UFC 3-520-05
1 May, 2015
Change 1, 11 September, 2015

UNIFIED FACILITIES CRITERIA (UFC)

STATIONARY BATTERY AREAS

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

UNIFIED FACILITIES CRITERIA (UFC)

STATIONARY BATTERY AREAS

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**
1	09/09/15	Clarified NFPA 1 applicability to stationary batteries. Updated ventilation requirements for valve-regulated lead acid batteries. Removed dates from industry standards for consistency with other UFCs; this administrative edit is not marked with a \1\ /1/.

This UFC supersedes UFC 3-520-05, dated 14 April 2008.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request. The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Refer to UFC 1-200-01, *General Building Requirements*, for implementation of new issuances on projects.

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UNIFIED FACILITIES CRITERIA (UFC)
NEW DOCUMENT SUMMARY SHEET

Document: UFC 3-520-05, *Stationary Battery Areas*

Superseding: This is a complete revision and reissuance of UFC 3-520-05, *Stationary Battery Areas*, dated April 14, 2008.

Description: This UFC 3-520-05 provides criteria for the design of stationary battery installations.

Reasons for Document:

- Provide technical requirements for enclosed battery areas.
- Address multi-discipline requirements for battery area layout and design. This document addresses architectural, electrical, mechanical, civil, fire protection, and plumbing requirements.
- Incorporate new and revised industry standards.

Impact: There are negligible cost impacts associated with this UFC. However, the following benefits should be realized:

- Standardized criteria have been prepared to assist engineers with the unique installation requirements for battery systems.
- Over design of battery areas should be avoided by ensuring that industry standard documents are preferentially applied.
- Safety requirements associated with batteries are addressed.

Unification Issues:

None.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

Unified Facility Criteria (UFC) 3-520-05 provides design criteria for stationary secondary battery installations. These batteries are operated on a continuous float charge and may require ventilation to limit hydrogen gas concentrations. This UFC also addresses lithium-based batteries that are stored or charged inside facilities.

This UFC serves as a planning, engineering, and design reference for professional facility planners, designers, and constructors, including DoD personnel and Government contractors. Designers and planners will use this document for individual project planning, for preparing engineering documentation, and for preparing contract documents for construction and renovation projects.

1-1.1 UFC Hierarchy.

UFC 3-501-01 provides the governing criteria for electrical systems, explains the delineation between the different electrical-related UFCs, and refers to UFC 3-520-01 for interior electrical system requirements. This UFC cites and supplements existing Government and commercial standards and specifications governing the architectural, mechanical, plumbing, and electrical requirements for design of stationary secondary battery installations.

1-1.2 Upgrades and Modifications to Existing Systems.

Modernization of electrical systems within existing facilities solely for the purpose of meeting design criteria in this UFC is not required. Upgrades or modifications of existing facilities should consider the design criteria in this UFC, but it is not intended that an entire facility require modernization solely because of a minor modification to a part of the facility.

1-2 EXCLUSIONS.

Appendix B provides examples of battery installation types that are covered by this UFC.

1-2.1 Excluded Battery Applications.

Design of primary battery installations, mobile applications of secondary batteries, batteries used in consumer electronics, and battery maintenance facilities are not covered by this UFC.

1-2.2 Lithium Batteries.

Mobile applications of lithium batteries when the batteries are installed in the end-use application are not covered by this UFC.

Note: This UFC does provide guidance for lithium-based batteries when stored or charged inside a facility; refer to Chapter 3 for requirements. Refer to Appendix B for additional information regarding applicability of lithium-based batteries. Lithium-ion batteries are the most common technology used. In general, this UFC refers to batteries using lithium as "lithium batteries".

1-2.3 Electric Vehicle Charging.

Refer to NFPA 70 for charging requirements for electric vehicles.

1-3 APPLICATION.

1-3.1 Battery Types.

The following battery types are addressed:

- Vented (flooded) lead acid.
- Valve-regulated lead acid (VRLA).
- Vented (flooded) nickel cadmium.
- Lithium.

Note: NFPA 1 uses the term "flooded" to describe vented batteries with a free-flowing liquid electrolyte.

Note: The term "battery cabinet" refers to a cabinet or enclosure designed to contain one or more batteries or battery cells; this term is preferentially used to maintain consistency with industry codes and standards.

1-3.2 Facilities.

Criteria in this UFC apply to DoD-owned or -leased facilities located on or outside of DoD installations, whether acquired by appropriated or non-appropriated funds, or third-party financed and constructed. Facilities include all temporary or permanent structures independent of their size.

1-3.3 Conflicts.

If a conflict exists between this UFC and any other DoD document, referenced code, standard, or publication, this UFC takes precedence.

1-3.4 Compliance.

Comply with the design criteria of this UFC for new construction and major renovation projects. For Air Force projects, comply with the additional criteria of AFPAM 32-1186, *Valve-Regulated Lead Acid Batteries for Stationary Application*. Renovation of existing battery installations solely for the purpose of meeting the design criteria of this UFC is not required. Apply the criteria in this UFC for retrofits of existing installations.

1-4 SAFETY.

Comply with UFC 3-560-01, *Electrical Safety, O&M*, and NFPA 70E, *Standard for Electrical Safety in the Workplace*, Article 320, for battery-related electrical safety requirements. EM 385-1-1, *Safety and Health Requirements*, and OSHA 1926.441 also apply to this UFC.

1-5 REFERENCES.

Appendix A contains a complete list of references used in this manual. \1\ The publication date of the code or standard is not included in this document.

The design is intended to use the most current version of a publication, standard, or code in effect when the design contract is signed unless written direction is provided to the contrary. If dates are not indicated in the contract or in the absence or other direction, the issue/version of publication in effect at the time the design started is to be used. Designs that have been started and then delayed will need to evaluate which version is applicable, and may have to update to the newer version if considerable time has gone by. This may require some redesign. /1/

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CHAPTER 2 STATIONARY BATTERY DESIGN CRITERIA

2-1 GENERAL.

2-1.1 Battery Types.

Chapter 2 provides requirements for the following battery types:

- Vented (flooded) lead acid.
- Valve-regulated lead acid (VRLA).
- Vented (flooded) nickel cadmium.

Note: UFC 3-520-01 prohibits lithium batteries for traditional stationary applications. Refer to Chapter 3 for requirements for lithium batteries used in military mission systems that are stored or charged inside facilities.

2-1.2 Required Criteria.

Comply with NFPA 70, *National Electrical Code* (NEC), and NFPA 1, *Fire Code*, for battery room design requirements. \1\ Apply the NFPA 1 criteria to all stationary batteries with a nominal voltage of 48 VDC or higher, regardless of the battery electrolyte capacity. /1/ Comply with UFC 3-520-01, *Interior Electrical Systems*, for battery selection, sizing, and application.

\1\ *Note: Refer to Appendix B-1 for examples of stationary batteries.* /1/

Regulatory requirements and restrictions vary depending upon location. Battery installations may require permits and environmental control and reporting due to their component heavy metals and acidic or basic electrolyte. Consult Title 29 Code of Federal Regulations (CFR) Parts 1910 and 1926 *Occupational Safety and Health Standards*, Title 40 Code of Federal Regulations *Protection of Environment*, and other applicable regulations for additional information.

2-2 ARCHITECTURAL REQUIREMENTS.

2-2.1 Location.

Where required by NFPA 1, install stationary batteries in a noncombustible, locked cabinet or other enclosure to prevent access by unauthorized personnel unless located in a separate equipment room accessible only to authorized personnel.

Locate the battery near the loads to be served while still satisfying the mechanical design criteria. UPS systems containing batteries can be located in the same room as the equipment they support.

2-2.2 Battery Rooms.

Provide the occupancy separation requirements specified in NFPA 1. When more than one battery chemistry is employed, locate each type of battery in a separate room with each room individually meeting the occupancy separation requirements and with no direct access between the rooms. Services not associated with the battery room must not pass through the room. Do not design the battery room to have access to other spaces. Do not use battery rooms for material storage, such as storage of office supplies, cleaning supplies, or spill control equipment; design a separate space for these materials.

2-2.3 Battery Cabinets.

Provide battery cabinets, including battery cabinets for UPS systems, that are a commercial manufactured product, designed and UL listed or third-party verified and tested for battery containment. Provide a minimum 200 mm (8 in.) working clearance around the batteries within the cabinet or provide drawout racks that allow for the specified working clearance. For outside installations prevent entry of contaminants, water, insects, and wildlife.

2-2.4 Spill Control.

Provide spill control for battery installations as required by NFPA 1. An electrolyte spill is defined as an unintended release of liquid electrolyte that exceeds 1.0 liters. Do not use battery cabinets without integral spill containment for vented lead acid or nickel cadmium batteries. Permanently installed physical containment structures must be capable of resisting continuous exposure to a 70 percent concentration of the electrolyte's acid or alkaline chemical. Do not allow the containment area to encroach upon space designated for room egress.

Note: VRLA batteries do not require spill containment.

When floor drains are provided in the battery area, design them in accordance with UFC 3-420-01, *Plumbing Systems*.

2-2.5 Electrolyte Neutralization.

Provide for spilled electrolyte neutralization in accordance with NFPA 1. Provide neutralizing and absorbing materials local to, but outside of, the battery area to address local incidents.

Select a slip-resistant floor finish in all battery rooms. Select an acid or alkali resistant floor finish and battery cabinet finish as appropriate for the battery chemistry employed. Wall and ceiling finishes in vented (flooded) cell installations must be acid or alkali resistant.

2-2.6 Battery Racks.

Obtain the battery rack from the same manufacturer that supplies the battery. Racks and trays must resist corrosion from continuous exposure to a 70 percent concentration of the electrolyte's acid or base chemical. Provide insulated battery lifting devices and provide tools with insulated handles.

Select the battery rack to fit within the defined footprint while also satisfying the need for maintenance access. Figures 2-1 and 2-2 show acceptable battery rack configurations for vented cells.

Figure 2-1. Two-Step Battery Rack Configurations (End View)

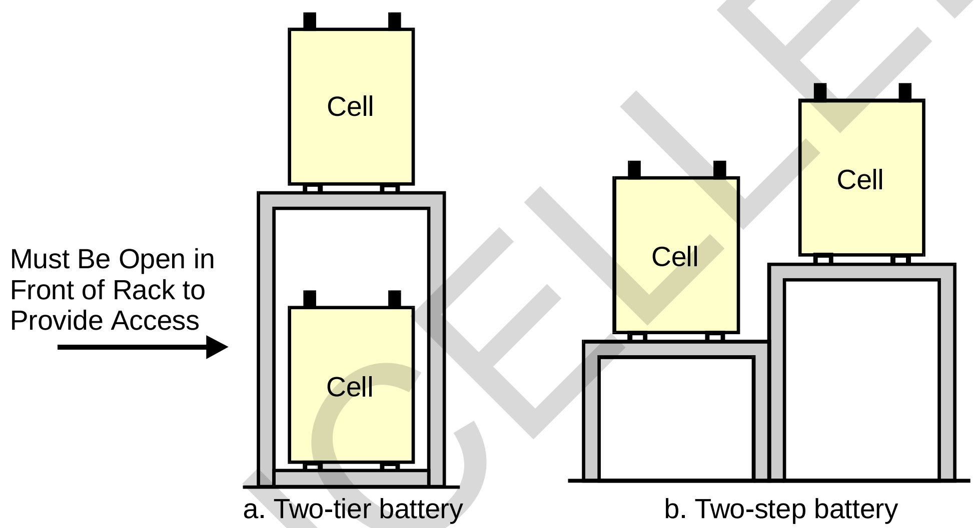
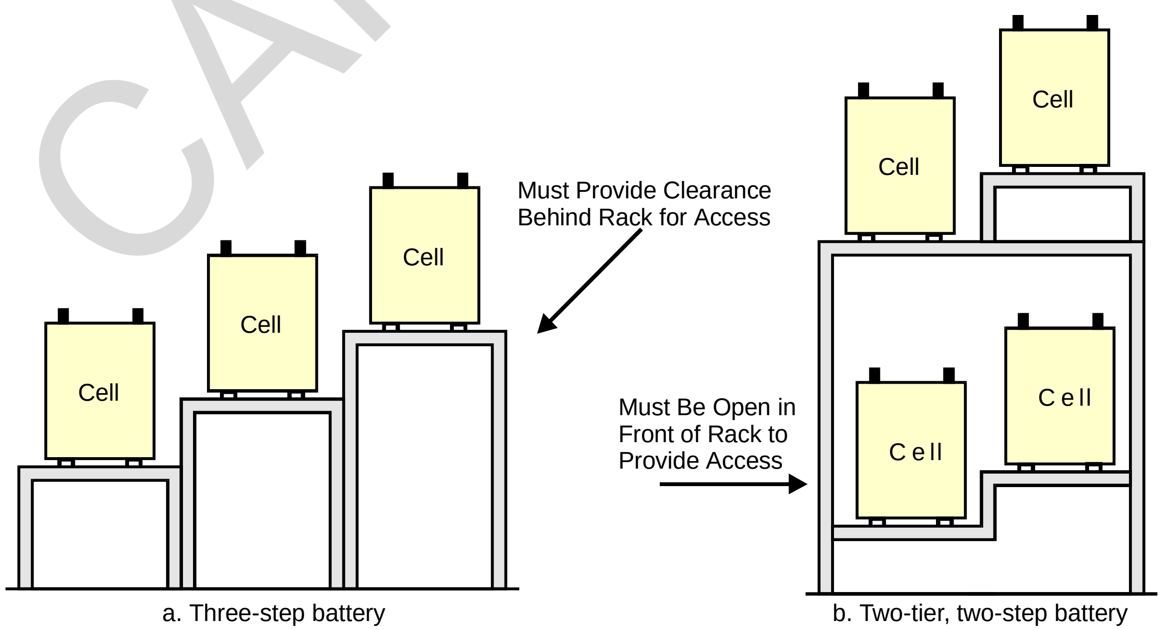


Figure 2-2. Larger Battery Rack Configurations (End View)



2-2.7 Seismic Design.

Provide restraints in all racks for vented cell installations to prevent the individual cells from overturning. In addition, comply with ASCE/SEI 7-10 for battery racks. Table 2-1 shows the rack requirements based on seismic design category.

Table 2-1. Battery Rack Requirements by Seismic Design Category

Seismic Design Category	Description
A—earthquakes are unlikely.	Racks do not require cell restraints.
B—distant earthquakes might cause minor motion.	Racks require side restraints.
C, D, E, F—local or nearby earthquake.	Racks require heavy-duty construction with side restraints and should have additional floor anchor points.

If the stationary battery supports a Mission-Critical Level 1 system as classified by UFC 3-310-04, *Seismic Design of Buildings*, seismically qualify the battery and battery rack in accordance with UFC 3-310-04 and IEEE 693, *IEEE Recommended Practice for Seismic Design of Substations*.

2-2.8 Additional Criteria.

Provide an overhead hoist or equivalent portable material handling equipment for the handling of batteries if the battery cells or modules each weigh over 50 lb (23 kg).

2-3 MECHANICAL REQUIREMENTS.

2-3.1 Installation.

Installation, operating, and maintenance requirements vary for each battery type. Comply with the following IEEE documents for installation criteria, as appropriate for the selected battery type:

- IEEE Std 484, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead acid Batteries for Stationary Applications*.
- IEEE Std 1106, *IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel cadmium Batteries for Stationary Applications*.
- IEEE Std 1187, *IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead acid Storage Batteries for Stationary Applications*.
- IEEE 1635, *IEEE/ASHRAE Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications*.

2-3.2 Ventilation and Hydrogen Control.

2-3.2.1 Hydrogen Generation.

Design ventilation systems to maintain concentrations of hydrogen gas in the battery room below 1 percent concentration.

Calculate the hydrogen generation rate based on the worst-case event of simultaneous boost (equalize) charging of all of the batteries in accordance with NFPA 1. \1\ Refer to IEEE 1635 for examples of fire code worst-case calculations. /1/ Obtain the hydrogen generation rate for the installed battery model and size from the battery manufacturer or apply IEEE 1635 if manufacturer data is not available. \1\ For VRLA stationary batteries, calculate the hydrogen generation rate based on a maximum hydrogen generation rate of 1.27×10^{-7} m^3/s (2.69×10^{-4} cfm) per charging ampere per cell at 25 °C and standard pressure. /1/

2-3.2.2 Ventilation System Design.

Provide ventilation and alarm in accordance with the *International Mechanical Code*, Section 502.4.

2-3.2.2.1 Makeup and Exhaust.

When batteries are located in a separate room, design the makeup (replacement) air volumetric flow rate equal to approximately 95 percent of the exhaust flow rate to maintain the battery room under negative pressure and prevent the migration of fumes and gases into adjacent areas. Provide means for balancing air flow to ensure a negative pressure relationship.

Exhaust all air directly to the outdoors. Exhaust air through a dedicated exhaust duct system if the battery room is not located on an outside wall. Makeup air can be transferred from a Class 1 or Class 2 area in the facility as defined in ANSI/ASHRAE 62.1, *Ventilation for Acceptable Indoor Quality*, or supplied directly. If supplied directly, it must be filtered.

2-3.2.2.2 Fans and Air Inlets.

Provide roof-mounted fans with an upwardly directed discharge. Select fans with non-sparking wheel and motor location outside of the air stream. Install the air inlets no higher than the tops of the battery cells of the lower tier if more than one tier is present. Locate exhaust grills at highest point of room.

2-3.2.2.3 System Design.

Design mechanical systems for continuous operation, free from excessive vibration. Provide green indicator light confirming fan operation located in battery area. Isolate mechanical equipment to eliminate structure-borne vibration that will have an adverse effect on battery usage and performance.

2-3.2.3 Ventilation for Batteries Inside Cabinets.

Provide ventilation for batteries inside cabinets, including UPS systems, in accordance with the *International Mechanical Code*, Section 502.5. The requirement to maintain concentrations of hydrogen gas below 1 percent concentration applies to the inside of the cabinet as well as the area in which the cabinet is installed.

2-3.3 Thermal Management.

The optimal operating temperature range for a lead acid or nickel cadmium battery is between 68° F (20° C) and 77° F (25° C). Operation in this range provides the best balance between capacity and service life. Maintaining the battery installation within the optimal temperature range reduces the possibility of thermal runaway in VRLA batteries.

Maintain the battery area temperature for lead acid batteries below 85° F (29° C) using transfer air when available.

2-4 ELECTRICAL REQUIREMENTS.

2-4.1 Electrical Equipment.

2-4.1.1 Overcurrent Protection and Isolation.

Provide overcurrent protection for each battery string. Provide separate overcurrent protection for each individual string in a paralleled battery string. If the DC conductors leave a separate battery room:

- Provide a disconnect device outside the room near the entrance, or
- Provide a shunt trip device near the entrance that opens a disconnect device inside the battery room.

2-4.1.2 Conductors and Terminations.

Do not use Type AC, NM, NMC, NMS, and UF cable in battery rooms. Do not use flexible metal conduit or flexible metallic tubing.

Install connections to battery terminal posts, including intercell connections, in a manner that minimizes strain on the battery posts.

2-4.1.3 Battery Charging.

Provide temperature compensated charging for VRLA batteries based on the battery temperature, not the ambient temperature.

Include temperature compensated charging for \1\ vented lead acid or nickel cadmium battery /1/ installations where the area is not environmentally controlled and large temperature variations can occur.

2-4.2 Bonding.

Bond conductive battery racks, cabinets, and cable racks to ground using #6 AWG minimum conductors.

2-4.3 Lighting.

Design illuminance levels in the battery room to comply with UFC 3-530-01 and IESNA Lighting Handbook Reference and Application recommendations with a minimum illumination level of 300 lux (30 fc). Consider the type of battery rack and the physical battery configuration to ensure that all points of connection, and maintenance and testing are adequately illuminated.

Install battery room lighting fixtures that are pendant or wall mounted, and do not provide a collection point for explosive gases. Provide fixtures that include lamp protection by shatterproof lenses or wire guards. Select fixtures in battery rooms for vented cells that are constructed to resist the corrosive effects of acid vapors. Luminaires and lamps must provide minimal heat output in general and provide minimal radiant heating of the batteries. Do not install lighting track in battery rooms. Fixture mounting must not interfere with operation of lifting devices used for battery maintenance. Receptacles and lighting switches should be located outside of the battery area.

2-4.4 Instrumentation and Control.

Provide instrumentation to measure battery voltage with high and low alarms, battery current, and ground detection for ungrounded systems. Provide the alarm system operation, level of reporting, and any additional instrumentation and alarm options appropriate for the specific conditions of each battery system.

2-5 EMERGENCY FACILITIES.

Provide portable or stationary water facilities for rinsing eyes and skin in case of electrolyte spillage. Locate within 20 feet of the battery. Design stationary facilities in accordance with UFC 3-420-01. Design portable facilities in accordance with ISEA Z358.1.

2-6 FIRE PROTECTION REQUIREMENTS.

Comply with UFC 3-600-01 and NFPA 1; however, smoke detection is not required.

2-6.1 Sprinkler System.

When the facility requires a wet-pipe automatic sprinkler system, provide an automatic sprinkler system in each battery room. Provide a supervised shut-off valve, check valve, flow switch, and test valve for the sprinkler line supplying a battery room. These items must be located outside of and adjacent to the associated battery room.

Actuation of the flow switch must remove power to the battery chargers that serve that battery room.

2-6.2 Portable Fire Extinguishers.

Portable fire extinguishers are not required to be installed.

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CHAPTER 3 LITHIUM BATTERY DESIGN CRITERIA.

3-1 GENERAL.

Chapter 3 provides requirements for lithium batteries used in military mission systems that are stored or charged inside facilities.

UFC 3-520-01 does not authorize the use of lithium batteries for stationary applications. This chapter applies only to non-stationary applications for lithium batteries that will be stored or charged inside facilities. Refer to Appendix B for a discussion of the typical battery applications.

3-2 REQUIRED CRITERIA.

Comply with NFPA 70, *National Electrical Code* (NEC), and NFPA 1, *Fire Code*, for battery room design requirements. Comply with the additional requirements provided in the following sections.

3-3 ARCHITECTURAL REQUIREMENTS.

3-3.1 Location.

Locate the batteries in dedicated rooms, separated from other portions of the building by a fire barrier in accordance with NFPA 1.

Isolate charging rooms from storage rooms, including the isolation of heating, ventilation, and air-conditioning system air from adjacent work areas. Do not store or charge lithium batteries in the same room with either nickel cadmium or lead acid batteries.

3-3.2 Enclosures.

Store lithium batteries in fire-rated enclosures designed specifically for the particular battery model. Charge or discharge lithium batteries in fire-rated enclosures designed specifically for the particular battery model.

Note: Plans for battery storage compartments have been developed for shipboard use and may be obtained on an as-needed basis for a specific project from the NAVFAC Engineering Criteria Office. Submit requests via http://www.wbdg.org/contact.php,

3-3.3 Seismic Design.

Comply with Section 2-2.7.

3-4 VENTILATION.

Lithium batteries do not vent hydrogen and do not require ventilation for combustible gas control.

3-5 EMERGENCY EXHAUST SYSTEM.

3-5.1 Exhaust System Criteria.

Design emergency exhaust system for minimum 2,000 cfm to contain and directly exhaust smoke and gases from the fire-rated enclosures in the event of a thermal incident.

3-5.2 Fans and Air Inlets.

Provide roof-mounted fans with an upwardly directed discharge. Select fans with non-sparking wheel and motor location outside of the air stream.

Locate makeup air inlets on the opposite side of the room from the exhaust.

3-6 THERMAL MANAGEMENT.

Maintain battery room temperature within the range specified by the battery manufacturer. This requirement applies to storage and charging.

3-7 FIRE PROTECTION.

Comply with UFC 3-600-01 and NFPA 1; however, smoke detection is not required.

3-7.1 Sprinkler System.

Provide a wet-pipe automatic sprinkler system for each battery room. Provide a supervised shut-off valve, check valve, flow switch, and test valve for the sprinkler line supplying a battery room. These items must be located outside of and adjacent to the associated battery room. Actuation of the flow switch must remove power to the battery chargers that serve that battery room.

Note: Sprinkler systems are not required for small remote facilities or mobile storage containers (Conex boxes) that have been designed specifically for storage and charging of lithium batteries, and are physically separated from other facilities by a minimum of 50 feet.

3-7.2 Fire Department.

Coordinate with and inform the base fire department of the type of operations performed at the facility and the maximum credible event mishap.

Note: The base Fire Map at the fire station(s) should include charging and storage areas for lithium batteries.

3-8 BATTERY CHARGING EQUIPMENT.

Install battery charging equipment designed for the specific lithium battery model.

3-9 LIGHTING.

Design illuminance levels in the battery room to comply with UFC 3-530-01 and IESNA Lighting Handbook Reference and Application recommendations with a minimum illumination level of 300 lux (30 fc).

Install battery room lighting fixtures that are pendant or wall mounted. Provide fixtures that include lamp protection by shatterproof lenses or wire guards. Luminaires and lamps must provide minimal heat output in general and provide minimal radiant heating of the batteries. Do not install lighting track in battery rooms. Fixture mounting must not interfere with operation of lifting devices used for in the battery room. Receptacles and lighting switches should be located outside of the battery area.

3-10 EMERGENCY FACILITIES.

Provide portable or stationary water facilities for rinsing eyes and skin in case of electrolyte spillage. Locate within 20 feet of the battery. Design stationary facilities in accordance with UFC 3-420-01. Design portable facilities in accordance with ISEA Z358.1.

3-11 LITHIUM BATTERY SAFETY.

For the Navy, refer to NAVSEA S9310-AQ-SAF-010, *Technical Manual for Navy Lithium Battery Safety Program, Responsibilities and Procedures*.

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APPENDIX A **REFERENCES**

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

www.ansi.org

ANSI/ISEA Z358.1-2009, *Emergency Eyewash and Shower Equipment*

AMERICAN SOCIETY OF CIVIL ENGINEERS (AFCE)

www.asce.org

ASCE/SEI 7-2010, *Minimum Design Loads for Buildings and Other Structures*

AMERICAN SOCIETY OF HEATING, REFRIGERATION, AND AIR CONDITIONING ENGINEERS (ASHRAE)

www.ashrae.org

ANSI/ASHRAE Standard 62.1-2010, *Ventilation for Acceptable Indoor Quality*

CODE OF FEDERAL REGULATIONS

http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR

Title 29 Code of Federal Regulations, *Labor – Occupational Safety and Health Administration (OSHA), Department of Labor – Parts 1910 and 1926*

Title 40 Code of Federal Regulations, *Protection of Environment*

DEPARTMENT OF THE AIR FORCE

http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

AFPAM 32-1186, *Valve-Regulated Lead Acid Batteries for Stationary Applications*

DEPARTMENT OF THE ARMY

http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

EM 385-1-1, *Safety and Health Requirements*

DEPARTMENT OF THE NAVY

http://www.public.navy.mil/comnavsafecen/Documents/afloat/Surface/CS/Lithium%20Batteries%20Info/LithBattSafe.pdf

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

IEEE

www.ieee.org

IEEE Std 484, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead acid Batteries for Stationary Applications*

IEEE Std 1106, *IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel cadmium Batteries for Stationary Applications*

IEEE Std 1187, *IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead acid Storage Batteries for Stationary Applications*

IEEE 1635*, IEEE/ASHRAE Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications*

IEEE 693, *IEEE Recommended Practice for Seismic Design of Substations*

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (ESNA)

www.ies.org

Lighting Handbook Reference and Application, Tenth Edition

INTERNATIONAL CODE COUNCIL (ICC)

http://www.icc-safe.org/

International Mechanical Code (IMC), 2012

NATIONAL FIRE PROTECTION ASSOCIATION

www.nfpa.org

NFPA 1, *Fire Code*

NFPA 10, *Standard for Portable Fire Extinguishers*

NFPA 70, *National Electrical Code*

NFPA 70E, *Electrical Safety in the Workplace*

Lithium-Ion Batteries Hazard and Use Assessment, Fire Protection Research Foundation, www.nfpa.org/assets/files/pdf/research/rflithiumionbatterieshazard.pdf

UNIFIED FACILITIES CRITERIA

http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

UFC 3-310-04, *Seismic Design of Buildings*

UFC 3-400-02*, Design: Engineering Weather Data*

UFC 3-410-04N, *Industrial Ventilation*

UFC 3-420-01, *Plumbing Systems*

UFC 3-520-01, *Interior Electrical Systems*

UFC 3-530-01, *Design: Interior, Exterior Lighting and Controls*

UFC 3-560-01, *Electrical Safety, O&M*

UFC 3-600-01, *Fire Protection Engineering for Facilities*

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APPENDIX B **STATIONARY BATTERY APPLICABILITY**

Appendix B provides examples of the types of stationary batteries that are addressed by this UFC. Examples of batteries not addressed by this UFC are also provided. The examples are typically provided in terms of the end-use application.

B-1 APPLICABLE BATTERY TYPES/LOCATIONS.

- Power plant backup power applications.
- Substations and switching stations – switchgear power.
- UPS systems.
- Engine generator batteries, if installed inside enclosed areas.
- Centralized emergency lighting.
- Communication center batteries.
- Stationary batteries in storage on float charge.
- Stationary batteries maintained on float charge before shipboard installation.

B-2 EXCLUDED BATTERY TYPES/LOCATIONS.

- Small batteries used for portable equipment.
- Vehicle batteries.
- Batteries in storage and not on float charge.
- Small emergency lights with an internal battery.
- On board batteries, such as those on boats/amphibious craft or aircraft, are not addressed by this UFC except when those batteries are not installed in the craft but stored or maintained on float charge inside a facility prior to the intended use.
- Battery maintenance and repair facilities – these facilities typically handle large quantities of electrolyte, which leads to unique designs for ventilation control.

B-3 LITHIUM BATTERIES.

Lithium batteries are addressed by this UFC as follows:

- Lithium batteries for consumer electronics devices, such as cellular phones or notebook computers, are not addressed by this UFC.
- Lithium batteries for use in the traditional stationary applications listed above in Section B-1 are not addressed by this UFC and are not

authorized by UFC 3-520-01. Industry standards for the use of lithium batteries in stationary applications are still under development.

- Lithium batteries used in military mission systems are addressed by this UFC for their storage and charging inside a facility. These batteries are typically large format lithium-ion batteries and the end-use application is for shipboard, aircraft, and mobile applications.

Examples of military mission systems that use lithium-ion batteries include:

- Joint Strike Fighter aircraft – 28-volt and 270-volt systems.
- Ground Combat Vehicle program – rechargeable battery packs.
- Improved Target Acquisition System – rechargeable battery packs.
- Active Denial System – rechargeable battery packs.
- Global Hawk/Triton and similar unmanned aerial vehicle applications.

APPENDIX C **LITHIUM BATTERIES RISK ASSESSMENT**

Appendix C provides an overview of lithium battery applications and failure modes.

C-1 DESCRIPTION.

Lithium batteries have been used in non-stationary applications for many years and lithium-ion batteries have become the dominant type of rechargeable battery for consumer electronics devices.

C-1.1 Design.

Lithium batteries use lithium metal or some other source of lithium ions in the negative electrode. During the battery discharge, the lithium ions travel to the positive electrode, which can be one of various materials, including a transition metal oxide, a transition metal phosphate, a sulfur compound, or even oxygen in the atmosphere or water. The electrolyte is typically a conductive salt in a solution, or a conductive polymer. Li-ion battery technology is most commonly used.

C-1.2 Packaging.

Lithium batteries are packaged as battery packs, which typically contain the individual cells, the battery management system (BMS), safety systems as necessary, thermal systems as necessary, and either a charger or the interface to an external charger. In order to ensure safety and performance, complete lithium-ion battery packs and systems should be provided as an integrated system and all manufacturer requirements must be followed.

C-2 FAILURE MODES.

Both energetic and non-energetic failures of lithium batteries can occur for a number of reasons including: poor cell design (electrochemical or mechanical), cell manufacturing flaws, external abuse of cells (thermal, mechanical, or electrical), poor battery pack design or manufacture, poor protection electronics design or manufacture, and poor charger or system design or manufacture. Reliability and safety is a function of the entire integrated system.

Refer to *Lithium-Ion Batteries Hazard and Use Assessment*, Fire Protection Research Foundation, for a detailed assessment of lithium battery failure modes and effects.

C-2.1 Non-Energetic Failures.

Lithium-ion batteries can fail in both non-energetic and energetic modes. Typical non-energetic failure modes (usually considered benign failures) include loss of capacity, internal impedance increase (loss of rate capability), activation of a permanent disabling mechanism, shutdown separator, fuse, or battery pack permanent disable, electrolyte leakage with subsequent cell dry-out, and cell swelling. The ideal lithium-ion battery failure mode is a slow capacity fade and internal impedance increase caused by normal aging of the cells within the battery. This is the most common failure mode.

C-2.2 Energetic Failures.

Energetic failures can cause overheating and fires. Energetic failures include thermal runaway, in which a cell rapidly releases its stored energy. These failures can initiate by thermal abuse, mechanical abuse, electrical abuse, poor design, or manufacturing. Although these types of failures are rare, the consequences of failure can be significant.

C-2.3 Charging.

Lithium batteries require that charging be matched to the battery for proper and safe operation. Proper matching of the battery and charger requires knowledge of the lithium cell chemistry, voltage, current requirements and all safety limitations. Improper matching can result in damage to the cells and possible cell failure.

C-3 STATIONARY APPLICATIONS.

Lithium batteries are still developing for stationary applications. They are considered suitable for various stationary battery applications with the proper design, and the proper safety and electronic control systems. Lithium batteries can be designed and optimized for high-power applications such as uninterruptible power supplies They can also be optimized for long-duration discharge applications such as telecommunications and renewable energy storage. Lithium batteries are smaller and lighter than most other battery alternatives, making them suitable as replacements and for applications that have limited space and increasing energy requirements. It is important to recognize that a lithium battery that is optimized for one stationary application may not be appropriate or safe to use in a different application.

Although lithium batteries have been used for several years in consumer electronics devices and are growing in their use for military mission applications, they are still not significantly used in traditional stationary applications. UFC 3-520-01 prohibits their use in stationary applications for the following reasons:

- The technology is new and is still developing for stationary applications.
- These batteries are still more expensive than equivalent lead acid or nickel cadmium batteries.
- There are no industry standards available to help with selecting, sizing, or installing a lithium battery for stationary applications. IEEE 1679.1, *Draft Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications*, is under development but will likely not be issued for several years.
- The Tri-Service does not yet have criteria in place to assist with specifying this type of battery for stationary applications.

APPENDIX D **GLOSSARY**

ACRONYMS

A	Ampere
AC	Designation for NFPA 70 Armored Cable
Ah	Ampere-hour
AFPAM	Air Force Pamphlet
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
AWG	American wire gauge
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
DC	Direct Current
DoD	Department of Defense
Fc	Foot-candle
FRP	Fiberglass Reinforced Plastic
HR	Hydrogen Rate
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
In	Inches
mm	Millimeters
NEC	National Electrical Code
NFPA	National Fire Protection Association
NM, NMC	Designations for NFPA 70 Nonmetallic Sheathed Cable
O&M	Operations & Maintenance
PVC	Polyvinyl Chloride

UF Designation for NFPA 70 Underground Feeder and Branch-Circuit Cable

UFC Unified Facility Criteria

VR Ventilation Rate

VRLA Valve-Regulated Lead acid

TERMS

Battery Cabinet: Refer to **Enclosure**.

Enclosure: A surrounding case or housing to protect the contained equipment against external conditions and to prevent personnel from accidentally contacting live parts. With respect to enclosures for stationary batteries, the enclosure might be a dedicated battery cabinet or it might contain additional equipment, such as an uninterruptible power supply.

Float Charge: The method of maintaining a battery in a charged condition by continuous, long-term charging at a level to balance self-discharge.

Full Float Operation: Operation of a dc system with the battery, battery charger, and load all connected in parallel, and with the battery charger supplying the normal dc load plus any self-discharge or charging current, or both, required by the battery. The battery will deliver current only when the load exceeds the charger output.

Primary Battery: A battery that produces electric current by electrochemical reactions without regard to the reversibility of those reactions. In the context of this UFC, a primary battery is not rechargeable, and is intended to be used once, then discarded.

Recombinant Cell: A battery cell characterized by the recombination of internally generated gases. For example, a VRLA cell is designed to recombine internally generated oxygen and suppression of hydrogen gas evolution to limit water consumption.

Room: A contained area within a facility, normally accessible through a door. With respect to stationary batteries, a room might be dedicated for the battery installation or it might contain additional equipment.

Secondary Battery: A battery that is capable of repeated use through chemical reactions that are reversible, i.e., the discharged energy can be restored by supplying electrical current to recharge the cell.

Stationary Battery: A storage battery designed for service in a permanent location.

Storage Battery: A battery consisting of one or more cells electrically connected for producing electric energy.

Valve-Regulated Lead acid (VRLA) Cell: A cell that is sealed with the exception of a valve that opens to the atmosphere when the internal gas pressure exceeds atmospheric pressure by a pre-selected amount. VRLA cells provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption.

Vented Battery: A battery in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries are commonly referred to as “flooded.”