ELECTRICAL—TH!NK NEIGHBOR BATTERY PACK DIAGNOSIS—SERVICE TIPS	Article No. 02-13-3

THINK: 2002 TH!NK NEIGHBOR

ISSUE

Some TH!NK neighbors may exhibit a gauge malfunction, failure to charge, reduced mileage range, or inability to move forward or reverse. This may be due to damage to the battery pack from excessive discharge, reduced battery pack capacity or failed battery modules within the battery pack. Proper battery pack maintenance is critical to maximizing battery pack life. This TSB outlines a procedure for evaluating battery health, and replacing individual battery modules under certain circumstances to improve pack performance.

ACTION

Refer to the following procedures for diagnosing health of battery modules. Replace module or modules as determined by procedure.

SERVICE INFORMATION

The TH!NK neighbor uses lead-acid batteries that are designed for repetitive deep discharge service; however, completely discharging a neighbor battery may cause permanent internal damage which will decrease the capacity and life of the battery.

Figure 1 outlines gauge reading, corresponding voltage range and symptoms exhibited by vehicle at the various stages. When the battery outline begins to flash (see Note 2), the vehicle should be put on charge as soon as possible (within 4 hours) to avoid damaging the pack. Under normal conditions, the battery pack is expected to last about 400 deep cycles, 800-1280 k/m (500-800 miles). A cycle is a complete discharge, to the point where battery outline begins to flash, followed by a recharge.

To prevent battery pack damage, advise customers to avoid completely discharging the batteries or leaving the vehicle in a discharged state. Leaving the vehicle on charge will not damage the batteries.

NOTE

WHEN YOU RECEIVE A TH!NK NEIGHBOR, CHARGE THE VEHICLE IMMEDIATELY FOR AT LEAST 12 HOURS SINCE PACK DISCHARGE TYPICALLY OCCURS DURING SHIPPING.

The neighbor is equipped with a “Service Disconnect Switch” to help preserve battery life. The switch is located under the seats, to the rear of the parking brake. For vehicles produced after 6/21/02, the switch is located directly under the driver’s seat. Beginning with a fully charged vehicle, the battery pack will last about 14 days with the switch left ON and about six months with the switch left OFF. To preserve battery pack charge, Neighbors shipped by rail are shipped with the switch in the OFF position. TH!NK neighbors shipped by truck can be shipped with the switch ON. Always store the vehicle with the service disconnect switch OFF at the dealership unless you are using and charging the vehicle every day. While the vehicle is in dealer inventory you must charge the battery pack every 30 days, even if the service disconnect switch is OFF. If the service disconnect switch is ON then it is recommended that the vehicle be left on charge at all times.

BATTERY PACK/MODULE DIAGNOSIS

Diagnose health of battery pack and individual battery modules to determine repair action. Diagnosis may lead to the following actions:

- (1) No action
- (2) Up to two modules in the pack have degraded and should be replaced with new modules
- (3) Three or more modules have degraded due to age or pack being left in a deep discharge state and the pack requires full replacement

Step 1

Check that the gauge has been set to the correct battery mode, either flooded or gel, depending upon the type of batteries installed in the vehicle. If the battery mode is set incorrectly, refer to the Shop Manual for how to set battery type. If flooded batteries are installed, check electrolyte level in batteries. Low electrolyte levels will damage flooded batteries.

Step 2

Ensure key is in OFF position. With service disconnect switch ON, place vehicle on charge for a minimum of 8 hours to ensure the pack is allowed to reach full charge. Assess the state of charge of the battery pack by measuring voltage across Battery 1 Negative and Battery 6 Positive (see Figure 1). Verify that the charger and charging receptacle are functioning properly by measuring pack voltage after the vehicle has been on charge for 2 minutes. With the vehicle on charge, you should observe a rise in pack voltage as the batteries are charged. If the pack voltage is less than 20 volts, the batteries have been damaged and their life and capacity have been decreased. If pack voltage is less than 20 volts, the charger will not charge the batteries. The initial pack voltage determines the charging algorithm used, as explained in Figure 2 and Note 1. Pack replacement is required if the pack voltage is less than 20 volts. Refer to Step 7 for pack replacement instruction.

NOTE 1

CHARGER OPERATION:

1. If battery pack voltage is above 63V at plug-in, charger will charge at full 10A rate (normal operation).
2. If battery pack voltage is below 63V at plug-in (deep-discharge condition), charger will charge at 2A for 3 hours.

At completion of 2A for 3 hours (Step 2 above), the charger will check battery pack voltage and determine next charging sequence.

a. If voltage is below 50V, charger will shut down (error condition).

b. If voltage is between 50V and 63V, charger will charge 4A for 2 more hours.

c. If voltage is greater than 63V, charger will begin a normal charge cycle at 10A.

At completion of 4A for 2 hours (Step b above), the charger will check battery pack voltage and determine next sequence.

(1) If voltage is below 63V, charger will shut down (error condition).

(2) If voltage is greater than 63V, charger will begin a normal charge cycle at 10A.

NOTE 2

INSTEAD OF 0 BARS, OUTLINE FLASHING FAST, YOU MAY SEE 5 BARS, OUTLINE FLASHING FAST.

Step 3

Leaving service disconnect switch ON, disconnect the charger cord and let the fully charged vehicle stand for between one to six hours to remove surface charge. Measure the pack voltage as shown in Figure 2. If pack voltage is greater than 76 V, you can assume a fully charged pack. Skip to Step 5.

Step 4

If pack voltage is less than 76 V, measure individual module voltages with the voltmeter. You can do this without removing battery cables as long as you touch the voltmeter probes to the lead donuts at the base of the terminals. The module voltages should be within 0.5V of each other. If one or two modules have a voltage difference greater than 0.5 V from the rest, these modules need to be replaced. For Individual Module Replacement, refer to Step 6.

NOTE

VEHICLE MUST BE WITHIN 90 DAYS OF THE WARRANTY START DATE TO REPLACE INDIVIDUAL MODULES. IF GREATER THAN 90 DAYS OF THE WARRANTY START DATE, REPLACE THE ENTIRE PACK. IF MORE THAN 2 MODULES HAVE A VOLTAGE DIFFERENCE OF GREATER THAN 0.5V, REPLACE THE ENTIRE PACK. REFER TO STEP 7 FOR PACK REPLACEMENT INSTRUCTION.

Step 5

If pack voltage is greater than 76 V, drive vehicle on known course until there is a noticeable decrease in performance (speed degradation, degradation in performance inconsistent with gauge reading, or the battery outline begins to flash), etc. Return to the shop and wait at least one hour, but no more than six hours. Measure the individual module voltages with the voltmeter. You can do this without removing battery cables as long as you touch the voltmeter probes to the lead donuts at the base of the terminals. The module voltages should be within 0.5 V of each other. If one or two modules have a voltage difference of greater than 0.5 V from the rest OR have a voltage reading of less than 11.9 V, these modules need to be replaced. For Individual Module Replacement refer to Step 6.

NOTE

VEHICLE MUST BE WITHIN 90 DAYS OF THE WARRANTY START DATE TO REPLACE INDIVIDUAL MODULES. IF GREATER THAN 90 DAYS OF THE WARRANTY START DATE, REPLACE THE ENTIRE PACK. IF MORE THAN 2 MODULES HAVE A VOLTAGE DIFFERENCE OF GREATER THAN 0.5V OR ARE BELOW 11.9 V, REPLACE THE ENTIRE PACK. REFER TO STEP 7 FOR PACK REPLACEMENT INSTRUCTION.

Step 6

Individual Module Replacement:

1. Verified good battery modules from the original pack as well as the new replacement modules from the supplier need to be charged to full capacity prior to being placed into the vehicle as a new pack. This is to ensure all six modules are at a matched state of charge for optimal vehicle operation.
2. All charging must be performed with the DPI model 12008-CH3BA 12V charger. Follow the manufacturer's operating instructions for battery module charging. It is critical that the charge leads be applied to the lead base of the battery terminal and not to the stainless steel stud. Incorrect charge result may occur unless the lead base is used as the connection.

NOTE

IF YOU DO NOT HAVE THE DPI CHARGER, CONTACT DIVERSIFIED POWER INTERNATIONAL LLC AT 423-538-9002 OR FAX 423-538-9202. DO NOT USE A ROTUNDA OR ANY OTHER BATTERY CHARGER WHICH CHARGES AT GREATER THAN 14.1V, BECAUSE THIS WILL DAMAGE THE TH!NK NEIGHBOR BATTERIES.

3. It is acceptable for the battery modules to be charged sequentially (one after another). It is not a requirement that they be charged simultaneously. It should take no more than 4 hours to charge one battery module.
4. It is preferred to remove the batteries from the vehicle prior to charge. If batteries are left in the vehicle, each battery interconnect cable should be removed on at least one side of cable.
5. Continue charging a battery module until the charger mode LED displays solid green. At this point, charging has finished. Any battery that the charger recognizes as having a fault must be scrapped.

Step 7

Full Pack (6 Module) Replacement:

Gel Batteries Only:

If you are replacing the entire pack, test the replacement batteries with the Micro 490 tester. If any replacement batteries fail, contact the distributor or supplier immediately.

- Only use the Micro 490 or other equivalent Midtronics tester
- Clamp on the lead donut, NEVER on the stud. Clamping on the stud will result in inaccurate test results. Set the CCA rating at 550
- Set in Out of Vehicle mode

Gel and Flooded Batteries:

It is preferred that each module be charged individually prior to installation in a vehicle pack with the DPI model 12008-CH3BA 12V charger. This is optimal to ensure all battery modules are at a full state of charge prior to installation in vehicle. Follow the manufacturer's operating instructions for battery module charging. It is critical that the charge leads be applied to the lead base of the battery terminal and not to the stainless steel stud. If a DPI charger is not available, place the vehicle on charge using the on-board vehicle charger to ensure the pack is given a full charge.

NOTE

IT IS NORMAL THAT, OVER TIME, THE BATTERY PACK CAPACITY WILL DECREASE RESULTING IN DECREASED MILEAGE RANGE PERFORMANCE. WARRANTY REPLACEMENT OF A BATTERY PACK DOES NOT COVER A BATTERY PACK THAT HAS BEEN CYCLED THROUGH A NORMAL LIFE EXPECTANCY. REFER TO ADDITIONAL INFORMATION PROVIDED BELOW WHEN ASSESSING WHETHER BATTERIES SHOULD BE REPLACED UNDER WARRANTY.

Additional Information

Vehicle Current Loads:

There are up to 5 loads on the battery pack while the service disconnect switch is ON, and the drive mode selector switch is OFF. There is an 80 mA draw from the instrument cluster gauge, a 30 mA draw from the motor controller, a 15 mA draw per DC/DC converter (there is an option for 1 or 2 converters), and a 1 mA draw from the charger (the charger has power at all times).

Battery Capacity:

Mileage range of the neighbor is determined by customer driving cycle and battery capacity, and is not directly related to voltage. A neighbor battery may test above 12 volts yet still have poor capacity. Capacity is analogous to the size of the fuel tank in an internal combustion vehicle. Battery capacity is affected by temperature (Figure 3) and changes as batteries age. It is also affected by the rate of discharge. The faster the batteries are discharged, the less battery capacity is available (and the faster the batteries will be recharged). The more slowly the batteries are discharged, the more pack capacity is used, and the longer it will take to recharge the batteries. Battery capacity increases for about the first 75 to 150 cycles of a flooded battery, and the first 25 to 75 cycles of a gel battery. After the capacity peak is reached, the battery pack stabilizes, and then capacity begins to decline. Battery maintenance and charging habits directly impact peak capacity and the point in time when peak capacity is reached. Proper maintenance and regular charging will increase time to peak as well as peak capacity. After battery capacity has stopped increasing, which is estimated to take approximately 90 days, individual modules should not be replaced because the individual battery capacities will never be matched, and overall pack capacity will be greatly reduced. The manufacturer's rated capacity of the flooded battery is 130 amp-hours, and the gel battery is 97 amp-hours. The state of charge (the amount of energy available from the battery at any particular time) of the individual modules within the pack must be similar for the pack to function correctly.

Testing Mileage Range:

The neighbor achieved 31 miles on the Federal Urban Driving Standard test. This drive cycle is complex and probably not reproducible in a dealership environment. However, the following guidelines will help establish a driving course to determine if a customer is experiencing poor range, or if the battery pack is performing as expected.

- Choose driving surfaces that are paved, and relatively flat
- Some moderate hills are acceptable, as long as they are not more than 1/2 mile and less than 5% grade
- Try to find a route that has five or less stops and starts (i.e. stoplights)
- Try to spend at least 55% of the drive cycle time at 70% max speed, or around 18 mph.

Factors Affecting Mileage Range Of The Neighbor:

The battery pack will decrease in capacity over time, resulting in decreased mileage range. This is a characteristic of these batteries. Batteries should not be replaced simply because the customer achieves less range than when the vehicle was new. Some judgment should be exercised when evaluating range. Factors affecting mileage range on electric vehicles include:

- **Type of tire** - Vehicles equipped with turf tires will have less range than vehicles equipped with street tires, due to greater frictional drag from the wider turf tire
- **Age of battery pack** - battery capacity decreases as batteries age
- **Temperature** - battery capacity decreases as temperature drops
- **Driving style** - heavy acceleration demands more power from the battery pack than gradual acceleration
- **Terrain** - Climbs up steep grades may deplete the battery pack
- **Pavement vs. Off-Road** - vehicles driven off road will have less range
- **Lack of free wheel movement** - Check vehicle for any evidence of brake drag, by putting the vehicle on a hoist and checking wheels for free rotation
- **Other Electrical Loads** - Lights, Heater/Defogger, Powerpoint accessories, etc. (note that all Powerpoint accessories should be disconnected when the vehicle is charging

Before recommending replacing the entire pack to a customer simply because pack capacity has decreased due to age, discuss the situation with the customer. If the customer is in the second or third year of vehicle warranty, when battery coverage is prorated, the customer may choose to accept some reduced range and delay pack replacement until absolutely necessary.

OTHER APPLICABLE ARTICLES: NONE
WARRANTY STATUS: INFORMATION ONLY
OASIS CODES: 203000, 203100, 204000, 206000, 603300, 607000, 614000, 622000

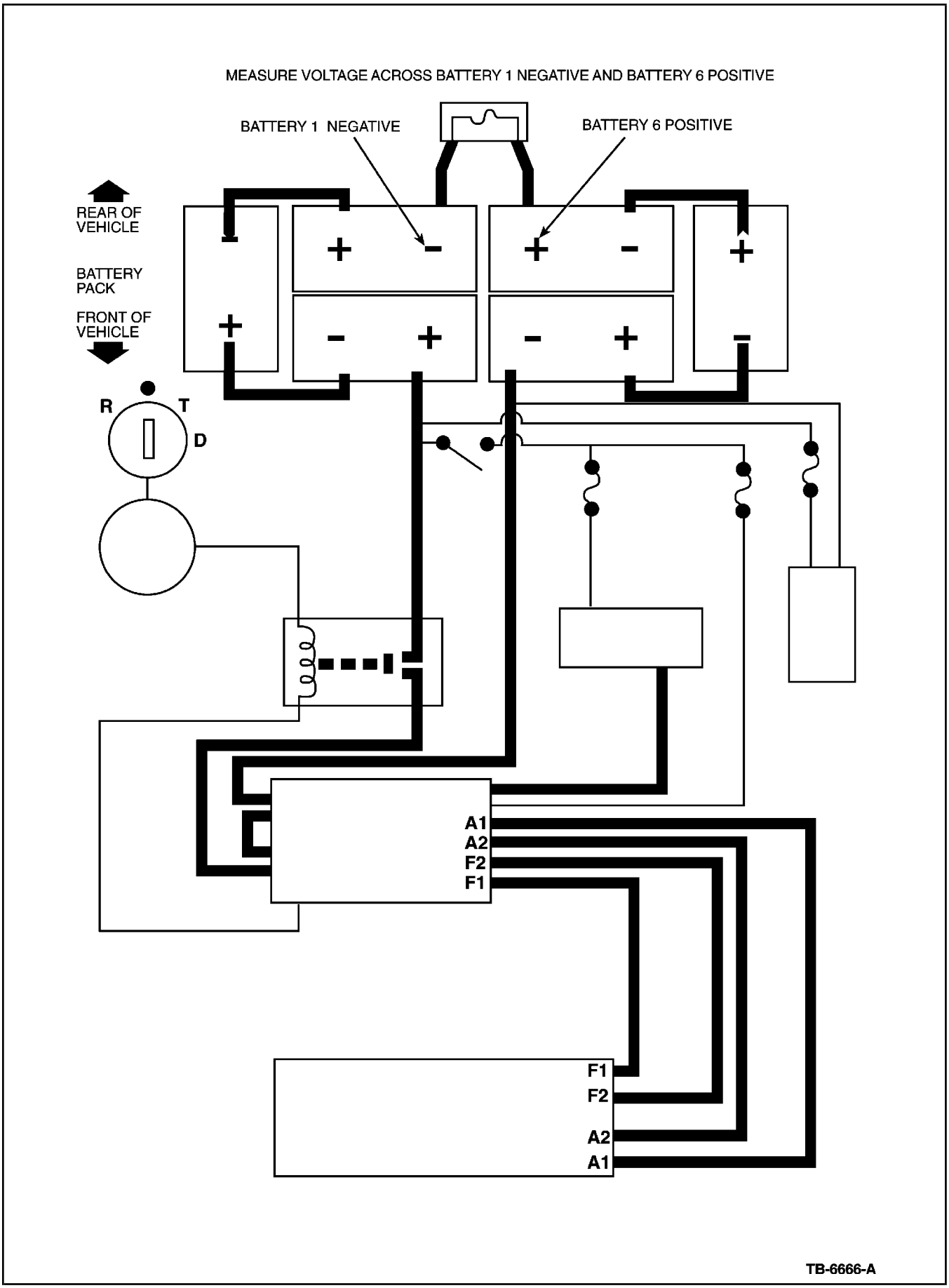
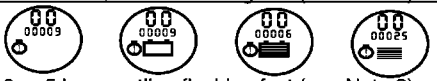
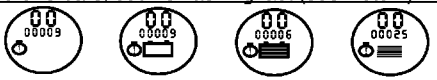
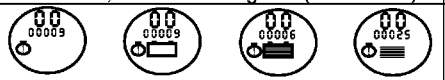
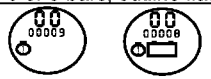


Figure 1 - Article 02-13-3

Figure 2 - Article 02-13-3

NEIGHBOR FUNCTIONAL CHART

Battery Pack Voltage	Gauge	Charger (see Note 1)	Controller	DC/DC Converter
0V to 20V	Non-functional vehicle, AC plug icon will not display **NOTE: No backlight on gauge**	Charger hums, will not charge	Contactor will not close	No function
20V to 40V	 0 or 5 bars, outline flashing fast (see Note 2) Clicking may be heard from gauge backlight on gauge operational.	Charger hums, vehicle charges at 2A rate, battery pack voltage will rise	Contactor will not close	No function
40V to 50V	 0 or 5 bars, outline flashing fast (see Note 2)	Charger hums, vehicle charges at 2A rate, battery pack voltage will rise	Contactor will not close	12V DC/DC converter output low, dim lights
50V to 63V	 0 or 5 bars, outline flashing fast (see Note 2)	Charger hums, vehicle charges at 2A rate, battery pack voltage will rise	Contactor will not close	12V DC/DC converter operational
63V to 68V	 0 or 5 bars, outline flashing fast (see Note 2)	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Contactor will not close	12V DC/DC converter operational
68.3V to 69.8V	 0 or 5 bars, outline flashing fast (see Note 2)	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
69.8V to 70.6V	 1 bar, outline flashing slow	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
70.6V to 72.0V	 2 bars, outline solid	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
72.0V to 73.4V	 3 bars, outline solid	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
73.4V to 74.9V	 4 bars, outline solid	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
74.9V to 80V	 5 bars, outline solid	Charger hums, vehicle charges at 10A rate, battery pack voltage will rise	Vehicle will drive	12V DC/DC converter operational
80.1V to 95.0V	 5 bars, outline solid	Charger hums, vehicle charge is near competition, current will be 10A or less	Contactor will not close. These voltages only seen while on charge or while going downhill, with regenerative braking activated and full state of charge	12V DC/DC converter operational

TB-6665-A

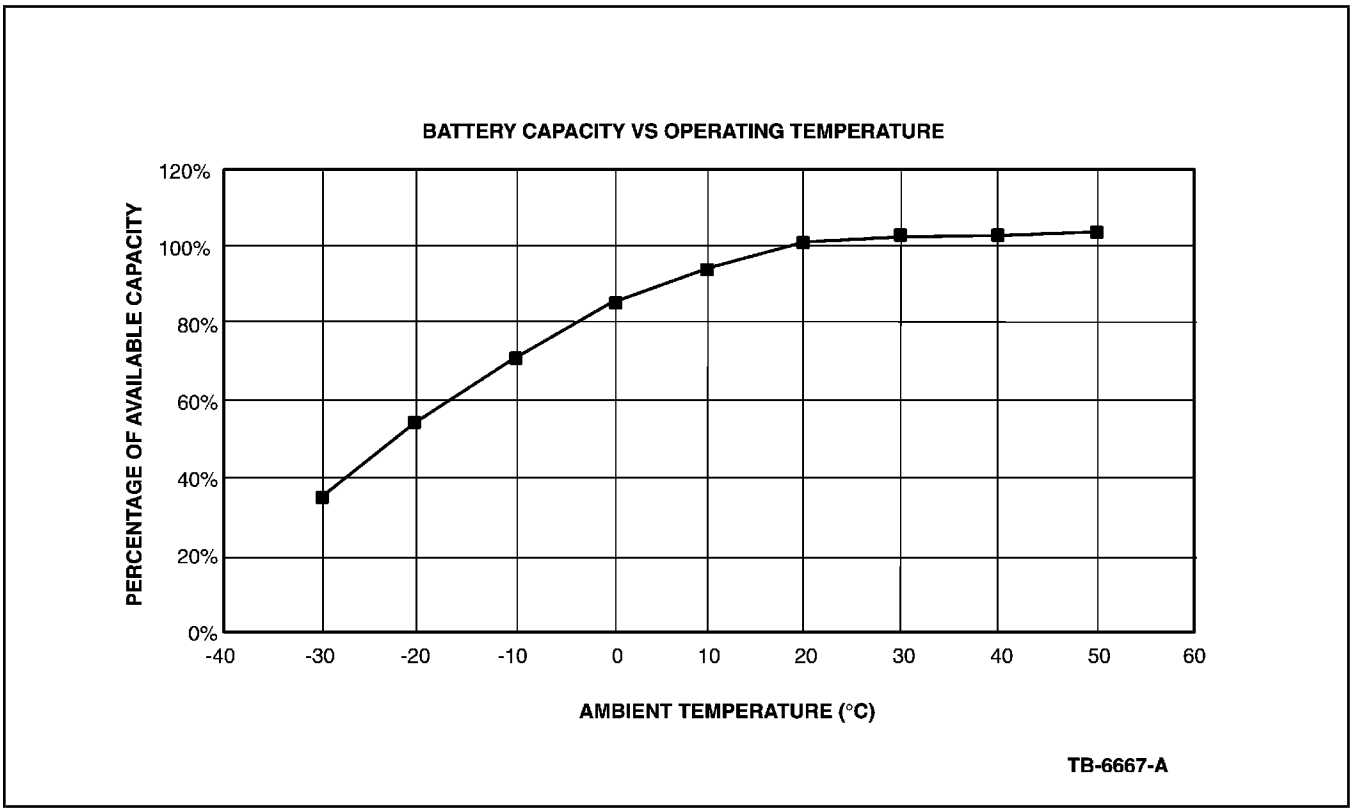


Figure 3 - Article 02-13-3