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PERFORMANCE SPECIFICATION

BATTERIES AND CELLS, LITHIUM, RECHARGEABLE, AIRCRAFT, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for secondary (rechargeable) storage batteries of lithium electrochemistry including, but not limited to, lithium-ion, gel-polymer lithium-ion, and lithium polymer.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 or 4 of this specification, whether or not they are listed.

Comments, suggestions, or questions on this document should be addressed to the Naval Air Systems Command (Commander, Naval Air Warfare Center Aircraft Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100) or e-mailed to michael.sikora@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.daps.dla.mil.

AMSC N/A FSC 6140

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards, form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

FEDERAL STANDARD

FED-STD-595/17875	-	Miscellaneous, Gloss

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-18148/3	-	Receptacles, Electric, Aircraft Storage Battery
MIL-PRF-24236	-	Switches, Thermostatic, (Metallic and Bimetallic), General Specification For

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Electronic and Electrical Component Parts.
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.
MIL-STD-810	-	Environmental Engineering Considerations And Laboratory Tests

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch/ or https://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government document, drawing, and publication form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

S9310-AQ-SAF-010	-	Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures
NAVSEAINST 9310.1	-	Naval Lithium Battery Safety Program

(Copies of Navy Technical Manual S9310-AQ-SAF-010 are available from https://nll.ahf.nmci.navy.mil/ or Navy Logistics Library, Naval Supply Systems Command, 5450 Carlisle Pike, Mechanicsburg, PA 17055-0791. Copies of NAVSEA Instruction 9310.1 are available from http://www.navsea.navy.mil/NAVINST/09310-001B.pdf.)

2.3 Non-Government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of this document are those cited in the solicitation or contract (see 6.2).

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME-Y14.38 - Abbreviations and Acronyms (DoD adopted)

(Copies of this document are available from http://www.asme.org or ASME International, Three Park Avenue, New York, NY 10016-5990.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Cells and batteries furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) before contract award (see 4.2 and 6.4).

3.3 Components. Components that are specified shall be in accordance with the applicable specification. Components shall be chosen so that the battery meets the performance requirements of this specification and if requested by the qualifying activity, the manufacturer shall supply a certification of conformity of the component (see 6.2.e and 6.10).

3.4 Dissimilar metals. Unless protected against electrolytic corrosion, dissimilar metals shall not contact each other (see 6.10.4).

3.5 Design. The design shall conform to the requirements specified herein when examined in accordance with the visual and mechanical tests of 4.5.2. The design shall also conform to the requirements specified in S9310-SAF-AQ-010 (see 6.17 and 6.18). Requirements for the individual types of batteries are specified in the applicable specification sheets (see 3.1).

3.5.1 General. The battery shall be free from defects that will affect life, functioning, and appearance. Batteries shall not have loose contacts, poor or improper molding or fabrication, damaged or improperly assembled contacts, peeling, flaking or chipping of plating or finish,

mechanical damage due to testing environments, nicks or burrs of metal parts of surfaces, nor improper or incorrect marking.

3.5.2 Batteries. After delivery from the manufacturer, batteries shall not require the addition of any substance before being put into service. The battery shall not require any maintenance besides a conditioning charge, in meeting the provisions of this specification (see 6.14.8).

3.5.3 Battery container and cover. The battery container and cover shall be free of pits, blow holes, rough spots, and other deformations. The dimensions and locations of receptacles, hold-downs, vent tubes, and battery identification shall conform to the applicable specification sheet. The cover shall not be removable from the container. The battery container and cover shall neither support combustion nor emit toxic vapors when subjected to flame.

3.5.4 Venting. Each cell and battery shall incorporate a safety-venting device or be designed and manufactured in such a manner that will preclude a violent rupture as a result of cell venting. The design and construction shall not degrade or obstruct the vent. If a battery includes vent tubes, the tubes shall be located as shown on the applicable specification sheet. Each vent tube shall be capable of supporting the test sample such that the requirements of 3.9.5 are met after being tested in accordance with 4.5.6.

3.5.5 Receptacles. Each battery shall include a main power receptacle in accordance with the applicable specification sheet. This receptacle provides the battery's interface to the aircraft or equipment electrical system. The hardness of the wormgear retaining pins within the sockets of receptacles in accordance with MIL-PRF-18148/3 receptacles shall be not less than 55 on the Rockwell C Scale when tested in accordance with 4.5.24.

3.5.6 Connectors, intercell. All electrical connections within the battery shall be by surface-to-surface conduction and not through screw threads.

3.5.7 Leakage. Evidence of leakage of electrolyte or any other substance during the performance of any of the tests specified in section 4 shall not occur.

3.5.8 Voltage. Unless otherwise specified in the applicable specification sheet, the nominal potential of the battery shall be 26 volts. The battery potential shall be not greater than 29.0 volts at any time.

3.5.9 Heaters. Heaters may be incorporated into batteries to meet the cold temperature charging requirements. Heater power shall not be provided during any discharge performed in section 4. Heater power shall be provided during all constant potential charges (see 4.4.2). When heaters are incorporated, the following requirements shall apply:

a. Heaters shall be powered by 115 VAC or by 28.0 volts direct current (VDC) (see applicable specification sheet for heater power requirements).

b. The rated current of each heater control device shall be compatible with the current specified in the applicable battery specification sheet.

c. Heater elements and wire assemblies shall be electrically insulated and installed in a manner which minimizes potential battery damage due to electrical shorting, sparking, or other electrical hazards.

d. All electrical switches, controls, circuits, and installations shall be explosion-proof. When operating, they shall not ignite explosive mixtures of hydrogen and oxygen gasses generated inside the battery container.

e. Both primary and secondary (backup) temperature limiting controls shall be incorporated into the battery's electrical circuits to prevent overheating and shall be wired in series. If the primary heater control fails, the battery shall not reach a damaging temperature.

f. All thermal switches shall be snap-action type in accordance with MIL-PRF-24236.

g. All heater components shall be located inside the battery container.

h. When the battery is operating in accordance with any specified environmental condition (see 4.4.1), the exterior surface of the battery container shall not be greater than 75° C (167° F) due to the heater operation.

3.6 Physical requirements.

3.6.1 Atmospheric operating conditions. Unless otherwise specified in the applicable specification sheet, the cell or battery shall be capable of performing electrically while encountering the environments of 3.6.1.1 through 3.6.1.3.

3.6.1.1 Humidity. The operating relative humidity shall be from 0 percent to 100 percent including condensation.

3.6.1.2 Pressure. The operating atmospheric pressure shall range from that found at sea level to that found at an altitude of 18,288 meters (60,000 feet).

3.6.1.3 Temperature. The operating temperature shall be from -40° C to +71° C (-40° F to 160° F).

3.6.2 Attitude. The battery shall be designed for operation in any position while meeting the capacity, voltage and electrolyte leakage requirements (see applicable specification sheet).

3.7 Color and marking. The batteries shall conform to the requirements listed below when examined in accordance with 4.5.2.

3.7.1 Color. The battery shall conform to one of the following color styles:

a. The color under natural light of four out of six faces of the battery, except the mounting points, hold-down hooks, other external hardware, identification marking, and instructions, shall conform to the color listed in table I.

b. Color only the container cover and marking backgrounds in accordance with those listed in table I under natural light; the rest of the container shall be white or grey.

c. Color only the container cover and marking backgrounds in accordance with those listed in table I under natural light; the rest of the container shall be of stainless steel.

3.7.2 Polarity marking. The container body shall be conspicuously and durably marked "+" in red in the location shown on the applicable specification sheet.

3.7.3 Identification marking. The battery identification marking shall be in white or black print and shall be clear and legible throughout all tests. Unless otherwise specified in the applicable specification sheet, the marking shall use a type size of not less than 4.2 mm. The marking shall contain the required titles and information as shown in figure 1 herein and shall be placed in accordance with the applicable specification sheet. The lot code shall be constructed in accordance with 3.7.6. The blank area following the entry Date First Placed in Service shall be capable of being written on with a felt tip permanent marker. The manufacturer shall fill in the applicable information at the indicated areas. Abbreviations in accordance with ASME-Y14.38 and acronyms are permitted.

3.7.4 Battery caution marking. The battery caution marking shall contain the required titles and information as shown on figure 2 herein and shall be placed in accordance with the applicable specification sheet. The lettering height shall be not less than 6.3 mm. The marking shall be in black print.

3.7.5 Marking for batteries with heaters. If any exterior surface of the battery container exceeds 49° C (120° F) when all heater elements are energized and all other battery electrical circuits are not functioning for 1 hour, the following caution statement shall be inscribed on the battery identification marking and battery caution marking: CAUTION HOT SURFACE (see figures 1 and 2). The height of all statement letters shall be equal and not less than 6.2 mm. The battery container shall also display an electrical schematic for internal heaters. The height of the letters and numbers shall be equal and not less than 3.8 mm.

3.7.6 Lot code. The month and year that the manufacturer compiled the batteries into a group for inspection and the lot code of the battery shall be clearly shown on the battery identification marking. The information shall be coded such that the first two digits indicate the month of the year, the middle two digits indicate the year (followed by a dash), and the last two digits indicate the inspection lot (see 6.14.7) number. Months earlier than the tenth shall be

indicated by a single digit preceded by "0". When the inspection lot is compiled during the first three or the last three working days of the month, the manufacturer is permitted to use either that month or the nearest adjacent month as the coded month. For example, lot code 0409-12 indicates the lot was compiled in April 2009 and was the twelfth lot.

3.7.7 Warnings. The cell or battery shall be marked with the following warnings and shall be placed in accordance with the applicable specification sheet. The warning shall be as follows:

For Use in Designated Equipment Only

Caution

Lithium Ion Battery

Recharge in accordance with authorized/approved instructions

Do not pierce, cannibalize, mutilate, puncture, short circuit, expose to temperatures above 85° C, or incinerate. Use in equipment approved for this cell or battery. Do not throw in trash.

3.8 System safety design requirements.

3.8.1 General safety requirements. The cell or battery, when subjected to any tests specified in section 4, shall not show:

a. Explosion, flame, fire, venting of solid material, disassembly, cell leakage, or rupture of cell or battery within 24 hours after the completion of the test. The cell or battery shall not produce shrapnel within 24 hours after the completion of the test.

b. Dimensional distortion beyond specified limits.

c. Improper operation of safety devices that create an unsafe condition.

d. Cracking of cases or covers.

e. Radical current or voltage fluctuations during any test. Degradation of electrical performance beyond limits specified by the test requirements, if applicable.

f. Mechanical failure of any part.

g. Liquid leakage or spilling of liquid at any time during the test. Liquid discharge visible from outside the battery or detectable within the battery shall not occur during testing to

this specification. With the battery vent ports open and the battery operating within design requirements of this specification, cell venting shall not cause liquid discharge from the battery. Products of cell venting that are discharged through the vent tubes shall be non-toxic.

h. Breakdown of insulation, flashover, arcing, stripping of metal plating from any component part, corrosion of metal parts, or loosening of protective coating from the battery container or cover.

i. Deterioration of cell or battery identification markings.

j. Charred or discolored areas of the cell or battery.

k. Opening of cell or battery vents.

l. Cracking, pitting, chipping, scaling, corrosion, or other deleterious effects on the external and internal metal or component parts of each cell or battery.

m. Cracking, peeling, fading or discoloration of the container and battery markings.

n. Improper indication by state of charge indicator or other state of health indicators.

3.8.2 Thermal protection. When required, thermal protection shall conform to the applicable specification sheet. The thermal protection shall remain closed below 82 ±2° C (180 ±4° F) and shall remain open above 88 ±2° C (190 ±4° F) after being tested in accordance with 4.5.17. The thermal protection shall be located as close as possible to the geometric center of the battery or as delineated in the applicable specification sheet. For a two- or three-cell in-line arrangement, the thermal protection shall be located between any two adjacent cells. For a cluster arrangement of three or more cells, the thermal protection device shall be located within the cluster.

3.8.3 Potting. Cell or battery vents shall not be potted over. If potting is essential, care shall be exercised to ensure that venting shall not be obstructed. Potting shall not adversely affect cell or battery thermal management.

3.8.4 Pressurized cells or batteries. All internally pressurized cells shall be hermetically sealed and constructed so that the case-to-cover seal is continuous, free from holes and other imperfections. The seal between the electrode and the cover shall be free from imperfections. Each cell, battery, and battery enclosure shall incorporate a safety venting device or be designed and manufactured so as to preclude a violent rupture as a result of cell venting. The design and construction shall not degrade the vent.

3.8.5 Interchangeability restraints. Lithium batteries with two or more cells shall be constructed so that they are not interchangeable with alkaline batteries used in consumer products such as flashlights or radios.

3.8.6 Shorting protection. Individual cells or batteries shall be delivered and stored with the leads or connector plug insulated against accidental shorting.

3.8.7 Age documentation. The manufacturer shall provide the following documentation with each delivery of cells or batteries:

a. The maximum age of cells or cells assembled into batteries, from the time of their initial manufacture to the time of their shipping date, shall be not greater than 180 days.

b. Batteries or cells shall be submitted for Government testing within 30 days of battery assembly.

3.8.8 General battery safety requirements. NAVSEAINST 9310.1 requires all lithium batteries be reviewed, tested and approved in accordance with S9310-AQ-SAF-010. Before listing on the qualified products list, the manufacturer shall comply with the requirements of S9310-AQ-SAF-010, unless modified by the applicable specification sheet (see 6.2.h, 6.17.1 and 6.17.2).

3.9 Detail requirements.

3.9.1 Condition of battery. The battery container shall not exhibit scratches, gouges, dents, torn material, leakage, or other damage when inspected in accordance with 4.5.1 (see 6.6).

3.9.2 Visual and mechanical. Batteries shall be in accordance with 3.5, 3.7 and table II, when subjected to the examination of 4.5.2.

3.9.3 Dimensions and weight. The dimensions and weight of batteries shall be as shown on the applicable specification sheet after the inspection of 4.5.3.

3.9.4 Dielectric strength and insulation resistance. The battery and its components shall meet the requirements of 3.8.1 after being tested in accordance with 4.5.5. The leakage current shall not be greater than 0.5 milliampere$_{RMS}$ between each of the items listed in 4.5.5.a through 4.5.5.c. The insulation resistance shall be not less than 1 megohm between each of the items listed in 4.5.5.a through 4.5.5.c.

3.9.5 Vent tubes. If applicable, the vent tubes shall support the load without shearing, breaking, bending, or deterioration at the point of connection with the battery or other distortion of the case after being tested in accordance with 4.5.6 (see 4.3.4). The battery shall also meet the requirements of 3.8.1.

3.9.6 State of charge indicator. A state of charge device with indicator having not less than four segments and communications bus shall be incorporated when required by the applicable

specification sheet. State of charge indicators, when applicable, shall be checked before and after each test of section 4 and be accurate within ±10 percent.

3.9.7 Built-in test. The battery shall have provisions to perform built-in tests (BIT) to indicate that the battery's electronics are operating properly. BIT shall be performed when commanded by an external means such as an RS485 bus. The battery state of health and state of charge shall be checked when the BIT is performed. The BIT shall be tested in accordance with the applicable specification sheet.

3.9.8 Open circuit voltage. The cell or battery open circuit voltage shall be not greater than 29.0 volts before being tested in accordance with 4.5.4.

3.9.9 Capacity and electrical performance. The capacity (see 6.14.1 and 6.14.9) shall be as shown on the applicable specification sheet. The discharge requirements and associated parameters shall be as shown in table III (see 6.9). The battery shall produce not less than the cutoff voltage (see 6.14.3) at the designated discharge rate (see 6.14.2) for not less than the indicated length of time at the listed temperature after being tested in accordance with 4.5.8. Battery capacity shall vary not greater than ±5 percent within a given inspection lot. The tolerance of the discharge current shall be ±1percent of the specified value. The cell or battery temperature shall be not greater than 82° C (180° F) at any time during a capacity test. The state of charge indicator shall produce the proper indication corresponding to the battery capacity at the states of highest charge and lowest charge (i.e., at cut-off voltage) before and after the test of 4.5.8. Indications at intermediate levels shall be as specified in the applicable specification sheet.

3.9.10 High and low voltage charge test. The battery shall produce no less than 80% of its capacity after being tested in accordance with 4.5.9.b. The battery shall produce not less than 100 percent of its capacity after being tested in accordance with 4.5.9.f. At all times during the charge and discharge of 4.5.9 the battery shall conform to the requirements of 3.8.1.

3.9.11 Strength of receptacle (MIL-PRF-18148/3 or equivalent). The receptacle shall withstand a torsion force of 8.1 ±0.7 Newton-meters (6 ±0.5 foot-pounds) after being tested in accordance with 4.5.10. The battery shall also meet the requirements of 3.8.1.

3.9.12 Cycling. The battery shall successfully complete not less than 600 cycles or the number of cycles specified in the applicable specification sheet (see 6.14.4) after being tested in accordance with 4.5.11. The inability of the battery to meet the requirements of table III, for the respective temperature requirement, for three consecutive discharges shall constitute a failure.

3.9.13 Functional discharge. The battery potential shall be not less than 20.0 volts at not less than 3 minutes into the discharge after being tested in accordance with 4.5.18, 4.5.26, 4.5.28, 4.5.29, 4.5.30 through 4.5.33.

3.9.14 Electromagnetic interference. The battery shall not exhibit any malfunction or degradation of performance. The battery shall meet the applicable requirements of MIL-STD-461 after being tested in accordance with 4.5.12.

3.9.15 Temperature rise and float. The battery shall perform as follows after being tested in accordance with 4.5.15. If the charging current rises, its increase (in amperes) compared to the current's minimum value shall be not greater than 10 percent of the battery's rated capacity (for example, 1.5 amperes for a 15-ampere-hour battery) at any time during charge. The battery shall meet requirement (1) of table III and the requirements of 3.8.1.

3.9.16 Penetration test. Batteries shall not fail violently when their containers are penetrated by sharp objects. Samples tested in accordance with 4.5.38 shall not explode nor create shrapnel. When tested in accordance with 4.5.38.a, the temperature of each test sample shall be not greater than 170° C (338° F).

3.9.17 Crush test. When tested in accordance with 4.5.39 the cell or battery shall not explode nor create flame or fire within 24 hours after the completion of the test. The cell or battery shall not produce shrapnel within 24 hours after the completion of the test.

3.9.18 Ground storage. The cell or battery shall be capable of storage in uncontrolled temperature conditions from -40° C to +50° C (-40° F to +122° F) for not less than 30 days, after which it shall deliver not less than 50 percent of rated capacity after being tested in accordance with 4.5.36.

3.9.19 Shelf life. In order to maintain qualification, successful completion of the shelf life test shall be required. The cell or battery shall be capable of storage in uncontrolled temperature conditions from -40° C to +50° C (-40° F to +122° F) for not less than 18 months without damage (see 6.2.f). The capacity shall be recoverable after being tested in accordance with 4.5.37. The cell or battery shall also meet the requirements of 3.9.12 after being tested in accordance with 4.5.11.

3.9.20 Deep discharge recovery. If the battery uses protective circuitry to protect it from deep discharge, the battery shall meet the test requirements of 3.9.20.a. Otherwise the battery shall meet the test requirements of 3.9.20.b.

a. If the battery uses protective circuitry (the battery while under load), the protective circuitry shall allow the battery to discharge down to 20.0 volts before stopping the discharge. If protective circuitry is utilized to stop the discharge, there must be a time delay of 30 seconds before the battery is removed from the DC bus to allow for voltage dips below 20.0 volts during engine starts. If at any time during the 30 second time delay the battery voltage is greater than 20.0 volts then the 30 second timer shall be reset. If the battery open circuits at 20.0 volts, the battery must stay off line (no on-off-on-off chatter) until a charge voltage of not less than 24.0 volts or greater is applied to the battery terminals.

b. Whether or not protective circuitry is used, the battery shall be capable of storage at 0.0 volts (see 6.14.5) in uncontrolled temperature conditions from -40° C to +50° C (-40° F to +122° F) for not less than 168 ±2 hours without damage. After such storage, the battery shall deliver not less than the capacity specified by the applicable specification sheet after being tested in accordance with 4.5.20. The battery shall also meet the requirements of 3.8.1 during and after charge and discharge.

3.9.21 Impact resistance (nonmetallic battery container only). The nonmetallic battery container shall not crack on the inside opposite the point of impact after being tested in accordance with 4.5.19.

3.9.22 Output performance. The battery shall produce not less than the potential specified in the applicable specification sheet during the test of 4.5.21.

3.9.23 Discharge and charge at 71° C. The battery shall produce not less than the potential specified in the applicable specification sheet during the test of 4.5.22. When being discharged in accordance with 4.5.22.f, the battery shall show not less than 75 percent of its nominal rated capacity. The battery shall also meet the requirements of 3.8.1.

3.9.24 Cold and hot temperature charge. The battery shall produce not less than the capacity and potential specified in the applicable specification sheet after being discharged in accordance with 4.5.23. The battery shall also meet the requirements of 3.8.1.

3.9.25 Vibration. During the random vibration tests of 4.5.26, the fluctuation of the cell or battery voltage shall be not greater than 1.5 volts of the load voltage and shall not fall below the minimum closed circuit voltage specified in the applicable specification sheet. Also, the fluctuation of the cell or battery output current shall be not greater than 10 percent of the load current.

3.9.26 Transient drop test. Samples tested in accordance with 4.5.27 shall not show:

a. Explosion, flame, fire, venting of solid material, disassembly, cell leakage, or rupture of cell or battery within 24 hours after the completion of the test.

b. The cell or battery shall not produce shrapnel within 24 hours after the completion of the test.

c. Liquid leakage or spilling of liquid at any time during the test. Liquid discharge visible from outside the battery or detectable within the battery shall not occur during testing.

3.9.27 Shock (crash safety). The battery shall perform as follows after being tested in accordance with 4.5.29.

a. The battery's normal attachment points (such as brackets, flanges, or hold-down bars) shall retain the entire battery intact in the test fixture during and after the test.

b. Mechanical bending and distortion are acceptable.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 Qualification inspection. Qualification inspection shall consist of the examinations and tests specified in the applicable specification sheet and S9310-AQ-SAF-010 safety testing (see 6.4, 6.5, 6.17.1, and 6.17.2). The specification sheets also list the order in which the tests shall be conducted. The samples shall be representative of the items intended to be supplied under this specification. The samples shall not be produced with the use of any equipment or procedure not normally used in production of the battery. Eighteen complete batteries and one dry unassembled battery with all parts shall be furnished for inspection, if new cell technology. If existing cell technology is utilized, then 10 complete batteries and one dry unassembled battery with all parts shall be furnished for inspection. If the battery has an integral charger, then all qualification samples shall contain the integral charger; in addition, one charger shall be supplied separately from the battery. If receptacles that are dimensionally equivalent to MIL-PRF-18148/3 receptacles are used, then five wormgear retaining pins shall be furnished for inspection. If the outer battery container is nonmetallic, two such containers and a piece of the container material at least 15.24 centimeters (6 inches) by 7.62 centimeters (3 inches) (nominal) shall be supplied as test samples for qualification testing. All samples shall be marked with identifying information in accordance with 3.7 (see 6.2.d).

4.3 Conformance inspection. Conformance inspection shall consist of the tests specified in the applicable specification sheet (see 6.6, 6.7, and 6.8). Batteries produced under this specification shall be identical in every respect to the qualification sample tested and found satisfactory, except for changes previously approved by the Government. Any unapproved changes from the qualification sample shall constitute cause for rejection.

4.3.1 Inspection of product. Every battery shall be subjected to and pass group A tests; each shall also have been part of the same inspection lots from which group B samples were selected and which passed group B testing. Batteries produced under this specification shall successfully complete groups A and B inspection (see 4.3.4 and 4.3.5).

4.3.2 Inspection lots. Units shall be compiled into inspection lots (see 6.14.7 and 6.14.11). Unless otherwise specified by the contract or purchase order, the inspection lot size shall be determined as follows:

a. When the entire stock quantity specified by a contract, delivery order, or purchase order is to be delivered at one specified time, no more than two lot codes (see 3.7.6) shall appear among the units in a particular inspection lot. A specific lot code shall not be found in any more than two inspection lots.

b. When the entire contract quantity is to be delivered in several shipments over a period of months or years (such as direct vendor delivery style contracts), the inspection lot size and resulting sample quantity shall consist of the quantity of batteries that the Government or contractor estimates will be delivered during a period of up to three months.

4.3.3 Sample size and selection for groups A and B inspection. Each unit shall undergo group A inspection (see 6.8). Unless otherwise specified by the contract or purchase order, the sample size for group B shall be as shown in table IV (see 6.2.d).

4.3.4 Group A inspection. Each unit shall be subjected to the examination and test requirements in the applicable specification sheet (see 6.8). Each unit shall meet the requirements for group A inspection in the applicable specification sheet. Defective units discovered during group A inspection shall be individually rejected. Corrective action for group A strength of vent tube failures (see 3.9.5 and 4.5.6) shall be provided to the qualifying activity for approval before start of manufacture of the next production lot.

4.3.5 Group B inspection. The group B tests shall be performed in accordance with the applicable specification sheet (see 6.8).

4.4 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the following test conditions.

4.4.1 Temperature and storage conditions. Unless otherwise specified in the description of the test, all measurements, tests, and capacity discharges shall be made at room temperature, ambient atmospheric pressure, and ambient relative humidity. Unless otherwise specified in the description of the test, room temperature for all tests except group A inspection shall be 25° ±5° C (77° ±9° F). Room temperature for group A inspection shall be 24° ±8° C (75° ±15° F). Unless otherwise specified in the description of the test, all high and low temperature charge and discharge tests shall be conducted at the temperature indicated in the applicable test paragraph; a tolerance of ±2° C (4° F) shall be allowed. Stabilize the battery in the environmental chamber at the specified temperature for 22 ±2 hours before discharge.

4.4.2 Constant potential charging method. Unless otherwise specified in the applicable specification sheet, constant potential charge the batteries at 28.25 ±0.25 volts for 2.0 ±0.1 hours.

The power source used for charging shall have a current capacity of not less than 300 amps to simulate an aircraft 28 volt DC bus. If the battery contains a heater circuit, the circuit shall be energized during the complete charge (see 3.5.9).

4.4.3 Discharges. For all discharges, the current, resistance, or voltage (whichever is applicable) shall be maintained within ±1 percent of the value specified in the applicable test at all times, and the duration of the discharges shall be within ±2 percent of the nominal discharge time. Unless otherwise specified by the test, all discharges shall be continuous.

4.4.4 Mounting. For the vibration and mechanical shock tests, the mounting shall be by normal aircraft attachment points (see figure 3). Vibration isolators shall not be used. For all other tests, the bottom of the battery shall be supported on a rigid surface.

4.4.5 Repeat upon failure of test. Unless otherwise specified in the description of the test, if the battery fails to meet the specified minimum requirements of any electrical test except 4.5.8, 4.5.9, 4.5.21, or 4.5.23, the sample shall have failed the test. If the battery fails 4.5.8, 4.5.9, 4.5.21, or 4.5.23, the battery shall be recharged as described in 4.4.2, after which the test will be repeated. Inability to meet the specified minimum requirements during the repeated test shall constitute a failure of that particular sample. If the battery meets the requirements of the repeated test, the specified test schedule shall be resumed.

4.5 Methods of inspection. The tests on each battery shall be performed in the order listed in the applicable specification sheet. The following tests and examinations (see 6.11) shall be performed as follows.

4.5.1 Incoming inspection. Examine the battery container for the requirements of 3.9.1.

4.5.2 Visual and mechanical examination. Examine the battery for the requirements of 3.9.2.

4.5.3 Dimensions and weight. Examine the battery for the requirements of 3.9.3. Measure the weight of each sample. Examine each dimension of the following samples:

a. Qualification inspection: Each sample.

b. Group A inspection: On 2 percent of the batteries in the lot or not less than one battery from the lot (whichever is greater).

c. Group B inspection: On one battery from the lot.

4.5.4 Open circuit voltage. Measure and record the open circuit voltage of the test sample before and after each test. Examine the items for the requirements of 3.9.8.

4.5.5 Dielectric strength and insulation resistance test. During group A inspection, perform this test on 5 percent of the units. For dielectric strength, apply a DC potential of 500 ±25 volts for 60 +5, -0 seconds to the following combination of components. For insulation resistance, apply an alternating 500 ±25 $volts_{RMS}$ for 60 +5, -0 seconds to components listed below. Test the following combinations of components:

a. The current-carrying parts of the battery and the battery case.

b. The heater pins of the auxiliary connector and the current-carrying parts of the battery.

c. The pins of the auxiliary connector and the battery case.

Measure the insulation resistance of the components listed above in accordance with MIL-STD-202, method 302, test condition B, for 60 seconds. Examine the items for the requirements of 3.9.4.

4.5.6 Strength of vent tubes test. If vent tubes are applicable: Place one battery directly on top of a second, identical, test sample battery. Orient both batteries in the same direction. Lift the test sample (bottom) battery by both vent tubes to a height of 12.7 centimeters (5 inches) (nominal) above the work surface for a period of 10 seconds. Observe any evidence of shearing, binding, or deterioration at the point of connection of the vent tube and the test sample battery. Examine the test sample battery for the requirements of 3.9.5. During group A inspection, perform this test on 5 percent of the units. If a failure occurs during group A inspection, then 100 percent of the units shall be tested in that lot (see 4.3.4).

4.5.7 Electrical test preparation. Discharge the battery at the 1.0 C-rate to 20.0 volts. Charge the battery at 28.25 ±0.25 volts for 16.0 ±0.1 hours.

4.5.8 Capacity discharge. Stabilize the battery at the temperature(s) specified by the applicable specification sheet (e.g., -40° C, 20° C, and 55° C). Discharge the battery at the 1.0 C-rate to the cutoff voltage specified by the applicable specification sheet. Constant potential charge the battery in accordance with 4.4.2. For group A conformance inspection, any charge method (4.4.2 or other method not listed in section 4) may be selected as long as all batteries are charged by the same method and still meet all the requirements of this specification. Examine the battery for the requirements of 3.9.9 and requirement (1) of table III. For group A, requirement (4) of table III shall be used.

4.5.9 High and low voltage charge test. This test consists of the following steps.

a. Discharge the battery at the C-rate to a cutoff voltage of 20.0 volts.

b. Constant potential charge the battery in accordance with 4.4.2 except using a voltage of 22.0 volts.

c. Discharge the battery at the C-rate to a cutoff voltage of 20.0V.

d. Constant potential charge the battery at 28.25 ±0.25 volts for 16.0 ±0.1 hours.

e. Discharge the battery at the C-rate to a cutoff voltage of 20.0V.

f. Constant potential charge the battery in accordance with 4.4.2 except using a voltage of 29.0 volts.

g. Discharge the battery at the C-rate to a cutoff voltage of 20.0V.

h. Examine the battery for the requirements of 3.8.1 and 3.9.10.

4.5.10 Strength of receptacle test. If the battery uses a MIL-PRF-18148/3 receptacle or equivalent, insert a grooved steel shaft that mates with the receptacle socket such that the socket pins are secured in the steel shaft. Subject the steel shaft to a torsion force of 8.1 ±0.7 Newton-meters (6 ±0.5 foot-pounds). Examine the receptacle mounting for the requirements of 3.9.11.

4.5.11 Cycling test. Subject the battery to 600 cycles of discharge-charge-open circuit and to the temperature environments below. This test consists of the following steps.

a. Constant potential charge the battery at 28.25 ±0.25 volts for 2.0 ±0.1 hours at room temperature (see 4.4.1).

b. First sequence: Cold temperature environment (cycles 1 through 100).

(1) Stabilize the battery temperature at -18° C (0° F) (see 4.4.1). Perform steps 4.5.11.b(2) through 4.5.11.b(5) with the battery in the -18° C (0° F) temperature environment.

(2) Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

(3) Immediately after completing step 4.5.11.b(2), constant potential charge the battery at 28.25 ±0.25 volts for 2.0 ±0.1 hours.

(4) Place the battery on open circuit for a period of 1.0 ±0.1 hours.

(5) Repeat above steps 4.5.11.b(2) through 4.5.11.b(4) for a total of 100 cycles.

c. Second sequence: Hot temperature environment (cycles 101 through 200).

(1) Stabilize the battery temperature at 43° C (110° F) (see 4.4.1). Perform steps 4.5.11.c(2) through 4.5.11.c(5) with the battery in the 43° C (110° F) temperature environment.

(2) Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

(3) Immediately after completing step 4.5.11.c(2), constant potential charge the battery at 28.25 ±0.25 volts for 2.0 ±0.1 hours.

(4) Place the battery on open circuit for a period of 1.0 ±0.1 hours.

(5) Repeat above steps 4.5.11.c(2) through 4.5.11.c(4) for a total of 100 cycles.

d. Third sequence: Ambient temperature environment (cycles 201 through 300).

(1) Stabilize the battery temperature at 24° C (75 °F) (see 4.4.1). Perform steps 4.5.11.d(2) through 4.5.11.d(3) with the battery in the 24° C (75 °F) temperature environment.

(2) Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

(3) Immediately after completing step 4.5.11.d(2), constant potential charge the battery at 28.25 ±0.25 volts for 2.0 ±0.1 hours.

(4) Place the battery on open circuit for a period of 1.0 ±0.1 hours.

(5) Repeat above steps 4.5.11.d(2) through 4.5.11.d(4) for a total of 100 cycles.

e. Repeat steps 4.5.11.b through 4.5.11.d for a total of 600 cycles.

f. Stabilize the battery temperature at 24° C (75° F) and discharge at the 1C-rate to 20.0 volts.

g. Examine the battery for the requirements of 3.9.12.

4.5.12 Electromagnetic interference. Electromagnetic interference shall be conducted in accordance with MIL-STD-461 test procedures of CE102, CS101, CS114, CS115, CS116, RE102 and RS103 (30 MHz to 18 GHz at 200 v/m). The test setup shall include the battery, a battery charger (power source), and DC load all connected to a common bus. Line impedance stabilization networks (LISNs) shall be installed on both the 28 VDC power leads and on the 115 VAC, single-phase heater circuit. The charger and DC load shall be located outside of the EMI chamber. Testing shall be conducted for two modes of operation, discharging at a 5-ampere rate with the charger off and charging/floating on the load bus at any rate of charge with the charger on. The battery shall remain on and connected to the load bus throughout the test and shall not disconnect from the bus. The functionality of the battery shall be demonstrated and recorded before and after each EMI test by discharging the battery to cutoff and recharging the battery. Examine the battery for the requirements of 3.9.6, 3.9.7, and 3.9.14.

4.5.13 Charge and discharge test at low temperature. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2 at room temperature (see 4.4.1).

b. Place the battery in a temperature chamber at -18° C (0° F) and stabilize the battery (see 4.4.1). Perform the following with the battery in the temperature environment.

c. Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

d. Examine the battery for the requirements of 3.9.9 and requirement (3) of table III.

e. Constant potential charge the battery in accordance with 4.4.2.

f. Immediately following charge, remove the battery from the test chamber. Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

g. Examine the battery for the requirements of 3.9.9 and requirement (3) of table III.

4.5.14 Discharge while inverted. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2 at room temperature (see 4.4.1).

b. Invert the battery (see 6.14.10).

c. Discharge the battery at the 4.0C-rate for 5 minutes or to a cutoff voltage of 20.0 volts, whichever occurs first. At 2.5 minutes into the discharge, place the battery upright.

d. Examine the battery for the requirements of 3.6.2 and requirement (4) of table III.

4.5.15 Temperature rise and float test. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2.

b. Place the battery in a temperature chamber at 49° C (120° F) for not less than 12 hours.

Perform the following with the battery in the 49° C (120° F) temperature environment.

c. Discharge the battery at the 4.0C-rate for 5 minutes or to a cutoff voltage of 20.0 volts, whichever occurs first.

d. Immediately after the 4.0C-rate discharge and with the battery still in the temperature chamber, constant potential charge the battery at 28.6 ±0.10 volts for 24 ±0.1 hours.

e. Stabilize the battery temperature at room temperature (see 4.4.1). Discharge the battery at the 1.0 C-rate to a cut-off voltage of 20.0 volts.

f. Record voltage, current, and time throughout the test.

g. Repeat steps 4.5.15.a through 4.5.15.f for a total of 3 cycles.

h. Remove the battery from the temperature chamber.

i. Examine the battery for the requirements of 3.9.15.

4.5.16 Short circuit test. Continuously monitor and record voltage, current, pressure, and temperature. Bypass all external and accessible internal electrical safety devices and short the test sample through a load of not greater than 0.002 ohm. The load shall remain attached for not less than 24 hours. Verify that the test sample met the requirements of 3.8.1.a and 3.8.1.c.

4.5.17 Thermal protection. Place each test sample in a temperature chamber at 82 ±2° C (180 ±4° F) for not less than 2 hours. Check each sample to verify that the thermal protection is closed. Raise the temperature to 88 ±2° C (190 ±4° F). After 45 minutes, check each sample to verify that the switch or thermal protection is open. Lower the temperature to 82 ±2° C (180 ±4° F) and check each sample after 45 minutes to verify that the thermal protection is closed. Examine the thermal protection for the requirements of 3.8.2.

4.5.18 Physical integrity at high temperature test. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2.

b. Discharge the battery at the 1.0C-rate to a cutoff voltage of 20.0 volts.

c. Constant potential charge the battery in accordance with 4.4.2.

d. Place the battery in a temperature chamber at 85° C (185° F) for 16 ±0.1 hours.

e. Remove the battery from the temperature chamber. Lift the battery by its vent tubes.

f. Expose the battery to room temperature for 1 hour (see 4.4.1).

g. Discharge the battery at the 4.0C-rate for 3 minutes.

h. Examine the battery for the requirements of 3.9.13.

i. Stabilize the battery at room ambient conditions (see 4.4.1).

j. Constant potential charge the battery in accordance with 4.4.2.

k. Discharge the battery at the 1.0C-rate to a cutoff voltage of 20.0 volts.

l. Examine the battery for the requirements of 3.8.1 and requirement (1) of table III.

4.5.19 Impact resistance test (nonmetallic battery container). This test consists of the following steps.

a. Rest an undamaged nonmetallic container for not less than 24 hours after manufacture.

b. Place the container on a flat steel plate which is not less than 25 centimeters (1 inch) longer and wider than the container. Position the container such that the ball will strike one-third down from the top of the container and near the centerline of the sides.

c. Condition the container for 4 hours at 71° C ±3° C (160° F ±5° F).

d. Drop a free-falling 0.907 ±0.023-kilogram (2.00 ±0.05-pound) solid steel ball one time on the container from a height of 2.29 meters (90 inches) (nominal).

e. Examine the container for the requirements of 3.9.21.

f. Repeat step 4.5.19.c but use a temperature of -18° C ±1° C (0° C ±2° F). Repeat step 4.5.19.d but use a height of 1.52 meters (60 inches) (nominal). Repeat step 4.5.19.e.

g. Repeat step 4.5.19.c but use a temperature of -40° ± 1° C (-40° ±2° F). Repeat step 4.5.19.d but use a height of 1.27 meters (50 inches) (nominal). Repeat step 4.5.19.e.

4.5.20 Deep discharge recovery test. This test consists of the following steps:

a. Discharge the battery at the C-rate to 20.0 volts at room temperature (see 4.4.1).

b. Connect a resistive load of 1.0 ohms across the battery terminals. Place the battery in a 50° C (122° F) environment for 168 ±2 hours.

c. Place the battery in the ambient conditions of 4.4.1 for not less than 24 hours.

d. Constant potential charge the battery in accordance with 4.4.2 for 30 ±0.1 hours.

e. Place the battery on open circuit for a period of 1.0 ±0.1 hours.

f. Discharge the battery at the C-rate to 20.0 V.

g. Constant potential charge the battery in accordance with 4.4.2.

h. Place the battery on open circuit for a period of 1.0 ±0.1 hours.

i. Discharge the battery at the C-rate to 20.0 V.

j. Examine the battery for the requirements of 3.9.20.

4.5.21 Output performance test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2

b. Stabilize the battery at a temperature of 65° C (149° F) for 22 ±2 hours on open circuit. Perform steps (c) through (e) with the battery in the 65° C (149° F) temperature environment.

c. Discharge the battery at the 1.0 C-Rate for 1.0 ±0.1 hour of 20.0 volts whichever occurs first.

d. Immediately after discharge, constant potential charge the battery in accordance with 4.4.2. Rest battery on open circuit for 22 ±2 hours.

e. Repeat steps (c) and (d) for a total of 5 cycles.

f. At the completion of cycle 5, stabilize the battery at a temperature of -29° C (-20° F) for 22 ±2 hours on open circuit (see 4.4.1).

g. Discharge the battery in accordance with applicable specification sheet to a cutoff voltage of 20.0 volts.

h. Examine the battery for the requirements of 3.9.22.

4.5.22 Discharge and charge at 71° C. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2.

b. Stabilize the battery's temperature at 71° C (160° F) for 24 ±0.1 hours.

c. With the battery still in the temperature chamber at 71° C (160° F), discharge the battery in accordance with the applicable specification sheet.

d. With the battery still in the temperature chamber at 71° C (160° F), constant potential charge the battery in accordance with 4.4.2.

e. Stabilize the battery at room ambient conditions (see 4.4.1).

f. With the battery at room temperature, discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

g. With the battery at room temperature, constant potential charge the battery in accordance with 4.4.2.

h. Examine the battery for the requirements of 3.9.23.

4.5.23 Cold and hot temperature charge test. This test consists of the following steps.

a. Constant potential charge the battery in accordance with 4.4.2.

b. Stabilize the battery's temperature at the test temperature specified in the applicable specification sheet (see 4.4.1). Perform steps 4.5.23.c through 4.5.23.e with the battery in the environmental chamber at the specified temperature.

c. Discharge the battery in accordance with the specification sheet.

d. Stabilize the battery's temperature at the test temperature specified in the applicable specification sheet.

e. Constant potential charge the battery in accordance with 4.4.2.

f. Immediately after completing 4.5.23.e, place the battery in a room temperature environment (see 4.4.1) and discharge the battery in accordance with the specification sheet.

g. Examine the battery for the requirements of 3.9.24.

4.5.24 Wormgear retaining pin hardness. Mount and polish five samples of the wormgear retaining pins, making polished metallurgical cross-sections. Use a 100-gram load and a Knoop micro-hardness tester to make 6 indentions on each of the five pins. Average the results for each pin. Calculate the hardness of the pins and convert the results to the Rockwell C scale. Examine the pins for the requirements of 3.5.5.

4.5.25 Low pressure (altitude). This test consists of the following steps:

a. Subject the test sample to explosive decompression in accordance with MIL-STD-810, method 500.4, procedure IV.

b. Perform the tests of 4.5.2 and 4.5.3.

c. Examine the battery for the requirements of 3.9.3.

d. Perform the tests of 4.5.4 and 4.5.8.

e. Examine the battery for the requirements of 3.8.1, 3.9.6, and 3.9.7.

4.5.26 Vibration test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. For all batteries using the MIL-PRF-18148/3 main battery receptacle: Connect two AN-6 cables to the positive terminal and another two AN-6 cables to the negative terminal. Clamp the cables to the test fixture at a cable length of 46 ±5 centimeters from the battery.

c. Mount the battery assembly, including connector and cables, to the test fixture via the normal battery attachment points (see 4.4.4).

d. Vibrate the battery along each orthogonal axis (in the axis order shown on figure 3) in accordance with the test levels of table V to provide a composite level of 59.62 meters per second squared (6.08 g_{RMS}). The random vibration cycling time in each axis shall be 1 hour.

e. Constant potential charge the battery in accordance with 4.4.2 at 28.25 ±0.50 volts during vibration. Discharge the battery at the 1.0 C-rate for 10 minutes before beginning each axis.

f. After completion of the vibration test, constant potential charge the battery in accordance with 4.4.2.

g. Discharge the battery at the 4.0C-rate for 3 minutes.

h. Examine the battery for the requirements of 3.8.1, 3.9.3, 3.9.6, 3.9.7, 3.9.13, and 3.9.25.

4.5.27 Transient drop test. This test consists of the following steps:

a. Constant potential charge the battery or cell in accordance with 4.4.2.

b. Perform four drops from a height of 122 centimeters (48 inches) allowing the test unit to bounce and naturally come to a resting position. After each drop visually inspect the test item and note any obvious damage. Document the impact points. The test item shall not be dropped subsequent times on the same face.

(1) Prismatic – Drop the test unit twice with a face parallel to the concrete surface and facing downward upon release, but need not be parallel upon impact. Drop the test unit twice with a corner parallel to the concrete surface and facing downward upon release, but need not be parallel upon impact.

(2) Cylindrical – Drop the test unit twice with the axis of the cylinder parallel to the concrete surface and facing downward, but need not be parallel upon impact. Drop the test unit twice with the axis of the cylinder perpendicular to the concrete surface and facing downward, but need not be parallel upon impact.

c. Perform the tests of 4.5.2 and 4.5.3.

d. Examine the battery for the requirement of 3.9.26.

e. Discharge the battery at the 1.0 C-rate to a cutoff voltage of 20.0 volts.

f. Examine the battery for the requirement of 3.9.26.

4.5.28 Shock test (basic design). This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. Mount the battery to the test fixture in accordance with 4.4.4.

c. Discharge the battery at the C/2 rate during the test.

d. Subject the battery to the shock pulse of figure 4, where P equals 20 *g* and D equals 11 milliseconds. Shock the battery in a normal upright position (see 6.14.10) and in two additional mutually perpendicular directions from the vertical. However, the battery shall not be mounted or shocked in the inverted position. Deliver three shocks in both directions of each orthogonal axis for a total of 15 impacts.

e. After each shock, examine the battery for the requirements of 3.8.1.

f. After the fifteenth impact, discharge the battery at the 4.0C-rate for 3 minutes.

g. Examine the battery for the requirements of 3.9.6, 3.9.7, and 3.9.13.

4.5.29 Shock test (crash safety). This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. Mount the battery to the test fixture in accordance with 4.4.4.

c. Subject the battery to the shock pulse of figure 4, where P equals 40 *g* and D equals 11 milliseconds. Shock the battery in a normal upright position (see 6.14.10) and in two additional mutually perpendicular directions from the vertical. However, the battery shall not be mounted or shocked in the inverted position. Deliver two shocks in both directions of each orthogonal axis for a total of 10 impacts.

d. After each axis of shock, dismount the battery from the test fixture.

e. Examine the battery and its attachment points for the requirements of 3.9.27.

f. After the last impact, remove the battery from the test fixture. Discharge the battery at the 4.0C rate for three minutes.

g. Examine the battery for the requirements of 3.9.13 and 3.9.27.

4.5.30 Altitude test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.1 and 4.4.2.

b. Immediately after completion of charge, place the battery inside an environmental chamber.

c. Within 15 minutes after completing step 4.5.30.b, lower the chamber temperature to -29° C (-20° F) and lower the pressure inside the chamber to simulate the ambient pressure at 18,288 meters (60,000 feet) altitude. Perform the remainder of the test with the battery in the temperature environment. Invert the battery for 2 minutes while the chamber air pressure is being reduced and then return the battery to its normal upright position (see 6.14.10).

d. Discharge the battery at the 4.0C-rate for 3 minutes. Examine the battery for the requirements of 3.9.13.

e. Constant potential charge the battery in accordance with 4.4.2 for 2.0 ±0.1 hours. Invert the battery for 5 minutes during the 2-hour charge and then return the battery to its normal upright position.

f. Open-circuit the battery and, within 5 minutes, return the chamber to ground ambient air pressure (see 4.4.1). Invert the battery for 2 minutes while the chamber air pressure is being increased to ground ambient and then return the battery to its normal upright position.

g. Discharge the battery at the 4.0C-rate for 3 minutes. Examine the battery for the requirements of 3.9.13.

h. Repeat step 4.5.30.c. Repeat steps 4.5.30.e, 4.5.30.f, and 4.5.30.g.

i. Examine the battery for the requirements of 3.6.2, 3.8.1, 3.9.6, and 3.9.7.

4.5.31 Humidity test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. Gradually raise the internal chamber temperature to 60° C (140° F) and the relative humidity to 95 ±5 percent over a period of 2.0 ±0.1 hours.

c. Maintain the conditions of step 4.5.31.b for not less than 6 hours.

d. Maintain not less than 85 percent relative humidity and reduce the internal chamber temperature in 8.0 ±0.1 hours to 30° C (86° F) and 95 ±5 percent relative humidity.

e. Maintain the 30° C (86° F) and 95 ±5 percent relative humidity for an additional 8.0 ± 0.1 hours.

f. Repeat steps 4.5.31.b, 4.5.31.c, and 4.5.31.d for a total of 10 cycles (not less than 240 hours).

g. While the battery is still in the chamber, C-rate discharge the battery for 15 ±1 minute.

h. While the battery is still in the chamber, constant potential charge the battery in accordance with 4.4.2.

i. Remove the battery from the chamber and open-circuit the battery for 8.5 ±7.5 hours.

j. Examine the battery for the requirements of 3.8.1.

k. Discharge the battery at the 4.0C-rate for 3 minutes.

l. Examine the battery for the requirements of 3.9.6, 3.9.7, and 3.9.13.

4.5.32 Salt fog test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. Open-circuit the battery.

c. Dissolve 0.91 kilograms (2 pounds) (nominal) of salt into 17.24 kilograms (38 pounds) (nominal) of distilled or demineralized water. The resistance of the water shall be not less than 500,000 ohms per centimeter. The salt shall contain not greater than 0.1 percent sodium iodide per weight and shall contain not greater than 0.5 percent total impurities. The pH of the solution shall range from 6.5 to 7.2. Add the solution to the salt fog test chamber and prepare the chamber for use. Stabilize the temperature of the chamber at 35° ±5° C (95° ±3° F).

d. Place not less than two salt fog collection receptacles in the chamber, with one placed nearest to the nozzle and one farthest from the nozzle. These shall be approximately 10 cm (4 in.) diameter and shall collect from 0.5 to 3 milliliters of solution per hour for each 80 square centimeters of horizontal collecting area in an average test of not less than 16 hours.

e. Place the battery in the salt fog chamber. Elevate the battery above the floor of the chamber such that the bottom of the battery does not rest in any liquid.

f. Continuously atomize the salt solution into the test chamber for 48 ±2 hours. Measure the salt fog fallout rate and pH of the fallout solution at not less than 24-hour intervals.

g. Remove the battery from the salt fog chamber.

h. Open-circuit the battery for 8.5 ±7.5 hours.

i. Examine the battery for the requirements of 3.8.1.

j. Discharge the battery at the 4.0C-rate for 3 minutes.

k. Examine the battery for the requirements of 3.8.1, 3.9.6, 3.9.7, and 3.9.13.

4.5.33 Temperature shock test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2. Upon completion of charge, the battery shall remain on open-circuit through the completion of step 4.5.33.i.

b. Place the battery in a temperature chamber at 71° C (160° F) and expose the battery for 4.00 ±0.25 hours. At the end of this exposure period, lift the battery by its vent tubes.

c. At the conclusion of this time period, transfer the battery, within 5 minutes, to a chamber with an internal chamber temperature of -57° C (-70° F).

d. Expose the battery to -57° C (-70° F) for 4.00 ±0.25 hours. At the end of this exposure period, lift the battery by its vent tubes.

e. At the conclusion of this time period, transfer the battery, within 5 minutes, to a chamber with an internal chamber temperature of 71° C (160° F).

f. Expose the battery to 71° C (160° F) for 4.00 ±0.25 hours. At the end of this exposure period, lift the battery by its vent tubes.

g. Repeat steps 4.5.33.c through 4.5.33.f.

h. Repeat steps 4.5.33.c and 4.5.33.d.

i. Return the battery to room temperature and stabilize.

j. Discharge the battery at the 4.0C-rate for 3 minutes.

k. Examine the battery for the requirements of 3.8.1, 3.9.6, 3.9.7, and 3.9.13.

4.5.34 Fluid susceptibility. This test consists of the following steps:

a. Conduct the fluid susceptibility test in accordance with MIL-STD-810, method 504 using fluids:

(1) Fuels: Kerosene aviation turbine fuel.

(2) Hydraulic oils: Mineral oil based.

(3) Lubricating oils: Ester based (synthetic).

(4) Solvents and cleaning fluids: Cleaning compound for aircraft surfaces.

b. Spray the battery with the appropriate fluid one or more times per day to maintain a wetted condition for a time not less than 24 hours.

c. Place the battery in a temperature chamber at 65° C (149° F) for 24 ±0.1 hours.

d. Return the battery to room temperature (see 4.4.1) and stabilize for 2 ±0.1 hours.

e. Examine the battery for the requirements of 3.8.1, 3.9.2, and 3.9.3.

f. Perform the tests of 4.5.4 and 4.5.8.

g. Examine the battery for the requirements of 3.8.1, 3.9.3, 3.9.6, 3.9.7, and 3.9.8.

4.5.35 Sand and dust test. This test consists of the following steps:

a. Conduct the sand and dust test in accordance with MIL-STD-810, method 510.4, procedure I.

b. Perform the tests of 4.5.2 and measure the dimensions of 4.5.3.

c. Examine the battery for the requirements of 3.8.l, 3.9.2, and 3.9.3.

d. Perform the tests of 4.5.4 and 4.5.8.

e. Examine the battery for the requirements of 3.8.1, 3.9.6, 3.9.7, 3.9.8, and 3.9.9.

4.5.36 Ground storage test. This test consists of the following steps:

a. Constant potential charge the battery in accordance with 4.4.2.

b. Place the battery in a temperature chamber at 50° C (122° F) for 30 days on open-circuit.

c. After the storage period, remove the battery from the chamber and let it stand open-circuit for 8 ±2 hours.

d. Discharge the battery at the 1.0 C-rate to 20.0 volts.

e. Examine the battery for the requirements of 3.9.18.

f. Repeat steps 4.5.36.a through 4.5.36.e but for step 4.5.36.b use a temperature of -40° C (-40° F).

g. Examine the battery for the requirements of 3.9.18.

4.5.37 Shelf life test. Constant potential charge the battery in accordance with 4.4.2. Store the battery for not less than 18 months in an uncontrolled temperature environment (such as an unheated, uncooled warehouse) where the ambient air temperature shall be within the range of -40° C to +50° C (-40° F to +122° F). Bring the battery to the test facility. Constant potential charge the battery in accordance with 4.4.2. Stabilize the battery at room temperature (see 4.4.1). Discharge the battery at the C-rate to 20.0 volts. Constant potential charge the battery in accordance with 4.4.2. Subject the battery to the cycling test of 4.5.11. Examine the battery for the requirements of 3.9.12 and 3.9.19.

4.5.38 Penetration test. Test in accordance with either step (a) or step (b), see applicable specification sheet.

a. Nail penetration shall be tested in accordance with 4.5.38.a(1) through 4.5.38.a(4).

(1) Insert a 2.5mm diameter stainless steel nail with a length that exceeds the width or diameter of two cells in the battery to be tested. Insert the nail into the battery such that each cell is penetrated at right-angles to the electrode surface close to the center of the cell.

(2) Leave the nail in the cell for 24 hours.

(3) Monitor the voltage and temperature of the cell for the duration of the test.

(4) Examine the battery for the requirements of 3.9.16.

b. Bullet penetration shall be tested in accordance with 4.5.38.b(1) through 4.5.38.b(4).

(1) Secure the battery to a mounting apparatus in the same way the battery will be mounted in the end application.

(2) Impact direction.

(i) Cylindrical battery – Direct the line of fire such that it is parallel to the longitudinal axis of the battery.

(ii) Prismatic battery – Direct the line of fire through one sample battery such that it is parallel to axis 2 (see figure 3) of the battery and nominally through the centerline of the battery. Direct the line of fire through a second sample battery such that it is parallel to axis 3 (see figure 3) of the battery and nominally through the centerline of the battery in that direction. Ensure that the bullet's path goes through cells vice only through the integral charger or open areas within the battery.

(3) Fire three bullets of caliber specified by applicable specification sheet through the battery in the directions specified above. One of the bullets shall be a tracer bullet.

(4) Examine the battery in accordance with 3.9.16.

4.5.39 Crush. A battery is to be crushed between two flat surfaces. The force for the crushing is to be applied by a vise or by a hydraulic ram with a 1.25in (32mm) diameter piston. The crushing is to be continued until a pressure reading of 2500 psig (17.2 MPa) is reached on the hydraulic ram, applied force approximately 3000 pounds (13 kN). Once the maximum pressure has been obtained it is to be released. A cylindrical or prismatic battery is to be crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. A prismatic

battery is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the crushing force. Each sample battery is to be subjected to a crushing force in only one direction. Separate samples are to be used for each test. A coin or button battery is to be crushed with the flat surface of the battery parallel with the flat surfaces of the crushing apparatus. Examine the battery in accordance with 3.9.17.

4.5.40 Special tests. Cells and batteries shall be subjected to any special tests called out on the specification sheet.

4.5.41 Final examination. Without dissecting the battery, examine it for the requirements of 3.8.1. Subject the battery to the dielectric strength test of 4.5.5. Examine the battery for the requirements of 3.9.4.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The storage batteries covered by this specification are used in fixed-wing and rotary-wing military aircraft. The batteries are used for starting engines or auxiliary power units. They also provide electricity to support aircraft emergency loads, aeronautical and ground systems, and associated equipment, have non-removable covers, and are designed for maintenance-free operation (see 6.14.8). Some of the batteries may have a separate charger. Most of the batteries under this specification, however, are designed to be charged directly from the electrical bus via an integral charger that either is contained within the battery or is connected to the battery exterior. The batteries are also exposed for prolonged periods to extreme seagoing environments not encountered by civilian aircraft.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification and applicable specification sheet.

b. Packaging requirements (see 5.1).

c. Battery required, including quantity, NSN, and part or identifying number (PIN; see 6.15).

d. Qualification under this specification is required unless agreement is obtained in writing from the qualifying activity. Qualification testing and conformance inspections are required as indicated herein (see 4.2, 4.3.3, 6.8, and table IV for the quantity of samples required).

e. Whether certification of conformity is required (see 3.3).

f. Shelf-life coding for a 18-month shelf life period (see 3.9.19).

g. Responsibility for inspection and sample selection (see 6.8).

h. If certification to S9310-AQ-SAF-010 is required (see 3.8.8).

6.3 Material Safety Data Sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313. Note that 29 CFR 1910.1200 requires that the Material Safety Data Sheet for each hazardous chemical used in an operation must be readily available to personnel using the material. Contracting officers will identify the activities requiring copies of the Material Safety Data Sheet.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL-29595, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Crane Division, Naval Surface Warfare Center, Energy Power & Interconnect Technologies Division, Submarine & Aircraft Branch, Code GXSL, 300 Highway 361, Crane, IN 47522-5001 or the Electrical Power Systems Division, AIR-4.4.5.2, Bldg. 1461, Naval Air Warfare Center Aircraft Division, 48298 Shaw Road, Unit 4, Patuxent River, MD 20670-1900. The preferred qualification testing facility is the Crane Division, Naval Surface Warfare Center, Energy Power & Interconnect Technologies Division, Submarine & Aircraft Branch, Code GXSL, 300 Highway 361, Crane, IN 47522-5001. An online listing of products qualified to this specification may be found in the qualified products database (QPD) at https://assist.daps.dla.mil.

6.5 Application for qualification. Applicants obtain the approval of the qualifying activity before submitting samples for qualification inspection. The process starts when the manufacturer applies for qualification by letter to the qualifying activity indicated in 6.4. SD-6 "Provisions Governing Qualification" provides guidance concerning the necessary information and certification (see 6.10.7). Copies of the SD-6 are available from the ASSIST database at https://assist.daps.dla.mil.

6.6 Conformance inspection. Conformance inspection by the qualifying activity will be limited to the amount deemed necessary to determine compliance with the contract and will be limited in severity to the definitive quality assurance provisions established in this specification and the contract. The amount of conformance inspection by the qualifying activity may be adjusted to make maximum use of the contractor's quality control system and the quality history of the product (see 4.3). Any or all qualification tests may be performed on group B samples if the manufacturer has not supplied the product to the procuring activity for a period greater than 2 years, or if the qualifying activity suspects that the product no longer conforms to prescribed requirements. When only one sample is received for group B inspection, the qualifying activity will decide which one of the test sequences indicated by the specification sheet will be performed. If a sample does not meet the requirements of 3.9.2, the qualifying activity may terminate further test and inspection. The preferred conformance testing facility is the Crane Division, Naval Surface Warfare Center, Energy Power & Interconnect Technologies Division, Submarine & Aircraft Branch, Code GXSL, 300 Highway 361, Crane, IN 47522-5001.

6.7 Group B costs. An estimate of the qualifying activity's cost for testing for single service procurements, for use by a contractor at time of preparation of bids, may be obtained from the Crane Division, Naval Surface Warfare Center, Energy Power & Interconnect Technologies Division, Submarine & Aircraft Branch, Code GXSL, 300 Highway 361, Crane, IN 47522-5001.

6.8 Responsibility for inspection and sample selection. The qualifying activity (see 4.2, 6.2, and 6.4) performs qualification inspection on samples furnished by the contractor. The contractor performs the inspections specified for group A conformance inspection (see 4.3.4). The Government selects samples for group B conformance inspection in accordance with 4.3.3. The qualifying activity conducts group B conformance inspection (see 4.3.5). The Government reviews and examines the contractor's inspection procedures and inspection records as necessary (see 6.2.d and 6.2.g).

6.9 Charge/discharge rate discussion. The designated discharge rate is determined by multiplying the nominal rated capacity (C-rating) (see 6.14.1) in ampere-hours times the rate of discharge factor listed in a test. Some examples of charge and discharge rates (see 6.14.2) are explained below.

A battery undergoing a 1C or C-rate discharge must produce a current equal to its ampere-hour capacity for at least 60 minutes at a specified temperature before its potential drops

below the cutoff or end voltage. For example, a battery with a nominal capacity rating of 35.0 Ah/1 hr/25° C/20.0 V undergoing a 1C or a C-rate discharge must produce a current of:

1C or C-rate	=	1 × 35 ampere-hours
	=	35 amperes for at least 60 minutes at 25° C ambient temperature before the battery potential drops below the cutoff or end voltage of 20.0 volts

The charge or discharge may take place over a period other than 60 minutes or may instead continue until a desired voltage level is reached. For example, a 35-ampere-hour battery charged at C/5 for 3 hours would receive:

C/5-rate	=	35 ampere-hours ÷ 5
	=	7 amperes delivered to the battery for 3 hours

6.10 Design practices and lessons learned.

6.10.1 Cell or battery compartment. A special compartment must be designed for the cell or battery for isolation from the electronics of the end item equipment or weapon system. The compartment must have no interior projections nor sharp edges that could damage the electrical insulation around the cell or battery. The cell or battery must be secured within the compartment to reduce shock and vibration to the levels required for end item use. The compartment must be designed either to provide vent paths or else contain gases emitted by a venting battery. If vent paths are to be used, they must be identified on the compartment drawings. If the compartment is designed to contain the vented gas, the drawings must identify the pressure-containing capabilities of the compartment (including pressure level) and the containment designs or methods.

6.10.2 Switches. Battery or cell switches in the end item equipment or weapon system must be carefully selected to prevent accidental cell or battery turn-on. No switching may occur in the ground leg(s).

6.10.3 Cell or battery dissimilarity. Cells or batteries with different physical characteristics, chemistries, or electrical parameters must not be used concurrently in the same electrical circuit.

6.10.4 Dissimilar metals. MIL-STD-889 provides methods for protecting joined dissimilar metals (see 3.4).

6.10.5 Charging the battery from the aircraft DC bus on the aircraft. Due to such factors such as internal impedance, polarization effects, and gassing during charging, batteries do not charge at 100 percent efficiency. Therefore, a nominal 26-volt battery needs a potential of 28.0 ±0.5 volts for proper charging. The period of time required to reach full charge is affected by charging potential and battery temperature. Charging while at the lower end of the potential

range will require a longer period of time than at the higher end. As battery temperatures decrease, higher charging potentials are required for optimum charging efficiency. The characteristics of power provided by the aircraft DC bus, as well as aircraft power characteristics in general, are often specified in accordance with MIL-STD-704. When determining whether the battery can be adequately charged from the bus, designers must consider how heavily the DC bus is loaded, what percentage of the time the potential is outside the charging range, how often batteries will be charging versus supplying the bus, the potential for load growth on a bus that is currently satisfactory, the ambient temperature of the battery compartment, and similar situations. If the power provided to the battery is not sufficient for proper charging, special arrangements (such as a charger or dedicated transformer/rectifier) will be required to ensure that batteries will be properly charged within an acceptable period of time.

6.10.6 Additional battery information. See NAVSO P-3676, Navy Primary and Secondary Batteries: Design and Manufacturing Guidelines, for additional information on batteries. Copies are available from Customer Service (Code 033343), NAVSUP Weapon Systems Support, 700 Robbins Avenue, Philadelphia, PA 19111.

6.10.7 Additional qualification information. See SD-6 for guidance on obtaining qualification. The document describes the manufacturer's obligations to:

a. Maintain process and quality control procedures that ensure that the items comply with all specification requirements.

b. Immediately report any discrepancies disclosed during testing or periodic reexamination of the product and his production process controls.

c. Ensure that delivered items conform to all specified product characteristics (in no way relieving manufacturers of contractual obligations to ensure delivered items comply with all specification requirements).

6.11 Test equipment and facilities. Measurements should be performed (see 4.5) with equipment that has the following characteristics. Test equipment and inspection facilities should have sufficient accuracy, quality, and quantity to permit performance of the required inspection. Test and measurement equipment should be calibrated and traceable to the National Institute of Standards and Technology. All voltmeters and ammeters should be accurate within ±0.5 percent of the full scale reading. The range of analog type meters should be such that the readings are taken on the upper half of the scale. Timers should be accurate within ±0.5 percent. The sensitivity of voltmeters should be not less than 5000 ohms per volt. In all tests involving discharge through a resistance, the total circuit resistance should be accurate within ±1 percent. For all discharges, the current or voltage (whichever is applicable) should be maintained within ±1 percent of the specified value at all times, and the duration of the discharges should be within ±2 percent of the nominal discharge time. All discharges will be continuous unless otherwise stated.

6.12 Safety and storage. Lithium batteries with aluminum battery containers should not be maintained in the same area as vented nickel-cadmium batteries. The potassium hydroxide electrolyte of the nickel-cadmium battery will damage aluminum. However, lithium batteries with aluminum battery containers may be stored together. S9310-AQ-SAF-010 contains additional storage procedures.

6.13 Disposal. End users will comply with federal, state, and local regulations and S9310-AQ-SAF-010 for disposal of used batteries. Such items should be sent to the end user's local Defense Reutilization and Marketing Office, which will dispose of the items via contracts for recycling or other means.

6.14 Definitions.

6.14.1 Capacity. A measure of the energy content of a battery, usually stated in terms of ampere-hours. Capacity is computed by multiplying the number of amperes flowing from a cell or battery on discharge (at a given temperature and down to a specified end voltage) by the time in hours the cell or battery will deliver the amperes of current (see 3.9.9 and 6.14.9). An example of a shorthand way of stating capacity is 35.0 Ah/1 hr/25° C/20.0 V, which means the battery provides not less than 35.0 ampere-hours of capacity when continuously discharged at 35 amperes for not less than 1 hour while maintaining a voltage of not less than 18.0 volts at the battery terminals, all of which occurs in an ambient air temperature of 25° C.

6.14.2 Charge or discharge rate. The amount of current and length of time required to charge or discharge a battery or cell (see 3.9.9 and 6.9). Unless otherwise specified herein or in the specification sheet, the rate is expressed as xC, where x is a multiplier and C is the capacity required by the specification sheet. When stated as the C-rate, x equals 1.

6.14.3 Cut-off voltage. A specified voltage during the discharge of a cell or battery at which point the discharge will be terminated (see 3.9.9 and 4.5.8).

6.14.4 Cycle. A combination of a charge and discharge (see 3.9.12).

6.14.5 Fully discharged battery. A fully discharged battery or cell will have been discharged to show an output voltage of 0.0 volts. This can be accomplished by cutoff circuitry. Such batteries and cells are entirely capable of recovering the capacity specified by the applicable specification sheet (see 3.9.20).

6.14.6 Initial voltage delay. Initial voltage delay is the time required at the beginning of discharge for the cell or battery to reach minimum voltage after the load is applied (see 3.9.9).

6.14.7 Inspection lot. The quantity of batteries, harnesses, or components of any one type, produced at any one place of manufacture, submitted at one time to conformance inspection (see 3.7.6 and 4.3.2).

6.14.8 Maintenance-free. A lithium battery will not require any electrolyte additions. However, they may still require a conditioning charge before initial issue because of long storage times and self-discharge. Such a battery may require exterior cleaning, capacity checks, charging before initial issue, and recharging after deep discharge (see 1.1 and 3.5.2).

6.14.9 Nominal rated capacity (C-rating). The capacity listed on the battery identification marking in accordance with the specification sheet; sometimes called end-of-life or minimum capacity (see 6.9). Note that when batteries and cells produce less than this amount of capacity (see 3.9.9 and 6.14.1) after testing and treatment in accordance with the appropriate military technical manual, the batteries and cells are considered to be at the end of their useful life and must be properly disposed of.

6.14.10 Normal upright position. The battery cover is on top of the battery with respect to the earth's surface (see 4.5.14, 4.5.28, 4.5.29, and 4.5.30).

6.14.11 Unit. One single, individual battery (see 4.3.2).

6.15 Part or identifying number (PIN). The PIN (see 6.2.c) for batteries acquired to this specification is created as follows: M29595/X-Y with "M29595" representing the specification number, "X" signifying the specification sheet number, and "Y" indicating any variation of the battery on a particular specification sheet.

6.16 Specification sheets. Each specification sheet should include as a minimum the following information:

a. Part or identifying number (PIN) (6.15).

b. Shape and size of cell or battery (see 3.9.3).

c. Weight (see 3.9.3).

d. Terminal labeling (see 3.7).

e. Capacity requirements (see 3.9.9).

f. Sequence of tests (see 4.5).

6.17 Safety.

6.17.1 Lithium cell and battery safety. NAVSEA technical manual S9310-AQ-SAF-010 gives requirements for lithium cell or battery safety testing. This manual also requires the development of a safety data package prior to approval of the testing by the Naval Ordnance Safety and Security Activity. NAVSEA instruction 9310.1 establishes the policy and

responsibilities for the safety of all lithium batteries and equipment powered by these batteries used in Naval applications. Adherence to the policies contained in NAVSEA instruction 9310.1 is required when testing batteries in accordance with S9310-AQ-SAF-010. A description of the lithium cell- or battery-powered system is also required prior to testing approval. NAVSEA ltr 8020 Ser N84/521 dated 2 Apr 09 provides interim guidance and changes to NAVSEA instruction 9310.1. Copies of NAVSEA instruction 9310.1 are available on the Internet at http://www.navsea.navy.mil/NAVINST/09310-001B.pdf. Copies of the NAVSEA letter are available from the Naval Ordnance Safety and Security Activity (Code N841), 3817 Strauss Avenue, Suite 108, Indian Head, MD 20640.

6.17.2 System testing. Lithium cell or battery safety testing is specifically designed to force the lithium cells or batteries into an abused condition which will most likely cause the cells or batteries to swell, rupture (vent), catch on fire, or explode. After analyzing the safety data package, the Naval Ordnance Safety and Security Activity will determine whether the lithium cells or batteries must be installed into the actual lithium cell- or battery-powered device or weapon system while undergoing the abusive testing. Therefore, program managers must be aware of the necessary hardware requirements and plan accordingly.

6.17.3 FMECA testing. Failure mode effects and criticality analysis (FMECA) is used to systematically evaluate and document, by item failure mode analysis, the potential impact of each functional or hardware failure on mission success, personnel and system safety, system performance, maintainability, and maintenance requirements. The SAE standard ARP5580 can be used for guidance on FMECA testing.

6.17.4 Software certification testing. Software certification is used in critical systems that must meet minimum safety, security, and reliability standards. The battery software will need to interact with the aircraft software in order to provide state-of-health information, for this reason software certification testing may be necessary. The IEEE standards of 12207 and 12207.1 can be used for guidance on software certification testing. The qualifying activity will issue a letter of authorization for qualification stating the requested software.

6.18 Transportation. Official Department of Transportation guidance is provided in 49 CFR. Official Navy guidance is provided in Technical Manual S9310-AQ-SAF-010.

6.18.1 New cells and batteries. All transportation of new lithium cells and batteries in the public domain is controlled by federal law regulating shipment of hazardous materials. The general regulations are stated in 49 CFR 172.101 and 173.185. Any deviation from the methods described in the CFR must be approved before shipment in the form of an “Exemption” by the Office of Hazardous Material Safety Research and Special Programs Administration, U.S. Department of Transportation, Washington, DC 20590.

6.18.2 Used cells and batteries. All transportation of used lithium cells and batteries in the public domain is controlled by federal law regulating shipment of hazardous materials. The general regulation, as stated in 49 CFR 172.101 and 49 CFR 173.185, permits shipment of waste

lithium cells and batteries to a disposal site by motor vehicle only. The transportation of hazardous waste is regulated by 40 CFR 263, which provides for the proper identification of the transporter and manifesting of the waste.

6.19 Storage. Official Navy Guidance for storage is provided in Technical Manual S9310-AQ-SAF-010.

6.20 Subject term (key word) listing.

Capacity
Charging
Discharging
Electrolyte
Electrochemistry
Gel-polymer lithium-ion
Heaters
Lithium-ion
Lithium polymer
Materials, hazardous
Qualified Products List
Rechargeable lithium
Safety Data Package
Storage, electrical
Systems, electrochemical
Tests, abusive
Tests, safety

6.21 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

TABLE I. Color.

Battery type	Color
Secondary (rechargeable)	FED-STD-595 color number: 17875

TABLE II. Identification of defects.

Method of inspection	Defect number	Description
Visual	1	Electrical contact surfaces obstructed by insulation, potting, or sealing compounds
Visual	2	Pitting or blow holes in the cell or battery case
Visual	3	Electrolyte leakage
Visual	4	Location and polarity of terminals not as specified
Visual	5	Corrosion
Visual	6	Particles of foreign material in insulation, potting, or sealing compounds
Visual	7	Insulation missing or damaged
Visual	8	Welds contain blow holes, cracks, or slag inclusions
Visual	9	Crazing of glass in glass-to-metal seals
Visual	10	Burrs on cell or battery case
Visual	11	Cell or battery marking not as specified

TABLE III. Capacity performance requirements.

Requirement Number	Discharge Cutoff Volts & Temperature (see 4.4.1)	Rate of Discharge Factor	Minimum Time to Cutoff Voltage
(1)	20.0 volts at room temperature	1.0C	1 hour
(2)	20.0 volts at 49° C	1.0C	1.1 hours
(3)	20.0 volts at –18° C	1.0C	45 minutes
(4)	20.0 volts at room temperature	4.0C	5 minutes

TABLE IV. Group B sample size (see 6.2.d).

Inspection lot size	Total number of samples
1 through 20	1
21 through 200	2
201 through 500	4
501 through 1000	6
1001 through 3000	8

TABLE V. Broadband random background for vibration.

Frequency (Hz)	Amplitude (g^2/Hz)
10 to 40	0.002 to 0.04 (slope of ±6 dB/octave
40 to 500	0.04
500 to 2000	0.04 to 0.002 (slope of ±6 dB/octave)

BATTERY, STORAGE, AIRCRAFT
26-VOLT, MAINTENANCE-FREE
ELECTROCHEMISTRY: LITHIUM XXXXXX

Information Required	Example
MIL Part No.	M29595/X-X
Replaces (include replacement data from applicable battery specification sheet)	Replaces D8565/X-X
Maximum Weight	29.0 kg
Military "C" Rated Capacity	24.0 Ah/1.0 HR/24°C/20.0 V
National Stock Number	6140-XX-XXX-XXXX
Contract Number	XXXXX
Lot Code	1209-02
Battery S/N	XXXXX
Manufacturer's Name	XXXXX
Date Battery Placed in Service	*

CAUTION HOT SURFACE **

XXX Fill in applicable information.
* To be filled in by user (see 3.7.3)
** Applies to certain batteries with heaters (see 3.7.5)

FIGURE 1. Battery identification marking.

MAINTENANCE-FREE BATTERY

Lithium Ion

DO NOT REMOVE COVER

THIS BATTERY SHALL BE SERVICED

ONLY IN AN AUTHORIZED BATTERY SHOP.

THIS BATTERY IS TO BE REMOVED FROM

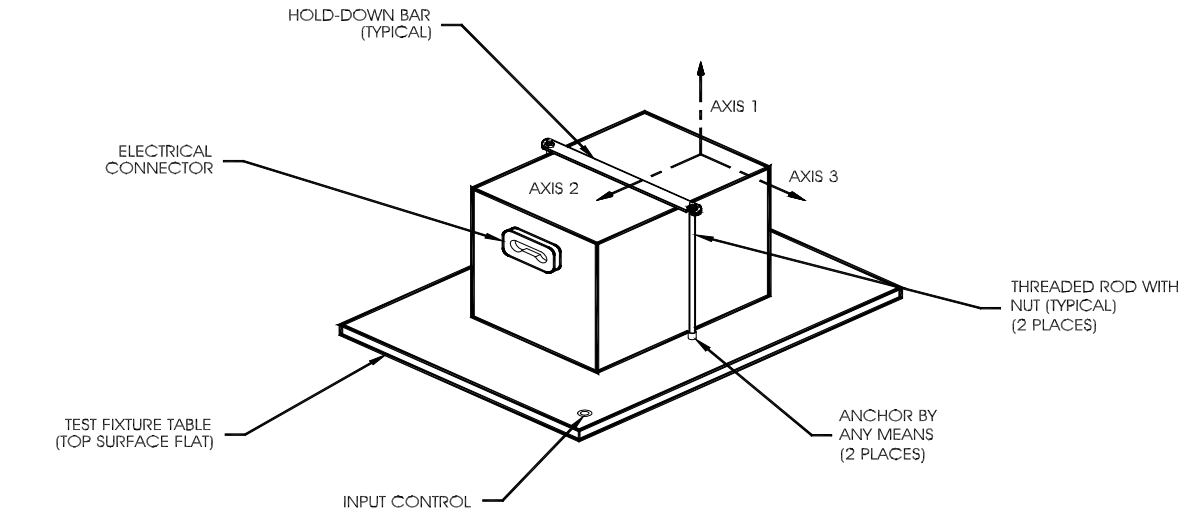
SERVICE ** YEARS FROM DATE FIRST PLACED

IN SERVICE.

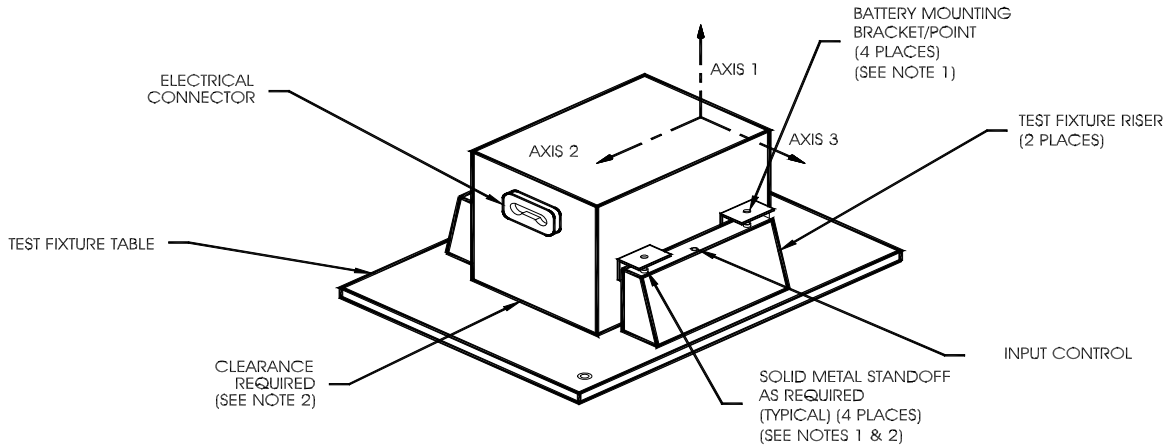
CAUTION: HOT SURFACE ★

** Fill in information from applicable specification sheet.
★ Applies to certain batteries with heaters (see 3.7.5).

FIGURE 2. Battery caution marking.



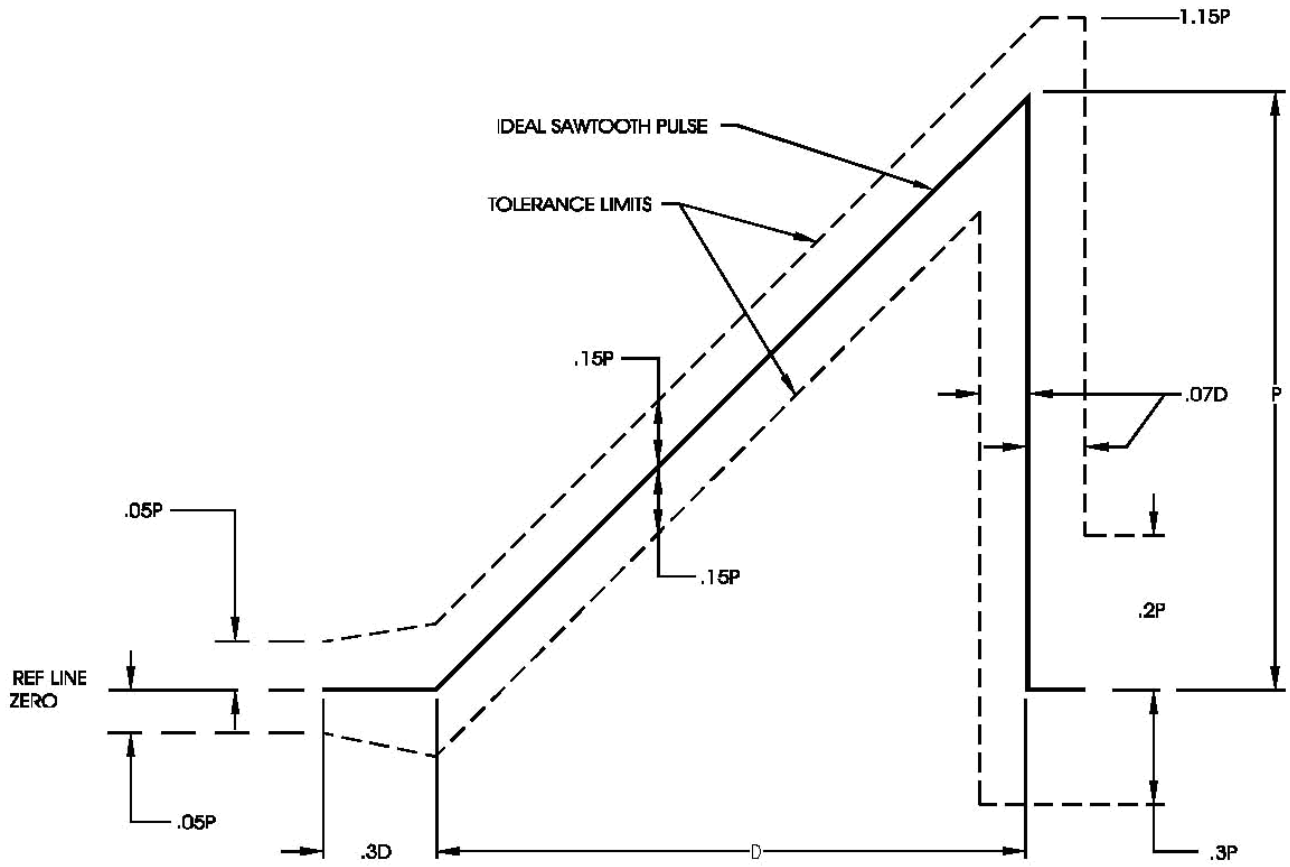
CONVENTIONAL MOUNTED BATTERY



SHOCKMOUNTED BATTERY

NOTES:
1. VIBRATION ISOLATORS SHALL NOT BE USED AT MOUNTING POINTS DURING TESTS SPECIFIED HEREIN.
2. .125 INCH MINIMUM CLEARANCE REQUIRED BETWEEN BOTTOM SURFACE AND TABLE TOP SURFACE.

FIGURE 3. Battery mounting.



NOTE: The oscillogram shall include a time about 3D long with a pulse located approximately in the center. The peak acceleration magnitude of the sawtooth pulse is P and its duration is D. The measured acceleration pulse shall be contained between the broken line boundaries and the measured velocity change (which may be obtained by integration of the acceleration pulse) shall be within the limits of $V_i \pm 0.1\ V_i$, where V_i is the velocity-change associated with the ideal pulse which equals 0.5 DP. The integration to determine velocity change shall extend from 0.4D before the pulse to 0.1D after the pulse.

FIGURE 4. Terminal-peak sawtooth shock pulse configuration and its tolerance limits.

CONCLUDING MATERIAL

Custodians:
Army - CR
Navy - AS
Air Force - 99
DLA - GS

Preparing activity:
Navy - AS

(Project 6140-2011-006)

Review activities:
Army - AV
Air Force - 11, 71

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla.mil.