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REVISION 2

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 313

PORTABLE STORAGE AND DRY BATTERIES

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THE CHAPTER HAS BEEN REFORMATTED FROM DOULBE COLUMN TO SINGLE COLUMN TO SUPPORT THE NSTM DATABASE. THE CONTENT OF THIS CHAPTER HAS NOT BEEN CHANGED.

CHAPTER 313

PORTABLE STORAGE AND DRY BATTERIES

SECTION 1

GENERAL

313-1.1 GENERAL CLASSIFICATION SUMMARY

313-1.1.1 Commonly used portable batteries are either rechargeable (secondary cells) or non-rechargeable (primary cells). There are two types of rechargeable batteries - acid (most common is sulfuric acid) and alkaline (most common is potassium hydroxide). Non-rechargeable batteries are used once (one single discharge) and then surveyed. Non-rechargeable batteries are generally referred to as being dry-cell batteries or dry batteries. In this chapter the terms dry battery and dry-cell batteries are used interchangeably.

313-1.2 TYPES

313-1.2.1 The following types of rechargeable and nonrechargeable batteries are among those in Navy use:

a Rechargeable - Secondary batteries
1. Lead-acid
2. Alkaline
   (a) Nickel cadmium
   (b) Silver-zinc

b Nonrechargeable - Primary batteries
1. Dry cells
2. Lithium cells

313-1.3 CONTENTS OF THIS CHAPTER

313-1.3.1 Only rechargeable secondary lead-acid batteries and non-rechargeable primary batteries are covered in this chapter. Nickel-cadmium battery operation is covered in NAVAIR 17-15BAD-1. Silver-zinc battery operation is covered in NSTM Chapter 223, Submarine Storage Batteries - Silver-Zinc Batteries, Volume 2.

313-1.4 SAFETY PRECAUTIONS

313-1.4.1 Care must be taken in the use and maintenance of batteries. In addition to the danger of electrical shock, chemical hazards include the possibility of explosion and the release of hazardous chemicals. In addition to the precautions set forth in this chapter, see NSTM Chapter 300, Electric Plant-General and NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables for additional guidance.

313-1.5 FIRE RETARDANT ENGINEERING COVERALLS

313-1.5.1 When working with and around fire and explosive hazards created by batteries, wear fire retardant engineering coveralls to provide flash and fire protection.

SECTION 2

LEAD-ACID BATTERIES

313-2.1 DEFINITIONS AND CHARACTERISTICS

313-2.1.1 GENERAL. Refer to P-Document NAVSO P-3676, Navy Primary and Secondary Batteries, for detailed design and manufacturing guidelines.

313-2.1.1.1 Definitions. The following paragraphs define terms frequently used in this section (see Figure 313-2-1):

a. Cell. A storage battery cell is a unit consisting of positive and negative plates, separators, a cell cover and electrolyte, properly assembled in a single jar or one compartment of a monobloc case.

b. Tray. A tray consists of one or more cells assembled in a common container or monobloc case.

c. Battery. A battery may consist of one cell, one tray of cells or a number of trays of cells connected in series, parallel or series-parallel.

d. Positive group. This consists of all the positive plates of a cell, with the positive plate lugs being lead-burned to a common carrier known as a plate strap. Rising from the strap and an integral part of it is the positive terminal post. The post protrudes through the top of the cell cover.

e. Negative group. This consists of all the negative plates of a cell, with the negative plate lugs being lead-burned to a common carrier known as a plate strap. Rising from the strap and an integral part of it is the negative terminal post. The post protrudes through the top of the cell cover.

f. Separators. Spacers placed between positive and negative plates to prevent short circuiting between plates of opposite polarity. They may be made of wood or microporous rubber, either ribbed or nonribbed. Where ribbed separators are used, the flat surface is placed next to the negative plate.

g. Retainers. Sheets of suitable material used in conjunction with the separators to aid in holding the active material of the positive plates in place and to protect the separator from the action of the positive material. They measurably increase the life of a battery. These sheets may be made of hard rubber or synthetic compounds properly perforated or slotted to permit free flow of electrolyte. They also may be made of fibrous glass mats, with the fibers being held in place by a binder. Retainers add to the internal resistance of the battery, reducing the capacity at high-rate discharges. Accordingly, retainers are not always used, especially in certain batteries designed for high discharge rates and relatively short life.

h. Cell cover. The cover, made of suitable material, fitted and sealed in place in the top of the cell compartment of a monobloc case. There are holes in the cover through which the terminal posts of the elements are passed then sealed in place by the post seal nuts and gaskets. There is also an unsealed opening provided for watering the cell and for taking specific gravity and temperature readings. This opening is threaded in a suitable manner to receive the vent plug. In a few special assemblies there may be a separate opening for venting gases.

i. Vent plug. A suitable threaded plug with a vent hole and baffles arranged so that when in place with a gasket it will prevent electrolyte from spraying or splashing out of the cell but still allow gases to escape. A vent plug is used only on a vented battery. Sealed batteries use a one-way pressure valve to prevent atmospheric oxygen from entering the battery. The valve releases small quantities of gas when the internal pressure of the battery exceeds the valve operating pressure (typically 4 to 6 psi).

j. Element. An element is the assembly of a positive group and a negative group with separators and retainers, as necessary, in place. Elements may include the cell cover, sealing nuts with gaskets, and vent plug with gasket. The assembly of retainers, plates, and separators may take any one of the following arrangements:

   1. Positive plate, slotted or perforated retainer, separator, negative plate.
   2. Positive plate, glass mat, slotted or perforated retainer, separator, negative plate.
   3. Positive plate, glass mat, separator, negative plate.

k. Electrolyte. The mixture of sulfuric acid, $H_2 SO_4$, and pure distilled water which is placed in the cell.

l. Jar. A jar is a container of suitable material in which a single cell is assembled.

m. Monobloc case. This is a case in which a number of individual cell jars are molded in one piece.

n. Cell terminal posts. The positive and negative posts are the outside electrical connections of the cell.

o. Intercell connectors. The electrical conductors which connect the cells of a tray in series.

p. Tray terminals. The positive and negative, and in some types center, terminal which are the outside electrical connections of the tray. In two-terminal types, the positive is painted red and marked (+) or POS; the negative, black and marked (-) or NEG. The three-terminal type is marked P or POS, 24-volt, and N or NEG.

q. Sealing compound. An asphaltic bituminous compound used to seal the cell cover to the case so that there will be no loss of electrolyte at this point. Batteries with polystyrene instead of rubber parts are sealed with a polystyrene cement.

r. Sediment space. A space formed by raised ribs built into the bottom of a battery jar or monobloc case. This space serves as a receptacle for residue from the element plates and separators due to deterioration caused by the chemical action between the electrolyte and the plates across the separators. The raised ribs also serve as baffles, preventing buildup of sediment in any one area in the bottom of the case which could possibly cause a short circuit between the negative and positive plates.

s. Element bridge or rest. The top surface of the raised ribs forming the sediment space serves as the base upon which the element rests.

t. Plate feet. Projections at the bottom of the plates (containing no active material). They serve as the point of contact between the elements and the bridge or rest.

u. Discharge rate. The 10-hour discharge rate of a battery is equal to the constant current in amperes which the battery, starting with an initial electrolyte temperature of 27° C (80° F), can supply continuously for 10 hours before the voltage has dropped to the low voltage limit at which the discharge should be stopped. Other hourly discharge rates are defined in a similar way.

v. Ampere-hour capacity. The ampere-hour (Ah) capacity of a battery at a specified constant discharge rate (in amperes) is the number of ampere-hours the battery will deliver at that rate before the voltage drops below a specified limiting voltage. The ampere-hour capacity of a battery depends upon the rate of discharge and is greater when the battery is discharged slowly than when it is discharged rapidly.

w. Vented battery. A vented battery uses large amounts of electrolyte (compared to a sealed battery) to produce chemical reactions within its cells. Consequently, large amounts of gases are produced during the chemical reactions and a vent plug must be provided to allow the escape of these gases. The level and specific gravity of the liquid electrolyte must be checked periodically and adjusted by the addition of distilled water. Where a separate filling aperture is not provided, the vent plug must be temporarily removed for the addition of water.

x. Sealed battery. A sealed battery uses small amounts of electrolyte (compared to a vented battery) absorbed in a microporous material or fixed in a thixotropic gel. A major portion of the gases produced during the internal chemical reactions recombine, so there is no need for a vent plug or the periodic renewal of electrolyte or water. Internal battery pressure is very low (typically 2 to 3 psi) during normal operation, but a safety valve is provided to release small quantities of gas when the internal pressure of the sealed battery reaches the valve's operating point (typically 4 to 6 psi).

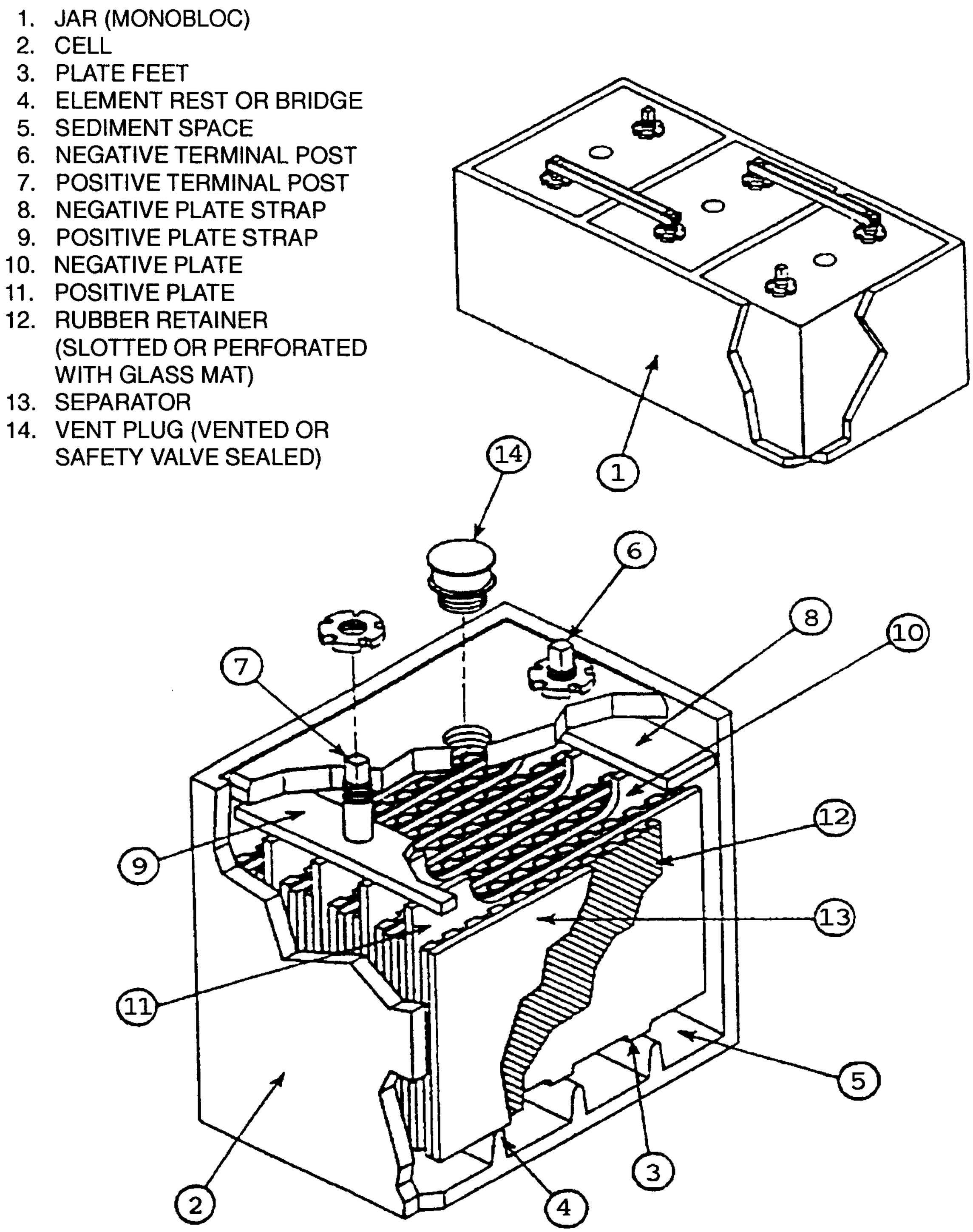

Figure 313-2-1 Three-Cell (6 V) Battery

313-2.1.1.2 Characteristics. Table 313-2-1 and Table 313-2-2 summarize the characteristics, dimensions, and mass of Navy portable storage batteries. Table 313-2-3 presents typical applications of lead-acid storage batteries.

Table 313-2-1 CHARACTERISTICS OF NAVY PORTABLE STORAGE BATTERIES VENTED BATTERIES (DOD-B-15072)

Type Designation	Usage	Capacity (Ah)	Discharge Rate (in amperes)			Maximum Mass Filled kg (lbs)	Max Dimensions mm (in)			DOD-B-15072 Spec Sheet
			10 hr	**2 hr**	**5 min**		**10 hr**	**2 hr**	**5 min**	
12V-15AH	L/D	15	1.5	5	-	10 (22)	186 (7.3)	197 (7.8)	132 (5.2)	/1
2V-20AH	L/D	20	2	6.5	-	1.8 (4)	141 (5.6)	98 (3.9)	73 (2.9)	/3
6V-50AH-A	L/D	50	5	16	-	20 (44)	238 (9.4)	232 (9.1)	181 (7.1)	/9
6V-50AH-B	L/D	50	5	16	-	20 (44)	238 (9.4)	232 (9.1)	181 (7.1)	/9
12V-50AH	L/D	50	5	16	-	29 (64)	238 (9.4)	343 (13.5)	173 (6.8)	/9
6V-100AH-A	L/D	100	10	32.5	-	25 (55)	238 (9.4)	333 (13.1)	181 (7.1)	/12
6V-100AH-B	L/D	100	10	32.5	-	25 (55)	238 (9.4)	333 (13.1)	181 (7.1)	/12
8V-100AH	L/D	100	10	32.5	-	45 (99)	275 (10.8)	545 (21.5)	191 (7.5)	/12
12V-100AH	L/D	100	10	32.5	-	50 (110)	276 (10.9)	540 (21.3)	283 (11.1)	/12
6V-130AH-A	H/S	130	13	42.5	312	35 (77)	238 (9.4)	413 (16.3)	181 (7.1)	/13
6V-130AH-B	H/S	130	13	42.5	312	35 (77)	238 (9.4)	413 (16.3)	181 (7.1)	/13
8V-130AH	H/S	130	13	42.5	312	50 (110)	275 (10.8)	625 (24.6)	191 (7.5)	/13
12V-130AH	H/S	130	13	42.5	312	60 (132)	276 (10.9)	540 (21.3)	283 (11.1)	/13
6V-200AH-A	H/S	200	20	67	480	65 (144)	245 (9.6)	650 (25.6)	195 (7.7)	/10
6V-200AH-B	H/S	200	20	67	480	65 (144)	245 (9.6)	650 (25.6)	195 (7.7)	/10
8V-200AH	H/S	200	20	67	480	85 (188)	275 (10.8)	685 (27.0)	254 (10.0)	/10
6V-300AH-A	L/D	300	30	97.5	-	55 (121)	248 (9.8)	515 (20.3)	252 (9.9)	/14
6V-300AH-B	L/D	300	30	97.5	-	55 (121)	248 (9.8)	515 (20.3)	252 (9.9)	/14
8V-300AH	L/D	300	30	97.5	-	85 (188)	273 (10.7)	683 (26.9)	254 (10.0)	/14

Table 313-2-2 CHARACTERISTICS OF NAVY PORTABLE STORAGE BATTERIES SEALED BATTERIES

Type Designation	Usage	Capacity (Ah)	Discharge Rate (in amperes)			Maximum Mass Filled kg (lbs)	Max Dimensions mm			CID No. A-A-
			10 hr	**2 hr**	**5 min**		**Height**	**Length**	**Width**	
2V-S-10AH	L/D	10	1	3	-	0.9 (2)	141	53.3	53.3	50608
12V-S-15AH	L/D	15	1.5	5	-	10 (22)	186	198	132	50609
2V-S-20AH	L/D	20	2	6.5	-	1.8 (4)	142	99	74	50610
6V-S-50AH-N	L/D	50	5	16	-	20 (44)	239	232	180	50611
6V-S-50AH-R	L/D	50	5	16	-	20 (44)	239	232	180	50611
12V-S-50AH	L/D	50	5	16	-	31 (68)	241	343	180	50612
6V-S-100AH-N	L/D	100	10	32.5	-	25 (55)	239	333	180	50613
6V-S-100AH-R	L/D	100	10	32.5	-	25 (55)	239	333	180	50613
12V-S-100AH	L/D	100	10	32.5	-	50 (110)	277	541	282	50614
6V-S-130AH-N	H/S	130	13	42.5	312	35 (77)	239	414	180	50615
6V-S-130AH-R	H/S	130	13	42.5	312	35 (77)	239	414	180	50615
12V-S-130AH	H/S	130	13	42.5	312	60 (132)	277	541	282	50616
6V-S-200AH-N	H/S	200	20	65	480	65 (144)	244	650	196	50617
6V-S-200AH-R	H/S	200	20	65	480	65 (144)	244	650	196	50617
6V-S-300AH-N	L/D	300	30	97.5	-	55 (121)	249	516	251	50618
6V-S-300AH-R	L/D	300	30	97.5	-	55 (121)	249	516	251	50618
6V-S-300AH	L/D	300	30	97.5	-	55 (121)	249	516	251	50618
6V-S-780AH-N	L/D	780	78	260	-	191 (420)	596	749	215	50619

313-2.1.1.3 Reactions During Charge and Discharge. The exact nature of the chemical reactions which take place in a cell is rather involved, but the following brief description will give some idea of what occurs during a cycle of discharge and charge. See Figure 313-2-2, Figure 313-2-3, Figure 313-2-4 and Figure 313-2-5.

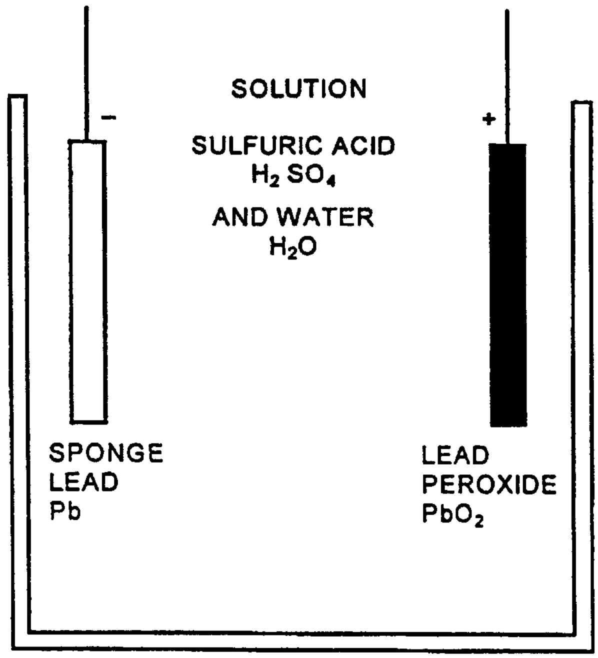

Figure 313-2-2 Charged Battery

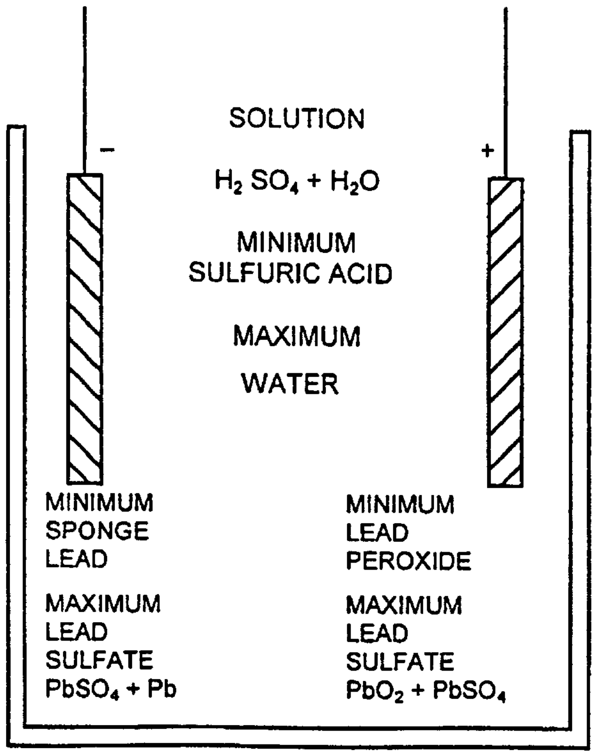

Figure 313-2-3 Discharged Battery

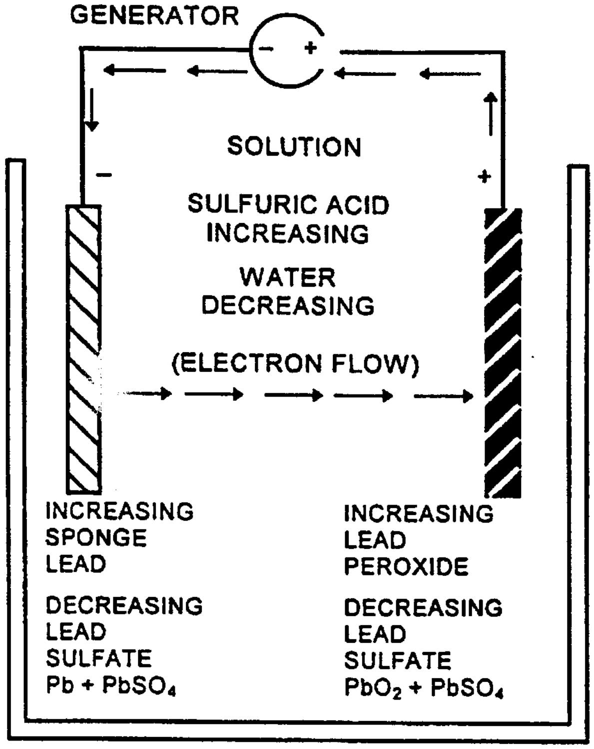

Figure 313-2-4 Charging Battery

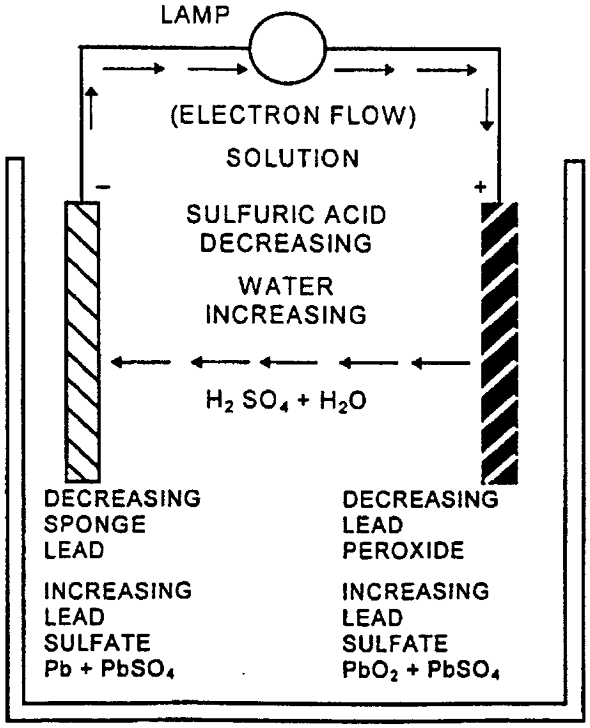

Figure 313-2-5 Discharging Battery

a. When a cell is fully charged, the active material of the positive plate is in the form of lead peroxide, PbO_2 , and the negative plate of pure sponge lead, Pb. The specific gravity of the electrolyte (sulfuric acid, $H_2 SO_4$, and water, $H_2 O$) is at its maximum. Chemical energy is stored in the cell in this condition.

b. If an external circuit is closed between the positive and negative terminals of a cell, current begins to flow due to the action of the electrolyte upon the active material. The chemical energy is transformed into electrical energy and the cell is said to be discharging. The electrolyte reacts with the active material to form lead sulfate on both the positive and negative plates. As the discharge progresses, the acid content of the electrolyte decreases as it is used to form lead sulfate, and the specific gravity of the electrolyte therefore decreases. A point is reached where so much of the active material has been converted into lead sulfate that the cell can no longer produce sufficient current (electrical energy) to be of practical value, at this point the cell is said to be discharged. Since the amount of sulfuric acid combining with the plate at any time during discharge is a function of the ampere-hours of discharge, hydrometer readings can be used as a guide in determining the state of discharge of a vented, lead-acid cell.

c. If the discharged cell is properly connected to a direct current charging source of voltage slightly higher than that of the cell, current will flow through the cell in the opposite direction to that of discharge and the cell will be said to be charging. The effect of the current will be to change the lead sulfate on both the positive and negative plates back into its original active form of lead peroxide and sponge lead, respectively. At the same time, the sulfate is restored to the electrolyte in the form of sulfuric acid, increasing the specific gravity of the electrolyte. When all the sulfate has been restored to the electrolyte, the specific gravity will be at a maximum. The cell is then fully charged and ready to be discharged again.

NOTE

The addition of sulfuric acid to a discharged storage battery does not recharge the battery. Adding acid increases the specific gravity of the electrolyte but does not convert the lead sulfate on the plates back into active material, sponge lead and lead peroxide and, consequently, does not bring the battery back to a charged condition. A charging current must be passed through the battery to do this.

d. The combined reactions during charge and discharge may be represented by the relation:

$Pb + PbO_2 + 2H_2 SO_4 \rightarrow 2PbSO_4 + 2H_2 O$ (DISCHARGING)

$Pb + PbO_2 + 2H_2 SO_4 \leftarrow 2PbSO_4 + 2H_2 O$ (CHARGING)

e. In addition to the above reactions, as a vented battery charge nears completion, some hydrogen gas, H_2 , is liberated at the negative plate and oxygen gas, O_2 , at the positive plate. This is because the charging current is greater than is necessary to reduce the small remaining amount of lead sulfate on the plates and the excess current applies itself to the electrolysis of the water in the electrolyte. This is necessary to ensure a full charge to the battery.

Table 313-2-3 CLASSES AND APPLICATIONS OF NAVY PORTABLE STORAGE BATTERIES

Type Designation	Spec. Sheet No. DOD-B-15072	Typical Uses
12V-15AH-L/D	/11	Gyros and emergency communications on submarines
2V-20AH-L/D	/3	Portable Floodlights
6V-50AH-L/D 12V-50AH-L/D	/9	Dial telephone systems having a capacity of 50 lines or less, interior communication and gyrocompass emergency power
6V-100-AH-L/D 8V-100-AH-L/D 12V-100-AH-L/D	/12	All purposes mentioned for 50 Ah type and for gun firing, sight lighting circuits, director instrument illumination, fire control instrument illumination, radio power, and 100- or 150-line telephone systems
6V-130-AH-H/S 8V-130-AH-H/S 12V-130-AH-H/S	/13	Engine starting services
6V-200-AH-H/S 8V-200-AH-H/S	/10	Engine starting services requiring greater capacity than 130 Ah
6V-300-AH-L/D 8V-300-AH-L/D	/14	General service emergency batteries, electronic, and dial telephone systems having a capacity of more than 150 lines
See MIL-STD-15367	WB 133 and MIL-STD-15367	Forktruck

313-2.2 SHIPMENT AND STORAGE

313-2.2.1 CONDITION OF BATTERIES ON SHIPMENT . Batteries are shipped in one of the following conditions:

a. Vented

1. Filled and charged. All batteries received filled and charged are ready for use.
2. Dry and charged. When a vented battery is shipped dry and charged, it is assembled but contains no electrolyte. The plates are in the charged condition. To place these batteries in service, it is only necessary to fill them with electrolyte in accordance with the manufacturer's instructions attached to the battery.

b. Sealed
   1. Filled and charged.

313-2.2.2 UNPACKING BATTERY. If batteries are received in crates or packing boxes, care must be taken in unpacking and handling. While sealed batteries are considered to be spillproof, they may not be leakproof. It is good practice to keep all batteries right side up.

313-2.2.2.1 Receipt of Battery Shipped Filled and Charged. On receipt of vented batteries in the filled and charged condition, proceed as follows:

1. Remove vent plugs and examine height of electrolyte. Take specific gravity and temperature readings of all cells to ascertain state of charge.
2. If the level of electrolyte is below the bottom of the filling tube or the level mark on polystyrene cells and there is no evidence of spilling or other leakage, add sufficient distilled water to bring the level even with the bottom of the filling tube or mark. Unless otherwise specified, the electrolyte level should be 9 mm (3/8 inch) above the separators.
3. If inspection indicates that electrolyte has been spilled during shipment, replace it with electrolyte in accordance with the manufacturer's instructions attached to the battery.
4. If loss of electrolyte has been caused by a cracked or broken jar or case, discard the battery.
5. If water or electrolyte is added, place the battery on charge until specific gravity readings, corrected for temperature, are constant for a period of five hours.
6. If the battery is not to be put into service immediately, give it a boost charge in accordance with paragraph 313-2.4.6.3 within one month from the date of initial charge stamped on the name plate. Thereafter, the battery shall be given a boost charge in accordance with paragraph 313-2.4.6.2.

313-2.2.2.2 Receipt of Battery Shipped Dry and Charged. Proceed as follows:

1. If a battery is received in the dry-charged condition and is not to be placed in service upon receipt, keep the vent plugs tightly in place and the battery stored (see paragraph 313-2.2.3) in a clean, dry place until ready for placing in service. A period of one day should be allowed for giving a dry-charged battery the initial charge before placing in service.
2. When a vented battery is to be placed in service, follow the instructions on the tag accompanying the battery. It specifies the specific gravity of the electrolyte to be used in filling the cells, the time to allow for soaking of the electrolyte into the plate before charging, temperature limit, method of conducting the initial charge, and other instructions.

313-2.2.2.3 Grease on Terminal Bolt Studs. Terminal bolt studs of all batteries may be found covered with grease. This is used to prevent corrosion around the terminals and must not be removed until installation.

313-2.2.3 STORAGE OF BATTERIES. If dry-charged batteries are to be stored over long periods of time, put them in a dry, clean place where the temperature is between 0° C (32° F) and about 24° C (75° F). Dry-charged batteries stored under these conditions will retain most of their charge for as long as two years. Wet batteries (vented or sealed) must be charged every four to six months.

313-2.3 PLACING BATTERY IN SERVICE

313-2.3.1 INITIAL CHARGE. When batteries are shipped, filled, and charged, battery manufacturers attach instructions to each tray for placing the battery in service and for giving it an initial charge when required. The following applies to dry-charged batteries.

313-2.3.1.1 Dry-Charged Batteries. After the electrolyte is placed in the cells, they will have 70 to 80 percent charge and are available for immediate use in case of emergency. It is preferable to first give the battery a boost charge (see paragraph 313-2.4.6.3) after filling. Once the battery has been properly prepared, its capacity, life and characteristics are the same as a battery shipped filled and charged.

313-2.3.1.2 Name Plate Inscription. For dry-charged batteries, the date on which the battery was filled for activation shall be stamped or scribed in the proper place on the name plate of each tray in an easily legible manner. This is important since it gives the date at which useful life of the battery begins.

313-2.3.2 INSTALLATION. To install a battery into an electrical system, proceed as follows:

1. Determine polarity of battery terminals. Arrange connections so that the positive of the charging source will connect with the positive of the battery; and the negative of the charging source, with the negative of the battery. If the battery terminals or posts are not properly marked, the polarity may be determined by the use of a voltmeter between the terminals.
2. Arrange the trays so that the positive terminal of one tray can be conveniently connected to the negative terminal of the next, throughout the battery.
3. Clean the surfaces to be bolted together. The metal surfaces of the terminals are likely to be covered with a thin film of acid, corrosion products or grease. Wipe the grease off with a clean dry rag. Unless the acid is neutralized and removed before making connections, there may be trouble from corrosion later. Before making connections, all surfaces which are to be bolted together must be cleaned with dilute ammonia or bicarbonate of soda solution and dried.
4. Make connections. Care must be taken not to allow the ammonia or bicarbonate of soda solution to get into the cells. It is advisable to brighten the contact surfaces with a wire brush or fine sandpaper after neutralizing with ammonia or bicarbonate of soda solution. Connect the cells or trays by bolting the connectors to the cell terminal, making sure the connectors are placed under the head of the bolt and not under the nut.
5. Fasteners should be re-examined and tightened until connector lugs are firmly in place.
6. After all connections are completed, recheck each one to ensure the polarity is correct and that any exposed metal in the connectors is thoroughly protected by grease (DOD-G-24508).
7. Clean the top and sides of batteries by wiping with a cloth dampened with dilute ammonia or bicarbonate of soda solution. If bicarbonate of soda is used, the battery then should be rinsed thoroughly with distilled water.

313-2.3.3 NUMBERING BATTERIES. A systematic method of battery identification is necessary to keep accurate battery records. Such identification may be accomplished by assigning a number to each tray. In addition, the cells in a tray should be numbered consecutively, beginning at the positive end.

a. Identification Numbers. Identification numbers assigned should be stenciled in a conspicuous place on the side of the container of each tray in figures of sufficient size to be easily identified. Identification numbers should be used habitually in keeping all required records. Whenever reference to a particular battery is made, the serial numbers of included trays, as well as a statement of the purpose for which the battery is used, should be given.

b. Replacement of Trays. When a new tray replaces an old one, it shall be given the number of the old one, and a new log begun.

313-2.3.4 PILOT CELLS. Whenever pilot cell readings are required, two cells of each battery system, consisting of individual monobloc batteries (6 V, 8 V, 12 V), shall be selected at random for this purpose, located in the center of the battery system. To do this, place N small cards marked with numbers 1 to N (where N = number of cells in the battery system) in a can, mix them thoroughly, draw two, and make the pilot cell readings on the cells whose numbers are drawn.

313-2.4 OPERATION

313-2.4.1 GENERAL. The same careful attention must be given to the operation of a storage battery that is given to the operation of any other power unit. Lack of intelligent supervision in the operation or care of a battery results in temporary impairment or permanent damage. The instructions contained herein, the manufacturer's instructions, and the data on the name plates of the individual trays must be carefully studied and followed to ensure that batteries perform as designed. A typical nameplate is illustrated in Figure 313-2-6.

NAVY STANDARD BATTERY DESIGNATION ____________

CONTRACT NO. ____________

MANUFACTURER'S NAME ____________

MANUFACTURER'S DESIGNATION ____________

CAPACITY ______ Ah AT THE 10-HOUR RATE.

DISCHARGE RATE ______ A FOR 10 HOURS.

______ A FOR 2 HOURS.

______ A FOR 5 HOURS.

FINAL VOLTAGE ______ V PER CELL AT 10- HOUR RATE.

______ V PER CELL AT 2-HOUR RATE.

______ V PER CELL AT 3-HOUR RATE.

CHARGE ON CONSTANT POTENTIAL SET AT 2.35 V AVERAGE/CELL

MAXIMUM CURRENT ALLOWED ON A FULLY DISCHARGED BATTERY: ____ A

DATE PLACED INTO SERVICE ____________

Figure 313-2-6 Battery Nameplate

313-2.4.2 DETERMINATION OF STATE OF CHARGE. The specific gravity of the electrolyte gradually decreases on discharge and gradually increases on charge. This decrease or increase is a function of the number of ampere-hours taken out of or put into the battery. Thus, the state of charge of a vented battery, where the electrolyte is accessible, can be determined by testing the specific gravity of the electrolyte. The state of charge of a sealed battery can only be estimated by measuring its open-circuit voltage.

313-2.4.2.1 Specific Gravity

a. Change. Except for some special applications (see paragraph 313-2.5.4.5), Navy portable batteries use electrolyte of 1.220 specific gravity, or in accordance with the manufacturer's instructions attached to the battery. Electrolyte of this low specific gravity is used to prolong the life of batteries and at the same time supply sufficient power for the intended purposes of the battery. When completely discharged from full charge at the 10-hour rate (the basic rate for purposes of comparison), the specific gravity drops to about 1.060, giving a range of 160 points. This figure is true of the larger size batteries; in the smaller sizes, however, the drop in specific gravity is less. The number of points drop in specific gravity per ampere-hour must be determined for each type of battery.

b. Relation to Capacity. As an approximation, the number of ampere-hours taken out of a battery can be determined from the specific gravity when fully charged, the specific gravity after discharging, and the number of points drop in specific gravity per ampere-hour. For each ampere-hour taken out of a battery a certain definite amount of acid is removed from the electrolyte and combined with the plates. Suppose a battery has been discharged from full charge to the low-voltage limit at the 10-hour rate and 100 ampere-hours obtained with a specific gravity drop of 150 points. Then for each ampere hour obtained there has been a drop of 1.5 points in specific gravity. If 70 ampere hours are taken out of the battery at the 10-hour rate or at any other rate or collection of rates, then the drop in specific gravity will be 70 x 1.5 = 105 points. Conversely, if the specific gravity is 1.220 when fully charged and 1.160 after a partial discharge, there has been a drop in specific gravity of 60 points. This indicates that approximately 60/1.5 = 40 ampere hours have been taken out of the battery.

313-2.4.2.2 Charge Indicator. Some batteries have a charge indicator of the floating-ball type placed inside the battery and readily visible from the outside of the container. It consists of three colored balls floating in free electrolyte thus indicating the remaining percentage of rated capacity. See Table 313-2-4.

Table 313-2-4 FLOATING BALL CHARGE INDICATOR

Color of Balls Floating	**Remaining Capacity (percent)**
Red, white, green	90
Red, white	50
Red (alone)	10

313-2.4.2.3 Voltage. Much like specific gravity, the open circuit voltage level of a battery will vary with the state of charge. A completely discharged vented battery (with a specific gravity of 1.060) will measure about 2.05 volts per cell, while a fully charged vented battery (with a specific gravity of about 1.220) will measure about 2.15 volts per cell at open circuit. Since vented batteries provide access to the electrolyte, the preferred method of determining the state of charge of a vented battery is to measure the specific gravity of the electrolyte.

313-2.4.2.4 Low-Voltage Limit. The low-voltage limit is the limit set by the manufacturer as that beyond which very little useful energy can be obtained. In general, low-voltage limits for batteries at different rates of discharge will vary slightly with the size and make of the battery. For Navy portable batteries, the low-voltage limits for all sizes are approximated in Table 313-2-5.

Table 313-2-5 LOW-VOLTAGE LIMITS

Rate of Discharge [Time at Discharge Rate at 27° C (80° F)]	Final Volts per Cell (Low-Voltage Limit)
5 minute	1.20
2 hour	1.60
10 hour and over	1.75

313-2.4.2.5 Readings When Charged and Discharged. At the conclusion of a discharge at the 10-hour rate the voltmeter reading (closed circuit) will be approximately 1.75 volts per cell and specific gravity approximately 1.060. At the completion of a charge, the voltmeter reading on closed circuit at the finishing rate will be an average of 2.35 volts per cell and the specific gravity 1.210 to 1.220 at 27° (80° F).

313-2.4.3 TYPES OF CHARGES. The following types of charge may be given to a battery:

a. Normal charge. A routine charge given in accordance with the data on the nameplate during ordinary cyclic operation to restore the battery to a substantially fully charged condition. See paragraph 313-2.4.6.1.

b. Boost charge. An extended charge given periodically to ensure that all the sulfate is driven from the plates and all cells are restored to a uniform maximum specific gravity. See paragraphs 313-2.4.6.2 and 313-2.4.6.3.

c. Floating charge. A battery may be maintained at full charge by floating. Float charge voltage, corrected to 80° F, should be maintained at about 2.15 volts per cell for vented batteries and 2.25 volts per cell for sealed batteries, based on the nominal fully charged specific gravity of the battery. Batteries with 1.210 to 1.220 specific gravity will float at 2.15 volts per cell. Sealed, maintenance-free batteries have specific gravities of 1.300 and float at 2.25 volts per cell. Charging circuits should be adjusted for the specific gravity of the batteries; see paragraph 313-2.4.6.4.

d. Temperature Compensation. Temperature compensation of charging voltage is required where large fluctuations of ambient temperature occur between in-port operation and at-sea operation, such as in Auxiliary Machinery Rooms in FFG 7 Class frigates. Standard Navy battery chargers provide temperature compensation of charging voltage based on ambient temperature. Batteries used in uninterruptible power supplies (UPS) and other applications where the batteries are charged by the system served, require adjustments while on float charge when temperature changes of more than 10° F occur. The formula for computing float voltage for sealed batteries is as follows:

$V_F = (2.49 - 0.003T)N$

where:

V_F = float voltage

T = ambient temperature in ° F

N = number of cells.

For vented batteries with a specific gravity of 1.215 the formula is as follows:

$V_F = (2.39 - 0.003T)N$.

In order to preclude excessive voltage adjustments, adjustments should be made when major temperature changes occur, such as after ″light off″ for getting underway or after shut-down upon returning to port.

313-2.4.4 FREQUENCY. In order to obtain good results from a portable storage battery and to assure long life, proper attention to charging must be given. From the nature of their uses some batteries will require more charging than others. For example, engine-starting batteries get moderately heavy use and may require frequent charging in addition to that provided by the engine generator. Conversely, batteries used for auxiliary lighting and power purposes are maintained on float and need correspondingly less extra charging. Too frequent charging is to be avoided. A vented battery should be charged every four to six months or when the specific gravity of any cell has dropped 15 points below full charge. Sealed batteries should be charged every four to six months. Ample reserve power for ordinary operation, without too frequent charging, is the ideal condition.

a. Standby Service. Batteries on standby service shall be recharged no later than once a month regardless of specific gravity.

b. Low-Voltage Limit. Except in an emergency, discharge must be stopped when the low-voltage limit is reached.

c. Recharge Requirements. Recharge promptly. Never allow a battery to stand in a completely discharged condition for more than 24 hours before recharging.

313-2.4.4.1 Enclosed Spaces. Except in an emergency, batteries should not be charged in an enclosed space, unless such space is provided with adequate ventilation. Stop charging if ventilation is interrupted and do not resume until ventilation is restored. See paragraph 313-2.4.8 and NSTM Chapter 510, Heating, Ventilating, and Air Conditioning Systems for Surface Ships, for additional ventilation data.

313-2.4.4.2 Electrolyte Level in Charging (Vented Batteries).

a. Electrolyte Level Prior to Charging. Before starting a charge, ensure that the electrolyte is at the proper level, adding water if necessary (see paragraph 313-2.5.4.2). The proper height is just at the bottom of the filling tube or the level mark on polystyrene jars. However, if not specified, the level should be 9 mm (3/8 inch) above the separators. If the electrolyte is too high, it will flood out of the filling tubes during the charge. This is due to the expansion which takes place inside the cell as the temperature rises, and to gassing.

b. Electrolyte Level Versus Battery Performance. If the electrolyte is at the correct height above the plates, heat transfer to the metal straps and risers is much greater than if the plates are barely covered. Consequently, temperature rise during charge and discharge will be less for a properly filled cell than for a cell in which the level is low. If electrolyte gets too far below the top of the plates or separators and remains there, the exposed parts dry, harden and are no longer functional. This will cause a reduction in capacity and shorten battery life.

313-2.4.5 CHARGING VOLTAGE. In order to charge a battery it is necessary that the voltage of the charging line exceeds the total voltage of the batteries connected in series and being charged. Select the proper number of cells on the battery charger selector switch.

313-2.4.5.1 Connection. When charging more than one tray at a time in series or parallel, connections should be arranged so that only one positive and one negative terminal can be connected to the corresponding terminals of the charging circuit.

313-2.4.5.2 Charging Rate. Batteries charged in series must be of the same capacity to maintain the proper charging rate.

313-2.4.6 CHARGING PROCEDURES. Comply with the following procedures for charging batteries:

313-2.4.6.1 Normal Charge. To give a portable storage battery a normal charge, proceed as follows:

a. GNB Battery Technologies Model 12-170C-13EE only. This battery is a specific example of a vented battery; it is discussed separately because of its large capacity (1020 Ah, 24 V), which is beyond the typical capacity of the battery charger. It is larger than any other vented battery installed aboard Navy ships. See Appendix A of this technical manual for complete details on specific procedures for battery and its accompanying charger, Trilectron Industries Charger Model 8945. For additional information on the battery itself, see paragraph 313-2.5.2.5.

b. Vented Batteries.
    1. Add enough distilled water to vented batteries to bring the electrolyte to the proper level.
    2. Ensure that the vent plug is in place and the vent hole in the plug is clear.

WARNING

Never connect or disconnect batteries with power on the battery charging leads. Death or severe injury can result.

    3. Connect the positive wire from the battery charger to the positive terminal of the storage battery and the negative wire to the negative terminal. Verify that connections are tight and have ample, clean surface.
    4. Turn the battery charger on and ensure that the charger output voltage and current are correct.
    5. Take voltage, temperature and specific gravity readings of pilot cells hourly while the battery is on charge.
    6. Do not allow the temperature of the electrolyte to exceed 52° (125° F). If necessary, deenergize the battery charger and allow the battery to cool before continuing the charge.
    7. The normal charge of a vented battery is complete when the specific gravity, corrected for temperature, has reached a value within five points (0.005) of that obtained on the previous charge.

c. Sealed batteries.
    1. Connect the positive wire from the battery charger to the positive terminal of the storage battery and the negative wire to the negative terminal. Verify that connections are tight and have ample, clean surface.
    2. Turn the battery charger on and ensure that the charger output voltage and current are correct.
    3. The normal charge is complete when the closed circuit voltage, corrected for temperature, reaches at least 2.33 volts per cell for two consecutive hourly readings.

313-2.4.6.2 Boost Charge Criteria. Engine-starting batteries, which are charged from their own battery charging generator, and batteries which are normally on floating charge shall be checked at 90-day intervals. All other batteries shall be checked at 30-day intervals to determine the need for a boost charge.

a. Vented batteries. The specific gravity, corrected for temperature (paragraph 313-2.5.6.2), of each cell in a vented battery shall be compared to the specific gravity of all other cells in the battery and to the normal full charge reading. If any cell reading is more than 10 points (0.010) different from any other cell or if it is more than 15 points (0.015) below the normal full charge reading, a boost charge shall be given (see paragraph 313-2.4.6.3).

b. Sealed batteries. When the average open circuit voltage, corrected for temperature, of any cell in a sealed battery falls below 2.10 volts, a boost charge shall be given (see paragraph 313-2.4.6.3).

313-2.4.6.3 Boost Charge Procedure. A boost charge is a normal charge followed by an extended charge. It is given to ensure that all the sulfate is driven from the plates and all cells are restored to a uniform, maximum capacity. The boost charge procedure is as follows:

a. Vented batteries. Continue the normal charge until hydrometer readings, corrected for temperature and taken at 30-minute intervals, show no increase in corrected specific gravity for any cell over a period of four hours. Temperature readings must be taken at the same time the specific gravity readings are taken. Terminate the charge when this condition is reached.

b. Sealed batteries. Continue the boost charge for at least four hours, until voltage readings, taken at 30 minute intervals with the battery charger connected, remain constant. Terminate the charge when this condition is reached.

NOTE

A boost charge may be given to a battery regardless of its state of charge (discharged, partially charged, or having completed a normal charge). The usual criteria are covered in paragraph 313–2.4.6.2. Criteria for special applications of standby power are covered in paragraph 313-2.5.2.2.

313-2.4.6.4 Float Charge. Some systems use a battery as a standby source of power by connecting the battery in parallel with the system load. Under normal conditions the system itself provides all of the power to the load and the small amount of power necessary to maintain the battery on float charge. The system maintains the float charge voltage at about 2.15 volts per cell (for vented batteries) or 2.25 volts per cell (for sealed batteries). If the system output should fail or otherwise fall below 2.15 volts per cell, the battery will then supply power to the load until proper system operation is restored. By the nature of its application, a standby battery is permanently on float charge and is partially or fully discharged only a few times during its operating life. After a known period of discharge, a standby battery should be disconnected from the system and given a boost charge.

313-2.4.7 TEMPERATURE LIMITATIONS. The temperature of the electrolyte in a vented battery should be monitored during charging and never be allowed to exceed 52° (125° F). If necessary, deenergize the battery charger and allow the battery to cool before continuing the charge.

313-2.4.8 VENTILATION. Ventilation of portable storage batteries (where the worst case occurs during normal or boost charging) is much less involved than ventilation of the main battery aboard a submarine. This is because of the comparatively smaller sizes of the batteries. The largest portable battery the Navy uses is only a 300 Ah battery. This is about 20 times smaller than just a single cell of a submarine battery, making ventilation requirements far less stringent. While hydrogen hazards must not be overlooked, the following few basic rules will eliminate any danger associated with charging portable batteries:

1. Place NO SMOKING signs in the vicinity of all batteries, whether being charged, discharged or on open-circuit.

2. Open nonvented battery compartments prior to charging to allow any accumulated gases to dissipate.

3. If ventilation of any area is required, always establish the ventilation prior to working in the area. Never disconnect or make connections to batteries until the required ventilation has been established.

4. Calculate (see paragraph 313-2.4.9) and provide the minimum ventilation required for each battery on charge. Where inadequate ventilation is felt to exist, use portable blower or exhaust units to provide adequate ventilation.

5. Since the limiting temperature of a battery is 52° (125° F), battery charging stations should be protected from outside heat sources and every effort should be made to keep the temperature below 36° (96° F).

313-2.4.9 MINIMUM VENTILATION REQUIREMENTS. Laboratory measurements show that a forced air volume of 129 liters/hour (4.55 ft^3 /hr) for each ampere-hour is required to prevent an explosive mixture of hydrogen (anything above three percent hydrogen by volume). Required ventilation may be calculated as follows:

V = 129 nC

where:

V = volume flow of air (liters/hour)

n = number of cells

C = capacity (ampere-hours).

Example: To charge four 300 Ah batteries of three cells each, the required ventilation is:

V = 129 x 4 x 3 x 300

V = 464,400 liters/hour

(16,380 ft^3 /hr)

Normal shipboard ventilation per person is 900 ft^3 /hr. Thus, on a ship with a crew of 200, normal ventilation (200 x 900 = 180,000 ft^3 /hr) would far exceed the requirements of this example.

313-2.4.10 FLAMES AND SPARKS. Since a certain amount of gas is given off from a vented battery at all times, flames or sparks of any kind must never be allowed in the vicinity of any storage battery. Extra care is necessary after opening a battery compartment which has been sealed. No light switches shall be turned on, no electrical connections of any kind shall be made or broken, and no work shall be performed in the compartment until it has been thoroughly ventilated.

313-2.4.11 VENT PLUGS. In order to prevent electrolyte from spraying out or foreign matter from entering the battery, the vent plug must be kept in place and tightened at all times except when taking temperature and specific gravity readings or when adding water. The vent hole in the plug should always be kept free of obstructions.

313-2.4.12 CAPACITY. Batteries are rated by their ampere-hour capacity at some definite rate of discharge. Navy batteries are rated at the 10-hour rate (100 percent). The capacity of a battery varies with the rate of discharge; the lower the rate of discharge, in amperes, the greater the capacity. Table 313-2-6 gives the approximate relative ampere-hour capacities obtainable from a typical battery at different rates.

Table 313-2-6 BATTERY CAPACITY AT VARIED DISCHARGE RATES

Rate of Discharge	Ampere-Hour Capacity (percent)
1-hour	55
2-hour	65
3-hour	75
6-hour	90
10-hour	100

313-2.4.13 BATTERY RECORDS. Where applicable, ship maintenance cards will be used to keep battery records. The cards shall be inspected and approved monthly by the Electrical Officer (or in the case of radio batteries by the Radio Officer) and a note of such inspection and approval shall be made on the cards at that time. The cards shall accompany the battery trays whenever transferred.

313-2.5 MAINTENANCE

313-2.5.1 GENERAL. Lead-acid storage batteries will deteriorate rapidly unless given proper care. When cared for properly, they will give a useful life of four or more years, depending upon type and use.

NOTE

Only shore activities and ships designated as Intermediate Maintenance Activities (IMA) are permitted to mix acid and water to make electrolyte or to adjust the specific gravity of a cell or battery. (vented only)

313-2.5.2 BATTERY SERVICE. The service for which a battery is used primarily determines the nature of the care and maintenance which will assure maximum reliability and life.

313-2.5.2.1 Engine-Starting Batteries. Due to the heavy drain on batteries used for starting propulsion engines, motor boat engines, or ship service engine-generator sets, they are particularly liable to damage by failure of the generator to charge the battery adequately due to the following conditions:

a. Frequent starts or short periods of engine operation

b. Low charging rate on the generator

c. Extreme cold weather starting conditions

d. A particularly tight (new or recently overhauled) engine

e. High temperature, high voltage, or overcharging.

313-2.5.2.1.1 These batteries, therefore, require frequent checking by competent personnel to ensure they are being properly maintained. Due to the extreme importance of getting a ship under way in any circumstances, proper maintenance of propulsion engine starting batteries cannot be stressed too highly. During inspections particular attention should be paid to the electrolyte level and specific gravity for vented batteries. A boost charge shall be given if the specific gravity of the battery cells meet the conditions described in paragraph 313-2.4.6.2. Care should also be taken to ensure that the battery is not being overcharged by the generator. Keep engine-starting batteries clean, dry and free of seawater. At the beginning of a period of inactivity for the ship of a week or more, give the battery a normal charge. During a period of inactivity arrangements should be made to give the battery a boost charge in accordance with paragraph 313-2.4.6.3.

313-2.5.2.2 Standby Batteries. Batteries on standby service, such as auxiliary lighting and power batteries, are rarely discharged by actual use. A normal healthy battery on open circuit will discharge 50 percent or more in three to four months time. This is a normal condition and is caused by minute cells set up by the different materials in the individual plates grids and active material, and is usually called local action or self-discharge. The lead sulfate so formed is much harder to reduce by charging. Thus, if the limits of paragraph 313-2.4.6.2 are recorded during the monthly measurement of specific gravity, such batteries should be given a boost charge as noted in paragraph 313-2.4.6.3, if on open circuit and not delivering power. If such batteries show abnormal signs of decreasing specific gravity or open circuit voltage on subsequent monthly checks, they should be given two to four cycles to restore them to a healthy condition. These cycles consist of a boost charge followed by a capacity discharge (procedure covered in paragraph 313-2.5.3) or discharge may be provided by using these batteries for the purpose for which they were provided, as standby units. However, this latter method is less desirable because the discharge current is not constant and an accurate capacity cannot be measured at the same time the batteries are being conditioned. Vented batteries on standby service must be inspected weekly for cleanliness, need of water and tightness of connections. The specific gravity and temperature of all cells are taken and recorded monthly. Sealed standby batteries must be inspected semi-annually for tightness of connections unless otherwise prescribed by PMS.

313-2.5.2.3 Telephone, Fire Control, Inertial Navigation System and Interior Communication Batteries. Standby batteries for services such as battle telephone, fire control, inertial navigation system and interior communication are usually on float charge. Batteries for automatic telephones are usually intermittently charged automatically. In case of failure of the normal supply, the storage battery automatically takes over the load. Care should be taken in adjusting the float voltage to avoid excessive potentials with consequent overcharging.

313-2.5.2.4 Gunfiring Batteries. Batteries used for gunfiring and sight lighting purposes are idle a large part of the time. Such batteries should be given boost charges in accordance with paragraph 313-2.4.6.3. Batteries at 1.180 specific gravity will freeze at -13° (9° F). Batteries which are exposed to low temperatures should be kept well charged to avoid freezing (see paragraph 313-2.5.11) and should be cycled and given periodic inspection as described in paragraph 313-2.5.2.2.

313-2.5.2.5 Forktruck Batteries. The physical characteristics of truck and tractor batteries listed in MIL-STD-15367 are contained in Appendix B. A battery not specifically listed in the MIL-STD is the GNB Battery Technologies Model 12-170C-13EE. At 1020 Ah capacity, this battery is much larger than any ever put onto Navy ships and, in effect, is oversized for the capacity of the charger to perform its job in 8 to 8.5 hours on a fully discharged battery.

313-2.5.3 CAPACITY CHECK. The capacity of a battery is determined by carrying out a test discharge. Such a discharge may be performed onboard ship if the necessary equipment is available; if not available, onboard a tender or at a naval shipyard or other shore establishment.

a. Requirements. A test discharge to determine battery capacity applicable to all portable storage batteries shall be conducted in accordance within the following criteria:
    1. After four years service
    2. Any time the battery's capability to perform its functional test (see paragraph 313-2.5.13) or provide rated capacity is questioned. Such circumstances are illustrated in paragraph **313-2.5.12** .

b. Procedure. To ensure that reliable data is obtained, a test discharge must be preceded by a boost charge (paragraph 313-2.4.6.3). Immediately following the boost charge, the battery should be discharged at the 10-hour rate until either the total battery voltage drops to a value which is equal to 1.75 times the number of cells in series or the voltage of any individual cell drops to 1.65 volts, whichever occurs first. Navy standard batteries are rated upon the 10-hour capacity; thus, the correct discharge rate for a 200 ampere-hour battery would be 200/10 = 20 amperes and must be kept constant throughout the discharge. For a battery of 100 percent capacity, the discharge will continue for a period of 10 hours before reaching either of the low-voltage limits mentioned above provided the temperature of the electrolyte at the beginning of the discharge is exactly 27° (80° F). If the temperature of the electrolyte at the beginning of the discharge is not exactly 27° (80° F), the time duration of the discharge for 100 percent capacity must be corrected for the actual temperature of the electrolyte existing at the start of the test. The correction in time of discharge may be determined from Table 313-2-7. It should be noted that the corrections given in the table apply only to the 10-hour rate.

c. Computation of capacity. The percent of ampere-hour capacity is computed from the following:

$$C = (H_a \times 100) / H_t$$

where:

H_a = total actual hours of discharge

H_t = total hours for 100 percent capacity

C = percent of ampere-hour capacity

Data on the percent capacity obtained on each test discharge taken on a storage battery shall be recorded on the maintenance card.

d. Test discharge. The test discharge should be made through a rheostat or other loading device which is adjustable through a range sufficient to permit the discharge rate to be maintained constant in value throughout the discharge. Where a battery test discharge panel, in accordance with NAVSEA drawing 9000-S620l-74397 is available, the test discharge may be made at the 2-hour rate. The discharge current at the 2-hour rate is found from the relation: $I = 0.65Q/2$ Where I is the discharge current in amperes and Q is the 10-hour rate capacity in ampere-hours. The battery should be discharged at the 2-hour rate until either the total battery voltage drops to a value which is equal to 1.60 times the number of cells in series, or the voltage of any individual cell drops to 1.50 volts, whichever occurs first. The correction for temperature in the time of discharge at the 2-hour rate may be determined from Table 313-2-8. If the percent ampere-hour capacity at the 2-hour rate is 80 percent or more of the rated capacity (at the 10-hour rate), the battery is to be kept in service. If it is less than 80 percent, the battery is to be treated in accordance with the provisions of paragraph 313-2.5.3.

e. Criteria. If the percent ampere-hour capacity is 80 percent or more, the battery is to be kept in service; if it is less than 80 percent, give it two more cycles of boost charge and capacity discharge (see paragraph 313-2.5.2.2) in an effort to rejuvenate the battery. If such efforts are unsuccessful, dispose of the battery with permission of the Electrical Officer.

313-2.5.4 ELECTROLYTE IN VENTED BATTERIES. Maintain the electrolyte in vented batteries according to the procedures in the following paragraphs:

313-2.5.4.1 Level Inspection. Pilot cells (paragraph 313-2.3.4) shall be inspected for height of electrolyte once each week or more often if experience shows this to be necessary. The electrolyte level shall never be allowed to fall below the top of the separators.

313-2.5.4.2 Replacement. Replace the electrolyte in vented batteries using the following steps:

1. Add pure distilled water at any time to replace that which has evaporated. It is preferable, however, to add

water just before the battery is placed on charge, as the water remains on top of the electrolyte until mixed with it by charging. If the water is allowed to remain on top of the electrolyte in cold weather, it may freeze, cracking the monobloc cases or jars.

2. After adding water, replace and tighten the vent plugs. If they are not tightened, the electrolyte will spray out when charging and the resultant loss of electrolyte will cause a decrease in battery capacity. Remove all water or electrolyte spilled during watering and make sure that the tops and sides of the cells are clean and dry.

3. Ensure that distilled water that is to be used for watering batteries and mixing electrolyte does not contain impurities in excess of Table 313-2-9.

4. Nothing but water of the purity specified shall ever be added to a battery except when it is necessary to replace electrolyte spilled from a battery. Use only premixed electrolyte when replacing spilled electrolyte. Adjustment of specific gravity shall be in strict compliance with paragraph 313-2.6.3.

Table 313-2-7 10-HOUR RATE DISCHARGE CORRECTION VS. TEMPERATURE

Temperature °C (°F) of electrolyte at beginning of discharge	Subtract minutes indicated from 10 hour period
9° C (48° F)	139
12° C (54° F)	110
15° C (59° F)	84
18° C (64° F)	61
21° C (70° F)	36
24° C (75° F)	15
27° C (80° F)	0
	Add minutes indicated to 10 hour period
30° C (86° F)	7
33° C (91° F)	13
36° C (97° F)	18
39° C (102° F)	25
42° C (108° F)	31
45° C (113° F)	36

Table 313-2-8 2-HOUR RATE DISCHARGE CORRECTION VS. TEMPERATURE

Temperature °C (°F) of electrolyte at beginning of discharge	Subtract minutes indicated from 2 hour period
9° C (48° F)	34
12° C (54° F)	27
15° C (59° F)	21
18° C (64° F)	15
21° C (70° F)	9
24° C (75° F)	5
27° C (80° F)	0
	Add minutes indicated to 2 hour period
30° C (86° F)	2
33° C (91° F)	4
36° C (97° F)	5
39° C (102° F)	7

Table 313-2-8 2-HOUR RATE DISCHARGE CORRECTION VS.

TEMPERATURE - Continued

Temperature °C (°F) of electrolyte at beginning of discharge	Subtract minutes indicated from 2 hour period
42° C (108° F)	8
45° C (113° F)	9

Table 313-2-9 MAXIMUM IMPURITIES IN DISTILLED WATER

Impurities	Parts per Million (ppm)
Suspended matter (lead compound only)	Trace
Total solids	100
Calcium and magnesium oxides	40
Iron	0.5
Chlorides	5
Organic and volatile matter	50
Nitrites as NO_2	5
Nitrates as NO_3	10

313-2.5.4.3 Specific Gravity Limits. The capacity of Navy standard portable batteries is based upon a fully charged specific gravity between the limits of 1.220 and 1.210 specific gravity at 27° C (80° F). The specific gravity of a cell that has fallen below these limits shall not be increased by the addition of acid except by authorized repair personnel at naval shipyards or other shore establishments, or onboard repair ships and tenders, and then only when it has been definitely ascertained by test that the low-gravity condition is not due to sulfation. The addition of acid to increase the specific gravity of a sulfated cell will aggravate the existing condition. With proper care there should be no loss of acid from the electrolyte, and, therefore, little need should arise for adding acid to restore the specific gravity of a healthy cell.

313-2.5.4.4 Reducing Specific Gravity. Except as indicated in paragraph 313-2.5.4.5, the specific gravity of a cell shall not be allowed to remain above the upper limit of 1.220. The specific gravity of cells which exceed this limit shall be cut by the removal of an appropriate amount of electrolyte and the addition of distilled water (see paragraph 313-2.6.3).

313-2.5.4.5 Raising Specific Gravity. If operating personnel determine that the weather conditions under which any 1.210 to 1.220 specific gravity batteries are required to operate result in temperatures consistently below 4° C (40° F), authority is granted to raise the specific gravity by the addition of diluted acid to within the limits of 1.270 to 1.285 (average 1.280 specific gravity) upon request to naval shipyards or other shore establishments, onboard repair ships or tenders, by authorized personnel (see paragraph 313-2.6.3). Whenever this is done, notation shall be made on the storage battery tray record. When weather conditions become more moderate, resulting in operating temperatures consistently higher than 4° C (40° F), the specific gravity of these batteries shall be reduced to within the limits of 1.210 to 1.220 specific gravity by removing electrolyte and adding pure distilled water and further notation made on the storage battery tray record.

313-2.5.4.6 Maximum Specific Gravity. Sulfuric acid of a specific gravity greater than 1.350 shall not be added to a battery. Mixing acid, if it is of higher specific gravity than this, shall be diluted to 1.350 or below before being poured into a battery.

313-2.5.4.7 Mixing Instructions and Precautions

a. Precautions. Certain precautions must be taken while mixing electrolyte. See paragraph 313-2.5.5.4 for personnel equipment to be used while handling sulfuric acid.

CAUTION

During electrolyte mixing the acid must be poured into the water and not the water poured into the acid. The acid must be added slowly and cautiously to the water to prevent excessive heating and splashing. Splattered acid will cause painful burns.

The solution should be continually stirred while the acid is being poured into the water to prevent the heavier acid from flowing to the bottom of the vessel. When the concentrated acid is diluted, the solution becomes very hot. For treatment of acid burns, see paragraph 313-2.5.5.5.

b. Mixing Instructions. To prepare electrolyte, lead or rubber vessels and stirring rods are necessary. Only pure distilled water shall be used, purchased in accordance with Federal Specification O-B-41. Specification O-S-801 shall be used to procure sulfuric acid. Every effort must be made to keep impurities from the electrolyte while mixing, since they shorten battery life. Amounts of water and acid to be used to make electrolyte of a desired specific gravity are given in Table 313-2-10. For treatment of acid burns see paragraph 313-2.5.5.4.

c. Substitute Electrolyte. No satisfactory substitute electrolyte has been found for the simple mixture of sulfuric acid in water. The use of a substitute or additive may injure the battery and void the manufacturer's guarantee.

313-2.5.4.8 Electrolyte Testing. If it is desired to test the electrolyte at any time, a sample should be sent to a naval shipyard chemist. The limit of allowable impurities is in accordance with Table 313-2-11.

313-2.5.5 ACID. The following maintenance information shall be observed when working with acid:

313-2.5.5.1 Electrolyte. Only premixed electrolyte is to be used or stored on U.S. Navy ships. The use and storage of acid for the purpose of preparing electrolyte or for adjustment of specific gravity are authorized only for shore activities or for ships designated as Intermediate Maintenance Activities (IMA).

313-2.5.5.2 Storage. Carboys containing sulfuric acid shall be stored in a place where freezing cannot occur. The freezing temperature of sulfuric acid electrolyte is shown in Table 313-2-12. Since sulfuric acid is highly hygroscopic, extreme care must be taken to ensure that carboys are absolutely airtight. The entry of even a small quantity of water into an open carboy may reduce the specific gravity sufficiently to cause the jar to break in cold weather due to freezing, with the consequent grave danger of serious acid burns to personnel. Even at any temperature, the addition of even a small quantity of water to a carboy of strong sulfuric acid may cause an explosion due to the sudden evolution of heat.

313-2.5.5.3 Effect of Acid Specific Gravity on Battery Life. Navy-type batteries generally use 1.215 specific gravity sulfuric acid. The low initial acid specific gravity and heavier battery construction favors longer life. Stronger acid (higher initial specific gravity) increases battery capacity. For example, a 130 ampere-hour battery will deliver 130 ampere-hours at the 10-hour rate when 1.215 specific gravity acid is used. The rated capacity is increased to 175 ampere-hours by using 1.280 specific gravity acid, but the cycle life is reduced.

313-2.5.5.4 Personnel Equipment for Acid Handling. Personnel handling or mixing electrolyte shall wear rubber aprons, rubber boots and rubber gloves, so that the acid does not come into contact with clothing or skin. In particular, the face must be guarded by a full face shield.

313-2.5.5.5 Treatment of Acid Burns. Should concentrated acid or electrolyte come in contact with the skin, immediately wash the affected area freely with a large quantity of freshwater for about 15 minutes. Should concentrated acid or electrolyte come in contact with the eyes, flush the eyes with freshwater for a minimum of 15 minutes, ensuring that both upper and lower lids are pulled sufficiently to allow the freshwater to flush under them. In either case, the medical department must be notified of the accident as soon as possible and must be requested to come to the site. If the medical department cannot be notified, do not attempt to transport the victim to sick bay prior to washing or flushing with freshwater for 15 minutes. In an extreme emergency, where freshwater is not available, seawater may be used, but ONLY AS A LAST resort. Clothing that may have been splattered with acid should be promptly removed. Skin areas touched by acid beneath contaminated clothing should be promptly treated as described herein.

Table 313-2-10 DATA FOR PREPARING ELECTROLYTE FROM ACID

Desired Electrolyte Specific Gravity	**Mass of water per unit mass of acid**			**Volume of water per unit volume of acid**			**Mass units of acid to make 100 mass units of electrolyte**			**Volume units of acid to make 100 volume units of electrolyte**		
Added acid → (specific gravity)	**1.350**	**1.400**	**1.835**	**1.350**	**1.400**	**1.835**	**1.350**	**1.400**	**1.835**	**1.350**	**1.400**	**1.835**
1.10.....	1.98	2.33	5.21	2.67	3.26	9.55	033.6	30.0	16.1	027.5	23.7	09.7
1.11.....	1.71	2.03	4.66	2.31	2.84	8.45	036.9	33.0	17.7	030.5	26.3	10.8
1.12.....	1.51	1.81	4.24	2.04	2.53	7.79	039.8	35.6	19.1	033.2	28.6	11.7
1.13.....	1.34	1.62	3.89	1.81	2.27	7.15	042.7	38.2	20.4	035.9	30.9	12.6
1.14.....	1.19	1.45	3.58	1.61	2.03	6.57	045.7	40.8	21.8	038.7	33.4	13.6
1.15.....	1.05	1.30	3.28	1.42	1.82	6.02	048.8	43.5	23.3	041.7	35.7	14.7
1.16.....	0.95	1.18	3.07	1.28	1.65	5.63	051.3	45.8	24.6	044.3	38.2	15.6
1.17.....	0.85	1.07	2.86	1.15	1.50	5.25	054.0	48.3	25.9	047.1	40.5	16.6
1.18.....	0.75	0.96	2.65	1.01	1.35	4.87	057.2	51.0	27.4	050.1	43.2	17.7
1.19.....	0.67	0.87	2.49	0.90	1.22	4.57	059.8	53.5	28.6	053.1	45.8	18.7
1.20.....	0.59	0.78	2.31	0.80	1.09	4.24	062.8	56.2	30.2	056.2	48.5	19.9
1.21.....	0.52	0.70	2.18	0.70	0.98	4.00	065.7	58.8	31.4	059.4	51.2	20.8
1.22.....	0.46	0.64	2.05	0.62	0.90	3.76	068.5	61.0	32.8	062.3	53.5	21.9
1.23.....	0.41	0.58	1.94	0.55	0.81	3.56	070.9	63.3	34.0	065.0	56.0	22.9
1.24.....	0.36	0.52	1.83	0.49	0.73	3.36	073.5	65.8	35.3	068.0	58.6	24.0
1.25.....	0.31	0.46	1.73	0.42	0.64	3.17	076.3	68.5	36.6	071.1	61.5	25.1
1.26.....	0.26	0.42	1.64	0.35	0.59	3.01	079.4	70.5	37.9	074.5	63.7	26.2
1.27.....	0.22	0.37	1.55	0.30	0.52	2.84	082.0	73.0	39.2	077.5	66.6	27.3
1.28.....	0.18	0.32	1.47	0.24	0.45	2.70	084.7	75.7	40.5	080.8	69.6	28.4
1.29.....	0.15	0.29	1.40	0.20	0.41	2.57	087.0	77.5	41.7	083.5	71.8	29.5
1.30.....	0.12	0.25	1.33	0.16	0.35	2.44	090.2	80.0	42.9	086.5	74.6	30.6
1.31.....	0.09	0.22	1.27	0.12	0.31	2.33	091.7	82.0	44.0	089.5	77.2	31.6
1.32.....	0.06	0.18	1.20	0.08	0.25	2.20	094.3	84.7	45.5	092.7	80.3	32.9
1.33.....	0.03	0.15	1.15	0.04	0.21	2.11	097.0	87.0	46.5	096.1	83.0	33.9
1.34.....	0.00	0.12	1.09	0.00	0.17	2.00	100.0	89.3	47.8	100.0	86.0	35.1
1.35.....	--	0.09	1.04	--	0.13	1.96	--	91.7	49.0	--	89.0	36.2

Table 313-2-11 MAXIMUM IMPURITIES IN ELECTROLYTE

Impurities	Determined as	Maximum (in ppm)
Iron	Fe	120
Copper	Cu	50
Chloride	Cl	120
Arsenic	As	1
Antimony	Sb	10
Nitrates	NO_3	20
Manganese	Mn	0.6
Platinum	Pt	None
Suspended matter	-	*

*Lead compounds only.

Table 313-2-12 FREEZING TEMPERATURES OF ELECTROLYTE

Specific Gravity	Temperature °C (°F)
1.150	-15.0 (+5.0)
1.210	-30.6 (-23.0)
1.250	-51.7 (-61.0)
1.280	-68.3 (-91.0)
1.300	-70.6 (-95.0)
1.350	-48.9 (-56.0)
1.400	-36.1 (-33.0)
1.500	-28.9 (-20.0)
1.700	-14.4 (+6.0)
1.726	-2.6 (+27.3)
1.768	+7.8 (+46.1)
1.790	+8.0 (+46.4)
1.796	+6.4 (+43.6)
1.800	+5.6 (+42.0)
1.807	+3.3 (+37.9)
1.812	+0.6 (+33.1)
1.818	-4.1 (+24.6)
1.824	-10.3 (+13.4)
1.830	-18.3 (-1.0)
1.835	-33.9 (-29.0)
Note Between 1.614 and 1.667 specific gravity, the freezing point is indeterminate.	

313-2.5.5.6 Eyewash and Deluge Shower Requirements. At battery maintenance facilities where acid diluting, activation of new batteries and adjustment of electrolyte concentrations for older batteries are required, an eyewash and deluge shower within easy reach of personnel shall be installed. Other areas of routine battery storage and charging shall be provided with two battery water containers and one soda water container. Containers shall be 5-gallon polyethylene bottles. For acid storerooms and flammable liquid storerooms, a tank-type portable combination shower and eye and face bath, with dedicated storage rack, shall be located within the operational facility. Portable units shall be pressure or gravity fed with a self-contained supply of freshwater (not less than 3 nor more than 5 gallons), operated by inversion hose release from storage rack, pull chain or squeeze-type valve at outlet opening. Unit shall be of the type that will not break under rough shipboard use. Should an accident occur in a remote or primitive area, pour freshwater from buckets or other suitable containers on the affected areas or into the eyes. However, a steady stream of freshwater from a garden hose would be preferable, if available.

313-2.5.6 HYDROMETER READINGS. When taking hydrometer readings, exercise care and do not spill any electrolyte. Loss of even a few drops each time a reading is taken will eventually cause the specific gravity of the pilot cells to be lower than that of other cells. In reading the hydrometer, hold it so that the eye is at the same level as the surface of the liquid, and note the scale reading at the bottom of the curved surface of the liquid, or meniscus. Be sure the float is free in the hydrometer syringe barrel.

313-2.5.6.1 Low Readings. Hydrometer readings taken when the battery is gassing may read low by as much as five to ten points gravity, owing to the presence of minute bubbles of gas. To obtain accurate readings under this condition, the electrolyte in the hydrometer barrel must be given time to clear before the reading is taken.

313-2.5.6.2 Corrections. In order to establish a uniform basis for comparison it is important that all specific gravity readings taken when charging, discharging or mixing acid be corrected to 27° C (80° F). To correct to this temperature add 0.001 to the hydrometer reading for each 1.7° C (3° F) the temperature is above 27° C (80° F) and subtract 0.001 for each 1.7° C (3° F) the temperature is below 27° C (80° F). For example, a reading of 1.211 at 33.3° C (92° F) equals 1.215 at 27° C (80° F), and a reading of 1.220 at 18.3° C (65° F) equals 1.215 at 27° C (80° F). A correction scale is provided which may be read directly on all thermometers furnished with type B testing outfits (MIL-H-16384).

313-2.5.6.3 Hydrometer Cleanliness. Hydrometers used on storage batteries must be used for no other purpose. They should be flushed with distilled water before and after use to prevent the accumulation of sticky substances inside the glass barrel. These substances gradually gather on the hydrometer float, causing readings to be inaccurate. If such substances have collected on the barrel or hydrometer, take the hydrometer apart, clean with an ammonia solution, rinse with clean water and dry with a clean cloth. Allow the parts to air dry before they are reassembled.

313-2.5.6.4 Cleaning Instructions. When assembling or disassembling a hydrometer, a heavy piece of cloth should be wrapped around the glass barrel to prevent personal injury in case of glass breakage. During reassembly the rubber bulb should be slightly moistened with water where the rubber contacts the glass barrel. This will reduce the amount of pressure or torque required to replace the bulb.

313-2.5.7 TEMPERATURE READINGS. To obtain accurate temperature readings, the tip of the thermometer must be completely immersed in the electrolyte for at least 30 seconds. The thermometer should be read while still immersed in the electrolyte.

313-2.5.8 BATTERY CARE. All batteries and battery lockers must be kept clean and free of foreign matter. Clothing, cloth or wiping rags should not be allowed to remain in battery rooms or lockers. When vent plugs are removed from cells, care must be taken to prevent anything falling in. Avoid spilling acid or water. Collections of acid or dirt around a battery will lead to trouble and will cause corrosion. After each watering, the tops of cells and sides of jars should be wiped clean.

313-2.5.8.1 Case. If acid has accumulated, it may be removed by wiping it clean with a cloth moistened in a dilute ammonia solution or bicarbonate of soda solution. While using ammonia or bicarbonate of soda, care must be taken so that it does not enter the cell.

313-2.5.8.2 Connections. Keep battery connections and bolts covered with a light film of grease (DOD-G-24508), as this will prevent acid from reaching them. If these parts are attacked by acid, a sulfate is formed which will make it difficult to disconnect leads from terminals and increase the resistance of the terminal connections which lowers the voltage on discharges. At the end of each watering, all cell connections should be checked for tightness. If sulfate has formed at the terminals, it must be removed and grease applied. Sealed batteries need only to have their terminals cleaned and checked for tightness every six months.

313-2.5.9 BATTERY GROUNDS. Battery grounds are undesirable for the following reasons:

a. A ground in the vicinity of the battery may furnish the spark necessary to ignite an explosive gas mixture, if present.

b. A ground of the battery may cause disarrangement of the complete circuit of which the battery is a part.

c. Battery grounds cause dissipation of battery energy.

d. Grounds may be formed by dirty or acid wet cell tops and sides. The path of the ground in this case is from the terminals, along the jar sides, to the battery racks, and finally to the ship's hull. A loss of charge by direct leakage from terminal to terminal may occur in the presence of dirt and moisture without an actual path to ground existing.

313-2.5.10 LOW CAPACITY CELLS. The most common trouble encountered in the operation of storage batteries is that of low cells. This condition may be brought about by various causes, such as poor connections, sulfation, loss of active material, local action, short circuits, loss of electrolyte, hardened negatives, disintegration of positive grids and impure electrolyte. It may be detected by a progressive loss of capacity, low voltage on discharge, low specific gravity, comparatively high or low voltage on charge, and comparatively high temperature. The specific gravity of electrolyte in the low cells will usually be below that of the other cells on charge and discharge. Any cell with which trouble is being experienced should be examined immediately for low electrolyte and poor connections. Portable voltmeter readings at the cell terminals should be taken while the battery is being charged or discharged. If the portable meter voltage reading is much higher or lower than that of normal cells, the trouble probably lies within the cell itself and must be investigated further.

313-2.5.10.1 Sulfation. Sulfation is one of the causes for failure of cells to maintain a normal condition. But before finally attributing a faulty condition to sulfation, it should be definitely ascertained that the condition has not been occasioned by other causes. Many cases of low cells are erroneously attributed to sulfation and the actual defective condition aggravated by consequent sulfation treatment.

313-2.5.10.2 Indications of Sulfation. A sulfated cell may be indicated by one or more of the following conditions: falling off of specific gravity, low voltage on discharge, and loss of capacity.

313-2.5.10.3 Causes of Sulfation. Most cases of sulfation are caused by the following:

a. Undercharging, partial charging or infrequent boost charging. The practice of giving undercharges or partial charges, or the neglect of boost charges will bring about a sulfated condition. It is difficult in normal battery operation to determine just when sulfation begins. Only by giving periodic boost charges and comparing individual cell specific gravity and voltage readings, can it be detected in its early stages and corrected or prevented. Boost charges must be given as frequently as required by paragraph 313-2.4.6.2.

b. Standing in a partially or completely discharged condition. Permitting a battery to stand in a partially discharge condition allows the sulfate deposited on the plates to harden and the pores to close, which is the condition of sulfation. Batteries should be charged as soon as practical after discharge. Under no circumstances shall any battery be allowed to stand in a completely discharged condition for more than 24 hours.

c. Low electrolyte. If the level of the electrolyte is permitted to fall below the tops of the plates, the exposed surfaces will harden and become sulfated. (in vented batteries)

d. Adding acid. If acid is added to a cell in which sulfation exists, the condition will be aggravated.

e. High specific gravity. In general, the higher the fully charged specific gravity of a cell the more likely sulfation is to occur and the more difficult to reduce. If in any battery there exist cells of which the specific gravity is more than 0.015 above the average, the possibility of sulfation of these cells will be increased.

f. High temperature. High temperatures accelerate sulfation, particularly of an idle, partially discharged battery.

313-2.5.10.4 Reducing Sulfation. Sulfation of a battery, except in extreme cases, may be reduced by a boost charge. This procedure is necessary in order to break down the sulfate which has not been reduced by normal charges.

313-2.5.10.5 Loss of Active Material. Loss of active material may be determined by visual inspection of the plates in vented batteries. In all batteries there is a normal loss of active material due to erosion caused by gassing at the end of charge. Excessive loss of active material results in a reduction of capacity. When excessive shedding is not the result of improper design, it may be caused by undue gassing, by overcharging, or by expansion brought about by high temperatures. Loss of active material is also a sign of wear and is often evident in batteries that have given long service.

313-2.5.10.6 Local Action. Local action is indicated by an excessive drop in the specific gravity of the electrolyte while the cell is on open circuit and by excessive gassing on an open circuit and on discharge. In general, the higher the specific gravity, the greater the tendency for local action and the more rapid the fall in specific gravity while the battery is standing idle. Local action is caused by nonhomogeneity of, and impurities in, the material in the plates or the electrolyte, the most common is iron. If impurities are suspected, the electrolyte should be dumped, the plates rinsed with distilled water and the cells refilled with new electrolyte of the same specific gravity as the electrolyte discarded.

313-2.5.10.7 Short Circuits. Short circuits are indicated by abnormal temperature, low specific gravity, low voltage and reduced gassing on charge. A cell containing a short circuit will gradually discharge itself and become unduly heated on charge. Short circuits may be caused by the following conditions:

a. Faulty separators

b. Lead particles or other metal forming a circuit between the positive and negative plates

c. Buckling of plates, resulting in direct contact of the positive and negative plates

d. Excessive accumulation of sediment in bottom of jar

e. Mossing, usually between the tops of the negative plates and the positive plate strap

f. A crack in a partition between cells in a monobloc case.

313-2.5.10.8 Loss of Electrolyte. Loss of electrolyte is indicated by an excessive drop in the electrolyte level in comparison with normal cells. This indicates a crack in the jar.

313-2.5.10.9 Hardened Negatives. Hardening of negative plates is a condition where the active material becomes hard and nonporous. It is caused by insufficient charging.

313-2.5.10.10 Reversal of Cell Voltage. If a low cell is discharged much below the low-voltage limit in series with other cells, the low cell will reverse its polarity. If a cell reverses polarity before adjacent cells are near their voltage limit, it should be assumed that this condition is caused by faults within the cell itself. A reversed cell may be detected by the voltage reading of the cell. The presence of a reversed cell in a battery will be indicated by a rapid fall in the battery voltage; this may be as much as three to four volts. This occurs because the cell voltage may change from 2.35 volts in the proper direction to as much as two volts in the reverse direction in a short time. Except in an emergency, as soon as a reversed cell is discovered the charge must be discontinued until the cell or tray is cut out.

313-2.5.11 BATTERIES EXPOSED TO COLD. Batteries in exposed locations which are subject to low temperatures shall be kept charged during cold weather and should, in extremely cold weather, be removed to a warm room, if possible. (See Table 313-2-12 for freezing temperature of electrolyte of various densities.)

313-2.5.12 ROUTINE CARE FOR BATTERIES. The conditions under which batteries are used vary from ship to ship. The frequency of inspection necessary to ensure that batteries are in good operating condition will also vary to some extent. The following are considered to be the minimum requirements consistent with good engineering practice for average operating conditions. In all cases where experience indicates that inspections as scheduled below are not sufficient to ensure that batteries will be ready and able to perform their functions whenever needed, the frequency of inspection should be increased as necessary. In cold weather operations, for example, daily inspection of boat batteries may be necessary.

313-2.5.13 PLANNED MAINTENANCE SYSTEM (PMS)

a. Daily. See that all parts of the ventilation system in battery rooms and battery lockers are in proper condition.

b. Weekly. Observe the height of electrolyte in pilot cells (paragraph 313-2.3.4) and take and record pilot cell specific gravity and temperature readings for all batteries. Water batteries if the height of electrolyte in pilot cells is at the low mark or will drop below the low mark before the next weekly inspection (paragraph 313-2.5.4.1). Check the charging rate of engine-starting battery charging generators (paragraph 313-2.5.2.1) and voltage at which batteries are being floated (paragraph 313-2.4.6.4).

c. Monthly. Clean batteries and apply grease (DOD-G-24508) to the terminals as necessary. Examine battery connections and correct any faulty condition, such as breaks, frayed insulation or grounds. Inspect for broken or cracked battery cases or jars. Give all batteries, except those which are charged from their own generator or are being floated, a boost charge (paragraph 313-2.4.6.3). Take a complete set of voltage, temperature and specific gravity readings on all batteries which have been given a boost charge.

d. Quarterly. Give a boost charge to all batteries which are charged from their own generator or are being floated (paragraph 313-2.4.6.3). Take a complete set of voltage, temperature and specific gravity readings on all batteries which have been given a boost charge.

e. Semiannually. Give each battery a test discharge (paragraph 313-2.5.3).

f. Records. A record of the complete readings of cell voltages, temperatures and the specific gravity after boost charges needs to be kept only on those batteries for which tray records are required. Records are not necessary for portable batteries which are the sole power source for frequently-used equipment, but should be kept up-to-date on emergency portable batteries which float on the line.

g. Ship’s Maintenance Cards and Records. Where provided, ship’s maintenance cards and records may be substituted for the above instructions if functional testing, as provided by the cards, is performed.

313-2.5.14 FUNCTIONAL BATTERY TESTING. A functional test is a method to determine if a battery is sufficiently operational to provide energy to satisfactorily operate specific equipment for a period of time. Test discharges are the most reliable means of determining storage battery condition. Functional testing may be done in lieu of a test discharge only when authorized by ship’s maintenance cards.

a. Test Requirements. Functional testing of Navy-type portable storage batteries for various shipboard applications vary with usage, size of battery and load. Test requirements are as follows:
   1. Engine-starting batteries. The batteries will be capable of starting an engine and shall be tested at least once a week.
   2. Portable lantern batteries (with wet, lead-acid batteries). The batteries will be capable of providing sufficient light for a period of ten seconds without any diminution of intensity and be tested at least once a week.
   3. Gyrocompass batteries. The gyrocompass will be functionally tested monthly for a 20 minute period on battery power alone.
   4. Telephone batteries. Telephones will be functionally tested monthly during a peak load period for four hours on battery power, alone.
   5. Functional testing of other portable storage battery service not covered above. Guidance may be obtained upon request from NAVSSES. This information will be required for new types of applications.
b. Test Failure and Retest. If the functional test fails, the battery shall be given a boost charge and retested. If the retest fails, the failed batteries shall be replaced.

313-2.6 REPAIR

313-2.6.1 SEAWATER CONTAMINATION. Batteries which have been immersed in the sea long enough for seawater to leak through the vent plugs are considered unfit for further service and should be replaced, never repaired.

313-2.6.2 SHIPBOARD REPAIR. Shipboard repair should be performed only under the following conditions:

1. No replacement battery is readily available and the existing battery is capable of being repaired.
2. The minor repairs required, such as a small crack in the jar, terminal post, or intercell connector; unsealed spots of sealing compound between cell cover and case; or other repairs, can be made quickly and readily aboard the ship.

313-2.6.2.1 Safety Precautions. To prevent short circuits, care shall be exercised in the use of tools on or near a battery.

313-2.6.2.2 Disposition. Unless a battery has been shown to be beyond economical repair, it shall be kept filled and charged. Repaired batteries shall always be returned to fully charged condition. Battery repairs shall be handled as expeditiously as possible. Many batteries can be saved for future useful work if problems are detected promptly and immediate steps taken to remedy them.

313-2.6.3 CORRECTING SPECIFIC GRAVITY FOR VENTED BATTERIES. Only authorized repair personnel at shore activities or on ships designated as an IMA are authorized to increase or decrease the specific gravity of a cell or battery. The following procedures shall be followed:

a. Increasing Specific Gravity. To increase the specific gravity in any cell under the condition defined in paragraph 313-2.5.4.5, the following procedure shall be observed:
   1. Give the affected cells a 4-hour boost charge. At the conclusion, accurately determine the specific gravity, correcting for the existing electrolyte temperature.
   2. Withdraw electrolyte. In no case shall the electrolyte level be lowered below the tops of the separators by such withdrawal.
   3. Restore the electrolyte level to normal by the addition of electrolyte of 1.300 gravity. The 1.300 gravity electrolyte should be added while the cells are on charge and gassing; this will ensure thorough mixing.
   4. Charge affected cells for a period of one hour. At the conclusion, accurately determine the specific gravity, correcting for the existing electrolyte temperature.
   5. Repeat steps a, b, and c, as necessary, to bring the specific gravity of the cell within the limits of 1.210 to 1.220, at 27° C (80° F).
b. Decreasing Specific Gravity. The specific gravity for any cell which is above the upper limit of 1.220 (paragraph 313-2.5.4.4) may be reduced by following the procedure outlined above, except that the level should be restored to normal by the addition of pure distilled water.
c. Adjustment of Specific Gravity. If an accurate calculation for the adjustment of specific gravity is desired and the volume of electrolyte in the cell is known, the following formula may be used:

$$V(G_3 - G_1)/G_2 - G_1$$

where:

X = Volume of electrolyte at the initial specific gravity which is to be replaced by an equal amount of mixing electrolyte

V = Total volume of electrolyte in the cell, which is to remain constant

G_1 = Initial specific gravity of the electrolyte

G_2 = Specific gravity of the mixing electrolyte, i.e., 1.300 for raising, and 1.000 for lowering specific gravity of the cell

G_3 = Specific gravity desired.

In making adjustments of specific gravity, the reference level for the new specific gravity is at the normal height of electrolyte in the cell.

313-2.7 STORAGE OF BATTERIES

313-2.7.1 The following procedures shall be observed when laying up batteries:

1. Do not store vented batteries in a dry (no electrolyte) condition. All batteries taken out of service that have 80 percent or more capacity should be maintained in a fully charged condition and issued at the first opportunity.
2. If a battery is to be placed in storage, give it a boost charge first. Apply grease to all exposed terminals. Store the battery in such a way that it rests on wooden strips and ensure that there is air space all around the top and sides.
3. Check vented batteries in storage monthly for specific gravity and proper electrolyte level. Sealed batteries in storage shall be checked monthly for proper open circuit voltage. When necessary, or at least every four to six

months, all batteries shall be given boost charges, as described in paragraph 313-2.4.6.3, in order to maintain a fully charged condition. It is essential that these batteries be inspected at frequent regular intervals and the electrolyte level maintained above the tops of the separators. For battery trays for which records are kept, the battery tray record should be kept up-to-date during periods of wet storage.

313-2.8 DISPOSAL OF BATTERIES

313-2.8.1 GENERAL. It is the policy of NAVSEA to discard batteries when it is determined that they cannot be made to give more than 80 percent of their rated capacity. Since a battery may be only temporarily low in capacity, care must be exercised in determining its capacity before disposal.

313-2.8.2 PREREQUISITE PROCEDURE. A battery shall not be disposed of unless it is definitely known that it cannot be made to give further useful service. On the other hand, care must be taken that time and money are not spent in the effort to keep batteries that should be disposed of in service. When it is believed that a battery is not fit for further use, the following confirmatory procedure shall be used after first giving the battery a boost charge:

1. Discharge the battery in accordance with the procedure in paragraph 313-2.5.3. Compute the capacity obtained and compare with rated capacity.
2. Recharge and restore to service batteries that deliver at least 80 percent of rated capacity on the test discharge and are otherwise in good condition.
3. Batteries that do not deliver at least 80 percent of rated capacity on the test discharge should be disposed of by the ship or activity using the battery, upon approval of the electrical officer.
4. A battery that fails the function test after an equalizing charge may be considered to be unsatisfactory for service and should be disposed of.

313-2.8.3 INFORMATION REQUIRED ON SURVEY. All requests for survey of portable batteries shall contain the following information for each tray:

a. Name of manufacturer
b. Navy type and manufacturer's type
c. Contract or order number under which purchased
d. Date of initial charge
e. Service for which used (boat, radio, etc.)
f. Complete details of special treatments given to bring the capacity of battery (tray) to 80 percent or better
g. Complete description of the condition of the battery at time of survey.

313-2.9 DISPOSAL PROCEDURES

313-2.9.1 The following procedures shall be observed when disposing of batteries:

a. Battery Solid Components. Battery solid components should be emptied of electrolyte before disposal. The metal, metal oxide and metal sulfate components of lead-acid batteries are heavy metals and are potential pollutants. Consequently, defective or unserviceable batteries should not be thrown overboard. See **NSTM Chapter 593, Pollution Control** , for detailed disposal methods.

b. Electrolyte. Liquid electrolyte from a lead-acid battery should be neutralized with baking soda or alkali to a pH of 7.0 to 8.5 before being thrown overboard. See **NSTM Chapter 593, Pollution Control** , for detailed disposal methods.

313-2.10 SAFETY PRECAUTIONS

313-2.10.1 The following safety precautions shall be observed:

1. Keep flames and sparks of all kinds away from the vicinity of storage batteries.
2. Verify that battery compartments which have been sealed are well ventilated before entering the compartment, turning on any lights, making or breaking any electrical connections, or doing any work in the compartment.
3. Verify that the ventilating apparatus of the battery compartment is running properly before starting a charge.
4. Stop the charge if ventilation is interrupted, except in an emergency. Do not resume the charge until ventilation has been restored.
5. Charge a battery at the rates given on its nameplate.
6. Never charge a battery at a higher finishing rate than that given on its name-plate.
7. When charging more than one battery at a time, ensure the voltage of the charging line exceeds the total voltage of the batteries being charged and that the charging rate does not exceed the maximum charging rate of the battery having the lowest capacity in the line.
8. Lower the charging rate as soon as the battery begins to gas or the temperature reaches 52° C (125° F).
9. Keep the temperature of the battery compartment below 36° C (96° F).
10. Make no repairs to battery connections when current is flowing. Never connect or disconnect batteries on the charging line without first turning off the charging current.
11. When using tools near a battery, be careful not to short circuit the battery terminals.
12. Always pour acid slowly into water and never water into acid. Guard skin and eyes against splashes of acid.
13. Exercise proper care in handling acid.
14. Do not add acid of greater specific gravity than 1.350 to a battery.
15. Do not store sulfuric acid in places where freezing temperatures are possible.
16. Keep the electrolyte level above the tops of separators.
17. Add only pure distilled water to a battery.
18. Do not, except in an emergency, discharge the battery below the given low-voltage limit.
19. Never allow a battery to stand in a completely discharged condition for more than 24 hours.
20. Do not operate a battery above 52° C (125° F).
21. All sparks should be avoided when removing or replacing batteries located in compartments which may con-

tain gasoline fumes. Only tools with insulated handles should be used. When batteries are used with one terminal grounded, the grounded terminal of the battery should be disconnected first when removing the battery and connected last when replacing the battery.

22. Seawater should not be used to wash batteries. Never allow seawater to enter a battery cell, as chlorine gas, which is extremely toxic, will evolve.

23. Verify that all terminal connections are tight to preclude sparks due to loose connections.

SECTION 3
DRY BATTERIES

313-3.1 GENERAL PRINCIPLES

313-3.1.1 Military dry batteries are covered by coordinated Military Specification MIL-B-18, Dry Batteries. This specification lists the type number, voltage, size, weight and load performance (initial and delayed) of military dry batteries. The fundamental use of a dry battery is as a source of electrical energy that can be transported, either while in use or prior to utilization, without the hazard of spilling corrosive material or the inconvenience of charging before electrical energy is available. A dry battery is made up of one or more dry cells that cannot be recharged after discharge. Each cell converts chemical energy into electrical energy (direct current) and consists of two electrodes immersed in a conductive medium with separators to keep the reactive elements physically apart. At the anode (negative electrode) a reactant with high electrochemical potential is oxidized, releasing electrons into the external circuit powered by the cell. At the cathode (positive electrode) a substance with low electrochemical potential is reduced by accepting electrons from the external circuit. The electrolyte is the conductive medium that transports ions between the electrodes to balance the net electrical charge. The electrolyte in a dry cell is immobilized in the form of a paste or gel. Water is an essential component of the electrolyte paste. In fact, a dry cell that loses all its water is useless. The term dry cell does not mean a cell in which water is absent, but merely one in which there is no free electrolyte. Dry cells should not leak regardless of the position of the cell.

313-3.2 DESIGN CONSIDERATIONS

313-3.2.1 GENERAL. Refer to P-Document P-3676, Navy Primary and Secondary Batteries for detailed design and manufacturing guidelines.

313-3.2.2 CELL VOLTAGE. The voltage at which a dry cell supplies electrons to an external circuit is determined by the driving force of the chemical reactions occurring at the anode and cathode of the cell. This is controlled by choosing the materials to be used for each electrode. Although many combinations of materials can be used, only a few combinations provide desirable performance characteristics at reasonable costs.

313-3.2.3 CELL CURRENT. The maximum current that a cell can provide to an external circuit is limited by the ability of the electrolyte to transport ions between the electrodes. The type of electrolyte used in a cell determines the cells maximum current rating.

313-3.2.4 CELL CAPACITY. The ampere-hour capacity of a given type of cell is determined by the amount of active materials (anode and cathode) used in the cell. Larger cell sizes provide higher ampere-hour capacities.

313-3.2.5 ENERGY DENSITY. Energy density is a measure of the energy (watt-hours) per unit volume (liter) or mass (kilogram) that a particular cell can deliver to an external circuit. Since this depends on the energy associated with the chemical reactions at the electrodes of the cell, energy density is largely determined by the electrode materials.

313-3.2.6 EFFECTS OF TEMPERATURE. The temperature of a dry cell strongly influences the ionic conduction of the electrolyte and the chemical reactions occurring at the electrodes. Each dry cell system performs differently depending on the cell materials used. In general, performance declines at temperatures below 20° C (68° F) while shelf life declines at temperatures above 20° C (68° F).

313-3.3 TYPES OF DRY CELLS

313-3.3.1 GENERAL. Common dry cell systems used in naval applications are carbon-zinc, alkaline-manganese dioxide, and magnesium-manganese dioxide. The materials used in each system are shown in Table 313-3-1. The advantages and disadvantages of each system are shown in Table 313-3-2. Table 313-3-3 is a list of typical applications of dry cell systems.

Table 313-3-1. DESCRIPTION OF MAJOR DRY CELL SYSTEMS

System	**Cathode**	**Anode**	**Electrolyte**	**Voltage**	
				Open Circuit	**Closed Circuit**
Carbon zinc (Heavy duty)	Manganese Dioxide Manganese Dioxide	Zinc Zinc	Ammonium Chloride Ammonium Chloride	1.50	1.20
Alkaline-MnO_2	Manganese Dioxide	Zinc	Potassium Hydroxide	1.50	1.25
Magnesium-MnO_2	Manganese Dioxide	Magnesium	Magnesium Perchlorate/ Lithium Chromate/ Barium Chromate	2.00	1.55

Table 313-3-2. COMPARISON OF MAJOR DRY CELL SYSTEMS

CARBON-ZINC	ADVANTAGES: Low cell cost; low cell cost per watthour; large variety of shapes, sizes, voltages, and capacities; various formulations; wide distribution and availability; long tradition of reliability
	DISADVANTAGES: Low energy density; poor low-temperature service, poor leakage resistance under abusive conditions, low efficiency under high current drains. Comparatively poor shelf life, voltage falls steadily with discharge.
CARBON-ZINC (Heavy Duty)	ADVANTAGES: Higher energy density. Better low-temperature service, good leakage resistance, high efficiency under heavy discharge loads.
	DISADVANTAGES: High gassing rate.

Table 313-3-2. COMPARISON OF MAJOR DRY CELL SYSTEMS - Continued

ALKALINE-MnO_2	ADVANTAGES: Good high-rate discharge capability, higher energy output than carbon-zinc cell (depending on load), good shelf life, good leakage resistance, ″rest periods″ not necessary - efficient when used continuously, good low-temperature performance, good shock resistance, low gassing rate.
	DISADVANTAGES: Higher initial unit cost than carbon-zinc cells; if shorted or abused, cell temperatures could rise to high levels (e.g., 100° C [212° F]); sloping discharge curve, but less pronounced than carbon-zinc cell.
MAGNESIUM-MnO_2	ADVANTAGES: Good capacity retention, even under high-temperature storage; twice the capacity of corresponding carbon-zinc cell. Higher cell voltage than carbon-zinc cells.
	DISADVANTAGES: Delayed action (voltage delay), evolution of hydrogen during discharge, heat generated during use, poor storage after partial discharge.

Table 313-3-3. TYPICAL APPLICATIONS OF MAJOR DRY CELL SYSTEMS

Application	Battery System	Load requirement	Life (approx.)	Acceptable voltage regulation (%)	Reason for battery choice
Roadside hazard lamp (flashing)	Carbon-zinc	6 V 0.3 A bulb	1200 hr	40	economy, availability
Roadside hazard lamp, continuously burning	Carbon-zinc	12 V 0.1 A bulb	63 hr	30	economy, availability
Intruder alarm system	Carbon-zinc	12 V 300 mA	8 hr after 12 months	30	economy, availability
Emergency and portable fluorescent handlamp	Carbon-zinc	12 V 600 mA	3 hr, continuously	25	economy, availability
Direct-reading frequency meter	Carbon-zinc	9 V 25 mA	200 hr at 4 hr/day	25	size, economy, availability
Wide-range oscillator	Carbon-zinc	18 V 25 mA	200 hr at 4 hr/day	25	size, economy, availability
Communication transceiver	Carbon-zinc	12 V T_x 1.2 A R_x 0.6 A	24 hr, continuous on T_x /R_x = 1/9	30	economy, weight
Tape recorder	Alkaline	6 V 200 mA	20 days at 30 min./day	35	economy, availability
Miniature ignition	Carbon-zinc	400 mA, pulse	6 to 9 months	30	miniaturization
Note T_x transmission; R_x reception					

313-3.3.2 CARBON-ZINC BATTERIES. The carbon-zinc battery (more commonly referred to over the past 100 years as a Leclanche cell) is still one of the most widely used batteries because of its low cost and widespread availability. Its most common construction uses a cylindrical zinc can as the negative electrode and manganese dioxide (mixed with carbon) as the positive electrode. The electrolyte is an aqueous solution of ammonium chloride immobilized in a paste or paper separator. The cell is fabricated in a number of different cylindrical sizes of varying diameter and height. It is also available in a flat design, used only in multicell batteries, which offers better volume utilization.

313-3.3.3 HEAVY-DUTY CARBON-ZINC BATTERIES. The heavy-duty carbon-zinc battery is a fairly recent modification to the standard carbon-zinc battery. Construction is similar to the standard cell except the electrolyte is primarily zinc chloride rather than ammonium chloride. The heavy-duty battery offers improved high rate and low temperature performance.

313-3.3.4 ALKALINE-MANGANESE DIOXIDE BATTERIES. The alkaline-manganese dioxide (or simply ″alkaline″) battery is similar to the carbon-zinc battery in that the same active materials are used for the electrodes. However, unique cell construction and active material formulation, together with the use of potassium hydroxide as the electrolyte, increase capacity by as much as 50 percent over a carbon-zinc battery of the same size. Low temperature performance, high rate performance and extended shelf life are also benefits. For these reasons alkaline batteries are rapidly becoming more popular than carbon-zinc batteries.

313-3.3.5 MAGNESIUM-MANGANESE DIOXIDE BATTERIES. The construction of the magnesium-manganese dioxide (or simply ″magnesium″) battery is similar to that of the cylindrical carbon-zinc cell except that a magnesium can is used instead of a zinc can. A mechanical vent must also be provided for the escape of hydrogen gas that forms during discharge of the cell. The magnesium cell provides about twice the capacity of an equivalent-size carbon-zinc cell and also has better shelf life, particularly at elevated temperatures.

313-3.4 CHARACTERISTICS

313-3.4.1 PERFORMANCE CHARACTERISTICS. The performance characteristics of each of the major dry cell systems are summarized in Table 313-3-4.

Table 313-3-4. CHARACTERISTICS OF MAJOR DRY CELL SYSTEMS

System	Carbon-zinc		Alkaline	Magnesium
	Normal	Heavy-Duty		
Cell voltage:				
Operating (V)	1.25-1.15	1.25-1.15	1.25-1.15	1.8-1.6
End (V)	0.9	0.9	0.9	1.2
Capacity	60-30,000	200-9,000	30-30,000	50-65,000
Energy density [1]				
675 Button cell				
Wh/kg			80	
Wh/L			350	
D cell				
Wh/kg	65	75	125	115
Wh/L	100	135	315	225
Voltage profile	high slope	high	moderate	moderate
Temperature °C (°F)				
Max storage	-40 to 45 (-40 to 113)	-40 to 55 (-40 to 131)	-40 to 50 (-40 to 122)	-40 to 70 (-40 to 158)

Table 313-3-4. CHARACTERISTICS OF MAJOR DRY CELL SYSTEMS - Continued

System	Carbon-zinc		Alkaline	Magnesium
	Normal	**Heavy-Duty**		
Operating	-5 to 45 (23 to 113)	-10 to 50 (14 to 122)	-20 to 50 (-4 to 122)	-20 to 60 (-4 to 140)
Leakage	moderate	low	very low	moderate
Gassing	moderate	high	low	high
Shock resistance	fair	good	fair	fair

[1]Energy density is at 20° C (68° F) and is in watt-hours per kilogram (Wh/kg) or watt-hours per liter (Wh/L).

313-3.4.2 VOLTAGE PROFILE. The discharge curves of the major dry cell systems are given in Figure 313-3-1. Carbon-zinc and alkaline cells have sloping profiles, while magnesium cells have less of a slope.

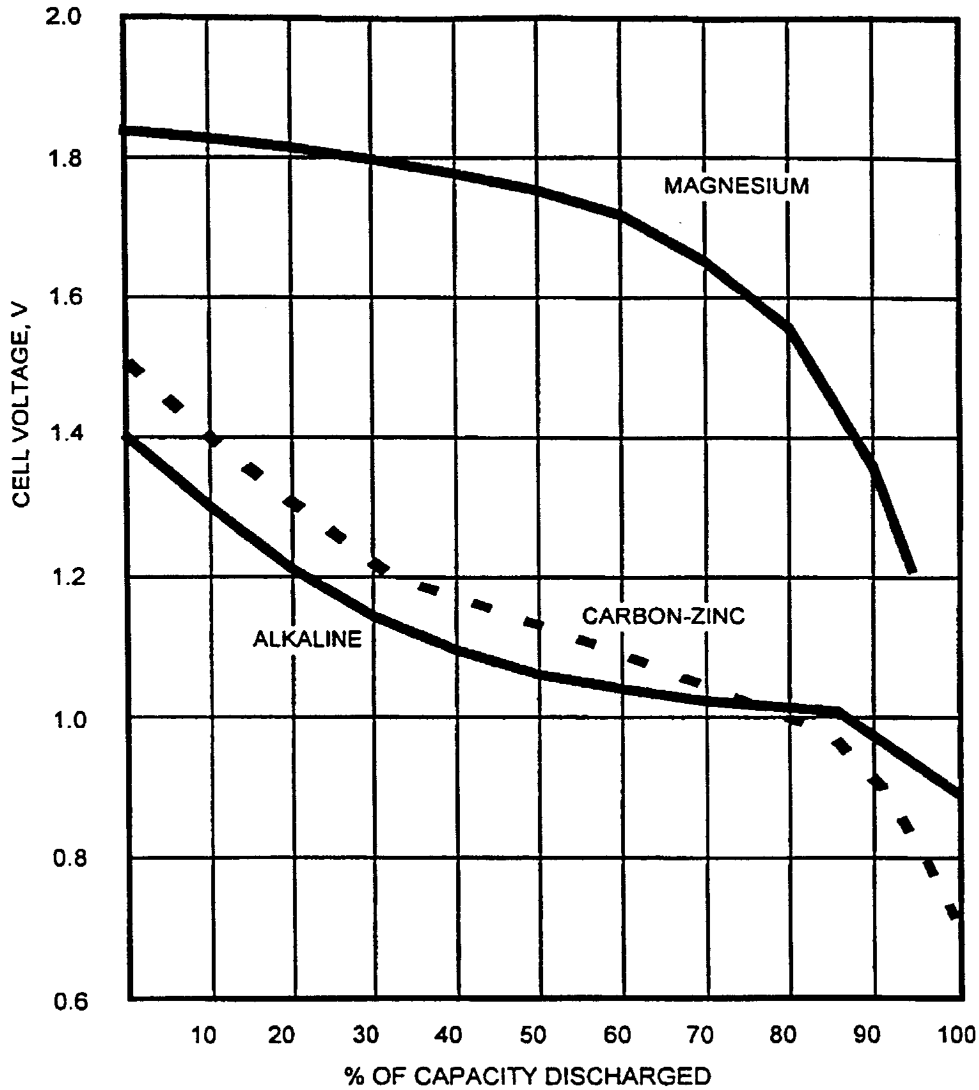

Figure 313-3-1 Voltage Profiles of Major Dry Cell Systems

313-3.4.3 ENERGY DENSITY. Energy density is a measure of the energy (watt-hours) that a cell or battery can deliver per unit volume (liter) or per unit mass (kilogram). Figure 313-3-2 compares the volumetric energy density of each of the major cell system at various temperatures, while Figure 313-3-3 compares the gravimetric energy densities.

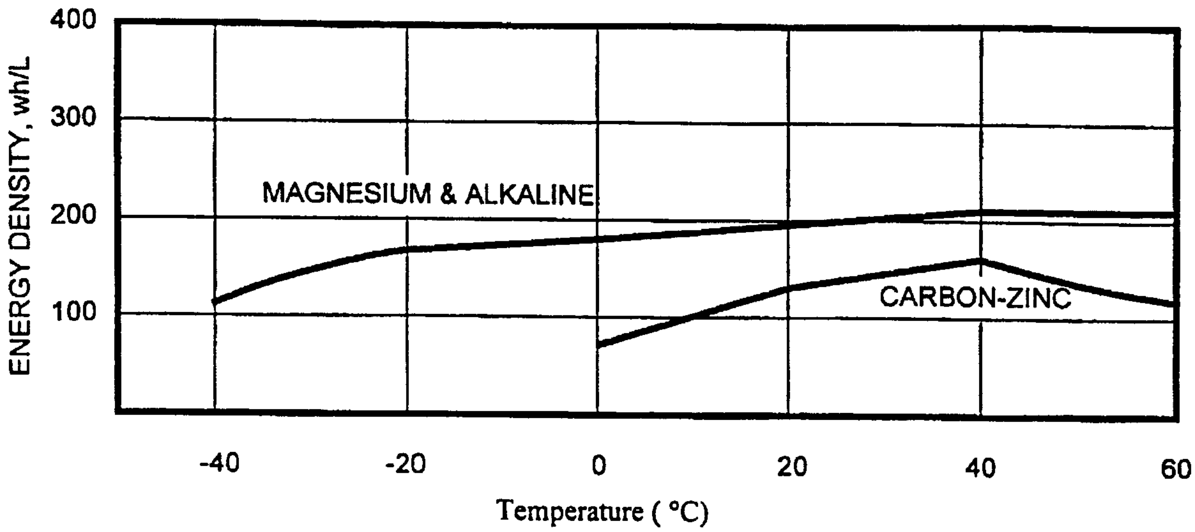

Figure 313-3-2 Volumetric Energy Densities of Major Dry Cell Systems

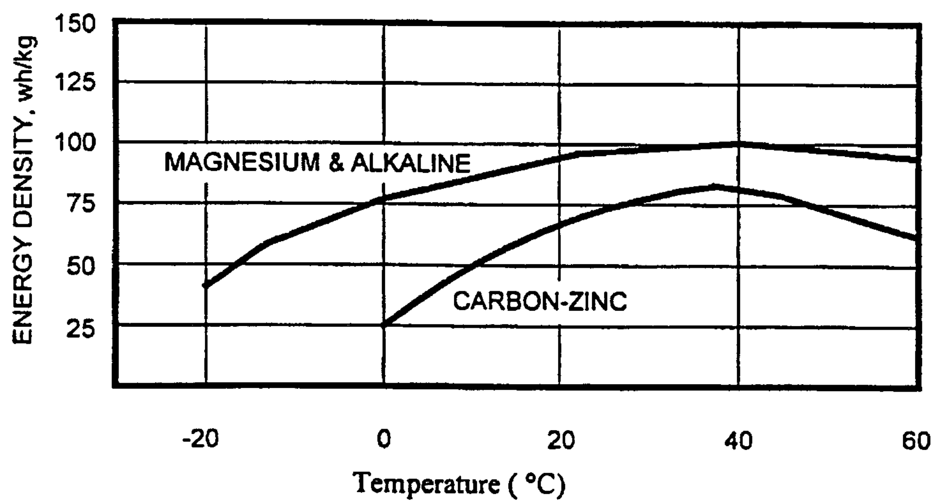

Figure 313-3-3 Gravimetric Energy Densities of Major Dry Cell Systems

313-3.4.4 EFFECT OF TEMPERATURE.

a. On Performance. The effect of temperature on the performance of major dry cell systems is also shown in Figure 313-3-2 and Figure 313-3-3. Optimum performance for all of the systems is achieved at near room temperature. The performance of all systems decreases at lower temperatures due to reduced chemical activity and higher internal resistance. Performance can also decrease at temperatures above room temperature due to parasitic (unwanted) side reactions within the cell.

b. On Shelf Life. Temperature also affects the shelf life of dry batteries. The shelf life characteristics of the major dry cell systems are shown in Figure 313-3-4, where the percentage of capacity lost per year is shown for temperatures from 15° C to 45° C (59° F to 113° F). These results may vary slightly from manufacturer to manufacturer depending on the design and chemical composition of each cell. In addition, the loss of capacity does not remain constant from year to year. The rate of loss generally tapers off as storage time increases.

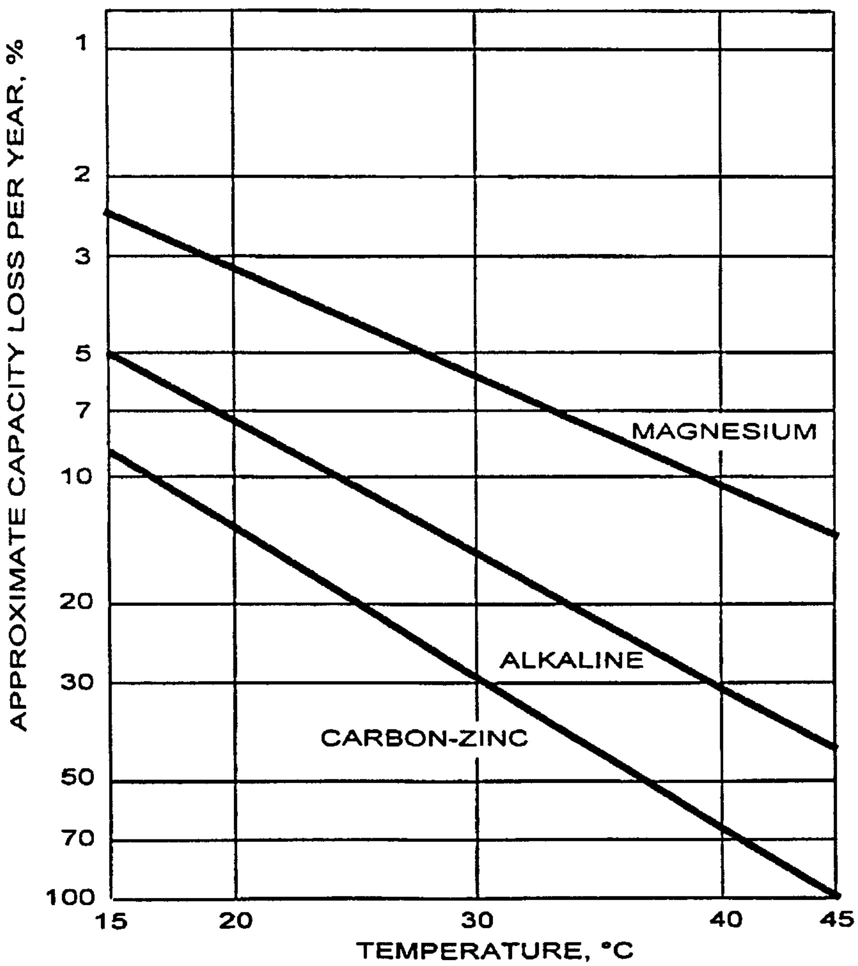

Figure 313-3-4 Shelf Life Characteristics of Major Dry Cell Systems

313-3.4.5 SIZES. Dry cell batteries are manufactured in many different sizes and shapes as described in MIL-B-18. Common sizes for cylindrical, button and multicell batteries are shown in Figure 313-3-5, Figure 313-3-6 and Figure 313-3-7, respectively. Their dimensions are given in Table 313-3-5, Table 313-3-6, and Table 313-3-7.

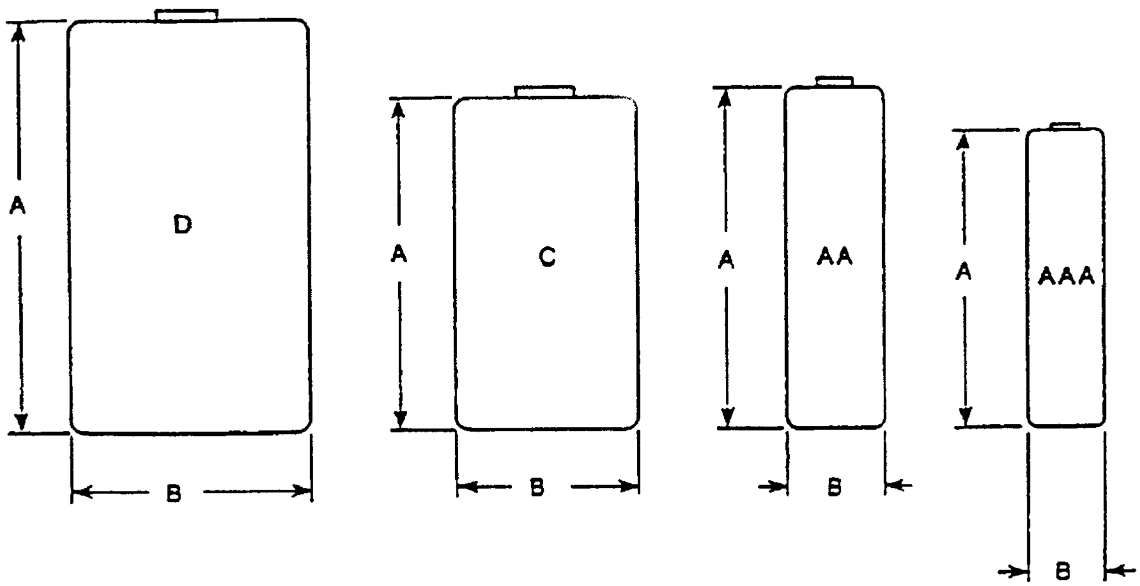

Figure 313-3-5 Common Cylindrical Cell Sizes

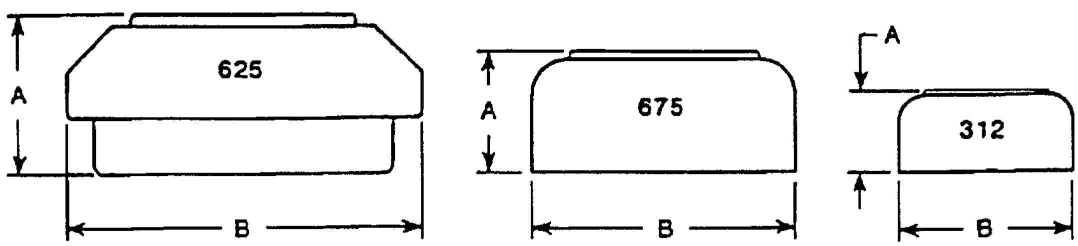

Figure 313-3-6 Common Button Cell Sizes

Table 313-3-6. COMMON BUTTON CELL DIMENSIONS

			Designation	A	B
NEDA[1]	INDUSTRY	**mm**	**NOMINAL (inches)**	**mm**	**NOMINAL (inches)**
1114, 1112 1123, 1124	625	5.9	(0.23)	15.5	(0.61)
1107, 1127 1128, 1131 1152, 1166 1184	675	5.2	(0.20)	11.5	(0.45)
1134, 1135 1155, 1178 1179	312	34	(0.13)	7.7	(0.30)

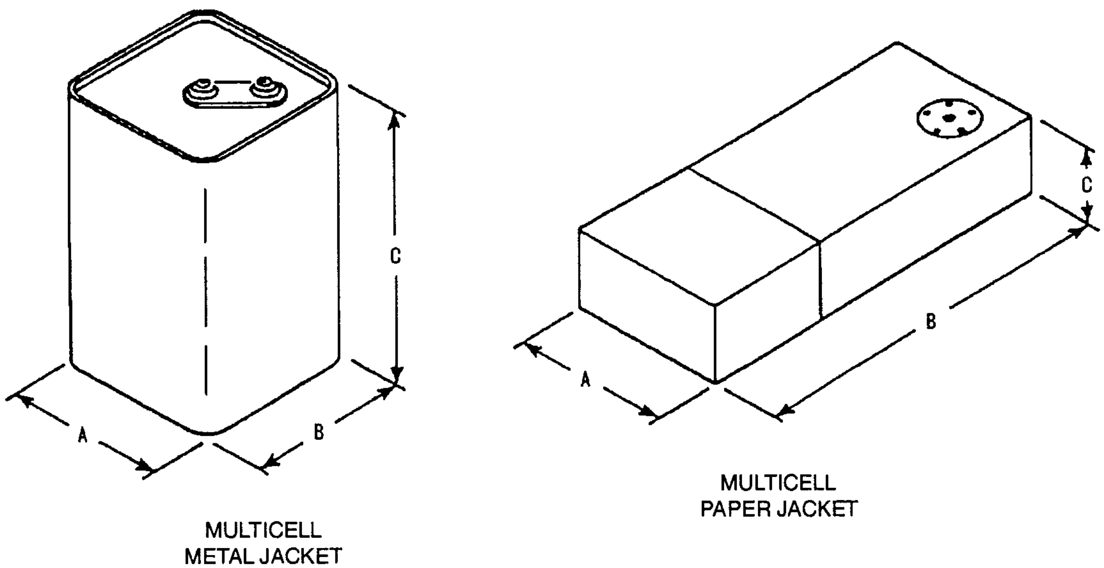

Figure 313-3-7 Common Multicell Battery Sizes

313-3.5 SHIPMENT AND STORAGE

313-3.5.1 PACKAGING. All batteries and materials used in their construction are carefully inspected by government inspectors to make sure they are in conformity with the specifications. Specifications require batteries to be wrapped in small unit packages containing one or more batteries. The unit packages are wrapped in polyethylene plastic bags. The polyethylene bags on the unit packages should not be removed until the batteries are needed for actual use. This wrapping helps to protect the batteries from the detrimental action of outside temperature and humidity. The unit packages are packed in intermediate packages made of corrugated cardboard, then packed in wooden shipping containers.

313-3.5.2 SPECIAL PACKAGING. The Navy-type 19026 dry battery is the only exception to the packaging procedure. Due to its large size, it is always delivered to store activities packed in wooden boxes suitable for export and should be kept in this packing box until issued for service.

Table 313-3-5. COMMON CYLINDRICAL CELL DIMENSIONS

Designation		A		B	
		NOMINAL		NOMINAL	
NEDA[1]	INDUSTRY	mm	(inches)	mm	(inches)
13	D	60	(2.36)	33	(1.30)
14	C	49	(1.93)	25	(0.98)
15	AA	50	(1.97)	14	(0.55)
24	AAA	44	(1.73)	10	(0.40)

[1]National Electronic Distributors Association

Table 313-3-6. COMMON BUTTON CELL DIMENSIONS

Designation		A		B	
		NOMINAL		NOMINAL	
NEDA[1]	INDUSTRY	mm	(inches)	mm	(inches)
1114, 1122, 1123, 1124	625	5.9	(0.23)	15.5	(0.61)
1107, 1127 1128, 1131, 1152, 1166, 1184	675	5.2	(0.20)	11.5	(0.45)
1134, 1135, 1155, 1178, 1179	312	34	(0.13)	7.7	(0.30)

Table 313-3-7. COMMON MULTICELL BATTERY DIMENSIONS

METAL JACKET						
	A		B		C	
	NOMINAL		NOMINAL		NOMINAL	
NEDA[1]	mm	(inches)	mm	(inches)	mm	(inches)
908	66	(2.60)	66	(2.60)	111	(4.37)
1604	26	(1.02)	16	(0.63)	48	(1.89)
PAPER JACKET BATTERY						
	A		B		C	
GOVT. DESIG.	NOMINAL (inches)		NOMINAL (inches)		NOMINAL (inches)	
BA-4386	3.44		2.06		9.44	

313-3.6 STORAGE

313-3.6.1 GENERAL. Dry batteries are perishable, they deteriorate even when not in use. Care should be taken to provide storage conditions which will minimize deterioration. Where possible, dry batteries should be stored at temperatures equal to or less than 2° C (35° F), in a room which is not dehumidified. Where refrigeration is not available, dry batteries should be stored in the coolest available space where they are not subject to excessive dampness or large temperature fluctuations. Any battery taken from refrigerated storage should be allowed to warm up to between 18° C (65° F) and 27° C (80° F) before use in order to obtain maximum capacity.

313-3.6.2 IDLE BATTERIES. If it is expected that dry-battery-operated equipment is to be idle for two weeks or longer, the dry batteries should be removed from the equipment. Batteries that are comparatively fresh (used only a short time), may be turned into ship stores with a record of approximate amount of use. Batteries that have been used extensively should be removed and disposed of. When the amount of service given by a battery is not known, it is best to remove and, if replacement stock is readily available, scrap it. Where stock is not readily available, it may be possible to save the battery and use it when the equipment is returned to service. In this case, the battery should be removed from the equipment and stored, preferably under conditions approaching as nearly as possible those described above. If dry batteries are left in equipment while the equipment is idle, there is a possibility that rupture of the battery may cause electrolyte to leak out of the battery and corrode the equipment. In addition, the battery may expand, making its removal difficult.

313-3.6.3 SHELF LIFE. The Navy defines shelf life as the length of storage time beyond which a group of batteries will contain so many dead batteries that the group is not considered fit for use. Shelf life depends not only upon the kind and size of a cell, but also upon the intended application. If a specific use requires that a high percentage of a battery's initial capacity be available and that the voltage drop on discharge be small, the shelf life assigned to a group of batteries intended for this application will be less than for a use which needs less capacity retention and can tolerate a greater voltage drop during discharge.

a. Effect of Cell Size. Batteries containing smaller cell sizes do not retain capacity as well as those which contain larger cell sizes. Shelf life tables are issued by the various supply offices. Present shelf life tables are derived on the basis of general use requirements and will give a longer shelf life than may be tolerable for critical applications.

b. Effect of Battery Type. It is evident from the definition of shelf life that the assignment of a certain shelf life to a given type of battery does not ensure that each individual battery will be good as long as it has not reached the end of its shelf life. It only means that, as a group, a substantial percentage of the batteries will be good as long as the end of the shelf life is not reached. The determination of whether an individual battery is usable or not can best be made by placing it in the equipment which it is supposed to operate and seeing whether it works or not. If this is not convenient, the battery can be tested by connecting it to a load which is equivalent to that of the equipment and measuring the closed circuit battery voltage. If this is above that required for satisfactory equipment operation, the battery is fit for use. No inference as to the hours of use left in the battery can be drawn from either of these tests or from any other nondestructive test now available.

c. Disposal. Dispose of those batteries which have reached the end of their shelf life.

313-3.6.4 SEPARATION FROM EQUIPMENT. Dry batteries should not be shipped or stored in the equipment with which they are to be used. The reasons include:

a. Dry batteries deteriorate in storage. Putting fresh batteries in the equipment as near as possible to the time of use gives the only assurance of reliable operation.

b. Dry batteries shipped or stored in equipment may become discharged either by internal chemical reaction or by leakage currents across normally open contacts. As a result, water is generated in the cells and electrolyte may leak out and corrode the equipment.

313-3.7 ISSUANCE

313-3.7.1 There is no reliable nondestructive test which can determine the amount of capacity remaining in a battery after it has been stored for a considerable length of time. For this reason, the discretion of the issuing officer is an important factor in issuing batteries. It is usually desirable to issue the oldest stock first. This is satisfactory when the batteries are to be used close to the warehouse and can be replaced readily. However, if batteries are to be used in a remote locality where premature failure may cause serious inconvenience, it is recommended that only batteries less than six months old be issued. The specifications require all batteries to be marked with the date of manufacture in order to show their age. The date of manufacture is given by a coded three-digit number. The first two numbers represent the month the batteries were made, the third the year of the decade in which they were made. For example, 041 means the battery was made in April 1991, 04 for April and 1 for 1991. Batteries which have been subjected to extraordinary heat or humidity should never be issued except in an emergency.

313-3.8 SERVICE

313-3.8.1 One of the main advantages of dry batteries is the ease with which they are put in service. All that is required is to place the battery in its operating position and connect it to the apparatus to be operated. Batteries with wire leads are connected after removing the waterproof tape covering the ends of the wires. In some cases, the insulation on the wire leads may be extended all the way to their ends. In this case, the wires must be bared. Care should be taken not to cut or scratch the wire, as this will make it liable to break. In placing batteries with socket connections in service, it is necessary to remove the protective covering on the socket. Care must be taken not to short circuit the battery across any of the socket terminals. The limited attention necessary for the operation of dry batteries is one of the reasons that they are used so extensively. The only precautions necessary are:

a. Avoid exposing the battery to high temperatures or extremes of high or low humidity for a long period of time.

b. Avoid short circuiting the connections of the battery.

313-3.9 DISPOSAL

313-3.9.1 The need for proper disposition of used batteries has arisen from an increased awareness of the effects of heavy metals and corrosive liquids on people and our natural environment. Consequently, defective, exhausted or unserviceable batteries should not be thrown overboard. All military bases have an office known as DRMO, Defense Reutilization Marketing Office, or as a memory aid, ″Doctor Mo.,″ which provides for the disposition of batteries and other waste material. DRMO can advise the user as to the proper packaging and labeling of items for disposal and will arrange transportation.

313-3.10 SAFETY PRECAUTIONS

313-3.10.1 The following safety precautions should be observed:

a. Care should be taken to store dry batteries under conditions outlined in paragraph 313-3.6 and to keep them from exposure to heat, extremes of high or low humidity, and water.

b. The 300-volt B section of the Navy-type 19026 pack battery is capable of imparting a very serious, if not fatal, shock to anyone coming in contact with it. Therefore, great care should be taken not to come in contact with the terminals of this battery, or of any other high-voltage battery.

c. When equipment operated by dry batteries is to remain idle for more than two weeks, the batteries should be removed and then either disposed of or stored.

d. When disconnecting the Navy-type 19026 battery from the operating apparatus, the current flow should be stopped before disconnecting the plug. It is possible for sufficient gaseous hydrogen to accumulate in this battery to produce a serious explosion if ignited. A spark produced by pulling the plug from the socket while current is flowing is sufficient to ignite this gas.

e. Wire lead terminals should be kept insulated when the battery is not connected to an apparatus in order to prevent a short circuit. This could result in sufficient heat to cause a fire. In addition, a discharge caused by a short circuit generally produces so much water within the cells that they burst, spilling corrosive electrolyte which can damage furniture and equipment.

f. Never continue to use a multicell dry battery after its closed circuit voltage has dropped below a value equal to 0.9 volts per cell. Discharging a battery beyond this point will force current through some cells of the battery which may be completely discharged. This results in the generation of hydrogen and oxygen gas due to electrolysis of water. When this happens, there is a danger of hydrogen explosion and possible injury to personnel and damage to equipment.

g. Never mix fresh and old batteries. Always replace all batteries in a unit at the same time.

h. Never mix batteries with different chemical systems, sizes or manufacturers.

i. Replacement batteries should utilize the same chemical system as the original equipment batteries. Never replace dry batteries with lithium batteries, and vice-versa.

j. Never leave the battery switch on when the equipment is not in use or after the battery fails to operate the equipment.

SECTION 4

LITHIUM BATTERIES

313-4.1 GENERAL

313-4.1.1 Lithium batteries have highly desirable characteristics such as high cell voltage, flat voltage profile and high-energy density. However, current applications using lithium cells are severely restricted because of legitimate concerns regarding safe operation, transportation and disposal of the cells. Until technological improvements can be made, it is unlikely that lithium cells will be used on anything but special applications. Refer to NAVSEA Battery Document AH-300 for detailed technical characteristics, and to P-Document NAVSO P-3676, Navy Primary and Secondary Batteries, for detailed design and manufacturing guidelines.

313-4.2 DISPOSAL

313-4.2.1 Discharge or defective lithium batteries are considered to be reactive and hazardous wastes. No lithium battery should be disposed of by fire or incinerator, nor should it be thrown overboard. All military bases have an office known as DRMO, Defense Reutilization Marketing Office, or as a memory aid, ″Doctor Mo.,″ which provides for the disposition of batteries and other waste material. DRMO can advise the user as to the proper packaging and labeling of items for disposal and will arrange transportation.

313-4.3 SAFETY PRECAUTIONS

313-4.3.1 Lithium is a highly reactive and flammable metal. Consequently, batteries containing lithium are subject to strict state, national, and even international controls. The Navy’s current policies regarding lithium cells are defined in publication S9310-AQ-SAF-010 (0910-LP-128-4800), Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures.

CAUTION

Never replace dry batteries with lithium batteries, and vice-versa.

APPENDIX A.

SUPPLEMENTAL INFORMATION FOR THE GNB 1020 AH FORKTRUCK BATTERY

313-A.1 GENERAL

313-A.1.1 The 1020 Ah battery (Model 12-170C-13EE from GNB Battery Technologies) is much larger than any ever put onto Navy ships and, in effect, is oversized for the capacity of the charger to perform its job in 8 to 8.5 hours on a fully discharged battery. The charger manufacturer only produces what specification DOD-C-24529 required for Type II chargers (for batteries up to 900 Ah).

313-A.2 PROCEDURE FOR CHARGING THE 1020 AH GNB BATTERY

a. If the battery is completely discharged and then recharged for 8 hours or less, used and then recharged again in 8 hours or less repeatedly, serious cumulative undercharging occurs which leads to sulfation, low capacity, low voltage, and low specific gravities. The battery charger operates at a maximum voltage of 2.35 V per cell corrected to 80° F (26.7° C), and has a rated maximum current of 200 A when the largest battery size is selected. For a battery of the GNB 1020 Ah capacity, a higher charge current limit is required to achieve the 8 to 8.5 hour recharge time.

b. The charter has or should have 250 A fuses in the output of the charger and has adjustments to increase output voltage and current. By increasing the voltage to 2.40 V per cell (or as near to 2.40 V per cell if that limit cannot be reached) and 28.8 V on the voltmeter, the current will rise somewhat, and the charge will last longer before the current begins to taper down once the voltage limit has been achieved. This may not provide a full charge in 8 to 8.5 hours.

c. Another method of charge completeness can be used. In this method, the charger should be left attached to the battery until a finishing current of 2 to 3 A is reached, which may be as long as 16 hours or more (if no adjustments are made). On the other hand, a procedure for making adjustments (to the output voltage) is discussed in greater detail in the following procedure. With the adjustments discussed in this procedure, the time to charge completeness should be shorter. These remedies are for new or recovered batteries only.

313-A.3 PROCEDURE FOR ADJUSTING OUTPUT VOLTAGE OF THE TRILECTRON INDUSTRIES CHARGER MODEL 8945

a. The charger Trilectron Industries Model 8945 is capable of charging Navy batteries up to 900 Ah capacity. The largest 24 V forktruck battery listed in MIL-STD-15367 Rev D (28 June 1991) is 870 Ah (see Appendix B). The 1020 Ah battery (Model 12-170C-13EE from GNB Battery Technologies) can be accommodated with the existing Trilectron battery charger as follows:

    1. In the battery charger technical manual, locate the section on corrective maintenance, adjustment and alignment, voltage adjustment, and current limit adjustment. Assemble the required fully charged new or recovered GNB 1020 Ah battery, resistive load, and shunt to adjust voltage output level and current limit. Check that the DC output fuses are rated at 250 A; if not, replace with the proper 250 A fuses.

2. Set the charger to the 900 Ah capacity setting. Set up the system per the technical manual for voltage adjustment, and turn the charger on. Make voltage adjustments to output voltage based on temperature as follows:
   (a) For 70° F (21.1° C), output voltage should be 28.83 V
   (b) For 80° F (26.7° C), output voltage should be 28.80 V
   (c) For 90° F (32.2° C), output voltage should be 28.77 V

NOTE

These output voltage equate to 2.40 V per cell for the temperatures listed. Voltage level should be adjusted for the actual temperature of the battery through interpolation.

3. Observe the charging current, and stop the adjustment at 230 to 240 A output at the maximum rate. If the fuses blow during the adjustment to the higher voltage, then the current was too high for the set voltage. Replace the fuses, and adjust the voltage down.
4. Follow the instructions for setting the current limit so that the fuses will not blow because of excessive current. Set up the system per the manual for current adjustment, and adjust for the new charging voltage level per the manual.
5. After the adjustments are completed, an 80 percent discharged forktruck battery should be placed on charge to determine the initial current limit, end of charging voltage, when finishing current of 2 to 3 A is reached, and the total time to reach finishing current. This charging time and current limit then becomes the standard for achieving a fully charged battery at the new voltage; anything less will undercharge the battery. The primary parameter for charge completion is the 2 to 3 A finishing current.
6. To recover a battery from sulfation, a special procedure is required, and may not be able to be performed aboard ship. See paragraph 313-A.4.

313-A.4 PROCEDURE FOR RECOVERING A SULFATED FORKTRUCK BATTERY, GNB MODEL 12-170C-13EE

313-A.4.1 FACILITY. In order to recover a sulfated GNB 12-170C-13EE battery exhibiting low voltage on charge and open circuit, and low specific gravities, the battery must be taken to a facility with the following capabilities:

a. The ability to discharge a battery at from 50 to 200 A.

b. The ability to recharge the battery at up to 2.6 V per cell, 31.2 V for the battery corrected to 80° F (26.7° C) at a current of at least 150 A.

c. The ability to measure charging voltage and charging current during charge and discharge.

313-A.4.2 PROCEDURE

1. The battery must first be discharged at 50 A down to a battery volts of 18 V (1.5 V per cell average); however, the discharge must be terminated when any cell reaches 1.0 V prior to battery volts reaching 18 V.

2. Recharge the battery in the normal manner with maximum current limit of the charger, not to exceed 250 A and a maximum voltage not to exceed 2.6 V per cell, or about 31.2 battery volts.

3. The recharge will be complete when battery volts have reached the maximum, and the charging current has dropped to about 10 A or less, and stable for 3 hours. Terminate the charge, and record the specific gravities.
4. If any specific gravity deviates more than 0.010 point from the average (specific gravity), the battery may need a second 50 A discharge and recharge. If gravities and cell voltages are uniform and within 0.010 points and volts respectively, then the battery may be placed in normal service. The regular charger for the battery must be adjusted to provide higher voltage (per the instruction for adjustment using the GNB 1020 Ah battery) if the 8 to 8.5 hour recharge time is desired.

APPENDIX B.

Table 313-B-1. PHYSICAL CHARACTERISTICS OF BATTERIES FROM INDUSTRIAL TRUCKS AND TRACTORS (EXCERPTED FROM MIL-STD -15367, REV D DATED 28 JUNE 1991)

Dash Number	Figure	Nominal Voltage	Number of Cells	Number of Plates	Ah Capacity (6 hour rate)	Maximum Battery Dimensions - cm (in)			Maximum Weight Filled kg (lbs)
						Length (x)	Width (y)	Height (z)	
-1	1	36	18	13	510	79.0 (31 1/8)	19 1/4 (48.9)	57.8 (22 3/4)*	801 (1764)
-2	1	36	18	17	680	98.1 (38 5.8)	51.7 (20 3/8)	57.8 (22 3/4)*	1051 (2313)
-3	1	36	18	21	850	98.4 (38 3/4)	63.5 (25)	57.8 (22 3/4)*	1268 (2791)
-4	2	24	12	11	800	91.1 (35 7/8)	34.9 (13 3/4)	78.7 (31)	844 (1858)
-5	2	24	12	13	870	90.1 (35 1/2)	40.0 (15 3/4)	78.7 (31)	990 (2180)
-6	2	24	12	19	765	66.3 (26 1/8)	57.5 (22 5/8)	57.8 (22 3/4)*	779 (1714)
-7	3	12	6	13	510	78.7 (31)	16.8 (6 5/8)	59.0 (23 1/4)	264 (582)
-8	3	12	6	19	765	57.1 (22 1/2)	33.3 (13 1/8)	59.0 (23 1/4)	390 (858)
-9	3	12	6	23	935	68.9 (27 1/8)	33.3 (13 1/8)	59.0 (23 1/4)	466 (1026)
-10	2	24	12	13	510	78.4 (30 7/8)	33.3 (13 1/8)	59.3 (23 3/8)	466 (1026)

*Without cover, add 1 1/2 inches (3.8 cm) for cover.

APPENDIX B.

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REAR SECTION

NOTE

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