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## SECTION 1

### 1.0 General Information

Caution! Before proceeding with the unpacking, handling, installation and operation of this lead-acid storage battery, the following general information should be reviewed together with the recommended safety precautions.

A lead-acid battery is an electro-chemical device containing electrolyte which is a dilute solution of sulfuric acid and water. This electrolyte is corrosive and can cause injury.

Lead-acid batteries, when installed, are capable of high voltage which can cause electrical shocks to personnel.

All lead-acid batteries, in the course of normal operation, generate gases which could be explosive.

Stationary batteries (when installed) are usually on float charge continually, unless on discharge in the event of AC failure, or on recharge following a discharge.

## SECTION 2

### BATTERY WARNING STATEMENT DANGER

#### HIGH VOLTAGE



High voltages are present on most battery systems. Exercise caution and REMOVE ALL METAL OBJECTS FROM PERSON when working on or around battery.

#### EXPLOSIVE GASES



Gases produced by battery can be explosive. DO NOT SMOKE, USE AN OPEN FLAME, CREATE AN ARC or SPARKS IN VICINITY OF BATTERY. WEAR EYE PROTECTION. Personnel should discharge static charges from their person to ground before working on battery. Ventilate well in an enclosed space and when charging.



#### ACID BURNS



Battery contains SULFURIC ACID WHICH CAN CAUSE SEVERE BURNS. Avoid getting in eyes, on skin, or on clothing. In case of contact, flush immediately and thoroughly with clean water. OBTAIN MEDICAL ATTENTION.



### 2.0 Safety Precautions

- Wear rubber apron, gloves and safety goggles (or face shield) when handling, installing, or working with batteries. This will help prevent injury due to splashing or spillage of sulfuric acid.
- Prohibit smoking. Keep flames and sparks of all kinds away from vicinity of storage batteries as liberated or entrapped hydrogen gas in the cells may be exploded, causing injury to personnel and damage to cells.
- Never place metal tools on top of cells, since sparks due to shorting across cell terminals may result in an explosion of hydrogen gas in or near the cells. Insulate tool handles to protect against shorting.

- When preparing electrolyte, always pour acid into water, **NEVER water into acid**. Failure to follow this precaution will result in excess heat and violent chemical reaction which may cause serious injury to personnel.
- If electrolyte comes into contact with skin or clothing, immediately wash with water and neutralize with a solution of baking soda and water. Secure medical treatment. If electrolyte comes into contact with the eyes, wash or flush with plenty of clean water. Secure medical treatment immediately.
- Exercise care when handling cells. When lifting straps and strap spreaders are provided, use them with appropriate mechanical equipment to safely handle cells and avoid injury to personnel.
- Promptly neutralize and remove any electrolyte spilled when handling or installing cells. Use a baking soda/water solution (1 lb. per gallon of water) to prevent possible injury to personnel.
- Make sure that all battery connections are properly prepared and tightened to prevent possible injury to personnel or failure of system.
- Familiarize personnel with battery installation, charging and maintenance procedures. Restrict access to battery area, permitting trained personnel only, to reduce the possibility of injury.
- Whenever possible, when making repairs to charging equipment and/or batteries, interrupt AC and DC circuits to reduce the possibility of injury to personnel and damage to system equipment. This is particularly important with high voltage systems (110 volts and above).
- When maintaining a connected battery string, care must be taken to prevent a build-up of static charge.** This danger is particularly significant when the worker is electrically isolated, ie. working on a rubber mat or an epoxy painted floor or wearing rubber shoes. **Prior to making contact with the cell, discharge static electricity by touching a grounded surface.** Wearing a ground strap while working on a connected battery string is not recommended.

**NOTE:** If the foregoing precautions are not fully understood, clarification should be obtained from your nearest GNB representative. Local conditions may introduce situations not covered by MEI Safety Precautions. Here again, contact the nearest MEI representative for guidance with your particular safety problem; also refer to applicable federal, state, and local regulations as well as industry standards.

## SECTION 3

### 3.0 Receipt of Shipment

Immediately upon delivery by the carrier, examine for possible damage caused in transit. Damaged packing material or staining from leaking electrolyte would indicate rough handling.



Remove material holding cartons to pallets, exercising care when cutting banding material to prevent injury. If individual cells are to be moved to another location, do not remove carton at this time. Exercise caution if using a two-wheeled hand truck and, to prevent spillage of electrolyte, do not tilt cell more than 25 degrees from vertical. When cells have been brought to the installation sight, remove carton sleeve and top corrugated spacers.

**DO NOT LIFT CELLS BY THEIR TERMINAL POSTS.**

Support the cells from the bottom when handling and unpacking. In general, units weighing less than 75 pounds are handled manually, being supported from the bottom.

After removal of outer carton and top spacers, the cell should still be resting in the bottom corrugated tray. This tray is designed to be easily broken away to permit positioning of a lifting strap under the cell with a minimal amount of cell tilting.

A lifting strap and a strap spreader are furnished for use with mechanical lifting devices, when cells weigh 75 pounds or more. See Figure 1 which shows typical positioning of strap and spreader. Large cells are provided with 2 lifting straps and a special spreader for stability in handling during installation.

Always use lifting straps and spreaders, when provided, together with suitable mechanical lifting devices to prevent injury to personnel or damage to cells.

Platform lifts of adequate capacity to handle cell weights and dimensions may be used provided they are stable and capable of reaching needed heights and used on smooth and level floor conditions.

Never slide cells across rough surfaces as severe scratching of plastic container bottom may result in stressing and rupturing of the jar with subsequent loss of electrolyte. At all times, exercise care when handling cells to prevent scratching of plastic jars and covers.

## **SECTION 7**

### **7.0 Installation**

#### **7.1 Battery Location**

It is recommended that the battery be installed in a clean, cool, dry location. Cells should not be exposed to heating units, strip heaters, radiators, steam pipes or sunshine through a window. Any of these conditions can cause a serious electrolyte temperature variation among cells within a battery (see Section 7.3).

#### **7.2 Temperature**

A battery location having an ambient temperature of 75°F (24°C) to 77°F (25°C) will result in optimum battery life. Batteries operated in high ambient temperatures will result in reduced life. Therefore, for longer life and ease of maintenance, locations having cooler ambient temperatures are recommended. The normal battery operating temperatures are between 60°F (16°C) and 90°F (32°C).

### **7.3 Temperature Variation**

The location of rack arrangement should result in no greater than 5°F (2.78°C) variation in cell temperatures in a series string at any given time. If a greater variation is found, steps should be taken to correct the condition. When uniform cell temperature is maintained, the need for equalizing charges may be eliminated or reduced in frequency.

### **7.4 Ventilation**

In the operation of lead-acid battery whether it be on initial charge, float charge, equalizing charge or recharge following a discharge, hydrogen and oxygen gases are produced. This results from electrolysis of the water portion of the electrolyte by the charging current.

Ventilation should be provided in the battery room or area to prevent hydrogen, liberated from the cells in service, from exceeding a 1% concentration. Concentrations above this percentage can result in an explosive mixture, which could be ignited by sparks from adjacent electrical equipment as well as accidental sparks or open flames introduced by personnel. All air moved by ventilation in the battery room or area should be exhausted into the outside atmosphere and should not be allowed to recirculate into other confined areas.

### **7.5 Placement of Cells**

It is assumed at this point that the battery rack has been assembled. Study the rack layout and wiring drawings to determine proper location of the positive and negative terminals of the battery; this will establish correct positioning of the initial cell on each rack row. Cells are normally installed with plate edges perpendicular to rack length.

Measure and mark the center of the rack stringer length. Determine the number of cells to be placed in each row. When an odd number of cells are in the row, place the center of the initial cell at the center point of the rack stringer length.

When an even number of cells are in the row, locate the initial cells so that the center of the space between the cells coincides with the center mark of the stringer length.

To minimize friction of cells when transferring from platform lift to the rack rails or for positioning of cells, talcum powder may be used on the platform surface or plastic rack strips to ease movement.

**CAUTION!**

**DO NOT USE ANY OTHER TYPE OF LUBRICANT SUCH AS GREASE OR OIL AS THEY MAY CONTAIN MINERAL SPIRITS WHICH CAUSE CRAZING AND CRACKING OF THE PLASTIC JAR MATERIAL.**

**DO NOT USE METAL RODS, SCREWDRIVERS, ETC. THROUGH POST HOLES TO Laterally move cells as cell shorting as well as damage to the post seals could occur.**

When installing cells on the rack, start at the lower step or tier for stability and safety reasons.

Place cells on the rack so that the positive terminal (marked "+") of each cell adjoins the negative terminal (marked "-") of the next cell. The standard spacing between cells is 1/2" at the top of the jars.

Adjacent cells should not touch; nor should any cell contact the metal rack supports or metal cable conduits. Check for proper alignment and 1/2" spacing between cells. Adjust cell position where necessary. This should be completed before installation of intercell connectors.

Use two 1/2" thick pieces of plywood cut to cell width and 1" higher than jar height to expedite positioning of cells. Space cells by placing one piece between the first cell positioned and the next cell. In positioning the third cell, use the second piece of plywood for spacing. The first piece is removed and used for the next cell placement, etc.

The cell post surfaces have a coating of NO-OX-ID grease or approved equal applied at the factory. Do not remove any grease from posts. Re-coat any surfaces that may have been exposed during handling of cells.

Also closely examine factory coated post contact surfaces for presence of foreign substances which may have been introduced through handling or construction activity in the installation area. If the foregoing is noted, remove the NO-OX-ID grease or approved equal with paper wipers and apply a new coating. Also inspect posts for corrosion. If corrosion is found, clean posts with brass suede brush or plastic scouring pad and re-grease.

**CAUTION!**

FAILURE TO OBSERVE ABOVE PROCEDURE  
MAY IMPAIR INTEGRITY OF ELECTRICAL  
CONNECTION AND CELL PERFORMANCE.

## 7.6 Connecting Cells

Refer to the cell arrangement drawing to determine the quantity, size, and correct positioning of the intercell connectors. On the "N" type cells using 1 1/4" wide connectors, the bolt holes are located off-center. Position the connector so that the lesser dimension faces downward on the cell post.

Gently clean contact surfaces only of the lead plated intercell connectors, terminal plates and cable lugs using a brass suede brush or 3M Scotch Brite scouring pad. Caution: Do not use powered wire brush or coarse abrasives, as lead plating may be removed exposing copper.

As contact surfaces of posts and connectors are cleaned, apply a thin coating of NO-OX-ID grease or approved equal to these surfaces only.

Starting at center of the cell row, install connectors per wiring diagram and cell arrangement drawing furnished with the battery.

On cells using stainless steel bolts, washers and nuts, make

sure a washer is placed between the bolt head and connector as well as between the nut and connector with the rolled edge against the connector. Never install washers between the connector and the cell post. (See figure 2A).

**CAUTION!**

WHEN INSTALLING TERMINAL HARDWARE  
DO NOT PERMIT ANY ITEMS TO FALL INTO  
CELL. IF SUCH MATERIAL REMAINS IN THE  
CELL, CONTAMINATION WILL RESULT,  
REQUIRING REPLACEMENT OF THE CELL.

As intercell connectors are installed, adjust them to a level position and finger tighten hardware.

After all connectors are installed, the hardware should be tightened using insulated tools as outlined in the following illustration. (Figure 2):


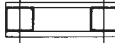


QUANTITY AND THICKNESS OF INTERCELL CONNECTORS	TORQUE (INCH LBS).
 <span style="margin-left: 20px;">1/8" or 1/4"</span>	(D cells only) 100
 <span style="margin-left: 20px;">1/8"</span>	(M & N cells) 100
 <span style="margin-left: 20px;">1/4" or two 1/8"</span>	(M & N cells) 150
 <span style="margin-left: 20px;">1/4" (PDQ, N &amp; H cells)</span>	150

Figure 2

Torque both the bolt head and the nut of stainless steel hardware to their prescribed torque values. Torquing only one side of either combination will not provide the desired tightness.

Re-torque stainless steel hardware 4 to 6 hours after initial torquing to allow for initial relaxation of connection components.

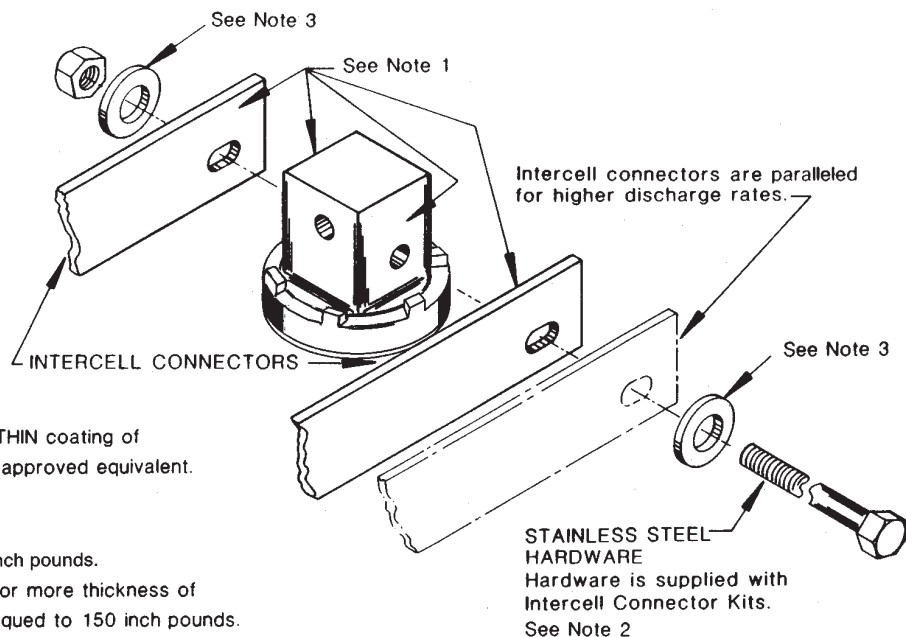
Complete connecting of cells by installing necessary inter-row, inter-tier or inter-rack cable connectors. Do not connect battery to charger at this time.

Take and record connection resistances (See Section 19.0) of cell to cell and cell to terminal (including inter level and load connections). This is particularly important on high rate applications. Remake any connection that has a value more than 10% or 5 u Ω, whichever is greater.

Re-check to be certain that the cells are connected positive (+) to negative (-) throughout the battery string. Measure the total voltage at the battery terminals. The voltage should be equal to the number of cells times the voltage of one of the cells. Example: 60 cells times 2.05 volts = 123 volts.

# INSTALLATION INFORMATION

## Battery Post Connection



### Note 1

Coat these surfaces with a THIN coating of No-Oxide Grease or a GNB approved equivalent.

### Note 2

Torque all connection bolts:

PDQ cells are torqued to 150 inch pounds.

M,N & H cells with 1/4 inch or more thickness of intercell connectors are torqued to 150 inch pounds.

M cells with 1/8 inch thickness of intercell connectors are torqued to 100 inch pounds.

Terminal plate connections are torqued at 100 inch pounds.

### Note 3

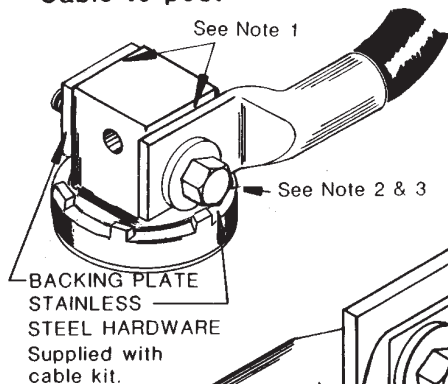
Flat washers must be installed with the rounded (rolled) edge against the Intercell Connector, Backing Plate or Terminal Plate to insure corrosion protection and contact integrity. (See detail A)

### Note 4

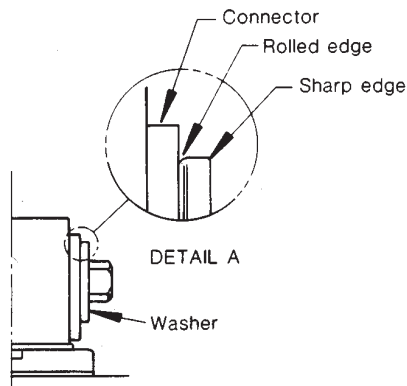
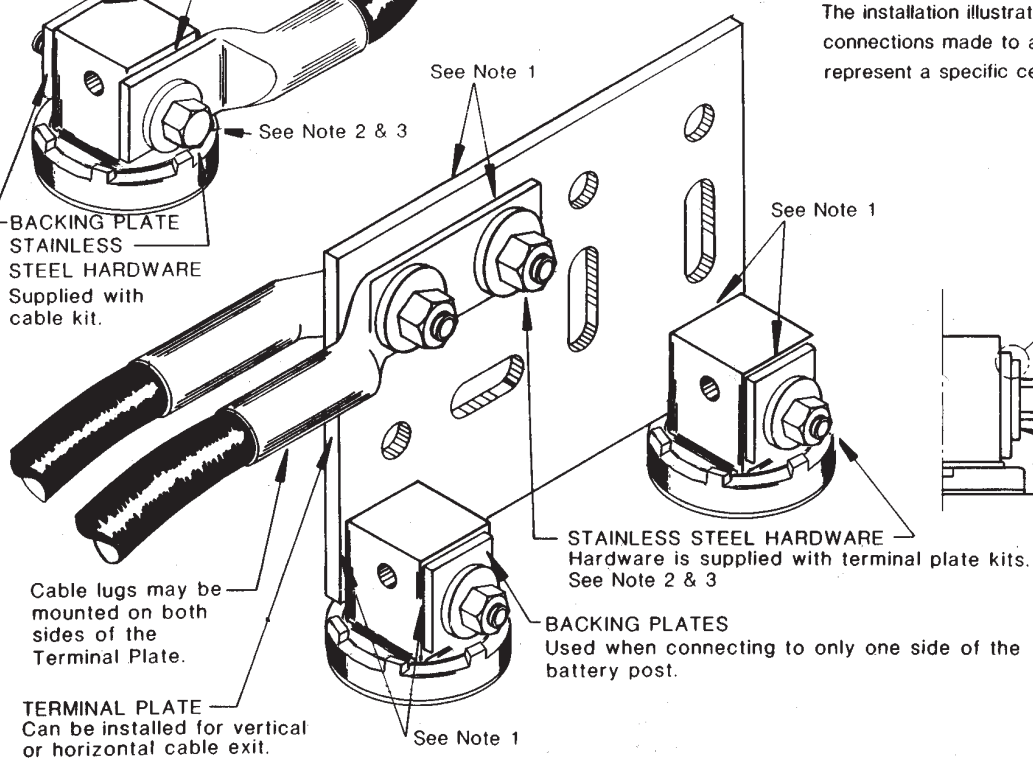
The installation illustrations on this page are typical of connections made to all battery post and do not represent a specific cell type.

## Row Interconnection

### Cable to post



### Cable to Terminal Plate









- D. Equalize to complete a recharge of the battery in a minimum length of time following an emergency discharge.
- E. If accurate quarterly records are maintained (See Section 14.0) and the individual cell voltages and temperature corrected specific gravities show no increase instead from the previous quarterly readings, equalizing may be deferred. (See Section 11.2)
- F. Equalize once a year even though preceding conditions did not require. (Lead-calcium types floated per paragraph A, may not require annual equalizing).

## 10.2 Equalizing Charge Method

Constant voltage charging is the preferred method for giving an equalizing charge. Determine the maximum voltage that may be applied to system equipment. This voltage, divided by the number of cells connected in series, will establish the maximum voltage per cell that may be used to perform the equalizing charge in the shortest period of time.

For lead-antimony types, refer to Table D and for lead-calcium type, refer to Table E to obtain various voltage and associated time period recommended.

The recommended time periods below are considered minimum. Raise the voltage to the maximum value permitted by the system equipment. When charging current has tapered and stabilized (no further reduction for three hours), charge for the hours shown in the appropriate table and for the battery temperature, at the time of stabilization, until the lowest cell voltage ceases to rise. Monitoring of cell voltages should be started during the latter 10% of the applicable time period to determine the lowest cell in battery.

### EQUALIZING CHARGE

#### Recommended Voltages and Time Periods

**TABLE D**

#### Lead-Antimony Types

Cell Volts	Time-Hrs.	Time-Hrs.
	1.215 sp. gr.	1.250 sp. gr.
2.24	80	—
2.27	60	—
2.30	48	—
2.33	36	58
2.36	30	51
2.39	24	39
2.42	—	29
2.45	—	26
2.48	—	24

**TABLE E**

#### Lead-Calcium Types

Cell Volts	Time-Hrs.	Time-Hrs.	Time-Hrs.
	1.215 sp. gr.	1.250 sp. gr.	1.300 sp. gr.
2.24	222	—	—
2.27	166	—	—
2.30	105	—	—
2.33	74	166	—
2.36	50	118	200
2.39	34	80	134
2.42	—	54	91
2.45	—	36	62
2.48	—	—	42

**NOTE:** Time periods listed in Tables D and E are for cell temperatures from 70°F (21°C) to 90°F (32°C). For temperatures 55°F (13°C) to 69°F (20.5°C) double the number of hours. For temperatures 40°F (4°C) to 54°F (12°C) use four times the number of hours.

## 10.3 Equalizing Individual Cells

When only a few cells in a battery require equalizing, and system voltage limitations do not permit raising the battery voltage up to a recommended equalizing voltage, a separate voltage regulated charger may be used on the affected cells.

The charger must have complete AC line isolation and should be paralleled across the below normal cell. Select the equalizing voltage values listed in Tables D or E for the type cell involved. The hours of equalizing may have to be increased from listed values before stabilization of cell voltage and specific gravity is achieved, especially where below normal condition has existed for a prolonged period.

### CAUTION!

WHEN INDIVIDUAL CHARGER IS REMOVED FROM CELL WHICH HAS BEEN EQUALIZED, A DROP IN VOLTAGE BELOW THE AVERAGE STRING VOLTAGE MAY OCCUR. THIS IS NORMAL, DUE TO THE EXCESS INTERNAL CELL GASES PRESENT. AS THESE EXCESS GASES DISLodge FROM INTERNAL CELL COMPONENTS, THE CELL VOLTAGE WILL RISE GRADUALLY, WHICH MAY TAKE FROM TWO TO FOUR WEEKS.

## 10.4 Equalizing Charge—Electrolyte Levels

A battery which has electrolyte levels at the high level line while on a float and then placed on equalizing charge will result in a rise in electrolyte above the high level line. This is a normal condition. **DO NOT** remove any electrolyte as the levels will return to their former condition when the battery is returned to normal float. Removal of the electrolyte with subsequent restoration to proper electrolyte levels by water addition could result in variations or sub-normal specific gravity values.

## SECTION 11

### 11.0 Specific Gravity

In a lead-acid cell, the electrolyte is a dilute solution of water and sulfuric acid. Specific gravity is a measure of the weight of acid in the electrolyte as compared to an equal volume of water. Therefore, electrolyte with a specific gravity of 1.215 means it is 1.215 times heavier than an equal volume of water which has a specific gravity of 1.000.



## NORMAL VOLTAGE RANGE

Type	Average Float Voltage	Variation
<b>Lead-Antimony</b>		
Nominal 1.215 sp. gr.	2.15 to 2.17 V.P.C.	± .04 V.P.C.
Nominal 1.250 sp. gr.	2.19 to 2.23 V.P.C.	± .04 V.P.C.
<b>Lead-Calcium</b>		
Nominal 1.215 sp. gr.	2.17 to 2.25 V.P.C.	± .05 V.P.C.
Nominal 1.250 sp. gr.	2.23 to 2.33 V.P.C.	± .05 V.P.C.
Nominal 1.300 sp. gr.	2.28 to 2.37 V.P.C.	± .05 V.P.C.

### 12.1 Cell Voltage Variation Damp Covers

Cell voltage variation can also be the result of damp cell cover tops. Spilled electrolyte when taking hydrometer readings can result in parasitic currents paths across the tops of cell covers. This reduces the float current through the cell resulting in voltage variations. See Section 18.0 - Battery Cleaning—to correct damp cover condition.

### 12.2 Cell Voltage - Temperature Correction

To properly analyze cell uniformity within the string, cell voltages should be corrected for cell electrolyte temperature. Cell voltage variation that may have developed since a previous quarterly set of readings may be due to cell temperature variations within the string that may have resulted from a change in ambient conditions. Therefore, correcting cell voltage for cell temperature may make it unnecessary to apply an equalizing charge which otherwise had been believed necessary. See Section 10.1 - Equalizing Frequency.

### 12.3 Correction Factor

The temperature correction factor for cell voltage equals 0.003 volts for each degree fahrenheit (0.0055V/C°) using a base 77°F (25°C). The correction is added to the measured cell voltage above 77°F (25°C) and subtracted below 77°F (25°C).

**Example:** Measured cell voltage = 2.19V @ 87°F(30.5°C) cell temperature. Correction = 10°F x .003V (3.5°C x .0055V) = .03V. Therefore, corrected cell voltage = 2.19V + .03V = 2.22 volts.

If the cell temperature in the example had been 67°F (19°C), the correction would be .03 volts which is subtracted from the measured voltage of 2.19V. The corrected cell voltage = 2.19V - .03V = 2.16V.

## SECTION 13

### 13.0 Pilot Cell

A pilot cell is selected in the series string to reflect the general condition of all cells in the battery regarding specific gravities, float voltage and temperature. It serves as an indicator of battery condition between scheduled overall indi-

vidual cell readings.

A slight amount of electrolyte may be lost each time a specific gravity reading is taken, even though it is recommended that all electrolyte in the hydrometer be returned to the cell after reading. Therefore it is suggested that the pilot cell be changed to another cell annually to provide a representative specific gravity indicator for the battery.

## SECTION 14

### 14.0 Records

A complete recorded history of the battery operation is required. Good records will also show when corrective action may be required to eliminate possible charging, maintenance or environmental problems.

Data should be recorded on Stationary Battery Maintenance Report shown on page 15. Report headings should be filled in completely on the date of installation.

The following data should be read and permanently recorded for review by supervisory personnel.

A. Upon completion of the initial charge and with the battery floating at the desired float voltage for one week, read and record individual cell voltages, connection resistances, specific gravities [corrected to 77°F (25°C)], ambient temperature plus cell temperatures and electrolyte levels for 10% of the cells. The cell temperature readings should be from each step or tier of the rack to reflect temperature range of the battery.

This first set of readings will be the basis for comparison with subsequent readings to reflect possible operating problems and the need for corrective action.

B. **Monthly** - Observe the general appearance and cleanliness of the battery. Record battery terminal voltage. Check electrolyte levels and adjust if necessary. Check for cracks in cells and leakage. Note any evidence of corrosion at terminals and connectors. Record pilot cell voltage, specific gravity and temperature.

C. **Quarterly** - Supplement the monthly inspection and record keeping with these additional measures. Check and record the specific gravity and voltage of each cell. Check and record the electrolyte temperature of one cell on each level of individual racks.

D. **Annual** - Supplement quarterly reports with these extra procedures. Make a detailed visual inspection of each cell. Tighten all bolted connections to the specified torque values. Take and record connection resistances of each cell to cell, cell to terminal, inter-level and load connections. Remake any connections that are more than 20% above installation base value. Check integrity of the rack.

E. Any time the battery is given an equalizing charge (see Section 10.1), an additional set of individual cell readings

should be taken after battery has been returned to normal float for one week. These will serve as an updated basis for comparison with future readings.

- F. Record dates of any equalizing charges as well as total quantity of water when added. Also record any maintenance and/or testing performed.

The foregoing frequency of record taking may have to be modified somewhat to suit local requirements.

See Page 16 for Battery nameplate

## SECTION 15

### 15.0 Water Additions

There are two conditions in the operation of batteries which cause a reduction in the amount of water in the electrolyte, resulting in a lowering of the electrolyte level. These are normal evaporation and the conversion of water into hydrogen and oxygen gases by the charging current. These gases are liberated through the cell vents. Periodically, this water loss must be replaced with approved or distilled water to maintain the electrolyte level at the mid point between the high and low level lines.

If suitability of the local water supply for use in storage batteries is questionable, contact your nearest GNB representative for instructions regarding procedure for submitting a sample for analysis. A report will be rendered as to whether or not the water is suitable.

If water is to be stored in containers they should be clean and of non-metallic material; such as: glass, hard rubber, porcelain or plastic.

Infrequently used water lines should be purged to remove accumulated impurities, thus preventing their introduction into the battery.

Water additions should be scheduled prior to an equalizing charge so that mixing with the electrolyte occurs. Also at unheated installations, arrange water additions when battery temperature is above 50°F (10°C).

Never introduce "battery additives" into a GNB battery.

### 15.1 Water Purity

The maximum allowable limits of impurities in the water used in GNB stationary batteries shall be as follows:

Total solids	500 ppm
Fixed solids	350ppm
Organic & volatile matter	200ppm
Iron as Fe	4.0 ppm
Manganese as Mn	0.007 ppm
Nitrates as NO2	15.0 ppm
Ammonia as NH4	5.0 ppm
Chlorides as CL	25.0 ppm

Distilled water or deionized water satisfying the above requirements may be used.

## SECTION 16

### 16.0 Tap Connections

It is not recommended that tap connections be used on a battery, as possible unbalance between groups of cells may result. This can cause overcharging of the untapped group of cells and undercharging of the tapped cells supplying the load. This condition can cause unsatisfactory operation and reduced battery life.

## SECTION 17

### 17.0 Temporary Nonuse

An installed battery that is permitted to stand idle for a period of time should be treated in the following manner. With the battery on normal float, add approved water to cells to bring electrolyte level to the high level line. Give the battery an equalizing charge per Section 10.2. Following completion of the equalizing charge, open connections at the battery terminals to separate charger and load circuit from battery.

Every three months for lead antimony and every six months for lead calcium, temporarily connect battery to charger and give it an equalizing charge.

To return to normal service, re-connect all open connections, give equalizing charge and then return battery to normal float voltage.

## SECTION 18

### 18.0 Battery Cleaning

#### CAUTION

DO NOT CLEAN PLASTIC CELL JARS OR COVERS WITH SOLVENTS, DETERGENTS, OILS OR SPRAY TYPE CLEANERS, AS THESE MATERIALS MAY CAUSE CRAZING AND CRACKING OF THE PLASTIC MATERIALS

### 18.1 Styrene Acrylonitrile Containers with Butadiene Styrene Covers and PVC Containers and Covers

Periodically, clean cell jars and covers with a water dampened cloth to remove accumulated dust. Cell parts damp with electrolyte should be neutralized with baking soda-water solution (1 lb. of soda per gallon of water). Apply with cloth dampened with the solution, making sure none is allowed to enter the cell. Continue to neutralize until fizzing action ceases, then wipe area with a water dampened cloth to remove soda solution. Wipe dry with a clean cloth.

### 18.2 Polycarbonate Containers and Covers

Cells with containers and covers made from polycarbonate plastic should be cleaned ONLY with a WATER dampened

cloth. Any surface that is damp with electrolyte should be neutralized with a baking soda—water solution (1 lb. of baking soda per gallon of water). DO NOT USE AMMONIA, SODIUM HYDROXIDE OR ANY STRONG ALKALIES.

## SECTION 19

### 19.0 Connections

Battery terminal connections should be corrosion free and tight to provide satisfactory operation while supplying emergency power and when on floating charging. Visual monitoring of all connections should be made quarterly. When corrosion is observed on any connection, DO NOT retorquing. Retorquing does not improve electrical integrity but only restores mechanical compression. Any connection suspected of having corrosion should be disassembled, cleaned and neutralized. All post contact surfaces, intercell connectors, terminal plates, cable lugs and hardware should be neutralized using a solution of baking soda (1 lb./gallon water). After allowing to dry, all contact surfaces should be burnished using 3M Scotch Brite scouring pads or a brass suede brush. Stubborn oxidized coatings on solid lead parts may be removed using a narrow paint scraper.

#### CAUTION!

1. **DO NOT USE POWER WIRE BRUSH AS THIS MAY REMOVE LEAD PLATING EXPOSING COPPER OR CAUSE RIPPLING OF LEAD CONTACT SURFACES.**
2. **DO NOT USE PAINT SCRAPER ON POSTS WITH COPPER INSERTS. INTERCELL CONNECTORS OR TERMINAL PLATES AS LEAD PLATING WILL BE REMOVED EXPOSING COPPER.**

After contact surfaces are burnished, a thin coating of NO-OX-ID grease should be applied to all contact surfaces and hardware. The connectors and hardware should then be reassembled and torqued per Section 7.6 - Connecting Cells.

It is important that properly prepared contact surfaces be coated with a thin film of NO-OX-ID grease to reduce possibility of oxidation or corrosion. Tests reveal that this will also prevent measurable increase in the connection resistance.

#### 19.1 Connection Resistance

Electrical integrity of connections can be objectively established by measuring the resistance of each connection. These resistances are typically in the microhm range. Meters are available which determine connection resistance in microhms by measuring voltage drop upon the application of a fixed direct current (DC) through the external cell connections. Some precautions must be observed to get consistent and meaningful values, however, and these are described in Section 19.3.

Resistance measurements or microhm measurements should be taken at the time of the installation and annually thereafter. Initial measurements at installation become the benchmark values and should be recorded for future monitoring of electrical integrity.

Specific values of connection resistance vary with cell type, quantity of connectors, etc. It is important that the benchmark value for all similar connections should be no greater than 10% or 5 microhms, whichever is greater, above the average resistance of all such connections in the battery. If any connection resistance exceed the average by more than 10% or 5 microhms, whichever is greater, the connection should be remade so that an acceptable benchmark value is established. Benchmark values for connection resistances should also be established for terminal plates, where used, as well as cable connections. Benchmark values should preferably be established upon installation. However, if that was not done, they may be established later provided the special procedure described below is followed.

Disconnect the battery from the charger and load and disassemble at least three (3) of the intercell connections. Clean, neutralize and burnish these connection components as though they had corrosion (See Section 19.0) Reassemble each connection per Section 7.7 and determine its resistance. Measure the resistance of all similar connections in the battery. If any connection resistance exceeds the average of the three remade connections by 10% or 5 microhms, whichever is greater, that connection should be remade to establish an acceptable benchmark value.

All benchmark values should be recorded. Annually, all connection resistances should be remeasured. Any connection which has a resistance value more than 20% above the benchmark value should be corrected.

Increase in connection resistance of more than 20% above the recorded benchmark definitely indicates a degrading connection. Such degradation may be caused by corrosion (See Section 19.0) or by relaxation in hardware torque value. If there is no sign of corrosion, the higher resistance at the connection may be corrected by retorquing (See Section 19.2). If connection resistance is reduced to within 20% of the benchmark value, no further action will be necessary. Failure to restore resistance to an acceptable value will necessitate reworking the connection.

Maintaining electrical integrity of connections is important as poor connection will result in reduced battery output and in extreme cases may cause melted cell posts, circuit interruptions or battery fires.

#### 19.2 Retorquing Connections

Retorquing of connections should be performed annually (See Section 9, 14) and when connection resistances have increased to more than 20% over the benchmark. Retorquing should not be done if visual inspection shows evidence of corrosion. Retorquing when corrosion is present only restores mechanical compression but will not improve electrical integrity.

Tests reveal that a reduction in the original torque value of 30% still provides a functional electrical connection if there is no corrosion between contact surfaces.

Retorquing of connections should always be to the recommended value (See Section 7.7).

**CAUTION!**

TOO FREQUENT RETORQUING OF CONNECTIONS IS NOT RECOMMENDED AS THIS WILL RESULT IN DISTORTION OF CELL POSTS, CONNECTORS, ETC., THUS **DEGRADING** RATHER THAN IMPROVING THE CONNECTIONS.

### 19.3 Connection Resistance Measurements

Connection resistances are very small, usually in microhms. Therefore, precautions must be observed so that the measured values are meaningful and not misleading. Different connector hook-ups require that the measurement technique allows for these differences.

(i) **Single Connector Hook-ups.** (Figure 6)

When measuring the resistance of single connector hook-ups between adjacent cell posts (or in the case of flag terminals between multi-cell units), the probe point locations must be at the same location for each similar type connection. If the probe part departs from the center point indicated by "X" in Figure 6, the measured resistance value can vary due to either an increase or decrease in the lead mass included in the measuring points. When conducting subsequent monitoring of connection resistance, it is important that the same probe point locations are used so that any measured increase (or decrease) is a true increase (or decrease) due to connection degradation and not due to using a different probe point location.

(ii) **Parallel Connector Hook-Ups.** (Figure 7)

Parallel paths exist in this hook-up and measurement of connection resistance include all four connector post interfaces. The location of probe points is not critical here because of the existence of parallel paths. An increase (decrease) in the lead mass between post and connector interface on one side is cancelled by an equal decrease (increase) in the mass on the opposite side.

(iii) **Four Post, Four Connector In-Line Hook-Ups.** (Figure 8)

Cells with four post connector hook ups require two measurements to monitor all eight post-connector interfaces. Measurement is made in two steps— First between points A and C and then between points B and D. The measured values should be the same. Values appreciably different (5 micrhoms or more) require reworking of connections as described in Section 19.0.

(iv) **Four Post, Two Connector Staggered Hook-Ups.**

(Figure 9).

Cells with four post staggered connector hook-ups require two step measurement as described above in (iii). In addition, the probe point locations for points A and D (See Figure 9) must be centered as described above in (i).

(v) **Four Post, Connector Parallel Hook-Ups.** (Figure 10)

Cells arranged end-to-end have parallel current paths above and below the cell covers and require that resistance measurement make allowance for the same. The current paths above the cover are provided by the connectors and the path under the cover is provided by the busbars (shown by dotted lines in Figure 10). Most resistance meters apply 10 amperes DC to the connections being monitored. If this was done between posts A and B in Figure 10, the current will divide through the busbars between AB and CD and the resistance value will be about half of the actual value, provided all connections are good. If the process is repeated for posts C and D and the two resistance values are compared, the difference, if any, indicates differences in the two parallel paths as well as poor connections at the post connector interfaces. A better and preferred technique is to apply the 10 amperes DC to posts A and D such that equal current paths are provided. Then, the differences in readings across AB and CD will reflect connector interface problems in either of the two external intercell connections. Both intercell connections should be reworked as described in Section 19.0.

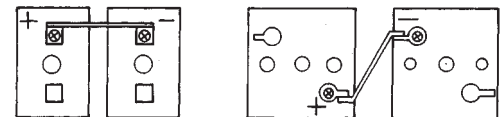


Figure 6 Single connector hook-ups

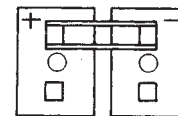


Figure 7 Parallel connector hook-ups

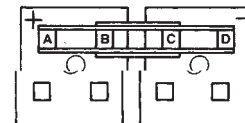


Figure 8 Four post, four connector in-line hook-ups

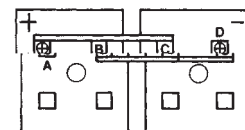


Figure 9 Four post, two connector staggered post hook-ups

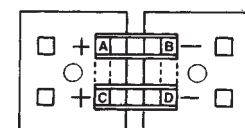


Figure 10 Four post, four connector parallel hook-ups