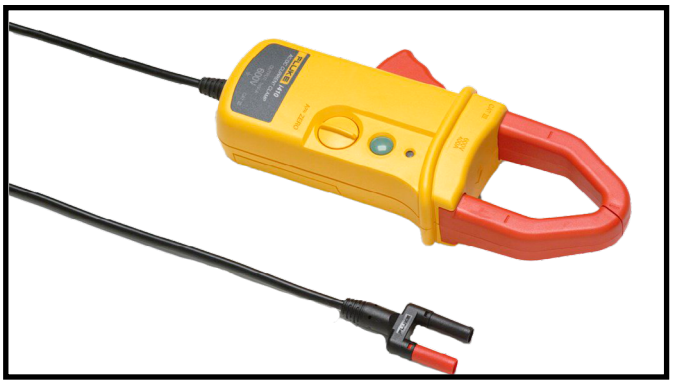


Fig. 1-5 Amp meter

Soldering Iron- Essential

All harness splices and service repairs should end up being a soldered connection. A soldering iron with a temperature controlled feature is the best tool for most wiring repair jobs. Weller and Hakko are two well known brands.

Fig. 1-6 Soldering Iron

Solder- Essential

The best way to make a wire or terminal repair is to solder the joint. For electrical component repairs 60/40 Rosin Core Solder is recommended.

Fig. 1-7 Solder

Backprobe Kit- Essential

There are a number of instances where a technician might want to determine the voltage on a specific lead or wire. During the manufacturing process, care is taken to insure all leads are terminated and sealed. NEVER probe a lead with a pin or “bed of nails” device. Once you break the insulation, moisture can enter the lead and cause corrosion and damage. A back probe will allow the technician to slide the probe underneath the seal in order to make contact with the lead.

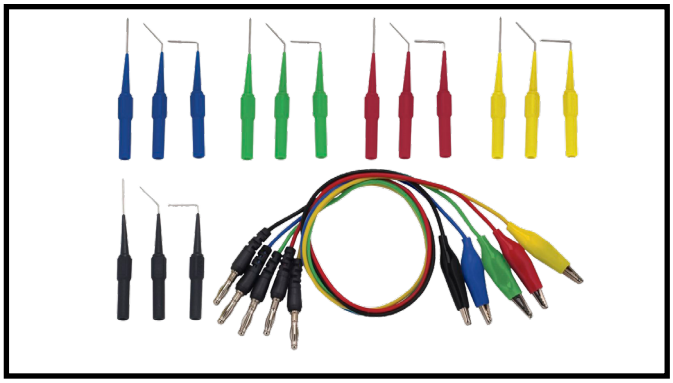


Fig. 1-8 Backprobe Kit

Heat Gun

Heat guns are used in the application of shrink tubing. Whenever a splice or repair is made by soldering a connection, shrink tubing should be applied over the splice or repair. Shrink tubing will electrically insulate the repair.

Fig. 1-9 Heat Gun

Thermal Camera

There may be times when the temperature of the battery pack may become hotter or colder. One frequent use will be to determine if a cell or the pack is in an over-heated condition. A thermal Camera or infrared heat gun will be an invaluable tool for this determination.

Fig. 1-10 Thermal Camera

Zip Ties

During assembly of the battery pack, zip ties are sometimes used to control lead routing. Routing is sometimes needed to prevent chafing of leads against parts of the battery pack. Always replace any zip ties that have been cut during the service process.

Fig. 1-11 Zip Ties

Wire Stripers- Essential

Wire strippers may be needed during lead service or repairs. The strippers pictured are for smaller primary wiring and should be able to accommodate wire leads from 22 to 10 gage.

Fig. 1-15 Wire Stripers

Computer With BMS Tool- Essential

Diagnostics for the battery pack is orchestrated through the **BMS Tool**. The tool runs on a standard PC and displays screen shots of several diagnostic modes. The user can read fault codes and messages. Additionally fault histories and graphing capabilities are available.

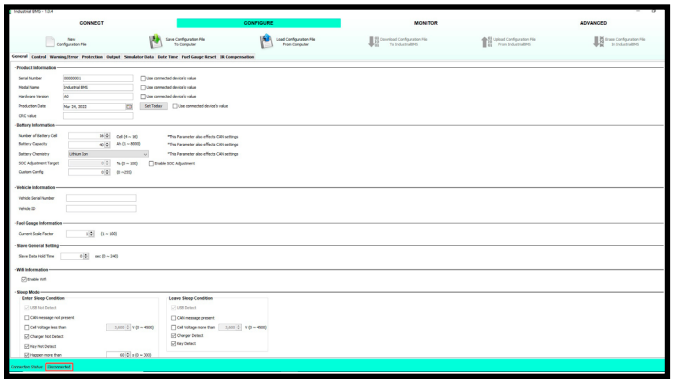


Fig. 1-12 Computer with BMS Tool

Tool Set

We highly recommend the use of insulated tools when working on battery packs. Green Cubes has assembled a tool kit with most of the required tools.

Fig. 1-16 Tool Set

Charger

There a number of appropriate chargers on the market and Green Cubes Technical Assistants can help you with selections for our larger battery packs. Our smaller packs have on-board chargers in the pack.

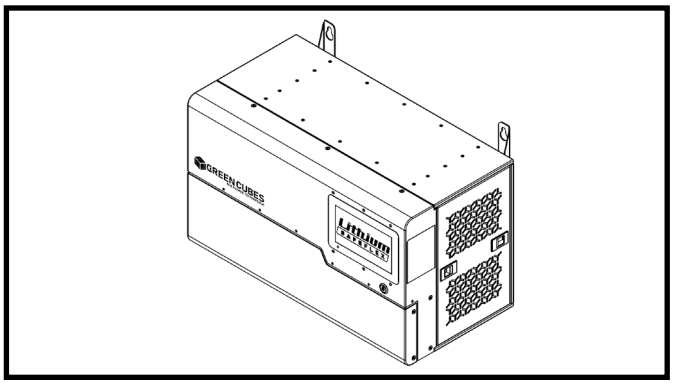


Fig. 1-17 On-board Charger

Protective Mat

During any type of battery service a protective mat is recommended. The mat protects exposed terminals and bus bars from accidental contact with tools or other devices that may conduct current.

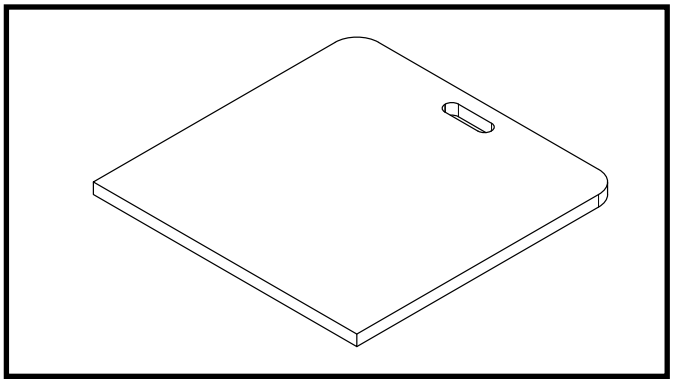


Fig. 1-18 Protective Mat

Service Precautions

Service Precautions

The following requirements must be observed when working on engines.

1. Before removing any BMS system component, disconnect the negative battery cable
2. Never separate the battery from the on-board electrical system while the system is switched on.
3. Never separate the battery feed wire from the charging system while battery pack is switched on.
4. Ensure that all cable harnesses are connected solidly and the battery connections are thoroughly clean.
5. Never connect or disconnect the wiring harness at the BMS when the ignition is switched “ON.”
6. Before attempting any electric arc welding on the equipment, disconnect the battery leads and the BMS connectors.
7. When steam cleaning equipment, do not direct the nozzle at any BMS or Battery Pack system components. If this happens, corrosion of the terminals or damage of components can take place.
8. Use only the test equipment specified in the diagnostic tables, since other test equipment may either give incorrect test results or damage good components.
9. All measurements using a Digital Volt Ohmmeter (DVOM) must use a digital meter with a rating of 10 megohm input impedance.
10. When a test light is specified, a “low-power” test light must be used. Do not use a high-wattage test light. While a particular brand of test light is not suggested, a simple test on any test light will ensure it to be safe for system circuit testing. Connect an accurate ammeter (such as the high impedance Digital Volt Ohmmeter DVOM) in series with the test light being tested, and power the test light ammeter circuit with the battery.

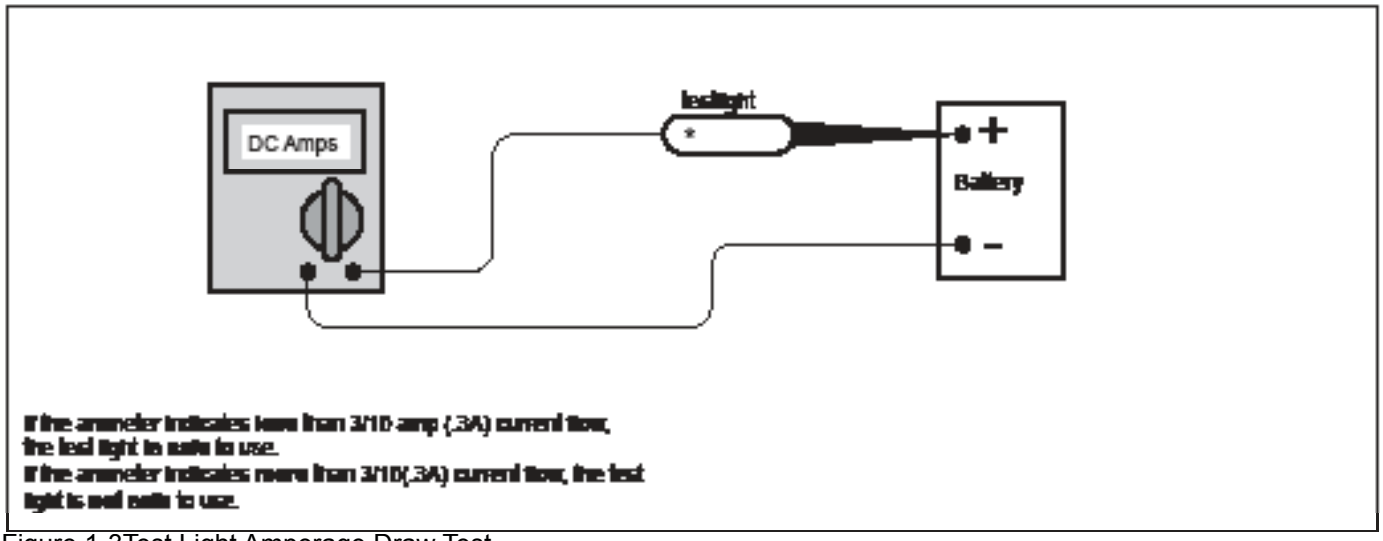


Figure 1-3Test Light Amperage Draw Test

General Circuit Testing

Visual / Physical Inspection

A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further diagnostics. Inspect all the wires in the battery pack compartment for proper connections, burned or chafed spots, pinched wires or contact with sharp edges.This visual/physical inspection is very important. It must be done carefully and thoroughly.

Basic Knowledge and Tools Required

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. You should be familiar with wiring diagrams, the meaning of voltage, ohms, amps and the basic theories of electricity. You should also understand what happens if a circuit becomes open, shorted to ground or shorted to voltage. To perform system diagnostics, several special tools and equipment are required. Please become acquainted with the tools and their use before attempting to diagnose the system. Special tools that are required for system service are illustrated in this section.

Wiring Connector Service

Most connectors on the battery pack wiring harness are protected against moisture and dirt which could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronic system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor, or in the wiring harness, may locate the open circuit condition. This should always be considered when an open circuit or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently.

Probing Electrical Connectors

Back probe

Back probing connectors, if done properly, is a safe and effective way to check and verify the wiring harness. To back probe a terminal, slide the metal pin side of the back probe adaptor inbetween the wire and the seal on the back side of the connector. Push the back probe adaptor gently into the connector until it stops. DO NOT force the back probe adaptor into the connector or it may damage the terminal.

Important:

- Back probe connector terminals only when required in diagnostic procedures.
- Back probing can be a source of damage to connector terminals. Use care in order to avoid deforming the terminal, either by forcing the back probe too far into the cavity or by using too large of a back probe. .
- After back probing any connector, inspect for terminal damage. If terminal damage is suspected, test for proper terminal contact.

Do not disconnect the connector and probe the terminals from the harness side (front) of the connector.

Notice: Do not insert test equipment probes into the mating side (front) of any connector or fuse block terminal. The diameter of the test probes will deform most terminals. A deformed terminal can cause a poor connection, which can result in system failures Do not use paper clips or other substitutes as they can damage terminals and cause incorrect measurements.

Testing for Intermittent and Poor Connections

Most intermittent conditions are caused by faulty electrical connections or wiring. Inspect for the following items:

- Wiring broken inside the insulation
- Poor connection between the male and

General Circuit Testing

female terminal at a connection.

- Poor terminal to wire connection—Some conditions which fall under this description are poor crimps, poor solder joints, crimping over the wire insulation rather than the wire itself and corrosion in the wire to terminal contact area, etc.
- Wire insulation which is rubbed through, this causes an intermittent short as the bare area touches other wiring or parts of the engine.

Troubleshooting with a Digital Volt Ohmmeter Test Probe Notice

A DVOM should be used instead of a test lamp in order to test for voltage in high impedance circuits. While a test lamp shows whether voltage is present, a DVOM indicates how much voltage is present.

The ohmmeter function on a DVOM shows how much resistance exists between 2 points along a circuit. Low resistance in a circuit means good continuity.

Important: Disconnect the power feed from the suspect circuit when measuring resistance with a DVOM. This prevents incorrect readings. A DVOM applies such a small voltage to measure resistance that the presence of any other voltages can upset the resistance reading.

Diodes and solid state components in a circuit can cause a DVOM to display a false reading. To find out if a component is affecting a measurement take a reading once, then reverse the leads and take a second reading. If the readings differ the solid state component is affecting the measurement.

Troubleshooting with a Test Light

A test lamp can simply and quickly test a low impedance (low resistance) circuit for voltage.

To properly operate a test light use the following procedure.

1. Attach 1 lead to ground.
2. Touch the other lead to various points along the circuit where voltage should be present.
3. When the bulb illuminates, there is voltage at the point being tested.

Measuring Voltage

Notice: Refer to Test Probe Notice

The following procedure measures the voltage at a selected point in a circuit.

1. Disconnect the electrical harness connector for the circuit being tested, if necessary.
2. Enable the circuit and/or system being tested. Use the following methods:
   - Ignition ON System OFF.
   - Ignition ON System ON.
   - Turn on the circuit and/or system with a scan tool in Output Controls.
   - Turn on the switch for the circuit and/or system being tested.
3. Select the V (AC) or V (DC) position on the DVOM.
4. Connect the positive lead of the DVOM to the point of the circuit to be tested.
5. Connect the negative lead of the DVOM to a good ground.
6. The DVOM displays the voltage measured at that point.

Introduction to Wiring

Visual / Physical Inspection

A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further diagnostics. Inspect all the wires in the battery pack for proper connections, burned or chafed spots, pinched wires or contact with sharp edges. This visual/physical inspection is very important. It must be done carefully and thoroughly.

Electrostatic Discharge Damage

Electronic components used in control systems are often designed to carry very low voltage, and are very susceptible to damage caused by electrostatic discharge. It is possible for less than 100 volts of static electricity to cause damage to some electronic components. By comparison, it takes as much as 4,000 volts for a person to feel the zap of a static discharge. There are several ways a person can become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Therefore, it is important to use care when handling and testing electronic components.

Battery Pack Wiring

When it is necessary to move any of the wiring, whether to lift wires away from their harnesses or move harnesses to reach some component, take care that all wiring is replaced in its original position and all harnesses are routed correctly. If clips or retainers break, replace them. Electrical problems can result from wiring or harnesses becoming loose and moving from their original positions, or from being rerouted.

Diagnosis

The diagnostic tables and functional checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The tables are prepared with the requirement that the system functioned correctly at the time of assembly and that there are no multiple failures.

Battery Pack control circuits contain many special design features not found in standard equipment wiring. Environmental protection is used extensively to protect electrical contacts. Proper splicing methods must be used when necessary.

The proper operation of low amperage input/output circuits depend upon good continuity between circuit connectors. It is important before component replacement and/or during normal troubleshooting procedures that a visual inspection of any questionable mating connector is performed. Mating surfaces should be properly formed, clean and likely to make proper contact. Some typical causes of connector problems are listed below:

- Improperly formed contacts and/or connector housing.
- Damaged contacts or housing due to improper engagement.
- Corrosion, sealer or other contaminants on the contact mating surfaces.
- Incomplete mating of the connector halves during initial assembly or during subsequent troubleshooting procedures.
- Tendency for connectors to come apart due to movement and/or temperature cycling.
- Terminals not fully seated in the connector body.
- Inadequate terminal crimps to the wire.

On-Board Wiring Harness Service

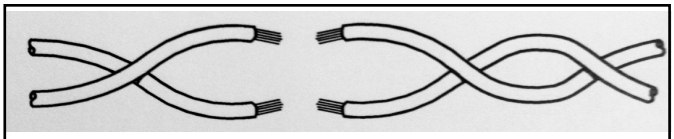
Wiring harnesses should be replaced with proper part number harnesses. When wires are spliced into a harness, use the same wire gauge with high temperature insulation only.

With the low current and voltage levels found in the system, it is important that the best possible

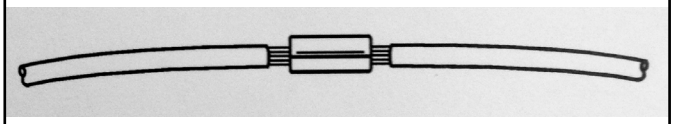
bond be made at all wire splices by soldering the splices as shown in Figure 1-4.

Use care when probing a connector or replacing a connector terminal. It is possible to short between adjacent terminals. If this happens, certain components can be damaged. Always use jumper wires with the corresponding mating terminals between connectors for circuit checking.

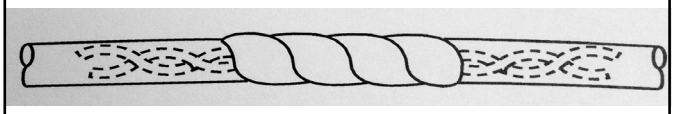
NEVER probe through connector seals, wire insulation, secondary ignition wires, boots, nipples or covers. Microscopic damage or holes may result in water intrusion, corrosion and/or component failure.



1. Locate damaged wire
2. Remove insulation as required.



3. Splice two wires together using splice clips and rosin core solder.



4. Cover splice with tape or heat shrink to insulate from other wires.
5. Re twist as before and tape with electrical tape or heat shrink and hold in place.

Figure 1-4 Wire Slicing Procedure

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