METRIC
MIL-B-29595(AS)
1 June 1994

MILITARY SPECIFICATION

BATTERIES AND CELLS, LITHIUM, AIRCRAFT, GENERAL SPECIFICATION FOR

This specification is approved for use by the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the general requirements for lithium cells and batteries acceptable for use in aircraft.

1.2 Classification. Cells and batteries are classified as follows:

a. Type I - Type I covers solid cathode primary cells or batteries. This type of cell or battery includes, but is not limited to, lithium/manganese dioxide [Li/MnO_2], lithium/carbon monofluoride [$Li/(CF)_n$], lithium/iron disulfide [Li/FeS_2], and lithium/iodine [Li/I_2] electrochemical systems.

b. Type II - Type II covers soluble cathode primary cells or batteries. This type of cell or battery includes, but is not limited to, lithium/sulfur dioxide [Li/SO_2], lithium/thionyl chloride [$Li/SOCl_2$], and lithium/sulfuryl chloride [Li/SO_2Cl_2] electrochemical systems.

c. Type III - Type III covers rechargeable lithium cells or batteries.

1.3 Part or identifying numbers. The applicable specification sheets specify the part or identifying numbers for cells and batteries.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Crane Division, Naval Surface Warfare Center, Code 6092, Bldg. 2949, 300 Highway 361, Crane, IN 47522-5001, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 6135

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-E-917	-	Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-P-6063	-	Packaging of Batteries, Storage, Charged and Dry Uncharged and Moist, General Specification for.
MIL-W-6858	-	Welding, Resistance: Spot and Seam.
MIL-F-14072	-	Finishes for Ground Based Electronic Equipment.

STANDARDS

FEDERAL

FED-STD-313	-	Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	-	Marking for Shipment and Storage.
MIL-STD-454	-	Standard General Requirements for Electronic Equipment.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.
MIL-STD-882	-	System Safety Program Requirements.
MIL-STD-1360	-	Fuses, Fuseholders, and Associated Hardware, Selection and Use of.
MIL-STD-2000	-	Standard Requirements for Soldered Electrical and Electronic Assemblies.
MIL-STD-5400	-	Electronic Equipment, Airborne, General Requirements for.
MIL-STD-45662	-	Calibration Systems Requirements.

HANDBOOKS

MILITARY

MIL-HDBK-729 - Corrosion and Corrosion Prevention Metals.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from Customer Service, Standardization Documents Order Desk, Defense Printing Service, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 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 are those cited in the solicitation.

40 CFR	-	Code of Federal Regulations, Title 40 - Protection of Environment
49 CFR	-	Code of Federal Regulations, Title 49 - Transportation
55 FR	-	Federal Register, Volume 55, No. 246, Friday, December 21, 1990
OPNAVINST 5090.1	-	Environmental and Natural Resources Program Manual
NAVAIRINST 5100.7	-	Naval Air Systems Command Safety Programs for Explosive Ordnance, Laser Systems, and Lithium Batteries
S9310-AQ-SAF-010	-	Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures

(Copies of 40 CFR, 49 CFR, and 55 FR are available from the Superintendent of Documents, United States Government Printing Office, Washington, DC 20402-0001. Copies of OPNAVINST 5090.1, NAVAIRINST 5100.7, and S9310-AQ-SAF-010 are available from Customer Service, Standardization Documents Order Desk, Defense Printing Service, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

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

3.2 Qualification. Cells and batteries furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.2.1 and 6.3).

3.3 Design and construction. The cell or battery shall be designed and constructed to conform to the requirements specified herein and as specified in 3.1. The cell or battery shall pass all the tests specified herein.

3.4 Materials, processes, and parts. Materials, processes, and parts shall conform to MIL-STD-5400 except as otherwise specified herein or as waived by the procuring activity.

3.4.1 Materials. Materials shall conform to the weight restrictions, strength and performance requirements, and environment specified herein and as specified in 3.1. Exposed parts shall be inherently corrosion-resistant or protected against corrosion.

3.4.1.1 Corrosion resistance. All metals which do not enter into the basic electrochemical reaction of the cell shall resist corrosion or be treated to resist corrosion in accordance with MIL-F-14072 and MIL-HDBK-729.

3.4.1.2 Dissimilar metals. When dissimilar metals contact each other, electrolysis and corrosion which would adversely affect cell or battery performance shall be prevented in accordance with MIL-F-14072 and MIL-HDBK-729.

3.4.1.3 Insulating compounds. When tested in accordance with 4.9, the insulating, potting, and sealing compounds shall not flow, crack, nor draw away from the sides of a container at any temperature tested.

3.4.1.4 Prohibited materials (Type I only). Cells or batteries shall not contain any prohibited materials as defined in MIL-E-917.

3.4.1.5 Material Safety Data Sheet(s). Material Safety Data Sheets shall be provided in accordance with FED-STD-313.

3.4.1.6 Jackets. The jackets (see 6.7.4) shall be a nonmetallic material. The contents of multi-cell batteries shall fit snugly enough in the jackets to minimize movement of the cells. When covering two or more cylindrical cells stacked end on end, jackets with an open top or bottom (or both) shall prevent the cells from slipping out. Nonmetallic jackets, whether cardboard or plastic, shall neither support combustion nor emit toxic vapors when subjected to flame. The seams of the jacket shall not open before or after any electrical or environmental

test to which the cell or battery is subjected (see 4.4 through 4.9). The color of exposed surfaces of the jackets shall be green with black lettering.

3.4.2 Processes.

3.4.2.1 Finish. The outside surface of the container or jacket shall be free of dirt and such surface imperfections as nicks, dents, and scratches.

3.4.2.2 Fungus treatment. The cell or battery shall be made either from fungus-inert materials and parts that conform to requirement 4 of MIL-STD-454 or from materials and parts appropriately treated before use so that overall spraying of the cell or battery with a fungicide is unnecessary. Contractors may forgo the fungus tests of 4.9.7 by submitting a certificate (signed by a company official) indicating that the cell or battery will not support fungal growth.

3.4.2.3 Welding. All welding of cell or battery parts shall conform to MIL-W-6858.

3.4.2.4 Soldering. All soldering of cell or battery parts shall conform to MIL-STD-2000.

3.5 Physical requirements.

3.5.1 Atmospheric operating conditions. The cell or battery shall be capable of performing electrically while encountering the environments of 3.5.1.1 through 3.5.1.3.

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

3.5.1.2 Pressure. The operating atmospheric pressure shall range from that found at sea level to that found at an altitude of 18,500 meters (see 3.1).

3.5.1.3 Temperature. The operating temperature shall be from -40°C to +55°C (see 3.1).

3.5.2 Shape and size. The shape and size of the cell or battery shall conform to the applicable specification sheet when measured in accordance with 4.4.1 and 4.4.2.

3.5.3 Weight. The cell or battery weight shall be minimal, consistent with material selection and fabrication processes necessary to meet the environmental and performance specifications. The cell or battery weight shall conform to the applicable specification sheet (see 3.1) when measured in accordance with 4.4.2.

3.5.4 Cell or battery system interface. The cell or battery system interface shall be configured or marked to prevent improper connection of the cell or battery to the equipment. The interface shall be examined in accordance with 4.4.1.

3.5.5 Labels and marking. All required labels and markings shall be clear and legible throughout all tests specified herein. The marking on the outside of each battery and on single

cell batteries shall conform to 3.5.5.1 through 3.5.5.9 (see 3.1). Each cell contained within a battery shall be marked as a minimum with the terminal labeling (see 3.5.5.1) and date and lot code (see 3.5.5.5). The warning of 3.5.5.6 shall be on both batteries and shipping containers.

3.5.5.1 Terminal labeling. The positive (+) and negative (-) terminal positions shall be conspicuously and durably marked on the battery jacket or container, adjacent to the terminals for easy identification as shown on the applicable specification sheets.

3.5.5.2 National stock number. Cells, batteries, and shipping containers for cells or batteries shall be labeled with the national stock number as specified by the procuring activity.

3.5.5.3 Nominal voltage. The nominal voltage shall be marked on the cell or battery in a clearly visible location.

3.5.5.4 Cell chemistry. The following information shall be marked on primary cells or batteries in a clearly visible location: Cell, Primary, (Anode Material)/(Cathode Material). The following information shall be marked on secondary (rechargeable) cells or batteries in a clearly visible location: Cell, Rechargeable, (type of lithium electrochemistry or technology). See the box below for an example. A hyphen (-) or blank space may be used vice the solidus (/).

Cell, Primary, Lithium/Sulfur Dioxide

3.5.5.5 Date and lot code. The date and lot code shall indicate the year and day of manufacture along with a lot number (see 4.2.2.2 for inspection lot definition) of the cell. The code shall be a five-digit number followed by a hyphen and a two-digit lot number. The first two digits shall indicate the year of manufacture and the next three digits the Julian date of manufacture. After the hyphen, the two digits shall indicate the lot code with 01 representing the first lot. For example, a cell manufactured on 15 February 1994 which was part of the first lot produced that day will bear the date and lot code 94046-01; a cell manufactured on 2 July 1994 as part of the third lot produced that day will bear the date and lot code 94184-03.

3.5.5.6 Warnings. The cell, battery, or shipping container shall be marked with the following warnings (see 3.1). The "Materials Under Pressure" warning shall be deleted for solid cathode cells or batteries. The warning for primary items shall be as follows:

For Use in Designated Equipment Only

Caution

Materials Under Pressure

Do not pierce, cannibalize, mutilate, puncture, recharge, short circuit, expose to temperatures above 54°C, or incinerate. Use in equipment approved for this cell or battery. Do not throw in trash.

The warning for secondary (rechargeable) items shall be as follows:

For Use in Designated Equipment Only

Caution

Recharge in accordance with manufacturer's instructions

Do not pierce, cannibalize, mutilate, puncture, short circuit, expose to temperatures above 54°C, or incinerate. Use in equipment approved for this cell or battery. Do not throw in trash.

3.5.5.7 Complete discharge device label. Batteries (but not single cells) shall have the following label affixed over the switch access opening of the complete discharge device. The label shall be a removable 25 ± 5 millimeters (width) by 50 ± 5 millimeters (length) two-panel label made of waterproof paper, paper product, or plastic material with lusterless black lettering. The label shall be centered as closely as possible over the switch access opening. The word ATTENTION in the top panel shall be in bold lettering and shall fill the available area of the top panel. The format shall be as follows:

ATTENTION

Before disposal, remove this label and push switch.

3.5.5.8 Complete discharge device card. Batteries (but not single cells) shall have a complete discharge device card packaged in the plastic bag containing the battery. The card shall be placed lettering side out over the face containing the connector. The card dimensions shall be not greater than 76.2 millimeters by 127 millimeters. The word ATTENTION shall be in bold lettering. The printing shall be clearly legible and read as follows:

ATTENTION

This battery has a discharge switch in order to make it nonreactive. After final use, remove attention label covering the switch, push switch, and store battery for five days. Maintain not less than a one-inch air space between batteries during the storage period. Coordinate disposal with your local environmental office/officer and Defense Reutilization and Marketing Office. State/local regulations will control disposal in your area.

3.5.5.9 Manufacturer information. The cell or battery shall be marked with the manufacturer's name and part number.

3.5.6 Workmanship. The cell or battery shall be of uniform quality and shall be free from defects that affect life, function, and appearance. Loose contacts, peeling, flaking or chipping of plating or finish, mechanical damage due to testing environments, nicks or burrs of metal parts of surfaces, or improper or incorrect marking shall not be present. Workmanship shall conform to requirement 9 of MIL-STD-454.

3.6 Electrical requirements.

3.6.1 Open circuit voltage. The cell or battery open circuit voltage shall be not greater than the maximum voltage specified in the applicable specification sheet when tested in accordance with 4.5.1.

3.6.2 Closed circuit voltage. The cell or battery closed circuit voltage shall be not less than the minimum voltage specified in the applicable specification sheet when tested in accordance with 4.5.2.

3.6.3 Capacity. When the cell or battery is tested for capacity in accordance with 4.5.3, the time required to reach its specified minimum voltage at the end of discharge shall be not less than the cell or battery capacity requirement specified in the applicable specification sheet. The cell or battery temperature shall be not greater than 82°C at any time during a capacity test.

3.6.4 Initial voltage delay. When the cell or battery is tested for capacity, the initial voltage delay (see 6.7.3) shall be not greater than the time specified in the applicable specification sheet when measured in accordance with 4.5.3.1.

3.7 System safety design requirements.

3.7.1 Cell construction. The cell shall incorporate a balanced chemistry (a 1:1 stoichiometric ratio of anode material to cathode material) to provide a safe and reliable

electrochemical system. The anode-to-cathode ratio shall be such that the anode shall be consumed by the end of discharge.

3.7.2 Charge protection. In batteries consisting of series-parallel strings, each parallel string shall be protected to prevent any possibility of charging. If a cell or battery is connected to an external power source, the cell or battery shall be protected so as to prevent charging by the external power source.

3.7.2.1 Reverse current flow. Diode(s) shall be inserted in the cell, the lead to the cell, or the battery as specified in the applicable specification sheet to prevent significant reverse current. The diode shall conform to requirement 30 of MIL-STD-454. The diode shall have the following characteristics:

Forward voltage drop (V_F) not greater than 0.65 volts.
Reverse current (I_R) not greater than 2 milliamperes.

3.7.2.2 Charging current. When the cell or battery is tested in accordance with 4.6 to ensure that the diode is functioning correctly, the charging current shall be not greater than 2.0 milliamperes.

3.7.3 Fuse protection. When required by the applicable specification sheet, each cell or battery shall contain a fuse that opens if the cell or battery is discharged at an excessive rate. Batteries shall be fuse-protected in the ground lead of each series string. If a battery type is composed of more than one leg, each individual leg shall be fused separately. Each separate circuit shall be protected. If the battery is tapped to provide different output voltages, each tap shall be protected with a fuse. Specific fuse values shall conform to the applicable specification sheet. Fuses shall be the nonreplaceable slow blow type conforming to MIL-STD-1360. When tested as specified in 4.7, the fuse shall remain closed below its rated amperage and voltage. The types of fuses acceptable for cells and batteries shall be as follows:

Types of fuses	Cell	Battery
Standard fuses	Not applicable	Acceptable
Fuse link	Acceptable	Acceptable
Internal fuse link	Acceptable	Not applicable

3.7.4 Thermal fuse. A thermal fuse shall conform to the applicable specification sheet. When tested in accordance with 4.8, the switch shall remain closed below 82 ± 2°C and shall remain open above 88 ± 2°C. The thermal fuse shall be located as close as possible to the geometric center of the battery or as delineated in the specification sheet. For a two- or three-cell in-line arrangement, the thermal fuse shall be located between any two adjacent cells. For a cluster arrangement of three or more cells, the high temperature switch, thermal fuse, or positive temperature coefficient (PTC) device shall be located within the cluster.

3.7.5 Complete discharge device. This requirement shall not apply to any single cell battery (see 3.1). The complete discharge device shall consist of a normally open switch and a resistor connected across each battery leg in series with the switch. A single switch action shall activate all complete discharge devices. Switch access in battery surface shall be through a rectangular hole measuring 12.7 +0, -3.1 millimeters by 4.7 +0, -1.5 millimeters. The effective hole size shall be provided if the battery's surface is curved. The top center of the switch plunger shall be located at the center of the slot ± 1.5 millimeters. The hole shall be covered by a removable label that may be made of either paper, paper products, or plastic (see 3.5.5.7). The top surface of the switch shall be 4.7 +0, -2.3 millimeters below the outer surface of the battery where the slot is located. The switch action shall move not less than 2 millimeters down and not more than 9.5 millimeters. The switch shall not be in the surface of the battery that contains the electrical connector. The resistor to be used in the complete discharge device shall be sufficient to provide a C/24 discharge rate and shall conform to requirement 33 of MIL-STD-454. None of the battery's fuses, diodes, or thermal switches shall prevent the discharge of any cell upon activation of the complete discharge device. When the battery is tested in accordance with 4.9.12 to ensure that the complete discharge device is functioning correctly, the device shall have discharged the battery to zero volts. The battery shall then conform to the requirements of 3.8.a through 3.8.g.

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

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

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

3.7.9 Shorting protection. Individual cells or batteries shall be delivered and stored with the leads or connector plug taped, guarded, or otherwise insulated against accidental shorting.

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

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

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

3.8 Environmental requirements. The cell or battery, when subjected to the environmental requirements of 3.8.1 through 3.8.12, shall show no:

a. Dimensional distortion beyond specified limits or cracking of the case or cell header.

b. Mechanical failure of any part.

c. Electrolyte leakage.

d. Breakdown of insulation, stripping of metal plating from any component part, corrosion of metal parts, or loosening of protective coating from the cell container or header.

e. Deterioration of cell or battery identification and warning markings. Charred or discolored areas of the cell or battery.

f. Opening of battery vents.

g. Following the inspection of a. through f., the cells or batteries shall be checked as specified herein for conformance to the electrical requirements of 3.6.1 through 3.6.4. Also, the cells or batteries shall have maintained the same physical requirement of 3.5.2 through 3.5.4 as measured before testing.

3.8.1 Temperature-altitude - nonoperating. After completion of the temperature-altitude test of 4.9.1, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.2 Vibration - nonoperating. After completion of the vibration test of 4.9.2, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.3 Vibration - operating. The cell or battery shall be subjected to the vibration tests of 4.9.3. During the following random and gunfire vibration tests, the fluctuation of the cell or battery voltage shall be not greater than 25 percent of the load voltage and shall not fall below the minimum closed circuit voltage specified in the applicable specification sheet. Also, the fluctuation of the cell or battery output current shall be not greater than 25 percent of the load current.

3.8.3.1 Random vibration. The cell or battery shall be subjected to the vibration test of 4.9.3.1. The cell or battery shall operate satisfactorily during the application of the vibration cycle. Following the vibration test, the cell or battery shall conform to the physical requirements of 3.5.2 through 3.5.4 as measured before testing. The cell or battery shall also conform to the requirements of 3.8.a through 3.8.f.

3.8.3.2 Gunfire vibration. The cell or battery shall be subjected to the vibration test of 4.9.3.2. The cell or battery shall operate satisfactorily when exposed to the vibration requirement of 4.9.3.2. Following the vibration test, the cell or battery shall conform to the physical requirements of 3.5.2 through 3.5.4 as measured before testing. The cell or battery shall also conform to the requirements of 3.8.a through 3.8.f.

3.8.4 Mechanical shock - operating. The cell or battery shall be subjected to the shock tests of 4.9.4 and 4.9.4.1. During this test, the fluctuation of the cell or battery voltage shall be not greater than 25 percent of the load voltage and shall not fall below the minimum closed circuit voltage required in the applicable specification sheet. Also, the fluctuation of the cell or battery output current shall be not greater than 25 percent of the load current. After completion of this test, the cell or battery shall have maintained the same physical requirements of 3.5.2 through 3.5.4 as measured before testing. The cell or battery shall also conform to the requirements of 3.8.a through 3.8.f.

3.8.5 Mechanical shock - nonoperating. After completion of the shock tests of 4.9.4 and 4.9.4.2, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.6 Humidity - nonoperating. After completion of the humidity test of 4.9.5, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.7 Salt fog - nonoperating. After completion of the salt fog test of 4.9.6, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.8 Fungus - nonoperating. After completion of the fungus test of 4.9.7, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.9 Temperature shock - nonoperating. After completion of the temperature shock test of 4.9.8, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.10 Explosive decompression - nonoperating. After completion of the explosive decompression test of 4.9.9, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.11 Water immersion - nonoperating. After completion of the water immersion test of 4.9.10, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.8.12 Sand and dust - nonoperating. After completion of the sand and dust test of 4.9.11, the cell or battery shall conform to the requirements of 3.8.a through 3.8.g.

3.9 Safety test requirements. Formal safety requirements regarding lithium cells or batteries within the Naval Air Systems Command (NAVAIR) are identified in NAVAIR INSTRUCTION 5100.7, which adopts the Naval Sea Systems Command requirements identified in Technical Manual S9310-AQ-SAF-010 (see 6.9.1).

3.9.1 Cell or battery. The following cell or battery tests shall be performed. Violent rupture or evidence of external fire or flame shall cause the cell or battery to fail the test (see 3.1). Unless otherwise specified, venting of electrolyte or electrolyte vapor through purposely designed vents is acceptable. Internal pressure buildup shall be not greater than 50 percent of the yield strength of the cell or battery housing assembly.

3.9.2 Constant current discharge and reversal. The cell or battery shall be subjected to the constant current discharge and reversal test of 4.10.2.

3.9.3 Short circuit. The cell or battery shall be subjected to the short circuit test of 4.10.3.

3.9.4 High temperature. The cell or battery shall be subjected to the high temperature test of 4.10.4.

3.9.5 Charging. The charging test of 4.10.5 shall be performed only if the cell or battery is to be connected to an external power source as applicable or if a battery consists of series-connected or series-parallel-connected strings.

3.9.6 Electrical safety device. The cell or battery shall be subjected to the electrical safety device test of 4.10.6. A cell or battery venting of any kind shall cause the cell or battery to fail the test.

3.10 Shelf life. After 5 years of storage at an average temperature of 25°C, the cell or battery shall deliver not less than 80 percent of the capacity requirement defined by 3.6.3 when tested in accordance with 4.5.3.2.

3.11 Packaging and packing. All unit packages (including groups B and C units) shall be packaged and packed in accordance with section 5.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the

contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

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

a. Qualification inspection. A qualification inspection shall consist of tests accomplished on cells or batteries submitted for qualification (see 4.2.1).

b. Quality conformance (group A) inspection. The quality conformance (group A) inspection shall consist of tests conducted on production samples to determine compliance with specification requirements and for qualification verification (groups B and C) inspection (see 4.2.2 and 4.2.3).

c. Qualification verification (groups B and C) inspection. The qualification verification (groups B and C) inspection shall consist of tests conducted on production lot samples to determine compliance with specification requirements (see 4.2.3).

4.2.1 Qualification inspection. Qualification inspection shall be performed by the Government on samples of cells or batteries furnished by the contractor. The samples shall be representative of the cells or batteries proposed to be furnished to the Government under contract and shall not be produced with the use of any equipment or procedure not normally used in production. Qualification inspection of these samples shall be conducted at a Government test facility (see 6.4) and shall consist of the examinations and tests specified herein. The cells or batteries will be considered qualified and will be placed on the Qualified Products List (QPL) upon successful completion of the qualification inspection tests. These tests can be found in table I of the applicable specification sheet (similar to table I of this specification) and shall be tested in the sequence shown on the applicable specification sheet. The cells or batteries shall be retained on the QPL as long as the sample test results from groups B and C continue to conform to the requirements of the specification. The cost of the qualification inspections shall be borne by the Government for the period of time required to establish not less than two qualified contractors on the QPL except as noted in 4.2.1.3.

4.2.1.1 Inspection of cells or batteries. Samples of complete cells or batteries shall be furnished for inspection in accordance with table I of the applicable specification sheet and shall be tested in the sequence shown on the applicable specification sheet. One unassembled cell or battery with all of its parts shall be supplied and will be retained at the Government agency which did the testing.

4.2.1.2 Retention of samples. If the contractor becomes qualified, the sample cell or battery on which the qualification is based will be retained at the Government agency which did the testing as long as the contractor is qualified.

4.2.1.3 Failure and retest. A qualification sample that fails any of the examinations or tests specified herein shall be cause for the Government to refuse to conduct additional testing until the defects revealed by the inspection have been corrected. With the approval of the Government, a retest may be allowed with an increase in the number of qualification samples as specified by the qualifying activity. The cost of retesting shall be borne by the contractor.

4.2.2 Quality conformance (group A inspection). Each cell or battery shall be subjected to the examination and test requirements (group A tests) in table I.

4.2.2.1 Inspection of product for delivery. The contractor shall perform the inspections specified for quality conformance (group A) inspection. This does not relieve the contractor of the responsibility for performing any additional inspection which is necessary to control the quality of the product and to ensure compliance with all specification requirements. The Government will review and examine the contractor's inspection procedures and inspection records. Cells or batteries produced under this specification will be accepted upon successful completion of quality conformance (group A) inspection as outlined in table I of the applicable specification sheet, provided that the samples for groups B and C have been shipped to the qualifying activity in accordance with 4.2.3.

4.2.2.2 Inspection lot. An inspection lot shall be defined as the quantity of cells or batteries of any one type chosen from a completed production run of cells or batteries that are fully assembled and identified in accordance with 3.5.5, produced at any one place of manufacture on any one contract, submitted at one time for quality conformance inspection. Cells or batteries with no more than two consecutive date codes shall appear in a particular inspection lot (see 6.7.4). A specific date and lot code shall be found in no more than one inspection lot.

4.2.3 Qualification verification (groups B and C) inspection. The qualifying activity shall conduct groups B and C inspection for qualification verification. The examination and test requirements of groups B and C inspection shall be those listed in table I of the applicable specification sheet and shall be performed in the sequence shown on the applicable specification sheet. Unless otherwise specified in the contract, the Government shall bear the cost of Government testing (see 6.4).

4.2.3.1 Sample selection and shipping. The Government inspector shall select samples at random from inspected lots representative of all cells or batteries that have passed quality conformance (group A) inspections. The samples shall be in quantities specified in table II and shall not be included in the contract lot size. The contractor shall furnish the samples at no cost to the Government. The contractor shall ship sample cells or batteries in quantities conforming to table II to the qualifying activity. The shipment shall occur within 3 working days after acceptance of the applicable inspection lots by the Government inspector. Shipment of inspection lots that have passed group A inspection requirements shall be held up pending results of the first 14 days of groups B and C inspection performed on samples representing these lots. Once qualified, production samples successfully passing the acceptance criteria are to be accepted until qualification is officially rescinded.

4.2.3.2 Non-compliance. A sample that fails any group B or group C test shall be cause, if deemed necessary by the qualifying activity, to initiate action to remove the contractor's product from the applicable QPL. The qualifying activity shall notify the procuring agency and the contractor of each group B or group C failure, including details of the failure and the characteristics affected. After notification, the contractor shall immediately investigate the cause of the failure. The contractor shall report the results of the investigation and the details of (1) the proposed corrective action to the process, materials, and components as applicable, and (2) the record of events leading to the failure in previously produced units, which the qualifying activity considers manufactured under the same conditions. Contractor reports shall be forwarded to the qualifying activity for evaluation with an information copy to the procuring agency.

4.2.3.3 Inspection of preparation for delivery. Preparation for delivery shall be examined for conformance to section 5. The sample unit shall be one item, one package, or one shipping container.

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in 4.3.1 through 4.3.7.

4.3.1 Ambient air temperature. Unless otherwise specified, all measurements and tests shall be made at ambient temperature (25 ± 5°C), ambient atmospheric pressure, and ambient relative humidity.

4.3.2 High and low temperature. Unless otherwise specified, all high and low temperature discharge tests shall be conducted at the temperature indicated in the applicable test with a storage time not less than 16 hours before discharge. A tolerance of ± 2.0°C shall be allowed.

4.3.3 Current tolerance. For all discharges, the current shall be maintained constant within ± 1 percent of the specified value at all times. Unless otherwise specified, all discharges shall be continuous.

4.3.4 Inspection facilities and equipment. The contractor shall ensure that inspection facilities and equipment of sufficient accuracy, quality, and quantity are established and maintained to perform the required inspections. Equipment used for the inspections specified herein shall be kept calibrated in accordance with MIL-STD-45662 by a facility acceptable to the procuring activity.

4.3.5 Electrical indicating instruments. All voltmeters and ammeters shall be accurate within ± 0.5 percent of full scale reading. The range of analog type meters shall be such that the readings are taken on the upper half of the scale. Timers shall be accurate within ± 0.5 percent. The sensitivity of voltmeters shall be not less than 5000 ohms per volt.

4.3.6 Resistance tolerance. In all tests involving discharge through a resistance, the total circuit resistance shall be accurate within ± 1.0 percent.

4.3.7 Sequence of tests. The tests on each cell or battery shall be performed in the sequence required by the applicable specification sheet.

4.4 Physical examination and test methods. The following examinations and tests shall be performed as described below.

4.4.1 Visual and mechanical examination. Examine the test samples to verify that the basic materials, component materials, parts, design, construction, marking, packaging, and workmanship meet all of the requirements of 3.3 through 3.11. Table III identifies the more prevalent workmanship defects.

4.4.2 Dimensions and weight. Measure and weigh the test samples to determine whether the requirements of 3.5.2 through 3.5.4 have been met.

4.5 Electrical tests. The following tests shall be performed as described below.

4.5.1 Open circuit voltage. Measure and record the open circuit voltage of the test sample before and after each test. Verify that the test sample met the requirements of 3.6.1.

4.5.2 Closed circuit voltage. Expose the test sample to ambient temperature conditions for not less than 16 hours. Connect the test sample to the load specified in the applicable specification sheet. Measure and record the closed circuit voltage of the test sample. Verify that the test sample met the requirements of 3.6.2.

4.5.3 Capacity tests. Select test samples for capacity tests specified in the individual specification sheet. Store and discharge the test sample at temperature conditions in accordance with 4.5.3.1 through 4.5.3.6, where applicable. During capacity testing, continually monitor the ambient and the test sample temperature. Maintain not less than a 5-centimeter separation among all test samples that are being discharged. Measure test sample capacity from test initiation to the first time the test sample voltage falls below the minimum closed circuit voltage specified in the individual specification sheet. Verify that the test sample met the requirements of 3.6.3. A test sample fails a capacity test when any one of the following conditions occurs:

a. The test sample dimensions exceed the maximum specified in the applicable specification sheet.

b. Any evidence of cell leakage, venting, rupturing, or fire is observed within 24 hours after the completion of the test.

c. Any fuse or safety device operates before the test is completed.

d. Insufficient discharge time (service) is delivered.

e. Initial voltage delay time is exceeded.

4.5.3.1 Closed circuit voltage and initial voltage delay. Expose the test sample to ambient temperature conditions for not less than 16 hours. At the start of the capacity discharge test, monitor each test sample with an oscillographic device or equivalent. Connect the test sample to the load specified in the applicable specification sheet. Determine and record the time in milliseconds required for the test sample closed circuit voltage to rise to the minimum voltage after the required loads are applied as specified in the applicable specification sheet. Measure and record the closed circuit voltage of the test sample. Verify that the test sample met the requirements of 3.6.2 and 3.6.4. From the time the test sample is shipped by the manufacturer to the time the closed circuit voltage and initial voltage delay test is conducted, no loads shall be applied at any time.

4.5.3.2 Ambient temperature capacity test (20°C). Store the test sample at 20 ± 2°C for not less than 16 hours. Discharge at a temperature of 20 ± 2°C.

4.5.3.3 Low temperature capacity test (-40°C). Store the test sample at -40 ± 2°C for not less than 16 hours. Discharge at a temperature of -40 ± 2°C.

4.5.3.4 High temperature capacity test (55°C). Store the test sample at 55 ± 2°C for not less than 16 hours. Discharge at a temperature of 55 ± 2°C.

4.5.3.5 Post storage low temperature capacity test (-40°C). Store the test sample at 70 ± 2°C for not less than 30 days before the capacity testing. Then store at a temperature of -40 ± 2°C for not less than 16 hours. Discharge the test sample at a temperature of -40 ± 2°C. A continuous temperature recording device shall demonstrate the accuracy of the storage temperature. No loads shall be applied at any time during storage before the discharge test following storage. Deviations from normal conditions are permitted provided that they exist for no greater than 5 percent of the required cumulative storage periods. Orient test samples in storage to have not less than 50 percent of the cell seals at the bottom of the test samples.

4.5.3.6 Post storage high temperature capacity test (55°C). Store the test sample at 70 ± 2°C for not less than 30 days before the capacity testing. Then store at a temperature of 55 ± 2°C for not less than 16 hours. Discharge the test sample at a temperature of 55 ± 2°C. A continuous temperature recording device shall demonstrate the accuracy of the storage temperature. No loads shall be applied at any time during storage before the discharge test following storage. Deviations from normal conditions are permitted provided that they exist for no greater than 5 percent of the required cumulative storage periods. Orient test samples in storage to have not less than 50 percent of the cell seals at the bottom of the test samples.

4.6 Diode breakdown test. Conduct this test immediately after the closed circuit voltage test for the test sample. The diode breakdown test shall be performed as follows. Obtain a fresh test sample. No test sample of a cell or battery shall undergo more than one test of 4.6, 4.9, or 4.10. Use a direct current (DC) power supply capable of delivering not less than 2.50 milliamperes. Set the power supply voltage at the manufacturer selected diode reverse voltage rating +0 or -1 volts plus the voltage obtained by multiplying the number of cells in series by the factor shown below.

Cell voltage	Factor to be used
2.6 V to 4.0 V	3.05
1.5 V to 2.6 V	2.05

Use low impedance contacts to connect the power supply to the connector terminals of series-connected cell strings of the battery. The circuit will force reverse current flow (charging) through the individual cell string (that is, positive to positive and negative to negative). Apply this voltage for not less than 1.0 second. The amount of current flowing shall be not greater than the amount specified in 3.7.2.2.

4.7 Fuse test. This test shall be performed as follows. Electrically connect each fuse test sample to a DC power source and subject it to its maximum voltage rating. Gradually increase the current to the maximum current rating of the fuse. Reject any fuse that opens at or below the maximum current rating. Verify that the fuse met the requirements of 3.7.3.

4.8 Thermal fuse test. This test shall be performed as follows. Place each test sample in a temperature chamber at 82 ± 2°C for not less than 2 hours. Check each sample to verify that the switch or thermal fuse is closed. Raise the temperature to 88 ± 2°C. After 45 minutes, check each sample to verify that the switch or thermal fuse is open. Lower the temperature to 82 ± 2°C and check each sample after 45 minutes to verify that the switch or thermal fuse is closed. Verify that the thermal fuse met the requirements of 3.7.4.

4.9 Environmental tests. The following tests shall be performed as described below. Unless otherwise specified herein, test the cells or batteries to the environmental requirements of MIL-STD-5400, class 1 equipment. Obtain a fresh test sample for each test listed below. No test sample of a cell or battery shall undergo more than one test of 4.6, 4.9, or 4.10. The Government qualifying activity shall determine which test of 4.5.3.2 through 4.5.3.4 shall be performed to fulfill the 4.5.3 test requirement in the subparagraphs below.

4.9.1 Temperature-altitude test - operating test conditions. During the temperature-altitude test, instrument the test sample to read voltage and current and to apply the discharge current load specified in the applicable specification sheet. Monitor the test sample voltage and current for fluctuation and minimum voltage during the tests. Place the test sample in an environmental chamber preheated to 55°C. One hour after the test sample has been inserted, evacuate the chamber pressure to simulate the ambient vacuum condition of 18,500 meters altitude. After reaching this altitude simulation, maintain the chamber at this temperature and altitude condition for 1 hour. Return the chamber to ambient conditions within a 15-minute period. After 30 minutes at ambient conditions, remove the test sample from the chamber and inspect it in accordance with 4.4.1 and 4.4.2 to verify conformance to the physical requirements of 3.5.2 through 3.5.4 and the requirements of 3.8.a through 3.8.f. Precool a chamber to -40°C. After no less than 2 hours at ambient conditions, place the test sample in the precooled chamber. One hour after the chamber has reached -40°C, again evacuate the chamber pressure to simulate the ambient vacuum condition of 18,500 meters. Maintain the

chamber at these conditions for 1 hour and then return to ambient conditions within a 15-minute period. After not less than 30 minutes at ambient conditions, remove the test sample from the chamber and inspect it in accordance with 4.4.1 and 4.4.2 to verify that the test sample met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.3, and 4.5.3.1. Verify that the test sample met the requirements of 3.8.1.

4.9.2 Vibration - nonoperating test conditions. The test sample does not have to be instrumented or discharged during this test. Subject the test sample to the vibration test curve on figure 1. Apply the vibration to the test sample in each of three mutually perpendicular axes. The test shall consist of one 30-minute logarithmic sweep from 5 Hz to 2000 Hz to 5 Hz in each axis. Position the control accelerometers as specified in the applicable specification sheet. The accelerometer measuring the highest level shall control the vibration level. After completing tests, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.3, 4.5.3.1, and 4.5.3.2. Verify that the test sample met the requirements of 3.8.2.

4.9.3 Vibration - operating test conditions. During the random and gunfire vibration tests, instrument the test sample to read voltage and current and to apply the discharge current load specified in the applicable specification sheet. Monitor the test sample voltage and current for fluctuation and minimum voltage during the tests.

4.9.3.1 Random vibration. Subject the test sample to the random vibration of figure 2 along each of three mutually perpendicular axes. The vibration time in each axis shall be 1 hour. The spectral density average of accelerometers located on the fixture shall control the test levels. After completion of this test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Verify that the test sample met the requirements of 3.8.3 and 3.8.3.1.

4.9.3.2 Gunfire vibration. Subject the test sample to gunfire vibration in accordance with MIL-STD-810, method 519.4. Expose the test sample to complex vibration in accordance with figure 3 along each of three mutually perpendicular axes. Apply excitation for 10 minutes in each axis for high and low rates of gunfire for a total of 60 minutes of gunfire vibration. Individual gunfire burst time will be 3 seconds on and 7 seconds off for a period of 200 cycles. The spectral density average of accelerometers located on the fixture shall control the test levels. After completion of this test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Verify that the test sample met the requirements of 3.8.3 and 3.8.3.2.

4.9.4 Mechanical shock tests. In both shock tests listed below, subject the test sample to 18 impact shocks consisting of 3 shocks in opposite directions along each of 3 mutually perpendicular axes. Each shock shall have an acceleration value of 15 *g* when measured with a 0.2 Hz to 250 Hz filter. The time duration of each shock shall be 11 $\pm$ 1 milliseconds, and the peak acceleration magnitude shall occur at approximately 5 milliseconds. After completing each of the shock tests listed below, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Additionally,

perform the tests specified below to determine conformance to the requirements unique to each shock test.

4.9.4.1 Operating. During this shock test, instrument the test sample to read voltage and current and to apply the discharge current load specified in the applicable specification sheet. Monitor the test sample voltage and current for fluctuation and minimum voltage during this test to determine compliance with 3.8.4. After completing this test, subject the test sample to the common tests specified in 4.9.4 and to the open circuit voltage test of 4.5.1 to verify conformance to 3.6.1.

4.9.4.2 Nonoperating. The test sample does not require instrumentation or discharge during this test. After completing this test, subject the test sample to the common tests specified in 4.9.4 and to the electrical tests of 4.5.1, 4.5.3, and 4.5.3.1 at ambient temperature to verify conformance to the requirements of 3.6 and 3.8.5.

4.9.5 Humidity test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Conduct the humidity test in accordance with MIL-STD-810, method 507.3, procedure III, for 15 days. After completing the humidity test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.6.

4.9.6 Salt fog test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Conduct the salt fog test in accordance with MIL-STD-810, method 509.3, procedure I, followed by a drying period of 24 hours. After completing the salt fog test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.7.

4.9.7 Fungus test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. If the fungus test is to be conducted (see 3.4.2.2), do so in accordance with MIL-STD-810, method 508.3. After completing the fungus test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.8.

4.9.8 Temperature shock test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Conduct the temperature shock test in accordance with MIL-STD-810, method 503.3. The test temperature extremes shall be -57°C to 71°C, and the duration of exposure at each temperature shall be 4.0 +0.5, -0.0 hours. After completing the temperature shock test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.3, and 4.5.3.1. Verify that the test sample met the requirements of 3.8.9.

4.9.9 Explosive decompression test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Subject the test sample to explosive decompression in accordance with MIL-STD-810, method 500.3, procedure II. The conditions simulate a pressure change from cockpit to high altitude pressure taking place within 0.1 second as if the pilot ejected from a pressurized cockpit at 18,500 meters. After completing the explosive decompression test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.10.

4.9.10 Water immersion test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Submerge the test sample in tap water under pressure to simulate the conditions of being in 9 meters of water for 10 minutes and then 1 meter of water for 15 hours. After completing the water immersion test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.11.

4.9.11 Sand and dust test - nonoperating test conditions. The test sample does not require instrumentation or discharge during this test. Conduct the sand and dust test in accordance with MIL-STD-810, method 510.3, procedure I. After completing the sand and dust test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.4 and 3.8.a through 3.8.f. Next, conduct the electrical tests of 4.5.1, 4.5.2, and 4.5.3. Verify that the test sample met the requirements of 3.8.12.

4.9.12 Complete discharge device test. Verify the location and operability of the complete discharge device on batteries. Remove the attention label covering the switch. Push the switch to discharge the battery at a C/24 rate to zero volts. After completing this test, inspect the test sample in accordance with 4.4.1 and 4.4.2 to verify that it met the requirements of 3.5.2 through 3.5.5 and 3.8.a through 3.8.f. Next, conduct the electrical test of 4.5.1. Verify that the test sample met the requirements of 3.7.5.

4.10 Safety tests. The following tests shall be performed as described below. Obtain a fresh test sample for each test listed below. No test sample of a cell or battery shall undergo more than one test of 4.6, 4.9, or 4.10. Perform all safety tests with test samples as specified in the applicable specification sheet.

4.10.1 Test instrumentation. The instrumentation for the safety tests shall include six thermocouples capable of measuring and withstanding temperatures up to 800°C, two voltage monitoring leads, one set of power leads, and, if needed, a pressure transducer capable of measuring pressure up to the failure pressure of the test sample. Place four thermocouples inside the test sample in the following manner: one secured on each end of the cell or battery pack, one secured at the center of the cell or battery pack, and one in the air space surrounding the cell or battery pack. Place and secure the remaining two thermocouples on the outside of the test sample 180° apart near the cell or battery pack. The pressure transducer, if needed, shall continually monitor the pressure inside the cell or battery pack housing.

4.10.2 Constant current discharge and reversal test. Obtain a DC power supply. Continuously monitor and record voltage, current, pressure, and temperature. Deactivate (short) all external devices and accessible internal electrical safety devices. Perform the discharge at the current equal to the rated value of the cell or battery pack fuse. Limit the voltage of the DC power supply to the open circuit voltage of the cell or battery pack. After the test sample voltage reaches zero volts, continue the discharge into voltage reversal at the same current. The duration of the voltage reversal shall equal 1.5 times the elapsed time from initial application of discharge current until test sample voltage reaches zero volts. Verify that the test sample met the requirements of 3.9.1 and 3.9.2. For example, assume a battery pack has a fuse rated at 5 amperes, and it takes 3 hours to discharge the battery at constant current from initial application of the 5 ampere load until the battery voltage reaches zero volts. Therefore, the battery would have to be discharged at 5 amperes for an additional 4.5 hours (i.e., 1.5 times 3 hours) after zero volts had been reached.

4.10.3 Short circuit test. Continuously monitor and record voltage, current, pressure, and temperature. Bypass all external and accessible internal electrical safety devices and short the test sample through a load of not greater than 0.02 ohm. The load shall remain attached for not less than 24 hours. Verify that the test sample met the requirements of 3.9.1 and 3.9.3.

4.10.4 High temperature test. Continuously monitor and record voltage, pressure, and temperature. Heat the test sample at a rate of approximately 20°C rise per minute up to a temperature of 500 ± 2°C or until the test sample vents, whichever occurs first. Verify that the test sample met the requirements of 3.9.1 and 3.9.4.

4.10.5 Charging test. Perform this test if a cell or battery consists of series-parallel strings or if a single-point failure can cause the battery to be connected to an outside DC power source. Continuously monitor and record voltage, current, pressure, and temperature. Deactivate all external and accessible internal electrical safety devices. Discharge the test sample to remove not less than 50 percent of its capacity (see 6.7.2) at a current equal to the rated fuse value. Allow the test sample to stand for not less than 72 hours and then charge it using a DC power supply at a current equal to the fuse value to 100 percent of capacity. Limit the voltage of the DC power supply to the cell or battery pack open circuit voltage or to the voltage of the outside source, whichever is larger. Verify that the test sample met the requirements of 3.9.1 and 3.9.5.

4.10.6 Electrical safety device test. Continuously monitor and record voltage, current, pressure, and temperature. The pass-fail criteria for this test shall be no venting of any kind. This test shall consist of constant current discharge using a DC power supply. All electrical safety devices shall be in place and operational. Perform the discharge at a current equal to 85 ± 5 percent of the cell or battery pack fuse value. Limit the voltage of the DC power supply to the open circuit voltage of the cell or battery pack. After the test sample voltage reaches zero volts, continue the discharge into voltage reversal at the same current. The duration of the voltage reversal shall equal 1.5 times the elapsed time from initial application of discharge current until the test sample voltage reaches zero volts. Verify that the test sample met the requirements of 3.9.1 and 3.9.6. For example, assume a battery pack has a fuse rated at 5 amperes, and it takes 3 hours to discharge the battery at constant current from initial

application of the 5-ampere load until the battery voltage reaches zero volts. Therefore, the battery would have to be discharged at 5 amperes for an additional 4.5 hours (i.e., 1.5 times 3 hours) after zero volts had been reached.

4.11 Special instructions. The procuring activity reserves the right to perform any inspection set forth in this specification when the procuring activity deems such inspection necessary to ensure the production item conforms to the specified requirements.

4.12 Methods of examination and inspection. All inspections shall be conducted in accordance with Government approved procedures. When approved inspection procedures are available from previous contracts, they may be provided and used upon the authorization of the procuring activity. The Government reserves the right to modify procedures or add inspections when deemed necessary to ensure that the cells or batteries comply with this specification and the specified requirements.

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

5. PACKAGING

5.1 Preservation, packaging, and packing. Preservation and packaging shall be level A, B, or C, and packing shall be level A, B, or C as specified in MIL-P-6063 (see 6.2) and 49 CFR 173.185 (see 6.11.1).

5.2 Preservation, packaging, and packing of test samples. Preservation, packaging, and packing of qualification, first article, and groups B and C samples shall be representative of the preservation, packaging, and packing used for production cells and batteries.

5.3 Marking. Interior packages and exterior shipping containers shall be marked on the two largest vertical sides with lettering not less than 13 millimeters in height as follows: ROTATE STOCK - USE OLDEST CELLS [or BATTERIES] FIRST. Additionally, the packages and containers shall be marked in accordance with the requirements of MIL-STD-129 with the date and lot code (see 3.5.5.5) included in the identification marking. A warning label (see 3.5.5.6) shall be marked on the interior packages and exterior shipping containers. A complete discharge device label (see 3.5.5.7) shall be affixed over the switch access opening for the complete discharge device. A complete discharge device card (see 3.5.5.8) shall be packaged in the plastic bag containing the battery, and the card shall be placed lettering side out over the face containing the connector. The national stock number shall be marked on the shipping container (see 3.5.5.2).

5.4 Packaging. Cells and batteries shall be packaged in accordance with the safety control measure for shipment of hazardous materials on military air transports in accordance with 49 CFR 172 and 49 CFR 173.185.

6. NOTES

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

6.1 Intended use. The cells and batteries covered by this specification are intended for use in supplying electrical power to equipment on board aircraft. Primary consideration must be given to the safe use of a non-lithium cell or battery; however, if the application requires the use of a lithium cell or battery, the following guidance will be considered.

6.1.1 Type I. Type I lithium cells or batteries are preferred for all locations within the aircraft. The frequency of occurrence of violent venting or explosion of Type I lithium cells or batteries is improbable during normal operation. If venting does occur, the vent products are non-toxic and non-corrosive; they would not immediately endanger personnel nor cause severe equipment damage.

6.1.2 Type II. Type II lithium cells or batteries are not recommended for use in cockpit or crew compartment areas unless appropriate eye and respiratory protection are provided. Type II lithium cells or batteries can be used in other areas of an aircraft only if vent products will not contaminate the cockpit or crew compartment areas or high priority equipment or systems. The frequency of occurrence for violent venting or explosion of type II lithium cells or batteries is remote during normal operation. If venting does occur, the toxic and corrosive vent products are likely to endanger personnel and cause severe equipment damage.

6.1.3 Type III. Type III lithium cells or batteries are expected to be used in such applications as aircraft computer memory backup.

6.1.4 Cell or battery selection. The smallest possible cells or batteries must be selected for the mission power requirement.

6.1.5 Battery assembly. In development programs, assembly of batteries by user personnel must be avoided.

6.1.6 Cell or battery compartment. A special compartment must be designed for the cell or battery for isolation from the electronics of the end item equipment or weapon system. The compartment must have no interior projections or sharp edges that could damage the electrical insulation around the cell or battery. The cell or battery must be secured within the compartment to reduce shock and vibration to the levels required for end item use. The compartment must be designed either to provide vent paths or else contain gases emitted by a venting battery. If vent paths are to be used, they must be identified on the compartment drawings. If the compartment is designed to contain the vented gas, the drawings must identify the pressure-containing capabilities of the compartment (including pressure level) and the containment designs or methods.

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

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

6.2 Acquisition requirements. Acquisition documents must specify the following:

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

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

c. Part number of cell or battery required.

d. Number of cells or batteries required.

e. Issue of DODISS to be cited in the solicitation and, if required, the specific issue of individual documents referenced (see 2.1.1 and 2.1.2).

f. Level of packaging and packing required.

g. Responsibility for inspection, if other than specified (Section 4).

h. Special preparation for delivery requirements, if applicable (Section 5).

6.3 Verification inspection. Verification by the Government will be limited to the amount deemed necessary to determine compliance with the contract and will be limited in severity to the definitive quality assurance provisions established in this specification and the contract. The amount of verification inspection by the Government will be adjusted to maximize use of the contractor's quality control system and the quality history of the product.

6.4 Provisions for qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Air Systems Command (AIR 53624), Naval Air Systems Command Headquarters, 1421 Jefferson Davis Highway, Arlington, VA 22243-5360; however, information pertaining to qualification of products may be obtained from Crane Division, Naval Surface Warfare Center, Electronics Development Directorate, Electrochemical Power Systems Department, Code 6092, Bldg. 2949, 300 Highway 361, Crane, Indiana 47522-5001.

6.5 Conformance to qualified sample. It is understood that cells or batteries supplied under contract are identical in every respect to the qualification sample tested and found satisfactory, except for previously approved Government changes. Any unapproved changes from the qualification sample will constitute cause for rejection.

6.6 Material Safety Data Sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.7 Definitions. The definitions of terms used in this specification are as follows.

6.7.1 Balanced electrochemistry. Balanced electrochemistry means that the ratio of the lithium to the cathode material is such that, under normal operating conditions, no excess anode or cathode reactants remain after all electrochemical reactions have occurred.

6.7.2 Capacity. Capacity is determined by discharging a cell or battery at a constant current in amperes equivalent to the rated fuse value to a voltage of zero volts.

6.7.3 Initial voltage delay. Initial voltage delay is the time required at the beginning of discharge for the cell or battery to reach minimum voltage after the load is applied.

6.7.4 Jacket. A jacket is a noncombustible insulating layer of material used to insulate a cell or battery electrically. The jacket may also be used to encase the components of a cell or battery.

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

a. Type of cell or battery (see 1.2).

b. Part or identifying number (PIN) (see 1.3 and 6.10.1).

c. Shape and size of cell or battery (see 3.5.2).

d. Weight (see 3.5.3).

e. Terminal labeling (see 3.5.5.1).

f. Maximum open circuit voltage (see 3.6.1).

g. Minimum closed circuit voltage (see 3.6.2).

h. Capacity requirements (see 3.6.3).

i. Initial voltage delay requirements (see 3.6.4).

j. Diode(s) insertion, if required (see 3.7.2).

k. Fuse value required in the ground lead of each string of cells in series in the battery (see 3.7.3).

l. Thermal fuse (see 3.7.4).

m. Table I and sequence of tests (see 4.2.1, 4.2.3, and 4.3.7).

n. Required loads for tests (see 4.5.3, 4.9.3, and 4.9.4).

o. Position of control accelerometers (see 4.9.2).

p. Recommended storage temperature.

6.9 Safety.

6.9.1 Lithium cell and battery safety. All lithium cell or battery safety testing must be conducted in accordance with the Naval Sea Systems Command (NAVSEA) Technical Manual S9310-AQ-SAF-010 and approved by Naval Ordnance Center (Code N713). Before Naval Ordnance Center review and approval, a safety data package must be developed as specified by S9310-AQ-SAF-010. The lithium cell- or battery-powered system description must also be included.

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

6.9.3 System safety. System safety requirements, if required, will be in accordance with MIL-STD-882.

6.10 Application information. The following information is provided for use when creating a specification sheet.

6.10.1 Part or identifying number (PIN). The PIN for cells and batteries acquired to this specification is created as follows: D29595/Y-Z with "Y" representing the specification sheet number and "Z" indicating any variation of the cell or battery on a specific specification sheet.

6.10.2 Discharge rate. If a specific discharge current is not identified, the following typical values for discharge rates should be used.

6.10.2.1 Low rate design. Cells of bobbin construction are considered low rate because of their limited electrode surface. Typical capacity discharge and closed circuit voltage rates for low rate cells are Capacity Rate (C_{Rate})/60 and C_{Rate}/48, respectively.

6.10.2.2 Moderate rate design. Moderate rate designed cells consist of more electrode surface than the low rate design and may be constructed using concentric cylinders of active electrode materials. Typical capacity discharge and closed circuit voltage discharge rates for moderate rate design cells are C_{Rate}/16 and C_{Rate}/8, respectively.

6.10.2.3 High rate design. Cells of spiral wound construction are considered high rate because of their large amount of electrode surface. Typical capacity discharge and closed circuit voltage discharge rates for high rate design cells are C_{Rate}/4 and C_{Rate}/2, respectively.

6.10.3 Voltage delay. The voltage delay (time to achieve minimal operational voltage after initial application of load) typically is not a problem with Type I lithium cells or batteries. However, Type II lithium cells or batteries have historically exhibited voltage delay which becomes more severe with increased storage time and temperature.

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

6.11.1 New cells and batteries. All transportation of new lithium cells and batteries on public domain is controlled by federal law regulating shipment of hazardous materials. The general regulations are stated in 49 CFR 172.101, 173, 175.3, and 206(e)(1), while 49 CFR 173.185 contains the specific regulations for lithium cells and batteries. The regulations of 49 CFR 173.185 permit shipment of lithium cells and batteries by highway, rail, vessel, and cargo-only aircraft provided the detailed requirements of the regulations have been met. Contractors may ship in accordance with 49 CFR 173.185, using performance-oriented packaging (see Docket HM181 in 55 FR 52402ff).

6.11.2 Used cells and batteries. All transportation of used lithium cells and batteries on public domain is controlled by federal law regulating shipment of hazardous materials. The general regulation, as stated in 49 CFR 172.101 and 49 CFR 173.185, permits shipment of waste lithium cells and batteries to a disposal site by motor vehicle only. The transportation of hazardous waste is regulated by 40 CFR 263, which provides for the proper identification of the transporter and manifesting of the waste.

6.12 Disposal. Official Navy guidance for disposal is provided in Technical Manual S9310-AQ-SAF-010.

6.12.1 At sea. At sea, dispose of cells or batteries consumed while underway or during ashore deployment by discharge overboard in deep water (in excess of 83 meters) outside the prohibited zone (92.6 kilometers). Do not stow for shore disposal.

6.12.2 Ashore. Ashore, dispose of cells or batteries as follows:

6.12.2.1 Routine disposal. Remove the cells or batteries from the equipment or system. Remove the attention label covering the complete discharge device switch. Push the switch and store the battery for five days, ensuring that such batteries are separated from each other by not less than 25 millimeters in each direction. Upon completion of discharge and storage, tape both the positive and negative leads of each cell or battery with electrical tape. This should be done by first wrapping the leads end-to-end with several layers of tape, then wrapping several layers around the body of the cell or battery. Use care when handling the cells or batteries to avoid inadvertent shorting prior to taping the leads. Place each cell or battery in its own appropriately sized polyethylene zipper-type bag. In case electrical tape and polyethylene bags are not available, the box from a fresh battery may be used instead. If a sizable amount of cells or batteries are involved, obtain a drum, polyethylene drum liner, and appropriate "Class 9" and hazardous waste labels. Insert the proper information onto the labels and affix the labels onto the drum. Sort the cells and batteries by chemistry. Ensure that each drum contains only one type of chemistry (e.g., only lithium/sulfur dioxide). Place approximately 5 to 7.5 centimeters of a non-combustible cushioning agent (such as vermiculite or equivalent) in the bottom of the drum. DO NOT USE PLASTIC BUBBLE WRAP AS THE CUSHIONING AGENT. Place a layer of the bagged or boxed cells and batteries in the drum, followed by another layer of the cushioning agent. Do not leave any voids between the lid and the waste. Fill voids with cushioning agent. Secure the lid onto the drum. Ensure the drum is located in a cool area away from personnel and flammable items. Do not store the drum for longer than the period set by law and regulation. The period starts on the day the first battery is placed in the drum. Turn the cells and batteries into the local Defense Reutilization and Marketing Office in accordance with OPNAVINST 5090.1 for disposal as a hazardous waste.

6.12.2.2 Emergency disposal. Evacuate the area and notify an explosive ordnance disposal team (EOD), who should immediately remove cells or batteries to a safe site when the cells or batteries are deemed to be too hazardous for routine disposal.

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

6.14 Subject term (key word) listing.

Anode
Cathode, liquid
Cathode, solid
Cathode, soluble
Complete discharge device
Electrochemistry
Lithium/carbon monofluoride
Lithium/iodine
Lithium/iron disulfide
Lithium/manganese dioxide
Lithium/sulfur dioxide
Lithium/sulfuryl chloride
Lithium/thionyl chloride

Materials, hazardous
Qualified Products List
Rechargeable lithium
Safety Data Package
Storage, electrical
Systems, electrochemical
Tests, abusive
Tests, safety

TABLE I. Inspection of cells or batteries.

Inspection number	Inspection title	Qualification inspection sample size	Requirement paragraph number	Method of inspection paragraph number	Quality conformance inspection group		
					A	B	C
1	Shape and size	All	3.5.2	4.4.1 & 4.4.2	X[1] Y[2]	X Y	
2	Dimensions and weight	All	3.5.3	4.4.2	X Y	X Y	
3	Cell or battery interface	All	3.5.4	4.4.1	X Y	X Y	
4	Labels and marking	All	3.5.5	4.4.1	X Y	X Y	
5	Visual and mechanical examination	All	3.5.6	4.4.1	X Y	X Y	
6	Open circuit voltage	All	3.6.1	4.5.1	X Y	X Y	
7	Closed circuit voltage	All	3.6.2	4.5.2	X Y	X Y	
8	Closed circuit voltage and initial voltage delay	All	3.6.3 & 3.6.4	4.5.3 & 4.5.3.1		X	
9	20°C capacity	3	3.6.3	4.5.3 & 4.5.3.2		X	
10	-40°C capacity	3	3.6.3	4.5.3 & 4.5.3.3		X	
11	55°C capacity	3	3.6.3	4.5.3 & 4.5.3.4		X	
12	Post storage -40°C capacity	3	3.6.3	4.5.3 & 4.5.3.5		X	
13	Post storage 55°C capacity	3	3.6.3	4.5.3 & 4.5.3.6		X	
14	Diode breakdown	3	3.7.2 thru 3.7.2.2	4.6			X
15	Fuse	3 fuses	3.7.3	4.7			X
16	Thermal fuse	3 thermal fuses	3.7.4	4.8			X

[1]X indicates group A, group B, and group C tests that are always conducted.

[2]Y indicates 100 percent inspection.

TABLE I. Inspection of cells or batteries - Continued.

Inspection number	Inspection title	Qualification inspection sample size	Requirement paragraph number	Method of inspection paragraph number	Quality conformance inspection group		
					A	B	C
17	Temperature-altitude operating	6	3.8 & 3.8.1	4.9 & 4.9.1			Z[3]
18	Flight vibration nonoperating	3	3.8 & 3.8.2	4.9 & 4.9.2			Z
19	Random vibration operating	3	3.8;3.8.3;3.8.3.1	4.9;4.9.3;4.9.3.1			Z
20	Gunfire vibration operating	3	3.8;3.8.3;3.8.3.2	4.9;4.9.3;4.9.3.2			Z
21	Mechanical shock operating	3	3.8 & 3.8.4	4.9;4.9.4;4.9.4.1			Z
22	Mechanical shock nonoperating	3	3.8 & 3.8.5	4.9;4.9.4;4.9.4.2			Z
23	Humidity nonoperating	3	3.8 & 3.8.6	4.9 & 4.9.5			Z
24	Salt fog nonoperating	3	3.8 & 3.8.7	4.9 & 4.9.6			Z
25	Fungus nonoperating	3	3.8 & 3.8.8	4.9 & 4.9.7			Z
26	Temperature shock nonoperating	3	3.8 & 3.8.9	4.9 & 4.9.8			Z
27	Explosive decompression nonoperating	3	3.8 & 3.8.10	4.9 & 4.9.9			Z
28	Water immersion nonoperating	3	3.8 & 3.8.11	4.9 & 4.9.10			Z
29	Sand and dust nonoperating	3	3.8 & 3.8.12	4.9 & 4.9.11			Z
30	Complete discharge device test	3	3.7.5	4.9 & 4.9.12			Z
31	Constant current discharge and reversal	3 3	3.9.1 & 3.9.2	4.10;4.10.1;4.10.2			Z
32	Short circuit	3	3.9.1 & 3.9.3	4.10;4.10.1;4.10.3			Z
33	High temperature	3	3.9.1 & 3.9.4	4.10;4.10.1;4.10.4			Z
34	Charging	3	3.9.1 & 3.9.5	4.10;4.10.1;4.10.5			Z
35	Electrical safety device	3	3.9.1 & 3.9.6	4.10;4.10.1;4.10.6			Z

[3]Z indicates the test shall be run at the discretion of the qualifying activity. Two tests shall be conducted per production lot. The tests shall be selected by the qualifying activity.

TABLE II. Groups B and C sample size.

Inspection lot size	Total number of samples
Less than 150	13
Greater than or equal to 150	Use sampling plan inspection level S-4 in accordance with MIL-STD-105

TABLE III. Identification of defects.

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

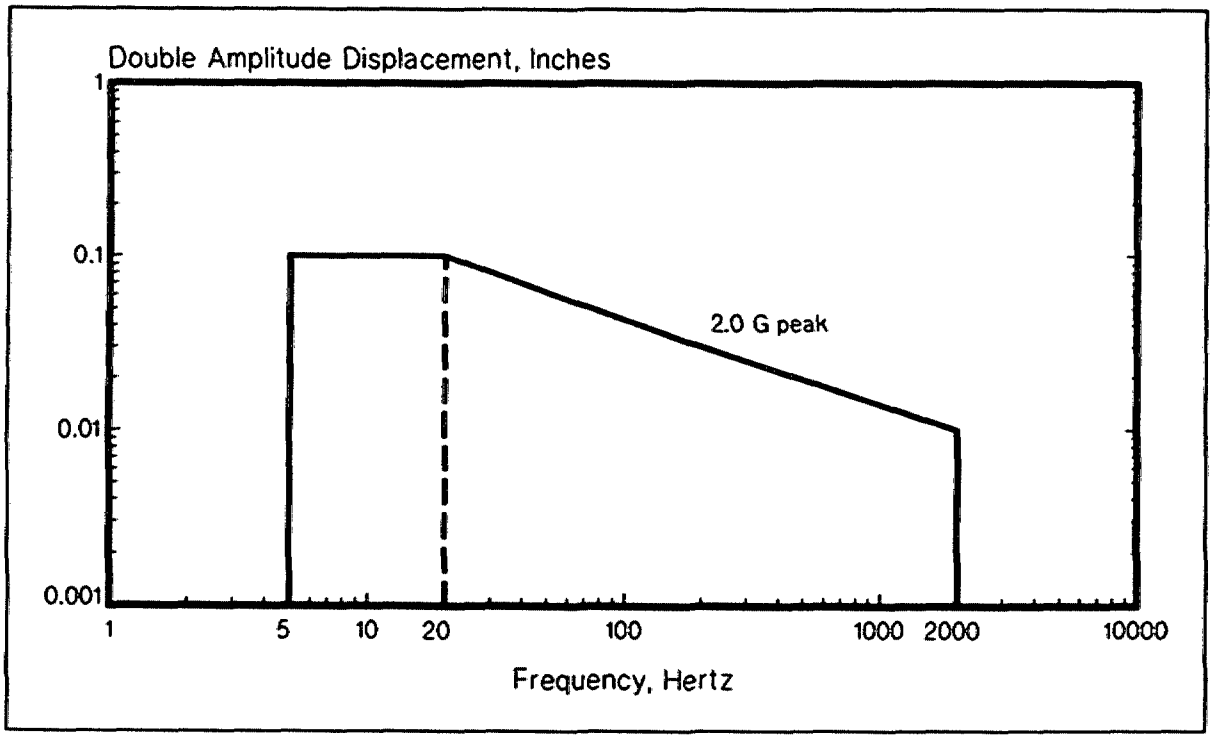


FIGURE 1. Nonoperating vibration spectrum.

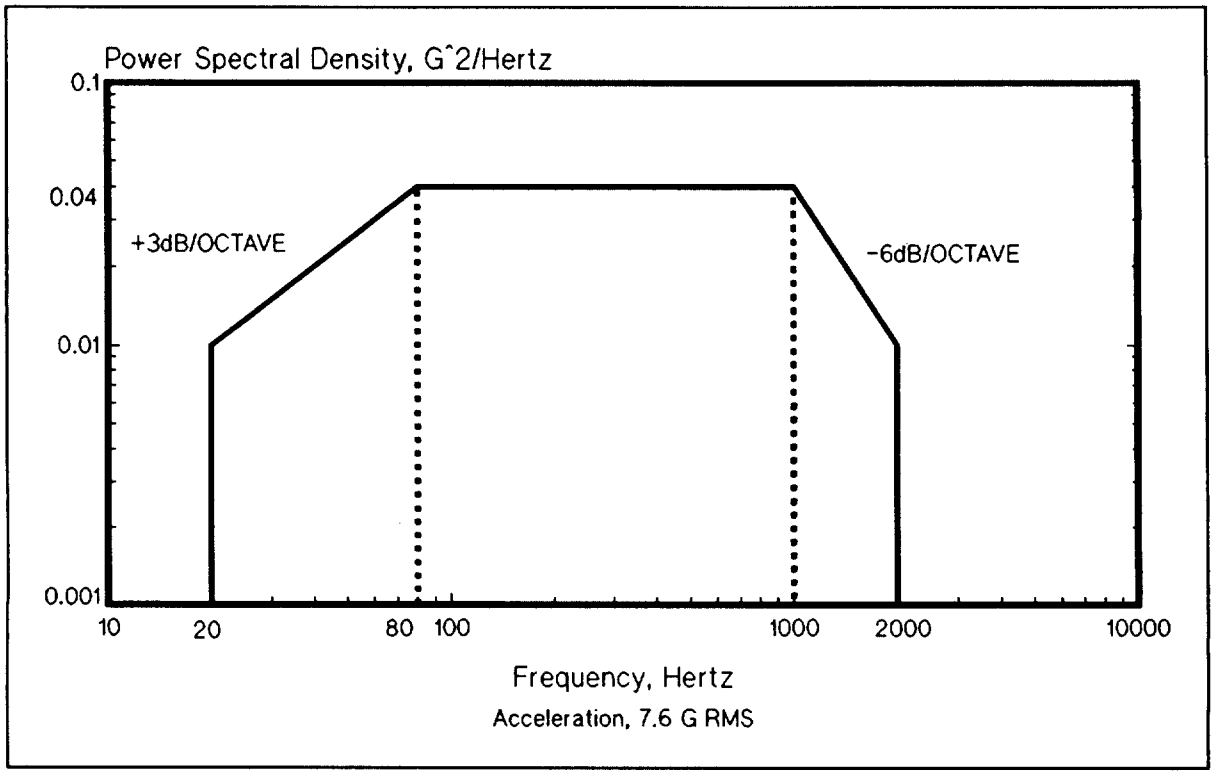
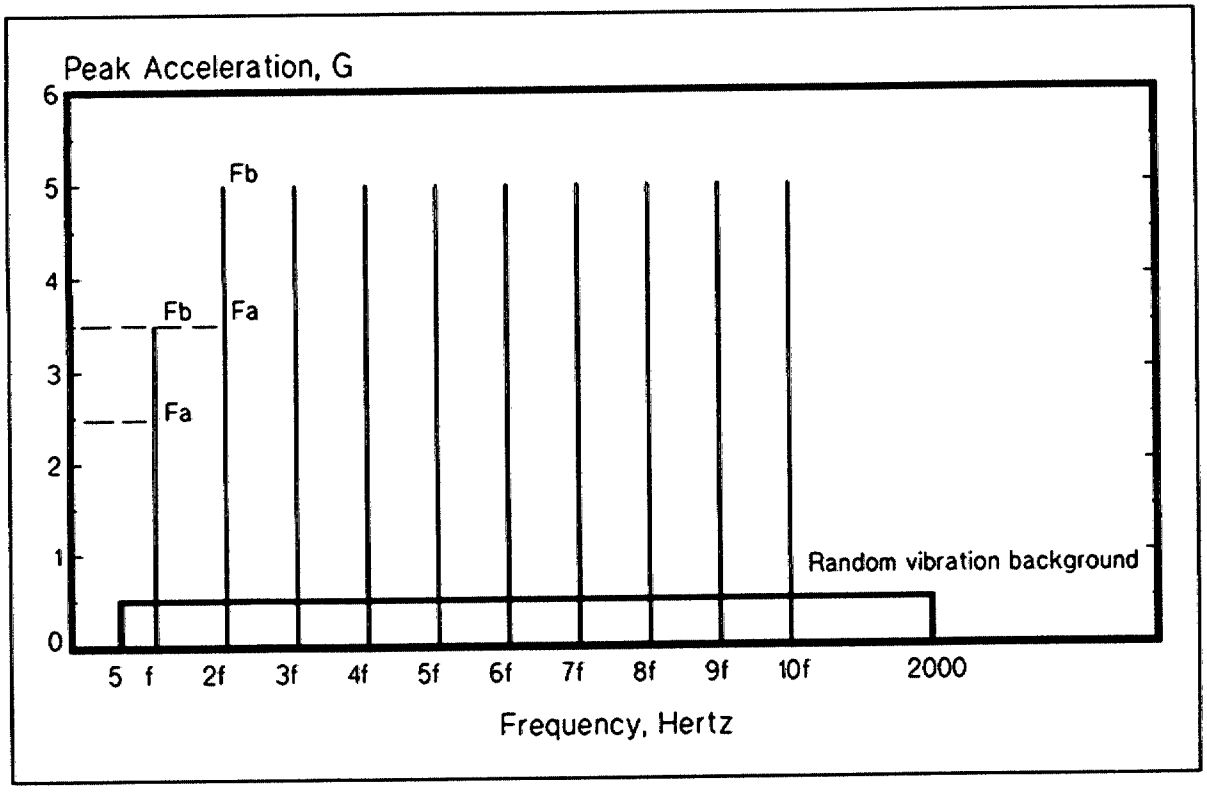


FIGURE 2. Random vibration spectrum.



Individual gunfire burst time: 3 seconds.
Two minutes total of each spectrum along each axis.

Vibrate using two fundamental frequencies: fa and fb

62.3 Hz < fa < 74.3 Hz
95.6 Hz < fb < 107.6 Hz

For f and 2f, amplitudes are as follows:

Test Frequency	Amplitude Designation	1f Amplitude	2f Amplitude
fa	Fa	2.5 *g*	3.5 *g*
fb	Fb	3.5 *g*	5.0 *g*

Amplitudes of frequencies f3 through f10 are 5.0 *g* for fa and fb.

Random vibration background: 0.0045 g^2/Hz, 5 Hz - 2000 Hz
Overall g_{RMS}: 11.0

FIGURE 3. Gunfire vibration spectrum.

CONCLUDING MATERIAL

Custodian:
Navy - AS

Preparing activity:
Navy - AS

(Project 6135-N256)