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REVISION 3

NAVSEA TECHNICAL PUBLICATION

NAVY LITHIUM BATTERY SAFETY PROGRAM

RESPONSIBILITIES AND PROCEDURES

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RECORD OF REVISIONS

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1	19 AUG 2004	Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures
2	15 JUL 2010	Technical Manual for Navy Lithium Battery Safety Program Responsibilities and Procedures
3	03 NOV 2020	NAVSEAINST 9310.1C, Naval Lithium Battery Safety Program, was issued 12 August 2015. Revision 3 implements the formal safety certification policy, process, and requirements of NAVSEAINST 9310.1C.

FOREWORD

The Navy has developed this manual as a guide for developing a structured and tailored Lithium Battery Safety Program (LBSP). This document establishes safety guidelines for the selection, design, testing, evaluation, use, packaging, storage, transportation, and disposal of lithium batteries; sets the conditions for minimizing the technical hazards associated with the use of lithium batteries; and provides a certification process to verify that safety guidelines have been considered and hazards appropriately characterized and accepted.

NAVY DISTANCE SUPPORT (DS) CUSTOMER ASSISTANCE CONTACT INFORMATION

Fleet users of this technical manual (TM) may request NAVY 311 assistance. NAVY 311 is the Fleet's single point of entry for technical and logistics support whenever routine sources of support are unavailable or are not readily identifiable. NAVY 311 is operated via the Global Distance Support Community (GDSC) of geographically dispersed, centrally coordinated, Tier 1/2 call centers that function on a 24/7 basis. Point of entry options:

Phone: 1-855-NAVY311 (1-855-628-9311)/DSN 510-NAVY311 (510-628-9311)

Navy Distance Support/Navy 311 Web: http://www.navy311.navy.mil/ (unclassified) or https://www.navy311.navy.smil.mil/ (classified). (Provides program information and links to an online Support Request Form and Support Request Status, Live CHAT with a Call Center Rep, Knowledge Base Searching, etc.)

Email: Navy311@navy.mil or Navy311@navy.smil.mil

TMDER INSTRUCTIONS

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA and NAVWAR TMs. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA and NAVWAR TMs shall be submitted as a Technical Manual Deficiency/Evaluation Report (TMDER). All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom.

The NAVSEA/NAVWAR TMDER form, NAVSEA 4160/1, is included at the back of the TM.

The Marine Corps uses form MAVMC 10722 to provide updates to technical manuals. Updates may be submitted through http://www.marcorsyscom.marines.mil/ProfessionalStaff/AcquisitionLogisticsProductSupport.aspx.

The following methods are available for generation and submission of TMDERs against unclassified TMs:

For those with a Technical Data Management Information System (TDMIS) account, the most expedient and preferred method of TMDER generation and submission is via the TDMIS website at https://mercury.tdmis.navy.mil/.

For those without a TDMIS account, generate and submit TMDER via the Naval Systems Data Support Activity (NSDSA) website at https://mercury.tdmis.navy.mil/def_external/pubsearch.cfm. (TDMIS accounts may be requested at the NSDSA website at https://nsdsa.dc3n.navy.mil, by submitting a Customer Service Request [CSR].)

When internet access is not available, submit TMDER via hardcopy to:

COMMANDER NAVAL SURFACE WARFARE CENTER
NAVAL SYSTEMS DATA SUPPORT ACTIVITY
4363 MISSILE WAY
ATTN: CODE 310 BLDG 1389 TMDERS
PORT HUENEME, CA 93043-4307

Additional copies of the TMDER form may also be downloaded from the NSDA website at https://nsdsa.dc3n.navy.mil/ by clicking on the blue tab labeled "Reference Docs/Forms".

TMDERs against classified/restricted TMs (includes all NOFORN) must be submitted using the hardcopy method cited above.

Urgent priority TM deficiencies shall be reported by naval message with transmission to Port Hueneme Division, Naval Surface Warfare Center (Code 310), Port Hueneme, CA. Local message handling procedures shall be used. The message shall identify each TM deficiency by Technical Manual Identification Number (TMIN) and title. This method shall be used in those instances where a TM deficiency constitutes an urgent problem, (i.e., involves a condition, which if not corrected, could result in injury to personnel, damage to the equipment, or jeopardy to the safety or success of the mission).

Complete instructions for TMDER generation and submission are detailed on the NSDSA website at https://nsdsa.nmci.navy.mil/, by clicking on the blue tab labeled “TMDER/ACN” and then clicking on the gray button labeled “TMDERs”.

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SAFETY SUMMARY

GENERAL SAFETY PRECAUTIONS

The following are general safety precautions that are not related to any specific procedures and therefore do not appear elsewhere in this manual. These are recommended precautions that personnel must understand and apply during all phases of operation. Should situations arise that are not covered in these safety precautions, the Commanding Officer or other authority will issue orders as necessary to cover the situation.

KEEP AWAY FROM LIVE CIRCUITS

Operational and maintenance personnel must observe all safety regulations. Do not replace components or adjust inside equipment with the power turned on. Under certain conditions, dangerous potentials may exist even after power is removed due to charges retained by internal capacitors.

DO NOT SERVICE OR ADJUST ALONE

Under no circumstances should any person reach inside any cabinet for the purpose of servicing or adjusting the equipment except in the presence of someone who is capable of rendering first aid. Whenever the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing through the body.

FIRST AID

An injury, no matter how slight, shall never go unattended. Always obtain first aid or medical attention immediately and file an injury report in accordance with OPNAVINST 5102.1.

RESUSCITATION

Personnel working with or near high voltage shall be familiar with approved methods of resuscitation. Should someone become injured and stop breathing, begin resuscitation immediately. A delay could cost the victim's life. Resuscitation procedures shall be posted in all electrically hazardous areas.

WARNING AND CAUTION STATEMENTS

Warnings and cautions appear throughout this manual. It is important that the significance of each be thoroughly understood by personnel using this manual. Definitions are as follows:

WARNING

WARNING is used to highlight a statement or some other notification about an operating or maintenance procedure, practice, or condition, that if not strictly observed could result in death, injury, or long-term health hazards.

CAUTION

CAUTION is used to highlight a statement or some other notification about an operating or maintenance procedure, practice, or condition, that if not strictly observed could result in damage to or destruction of equipment or loss of mission effectiveness.

The following warnings and cautions appear in the text of this manual and are repeated here for emphasis.

WARNING

Safety tests can cause violent venting of batteries with deflagration and fragment hazards and release of vapor clouds of chemically active, toxic, flammable, 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. (Page 13-4)

CAUTION

Do not package other batteries with a leaking lithium battery. (Page 12-1)

WARNINGS APPLICABLE TO HAZARDOUS MATERIALS

Warnings for hazardous materials listed in this manual are designed to warn personnel of hazards associated with such items when they come in contact with them by actual use. Additional information related to hazardous materials is provided in OPNAVINST 5100.23, OPNAVINST 5100.19, Navy Safety and Occupational Health Program Manual for Forces Afloat, and the DoD 6050.5, Hazardous Materials Information System (HMIS) series. For each hazardous material used within the Navy, a Safety Data Sheet (SDS) must be provided and available for review by users. Consult your local safety and health staff concerning any questions regarding hazardous materials, SDSs, personal protective equipment requirements, and appropriate handling and emergency procedures and disposal guidance.

Chapter 1
INTRODUCTION

1-1 PURPOSE.

The Lithium Battery Safety Program (LBSP), as required by NAVSEAINST 9310.1, addresses lithium batteries proposed for use in a specific system or device.

This manual provides safety guidelines for the selection, design, testing, evaluation, use, packaging, storage, transportation, and disposal of lithium batteries; sets conditions for minimizing the risks associated with the use of lithium batteries; and documents a certification process to verify that safety guidelines have been considered and hazards appropriately characterized.

The information and processes defined herein are intended to address the safe use of lithium batteries across all naval systems. Due to the extremely damaging effects of energy release resulting from catastrophic failures, requirements for testing and hazard analysis must be considered.

1-2 SCOPE AND APPLICABILITY.

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 active batteries, both primary (non-rechargeable) and secondary (rechargeable), as well as thermal and reserve lithium batteries. This includes all equipment powered by lithium electrochemical power sources that utilize lithium metal, alloys, or compounds, including lithium-ion batteries, through all phases of the life of such systems. Safety evaluation of lithium-ion super capacitors afloat will be covered by the SG270-BV-SAF-010 risk process at the time of this revision.

1-3 BACKGROUND.

The use of lithium cells and batteries in Navy systems and equipment offers the advantage of increased voltage and longer life when compared to other power sources. Lithium batteries can provide increased energy density, and extremely high current. Although these characteristics are useful in applications requiring sustained high current, excessive discharge of a lithium battery (such as when short-circuited) can result in a battery overheating and can lead to battery rupture or explosion. Because of these risks, lithium batteries shall be considered hazardous at all times. The Department of the Navy (DON) has adopted the LBSP to ensure safe operation in the environment intended by the procuring activity, purchasing agency, or user.

1-4 LITHIUM BATTERY SAFETY PROGRAM (LBSP).

A successful LBSP starts with the identification of a requirement to utilize a lithium battery power source and continues throughout the lifecycle of the program. Establishing contact with one of the Technical Agents (TAgs) early in the process is highly encouraged, as they can help minimize the costs of every step in the LBSP.

The certification process ensures that lithium batteries meet the requirements of this manual and applicable references for the safe design, acquisition, use, maintenance, storage, transportation, and disposal of the lithium battery system over the life cycle of the program. In order to certify a lithium battery system with the maximum reasonable assurance of safe operation, Systems Commands (SYSCOM) with certification authority (CA) must ensure that concurrences have been obtained from all SYSCOMs responsible for the platforms that will use, maintain, store, or transport the lithium battery system. For example, Naval Sea Systems Command (NAVSEA) concurrence must be obtained for shipboard applications, while Naval Air Systems Command (NAVAIR) concurrence is required if placed on an airframe, etc. The details of the LBSP can be found in Chapter 3.

1-5 RESPONSIBILITIES.

The Commander, Naval Sea Systems Command (COMNAVSEA) has been assigned by the Chief of Naval Operations (CNO) to be the LBSP Authority with the responsibility for lithium battery safety within the DON. NAVSEA 05Z has been assigned responsibility by COMNAVSEA as the LBSP Authority.

Additional details on the responsibilities of the participants in the LBSP can be found in Chapter 2. Points of contact for the LBSP Authority, CAs, and TAgs are identified in Appendix C.

1-6 LITHIUM BATTERY SAFETY CERTIFICATION PROCESS.

The Lithium Battery Safety Certification Process begins with the identification of a requirement to utilize a lithium battery power source and leads to certification of the battery for use in a given application. Lithium battery concerns continue throughout the lifecycle of the program, including maintenance, design changes that affect battery use, and disposal. The Program Manager (PM) is responsible for ensuring that battery certification costs and schedule are included in their program planning. Early contact with the TAg and CA ensures proper identification of the scope of any lithium battery efforts and will be the best opportunity to minimize the costs of battery certification to the program. The process is outlined in Chapter 3.

1-7 EXCEPTIONS.

Exceptions to Testing, Review, and Certification Requirements are detailed in Chapter 4.

1-7.1 Previous Testing. For batteries that have been previously tested, the TAg will determine when the test data is applicable to the current safety review (see 4-1).

1-7.2 Commercial Off the Shelf (COTS). Some small COTS cells and batteries are pre-authorized for use and do not require testing and review for certification but must be reported to the TAg (see 4-2).

1-7.3 Accelerated Review. Some small format batteries may be certified using an abbreviated review process, as defined by the SYSCOM CA (see 4-3).

1-7.4 Personally Procured Electronic Devices (PPED). PPEDs, such as phones, laptops, and personal vehicles, are not intended to be certified by the process described in this manual (see 4-4).

1-8 SEPARATE AND DISTINCT PROCESSES.

The Lithium Battery Safety Certification Process addresses the lithium battery as a component of a system, while the S9310-AQ-SAF-010 certification only indicates the successful completion of the battery safety program. Fielding a system to a Navy platform requires the completion of a process such as temporary alteration (TEMPALT), ship alteration (SHIPALT), or Carry-On Authorization that may include the Lithium Battery Safety Certification Process requirements.

Other processes that are separate and distinct from Lithium Battery Safety Certification Process are typically required in the course of acquiring and fielding systems. These include, but are not limited to, environmental qualification testing (i.e., shock, vibration, electromagnetic interference, etc.), flight clearances, non-standard parts approval, qualification to a military specification, platform configuration control procedures, safety review board concurrences (e.g., laser safety or Weapons Systems Explosive Safety Review Board [WSESRB]]), ship change document, fleet experiment ship change document, or equivalent processes. Required approval per any of these processes shall be completed in accordance with the associated requirements documents at the system level separately from this lithium battery safety certification.

Completion of one process does not imply completion of any of the other processes.

1-9 REQUIREMENTS.

Lithium batteries shall comply with the instructions contained in this manual regarding design, use, packaging, storage, transportation, and disposal. Additionally, the following general requirements apply:

a. Lithium batteries shall be used only in applications for which they have been certified under this manual.
b. Lithium batteries shall not be pierced, cannibalized, mutilated, punctured, crushed, dropped, dented, deformed, dismantled, short-circuited, exposed to temperatures exceeding manufacturer recommendations, incinerated, or modified.

c. Primary (non-rechargeable) lithium cells and batteries shall not be charged or recharged.

d. Lithium batteries shall be included in the overarching system safety program (SSP) in accordance with MIL-STD-882 or NAVSEA 5100.12-M for sea-based applications.

e. In development and procurement actions, applicable Department of Defense (DoD) SSP requirements shall be invoked by contract.

f. Changes that affect certification attributes shall be coordinated with the TAgs in accordance with 1-10.1.

1-9.1 Integration Requirements. The Technical Authority (TA) and SYSCOM CA responsible for evaluating the lithium battery powered equipment may impose additional requirements for some high-severity impact lithium batteries or those used in critical applications. There may be additional requirements imposed by the system CA as documented in the certification plan (CP) of Chapter 3.

NAVSEA requires adherence to SG270-BV-SAF-010 for large, high-severity-impact lithium batteries on ships. Completion of the SSP requirements in accordance with MIL-STD-882 may identify additional test scenarios that are outside the minimum required safety tests identified in this manual. This additional testing and analysis is required to define the platform-level risk and determine appropriate mitigation(s) to reduce risk to an acceptable level.

Lithium batteries used in ordnance, weapons, and weapon systems require adherence to NOSSAINST 9310.

1-9.2 Reporting Requirements.

1-9.2.1 Mishaps and Near-Mishaps. All mishaps and near-mishaps involving lithium batteries shall be reported in accordance with OPNAVINST 5102.1. Reports shall also be sent to the LBSP Authority at li-batts@navy.mil for distribution to CAs and TAgs.

1-9.2.2 Ventings, Incidents, or Malfunctions. Non-mishap ventings, malfunctions, or other incidents, either with or without visible damage to the battery, shall be reported to the LBSP Authority at li-batts@navy.mil and to the designated Distribution/Screening Point as a Product Quality Deficiency Report (PQDR) in accordance with the Navy and Marine Corps Product Data Reporting and Evaluation Program (PDREP) Manual, NAVSO P-3683. In addition, the Marine Corps shall submit PQDRs by SF 368 via mailbox smblogcompqdrstracking@usmc.mil. The Naval Sea Logistics PDREP website at http://www.nslcptsmh.csd.disa.mil includes a web PQDR application. The LBSP Authority will distribute the reports to CAs and TAgs.

1-9.2.3 Controlled Testing. Lithium battery incidents occurring during deliberate and controlled testing conducted in accordance with the guidance of Appendix G are excluded from these reporting requirements.

1-10 CONFIGURATION AND TEST PLAN CHANGES.

1-10.1 Configuration Management and Class I Battery Changes. Activities procuring batteries for limited or full-scale production should ensure that configuration management is imposed on the battery according to the guidance in MIL-HDBK-61 or an appropriate commercial standard, such as ISO 10007. In addition to the standard definition in MIL-HDBK-61, a class I change shall be defined, for the purposes of this manual, as any change affecting safety characteristics of the battery, such as any change in cell manufacturer, type, method of fabrication, insulation, cell materials, government-accepted quality inspection practices, circuit load changes, battery packaging, etc. Class I battery changes shall be reported to the TAgs in order to initiate an updated safety review and certification, if system changes impact the previous level of risks associated with the battery system. For all lithium batteries, any changes to the Concept of Operations (CONOPS), storage, or system that may alter the hazards associated with the system shall be reported to the TAgs. Updated safety reviews will be documented and retained by the assigned TAg.

Chapter 2
ORGANIZATION AND ROLES

2-1 LITHIUM BATTERY SAFETY PROGRAM (LBSP) AUTHORITY.

The COMNAVSEA has been assigned by the CNO to be the LBSP Authority with the responsibility for lithium battery safety within the DON.

The LBSP Authority establishes the safety policies and processes to administer the program across the DON and operates the certification process for the U.S. Navy. LBSP Authority formally designates CAs for SYSCOMs and is responsible for auditing them for conformance to their documented processes.

NAVSEA 05Z has been assigned responsibility by COMNAVSEA as the LBSP Authority. Additionally, NAVSEA 05Z serves as the CA and TA for the lithium battery systems assigned to NAVSEA program offices.

2-2 PROGRAM AUTHORITY (PA).

PA manages all aspects of assigned programs from concept to disposal, including oversight of cost, schedule, performance, and direction of life cycle management. PA is exercised by PMs; the Commander, Navy Installations Command (CNIC); and by the Fleet, depending on funding and program assignments. The PA for the system undergoing certification is responsible for resourcing and ensuring compliance with this manual. They are encouraged to contact the applicable SYSCOM CA and TAgs early in the program to seek assistance in the tailoring of the certification process.

Specific PA functions include:

a. Initiating conversation with TAgs.
b. Submitting request letter with initial Safety Data Package (SDP).
c. Funding testing, if needed.
d. Fielding system in accordance with CONOPS and details provided and documenting in the SDP and other documents supporting battery certification.
e. Retaining information provided to support lithium battery safety certification for the life of the system.

To reduce program execution risk, improve safety, and reduce the unnecessary proliferation of similar lithium batteries in the Fleet, PMs anticipating the use of lithium cells and batteries shall request a lithium battery safety review early in the program acquisition process. PMs are reminded that SYSCOMs may have other unique acquisition guidance concerning batteries that is not addressed within this manual.

2-3 CERTIFICATION AUTHORITY (CA).

CAs have the authority to certify that products meet established standards and exercise safety certification responsibilities for lithium batteries developed or procured by all activities within their Systems Command structure. The NAVSEA LBSP Authority assigns CA to each SYSCOM through a delegation process, upon receipt of a request by that SYSCOM. The CAs are responsible for establishing, directing, and coordinating efforts of all technical offices within their command structure regarding lithium battery safety, as well as for providing written concurrence and recommendations for any lithium battery use, based on a review of the safety design, analysis, and tests conducted.

Each SYSCOM with delegated CA has established a process for lithium battery safety certification that designates a point of contact for initiation. In some cases, it is the TAgs; in other cases, it is the CA or a Lithium Battery Steering Group. Ultimately, the TAgs can direct the user to the correct entry point.

2-4 TECHNICAL AGENT (TAg).

TAgs are the stewards of the Lithium Battery Safety Certification Process and operate under formally designated authority from the LBSP Authority. The LBSP Authority has designated NSWC Carderock Division (NSWCCD) and NSWC Crane Division (NSWCCR) as the TAgs for the LBSP. The TAg works directly with the PA, TA, and CA as required to complete the certification process. The TAgs serve as subject matter experts in lithium battery design, testing, and operations. Their primary function within the Lithium Battery Safety Certification Process is to provide support to complete lithium battery safety reviews and generate recommendations for use based on their technical assessment.

The LBSP Authority is responsible for formally assigning people or organizations as TAgs to support the CA. The PM is encouraged to contact a TAg as soon as practicable once the need for a lithium battery has been identified. Early engagement will provide valuable information on previous lithium battery approvals that may match the application, design expertise, and test tailoring that maximizes the chances of successful battery certification and reduces program costs.

2-5 SYSCOM TA.

The applicable TA has the responsibility, authority, and accountability to establish, monitor, and approve technical standards, tools, and processes in conformance with higher authority policy, requirements, architectures, and standards. The TA establishes and assures adherence to technical standards and policy, providing a range of technically acceptable alternatives with risk and value assessments.

The applicable TA(ies) shall conduct a technical review of any system that contains a lithium battery that is to be deployed, transported, or recharged on a surface ship, aircraft, or submarine or any system that contains a lithium battery that comes into proximity with naval military or civilian personnel afloat, ashore, or aloft, unless excepted under the criteria discussed in Chapter 4. A platform TA is responsible for assessing possible effects of the batteries outside of the battery interface to the surface ship, aircraft, submarine, or other system. All applicable TAs shall provide documented concurrence prior to certification.

a. For systems installed, deployed, or transported in naval aircraft, as indicated in SWP 4452-010, the designated TA for battery design and suitability in naval aircraft is NAVAIR, Naval Aircraft Warfare Center Aircraft Division (NAWC-AD) Power and Energy Division.

b. For systems installed, deployed, or transported in naval ships, submarines, and other NAVSEA-responsible platforms, the designated TA for batteries is the Technical Warrant Holder (TWH) for shipboard batteries, NAVSEA (SEA 05Z34).

c. For systems installed, deployed, or transported on Marine Corps platforms or by Marine Corps personnel, the designated TA is Marine Corps Systems Command (MCSC) 00T.

d. For any naval weapon system that contains a lithium battery system and ordnance or energetics, as indicated in NOSSAINST 9310, the designated TA for weapons system safety is the Naval Ordnance Safety and Security Activity (NOSSA) N84.

e. For systems installed, deployed, or transported in Military Sealift Command (MSC) vessels, the designated TA is MSC N7. Lithium battery use, approval, and transportation aboard MSC platforms shall be approved by COMSC N7 TAg in accordance with the Office of the Assistant Secretary Research, Development and Acquisition (OASRDA) memo as referenced in Appendix B.

2-5.1 Other TAs. Multiple TAs have cognizance over the safe carriage of lithium batteries on naval platforms. TAs are involved in the Lithium Battery Safety Certification Process at all levels of the project development. The system TA, if applicable, is responsible for the details of the system design and working with all other TAs during the certification process. Ship design managers are responsible for evaluating the integration hazards to their specific assigned Navy platform(s) and for assessing and approving the hazards to a Navy platform from the larger Navy perspective (e.g., battery and fire TWHs). NAVSEA concurrence may require review by ship design managers and various TWHs (e.g., Ship Damage and Fire Recoverability TWH, Climate Control Systems TWH, Submarine Payload TWH). This will be coordinated within NAVSEA and provided to the TAg. The extent of TA involvement will be documented in the CP in Chapter 3.

Chapter 3
LITHIUM BATTERY SAFETY CERTIFICATION PROCESS

3-1 LITHIUM BATTERY SAFETY PROGRAM (LBSP).

Certification of a Lithium Battery System is awarded based upon test results and TAg safety evaluation. Certification is specific to the battery design and system or device described in the SDP and the safety test report. The certification is not transferrable to other applications without specific review, and a recertification review is required after class I battery changes as described in 1-10.1. Further, certification may be limited with respect to time, place, duration, specific platforms, etc., to reduce potential risk. The CA is responsible for providing written recommendation for use to the requesting PM, with the exceptions noted in Chapter 4 for certain small batteries. Approval for the use of battery systems lies with the PM, following receipt of the CA certification letter. To certify a lithium battery system with the maximum reasonable assurance of safe operation, CAs shall ensure that concurrences have been obtained from all relevant TAs, as discussed in Chapter 2 through Chapter 6, responsible for the platforms that will use, maintain, store, or transport the lithium battery system.

a. For systems procured under the authority of NAVAIR, the CA is NAWC-AD Power and Energy Division.

b. For systems procured under the authority of MCSC, the CA is MCSC 00T.

c. For any other naval system, including naval forces afloat and ashore, the CA is SEA 05Z34.

3-2 LBSP PROCESS.

The LBSP process starts with the identification of a requirement to utilize a lithium battery power source and continues throughout the lifecycle of the program. The PM is responsible for ensuring that battery certification costs and schedule are included in their program planning. Early contact with the TAg and CA ensures proper identification of the scope of any lithium battery efforts and will provide the best opportunity to minimize the costs of battery certification to the program. Figure 3-1 illustrates the LBSP process.

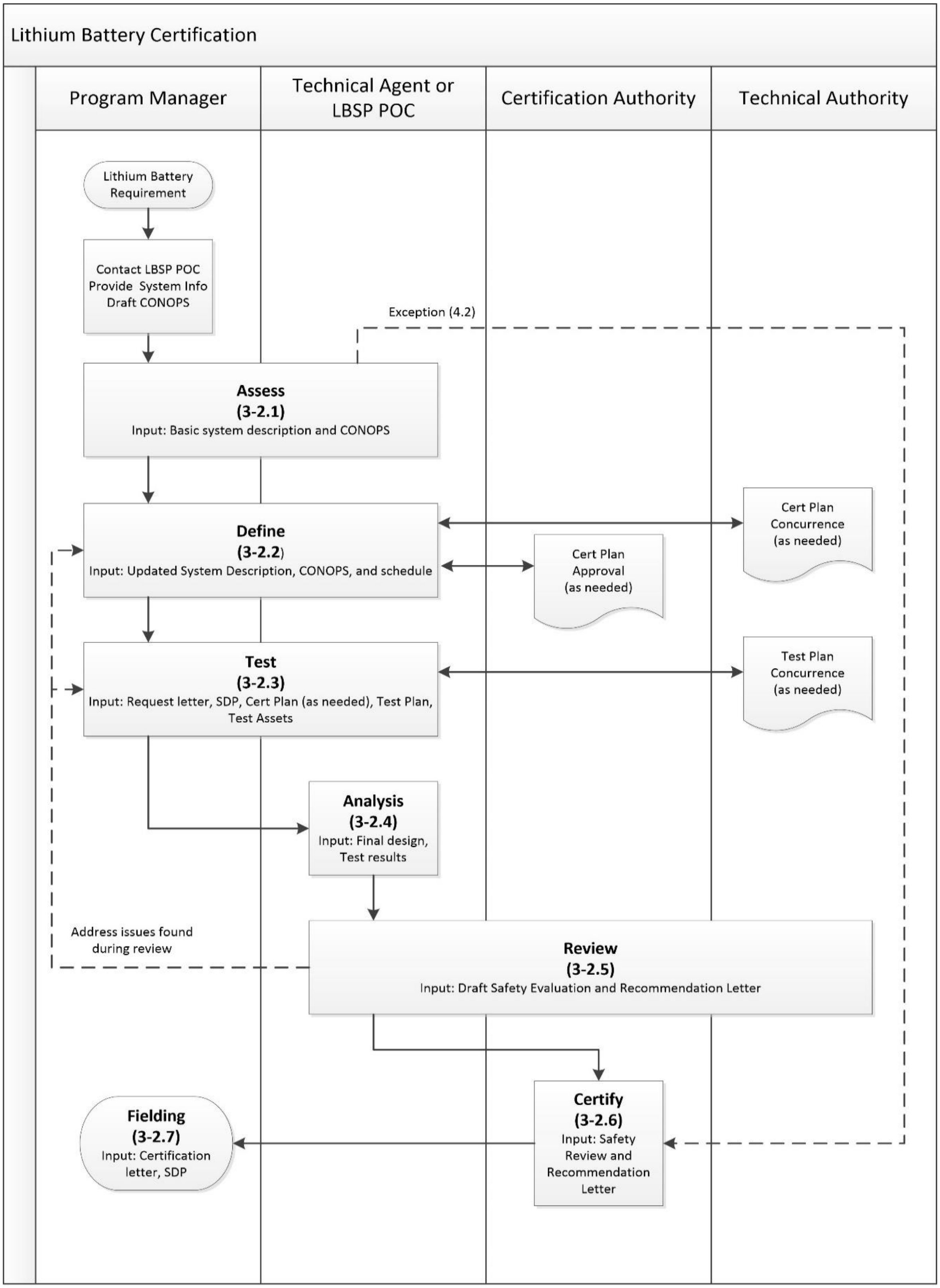

Figure 3-1. Lithium Battery Safety Program Process

There are various points in the LBSP process where new information necessitates re-evaluating prior steps. Examples of new information include test results that do not meet expected results or that do not adequately demonstrate safety requirements, hazard analyses that result in serious or high levels of residual risk, or inability to gain risk acceptance by the appropriate authority. These outcomes may result in re-engaging in the development process, new testing, or additional analysis.

The process includes the following steps.

3-2.1 Assess. Inputs: The PM establishes requirement, basic system description, and CONOPS or Initial Procurement Report (IPR) if applicable (see Table 3-1).

Soon after identifying the need for a lithium battery power source, the program office should call or email one of the points of contact listed in Appendix C. They should be prepared to present or develop a basic system description, preliminary CONOPS, and preliminary schedule. The TAg will assist with determining the first steps of the safety program based on the size and scope of the batteries to be used in the system. Some battery systems can be certified by going straight to the CA.

During the assessment phase, the TAg will investigate the proposed application to help determine the scope of the lithium battery approval effort. The steps taken by the TAg include:

a. Checking for applicability of coin cell or COTS li-ion blanket certifications (see 4-2) and assisting in completing the IPR as required.
b. Checking for existing lithium battery safety certification that is current and applicable.
c. Determining which platforms will be impacted so they can identify whether SG270-BV-SAF-010 may be required.

During the assessment phase, the TAg should outline and document the names and contact info of the CA for the program and identify applicable TAs required to concur, whether system level and platform hazard assessments in accordance with MIL-STD-882 are required, and whether a detailed CP is required. Note: For NAVSEA cognizant systems, NAVSEA 5100.12-M is invoked in lieu of MIL-STD-882.

The LBSP Authority has delegated CA responsibility to other naval commands. When the procuring activity for a lithium battery system resides external to the DON, or when there is no military command with the capability to properly exercise CA, the LBSP Authority may delegate the responsibility to an appropriate CA.

Table 3-1. Blanket Certification/Exemption for Certain Coin Cell or COTS li-ion (see 4-2)

1) Batteries meeting the following criteria shall be exempt from safety testing and evaluation processes and have blanket certification, including authorization for naval personnel and on naval activities, surface ships, submarines, and aircraft. Check whether your system meets the exception criteria of the following:
(a) 4-2.1 for certain primary coin cells used in single cell applications. If it does, proceed to step 2.
OR
(b) 4-2.2 for the use of COTS electronics and equipment powered by lithium-ion secondary (rechargeable) batteries. If so, proceed to step 2.
OR
(c) 4-2.3 for certain primary batteries. If so, proceed to step 2.
(2) Initial procurement shall be reported to NSWCCR. This option only requires reporting of the initial procurement of items to a TAg (contact information is available in Appendix C). The report shall include the information in Appendix E and can be emailed to li-batt@navy.mil. This data will be compiled to provide a basis for notice and recall in the case of unexpected incidents.
(3) All other batteries require an SDP. Proceed through the LBSP process steps in 3-2.2.

3-2.2 Define. Inputs: Established CA; Certification Form; TAg assignment; preliminary System Description, CONOPS, and schedule.

Chapter 6 of this manual provides guidance for the development of lithium power systems. In addition, the TAg can assist in identifying standard safety features and lessons learned from other power system designs that provide appropriate levels of safety and reliability for specific applications. Detailed design of battery system, including monitoring, maintenance, and charging, guides the test plan. Early engagement of the TAg with the program's battery designer will minimize the chances of impacting the program when the system is assessed for certification.

3-2.2.1 TAg's Role. If the TAg determines that a detailed CP is required, they will work with the Program Office to develop it and provide instructions on submitting the plan for approval prior to testing. The CP should be approved prior to the start of any testing. It shall include the names and contact info of the CA for the program; any required technical reviewers; the name and contact info for the person responsible for safety approval; relevant details of the system safety plan, including the hazard assessment process; tailored test requirements in accordance with Chapter 13; and integration of the lithium battery program into the overall system engineering efforts. The CP will be updated as needed during the battery certification process. The CP will be used to guide development testing of the proposed battery system. Coming out of the development process will be a detailed design for the battery system, including any safety features, monitoring, maintenance, and charging systems.

3-2.2.2 PM's Role. The PM is responsible for a preliminary hazard analysis.

Based on the assessment, the PM shall write a letter to either a TAg or their SYSCOM CA to request initiation of the LBSP for their program. The CP should be originated by the PM, concurred to by the TA, and approved by the CA prior to any testing. Cognizant CA and TA (as required) shall provide concurrence to the CP. Requests for safety review shall be submitted by letter correspondence from the PM to one of the TAgs. Lithium batteries shall be included in the overarching SSP and managed in accordance with MIL-STD-882 (Note: NAVSEA 5100.12-M will be required in lieu of MIL-STD-882 for programs under NAVSEA cognizance.). The letter shall:

a. Provide a basis for the decision to use a lithium system, which includes system cost versus risk trade-offs.
b. Identify platform(s) (naval facilities, submarines, ships, vessels, aircraft, vehicles, and subsystems) that will carry or deploy the system.
c. Submit a SDP. See Chapter 5 for complete SDP content. Additional information will be populated through the test and analysis phases.
d. Submit the CP (as required). The CP should be originated by the PM, concurred with by the TA, and approved by the CA prior to the start of any testing.
e. Be signed, serialized, and dated. A sample request letter is provided in Appendix D. Letters may be submitted electronically via email or electronic media.
f. Provide a hazard assessment (which also accounts for the applicable platform hazards) which has appropriate mitigations, has appropriate hazard responses, and is assessed based on test data or reliable engineering processes.

3-2.2.3 Determining Testing Requirements. To determine what testing is required (if any), the TAg shall:

a. Check for previous certifications with the same battery in another application.
b. Check for existing test data applicable to the new safety review based on cell and battery design.
c. Consider deployment plan and CONOPs to determine if previous test data are sufficient or if additional test requirements are necessary.

Cells or batteries may be required to be tested in accordance with Chapter 13 of this manual. These tests are intended to characterize the failure modes and effects of the batteries. If testing is required, a test plan for the battery system shall be developed by the test activity. For reasons of affordability, the CP should include all relevant tests needed to characterize system risks and not be constrained to just those imposed by the scope of this manual. Section 1-9.1 provides amplifying information.

3-2.3 Test. Inputs: Request Letter, SDP, CP (as required), Battery System Test Plan, test assets (as required).

The TAg shall approve the test plans and procedures with the concurrence of the relevant TAs, as needed. Test results and reports shall be submitted to the TAg in support of the safety evaluation performed in 3-2.4. Testing shall be performed at a test facility approved by the CA.

3-2.4 Analysis. Inputs: Final design documents, test results.

Results of the testing will be evaluated against the safety test assessment criteria of Chapter 13 and the approved CP. The TAg will work with the PM to determine if additional testing or mitigations are required. Hazard Assessments for the battery will be finalized at this time, and an SDP in accordance with Chapter 5 shall be updated (as needed) and finalized at this time. The TAg will complete a lithium battery safety analysis based on the review of the SDP and battery safety test results within the context of the system application and deployment plans. The TAgs provide the SDP, test results, hazard assessments, and their safety evaluation and recommendations to the TAs, stakeholders, and peers (as applicable; see **Error! Reference source not found.**) and work with the PM to r esolve comments. As part of the evaluation, if additional data is required by the TA, the program office will provide the data to support the evaluation. This new information will be referenced in the draft safety evaluation and recommendation letter and retained with the evaluation.

3-2.5 Review. Inputs: Draft Safety Evaluation and Recommendation Letter, including additionally requested supporting info.

For proposed battery system designs that exceed established precedents with respect to energy capacity, size, cost, or ability to mitigate hazards, a peer review may be required by the TA or CA and established in the CP. The peer review is performed by the TAg that is not performing the certification (i.e., NSWCCR will peer review NSWCCD Safety Analysis and vice versa) and other technical or platform subject matter experts as determined by the TAg.

TAs listed in Chapter 2 through Chapter 6 review the SDP, review the safety evaluation and recommendation provided by the TAg, and provide concurrence prior to the submission of the package to the CA.

3-2.6 Certify. Inputs: Recommendation letter with all applicable TA concurrences.

The CA will review the recommendation and the SDP and verify that the process and required concurrences were completed satisfactorily. To certify a lithium battery system with the maximum reasonable assurance of safe operation, SYSCOMs with CA shall ensure that concurrences have been obtained from all SYSCOMs responsible for the platforms that will use, maintain, store, or transport the lithium battery system. For example, NAVSEA concurrence shall be obtained for shipboard applications; whereas, NAVAIR concurrence shall be required if placed on an airframe. The CA will then issue a letter to the PM, certifying the battery has completed the LBSP. All applicable procedures and mitigating actions identified by the certification will be promulgated to the Fleet as required in the appropriate format.

A certification letter is not required for some of the exceptions in Chapter 4. When a system meets the criteria for exceptions, the TAg shall provide a response using a format suitable for digital signature (government email or PDF) back to the requestor that indicates successful completion of the requirements of this manual.

A certification letter is not required for some of the exceptions in Chapter 4. When a system meets the criteria for exceptions, the TAg shall provide a response using a format suitable for digital signature (government email or PDF) back to the requestor that indicates successful completion of the requirements of this manual.

3-2.7 Fielding. Inputs: Certification Letter, SDP.

The program office is responsible to field lithium batteries in accordance with the scope and any limitations or restrictions documented in the certification letter. It is the program office's responsibility to field according to the information provided in the SDP and during the review process.

All program decisions, design data, tests, and evaluations that have a bearing on the hazard characterization and safety of the high-density energy storage system shall be documented. This documentation shall be retained in a program library or archive maintained by the program office and shall be available for recovery and reference over the entire life of the program.

During the life of the system, any change affecting safety characteristics of the system shall be reported to the TAg. This includes cell manufacturer, type, model number, method of fabrication, material changes, insulation, circuit load changes greater than 10 percent, battery packaging, etc. Furthermore, any changes to the CONOPS, storage, or system change that may alter the hazards associated with the system shall be reported. The TAg shall initiate an updated safety review and approval if system changes impact the previous level of risks associated with the battery system. Updated safety reviews shall be documented and retained by the assigned TAg.

Chapter 4
EXCEPTIONS TO TESTING, REVIEW, AND CERTIFICATION REQUIREMENTS

4-1 TESTING.

The CA or a TAg with authority delegated by the appropriate CA may determine that sufficient safety test data are available from other sources for any lithium battery under review. Analyses or comparisons with similar cells or batteries in similar applications may be sufficient to eliminate the need for testing.

4-2 EXCEPTIONS.

Certain batteries specified in 4-2.1 through 4-2.3 are certified for all uses and do not require individual testing or review by CAs. However, they do require an IPR from the PM in accordance with Appendix E. Although exempt, storing large quantities of loose or spare lithium-ion batteries may pose a fire hazard if driven to thermal runaway, either from a latent defect or an external heat source. All secondary (rechargeable) lithium-ion batteries, including those exempted in 4-2.1 through 4-2.3, should be stored in a manner consistent with the best practices listed in 4-6 and the guidance provided in Chapter 9.

4-2.1 Coin Cells. Lithium coin cells meeting all the following criteria are certified for all uses and do not require individual testing or review by the CAs. However, they do require an IPR from the PM in accordance with Appendix E. The criteria are:

a. Unmodified, COTS item;
b. Used in single-cell or two-cell configuration;
c. Maximum nominal cell voltage of 3V; and
d. Maximum rated cell capacity of 1 ampere-hour (Ah).

4-2.2 Certain Lithium-Ion Batteries. The use of COTS electronics and equipment powered by lithium-ion secondary (rechargeable) batteries meeting all the following criteria is certified for all uses and does not require individual testing or review by the CAs. However, for naval equipment, the batteries do require an IPR from the PM in accordance with Appendix E. There shall be no attempt to open, modify, reform, or repair batteries in this certified category. The criteria are:

a. Unmodified, COTS battery;
b. User replaceable batteries are UL, LLC listed or equivalent third-party testing;
c. Used in the COTS device as recommended by the manufacturer. Modifications to the devices may only be made in accordance with the manufacturer’s recommendations; e.g., addition of memory in a computer or laptop;
d. Recharged only by devices expressly designed for recharge of the specific battery in use;
e. Less than or equal to 21V, nominal voltage; and
f. Rated for no more than 100 watt-hour (Wh), as listed in the manufacturer’s specification or calculated by multiplying the capacity in Ah by the nominal voltage.

4-2.3 Primary (Non-Rechargeable) Lithium Batteries. The use of systems powered by primary lithium batteries meeting the following criteria are certified for all uses and do not require individual testing or review by the CAs. However, the batteries do require an IPR from the PM in accordance with Appendix E. The criteria are:

a. Batteries built using a single 9-volt PP3 size, snap connector battery; or one to four BR123 or BR2 type lithium/carbon monoflouride cells, CR123 or CR2 type lithium/manganese dioxide cells, and L91 or L92 type lithium/iron disulfide cell;
b. UL listed cells;
c. Each device can use only one type of battery, and each battery can use only one type of cell;

d. Total energy content of the battery shall be no greater than 25 Wh; and
e. System design is compliant with charging prevention of 6-1.3.

4-3 ACCELERATED REVIEW.

4-3.1 Technical Agent Reviews and Delegated Certifications. The TAgs may review and independently recommend for program manager acceptance small lithium batteries that meet the following criteria.

a. Primary or secondary battery;
b. One battery with no more than two identical cells;
c. Maximum rated capacity of 3.0 Ah per cell.

A request letter and data package in accordance with Appendix D and Chapter 5, respectively, must be submitted.

4-3.2 SYSCOM CA Reviews. Each SYSCOM's CA has established SYSCOM-specific instructions for implementing this manual. These instructions may identify accelerated review for smaller batteries where either the TAg or the CA may review and independently recommend and certify lithium batteries. A request letter and data package in accordance with Appendix D and Chapter 5, respectively, must be submitted. The criteria for accelerated review shall be documented by the SYSCOM CA with concurrence by the LBSP Authority. The CA or TAg is authorized to engage related CAs, TA, Principals for Safety, PMs, TAgs, or the LBSP Authority for involvement if, in their opinion, it is needed to assure a complete safety review.

4-4 PERSONALLY PROCURED ELECTRONIC DEVICES (PPED).

PPEDs, such as phones, laptops, and other small devices are not intended to be certified by the process described in this manual. However, the proliferation of personal electronics that utilize lithium batteries does increase the chances of a fire on a Navy asset, and it is recommended that each SYSCOM CA develop platform-level guidance for managing the use of PPEDs on their respective platforms and installations. Government-procured commercial electronic devices and vehicles shall meet either the exception or certification requirements of this document.

4-5 PERSONAL VEHICLES.

Personal electric and hybrid vehicles are not covered by the Navy LBSP. Government-procured vehicles shall meet the certification requirements of this manual.

4-6 BEST PRACTICES FOR COTS LITHIUM BATTERIES.

4-6.1 Best Practice for Use and Storage of Lithium Batteries. The following are restrictions that apply to the use and storage of these items:

a. For batteries that are removed for charging (such as power tools), ensure the battery and charger being employed are manufactured by the tool manufacturer and the charger is identified for charging the intended battery pack.
b. Verify all batteries bear a UL listing, or equivalent third-party testing marking or listing.
c. Inspect batteries for signs of droppage, physical damage, or corrosion. Promptly remove poor performing, damaged, or corroded batteries from service. Do not attempt repair.
d. Devices and batteries shall be charged, stored, and/or used on non-combustible surfaces.
e. Charging and storage areas shall be kept free of combustibles on the same surface and behind, near, and under surface (i.e., no papers in drawer beneath storage location).
f. Manned charging should be performed when possible.
g. Ensure adequate ventilation around charging areas to prevent overheating.
h. Terminate charging when battery reaches 100 percent state of charge.

4-6.2 Use and Storage Aboard Ships and Submarines. The following restrictions apply to usage and storage aboard ships and submarines:

a. The quantity of smaller batteries shall be limited in any single location (of batteries or charging stations) to an aggregate energy content of 1,000 Wh or less.

b. The ship’s Damage Control Assistant (DCA) and Fire Marshal shall be informed of and approve the storage and charging locations of the lithium batteries. The chosen compartment shall not be within or contiguous to (aside or below) hazmat/flammable liquid storage compartments, ammunition magazines, fuel (ship or aviation) storage, pumping or handling areas, or any other areas the ship's DCA or Fire Marshall deem inappropriate. Access to a ship's telephone with access to Damage Control Central (DCC) shall be available.

Chapter 5
SAFETY DATA PACKAGE

5-1 SDP.

An SDP describing the following items for the battery and intended system in which it will be used shall be submitted as an enclosure to the request letter. Information not readily available may be so noted and omitted from the SDP; omitted information deemed critical shall be obtained during the safety review process.

5-1.1 Proposed Cell/Battery Design Data.

a. Manufacturer (name, address, phone number, or URL for the web site).
b. Model or part number.
c. Electrical description (voltage, Ah capacity, and nominal load profile).
d. Electrical safety devices integral to the cell/battery.
e. Cell/battery configuration (cells or batteries in parallel or series).
f. Operating life (shelf and functional life).
g. Physical dimensions and description (weight, size, geometry, number of cells, and battery housing description).
h. Battery chemistry including electrolyte, flammable contents, and electrode composition.
i. Cell and/or battery yield pressure (if unvented, battery/housing room ambient yield pressure).
j. All applicable Safety Data Sheets (SDS), Product Information Sheets, or equivalent document.
k. Cell failure mode (indicating whether a single cell failure can cascade into multiple cell failures).
l. Discharge rate.

5-1.1.1 Secondary Batteries Only. In addition to the criteria of 5-1.1, SDPs for secondary batteries shall include the following data.

a. Rated cycle-life (versus depth of discharge) and the mean-time-between failures for the cell or battery.
b. Discharge and recharge rates including any minimum rest periods and the limiting discharge and charge rates.
c. Case temperature information.

5-1.1.2 Thermal Batteries Only. In addition to the criteria of 5-1.1, SDPs for thermal batteries shall include the following data:

a. Case temperature information, to include:
    1) Specification requirements and actual battery performance.
    2) Complete temperature profile from activation to battery cool down (this is normally beyond specification life).
b. Method of activation.
c. Battery cool-down time.

5-1.1.3 Reserve Batteries Only. In addition to the criteria of 5-1.1, SDPs for reserve batteries shall include the following data:

a. Method of activation.
b. Expected activated life before self-depletion.

5-1.2 Lithium Battery-Powered System Description.

a. Description of system purpose or function.

b. Manufacturer (name, address, phone number).

c. Model or part number and device name.

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

e. Battery installation (i.e., mounting, seals, electrical connectors).

f. Battery housing or container, strength, and free volume.

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

h. Current drain (load profile of the system).

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

j. Electrical schematic (showing all protective circuitry, including but not limited to fuses, blocking diodes, and external power interface).

k. Description of the charger, charging profile, and charge control mechanism, if applicable. For example, identify whether cells are individually equilibrated or if the battery is charged as a series/parallel string. Provide information for large, high-severity impact lithium batteries sufficient to support evaluation that features of the charging system related to charging safety have been included in the design, validated, and tested, especially communications protocols.

l. Description of other controls or mechanisms to enhance battery safety, such as a Battery Management System (BMS), software shutdown mechanism and controls, mechanical isolation of individual cells, dielectric isolation (e.g., parylene conformal coating), thermal isolation of individual cells, ejecta management (in the event of thermal runaway), etc.

m. If applicable, specification of any existing override or battle short conditions.

n. Identification of ordnance, energetics, or weapons near the battery.

o. If appropriate, identification of the battery as a critical safety item in the application.

p. Number of batteries in the system.

5-1.3 <u>Logistical and Operational Use Data</u>.

a. Packaging: How will the system or battery be packaged?

b. Storage facilities: How will the system or battery be stored from delivery to disposal? Is system or battery co-located with ordnance, energetics, or weapons?

c. Transportation methods: How will the system or battery be moved after it is accepted and delivered?

d. Disposal information: How will the system or battery be discarded after it is no longer needed?

e. Operational use scenario, including:

   (1) A complete description of how the system or batteries will be handled and used.

   (2) What platform(s), e.g., naval facilities, submarines, ships, vessels, and aircraft, will carry or deploy the system.

   (3) Ambient temperatures in space where battery resides.

   (4) Location of recharging operations, if applicable.

   (5) Recovery operations, ashore and afloat, if applicable.

   (6) Number of units anticipated to be used and spared.

   (7) The sequence of events before system use, activation, deployment, etc., if applicable.

   (8) Battery integration or co-location with weapons or ordnance handling systems.

f. Description of the battery change out/replacement plan, including:

   (1) Number of batteries needed to support system during deployment and appropriate storage configuration.

(2) Expected life cycle.

5-1.3.1 Thermal or Reserve Batteries Only.

a. Activation method and sequence/failure analysis.

b. Hang-fire analysis.

5-1.4 Incoming Inspections of Individual Cells. For large or complex battery systems that involve multiple TAs or development activities, inspection of individual cells procured to fabricate battery modules or assemblies may be required for quality assurance. The following shall be noted during the individual cell inspection:

a. Counterfeit or damaged cells.

b. Dimensionally out-of-tolerance cells.

c. Gross electrical problem cells.

d. Inspection of each cell should include, but not be limited to:

(1) Inspection for damage to cell or wrapper.

(2) Inspection to ensure that manufacturer and model information is visible on each cell, with no additional stickers or markings.

(3) Inspection to ensure that construction is consistent with the verified sample (e.g., golden sample) with respect to cathode, anode, vent, and weld seam.

(4) Inspection for manufacturer's marking including manufacturer, cell model, and lot number.

(5) Association of lot numbers to purchase order from a vendor that certifies that the cells are genuine.

(6) Measurement of cell mass to ensure it is within defined limits.

(7) Dimensional check of diameter and length using pass or fail gauge mechanism.

(8) Measurement of voltage slope during load test.

5-1.5 Functional, Environmental, and Safety Test Data. The SDP shall include functional, environmental, and safety tests representative of the actual environments to be encountered by the complete end item, including the battery, performed to date. This shall include the description of the 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., UL). For weapons or ordnance systems, this shall include qualification safety test results (such as MIL-STD-2105, MIL-STD-464, MIL-STD-461, and MIL-STD-331) as applicable.

5-1.6 Safety Testing Program Plan or Completed Test Data. The SDP shall include the proposed safety testing program plan or completed test results from the specific lithium battery safety abuse tests identified in Chapter 13. In addition, cell vendor, and Department of Transportation safety test results should be included as available.

5-1.7 SSP. Summarized results from the SSP that are germane to lithium batteries shall be submitted within the SDP. When a platform hazard analysis is required, it shall be included in the SDP. For ships, submarines, and deep submergence system applications, a platform analysis is required in accordance with NAVSEAINST 5100-12.M, unless it falls under the exceptions of Chapter 4. For other batteries that do not fall under the exceptions of Chapter 4, a safety assessment report as described in MIL-STD-882 shall be required. For all ordnance, weapons, and energetics, point of contact information for the Principal for Safety shall also be included.

Chapter 6
LITHIUM BATTERY SYSTEM DESIGN

6-1 GENERAL REQUIREMENTS.

This chapter outlines best practices and design requirements for designing lithium battery systems. Required design elements are designated by ”shall” statements and best practices are designated with ”should” statements; all are recommended to be incorporated when designing battery systems. Deviations from requirements shall be sent to the CA for approval.

6-1.1 Battery Selection. Batteries or cells should be selected with the lowest possible total capacity to meet the mission requirements. The preferred non-rechargeable chemistry for aircraft is solid cathode chemistry. Liquid cathode chemistries are highly corrosive and toxic and should be avoided.

6-1.2 Over-Current Protection. Each battery used as a power source shall contain suitable over-current devices on each ungrounded conductor. Devices shall either go to the open-circuit position if the battery is discharged at an excessive rate (e.g., fuse or relay) or shall limit the current flow to a safe level (e.g., Positive Thermal Coefficient [PTC] Device). Batteries shall be over-current protected in the ground lead of each series string. Where parallel battery strings are used, each individual string shall be protected. Batteries should not be tapped to provide different voltages; however, if the design includes taps, each tap shall be protected with an over-current device.

6-1.3 Charging Prevention. If the system powered by a primary battery can be connected to an external power source, such as shore power connections or back electromotive force from motors, the battery shall be protected to prevent charging by the external power source. In primary batteries consisting of parallel strings, each parallel string shall be protected to prevent any possibility of charging from external sources or from the other parallel strings.

6-1.4 Venting. 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. A vent path for the toxic and corrosive and/or flammable vent products shall be designed to prevent case rupture or undirected venting except in applications where venting of any kind is not permitted. Housing for a battery assembly shall have a functional vent mechanism to preclude rupture or shall be qualified to resist overpressure resulting from a battery failure.

6-1.5 Battery Compartment. The battery should be physically separated from all other systems. The battery compartment shall have no interior projections or sharp edges that could damage the battery casing or the battery wiring. The battery shall be secured within the compartment to resist shock and vibration to the levels required for end-item use.

6-1.6 Power Switches. Power switches in the end item shall be selected to prevent accidental battery turn-on.

6-1.7 Cell Uniformity. Within a single battery, cells of identical type, size, rating, chemistry, and matched impedance shall be utilized. If systems utilize storage components of multiple kinds in a hybrid fashion, suitable protections shall be required to ensure appropriate power flow and protection from faults.

6-1.8 Cell Inspection. Incoming cells should be inspected, and results should be documented prior to assembly in battery systems (see 5-1.5).

6-1.9 Warning Labels. The end item shall have an external label that warns users of the hazards associated with lithium batteries and that shall be marked in accordance with container warning requirements of 29 Code of Federal Regulations (CFR) 1910.1200.

6-1.10 Battery Life. Each program shall consider battery service life limitations in logistics planning. The logistics plan shall ensure that batteries are changed out of the system or rotated out of stock prior to the end of the most conservative estimates for cycle and calendar life.

6-2 ACTIVE BATTERY REQUIREMENTS.

Design requirements for active batteries, both non-rechargeable and rechargeable, are described in the paragraphs below.

6-2.1 Internally Pressurized Cells. 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.

6-2.2 Safety-Venting Devices. Each cell, battery, and battery compartment shall incorporate a safety-venting device or be designed and manufactured in a manner shall preclude a violent rupture as a result of cell venting. Nothing in the design and construction of the battery that will degrade the vent.

6-2.3 Thermal Protection Devices. Consideration should 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. Thermal protection devices shall be located in close proximity to each cell string, not physically isolated from the cell, or the cell string being protected.

6-2.4 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.

6-2.5 Positive Protection Against Accidental Shorting. When the battery is not installed in equipment, the leads or connector plug shall be taped, guarded, or otherwise designed or provided with positive protection against accidental shorting.

6-3 THERMAL AND LIQUID RESERVE BATTERY REQUIREMENTS.

The following design requirements are for both thermal and liquid reserve batteries.

6-3.1 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.

6-3.2 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.

6-3.3 Safety-Venting Device. Each battery and battery compartment shall incorporate a safety-venting device or be designed and manufactured in a manner that will preclude a violent rupture condition. Nothing shall be done in the design and construction that will degrade the vent.

6-3.4 Electrical Initiation Leads. When the battery is not installed in the equipment, all electrical initiation leads shall be shorted. The output leads or connector plugs shall be taped, guarded, or provided with positive short circuit protection.

6-3.5 Thermal Battery Overheating. The battery shall be properly insulated and located to prevent overheating of the system or thermal damage to adjacent components.

6-3.6 Liquid Reserve Battery Bleeder Resistors. Consideration should 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 part of the battery design.

6-4 RECHARGEABLE BATTERIES.

6-4.1 Charging Sources. Systems that use rechargeable batteries shall be designed to prevent charging by any charging source other than that specifically approved for the batteries. Charging equipment for batteries shall be provided with reverse current protection.

6-4.2 Cell-to-Cell Balancing Mechanisms. . During charging, differences in individual cells can lead to differing voltages in cell groups, which leads to some cells being undercharged and a decrease in the overall battery capacity. Conversely, some cells have been overcharged, resulting in cell damage, shortened life cycle, or safety issues. To achieve a uniform state of charge, rechargeable batteries shall include a cell-to-cell balancing mechanism for use during charging.

6-4.3 Overcharge Protection. Systems using rechargeable batteries shall have integrated overcharge protection. This protection shall disconnect the battery from the charging source. Disconnect shall be automatic and not require operator action.

6-4.4 BMS. Designers of rechargeable batteries should use a BMS that provides access to information on the performance, cycle-count, age, and condition of the battery (if a BMS only collects and reports data, then it may be known as a battery monitoring system). A BMS may be integral to the battery and may include reporting functions, control functions, and the protections of paragraph 6-4.2 and 6-4.3 above. Conversely, a BMS may be an interface to the system in which the battery is installed. If the BMS monitors or performs safety critical functions, such as prevention of overcharge or other function that can lead to dangerous cell failures, additional objective quality evidence shall be developed to support a review of safety critical functions by the CA. PMs are strongly encouraged to contact the appropriate CA early in the development process to discuss BMS safety requirements. For a BMS that utilizes a processor and firmware that will receive, process, store, display, or transmit DoD information, the BMS shall maintain an Authorization to Operate or assess only designation via the Risk Management Framework (RMF). The complexity of the BMS and external interfaces will determine which process to follow within the RMF.

Chapter 7
USE

7-1 GENERAL.

7-1.1 Removal. Lithium batteries shall be removed from associated equipment upon completion of useful life, packaged in accordance with Chapter 8, stored in accordance with Chapter 9, and disposed of in accordance with Chapter 11. All exposed terminals shall be insulated to prevent short circuits.

7-1.2 Non-Sea-Based Usage Safety Precautions. In addition to the requirements of Unified Facilities Criteria (UFC) documents UFC 3-520-05 and UFC 3-600-01, designers of facilities where lithium batteries are handled and charged should consider the best practices listed below.

a. Isolate charging areas from storage areas, including the isolation of heating, ventilation, and air conditioning system air from adjacent work areas.

b. Ensure that the fire department has been specifically informed of the type of batteries and operations performed at the facility and the worst-case event (WCE). The base fire map at the fire station should include charging and storage areas for large, high-severity impact lithium batteries.

c. Establish a clear exit path from the work and charge stations.

d. Ensure access to an emergency hand pull alarm.

e. Temperature monitoring, and specifically, temperature control, is strongly encouraged.

f. Provide an automatic sprinkler system actuated by smoke or flame. Depending upon the application, an alternative to a water deluge system may be appropriate.

g. Ensure that the fire alarm system shuts down the chargers.

h. Using air handling systems, contain, redirect, and ventilate smoke and gases from a thermal incident.

i. Construct charging rooms using fire-proof material such as cinder block. The use of a dedicated Military-Owned Demountable Container (MILVAN) with adequate climate control for charging is another alternative.

j. Provide a combustible gas sensor to detect organics released by venting under charge.

k. Understand the basic electrical interface between the battery and any system to which it is connected (e.g., know whether the system allows the battery to float as opposed to grounding of the battery case or the battery negative connection) and isolate the battery accordingly. Understand electrical fail-safe circuits and the consequences of a controller software or hardware failure.

l. Review the physical configuration of the room to determine and mitigate mechanical risks as appropriate, including risks that may emerge as a result of a WCE.

m. When the battery is removed from system, insulate all exposed terminals shall be insulated to prevent short circuits.

7-1.3 Sea-Based Usage Safety Precautions. Identifying a space where lithium batteries are handled and charged aboard surface ships and submarines shall include consideration of the best practices listed below. While the best practices listed below are applicable to the usage or charging of all lithium-ion batteries, it should be noted that more detailed design guidance must be followed for large-format lithium-ion battery systems. This guidance, for surface ships, is available in NAVSEA 9555 Ser 05-5/180, Enclosure 1, NAVSEA 05P5 Design Criteria Standard Fire Safety Design Criteria for a Stowage and Charging Facility for Selected Approved and Compatible Lithium Batteries Aboard US Naval Surface Ships in NAVSEA.

a. Identify batteries as a hazardous material to the ship's commanding officer.

b. Coordinate usage/charging/storage areas with ship's safety officer.

c. Provide boundaries that have a minimum N-0 fire resistance rating with all adjacent spaces, in accordance with MIL-STD-3020.

d. Contain fire detection equipment, firefighting equipment, and limited volatile materials.

e. Provide adequate separation distance between usage locations.

f. Provide non-combustible surfaces on which the batteries can be used or charged.

g. Provide adequate ventilation around charging areas to prevent overheating.

h. Provide adequate ventilation to contain, redirect, and ventilate smoke and gases from a thermal incident to an exterior or overboard environment.

i. Provide a clear exit path from the work and charge stations.

j. Understand the basic electrical interface between the battery and any system to which it is connected (e.g., know whether the system allows the battery to float as opposed to grounding of the battery case or the battery negative connection) and isolate the battery accordingly. Understand electrical fail-safe circuits and the consequences of a controller software or hardware failure.

k. Review the room physical configuration to determine and mitigate mechanical risks as appropriate, including risks that may emerge as a result of a WCE.

l. Manned charging should be performed when possible.

m. The ship's DCA and Fire Marshal should be informed of and approve the charging and storage locations of the lithium batteries. The chosen compartment should not be within or contiguous to (aside or below) HAZMAT/flammable liquid storage compartments, ammunition magazines, fuel (ship or aviation) storage, pumping or handling areas, or any other areas the ship's DCA or Fire Marshal deem inappropriate. Access to a ship's telephone with access to DCC should be available. The ship's DCA and Fire Marshal should also be informed of the WCE.

n. When a battery is removed from system, insulate all exposed terminals to prevent short circuits.

7-2 ACTIVE NON-RECHARGEABLE BATTERIES.

7-2.1 Partially Discharged Lithium Batteries. Partially discharged lithium battery or cell in a system that uses more than one battery or cell shall not be used. 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 venting events.

7-3 THERMAL BATTERIES.

7-3.1 Activated, Not Deployed. If the battery has been activated, but not deployed, allow cool down time and dispose of the battery in accordance with Chapter 11.

7-3.2 Cooldown 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 in accordance with Chapter 11.

7-4 LIQUID RESERVE BATTERIES.

7-4.1 Activated, Not Deployed. If the battery has been activated, but not deployed, dispose of the battery as soon as possible in accordance with Chapter 11.

7-4.2 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 in accordance with Chapter 11.

7-5 RECHARGEABLE BATTERIES.

7-5.1 Charging System. Rechargeable batteries shall only be charged and conditioned using the charging system specifically approved for the battery.

7-5.2 Charging Protocols. Designated charging protocols shall be followed exactly. Charging regimes or hardware designed to fix damaged or failed batteries or cells not specifically approved for the battery shall not be used.

7-5.3 Charging Failure. In the event of a known charging system failure that cannot be recovered using existing operating or emergency procedures, any battery that was attached to the charging system at the time of the failure shall be removed from service as it may have been damaged by improper charging. The battery shall be removed from service until the BMS failure can be evaluated by the TAg. No attempt shall be made to modify the battery to allow charging by other than designated and approved charging systems.

Chapter 8
SHIPPING

8-1 GENERAL 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 172.101, 172.102, and 173.185. In addition to the minimum requirements of 49 CFR 173.185, Naval activities using, storing, transferring, or collecting lithium batteries shall adhere to the following regulations.

8-1.1 Battery Packaging Design Disclosure. A complete battery packaging design disclosure shall be obtained from the supplier of the equipment or manufacturer of the batteries before shipment.

8-1.2 Packaging Design Incorporation. Ensure that the packaging design is incorporated in the appropriate acquisition specification, contract, and manuals. Descriptive language shall be supplemented by drawings or figures.

8-1.3 Packaging Design Minimum Requirement. 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.

8-1.4 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 172.101, 172.102, and 173.185.

8-2 NON-CONFORMING PACKAGING.

Packaging not conforming to the package requirements of 49 CFR 172.101, 172.102, and 173.185 shall be reviewed by the Naval Packaging, Handling, Storage and Transportation (PHS&T) Division of the Detachment of Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal (EOD) Technology Division (NSWC IHEODTD), located in Picatinny Arsenal, New Jersey in conjunction with TAgs. A responsible military command is authorized to issue a Certificate of Equivalency (COE) in accordance with procedures prescribed by DLAD 4145.41/AR 700-143/AFJI 24-210/NAVSUPINST 4030.55/MCO 4030.40 when satisfied that the container design proposed will meet equal or more stringent requirements than those listed in 49 CFR 173.185. Before issuing a COE, NAVSEA will review the following:

8-2.1 Safety Test Results. Results of the safety tests described in Chapter 13 of this manual and those mandated by 49 CFR 172.101, 172.102, and 173.185.

8-2.2 Environmental Tests. The environmental tests performed on the unpackaged device and the packaged device.

8-2.3 Complete Design Disclosure. A complete design disclosure of the proposed package.

8-3 PACKAGING FOR DISPOSAL.

Coordinate packaging of new and used lithium batteries designated for disposal with the local Defense Logistics Agency Disposition Services (DLADS) or the servicing military environmental compliance branch. Disposal shall be in accordance with Chapter 11. Additional guidance for packaging batteries for disposal is provided in 9-1.13 and 9-1.14.

Chapter 9
STORAGE

9-1 STORAGE GUIDELINES FOR NON-SEA-BASED FACILITIES.

All lithium batteries and lithium battery-powered equipment shall be stored in compliance with the specific requirements stipulated in appropriate equipment documents or in accordance with base or platform regulations as specified in Standard Operating Procedures (SOPs). Storage areas for hazardous waste lithium batteries shall be in accordance with Chapters 7 and 9 for sea-based and non-sea-based stowage. The general storage requirements listed below shall be followed for Naval shore facilities and ships.

9-1.1 Ventilated Shelter. Store batteries in a dry, cool (below 130 °F [54 °C]) ventilated shelter out of direct sunlight.

9-1.2 Segregated Storage. Use the shelter only for the storage of lithium batteries and equipment containing lithium batteries.

9-1.3 Field Storage. In the field, avoid covering containers of batteries with a black or dark-colored tarp.

9-1.4 Handling and Moving Containers. Exercise special care in handling and moving containers to prevent crushing or puncturing.

9-1.5 Fire Response. Locations on shore facilities shall have a fire station in the vicinity. Sprinkler systems and smoke and flame sensors should be considered. See G-3.1.6 for information on the use of water being effective against lithium battery fires.

9-1.6 Isolation. Isolate the storage area from other hazardous and combustible material and only use the area for the storage of unused lithium batteries or equipment with lithium batteries installed.

9-1.7 Minimum Quantities. Based on mission requirements, keep battery quantities stored in an area to a minimum because mass storage of batteries will increase the hazard.

9-1.8 Inhabited Areas. Lithium batteries or battery-powered equipment with lithium batteries installed shall not be stored in inhabited areas, such as offices, berthing areas, etc. Batteries exempted by section 4-2 may be stored in inhabited areas subject to the requirements of 4-6.

9-1.9 Segregation of Batteries. Segregate the battery storage area into 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, with the exception of spares for common office electronic devices such as laptop computers and cameras.

9-1.10 Additional Storage Recommendations. Bulk storage locations and locations storing lithium batteries should consider the applicable best practices of 7-1.2. For rechargeable lithium-ion batteries, batteries should be stored at 50 percent state of charge or less whenever possible.

9-1.11 Marking. The storage area or shelter shall be marked as follows:

a. "STORAGE OF NEW LITHIUM BATTERIES" or "STORAGE OF EQUIPMENT CONTAINING NEW LITHIUM BATTERIES";

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

c. "STORAGE OF USED LITHIUM BATTERIES AWAITING DISPOSAL".

9-1.12 Containers and Packaging. Store new and unused batteries in the original shipping container, original individual package containers, or equivalent packaging. For cells or batteries placed in drums, appropriate cushioning shall be used in conjunction with packaging. This should not be polystyrene foam peanuts, but a vermiculite-type material. This keeps shock and vibration during transit to a minimum and prevents crushing among cells and batteries as well as from the side of the container.

9-1.13 Insulated Terminals. For partially used batteries intended for reuse and batteries awaiting disposal, 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.

9-1.14 Batteries Awaiting Disposal. For used batteries awaiting disposal refer to Appendix F. The following additional items also apply:

a. Establish a remote collection point and storage area for used or depleted lithium batteries awaiting disposal. Aboard ships, lithium batteries designated for disposal shall be stowed on the weather decks of surface ships. Separate batteries awaiting disposal from other combustible material. Stowage of used or depleted batteries on submarines or submersibles shall be established on a case-by-case basis.
b. Package used or depleted lithium batteries awaiting disposal or lithium-powered equipment with batteries installed and awaiting disposal in accordance with 9-1.12.
c. When practical, store no more than 30 pounds of used or depleted lithium batteries awaiting disposal.
d. It is good practice to store used or depleted lithium batteries awaiting disposal for no longer than 30 days.
e. Do not dispose of or transport lithium batteries with normally generated refuse.
f. 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.

9-1.15 Storage Aboard Aircraft. Lithium battery storage aboard aircraft shall be approved by AIR-4.4.5.

9-2 GUIDELINES FOR SEA-BASED STORAGE.

All lithium batteries and lithium battery-powered equipment shall be stored in compliance with the specific requirements stipulated in appropriate equipment documents or in accordance with base or platform regulations as specified in SOPs. For surface ship or submarine planned aggregate storage or transport of a lithium battery, lithium-battery-powered device, or any combination thereof, a platform level hazard assessment per SG270-BV-SAF-010 shall be performed, as required. The general storage requirements listed below shall be followed for shipboard applications. An example of an appropriate storage location would be the Lithium Battery Facility located on some surface ships.

9-2.1 Ventilated Shelter. Store batteries in a dry, cool (below 130 °F [54 °C]) ventilated space out of direct sunlight that provides a means to contain, redirect, and ventilate smoke and gases from a battery casualty to an exterior or overboard environment.

9-2.2 Segregated Storage. When possible, use space only for the storage, use, and charging of lithium batteries and equipment containing lithium batteries. Provide boundaries that have a minimum N-0 fire resistance rating with all adjacent spaces, in accordance with MIL-STD-3020.

9-2.3 Handling and Moving Containers. Exercise special care in handling and moving batteries or devices containing batteries to prevent crushing or puncturing.

9-2.4 Fire Response. Storage locations aboard ship shall have fire hose coverage of the entire compartment from two hose stations with 100 feet of 1.5- or 1.75-inch hose supply fitted with a MIL-N-24408 nozzle (minimum 95 gallons per minute). S9086-S3-STM-010/555 contains firefighting guidance for lithium batteries.

9-2.5 Fire Detection and Suppression. Storage locations aboard ship should consider the use of smoke detection (photoelectric/ionization), heat detection (fixed temperature), combustible gas detection, and an automatic overhead sprinkling system, when possible. Storage of lithium batteries in hazardous material storerooms is prohibited.

9-2.6 Containers. Lithium batteries not in use shall be kept in non-combustible storage containers and shall be separated from other hazardous and combustible materials, including other storage containers, by a minimum of 4 feet, or as approved by the Naval TA. Storage containers shall be fire-rated and grade B shock qualified in accordance with MIL-DTL-901 or be approved by the Naval TA. Hazardous Material cabinets in accordance with A-A-101 meet these requirements. Refer to S9086-WK-STM-010/670 for additional information.

9-2.7 Minimum Quantities. Based on mission requirements, the battery quantities stored aboard the ship shall be kept to a minimum because mass storage of batteries increases the hazard severity. No more than 1 kWh of total battery energy content should be stored in a single safety storage locker or container.

9-2.8 Segregation of Batteries. Segregate battery storage lockers into 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 LFORM ammunition, with the exception of spares for common office electronic devices such as laptop computers and cameras, which may be stored in inhabited areas.

9-2.9 Additional Storage Recommendations. Bulk storage locations and locations storing lithium batteries should consider the applicable best practices of 7-1.3. For rechargeable lithium-ion batteries, batteries should be stored at 50 percent SOC or less when possible.

9-2.10 Marking. The storage area or shelter shall be marked appropriately as follows:

a. Storage lockers and equipment containing embedded lithium-ion batteries whose energy content is greater than 250 Wh shall be clearly labeled with a lithium-ion battery specific class 9 HAZMAT diamond on the most functional side of the locker or equipment.
b. Storage containers should be marked appropriately, as follows, to ensure proper segregation of batteries:
    1. "STORAGE OF NEW LITHIUM BATTERIES" or "STORAGE OF EQUIPMENT CONTAINING NEW LITHIUM BATTERIES";
    2. "STORAGE OF PARTIALLY USED LITHIUM BATTERIES FOR REUSE" or "STORAGE OF EQUIPMENT CONTAINING PARTIALLY USED LITHIUM BATTERIES"; or
    3. "STORAGE OF USED LITHIUM BATTERIES AWAITING DISPOSAL".

9-2.11 Containers and Packaging. Use non-combustible storage containers, cases, and packaging. New and unused batteries should be stored in the original shipping container, original individual package containers, or equivalent packaging. For cells or batteries placed in drums, appropriate cushioning should be used in conjunction with packaging. This should not be polystyrene foam peanuts but a vermiculite-type material. This keeps shock and vibration during transit to a minimum and prevents crushing among cells and batteries as well as from the side of the container.

9-2.12 Insulated Terminals. For partially used batteries intended for reuse and batteries awaiting disposal, battery connectors or terminals shall be protected from inadvertent short circuits. Examples of protection methods include use of non-conductive tape, terminal plugs, or individual plastic bags.

9-2.13 Batteries Awaiting Disposal. All used lithium and lithium-ion batteries shall be turned in to the Hazardous Material Minimization Center (HAZMINCEN) for disposal. The HAZMINCEN shall consolidate batteries for offload as follows:

a. Establish a remote collection point and storage area for used or depleted lithium batteries awaiting disposal. Lithium batteries for disposal shall be stowed only on the weather decks or as approved by the Naval TA. Separate batteries awaiting disposal from other combustible material.

b. Package used or depleted lithium batteries awaiting disposal or lithium battery-powered equipment with batteries installed and awaiting disposal in accordance with 9-2.11. For storage on the weather decks, consideration should be given to ensure that the storage container allows pressure relief. Storage containers should be marked in accordance with 9-2.9.

c. When practical, store no more than 30 pounds of used or depleted lithium batteries awaiting disposal.

d. It is good practice to store used or depleted lithium batteries awaiting disposal for no longer than 30 days.

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

f. 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.

9-2.14 Stowage Aboard Ships or Submarines. Lithium battery stowage aboard ships or submarines shall be approved by SEA 05Z34.

9-3 HAZARDOUS WASTE STORAGE.

Storage areas for hazardous waste or used and excess HAZMAT lithium batteries shall meet the requirements and should incorporate best practices of Chapter 7 and Chapter 9. Additional guidance on environmental policies is contained in OPNAVINST 5090.1 and S9086-WK-STM-010/670.

Chapter 10
TRANSPORTATION

10-1 TRANSPORTATION BY MILITARY AIR SHIPMENT.

Requirements for the transportation of lithium batteries by military air shipment within the DoD are covered by Air Force Interservice Manual (AFMAN) 24-204/TM 38-250/NAVSUP PUB 505/MCO P4030.19/DLAI 4145.3. All transportation of lithium batteries on military aircraft shall be conducted in accordance with the regulations therein.

10-2 NEW LITHIUM BATTERIES ON PUBLIC DOMAIN.

All transportation of new lithium batteries on public highways is controlled by Federal law regulating shipment of hazardous materials. The general regulations are stated in 49 CFR 172.101 and 49 CRF 173.185. Any deviations from the methods described in the CFR shall be approved before shipment in the form of an exemption by the Office of Hazardous Material Safety Research and Special Programs Administration.

10-3 USED LITHIUM BATTERIES ON PUBLIC DOMAIN.

All transportation of used lithium batteries on public highways 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. If there is a chance for a battery to breach during transport causing electrolyte to leak, a drum liner or lined box shall be used to contain electrolyte.

10-4 TRANSPORTATION ABOARD US NAVY SURFACE SHIPS AND SUBMARINES.

Lithium battery transportation aboard US Navy surface ships and submarines shall be approved by SEA 05Z34.

10-5 TRANSPORTATION ABOARD NAVAL AIRCRAFT.

Lithium battery transportation aboard Naval aircraft shall be approved by AIR-4.4.5.

10-6 TRANSPORTATION ABOARD MSC VESSELS.

Lithium battery use, approval, and transportation aboard MSC platforms shall be approved by COMSC N7 TAg in accordance with OASRDA memorandum, Clarification of Responsibilities Between NAVSEA and MSC.

10-7 TRANSPORTATION ABOARD MARINE CORPS VEHICLES.

Lithium battery transportation aboard Marine Corps ground platforms shall be approved by MCSC 00T.

Chapter 11
DISPOSAL

11-1 GENERAL.

This chapter describes the guidelines for disposing of lithium batteries at shore facilities . Lithium batteries, regardless of chemistry or size, are managed as universal waste under the U.S. Code section 42 U.S.C. §6901. Any battery that shows evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions is managed as hazardous waste. See Appendix F for additional information on managing used or excess batteries.

11-1.1 DLADS. Lithium batteries should be turned in to the local DLADS in accordance with DoDM 4160.21 for disposal. Before initiating disposal of a lithium battery system, the local DLADS and servicing environmental compliance organization should be consulted to coordinate battery information, packaging, quantities, labeling, shipping, and tracking requirements.

11-1.2 Local Environmental Compliance Support. If the local DLADS will not accept the batteries, the servicing environmental compliance organization at the performing activity should be consulted for disposal.

11-1.3 EOD. Under certain emergency conditions, if batteries are deemed to be too hazardous for routine disposal, EOD should be contacted for immediate removal to a safe site.

11-2 DISPOSAL AT SEA.

Routine disposal of batteries at sea is prohibited per 40 CFR part 220, Subchapter H. When essential to mission needs, disposal of batteries at sea shall be included in system CONOPS and in the data package submitted for review.

11-3 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 a local DLADS, to the servicing military environmental compliance branch, or to a TAg.

Chapter 12
EMERGENCY RESPONSE PROCEDURES

12-1 MISHAP INVESTIGATION AND REPORTING.

All mishaps, near-mishaps, battery venting events, and other incidents involving lithium batteries shall be reported in accordance with the current version of OPNAVINST 5102.1. As described in 1-9.2.1 and 1-9.2.2 of this manual, reports shall also be sent to the LBSP Authority at li-batt@navy.mil, who will distribute them to the CA and the TAgs. When possible, failed batteries in an inert state and associated equipment should be retained to support failure analysis.

12-1.1 Exceptions. Lithium battery incidents occurring during deliberate and controlled testing conducted in accordance with guidance of Appendix G are excluded from this chapter.

12-2 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 for Naval shore facilities, ships, and vessels shall be followed.

12-2.1 Leaking Batteries. If a liquid is leaking from a lithium battery, use caution during cleanup. The liquid may be a strong acid or other toxic or flammable substance. In such cases, take the following measures:

a. Use Personal Protective Equipment (PPE) to approach the leaking battery. Use chemically resistant gloves when handling leaking batteries. Face masks or eye protection and chemically resistant overalls or coveralls are recommended. Under extreme conditions, respirators may be required.

b. Strong acids should be neutralized with baking soda (sodium bicarbonate) or another suitable base. To perform neutralization, cover the spill with baking soda; then layer an absorbent over the area until the liquid is completely absorbed.

c. Sweep up the absorbent and deposit in a strong doubled plastic bag. Place the bag in an appropriate waste container.

CAUTION

Do not package other batteries with a leaking lithium battery.

d. 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. Label the outside of the container as "HAZARDOUS LEAKING LITHIUM BATTERY FOR DISPOSAL."

e. 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.

f. Follow the instructions provided on the appropriate SDS.

12-2.2 Large Containers of Leaking Lithium Batteries. If there is evidence of leakage by lithium batteries in large containers, do not attempt to open or repack the original container. Take the following measures:

a. Follow the instructions provided on the appropriate SDS for the item.

b. Contact the military environmental compliance branch or DLADS for further information.

c. 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.

12-2.3 Swollen or Hot Lithium Battery. A lithium battery that shows signs of abuse, swelling, or feels hot may vent, catch fire, or explode without warning. If any lithium battery feels hot (some heating may be normal during charging, but be alert to abnormal heating), or if the case of the battery shows signs of abuse or swelling, evacuate the area and contact EOD personnel follow the instructions provided on the appropriate SDS for the item.

12-2.4 Actively Venting or Burning Lithium Batteries. If there is evidence of a venting lithium battery or a fire involving lithium batteries, including a fire in a location where lithium batteries are stored, immediately call the fire department.

a. Ensure that fire department responders know that lithium batteries are involved in the fire. Include the battery chemistry, size, and volume.

b. Secure the area.

c. Follow the instructions provided on the appropriate SDS for the item.

d. See G-3.1.6 for information on the use of water being effective against lithium battery fires.

Chapter 13
SAFETY ASSESSMENT TESTING

13-1 PURPOSE AND SCOPE.

An assessment shall be made of the capability of the proposed lithium battery to perform safely in the proposed environment (i.e., its use in a specific system or device). This chapter establishes the minimum safety assessment test requirements (number of units, types of tests, and test methods) for lithium batteries and lithium battery-powered equipment when used, charged, stored, or transported on Naval facilities, submarines, ships, vessels, and aircraft. The procedures, equipment, and pass/fail criteria for lithium battery safety tests are described in the following paragraphs. All testing should be documented with a test plan and procedure when new exceptions apply.

13-1.1 <u>Additional Tests</u>. In addition to the tests prescribed in 13-3, further tests or test modifications may be necessary for a variety of reasons.

13-1.1.1 <u>Specific End Use</u>. A given user community or a specific end use may require additional tests, such as atmosphere, heat release, and gas release characterization, aging, etc. to be added to the basic tests described to fully characterize and assess the safety behavior of the battery under expected normal conditions.

13-1.1.2 <u>Supplementary Data</u>. Unusual or unique battery or system designs or use scenarios may necessitate supplementary data to be requested, generated, or required for additional test assets and tests beyond the minimum required.

13-1.1.3 <u>New Knowledge</u>. New knowledge concerning lithium battery safety may emerge (e.g., changes in manufacturing practices, processes, variation in chemistry, new chemistries, impact of environments on battery performance, and responses to normal and extreme conditions), requiring additional tests to fully quantify new risks or hazards.

13-1.1.4 <u>Additional Test Scenarios</u>. Completion of the SSPs requirements (preliminary hazard lists, assessments, top-level hazards, and risks) in accordance with MIL-STD-882 may identify additional test scenarios that need to be assessed but are beyond the minimum required safety tests identified in this manual.

13-1.2 <u>Rationale</u>. 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 but still obtain enough data to effectively support risk assessments. These test methods represent a partial compilation of over 30 years of lithium battery safety testing experience from the DoD, other Government agencies, foreign governments, and industry.

13-1.2.1 <u>Abuses and Abusive Environments</u>. 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.

13-1.2.2 <u>Most Severe Battery Response</u>. Tests prescribed may provoke the most severe battery response to enable determinations and assessments of whether the response is acceptable based on the system and platform requirements.

13-1.2.3 <u>Battery-Level Safety Devices Bypassed or Excluded</u>. Characterization of most severe battery behavior is ensured by conducting some tests with battery-level safety devices bypassed, removed, excluded, or rendered ineffective in operation.

13-1.2.4 Maximum Credible Event (MCE) and Worst Case Event (WCE). An MCE is defined as the most severe outcome, or classes of outcomes, produced from a single point failure. These potential outcomes include generation of fragmentations, thermal conditions, and release of gases (flammable, toxic, or both) produced as a result of a single point failure. There can be a WCE for an approved battery which would create casualty conditions that exceed the safety design criteria of this document. These conditions may result in the extension of the casualty effects into the host ship. WCEs can result in the simultaneous reactions of all of the cells in a pack, but typically require multiple safety system failures to occur.

13-1.3 Abusive Test Facilities. Tests are authorized in the Navy Warfare Center building or facility location approved by the LBSP Authority and approved for lithium battery safety operations by the local Navy laboratory Commanding Officer or designee. The TAg shall approve the test plans and procedures with the concurrence of the relevant TAs, as needed. Test results and reports shall be submitted to the TAg in support of the safety evaluation performed in 3-2.4. Testing shall be performed at a test facility approved by the CA.

13-1.3.1 Test Facility Best Practices. As a minimum, the Navy Laboratory Commanding Officer or designee should consider the recommendations in Appendix G and the following test facility factors:

a. The facility shall include isolation methods to prevent detectable propagation of fragments, fumes, and flames to adjacent occupied areas and to the building structural elements not designed to withstand lithium battery abuse effects.

b. Facility operators shall minimize or eliminate flammable items in abusive test rooms during test planning and execution.

c. Risk management engineering considerations shall be documented and implemented to minimize the impact of lithium battery abuse.

d. All test operations shall be documented in procedures reviewed by Navy laboratory officials, including safety, fire, industrial hygiene, and environmental representatives independent of the lowest administrative organization element responsible for all battery test and engineering operations at the Navy laboratory.

13-2 PASSING CRITERIA CONSIDERATIONS.

An inability of a lithium battery or lithium battery-powered equipment to meet the passing criteria does not automatically prohibit the equipment from service use. The MCE for a battery or battery system is an important consideration as to whether it is acceptable for use in a given application. To fully characterize the platform-level risks, measurement of gas and heat release may be required. The complete test effort should be developed in a certification and test plan and considered prior to conducting any tests contained herein.

Venting of gas or materials from the battery or battery housing will require an evaluation of the event in terms of the platform on which it will be located. For example, submarines are enclosed and require strict atmosphere control, so an assessment of short- and long-term impacts of a gas discharge can be much more important than a similar event at a shore-based facility. The hazard posed by the event is affected by the platform constraints, the proximity of the battery to ordnance or flammable materials, the manning of the space, and other factors defined by the platform owner.

The TAg will recommend whether a formal Hazard Analysis should be completed by the system developer or if a more informal assessment of the probability and impact due to battery failure is appropriate. Risk characterization shall be conducted in accordance with NAVSEAINST 5000.8 and provided as part of the SDP per 5-1.7. The passing criteria by platform are presented in Table 13-1. SG270 applicability should be verified for all lithium batteries intended for shipboard use, maintenance, storage, or transport.

Table 13-1. Passing Criteria for Test Units by Platform

Platform	Passing Criteria
Submarines	Complete containment of all gaseous/liquid/solid material and flames from an MCE with temperatures measured below 100 °C and internal pressure below 50 percent of any venting mechanism (if present) or rupture condition is a passing condition. All other results need to be assessed under the conditions of use for risk mitigation and threat to the platform and personnel.
Aircraft[1/]	Venting of gaseous and liquid material is permitted. Venting of solid material and flames outside of the test unit is not permitted. Structural failure resulting in rupture of the test unit is not permitted. The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test. Operation of a safety mechanism designed to release pressure is permitted. All other results need to be assessed under the conditions of use for risk mitigation and threat to the platform and personnel. (1)
Ships	Complete containment of all flames from an MCE and peak pressure below 50 percent of any venting mechanism (if present) or rupture condition is a passing condition. Venting of gaseous, liquid, and solid material is permitted. Structural failure resulting in rupture of the test unit is not permitted. All other results would need to be assessed under the conditions of use for risk mitigation and threat to the platform and personnel.
Land	Venting of gaseous, liquid, and solid material and flames is permitted. Structural failure resulting in rupture of the test unit is not permitted. The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test. Operation of a safety mechanism designed to release pressure is permitted.
Naval R&D & Test Facilities	Venting or rupture of the test unit and release of toxic, flammable, or explosive gases and materials, projectiles, and fire jets is permitted. Non-expendable equipment and facility damage is maintained below the reportable threshold of MIL-STD-882 and supporting personnel are not injured.
NOTE: 1/ The location of the cell or battery in the aircraft will be closely scrutinized, especially regarding the possibility of toxic, corrosive gases affecting crew members, passengers, or high-priority equipment or systems.	

13-2.1 Test-Specific Passing Criteria. System-specific passing criteria shall be determined during the preliminary SDP review. However, the test-specific criteria in the following paragraphs exist for all applicable battery programs.

13-2.1.1 Active Non-Rechargeable Batteries. Batteries shall not vent in response to the Electrical Safety Device Test described in 13-3.5.5 or the Short Circuit Electrical Safety Device Test described in 13-3.5.6.

13-2.1.2 Thermal Batteries. Batteries shall not undergo inadvertent activation in response to environmental tests conducted in accordance with 13-3.6.1.

13-2.1.3 Liquid Reserve Batteries. Batteries shall not undergo inadvertent activation in response to environmental tests conducted in accordance with 13-3.7.1.1.

13-2.1.4 Rechargeable Batteries. Batteries shall not vent in response to the BMS and Electrical Safety Device Test described in 13-3.8.5, the high-power BMS and Electrical Safety Device Test (if applicable) described in 13-3.8.5.1, or the BMS Short Circuit Electrical Safety Device Test described in 13-3.8.6.

13-3 SAFETY TESTS.

WARNING

Safety tests can cause violent venting of batteries with deflagration and fragment hazards and release of vapor clouds of chemically active, toxic, flammable, 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.

13-3.1 Model Minimum Number of Test Units. The model set of safety characterization tests uses a minimum number of assets as its basis. The minimum number of test assets may be reduced depending on the nature and extent of the safety request being addressed. The PM shall provide the minimum number of test samples for evaluation, which is 15 assets for non-rechargeable active battery systems, 15 thermal batteries, 21 liquid reserve batteries, and 18 rechargeable batteries. These assets shall ideally be production-representative units and shall consist of an isolated battery (bare battery test), a battery (or battery complement) inside a complete system, or a battery inside sufficient system components to simulate the battery or system interactions, inclusive of rupture effects and release of corrosive or flammable fumes and gases. The final determination of the number of test units and the test configuration will be made upon review of the SDP by the cognizant TAg.

13-3.1.1 Additional Test Units. Additional test units may be required to address special battery design, equipment, or platform safety concerns.

13-3.1.2 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 in accordance with this manual or the use of previously tested batteries in new systems or applications.

13-3.1.3 Alternative Test Units. In some tests, individual cells, subsections, or partially populated batteries may be substituted as test units for large batteries. The use of alternative test units and configurations shall be justified by the PM in consultation with the designated TAg.

13-3.1.4 Multiple Use of Test Units. Test units that have been subjected to environmental compliance tests such as shock, vibration, and humidity exposure, which did not result in discharge of the battery (or when the battery can be recharged to its full capacity), may be used for safety testing. Alternate allocations of test units are possible. For example, a short-circuit test article with an expended non-removable safety device may be reused for high-temperature test evaluation, with justification.

13-3.1.5 Impact of Non-Production Test Articles. Use of non-production test articles or enclosures may require additional review and assessments by the TAgs or TA. This applies to the battery and the application enclosure if the result of the battery event to be assessed in the enclosure is a critical safety response. However, the use of non-production items may be needed to better assess the safety response and envelope of the battery and enclosures. These variations must be well-documented.

13-3.2 Test Conditions. When not specifically detailed in the tests below, all tests shall use room ambient conditions (temperature = 25±5 °C, pressure = 29±2 inches Hg, humidity (RH) = 30-90 percent). Any changes to the testing parameters require TAg and TA approval.

13-3.3 Test Preparations.

13-3.3.1 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, and a data acquisition system. All test iterations shall be documented using video recording with audio recording. These recordings will be retained for review and shall be made available upon request. Equipment providing quantitative data shall be in accordance with OPNAVINST 3960.16.

13-3.3.2 Battery Modifications. Some tests require bypass of electrical safety devices. Electrical safety devices inside cells shall not be bypassed. Electrical safety devices within the battery but outside of individual cells shall be bypassed for tests that require bypass of electrical safety devices.

13-3.4 Final Test Report. A full narrative description of each test shall be included in the final report. The test report shall be distributed as directed by the PM. Any final test report offered for LBSP review shall, at a minimum, include the following elements:

a. Introduction
b. Test method (including test sequences)
c. Sample description
d. Description of test equipment and apparatus
e. Individual test results (conditions; assets used; anomalies; and detailed responses to test conditions including photographic, schematic, or diagrammatic documentation and evidence of the test units, test unit conditions before and after the tests, test events of note, and special aspects of the test protocol used)
f. Data summary (including tabular data, graphical data, and discussion of the impact of test responses on personnel or system safety in support of MCE determination)

13-3.5 Active Non-Rechargeable Battery Tests. The following safety tests shall be completed on three test units each. Voltage, current, pressure, and temperature shall be continuously monitored and recorded, when applicable, as determined by the test engineer. The testing shall be video recorded.

13-3.5.1 Constant Current Discharge and Reversal Test. This test shall consist of a constant current discharge using a direct current (DC) 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 DC power supply shall be limited to 1.1 times the battery open circuit voltage. After the battery voltage reaches 0 volt, the discharge shall be continued into voltage reversal at the same current for a duration equivalent to 0.5 times the time required for the battery pack to reach 0 volt. The total discharge duration is defined as 1.5 times the time required for the battery pack to reach 0 volt.

13-3.5.2 Short Circuit Test. This test shall consist of shorting the battery, after all internal electrical safety devices have been bypassed, through an appropriate load to stress the battery (typically 0.02 ohm or less) and leaving the load attached for not less than 24 hours.

13-3.5.3 High-Temperature Test. This test shall consist of heating the battery pack at a rate of 10 to 20 °C rise per minute up to a temperature of 500 °C; this temperature shall be maintained until the battery vents or reactions stop. The temperature ramp rate may be revised depending on the battery pack size to ensure uniform thermal distribution. Test units may be tested with or without internal battery electrical safety devices.

13-3.5.4 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 DC power source. This test shall consist of charging the battery using a DC power supply. All internal battery electrical safety devices shall be bypassed. The battery shall be discharged to remove 0.5 times the maximum published capacity at a current equal to the fuse rating (not to exceed the maximum continuous discharge current rating). The battery shall then be charged at a current equal to the fuse value to 1.5 times circuit voltage or to the voltage of the outside source, whichever is greater.

13-3.5.5 Electrical Safety Device Test. This test shall consist of constant current discharge using a DC power supply. All electrical safety devices shall be in place and operational. The discharge shall be performed at a current equal to 85 to 90 percent of the battery pack fuse value. The voltage of the DC power supply shall be limited to 1.1 times the open circuit voltage of the battery pack. After the battery voltage reaches 0 volt, 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 time required to extract sufficient capacity for the battery or cell to reach 0 volt plus the time required to extract 1.5 times the maximum published capacity after reaching 0 volt.

13-3.5.6 Short Circuit Electrical Safety Device Test. All electrical safety devices shall be in place and operational. This test shall consist of shorting the battery through an appropriate load to stress the battery (typically 0.02 ohm or less) and leaving the load attached for not less than 24 hours.

13-3.6 Thermal Battery Tests. A program-specific battery Safety Test Plan (STP) must be approved by the designated Technical Agent prior to performing safety tests. The Navy shall have the prerogative to (1) conduct any and all safety tests, (2) to serve as the on-site safety test director, or (3) to witness any testing pursuant to determining risk exposure for battery safety certification. For safety testing at non-Navy facilities, the Navy shall be notified not less than 30 days before the start of safety testing, at which time the Navy will determine if a battery safety representative will be sent to the test facility. Prior to testing, as defined in 13-3.6.2, 13-3.6.3, 13-3.6.4, and 13-3.6.5, all batteries subject to test shall undergo environmental preconditioning to their qualification level and non-climatic environments as detailed in 13-3.6.1.

13-3.6.1 Unactivated Environmental Tests. Environmental tests (shock, vibration, Electromagnetic Interference (EMI), Electrostatic Discharge (ESD), Hazards of Electromagnetic Radiation to Ordnance (HERO), and temperature-altitude) shall be performed 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 Technical Agent approval.

13-3.6.2 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. At a minimum, this test shall continue until the discharge voltage drops below 1 percent of the peak output voltage and surface temperature has decreased to less than 50 percent of the maximum temperature measured at each point. 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, when applicable, as determined by the test engineer and TAg. Thermocouples shall be placed on a minimum of four locations on the battery: header, base, and on opposite sidewalls. The testing shall be video recorded.

NOTE

Where multi-sections (multiple output voltage and polarity) are designed for dependent or independent higher-current discharges than other output sections, these sections should be loaded at equivalent current rates to approximately 80 percent of local section fuse limits.

13-3.6.3 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 under open-circuit loads within 10 minutes after removing the battery from the conditioning chamber. At a minimum, 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 testing shall be completed on a minimum of three batteries. The testing shall be video recorded.

NOTE

If a quiescent discharge load always exists across the output(s) of the battery, these loads may be invoked and applied if shown that at least one battery subjected to an unloaded activation at the above thermal pre-condition causes a substantial thermal runaway and battery structural failure permitting substantial loss of cell-stack materials through the rupture area.

13-3.6.4 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, when applicable, as determined by the test engineer and TAg. Thermocouples shall be placed on a minimum of four locations on the battery: header, base, and on opposite sidewalls. The testing shall be video recorded.

NOTE

This test observation and discharge duration may be extended until such time as (1) the temperature monitoring indicates a return to initial ambient (maximum non-operating temperatures) or (2) the measured unloaded voltage(s) are less than 1 percent of maximum observed voltage(s) or less than 1.0 volts DC (whichever is less) to support EOD data collection when required.

13-3.6.5 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, at a minimum, battery activation, followed by discharge to 50 percent of the available rated capacity, at a rate equal to the average mission load current, followed by charging using a DC 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 applied charge voltage shall be limited to the battery open circuit voltage or the external power source voltage, whichever is greater. When conducted as a captive hang-fire test, the applied external platform power source voltage shall be set to the nominal voltage and be diode-isolated. This test shall be completed on three test units; voltage, current, battery skin temperature, and pressure shall be continuously monitored and recorded, when applicable, as determined by the test engineer and TAg. Thermocouples shall be placed on a minimum of four locations on the battery: header, base, and on opposite sidewalls. The testing shall be video recorded. The test is concluded when the battery under test no longer accepts current at a rate greater than 0.1 percent of peak charging current, or when the surface temperature of that battery falls below 50 °C.

NOTE

If a quiescent discharge load always exists across the output(s) of the battery, these loads may be invoked and applied if shown that at least one battery subjected to an unloaded activation at the above thermal pre-condition causes a substantial thermal runaway and battery structural failure permitting substantial loss of cell-stack materials through the rupture area.

13-3.7 Liquid Reserve Battery Tests.

13-3.7.1 Unactivated. The following two tests shall be performed on unactivated liquid reserve batteries.

13-3.7.1.1 Environmental Test. Environmental tests (shock, vibration, EMI, ESD, HERO, and temperature-altitude) shall be performed 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 CA approval.

13-3.7.1.2 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. The temperature ramp rate may be revised depending on the battery pack size to ensure uniform thermal distribution. 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.

13-3.7.2 Activated. The following six tests shall be performed on activated liquid reserve batteries. All tests shall be completed on three test units each. Voltage, current, pressure, and temperature shall be continuously monitored and recorded, when applicable, as determined by the test engineer and TAg. The testing shall be video recorded.

13-3.7.2.1 Constant Current Discharge and Reversal Test. This test shall consist of a constant current discharge using a DC 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 DC power supply shall be limited to 1.1 times the open circuit voltage of the battery pack. After the battery voltage reaches 0 volts, the discharge shall be continued into voltage reversal at the same current for a duration equivalent to 0.5 times the time required for the battery pack to reach 0 volts. The total discharge duration is defined as 1.5 times the time required for the battery pack to reach 0 volts.

13-3.7.2.2 Short Circuit Test. This test shall consist of bypassing all internal electrical safety devices, activating the battery, shorting the battery through an appropriate load to stress the battery (typically 0.02 ohm or less), and leaving the load attached for no less than 24 hours.

13-3.7.2.3 Open Circuit Test. This test shall consist of activating the battery into a no-load condition and allowing the battery to stand in this condition for a duration to be determined during the preliminary SDP review.

13-3.7.2.4 Electrical Safety Device 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 electric safety devices 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 0 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 time required to extract sufficient capacity for the battery or cell to reach 0 volts plus the time required to extract 1.5 times the maximum published capacity after reaching 0 volts.

13-3.7.2.5 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 0.5 times the maximum published capacity at the rate equal to 1.5 times the average mission load current. The battery shall then be charged using a DC 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.

13-3.7.2.6 High-Temperature Test. This test shall consist of heating the battery inside the unit at a rate of 10 to 20 °C rise per minute up to a temperature of 500 °C. The temperature ramp rate may be revised depending on the battery pack size to ensure uniform thermal distribution. Test units may be tested with or without internal battery electrical safety devices. This test shall be completed on three units; voltage, pressure, and current (where applicable) shall be continuously monitored and recorded. The testing shall be video recorded.

13-3.8 Rechargeable Battery Tests. As compared to non-rechargeable battery designs, for a rechargeable battery, loss of control during the recharge process and the potential for use at various rates, profiles, and temperatures drive the need for additional tests. A non-abusive and performance-based charge/discharge cycle, based upon standard nameplate capacity and including any minimum rest periods, shall be defined for each battery under test based on the manufacturer's recommended guidelines, or the actual use scenario. Cycle counts shall begin with the first discharge. This profile shall be the basis for the tests described below. Unless otherwise authorized by a cognizant Naval TA, all tests shall be conducted on three test units each. Voltage, temperature, pressure, and current (as applicable) shall be continuously monitored and recorded. The testing shall be video recorded. Unless otherwise authorized by the TAty, for those tests conducted in a sealed pressure vessel, a minimum of one test shall be conducted in open air to assess the behavior of the battery outside of containment.

13-3.8.1 Short Circuit Test. All safety devices located inside the battery but external to the cells, such as fuses, PTC Devices, diodes, charge control chips, and BMSs, 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 an appropriate load (typically 0.02 ohm or less) to electrically and thermally stress the battery under discharge and leaving the load attached for no less than 24 hours.

NOTE

Extremely high-power batteries and cells may require special low-resistance external shorts to meet the intent of the test; an external load of 50 percent or less of the DC internal resistance of the battery assembly is the intent.

13-3.8.2 Overcharge/Discharge Test. All safety devices located inside the battery but external to the cells such as fuses, PTCs, diodes, charge control chips, and BMSs shall be disabled or bypassed. Unless directed to be removed and authorized by the TA, 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 a minimum of 1.25 times the maximum charge voltage limit and discharging the unit using the standard non-abusive discharge regime; however, based on battery chemistry and design, the TA may authorize or require alternate charging criteria. For larger systems that have a dedicated charger, the test can be designed to consider those limits under normal and faulted conditions. A minimum of 20 cycles shall be conducted, unless the test unit vents, fails to accept charge, or delivers less than 25 percent of the manufacturer's published value on discharge.

13-3.8.3 Overdischarge/Charge Test. All safety devices located inside the battery but external to the cells such as fuses, PTCs, diodes, charge control chips, and BMSs 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. The total discharge duration is defined as 1.25 times the time required for the battery pack to deliver 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 percent of the manufacturer's published value on discharge.

13-3.8.4 High-Temperature Test. Unless otherwise authorized by the TA, this test shall consist of heating the fully charged battery pack at a rate of 10 °C to 20 °C rise per minute up to a temperature of 500 °C; this temperature shall be maintained until the battery vents or reactions stop. The temperature ramp rate may be revised depending on the battery pack size to ensure uniform thermal distribution. Test units may be tested with or without internal battery electrical safety devices.

13-3.8.5 Battery Management System and Electrical Safety Device Test. This test shall consist of charging and discharging the test unit at the maximum output rate of the designated charging source or at the maximum charge acceptance rate for the test unit. If no unique, dedicated voltage/current limited charging source is used, or if the device may be charged by general test or maintenance devices, then the battery shall be charged using a minimum setting of 1.25 times the maximum charge voltage limit until the current has decreased by 95 percent; then, the battery shall be discharged at the maximum sustainable output rate for 1.25 times the maximum published capacity of the battery. All safety devices shall be in place and operational; no bypassing of electrical or thermal fuses is intended. In the event that a resettable battery safety device trips prior to completing the test, resume testing as soon as the device resets. A minimum demonstration of BMS electrical safety for the test unit is completion of 10 cycles. If required by the TA, 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, until the test unit or any cell in the test unit vents, fails to accept charge, or delivers less than 25 percent of the manufacturer's published value on discharge during any test iteration. For larger systems that have a dedicated charger, the test may be designed to consider those limits under normal and faulted conditions.

13-3.8.5.1 High Power BMS and Electrical Safety Device Test. In cases in which high power batteries are implemented (i.e., designed for use at a discharge current greater than 4.0 times the published capacity of the battery divided by 1 hour), to induce realistic stresses on the BMS and safety devices, the test system for the test of 13-3.8.5 shall be constructed to simulate the end application, including the introduction of inductive voltage spikes caused by rapid interruption of high current flow. The test system shall create voltage transients that are representative of the end application. Unless otherwise specified by the TA, the test unit shall be exposed to one voltage transient at 2.0 times the battery voltage within 1 minute of discharge initiation per discharge and one voltage transient at 2.0 times the battery voltage within 1 minute of charge initiation per charge. Application-specific analysis can inform modifications to these test requirements.

13-3.8.6 BMS Short Circuit Electrical Safety Device Test. All electrical safety devices shall be in place and operational. Unless otherwise directed by the TA, this test shall consist of shorting the battery through an appropriate load to stress the battery (typically 0.02 ohm or less) and leaving the load attached for not less than 24 hours. Where practical, this test may be conducted in combination with that of 13-3.8.1, with a sequential elimination of protective devices and BMS assemblies and "layers" until unprotected battery assemblies have completed the short circuit tests of 13-3.8.1.

13-3.9 Propagation Test (Applicable to Rechargeable and Non-Rechargeable Batteries). Propagation tests are conducted to determine the effects of a critical failure of one cell to neighboring cells. When applicable as determined by the test engineer, the test shall be conducted in a fashion that simulates the real system's physical constraints (cell spacing and orientation, free volume, packing material, wiring, etc.). Multiple methods can be used to initiate the first cell failure, including, but not limited to internal short (as built in by the original equipment manufacturer's process), localized thermal abuse (to minimize the heating of neighboring cells prior to first cell failure), overcharge, or external short or puncture. If required to, initiate the test, electrical safety devices shall be bypassed. The Preliminary Hazards Analysis and CONOPs for the system should be evaluated to determine the best triggering event. Less than full-up battery tests or system tests may be conducted to understand the potential hazards from thermal, electrical, and mechanical effects of a propagation event prior to testing in an all-up platform and enclosures.

13-3.10 Heat Release. As indicated in 13-1.1.2, a measure of the heat released during a thermal runaway event may be required depending on system design and/or use scenario. When deemed necessary, heat release shall be measured using the principle of oxygen-consumption calorimetry with calorimeter instrumentation designed in accordance with UL 2043, or equivalent as approved by the NTA. Heat release data should be captured from the most severe thermal runaway event observed to provide conservatism in the results. At a minimum, measures of average, peak, and total heat release should be collected and reported.

13-3.11 Gas Release. As indicated in 13-1.1.2, a measure of the combustible, toxic, corrosive gas released during a thermal runaway event may be required depending on system design or use scenario. When deemed necessary, gas release shall be measured in real time and in a manner that allows cumulative constituent release volumes to be calculated. The minimum suite of gases that should be collected include oxygen, carbon dioxide, carbon monoxide, and combustible gas. Additional toxic and corrosive gases that are expected based on specific battery chemistry and/or system configuration should be characterized using appropriate laboratory gas sampling techniques, as needed. At a minimum, measures of average and peak concentrations as well as total constituent volume released should be collected and reported.

APPENDIX A
LIST OF ACRONYMS AND DEFINITIONS

A-1 LIST OF ACRONYMS.

This appendix contains definitions of terms and abbreviations related to lithium batteries and the Naval LBSP. Not all definitions listed are used in this document, but they may prove useful in understanding the subject matter.

ACRONYM	TITLE
Ah	Ampere-hour
BMS	Battery Management System
C	Celsius
CA	Certification Authority
CFR	Code of Federal Regulations
CNO	Chief of Naval Operations
COE	Certificate of Equivalency
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
CP	Certification Plan
DC	Direct Current
DCA	Damage Control Assistant
DCC	Damage Control Central
DLADS	Defense Logistics Agency Disposition Services
DoD	Department of Defense
EMI	Electromagnetic Interference
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
ESD	Electrostatic Discharge
F	Fahrenheit
HERO	Hazards of Electromagnetic Radiation to Ordnance
IPR	Initial Procurement Report
LBSP	Lithium Battery Safety Program
LFORM	Landing Force Operational Reserve Material
LQHUW	Large Quantity Handler of Universal Waste

ACRONYM	TITLE
MCE	Maximum Credible Event
MCSC	Marine Corps Systems Command
MSC	Military Sealift Command
NAVAIR	Naval Air Systems Command
NAWC-AD	Naval Air Warfare Center Aircraft Division
NAVSEA	Naval Sea Systems Command
NOSSA	Naval Ordnance Safety and Security Activity
PM	Program Manager
PPED	Personally Procured Electronic Device
PTC	Positive Thermal Coefficient
RMF	Risk Management Framework
SDP	Safety Data Package
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SQHUW	Small Quantity Handler of Universal Waste
SSP	System Safety Program
SYSCOM	Systems Command
TAg	Technical Agent
TWH	Technical Warrant Holder
Wh	Watt-hour
WCE	Worst Case Event

A-2 LIST OF DEFINITIONS.

TERM	DEFINITION
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.
Active Battery	A battery that 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.
Anode	The electrode in an electrochemical cell where oxidation takes place. During discharge, the anode is the negative electrode in a cell. Typical anodes are reactive metals, alloys, and supporting matrices containing lithium.

TERM	DEFINITION
Battery	An assembly of electrochemical cells connected in an appropriate series or parallel arrangement to provide the required operating voltage and current levels, which has been packaged for use, including, if any, ancillary components (fuses, diodes), case, terminals, and markings.
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. A BMS variant that only collects and displays battery data is known as a Battery Monitoring System.
Battery String	One or more cells connected in series to reach a desired voltage. It may not provide the full current supply or energy capacity needed for normal operations. Parallel strings may be needed to meet these mission requirements.
Bleeder Resistor	A resistor installed in a reserve battery that will discharge the battery at an appropriate rate should the battery be inadvertently activated.
Cathode	The electrode in an electrochemical cell where reduction takes place. During discharge, the cathode is the positive electrode in a 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, non-reactive 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.
Certification Authority (CA)	An individual designated to determine the safety suitability for lithium batteries developed or procured by all activities within their Systems Command structure.
Certification Plan (CP)	For large or complex battery systems that involve multiple TAs or development activities. The CP documents the safe design strategies, the safety testing required, and risk mitigations. The CP is drafted by the PM, concurred to by the TA, and approved by the CA.
Charge/Discharge Methods	The method used to charge or discharge a battery. The most common methods are constant current, constant voltage, constant power, and pulse current.
Cycle Life	The number of discharge/charge cycles expected from the battery before battery performance drops below minimum standards.
Depleted Battery	A battery that has been discharged to the recommended minimum voltage or capacity.
Depth of Discharge	A measure of the capacity removed from a battery compared to its rating.

TERM	DEFINITION
Diode	A semiconductor device that 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.
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.
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; for example, salts or acids, such as potassium hydroxide or sulfuric acid, in a poor/non-conductive solvent such as water. Non-liquid examples are polyethylene oxide 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.
Energy Density	The quantity of energy stored by a battery per unit weight or unit volume. Typical units include watt-hours per kilogram or watt-hours per liter. To be most useful, energy densities shall 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 4 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.
Large High-Severity Impact Lithium Battery	A primary or rechargeable lithium battery that packs over 1 kWh total energy content, or battery powered systems with total battery energy over 2 kWh.
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, as in the lithium-ion battery.
Lithium Battery Safety Program (LBSP) Authority	An individual, delegated responsibility by NAVSEA, the organization assigned by the Chief of Naval Operations, charged with lithium battery safety within the DON.

TERM	DEFINITION
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 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.
Maximum Credible Event (MCE)	The most severe outcome, or classes of outcomes, produced from a single point failure. These potential outcomes include generation of fragmentations, thermal conditions, and release of gases (flammable, toxic, or both) produced as a result of a single point failure.
Mishap	An event or series of events resulting in unintentional death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.
Near-Mishap	An event, including the use of an unplanned control, which had the potential to affect other commands, including the potential for unintentional death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.
Nominal Rated Capacity	The manufacturer's advertised capacity at a given current under ambient conditions.
Nominal Voltage	The voltage at which a cell or battery is designed to operate, usually the manufacturer's advertised voltage at ambient conditions.
Positive Thermal Coefficient (PTC) Device	A polymeric or ceramic element that 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 or vibration. (Verb) The process of surrounding the individual cells in a battery with a material designed to immobilize and support the battery contents.
Primary Battery	A battery that is designed to be discharged only once; i.e., it is NOT designed to be recharged. Also called a non-rechargeable battery.
Program Manager (PM)	For the purposes of this technical manual, anyone seeking to purchase or use a lithium battery in a specific system or device in a naval environment.
Reserve Battery	A battery 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. Due to the added expense of manufacture and reduced energy density, generally reserve systems are specially developed for the application in which they will be used. The two main categories of lithium reserve batteries are liquid reserve and thermal batteries.

TERM	DEFINITION
Room Ambient Conditions	Temperature = 25±5 °C, pressure = 29±2 inches Hg, humidity (RH) = 30-90 percent.
Safety Critical	A term applied to a condition, event, operation, process, or item whose mishap severity consequence is either Catastrophic or Critical (e.g., safety-critical function, safety-critical path, and safety-critical component).
Safety Data Package (SDP)	A collection of information about a battery and the system it will be used in. The required elements of an SDP are listed in 2-3 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.
Service Life	The service life of a battery, battery module, or battery cell starts at cell activation and continues through all subsequent fabrication, acceptance testing, handling, storage, transportation, testing, and mission operations until battery replacement or system deactivation.
State of Charge	A measure of the capacity retained in a battery compared to its rating.
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.
Technical Agent (TAg)	A technical expert for lithium battery safety designated by the LBSP Authority.
Technical Authority	A subject matter expert for a technical area as designated by a Systems Command.
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 that is built into the battery and 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.
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.

TERM	DEFINITION
Vent	(Noun) Most cells and batteries contain a 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 that 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 that 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.
Worst Case Event (WCE)	There can be a WCE for an approved battery, which would create casualty conditions that exceed the safety design criteria of this document, resulting in extension of the casualty effects into the host ship. WCEs can result in the simultaneous reactions of all of the cells in a pack but typically require multiple safety system failures to occur.

APPENDIX B
REFERENCE DOCUMENTS

B-1 INTRODUCTION.

This appendix contains a list of documents containing all types of information referenced in this manual. These documents, together with ship (station) instructions and notices, technical publications, and SOPs, shall be maintained in appropriate libraries as a collection of current information pertaining to lithium battery safety.

B-2 GOVERNMENT DOCUMENTS.

DEPARTMENT OF DEFENSE MANUALS

DoDM 4160.21, Volume 1 - Defense Materiel Disposition

Copies of this document are available online at www.esd.whs.mil/DD/.

NAVAL AIR SYSTEMS COMMAND (NAVAIR) GUIDANCE

NAVAIR STANDARD WORK PACKAGE (SWP) SWP 4452-010 - Lithium Battery Safety Certification

Copies of this document are available online at https://myteam.navair.navy.mil/air/44/swp/SWP%20Documents/Forms/AllItems.aspx.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) INSTRUCTIONS

NAVSEAINST 5000.8 - Naval SYSCOM Risk Management Policy

NAVSEAINST 9310.1 - Naval Lithium Battery Safety Program

Copies of these documents are available online at www.navsea.navy.mil.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

SG270-BV-SAF-010 - High-Energy Storage System Safety Manual

S9086-S3-STM-010/555 - NSTM Chapter 555, Volume 1, Surface Ship Firefighting

S9086-WK-STM-010/670 - NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables

Copies of these documents are available online via Technical Data Management Information System (TDMIS) at https://mercury.tdmis.navy.mil/ by searching for the document number without the suffix. Refer questions, inquiries, or problems to: DSN 296-0669, Commercial (805) 228-0669. These documents are available for ordering (hard copy) via the Naval Logistics Library (NLL) at https://nll.navsup.navy.mil. For questions regarding the NLL, contact the NLL customer service at nllhelpdesk@navy.mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.

NAVAL ORDNANCE SAFETY AND SECURITY ACTIVITY (NOSSA) INSTRUCTIONS

NOSSAINST 9310 - Lithium Battery Safety Program Requirements for Ordnance and Weapon Systems

Copies of this document are available at www.navsea.navy.mil.

MILITARY SEALIFT COMMAND (MSC) PUBLICATIONS

Office of the Assistant Secretary of the Navy, Research, Development and Acquisition, Memorandum for Distribution dated 21 January 2009, Clarification of Responsibilities Between NAVSEA and MSC

Copies of these documents are available online at www.navsea.navy.mil.

OPNAV INSTRUCTIONS

OPNAVINST 3960.16	-	Navy Test, Measurement, and Diagnostic Equipment
OPNAVINST 5090.1	-	Environmental Readiness Program Manual
OPNAVINST 5100.19		Navy Safety and Occupational Health Program Manual for Forces Afloat
OPNAVINST 5102.1	-	Navy and Marine Corps Mishap and Safety Investigation, Reporting and Record Keeping Manual

Copies of these documents are available online at https://www.secnav.navy.mil/doni/default.aspx.

SECNAV MANUALS

SECNAV M-5216.5	-	Department of the Navy Correspondence Manual

Copies of these documents are available online at https://www.secnav.navy.mil/doni/default.aspx.

B-3 STANDARDIZATION DOCUMENTS.

DEPARTMENT OF DEFENSE HANDBOOKS AND SPECIFICATIONS

MIL-HDBK-61	-	Configuration Management Guidance
MIL-N-24408	-	Nozzles, Fire Hose, Combination Aqueous Film Forming Foam, Water Spray, Adjustable Pattern (Shipboard Use)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-648	-	Specialized Shipping Containers
MIL-STD-882	-	System Safety
MIL-STD-3020	-	Fire Resistance of U.S. Naval Surface Ships

Copies of these documents are available online at https://quicksearch.dla.mil.

B-4 FEDERAL REGISTER.

CODE OF FEDERAL REGULATIONS (CFR)

Title 29	-	Labor
Title 40	-	Protection of Environment
Title 49	-	Transportation

Copies of these documents are available online at www.ecfr.gov.

B-5 JOINT SERVICE DOCUMENTS.

DLAD 4145.41/AR 700-143/ AFJI 24-210/ NAVSUPINST 4030.55/ MCO 4030.40	-	Packaging of Hazardous Material

Copies of these documents are available online at https://safety.army.mil/ON-DUTY/Workplace/Hazardous-Materials-HAZMAT.

AFMAN 24-204/ TM 38-250/ NAVSUP Pub 505/ MCO P4030.19/DLAI 4145.3	-	Transportation Preparing Hazardous Materials for Military Air Shipments

Copies of these documents are available online at www.e-publishing.af.mil.

B-6 UNIFIED FACILITIES CRITERIA (UFC).

3-520-05	-	Stationary Battery Areas
3-600-01	-	Fire Protection Engineering for Facilities

Copies of these documents are available online at www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc.

B-7 PRODUCT DATA REPORTING AND EVALUATION PROGRAM DOCUMENTS.

NAVSO P-3683	-	Navy and Marine Corps Product Data Reporting and Evaluation Program (PDREP) Manual

Copies of this documents are available online at https://www.pdrep.csd.disa.mil/.

B-8 NON-GOVERNMENT DOCUMENTS.

INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO)

ISO 10007	-	Quality Management - Guidelines for Configuration Management

Copies of this document are available online www.iso.org.

APPENDIX C
POINTS OF CONTACT AND ADDRESSES

C-1 TAgs.

The LBSP TAgs are:

Commander
Naval Surface Warfare Center, Carderock Division
Attn: Code 636
Bldg. 11
9500 MacArthur Boulevard
West Bethesda, MD 20817-5700
POC: Ms. Julie Simmons, DSN 287-1853, commercial 301-227-1853, or email: julie.simmons@navy.mil

Commander
Naval Surface Warfare Center, Crane Division
Attn: JXM Bldg. 3235
300 Highway 361
Crane, IN 47522-5000
POC: Mr. Mark Tisher, DSN 482-5912, commercial 812-854-5912, or email: mark.tisher@navy.mil

C-2 DEPARTMENT OF NAVY LBSP AUTHORITY.

The designated LBSP Authority is:

Commander, Naval Sea Systems Command
Attn: SEA 05Z34
1333 Isaac Hull Ave SE
Washington Navy Yard, DC 20376
POC: Ms. Tamera Barr, DSN 326-5042, commercial 202-781-5042, or email: tamera.barr@navy.mil

C-3 CERTIFICATION AUTHORITY.

C-3.1 Naval Forces Afloat. The designated CA for lithium battery design and suitability for Naval Forces Afloat is:

Commander, Naval Sea Systems Command
Attn: SEA 05Z34
1333 Isaac Hull Ave SE
Washington Navy Yard, DC 20376
POC: Ms. Tamera Barr, DSN 326-5042, commercial 202-781-5042, or email: tamera.barr@navy.mil

C-3.2 Naval Aviation. The designated CA for lithium battery design suitability for Naval Aircraft platform concurrence is:

Commander
Naval Air Systems Command
Attn: AIR 4.4.5
48298 Shaw Road, Building 1461
Patuxent River, MD 20670
POC: Mr. Nathan Kumbar, commercial 301-342-0800, or email: nathan.kumbar@navy.mil

C-3.3 MCSC. For systems procured for Marine Corps expeditionary applications, the designated CA for lithium battery design suitability is:

Commanding Officer
Marine Corps Systems Command
Attn: Code 00T
2200 Lester Street
Quantico, VA 22134
POC: Mr. Tripp Elliott, commercial 703432-4978, or email: kenneth.m.elliott@usmc.mil

C-4 TECHNICAL AUTHORITY.

C-4.1 Naval Forces Afloat. The designated TA for lithium battery design and suitability for Naval Forces Afloat is:

Commander, Naval Sea Systems Command
Attn: SEA 05Z34
1333 Isaac Hull Ave SE
Washington Navy Yard, DC 20376
POC: Ms. Liz Donohue, commercial 202-781-0525, or email: elizabeth.donohue@navy.mil

C-4.2 Naval Aviation. The designated TA for lithium battery design suitability for Naval Aircraft platform concurrence is:

Commander
Naval Air Systems Command
Attn: AIR 4.4.5
48298 Shaw Road, Building 1461
Patuxent River, MD 20670
POC: Mr. Douglas Harmon, commercial 301-342-0833, or email: douglas.harmon@navy.mil

C-4.3 Marine Corps Systems Command. For systems used by the Marine Corps, the designated TA for lithium battery design suitability is:

Commanding Officer
Marine Corps Systems Command
Attn: Code 00T
2200 Lester Street
Quantico, VA 22134
POC: Mr. Tripp Elliott, commercial 703-432-4978, or email: kenneth.m.elliott@usmc.mil

C-4.4 MSC. For systems transported or used on MSC platforms, the designated TA for lithium battery design suitability is:

Commander
Military Sealift Command
Attn: N7
471 E. C Street, Building SP-64
Norfolk, VA 23511-2419
POC: Mr. Matthew Matson, commercial 757-500-1564, or email: matthew.s.matson@navy.mil

C-5 OTHER REFERENCED POINTS OF CONTACT.

C-5.1 Approved Packaging.

Director
Naval Surface Warfare Center Indian Head Division Technical Detachment
Attn: G13
Naval PHST Center
458 Whittimore Ave
Picatinny Arsenal, NJ 07806
POC: Mr. Michael Kelly, DSN 449-2821, commercial 973-724-3388, or email: michael.l.kelly@navy.mil

C-5.2 Transportation of Lithium Batteries.

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration
East Bldg, 2nd Floor
1200 New Jersey Avenue SE
Washington, DC 20590
http://www.phmsa.dot.gov

C-5.3 Technical Management Deficiency Evaluation Reports (TMDERs).

Commander
Naval Surface Warfare Center
Port Hueneme Division
Attn: Code 312
4363 Missile Way,
Port Hueneme, CA 93043-4307
https://nsdsa2.phdnswc.navy.mil

C-5.4 Requests for Copies, Distribution Changes.

Naval Surface Warfare Center Crane Division
C-JXMT B-3287
300 Highway 361
Crane, IN 47522-5040
POC: Mr. Brett Estes, commercial 812-854-6551, or email: brett.estes@navy.mil

APPENDIX D
SAMPLE REQUEST LETTER

D-1 INTRODUCTION.

This appendix provides, as Figure D-1, an example of a letter requesting lithium battery safety review. Such request letters shall be submitted early in the program acquisition process by the PM of systems or equipment using lithium cells and batteries.

D-2 REQUEST FOR SAFETY REVIEW.

Requests for safety review shall be submitted by the PM to one of the TAgs for Lithium Batteries. The letter shall address the elements of 2-3.

077 (or correct system SSIC)
PMX PDQ Ser NUMBER
DATE

From: Program Manager for NAME SYSTEM
To: Commander, Crane Division, Naval Surface Warfare Center (JXM) ***or***
Commander, Carderock Division, Naval Surface Warfare Center (636)

Subj: SAFETY REVIEW OF LITHIUM BATTERY CONTAINED IN THE NAVY (NAME) SYSTEM

Ref: (a) NAVSEA S9310-AQ-SAF-010
(b) NAVSEAINST 9310.1

Encl: (1) Battery Safety Data Package for (NAME) system

1. (Program Manager office) requests that the (appropriate Certification Authority) provide certification for use of the (model or part number) battery as used in the (NAME) system in accordance with reference (a) as required by reference (b). A safety data package describing the battery and the system in which it is used is included as enclosure (1) for review by the Technical Agent.

2. BRIEFLY DESCRIBE THE BATTERY AND THE SYSTEM, WHO WILL BE USING IT, WHERE IT WILL BE USED … (i.e., the (model or part number) Battery used in the NAME system is a lithium/thionyl chloride battery manufactured by ABCDE Battery Manufacturers, Inc.) The battery is a ten-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 4.0 amp-hours (approximately two times the capacity of a bobbin construction “AA” $Li/SOCl_2$ cell). The manufacturer’s rated capacity is 3.80 amp-hours under a 0.5-ampere load at room temperature. Limited safety testing has been conducted on the (model or part number) battery in support of the (NAME) system. These results are included in the enclosed data package.

3. (Program Manager office) requests a response be returned by (date you need to know whether to fund additional safety tests). Any questions concerning this letter should be addressed to (POC, phone number, email, fax number…).

<digital or analog signature>
NAME OF SIGNER
By direction

Figure D-1. Sample Letter Requesting Safety Review of Lithium Battery.

APPENDIX E
INITIAL PROCUREMENT REPORT REQUIREMENTS

E-1 GENERAL.

Lithium batteries meeting the criteria of 4-2 are approved for all uses and do not require individual testing and review by the CA contact. However, these batteries do require an initial procurement report, which shall be submitted via email to Li-Batts@navy.mil. The following information shall be included in the initial procurement report:

a. Subject: Initial Procurement Report for [name of device, system, or TEMPALT]

b. Manufacturer/brand name of the device and battery

c. Model identification (name and number) of the device and battery

d. UL file number, or equivalent marking/listing for third-party testing

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

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

APPENDIX F
ENVIRONMENTAL REQUIREMENTS FOR MANAGEMENT OF USED/EXCESS BATTERIES

F-1 INTRODUCTION.

Environmental compliance in the management of battery disposal should be accomplished by the servicing environmental compliance organization at the performing activity. The following information is provided for information only.

F-1.1 Types of Hazardous Waste Covered by Universal Waste Rule. The U.S. Environmental Protection Agency (EPA) established requirements for the management of used lithium batteries under the Universal Waste Rule. The rule establishes an alternative set of management standards applicable to a set of widely generated hazardous wastes. These standards can be used in lieu of the management requirements already in place for all other hazardous wastes. The requirements under the rule are easier for a waste generator to comply with than the requirements under the general hazardous waste laws. Four types of wastes are covered under the universal waste regulations: hazardous waste batteries, hazardous waste pesticides that are either recalled or collected in waste pesticide collection programs, mercury-containing equipment designated as waste, and hazardous waste lamps. These four types of hazardous wastes share several characteristics related to their proper management:

a. They are frequently generated in a wide variety of settings other than the industrial settings usually associated with hazardous wastes;

b. They are generated by a vast community, the size of which imposes implementation difficulties for both those who are regulated and the regulatory agencies charged with implementing the hazardous waste program; and

c. They may be present in significant volumes in non-hazardous waste management systems.

F-1.2 Determination of Applicability of Rule to Lithium Batteries. The requirements for the management of lithium batteries (to include all primary [non-rechargeable] and secondary [rechargeable], active, thermal, and reserve lithium batteries, including "lithium-ion" batteries) as hazardous waste under the universal waste rule are set forth in 40 CFR 273. Not all lithium batteries that are "used" or no longer wanted are hazardous waste. However, the EPA determined that there was insufficient data available to make a broad generalization about whether various battery types are always or never hazardous; nor did they have the resources to perform sufficient testing. Therefore, it is up to the generator of the waste batteries to determine if the batteries are hazardous (i.e., are a listed hazardous waste or exhibit one or more characteristics of hazardous waste in accordance with 40 CFR 261) and subject to the hazardous waste regulations. The universal waste regulations are relatively simple for a generator to comply with and it may be easier and more efficient to manage all lithium batteries under the Universal Waste Rule rather than trying to determine if a specific battery is hazardous waste.

F-2 UNIVERSAL WASTE RULE APPLICABILITY.

F-2.1 Rule. A used battery becomes waste on the date it is discarded (e.g., when sent for reclamation). An unused battery becomes waste on the date the handler decides to discard it.

F-2.2 Universal Waste Participants. There are four types of participants in the universal waste system.

a. Small quantity handler of universal waste (SQHUW)

b. Large quantity handler of universal waste (LQHUW)

c. Transporter of universal waste

d. Destination facilities (recyclers or treatment/disposal)

F-2.3 Naval Installations. Naval installations will generally be either an SQHUW or an LQHUW. Non-naval entities will normally perform the transportation and final disposition (destination facility) of lithium batteries; therefore, this appendix does not address the requirements for these tasks. Information for requirements related to transporters is in 40 CFR 273.50. Information for requirements related to destination facilities is in 40 CFR 273.60.

F-2.3.1 SQHUW. An SQHUW does not accumulate 5,000 kilograms (11,000 pounds) or more total (all universal waste categories combined) of universal waste at their location at any time.

F-2.3.2 LQHUW. An LQHUW accumulates 5,000 kilograms or more total (all universal waste categories combined) of universal waste at any time. This designation as a large quantity handler of universal waste is retained through the end of the calendar year in which 5,000 kilograms or more total of universal waste is accumulated, at any one time.

F-2.4 Designation. The designation of SQHUW or LQHUW is based on the total quantity of universal waste generated or handled at an installation. This total includes the quantity of lithium batteries subject to the universal waste rule and the quantity of other hazardous wastes managed under the universal waste rule (other batteries, pesticides, mercury-containing equipment, and lamps). Shops generating waste lithium batteries shall notify the installation's Environmental Office to inform them of their activities so that the universal waste handler status can be appropriately established.

F-2.5 Handler Classifications. There are two further classifications of handlers of universal waste, regardless of whether they are SQHUWs or LQHUWs.

a. The first type of handler is a person who generates or creates universal waste. This is a person who uses batteries and who eventually decides that they are no longer usable and, thus, are waste.
b. The second type of handler is a person who receives universal waste from generators or other handlers; consolidates the waste; and then sends it on to other handlers, recyclers, or treatment/disposal facilities.

F-2.6 Universal Waste Handlers. Universal waste handlers accumulate universal waste but do not treat, recycle, or dispose of the waste. Each naval activity or installation that generates or collects used and excess lithium batteries is considered a handler of universal waste and a single location.

F-3 REQUIREMENTS.

F-3.1 Identical Requirements. The requirements for the following topic areas are the same for SQHUWs and LQHUWs:

a. Prohibitions
b. Waste Management
c. Labeling/Marking
d. Accumulation Time Limits
e. Response to Releases
f. Off-Site Shipments
g. Exports

F-3.2 Differing Requirements. The requirements for the following topic areas depend on whether the generator is SQHUWs or LQHUWs:

a. Notification
b. Employee Training
c. Tracking Universal Waste Shipments

F-3.3 Prohibitions. SQHUWs and LQHUWs are prohibited from disposing (final disposition performed by a destination facility) of universal waste. The hazardous waste lithium batteries shall be sent to another universal waste handler or to a destination facility. They are also prohibited from diluting or treating universal waste, except by responding to releases as provided in F-3.7 or by managing specific wastes as provided in F-3.4.

F-3.4 Waste Management. SQHUWs and LQHUWs shall manage universal waste batteries in a way that prevents releases of any universal waste or component of a universal waste to the environment, as follows:

a. Any universal waste battery that shows evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions shall be stored in a container. The container shall be closed, structurally sound, compatible with the contents of the battery, and shall lack evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions.

b. As long as the casing of each individual battery cell is not breached and remains intact and closed (except that cells may be opened to remove electrolyte, but shall be immediately closed after removal), the following activities may be conducted.

   1) Sorting batteries by type
   2) Mixing battery types in one container
   3) Discharging batteries so as to remove the electric charge
   4) Regenerating used batteries
   5) Disassembling batteries or battery packs into individual batteries or cells
   6) Removing batteries from consumer products, or
   7) Removing electrolyte from batteries

c. A small quantity handler and a large quantity handler of universal waste who removes electrolyte from batteries, or who generates other solid waste (e.g., battery pack materials, discarded consumer products) as a result of the activities listed above, shall determine whether the electrolyte or other solid waste exhibit a characteristic of hazardous waste identified in 40 CFR 261 Subpart C.

   1) If the electrolyte or other solid waste exhibit a characteristic of hazardous waste, it is subject to all applicable requirements of 40 CFR 260 through 272. The handler is considered the generator of the hazardous electrolyte or other waste and is subject to 40 CFR 262.
   2) If the electrolyte or other solid waste is not hazardous, the handler may manage the waste in any way that is in compliance with applicable federal, state, or local solid waste regulations.

F-3.5 Labeling/Marking. SQHUWs and LQHUWs shall label or mark the universal waste batteries in the following manner: Each individual universal waste battery, or a receptacle in which a number of batteries are contained, shall be labeled or marked clearly with one of the following phrases: “Universal Waste – Battery(ies)”, “Waste Battery(ies),” or “Used Battery(ies).”

F-3.6 Accumulation Time Limits.

F-3.6.1 1-Year Limit. SQHUWs or LQHUWs may accumulate universal waste for no longer than one year from the date the universal waste is generated or received from another handler, unless the requirements of F-3.6.2 are met.

F-3.6.2 Past 1-Year Limit. An SQHUW or LQHUW may accumulate universal waste for longer than 1 year from the date the universal waste is generated or received from another handler, if such activity is solely for the purpose of accumulating such quantities of universal waste as necessary to facilitate proper recovery, treatment, or disposal. However, the handler bears the burden of proving the purpose of such activity.

F-3.6.3 Documenting Length of Time. The requirements for the following topic areas depend on whether the generator is an SQHUW or an LQHUW. An SQHUW or LQHUW who accumulates universal waste shall be able to demonstrate the length of time that the waste has been accumulated, which includes the date it becomes a waste or is received. The handler may make this demonstration by:

a. Placing the universal waste in a container and marking or labeling the container with the earliest date that any universal waste in the container became a waste or was received;

b. Marking or labeling each individual item of universal waste (e.g., each battery or thermostat) with the date it became a waste or was received;

c. Maintaining an inventory system on-site that identifies the date each universal waste became a waste or was received;

d. Maintaining an inventory system on-site that identifies the earliest date that any universal waste in a group of universal waste items or a group of containers of universal waste became a waste or was received;

e. Placing the universal waste in a specific accumulation area and identifying the earliest date that any universal waste in the area became a waste or was received; or

f. Any other method that clearly demonstrates the length of time that the universal waste has been accumulated from the date it becomes a waste or is received.

F-3.7 Response to Releases.

F-3.7.1 Containment. An SQHUW or LQHUW shall immediately contain all releases of universal wastes and other residues from universal wastes.

F-3.7.2 Hazardous Waste Determination. An SQHUW or LQHUW shall determine whether any material resulting from the release is hazardous waste, and if so, shall manage the hazardous waste in compliance with all applicable requirements of 40 CFR 260 through 272. The handler is considered the generator of the material resulting from the release and shall manage it in compliance with 40 CFR 262.

F-3.8 Off-Site Shipments.

F-3.8.1 Prohibitions. An SQHUW or LQHUW is prohibited from sending or taking universal waste to a place other than another universal waste handler, a destination facility, or a foreign destination.

F-3.8.2 Transporter Role. If an SQHUW or LQHUW self-transports universal waste off-site, the handler becomes a universal waste transporter for those self-transportation activities and shall comply with the requirements for universal waste transporters while transporting the universal waste.

F-3.8.3 Preparation for Shipping. If a universal waste being offered for off-site transportation meets the definition of hazardous materials under 49 CFR 171 through 180, an SQHUW or LQHUW shall package, label, mark, placard the shipment, and prepare the proper shipping papers in accordance with the applicable Department of Transportation regulations under 49 CFR 172 through 180.

NOTE

A Hazardous Waste Manifest, normally required by the EPA for hazardous waste shipments, is not required for the shipment of universal waste.

F-3.8.4 Agreements. Prior to sending a shipment of universal waste to another universal waste handler, the originating handler shall ensure that the receiving handler agrees to receive the shipment.

F-3.8.5 Shipment Rejection. If an SQHUW or LQHUW sends a shipment of universal waste to another handler or to a destination facility and the shipment is rejected by the receiving handler or destination facility, the originating handler shall either:

a. Receive the waste back when notified that the shipment has been rejected, or

b. Agree with the receiving handler on a destination facility to which the shipment will be sent.

F-3.9 Exports. An SQHUW or LQHUW who sends universal waste to a foreign destination other than to Organization for Economic Co-operation and Development countries shall:

a. Comply with the requirements applicable to a primary exporter in 40 CFR 262.53, 262.56(a)(1) through (4), (6), and (b), and 262.57.

b. Export such universal waste only upon consent of the receiving country and in conformance with the EPA Acknowledgement of Consent as defined in 40 CFR 262 Subpart E.

c. Provide a copy of the EPA Acknowledgement of Consent for the shipment to the transporter for export of the shipment.

F-3.10 Requirements Specific to SQHUWs.

F-3.10.1 Notification. SQHUWs are not required to notify EPA of universal waste handling activities.

F-3.10.2 Employee Training. SQHUWs shall inform all employees who handle or have responsibility for managing universal waste of proper handling and emergency procedures appropriate to the type(s) of universal waste handled at the facility.

F-3.10.3 Tracking Universal Waste Shipments. An SQHUW is not required to keep records of shipments of universal waste.

F-3.11 Requirements Specific to LQHUWs.

F-3.11.1 Notification. Except as provided in this paragraph, an LQHUW shall have sent written notification of universal waste management to the Regional Administrator and received an EPA identification number before meeting or exceeding the 5,000-kilogram storage limit. An LQHUW that has already notified the EPA of their hazardous waste management activities and has received an EPA identification number is not required to re-notify under the requirements of this paragraph. Notification shall include:

a. The universal waste handler’s name and mailing address.

b. The name and business telephone number of the person at the universal waste handler’s site who should be contacted regarding universal waste management activities.

c. The address or physical location of the universal waste management activities.

d. A list of all types of universal waste managed by the handler (e.g., batteries, pesticides, thermostats).

e. A statement indicating that the handler is accumulating more than 5,000 kilograms of universal waste at one time and the types of universal waste (e.g., batteries, pesticides, thermostats) the handler is accumulating above this quantity.

F-3.11.2 Employee Training. An LQHUW shall ensure that all employees are thoroughly familiar with proper waste handling and emergency procedures relative to their responsibilities during normal facility operations and emergencies.

F-3.11.3 Tracking Universal Waste Shipments.

F-3.11.3.1 Receipt of Shipments. An LQHUW shall keep a record of each shipment of universal waste received at the facility. The record may take the form of a log, invoice, manifest, bill of lading, or other shipping document. The record for each shipment of universal waste received shall include the following information:

a. The name and address of the originating universal waste handler or foreign shipper from whom the universal waste was sent.

b. The quantity of each type of universal waste received (e.g., batteries, pesticides, thermostats).

c. The date of receipt of the shipment of universal waste.

F-3.11.3.2 Shipments Off-Site. An LQHUW shall keep a record of each shipment of universal waste sent from the handler to other facilities. The record may take the form of a log, invoice, manifest, bill of lading, or other shipping document. The record for each shipment of universal waste sent shall include the following information:

a. The name and address of the universal waste handler, destination facility, or foreign destination to whom the universal waste was sent.

b. The quantity of each type of universal waste sent (e.g., batteries, pesticides, thermostats).

c. The date the shipment of universal waste left the facility.

F-3.11.3.3 Record Retention. An LQHUW shall retain those records described in F-3.11.3.1.a and F-3.11.3.2.a for at least 3 years from the date of receipt of a shipment of universal waste, and those records described in F-3.11.3.1.b and F-3.11.3.2.b for at least 3 years from the date a shipment of universal waste left the facility.

APPENDIX G
RECOMMENDATIONS FOR SAFETY SELF-ASSESSMENT, LOCATION SELECTION, AND FACILITY DESIGN CONSIDERATIONS FOR LITHIUM BATTERY STORAGE AND SERVICING

G-1 INTRODUCTION.

This appendix provides the safety criteria for the storage and servicing of lithium batteries. This includes testing and charging of lithium-ion and other lithium-based rechargeable batteries. This guidance is extended to and includes the storage and servicing (including charging and discharging) of systems employing lithium batteries as part of the LBSP. The following information is provided as guidance, but the guidance shall be tailored for the building purpose, battery types, battery mass and quantity, and collateral hazards. The tailoring process shall include a self-assessment to determine the extent of potential loss of equipment, materials, and facilities; environmental damage; and personnel injury and death. Stowage and maintenance of primary and rechargeable batteries housed in their intended application (e.g., battery box, support container, pressure-vessel) or intended platforms (e.g., ground, sea-surface, submersible, or aerial vehicle) may change required consideration for potential impacts from a battery casualty.

G-1.1 Scope. The safety criteria are intended to mitigate the potential casualty severity of specific lithium batteries and systems approved by the LBSP Authority for a defined MCE. The MCE is defined as the most severe outcome, or classes of outcomes, produced from a single point failure. These potential outcomes include generation of fragment thrown at high velocity (shrapnel), thermal conditions, and release of gases (flammable, toxic, or both) produced as a result of a single point failure. Developers of these scenarios should assess a wide range of parameters, to include battery circuitry, potential for physical damage to the battery/cells, co-location of other batteries and energetic storage, characteristics of the battery chargers and safety mechanisms for approved batteries, and protection of personnel and facilities. WCEs involving an approved battery can create casualty conditions that exceed the safety criteria of this document, resulting in extension of the casualty effects into other adjacent areas. WCEs can result in the simultaneous reactions of all of the cells in a pack, but typically require multiple safety system failures to occur.

G-2 FACILITY CAPACITY CONSIDERATIONS.

G-2.1 Battery Size. The failure of metal cased lithium metal anode cells and batteries constructed from metal case cells may produce locally significant over-pressures with potentially severe impacts on nearby cells, batteries, and structures. Stand-off distances based on gas pressure releases from a sealed metal case will vary with the cell's constructions and containment used. Cell chemistry and design also have a significant effect on the potential pressure release. Energy release from large format cells and large collections of cells cannot be readily reduced to a single net-equivalent weight for TNT equivalent for structures and personnel and facility hazards calculations. Lithium battery casualties are best defined as deflagrations or rapid combustion events. Non-metallic lithium anode batteries in metal cases are less likely to produce abrupt case failures as the cells are usually vented and react at a slower rate compared to certain metallic lithium cells.

G-2.1.1 Lithium Metal Anode Cells and Batteries. Primary cell and battery assembly spontaneous ruptures from internal or externally triggered faults have released up to 50 percent of the electrical energy content of the cell in the form of high-pressure gases in 10 to 50 milliseconds, with an abrupt local volume peak over-pressures of 3,000 PSIG within the cell case and 250 PSIG in immediate local containment. The local volume peak over-pressures of 3,000 PSIG is based on the force required to rupture 30 mils of stainless steel in certain case designs, and the 250 PSIG in immediate local containment volumes is based on a single 15 Amp-hour oxyhalide cell in a 35-liter containment volume. Up to 100 percent of the reactant materials have been released as incandescent particulates and gases that may induce additional local cell and battery failures to occur. These lithium-cathode reactions produce gas jets that may exceed 2,000 °C. Work yield (pressure-volume) studies suggest that oxyhalide cells will yield 25 to 50 percent of the electrical energy content abruptly. A single 16-Ah oxyhalide D-cell will produce a 30-inch diameter bubble event under several feet of water with significant unreacted materials remaining (an approximate 100:1 volume expansion). Inorganic oxyhalide cells release little additional combustion energy from the cell failure than is expected from the electrical energy content. Solid cathode cells produce significantly less abrupt energy release as the reactions are typically a moderate deflagration or violent burn. Combustion energy release from most solid cathode metallic lithium anode cells will significantly exceed the electrical energy content due to organic flammable electrolytes used. The organics electrolyte may increase the total energy released from a cell or battery failure by 5 to 10 times the expected electrical energy content when compared to inorganic (oxyhalide) cells.

G-2.1.2 Non-Metallic Lithium Anode Cells and Batteries. Typically, in a lithium-ion cell anode where lithium bulk reactivity is limited by the intercalation matrix, the rate of reaction of the cell is considerably less from an internal fault or externally triggered casualty. The impact of lithium-ion cell and battery casualties predominately produce hot gases that contain flammable components capable of additional heat release if exposed to sufficient air and an ignition source. When gases are released from a failure and do not ignite immediately, latent combustible gas-air mixtures may be within the lower-to-upper flammability limits, potentially allowing a fuel-air volumetric combustion (deflagration) to occur, producing significant over-pressures. As a first-order estimate, the thermal energy from an immediate fire may produce 7 to 15 times the electrical energy of the cells in a battery. The duration of the combustion event will vary with cell-to-cell and battery-to-battery propagation rates. Moderate-sized batteries (100 to 5000 Wh) will usually complete combustion within 30 to 300 seconds. The local thermal environment from the immediate combustion will typically exceed 50 kW of radiant energy for the duration of the event and have reached 300 kW during rapid-burn events.

G-2.2 Battery Proximity. In general, the multiplication effect of mass storage on the MCE is unknown. Cells and batteries under normal conditions of storage or usage are not subject to mass-reaction (detonation) events, such as high-explosives (e.g., class 1.1). Close storage and packing of cells and batteries may lead to cell-by-cell cascading reactions from initial casualty's thermal output or possible shorting contamination. Isolation and separation requirements will vary by battery size, chemistry, and design. Isolation and separation for systems containing large format batteries must be evaluated on the design of the containment, failure modes of the containment, and the battery used.

G-2.2.1 Lithium Primary Batteries. If no other data is available, a cell-to-cell or battery-to-battery stand-off of at least one battery maximum dimension (diameter or length, whichever is greater) may be used. Barrier methods may allow reduction of minimum separation distances. Active mitigation and fire suppression may also reduce allowable separation.

G-2.2.2 Lithium Rechargeable Batteries. If no other data is available, cell-to-cell and battery-to-battery stand-off in open air should be based on the potential heat release from the organic solvent content, typically in the range of 12 to 15 percent by mass. Combustion energy release of 15 to 30 MJ/kg for 30 to 60 seconds should be considered. These rates will typically cause secondary combustion by radiant heating. Standoff distances to reduce surface heating should be calculated and used. A minimum of a 24-inch gap for large format batteries of 300 to 4000 Wh should be considered where feasible. Barrier methods may allow reduction of minimum separation distances. Active mitigation and fire suppression may also reduce allowable separation.

G-2.3 Battery Type. The composition of lithium batteries varies widely. Some batteries contain liquids for which MCE toxicity of gases is the greatest hazard. Other batteries contain liquids for which MCE flame and heat generation is the greatest concern. A few batteries have MCE risks combining toxicity, corrosiveness, flammability, blast, and fragmentation effects. If no other data is available, maximize separation from other manned operations to the greatest extent practical.

G-2.4 Common Battery Casualty Effects.

G-2.4.1 Venting Gases. Almost all lithium-anode type batteries will release gasses upon casualty. The gases released are specific to the chemistry and failure mode of the battery. Consequences of the gas release are large volumes of toxic, corrosive, or combustible gases depending upon chemistry released into an environment that may not be adequately ventilated or controlled.

G-2.4.2 Fire and Combustion. Lithium batteries may release stored energy as heat, fire, and kinetic burning materials. With exception of oxyhalide cathode batteries (e.g., thionyl chloride), all lithium battery systems may cause external fire from release of organic and flammable solvents and gases or localized heat (e.g., thermal batteries with skin temperatures above 150 °C once activated). Energy release from active primary or secondary batteries using organic solvents is exacerbated by ignition of the organic solvents. A rule of thumb is a ratio for the combustion energy equal to 5 times the electrochemical energy for primary batteries and 10 times the electrochemical energy for rechargeable lithium-ion chemistries.

G-2.4.3 Explosive Pressure Releases and Combustion Events. Batteries that are in a fire or are burning en masse may generate a single pressure release or series of near-simultaneous pressure releases that will:

a. Release fragments (i.e., projectiles) from battery cells or assemblies with sufficient force to be thrown significant distances from the fire
b. Generate local over-pressures up to several pounds per square inch gauge
c. Add to the local fire by the addition of combustible materials and aerosol organic solvents.

Large oxyhalide cells in a fire have been documented to throw steel casing materials several hundred feet. Large over-pressures can cause structural damages of storage areas, ventilation systems, and duct-work; and the over-pressures may incapacitate personnel.

G-2.4.4 Toxic Gases and Local Toxicity. Gases released from combustion of batteries include sulfurous and halide gases that will form acid gases with water vapor or upon contact with eyes, skin, and lung tissue. Combustion of organic solvents will generate carbon dioxide and carbon monoxide. Carbon dioxide displaces breathable air and can cause asphyxiation. Carbon monoxide reduces the ability of the blood to transport oxygen. Hydrogen chloride and sulfur dioxide byproducts will form acid gases that will damage and scar lung tissue and will cause internal fluid accumulation in the lungs, decreasing the ability to absorb oxygen. Batteries with high percentages of fluorinated materials will also generate hydrofluoric acid gases. Combustion products of plastics and other ancillary materials are also potentially toxic.

G-2.4.5 Smoke, Fumes, and Material Debris. Smoke and fumes from a battery casualty may obscure egress paths and the ability to locate the source of a fire and may contaminate surfaces with conductive or corrosive materials requiring a backup or emergency ventilation system. Material debris may clog safety ventilation mechanisms or pressure release vent pathways resulting in housing overpressures and mechanical yield.

G-2.4.6 Explosion of Batteries. Batteries (primary, rechargeable, reserve) are not explosives and do not undergo mass-detonation; nor does the reaction within a battery casualty event exceed the speed of sound. The possible exception to this rule would be a detonation of hydrogen gas if sufficient quantity and density, hydrogen gas is entrained during a battery mishap. The reactions within a battery casualty are chemical reactions. Pressure releases from large battery cells, pressure housings containing large cells or large quantity of cells, or large masses of battery cells at high temperature may produce locally measured over-pressures and transonic pressure waves due to the sudden structural failure of a pressure housing caused by fluids retained above their local boiling point. The structural failure of a battery cell case, battery assembly, or system containing a battery will produce a local overpressure that can be damaging to ear-drums and structures and can be referred to as an explosion. By definition, it is not a detonation.

G-2.5 Process Proximity. An MCE at one area of operation or storage site shall not affect adjacent areas. Areas of operation shall be separated by distance, barrier, or other approved alternatives so that fire in one area will not ignite material in another area. When the hazards of a specific lithium battery are unknown, the operator shall be protected by a personnel shield located between the operator and the lithium battery; this shield and its support shall be capable of withstanding the blast pressure deflagration energy of the battery. If a lithium battery area of operation or storage site is located in a building containing other tenants, the lithium battery area shall be separated from the other tenants by fire barriers having a fire resistance rating of no less than 2 hours.

G-2.6 MCE Effects Control. Unless other lithium battery information is available, lithium battery site selection planners shall consider and plan to mitigate the possible effects of an MCE as described in 2-4. Quantitative data may be available from either public reports from laboratories, such as the FAA Technical Center Research Laboratory (Atlantic City, NJ), National Fire Protection Association publications, Naval Research Laboratory, or from data generated from naval programs previously subjected to SG270-BV-SAF-010 (subject to distribution statements).

G-2.7 Emergency Response Planning. The standard operating procedure for the location shall address the following: access to each storage and use area; locations of emergency equipment; location where liaison will meet emergency responders; facility evacuation meeting point locations; the general purpose of other areas within the building; location of all above-ground and underground hazards; the hazard classes in each area; and emergency exit locations.

G-3 SITE RISK MANAGEMENT.

G-3.1 Facility Risk Assessment. Site operators and facility owners shall assess the risk of the storage and operation of batteries and battery-powered systems in their facility. A facility risk assessment using best practices shall be conducted to assess the limitation of the facility to be used and the allowable sizes and mass quantities of lithium batteries and any lithium-battery-powered equipment.

G-3.1.1 Military Facilities. For military sites, the Unified Facilities Command (UFC) series of documents and design criteria may be used in coordination with local facility management (e.g., for the Navy, Naval Facilities Command (NAVFAC) is responsible for the maintenance and construction of naval-owned facilities). Local and tenant command specialized equipment and installations into these structures are the joint responsibility of the tenant activity and NAVFAC.

G-3.1.2 Risk Assessment Facility Considerations. Facility risk assessment shall include the quantity and storage of equipment supported by the facility, requirements for charging, temperature control, and availability of fire-protection systems installed or to be installed to support mitigation of and minimization of severity of battery casualties. Emergency ventilation to dump smoke and fumes in conjunction with fire suppression system operations shall be considered. Compartmentalization or distribution strategies may be appropriate for minimizing the hazard. Conversely, the risk assessment shall consider facility systems as the potential to trigger battery failure.

G-3.1.3 Risk Assessment Facility Operation Considerations. The planned use of the facility is a critical element of risk assessment. Lithium battery storage and maintenance operations shall be separated from inhabited spaces such as office areas. Access control and minimal manning for safety is recommended for operations with lithium batteries or lithium-battery-powered equipment.

G-3.1.4 Fire Assessment Guidance. National Fire Protection Association guidance for areas designated as "lithium batteries" shall be considered. MIL-STD-882 or other risk and analysis assessment doctrines may be used to assess the overall risk and requirements.

G-3.1.5 Fire Detection, Gas, and Combustible Gas Detection. Risk management considerations shall include fire detection methods for both smoldering and active fire and smoke generation events. Combustible gas detection, detectors of methane, hydrogen, and other low flashpoint and easily ignitable organic gases should be located within any space to be protected against creation of an explosive atmosphere. Unlike smoke and heat detection systems, combustible gases originating from organic solvent electrolyte lithium batteries may be significantly heavier than local air and accordingly lay low in any space. Location of detectors should take into account the nature of the battery and the potential signatures from a precursor battery event that may cause a local fire. For example, lithium oxyhalide batteries generate acid gases that may be detected early in a battery failure prior to onset of active fire or smoke. A variety of detector types exist such as ion, heat, and volatile organic compound. Consideration should be given to the various types based on credible failure products. Some types may not be acceptable due to ambient gases that can chemically poison the detector.

G-3.1.6 Fire Suppression. Navy and public testing has demonstrated water and some aqueous fire suppressant agents to be effective against lithium battery fires. Lithium/water reactions are typically minimal due to the relatively small quantity or absence of metallic lithium as a battery component, the compartmentalization of lithium within individual cells, and the quantity of organic solvents and other flammable material as the predominance fuel. Water may not be appropriate when other hazards such as high voltage are present. Also, cell voltages are high enough to drive electrolysis-creating hydrogen, which is concern for hydrogen detonation in confined or poorly ventilated spaces.

Ref: NAVSEAINST 4160.3 NAVSEA S0005-AA-PRO-010/TMMP

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