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TECHNICAL MANUAL
FOR
BATTERIES, NAVY LITHIUM SAFETY PROGRAM RESPONSIBILITIES AND PROCEDURES

NAVAL SEA SYSTEMS COMMAND

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FOREWORD

This Technical Manual, S9310-AQ-SAF-010 of 19 August 04, is an unclassified publication.

This manual applies to all Navy and Marine Corps activities and all lithium battery powered devices intended for use or transportation on Navy facilities, submarines, ships, vessels and aircraft. Material to which this manual applies includes all primary (non-rechargeable) and secondary (rechargeable), active, thermal and reserve lithium batteries, including "lithium ion" batteries and all equipment powered by lithium electrochemical power source(s) through all phases of the life of such systems.

The purpose of this manual is to establish safety guidelines for the selection, design, testing, evaluation, use, packaging, storage, transportation and disposal of lithium batteries.

All errors, omissions, discrepancies and suggestions for improvements to NAVSEA technical manuals shall be reported to Commander, Naval Surface Warfare Center, Port Hueneme (see Appendix B) on NAVSEA Technical Manual Deficiency/Evaluation Report, NAVSEA Form 4160/1. To facilitate such reporting, three copies of NAVSEA Form 4160/1 are included at the end of this technical manual.

This publication is stocked at the Customer Service, Standardization Documents Order Desk, Defense Printing Service (see Appendix B). U.S. Government agencies desiring copies of this publication should refer to NAVSUP Pub 2002, Navy Stock List of Publications and Forms, for stock number assignment and requisitioning publications.

CHAPTER 1

GUIDELINES AND REQUIREMENTS FOR LITHIUM CELLS AND BATTERIES

1.1 INTRODUCTION.

1.1.1 Lithium Cells and Batteries. Lithium cells and batteries offer many advantages compared to other power sources. However, they are high-energy devices and shall be considered hazardous at all times. The Department of the Navy has adopted a Lithium Battery Safety Program to minimize hazards associated with their use. Appendix A contains a list of definitions that may prove useful in understanding this and other battery related documents.

1.1.2 Lithium Battery Safety Program. The Lithium Battery Safety Program, as required by NAVSEA Instruction 9310.1, addresses lithium batteries proposed for use in a specific systems or device. Program managers are encouraged to contact the Commanding Officer, Naval Ordnance Safety and Security Activity (NOSSA) (see Appendix B of this document for addresses) early in the program to seek assistance in the definition of test and approval requirements. This process includes several distinct steps:

1.1.2.1 Preparing and Submitting a Safety Data Package. Preparing and submitting a safety data package as described in paragraph 1.2.1.

1.1.2.2 Conducting and Reporting Safety Testing. Conducting and reporting safety testing of the lithium battery. This testing is described in detail in Chapter 2. Some small, commercially available cells and batteries are exempt from testing, as described in paragraph 1.3.1. Some small, commercially available batteries used in Commercial Off The Shelf (COTS) electronics and equipment are previously authorized, as described in paragraph 1.3.2.

1.1.2.3 Safety Evaluation and Determination of Approval. The safety evaluation and determination of approval, design change(s) or disapproval is made by NOSSA (see Appendix B). Lithium battery safety approval is specific to the battery design and system or device described in the safety data package and the safety test report. Approval is not transferable to other applications without specific review. Any lithium battery proposed for use or carriage aboard submarines shall also be approved by NAVSEA SEA-07T. Any lithium battery proposed for use or carriage aboard aircraft shall also be approved by NAVAIR AIR-4.4.4.1. Commander, Naval Surface Warfare Center, Carderock Division or Crane Division (NSWC Carderock/Crane) (see Appendix B) shall request these approvals from NAVSEA SEA-07T and NAVAIR AIR-4.4.4.1, as required.

1.1.3 Lithium Cells and Batteries Used in Equipment. Lithium cells and batteries shall be used only in approved equipment. They shall not be pierced, cannibalized, mutilated, punctured, crushed, dropped, dismantled, short circuited, exposed to high temperatures, incinerated, or modified. Primary (non-rechargeable) types of lithium cells and batteries shall not be charged or recharged.

1.1.4 Lithium Battery Applications. Lithium battery applications shall comply with the instructions contained herein regarding design, use, packaging, storage, transportation, and disposal.

1.2 PROGRAM OFFICE RESPONSIBILITIES.

1.2.1 Program Managers. Program Managers anticipating the use of lithium cells and batteries shall submit a letter requesting a lithium battery safety review early in the program acquisition process to NOSSA; or to NSWC Carderock/Crane as directed by NOSSA IAW NAVSEA Instruction 9310.1 (see Appendix B).

1.2.1.1 Request Letter. This request letter shall:

1.2.1.1.1 Explain why a lithium cell and/or battery is needed;

1.2.1.1.2 Identify platform(s) (Naval facilities, submarines, ships, vessels, and aircraft) that will carry or deploy the system;

1.2.1.1.3 Be submitted on letterhead; and be signed, serialized and dated;

1.2.1.1.4 Include the data package compiled in accordance with paragraph 1.2.2.

1.2.1.2 Submitting Request Letter. This request letter may be submitted electronically via electronic mail (email) or compact disk (CD). Sample request letters are provided in Appendix C.

1.2.2 Data Package. A data package describing the following items for the battery and intended piece of equipment in which it will be used shall be submitted as an enclosure to the request letter of 1.2.1.1. Information not readily available may be so noted and omitted from the data package; omitted information deemed critical shall be obtained during the Safety Review Process.

1.2.2.1 Proposed Cell/Battery Design.

1.2.2.1.1 Manufacturer (name, address, phone number)

1.2.2.1.2 Model Number and/or Part Number

1.2.2.1.3 Electrical description (voltage, ampere-hour capacity, and nominal load profile)

1.2.2.1.4 Electrical safety devices integral to the cell/battery

1.2.2.1.5 Cell/Battery configuration (cells in parallel or series; batteries in parallel or series)

1.2.2.1.6 Operating life (shelf life and functional life)

1.2.2.1.7 Physical dimensions and description (weight, size, geometry, number of cells, battery housing description)

1.2.2.1.8 Marking indicating battery chemistry

1.2.2.1.9 Thermal battery case temperature (include specification requirements and actual battery performance; include complete temperature profile from activation to battery cool down [this is normally beyond specification life])

1.2.2.1.10 Thermal battery cool down time

1.2.2.1.11 Thermal or reserve battery method of activation

1.2.2.1.12 Cell and/or battery yield pressure (if unvented, battery/housing room ambient yield pressure)

1.2.2.1.13 All applicable Material Safety Data Sheets (MSDS), Product Information Sheets, or equivalent document

1.2.2.1.14 Cell failure mode (Indicate whether a single cell failure can cascade into multiple cell failures.)

1.2.2.1.15 Rated cycle-life (*vs.* DOD) and the mean-time-between-failures (MTBF) for the cell/battery (for rechargeables only)

1.2.2.1.16 Discharge and recharge rates for the battery (Indicate the limiting discharge/charge rates for rechargeables only.)

1.2.2.2 Lithium Battery-Powered Equipment Description.

1.2.2.2.1 Manufacturer (name, address, phone number)

1.2.2.2.2 Model number and/or Part Number and device name

1.2.2.2.3 Diagram of the system's overall mechanical interfaces showing battery proximity to other equipment and energetic devices

1.2.2.2.4 Battery installation (mounting, seals, electrical connectors)

1.2.2.2.5 Battery housing/container, strength, and free volume

1.2.2.2.6 Safety features or venting mechanisms (description and estimate of operational venting pressure)

1.2.2.2.7 Current drain (load profile of the system)

1.2.2.2.8 Block diagram of system interfaces to the battery (electrical and physical)

1.2.2.2.9 Electrical schematic (showing fuses, blocking diodes, and external power interface)

1.2.2.2.10 Description of the charger and charge control mechanism. Are cells individually equilibrated, or is the battery charged as a series/parallel string?

1.2.2.2.11 Description of other controls or mechanisms to enhance battery safety, such as a Battery Management System (BMS), software shutdown mechanism, etc.

1.2.2.3 Logistics and Operational Use.

1.2.2.3.1 Packaging. How will system/battery be packaged?

1.2.2.3.2 Storage facilities. How will system/battery be stored from delivery to disposal?

1.2.2.3.3 Transportation methods

1.2.2.3.4 Disposal information

1.2.2.3.5 Operational use scenario (Include a complete description of how the system/batteries will be handled and used; what platform(s) (Naval facilities, submarines, ships, vessels, and aircraft) will carry or deploy the system; location of recharging operations; recovery operations; number of units anticipated to be used; and, where appropriate, the sequence of events before system use/activation/deployment, etc.).

1.2.2.3.6 Thermal or reserve battery activation method and sequence/failure analysis

1.2.2.3.7 Thermal or reserve battery hang-fire analysis

1.2.2.3.8 Description of the battery change out/replacement plan

1.2.2.4 Functional, Environmental and Safety Tests. Functional, environmental and safety tests representative of the actual environments to be encountered by the complete end item (including the battery) performed to date (description of testing performed, results, and supporting data). Data may include results from battery testing conducted by other services or agencies, manufacturers, or independent evaluators (e.g. Underwriters Laboratories (UL)).

1.2.2.5 Safety Testing Program Plan or Completed Test. Proposed safety testing program plan or completed test results from the specific lithium battery safety abuse tests identified in Chapter 2.

1.2.3 Development and Procurement Actions. In development and procurement actions, applicable portions of the current issue of MIL-STD-882 (System Safety Program Requirements) shall be invoked by contract. When available, summarized results from the System Safety Program may be submitted with the safety data package described in 1.2.2.

1.2.4 Configuration Management. Activities procuring batteries for limited or full-scale production shall ensure that configuration management is imposed on the battery IAW MIL-STD-973 or an appropriate commercial standard, such as ISO 1007. In addition to the usual definition, a Class I change shall be defined as any change affecting safety characteristics of the battery, such as cell manufacturer, type, method of fabrication, insulation, circuit load changes, battery packaging, etc. Class I battery changes shall be coordinated with the NSWC Carderock/Crane (see Appendix B) in order to initiate an updated safety review and approval.

1.2.5 Separate and Distinct Processes. NOSSA safety approval, non-standard parts approval, qualification to a military specification, platform configuration control procedures, and safety review board concurrences are all separate and distinct processes. Completion of one process does not imply completion of any of the other processes.

1.2.6 Reporting All Ventings, Accidents, and Incidents. All ventings, accidents, and incidents involving lithium batteries shall be reported In Accordance With (IAW) the current version of OPNAVINST 5102.1, "Mishap Investigation and Reporting." Reports shall also be sent to Naval Ordnance Safety and Security Activity (NOSSA)(see Appendix B).

1.3 EXCEPTIONS.

1.3.1 Exempted From Testing Requirements. Certain lithium batteries and lithium battery-powered equipment with the general design characteristics described in 1.3.1.1 through 1.3.1.2.2 are exempted from testing requirements. However, a request letter IAW paragraph 1.2.1.1 shall be submitted to document the use of such batteries in these systems.

1.3.1.1 Equipment Designed for Commercial Use. Equipment designed for commercial use and procured from commercial sources carrying approval of Underwriters Laboratory that uses a primary (non-rechargeable) lithium battery of no more than two identical cells with a maximum rated capacity of 1.5 ampere-hours per cell shall be exempted. For this exemption to apply, UL approved equipment shall not be modified to include replacing the battery with one of a different chemistry or size.

1.3.1.2 Equipment Designed for a Specific Navy Use. Equipment designed for a specific Navy use utilizing no more than two identical primary cells with a maximum rated electrical capacity of 1.5 ampere-hours per cell shall be exempted provided:

1.3.1.2.1 No other source of electrical power to the unit exists, or

1.3.1.2.2 The battery is protected from other sources of electrical power by appropriate combinations of blocking diodes and resistors. This exemption applies to normal repair and maintenance of the equipment, including procurement and storage of replacement batteries.

1.3.1.3 Test Data from other Sources. NSWC Carderock/Crane (see Appendix B) may determine that sufficient safety test data are available from other sources. Analyses or comparisons with comparable cells/batteries in comparable applications may be sufficient to eliminate the need for testing.

1.3.2 COTS Electronics and Equipment Powered by Lithium Ion Batteries. The use of COTS electronics and equipment powered by lithium ion secondary (rechargeable) batteries meeting the following criteria are approved for use by Naval personnel and on Naval activities, surface ships, submarines, and aircraft.

1.3.2.1 Battery Criteria. Batteries shall be:

1.3.2.1.1 Commercially available, UL listed, unmodified, and used in the device as recommended by the manufacturer. Modifications to the devices may only be made IAW manufacturer's recommendations (addition of memory, etc.);

1.3.2.1.2 Recharged only by devices expressly designed for recharge of the specific battery in use;

1.3.2.1.3 Comprised of no more than four cells in series (less than or equal to 18-volt output);

1.3.2.1.4 Rated for no more than 100 Watt-Hours (as listed in the manufacturer's specification or calculated by multiplying capacity in ampere-hours by the maximum working voltage);

1.3.2.2 Initial Procurement. Batteries meeting the above criteria shall be exempt from safety testing and evaluation processes, but initial procurement must be reported to NSWC Crane Division (see Appendix B). This data will be compiled to provide a basis for notice and recall in the case of unexpected incidents. Electronic notification is authorized. Report shall include the following information:

1.3.2.2.1 Manufacturer/brand name;

1.3.2.2.2 Model identification (name and number);

1.3.2.2.3 Use scenario/environment (e.g. office computer or test set, submarine);

1.3.2.2.4 Point of contact (name, organization, email and phone number).

1.3.2.3 Alteration of Batteries. There shall be no attempt to open, modify, reform, or repair batteries, which appear to be malfunctioning, or which have been physically damaged.

1.3.2.4 Failed Batteries. Failed batteries shall be returned to the manufacturer or properly disposed of in accordance with local regulations.

1.4 DESIGN.

1.4.1 General.

1.4.1.1 Battery Selection. Select batteries or cells as small as possible to meet the mission requirements.

1.4.1.2 Over-current Device. Each battery used as a power source shall contain a suitable over-current device. Devices may go to the open-circuit position if the battery is discharged at an excessive rate (e.g. fuse), or may limit current flow to a safe level (e.g. Positive Thermal Coefficient (PTC)). Batteries shall be over-current protected in the ground lead of each series string. Each separate circuit shall be protected. If the battery is tapped to provide different output voltages, each tap shall be protected with an over-current device. In primary (non-rechargeable) batteries consisting of series-parallel strings, each parallel string shall be protected to prevent any possibility of charging. If a primary (non-rechargeable) battery is connected to an external power source, the battery must be protected to prevent charging by the external power source.

1.4.1.3 Cell or Battery Vents. Cell or battery vents shall not be blocked. If potting is essential, ensure that venting will not be obstructed and that the potting does not adversely affect battery thermal management.

1.4.1.4 Battery Compartment. The equipment shall be designed with a special compartment for the battery. This compartment shall have no interior projections or sharp edges that could damage the electrical insulation around the battery. The battery shall be secured within the compartment to resist shock and vibration to the levels required for end item use. A vent path for the toxic and corrosive vent products shall be designed to prevent case rupture or undirected venting except in applications where venting of any kind is not permitted.

1.4.1.5 Power Switches. Power switches in the end item shall be selected to prevent accidental battery turn-on. Switching devices shall not be used in the ground leg(s).

1.4.1.6 Different Physical Characteristics. Cells of different physical characteristics, chemistries, or electrical parameters shall not be used in the same electrical circuit.

1.4.1.7 Warning Labels. The end item shall have an external label warning users of the hazards associated with lithium batteries and shall be marked IAW container warning requirements of Code of Federal Regulations Title 29, Part 1910.1200 (29 CFR 1910.1200) (Hazardous Communication Standards).

1.4.2 Active. (Non-rechargeable and rechargeable)

1.4.2.1 Hermetically Sealed. 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 or equivalent type and free from imperfections.

1.4.2.2 Safety-Venting Device. Each cell, battery, and battery compartment must incorporate a safety-venting device or be designed and manufactured in such a manner that will preclude a violent rupture as a result of cell venting. Nothing shall be done in the design and construction that will degrade the vent.

1.4.2.3 Thermal Protection Devices. Consideration shall be given to the use of thermal protection devices, which go to the open-circuit position at temperatures of 91°C (196°F) or less.

1.4.2.4 Interchangeable Commercial Batteries. Lithium batteries of two or more cells that are unique to military equipment shall be constructed so that they are not interchangeable with commercial batteries used in consumer products, such as flashlights or radios.

1.4.2.5 Positive Protection Against Accidental Shorting. When the battery is not installed in equipment, the leads or connector plug shall be taped, guarded, or otherwise given positive protection against accidental shorting.

1.4.3 Thermal

1.4.3.1 Inadvertent Activation. Thermal batteries shall be designed to prevent inadvertent activation from the environmental conditions to which the battery or end item may be subjected during Fleet use.

1.4.3.2 Hermetic Seal. Thermal batteries 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 connector pin and the cover shall be of the glass- or ceramic-to-metal type and free from imperfections.

1.4.3.3 Safety-Venting Device. Each battery and battery compartment shall incorporate a safety-venting device or be designed and manufactured in such a manner that will preclude a violent rupture condition. Nothing shall be done in the design and construction that will degrade the vent.

1.4.3.4 Electrical Initiation Leads. When the battery is not installed in the equipment, all electrical initiation leads shall be shorted. The output leads or connector plug shall be taped, guarded, or otherwise provide positive short circuit protection.

1.4.3.5 Prevent Overheating. The battery shall be properly insulated and located to prevent overheating of the system or thermal damage to adjacent components.

1.4.4 Liquid Reserve

1.4.4.1 Inadvertent Activation. Reserve batteries shall be designed to prevent inadvertent activation from the environmental conditions to which the battery or end item may be subjected during Fleet use.

1.4.4.2 Hermetic Seal. Reserve batteries 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 connector pin and the cover shall be of the glass- or ceramic-to-metal type and free from imperfections.

1.4.4.3 Safety-Venting Device. Each battery and battery container shall incorporate a safety-venting device or be designed and manufactured in such a manner that will preclude a violent rupture condition. Nothing shall be done in the design and construction that will degrade the vent.

1.4.4.4 Initiation Leads. When the battery is not installed in the equipment, all electrical initiation leads shall be shorted. The output leads or connector plug shall be taped, guarded, or otherwise provide positive short circuit protection.

1.4.4.5 Bleeder Resistors. Consideration shall be given to the incorporation of internal "bleeder resistors" so that battery depletion will automatically occur as a result of activation. An activation indicator should be considered as a part of the battery design.

1.4.5 Rechargeable Batteries.

1.4.5.1 Charging Sources. Rechargeable battery systems shall be designed to prevent charging by any inappropriate charging source.

1.4.5.2 Cell-to-Cell Balancing Mechanisms. Consideration shall be given to including cell-to-cell balancing mechanisms.

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1.5 USE.

1.5.1 General.

1.5.1.1 Approval Not Transferable. Lithium battery safety approval is specific to the battery design and system or device described in the safety data package and the safety test report. Approval is not transferable to other applications without specific review.

1.5.1.2 Partially Discharged Lithium Battery. Never use a partially discharged lithium battery or cell in a system, which uses more than one battery or cell. Parallel or series strings of used batteries containing varied amounts of remaining power can result in an imbalance of the cells and battery or cell ventings.

1.5.1.3 Removal From Associated Equipment. Lithium batteries shall be removed from associated equipment upon completion of useful life, packaged IAW paragraph 1.6, stored IAW paragraph 1.7, and disposed of IAW paragraph 1.9. All exposed terminals shall be insulated to prevent short circuits.

1.5.1.4 Reporting Accident, Incident, or Malfunction. In the event of an accident, incident, or malfunction, either with or without visible damage to the battery, notify the appropriate authorities IAW paragraph 1.2.6.

1.5.2 Active Non-Rechargeable. No additional specific comments.

1.5.3 Thermal.

1.5.3.1 Activated But Not Deployed. If the battery has been activated but not deployed, allow adequate cool down time and dispose of the battery IAW paragraph 1.9.

1.5.3.2 Cool Down Time. If the battery has been activated and deployed and if equipment recovery is planned, allow adequate cool down time before handling or removal for disposal IAW paragraph 1.9.

1.5.4 Liquid Reserve.

1.5.4.1 Activated But Not Deployed. If the battery has been activated but not deployed, dispose of the battery as soon as possible IAW paragraph 1.9.

1.5.4.2 Activated And Deployed. If the battery has been activated and deployed and if equipment recovery is planned, allow adequate time for battery depletion. Dispose of it IAW paragraph 1.9.

1.5.5 Rechargeable.

1.5.5.1 Charging System. Rechargeable batteries shall only be charged or conditioned using the charging system described in the safety data package IAW paragraph 1.2.2.2.10.

1.5.5.2 Charging Protocols. Designated charging protocols must be followed exactly. Charging regimes or hardware designed to "fix" damaged or failed batteries or cells not described in the safety data package shall not be used.

1.5.5.3 Charging System Failure. In the event of a known charging system failure, no attempts shall be made to recharge or reuse the battery.

1.6 PACKAGING FOR TRANSPORTATION.

1.6.1 Basic Packaging, Marking and Shipping Requirements. For new lithium batteries, the basic packaging, marking and shipping requirements imposed by the Department of Transportation are contained in 49 CFR 173.185. In addition to the minimum requirements of 49 CFR 173.185, Navy activities using, storing, transferring, or collecting lithium batteries shall:

1.6.1.1 Battery Packaging Design Disclosure. Ensure that a complete battery packaging design disclosure is obtained from the supplier of the equipment or manufacturer of the batteries before any shipment.

1.6.1.2 Packaging Design Incorporated. Ensure that the packaging design is incorporated in the appropriate acquisition specification, contract, and manuals. Descriptive language shall be supplemented by drawings or figures.

1.6.1.3 Packaging Design Minimum Requirements. Ensure that the packaging design meets the minimum requirements contained in MIL-STD-648 and verify that all packaging tests required by 49 CFR 173.185 have been successfully performed and approved.

1.6.1.4 Ship by "Cargo Only" Aircraft. Ensure that batteries entered in the supply system for organizational or intermediate maintenance level replacement are packaged for shipment by "cargo only" aircraft, unless the batteries are treated as unregulated per 49 CFR 173.185.

1.6.2 Non-Conforming Packaging. Packaging not conforming to the package requirements listed in 49 CFR 173.185 must be reviewed by Naval Weapons Station (NAVWPNSTA) Earle (see Appendix B) in conjunction with NOSSA. NAVSEASYSCOM is authorized to issue a Certificate of Equivalency (COE) pursuant to NAVMATINST 4030.11 when satisfied that the container design proposed will meet equal or more stringent requirements than the requirements listed in 49 CFR 173.185. Before issuing such a COE, NAVSEASYSCOM will review the following:

1.6.2.1 Safety Tests Results. Results of the safety tests described in Chapter 2 of this document.

1.6.2.2 Mandated Overpack. Results of the tests (if conducted) required by paragraph h of 49 CFR 173.185. Either the packaging must pass the tests or a special overpack must be used, such as a DOT 17C or DOT 17H drum (or equivalent) equipped with a gas-tight gasket. This special overpack is mandated by paragraph h (3) of 49 CFR 173.185.

1.6.2.3 Environmental Tests. The environmental tests performed on the unpackaged device and the packaged device.

1.6.2.4 Complete Design Disclosure. A complete design disclosure of the proposed package.

1.6.3 Packaging For Disposal. Coordinate packaging of new and used lithium batteries designated for disposal with the local Defense Reutilization Marketing Office/Service and/or the local Military environmental protection branch. Comply with the local hazardous waste accounting procedures.

1.7 STORAGE.

1.7.1 Storage Aboard Submarines. Lithium battery storage aboard submarines shall be approved by NAVSEA SEA-07T.

1.7.2 Storage Aboard Aircraft. Lithium battery storage aboard aircraft shall be approved by NAVAIR AIR-4.4.4.1.

1.7.3 Storage Guidelines for Naval Shore Facilities, Ships, and Vessels. All lithium batteries and lithium battery-powered equipment shall be stored in compliance with the specific requirements stipulated in appropriate equipment documents or IAW base or platform regulations as specified in Standard Operating Procedures. When such documentation is not available, the general storage requirements listed below shall be followed for Naval shore facilities, ships, and vessels:

1.7.3.1 Ventilated Shelter. Store batteries in a dry, cool (below 130°F (54°C)) ventilated shelter out of direct sunlight.

1.7.3.2 Shelter Stowage. Use shelter only for the stowage of lithium batteries and equipment containing lithium batteries.

1.7.3.3 Field Storage. In the field, avoid covering containers of batteries with a black or dark-colored tarp.

1.7.3.4 Handling And Moving Containers. Exercise special care in handling and moving containers to prevent crushing or puncturing.

1.7.3.5 Storage Aboard Ship or Shore Facilities. Storage locations aboard ship or on shore facilities shall have a fire station in the vicinity consisting of a hose reel with a 1" supply and fitted with a MIL-N-24408 nozzle if possible.

1.7.3.6 Isolated Storage. Isolate the storage area from other hazardous and combustible material and use only for the storage of unused lithium batteries or equipment with lithium batteries installed.

1.7.3.7 Minimum Storage. Keep the battery quantities stored in an area to a minimum because the effect of mass storage on the hazard degree is not known.

1.7.3.8 Inhabited Areas. Lithium batteries or lithium-battery-powered equipment with batteries installed shall not be stowed in inhabited areas, such as offices, berthing areas, etc.

1.7.3.9 Segregate Battery Storage Areas. Segregate battery storage areas: new and unused, partially used for reuse, and disposal. If stowed in a cargo hold, isolate batteries by using equivalent barriers to those used to separate non-compatible stows of Landing Force Operational Reserve Material (LFORM) ammunition.

1.7.3.10 Marking Storage Areas. Mark area or shelter appropriately.

1.7.3.10.1 "STORAGE OF NEW LITHIUM BATTERIES" or "STORAGE OF EQUIPMENT CONTAINING NEW LITHIUM BATTERIES."

1.7.3.10.2 "STORAGE OF PARTIALLY USED LITHIUM BATTERIES FOR REUSE" or "STORAGE OF EQUIPMENT CONTAINING PARTIALLY USED LITHIUM BATTERIES."

1.7.3.10.3 "STORAGE OF USED LITHIUM BATTERIES AWAITING DISPOSAL."

1.7.3.11 New And Unused Batteries. Store new and unused batteries in the original shipping container, original individual package containers, or equivalent packaging.

1.7.3.12 Partially Used Batteries. For partially used batteries intended for reuse, protect battery connectors or terminals from inadvertent short circuits. Examples of protection methods include use of non-conductive tape, terminal plugs, or individual plastic bags.

1.7.3.13 Batteries Awaiting Disposal. For used batteries awaiting disposal, the following additional items apply:

1.7.3.13.1 Establish a remote collection point and storage area for used or depleted lithium batteries awaiting disposal. Aboard ships, lithium batteries for disposal shall be stowed only on the weather decks. Separate batteries awaiting disposal from other combustible material.

1.7.3.13.2 Package used or depleted lithium batteries awaiting disposal or lithium-powered equipment with batteries installed and awaiting disposal IAW paragraph 1.6.

1.7.3.13.3 Store no more than 30 lbs. of used or depleted lithium batteries awaiting disposal.

1.7.3.13.4 Store used or depleted lithium batteries awaiting disposal no longer than 30 days.

1.7.3.13.5 Do not dispose of or transport lithium batteries with normally generated refuse.

1.7.3.13.6 Turn in or offload all used or depleted lithium batteries for disposal at the earliest possible time. However, in no case shall batteries be moved or offloaded during ammunition handling or fueling operations.

1.7.4 Hazardous Waste Storage.

NOTE:

A PERMITTED HAZARDOUS WASTE STORAGE FACILITY FOR THE STORAGE OF LITHIUM BATTERIES FOR DISPOSAL MUST BE APPROVED AND LEGALLY AUTHORIZED BY STATE/FEDERAL ENVIRONMENTAL PROTECTION GROUPS BEFORE USE.

A permitted hazardous waste storage facility shall meet the requirements listed in paragraph 1.7.3. In addition to those storage requirements, the permitted facility must meet all other local, state, and federal requirements including having a suitable means to prevent spills from escaping to the environment.

1.7.4.1 State Environmental Protection. The permit to store hazardous waste shall be applied for through the respective state environmental protection group.

1.7.4.2 Permitted Storage Hazardous Waste. Once a permit to store hazardous waste has been granted, this permit shall govern the quantities, duration, safe operation, and overall scope of the storage area.

1.7.4.3 Custodian of Permitted Storage Facility. The custodian of the permitted storage facility shall not accept lithium batteries, which are not packaged and labeled IAW, these guidelines (unless prior arrangements have been made for the receipt of batteries from a smaller facility, detachment, or the fleet).

1.8 TRANSPORTATION.

1.8.1 Transportation Aboard Submarines. Lithium battery transportation aboard submarines shall be approved by NAVSEA SEA-07T.

1.8.2 Transportation Aboard Aircraft. Lithium battery transportation aboard aircraft shall be approved by NAVAIR AIR-4.4.4.1.

1.8.3 Transportation Within Department of Defense (DoD). Transportation requirements within DoD are covered by Air Force Interservice Manual 24-204(AFMAN 24-204/TM 38-250/NAVSUP PUB 505/MCO P4030.19/DLAI 4145.3). All transportation of lithium batteries on military aircraft must be conducted IAW the regulations therein.

1.8.4 Transportation of New Lithium Batteries on Public Domain. All transportation of new lithium batteries on public domain is controlled by federal law regulating shipment of hazardous materials. The general regulations are stated in 49 CFR 172.101 and 173.185. Any deviation from the methods described in the CFR must be approved before shipment in the form of an "Exemption" by the Office of Hazardous Material Safety Research and Special Programs Administration, U.S. Department of Transportation, Washington, DC 20590 (see Appendix B).

1.8.5 Transportation of Used Lithium Batteries on Public Domain. All transportation of used lithium 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 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.

1.9 DISPOSAL.

1.9.1 At Sea. Routine disposal of batteries at sea is prohibited per 40 CFR 220 Sub Chap H.

1.9.2 Ashore. Guidelines for disposal of batteries ashore follow.

1.9.2.1 Defense Reutilization and Marketing Office. Turn into the local Defense Reutilization and Marketing Office (DRMO) IAW Chapter II of OPNAVINST 5090.1 for disposal as a hazardous waste. Before initiating a lithium battery disposal system, consult the local DRMO and military environmental protection branch to coordinate battery information, packaging, quantities, labeling, shipping, and tracking requirements.

1.9.2.2 Local Military Environmental Branch. If the local Defense Reutilization and Marketing Office will not accept the batteries, contact the local military environmental branch for disposal as hazardous waste.

1.9.2.3 Explosive Ordnance Disposal. Under certain emergency conditions, if batteries are deemed to be too hazardous for routine disposal, Explosive Ordnance Disposal (EOD) shall be contacted for immediate removal to a safe site.

1.9.2.4 Questions or Problems. Questions or problems regarding the packaging, transportation, labeling, storage, tracking, or contract requirements of lithium batteries for disposal should be addressed to NOSSA (see Appendix B).

1.10 EMERGENCY RESPONSE PROCEDURES.

1.10.1 Mishap Investigation and Reporting. Per paragraph 1.1.5 of this document, all ventings, accidents, and incidents involving lithium batteries shall be reported IAW the current version of OPNAVINST 5102.1, "Mishap Investigation and Reporting." Reports shall also be sent to NOSSA (see Appendix B). When possible, failed batteries (in an inert state) and associated equipment should be retained to support failure analysis.

1.10.2 Equipment Documents or Base Regulations. All lithium batteries and lithium battery-powered equipment shall have emergency response procedures stipulated in appropriate equipment documents or base regulations. When such documentation is not available, the general emergency response procedures listed below shall be followed for Naval shore facilities, ships and vessels:

1.10.2.1 Leaking Batteries. For lithium batteries that have leaked do the following:

1.10.2.1.1 Refer to the MSDS for the battery and respond accordingly.

1.10.2.1.2 Use Personal Protective Equipment(PPE) to approach the leaking battery. Use chemically resistant gloves when handling leaking batteries.

1.10.2.1.3 If a liquid is leaking from a lithium battery, use extreme caution during cleanup. The liquid may be a strong acid or other toxic or flammable substance. Strong acids should be neutralized with baking soda (sodium bicarbonate) or other suitable base. To perform such a neutralization, cover the spill with baking soda, then layer an absorbent over the area until the liquid is completely absorbed.

1.10.2.1.4 Sweep up the absorbent and deposit in a strong doubled plastic bag. Place in an appropriate hazardous waste container. If the cleanup equipment is contaminated, discard in an appropriate waste container.

1.10.2.1.5 Place the battery in a strong plastic bag and pack in an appropriate container. Place enough absorbent in this container to completely absorb all liquid contained in the battery. DO NOT PACKAGE OTHER BATTERIES WITH A LEAKING BATTERY. Label the outside of the container as "HAZARDOUS LEAKING LITHIUM BATTERY FOR DISPOSAL."

1.10.2.1.6 If any lithium battery electrolyte comes in contact with skin, eyes, mouth, etc., flush with copious amounts of water (for 15 minutes) and report immediately to the medical department for treatment.

1.10.2.2 Large Container(s). Large Container(s) of Lithium Batteries That Have Leaked

1.10.2.2.1 Refer to the MSDS for the battery and respond accordingly.

1.10.2.2.2 Do not attempt to open or repack the original container.

1.10.2.2.3 Contact the Military Environmental Protection Group or (DRMO) for further information.

1.10.2.2.4 If any lithium battery electrolyte comes in contact with skin, eyes, mouth, etc., flush with copious amounts of water for 15 minutes and report immediately to the medical department for treatment.

1.10.2.3 Swollen or Hot Lithium Battery.

1.10.2.3.1 Refer to the MSDS for the battery and respond accordingly.

1.10.2.3.2 If any lithium battery feels hot or if the case of the battery shows signs of abuse or swelling, evacuate the area and contact Explosive Ordnance Disposal personnel. A battery in this condition may vent, catch fire, or explode without warning.

1.10.2.3.3 All incidents concerning equipment damage or personnel injury shall be reported to NOSSA via an accident/injury form.

1.10.2.4 Actively Venting or Fire Involving Lithium Batteries. Actively Venting Battery, or a Fire Involving Lithium Batteries (including a fire in a location where lithium batteries are stored)

1.10.2.4.1 Refer to the MSDS for the battery and respond accordingly.

1.10.2.4.2 Call the Fire Department, making sure they know that lithium batteries are involved (chemistry, size and volume).

1.10.2.4.3 Secure the area.

CHAPTER 2

SAFETY ASSESSMENT TESTING OF LITHIUM BATTERIES

2.1 INTRODUCTION.

2.1.1 Scope. This chapter establishes the minimum safety testing requirements for lithium batteries and lithium battery-powered equipment when used, stored, or transported on Navy facilities, submarines, ships, vessels and aircraft.

2.1.2 Purpose. This chapter specifies the procedures, equipment, and pass-fail criteria for lithium battery safety tests. However, additional tests or test modifications may be necessary because:

2.1.2.1 Additional Tests. A given user community or a specific end user might also require additional tests (i.e. shock, vibration, atmosphere, etc.).

2.1.2.2 Supplementary Data. Unusual or unique battery or system designs or use scenarios may necessitate supplementary data.

2.1.2.3 New Knowledge. New knowledge concerning lithium battery safety emerges.

2.1.2.4 Additional Test Scenarios. Completion of the System Safety Program Requirements IAW MIL-STD 882 may identify additional test scenarios that are outside the minimum required safety tests identified in this document.

2.1.3 Rationale. Test methods and parameters were selected to rapidly generate sufficient data supporting a risk assessment of a given battery in its system configuration. Tests have been selected to minimize cost and schedule impacts and still obtain enough data to effectively support making risk assessments. These test methods represent a partial compilation of over 25 years of lithium battery safety testing experience from DoD, other government agencies, foreign governments and industry.

2.1.3.1 Abuses and Abusive Environments. These test methods use a combination of common battery abuses and extremely abusive environments to characterize the safety behavior of the battery during its life cycle.

2.1.3.2 Quantitative Assessment. Data from these tests support a quantitative assessment of the severity of the battery events and provide an estimate of the probability of such events.

2.1.3.3 Worst Case Battery Response. These tests provoke the worst-case battery response to determine if the response is acceptable based on the system and platform requirements.

2.1.3.4 Battery-Level Safety Devices Bypassed or Excluded. Characterization of worst-case battery behavior is assured by conducting some tests with battery-level safety devices bypassed or excluded.

2.2 PASS-FAIL CRITERIA. An inability of the lithium batteries or lithium battery-powered equipment to meet the "passing" criteria does not necessarily result in an automatic rejection of the equipment for service use. Test units that fail to meet such criteria will be rejected only if a technical evaluation of the test results by NOSSA (see Appendix B) establishes that rejection is the appropriate course of action. The passing criteria by platform are in the Table I.

TABLE I: PASSING CRITERIA FOR TEST UNIT BY PLATFORM

PLATFORM	**2- 6**		**CRITERIA**
Submarines	Venting of gaseous/liquid/solid material and flames outside of the test unit is **prohibited.**	**and**	The peak pressure remains **equal to or below** 50 percent of the yield pressure of the unit in any test.
Aircraft[1]	Venting of gaseous/liquid material is **permitted.** Venting of solid material and flames outside of the test unit is **prohibited.** Rupture of the test unit is **prohibited.**	**and**	The peak pressure remains **equal to or below** 50 percent of the yield pressure of the unit in any test.
Ships	Venting of gaseous/liquid/solid material is **permitted.** Venting of flames outside of the test unit is **prohibited.** Rupture of the test unit is **prohibited.**	**and**	The peak pressure remains **equal to or below** 50 percent of the yield pressure of the unit in any test.
Land	Venting of gaseous/liquid/solid material and flames is **permitted.** Rupture of the test unit is **prohibited.**	**and**	The peak pressure remains **equal to or below** 50 percent of the yield pressure of the unit in any test.
Unsafe	Rupture of the test unit	**or**	The peak pressure **exceeds** 50 percent of the yield pressure of the unit in any test.

(1) The preferred chemistry for aircraft is solid cathode chemistry. Liquid cathode chemistries are highly corrosive and toxic. The location of the cell or battery in the aircraft will be closely scrutinized, especially regarding the possibility of toxic, corrosive gasses affecting crew members, passengers, or high priority equipment or systems.

2.2.2 Test Specific Passing Criteria. System-specific pass-fail criteria shall be determined during the preliminary safety data package review. However, the following test specific criteria exist for all applicable battery programs:

2.2.2.1 Active Non-rechargeable Batteries: Batteries must not vent in response to the Electrical Safety Device Test described in paragraph 2.3.4.5.

2.2.2.2 Thermal Batteries: Batteries must not undergo inadvertent activation in response to environmental tests conducted IAW paragraph 2.3.5.1.

2.2.2.3 Liquid Reserve Batteries: Batteries must not undergo inadvertent activation in response to environmental tests conducted IAW paragraph 2.3.6.1.1.

2.2.2.4 Rechargeable Batteries: Batteries must not vent in response to the Electrical Safety Device Test described in paragraph 2.3.7.2.5.

2.3 SAFETY TESTS.

WARNING

These safety tests can cause violent venting of batteries with deflagration and fragment hazards, and release of vapor clouds of chemically active, toxic or corrosive materials. Appropriate safety precautions shall be observed during testing, including ventilation controls, containment of byproducts, or standoff distance to protect personnel and facilities.

2.3.1 Number of Test Units. A minimum of 15 non-rechargeable active, 15 thermal, 18 liquid reserve or 18 rechargeable units shall be provided. A test unit shall consist of a battery inside a complete system, or a battery inside sufficient system components to simulate the battery/system interactions. The final determination of the number of test units will be made upon review of the safety data package.

2.3.1.1 Additional Test Units. Additional test units may be required to address special battery design, equipment or platform safety concerns.

2.3.1.2 Smaller Population. A smaller population of test units may be acceptable for safety evaluations that involve revisions to battery designs that have previously been tested IAW this document, or use of previously tested batteries in new systems or applications.

2.3.1.3 Multiple Use of Test Units. Test units that have been subjected to environmental compliance tests (such as shock, vibration, and humidity exposure) that did not result in discharge of the battery, or when the battery can be recharged to full capacity may be used for these tests. In the case of thermal battery tests, this condition is preferred.

2.3.2 Test Instrumentation. All tests shall be instrumented as described in this paragraph. The minimum test instrumentation for the testing shall include thermocouples capable of measuring and withstanding temperatures up to 800°C, voltage monitoring leads, power leads, current sensing equipment, pressure sensing equipment and a data acquisition system. All test iterations must be documented using videotape with audio recording. These tapes will be retained for review and must be made available upon request.

2.3.3 Final Report. A full narrative description of each test will be included in the final report.

2.3.4 Active Non-rechargeable Battery Tests.

2.3.4.1 Constant Current Discharge & Reversal Test. This test shall consist of a constant current discharge using a D.C. power supply. All internal electrical safety devices shall be bypassed (shorted), and the discharge shall be performed at a current equal to the value of the battery pack fuse. The voltage of the D.C. power supply shall be limited to 1.1 times the battery open circuit voltage (OCV). After the battery voltage reaches zero volts, the discharge shall be continued into voltage reversal at the same current for a capacity equivalent to 1.5 times the nominal rated ampere-hour capacity of the battery pack. The total test duration is defined as the capacity of the battery/cell to zero volts plus 1.5 times the maximum published capacity after reaching zero volts. This test shall be completed on three test units; voltage, current, pressure, and temperatures shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.4.2 Short Circuit Test. This test shall consist of shorting the battery (after all internal electrical safety devices have been bypassed) through a load of 0.02 ohm or less and leaving the load attached for not less than 24 hours. This test shall be completed on three test units; voltage, current, pressure, and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.4.3 High Temperature Test. This test shall consist of heating the battery pack at a rate of 10°C to 20°C rise per minute up to a temperature of 500°C, and maintained until the battery vents or reactions stop. Test units may be tested with or without internal battery electrical safety devices. This test shall be completed on three test units; voltage, pressure, and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.4.4 Charging Test. This test shall be performed if a battery contains parallel strings, or the system containing the battery is to be connected to an outside D.C. power source. This test shall consist of charging the battery using a D.C. power supply. All internal battery electrical safety devices shall be bypassed. The battery shall be discharged to remove at least 50% of the maximum published capacity at a current equal to the fuse value. The battery shall then be allowed to stand for at least 72 hours and then be charged at a current equal to the fuse value to 1.5 times the maximum published capacity. The voltage of the D.C. power supply shall be limited to the battery pack open circuit voltage or to the voltage of the outside source, whichever is greater. This test shall be completed on three test units; voltage, current, pressure, and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.4.5 Electrical Safety Device Test. This test shall consist of constant current discharge using a D.C. power supply. All electric safety devices shall be in place and operational. The discharge shall be performed at a current equal to 85-90 percent of the battery pack fuse value. The voltage of the D.C. power supply shall be limited to 1.1 times the open circuit voltage of the battery pack. After the battery voltage reaches zero volts, the discharge shall be continued into voltage reversal at the same current for a capacity equal to 1.5 times the maximum published capacity of the battery pack. The total test duration is defined as the capacity of the battery or cell to zero volts plus 1.5 times the rated capacity after reaching zero volts. This test shall be completed on three test units; voltage, current, pressure, and temperature, shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.5 Thermal Battery Tests.

2.3.5.1 Unactivated Environmental Tests. Environmental tests shall be performed (shock, vibration, Electromagnetic Interference (EMI), Electrostatic Discharge (ESD), Hazards of Electromagnetic Radiation to Ordnance (HERO) and temperature-altitude) to demonstrate that no inadvertent activation or unsafe conditions exist under any unactivated use scenarios. Tests performed to satisfy other program requirements may be substituted for these tests, subject to NOSSA (See Appendix B) approval.

2.3.5.2 High Rate Discharge Test. This test shall consist of conditioning the test unit to the maximum non-operating temperature required by the end item specification, followed by activation into a load equivalent to approximately 80 percent of the current-carrying capability of the battery sections or of the fuse value. This test shall continue until the discharge voltage drops below 1 percent of the peak output voltage. Each battery section shall be instrumented separately. All battery sections shall be discharged simultaneously. This test shall be completed on three test units; voltage, current, pressure, and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.5.3 High Temperature Test. This test shall consist of preconditioning the battery to a temperature of 150°C ± 15°C (or no less than 75°C above the maximum non-operational storage or operational temperature condition, whichever is higher, but not to exceed 175°C) until fully equilibrated. The battery shall be activated within 10 minutes after removing the battery from the conditioning chamber. Battery voltage outputs and surface temperature shall be monitored until values have fallen to less than 10 percent of the peak values recorded during the test. Thermocouples shall be placed on a minimum of four locations on the battery (header, base, and on opposite sidewalls). This test shall be completed on a minimum of three batteries. The testing shall be video recorded.

2.3.5.4 Open Circuit Test. This test shall consist of conditioning the test unit to the maximum non-operating temperature required by the end item specification, activating the battery without a discharge load, and allowing the battery to stand in this condition until the voltage falls below 10 percent of the maximum observed voltage. This test shall be completed on three test units; voltage, pressure, and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.5.5 Charging Test. This test shall be performed if a battery consists of parallel-connected sections or can be connected to an external power source. This test shall consist of battery activation (after all safety devices have been bypassed) followed by discharge to 50 percent of the available rated capacity, at a rate equal to the average mission load current. The battery shall then be charged (using a D.C. power supply) until the battery no longer accepts the charge. The charge current will be limited to a rate equal to the maximum battery operational current. The charge voltage shall be limited to the battery open circuit voltage or the external power source voltage, whichever is greater. This test shall be completed on three test units; voltage, current, pressure, and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6 Liquid Reserve Battery Tests.

2.3.6.1 Unactivated.

2.3.6.1.1 Environmental. Environmental tests shall be performed (shock, vibration, EMI, ESD, HERO and temperature-altitude) to demonstrate that no inadvertent activation or unsafe conditions exist under any unactivated use scenarios. Tests performed to satisfy other program requirements may be substituted for these tests, subject to NOSSA approval (see Appendix b).

2.3.6.1.2 High Temperature Test. This test shall consist of heating the battery inside the unit at a rate of 10°C to 20°C rise per minute up to a temperature of 500°C. Test units may be tested with or without internal battery electrical safety devices. This test shall be completed on three units; voltage, pressure and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6.2 Activated.

2.3.6.2.1 Constant Current Discharge & Reversal Test. This test shall consist of a constant current discharge using a D.C. power supply. All internal electrical safety devices shall be bypassed (shorted), the battery shall be activated, and the discharge shall be performed at a current equal to the value of the battery pack fuse. The voltage of the D.C. power supply shall be limited to 1.1 times the open circuit voltage of the battery pack. After the battery voltage reaches zero volts, the discharge shall be continued into voltage reversal at the same current, for a capacity equivalent to 1.5 times the maximum published ampere-hour capacity of the battery pack. Total test duration is defined as the capacity of the battery/cell to zero volts plus 1.5 times the maximum published capacity after reaching zero volts. This test shall be completed on three test units; voltage, current, pressure and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6.2.2 Short Circuit Test. This test shall consist of bypassing all internal electrical safety devices, activating the battery, shorting the battery through a load of 0.02 ohm or less, and leaving the load attached for not less than 24 hours. This test shall be completed on three test units; voltage, current, pressure, and temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6.2.3 Open Circuit Test. This test shall consist of activating the battery into a no load and allowing the battery to stand in this condition for a period of time to be determined during the preliminary safety data package review. This test shall be completed on three test units; voltage, pressure and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6.2.4 Electrical Safety Device (ESD) Test with High Temperature Preconditioning. This test shall consist of heating the battery to the maximum unactivated temperature required by the end item specification with the ESD’s in place. The battery shall then be activated and discharged at a current rate equal to 80 percent of the fuse value or at the mission load current profile. After the battery voltage reaches zero volts, the discharge shall be continued into voltage reversal at the same current, for a capacity equivalent to 1.5 times the maximum published ampere-hour capacity of the battery pack. The total test duration is defined as the capacity of the battery/cell to zero volts plus 1.5 times the maximum published capacity after reaching zero volts. This test shall be completed on three test units; voltage, current, pressure, and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.6.2.5 Charging Test. This test shall be performed if a battery consists of parallel-connected sections or is connected to an external power source. The test shall consist of battery activation (after all internal electrical safety devices have been bypassed) followed by discharge to 50 percent of maximum published capacity at a rate equal to 1.5 times the average mission load current. The battery shall then be charged (using a D.C. power supply) to 1.5 times the maximum published capacity. The charge current will be limited to a rate equal to the maximum battery operational current. The charge voltage shall be limited to 1.1 times the battery open circuit voltage or the external power source voltage, whichever is greater. This test shall be completed on three test units; voltage, current, pressure, and battery skin temperature shall be continuously monitored and recorded. The testing shall be video recorded.

2.3.7 Rechargeable Battery Tests.

2.3.7.1 General Test Conditions.

2.3.7.1.1 Cycle counts shall begin with the first discharge.

2.3.7.1.2 A standard, non-abusive charge/discharge cycle shall be defined for each battery under test based on the manufacturer's recommended guidelines, or the actual use scenario. This profile shall be used in the tests described below.

2.3.7.1.3 Each test given in paragraph 2.3.7.2 shall be conducted on three test units.

2.3.7.1.4 Testing shall be video recorded.

2.3.7.1.5 Voltage, temperature, pressure, and current (where applicable) shall be continuously monitored and recorded.

2.3.7.2 Designated Tests.

2.3.7.2.1 Short Circuit Test. All safety devices located inside the battery but external to the cells (such as: fuses, Positive Thermal Coefficient (PTC) Device, diodes, charge control chips, Battery Management System (BMS)) shall be disabled or bypassed. All embedded, cell-level safety devices shall be left intact. This test shall consist of shorting the fully charged battery through a load of 0.02 ohm or less and leaving the load attached for not less than 24 hours.

2.3.7.2.2 Overcharge/Discharge Test. All safety devices located inside the battery but external to the cells (such as: fuses, PTC’s, diodes, charge control chips, BMS) shall be disabled or bypassed. All embedded, cell-level safety devices shall be left intact. This test shall consist of charging the test unit with a constant current at the maximum output rate of the designated charging source to 1.25 times the maximum charge voltage limit and discharging the unit using the standard non-abusive discharge regime. A minimum of 20 cycles shall be conducted, unless the test unit vents, fails to accept charge, or delivers less than 25% of the manufacturer's published value on discharge.

2.3.7.2.3 Overdischarge/Charge Test. All safety devices located inside the battery but external to the cells (such as: fuses, PTC’s, diodes, charge control chips, BMS) shall be disabled or bypassed. All embedded, cell-level safety devices shall be left intact. This test shall consist of charging the test unit using the standard non-abusive charge regime and discharging with a constant current at the maximum sustainable output rate for 1.25 times the maximum published capacity of the battery. A minimum of 20 cycles shall be conducted, unless the test unit vents, fails to accept charge, or delivers less than 25% of the manufacturer's published value on discharge.

2.3.7.2.4 High Temperature Test. This test shall consist of heating the fully charged battery pack at a rate of 10°C-20°C rise per minute up to a temperature of 500°C, maintained for one hour, or until the battery vents. Test units may be tested with or without internal battery electrical safety devices.

2.3.7.2.5 Electrical Safety Device Test. This test shall consist of charging the test unit at the maximum output rate of the designated charging source to 1.25 times the maximum charge voltage limit until the current has decreased by 95%; then, discharging the test unit at the maximum sustainable output rate for 1.25 times the maximum published capacity of the battery. All electric safety devices shall be in place and operational. In the event that a battery safety device trips prior to completing the test, resume testing as soon as the device resets. If the test unit completes the 20 cycles, repeat the test with the charging source voltage at 1.50 times the maximum charge voltage limit, then 1.75 times and 2.00 times, unless the test unit vents, fails to accept charge, or delivers less than 25% of the manufacturer's published value on discharge during any test iteration.

2.3.7.2.6 Aging Safety Test. This test shall consist of cycling the test unit at the manufacturer’s maximum recommended charge and discharge rates and voltages. All electric safety devices shall be in place and operational. Cycling should be continuous, unless precluded by battery electronics, until the battery capacity per discharge cycle drops below 50% of the original capacity or until 0.5 times the rated cycle life has been achieved (whichever comes first). Upon completion of the aging portion of the test, batteries shall be subjected to the Short Circuit Test IAW paragraph 2.3.7.2.1.

2- 7 APPENDIX A – DEFINITIONS

NOTE: Not all definitions listed are used in this document but may prove useful in understanding this and other battery related documents.

ACTIVE BATTERY: A battery which is designed to deliver electrical power any time a load is applied; ordinary flashlight batteries are examples of active batteries, as are lead-acid starting-lighting-ignition (SLI) batteries.

ACTIVATION: The process of making an electrochemical cell or battery functional. For example the process of introducing the electrolyte into a reserve cell; the firing of pyrotechnics to make a thermal battery active; or the first charge cycle on a lithium ion cell.

ANODE: The reactive material in a battery, which is oxidized during discharge. The anode is the negative electrode in a primary (non-rechargeable) or secondary (rechargeable) cell. Typical anodes are reactive metals, alloys, and supporting matrices containing lithium.

BATTERY: An assembly of electrochemical cells, which has been packaged for use. Electrochemical cells may be of either bipolar or monopolar construction.

BATTERY MANAGEMENT SYSTEM (BMS): An electronic system designed for a secondary (rechargeable) battery that monitors the charging cycle to protect the individual cells of a battery from overcharging. A BMS may also be used to control/monitor discharge of individual cells in either a primary (non-rechargeable) or secondary (rechargeable) battery. Also known as Battery Monitoring Systems.

BIPOLAR PLATE: An electrode construction where positive and negative materials are on opposite sides of an electrically conductive plate. The plates are usually stacked in series to generate a bipolar battery.

BLEEDER RESISTOR: A resistor installed in a reserve battery that will discharge the battery at an appropriate rate should the battery be inadvertently activated.

BOBBIN: A cylindrical electrode (usually the positive) pressed from a mixture of active material, conductive material (such as carbon black) and electrolyte and/or binder. A centrally located rod or screen is usually incorporated as a current collector. Bobbin cells are usually used for low rate applications, because of the thick cathode construction and relatively low electrode surface area.

"C" RATE: A unit of measure of battery discharge characteristics. The "C" rate is the discharge of a battery's nominally specified capacity in one hour. For example, for a 10 Ah cell the "C" rate = 10 amperes, a 10 Ah cell at the 2C rate = 20 amperes, and a 10 Ah cell at the C/2 rate = 5 amperes.

CAPACITY: The quantity of electrical charge delivered by a battery under specific conditions. It is usually expressed in ampere-hours (Ah).

CATHODE: The reactive material in a battery, which is reduced during discharge. The cathode is the positive electrode in the cell. Cathodes can be solids such as manganese dioxide and carbon monofluoride, liquids such as thionyl chloride, or gases such as sulfur dioxide. Cathodes may be pure materials or mixtures of reactive compounds and additives. In cells with non-solid cathodes, the term "cathode" is often applied to a solid, nonreactive current collector.

CATHOLYTE: The portion of an electrolyte in the galvanic cell adjacent to a cathode; if a diaphragm is present, the electrolyte on the cathode side of the diaphragm. In terms of composition, the catholyte is a mixture of cathodically reducible material with supporting ionic conductive salts of co-solvents.

CELL: An individual unit of a battery consisting of a container, anode, cathode, separator, and electrolyte.

CHARGE/DISCHARGE METHODS: The method used to charge or discharge a battery. The most common methods are constant current, constant voltage, constant power, and pulsed current.

CODE OF FEDERAL REGULATIONS (CFR): The formal collection of regulations issued by all Departments of the Executive Branch to implement in detail the laws passed by Congress.

COMPARTMENT, BATTERY: A separate enclosure in the system hardware, designed specifically to contain the battery.

DEFLAGRATE: To burn or to cause to burn with intense heat and light.

DEPLETED BATTERY: A battery that has been discharged to the recommended minimum voltage and/or capacity.

DEPTH-OF-DISCHARGE (DOD): The ratio of the quantity of electricity, usually expressed in ampere-hours, removed from a cell or battery on discharge to its rated capacity.

DIODE: A semiconductor device, which prevents significant flow of current in one direction. Diodes are used to prevent application of charging voltages to batteries that are not designed to be charged; i.e., primary (non-rechargeable) cells and batteries. A shunting diode may be used to prevent a battery or cell from being driven into voltage reversal by preferentially conducting current around that battery or cell.

DISCHARGE (DRAIN) RATE: The current flow during discharge of a cell or battery. It can be expressed in amperes, but is sometimes normalized to rated capacity (*see "C" Rate*).

ELECTROLYTE: The conductive material within a battery, which allows charged species to move between anode and cathode so that the cell reaction may proceed and ionic current will flow. Most electrolytes are liquid and are solutions of an ionic material (e.g., salts or acids, such as potassium hydroxide or sulfuric acid) in a poor/non-conductive solvent (e.g., water). Non-liquid examples are polyethylene oxides (PEO) plastics, which have been doped with lithium salts, or various ceramics or glasses doped with sodium or lithium oxides and hydroxides. Liquid, non-aqueous electrolytes are limited to molten, ionic salt mixtures, which require no additives to improve conductivity (usually operated at high temperatures), or mixtures of covalent organic or inorganic solvents, which require the addition of ionic, salt additives.

ELECTRICAL FUSE: A protective device containing a piece of metal that melts under heat produced by an excess current in a circuit, thereby breaking or opening the circuit.

ENERGY DENSITY: The quantity of energy stored by a battery per unit weight or unit volume; typical units include watt-hours per pound or watt-hours per cubic inch. To be most useful, energy densities must be measured at a specific discharge rate and temperature.

FULLY EQUILIBRATED: A battery system is considered to be fully equilibrated when both temperature and voltage are stable for at least four continuous hours.

HERMETIC SEAL: An airtight seal, usually rated at cc/sec leakage of air or air equivalent helium.

HOUSING, BATTERY: A fully enclosed case and support for the internal components of a battery.

INTERCALATION: A process where lithium ions are reversibly removed or inserted into a host material without causing significant structural change to that host. This process is the basis for the operation of the lithium ion batteries, and distinguishes those batteries from lithium rechargeable batteries with metallic anodes.

LEAKAGE CURRENT: One of several parasitic capacity loss mechanisms found in electrochemical cells and batteries. Common leakage currents are traceable to common electrical pathways of moderate resistance that allow the battery cells to discharge. Such pathways may be internal or external to the cell.

LIQUID RESERVE BATTERY: A battery that is inactive until the automatic addition of a liquid electrolyte or catholyte that was stored separately from the electrode assembly.

LITHIUM BATTERY: For the purpose of this document, lithium batteries include all cells or batteries in which lithium metal, any lithium alloy, or any form of lithium in a supporting matrix serves as the active anodic component.

LITHIUM ION BATTERY: Lithium ion batteries are comprised of cells that use lithium intercalation compounds as the positive and negative electrodes. As the battery is cycled, lithium ions (Li^+) exchange between the positive and negative electrodes.

LOAD PROFILE: An illustration of the power needed from a battery to support a given system. This is usually expressed by graphing required current versus time.

MISSION POWER REQUIREMENT: The minimum power required from the battery to complete a mission in a given system.

MONOPOLAR: A cell construction consisting of one or more identical electrodes connected to form a single cell.

NOMINAL RATED CAPACITY: The manufacturer's advertised capacity at a given current under ambient conditions.

NON-RECHARGEABLE BATTERY: A battery which is designed to be discharged only once; i.e., it is NOT designed to be recharged. Also called a primary battery.

OVER-CURRENT DEVICE: A protective component, such as an electrical fuse or a PTC device that limits current or opens a circuit if a maximum current level is exceeded.

OXYHALIDES: A family of active materials, most of which are liquids, which can serve as cathode reactants and electrolytes in cells and batteries. Typical examples are thionyl chloride ($SOCl_2$) and sulfuryl chloride (SO_2Cl_2).

POSITIVE THERMAL COEFFICIENT (PTC) DEVICE: A polymeric or ceramic element which has a very low resistance and conducts electricity with very little loss until a critical temperature or current range is reached. Upon reaching a predefined critical range, the internal resistance of the PTC increases exponentially, preventing the continued flow of current by the driving voltage applied. Resistance increase is typically five to six orders of magnitude over a temperature range of 25°C. Upon cooling below the critical temperature range, resistance of the PTC device recovers to nearly the same resistance as originally found.

POTTING: *Noun.* A supportive material in a battery used to immobilize cells and connections and protect them under shock and/or vibration. *Verb.* The process of surrounding the individual cells in a battery with a material designed to immobilize and support the battery contents.

POWER DENSITY: The quantity of power which a battery can deliver per unit weight or unit volume; typical units include watts per pound or watts per cubic inch. Power density per se does not describe how long a battery can sustain a given power output. Pulse capabilities may create artificially high power density rating, while sustained power rates are limited by excessive polarization and heating.

PRIMARY BATTERY: A battery which is designed to be discharged only once; i.e., it is NOT designed to be recharged. Also called a non-rechargeable battery.

PRISMATIC: An electrode construction consisting of parallel flat plates.

RECHARGEABLE BATTERY: A battery in which the electrochemical reaction is thermodynamically reversible and is designed to be recharged after use. Common rechargeable batteries include the lead-acid, nickel-cadmium and lithium-ion batteries common to many consumer products. May also be referred to as a secondary battery.

RESERVE BATTERY: A battery, which is stored in an inactive state such that some activation process must occur before use. Activation may be a manual process such as pouring electrolyte into a dry battery, or it may be automated as when the electrolyte is forced into the cell stack from an external reservoir. Added expense of manufacture and reduced energy density generally result in reserve system being specially developed for the application in which it will be used. The two main categories of lithium reserve batteries are liquid reserve and thermal batteries.

ROOM AMBIENT CONDITIONS: Temperature = 25±5°C, pressure = 29±2 inches Hg, humidity (RH) = 30-90 percent.

SAFETY DATA PACKAGE: A collection of information about a battery and the system it will be used in. The required elements of a safety data package are listed in Paragraph 1.2.2 of this document.

SECONDARY BATTERY: A battery in which the electrochemical reaction is thermodynamically reversible and is designed to be recharged after use. Common secondary batteries include the lead-acid, nickel-cadmium and lithium-ion batteries common to many consumer products. May also be referred to as a rechargeable battery.

SELF-DISCHARGE: A parasitic reaction, which occurs in all battery systems to some extent, which reduces the available capacity of the battery or cell during some intermediate storage. Self-discharge mechanisms are varied and dependent upon the electrochemistry and design of the cell. Self-discharge may be aggravated by temperature of operation, storage, state-of-charge during storage, or mishandling in charge/discharge control limits.

SEPARATORS: A material or physical separation placed between the anode and cathode to prevent electronic contact between electrodes. Separators should be permeable to the electrolyte to allow maximum flow of ions between the electrodes. Some battery systems use only a physical standoff to accommodate separation between electrodes, as is typical of seawater systems. Other separators are composed of micro porous membranes, which allow a circuitous path between electrodes through the membrane material to prevent dendritic growths. This type of separator is most common and can be found in lithium actives, aqueous active and reserve cells, and molten salt batteries.

SPIRAL WOUND: An electrode construction in which the electrodes and separator are wound together in a jellyroll construction. Spirally wound cells have a high surface area and are usually used for high rate applications.

SYSTEM: For the purpose of this document, "the system" refers to the entire unit that is powered by the battery in question. For example, a missile, sonobuoy, or mine with its battery installed would be a system. By extension, a missile interconnected to its launch platform is also a system.

TEST UNIT: For the purpose of this document, a test unit shall consist of a battery inside a complete system, or a battery inside sufficient system components to simulate the battery/system interactions.

THERMAL BATTERY: A reserve battery in which all of the components are solids at room temperature. The battery is activated by heating to a temperature at which the anode and cathode become reactive and the electrolyte becomes conductive. The heat source is often a pyrotechnic material which is built into the battery and which can be remotely ignited.

THERMAL FUSE: A fusible link electrical element that conducts current while it is below a critical threshold temperature. Once this threshold temperature is exceeded, the current-carrying capacity of the thermal fuse is irreversibly terminated, typically by melting a circuit breaker element allowing a spring to disconnect the circuit.

THERMAL RUNAWAY: Any discharge or charge condition in which a battery's internal temperature build-up continues until a cell/battery failure occurs. Typical causes of thermal runaway events can be forced discharge of electrodes, which are insufficiently wetted by electrolyte, or excessive discharge currents, as in an internal or external short circuit.

UNACTIVATED: The state of a reserve cell prior to introducing an electrolyte into the cell. OR The state of a thermal battery prior to firing the pyrotechnics that melt the electrolyte.

USED BATTERY: A battery that is not fresh, i.e., it has been partially discharged. A used battery may be re-used or it might be set aside for disposal, depending on the system requirements and operating procedures.

VENT: *Noun.* Most cells and batteries contain a vent mechanism, which is designed to release internal pressure in a benign manner in order to prevent any violent rupture of the battery case. In batteries which are known to release a gas during normal use (such as many aqueous electrolyte systems), the vent is often an open hole or spring-loaded valve. In batteries, which are designed to remain hermetically sealed, the vent is often an intentionally weakened part of the cell case, which will pop open before the case ruptures violently. *Verb.* The venting of a battery is considered to be a relatively mild event. In some cases, it is normal; in all cases, it represents the mildest form of release of material from the battery. If the material released is explosive, noxious, or toxic, even a mild venting can be unpleasant or dangerous. (An unofficial hierarchy often goes from mild venting to venting to vigorous venting to violent venting with flame to explosion to detonation. In a venting, the battery case remains intact.)

VOLTAGE DELAY: A phenomena associated with passivation layer formation on the anode of an electrochemical cell where the anode and cathode are thermodynamically unstable in contact with each other or the electrolyte. The passivation layer causes very high resistance when appreciable currents are drawn due to mass transfer limitations through the micropores of the layer. Continued high rate discharge disrupts the passivation layer and allows increasing amounts of current to be conducted. Voltage delay may be aggravated by prolonged storage at high temperatures and/or operation at low temperatures.

APPENDIX B – ADDRESSES

Commanding Office
Naval Surface Warfare Center
ATTN: Code 5E30
4363 Missile Way
Port Hueneme, CA 93043-4307

Commander
Defense Printing Service
ATTN: Documents Order Desk
Building 4D
700 Robbins Avenue
Philadelphia, PA 19111-5094

Commanding Officer
Naval Ordnance Safety and Security Activity
ATTN: Code N311
Farragut Hall, Bldg. D-323
23 Strauss Avenue
Indian Head, MD 20640-5555

Commander
Carderock Division, Naval Surface Warfare Center
ATTN: Code 644
9500 MacArthur Boulevard
West Bethesda, MD 20817-5700

Commander
Crane Division, Naval Surface Warfare Center
ATTN: Code 609A
300 Highway 361
Crane, IN 47522-5001

Commanding Officer
Naval Weapons Station
ATTN: Code C11
201 Highway 348
Colts Neck, NJ 07722-5001

U.S. Department of Transportation
ATTN: Office of Hazardous Material Safety
Research and Special Programs Administration
Washington, DC 20590

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APPENDIX C – SAMPLE REQUEST LETTERS

Example 1 Naval Ordnance Safety and Security Activity

IN REPLY REFER TO:
Ser …

2- 9

1 May 04

From: Your office

To: Commanding Officer, Naval Ordnance Safety and Security Activity (S. Andrews, N311)
Farragut Hall, Bldg. D-323
Indian Head, MD 20640-5555

Subj: REVIEW OF LITHIUM BATTERY CONTAINED IN ...

Ref: (a) NAVSEA Technical Manual S9310-AQ-SAF-010 of 19 Aug 04
(b) NAVSEA Instruction 9310.1B Ser 06/487 of 13 June 91

Encl: (1) Battery Safety Data Package for ...

1. (Your office) requests that Code N311 of the Naval Ordnance Safety and Security Activity (NOSSA) conduct a safety review of the (model or part number) battery as used in the PDQ system in accordance with reference (a) as required by reference (b). A data package describing the battery and the system it is used in is included as Enclosure (1).

2. BRIEFLY DESCRIBE THE BATTERY AND THE SYSTEM, WHO WILL BE USING IT, WHERE IT WILL BE USED... (i.e. The XYZ Battery used in the PDQ system is a reserve lithium/thionyl chloride battery manufactured by Acme Battery Manufacturers, Inc. The battery is a single cell, hermetically sealed lithium/thionyl chloride system with a mechanical activation mechanism. The system is currently in development by the Army and is proposed for use by Navy SEALS on surface ships and submarines. Total theoretical capacity is 0.314 amp-hours (approximately one-sixth the capacity of a bobbin construction "AA" $Li/SOCl_2$ cell). The manufacturer's rated capacity is 0.280 amp-hours under 0.5 a load at room temperature. Limited safety testing has been conducted on the XYZ Battery in support of the PDQ Program. These results are included in the enclosed data package.)

3. (Your office) requests that this package be reviewed, and that a response be returned by (date you need this). Any questions concerning this letter should be addressed to (POC, phone number, fax number...)

SIGNATURE

Example 2 Carderock Division Naval Surface Warfare Center,

IN REPLY REFER TO:
Ser …

2- 10

1 May 04

From: Your office

To: Commander, Carderock Division, Naval Surface Warfare Center(J. Banner, 644)
9500 MacArthur Blvd.
West Bethesda, MD 20817-5700

Subj: REVIEW OF LITHIUM BATTERY CONTAINED IN ...

Ref: (a) NAVSEA Technical Manual S9310-AQ-SAF-010 of 19 Aug 04
(b) NAVSEA Instruction 9310.1B Ser 06/487 of 13 June 91

Encl: (1) Battery Safety Data Package for ...

1. (Your office) requests that the Power Systems Branch (Code 644) of the Carderock Division, Naval Surface Warfare Center, conduct a safety review of the (model or part number) battery as used in the PDQ system in accordance with reference (a) as required by reference (b). A data package describing the battery and the system it is used in is included as Enclosure (1).

2. BRIEFLY DESCRIBE THE BATTERY AND THE SYSTEM, WHO WILL BE USING IT, WHERE IT WILL BE USED... (i.e. The XYZ Battery used in the PDQ system is a reserve lithium/thionyl chloride battery manufactured by Acme Battery Manufacturers, Inc. The battery is a single cell, hermetically sealed lithium/thionyl chloride system with a mechanical activation mechanism. The system is currently in development by the Army and is proposed for use by Navy SEALS on surface ships and submarines. Total theoretical capacity is 0.314 amp-hours (approximately one-sixth the capacity of a bobbin construction "AA" $Li/SOCl_2$ cell). The manufacturer's rated capacity is 0.280 amp-hours under 0.5 a load at room temperature. Limited safety testing has been conducted on the XYZ Battery in support of the PDQ Program. These results are included in the enclosed data package.)

3. (Your office) requests that this package be reviewed, and that a response be returned by (date you need this). Any questions concerning this letter should be addressed to (POC, phone number, fax number...)

SIGNATURE

Example 3 Crane Division, Naval Surface Warfare Center

IN REPLY REFER TO:
Ser …

2- 11
1 May 04

From: Your office

To: Commander, Crane Division, Naval Surface Warfare Center
(D. Mains, 609A)
300 Highway 361
Crane, IN 47522-5001

Subj: REVIEW OF LITHIUM BATTERY CONTAINED IN ...

Ref: (a) NAVSEA Technical Manual S9310-AQ-SAF-010 of 19 Aug 04
(b) NAVSEA Instruction 9310.1B Ser 06/487 of 13 June 91

Encl: (1) Battery Safety Data Package for ...

1. (Your office) requests that the Power Systems Branch (Code 609A) of the Crane Division, Naval Surface Warfare Center, conduct a safety review of the (model or part number) battery as used in the PDQ system in accordance with reference (a) as required by reference (b). A data package describing the battery and the system it is used in is included as Enclosure (1).

2. BRIEFLY DESCRIBE THE BATTERY AND THE SYSTEM, WHO WILL BE USING IT, WHERE IT WILL BE USED... (i.e. The XYZ Battery used in the PDQ system is a reserve lithium/thionyl chloride battery manufactured by Acme Battery Manufacturers, Inc. The battery is a single cell, hermetically sealed lithium/thionyl chloride system with a mechanical activation mechanism. The system is currently in development by the Army and is proposed for use by Navy SEALS on surface ships and submarines. Total theoretical capacity is 0.314 amp-hours (approximately one-sixth the capacity of a bobbin construction "AA" Li/$SOCl_2$ cell). The manufacturer's rated capacity is 0.280 amp-hours under 0.5 a load at room temperature. Limited safety testing has been conducted on the XYZ Battery in support of the PDQ Program. These results are included in the enclosed data package.)

3. (Your office) requests that this package be reviewed, and that a response be returned by (date you need this). Any questions concerning this letter should be addressed to (POC, phone number, fax number...)

SIGNATURE