SAMPLE BATTERY QUALIFICATION (ATTACHMENT 2) ALSTOM 6000 SERIES RAILCARS

TABLE OF CONTENTS

REVISION HISTORY

Rev. #	Date	Description

1.0 PURPOSE

The purpose of this test is to qualify sample batteries for use on the Alstom 6K series railcars.

2.0 BACKGROUND

The Alstom 6K series railcar battery in the "B" car is near its end of life. WMATA is considering to qualify manufacturers of equally operational battery at a lower cost.

3.0 APPLICABLE CARS

Alstom 6K series railcar

4.0 APPLICABLE EQUIPMENT

Battery compartments, cells and battery crates.

5.0 REFERENCES

- 6K Heavy Repair Maintenance Manual (HRMM), Pages 6-1-5 to 6-1-9 and 6-5-97 to 6-5-110 (Attachment D)
- 6K Running Maintenance Service Manual (RMSM) Page 6-4-11 to 6-4-14; 6-4-24 to 6-4-29 and Pages 6-5-113 to 6-5-120 (Attachment E)
- 6K Technical Specification Page TP14-6 to TP14-9
- 6K Illustrated Parts Catalog (IPC) Page 6-136 to 6-147 (Attachment C)

6.0 TOOLS

- Standard Electrical/Mechanic Tool Set
- Calibrated Digital Voltmeter
- Calibrated 0-250A Ammeter
- Portable Test Unit (PTU) Laptop with Low Voltage Power Supply (LVPS) Interface Cables
- Safety Glasses (R42-40-0019)
- Work Gloves (R42-40-0005)

7.0 MATERIALS

- Battery Cells and Mounting Racks

- Installation Fasteners
- Interconnection Cables
- No-Ox grease
- Distilled Water
- Clean Shop Cloths (R95-05-0005)

8.0 GENERAL SAFETY

All work shall be conducted in a safe manner and in accordance with the latest edition of the Metrorail Safety Rules and Procedures Handbook. All work shall be performed in such a manner that there is no danger to WMATA personnel or damage to WMATA Property. Proper Personal Protective Equipment (PPE) should be worn when servicing the battery (Attachment E).

9.0 PROCEDURE

WARNING:

- Always refer to the Warnings, Cautions, and Notes prior to beginning any activity.
- The battery electrolyte is corrosive. Exercise extreme care when handling the batteries. The test batteries are being shipped with the electrolyte already in the cell containers. Keep the batteries level at all times to avoid caustic spills.
- Ensure that there are no open flames, sparks, or high temperature elements anywhere in the immediate vicinity. Batteries release hydrogen gas which is highly explosive.
- When removing or installing the battery, use a lifting device or obtain assistance to avoid personal injury.
- During the installation verify that all electrical connections and their polarities are made correctly, including charge/discharge car power cables.
- Avoid shorting battery terminals to prevent electrical shock or burns.

9.1 Battery Installation

Batteries supplied fully charged must not be stored more than 6 weeks from its last charge date and can be put immediately into service. If the storage exceeds 6 weeks then proper commissioning cycle must be performed prior to placing cells in service.

The battery must be mounted firmly in the battery slide-out tray. Arrange the battery crate assemblies for series connection according to the applicable layout drawing (See Attachment A). Inter-crate flexible cable connections/assemblies and other components as identified by the battery layout drawing are provided as original equipment and can be ordered as parts. All contact surfaces including the battery slide-out tray and battery compartment must be clean and dry before making connections.

9.2 Removal of Old Battery from Battery Compartment

9.2.1 Open Low Voltage Circuit Breaker on the ‘B” car KP panel and the main Battery Breaker on the BB box. Tag the circuit breakers according to approved WMATA procedures. Verify that the battery breaker trip indicator (located between the A and B cars) illuminates when the battery breaker (BBCBB) is open.

9.2.2 Ensure that the brake pipe is charged prior to turning the battery box micro-switch handle. Alert personnel near the car that the brake pipe will be dumped, then verify that the brake pipe dumps immediately when the battery box turning the battery box micro-switch handle. If the train has recently been exposed to temperatures below freezing (32 °F), then allow sufficient time for any ice in the lines to thaw before the dump.

9.2.3 Pull and hold open the right hand release handle of the battery box (See Attachment C). At this moment, push the battery box from behind to extract.

9.2.4 Open the door of the battery box by unlocking the two latches. Remove the battery box cover. To release the tray bearing the batteries, pull and hold open the two locking pins, the tray is now released. At this moment attach the battery pull tool on the handles and pull to access the existing Ni-Cd Batteries.

9.2.5 Remove the five (5) cell wooden crates.

Caution: Exercise care when removing and replacing batteries into the Battery Tray. Each five (5) cell wooden crate weighs 133 lbs. Ensure proper lifting techniques are employed when moving crates. Use of a forklift and pallet is recommended for vertically lifting the crates to and from the Battery Tray.

Caution: Segregation of the spare, used pocket plate Ni-Cd cells and the scrap batteries is essential. Unnecessary mixing of scrap and reusable cells will present operational issues at a later date. SAFT SRX195 cells can be determined by looking at the manufacturing date code punched on top of each cell's positive terminal by month (upper number) and year (lower number), e.g., 1208 for December 2008.

Contact Greenbelt Electrical Shop Supervisor (301-955-2099) to determine proper disposition of scrap pocket-plate batteries.

Warning: Do not use the label on the crate to determine the age of the cells.

9.2.6 Packing Spent Batteries

9.2.6.1 Discharge batteries if possible. Remove all cable or loose connectors that may cause cells to short or discharge, and protect all battery terminals from short circuiting and generating heat during shipment.

9.2.6.2 Use pallets of uniform size with dimensions near 42 x 42 inches. The surface of the pallet must be flat without gaps to support the batteries. Add a plywood or other board surface if necessary.

9.2.6.3 Stand the batteries on a pallet with the vent caps installed and with shorter batteries surrounded by taller batteries.

9.2.6.4 Nail furring strips (1" x 2" or larger) around the outer edge of the batteries on the pallet.

9.2.6.5 Strap around the batteries. Place plywood or chipboard on top of the batteries.

9.2.6.6 Strap around the board and through the pallet in two directions to tie the batteries to the pallet. Two straps in each direction should secure the package. Or use stretch wrap to secure the batteries to the pallet.

9.2.6.7 Mark each pallet, issued by the vendor, with RMA#__________________. (Return Merchandize Authorization).

9.2.6.8 Mark with corrosive labels.

9.2.6.9 Mark each pallet in sequence with reference to the total number of pallets being shipped. Example: Pallet___ of____ pallets. These pallets will be picked up by the vendor.

9.2.6.10 To dispose, scrap, or recycle, ship as Universal Waste with the following description: Used batteries, Wet, Filled with Alkali, 8, UN2795.

9.3 PLACING THE NEW BATTERY IN BATTERY SLIDE-OUT TRAY AND IN COMPARTMENT

9.3.1 Check battery shipping container and other components externally for possible damage in shipment. Unpack the battery shipping container and segregate parts. Check the battery and its accessories against accompanying packing list or battery layout drawing.

9.3.2 Locate correct polarities.

Caution: Each cell's positive terminals are identified with red polarity washers and the negative terminals have black polarity washers. The positive (+) terminal can be further identified by a "+" raised symbol molded on the cell cover.

9.3.3 Place charged battery crates with correct electrolyte levels (refer to Attachment E: RMSM 6-4-6) and proper commissioning charge (refer to Attachment D: HRMM, Section 5).

9.3.4 Arrange the five (5) battery crate assemblies according to Figure 1 in the battery. Ensure the positive (+) labels on the side of the wooden crates correspond with the positive cell terminal closest to that edge. Ensure the five white serialization labels line up and are visible across the entire assembly.

9.3.5 Ensure that the vent caps will flip to the open position allowing proper service maintenance.

9.3.6 Connect flexible inter-crate cable connections/assemblies, in series from positive (+) to negative (-) terminals for each row of battery crate assemblies as shown on Figure 1. Torque to 11.0±1.5ft-lbs.

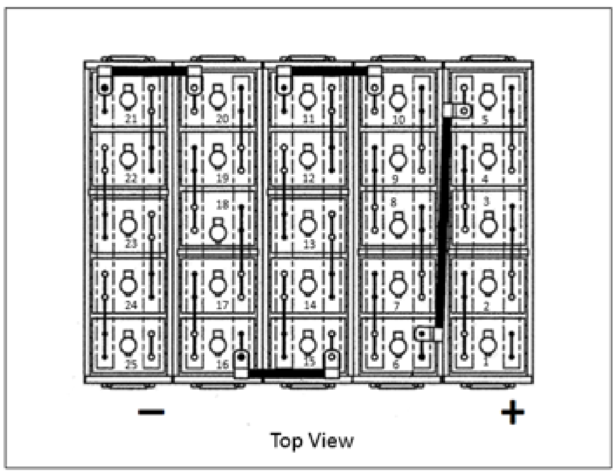


Figure 1

9.3.7 If a shim(s)/spacer(s) are required, insert at this time.

9.3.8 Apply non oxide grease to the lugs then connect positive (+) incoming car cables and negative (-) incoming car cables to the battery terminals as shown in Figure 1.

Note: If lug adapter kits are provided with the battery follow instructions provided and torque accordingly. If none, install the car cables directly to the battery leads and torque to 11.0±1.5ft-lbs.

9.3.9 Apply a thin coat of No-Ox anti-corrosion protective coating (PN R91-50-0010) using a small brush on exposed battery metal connections, where not already present such as where the flexible cable assemblies are connected.

Note: It is essential to coat corrosion prone areas with non-oxide grease. Poor electrical conductivity to vital equipment may result without application of the grease.

9.3.10 Tighten side clamping bolts to secure the assembly. Tighten the front clamping bolts.

9.3.11 Open the vent plugs and verify water levels are 1.77” above the cell material using the dip tube. If not, ensure the batteries are topped off with distilled water to the appropriate level per manufacturer’s technical specifications. Insert a plastic tube until it rests against the top of the sintered cell material. The maximum water level is 1.77”.

Caution: Minimum electrolyte level should never dip below 1” above top of cell. Any potential exposure of the battery cell alloy reduces operational life expectancy.

Caution: Electrolyte levels vary with the state of charge. For full commissioning, ensure 1.77” of electrolyte exists above sintered cell material. Complete final verification of electrolyte level after the full charging sequence.

Caution: Never allow a railcar LVPS to commission a battery assembly checked out from stock in a storage condition. Refer to the label on the front of the crate to verify date of commissioning. Stock replacement (fully discharged) battery assemblies require complete conditioning procedures utilizing off-car equipment. Water levels vary with state of charge.

9.3.12 Snap on or slide terminal covers along top of all connections.

9.3.13 Normalize the LVPS breaker in the KP panel first then normalize the main Battery (BBCBB) in the BB box and remove the red tags. The “Light Indicating Circuit Breaker (BBCBL) in the BB box may need to be opened and closed as a bypass to restore BBCBB to the closed position.

9.3.14 Verify that the battery breaker trip indicator (located between the A and B car) extinguishes after battery breakers are restored.

9.3.15 Using Digital Multi-meter check charging voltage, 37.5VDC.

9.3.16 Re-install battery slide-out compartment and put back battery box cover.

9.3.17 Verify proper mounting and operation of the battery box cover micro-switch handle. Ensure that all objects and debris interfering with the micro-switch are removed.

9.4 Test Label

The test label (Attachment G) will read as follows:

“ETP XXXXXX-00, Battery Qualification Test

Do Not Service, or Change Without Notifying

Karl Bejo @ 301-955-4311.”

This will be mounted on the front of the battery. (Attachment 1)

9.5 Maintenance/Service Requirements

Top off the batteries with distilled water prior to placing in service. There are no other maintenance requirements during the test, with the exception of adding distilled water, recording the amount added and recording the cell voltage

9.6 Test

The testing of the batteries will be done in three modes: 1) Shop Tests, 2) Dynamic Test, and 3) Long Term Test.

9.6.1 Shop Tests

9.6.1.1 If the 25 cell rack is confirmed to be fully charged, prior to installation, the shop power (LVPS) is to be removed and the discharge of the battery is to be timed. This is to be performed with the maximum 37.5 VDC load engaged.

9.6.1.2 Discharge the battery until Load Shedding occurs (25 +/- .5VDC). Record the voltage of each cell (1-25) in Table 1 (Attachment F). The value of each cell should be 1.02-1.07 VDC and that there are no shorted cells. Should a cell exceed 0.05 VDC differential, a discharge and conditioning must be performed (See Attachment B and D (HRMM 6-5-29 & 30). If the differential is still exceeded, the cell must be replaced.

9.6.1.3 Place the clamp on ammeter around the positive (+) cable thread attached to the battery. Also connect the PTU laptop to the LVPS to monitor the voltage and current. Turn the LVPS back on and monitor the charging of the battery. The time to reach the maximum charge must be recorded in Table 1 (Attachment F). It must be recognized that the train supplies constant voltage and variable current. Because of this configuration, a full charge cannot be obtained. (Time to charge in Hours X Average Charging Current X 100% = % Charge)

9.6.2 Rated Amp Hours

The percent of charge must be 80 - 86% or higher.

A typical current load, with all 37.5 VDC devices active, is 126-150A. (See Attachment H – Battery System Electrical Compatibility)

9.6.3 Dynamic Test

In this test a fully charged battery is taken into a revenue line and the LVPS is turned off. The normal loads (Head lights, PA, Doors, etc) remain active and 40 minutes of operation must be achieved. Typically 20 stations or more are serviced.

9.6.4 Long Term Test

During this test the operation of the battery is periodically monitored for a period of12 months. The voltage of each cell is monitored and the consumption of water is monitored. The results are recorder in Table 1 (Attachment F). Should the amount of water consumed exceed 150ml in a months' period, an immediate investigation must be made to determine why the water exceeds a typical 20-60 ml.

9.7 Inspection Requirements

- The inspection/test will be performed by CMNT, CENV and QAAW.
- The recording of information will be retained by the engineer and presented in the final Engineering Report (ER) for QAAW review.
- The removal of the old battery, installation of the new battery and possible replacement of bad cells will be performed by CMNT personnel.

9.8 Service Restrictions

There are no service restrictions for the Long Term and Dynamic Test. The Shop Test is scheduled to be performed at the Greenbelt S&I facility.

9.9 Duration

The revenue testing is limited to 12 months.

10.0 CONCLUSION

Pass/Fail Criteria – 10 Shop Test – the charging of the battery 80 – 86% utilizing carborne LVPS must not exceed 5 hours. 2) Dynamic Test – The simulated revenue test shall demonstrate at least 40 minutes of service operation using battery power only. 3) Long Term Test – This test must demonstrate that the battery does not consume large amounts of water. Also this test is an indication of the longevity of the cell. Typically the cell voltage will fluctuate between 1.25VDC and 1.35VDC at 80-86% charge. Lesser voltage is an indication for reconditioning or that the battery is failing.

Note: ETP needs to be entered in Maximo.

Should this battery pass all tests as determined by the test engineers, the battery must be removed from the car until the ER is approved its associated EMI.

11.0 ATTACHMENTS

11.1 Attachment 'A'

25 Cell Sample Battery Layout

11.2 Attachment 'B'

Battery Charging Procedure WMATA 6K Test

11.3 Attachment 'C'

6K IPC Chapter 6

11.4 Attachment 'D'

6K HRMM Chapter 6

11.5 Attachment 'E'

6K RMM Chapter 6

11.6 Attachment 'F'

Sample Battery Test Table

11.7 Attachment 'G'

Battery Test Notice

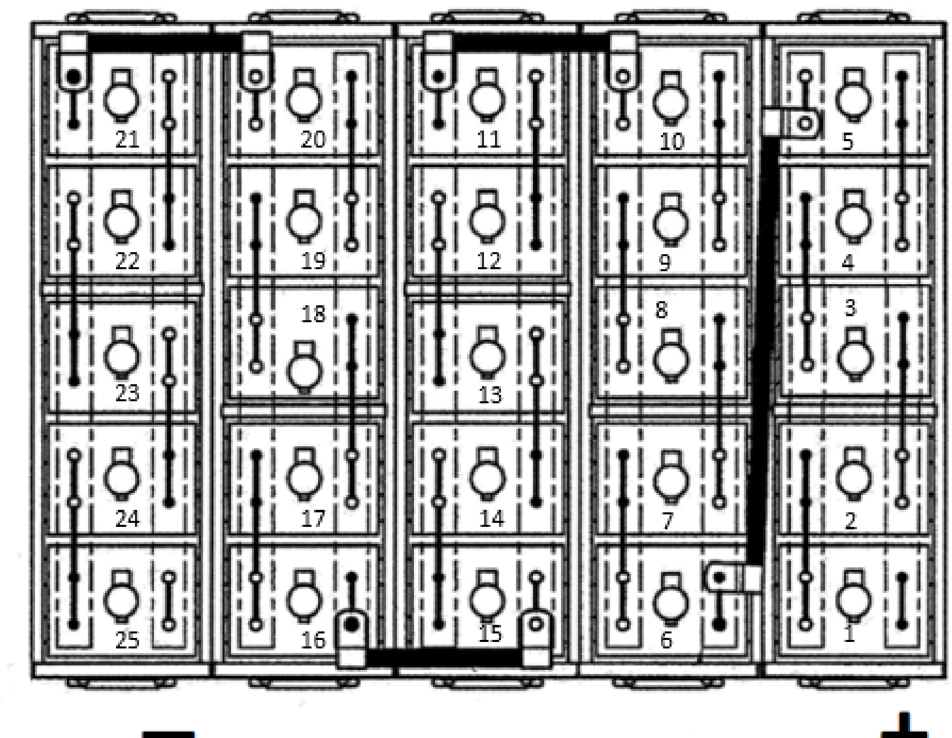
11.8 Attachment 'H'

Battery System Electrical Compatibility

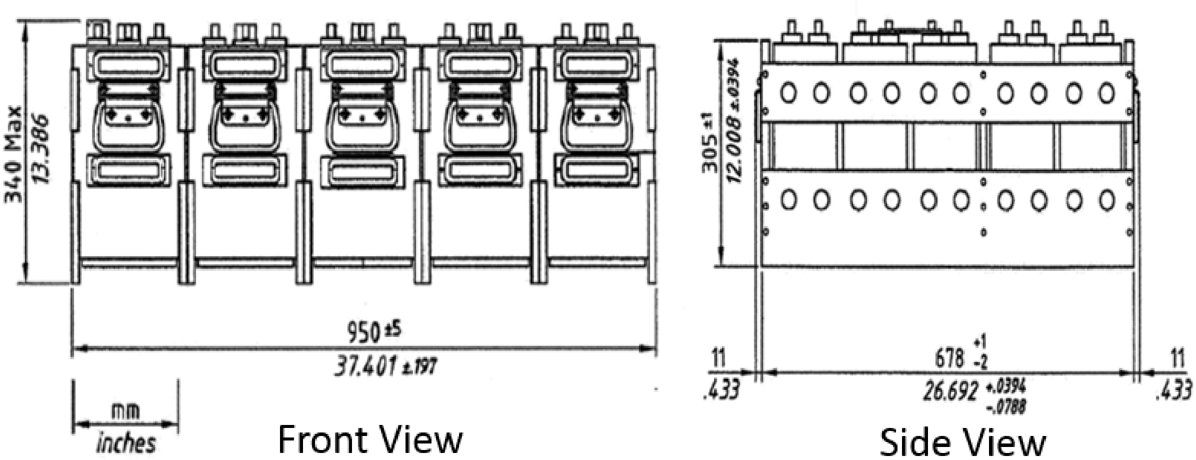
Attachment A

25 Cell Sample Battery Layout

Car Side



Top View



Front View

Side View

Attachment B

6K STATIC AND DYNAMIC CAR FACTORY ACCEPTANCE TEST PROCEDURE

1.0 BATTERY CHARGING PROCEDURE WMATA 6K TEST

NOTE: THIS TEST CAN BE DONE AT ANY TIME DURING ACCEPTANCE TESTING. THE EARLIER IN THE TEST PHASE THE BETTER IT IS FOR SCHEDULING PURPOSES.

1.1 General Safety Measures

Always wear gloves, rubber gloves and preferably alkali-proof clothing, when working on the battery or electrolyte. Always remember that battery electrolyte is a highly caustic potassium hydroxide.

- Before working on the battery, check that squeeze bottles suitable for irrigating the eyes and an emergency shower are available.
- During charging explosive gases may emerge, smoking, sparks or any kinds of flame in the surrounding of the battery are absolutely prohibited.
- Remember that the battery is virtually always live and cannot be insulated in the conventional sense. With steel cells even the cases are live. Take care that no short circuits are caused to cell terminals or in-between steel case cells by metal objects. Use insulated tools and remove metallic, adornments, such as ring and watches from hands and wrists.

1.2 General operating instructions

- On maintaining the battery you should never forget that lives may depend on its reliable operation under emergency conditions.
- Keep the battery clean and pay attention to proper electrolyte level.
- Only use purified water to fill up the batteries. Never add electrolyte or any additives whatsoever, unless you have been explicitly instructed to do so.
- Store and operate nickel cadmium batteries separately from lead acid batteries. Never work on the battery with equipment, which has previously been used on a lead acid battery, since Ni-Cd batteries might be damaged by sulfuric acid.
- When connecting cells, tighten the pole screws by using the following torque wrench: M8: 16Nm+1Nm.

1.3 Precautions

- Use eye protection (safety-goggles or face screens), rubber gloves and preferably, protective clothing where there is a high risk of electrolyte splashes. Don't wear clothing that produces static electricity, as explosions can occur through static electricity discharges.
- Always handle cells with care ensuring that they are in the upright position. Do not overfill batteries when filling with demineralized water.
- Avoid the use of conductive tools and use insulated tools only.

- Before working on a battery, remove metallic personal adornment, such as rings and watches, from your hands and wrists.
- Always disconnect the earth terminal, if any.
- Remember to switch off the charger before connecting or disconnecting a battery.

1.4 Emergency Action and Treatment

- Eye Contact: Irrigate the eye immediately with water for at least I 0 minutes by using a squeeze bottle or an eye douche. Immediate treatment in a specialist hospital is necessary.
- Skin Contact: Remove any contaminated clothing and wash the affected area with plenty of running water immediately. Consult doctor in case of any soreness or irritation.
- Swallowing: Immediately give your mouth a good rinse and drink a lot of water several times but DO NOT INDUCE VOMITING. Call for emergency doctor immediately.
- Burns: Apply a dry sterile dressing and consult a doctor.
- Electric Shock: Immediate action is essential in case of severe electric shock as breathing and heart action may be affected. Make sure that approaching the site of accident will not endanger yourself. Render first aid yourself without any delay. If necessary give artificial respiration. Call for an emergency doctor immediately.
- Explosion: Seek necessary medical attention and remember that alkaline electrolyte may have emerged.

1.5 Test Procedure

1.5.1 Tum off battery disconnect breaker (CBB) to the right of the battery box.
1.5.2 Remove locking brace and front cover of the battery box.
1.5.3 Pull and hold open the right hand handle of battery box to release the box.
1.5.4 Push the battery box from behind to extract.
1.5.5 Release tabs and slide batteries all the way out.
1.5.6 Discharge battery at 39A or less until every cell in the battery reaches less than 0.8Vdc and/or in reverse polarity. At this point, remove wires from battery and immediately connect a wire
1.5.7 Remove the wire shorting the battery and right away connect the battery charger in the opposite direction to charge at a constant current 39A in the reverse polarity. Charger leads can also be connected before removing shorting cable. Now charging (turned on) will cause the cells and overall battery voltage to be negative (reverse).This will cause the negative plates to completely discharge.
1.5.8 Continue the reverse charge until the cell voltages stabilize (no change in cell voltage readings). Start measuring individual cell voltages one hour after reverse charge begins. Continue to measure individual cell voltages every 1/2 hour until there is no change in voltage from prior reading. Hydrogen will be generated and water consumed when charged in the reverse. This step may take a few hours depending on how unbalanced the positive (+) and negative (-) plates are.
1.5.9 Once the reverse charging is completed, both polarities are totally discharged and the cells arc rebalanced. Let battery rest for at least one hour before charging.

1.5.10 Take voltage measurements across each cell. Verify that all cells are approximately the same voltage and that there are no shorted cells (0 VDC).
1.5.11 Connect battery charger to batteries.
1.5.12 Connect a clamp on amp meter to positive cable on battery charger.
1.5.13 Turn dial, on front of charger, all the way to the left or to its' minimum.
1.5.14 Turn on battery charger.
1.5.15 Slowly increase current, by turning dial on front of charger, until 39A are read on clamp on.
1.5.16 Maintain 39A, as batteries charge current will drop, need to maintain 39A for I5 hours.
1.5.17 Every 20 to 30 minutes check voltages per cell and record voltage on table below.
1.5.18 Visually check electrolyte level keeping the level over the top of the plates, use only demineralized water.
1.5.19 After 15 hours of charge time, turn off battery charger breaker on charger panel
1.5.20 Visually check electrolyte level to make sure it is above charging plates.
1.5.21 Take a final measurement across each cell, voltage range should be l.3VDC - 1.7VDC.
1.5.22 Disconnect charger from the batteries.
1.5.23 Push in battery box and install box cover and locking bar.

Attachment C: IPC Chapter 6

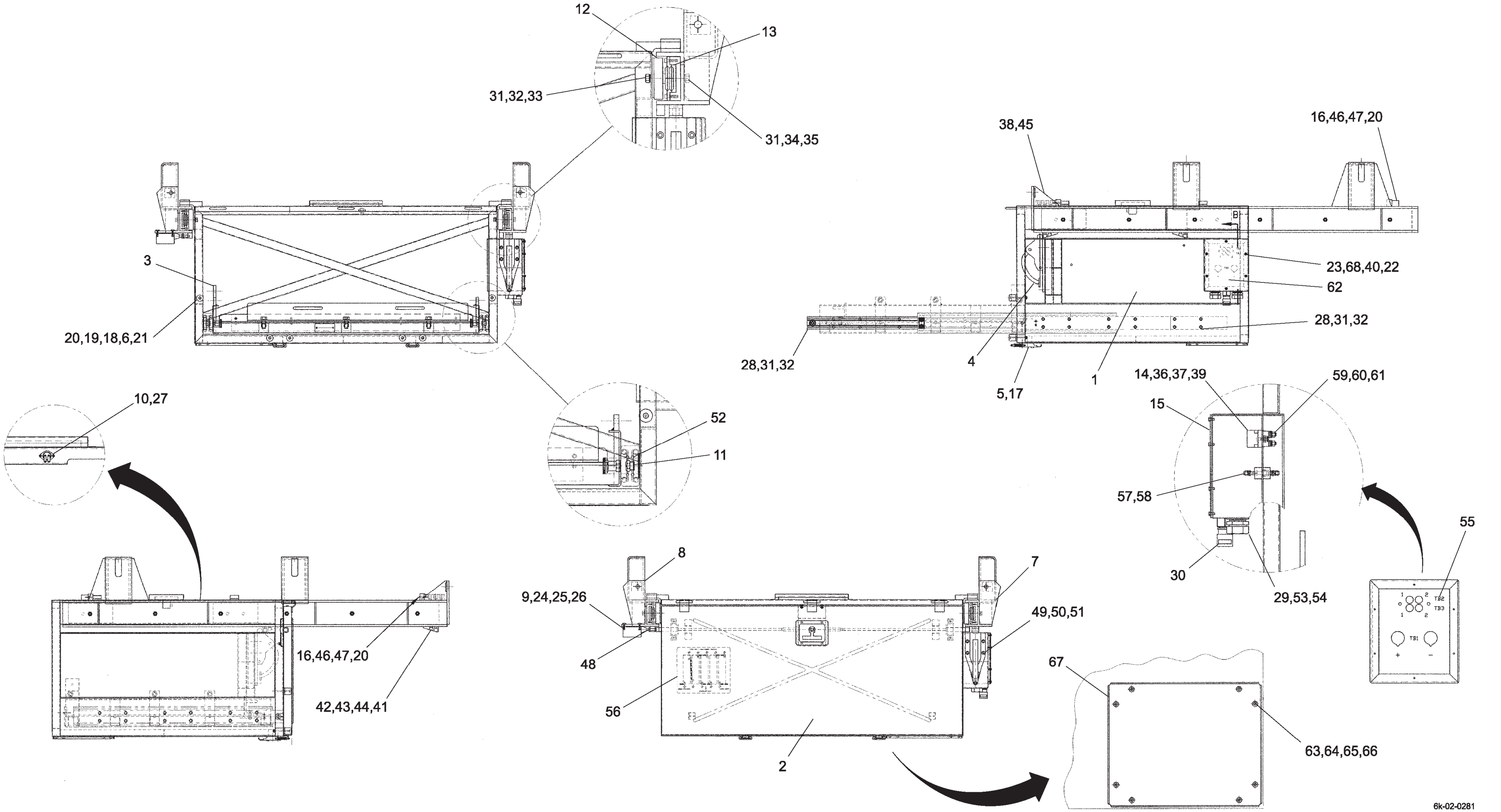


Figure 6-38. Battery Box Assembly,
B Car (AW00000001935)

Table 6-38. Battery Box Assembly, B Car (AW00000001935) Parts Listing

NEXT HIGHER ASSEMBLY PART NO.: AW00000001769
NEXT HIGHER ASSEMBLY FIGURE REFERENCE: 6-37

ITEM NO.	ITEM DESCRIPTION	VENDOR PART NO.	WMATA STOCK NO.	QTY	VENDOR
1	WELDMENT, BATTERY BOX ASSEMBLY	AW00000003867		1	ALSTOM
2	DOOR ASSEMBLY, BATTERY BOX (REFER TO FIG. 6-39)	AW00000003868		1	ALSTOM
3	TRAY ASSEMBLY, BATTERY BOX, B CAR (REFER TO FIG. 6-40)	AW00000003869		1	ALSTOM
4	LOCK ASSEMBLY	AW00000003870		1	ALSTOM
5	LATCH, SST, SPR. TENSION TOGGLE WITH SAFETY RELEASE	DTR0022421046		2	BRADLEY
6	BUMPER, DUROMETER 70, WITH WASHER	DTR0000065375		6	ALSTOM
7	SLIDING SUPPORT ASSEMBLY, RIGHT SIDE	AW00000003871		1	ALSTOM
8	SLIDING SUPPORT ASSEMBLY, LEFT SIDE	AW00000003872		1	ALSTOM
9	LIMIT SWITCH	DTR0000065376		1	ALSTOM
10	KLIXON THERMOSTAT	DTR0000065377		1	ALSTOM
11	TELESCOPIC SLIDE (MAX. EXT. 800 MM)	DTR0000065378		2	ALSTOM
12	CARRIAGE, ALUM., SST	DTR0000065408		4	ALSTOM
13	GUIDE RAIL, ALUM., SST	DTR0000065407		2	ALSTOM
14	INSULATOR, TERMINAL BLOCK	DTR0000065782		1	ALSTOM
15	COVER, 304, SST	AW00000003873		1	ALSTOM
16	BUMPER, NEOPRENE	DTR0000065583		4	ALSTOM
17	RIVET, SST, 0.188 X 0.126-0.188 GRIP	DTR0000065779		4	ALSTOM
18	SCREW, MACHINE, PHILLIPS PAN HD, #6-32 X 2.75 LG, SST 18-8	DTR0000082670		6	ALSTOM
19	LOCKNUT, NYLON INSERT, #6-32 UNC, 18-8, SST	DTR0000065350		6	ALSTOM
20	WASHER, #6, SST 18-8, TYPE A	DTR0000065346		12	ALSTOM
21	WASHER BB, #10, 1.00 OD, ZPSTL	DTR0000065795		24	ALSTOM
22	WASHER, #8, SST, TYPE A	DTR0000065347		6	ALSTOM
23	LOCKWASHER, #8, SST	DTR0000064097		6	ALSTOM
24	SCREW, MACHINE, SLOTTED PAN HD, M6 X 1, 25 MM LG, ZPSTL	DTR0000121344		4	ALSTOM
25	WASHER, REG. M6, ZPSTL	DTR0000065725		4	ALSTOM
26	LOCKWASHER, M6, ZPSTL	DTR0000065731		4	ALSTOM
27	RIVET, PROTRUDING HD, 3/32 X 0.20-0.125 GRIP, SST	DTR0000065345		2	ALSTOM
28	BOLT, HEX, GR 8.8, M10 X 1.5 REGULAR, 25 MM LG, ZPSTL	DTR0000065719		48	ALSTOM
29	STRAIN RELIEF, HUB SIZE=1, 0.625-0.750 GRIP	DTR0000027661		2	ALSTOM
30	STRAIGHT ADAPTER, PMAFIX, STR 1/2 IN. MNPT TO 17 CONDUIT	DTR0000066214		1	ALSTOM
31	WASHER, M10, REGULAR, ZPSTL	DTR0000065726		68	ALSTOM
32	WASHER, SPRING, M10, ZPSTL	DTR0000065733		56	ALSTOM
33	BOLT, HEX, GR 9.8, M10 X 1.5 REGULAR, 25 MM LG, ZPSTL	DTR0000065720		8	ALSTOM

Table 6-38. Battery Box Assembly, B Car (AW00000001935) Parts Listing (Cont)

NEXT HIGHER ASSEMBLY PART NO.: AW00000001769
NEXT HIGHER ASSEMBLY FIGURE REFERENCE: 6-37

ITEM NO.	ITEM DESCRIPTION	VENDOR PART NO.	WMATA STOCK NO.	QTY	VENDOR
34	SCREW, MACHINE, PHILLIPS PAN HD, GR 9.8, M10 X 1.5, 30 MM LG, ZPSTL	DTR0000065717		12	ALSTOM
35	LOCKNUT, NYLON INSERT, GR 8, M10 X 1.5 REGULAR, ZPSTL	DTR0000065716		12	ALSTOM
36	SCREW, MACHINE, PHILLIPS PAN HD, #10-24 X .875 LG, SST	DTR0000065330		2	ALSTOM
37	WASHER, #10, SST	DTR0000063921		4	ALSTOM
38	STOPPER, 304, SST	AW00000003875		2	ALSTOM
39	LOCKNUT, NYLON INSERT, #10-24, SST	DTR0000064877		2	ALSTOM
40	RETAINER, #8, SST	DTR0000065374		6	ALSTOM
41	KEEPER, 304, SST	DTR000003876		2	ALSTOM
42	SCREW, CAP, 1/4-28 UNF X 5/8 LG, ZPSTL	DTR000065300		2	ALSTOM
43	LOCKWASHER, 1/4, ZPSTL	DTR0000065342		4	ALSTOM
44	SCREW, CAP, 1/4-28 UNF X 1/2 LG, ZPSTL	DTR0000065348		2	ALSTOM
45	SCREW, CAP, 5/16-24 UNF X 1/2 LG, ZPSTL	DTR0000082674		6	ALSTOM
46	SCREW, MACHINE, PHILLIPS PAN HD, #6-32 UNC X 0.375 LG, SST	DTR0000065331		8	ALSTOM
47	LOCKWASHER, #6, ZPSTL	DTR0000065336		8	ALSTOM
48	PLUNGER, DELRINE	AW00000003877		1	ALSTOM
49	SCREW, MACHINE, PHILLIPS OVAL CTSK HD, 1/4-20 X 1.00 LG, SST	DTR0000065344		5	ALSTOM
50	WASHER, FLAT, TYPE A, 1/4 NARROW, SST	DTR0000056192		5	ALSTOM
51	LOCKNUT, STAND HEX, NYLON INSERT, 1/4-20 UNC, SST	DTR0000056012		5	ALSTOM
52	PLATE, 304, SST	AW00000003878		50%	ALSTOM
53	SEALING RING, CONDUIT, 1.00 IN., ZPSTL	DTR0000065738		2	ALSTOM
54	CONDUIT LOCKNUT, C/S, 1 IN., ZPSTL	DTR0000065722		2	ALSTOM
55	DECAL KIT FOR CONNECTOR BOX	AW00000004122		1	ALSTOM
56	BATTERY CONNECTIONS DECAL	AW00000005091		1	ALSTOM
57	INSULATOR	AW00000006399		2	ALSTOM
58	STUD, TERMINAL	AW00000006522		2	ALSTOM
59	NUT, JAM, ZPSTL, 1/4-20	DTR0000098154		8	ALSTOM
60	LOCKWASHER, ZPS, 1/4 HELICAL	DTR0000065342		8	ALSTOM
61	WASHER, FLAT, ZPS, 1/4 NARROW	DTR0000065160		8	ALSTOM
62	GASKET, SILICONE, 1.00 IN. X 0.125 THK, ADHESIVE BACKED, GRAY	DTR0000105790		28	ALSTOM
63	SCREW, MACHINE, PAN HEAD, #10-32 X 5/8 LG, ZPSTL	DTR0000064161		8	ALSTOM
64	WASHER, FLAT, TYPE A, ZPS, #10	DTR0000071721		8	ALSTOM
65	LOCKWASHER, HELICAL SPRING, ZPS, #10	DTR0000066468		8	ALSTOM

Table 6-38. Battery Box Assembly, B Car (AW00000001935) Parts Listing (Cont)

NEXT HIGHER ASSEMBLY PART NO.: AW00000001769
NEXT HIGHER ASSEMBLY FIGURE REFERENCE: 6-37

ITEM NO.	ITEM DESCRIPTION	VENDOR PART NO.	WMATA STOCK NO.	QTY	VENDOR
66	INSERT, THREADED, #10-32, 0.030-0.120 GRIP, ZPS	DTR0000069427		8	ALSTOM
67	COVER	AW00000008258		1	ALSTOM
68	SCREW, CAPTIVE, #8-32 UNC X 0.5 LG, SST	DTR0000110767		6	ALSTOM
N/I	SEAL, EDGE, 3M, P/N T000-060-162	DTR0018238111		.1	ALSTOM

END OF FIGURE

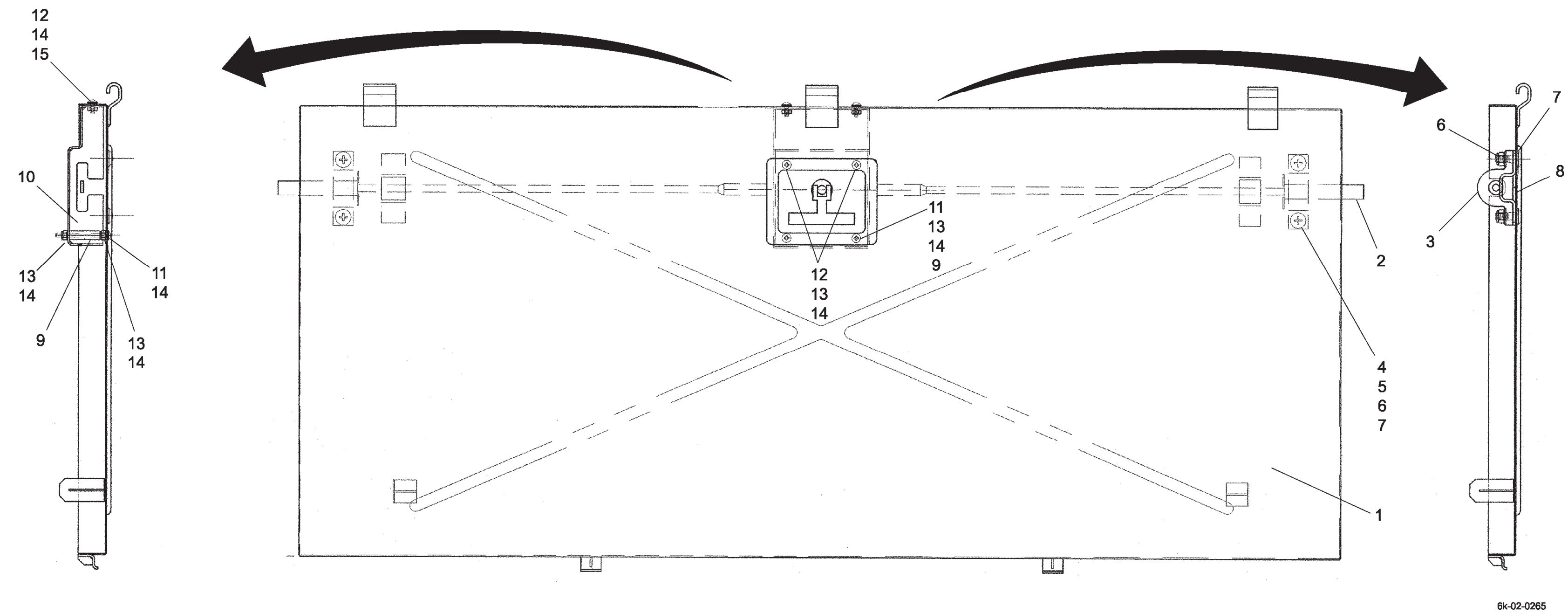


Figure 6-39. Battery Box Door Assembly, B Car (AW00000003868)

Table 6-39. Battery Box Door Assembly, B Car (AW00000003868, AW00000001935) Parts Listing

NEXT HIGHER ASSEMBLY PART NO.: WMATA 6000
NEXT HIGHER ASSEMBLY FIGURE REFERENCE: 6-38

ITEM NO.	ITEM DESCRIPTION	VENDOR PART NO.	WMATA STOCK NO.	QTY	VENDOR
1	WELDMENT, DOOR	AW00000003896	A18337073	1	ALSTOM
2	DEAD BOLT LATCH ASSEMBLY	AW00000003897	A18337202	1	ALSTOM
3	PILLOW BLOCK, ALUM. MOUNT BRONZE BEARING	DTR0000065371		2	ALSTOM
4	SCREW, MACHINE, PHILLIPS HEAD, 5/16-18 UNC X 1.00 LG, SST	DTR0000065325		4	ALSTOM
5	LOCKNUT, NYLON INSERT, 5/16-18 UNC, SST	DTR0000067238		4	ALSTOM
6	WASHER, FLAT, NARROW, 5/16, SST	DTR0000064700		4	ALSTOM
7	WASHER, FLAT, WIDE, 5/16, SST	DTR0000064699		4	ALSTOM
8	PLATE, 304, SST	AW00000003898		2	ALSTOM
9	SPACER, SST, 0.166 ID X 0.375 OD X 1.25 LG	DTR0000065372		2	ALSTOM
10	PROTECTOR ASSEMBLY	AW00000003899		1	ALSTOM
11	SCREW, MACHINE, PHILLIPS HEAD, #8-32 UNC X 2.125 LG, SST	DTR0000065326		2	ALSTOM
12	SCREW, MACHINE, PH HEAD, #8-32 UNC X 0.500 LG, SST	DTR0000065327		4	ALSTOM
13	LOCKNUT, NYLON INSERT, #8-32 UNC, SST	DTR0000065351		6	ALSTOM
14	WASHER, #8, SST	DTR0000065347		12	ALSTOM
15	LOCKWASHER, #8, SST	DTR0000064097		2	ALSTOM

END OF FIGURE

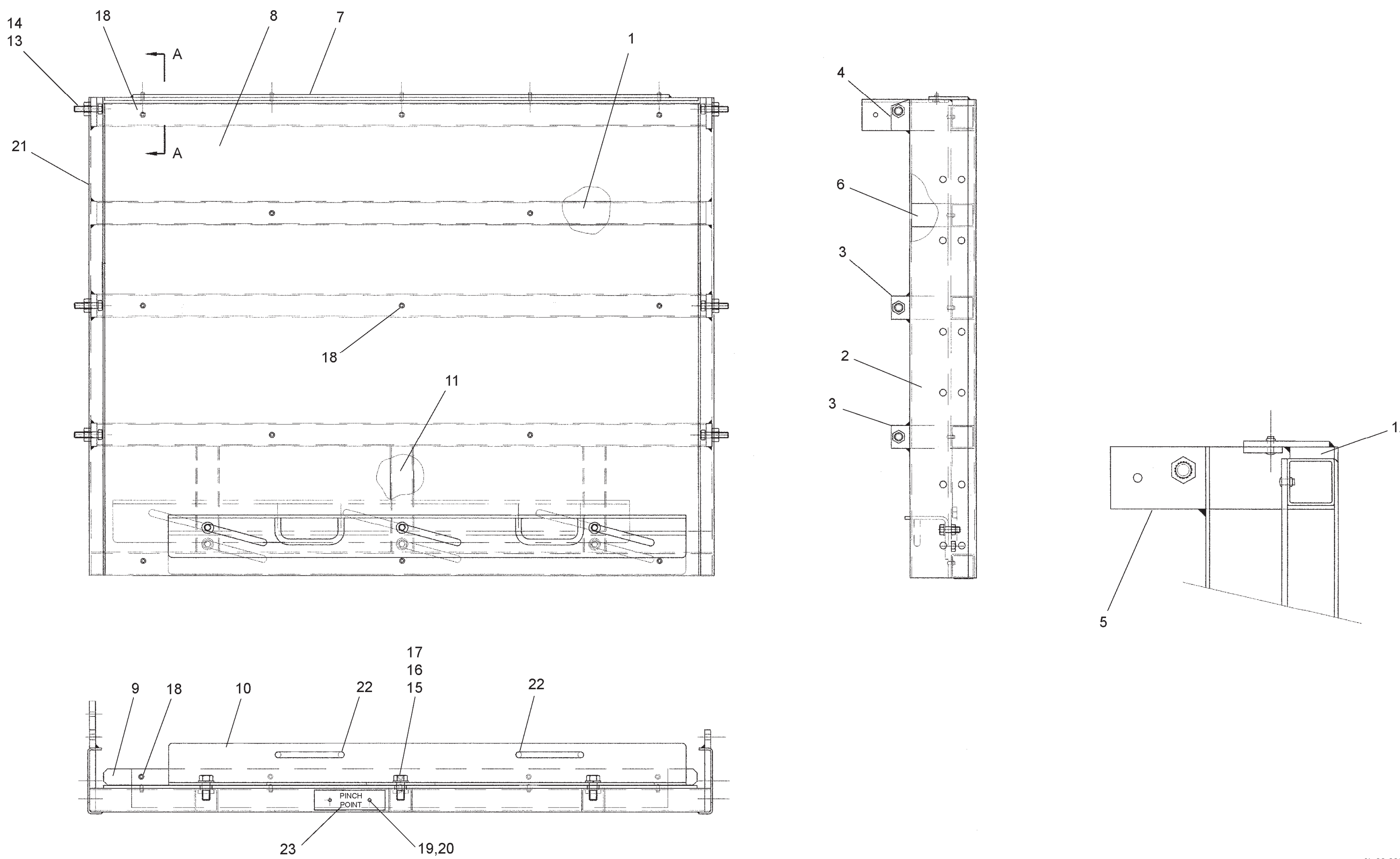


Figure 6-40. Battery Box Tray Assembly, B Car (AW00000003869)

Table 6-40. Battery Box Tray Assembly, B Car (AW00000003869) Parts Listing

NEXT HIGHER ASSEMBLY PART NO.: AW00000001935
NEXT HIGHER ASSEMBLY FIGURE REFERENCE: 6-38

ITEM NO.	ITEM DESCRIPTION	VENDOR PART NO.	WMATA STOCK NO.	QTY	VENDOR
1	TUBE, SST 304	AW00000004107		4	ALSTOM
2	CHANNEL, SST 304	AW00000004108		1	ALSTOM
3	PLATE, SST 304	AW00000003901		4	ALSTOM
4	PLATE, SST 304	AW00000003902		1	ALSTOM
5	PLATE, SST 304	AW00000003903		1	ALSTOM
6	PLATE, SST 304	AW00000004110		2	ALSTOM
7	PLATE, SST 304	AW00000003904		1	ALSTOM
8	PLATE, GP03, POLYESTER GLASS LAMINATE	AW00000003900		1	ALSTOM
9	PLATE, GP03, POLYESTER GLASS LAMINATE	AW00000003906		1	ALSTOM
10	ANGLE, 304, SST	AW00000003908		1	ALSTOM
11	SUPPORT ASSEMBLY, SST	AW00000003909		3	ALSTOM
12	BAR, SST 304	AW00000004111		1	ALSTOM
13	HEX BOLT, 3/8-16 UNC X 1.75, SST	DTR0000065785		6	ALSTOM
14	LOCKNUT, NYLON INSERT, 3/8-16 UNC, SST	DTR0000065787		6	ALSTOM
15	HEX BOLT, 3/8-16 UNC X 1.25, SST	DTR0000065786		3	ALSTOM
16	WASHER, 3/8, SST	DTR0000065788		3	ALSTOM
17	LOCKWASHER, SPRING, 3/8, SST	DTR0000065789		3	ALSTOM
18	RIVET, BLIND, REG. PROT. HEAD, 3/16, 0.251-0.375 GRIP, SST	DTR0000066729		18	ALSTOM
19	RIVET, BLIND, REG. PROT. HEAD, 3/16, 0.125-0.187 GRIP, SST	DTR0000065779		2	ALSTOM
20	TUBE, SST 304	AW00000004114		1	ALSTOM
21	CHANNEL, SST 304	AW00000004109		1	ALSTOM
22	PULL HANDLE, SST 304	AW00000005105		2	ALSTOM
23	LABEL, PINCH POINT	AW00000008264	L18333045	1	ALSTOM

END OF FIGURE

Attachment D: HRMM Chapter 6

The converter has a Control PCB whose front panel contains Light Emitting Diode (LED) indicators. There are three green, five yellow, and eleven red LED indicators. In normal operation, the three green LED indicators are lighted. When an abnormal condition is detected, an associated yellow or red LED indicator lights. This provides a means of easily monitoring system status and isolating a fault condition (refer to Running Maintenance and Servicing Manual, Section 2, Troubleshooting).

6-1-3.2 Battery, Equipment Overview

In the rail transit industry, the nickel cadmium battery is used to store energy in order to supply emergency power to low voltage circuits in case of high voltage loss or charging equipment failure. The WMATA 6000 series passenger trains use Saft vented, sintered / Plastic Bond Electrode (PBE) nickel cadmium batteries. The following is a general description of the components of the battery.

6-1-3.2.1 Electrodes (Figure 6-1-2)

The electrodes/plates inside the nickel cadmium cells are sintered positive and plastic bonded negative. The positive active material is nickel hydroxide, while the negative active material is a cadmium-oxide mixture. The sintered positive is obtained by chemical impregnation of nickel hydroxide into a porous nickel sinter coated thin steel strip that was previously perforated and nickel-plated. The PBE is obtained by the coating of slurry, consisting of cadmium oxide mixed with a plastic binder onto a nickel-plated thin perforated steel strip.

Each cell has plate stacks consisting of a number of positive and negative plates that are separated by a multi-layer separator. The plate stacks are bolted to the corresponding positive or negative terminal post(s). A cutaway view of a typical cell is shown in Figure 6-1-2.

6-1-3. EQUIPMENT OVERVIEW (CONT)

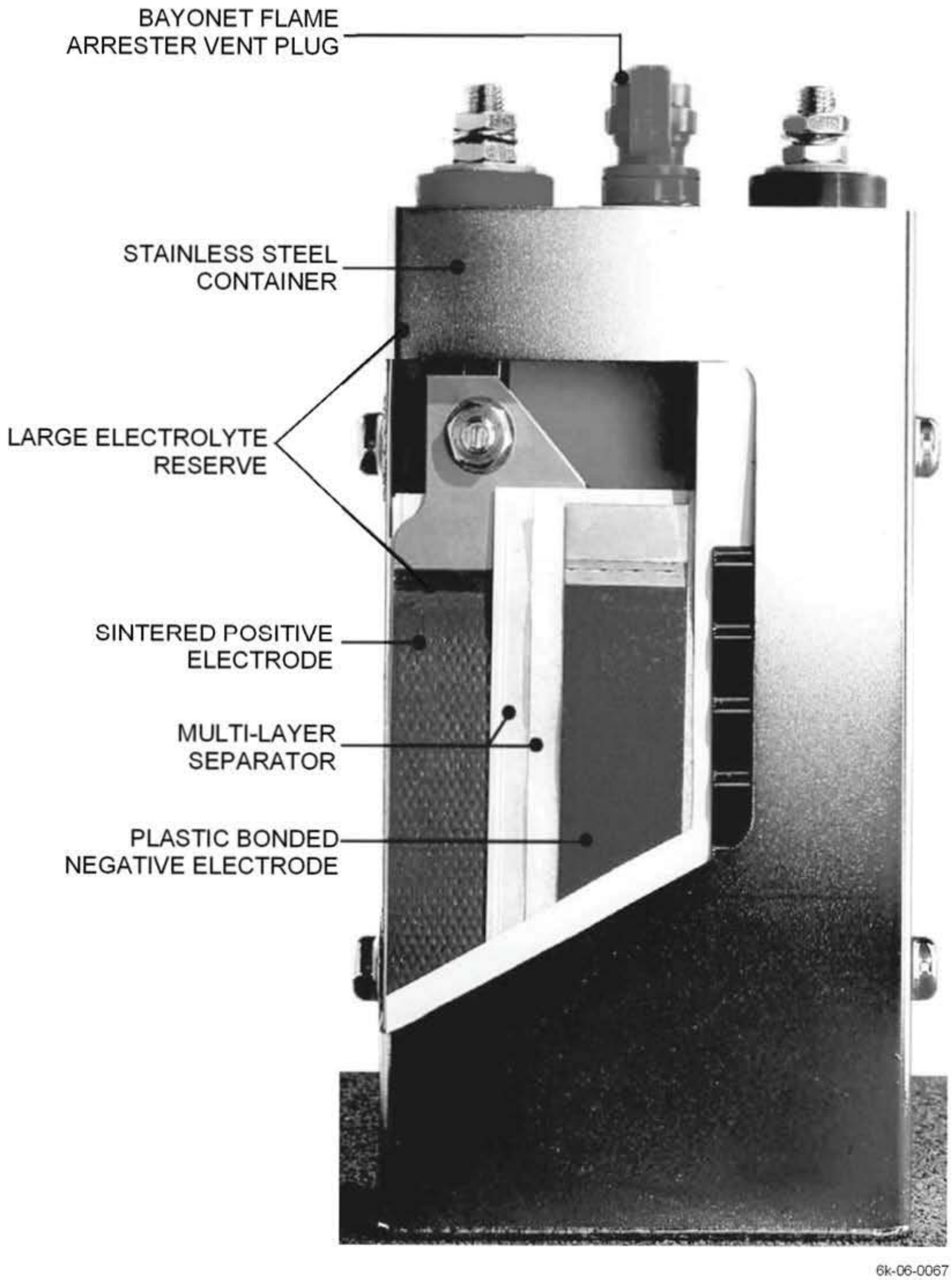


Figure 6-1-2. Battery Cell

6-1-3.2.2 Electrolyte

CAUTION

The sulfuric acid used in lead acid batteries will ruin a nickel cadmium battery. Do not put sulfuric acid in a nickel cadmium cell.

The alkaline electrolyte in a nickel cadmium battery is a solution of potassium hydroxide (KOH), lithium hydroxide (LiOH), and distilled or de-ionized water. The electrolyte does not participate in the electrochemical reaction, which takes place in the battery cell, but only acts as an ion-carrying medium and its specific gravity remains relatively constant. Thus, a specific gravity reading from a nickel cadmium cell does not give an indication as to its state of charge but may alter slightly due to plate and separator absorption.

6-1-3.2.3 Cell Container (Figure 6-1-3)

CAUTION

Detergent solvents or any other chemical agents are not to be used unless approved by Saft. Direct sunlight and heat must be avoided.

6-1-3. EQUIPMENT OVERVIEW (CONT)

The cell container is made of stainless steel assembled in flame-retardant plywood crates. It is a high impact, flame retardant container that resists most kinds of abuse. All its seams are welded. Several cells are assembled together into plywood crates with stainless steel lifting handles. Figure 6-1-3 depicts a multi-cell crate assembly. Jumper arrangement can be seen in the illustration. Terminal polarity is marked by the washer color at each terminal (black or blue for negative and red for positive). Additionally there is a "+" sign stamped next to the positive terminal of each cell.

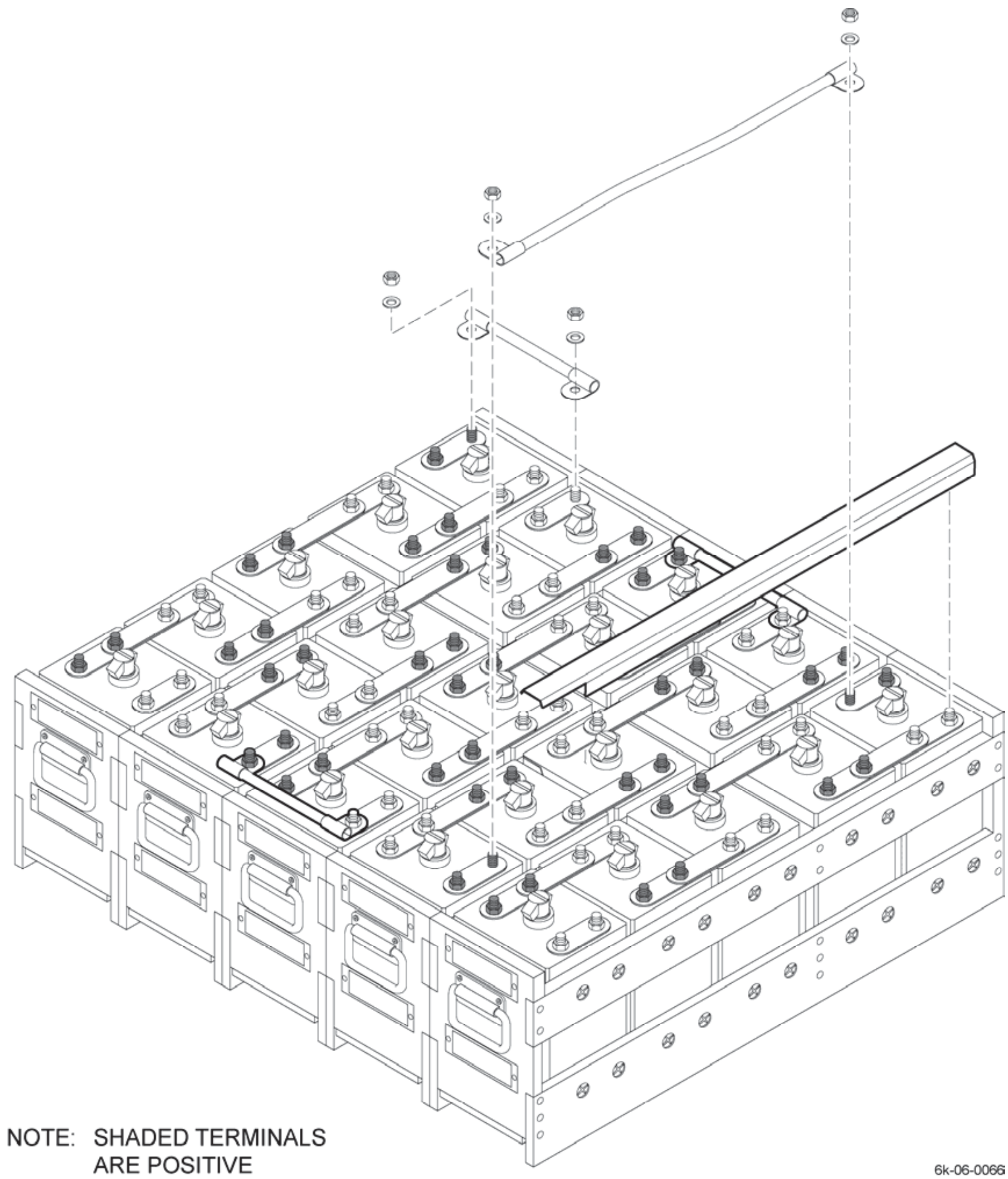


Figure 6-1-3. Battery Assembly

6-1-3.2.4 Cell Vent Plug

WARNING

Cell vent plug covers must remain closed at all times except when topping-up or filling. Failure to observe this safety precaution can lead to personal injury.

Each cell is equipped with a flip-top flame arrester vent plug. The cell vent plug cover or cap, when closed, allows the escape of hydrogen and oxygen gases developed during the charging process and prevents a flame or spark from entering the cell that could ignite this gas mixture contained internally in the upper cell compartment leading to an explosion.

6-1-3.2.5 Battery Assembly

The nickel cadmium battery is assembled into a stainless steel battery box. Five cells are assembled together and connected in series to form a crate, and five crates are installed in the box, connected in series to form the battery assembly. These series connections are achieved by using rigid intercell connectors made of nickel-plated copper and flexible cable connections/assemblies. The battery is equipped with a temperature sensor assembly mounted on the inside of the box, above the battery, approximately at its center. Refer to Figure 6-1-3 for a depiction of the battery assembly.

6-1-3.2.5.1 Battery Box Overtemperature Switch

There is an overtemperature switch mounted inside the battery box. When a temperature of 401 °F is detected in the battery box, this "klixon" switch closes, causing the Undervoltage Relay (UVR) to drop, which, in turn, opens the battery circuit breaker. This removes the battery load, allowing the battery to cool.

6-1-3.2.6 Cell Identification

The cell type identification and the International Electrotechnical Commission (IEC) standard designation that includes the capacity are shown on the label(s) of each cell (e.g. KH195 for an SRX195 is 195Ah), as per the IEC 60623 designation. Each battery crate has label(s) with the same identification and other battery crate details.

The positive terminal has a red polarity washer and the negative terminal has a blue or black polarity washer. The "+" terminal can be further identified by a "**+**" raised symbol molded on the cell cover.

6-1-3.2.7 Date Code

The manufacturing date code is punched on top of each cell's positive terminal by month (upper number) and year (lower number), e.g., 1203 for December 2003. The manufacturing date code is also on the crate identification label as year and month.

6-5-28. BATTERY CELL REPLACEMENT

Activities
Remove Cell
Install Cell

Applicable Car(s)
A Car

Equipment Condition
Battery Crate Removed from Battery Compartment ("Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5)

References
IPC Figure 6-34
Paragraph 6-5-3
Paragraph 6-5-30

Special Tools
None

Supplies
Cell Assembly, Battery, SRX195, Saft, P/N 213166

Test Equipment
None

WARNING

Always refer to Paragraph 6-5-3 "Battery Safety Precautions" prior to following instructions in this Section. Follow all maintenance procedures exactly as written in this manual and observe all warnings and cautions to prevent electrical shocks.

The battery box can detach from car if it is not installed properly. Follow maintenance procedures as directed in this manual and assure maintenance is performed by qualified, trained personnel. Use a lifting device or obtain assistance when attempting to lift heavy or bulky equipment.

Failure to observe safety precautions can lead to personal injury.

CAUTION

When cell replacement is necessary, it is recommended to replace with cell(s) or crate(s) having similar service life, age, and capacity as the rest of the battery. New cells or battery crate(s) shall be part of new batteries.

After replacing one or more battery crates in a battery out of service, it is recommended to commission the entire battery (refer to Paragraph 6-5-30). All contact surfaces must be clean and dry before making connections.

6-5-28. BATTERY CELL REPLACEMENT (CONT)

CAUTION

Never mix charged and discharged cells or battery crates in the same carset battery.

The battery consists of cells connected in series with rigid intercell connectors and flexible cable connections/assemblies. Each cell's positive terminals are identified with red polarity washers and the negative terminals have blue or black polarity washers. The "+" terminal can be further identified by a "+" raised symbol molded on the cell cover.

All battery hardware such as nuts, washers, rigid connectors, and cable lugs are nickel-plated and metric-sized.

Remove Cell (Figures 6-5-25)

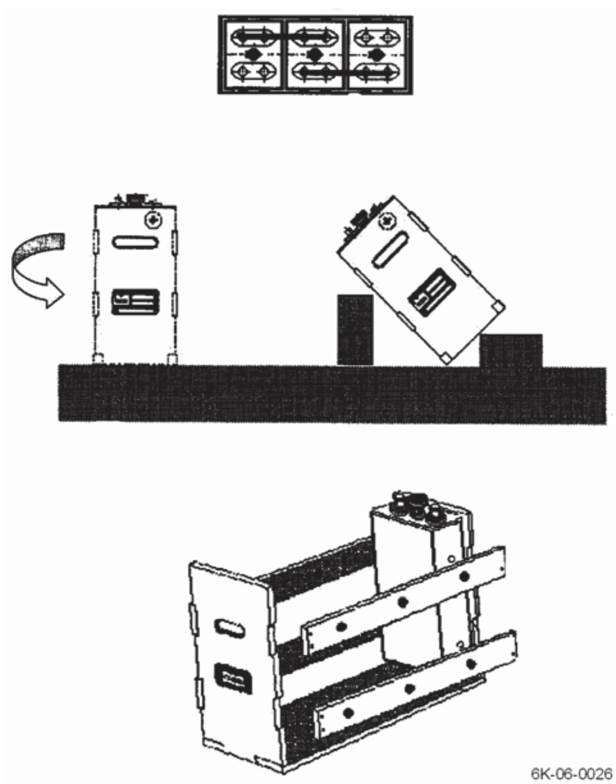


Figure 6-5-25. Battery Cell Removal

1. Loosen and remove nuts from the cell to be removed.
2. Loosen and remove nuts on terminals of cells directly connected to the cell you are removing.
3. Slope and wedge the crate at about 45 degrees.
4. Remove screws from slides.

5. Disassemble slides of crate.

6. Remove cell.

Install Cell (Figure 6-5-26)

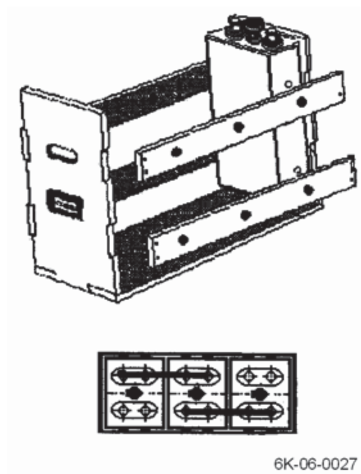


Figure 6-5-26. Battery Cell Installation

1. Place new cell into position in crate respecting polarities.

2. Reassemble crate slides.

3. Fasten slides to cell with screws.

4. Place the crate in a horizontal position.

5. Connect rigid connections, insert washers, and tighten nuts to 11 ± 1.5 ft-lb torque.

End of Replacement

6-5-29. BATTERY CAPACITY CHECK

Activities
Check Battery Capacity

Applicable Car(s)
A Car

Equipment Condition
Battery Removed from Battery Compartment ("Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5) and on Bench

References
"Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5
"Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 4
IPC Figure 6-33
Paragraph 6-1-6.2
Paragraph 6-5-3
Paragraph 6-5-28
Paragraph 6-5-30

Special Tools
None

Supplies
None

Test Equipment
None

Check Battery Capacity (Figures 6-5-27 and 6-5-28)

As part of the periodic maintenance operations, it is recommended to perform a capacity check every five years. While the routine maintenance operations are conducted on the cars, the battery capacity check requires the removal of the battery from the car to the battery room/maintenance shop. Record test values on the Discharge Test Record form (QC130) located at the end of this task.

WARNING

Always refer to Paragraph 6-5-3 "Battery Safety Precautions" prior to following instructions in this Section.

Verify that all electrical connections and polarities are made correctly including charge/discharge cables. The cells' positive terminals are identified with red polarity washers and negative terminals have blue or black polarity washers. The "+" terminal can also identified by a "+" raised symbol molded on the cell cover.

6-5-29. BATTERY CAPACITY CHECK (CONT)

WARNING

During charging there are gases (oxygen and hydrogen) generated by the battery. Due to this gassing each cell will be bubbling internally. The work area shall be well ventilated to prevent from an explosive mixture forming when the hydrogen concentration exceeds 4 percent volume hydrogen to air. Follow all maintenance procedures exactly as written in this manual and observe all warnings and cautions to prevent electrical shocks.

Failure to observe safety precautions can lead to personal injury.

CAUTION

When cell replacement is necessary, it is recommended to replace with cell(s) having similar service life, age, and capacity as the rest of the battery. New cells shall be part of new batteries. Refer to Paragraph 6-5-28 for cell replacement procedures.

Never mix charged and discharged cells in the same battery.

If a defect is found on any cell, the entire battery must be removed from the car and sent to battery room or maintenance shop.

NOTE

The following procedure must be followed to check the battery capacity (refer to Paragraph 6-1-6.2 for the description of rated capacity. (The rated capacity for a new battery is 195 aH). A capacity test is easier to be controlled and performed in a battery room/shop with the appropriate tools and equipment.

When the batteries were sized, all or some of the following factors were utilized depending on the specification; state of charge, temperature, aging, voltage window, load profile, discharge time, charge time, watering interval, battery materials, physical dimensions and weight.

Battery life depends on ambient temperature, cycling frequency, depth of discharge, charging parameters, and type of maintenance performed. End of life for a nickel cadmium cell/battery is when it can no longer satisfy the acceptable specification by the Transit Authority.

Since there is no risk of sudden death, the nickel cadmium battery will continue to provide a service even when the capacity falls to a low value. The Transit Authority needs to establish by field trial or by actually conducting a load profile discharge test, at what capacity should there be a cell or battery replacement.

Refer to Paragraph 6-5-30 for more information about charging the battery.

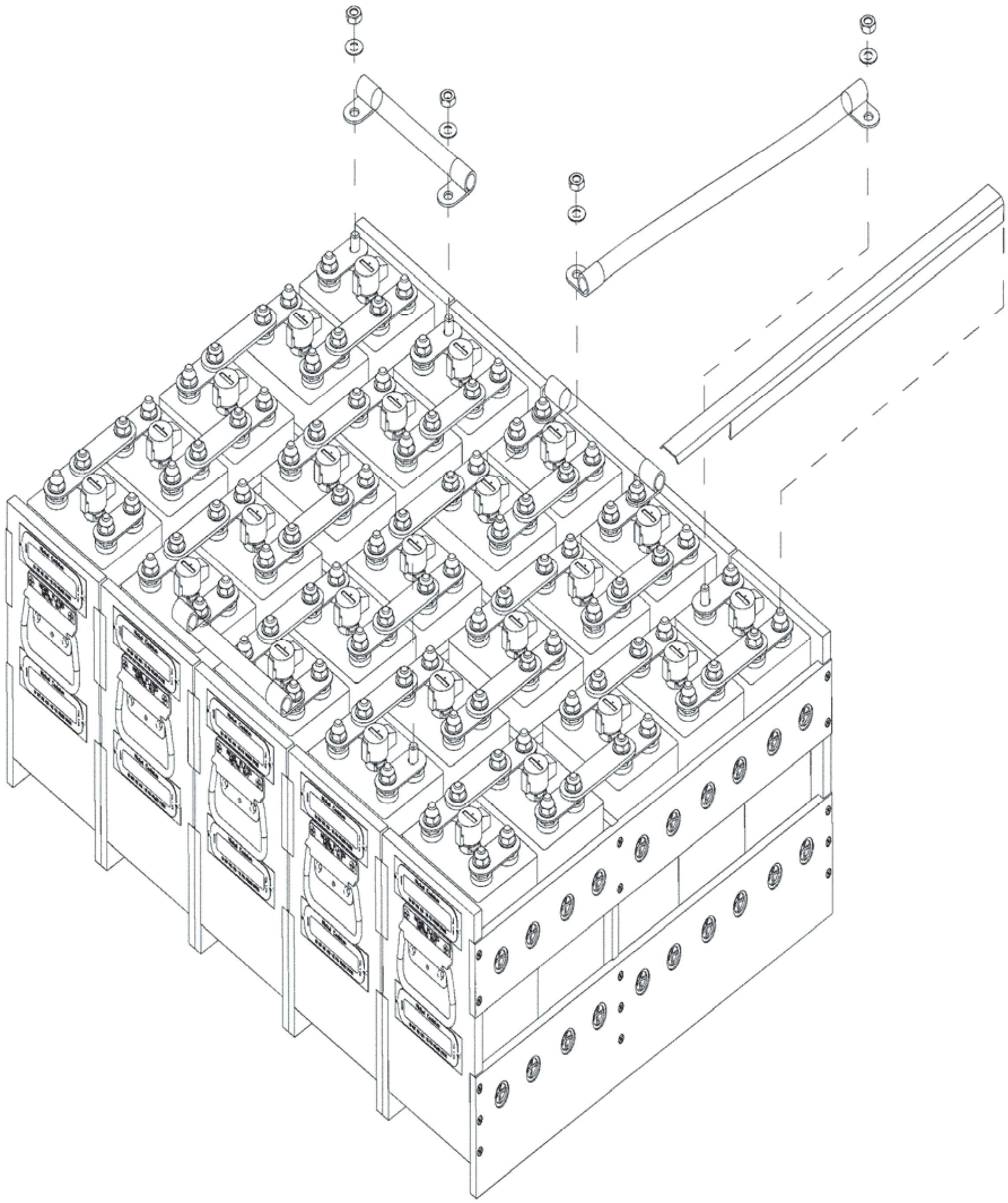


Figure 6-5-27. Battery Configuration

1. Take carset battery to battery room/maintenance shop and place on a flat bench, keeping it level.

2. Reassemble battery as shown in Figure 6-5-27 and using guidelines in the Running Maintenance and Servicing Manual, Chapter 6, Section 5.

3. Top-up battery (Refer to "Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 4).

6-5-29. BATTERY CAPACITY CHECK (CONT)

4. Discharge at $0.2C_5A$ down to below 0.8 V per cell. This will allow all cells to be approximately the same state of charge. Reversing polarities of cells will not damage them, but will consume more water and generate more gases (oxygen and hydrogen).

5. Charge using constant current charging at $0.2C_5A$ for 8 hours.

6. Allow battery to rest for 1 to 4 hours.

7. Discharge at $0.2C_5A$ to 1.0 V/cell. Record voltage of each cell and overall battery every hour and every half-hour after the first three hours (refer to Figure 6-5-28, QC130 "Discharge Test" record form). If an Ah counter is used, record Ah discharged.

saft

DISCHARGE TEST

REF. SPEC. NR.: ____________________

DATE: ____________________

TEST FOLLOWING:

AMBIENT TEMP. : START ________ °F END ________ °F

TYPE OF CELLS: ____________

CAPACITY: ____________

QUANTITY: ____________

ORDER NR.:

DISCHARGE AT: ________AMP.

________ AFTER

CHARGING TIME: HRS.@ AMP.

PREVIOUS OPERATION

CHARGING TIME:_____ H AT ________A : DISCHARGING AT:____A
A

CHARGING TIME:_____ H AT ________A : DISCHARGING AT:____A
A

CHARGING TIME:_____ H AT ________A : DISCHARGING AT:____A
A

PREVIOUS ELECTROLYTE CHANGES

1ST ELECTROLYTE USED: NR. ________ S.G. ________

2ND ELECTROLYTE USED: NR. ________ S.G. ________

HOURS	DURAT.	COUNTER	Ah	TEMP.	CELL TERMINAL VOLTAGE														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

PERFORMED BY: TEST WITNESSED IN PRESENCE OF: CUSTOMER ACCEPTANCE:

Instruction No. 030924-4241 Rev. 1 Page 27

6k-06-0069

Figure 6-5-28. Battery Discharge Test Record Form

6-5-29. BATTERY CAPACITY CHECK (CONT)

8. Remove any cell(s) that are not acceptable and reinstall with replacement discharged cells.

9. Commission battery per Paragraph 6-5-30 (charge, discharge, charge, topping-up, and cleaning).

10. Disassemble inter-crate cable connections / assemblies.

11. Install battery back in the battery compartment, (refer to "Battery Replacement," Running Maintenance and Servicing Manual, Section 5) and place into service.

End of Battery Capacity Check

6-5-30. BATTERY COMMISSIONING CHARGE

Activities
Commission Battery

Applicable Car(s)
A Car

Equipment Condition
Battery Removed from Battery Compartment ("Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5) and on bench

References
"Battery Cleaning," Running Maintenance and Servicing Manual, Chapter 6, Section 4
"Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5
"Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 5
IPC Figure 6-33
Paragraph 6-5-3

Special Tools
None

Supplies
None

Test Equipment
None

Commission Battery

WARNING

Always refer to Paragraph 6-5-3 "Battery Safety Precautions" prior to following instructions in this Section.

Verify all electrical connections and polarities are made correctly including charge/discharge cables. The cells' positive terminals are identified with red polarity washers and the negative terminals have blue or black polarity washers. The "+" terminal can be further identified by a "+" raised symbol molded on the cell cover.

During charging there are gases (oxygen and hydrogen) generated by the battery. Due to this gassing each cell will be bubbling internally. The work area shall be well ventilated to prevent an explosive mixture from forming when the hydrogen concentration exceeds 4 percent volume hydrogen to air.

6-5-30. BATTERY COMMISSIONING CHARGE (CONT)

WARNING

Follow all maintenance procedures exactly as written in this manual and observe all warnings and cautions to prevent electrical shocks. All cells in a carset battery must be commissioned at the same time.

Failure to observe these safety precautions can lead to personal injury.

CAUTION

It is possible that the electrolyte will fall to a lower level during long periods of storage. However, after charging, the electrolyte level will rise back up again. Do not top-up with distilled or deionized water until after commissioning charge is completed.

NOTE

A charge or discharge current expressed as $0.2C_5A$ means 0.2 x battery capacity or 20 percent of the battery capacity in Amps (A).

There are two charging methods used to charge nickel cadmium batteries: constant current and constant voltage. To properly commission or check the actual battery capacity, a constant current charge is required. An onboard car charger or LVPS provides a constant voltage charge.

Constant current charging: The charging current, $0.2C_5A$, is kept constant throughout the charging process while the charging voltage is being determined by the characteristics of the cell/battery being charged. Therefore, a cell/battery charge voltage will increase but will not reach the upper voltage limit setting of a constant current charger of at least 1.9 V/cell @ 68° F. However, some constant voltage chargers can be adjusted to higher voltage settings to act like constant current chargers. In this case, a setting of at least 1.90 V/cell must be used and current limited to $0.2C_5A$. If the electrolyte temperatures are lower than 68° F, a higher charging voltage must be used. A charge voltage of at least 2 V/cell is sufficient for temperatures down to 32° F.

Constant voltage charging: Initially, the charging system will work at its current limit (for a discharged cell/battery) and when the charging voltage setting is reached, the charging process changes to constant voltage charging where the charging current decreases rapidly to stabilize to a typical low value. At this point, the charging voltage is kept constant throughout the charging process.

A good first charge is important. Charging by constant current is recommended. Performing this operation in a battery room / maintenance shop is also recommended.

Discharged Cells Stored Less Than One (1) Year (Figure 6-5-29)

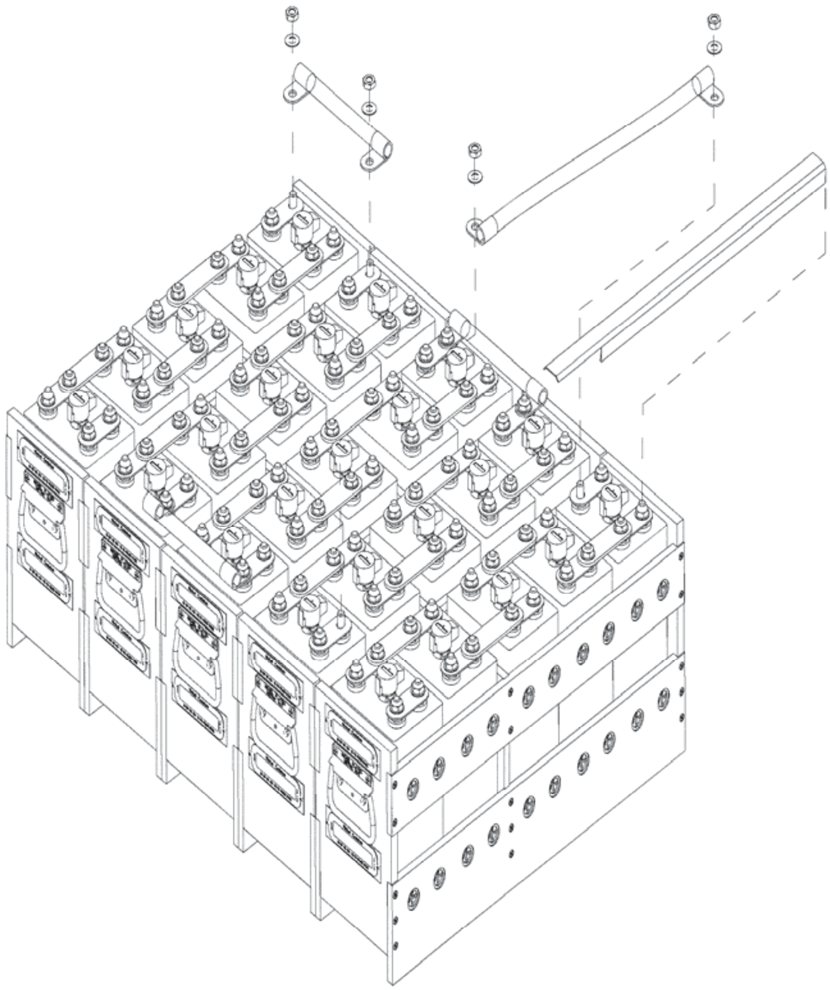


Figure 6-5-29. Proper Battery Assembly Before Commissioning Charge

1. Assemble battery (refer to Figure 6-5-29 and "Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5).

2. Charge using constant current charging at $0.2C_5A$ for 8 hours or using constant voltage charging with a charging voltage of 1.55 V/cell at $0.2C_5A$ for 20 hours.

3. Top-up battery if required (refer to "Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 4).

4. Clean battery (refer to "Battery Cleaning," Running Maintenance and Servicing Manual, Chapter 6, Section 4).

5. Disassemble intercrate cable connections/assemblies.

6. Install battery in battery compartment (refer to "Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5) and place into service.

6-5-30. BATTERY COMMISSIONING CHARGE (CONT)

Discharged Cells Stored More Than One (1) Year (Figure 6-5-29)

1. Assemble battery (refer to Figure 6-5-29 and Running Maintenance and Servicing Manual, Section 5).
2. Charge using constant current charging at $0.2C_5A$ for 10 hours.
3. Discharge at $0.2C_5A$ to below 0.8 V for each and all cells. Reversing polarities of cells will not damage them, but will consume more water and generate more gases (oxygen and hydrogen).
4. Charge using constant current charging at $0.2C_5A$ for 8 hours.
5. Top-up battery if required (refer to "Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 4).
6. Clean battery (refer to "Battery Cleaning," Running Maintenance and Servicing Manual, Chapter 6, Section 4).
7. Disassemble inter-crate cable connections/assemblies.
8. Install battery in battery compartment (refer to "Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5) and place into service.

80 Percent Charged Cells Stored More Than Three (3) Months or above +86 º F (Figure 6-5-29)

1. Assemble battery (refer to Figure 6-5-29 and "Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5).
2. Charge using constant current charging at $0.2C_5A$ for 10 hours.
3. Discharge at $0.2C_5A$ to below 0.8 V for each and every cell. Reversing polarities of cells will not damage them, but will consume more water and generate more gases (oxygen and hydrogen).
4. Charge using constant current charging at $0.2C_5A$ for 8 hours.
5. Top-up battery if required (refer to "Electrolyte Level Adjustment/Topping Up," Running Maintenance and Servicing Manual, Chapter 6, Section 4).
6. Clean battery (refer to "Battery Cleaning," Running Maintenance and Servicing Manual, Chapter 6, Section 4).
7. Disassemble intercrate cable connections/assemblies.
8. Install battery in battery compartment (refer to "Battery Replacement," Running Maintenance and Servicing Manual, Chapter 6, Section 5) and place into service.

End of Commissioning Charge

Attachment E: RMSM Chapter 6

2) Visually inspect equipment attaching hardware (1) for corrosion. Replace as required. Tighten as required.

3) Visually inspect terminal box covers attaching hardware (2) for corrosion. Replace as required. Tighten as required.

4) Visually inspect signaling connector (3) and communications connector (4) integrity. Connect or replace as required.

5) Visually inspect alternative connector cap (5). Tighten as required.

6) Visually inspect cable glands (6) and (7) integrity. Tighten or replace as required.

3. Battery

WARNING

Always refer to Paragraph 6-2-4.1, "Battery Safety Precautions," prior to performing any battery inspections and/or maintenance. Failure to observe this safety precaution can lead to personal injury.

NOTE

Use the maintenance record chart (refer to Figure 6-4-5) to record data collected during battery preventive maintenance checks.

The electrolyte level in the cells should be topped-up with distilled water when its level is at the midway point of the electrolyte reserve, between the minimum (lower) and maximum (upper) levels. This method reduces the chances of having a cell run dry if it had been missed at the previous topping-up interval. By monitoring the water consumption for the first 12 months on a quarterly basis, the actual water consumption rate can be established more accurately for the environmental conditions and type of usage encountered.

a. Cell

1) Inspect battery. Clean battery and battery compartment as necessary (refer to Paragraph 6-4-4.1 and 6-4-4.2). Replace if damaged or at end of usable life (refer to Paragraph 6-5-23 and Heavy Repair Maintenance Manual, Section 5).

b. Terminal Cover

1) Inspect terminal covers and clean as necessary (refer to Paragraph 6-4-4.2). Replace if damaged.

6-4-3. PERIODIC INSPECTION AND MAINTENANCE (CONT)

Annually (Cont)

BATTERY MAINTENANCE RECORD CHART

CAR NO: ____________

TOTAL CHARGING VOLTAGE AT BATTERY TERMINALS: →

Note:
- If the cells are not numbered, always consider the cell with the positive car cable terminal as cell No. 1.
- O.C.V. is the open circuit voltage measured without charge or discharge and 1 hour after the end of charge when it is stabilized.

CELL	VOLTAGE (OCV)	ELECTROLYTE LEVEL	WATER YES	ADDED NO	COMMENTS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

CELL TEMP. (MIDDLE OF BATTERY)	TORQUE CHECKED: (ALL CELLS)	TOTAL WATER ADDED:	BATTERY CLEANING COMPLETED:
☐ °C ☐ °F	☐ Yes ☐ No	QTY: ______ ☐ liter(s) ☐ quart(s)	☐ Yes ☐ No
GENERAL COMMENTS:		SERVICE DATE:	SERVICED BY:

6k-06-0068

Figure 6-4-5. Battery Maintenance Record

c. Terminal Lugs c/w Charge Discharge Cables

   1) Visually inspect terminal lugs and clean as necessary. After cleaning, reapply a fresh, thin coat of protective coating on exposed battery metal connections (refer to Paragraph 6-4-5.1). Replace if damaged.

d. Inter-row Flexible Connection/cable assembly (if supplied)

   1) Inspect flexible connections and clean as necessary (refer to Paragraph 6-4-4.2). Replace if damaged.

e. Intercell Connectors

   1) Inspect rigid connectors and clean as necessary (refer to Paragraph 6-4-4.2). Replace if damaged.

f. Equalize Connector/Collecting Bar (if supplied)

   1) Inspect equalize connectors and collecting bar and clean as necessary (refer to Paragraph 6-4-4.2). Replace if damaged.

g. Terminal Nut

   1) Inspect all terminal nuts and clean as necessary (refer to Paragraph 6-4-4.2). Ensure all terminal nuts are torqued properly (including cap screws when supplied) (11 ± 1.5 ft-lb).

h. Terminal Spring Washer

   1) Clean and inspect terminal spring washers (refer to Paragraph 6-4-4.2). Ensure washers are underneath top terminal nuts, and flat (refer to Paragraph 6-4-5.1). Replace if damaged.

6-4-3. PERIODIC INSPECTION AND MAINTENANCE (CONT)

Annually (Cont)

i. Vent Plug Assembly

1) Clean vent plugs. Check cover for proper operation. Replace any vent plugs that can not be cleaned, or are damaged (refer to Paragraph 6-4-4.3).

j. Plywood Crate Assembly

1) Inspect structural integrity of plywood crate assembly. Clean as necessary (refer to Paragraph 6-4-4.3). Replace if damaged.

k. Thermostat Assembly (if supplied)

1) Clean and inspect temperature switch assembly (refer to Paragraph 6-4-4.2). Replace if damaged.

l. Electrolyte Level

1) Check electrolyte level and top-up if necessary (refer to Paragraph 6-4-6).

NOTE

The electrolyte level in the cells should be topped-up with distilled water when its level is at the midway point of the electrolyte reserve, between the minimum (lower) and maximum (upper) levels. This method reduces the chances of having a cell run dry if it had been missed at the previous topping-up interval. By monitoring the water consumption for the first twelve months on a quarterly basis, the actual water consumption rate can be established more accurately for the environmental conditions and type of usage encountered.

m. Charging System

1) Check charging system to ensure it is operating within specified limits (refer to Paragraph 6-1-4.2 and battery system charging manual). Adjust as necessary.

6-4-4. BATTERY CLEANING

WARNING

Follow all maintenance procedures exactly as written in this manual and observe all warnings and cautions to prevent electrical shocks. Failure to observe this safety precaution can lead to personal injury.

CAUTION

Use clean water to clean battery surface. Never use detergents, solvents, or other chemical agents since they can damage the plastic battery materials.

Cell vent plug covers must remain closed at all times except when topping-up or filling.

6-4-4.1 Keep Battery and Battery Compartment Dry

The battery must be kept clean and dry. This contributes to top performance and maximum service life. It also minimizes the risk of ground leakage currents and the risk of contaminating the electrolyte in the cells during the topping-up process. Clean and inspect the battery and battery compartment at least once every 12 months and the battery after each topping-up operation.

6-4-4.2 Clean With Water

Compressed air and, if necessary, water is recommended to remove dust and dirt, and any grayish white deposits (refer to Paragraph 6-4-7.2) from the battery and battery compartment. Use only plain water for cleaning. A soft non-metal brush and/or a lint free cloth may be also used. The covers of the vent plugs must be closed. Refer to Paragraph 6-4-5.1 to apply protective coating.

6-4-4.3 Cleaning Flame Arrester Vent Plugs

WARNING

Plugged vent plugs or vent plug covers that do not open or close properly can lead to personal injury and/or equipment damage.

Dirty vent plugs should be rinsed in clean water. The vent plugs are of the bayonet-mount type and can be easily removed by turning them 1/4-turn counterclockwise. The cover on the vent plug assembly should be checked for proper operation. To open, the clip on the side should be pushed in and the vent cover should snap open (spring loaded). The vent cover should snap closed and remain closed after pushing it down. Replace any vent plugs that cannot be cleaned and/or are damaged.

6-4-5. BATTERY CONNECTIONS

CAUTION

Do not over-torque terminal nuts as this can permanently damage the terminal post(s) of the cell(s).

Once a year, check that all terminal nuts are torqued properly. The terminal spring washers must be underneath the top terminal nuts and flat. Look for hot spots revealing bad connections. Replace all battery cable connections/assemblies including the charge/discharge cables if damaged or frayed. Torque to 11 ± 1.5 ft-lb.

6-4-5.1 Protective Coating

The battery terminals and the interconnecting hardware are protected with a thin layer of neutral petroleum jelly or anti-corrosion coating before leaving the factory. After some time in service, or during battery removal and installation (refer to Paragraph 6-5-32), it may be necessary to clean and reapply a fresh thin coat on exposed battery metal connections.

6-4-6. ELECTROLYTE LEVEL INSPECTION

Refer to the following guidelines when inspecting and topping up battery cell electrolyte.

6-4-6.1 Electrolyte Level Adjustment / Topping-up

WARNING

Always review Paragraph 6-2-4.1, "Battery Safety Precautions," prior to following the instructions below.

Electrolyte levels below the minimum (lower) level can heat the cell and within time can lead to a fire.

Do not overfill above the maximum (upper) level; that could cause an overflow resulting in ground leakage. Wrong specific gravity can lead to personal injury or equipment damage.

WARNING

Vent plug covers must be closed after filling / topping-up. Failure to observe these safety precautions can lead to personal injury and/or equipment damage.

6-4-6. ELECTROLYTE LEVEL INSPECTION (CONT)

CAUTION

Never use any piece of servicing equipment such as filling equipment, hydrometers, cleaning brushes, etc., that has been used to service lead acid batteries. Traces of sulfuric acid, as used by lead acid batteries, can ruin nickel cadmium batteries.

Never use sulfuric acid or acidified water with pH lower than 5 to top-up electrolytes. Acid can destroy the battery. Ordinary tap water contains impurities that contaminate the electrolyte solution and thus affect the operation of the cells. Use distilled or de-ionized water. It must be kept in plastic containers and be labeled accordingly. Refer to the IEC 60993 standard for water quality to be used.

Opaque or Steel Containers: A transparent glass or plastic tube (alkali resistant, 5-6 mm in diameter) can be inserted into the cell, after the cover of the vent plug is opened, until it touches the top of the plates. Do not force down. Close the top end of the dip tube with a finger and remove from cell. The height of the liquid in the dip tube indicates the level of electrolyte above the plates. Refer to Table 6-1-5 in Paragraph 6-1-4.2 for the maximum and minimum levels measured above the plates in the dip tube.

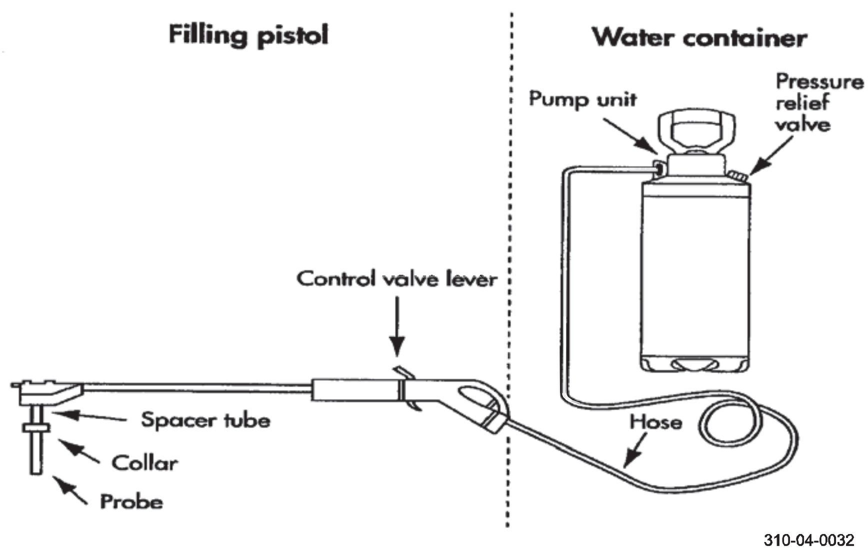


Figure 6-4-12. Water Container and Filling Pistol

Using filling equipment, such as the celltopper (refer to Figure 6-4-12), can save time and money when conducting maintenance.

CAUTION

> The celltopper filling pistol must have the 11mm probe and appropriate spacer tube number (refer to Paragraph 6-1-4.2) installed and properly secured by the collar on the probe. The spacer tube must not slide up or down on the probe. Refer to instructions with celltopper equipment for proper operation. Failure to use equipment properly can result in overfilling or underfilling of battery cells.

When the celltopper filling equipment is used, insert the end with the probe through the vent hole of a battery cell making sure that the collar on the probe sits on the open vent plug without pressing the trigger (control valve lever). If the buzzer and light signal come on, the cell does not need topping-up. If topping-up of cell is required, press the trigger (control valve lever) to allow the flow of the distilled or deionized water and release the trigger to stop the flow of water when the buzzer and/or light signal come on. Repeat for all cells and clean battery (refer to Paragraph 6-4-4).

6-4-6.2 Water Loss

All storage batteries lose water by electrolysis during charge and overcharge and also due to natural evaporation depending on the ambient temperature. A battery in reverse polarity will consume a considerable amount of water.

6-4-6.3 Too Much or Too Little Water Loss

Excessive water consumption may indicate too high a charging voltage (charging system not properly adjusted). Little water consumption may indicate that the battery is being inadequately charged.

6-4-6.4 Topping-Up Frequency

NOTE

> The water consumption varies due to several variables (i.e., charging voltage, battery temperature, the way the battery is used, age, etc.).

To establish the water consumption rates on a new car, the electrolyte levels should be monitored once every 3 months for the first 12 months of operation.

6-4-6.5 Water Type

Use only distilled or de-ionized water for topping-up. Also, refer to Paragraphs 6-2-4.1.5 and 6-2-4.1.6.

6-4-6.6 Avoid Splashes

Avoid splashing water when topping-up. A wet battery can lead to ground faults and/or erratic operation. Refer to Paragraph 6-4-4 for cleaning guidelines if this occurs.

6-4-6. ELECTROLYTE LEVEL INSPECTION (CONT)

6-4-6.7 Keep Vent Plug Covers Closed

For safety reasons and in order to minimize the chances of electrolyte contamination, keep the vent plug covers closed and locked, except when topping-up or filling.

6-4-6.8 Tools

WARNING

Do not lay any tools or metal parts on top of the cells as this action may cause an arc that can ignite the gases. To prevent an arc or spark when the batteries are either connected or disconnected, the charging and load circuits must be disconnected first. Failure to observe this safety precaution can lead to personal injury.

CAUTION

Since traces of sulfuric acid, as used in lead acid batteries, can ruin nickel cadmium batteries, all tools including wrenches, filling equipment, etc., must be dedicated only to the appropriate technology of the battery.

Use tools dedicated to nickel cadmium batteries with insulated handles.

6-4-7. ELECTROLYTE INSPECTION

Although changing the electrolyte is a rare occurrence in the life of a cell, consider the following when inspecting the electrolyte solution:

6-4-7.1 Changing Electrolyte

Due to the sintered/PBE technology, it is not necessary to change the electrolyte during the life of the cells. In certain circumstances the electrolyte will require changing if contaminated water was used for topping-up, possibly reducing the cell performance and capacity. If the contaminant were carbonate, a change of electrolyte would recover the previous performances and capacity.

However, changing electrolyte due to other contaminants in the cells would not recover the previous performances and capacity as they would cause permanent damage and reduce the life.

Prior to emptying the electrolyte from the cells, discharge at 0.2 C_5A to below 0.8 V for each and every cell. Refer to Table 6-1-5 for the type and quantity of electrolyte required for each cell. Contact Saft, if necessary, for assistance.

6-4-7.2 Grayish-White Deposits

These deposits are potassium carbonate (K_2CO_3), which are a result of small quantities of potassium hydroxide (KOH) electrolyte, being expelled from the vents, combining with carbon dioxide (CO_2) in the air to form K_2CO_3.

K_2CO_3 is electrically conductive when damp. It can cause current leakage if allowed to buildup. If buildup is excessive, it may be an indication that the charge voltage is adjusted too high. A higher charge voltage will not damage the battery, but will result in increased water consumption. Refer to Paragraph 6-4-4 for cleaning the battery and Paragraph 6-4-6 for topping-up electrolyte levels.

6-4-8. CAPACITY CHECK

As part of the periodic maintenance operations, it is recommended a battery capacity check be performed every 5 years. While the routine maintenance operations are conducted on the cars, the removal of the battery from the car to the battery room/maintenance shop is required to perform a battery capacity check. Refer to the Heavy Repair Maintenance Manual, Section 5 for instructions on performing this procedure. A "Discharge Test" record form (QC130) is also provided there for recording test values.

6-4-9. BATTERY CHARGING SYSTEM

CAUTION

High water consumption requires immediate check of the charging system to prevent permanent damage to the battery. Also, check open circuit (no charge/discharge) cell voltages for shorted cells (0 Vdc) that may also have consumed very little or no water.

Check the charging system at least once yearly to insure that it is operating within specified limits. The battery charging voltage single rate is 37 Vdc at 68 °F.

6-4-9.1 Charging Effects on Battery

The following fault conditions in the battery may be indicative of a charger malfunction:

- Low water consumption = Low charging system output voltage
- High water consumption = High charging system output voltage
- Insufficient battery capacity = Incomplete recharge

6-5-30. BATTERY INSPECTION (UPON ARRIVAL)

Activities
Inspect Battery

Applicable Car(s)
A Car

Equipment Condition
None

References
Paragraph 6-5-31

Special Tools
None

Supplies
None

Test Equipment
None

Inspect Battery

The following guidelines outline proper procedures to be followed after receiving a new battery, or when storing the battery.

WARNING

The MSDS (Material Safety Data Sheets) must be readily available.

Always follow applicable federal, state or provincial, and local regulations.

Avoid shorting battery terminals to prevent electrical shock or burns.

Failure to observe these precautions can lead to personal injury.

NOTE

The instructions in this paragraph mainly apply to batteries that are supplied separately, that have been supplied as spares or, that have been temporarily removed from operation. However, the safety precautions shall always apply.

Receiving Shipment

Batteries that are shipped separately are filled with electrolyte and are in a discharged, 80 percent charged, or fully charged condition. It is understood that most of the original equipment batteries will be supplied installed on the cars.

6-5-30. BATTERY INSPECTION (UPON ARRIVAL) (CONT)

Unpacking and Inspection

WARNING

Never charge the battery with the plastic transport seal(s) in place under the vent plug cover, as this is dangerous and can cause bodily injury and permanent damage to the batteries.

To avoid personal injury when removing or installing the battery, always get assistance and use a suitable lifting device.

Failure to observe these precautions can lead to personal injury.

1. Unpack the batteries immediately upon arrival. Check cells, battery shipping box, and other components externally for possible damage in shipment.

NOTE

Specific attention must be given to any electrolyte spillage that may have occurred during transportation.

Damage must be reported immediately to the carrier. At the same time, notify manufacturer of the nature of the damage and order the necessary replacement parts.

2. Check the battery and its accessories against the accompanying packing list, or battery layout drawing.

NOTE

Make sure that small packages containing hardware, spare parts, and accessories are not thrown out with the packing materials. As a precaution, do not discard packing materials until the battery has been completely assembled.

3. Remove the plastic transport seals from under the covers of the vent plugs before installation unless the battery is to be stored. Refer to Paragraph 6-5-31 for storage details.

End of Inspection

6-5-31. BATTERY STORAGE

Activities
Store Battery

Applicable Car(s)
A Car

Equipment Condition
None

References
Heavy Repair Maintenance Manual, Chapter 6, Section 5, "Commissioning Charge" Procedure

Special Tools
None

Supplies
None

Test Equipment
None

Store Battery

WARNING

Use a lifting device or obtain assistance when attempting to lift heavy or bulky equipment. Failure to observe this safety precaution can lead to personal injury.

Avoid shorting battery terminals to prevent electrical shock or burns.

CAUTION

Never drain the electrolyte from the cells.

Batteries for storage must be clean and dry. Clean metal parts including connectors, nuts, bolts, washers, and protect from corrosion by applying a thin layer of petroleum jelly or anti-corrosion protective coating.

It is possible that the electrolyte will fall to a lower level during long periods of storage. However, after charging, the electrolyte level will rise up again. Do not top-up with distilled or de-ionized water until after commissioning charge is completed.

Direct sunlight, fluorescent light, and heat could damage the plastic components of the cell. The storage temperature must be below +86° F.

6-5-31. BATTERY STORAGE (CONT)

CAUTION

Store batteries in an enclosed area that is dry, clean, and away from any heat sources, with the plastic transport seal(s) under the vent plug covers.

Failure to observe these guidelines can lead to equipment malfunction and/or equipment damage.

NOTE

Normally batteries are supplied filled and discharged and must be commissioned prior to placing into service.

Batteries that are filled and at a discharged state (discharged to less than 0.8 V/cell under load) can be stored for at least four years with no loss of capacity and no damage in performance as long as a proper commissioning cycle is performed prior to placing the cells in service (refer to Heavy Maintenance Manual, Section 5). The type of commissioning required is dependent on the length of storage time.

In some instances, batteries may be supplied as 80 percent charged or fully charged. An 80 percent charged battery must not be stored more than three months from its last charge date while a fully charged battery must not be stored more than six weeks from its last charge date. Storage temperatures must be below +86 °F.

Factory supplied batteries have tags indicating end of storage date when a battery needs to be commissioned or permanently connected to the charging system.

If batteries are supplied filled and charged and the storage period will exceed the above period or temperature, they must be discharged to less than 0.8 V/cell using the discharge step (refer to Heavy Maintenance Manual, Section 5 ("Commissioning Charge" procedure) before storage. When ready to be used, a proper commissioning cycle needs to be performed prior to placing the cells in service (refer to Heavy Maintenance Manual, Section 5 ("Commissioning Charge" procedure). However, if storage time has exceeded the above period, an 80 percent previously charged battery must be commissioned (refer to Heavy Maintenance Manual, Section 5 ("Commissioning Charge" procedure). For a previously fully charged battery, contact Saft.

End of Service

6-5-32. BATTERY REPLACEMENT

Activities

Remove Battery from Compartment
Install Battery in Compartment

Applicable Car(s)

A Car

Equipment Condition

Open CBB

References

Heavy Repair Maintenance Manual, Chapter 6, Section 5, "Capacity Check" Procedure
IPC Figures 6-33 & 6-34
Paragraph 6-2-4.1
Paragraphs 6-5-30 & 6-5-31

Special Tools

Torque Wrench, Rated 0-20 ft-lb

Supplies

Crate Assembly, Battery, Saft, P/N 217909
Petroleum Jelly or Anti-Corrosion Coating

Test Equipment

None

WARNING

Refer to Paragraph 6-2-4.1 and Paragraphs 6-5-30 and 6-5-31 prior to following instructions in this procedure.

The battery box can detach from car if it is not installed properly. Follow maintenance procedures as directed in this manual and assure maintenance is performed by qualified, trained personnel. To avoid personal injury when removing or installing the battery, always get assistance and use a suitable lifting device.

Follow all maintenance procedures exactly as written in this manual and observe all warnings and cautions to prevent electrical shocks.

Avoid shorting battery terminals to prevent electrical shock or burns.

Failure to observe safety precautions can lead to personal injury.

CAUTION

If a defect is found on any cell, the entire battery must be removed from the car and sent to battery room of maintenance shop. When cell replacement is necessary, it is recommended to replace with cell(s) or crate(s) having similar service life, age, and capacity as the rest of the battery (refer to Heavy Repair Maintenance Manual, Section 5). New cells or battery crate(s) shall be part of new batteries.

6-5-32. BATTERY REPLACEMENT (CONT)

CAUTION

After replacing one or more battery crates in a battery out of service, it is recommended to commission the entire battery including the replacement battery crate(s) (refer to Heavy Repair Maintenance Manual, Section 5).

All contact surfaces (including the battery compartment) must be clean and dry before making connections.

Never mix charged and discharged cells or battery crates in the same carset battery.

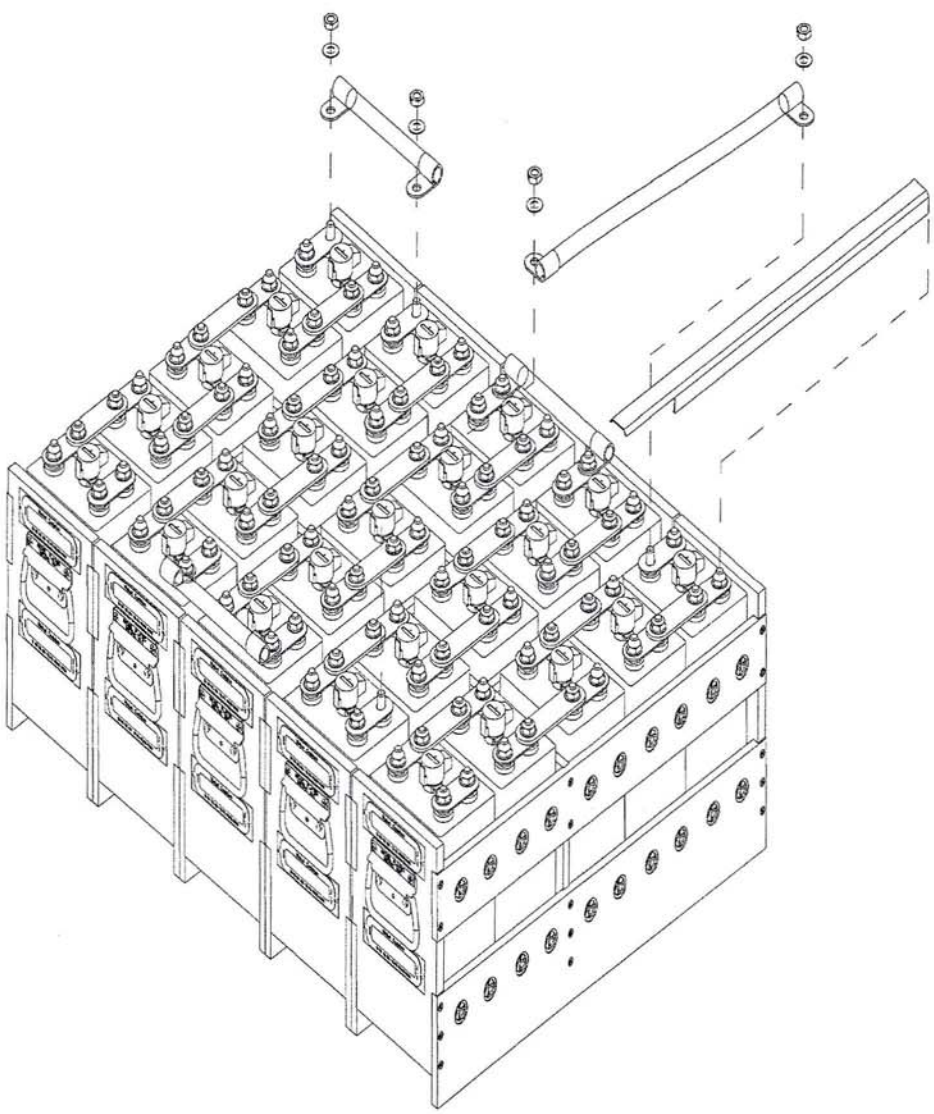


Figure 6-5-30. Battery Configuration

CAUTION

After removal of washers and nuts, they must be reinstalled loosely to avoid losing them.

Refer to Figure 6-5-30 for proper connections and torque all terminal hardware to 11 ± 1.5 ft-lb.

NOTE

A battery is considered as an assembly of cells shown in Figure 6-5-30 for a carset.

The battery consists of cells connected in series with rigid intercell connectors and flexible cable connections/assemblies. Each cell's positive terminals are identified with red polarity washers and the negative terminals have blue or black polarity washers. The "**+**" terminal can be further identified by a "**+**" raised symbol molded on the cell cover.

All battery hardware such as nuts, washers, rigid connectors, and cable lugs are nickel-plated and metric-sized.

Remove Battery from Compartment (Figure 6-5-30)

1. Ensure battery breaker or fuses are in **OFF** position (de-energized) so that battery will be completely isolated from car loads and charging system during installation.

2. Remove terminal covers from top of battery connections.

3. Locate correct polarities.

CAUTION

Each cell's positive terminals are identified with red polarity washers and the negative terminals have blue or black polarity washers. The "**+**" terminal can be further identified by a "**+**" raised symbol molded on the cell cover.

4. Disconnect "-" and then "+" incoming car cables to battery. Secure cables safely out of way.

5. Disconnect thermostat and secure safely out of way.

6. Disconnect flexible cable connections/assemblies connecting rows of crate assemblies together from "-" and then "+".

7. Remove shim(s)/spacer(s) if present.

8. Remove battery crate assemblies.

6-5-32. BATTERY REPLACEMENT (CONT)

Install Battery in Compartment (Figure 6-5-30)

1. Ensure battery breaker or fuses are in **OFF** position (de-energized) so that battery will be completely isolated from car loads and charging system during installation.

2. Locate correct polarities.

CAUTION

Each cell's positive terminals are identified with red polarity washers and the negative terminals have blue or black polarity washers. The "+" terminal can be further identified by a "**+**" raised symbol molded on the cell cover.

3. Place charged battery crates with correct electrolyte levels (refer to Paragraph 6-4-6) and proper commissioning charge (refer to Heavy Repair Maintenance Manual, Section 5), in battery compartment (refer to Figure 6-5-30).

4. Remove plastic transport seals from underneath vent plug covers (usually red).

5. Connect intercrate flexible cable connections/assemblies, in series (from "+" to "-") for each row of battery crate assemblies (refer to Figure 6-5-37). Torque terminal hardware to 11 ± 1.5 ft-lb.

6. If a shim(s)/spacer(s) are required, insert at this time.

7. Connect thermostat in middle of battery.

8. Connect "+" incoming car cable and then "-" incoming car cable and torque to 11 ± 1.5 ft-lb.

9. Apply a thin coat of petroleum jelly or anti-corrosion coating on exposed battery metal connections where not already present.

10. Snap-on terminal covers along top of all connections.

11. Connect battery to power with breaker or fuses to **ON** position (energized).

12. Check charging voltage setting at battery terminals at end of charge. Adjust accordingly, if required, per instructions in charging system manual. Charging voltage should be 37.5 Vdc at 68 °F. Refer to Heavy Maintenance Manual, Section 5, "Capacity Check" procedure for more information.

End of Replacement

Attachment F

Sample - Battery Test Table

<table>
<tr><th rowspan="3">Car Number</th><th rowspan="3">Cell Number</th><th colspan="2">First Day</th><th colspan="2">3 Months</th><th colspan="2">6 Months</th><th colspan="2">12 Months</th></tr>
<tr><th>Date:</th><th></th><th>Date:</th><th></th><th>Date:</th><th></th><th>Date:</th><th></th></tr>
<tr><th>Volt</th><th>Ml/oz</th><th>Volt</th><th>Ml/oz</th><th>Volt</th><th>Ml/oz</th><th>Volt</th><th>Ml/oz</th></tr>
<tr><td rowspan="25">Cell Voltage and Water Consumption</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>14</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>16</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>19</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>21</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>22</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>23</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>24</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Charging Time (1.04V to Full Charge)</td><td>Charging Time (Hrs and Min)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Charging Current (Amp)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Load Shedding Operation</td><td>Holding Time Until UVR CB trips (Minutes)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Current Drawn (Amps)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note: If the cells are not numbered, consider the cell with the positive car cable terminal as cell #1.

Attachment G: Battery Test

ETP XXXXXX-00

BATTERY

QUALIFICATION TEST

Do Not Service, or Change

Without Notifying

Karl Bejo @ 301-955-4311

Attachment H

ALSTOM

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
6000-SERIES RAPID TRANSIT CARS

CONTRACT: TC-6000

BATTERY SYSTEM ELECTRICAL COMPATIBILITY PLAN
CDRL 1408

	Signature	Printed Name / Title	Date
Prepared:	Bill Kroneberg	Bill Kroneberg/Design Engineer	10/29/02
Approved	Haissam Khalife	Haissam Khalife/System Integration Engineer	10/29/02
Approved:	Phil Hoeffner	Phil Hoeffner/Chief Program Engineer	10/29/02

Document No.:	WBS No.:	Rev.:	Page:
AW00000002430	67.01.09.013	E	1 of 19

DOCUMENT REVISION

Rev.	Date	Description of Change
-	10/29/02	Original issue
A	01/16/03	Added standards references, clarified text, updated loads
B	02/24/03	Updated loads, clarified modes
C	06/04/03	Removed layover load w/o brakes, updated emergency load info., added aging factor to layover load
D	08/04/03	Changed reference location of low voltage distribution panel. Added one additional sign power supply / car. Updated Friction brake ECU load. Revised lighting loads.
E	07/12/04	Updated Figures 6.1, 6.2, & 6.3. Added Friction Brake quiescent load to Stranded Mode. Changed duty cycle for Battery Charge current. Updated duty cycle for the Emergency Door Handle Solenoid.

TABLE OF CONTENTS

PAGE NO.

1.0 OBJECTIVE:

1.1 APPLICATION:

This analysis applies to Washington Metropolitan Area Transit Authority 6000-series rapid transit cars, which will be built at the ALSTOM car shop in Hornell for WMATA.

1.2 PURPOSE:

The purpose of this document is to present a plan for insuring electrical compatibility of the battery supply system with the various systems and subsystems which utilize battery voltage as their power source. Also, this document will present an analysis of the battery voltage loads and battery system capacity.

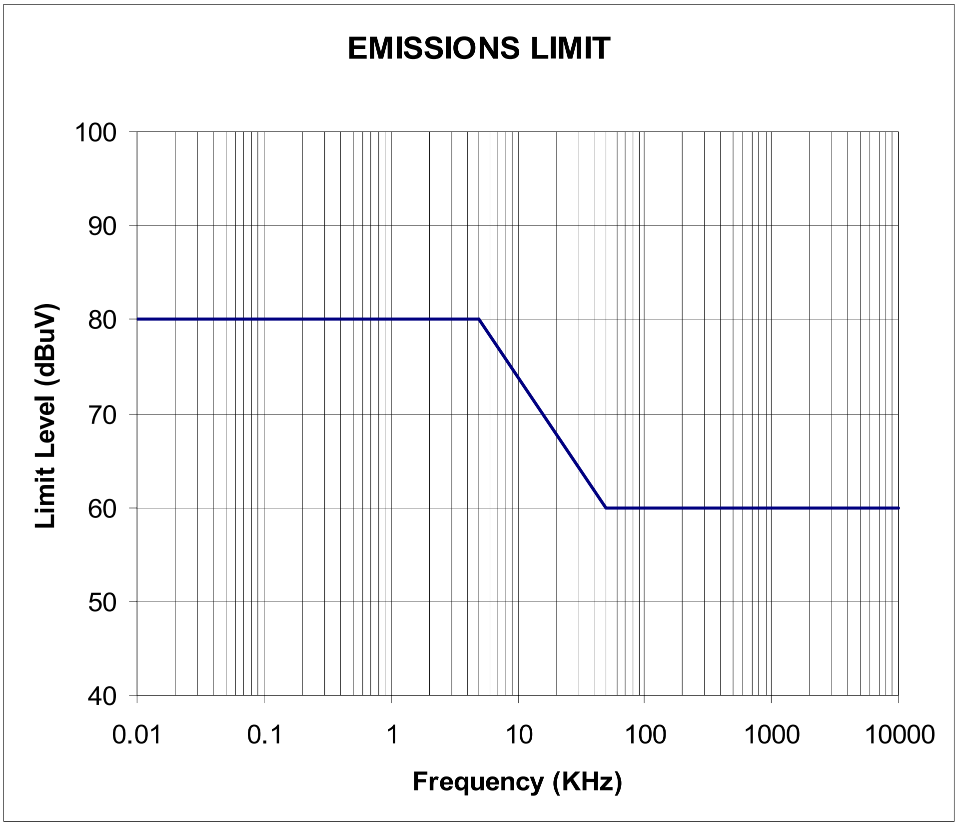
1.3 DISCUSSION:

Although this document will present recommended conducted EMI limits for system and subsystem emissions and susceptibility, ALSTOM does not plan to measure the conducted EMI on the battery system unless difficulties arise during production testing.

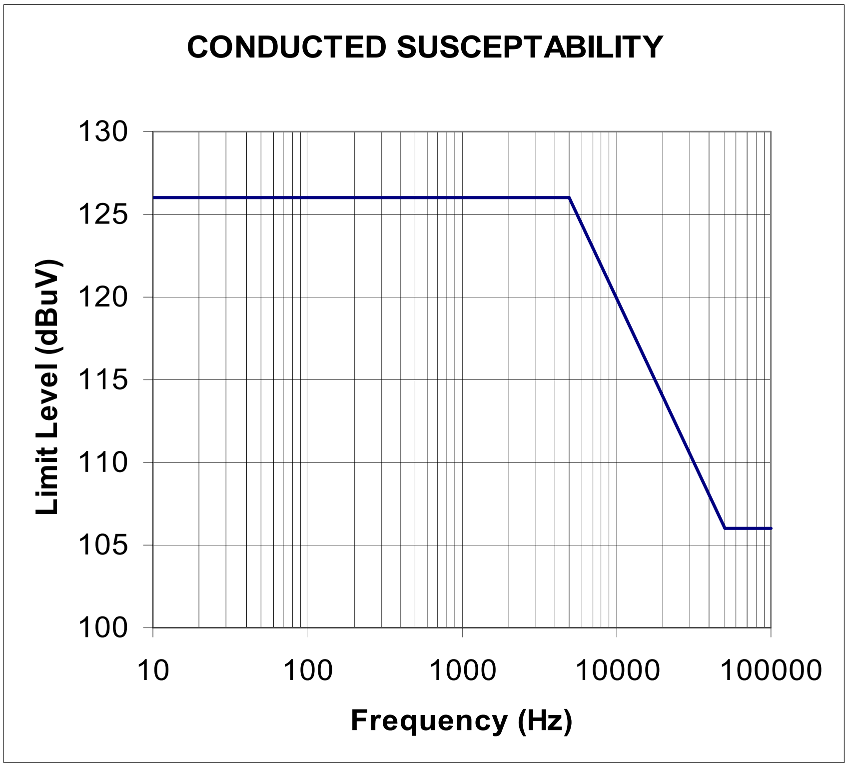
The conducted EMI of the LVPS and APS will be tested by SEPSA using IEC 60571 & IEC 61287-1 for testing procedures and ENV 50121-3-2 for limits. The emission and susceptibility recommended limits shown below will be submitted to SEPSA and the other system suppliers as a design guideline. ALSTOM plans to mitigate the effects of the remaining conducted EMI by utilizing proper design techniques in the development of the battery supply system.

2.0 CONDUCTED EMI LIMITS:

The following limits for conducted EMI emissions and susceptibility are derived from MIL-STD-461D (MIL-STD-461A was referenced in the WMATA specification). The emissions curve is based on MIL-STD-461D “Figure CE102-1, (EUT power leads, AC and DC) for all applications”, 28 V source and the susceptibility curve is based on “Figure CS101-1, (EUT power leads, AC and DC) for all applications”, curve #2, 28 volts or below. They represent stringent limits, but previous measurements on similar systems indicate that there should be little difficulty in achieving levels shown in the following graphs.



CONDUCTED EMI EMISSIONS LIMIT

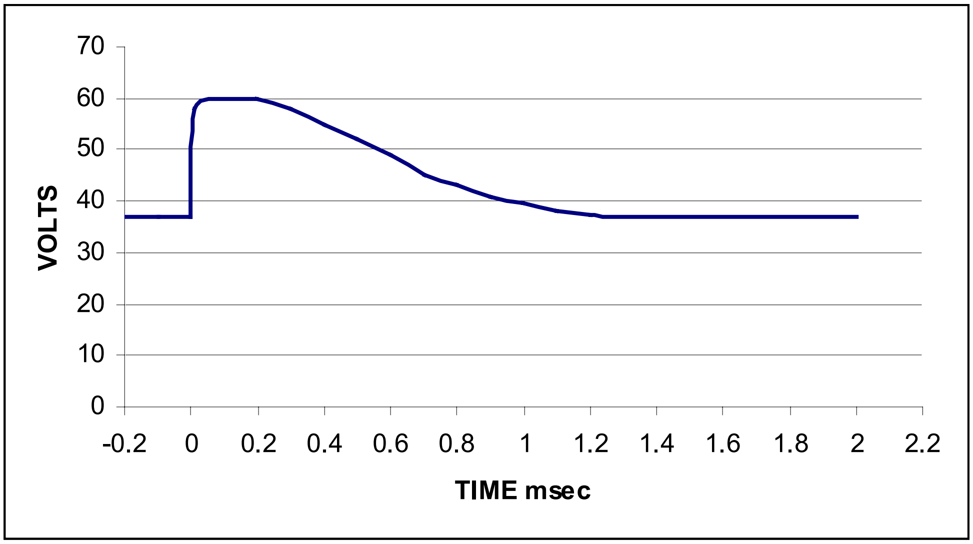


CONDUCTED EMI SUSCEPTABILITY LIMITS

3.0 TRANSIENTS:

Most of the transients generated of the battery voltage distribution system are caused by the de-energization of inductive devices such as relay and contactor coils and magnet valves. Although such devices will be equipped with either a free wheeling diode or a metal oxide varistor, there will be a transient generated. This transient results as the voltage across the suppression device rises to the conduction voltage of the suppressor. Typical voltage transient levels, which can be expected on the battery voltage distribution system, are shown in FIGURE 3.0.

FIGURE 3.0 TYPICAL BATTERY LEVEL TRANSIENT



The magnitude of the transient may vary slightly and the time base for the transient may change considerably. The transients may occur as frequently as multiple times per minute.

4.0 DESIGN TECHNIQUES:

There are design techniques which will be applied to the battery supply system to minimize the effects of conducted EMI. The following methods of EMI control are derived from two documents: ALSTOM Transport, “Electromagnetic Compatibility Design Guide”, Version 1 October 1997, and ALSTOM Transport, “Electromagnetic Interference/ Electromagnetic Compatibility”, Rev - , Document number AW00000002221.

4.1 Feed Wire Routing
Maintaining close proximity of the positive and negative supply feed wires in the distribution system minimizes the radiation of any conducted EMI caused by the supply and the source. The battery supply wires for the various car systems will be routed to maintain a minimum of separation between the lines. Supply wires will be bundled together with ty-wraps, routed in conduit or laid adjacently in wire trays to minimize effects of conducted EMI.

4.2 Class Separation
The wiring in the car will be divided into the following classes, based upon the voltage and power level of their operation:
1. 700 Vdc primary power.
2. 230 and 120 Vac distribution
3. Traction motor power cables
4. Battery supply system

5. Analog and digital signal wires
6. ATC system wires

Battery supply system and analog and digital wiring will be routed in the same wire tray, but there will be a conductive metal separator between the battery level wires and the others.

Primary power cables and 230/120 Vac wiring will be routed in a high voltage wire tray, but again there will be a metal separator between them. In general, the high voltage wire trays will be on the opposite side of the car from the low voltage trays.

Traction motor cables will be routed separately from all other wiring and they will generally be twisted with their respective ground return conductor where possible. The twisting will minimize the EMI effects of the harmonic rich currents on these cables.

Where possible, where wires of dissimilar classes must cross in proximity, the crossing will be at 90 degrees to minimize coupling between them. Where this is not possible due to mechanical constraints, the more sensitive wires will be located in steel conduit.

4.3 Conducted Interference

Conducted interference reduction efforts must consider the radiation from two types of unintentional circuits which can occur in a rail car. These circuits are caused by differential mode currents (fields caused by differences between signal or power lines and their returns) and common mode currents (fields caused by differences between active cables and the car body or system chassis). Common mode currents constitute the greater problem in conducted EMI, since they are difficult to filter. EMI couples less strongly in differential mode than in common mode and differential mode currents are easier to filter. The following design techniques will be utilized to minimize common mode currents.

4.3.1 Cable proximity to car structure

The battery supply system wiring and cables will be routed as close as possible to the underfloor of the car to minimize the generation of common mode loops.

4.3.2 Grounding of wire trays

The cable trays must be grounded to the car structure through the tray support brackets and grounding shunts. The cable tray coating must be removed in the area of the support brackets and the shunt attachments to allow the tray support screws to provide a low impedance electrical path through the brackets and the shunts to the car body.

4.3.3 Wiring length

All wiring runs, particularly low voltage supply to the various systems, must be routed to provide the shortest possible length to minimize the common mode current effect on conducted EMI.

4.4 System Filters

4.4.1 System low voltage supply inputs must be filtered, preferably with differential mode L-C type filters. This will minimize the effects of conducted EMI on the system power input and will minimize the effects of Conducted EMI caused by the internal power converter of the particular system.

4.4.2 The systems supplied by the low voltage source should have common mode filters, preferably installed on the load side of the input differential mode L-C filter.

4.4.3 The Low Voltage Power Supply should have a common mode filter installed at its output or it should be designed to minimize the generation of common mode currents.

4.5 Suppression

All relay/contactor coils and other inductive devices must have a diode or MOV type suppressor installed across it to minimize the transients generated when the device is de-energized. This does not apply to certain vital relays.

4.6 Circuit wiring impedance

The impedance, resistance, of circuits supplying low voltage to the various systems should be as low as possible to minimize the effects of conducted EMI and to provide as little voltage drop as possible.

4.7 System Car Body Grounding

All electrical/electronic panels and enclosures must be connected to the car body in a manner, which provides the lowest possible impedance. It is most desirable to achieve this low impedance grounding through the mounting hardware. If the enclosure is painted, the paint should be removed where the mounting hardware contacts the enclosure and plated hardware must be used. If a separate grounding conductor is necessary, it should be accomplished with a tin plated copper shunt material.

The Auxiliary Power Supply and the Low Voltage Power Supply must have an enclosure ground cable which is as large as the primary power input cables connecting it to car body ground with a length as short as is practical.

5.0 Battery System to LVPS and Low Voltage Distribution Network (LVDN) Interface

The LVDN derives its power from the Low Voltage Power Supply (LVPS), which takes 700-volt DC power from the “B” Car and converts it to nominal 37.5 volts DC for the low-voltage loads in both “A” Car and “B” Car, and for charging the battery. The LVDN buses of married-pair car units are connected in parallel through coupler pins. The LVDN will be compatible with the LVDN in the existing WMATA cars.

The LVDN in each married pair is single-point grounded through a low value resistor in the “B” Car to reduce primary power return current through the LVDN return bus. A current interrupting isolation switch near the LVPS provides input power isolation for maintenance purpose. An output circuit breaker near the LVPS prevents continuous feedback current from the train’s LVDN in case the LVPS output capacitor or terminals are short-circuited. This circuit breaker is also used to isolate the LVPS for its removal from the LVDN.

The battery floats on the LVDN Bus and is protected by a double–pole circuit breaker, which has both over-current series trip and shunt trip. A shunt trip isolates the battery when battery temperature has become too high or when the battery has been discharged below approximately 1.00 volts per cell, 25 volts at the battery terminals. The operational voltage of this battery disconnection circuit is 25.5 VDC for a time period of 6 seconds.

The LVDN maintains the same configuration as the existing WMATA cars. A distribution panel located behind the operator in the cab contains the “Main Service” and all LVDN branch circuit breakers of a car. Loads connected to the “Cab Activated” contactor will be energized when the car has its cab activated. Loads connected to the auxiliary bus contactor will be energized whenever a cab in the train is activated. The “Load Shed” contactor removes the non-essential lighting in revenue service whenever the LVPS in its married pair has failed, or in the event of loss of third rail power. Loads connected to branch circuit breakers, which are not controlled by any contactors, will be turned on whenever the train is in revenue service. They will be isolated on the load side of the branch circuit breakers in layover mode, with the exception of HVAC compressor crank case heaters, air compressor, door control and layover heating, which may be turned on if required.

Battery charging current is monitored by the LVPS. Should the charging current rise above 70 amperes, as in the case of recharging a battery after having a deep discharge, the local LVPS will lower its voltage to about 32 volts to limit the current. As the battery is sufficiently re-charged and the charging current has been reduced well below 70 amperes, normal LVPS output voltage will be restored.

6.0 BATTERY SYSTEM LOAD/CAPACITY ANALYSIS:

Figure 6.1 is the LVPS normal load schedule. The maximum load demand is calculated to be 10.083 kW , based on nominal output of 37.5 volts. Capacity of the LVPS, according to Section 14.3.1 of the Technical Specification, has to be 14.1 kW (375 amperes).

The battery is located in the “B” Car, close to the LVPS. It is a 25-cell, 190-ampere-hour rated, sintered/plastic, bonded electrode (S/PBE), high discharge type battery. A double-pole circuit breaker located near the battery protects it from short-circuits. It also allows isolation of the battery from ground and from the LVDN for servicing. The circuit breaker incorporates a shunt trip feature, which enables the battery to be disconnected if the output voltage decreases to 25.5 volts for 6 seconds or the battery temperature sensor indicates too high a temperature.

Figure 6.2 shows the load schedule for a two-car train in the event of loss of third rail 700-volt power. The car is in STRANDED mode. The battery supplies the loads in both “A” Car and “B” Car. The average battery discharge voltage is 29 volts. At this voltage, the average battery load is 631 watts and the average current is 21.755 amperes.

Using the SRX190, 190-AHr battery data at 40° C (104° F), the battery discharge voltage profiles in emergency mode is plotted in Figure 6.4. This battery will be discharged to 1.02 volts per cell (25.5 volts at battery terminals) after 53 minutes of discharge in emergency mode.

The SRX Series battery has better discharge voltage characteristics compared to the FM Series battery, used on the 2000 and 3000 series cars. Chart 2 in Figure 6.4 shows the battery constant discharge current characteristics from which the above battery discharge voltage profiles in Chart 1 are calculated. Two constant current characteristics were selected from Chart 2, one just above the actual initial discharge current and the other just below. The actual discharge-time curve lies between the two calculated discharge-profile-time curves in Chart 1.

Explanation of Load Calculation Spreadsheets

The spreadsheet calculations of LVPS and battery loads are shown in the tables of Figure 6.1, Figure 6.2 and Figure 6.3. Loads are classified as constant current, constant wattage or constant resistance type. The following explains the columns shown in the tables:

- **DC Load Description (Column 1)-** Description of the loads according to the operation mode.
- **Item No. (Column 2)-** Line number for easy reference.
- **Quantity (Column 3)-** Quantities are for units described in "DC Load Description" column.
- **Diversity Factor (Column 5)-** The faction of total quantity in "A" and "B" Cars that is used at any time. For example, 2 out of 4 headlights (Item 13) are used at any time. The Diversity Factor is 2/4=0.5.
- **Duty Cycle (Column 6)-** The fraction of time the described load is turned on. For example door solenoid lock (Item 56) is used 14 seconds for every 2 minutes. The Duty cycle is 14/60/2=0.12.
- **Raw Information of load (Columns 7, 8 & 9)-** Load information received for reference only. This is not used for calculation.
- **Constant Amp, Constant Watt and Constant Resist (Columns 10, 11 & 12)-** Loads are either considered constant-current (Amp), constant–power or constant-resistance type. They are used in the calculations. The values are calculated from the raw information and based on the average Va shown at the top of Column 17.
- **Check Entry (Column 13)-** Cells in this column shows '1' if entry in the "Constant Amp", "Constant Watt" or "Constant Resist" column is accepted. It shows '0' if there is no entry, and 'Error' if more than one type of load is entered for the same load by mistake.
- **Current W_{ta}(Column 14)-** Total power in both "A" Car and "B" Car of the constant-current(Amp) load described in the same row.
- **Watt W_{tw} (Column 15)-** Total power in both "A" Car and "B" Car of the constant-power load described in the same row.
- **Admit A_d(Column 16)-** Total admittance in both "A" Car and "B" Car of the constant-resistance load described in the same row.
- **Watt W_{tr}(Column 17)-** Total power in both "A" Car and "B" Car of the constant-resistance load described in the same row.
- **Wattage %(Column 18)-** Percentage of total battery load contributed by the load described. For constant-current and constant-resistance loads, this is based on average battery discharge voltage V_a shown on top of Column 17.
- **Battery Discharge Average Voltage V_a** (Top of Column 17)- The voltage from which the percentage of constant-current and constant-resistance loads are calculated in the right-hand most Column 18.
- **Total Resist R_s** (Top of Column 16)- Single total resistance of the constant-resistance loads the battery sees.
- **Total Watt W_s** (Top of Column 15)- Single total power of the constant-power loads the

battery sees.

- **Total Current A_s** (Top of Column 14)- Single total current of the constant-current loads the battery sees.
- **Total Watts** (bottom of Columns 14, 15 & 17)**-** Total battery load powers of constant-current, constant–power and constant-resistance loads in both "A" Car and "B" Car.
- **Grand total Watts (Bottom of Column 18)-** Total power the battery is required to support, at the average battery discharge voltage V_a shown.

Explanation of Discharge Voltage Profiles

A discharge profile is shown in Figure 6.4. It was calculated as follows:

From the total constant-current load $A_{S,}$ total constant–power load W_S and total constant –resistance load R_S in Figure 6.3, the initial discharge current I is calculated from the discharge voltage V in Chart 2,

$$I = A_S + \frac{W_S}{V} + \frac{V}{R_S}.$$

At 0°C, the battery is assumed to be initially 15% discharged (85 % stabilized available capacity). At 40°C, the battery charge efficiency of 91% is taken into account. The battery is assumed to have initially 85x0.91=77.35% available capacity, or 22.65% discharged.

The discharge current, I, is assumed constant for a 15-second period. The ampere-hours, ΔC, drawn in this period is added to the total battery percentage discharged-capacity C. The new discharge voltage, V, at percentage discharged capacity C+ΔC at the end of the period is read from Chart 2, and is used for the calculation of the discharge current, I and ampere-hour, ΔC drawn from the battery in the next 15 seconds. The calculation is repeated until the discharge voltage V drops below 0.1 volt per cell. (Note that the discharge profiles in Chart 1 of both figures show discharge voltage down to 0.5 volt only.)

The battery discharge voltage V, percentage discharged-capacity C, and discharge current ratio I/I_c against time are plotted in Chart 1. Since the characteristics in Chart 2 are for constant current I_c, two discharge profiles, Discharge-1 and Discharge-2, are plotted in Chart 1 by selecting 2 characteristic curves in Chart 2, one with I_c above and one below the initial calculated discharge current. The actual discharge profile falls between the two calculated discharge profiles in Chart 1, and closer to the Discharge curve with I/I_c ratio nearer to unity.

WMATA 6000

LVPS Load in Normal Mode

Calculated total of each load type	A_s	W_s	R_s	V_a
	126.053	2983.5	0.64	37.5

Enter LVPS Load Information:

Date: 7/12/2004 10:46

DC Load Description	Describe Duration	Item No. #	Quantity A car Q_A	Quantity B car Q_B	Normal Mode Diversity Factor D_f	Normal Mode Duty Cycle D_c	Unit Raw Information of load Watt	Unit Raw Information of load Volt	Unit Raw Information of load Ampere	Unit Const Amp A	Unit Const Watt W	Unit Const Resist R	Check Entry	Const. Current Load P_a	Const. Wattage Load P_w	Const Resist Load @ 37.5 volts Admit Y_t	Const Resist Load @ 37.5 volts Watt P_r	Percent of total wattage %
Column No: 1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
Interior Lighting:		1											0					
Emergency Passenger ltg 70W/lamp		2	3	3	1	1	70	37.5	1.87	1.87			1	420.00				5.44
Non-emergency Passenger ltg 70W/lamp	continuous	3	11	11	1	1	70	37.5	1.87	1.87			1	1540.00				19.95
Non-emergency Passenger ltg 43W/lamp	continuous	4	3	3	1	1	43	37.5	1.15	1.15			1	258.00				3.34
Non-emergency Passenger ltg 24W/lamp	continuous	5	1	1	1	1	24	37.5	0.64	0.64			1	48.00				0.62
Non-emergency Passenger ltg 20W/lamp	continuous	5A	0	1	1	1	20	37.5	0.53	0.53			1	20.00				0.26
Threshold light (Luminator), 4.5 watts	20sec/2min	6	8	8	0.5	0.17	4.5	37.5				312.50	1			0.0044	6.12	0.08
Cab Light Fixture:		7											0					
Reading light(Cab light), 20 watts		8	1	1	0.5	1	20				20		1		20.00			0.26
Console lighting LED		9	1	1	0.5	1	30					46.88	1			0.0213	30.00	0.39
Console illumination flood ltg.		10	1	1	0.5	1	50					28.13	1			0.0355	49.99	0.65
Exterior Lighting:		11											0					
F-End		12											0					
*Headlight 200w 30VDC with 4 ohm dropping resistor		13	2	2	0.5	1	200	30	(4.5 ohms)			7.50	1			0.2667	375.00	4.86
Tail Light, LED, 4.5 watts		14	2	2	0.5	1	4.5	37.5				312.50	1			0.0064	9.00	0.12
Running ltg, red LED, 2.5 watts/lamp		15	2	2	0.5	1	2.5	37.5				562.50	1			0.0036	5.00	0.06
Running ltg, white LED, 2.5 watts/lamp		16	2	2	0.5	1	2.5	37.5				562.50	1			0.0036	5.00	0.06
R-End:		17											0					
Existing Brake Released ind. changed to LED		18	1	1	1	1	2.5	37.5				562.50	1			0.0036	5.00	0.06
Existing Brake Applied ind. changed to LED		19	1	1	0	1	2.5	37.5				562.50	1			0.0000	0.00	
Existing Front Truck Fault ind, changed to LED		20	1	1	0	1	2.5	37.5				562.50	1			0.0000	0.00	
Existing Rear Truck Fault ind. changed to LED		21	1	1	0	1	2.5	37.5				562.50	1			0.0000	0.00	
Existing Brake System Fault ind. Changed to LED		22	2	2	1	1	2.5	37.5				562.50	1			0.0071	10.00	0.13
New T/L C.B. ind.- LED		23	1	1	1	1	2.5	37.5				562.50	1			0.0036	5.00	0.06
New Battery C.B. Trip ind.- LED		24	0	1	1	0	2.5	37.5				562.50	1			0.0000	0.00	
New Propulsion System Fault ind.- LED		25	1	1	0	1	2.5	37.5				562.50	1			0.0000	0.00	
Side:		26											0					
Existing Door Status ind. Changed to LED		27	2	2	0.5	1	2.5	37.5				562.50	1			0.0036	5.00	0.06
		28											0					
		29											0					
Destination & Next Station sign (Luminator):		30											0					
Sign Controller (SC):		31	1	0	1	1	42	37.5			42		1		42.00			0.54
supplyingFront Destination sign (FDS)		32											0					
Sign Power Supply Module (SPS):		33	2	2	1	1	150	37.5			150		1		600.00			7.77
supplying Side(SDS), Front(FDS), Next Station Sign (		34											0					
		35											0					
HVAC:		36											0					
Controls, 37VDC 2.67A (Heating and cooling modes)		37	1	1	1	1	100	37			100		1		200.00			2.59
CAB:		38											0					
Heating control		39	1	1	0.5	1	20	37.5				70.31	1			0.0142	20.00	0.26
Windshield heater		40	1	1	0.5	1		37.5	14			2.68	1			0.3731	524.72	6.80
Windshield wiper		41	1	1	0.5	1	100	37.5				14.06	1			0.0711	100.00	1.30
Air Brake System:		42											0					
Electronic Control Unit		43	2	2	1	1	170	23			170		1		680.00			8.81
Antiskid Pnl		44	1	1	1	0.01	15				15		1		0.30			0.00
Brake Status Unit (Brakes applied no white light)		45	1	1	1	1	5	37.5				281.25	1			0.0071	10.00	0.13
Truck Control Unit (4 mag valves included in ECU load)		46	2	2	1	0.1	21	37.5					0					
Emergency Pipe Control Unit (included in ECU load)		46A	1	1	1	1	21	37.5					0					
Air compressor system:		47											0					
Compressor control - Cold weather		48	1	0	1	1	113					12.50	1			0.0800	112.50	1.46
Compressor Control - Warm weather		49	1	0	0	0.5	37.5					5.86	1			0.0000	0.00	
		50											0					
ATC:		51											0					
Control unit, 4.3A, 23 to 42 VDC		52	1	0	1	1		37.5	4.3		161.25		1		161.25			2.09
Cab display unit (CDU), 0.75A 12 VDC		53	1	1	0.5	1		12	0.75		9		1		9.00			0.12
Door:		54											0					
Motor, 6A, 24 VDC, per door	6 sec/2 min	55	12	12	0.5	0.05		24	6		144		1		86.40			1.12
Solenoid lock, 6W, 37.5VDC	106/120 Sec	56	2	2	1	0.88	6	37.5	2.6			234.38	1			0.0150	21.12	0.27
Door Control Unit		57	12	12	1	1	6	37.5			6		1		144.00			1.87
Horns:		58											0					
Road Horn, 24VDC		59	1	1	0.5	0.1	9	37			9		1		0.90			0.01
Yard Horn		60	1	1	0.5	0.1	23	24			23		1		2.30			0.03
Propulsion Control:		61											0					
Propulsion Common Case (PCC)		62	1	1	1	1	420	37.5				3.35	1			0.5970	839.55	10.88
Converter Functional Module (CFM)		63	2	2	1	1	128	37.5			120		1		480.00			6.22
Communication:		64											0					
P.A. amplifier (Broacasting mode)	20sec/2 min	65	1	1	1	0.17	150				150		1		51.00			0.66
PAC (P.A. & ADA audio amplifier) Idling mode		66	1	1	1	0.83	22				22		1		36.52			0.47
Control and I.C.		67	0	1	1	0.1	70				70		1		7.00			0.09
Radio (Receiving mode)		68	0	1	1	0.83	35				35		1		29.05			0.38
Radio (Transmitting mode)	20 sec/2 mi	69	0	1	1	0.17	140				140		1		23.80			0.31
Vehicle Monitoring System, 150 watts		70											0					
Vehicle Control Unit (VCU)		71	1	0	1	1	50				50		1		50.00			0.65
Dara Acquisition Module (DAM)		72	1	1	1	1	30				30		1		60.00			0.78
Train Control Relay panel:		73	10	10	0.5	1		36	268			268.00	1			0.0373	52.47	0.68
37.5 VCD Outlet		74	1	1	0.5	0			50	50			1	0.00				
Auxiliary Power Control		75											0					
APS control		76	1	1	1	1	100				100		1		200.00			2.59
LVPS control		77	0	1	1	1	100				100		1		100.00			1.30
Battery charging current		78	0	1	1	0.1		37.5	70	70			1	262.50				3.40
		79											0					
Add rows above this line if required.							**Add rows above this line if required.**						**Add rows above this line if required.**					
*Resistance of headlight is 30x30/200=4.5 ohms. Total load resistance in high beam is 4.5+3=7.5 ohms.										Total Watts (of each load type)=				2548.50	2983.52		2185.48	**7717.50**
														Grand Total Watts (of all load types)=P_T ^				

Figure 6.1: LVPS Normal Mode Load Schedule (For one Pair of Cars)

Project: WMATA 6K

LVPS Load in Stranded Mode (Ref. WMATA Spec. 14.2.1, C.)

Enter LVPS Load Information:

Calculated total of each load type	A_s	W_s	R_s	V_a
	11.2	411.37	74.01	29

Column No: 1	2	3	4	5	6	7	8	9	10	11	12	13.00	14	15	16	17	18	19
Date:					**Worst-Case Mode**		**Unit**				**Unit**			Const.	Const.	Const Resist Load @		Percent
7/12/2004 10:50		**Item**	**Quantity**		Diversity	Duty	Raw Information of load			**Const**	**Const**	**Const**	Check	Current	Wattage	29 volts		of total
	Describe	**No.**	A car	B car	Factor	Cycle	Watt	Volt	Ampere	**Amp**	**Watt**	**Resist**	Entry	Load	Load	Admit	Watt	wattage
DC Load Description	Duration	#	Q_A	Q_B	D_f	D_c				**A**	**W**	**R**		P_a	P_w	Y_t	P_r	%
Interior Lighting:		1											0					
Emergency Passenger ltg 70W/lamp		2	3	3	1	1	70	37.5	1.87	1.87			1	324.80				36.29
Non-emergency Passenger ltg 70W/lamp	(15 Sec)	3	11	11	0	0	70	37.5	1.87	1.87			1	0.00				
Non-emergency Passenger ltg 43W/lamp	(15 Sec)	4	3	3	0	0	43	37.5	1.15	1.15			1	0.00				
Non-emergency Passenger ltg 24W/lamp	(15 Sec)	5	1	1	0	0	24	37.5	0.64	0.64			1	0.00				
Non-emergency Passenger ltg 20W/lamp		5A	0	0	0	0	20	37.5	0.53	0.53			1	0.00				
Threshold light (Luminator), 4.5 watts	20sec/2min	6	8	8	0	1	4.5	37.5				312.5	1			0.0000	0.00	
Cab Light Fixture:		7											0					
Reading light(Cab light), 20 watts		8	1	1	0	1	20				20		1		0.00			
Console lighting LED		9	1	1	0	1	30					46.88	1			0.0000	0.00	
Console illumination flood ltg.		10	1	1	0	1	50					28.13	1			0.0000	0.00	
Exterior Lighting:		11											0					
F-End		12											0					
*Headlight 200w 30VDC with 4 ohm dropping resistor		13	2	2	0	1	200	30	(4.5 ohms)			7.50	1			0.0000	0.00	
Tail Light, LED, 4.5 watts		14	2	2	0.5	1	4.5	37.5				312.5	1			0.0064	5.38	0.60
Running ltg, red LED, 2.5 watts/lamp		15	2	2	0.5	1	2.5	37.5				562.5	1			0.0036	2.99	0.33
Running ltg, white LED, 2.5 watts/lamp		16	2	2	0.5	1	2.5	37.5				562.5	1			0.0036	2.99	0.33
R-End:		17											0					
Existing Brake Released ind. changed to LED		18	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Brake Applied ind. changed to LED		19	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Front Truck Fault ind, changed to LED		20	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Rear Truck Fault ind. changed to LED		21	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Brake System Fault ind. Changed to LED		22	2	2	0	1	2.5	37.5				562.5	1			0.0000	0.00	
New T/L C.B. ind.- LED		23	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
New Battery C.B. Trip ind.- LED		24	0	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
New Propulsion System Fault ind.- LED		25	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Side:		26											0					
Existing Door Status ind. Changed to LED		27	2	2	0	1	2.5	37.5				562.5	1			0.0000	0.00	
													0					
													0					
Destination & Next Station sign (Luminator):		1											0					
Sign Controller (SC):		2	1	0	0	1	42	37.5			42		1		0.00			
supplyingFront Destination sign (FDS)		3											0					
Sign Power Supply Module (SPS):		4	2	2	0	1	150	37.5			150		1		0.00			
supplying Side(SDS), Front(FDS), Next Station Sign (		5											0					
		6											0					
HVAC:		7											0					
Controls, 37VDC 2.67A (Heating and cooling modes)		8	1	1	0	1	100	37			100		1		0.00			
CAB:		9											0					
Heating control		10	0	0	0	1	20	37.5					0					
Windshield heater		11	1	1	0	1		37.5	14			2.68	1			0.0000	0.00	
Windshield wiper		12	1	1	0	1	100	37.5				14.06	1			0.0000	0.00	
Air Brake System:		13											0					
Electronic Control Unit		14	2	2	1	1	66	23			66		1		264.00			29.50
Antiskid Pnl		15	1	1	0	0.01	15				24.2		1		0.00			
Brake Status Unit (Brakes applied no white light)		16	1	1	0	1	5	37.5				281.3	1			0.0000	0.00	
Truck Control Unit (included in ECU load)		17	2	2	0	0.1	21	37.5				67.0	0			0.0000	0.00	
Emergency Pipe Control Unit (included in ECU load)		17A	1	1	0	1	21	37.5					0					
Air compressor system:		18											0					
Compressor control - Cold weather		19	1	0	0	0.8	122.5	37.5				12.50	1			0.0000	0.00	
Compressor Control - Warm weather		20	1	0	0	0.2	37.5	37.5				37.50	1			0.0000	0.00	
ATC:		21											0					
Control unit, 4.3A, 23 to 42 VDC		22	1	0	0	1		37.5	4.3		161.25		1		0.00			
Cab display unit (CDU), 0.75A 12 VDC		23	1	1	0	1		12	0.75		9		1		0.00			
Door:		24											0					
Motor, 6A, 24 VDC, per door	6 sec/2 min	25	12	12	0	0.05		24	10		240		1		0.00			
Solenoid lock, 6W, 37.5VDC	14 sec/2 mi	26	2	2	0	0.12		37.5	2.6			14.42	1			0.0000	0.00	
Door Control Unit		27	12	12	0	1	6	37.5			6		1		0.00			
Horns:		28											0					
Road Horn, 24VDC		29	1	1	0	0.1	23	24			23		1		0.00			
Yard Horn		30	1	1	0	0.1	23	24			23		1		0.00			
Propulsion Control:		31											0					
Propulsion Common Case (PCC)		32	1	1	0	1	420	37.5				3.35	1			0.0000	0.00	
Converter Functional Module (CFM)		33	2	2	0	1	128	37.5			120		1		0.00			
Communication:		34											0					
P.A. amplifier (Broacasting mode)	20sec/2 mi	35	1	1	1	0.17	150				150		1		51.00		51.00	5.70
PAC (P.A. & ADA audio amplifier) Idling mode		36	1	1	1	0.83	22				22		1		36.52		36.52	4.08
Control and I.C.		37	0	1	1	0.1	70				70		1		7.00		7.00	0.78
Radio (Receiving mode)		38	0	1	1	0.83	35				35		1		29.05		29.05	3.25
Radio (Transmitting mode)	20 sec/2 mi	39	0	1	1	0.17	140				140		1		23.80		23.80	2.66
Vehicle Monitoring System, 150 watts		40											0					
Vehicle Control Unit (VCU)		41	1	0	0	1	50				50		1		0.00		0.00	
Dara Acquisition Module (DAM)		42	1	1	0	1	30				30		1		0.00		0.00	
Train Control Relay panel:		43	10	10	0	1		36	268			268.0	1			0.0000	0.00	
37.5 VCD Outlet		44	1	1	0	1			50	50			1	0.00				
Auxiliary Power Control		45											0					
APS control		46	1	1	0	1	100				100		1		0.00			
LVPS control		47	0	1	0	1	100				100		1		0.00			
Battery charging current		48	0	1	0	0.1		37.5	70	70			1	0.00				
		49											0					
Add rows above this line if required.						**Add rows above this line if required.**							**Add rows above this line if required.**					
*Resistance of headlight is 30x30/200=4.5 ohms. Total load resistance in high beam is 4.5+3=7.5 ohms.										Total Watts (of each load type)=				324.80	411.37		158.73	**894.90**
										Amps =	30.859			**Grand Total Watts (of all load types)=P_T ^**				

Figure 6.2 Stranded Mode

Project: WMATA 6000

Battery Load in Emergency service Mode (Ref. WMATA Spec. 14.2.1, A.)

Calculated total of each load type	A_s	W_s	R_s	V_a	I_a
	11.20	2940.94	0.79	29	149.32

Enter Battery Load Information:

Column No: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Date:					**Emerg. Mode**		**Unit**				**Unit**			Const.	Const.	Const Resist Load @		Percent
7/12/2004 10:57		**Item**	**Quantity**		Diversity	Duty	Raw Information of load			**Const**	**Const**	**Const**	Check	Current	Wattage	**29** volts		of total
	Describe	**No.**	A car	B car	Factor	Cycle	Watt	Volt	Ampere	**Amp**	**Watt**	**Resist**	Entry	Load	Load	Admit	Watt	wattage
DC Load Description	Duration	#	Q_A	Q_B	D_f	D_c				**A**	**W**	**R**		P_a	P_w	Y_t	P_r	%
Interior Lighting:		1											0					
Emergency Passenger ltg 70W/lamp		2	3	3	1	1	70	37.5	1.87	1.87			1	324.80				7.50
Non-emergency Passenger ltg 70W/lamp	(15 Sec)	3	11	11	0	0	70	37.5	1.87	1.87			1	0.00				
Non-emergency Passenger ltg 43W/lamp	(15 Sec)	4	3	3	0	0	43	37.5	1.15	1.15			1	0.00				
Non-emergency Passenger ltg 24W/lamp	(15 Sec)	5	1	1	0	0	24	37.5	0.64	0.64			1	0.00				
Non-emergency Passenger ltg 20W/lamp	(15 Sec)	5A	0	1	0	0	20	37.5	0.53	0.53			1	0.00				
Threshold light (Luminator), 4.5 watts	20sec/2min	6	8	8	0.5	0.17	4.5	37.5				312.5	1			0.0044	3.66	0.08
Cab Light Fixture:		7											0					
Reading light(Cab light), 20 watts		8	1	1	0.5	1	20				20		1		20.00			0.46
Console lighting LED		9	1	1	0.5	1	30					46.88	1			0.0213	17.94	0.41
Console illumination flood ltg.		10	1	1	0.5	1	50					28.13	1			0.0355	29.90	0.69
Exterior Lighting:		11											0					
F-End		12											0					
*Headlight 200w 30VDC with 4 ohm dropping resistor		13	2	2	0.5	1	200	30	(4.5 ohms)			8.50	1			0.2353	197.88	4.57
Tail Light, LED, 4.5 watts		14	2	2	0.5	1	4.5	37.5				312.5	1			0.0064	5.38	0.12
Running ltg, red LED, 2.5 watts/lamp		15	2	2	0.5	1	2.5	37.5				562.5	1			0.0036	2.99	0.07
Running ltg, white LED, 2.5 watts/lamp		16	2	2	0.5	1	2.5	37.5				562.5	1			0.0036	2.99	0.07
R-End:		17											0					
Existing Brake Released ind. changed to LED		18	1	1	1	1	2.5	37.5				562.5	1			0.0036	2.99	0.07
Existing Brake Applied ind. changed to LED		19	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Front Truck Fault ind, changed to LED		20	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Rear Truck Fault ind. changed to LED		21	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Existing Brake System Fault ind. Changed to LED		22	2	2	1	1	2.5	37.5				562.5	1			0.0071	5.98	0.14
New T/L C.B. ind.- LED		23	1	1	1	1	2.5	37.5				562.5	1			0.0036	2.99	0.07
New Battery C.B. Trip ind.- LED		24	0	1	1	0	2.5	37.5				562.5	1			0.0000	0.00	
New Propulsion System Fault ind.- LED		25	1	1	0	1	2.5	37.5				562.5	1			0.0000	0.00	
Side:		26											0					
Existing Door Status ind. Changed to LED		27	2	2	0.5	1	2.5	37.5				562.5	1			0.0036	2.99	0.07
		28											0					
		29											0					
Destination & Next Station sign (Luminator):		30											0					
Sign Controller (SC):		31	1	0	1	1	42	37.5			42		1		42.00			0.97
supplyingFront Destination sign (FDS)		32											0					
Sign Power Supply Module (SPS):		33	2	2	1	1	150	37.5			150		1		600.00			13.86
supplying Side(SDS), Front(FDS), Next Station Sign (NSS)		34											0					
		35											0					
HVAC:		36											0					
Controls, 37VDC 2.67A (Heating and cooling modes)		37	1	1	1	1	100	37			100		1		200.00			4.62
CAB:		38											0					
Heating control		39	1	1	0.5	1	20	37.5				70.31	1			0.0142	11.96	0.28
Windshield heater		40	1	1	0.5	1		37.5	14			2.68	1			0.3731	313.81	7.25
Windshield wiper		41	1	1	0.5	1	100	37.5				14.06	1			0.0711	59.80	1.38
Air Brake System:		42											0					
Electronic Control Unit		43	2	2	1	1	170	23			170		1		680.00			15.70
Antiskid Pnl		44	2	2	1	0.01	15				15		1		0.60			0.01
Brake Status Unit (Brakes applied no white light)		45	1	1	1	1	5	37.5				281.3	1			0.0071	5.98	0.14
Truck Control Unit (4 mag valves included in ECU load)		46	2	2	1	0.1	21	37.5					0					
Emergency Pipe Control Unit (included in ECU load)		46A	1	1	1	1	21	37.5					1					
Air compressor system:		47											0					
Compressor control - Cold weather		48	1	0	1	0.5	113	37.5				12.50	1			0.0400	33.64	0.78
Compressor Control - Warm weather		49	1	0	0	0.5	37.5	37.5				37.50	1			0.0000	0.00	
		50											0					
ATC:		51											0					
Control unit, 4.3A, 23 to 42 VDC		52	1	0	1	1		37.5	4.3		161.25		1		161.25			3.72
Cab display unit (CDU), 0.75A 12 VDC		53	1	1	0.5	1		12	0.75		9		1		9.00			0.21
Door:		54											0					
Motor, 6A, 24 VDC, per door	6 sec/2 min	55	12	12	0.5	0.05	144	24	6		144		1		86.40			2.00
Solenoid lock, 6W, 37.5VDC	106/120 Sec	56	2	2	1	0.88	6	37.5				234.4	1			0.0150	12.63	0.29
Door Control Unit		57	12	12	1	1	6	37.5			6		1		144.00			3.33
Horns:		58											0					
Road Horn, 24VDC		59	1	1	0.5	0.01	9	37			9		1		0.09			0.00
Yard Horn		60	1	1	0.5	0.01	23	24			23		1		0.23			0.01
Propulsion Control:		61											0					
Propulsion Common Case (PCC)		62	1	1	1	1	260	37.5				5.26	1			0.3802	319.77	7.38
Converter Functional Module (CFM)		63	2	2	1	1	128	37.5			120		1		480.00			11.08
Communication:		64											0					
P.A. amplifier (Broacasting mode)	20sec/2min	65	1	1	1	0.17	150				150		1		51.00			1.18
PAC (P.A. & ADA audio amplifier) Idling mode		66	1	1	1	0.83	22				22		1		36.52			0.84
Control and I.C.		67	0	1	1	0.1	70				70		1		7.00			0.16
Radio (Receiving mode)		68	0	1	1	0.83	35				35		1		29.05			0.67
Radio (Transmitting mode)	20 sec/2 min	69	0	1	1	0.17	140				140		1		23.80			0.55
Vehicle Monitoring System, 150 watts		70											0					
Vehicle Control Unit (VCU)		71	1	0	1	1	50				50		1		50.00			1.15
Dara Acquisition Module (DAM)		72	1	1	1	1	30				30		1		60.00			1.39
Train Control Relay panel:		73	10	10	0.5	1		36	268			268.0	1			0.0373	31.38	0.72
37.5 VCD Outlet		74	1	1	0	0			50	50			1	0.00				
Auxiliary Power Control		75											0					
APS control		76	1	1	1	1	100				100		1		200.00			4.62
LVPS control		77	0	1	1	1	60				60		1		60.00			1.39
Battery charging current		78	0	0	0	0		37.5	70	70			1	0.00				
		79											0					
Add rows above this line if required.						**Add rows above this line if required.**						**Add rows above this line if required.**						
*Resistance of headlight is 30x30/200=4.5 ohms. Total load resistance in high beam is 4.5+3=7.5 ohms.										Total Watts (of each load type)=				324.80	2940.94		1064.67	**4330.4**
											Amps =	149.32		**Grand Total Watts (of all load types)=P_T ^**				

Figure 6.3 Emergency Service Mode

6.1 NORMAL LVPS LOAD

The LVPS normal load calculation sheet, Figure 6.1, is shown as a reference to establish the basic loads which must be supported on a married pair of cars. The friction brake load used for calculation is 170 watts normal, including all magnet valves, and 66 watts, including all magnet valves, during layover

6.2 WORST CASE LVPS LOAD

The capacity of the LVPS can be defined by insuring that it is 120% of the worst case load. In this case, the only additional loading for the worst case situation is continuous operation of the air compressor, adding less than 200 watts. The 10083 watt worst case load multiplied by the required 120% capacity is 12100 watts. Since the LVPS will have a capacity of 14.1 Kw., it exceeds the required margin of capacity.

6.3 BATTERY LOADING FOR STRANDED MODE

The Stranded Mode is defined as specified in the WMATA Specification Section 14.2.1.C., “carry emergency lighting, communications equipment, running lights, and any loads that cannot be shed by the use of cab circuit breakers and switches on a two-car train standing still with no third rail power for two hours”. The battery load for this condition is shown in figure 6.2.

The load under these conditions is 631 watts or 21.76 amperes.

The period of time during which this load can be supported is:

T = (AHr X 85% X Aging Factor)/load = (190 X .85 X .9)/21.76 = 6.68 hours

This far exceeds the required 2 hours

6.4 BATTERY LOADING FOR EMERGENCY MODE

The EMERGENCY MODE is as specified in the WMATA Specification Section 14.2.1.A., “carry all loads of the married pair until load shedding, then provide all 37.5-volt loads (including emergency lighting) on a two-car train in the absence of battery charging voltage for a period of 40 minutes, including 20 station stops with passengers boarding and alighting”. The main lights are load shed 15 seconds after the LVPS ceases operation. The load under these conditions is shown in figure 6.3 and is 4514.4 watts or 155.67 amperes. The battery discharge for these conditions is shown in figure 6.4 below.

Battery Load Discharge above 17°C (62.6°F)-						Project: WMATA 6000		
Constant Current Load						Battery Load in Emergency Mode		
A_s(Amp):	11.20	Batt Rating		Select	Initial	Number	Stabilized	Discharge
Constant wattage Load			Ah	I_c Curve	I_o/I_c(at t=0)	of cells	Charge	Time
W_s (Watts):	2940.94	Discharge-1	190	0.5	1.60	N	C_{st}(%)	T(Minutes)
Constant resistance Load		Discharge-2	190	1.0	0.81	25	85	53
R_s (Ohms):	0.67							
					Charge Temp		Initial Charge	Charge
Batt. Load P_T=	4514.45	Watts @ V_a=	29	Volts average.	(°F)	(°C)	C_{in} (%)	Efficiency n_c(%)
Approx Ah_a=	179	A-Hr @ V_a=	29	Volts average.	104.0	40	76.62	90.14

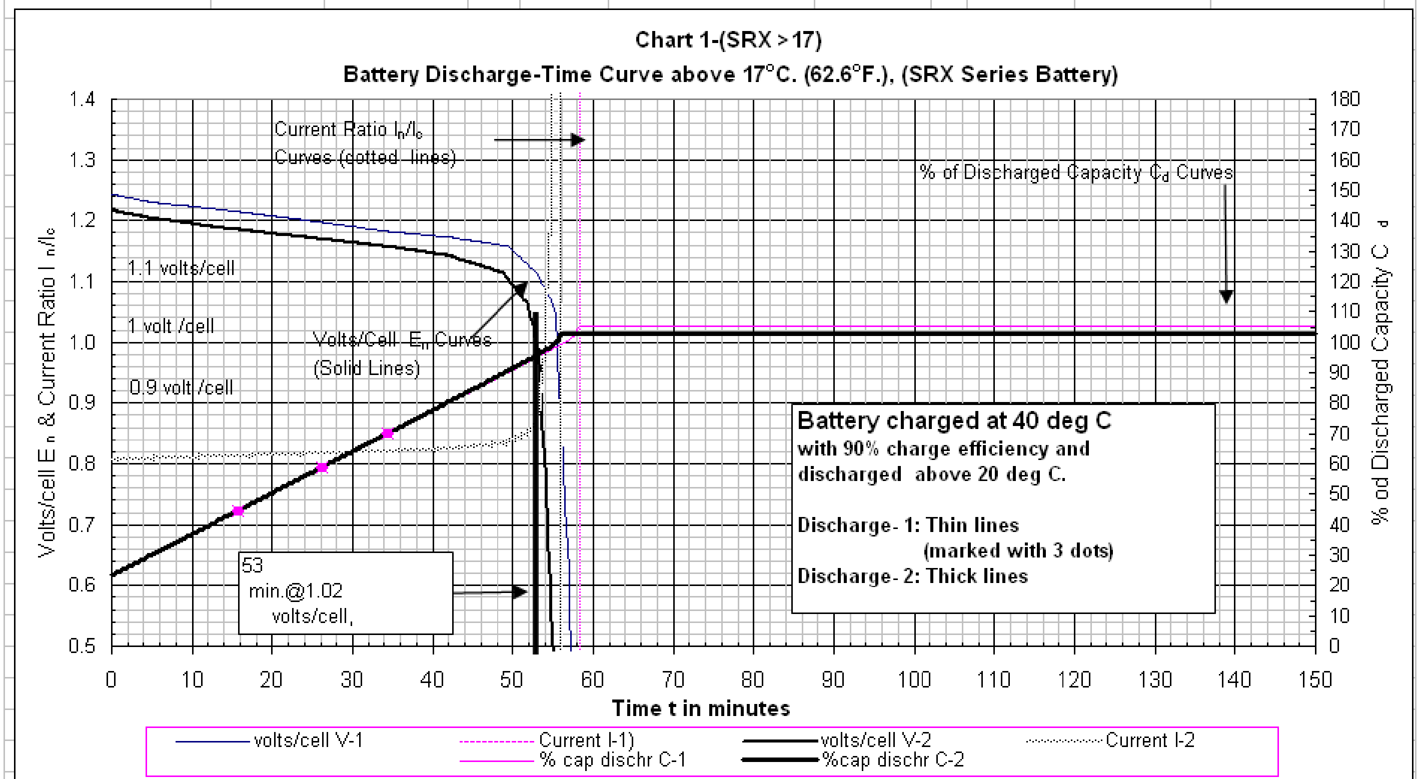


Figure 6.4 Battery discharge, Emergency mode

The battery is able to support the loads for a period of 53 minutes, exceeding the required 40 minutes. The discharge is shown for a temperature exceeding 17 degrees Celsius since that is the worst case temperature for the battery.

7.0 CONCLUSIONS:

The SAFT SRX190, 190 AHr battery will provide 53 minutes (40 minutes minimum) of discharge in Emergency mode (Figure 6.4) and 6.68 hours (2 hours minimum) of discharge in Stranded mode at 40 degrees Celsius.

The SAFT SRX190 therefore meets the requirements of the WMATA Specification Section 14.2.1, A & C.

The requirements of the WMATA Specification Section 14.2.1, B, however cannot be achieved.

Paragraph B in Section 14.2.1 of WMATA's Specification requires that battery terminal voltage to be adequate to operate all connected system after 60 hours operation on a stored pair of cars with the battery system power converter inoperative, assuming normal loading. Major load in layover mode in old WMATA cars with DC propulsion is floor-heating control. The layover loads required by WMATA in the 6K cars also include the ATC, tail and red marker lights as "normal loading". The table below shows the loads in layover mode for the 6000 Series cars

The Brake System load has been added as requested by WMATA. The brake system ECU quiescent load is 66 watts.

WMATA 6000 Series												Total=	A_s	W_s	R_s	V_a	
Battery Load in LAYOVER Mode													**0.00**	**441.25**	**74.02**	**29**	
Enter Battery Load Information:																	
						Unit				Unit			Const.	Const.	Const Resist Load		Percent of
	Item	**Quantity**		Diversity	Duty	Raw Information of load			**Const**	**Const**	**Const**	Check	Current	Wattage		At 29 V	total load
	No.	A car	B car	Factor	Cycle	Watt	Volt	Ampere	**Amp**	**Watt**	**Resist**	Entry	Load	Load	Admit	Watt	wattage
DC Load Description	**#**	Q_A	Q_B	D_f	D_c			(or ohms)	A	W	R		W_{ta}	W_t	A_d	W_{tr}	%
HVAC:	1											0					
Controls, 37VDC 8W (Layover modes)	2	1	1	1	1	8	37			**8**		1		16.00			3.54
ATC:	3											0					
Control unit, 4.3A, 23 to 42 VDC	4	1	0	1	1		37.5	4.3		**161.25**		1		161.25			35.63
Air Brake System	5											0					
Electronic Control Unit (Incl. Em. Brake Pipe Unit)	6	2	2	1	1	66		23		**66**		1		264.00			58.33
Antiskid Pnl	7	2	2	0	0.01	15				**15**		0		0.00			
Brake Status Unit (Brakes applied no white light)	8	1	1	1	1	5		37.5			**281.30**	1			0.0036	2.99	0.66
Truck Control Unit (Included in ECU load)	9	2	2	1	0.1	30		37.5				1					
Tail Light, LED, 4.5 watts	*10*	2	2	0.5	1	4.5	37.5				**312.5**	1			0.0064	5.38	1.19
Running ltg, red LED, 2.5 watts/lamp	*11*	2	2	0.5	1	2.5	37.5				**562.5**	1			0.0036	2.99	0.66
Add rows above this line if required.				**Add rows above this line if required.**								**Add rows above this line if required.**					
												Total Watts=	0.00	441.25	0.0036	11.36	452.61
													AMPS	15.60732		**Grand Total Watts**	

The battery discharge time T in hours for the 190 A-Hr SRX190 battery is:

$$T=(AHr \times 85\% x Aging\ factor)/load\ A$$

$$= (190 \times 0.85 x.9) / 15.61 = 9.31\ \textit{hours}$$

where *AHr* is the ampere hour rating of the battery, Aging factor is 0.9, and 85% is the percentage of the battery charged as required in WMATA's Technical Specification.