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PERFORMANCE SPECIFICATION

BATTERIES, NON-RECHARGEABLE, LITHIUM

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 non-rechargeable lithium batteries of the non-reserve type composed of electrochemical cells using lithium metal in the anode. They are intended for use in military communications and electronics equipment.

1.2 Classification.

1.2.1 Type. Batteries described by this specification are of the following types and have the following features described (see applicable specification sheet).

Type I – Lithium batteries made with cells having solid cathodes contained in metallic cell containers.

Type II – Lithium batteries made with cells having liquid cathodes contained in metallic cell containers.

Type III – Lithium batteries made with cells having solid cathodes in pouch cell containers.

1.2.2 Class. Batteries described by this specification are of the following classes:

Class 1 – Lithium batteries that are non-reactive waste after use due to minimal lithium content.

Class 2 – Lithium batteries that require and are capable of complete discharge in order to be considered non-reactive. Requirements for these batteries include a Complete Discharge Device.

Comments, suggestions, or questions on this document should be addressed to Commander, US Army Communications-Electronics RDEC, ATTN: RDER-PRQ-QE, Fort Monmouth, NJ 07703-5201, or emailed to Robert.Francis@us.army.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 6135

Class 3 – Lithium batteries that are considered hazardous waste after use based on lithium content

1.2.3 Features. Batteries described by this specification have the following built-in features (see applicable specification sheet):

Features A – Batteries with short circuit protection

Features B – Batteries that contain short circuit and over-current protection

Features C – Batteries that contain short circuit, over-current, over-temperature and charge protection

Features D – Batteries that contain short circuit, over-current, over-temperature and charge protection, as well as a State of Charge Indicator (SOCI)

Features E – Batteries that contain short circuit, over-current, over-temperature and charge protection, as well as a SOCI and State of Charge data output terminals

1.3 Part or Identifying Number (PIN). PINs to be used for batteries described by this specification are created as follows:

M	32271	/9	-1[1]	1	A
M prefix	Specification number	Specification slash sheet number	Type (see 1.2.1)	Class (see 1.2.2)	Features (see 1.2.3)

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 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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.

FEDERAL STANDARDS

FED-STD-595 Colors Used in Government Procurement
Chip numbers 33105, 34128, and 36463

[1] Roman numeral type numbers are converted to Arabic digits in the PINs in order to provide a consistent number of characters in the PINs assigned by this specification.

DEPARTMENT OF DEFENSE SPECIFICATIONS

(See ASSIST database for list of specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-810 Department of Defense Test Method Standard For Environmental Engineering Considerations And Laboratory Tests

(Copies of this document are available online at 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 documents, drawings, and publications 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.

NAVSEA S9310-AQ-SAF-010 Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures

(Copies of this document may be obtained from the Naval Ordnance Safety and Security Activity (NOSSA), Farragut Hall Building D-323, 23 Strauss Avenue, Indian Head, MD 20640-5555.)

2.3 Non-Government publications. The following documents 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.

ASTM-D-1141 Standard Practice for the Preparation of Substitute Ocean Water

(Copies of these documents may be obtained from the American Society for Testing and Materials, 100 Bar Harbor Drive West, Conshohocken, PA, USA, 19428-2959, or at www.astm.org)

NATIONAL CONFERENCE OF STANDARDS LABS (NCSL)

NCSL-Z540.1 Calibration Laboratories and Measuring Test Equipment – General Requirements

(Copies of these documents are available online at http://www.sae.org or from the SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

System Management Bus Specification

Smart Battery Data Specification

System Management Bus, SMBus, Smart Battery, Smart Battery System, SBS, SMBus and SBS logos are trademarks of the System Management Interface Forum (SMIF), Inc.

(Copies of these documents may be obtained from the System Management Interface Forum (SMIF), Inc, 100 North Central Expressway, Suite 600, Richardson, TX, 75080, or on-line at http://smartbattery.org/specs/)

UL 94 Standard for Safety, Test for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 1642 Standard for Safety, Lithium Batteries

(Applications for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, or at http://ulstandardsinfonet.ul.com)

UN Manual of Tests and Criteria

(Copies of this document may be obtained from the United Nations Publications Centre, 2 United Nations Plaza, Room DC2-853, New York, NY 10017, or at www.un.org)

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 sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern.

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.4.

3.2.1 Certifications. When specified (see 6.2), certification of conformity shall be provided for the following requirements. The Government reserves the right to verify any or all certifications.

REQUIREMENT	PARAGRAPH
Metals	3.3.1
Dissimilar metals	3.3.1.1
Compounds – flow or shrinking	3.3.2
Insulating materials	3.3.3
Parallel arrangement of cells	3.4
Cell water content	3.4.1
Intercell connections	3.4.2
Battery enclosure	3.4.3*
Battery enclosure color	3.4.3.1
State of charge indicator	3.4.8a, c, d, l, n, & p
Shelf life	3.4.9
Connector material	MIL-PRF-32271/1; MIL-PRF-32271/6; & MIL-PRF-32271/13
Dust cap	MIL-PRF-32271/10

*Certification for UL-94 classification of battery enclosure material is only required if material is classified; if it is not, submit battery enclosure samples for Group II testing where required.

3.3 Materials.

3.3.1 Metals. All metals which do not enter into the basic electrochemical reaction of the cell shall resist, or be treated to resist, corrosion. Protection of metals from corrosion shall be certified.

3.3.1.1 Dissimilar metals. When dissimilar metals are used in intimate contact with each other, protection against electrolysis shall be provided. When applicable, certification shall be provided.

3.3.2 Compounds - flow or shrinking. Insulating, impregnating, potting and sealing compounds used in manufacturing shall be capable of performing their intended purpose under the use conditions described by this specification. When tested as specified in 4.6.1.1, the insulating, impregnating, potting and sealing compounds shall not flow at high temperature, and shall not crack or draw away from the sides of a container at low temperature. Any compound used shall be non-flammable and non-toxic (see 6.4.1). The non-flammable and non-toxic nature of all compounds used shall be certified. Compounds shall not inhibit the operation of any safety features.

3.3.3 Insulating materials. All points inside a battery that have positive and negative polarity in close proximity, including the positive terminal of each cell, shall have not less than one layer of insulation between the positive and negative. Insulating material, or layers of multiple insulating materials between positive and negative points, shall have the following characteristics as a minimum:

Softening temperature: Not less than 302°F (150°C)
Lengthwise shrinkage: Not greater than 3% after application
Thickness: Not less than 0.005 inch
Material shall not shrink, soften, or crack during or after any tests of this specification except for the Projectile test and the tests of Group VI.
The material shall be non-flammable, non-toxic[2], and impervious to the electrolyte of the battery. Certification is required.

3.3.4 Toxic chemicals, hazardous substances, and ozone-depleting chemicals. The use of toxic chemicals, hazardous substances, or ozone-depleting chemicals shall be avoided where feasible. Those known to be necessary to meet the requirements of this specification are listed as key words in section 6 of this specification. Others may also be necessary, such as electrolyte components. The Environmental Protection Agency maintains an online list of toxic chemicals and hazardous substances at www.epa.gov/ebtpages/pollutants.html that may be consulted.

3.4 Design and construction. Batteries shall be of the design, construction, physical dimensions, weight, and polarity as specified in the applicable specification sheet. Cells shall have a lithium anode and be hermetically sealed (see 3.5.2). The cells used in Types I & III batteries shall include internal over-temperature protection. Parallel arrangements of cells are permitted only when specified (see applicable specification sheet). Parallel cell arrangements, when used, shall be assembled in a controlled manner that prevents assembly of inverted cells into batteries. When parallel arrangements of cells are used, charge protection shall be required for each series cell string (see 3.5.6.1). Certifications for controls to prevent reverse polarity during assembly of parallel cell strings are required.

3.4.1 Cell water content. Water content inside a cell shall be not greater than 800 parts per million by weight upon the completion of cell manufacture. Controls shall be established to ensure that this limit is not exceeded in production. Certification is required.

3.4.2 Intercell connections. Intercell connections shall be connected in accordance with the manufacturer's established procedures. These procedures shall ensure that intercell conductors are insulated to prevent or preclude short circuiting within a multi-cell battery. Certification is required.

3.4.3 Battery enclosure. Battery enclosures shall be built with plastic materials classified in accordance with UL Standard 94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances, except as otherwise noted herein. Acceptable ratings include: HB; V-0; V-1; V-2; 5VA; 5VB; VTM-0; VTM-1; and VTM-2. The government reserves the right to require verification tests to ensure nonflammable battery enclosures. If the manufacturer elects to use material classified in accordance with UL 94, certification is required. If the manufacturer elects to use a material that doesn't have UL-94 classification, then the test of 4.6.1.2 shall be performed. Enclosure material used shall be non-metallic. When tested in accordance with 4.6.1.2, the test specimen shall self-extinguish within 5 seconds after removal from the flame.

3.4.3.1 Color of enclosures. The enclosure for each battery shall be a lusterless color as specified below. Chip numbers of FED-STD-595 shall be as follows:

[2] See 6.4.1 for a definition of non-flammable, non-toxic

Type I – Lithium manganese dioxide
Lusterless gray – Chip No. 36463
Type II – Lithium sulfur dioxide
Lusterless green – Chip No. 34128
Type III – Lithium manganese dioxide
Lusterless yellow – Chip 33105

The use of the proper color chip shall be certified.

3.4.4 Battery voltage.

3.4.4.1 Battery open-circuit voltage. The open-circuit voltage shall neither be greater than the maximum voltage specified nor less than the minimum voltage specified (see applicable specification sheet and 4.6.1.5.1).

3.4.4.2 Battery closed-circuit voltage. The closed-circuit voltage shall be not less than the minimum voltage specified after not greater than 10 seconds under the load specified (see applicable specification sheet and 4.6.1.5.2). In the case of Type I and Type III batteries with independent sections, the measured voltages of the sections under load shall not vary from one another on any individual battery by more than 2.0%.

3.4.4.3 Cell closed-circuit voltage. When cells are tested as specified in 4.6.1.3, the voltage shall be above the minimum value specified within 5 seconds on load (see applicable specification sheet). Any cell whose voltage is below the minimum voltage specified after 5 seconds on load shall be rejected.

3.4.5 Connectors. When specified (see applicable specification sheet), connectors shall be as specified on the applicable specification sheet. Location of the connectors shall be in accordance with the applicable drawing (see applicable specification sheet). Unless otherwise specified, insertion force shall be not greater than 12 pounds and removal force shall be not less than 1.25 pounds when connected to the specified mating connector (see applicable specification sheet). Continuity through the mating connector shall be demonstrated in accordance with 4.6.1.7. Only sockets which are electrically connected shall require electrical contacts.

3.4.5.1 Battery charger connection. When specified (see applicable specification sheet), each battery shall be subject to a no-go mating test with the battery charger connector identified in the applicable specification sheet. When tested in accordance with 4.6.1.7.1, no connection attempts shall be successful in measuring the voltage of the battery. After test, batteries shall meet the open-circuit voltage requirements of 3.4.4.1.

3.4.5.2 Connection integrity, static and dynamic. When specified (see applicable specification sheet), battery open circuit voltage (see 3.4.4.1) shall remain above the voltage specified (see applicable specification sheet) and shall not vary by more than 0.5 volts throughout the voltage monitoring period when tested in accordance with 4.6.1.7.2 or 4.6.1.7.3. Batteries shall then meet the visual mechanical and battery open circuit voltage requirements after testing.

3.4.6 Terminal integrity. When specified (see applicable specification sheet), either the plastic socket or the metal plate terminals of each battery shall meet one of the following strength requirements.

3.4.6.1 Socket strength. When specified (see applicable specification sheet), sockets shall be of sufficient strength to withstand normal use without breakage. When tested as specified in 4.6.1.8.1, sockets shall not break or crack, and the batteries shall meet the open-circuit voltage and visual and mechanical requirements (see 3.4.4.1 and Table XIV).

3.4.6.2 Terminal strength. When specified (see applicable specification sheet), the battery terminals shall be of sufficient strength to withstand normal use without damage that would interfere with connections. When tested as specified in 4.6.1.8.2, battery terminals shall not tear, rip, or separate from the battery enclosure, and the batteries shall meet the open-circuit voltage and visual and mechanical requirements (see 3.4.4.1 and Table XIV).

3.4.7 Complete discharge device. When specified (see applicable specification sheet), each battery shall be equipped with a device capable of rendering the battery non-reactive after use. The device shall be located as required (see applicable specification sheet). The device shall consist of, as a minimum, a load that can discharge the battery within seven days, an activator for connecting the load with the cells inside the battery and a Light Emitting Diode (LED) to provide an indication of circuit continuity once activated. The circuit for the device shall bypass all non-resetable cutouts and fuses within the battery with the exception of cell series string short circuit protection devices, where applicable. The device shall be protected from inadvertent activation. The activator shall initiate the complete discharge by a pull motion of the removable label (see 3.8.4) by the user and shall require not greater than 6 pounds of force to activate. The use of an additional tab underneath the label for the purpose of activating the device is permitted but not required. When used, the tab shall be attached to the removable label. Attachment by adhesive is permitted but not required. The device shall provide a positive indication of circuit continuity once it has been activated with yellow or amber light. In the case of multi-sectioned batteries, the LED shall only illuminate if both sections have continuity after activation. Once the device is activated, the yellow or amber light shall be bright enough to be seen by the unaided human eye under indoor lighting conditions. Once activated, the LED shall remain illuminated until the battery voltage or all battery section voltages falls below either 1-volt times the number of cells in series or 4 volts, whichever is less. After the LED light extinguishes, battery or battery section voltage shall remain below this voltage value. When tested in accordance with 4.6.1.9, each device shall activate as designed with not greater than 6 pounds of force; yellow or amber light shall be visible once the device is activated; and no battery shall have a voltage in excess of 1 volt per cell or 4 volts per section, whichever is less, at the end of the required storage period. The yellow or amber light shall be off at the end of the storage period and shall remain off. No cell within the battery shall bulge, leak, vent, rupture, burn, or explode during or after complete discharge.

3.4.8 State of charge device. When specified (see applicable specification sheet), the battery shall contain a state of charge device with a State of Charge Indicator (SOCI). The device shall be located on the battery as required by the applicable drawing (see applicable specification sheet). The device shall have the following characteristics:

a. The device shall not apply a load to the battery greater than 20 micro-amperes while the battery is in storage prior to first use. If activation of the state of charge device is required prior to first use, activation shall be accomplished by a pull motion by the user. If used, the activator shall not electrically connect to the battery connector or any battery terminals. Unless otherwise specified herein, the activator may remain in place with the battery during the inspections and tests of this specification, provided that it does not interfere with verification requirements. The state of charge device shall be active during the following inspections and tests: All capacity

discharge tests of 4.6.4; Abuse test of 4.6.2.12; Complete discharge device test of 4.6.1.9; and State of charge test of 4.6.1.10. Maximum discharge rate while in storage shall be certified.

b. Once the state of charge device is activated, no part or component of the device shall protrude beyond the surface of the battery.

c. Once the state of charge device is activated, the load applied by the device on the battery shall be not greater than 50 micro-amperes in the non-operating mode.

d. Only a single display shall be used. This includes multi-sectioned batteries. Additionally, multi-sectioned batteries shall be designed to ensure equal loading of both sections in parallel discharge (see applicable specification sheet). The design to ensure equal loading in multi-sectioned batteries shall be certified. For multi-sectioned batteries, the state of charge circuit shall be located in the section specified in the applicable specification sheet.

e. When specified (see applicable specification sheet), the state of charge device shall be capable of providing state of charge information to external devices through the connections indicated (see applicable specification sheet) that can be read by System Management Bus (SMBus) Specification compliant systems. The following Smart Battery System (SBS) fields are required unless otherwise specified herein:

Function/Parameter	Code	Notes
BatteryMode	03	
Temperature	08	
Voltage	09	
Current	0A	
RelativeStateOfCharge	0D	
AverageTimeToEmpty	12	
BatteryStatus	16	
DesignCapacity	18	See Appendix A
DesignVoltage	19	
ManufactureDate	1B	
SerialNumber	1C	Leave blank
ManufacturerName	20	
DeviceName	21	
DeviceChemistry	22	
ManufacturerData	23	

f. The SOCI shall indicate the highest state of charge when actuated prior to capacity testing (i.e., five LEDs on).

g. The device shall be designed to compensate for usage temperature and discharge rate and shall monitor and adjust for changes in both during battery use.

h. During initial use, the SOCI shall indicate no remaining capacity in the event that the battery voltage or individual battery section voltages stay below the rated cut-off voltage for more than 60 seconds. In the event that the battery's output voltage or either section's output voltage (in the case of multi-sectioned batteries) falls below the battery or section closed circuit

voltage minimum (see applicable specification sheet) and stays below that value for more than 20 seconds after the initial use, the SOCI shall indicate no remaining capacity. In the event that an open-circuit condition should occur in a battery or in either section of a multi-sectioned battery, the SOCI shall indicate no remaining capacity.

i. The SOCI shall indicate no remaining capacity once the complete discharge device is activated.

j. The SOCI and SMBus data output terminals shall be located as required by the applicable drawing (see applicable specification sheet). Additionally, the SOCI and SMBus data terminals shall not require openings in the battery enclosure that are large enough to allow water ingress during immersion or submersion (see 3.7.8 and 3.7.9d).

k. The SOCI shall display five distinct ranges of remaining capacity in the battery. The five ranges shall be:

1) ≥90% (greater than or equal to 90 percent)
2) ≥70%
3) ≥50%
4) ≥30%
5) ≥10%

Below 10 percent remaining capacity, all indicators shall be off.

l. The SOCI shall consist of a single row of green Light Emitting Diodes (LEDs) of equal size and an actuator button. The LED's and the actuator shall be located in accordance with the applicable drawing (see applicable specification sheet). The output of each Light Emitting Diode (LED) at full intensity, measured in a direction normal to the State of Charge Indicator display, shall be 1.0 to 6.0 millicandelas. The LEDs shall be capable of providing the correct state of charge indication in a temperature range of -20 to 130ºF and be capable of surviving temperature extremes of -40ºF and 195ºF. Certification to the full intensity output and storage temperature range requirements is required.

m. The SOCI display shall normally be in the 'off' mode and shall require a push-button actuator to activate the LED display. The push-button shall be capable of actuation by finger. It shall be protected from inadvertent actuation. The push-button actuator shall comply with the following displacement and resistance requirements:

	DISPLACEMENT	RESISTANCE
Not less than	0.008 in.	0.25 lbs
Not greater than	0.050 in.	5.50 lbs

n. The LEDs shall start at an initial intensity of not greater than 0.5% of the full intensity. The output of the LEDs shall increase in not less than five steps in a time span of one to two seconds when the actuator is held down; the increase in output steps shall be in steps of equally perceived brightness ratio. At full intensity, The LEDs shall only illuminate the state of charge level appropriate to its usage level when viewed from a direction normal to the indicator (i.e., no light bleed-through to levels/spaces meant for higher states of charge). The LEDs shall remain at full intensity for not less than 3 seconds and shall self-extinguish in not greater than 7 seconds of actuation when the actuator is held down. The LEDs shall extinguish any time the actuator is released. Certification of the initial intensity of not greater than 0.5% of full intensity is required.

o. During testing in accordance with 4.6.1.10, the SOCI shall indicate the correct state of charge at each stage of discharge. The actuator shall comply with displacement and resistance values stated above in 3.4.8m. Time to full light intensity shall be not less than one second and shall be not greater than two seconds. Time for the LEDs to remain at full intensity shall be not less than 3 seconds; Time until the lights extinguish while the actuator is depressed shall be not greater than 7 seconds. The indicator shall not illuminate when the battery face including the actuator is pressed against a transparent flat surface. SOC indications obtained during testing shall comply with the table below. SMBus data output, where applicable, shall be accurate to +0, -5% of the test point value. After discharge to cut-off voltage, the indicator shall indicate no remaining capacity. The SOCI shall also indicate no remaining capacity after the complete discharge device has been activated.

SOC Thresholds	Test Points	Required SOC Readings
≥ 90%	100%	5 LEDs
≥ 70%	80%	4 LEDs
≥ 50%	60%	3 LEDs
≥ 30%	40%	2 LEDs
≥ 10%	20%	1 LEDs
	0%	0 LEDs

p. In accordance with the state of charge requirements herein, the following require certification (see 6.2).

(3.4.8a) Discharge rate limit in storage (not greater than 20 micro-amperes)
(3.4.8c) Load limit when not operating after first use (not greater than 50 micro-amperes)
(3.4.8d) Design to ensure equal loading in multi-sectioned batteries
(3.4.8l) LED full intensity of 1.0-6.0 millicandelas in a direction normal to display
(3.4.8l) Storage temperature range capability
(3.4.8n) Initial intensity not greater than 0.5% of full intensity

3.4.9 Shelf life. The manufacturer shall certify that the battery is capable of delivering 85 percent of the minimum capacity (see the applicable specification sheet) after 60 months of casual storage. See 6.12 for further information on shelf life.

3.4.10 Workmanship. Batteries shall be processed in such a manner as to be uniform in quality and shall be free from defects that will affect their life, serviceability, interchangeability, or appearance (see applicable specification sheet).

3.5 Safety Features. For definitions of the failure modes described herein, see 6.4.4.

3.5.1 Containers. Metallic cell containers shall be capable of releasing excess pressure due to heating or short circuits to prevent explosions and expulsion of solid material. When

tested in accordance with 4.6.2.1, cell containers for Types I and II batteries shall open only as designed at a pressure not greater than 645 psig.

3.5.2 Cell leakage. Cells shall not be subject to leakage. No cell shall exhibit visual signs of leakage on the seventh day or twenty-eighth day of the test required by 4.6.2.2. Additionally, no cell shall have a leakage amount greater than 0.01% of the total cell weight upon completion of the test specified in 4.6.2.2.

3.5.3 Cell charging. When specified (see applicable specification sheet), cells shall not react violently when charged. When tested in accordance with 4.6.2.3, no cell shall burn or explode.

3.5.4 Nail penetration. When specified (see applicable specification sheet), cells shall not react violently when cell containers are penetrated by sharp objects. Cells tested in accordance with 4.6.2.4 shall not burn or explode, and the external temperature of each test sample shall be not greater than 338ºF (170°C).

3.5.5 Crush. Cells shall not react violently when crushed. When subjected to the test of 4.6.2.5, no cell shall burn or explode.

3.5.6 Cell series string short circuit protection. When specified (see applicable specification sheet), each series string of cells within a battery shall be protected from cell series string short circuits that might result in overheating, leaking, bulging, venting, rupturing, burning or exploding whenever a cell series string short circuit develops. This requirement is in addition to the overload protection requirements of 3.5.13. The protection applied shall not open prior to the over-current protection of 3.5.13.1 throughout the range of its operating temperature and current ratings. When tested in accordance with 4.6.2.6, cell and intercell connection insulation shall not melt, shrink, or burn, and all cells in the series string shall not leak, bulge, vent, rupture, burn, or explode.

3.5.6.1 Parallel string charge protection. When parallel cell strings are used (see applicable specification sheet for parallel string allowance), cells shall not bulge, leak, vent, rupture, emit flame, burn or explode as a result of a charging current. Each series string of cells connected in parallel to other series strings shall contain charge protection to protect each string from charge current from the series strings to which they are connected. When tested in accordance with 4.6.2.6.1, no cell shall bulge, leak, vent, rupture, emit flame, burn, or explode, and the charge current shall be not greater than 2.0 milliamperes[3].

3.5.7 Cell short circuit. Cells shall not rupture, burn, or explode when subjected to a short circuit. Additionally, Type I cells shall not leak or vent when subjected to a short circuit; Type III cells shall not leak. When tested as specified in 4.6.2.7, the external temperature of the test samples shall be not greater than 338ºF (170ºC); cells used in Type II batteries shall not rupture, burn, or explode; cells used in Type I and Type III batteries shall not leak, vent (Type I), rupture, burn, or explode. See 6.4.4 for clarification of Type III cell failure modes.

3.5.8 Impact. Cells shall not burn or explode as a result of impact. When tested in accordance with 4.6.2.8, external temperature of the cells shall be not greater than 338ºF (170°C) and there is no disassembly and no fire within six hours of the test.

[3] Charge protection design for parallel strings must take total battery or section charge protection into consideration in determining proper charge current values.

3.5.9 Cell forced discharge. Cells shall not leak, vent, rupture, burn, or explode under conditions of forced discharge. When tested as specified in 4.6.2.9, no cell shall leak, vent, rupture, burn, or explode.

3.5.10 Insulation resistance. Terminals shall be as specified on the applicable specification sheet and insulation resistance of completed batteries shall be not less than 150 megohms when tested as specified in 4.6.2.10.

3.5.11 Charge protection. When specified (see applicable specification sheet), each battery or each section in a multi-section battery shall contain protection that prevents charging. When tested in accordance with 4.6.2.11, reverse current shall be not greater than 2.0 milliamperes.

3.5.12 Abuse Protection. Batteries shall not leak, vent, rupture, burn, or explode when subjected to heat, intermittent discharge, and environmental stress. When subjected to the test in 4.6.2.12: batteries shall not fall below the cut-off voltage, after the initial voltage delay, during the abuse testing predischarge; batteries shall meet the visual and mechanical criteria of Categories 001, 002, 101, and 102 of Table XIV and the battery open circuit voltage requirements of 3.4.4.1 after drop, heat exposure, and after vibration testing; batteries shall complete the pulse discharge to cut-off voltage without any open circuit conditions and provide the minimum ampere-hour capacity specified in the applicable specification sheet (to include energy consumed in predischarge where applicable).

3.5.13 Overload protection.

3.5.13.1 Over-current protection. When specified (see applicable specification sheet), each battery shall be protected from bulging, leaking, venting, ruptures, burning, or exploding when subjected to the over-current discharge rate specified (see applicable specification sheet). When tested in accordance with 4.6.2.13, each battery shall be capable of maintaining the load for not less than 10 seconds and shall not bulge, leak, vent, rupture, burn, or explode. Any open-circuit conditions that occur during this test shall be accomplished with the designed over-current protection only.

3.5.13.2 Short-circuit protection. Each battery shall be protected from short-circuit conditions to prevent bulging, leaking, venting, emission of flame, rupturing, burning or exploding of the battery when subjected to a direct short. When tested in accordance with 4.6.2.15: the external temperature of the test samples shall be not greater than 338ºF (170ºC); batteries shall not bulge, leak, vent, rupture, burn, or explode. Any open-circuit conditions that occur during this test shall be accomplished with the designed short-circuit protection only.

3.5.14 Over-temperature protection. When specified (see applicable specification sheet), each battery shall be protected from over-temperature conditions due to self-heating in discharge that could result in leaking, venting, ruptures, burning, or exploding of the battery. When tested as specified in 4.6.2.14 during first article testing, batteries shall meet the open circuit voltage requirement of 3.4.4.1 after the eight-hour storage period at the storage temperature required. For Types I & II batteries, the temperature at which the open circuit condition occurs shall be not less than 200ºF (93.3ºC) and not greater than 230ºF (110ºC); and batteries shall not leak, vent, rupture, burn, or explode. For Type III batteries, batteries shall not leak, rupture, burn, or explode. Any open-circuit conditions that occur during this test shall be

accomplished with the designed over-temperature protection only. Softening or distortion of the battery enclosures is permitted.

3.5.15 Projectile. Batteries shall not produce shrapnel when subjected to a flame. When tested as specified in 4.6.2.16, no part of a battery under test shall penetrate the wire screen such that some or all of the battery passes through the screen. When tested, the production of smoke and flames and the passing of small particles through the wire mesh are permitted; heat damage to the wire mesh is also permitted.

3.5.16 Lithium Battery Safety Program (US Navy). Batteries shall be designed and built in a manner that provides protection from bulging, leaking, venting, rupturing, burning and exploding under conditions of extreme electrical abuse. Additionally, batteries shall be designed in a manner that prevents the production of shrapnel in the event of failure of internal protection devices under extreme conditions. When tested in accordance with 4.6.3.1 through 4.6.3.3, the battery enclosure shall not fragment; enclosure distortion, cracking, or bulging, and venting of gases or liquids through purposely designed cell vents, are permitted. When tested in accordance with 4.6.3.4, no battery shall bulge, leak, vent, rupture, burn, or explode.

3.6 Capacity. Batteries shall have the required minimum capacity (see applicable specification sheet). When a battery is tested for capacity as specified in 4.6.4, the time required to reach its specified cut-off voltage shall be not less than the minimum capacity requirement specified (see applicable specification sheet). If a voltage delay occurs when the battery is tested for capacity as specified in 4.6.4, the start time for capacity will begin when the battery reaches the voltage specified under “Initial voltage delay” (see applicable specification sheet). The end time for capacity will occur when the battery voltage falls to its cut-off voltage while on discharge. A failure shall be defined as below:

a. The battery voltage or the voltage of any one section in a multi-sectioned battery falls below the specified cut-off voltage prior to exceeding the minimum capacity requirement for the specific test (see applicable specification sheet).

b. Any battery on test experiences an open circuit condition prior to discharge to cut-off voltage. During discharge below cut-off voltage on I/IP tests, open circuit conditions resulting from activation of circuit protective devices are permitted.

c. Excessive initial voltage delay occurs (see 3.6.1 below).

d. Battery exceeds dimensional tolerances after discharge.

e. Battery bulges, leaks, vents, ruptures, burns or explodes at any time during storage or discharge, or after completion of capacity testing.

f. If a SOCI is required (see applicable specification sheet), SOCI either fails to indicate highest level of capacity before initiation of the capacity discharge or fails to indicate the lowest level of indication after completion of discharge.

g. If a complete discharge device is required (see applicable specification sheet), batteries shall meet the requirements of 3.4.7 when tested as specified in 4.6.4.1. Failure of the LED to light for the discharged I, IP, LR and LRT test samples is permitted.

h. Unless otherwise specified (see applicable specification sheet), the surface temperature of a battery exceeds 185°F (85°C) during capacity testing.

3.6.1 Initial voltage delay. Batteries shall not be subject to excessive voltage delays under load. When the battery is tested for capacity, the time required at the beginning of discharge for the battery or its sections to meet the specified initial voltage delay value after the load is applied shall be not greater than the time specified (see applicable specification sheet and 4.6.4.1.1).

3.7 Environmental requirements.

3.7.1 Altitude. Batteries shall experience no deleterious effects from high altitude conditions. After testing as specified in 4.6.5.1: mass loss of test samples shall be not greater than 0.1%; test samples shall not exhibit leakage, venting, disassembly, rupture or fire; and all batteries shall meet the visual and mechanical requirements (see Table XIV) Additionally, the undischarged batteries shall meet the battery open circuit and closed circuit voltage requirements (see 3.4.4).

3.7.2 Thermal test. Batteries shall not experience deleterious effects when subject to conditions of extreme temperature changes. When tested in accordance with 4.6.5.2: mass loss of test samples shall be not greater than 0.1%; test samples shall not exhibit leakage, venting, disassembly, rupture or fire; and all batteries shall meet the visual and mechanical requirements (see Table XIV) Additionally, the undischarged batteries shall meet the battery open circuit and closed circuit voltage requirements (see 3.4.4).

3.7.3 Vibration. Batteries shall be capable of withstanding vibration environments without sustaining physical or electrical damage. After testing as specified in either 4.6.5.3.1 or 4.6.5.3.2: mass loss of test samples shall be not greater than 0.1%; test samples shall not exhibit leakage, venting, disassembly, rupture or fire; all batteries shall meet the visual and mechanical requirements (see Table XIV) Additionally, the undischarged batteries shall meet the battery open circuit requirements (see 3.4.4.1).

3.7.4 Shock. Batteries shall be capable of withstanding mechanical shock environments without sustaining physical or electrical damage. After the batteries have been tested as specified in either 4.6.5.4.1 or 4.6.5.4.2, they shall meet the following requirements: mass loss of test samples shall be not greater than 0.1%; test samples shall not exhibit leakage, venting, disassembly, rupture or fire; and all batteries shall meet the visual and mechanical requirements (see Table XIV). Additionally, the undischarged batteries shall meet the battery open circuit voltage requirements (see 3.4.4.1).

3.7.5 Drop test. Batteries shall be capable of withstanding drops at extreme temperature conditions without sustaining physical or electrical damage. After the batteries have been tested at each temperature as specified in 4.6.5.5, they shall meet the battery open circuit and closed circuit voltage requirements (see 3.4.4). When batteries are visually examined before and after each drop, no cells shall be visible with a multi-cell battery and there shall be no gap along glued or welded seams. Following the battery drop test, batteries shall meet envelope dimension requirements (height, width, and length or diameter as applicable) and the socket/terminals/connector shall have remained within the limits specified (see applicable specification sheet). Following the test, batteries shall meet the battery open circuit and closed circuit voltage requirements (see 3.4.4).

3.7.6 Thermal shock. Batteries shall not bulge, leak, vent, rupture, burn, or explode as a result of varying rates of thermal expansion or contraction of cell and battery components. After the batteries have been tested as specified in 4.6.5.6 they shall meet the visual and mechanical and battery open circuit and closed circuit voltage requirements (see Table XIV and 3.4.4).

3.7.7 Humidity. Batteries shall experience no deleterious effects from humid conditions. After the batteries have been tested as specified in 4.6.5.7, they shall meet the visual and mechanical and battery open circuit and closed circuit voltage requirements (see Table XIV and 3.4.4).

3.7.8 Immersion. When specified (see applicable specification sheet), batteries shall be capable of sustaining immersion in salt water without rupturing, burning, or exploding. Samples tested in accordance with 4.6.5.8 shall not exhibit signs of rupturing, burning, or exploding. Open circuit conditions, illuminated LEDs, and ventings due to immersion are permissible but not required.

3.7.9 Watertight integrity. When specified (see applicable specification sheet), batteries shall retain their watertight integrity and shall be capable of safe and continuous use when subjected to extreme environmental conditions. Test samples, when subjected to any part of the Watertight Integrity tests of 4.6.5.9, shall meet the requirements described below.

a. Altitude cycling. Each battery shall meet the visual mechanical and battery open circuit and closed circuit voltage requirements of 3.4.4 prior to and following the altitude cycling of 4.6.5.9a. Weight loss of batteries shall be not greater than 0.1 grams during this test. The labels used on the battery shall show no evidence of softening, peeling, or blistering after test.

b. Explosive decompression. Following the Explosive Decompression test of 4.6.5.9b, each battery shall meet the visual mechanical and battery voltage requirements (see Table XIV and 3.4.4). Weight loss of batteries shall be not greater than 0.1 grams during this test. The labels used on the battery shall show no evidence of softening, peeling, or blistering after test.

c. Parachute drop. Following the Parachute Drop test of 4.6.5.9c, weight increase of each battery shall be not greater than 0.1 grams and no water shall come into contact with the battery contacts. Each battery shall meet the visual mechanical and battery open circuit and closed circuit voltage requirements (see Table XIV and 3.4.4). The labels used on the battery shall show no evidence of softening, peeling, or blistering after test.

d. Submersion. Following the Submersion test of 4.6.5.9d, weight increase of each battery shall be not greater than 0.1 grams and no water shall come into contact with the battery contacts. There shall be no sign of corrosion on the battery contacts. Each battery shall meet the visual mechanical and battery open circuit and closed circuit voltage requirements (see Table XIV and 3.4.4). The labels used on the battery shall show no evidence of softening, peeling, or blistering after test.

e. Capacity H2. When tested in accordance with 4.6.5.9e, batteries shall meet the requirements of 3.6.

3.8 Labeling and marking. All labeling and marking shall be clear and legible throughout all the tests and inspections specified herein. Labeling and marking shall be the colors specified below. Where the marking is engraved, the text shall be the same color as the background. Labeling, where used, shall have either a clear background or match the color of the enclosure, and shall be legible, free from blisters and shall not peel or shift as a result of any test or inspection described herein, with the exception of the following tests: Projectile (4.6.2.16); Constant current discharge & reversal (4.6.3.1); Short circuit (4.6.3.2); Charging (4.6.3.3); and Immersion (4.6.5.8).

3.8.1 Identity and safety marking.

3.8.1.1 Identity marking. Each battery shall be marked as specified herein and in the applicable specification sheet. Marking shall be either black or colorless engraving on the battery enclosure (carved into or etched on the plastic surface of the enclosure) unless otherwise specified herein. Lettering shall be capital letters without serifs (sans-serif). The following identity information shall be on the battery:

BATTERY, NON-RECHARGEABLE, (electro-chemistry)
(Military Type Designation), PIN (Insert PIN)
P/N (Insert manufacturer's part number)
(Manufacturer's name or Trade name)
(Manufacturer's location)
(Contract Number)
MFD (Insert date code; see 3.8.2), S/N: (Insert serial number; see 3.8.6)

Font size shall be appropriate to the space available on the battery. As an alternative, the following may appear on the same or separate lines as space permits: battery title and electro-chemistry; date code and serial number.

EXAMPLE 1:

BATTERY, NON-RECHARGEABLE, LITHIUM SULFUR DIOXIDE
BA-5590A/U, PIN: M32271/1-22D
P/N JEDCO-C-6789A
JAMES E. DOE COMPANY
BRUNTHERMAN, NJ
SPM4L1-08-C-1234
MFD 03/08B, S/N 0000001

EXAMPLE 2:

BATTERY, NON-RECHARGEABLE,
LITHIUM MANGANESE DIOXIDE
BA-5372/U, PIN: M32271/8-11A
P/N JEDCO-A-4321
JAMES E. DOE COMPANY
BRUNTHERMAN, NJ
SPM4L1-09-C-5678
MFD 03/12C
S/N 0000013

3.8.1.2 Safety marking.

a. The following safety marking shall appear on each battery where indicated on the applicable specification sheet:

DO NOT CHARGE, SHORT CIRCUIT, INCINERATE, OR MUTILATE THIS BATTERY
OTHERWISE BATTERY MAY VENT OR RUPTURE RELEASING HAZARDOUS MATERIALS

b. When specified (see applicable specification sheet), the following marking shall appear where specified in bold capital letters:

DO NOT CHARGE!

3.8.2 Manufacturing date code (MFD). The date code shown shall indicate the month and year of manufacture of the battery by means of a four-digit number. This shall be followed by a single letter. The first two digits shall indicate the number of the month. The last two digits shall indicate the year and shall be separated from the first two digits by a forward slash (“/”). Months earlier than the tenth month shall be a single digit preceded by "0". The letter shall represent the week of the month. The letter "A" shall be used for the first week of the month, "B" for the second week of the month, etc. Sunday shall be considered the first day of a week. Actual date and printed date cannot be more than two days apart.

EXAMPLES:

A battery manufactured during the second week of March 2009 will bear the code "03/09B".

A battery manufactured during the third week of November 2012 will bear the code "11/12C".

3.8.3 Terminal marking. Terminal markings shall be as required by the applicable specification sheet. Terminal markings shall be either black or colorless engraving.

3.8.4 Complete discharge device marking/label. When specified (see applicable specification sheet), each battery shall have a removable label affixed to it that provides the activation procedures for the complete discharge device and permanent marking that provides instructions on the complete discharge process. Label text for the removable label shall be yellow or amber in color. The permanent marking can either be a separate label or marked directly on the battery enclosure in either black lettering or colorless engraving. Label background shall be either clear or match the color of the battery enclosure. The content shall be as follows:

Permanent marking:

WARNING

DISCHARGE FOR DISPOSAL
BY DESIGNATED PERSONNEL ONLY

AFTER ACTIVATING COMPLETE DISCHARGE
DEVICE SEPARATE BATTERIES BY AT LEAST
TWO INCHES. ALLOW BATTERIES TO
DISCHARGE UNTIL LED GOES OUT OR FOR
SEVEN DAYS, MAXIMUM.

Removable label:

ATTENTION

WHEN PREPARING FOR DISPOSAL
IF BATTERY IS UNDAMAGED,
PEEL OFF THIS LABEL, PULL IT FREE
FROM BATTERY. ILLUMINATION OF THE
LED INDICATES ACTIVATION OF THE COMPLETE
DISCHARGE DEVICE. IF LED FAILS TO LIGHT,
OR BATTERY IS DAMAGED, PROCESS THE
BATTERY AS HAZARDOUS WASTE.

3.8.5 State of charge marking. When specified (see applicable specification sheet), each battery with a state of charge indicator shall have the marking indicated below. In addition, each indicator stage shall be marked with the following values as indicated on the applicable drawing (see applicable specification sheet): ≥10%; ≥30%; ≥50%; ≥70%; and ≥90%. Marking shall be either black or colorless engraving on the battery enclosure.

STATE OF CHARGE

TO DETERMINE STATE OF CHARGE,
DEPRESS AND HOLD BUTTON.
LEDS WILL INDICATE STATE OF CHARGE

3.8.6 Serial number (S/N). Each battery shall have a serial number assigned. The serial number shall be composed of seven digits using Arabic numerals without commas or decimal points and shall be assigned to the batteries in production sequence starting with the number 1 for each contract. For numbers less than 1 million, leading zeroes shall be used.

4. VERIFICATION

4.1 Classification of inspection.

a. First article inspection (see 4.4).

b. Conformance inspection (see 4.5).

4.2 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the

required inspections shall be used. The establishment and maintenance of a calibration system to control the accuracy of the test and measuring equipment shall be in accordance with NCSL-Z540.1 or equivalent.

4.2.1 Instrument accuracy.

4.2.1.1 Voltmeters and ammeters. All voltage and current measuring devices used in testing the batteries shall be accurate within 1 percent of the full scale value. The sensitivity of voltmeters shall be not less than 10,000 ohms per volt.

4.2.1.2 Resistor tolerance. During all tests involving discharge through a resistance, such resistance shall be accurate within the following percentages:

	percent
Up to and including 1 megohm	±1.0
Above 1 megohm	±5.0

In determining the resistance used as a test load, the resistance of all continuously operating voltmeters shall be considered as part of the specified load.

4.2.1.3 Power supplies. Power supplies used for testing shall be accurate within ±1 percent of the range of use.

4.2.1.4 Timing. Timing equipment shall be accurate within 0.1 percent or better when the measured time is greater than 120 seconds. Otherwise, the accuracy shall be 0.5 percent or better.

4.3 Inspection conditions. Except as otherwise specified herein, all examinations and tests shall be performed at a temperature of 80 ± 20ºF (27ºC), ambient humidity and ambient atmospheric pressure conditions.

4.4 First article inspection. First article inspection shall consist of the examinations and tests specified in Tables I through VI except that Table I tests shall be performed only when necessary (see 4.4.1). Sample sizes for the cells, components, and batteries requiring test shall be as required herein. The samples shall be representative of the items intended to be supplied under this specification. The samples shall be produced with the use of equipment and procedures normally used in production.

4.4.1 Samples requiring test. The cells, components, and batteries required for the inspections and tests indicated below (see Tables I through VI) shall be subjected to first article testing. Group I tests are described by the UN Manual of Tests and Criteria and are mandated by federal regulations and international trade agreements for the transport of lithium batteries. Existing test results may suffice as proof of conformance only if it meets the criteria of the applicable federal regulations and the UN Manual. Otherwise, Group I tests shall be performed as part of first article.

4.4.2 Inspection routine. Inspections and tests of Tables I through VI shall be conducted in the order shown. Tests requiring a division of samples may be conducted concurrently.

TABLE I – Group I Transportation Tests, Cells and Batteries

Group No.	Sample Size	Inspection	Requirement Paragraph	Test Method Paragraph
I A	40	Cell tests		
I A 1	20	Altitude	3.7.1	4.6.5.1
I A 1	20	Thermal test	3.7.2	4.6.5.2
I A 1	20	Vibration, Method 1	3.7.3	4.6.5.3.1
I A 1	20	Shock, Method 1	3.7.4	4.6.5.4.1
I A 1	20	Cell short circuit	3.5.7	4.6.2.7
I A 2	10	Impact	3.5.8	4.6.2.8
I A 3	10	Cell forced discharge	3.5.9	4.6.2.9
I B	8	Battery tests		
I B	8	Altitude	3.7.1	4.6.5.1
I B	8	Thermal test	3.7.2	4.6.5.2
I B	8	Vibration, Method 1	3.7.3	4.6.5.3.1
I B	8	Shock, Method 1	3.7.4	4.6.5.4.1
I B	8	Battery short circuit	3.5.13.2	4.6.2.15

TABLE II – Group II Cell, Component, & Cell String Level Inspections and Tests

Group No.	Sample Size	Inspection	Requirement Paragraph	Test Method Paragraph
II	Volume	Compounds	3.3.2	4.6.1.1
II	5	Battery enclosure	3.4.3	4.6.1.2
II	5	Containers	3.5.1	4.6.2.1
II A	5 to 25	Cell Voltage	3.4.4.3	4.6.1.3
II A	5 to 25	Cell Leakage	3.5.2	4.6.2.2
II A 1	10	Cell Charging 1/	3.5.3	4.6.2.3
II A 2	10	Nail penetration 1/	3.5.4	4.6.2.4
II A 3	5	Crush	3.5.5	4.6.2.5
II B	3	Parallel string charge protection 2/	3.5.6.1	4.6.2.6.1
II B	3	Cell series short circuit 1/	3.5.6	4.6.2.6

NOTES:
1/ When specified (see applicable specification sheet)
2/ When specified (see applicable specification sheet), tests of cell strings shall be performed on 3 cell strings; If required, the parallel string charge protection test shall be performed immediately prior to the cell series short circuit protection test.

TABLE III – Group III Battery Inspections and Tests

Group No.	Sample Size 1/	Inspection	Requirement Paragraph	Test Method Paragraph
III	18 to 29	Visual mechanical	3.1	4.6.1.4
III	18 to 29	Battery voltage	3.4.4	4.6.1.5
III	18 to 29	Dimensions & weight	3.1	4.6.1.6
III	18 to 29	Insulation resistance	3.5.10	4.6.2.10
III	18 to 29	Charge protection 2/	3.5.11	4.6.2.11
III	18 to 29	Connector 2/	3.4.5	4.6.1.7
III	18 to 29	Battery charger connection 2/	3.4.5.1	4.6.1.7.1
III	18 to 29	Terminal integrity 3/	3.4.6	4.6.1.8
III	18 to 29	Socket strength 2/	3.4.6.1	4.6.1.8.1
III	18 to 29	Terminal strength 2/	3.4.6.2	4.6.1.8.2
III	23	Static connection integrity 2/	3.4.5.2	4.6.1.7.2
III	18 to 29	Shock, Method 2	3.7.4	4.6.5.4.2
III	18 to 29	Vibration, Method 2	3.7.3	4.6.5.3.2
III	18 to 29	Drop	3.7.5	4.6.5.5
III A	6	Capacity test I (& IP 4/)	3.6	4.6.4.1.2
III B	6	Capacity test L (& LP 4/)	3.6	4.6.4.1.3
III C	6	Capacity test H (& HP 4/)	3.6	4.6.4.1.4
III D	6	Capacity test LR 2/	3.6	4.6.4.1.5
III E	5	Complete discharge device 5/	3.4.7	4.6.1.9

NOTES:
1/ For Types I & III, Class 2 batteries, 23 samples are required; for Type II, Class 2, 29 samples are required. 18 samples are required for Class 1 or 3 batteries.
2/ Only when specified (see applicable specification sheet).
3/ When terminal integrity applies, either the socket strength test or the terminal strength test is required (see applicable specification sheet)
4/ Parallel discharges (IP, LP, and HP) are only required when specified (see applicable specification sheet). One half of the samples assigned to the test shall be subjected to the series discharge tests (I, L, & H); the other half will be subjected to the parallel discharge tests.
5/ This test is required for all Class 2 batteries regardless of Type.

TABLE IV – Group IV Battery Inspections and Tests

Group No.	Sample Size 1/	Inspection	Requirement Paragraph	Test Method Paragraph
IV	18 to 24	Visual mechanical	3.1	4.6.1.4
IV	18 to 24	Battery voltage	3.4.4	4.6.1.5
IV A	6	Capacity test IT (& ITP 3/)	3.6	4.6.4.1.6
IV B	6	Capacity test LT (& LTP 3/)	3.6	4.6.4.1.7
IV C	6	Capacity test HT (& HTP 3/)	3.6	4.6.4.1.8
IV D	6	Capacity Test LRT 2/	3.6	4.6.4.1.9

NOTES:
1/ For Types I & III batteries, 18 samples are required; for Type II, 24 samples are required.
2/ Only when specified (see applicable specification sheet).
3/ Parallel discharges (ITP, LTP, and HTP) are only required when specified (see applicable specification sheet). One half of the samples assigned to the test shall be subjected to the series discharge tests (IT, LT, & HT); the other half will be subjected to the parallel discharge tests.

TABLE V – Group V Battery Inspections and Tests

Group No.	Sample Size 1/	Inspection	Requirement Paragraph	Test Method Paragraph
V	30 to 46	Visual mechanical	3.1	4.6.1.4
V	30 to 46	Battery voltage	3.4.4	4.6.1.5
V A	20	Altitude	3.7.1	4.6.5.1
V A	20	Thermal shock	3.7.6	4.6.5.6
V A	20	Dynamic connection integrity 1/	3.4.5.2	4.6.1.7.3
V A	20	Abuse test	3.5.12	4.6.2.12
V B	10 to 26	Humidity	3.7.7	4.6.5.7
V B	10 to 26	Drop	3.7.5	4.6.5.5
V B 1	5	Immersion 2/	3.7.8	4.6.5.8
V B 2	5	Watertight integrity 2/	3.7.9	4.6.5.9
V B 3	5	Over-current protection 1/	3.5.13.1	4.6.2.13
V B 4	5	Over-temperature protection 1/	3.5.14	4.6.2.14
V B 5	6	State of charge device 1/	3.4.8	4.6.1.10
V B 6	5	Projectile	3.5.15	4.6.2.16

NOTES:
1/ Inspection only required when specified (see applicable specification sheet).
2/ Either the Immersion test OR the Watertight Integrity test will be required for each battery.

TABLE VI – Group VI Battery Inspections and Tests

Group No.	Sample Size	Inspection	Requirement Paragraph	Test Method Paragraph
VI	12	Visual mechanical	3.1	4.6.1.4
VI	12	Battery voltage	3.4.4	4.6.1.5
VI	12	US Navy Safety Tests	3.5.16	4.6.3
VI A	3	Constant current discharge & reversal	3.5.16	4.6.3.1
VI B	3	Short circuit	3.5.16	4.6.3.2
VI C	3	Charging	3.5.16	4.6.3.3
VI D	3	Electrical safety device	3.5.16	4.6.3.4

4.5 Conformance inspection.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of Groups A, B and C inspection.

4.5.1.1 Group A inspection. Each battery on contract or purchase order shall be 100 percent inspected for conformance to the inspections in the order specified in Table VII. All failures shall be removed. Discrete lots shall be formed from batteries that pass this inspection.

TABLE VII - Group A inspection.

Examination or Test	Requirement Paragraph	Method or Test Paragraph
Visual-mechanical inspection	Applicable specification sheet	4.6.1.4
Dimensions	Applicable specification sheet	4.6.1.6
Battery voltage	3.4.4	4.6.1.5

4.5.1.2 Group B inspection. Group B inspection shall consist of the tests specified in Table IX. Inspections and tests shall be performed in the order shown except that tests requiring a division of samples may be conducted concurrently. Sample size shall be as specified in Table VIII. Group B inspection shall be performed on sample units from each shipment lot (as defined in 6.4.2) which has been subjected to and passed group A inspection.

Table VIII – Sample Size Requirements, Groups B and C Inspections and Tests

LOT SIZE 1/	Inspection Level	Group B	Group C (C1 or C2)
Up to 500	1	13	13
501 to 3,200	2	20	20
Over 3,200	3	32	32

NOTE:
1/ Lot Size based on quantity of batteries in shipment lot.

Table IX – Group B Inspections and Tests

Inspection or Test	Requirement Paragraph	Method or Test Paragraph	Test sample break-out by test
Weight	Applicable specification sheet	4.6.1.6	All
Connector 1/	3.4.5	4.6.1.7	All
Battery charger connection 1/	3.4.5.1	4.6.1.7.1	All
Static connection integrity 1/	3.4.5.2	4.6.1.7.2	All
Terminal integrity 1/	3.4.6	4.6.1.8	All
Insulation resistance	3.5.10	4.6.2.10	All
Charge protection 1/	3.5.11	4.6.2.11	All
Complete discharge device 1/	3.4.7	4.6.1.9	Table X
Capacity I (and IP 1/)	3.6	4.6.4.1.2	Table X
Capacity L (and LP 1/)	3.6	4.6.4.1.3	Table X
Capacity H (and HP 1/)	3.6	4.6.4.1.4	Table X
Battery over-temperature protection 1/	3.5.14	4.6.2.14	Table X
Capacity LR 1/	3.6	4.6.4.1.5	Table X

NOTE:
1/ When specified (see applicable specification sheet)

Table X – Sample Break-out For Group B Inspections and Tests

Types and Classes:	Type I, Class 1 or 3			Types I & III, Class 2			Type II, Class 2		
Inspection Levels:	1	2	3	1	2	3	1	2	3
TESTS									
Capacity LR 1/	0	0	0	0	0	0	3	4	7
Complete discharge 1/	0	0	0	2	3	8	2	3	6
Capacity I (and IP 1/ 2/)	5	7	11	4	6	8	3	5	7
Capacity L (and LP 1/ 2/)	4	7	11	4	6	8	3	4	6
Capacity H (and HP 1/ 2/)	4	6	10	3	5	8	2	4	6
Battery over-temperature 3/	4	6	10	3	5	8	2	4	6

NOTES:
1/ When specified (see applicable specification sheet)
2/ When parallel discharges are required (see applicable specification sheet), the quantities for the I, L, and H tests shall be divided in two; in the case of odd quantities, the extra sample shall be subjected to the parallel discharge test.
3/ Use capacity H (and HP) test samples for the battery over-temperature protection test after completion of the H test prior to complete discharge (where applicable). If any of the samples have an open circuit condition prior to the battery over-temperature protection test, capacity L samples may be substituted.

4.5.1.3 Group C inspection. Group C inspection shall consist of either sub-group C1 or sub-group C2 tests listed in Table XI. Sub-group C1 requirements shall apply to the first shipment lot; sub-group C2 requirements shall apply to the next if required. The same sequence shall apply to all subsequent shipment lots if required. Tests shall be performed in

the order shown except that tests requiring a division of samples may be conducted concurrently.

4.5.1.3.1 Sampling plan. Samples shall be in accordance with Table VIII and selected at random from each shipment lot that has been subjected to and passed Group A inspection. Sample quantity break-out shall be as specified in Table XII for sub-group C1 or Table XIII for sub-group C2.

Table XI – Group C Inspections and Tests

Inspection or Test	Requirement Paragraph	Method or Test Paragraph	Test sample break-out by test
SUB-GROUP C1			
Desert Cycle (7 cycles)	n/a	4.6.4.2.2	All
Shock, Method 2	3.7.4	4.6.5.4.2	All
Vibration, Method 2	3.7.3	4.6.5.3.2	All
Capacity IT (and ITP 1/)	3.6	4.6.4.1.6	Table XII
Capacity LT (and LTP 1/)	3.6	4.6.4.1.7	Table XII
Capacity HT (and HTP 1/)	3.6	4.6.4.1.8	Table XII
Capacity LRT 1/	3.6	4.6.4.1.9	Table XII
Abuse test	3.5.12	4.6.2.12	Table XII
SUB-GROUP C2			
Humidity (1 cycle)	3.7.7	4.6.5.7	All
Thermal Shock	3.7.6	4.6.5.6	All
Shock, Method 2	3.7.4	4.6.5.4.2	All
Vibration, Method 2	3.7.3	4.6.5.3.2	All
Over-current protection 1/	3.5.13.1	4.6.2.13	Table XIII
Short circuit protection	3.5.13.2	4.6.2.15	Table XIII
Dynamic connection integrity 1/	3.4.5.2	4.6.1.7.3	Table XIII
Submersion 2/	3.7.9d	4.6.5.9d	Table XIII
Capacity H2 2/	3.7.9e	4.6.5.9e	Table XIII
Immersion 1/	3.7.8	4.6.5.8	Table XIII
State of charge device 1/	3.4.8	4.6.1.10	Table XIII

NOTE:
1/ When specified (see applicable specification sheet)
2/ When watertight integrity is specified (see applicable specification sheet)

Table XII – Sample Break-out for Group C1 Inspections and Tests

Types:	Types I & III			Type II		
Inspection Levels:	1	2	3	1	2	3
TESTS						
Capacity LRT 1/	0	0	0	2	3	4
Capacity IT (and ITP 2/)	3	5	7	2	4	6
Capacity LT (and LTP 2/)	3	4	7	2	3	5
Capacity HT (and HTP 2/)	2	4	6	2	3	5
Abuse test	5	7	12	5	7	12

NOTES:
1/ When specified (see applicable specification sheet)
2/ When parallel discharges are required (see applicable specification sheet), the quantities for IT, LT, and HT tests shall be divided in two; in the case of odd quantities, the extra sample shall be subjected to the parallel discharge test.

Table XIII – Sample Break-out for Sub-Group C2 Inspections and Tests

Features:	A			B&C			D&E		
Inspection Levels:	1	2	3	1	2	3	1	2	3
TESTS									
Over-current protection 1/	0	0	0	3	4	5	2	3	4
Short circuit protection	3	4	5	3	4	5	2	3	4
Dynamic connection integrity 1/	10	16	27	7	12	22	3	5	12
Submersion 1/	10	16	27	7	12	22	3	5	12
Capacity H2 1/	10	16	27	7	12	22	3	5	12
Immersion 1/	10	16	27	7	12	22	3	5	12
State of charge device 1/	0	0	0	0	0	0	6	9	12

1/ When specified (see applicable specification sheet)

4.6 Test methods and examination.

4.6.1 Materials, design, & construction inspections.

4.6.1.1 Flow or shrinking (compounds). The following test shall be performed on compounds. Place compound in a container, approximately 3 inches wide by 6 inches long by 3/4 inch high, to within 1/2 inch of the top and allow to cure in accordance with the manufacturer's standard procedures. Place the container in an environmental chamber in an inverted position and raise the temperature to +200±5ºF (93.3ºC). Keep the container inverted at these conditions for not less than 24 hours. Inspect the container for the requirements of 3.3.2. Place the container in an environmental chamber and lower the temperature to -40±5ºF (-40ºC); hold these conditions for not less than eight hours. The test sample shall then be inspected for the requirements of 3.3.2.

4.6.1.2 Battery enclosure. If the battery enclosure material does not have UL-94 classification, then the following test shall be performed on 5 sample enclosures. Expose to a flame for not less than 30 seconds. Sample enclosures may be tested alone or in a

configuration similar to that of a completed battery, provided there are no active materials in the test samples. Use the Horizontal Burning Test method of UL 94 to determine the test apparatus criteria. Samples shall meet the criteria of 3.4.3.

4.6.1.3 Cell closed-circuit voltage. The cells shall be on load for not greater than five (5) seconds at the load specified (see applicable specification sheet). Cells shall meet the requirements of 3.4.4.3.

4.6.1.4 Visual and mechanical examination. Batteries shall be examined to determine compliance with all applicable requirements and characteristics as specified herein (see 3.1, 3.8, and Table XIV).

TABLE XIV - Classification of visual and mechanical examination defects.

Categories 1/	Defects
001	Improper assembly causing parts to be inoperative or unsafe in service.
002	Electrolyte leakage.
101	Deformed or damaged parts which are inoperative or malfunction in service.
102	Contact surfaces obstructed by insulation material so that electrical use is affected. Rust, corrosion, or any type of non-conductive material on contact surfaces.
103	Battery enclosures - any hole, tear, rip, or crack.
104	Improper jacket closure (i.e., any gap 2/ along glued or welded seams).
105	Location, orientation, polarity and marking of terminals not as specified.
106	Labeling and marking wrong, missing or illegible (see 3.8).
107	Blistering, peeling, or shifting of labels.
108	State of Charge Indicator: When required, SOCI is missing, does not comply with physical requirements, or does not include required markings.
109	Any sharp edges on exterior of battery
110	When applicable, light emitting diodes are illuminated without either the State of Charge Indicator actuated or the Complete Discharge Device activated
201	Deformed or damaged parts which do not adversely affect electrical performance.
202	Burrs or imperfections which do not interfere with proper use or cause unsafe conditions in service.
203	Color not as specified (see 3.4.3.1)
204	Loose parts inside battery.

NOTES:
1/ Category 0XX defects are critical, category 1XX are major, and category 2XX are minor. These categories are used to qualify the levels of nonconformance. Critical defects affect safety; major defects affect use; batteries with minor defects may be serviceable with some limitations.
2/ A “gap” is defined as any opening along glued or welded seams that goes completely through the enclosure surface to the battery’s interior.

4.6.1.5 Battery voltage.

4.6.1.5.1 Open-circuit voltage. The open-circuit voltage of the battery under test shall be measured. In the case of multi-sectioned batteries, open-circuit voltage shall be measured in

both series and parallel modes (see applicable specification sheet). Batteries shall meet the requirements of 3.4.4.1.

4.6.1.5.2 Closed-circuit voltage. The following closed-circuit voltage test shall be performed. Apply the load specified (see applicable specification sheet) to the output terminals; measure the voltage in not greater than 10 seconds. In the case of multi-sectioned batteries, each section shall be tested independently. Batteries shall meet the requirements of 3.4.4.2.

4.6.1.6 Dimensions and weight. Batteries shall be examined by gauging or measuring and by weighing to determine conformance (see applicable specification sheet for specific requirements). All measurements shall include any coating which may be used. Battery dimensions shall be measured during the dimension inspections of first article. Dimensions may be checked by gauging whenever a first article test requires dimensional compliance as passing criteria following capacity and environmental tests. Dimension inspections during conformance inspections may be accomplished by gauging. Batteries shall meet the requirements specified in the applicable specification sheet.

4.6.1.6.1 Gauging. When box gauges are used, batteries, loaded with a weight not greater than five pounds, shall pass freely through the applicable gauge openings. The dimensions of the box gauge shall be the specified maximum outside dimensions of the battery (see applicable specification sheet). Cylindrical battery dimensions shall be checked with a ring gauge meeting the above requirements.

4.6.1.7 Connector. When specified (see applicable specification sheet), the following test shall be performed on connectors. Verify connector location. Engage and withdraw the mating connector a total of ten times. Unless otherwise specified (see applicable specification sheet), measure engagement force on the first mating; measure withdrawal force on the tenth withdrawal. Measure voltage of battery or each battery section on each mating to ensure continuity. Connectors shall meet the requirements of 3.4.5.

4.6.1.7.1 Battery charger connection test. When specified (see applicable specification sheet), each battery designated for this test shall be tested as follows: Connect the output of a charger connector (see applicable specification sheet) to voltage sensing equipment. Attempt to connect the charger connector to the battery connector with not less than 12 pounds of force. In the case of multi-sectioned batteries, connect volt-sensing connections for each independent section. Repeat for a total of 3 attempts. After the third attempt, measure battery voltage in accordance with 4.6.1.5.1. After test, batteries shall meet the requirements of 3.4.5.1.

4.6.1.7.2 Static connection integrity test. When specified, (see applicable specification sheet), the following test shall be performed. Connect to the test fixture described in the applicable specification sheet. Secure the fixture in a vice or clamp so that the battery face that includes the identity and safety marking is parallel to the plane of the horizon (do not vice or clamp the battery). Apply a weight of not less than 15 lbs. to the top surface of the battery (as mounted) so that its center of gravity is at the point specified (see applicable specification sheet). Leave the weight in place for not less than 30 seconds and then remove it from the battery. Ensure that the test fixture does not deflect by more than 5 degrees while the weight is applied. Measure battery open-circuit voltage continuously for not less than 10 seconds prior to the application of the weight, throughout the time the weight is applied, and for not less than 10 seconds after it is removed. Upon completion, rotate the battery and fixture 180 degrees and repeat the test. Batteries shall meet the requirements of 3.4.5.2.

4.6.1.7.3 Dynamic connection integrity test. When specified (see applicable specification sheet), the following test shall be performed. Connect to the test fixture described in the applicable specification sheet. Securely mount the fixture to a vibration table with the battery/fixture interface parallel to the direction of motion. Ensure that the battery is held in place by the fixture only. Ensure that the direction of motion is across the narrow face of the battery, in line with the battery contacts. Connect voltage sensing equipment to the battery under test through the test fixture contacts. Vibrate the battery with an amplitude of 0.03 in. (0.06 in. total excursion), and vary vibrations uniformly from 10 Hz to 55 Hz back to 10 Hz in 60 seconds +/- 10 seconds. Monitor battery voltage continuously during the vibration period. After test, visually inspect each battery in accordance with 4.6.1.4 and measure the open-circuit voltage in accordance with 4.6.1.5.1. Batteries shall meet the requirements of 3.4.5.2.

4.6.1.8 Terminal integrity. When specified (see applicable specification sheet), one of the following tests shall be performed on either the plastic socket or the metal terminals of the battery, as specified. After either test, visually inspect each battery in accordance with 4.6.1.4 and measure the open-circuit voltage in accordance with 4.6.1.5.1.

4.6.1.8.1 Socket strength. When specified (see applicable specification sheet) use a 0.250 ±0.050 inch diameter rod to apply a force to the center of the socket and deflect it downward a distance of 0.250 +0.0625, -0 inch below the top surface of the battery. Batteries shall meet the requirements of 3.4.6.1.

4.6.1.8.2 Terminal strength. When specified (see applicable specification sheet) use a 0.200 ±0.050 inch diameter rod to apply a force of not less than 10 pounds to each battery terminal excluding state of charge data output terminals. Batteries shall meet the requirements of 3.4.6.2.

4.6.1.9 Complete discharge device. When specified (see applicable specification sheet), the following test shall be performed. Activate the device in accordance with the instructions on the battery while measuring the force required to activate. If a tab is used underneath the removable label, ensure that it is pulled out of the battery. Ensure that yellow or amber light is visible once the device is active. Leave batteries undergoing complete discharge in the inspection conditions of 4.3 for not less than seven days with not less than 2 inches of separation between all batteries. Batteries shall meet the requirements of 3.4.7.

4.6.1.10 State of charge device. When specified (see applicable specification sheet), the following test shall be performed. Verify location and marking, (see 3.8.5). Prior to discharge, press and hold the SOCI actuator. Measure and record the following to the nearest tenth of the second: (1) time from actuation to full intensity of the lights; (2) time from reaching full intensity until the lights extinguish; and (3) the total time from actuation until the lights extinguish. Measure displacement and resistance values for the actuator and record the results. Press each sample against a flat, transparent surface with not less than 5 lbs of force, with the face including the actuator against the surface. Observe whether or not the LEDs illuminate; record the response. Discharge batteries at the 10±1 hour rate (See Appendix A) as follows: two batteries at +14±5ºF (-10ºC); two at 70±5ºF (21ºC); and two at 130±5ºF (55ºC). If parallel discharge is specified (see applicable specification sheet), then discharge one battery in parallel and one in series for each discharge temperature. Continuously discharge batteries to the following approximate states of charge, stopping the discharge at each state: 80%; 60%; 40%; and 20%. Obtain the SOCI readings while the test battery is not subject to discharge. Observe the indication of the state of charge indicator, read the SMBus data output (where applicable), and record both indications after each partial discharge. Environmental chambers may be

paused or shut off while accessing batteries to obtain the SOCI readings. For samples tested at +14°F, care is needed to limit the freezing of condensation at the battery to test circuit interface. Once the SOCI readings have been obtained, restart the environmental chamber and restart the discharge in not less than 15 minutes after return to the required test temperature (for samples tested at +14°F, allow sufficient time to clear the frost if condensation has frozen on batteries). Discharge the batteries to cut-off voltage; continue discharge for not less than 30 seconds. Observe the indication of the state of charge indicator, read the SMBus data output (where applicable), and record the indications. Activate the CDD on all test samples as specified in 4.6.1.9 above. Batteries shall meet the requirements of 3.4.8.

4.6.2 Safety Features[4].

4.6.2.1 Container pressure test. When specified (see 3.5.1), the following test shall be performed. Apply an airtight seal to each cell container and have its internal pressure raised to 100 psig. After this, raise the internal pressure at a rate not less than 25 psig per minute. Continue raising the pressure until the vent mechanism opens. Record the pressure required to open the vent mechanism. Containers tested shall meet the requirements of 3.5.1.

4.6.2.2 Cell leakage test. The following test shall be performed. Application of potting substances and insulating materials is permitted, provided the application is uniform for all test samples. If potting substance or cell jackets are applied to the cells, apply prior to the storage portion of this test. Store cells for seven days at 160 ± 5ºF (71ºC). On the seventh day, remove the cells from the temperature cabinet, place them in a desiccator, and cool at the conditions of 4.3 for not less than two hours. Weigh each cell to the nearest tenth of a milligram. Record weight. Visually examine the cells to determine if leakage has occurred. Place all cells in the temperature cabinet and store for another twenty-one days at 160 ± 5ºF (71ºC) for a total storage time of twenty-eight days. At the completion of this 21-day storage period, remove the cells from the temperature cabinet, place in a desiccator and cool for not less than two hours at the conditions of 4.3. Weigh each cell to the nearest tenth of a milligram. Determine the weight loss between day 7 and day 28 and record. The cells shall be visually examined to determine if leakage has occurred. Cells shall meet the requirements of 3.5.2.

4.6.2.3 Cell charging test. When specified (see applicable specification sheet), the following test shall be performed on 5 fresh and 5 completely discharged cells. Prior to testing, discharge 5 cells to 0.2 volts while on load, using a load not less than that specified for the cell closed-circuit voltage test (see applicable specification sheet). Measure voltage and record prior to performing test. Subject individual cells to 20mA of charging current with a voltage of not greater than 36 volts until the cell vents, ruptures, or for not less than 96 hours, whichever occurs first. Record the time of any rupture or venting. Cells shall meet the requirements of 3.5.3.

4.6.2.4 Nail Penetration test. When specified (see applicable specification sheet), the following test shall be performed. Insert a 2.5 mm DIA stainless steel nail with a length that exceeds the width or diameter of the cell to be tested into each cell at right-angles to the electrode surface close to the center of the cell. Drive the nail completely through on five of the ten samples; Drive the nail to a depth of 2/3 of the width of the cell for the remaining five. Leave

[4] The verification methods of 4.6.2 and 4.6.3 involve tests that may damage test equipment, release toxic materials, or present hazards to test personnel. Users of this document are cautioned to ensure compliance with applicable occupational safety and environmental regulations.

the nail in the cell for 24 hours. Monitor the voltage and external temperature of the cell for the duration of the test. Cells shall meet the requirements of 3.5.4.

4.6.2.5 Crush test. The following test shall be performed. Subject cells designated for the crush test to the crush test of UL 1642. Crush each sample cell with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. Subject each sample cell to a crushing force in only one direction. Cells shall meet the requirements of 3.5.5.

4.6.2.6 Cell series string short circuit protection test. When specified (see applicable specification sheet), the following test shall be performed. Assemble fresh cells into cell strings in the same manner as would be used in battery production. Stabilize cell strings at +130±5ºF (55ºC) for not less than two hours prior to shorting. Use a circuit with not greater than 0.1 ohms resistance to apply the short circuit. Apply the short at these same conditions and maintain for not less than one hour. In the event that an open-circuit condition occurs, verify the cause of the open circuit. Visually examine cell strings after the test for signs of insulation melting, shrinking or burning. Cells shall meet the requirements of 3.5.6.

4.6.2.6.1 Parallel string charge protection test. When specified (see applicable specification sheet), the following test shall be performed. Assemble fresh cells into cell strings in the same manner as would be used in battery production. Connect a DC power supply capable of delivering not less than 2.50 milliamperes to the terminations of each cell string. Use a voltage of 32 (+0, -1) volts, plus the specified minimum open circuit voltage for the battery under test (see applicable specification sheet). In the case of multi-sectioned batteries, use the voltage specified for each section. Electrically connect the power supply to the cell strings to force reverse current flow (charging) through each individual cell string (i.e., positive to positive and negative to negative). Apply for not less than 1.0 second; Record the current flowing during this time period. Cells shall meet the requirements of 3.5.6.1.

4.6.2.7 Cell short circuit test – The following test shall be performed. Subject each cell designated for the cell short circuit test to the external short circuit test for lithium batteries, UN No. 3090, of the UN Manual of Tests and Criteria. Prepare and fixture the cells as required in the manual prior to testing. Cells shall meet the requirements of 3.5.7.

4.6.2.8 Impact test. The following test shall be performed. Subject each test sample cell to the Impact test for lithium batteries, UN No. 3090, of the UN Manual for Tests and Criteria. Prepare and fixture the cells as required by the manual prior to testing. Cells shall meet the requirements of 3.5.8.

4.6.2.9 Cell forced discharge test. The following test shall be performed. Subject cells designated for the cell forced discharge test to the forced discharge test for lithium batteries, UN No. 3090, of the UN Manual of Tests and Criteria. Prepare and fixture the cells as required by the manual prior to testing. Cells shall meet the requirements of 3.5.9.

4.6.2.10 Insulation resistance test. The following test shall be performed. Apply a direct-current potential as specified below between any two battery terminals not electrically connected and between all terminals and the container of the battery except as otherwise specified herein. For batteries with a State of Charge Indicator, do not test the terminals designated for data output. Measure the insulation resistance of batteries by the use of a copper plate making physical contact with the container. The plate shall exceed the dimensions of the surface to be tested. Place the battery under test on the plate so that the plate is visible outside all edges of the surface under test. Test each battery in a minimum of three locations.

Test each battery on all surfaces with an enclosure seam other than that on which the battery terminals are located; for cylindrical batteries, test in not less than three locations around the diameter including on seams if present. Batteries shall meet the requirements of 3.5.10.

a. For a battery with a State of Charge Indicator, use a potential not less than 100 volts.

b. For a battery without a State of Charge Indicator, use potential not less than 500 volts.

4.6.2.11 Charge protection test. When specified (see applicable specification sheet), the following test shall be performed. Use a DC power supply capable of delivering at least 2.50 milliamperes. Use a voltage of 32 (+0, -1) volts, plus the specified minimum open circuit voltage for the battery under test (see applicable specification sheet). Electrically connect the power supply to the terminals of the battery or to each independent section of a multi-section battery to force reverse current flow (charging: positive to positive and negative to negative connections). Apply this voltage for not less than 1.0 second; record the current flowing during this time period. Multi-sectioned batteries require testing of all independent sections. Batteries shall meet the requirements of 3.5.11.

4.6.2.12 Abuse test – The following test shall be performed. Batteries shall meet the requirements of 3.5.12:

a. Predischarge. Discharge required quantity of samples (see Table XV below) at the rate specified for the Abuse Test predischarge (see applicable specification sheet). Record ampere-hours consumed.
b. Drop. Subject all samples to the drop test of 4.6.5.5 without preconditioning at 130°F or -20°F.
c. Visual inspection. Visually inspect and perform the battery open circuit voltage inspection of 4.6.1.5.1.
d. Heat. Store all Types I & II samples at 195±5°F (90.5ºC) for not less than eight hours; Store Type III samples at 167±5°F (75ºC) for not less than eight hours.
e. Visual inspection. Visually inspect and perform the battery open circuit voltage inspection of 4.6.1.5.1.
f. Vibration, Method 2. Subject all samples to the vibration test (see 4.6.5.3.2).
g. Visual inspection. Visually inspect and perform the battery open circuit voltage inspection of 4.6.1.5.1.
h. Battery over-current. Unless otherwise specified (see 4.6.2.12i below), select required quantity of samples. Subject these batteries to the Battery over-current test (see 4.6.2.13).
i. Pulse Discharge. Subject required quantity of samples to the Pulse Discharge conditions using continuous cycles of 1 minute on the heavy load followed by 4 minutes of moderate load (see applicable specification sheet for loads). Continue discharge until battery voltage drops below the specified cut-off voltage. Record ampere-hours consumed to cut-off voltage. When the battery over-current test is not required (see applicable specification sheet), use all samples for this test.

Table XV – Abuse Test Sample Break-out

Inspection Level 1/:	1 (5 samples)		2 (7 samples)		3 (12 samples)	
Abuse test stage:						
Predischarge	3		4		6	
Sample type:	Predischarged	Undischarged	Predischarged	Undischarged	Predischarged	Undischarged
Drop	3	2	4	3	6	6
Heat	3	2	4	3	6	6
Visual inspection	3	2	4	3	6	6
Vibration, Method 2	3	2	4	3	6	6
Visual inspection	3	2	4	3	6	6
Over-current 2/	1	1	2	1	3	3
Pulse discharge	2	1	2	2	3	3

1/ For Group V tests, divide samples in half: predischarge 10, and use 5 of each sample type for the over-current (when applicable) and pulse discharge.
2/ When specified (see applicable specification sheet). When the over-current test is not required, subject all samples to the pulse discharge test.

4.6.2.13 Battery over-current protection test. When specified (see applicable specification sheet), the following test shall be performed. Discharge batteries at the over-current rate specified (see applicable specification sheet). Use a driving power supply capable of not less than 36 volts DC output to maintain the required load (see applicable specification sheet). Continue discharge until the battery reaches cut-off voltage, the battery experiences an open circuit, or the battery's internal circuitry limits current to less than the rate specified. Load batteries with independent multiple sections in the series mode only. In the event that an open circuit condition occurs during this test, determine the source of the open circuit. Batteries shall meet the requirements of 3.5.13.1.

4.6.2.14 Battery over-temperature protection test. When specified (see applicable specification sheet), the following test shall be performed. Monitor The surface temperature and voltage of each test sample throughout this test. Store Types I & II batteries at a temperature not less than 190ºF (87.8ºC) for not less than 8 hours; Store Type III batteries at a temperature not less than 162ºF (72.2ºC) for not less than 8 hours. Following storage, raise the temperature at a rate not greater than 10ºF (5.6ºC) in five minutes until the battery experiences an open-circuit condition. Record the test chamber and battery surface temperature at which the open circuit condition occurs. In the event that an open circuit condition occurs during this test, determine the source of the open circuit. Batteries shall meet the requirements of 3.5.14.

4.6.2.15 Battery short circuit protection test. The following test shall be performed. Subject each battery designated for the battery short circuit test to the external short circuit test for lithium batteries, UN No. 3090, of the UN Manual of Tests and Criteria. Prepare and fixture batteries as required by the manual prior to testing. In the event that an open circuit condition occurs during this test, determine the source of the open circuit. Batteries shall meet the requirements of 3.5.13.2.

4.6.2.16 Projectile. The following test shall be performed. Subject each battery designated for the projectile test to the projectile test of UL 1642. Batteries shall meet the requirements of 3.5.15.

4.6.3 Lithium Battery Safety Program (US Navy) Tests (see 3.5.16). The following tests shall be performed as specified. Test each battery in a test vessel (see 6.5.2) in order to facilitate pressure readings in lieu of the “complete system” described by NAVSEA S9310-AQ-SAF-010. Battery voltage, charge or discharge current, and test vessel pressure shall be monitored continuously during testing (see 6.5.1).

4.6.3.1 Constant current discharge and reversal. The constant current discharge and reversal test for active non-rechargeable batteries of NAVSEA S9310-AQ-SAF-010 shall be performed. For batteries with multiple independent sections, test 2 samples in series connection and 1 in parallel. Batteries shall meet the requirements of 3.5.16.

4.6.3.2 Short circuit. The short circuit test for active non-rechargeable batteries of NAVSEA S9310-AQ-SAF-010 shall be performed. Apply the short to each section separately for batteries with multiple independent sections. Batteries shall meet the requirements of 3.5.16.

4.6.3.3 Charging. The charging test for active non-rechargeable batteries of NAVSEA S9310-AQ-SAF-010 shall be performed. Apply charge current to each section for batteries with multiple independent sections. Batteries shall meet the requirements of 3.5.16.

4.6.3.4 Electrical safety device. The electrical safety device test for active non-rechargeable batteries of NAVSEA S9310-AQ-SAF-010 shall be performed. For batteries with multiple independent sections, test 2 samples in series connection and 1 in parallel. Batteries shall meet the requirements of 3.5.16.

4.6.4 Capacity (see 3.6).

4.6.4.1 Capacity tests. The following test shall be performed. Select and store sample batteries for capacity tests and discharge in accordance with the temperature conditions specified herein unless otherwise specified (see applicable specification sheet). Subject batteries to the battery open-circuit voltage test of 4.6.1.5.1 and visually inspect for bulging, leaking, venting, rupturing, burning, or exploding prior to stabilization storage and discharge. Where applicable (see applicable specification sheet), check the SOCI for indication of the highest level of capacity (see 3.6f) prior to stabilization storage and discharge. Do not apply any load during the desert cycle conditions of 4.6.4.2.2 (when specified) or during stabilization storage. When specified (see applicable specification sheet), affix temperature sensing devices on the batteries’ surfaces for all discharge tests. Place not less than one device on the top of the battery as oriented during discharge; more devices may be placed at various locations on the battery if desired. Discharge all batteries to the cut-off voltage specified in the applicable specification sheet, then discharge for not less than 30 seconds. Continued discharge beyond this point is necessary only when specified for a given test. Use the time required to fall to the specified cut-off voltage during discharge to determine the battery capacity. Inspect discharged batteries for: exceeding dimensional tolerances (see 3.6d); bulging, leaking, venting, rupturing, burning, or exploding (see 3.6e); and SOCI (where applicable) indication of the lowest level of capacity (see 3.6f). When specified, (see 4.5.1.2 and Table X), select discharged samples required for the over-temperature protection test. When a complete discharge device is applicable (see specification sheet), perform the test of 4.6.1.9 after discharge and verify the

positive indication of circuit continuity required for the complete discharge device for batteries that have passed all capacity test requirements except for those completing the I (and IP, where applicable), LR and LRT tests (where applicable). Batteries shall meet the requirements of 3.6 and the capacity requirements of the applicable specification sheet.

4.6.4.1.1 Initial voltage delay. The following test shall be performed as part of each discharge test. Monitor the voltage of each battery at the start of discharge to determine the time in seconds required for battery voltage to rise to the minimum voltage after the specified loads are applied (see applicable specification sheet). Do not include the time required to rise to the specified minimum initial voltage in the capacity determination. The device used to monitor the voltage rise to the minimum voltage shall have a scan rate with a reading interval not greater than 1 second. The time required for each battery to reach the specified initial voltage delay value shall be recorded. Batteries shall meet the requirements of 3.6.1.

4.6.4.1.2 Capacity test I (& IP, where applicable). The following test shall be performed. Discharge at +70 ±5ºF (21ºC) to zero volts. Force discharge at the same conditions at the rate specified for the time specified (see applicable specification sheet). If an open circuit condition occurs during the discharge to zero volts or forced discharge portions of this test, determine the source of the open circuit.

4.6.4.1.3 Capacity test L (& LP, where applicable). The following test shall be performed. Discharge Type I and Type II batteries at -20 ±5ºF (-29ºC) to cut-off voltage after stabilization storage at -20 ±5ºF for not less than eight (8) hours. Discharge Type III batteries at -4 ±5ºF (-20ºC) to cut-off voltage after stabilization storage at -4 ±5ºF for a minimum of eight (8) hours.

4.6.4.1.4 Capacity test H (& HP, where applicable). The following test shall be performed. Discharge at +130 ±5ºF (55ºC) to cut-off voltage after stabilization storage at +130 ±5ºF for not less than eight (8) hours.

4.6.4.1.5 Capacity Test LR (where applicable). When specified (see applicable specification sheet), the following test shall be performed. Discharge at +95 ±5ºF (35ºC) after stabilization storage at +95 ±5ºF for not less than eight (8) hours. Discharge multi-sectioned batteries in the series mode only. Discharge at the constant current rate specified to the voltage specified, then at the constant wattage load specified to cut-off voltage (see applicable specification sheet). Measure capacity from the time the battery initially reaches the cut-off voltage specified for capacity in the applicable specification sheet until it then falls to the second LR cut-off voltage specified.

4.6.4.1.6 Capacity test IT (& ITP, where applicable). The following test shall be performed. Discharge at +70 ±5ºF (21ºC) to cut-off voltage after the required number of cycles of storage (see 4.6.4.2.2) and not less than eight (8) hours stabilization storage at +70 ±5ºF.

4.6.4.1.7 Capacity test LT (& LTP, where applicable). The following test shall be performed. Discharge Type I & II at -20 ±5ºF (-29ºC) to cut-off voltage after the required number of cycles of desert cycle storage (see 4.6.4.2.2) followed by not less than eight (8) hours stabilization storage at -20 ±5ºF. Discharge Type III batteries at -4 ±5ºF (-20ºC) to cut-off voltage after storage for the required number of cycles of desert cycle storage (see 4.6.4.2.2) followed by not less than eight (8) hours stabilization storage at -4 ±5ºF.

4.6.4.1.8 Capacity test HT (& HTP, where applicable). Discharge at +130 ±5ºF (55ºC) to cut-off voltage after the required number of cycles of desert cycle storage (see 4.6.4.2.2) followed by not less than eight (8) hours stabilization storage at +130 ±5ºF.

4.6.4.1.9 Capacity test LRT (where applicable). When specified (see applicable specification sheet), the following test shall be performed. Discharge at +95 ±5ºF (35ºC) after the required number of cycles of desert cycle storage (see 4.6.4.2.2) followed by not less than eight (8) hours stabilization storage at +95 ±5ºF. Discharge multi-sectioned batteries in the series mode only. Discharge at the constant current rate specified to the voltage specified, then at the constant wattage load specified to cut-off voltage (see applicable specification sheet). Measure capacity from the time the battery initially reaches the cut-off voltage specified for capacity in the applicable specification sheet until it then falls to the second LRT cut-off voltage specified.

4.6.4.2 Capacity test conditions. The storage conditions specified for each capacity test and the desert cycle conditions of 4.6.4.2.2 shall prevail during storage periods specified and during discharge. Storage conditions shall be monitored throughout the specified storage periods and recorded at a rate not less than one reading every 30 minutes.

4.6.4.2.1 Discharge. After storage at the desert cycle conditions (where applicable) and following stabilization (where applicable), discharge the batteries at the rate specified for each capacity test in the applicable specification sheet. Ensure not less than two (2) inches of separation between all batteries that are being discharged.

4.6.4.2.2 Desert cycle conditions. The conditions specified in Table XVI below shall be used whenever storage at desert cycle conditions are required by this specification. Conditions start at 95ºF and hold, ramp up or ramp down to the conditions specified in the table each hour. Use the same temperature/time ramp to lower the temperature as that used to raise the temperature. A tolerance of ±5°F applies throughout the specified storage period. Test samples may enter storage at any point in the 24-hour cycle provided they complete the required number of cycles described below. The cycle may be interrupted to allow for adding or withdrawing samples from the chamber provided the chamber is then set to resume the cycle conditions immediately after samples are added or withdrawn.

a. First article for batteries. The required number of cycles is 28 (4 weeks).

b. Conformance inspections for batteries. The required number of cycles is 7 (1 week).

Table XVI – Desert Cycle (24 hours)

Cumulative Test Time	**Temp °C** For reference only	**Temp °F**	**Cumulative Test Time**	**Temp °C** For reference only	**Temp °F**
1 Hr.	35	95	13 Hrs.	69	156
2 Hrs.	34	94	14 Hrs.	70	158
3 Hrs.	34	94	15 Hrs.	71	160
4 Hrs.	33	92	16 Hrs.	70	158
5 Hrs.	33	92	17 Hrs.	67	153
6 Hrs.	33	91	18 Hrs.	63	145
7 Hrs.	36	97	19 Hrs.	55	131
8 Hrs.	40	104	20 Hrs.	48	118
9 Hrs.	44	111	21 Hrs.	41	105
10 Hrs.	51	124	22 Hrs.	39	103
11 Hrs.	56	133	23 Hrs.	37	99
12 Hrs.	63	145	24 Hrs.	35	95

4.6.5 Environmental tests.

4.6.5.1 Altitude. Batteries designated for the altitude test shall be subjected to the altitude test for lithium batteries of the UN Manual of Tests and Criteria. Prepare and fixture batteries as required by the manual prior to testing. Weigh batteries prior to and after the specified conditions. Upon completion, visually examine the batteries in accordance with 4.6.1.4 and subject each undischarged battery to the battery voltage tests of 4.6.1.5. Batteries shall meet the requirements of 3.7.1.

4.6.5.2 Thermal test. Batteries designated for the thermal test shall be subjected to the thermal test for lithium batteries of the UN Manual of Tests and Criteria. Prepare and fixture the batteries as required by the manual prior to testing. Weigh batteries prior to and after the specified conditions. Upon completion, visually examine the batteries in accordance with 4.6.1.4 and subject each undischarged battery to the battery voltage tests of 4.6.1.5. Batteries shall meet the requirements of 3.7.2.

4.6.5.3 Vibration.

4.6.5.3.1 Method 1. Batteries designated for method 1 vibration test shall be subjected to the vibration test for lithium batteries of the UN Manual of Tests and Criteria. Prepare and fixture batteries as required by the manual prior to testing. Weigh batteries prior to and after the specified conditions. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each undischarged battery to the battery open circuit voltage test of 4.6.1.5.1. Batteries shall meet the requirements of 3.7.3.

4.6.5.3.2 Method 2. Batteries designated for the method 2 vibration test shall be tested in accordance with the vibration test method of UL-1642. Weigh batteries prior to testing. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each battery to the battery open circuit voltage test of 4.6.1.5.1. Batteries shall meet the requirements of 3.7.3.

4.6.5.4 Mechanical shock.

4.6.5.4.1 Method 1. Batteries designated for the method 1 shock test shall be subjected to the shock test for lithium batteries of the UN Manual of Tests and Criteria. Prepare and fixture batteries as required by the manual prior to testing. Weigh prior to and after the specified conditions. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each undischarged battery to the battery open circuit voltage test of 4.6.1.5.1. Batteries shall meet the requirements of 3.7.4.

4.6.5.4.2 Method 2. Batteries designated for the method 2 shock test shall be subjected to the shock test of UL 1642 Weigh prior to and after the specified conditions. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each battery to the battery open circuit voltage test of 4.6.1.5.1. Batteries shall meet the requirements of 3.7.4.

4.6.5.5 Drop test. The following test shall be performed. Visually examine each sample for the criteria of 3.7.5. Divide total samples for this test in two with one-half subjected to -20ºF (-29ºC) and one-half subjected to 130ºF (55Cº). When an odd number of samples are required, test the odd sample at 130ºF. Precondition batteries at 130ºF or -20ºF for not less than 4 hours. Tolerances of ±5ºF apply throughout the storage period. Perform the drop at the conditions specified in 4.3 in not greater than 10 minutes after removal from the preconditioning temperature. Drop each battery once from a height of 30 ±2 inches onto a hard surface consisting of concrete. The smallest side of the battery perpendicular to the plane of the connector face and nearest to the connector (where applicable) shall be parallel to the concrete surface and facing downward upon release, but need not be parallel upon impact. In the case of cylindrical batteries, the axis of the cylinder shall be parallel to the concrete surface upon release. Upon completion, subject batteries to the battery voltage tests of 4.6.1.5. After each drop, visually examine each sample and measure battery dimensions and verify connector, socket, or terminal location (as applicable). Batteries shall meet the requirements of 3.7.5.

4.6.5.6 Thermal Shock. The following test shall be performed. Subject batteries designated for the thermal shock test as detailed below. Store batteries at the conditions specified in 4.3 for not less than four hours prior to the start of this test. Prior to the start of testing, set two separate environmental chambers to the two test conditions of -40±5ºF (-40ºC) or 167±5ºF (75ºC) and allow to stabilize. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each battery to the battery voltage tests of 4.6.1.5. Batteries shall meet the requirements of 3.7.6.

Step 1. Place batteries in the chamber set to -40±5ºF. Batteries shall remain at -40±5ºF for a period of not less than 4 hours.
Step 2. Transfer the batteries to the chamber set at 167±5ºF within 5 minutes. During the transfer, the conditions of 4.3 apply.
Step 3. After insertion of the batteries into 167±5ºF, they shall remain at this condition for not less than 4 hours*.
Step 4. Transfer batteries to the chamber set at -40±5ºF within 5 minutes. During the transfer, the conditions of 4.3 apply.
Step 5. After insertion of the batteries into -40±5ºF, they shall remain at this condition for not less than 4 hours*.
Step 6. During first article, repeat steps 2 through 5 three times. For Sub-Group C2 testing, proceed to step 7.
Step 7. Transfer the batteries to the chamber set at 167±5ºF within 5 minutes During the transfer, the conditions of 4.3 apply.

Step 8. After insertion of the batteries into 167±5ºF, they shall remain at this condition for not less than 4 hours*.
Step 9. Transfer the batteries to the conditions of 4.3. Store batteries at these conditions for not less than 4 hours.
Step 10. Visually examine batteries in accordance with 4.6.1.4 and subject each battery to the battery voltage tests of 4.6.1.5
*NOTE: Count the minimum time after insertion from the time that the chamber returns to the set temperature.

4.6.5.7 Humidity. The following test shall be performed. Place batteries designated for the humidity test in a test chamber capable of controlling both temperature and humidity. Raise the temperature of the chamber to 149±4ºF (65ºC) and control the relative humidity to not less than 95% over a period of 2 hours; hold these conditions for not less than 6 hours. Reduce the temperature to 86±4ºF (30ºC) in not less than sixteen hours while maintaining a relative humidity of not less than 85%. During first article testing, repeat this procedure for a total of 10 cycles. Upon completion, visually examine batteries in accordance with 4.6.1.4 and subject each battery to the battery voltage tests of 4.6.1.5. Batteries shall meet the requirements of 3.7.7.

4.6.5.8 Immersion[5]. When specified (see applicable specification sheet), the following test shall be performed. Store batteries designated for the immersion test in air at 113±5ºF (45ºC) for not less than 4 hours and then place under the specified discharge load (see applicable specification sheet) for not less than 2 hours. Prior to immersion, protect each around the connector and the exposed terminals from exposure to water. This protection shall not extend beyond the minimum needed to protect the connector or exposed terminals. Immerse batteries under not less than 39.4 inches (1 meter) depth of 68±4.5ºF (20ºC) salt water substitute prepared in accordance with ASTM D-1141, still under discharge load for not less than 30 minutes unless an open circuit condition occurs during the immersion period. After this immersion period, terminate discharge if necessary and remove batteries from water. After removal from the water, shake batteries by hand to remove any moisture that has accumulated inside them, towel-dry batteries and visually examined for the criteria at 3.7.8. If accumulated water does not come out, the battery enclosure may be drilled to allow water egress prior to visual examination. Batteries shall meet the requirements of 3.7.8.

4.6.5.9 Watertight integrity. When specified (see applicable specification sheet), the following test shall be performed in the order shown. Batteries shall meet the requirements of 3.7.9.

a. Altitude cycling. After the following altitude cycling test, batteries shall meet the requirements of 3.7.9a.

Step 1: Weigh each battery to the nearest hundredth of a gram and visually inspect all test samples in accordance with paragraph 4.6.1.4. Record weight of each sample.
Step 2: Perform battery open-circuit voltage test in accordance with paragraph 4.6.1.5.1 and record voltage.
Step 3: Place sample batteries in a test chamber and adjust air temperature to –26±5ºF

[5] The immersion test is potentially hazardous; should water flood the inside of a battery under discharge, electrolysis could occur, resulting in an explosion hazard. Users are again cautioned to assure compliance with applicable occupational safety and environmental regulations.

(-32ºC) and a pressure of not less than 14.7 psia. Batteries shall stay at these conditions for not less than 4 hours.
Step 4: Reduce the pressure to not greater than 1.69 psia, the equivalent to an altitude of 50,000 feet above sea level, at a rate not greater than 3.5 feet per second (f/s), while maintaining the temperature conditions of –26±5ºF. Hold these conditions for not less than 1 hour.
Step 5: Return the pressure to not less than 14.7 psia, the equivalent to an altitude of sea level, at a rate not greater than 3.5 f/s, while maintaining the temperature conditions of –26±5ºF. Hold these conditions for not less than 1 hour.
Step 6: Repeat steps 4 and 5 for a total of 10 cycles.
Step 7: Adjust the chamber temperature to 70±5ºF (21ºC) in not greater than 1 hour. Hold these conditions for not less than 4 hours.
Step 8: Repeat steps 1 and 2. In addition to the criteria of paragraph 4.6.1.4, inspect all labels on the battery to include possible damage to any adhesives that may have been used.

b. Explosive decompression. Batteries shall be subjected to the explosive decompression test of MIL-STD-810, Method 500, Procedure IV. Weigh each sample to the nearest hundredth of a gram and record. Connect each battery to a test fixture as specified (see applicable specification sheet). Ramp pressure down at a rate not greater than 3.5 feet per second (f/s) to establish the cabin altitude. After sustaining the low pressure conditions for the time specified in MIL-STD-810, reduce air pressure to the required test altitude of MIL-STD-810 in not greater than 0.1 seconds. Hold these conditions for not less than 10 minutes, then return the test item to ambient conditions at a rate not greater than 3.5 f/s. Visually inspect all test samples in accordance with paragraph 4.6.1.4, perform battery voltage tests in accordance with paragraph 4.6.1.5 and weigh each battery to the nearest hundredth of a gram upon completion of the explosive decompression test of MIL-STD-810. Batteries shall meet the requirements of 3.7.9b.

c. Parachute drop. Weigh each sample to the nearest hundredth of a gram and record. Connect each battery to a test fixture as specified (see applicable specification sheet) prior to the drop. Drop each battery once from a height of 10 feet into a synthetic solution containing 3.6 percent sea salt in accordance with ASTM-D-1141 with a depth of not less than three feet. Towel-dry batteries and leave to air dry for not less than 15 minutes after the drop. Visually inspect all test samples in accordance with paragraph 4.6.1.4, perform battery voltage tests in accordance with paragraph 4.6.1.5, and weigh each battery to the nearest hundredth of a gram upon completion of the parachute drop test. Batteries shall meet the requirements of 3.7.9c.

d. Submersion. Weigh each sample to the nearest hundredth of a gram and record. Connect each battery to a test fixture as specified (see applicable specification sheet). Submerge test samples in saltwater substitute salt in accordance with ASTM D-1141. Pressurize the solution with the battery samples to simulate three-foot submersion for not less than 24 hours and then raise the pressure to simulate 50-foot submersion for not less than 15 minutes. Towel-dry the battery samples and leave to air dry for not less than 15 minutes. Visually inspect all test samples in accordance with paragraph 4.6.1.4, perform battery voltage tests in accordance with paragraph 4.6.1.5, and weigh each battery to the nearest hundredth of a gram upon completion of the submersion test. Batteries shall meet the requirements of 3.7.9d.

e. Capacity test H2. The test method of 4.6.4.1 shall be used for the H2 capacity test. Discharge at +130 ±5ºF (55ºC) to cut-off voltage after stabilization storage at +130 ±5ºF for not less than three and one-half (3.5) hours.

5. PACKAGING

5.1 Packaging requirements. 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 which may be helpful, but is not mandatory.)

6.1 Intended use. The primary batteries included are of the non-reserve type composed of hermetically sealed electrochemical cells with a lithium anode. The batteries are capable of storage and use under wide temperature ranges. While they are intended for portable military electronics equipment, they are used in a wide variety of military communications and electronics equipment and systems.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification

b. Applicable specification sheet (see 3.1)

c. Complete type designation (see 3.8.1)

d. Requirement for first article testing (see 4.4)

e. Packaging requirements (see 5.1)

f. The specific issue to individual documents referenced (see 2.2)

g. Shelf life coding for a 5 year shelf life (see 3.4.9)

h. Whether or not First Article is required; if so, whether or not a waiver may be requested

i. Whether certification of conformity is required (see 3.2.1).

6.3 First article. When a first article inspection is required, the item(s) should be a first article sample. The first article should consist of the number of cells and batteries specified in 4.4. The contracting officer will include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first

articles. Solicitations normally provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Definitions.

6.4.1 Non-flammable and non-toxic materials. Non-flammable and non-toxic materials are those materials which will not support combustion, produce smoke, or be capable of emitting toxic fumes when subjected to the environmental conditions specified for the battery. For a description of the specified environmental conditions, see 4.6.2.12, 4.6.4.1.2 thru 4.6.4.1.9, 4.6.4.2.2, and 4.6.5.1 through 4.6.5.9. Please note that “non-flammable” requirements do not apply to the Projectile test (4.6.2.16). This is due to the fact that the batteries will be set on fire during the test and are expected to burn.

6.4.2 Shipment lot. The shipment lot is the quantity of batteries (exclusive of the number of batteries required as samples) of any one PIN, produced at any one place of manufacture on any one contract, that is presented to the Government for acceptance at the same time.

6.4.3 Contract lot. The contract lot is the total of all batteries (exclusive of the number of batteries required as samples) of any one PIN, delivered in one or more shipment lots, under the terms of any one contract.

6.4.4 Safety related failure modes. The following are the definitions for the safety related failure modes cited in section 3 of this specification, listed in order of severity, least to worst:

a. Surface temperature limit: Whenever any area on the surface of the battery exceeds the limit of 3.6h during discharge, a hazardous condition exists (see “Thermal contact hazards”, MIL-STD-1472).

b. Bulge/Bulging: Visual distortion of a battery’s outer surface that projects outward from the surface. A bulge can be verified by demonstrating that the battery exceeds at least one of its maximum dimensional requirements after testing.

c. Leak/Leaking: A slow escape of a cell’s internal liquid or gas components.

d. Vent/Venting: Rapid escape of a cell’s internal liquid or gas components through a mechanism designed for release of excessive internal pressure. Since Type III (pouch) cells do not have such a mechanism, they cannot “vent”; any rapid escape of liquid or gas through a pouch cell’s seam will be considered leaking, and the same through any other point will be considered rupturing.

e. Rupture/Rupturing: Rapid escape of a cell’s internal liquid or gas components through any means other than the designed vent mechanism.

f. Emit Flame: A battery or cell may emit flame upon venting or rupturing that self-extinguishes in seconds. This alone does not qualify as a burn or burning failure mode.

g. Burn/Burning: Any sign of charring of battery or cell components can be used to demonstrate that burning has occurred.

h. Explode/Exploding: Shattering of a battery or cell, demonstrated by disassembly and expulsion of solid internal components.

i. Fragmentation of battery enclosure (see 3.5.16): If any piece or part of the plastic battery enclosure comes free from the rest of the battery, the enclosure has fragmented.

6.4.5 Stabilization storage. Stabilization storage is that period of time when test sample batteries equilibrate to the test temperature, typically 8 hours for capacity tests.

6.5 Lithium Battery Safety Program (US Navy). Potential offerors and contractors should be aware that passing the test criteria specified herein for the US Navy Lithium Battery Safety Program will not constitute a “Safety Approval” for the battery by the US Navy. In accordance with S9310-AQ-SAF-010, Navy department users must still apply for battery safety approvals based on the NSN of the battery intended for use, as well as both the intended Navy platform and each specific using end item.

6.5.1 Test data. The intent of including these test requirements in this specification are primarily to give manufacturers visibility into the essential safety characteristics needed by the Navy. Until now, the tests were performed in evaluating system or device safety without any knowledge of these requirements by battery manufacturers. Additionally, these requirements will provide the Navy with test data on file when assessing applications for safety approvals. The data provided will be used for engineering assessments that are capable of providing recommendations for safer battery compartments in battery-using devices.

6.5.2 Test vessel. Due to the need to record pressure changes during test, the Navy safety tests require use of a test “vessel”, defined as a sealed container larger than the battery under test. A “sealed container” could be something as simple as an unused paint can with the lid on, provided that gaskets, plugs, or sealants are used around the access points for load and sensing leads to preserve the seal. A calculation of the remaining void space inside the vessel containing the battery under test will be needed for proper interpretation of the pressure readings.

6.5.3 Navy test facility. The Department of Defense has a preference for having the tests described by S9310-AQ-SAF-010 (see Table VI) conducted in a US Navy test facility. Potential offerors are cautioned to review solicitations for such requirements. Should testing at a Navy facility be required, offerors will need to obtain a quote for Navy testing from the Navy in order to respond to the solicitation. Points of Contact in the Navy for the quote will be identified in the solicitation documentation. Offerors will need to assure that Navy testing costs are covered in their price proposal. Successful offerors will need to establish a Test Service Agreement (TSA) with the Navy after award. Unsuccessful offerors will be under no obligation to pay for anything associated with the quote obtained earlier. TSAs have expiration dates; if an agreement is already established, check to make sure that it will still be in effect at the time when testing may be required.

6.6 Design practices and lessons learned.

6.6.1 Design practices. Guidelines for designing and building safe lithium batteries can be found on line at www.bmpcoe.org/library/books/index.html. Search for NAVSO P-3676.

6.6.2 Lessons learned (manufacturing). Based on the test and field history of the items described by this specification, control of the following processes in production are critical to the safe performance of the batteries delivered to the Government:

a. Control of contaminants in basic cell components

b. Control of the electrolyte mixing process to ensure no contaminants are introduced, no overheating occurs during mixing, and each batch contains the proper proportions of each component

c. Control of the minimum amount of carbon needed in each cathode (for Type II batteries, unsafe conditions can occur at end of discharge without sufficient cathode surface area)

d. Control of the proper balance of active materials to avoid unsafe operation at the end of discharge, particularly after long-term storage prior to use

e. Control of electrode alignment during the core winding operation

f. Avoiding use of tapes or sealing methods on the electrode core wind (or “jelly roll”) as a means of facilitating automated assembly operations. Sealing of the core wind results in excessive stress on cell internal connections during vibration testing

g. Providing strong weld adhesion of the positive tab inside the cell and adequate stress relief on the positive electrode tab inside each cell, to include restricting re-work of rejected weld connections

h. Control of all cell closure processes, including the control of weld burrs that could damage insulating materials inside batteries

i. Controls for weld burrs on cell top-shell welds with a potential to cut through cell insulation and shorting a cell against an adjacent cell

j. Assurance that heat-shrink insulating materials will perform as specified and control of their application to ensure proper insulation

k. Control of the sealing process for plastic battery enclosures to ensure the watertight integrity of the battery (when specified).

6.6.3 Lessons learned (specification content).

6.6.3.1 Safety assurance. The test methods of 4.6.2 through 4.6.5, as well as the matching requirements of 3.5 through 3.7, have proven their ability to provide adequate assurance of safe performance for both lithium manganese dioxide (Type I and III) and lithium sulfur dioxide (Type II) batteries. Users of this document are cautioned that experience has shown the need to assess the safety characteristics and safety assurance needs of each lithium battery electro-chemistry intended for portable military electronics equipment independently prior to establishing the minimum requirements for safety assurance. Failure to do so may result in false-positive indications for some of the tests in this specification, and a lack of adequate stresses to properly evaluate a different electro-chemistry, increasing the risk of damage to equipment and injury to the users. The System Safety Risk Assessment techniques

of MIL-STD-882 are recommended as a source for determining the safety assurance needs of other lithium battery electro-chemistries. Those electro-chemistries whose safety characteristics are known and can be proven safe using the methods of this specification are as follows (more may be added as safety characteristics are identified and tested):

Type I, Solid Cathode – Lithium manganese dioxide
Type II, Liquid Cathode – Lithium sulfur dioxide
Type III, Solid Cathode, pouch cells – Lithium manganese dioxide

6.6.3.2 Hermetically sealed cells. Reference 3.4 and 3.5.2: This specification requires hermetically sealed cells for all types of batteries. Type II batteries typically have pressurized gas inside each cell, either throughout their service life or simply as they discharge. Type I and III batteries do not. However, in order to meet the stringent low-temperature performance requirements of this specification, cell manufacturers typically need to use flammable ethers in the electrolyte. While tests have been conducted that provide assurance that crimp-sealed cells typically will not give off enough flammable vapors in high temperature storage to cause unsafe conditions, the smell of the ethers has been cause for alarm. People working in storage areas for solid cathode lithium batteries with crimp-sealed cells have inquired about the source for the odor and whether or not any hazards are associated with it. Further, loss of ethers in high temperature storage may adversely affect the low-temperature performance of the batteries later should they be deployed in low-temperature environments. For these reasons, hermetically sealed cells are required for all batteries covered by this specification.

6.6.3.3 Desert Cycle. Previous lithium battery specifications stressed batteries at either a constant 160ºF (71ºC) or 130ºF (55ºC) for periods of four weeks. Neither condition adequately describes the needs of military users when it comes to high temperature storage. The Desert Cycle conditions of this specification are based on MIL-STD-810 conditions for hot, induced environments. They are intended to replicate storage in unventilated spaces (without windows) subjected to solar loading, such as shelters or metal shipping containers. Army experience has shown that such storage conditions are typical for deploying units between the time the unit deploys to a hot environment and the batteries are put into use. Batteries that can't tolerate the Desert Cycle conditions should not be used for portable military communications electronics equipment deployed to hot environments.

6.6.3.3.1 Storage periods. Previous lithium battery specifications typically required high temperature storage for four weeks for cell leakage and delayed capacity tests. High temperature storage was used to mimic long-term storage in temperate climates for shelf life purposes and to reveal stress corrosion problems in cell containers. Experiments for lithium sulfur dioxide batteries demonstrated that most of the capacity lost in high temperature storage would typically occur within this four week period. However, recent military operations have demonstrated that the military needs far more than four weeks of storage in hot environments in order to provide them with the maximum flexibility in distributing batteries down to the unit of action. Experiments for both lithium sulfur dioxide and lithium manganese dioxide batteries have shown that most batteries will retain at least 90% of their original capacity after up to 12 weeks of Desert Cycle conditions. Unfortunately, a 12-week delay inside a first article test sequence is an intolerable delay, adding far too much to production lead times. For this reason, we must depend on the shorter 4-week period. To shorten lead times during production, the delay time is reduced to one week. Experience has indicated that one week of high temperature storage is usually enough time to reveal problems with stress corrosion in cell containers.

6.6.4 Inspection measurement considerations. All the required inspections and tests in tables I through V of this specification can be accomplished on commercially available inspection equipment; the inspections of table VI require specialized jigs and fixtures. However, the cell electrolyte leakage inspection of 4.6.2.2 will require extreme accuracy, especially for the smaller cells, where the maximum 0.01% leakage rate will be in the range of a few micrograms. It is advisable to use the same device for the 7-day and 21-day weight measurements without any adjustments in the interval between them. In addition to the needed equipment sensitivity, the manufacturer will have to control the test method to prevent environmental factors from adversely affecting measurement accuracy. Factors that could adversely affect accuracy include, but are not limited to: Vibration transferred through building structural supports, air flow in the test area, temperature or humidity changes during or in between measurements, contaminants on cells during handling, etc. It should also be noted that application of insulating or potting materials, while allowed, may adversely impact on the accuracy of the weight measurements and create false-negative results due to moisture loss of the material during high temperature storage.

6.7 Subject term (key word listing).
Manganese dioxide
Non-reserve
Sulfur dioxide

6.8 Temperature statements. Temperature requirements of this specification are stated in Fahrenheit, with the applicable tolerances also in Fahrenheit. This is done as a way to provide the needs of the military in a way that military personnel can easily understand (i.e., an American service member knows exactly how hot 130ºF is, but might need an interpreter to figure out what 55ºC means). The Celsius equivalents for the nominal values are provided for reference only in parentheses. This is done to provide a reference for those who use the Celsius scale in their work.

6.9 Material Safety Data Sheets. Federal regulations and International transportation agreements mandate the inclusion of Material Safety Data Sheets (MSDS) with shipments of hazardous materials. Contracting officers will identify those activities requiring copies of completed MSDS prepared in accordance with 29 CFR 1910.1200 (Reference: 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 MSDS for each hazardous chemical used in an operation must be readily available to personnel using the material.

6.10 Serial numbers. Serial number markings are required for batteries manufactured in accordance with this specification (see 3.8.6). This is required in order to facilitate manufacturing traceability in the event of failure or failures due to certain components or batches of materials. The components and materials used to build these batteries have common vendors, used throughout the battery industry. The government may need to assess the broader implications of failures once traced down to the root cause. Non-rechargeable lithium batteries are not serially-managed by the Department of Defense; therefore, they do not require Item Unique Identification (IUID) in accordance with DFARS 252.211-7003.

6.11 Changes from previous issue. The margins of this amended specification are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.12 Shelf life. This specification covers items where the assignment of a Federal shelf-life code is a consideration. Specific shelf-life requirements should be specified in the contract or purchase order, and should include, as a minimum, shelf-life code, shelf-life package markings in accordance with MIL-STD-129 or FED-STD-123, preparation of a materiel quality storage standard for type II (extendible) shelf-life items, and a minimum of 85 percent shelf-life remaining at time of receipt by the Government. These and other requirements, if necessary, are in DoD 4140.27-M, *Shelf-life Management Manual*. The shelf-life codes are in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from DoD 4140.27-M, or the designated shelf-life Points of Contact (POC). The POC should be contacted in the following order: (1) the Inventory Control Points that manage the item and (2) the DoD Service and Agency administrators for the DoD Shelf-Life Program. Appropriate POCs for the DoD Shelf-Life Program can be contacted through the DoD Shelf-Life Management website: https://www.shelflife.hq.dla.mil/.

APPENDIX A

STATE OF CHARGE INDICATOR TEST, DISCHARGE RATE

A.1 Scope. This appendix provides information on determining the proper discharge rate for the state of charge test at paragraph 4.6.1.10. This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

A.2 State of charge principles. State of charge indicators (SOCIs) work from a device called a coulomb counter. As batteries are discharged, coulombs of electrons flow from the battery's negative terminal to power using end items. The counter simply counts the number of coulombs as they pass. The electronics that work the SOCI then subtract that quantity from a total in a memory register inside the battery. The result is used to determine the current state of charge for that battery. The total is programmed into the device by the manufacturer or the SOCI vendor, based on the capabilities of the battery into which the SOCI is incorporated. This total is typically slightly less than full expected capacity for much the same reason that automobile gas gages typically indicate empty before the gas tank is fully depleted. The manufacturer is free to pick how much less than full is considered a safe amount to count down. The purpose of testing the SOCI required by this specification is to test the accuracy of the counter for that less-than total amount.

A.3 Look-up tables. Battery total capacity varies according to the battery type, discharge temperature and discharge rate. Battery manufacturers characterize battery capability from actual test data and represent it in the form of "look-up tables", which include data on expected performance at a wide range of discharge rates and use temperatures. Since the test of 4.6.1.10 calls specifically for a 10-hour discharge rate at three temperatures [+14±5ºF (-29ºC), 70±5ºF (21ºC), & 130±5ºF (55ºC)], the manufacturer will need three discharge rates. The value of the discharge current for this test will vary according to (in order of importance):

a. The battery under test
b. The discharge temperature
c. The discharge rate, which may add a slight variation

A.4 Determining the correct discharge rates. The manufacturer of the battery will need to determine the proper discharge rates based on the data in the look-up tables used to program the electronics of the SOCI. It is in the best interests of both the manufacturer and the Government that this rate be chosen in a manner that gives the batteries under test the best possible conditions for passing this test. Choosing an incorrect or approximate discharge rate may result in false-negative outcomes from the test. The alternative would be to choose various discharge rates, obtain indications at various intervals, and see at the end of discharge how close the indications were. But such methods would require excessive sample quantities to be valid and may still yield false-negative outcomes; allowing the manufacturer to pick the right discharge value reduces both the total number of batteries requiring test and the risk of false-negative results.

Custodians:
Army – CR
Navy – SH
Air Force – 99
DLA – GS

Review activities:
Navy – SH, AS, MC
Air Force – 71

Preparing Activity
Army – CR
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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.