DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LIFE CYCLE MANAGEMENT CENTER
WRIGHT-PATTERSON AIR FORCE BASE OHIO

CIRCULAR
AC-20-04A
12 JAN 22

AIRWORTHINESS CIRCULAR

AIRWORTHINESS REQUIREMENTS FOR EQUIPMENT WITH NON-RECHARGEABLE LITHIUM BATTERIES

1. Purpose. This Airworthiness Circular (AC) informs organizations, managing equipment with non-rechargeable lithium batteries (NRLBs), of NRLB-specific airworthiness (AW) requirements.

2. Scope. This AC applies to equipment with NRLBs.

3. Attachments. (1) FAA AC-20-192, *Guidance on Testing and Installation of Non-rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft*, draft

4. Cancellations. This revision replaces the original issuance of this AC published on 30 September 2020.

5. Referenced Documents.

AFPD 62-6, USAF Airworthiness, 16 January 2019

FAA TSO-C142b, Non-Rechargeable Lithium Cells and Batteries, 26 March 2018

RTCA DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries, 21 September 2017

AWB-100A, Airworthiness Process Overview and Terminology, 3 June 2021

6. Background.

6.1. The USAF develops and/or procures equipment with NRLBs, often common across the Department of Defense, for installation on both commercial derivative aircraft (CDA) and non-CDA. During development and/or procurement, it is often unknown whether the equipment will be installed on CDA. As such, requirements for common, military-specific equipment with NRLBs have not historically included Federal Aviation Administration (FAA) AW requirements for NRLBs. The FAA recently updated AW requirements for NRLBs based on both laboratory testing and mishaps, including an on-aircraft mishap involving NRLBs in 2013. Consequently, CDA are encountering FAA certification issues with installing common, military-specific equipment with NRLBs that do not meet current FAA AW requirements.

6.2. AFPD 62-6, *USAF Airworthiness*, requires the USAF to obtain and maintain FAA type certification for CDA whose primary mission is to transport passengers. For all other CDA, AFPD 62-6 requires the USAF to obtain and maintain FAA type certification to the maximum extent practical. This includes FAA type certification of equipment with NRLBs to be installed on CDA.

7. Discussion and Recommendations.

7.1. To obtain FAA type certification, equipment with NRLBs to be installed on CDA must comply with FAA AW requirements, which includes NRLB-specific requirements. FAA AC 20-192, *Guidance on Testing and Installation of Non-rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft*, (Attachment 1) and FAA TSO-C142b, *Non-Rechargeable Lithium Cells and Batteries*, document the FAA's NRLB-specific requirements, which require NRLBs to meet the requirements in RTCA DO 227A, *Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries*.[1] ,[2]

7.2. RTCA DO-227A requires both functional and safety testing of the cell, battery, and end item (equipment with NRLB). Currently, the FAA has not accepted any current military standards, handbooks, or performance specifications to be equivalent to RTCA DO-227A.

7.3. To support obtaining FAA type certification of equipment with NRLBs to be installed on CDA, organizations managing equipment with NRLBs that may be installed on CDA should ensure equipment technical requirements include RTCA DO-227A requirements. Organizations should contact the USAF AW Office for additional guidance on developing plans for complying with RTCA DO-227A requirements or establishing alternate means of compliance.

7.4. When contracting for RTCA DO-227A testing, organizations should obtain the appropriate data rights for the test data and associated FAA data approvals to ensure they may be leveraged by other government organizations. Alternatively, organizations should require their contractor to obtain an FAA TSO-C142b authorization for the equipment.

7.5. The USAF AW Office maintains a list of NRLBs and equipment with NRLBs for which RTCA DO-227A test data exists or is being developed. The list is available at the USAF AW Office SharePoint site (ref. AWB-100, *Airworthiness Process Overview and Terminology*, for a link to the site). Organizations should inform the USAF AW Office of activities to obtain test data for equipment with NRLBs and/or install equipment with NRLBs on CDA.

8. Point of Contact. USAF AW Office, USAF.Airworthiness.Office@us.af.mil.

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[1] The draft FAA AC-20-192 is consistent with Special Conditions approved for many transport aircraft, which are available at https://drs.faa.gov/.

[2] The FAA has established other acceptable means of compliance for button/coin cells containing less than 2 watt-hours (Wh) of capacity and cells or batteries containing less than 5 Wh of capacity. FAA. Refer to AC-20-192 and TSO-C142b for additional information.

U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Guidance on Testing and Installation of Non-rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft

Date: xx/xx/xx

AC No: 20-192

Initiated By: AIR-6B3

This advisory circular (AC) provides manufacturers and installers an acceptable means of compliance to meet the installation, operation, maintenance and airworthiness requirements including special conditions, safety objectives and safety criteria for the use of non-rechargeable lithium batteries on aircraft.

If you have any suggestions for improvements or changes, you may use the Advisory Circular Feedback Information form provided in Appendix G of this AC.

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CHAPTER 1. INTRODUCTION

1.1 Purpose of This Advisory Circular (AC).

1.1.1 This AC provides an acceptable means to show compliance to the airworthiness requirements for installed non-rechargeable Lithium cells, batteries and batteries within end items on aircraft as defined in RTCA, Inc., document RTCA DO-227A, *Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries*. This AC provides guidance on how to obtain installation approval for installed non-rechargeable Lithium cells, batteries and batteries within end items on aircraft.

1.1.2 The guidance in this AC is intended for battery manufacturers, installers, maintenance personnel, and users of installed non-rechargeable lithium cells, batteries and batteries within end items on aircraft. As with all advisory material, this AC is not mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline a method of compliance with applicable airworthiness requirements. However, if you elect to use the guidance in this AC, the term "**must**", refers to mandatory requirements necessary to show compliance.

1.1.3 For the purpose of this AC, all installed non-rechargeable lithium cells, batteries and batteries within end items will be referred to as lithium batteries.

1.2 Scope of This AC.

1.2.1 Chapter 2 of this AC applies to the certification of installed lithium batteries on aircraft approved pursuant to Title 14 of the Code of Federal Regulations (14 CFR) parts 23, 25, 27, and 29 for:

1.2.1.1 Type certificates (TC),

1.2.1.2 Amended type certificates (ATC),

1.2.1.3 Supplemental type certificates (STC)

1.2.1.4 Amended supplemental type certificates (ASTC), and

1.2.1.5 Parts manufacturer approvals (PMA).

Note: The guidance in chapter 2 also applies to the installation approval of installed lithium batteries on aircraft in accordance with the field approval process using Federal Aviation Administration (FAA) Form 337 for major repairs and major alterations.

1.2.2 Chapter 3 of this AC provides guidance on maintenance and operational considerations for lithium batteries on aircraft.

1.3 Non-rechargeable Lithium cells, Batteries and Batteries within End Items Covered in This AC.

1.3.1 Lithium batteries are installed in various aircraft types and serve various purposes. Lithium batteries are of different sizes, chemistries, and produced under different manufacturing processes. They are also of different levels of complexity. Some of the benefits of lithium batteries include weight savings, high energy density per unit weight and per unit volume, relatively constant voltage during discharge, good low-temperature performance, and long shelf life. Because of their high energy content and potential thermal instability, lithium batteries can present hazards if improperly designed, tested, used, and/or stored. Some of the uses for lithium batteries on today's aircraft include, but are not limited to:

- Emergency Locater Transmitters;
- Defibrillators;
- Back up batteries for avionics equipment;
- Special function batteries (such as flashlights, electronic equipment, life vests, safety equipment, avionics equipment, communications equipment, and emergency medical equipment).

1.3.2 Lithium batteries have certain failure and operational characteristics, as well as maintenance requirements that differ significantly from those of aircraft nickel-cadmium and lead-acid non-rechargeable batteries. The introduction of lithium batteries into aircraft raises some concern about associated battery monitoring systems (such as temperature or state of charge) and should be evaluated and tested regarding the expected extremes in the aircraft operating environment. Lithium batteries typically have different electrical impedance characteristics than lead-acid or nickel-cadmium batteries. Other components of the aircraft electrical system should be evaluated regarding these characteristics as a system.

1.3.3 Lithium batteries have certain failure conditions due to impurities, manufacturing defects, foreign object deposit or abuse/misuse of the battery. These conditions have known to create conditions that may result in thermal runaway (per RTCA DO-227A, *Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries*). A thermal runaway results from the initiation of an irreversible exothermic chemical reaction within the cell causing an uncontrollable release of internal electrical and chemical energy resulting in a rapid and accelerating temperature rise to a peak, with an accompanying collapse of cell voltage, and the chemical decomposition of metallic Lithium.

1.4 **Background.**

1.4.1 The proposed use of lithium batteries for equipment and systems on the aircraft has prompted the Federal Aviation Administration (FAA) to review the adequacy of its guidance.

1.4.2 At present, there is limited in-service experience with the use of lithium battery technology in applications on aircraft. However, users of this technology from aircraft operators to personal computer users, wireless manufacturers, and the electric vehicle industry have noted safety problems with lithium batteries. These conditions may result from imbalance, reverse charge over-discharging, flammability of cell components and internal cell defects. In general, lithium batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (thermal runaway) than nickel-cadmium or lead-acid batteries. Results of the above mentioned failures could lead to a potentially dangerous smoke, fire and/or fume event.

1.4.2.1 Fast or Imbalanced discharging.

Fast discharging or an imbalanced discharge of one cell of a multi-cell battery may create an overheating condition that could result in an uncontrollable venting condition, leading to a potential thermal event or an explosion.

1.4.2.2 Flammability.

Unlike nickel-cadmium and lead-acid batteries, lithium batteries use higher energy and current in an electrochemical system to maximize energy storage of lithium. Some lithium battery manufacturers use liquid electrolytes and/or cathodes which is extremely flammable and/or explosive. The electrolyte and cathode, as well as the electrodes, can serve as a source of fuel for an external fire if the battery casing is breached.

1.4.2.3 Internal Failures.

In general, these batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (i.e., thermal runaway) than their nickel-cadmium or lead-acid counterparts. The metallic lithium can ignite, resulting in a self-sustaining fire or explosion.

CHAPTER 2. INSTALLATION OF LITHIUM BATTERIES ON AIRCRAFT

2.1 Certification Process.

This chapter provides certification guidance for the installation of lithium batteries on aircraft. Coordinate the certification program with the responsible FAA Aircraft Certification Office as described in FAA Order 8110.4, *Type Certification*, through the certification program notification (CPN) process, FAA Order 8110.48, *How to Establish the Certification Basis for Changed Aeronautical Products,* or FAA Order 8110.42, *Parts Manufacturer Approval Procedures.*

2.2 Acceptable Means of Compliance (MOC) for Installation Approval.

2.2.1 Certification Plan.

Prepare a certification plan that provides a method of compliance to the airworthiness regulations, including special conditions (if any)for the installation of the lithium batteries on the aircraft. We recommend submitting the certification plan early in the process. Include the following items at a minimum:

NOTE: FAA Order 8110.4 provides directions on how to address the following provisions of a certification plan.

- Project description and schedule;
- System description, including a description of the aircraft system interfaces and any aircraft system modifications made to accommodate the aircraft battery system installation;
- System safety assessment;
- Certification basis and MOC, including itemized MOC to all applicable requirements or special conditions;
- Communication and coordination of the test plan(s);
- Conformity plan;
- Instructions for continued airworthiness; and
- Compliance and substantiation documentation.

2.2.2 Compliance Checklist.

Lithium battery installations must meet all applicable airworthiness regulations applicable to the product and all applicable special condition imposed. The installations should also meet the guidance in this chapter and

the applicable airworthiness regulations. Table 2 provides a guide to airworthiness regulations that may be applicable.

Note: For 14 CFR part 23, Table 2 lists applicable regulations with Amendment 23-64. Certification basis with earlier amendment level should use equivalent subpart regulations respectively.

Table 2. Airworthiness Regulations Concerning Lithium Battery Installations

14 CFR Section	Subject Matter
§ 21.50(b)	Instructions for Continued Airworthiness and Maintenance Manuals
§§ 25/27/29.301	Loads
§§ 23.2210	Structural design loads
§§ 25/27/29.303	Factor of safety
§ 23.2230	Limit and ultimate loads
§§ 25/27/29.305	Strength and deformation
§ 23.2235	Structural strength
§ 23.2205	Interaction of systems and structures
§§ 25/27/29.307	Proof of structure
§ 25.581	Lightning protection
§§ 27/29.610	Lightning and Static Electricity Protection
§§ 25/27/29.785	Seats, Berths, Litters, Safety Belts, and Harnesses
§ 23.2265	Special factors of safety
§23.2270	Emergency conditions
§§ 25/27/29.787(b)	Cargo baggage compartments
§23.2315(a)	Means of egress and emergency exits
§§ 25/27/29.831	Ventilation (Smoke and Toxicity)
§ 23.2320(c)	Occupant physical environment

§§ 25/27/29.853	Compartment interiors (Flammability)
§ 23.2325	Fire protection
§§ 23/25/27/29.863	Flammable fluid fire protection
§ 25.869	Fire protection: systems
§29.1359	Electrical system fire and smoke protection
§§ 23.2330	Fire protection in designated fire zones and adjacent areas
§ 23.2440	Powerplant fire protection.
§§ 25/27/29.1301/23.2250(a)	Design and construction principles
§23.2605	Installation and operation.
§§ 25/27/29.1309/23.2510	Equipment, systems, and installations
§§ 25/27/29.1316	Electrical and electronic system lightning protection
§§ 25/27/29.1317	High–intensity Radiated Fields (HIRF) protection
§ 25/27/29.1322	Warning, caution, and advisory lights
§§ /25/27/29.1351	Electrical systems and equipment, general
§§ 25/29.1353	Electrical equipment and installations
§ 27.1353	Storage battery design and installation
§ 23.2525	System power generation, storage, and distribution
§ 23.2500	Airplane level systems requirements
§§ 25/29.1355	Distribution system
§§ 25/27/29.1357	Circuit protection devices
§§ 25/29.1363	Electrical system tests
§§ 23/25/27/29.1529	Instructions for Continued Airworthiness
§§ 25/27/29.1581	General (Aircraft Flight Manual)
§ 23.2620	Airplane flight manual.
§§ 25/27/29.1583	Operating limitations
§§ 25/27/29.1585	Operating procedures

§ 23.2335	Lightning protection.
§§ 25/27/29.1541	General (Markings and Placards)
§ 23.2610	Instrument markings,control markings, and placards.
§§ 25/29.1431	Electronic equipment
§ 27.1365	Electric cables
§27.1367	Switches
§ 23.2600	Flightcrew interface.
§ 23.2610	Instrument markings, control markings, and placards.
§§ 27/29.1559	Limitations placard

Additional requirements (beyond listed in Table 2) and method of compliance pertaining to lithium batteries are the following:

FOR Part 23 Certificated Aircraft:

Part 23 Amendment 23-64 became effective August 30, 2017. See installation guidance in Appendix F of this AC that addresses installing non-rechargeable lithium battery in part 23 airplanes.

FOR Part 25 Certificated Aircraft:

Pursuant to Part 25, the FAA, upon considering the state of technology, determined that non-rechargeable lithium batteries are novel and unique. As such, the FAA requires special conditions (SCs) for non-rechargeable lithium battery installations on transport category airplanes. Appendix C of this AC provides typical non-rechargeable lithium battery SCs. Applicants, who elect to follow the SCs in Appendix C of this AC for their project, should submit a letter indicating this to the Aircraft Certification Service (AIR) office responsible for their project. An acceptable method of compliance (MOC) with the non-rechargeable lithium battery SCs in Appendix C of this AC and related Part 25 requirements is provided in Appendix D of this AC. Appendix D of this AC also provides guidance related to the applicability statements in previously issued non-rechargeable lithium battery SCs.

FOR Parts 27 and 29 Certificated Rotorcraft:

For rotorcraft, see Appendix E of this AC for safety objective requirements and means of compliance.

For Button and/or Coin cell batteries (less than 2Wh):

The use of Underwriters Laboratories (UL) 1642 Standard is an acceptable MOC for showing that Safety Objectives 1 through 6 are met for 2 watt-hours of energy button/coin sized non-rechargeable lithium batteries .

Meeting the minimum performance standard for TSO C142b-7 is an acceptable means of showing compliance for cells or batteries less than 5 Wh.

For all aircrafts in general:

Interconnection of lithium battery cells in battery packs introduces failure modes that require unique design considerations, such as provisions for thermal management. Based on laboratory testing and events, both independent of aviation and within actual aviation applications, including the events of 2013, the FAA now more fully recognizes potential hazards and failure modes associated with non-rechargeable lithium batteries including:

- **Internal failures:** In general, lithium batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (i.e., thermal runaway) than their nickel-cadmium or lead-acid counterparts. These failures can result in toxic, flammable, or corrosive fluid leakage, gas venting, fire and explosion.
- **Fast or imbalanced discharging:** Fast discharging or an imbalanced discharge of one cell of a multi-cell battery may create a thermal runaway that could result in an uncontrollable venting of corrosive flammable gases, fluid leakage, fire and explosion.
- **Flammability:** Lithium batteries contain more energy and deliver higher currents than nickel cadmium and lead acid batteries of similar size, and may use liquid electrolytes that can be extremely flammable. The electrolyte, as well as the electrodes, can be fuel for an external fire if the battery casing is breached.

Some known potential hazards and failure modes associated with non-rechargeable lithium batteries are:

- **Internal failures:** In general, these batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (i.e., thermal runaway) than their nickel-cadmium or lead-acid counterparts. The metallic lithium can ignite, resulting in a self-sustaining fire or explosion.
- **Fast or imbalanced discharging:** Fast discharging or an imbalanced discharge of one cell of a multi-cell battery may create an overheating condition that results in an uncontrollable venting condition, which in turn leads to a thermal event or an explosion.
- **Flammability:** Unlike nickel-cadmium and lead-acid batteries, lithium batteries use higher energy and current in an electrochemical system that can be configured to

maximize energy storage of lithium. They also use liquid electrolytes that can be extremely flammable. The electrolyte, as well as the electrodes, can serve as a source of fuel for an external fire if the battery casing is breached.

2.3 Test Requirements.

2.3.1 Environmental Test Requirements.

- Lithium battery systems on aircraft must meet environmental qualification standards in:
  - RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 8, 2010, or the most recent revision,
  - RTCA DO-227A, *Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries*, dated September 21, 2017,
  - These environmental tests are representative of the conditions that the battery system may encounter during its life cycle. Consider the following areas when determining the scope and type of environmental tests:
    - Equipment configuration,
    - Installation specific environment encountered on in-service platforms,
    - Duration of exposure periods,
    - Geographical locations, and
    - Frequency of environmental occurrences alone or in combination with other approved systems.

2.4 Means of Compliance Testing and Validation.

2.4.1 Ground and Flight Test Requirements for Installed Lithium Batteries.

2.4.1.1 When ground and/or flight tests are required per the compliance checklist for the project, the tests should be performed to demonstrate the lithium battery systems and the systems in which they are installed will perform their intended functions.

2.4.1.2 When ground and/or flight tests are required per the compliance checklist for the project, they should be performed to demonstrate the lithium battery systems and the systems in which they are installed will not have any adverse effect on the aircraft.

2.4.1.3 When an EMI/RFI test is required per the compliance checklist of the project. The electromagnetic compatibility test should be performed to determine the installation of the lithium battery does not have any adverse effect on aircraft systems and that the aircraft systems do not have any adverse effect on the lithium battery. Demonstrate the battery system functions during all intended aircraft operation.

2.5 **System Safety Assessment.**

2.5.1 Perform a system safety assessment to show compliance with §§ 25/27/29.1309, § 23.2510 and all applicable special conditions/requirements. This assessment should address concerns associated with the installation of the lithium batteries, the possibility of direct (or indirect) injury to a person, any adverse effect on crew function, or any adverse effect on other aircraft equipment and systems. These adverse effects could be a result of normal operation or a failure in the lithium batteries. Your system safety assessment should consider, but not be limited to, the following:

2.5.1.1 The level of hazards associated with installation and use of lithium batteries;

2.5.1.2 Whether the lithium batteries installation design assurance level is appropriate for performance and safety requirements based on location and intended function;

2.5.1.3 No interference due to any failures of the lithium batteries;

2.5.1.4 System separation and zonal analysis;

2.5.1.5 Impact on flight crew and egress procedures;

2.5.1.6 Protection against fire, smoke, and electrical shock hazards;

2.5.1.7 Other safety analysis appropriate to the system being installed; and

2.5.1.8 Statement of compliance for each requirement.

2.5.2 Coordinate your safety assessment with the responsible FAA Aircraft Certification Office to determine the depth of analysis required. Include a system description, a description of the system’s installation, and a list of its functions and criticality.

2.5.3 The safety assessment of the lithium battery installation should address the battery system, the aircraft interface, and the aircraft functional loads to which the battery system provides power.

2.6 **Software.**

All lithium batteries that use software should comply with RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, or equivalent, for the

appropriate design assurance level. You can find additional guidance in the following ACs:

- AC 25.1309-1A, System Design and Analysis;
- AC 29-2C, Certification of Transport Category Rotorcraft;
- AC 27-1B, Certification of Normal Category Rotorcraft;
- AC 23.1309-1E, System Safety Analysis and Assessment for Part 23 Airplanes; and
- AC 20-115D, Airborne Software Development Assurance Using EUROCAE ED-12( ) and RTCA DO-178( ).

2.7 **Complex Electronic Hardware.**

All lithium batteries hardware that contains complex electronic hardware should comply with the most recent revision, of AC 20-152, RTCA, Inc., Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, dated June 30, 2005.

2.8 **State of Charge.**

Lithium batteries that are not maintained at a high enough state of charge degrade at a significantly higher rate.

2.9 **Flammability.**

Unlike nickel-cadmium and lead-acid cells, some types of lithium cells use electrolytes in a liquid state known to be flammable. This material can serve as a source of fuel for an external fire if a cell failure occurs. Lithium batteries have the potential to ignite spontaneously or experience an uncontrolled temperature and pressure increase, resulting in propagation to adjacent cells.

2.9.1 Pursuant to §§ 23.2325, 23.2330, 25/27/29.853, 25/27/29.863, and 25.869, aircraft battery equipment must meet the flammability requirements of that ensure the protection of structure and critical systems. Test the materials to ensure they meet applicable certification requirements.

2.9.2 Pursuant to Part 25, Appendix F, The FAA Aircraft Materials Fire Test Handbook, DOT/FAA/AR-00/12 Chapters 1 through 10 and Chapter 15, describes an acceptable method of compliance for material Test Criteria and Procedures. Pursuant to § 25.856(a), Appendix F, Part VI, Amendment 25-111, provides the criteria for using exposed thermal and acoustic insulation material as part of the battery equipment ,. Refer to the test methods described by AC 25.856-1, *Thermal/Acoustic Insulation Flame Propagation Test Method Details*.

2.10 Instructions for Continued Airworthiness (ICA).

2.10.1 During the certification process of the lithium batteries, complete the ICA in accordance with the following:

- Section 21.50(b);
- Sections 23/25/27/29.1529;
- Sections 25.1709 and 25.1729;
- Part 23, appendix A, Part 27/29 appendix A, part 25 appendix H and
- FAA Order 8110.54, *Instructions for Continued Airworthiness, Responsibilities, Requirements, and Contents*.

2.10.2 Develop the ICA so it is compatible with other maintenance instructions for the aircraft.

2.10.3 Refer to Chapter 3 of this AC for additional details specific to the maintenance of lithium batteries on aircraft.

2.10.4 Pursuant to §§ 43.16 and 91.403, the Airworthiness Limitations section is FAA-approved and specifies maintenance requirements unless the FAA has approved an alternative program.

2.10.5 The ICA should also include, but not limited to, the following information:

2.10.5.1 Specifics of the lithium battery installation, including individual component part numbers and any other unique installation requirements;

2.10.5.2 Electrical wiring diagrams/schematics, electrical equipment drawings and,

2.10.5.3 Configuration control, storage instructions.

2.10.6 The ICA must contain the recommended battery manufacturer's maintenance and inspection requirements to ensure the batteries whose function is required for safe operation of the aircraft will function when installed in the aircraft. The ICA must contain:

2.10.6.1 Operating instructions and equipment limitations in an installation maintenance manual.

2.10.6.2 Installation procedures and limitations sufficient to ensure cells or batteries, when installed according to the installation procedures, still meet the airworthiness requirements of the aircraft. The limitations must identify any unique aspects of the installation.

2.10.6.3 Maintenance requirements for measurements of battery capacity at appropriate intervals to ensure the batteries whose function is required for safe operation of the aircraft will perform their intended function when installed in the aircraft.

2.10.6.4 Scheduled servicing information to replace batteries at the battery manufacturer's recommended replacement time.

2.10.6.5 Maintenance and inspection requirements to visually check for battery and/or charger degradation.

2.10.6.6 Maintenance instructions, basic control and operation, testing, servicing, maintenance schedule, inspection, troubleshooting, removing and replacing parts, repairs, special tools, fixtures and equipment, component manual.

2.10.7 The ICA should also contain maintenance procedures for lithium batteries in spares storage to prevent the replacement of batteries with batteries that have experienced degraded charge retention ability or other damage due to prolonged storage.

2.10.8 The ICA must contain instructions to replace batteries based on the battery manufacturer maintenance manual. Replacement of individual cells within a lithium battery must be approved by the battery manufacturer and the FAA. Do not mix cells from different manufactures within a lithium battery, unless an alternate means proposed by the OEM and approved by the FAA exist.

CHAPTER 3. MAINTENANCE AND OPERATIONAL CONSIDERATIONS FOR LITHIUM BATTERIES

3.1 Introduction.

Lithium batteries can be hazardous if not maintained and handled properly. This chapter provides guidance for maintenance considerations for aircraft lithium batteries.

3.2 Aircraft Battery Maintenance.

Follow each battery manufacturer's maintenance and inspection requirements for their specific aircraft lithium battery. In-service performance of lithium batteries for a given installation will depend on several factors that include but are not limited to the following:. (Also refer to §43.13 for additional requirements)

3.2.1 Lithium Battery Chemistry.

The electrolyte used in lithium batteries can be a highly reactive substance, and care must be observed in maintaining the lithium batteries in accordance with the OEM maintenance manual.

3.2.2 Age.

To determine the life and age of the lithium battery, record the installation date of the battery. During normal battery maintenance, document battery age in either the aircraft maintenance log or the shop maintenance log. Do not keep batteries in service longer than recommended by the battery manufacturer.

3.2.3 State of Charge.

State of charge of the lithium battery is determined by the cumulative effect of discharging the battery. Therefore, safeguards must be implemented to ensure the aircraft does not begin flight with a battery not sufficiently charged to accomplish its intended function.

3.2.4 State of Health.

Determine the state of health of the lithium battery by recording the following:

- Length of time the battery has been in service.
- The State of Charge of the battery. The output of this function may be used for dispatch or maintenance purposes.
- Any activation of temporary safety devices such as resettable fuses or positive temperature coefficient (PTC), if present in the design.

3.2.5 Mechanical Integrity.

To ensure proper mechanical integrity, the battery must be installed and connected correctly and be free of any physical damage. The buildup of explosive gases can be avoided by incorporating positive battery and battery compartment venting systems. Check periodically to ensure the venting system is securely connected and oriented in accordance with the maintenance manual's installation procedures. Follow the procedures approved for the specific aircraft and battery system to ensure the battery system is capable of delivering specified performance. The venting system should take into account specific installation requirements of the aircraft.

3.2.6 Shop-Level Maintenance Procedures.

Shop procedures must follow the battery manufacturer's recommendations. (Also refer to §43.13 for additional requirements)

3.2.7 Aircraft Battery Inspection.

Evidence of battery failure can sometimes be detected by a general visual inspection. Battery manufacturer-recommended inspections should include, but not be limited to, the following actions—

3.2.7.1 Inspect battery terminals and all other connections for evidence of corrosion, pitting, arcing, and burns. Clean as required.

3.2.7.2 Inspect the battery for improper installation (loose terminal screws, battery terminal links, or connector).

3.2.7.3 Inspect the battery mounting.

3.2.7.4 Inspect for evidence of physical damage.

3.2.8 Prior to installation on aircraft batteries in a rotable stock (which are parts and components that are easily exchanged between product) must be functionally checked at the battery manufacturer's recommended inspection intervals. Some failure modes may include degraded charge retention capability, settling of particulates, or other damage due to prolonged storage.

3.3 **Aircraft Battery Replacement.**

3.3.1 Make sure replacement batteries are in airworthy condition. Refer to the battery manufacturer maintenance manuals for proper maintenance of lithium batteries. Refer to the aircraft maintenance procedures for replacement of lithium batteries.

3.3.2 The ICA should include the battery manufacturer's requirements for the battery mandatory replacement schedule and periodic maintenance.

3.3.3 Installation of lithium batteries differs from aircraft system to aircraft system. Refer to the applicable aircraft manuals to remove and install batteries.

3.3.4 When replacing batteries, check for corrosion and moisture on the battery interfaces.

3.3.5 The maintenance record should reflect all battery replacements. Record the expiration date of the battery.

3.3.6 The lithium batteries should be replaced with an approved battery for the specific aircraft application.

3.3.7 Deep discharge may result in potential unsafe condition. Replace the battery based on the battery manufacturer's recommendation.

3.4 **Aircraft Battery Storage and Handling.**

3.4.1 Follow the battery manufacturer's recommended storage procedures that will permit users to achieve the best results from their batteries.

3.4.2 Storage requirements vary with the battery type. Record the date of 100% state of charge and, if the battery is not used within the battery manufacturer's recommended interval, service the battery per the battery manufacturer's recommendation.

3.4.3 Handling procedures and precautions vary with battery size and configuration. Follow the battery manufacturer's recommendation to prevent mishandling of the battery.

3.4.4 Follow the battery manufacturer's recommendation procedure to prevent electrostatic discharge during storage and handling.

3.4.5 For packaging and shipping, follow the battery manufacturer's recommended procedures.

3.4.6 Check batteries before use for any leakage or deformity. Do not use the batteries if there is any evidence of leakage or deformity.

3.4.7 Aircraft vibration and/or contact oxidation can result in poor electrical connections. Ensure proper connector maintenance procedures are followed.

3.4.8 Observe the following precautions when handling lithium batteries:

3.4.8.1 Do not store lithium batteries with other hazardous or combustible materials.

3.4.8.2 Do not heat or incinerate lithium batteries.

3.4.8.3 Do not dispose of lithium batteries with other waste unless allowed by applicable regulations.

3.4.8.4 Use special care in handling lithium batteries. Do not open, puncture, crush, disassemble, or subject batteries to physical abuse.

3.4.9 Lithium batteries can be a personal safety hazard due to the possibility of lethal shock and must be labeled to clearly indicate the hazard.

3.4.10 Follow all battery manufacturer’s recommended safety precautions and procedures.

3.4.11 Material Safety Data Sheets must be enclosed with lithium batteries for shipping.

3.4.12 Wear protective clothing before handling and disposing of lithium batteries.

Appendix A. Related Regulations and Documents

A.1 Regulations

14 CFR part 21	Certification procedures for products and Parts
14 CFR part 23	Airworthiness standards: Normal Category Airplanes
14 CFR part 25	Airworthiness standards: Transport Category Airplanes
14 CFR part 27	Airworthiness standards: Normal category rotorcraft
14 CFR part 29	Airworthiness standards: Transport category rotorcraft
14 CFR part 43	Maintenance, preventive maintenance, rebuilding, and alteration
14 CFR part 145	Repair stations

A.2 Advisory Circulars

AC 20-115D	Airborne Software Development Assurance Using EUROCAE ED-12 and RTCA DO-178()
AC 20-128A	Design Considerations for Minimizing Hazards caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure
AC 20-135	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria
AC 20-136B	Aircraft Electrical and Electronic System Lightning Protection

AC 20-152	RTCA, Inc., Document RTCA/DO-254 Design Assurance Guidance for Airborne Electronic Hardware
AC 20-158A	The Certification of Aircraft Electrical and Electronic Systems for Operation in the High intensity Radiated Fields (HIRF) Environment
AC 21-16G	RTCA Document DO-16o versions D, E, F, and G, "Environmental Conditions and Test Procedures for Airborne Equipment"
AC 23.1309-1E	System Safety Analysis and Assessment for Part 23 Airplanes
AC 23-17C	Systems and Equipment Guide for Certification of Part 23 Airplanes and Airships
AC 25.1309-1A	System Design and Analysis
AC 25-16	Electrical Fault and Fire Prevention and Protection
AC 25-1581-1	Airplane Flight Manual
AC 27-1B	Certification of Normal Category Rotorcraft
AC 29-2C	Certification of Transport Category Rotorcraft
AC 43.13-1B	Acceptable Methods, Techniques and Practices-Aircraft Inspection and Repairs
AC 43.13-2A	Acceptable Methods, Techniques, and Practices – Aircraft Alterations
AC 120-16	Air Carrier Maintenance Programs
AC 120-42A	Extended Range Operation with Two Engine Airplanes (ETOPS)

A.3 Orders and Handbooks

FAA Order 8110.4C	Type Certification
FAA Order 8110.42	Parts Manufacturer Approval Procedures
FAA Order 8110.54	Instructions for Continued Airworthiness, Responsibilities, Requirements, and Content
FAA Aircraft Materials Fire Test Handbook	www.fire.tc.faa.gov Aircraft Materials Fire Test Handbook

A.4 Other

DOT/FAA/AR-04/26	Flammability Assessment of Bulk-Packed, Non-non-rechargeable Lithium Primary Batteries in Transport Category Aircraft, June 2004

A.5 Industry Documents

SAE ARP 4754	Guidelines for Development of Civil Aircrafts and Systems
SAE ARP 4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
RTCA DO-178C	Software Considerations in Airborne Systems and Equipment Certification
RTCA DO-254	Design Assurance Guidance for Airborne Electronic Hardware
RTCA DO-227A	Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries, dated September XX, 2017
RTCA DO-160G	Environmental Conditions and Test Procedures for Airborne Equipment

Appendix B. Terms and Definitions

For purposes of this AC, the following definitions apply:

Airworthiness. The compliance of a battery or part thereof with all conditions and regulations required by the regulatory authorities for their safe operation and performance in an airborne environment.

Battery Cell. In a battery, a cell is a single energy or charge-storing unit within a pack of cells that form the battery. Each cell has a voltage rating that is combined with the other cells' voltages to form the overall battery voltage rating.

Battery. One or more electrically connected cells, assembled in a single container having positive and negative terminals. A battery may include inter-cell connectors and protective and other devices.

Battery System. One or more electrically connected batteries that provide power to equipment. A battery system may include a charger, controlling circuitry and means for monitoring of battery temperature, battery state, and current as well as system testing and related functions.

Charged Battery. A battery that has been fully charged in accordance with the battery battery manufacturer's instructions or as defined in the design documentation.

Continued Safe Flight and Landing. The aircraft is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill or strength. Upon landing, some aircraft damage may occur as a result of a failure condition.

Failure. An occurrence that affects the operation of a component, part, or element such that it can no longer function as intended (this includes both loss of function and malfunction). No**te:** Errors may cause failures if they are directly traced to the errors.

Primary (Non-rechargeable) Versus Secondary (Non-rechargeable) Battery. One of the basic differences among battery types is whether the battery is to be used once or is to be recharged. Batteries that are used and discarded are known as primary or non-rechargeable. Batteries that can be used repeatedly are known as secondary or non-rechargeable.

Redundancy. The presence of more than one independent means for accomplishing a given function or flight operation.

Serviced Battery. A battery fully prepared and maintained in accordance with the battery manufacturer's instructions or as defined in the design documentation.

Service Life. The maximum combined storage and installed life of an undischarged cell or battery. Service life cannot be greater than shelf life and will be stated by the equipment manufacturer. The end of service life is indicated by a “replace-by” or expiration date. Service life is equivalent to useful life.

Shelf Life. The maximum period at which an undischarged cell or battery stored under standard conditions retains 80 percent of rated ampere-hour capacity. The cell/battery manufacturer specifies shelf life.

System. A combination of components, parts, and elements, which are interconnected to perform one or more functions.

Appendix C. Previously issued non-rechargeable lithium battery special conditions for Transport Airplanes

For the purpose of this appendix, we refer to a battery and battery system as a battery. A battery system consists of the battery and any protective, monitoring, and alerting circuitry or hardware inside or outside of the battery. It also includes vents (where necessary) and packaging.

The Federal Aviation Administration (FAA) has issued several special conditions (SCs) for non-rechargeable lithium battery installations on transport category airplanes. These SCs are located in this appendix. Applicants, who propose using these SCs for their project, must submit a letter indicating their intentions to the Aircraft Certification Service (AIR) office responsible for their project.

Definition of Key Terms

In this policy, the terms "must," "should," and "recommend" have specific meanings:

- The term "must" refers to a regulatory requirement that is mandatory for design approval. The functional impact of the term "must" is that the requirement has to be met to achieve design approval.

- The term "should" refers to instructions for a particular acceptable method of compliance (MOC). The functional impact of the term "should" is that all proposed alternative MOC are evaluated through the issue paper process.

- The term "recommendation" refers to a recommended practice that is optional. There is no functional impact of the term "recommend" because it is optional.

"End Item" is used in this this appendix and is defined in RTCA/DO-227A, *Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries*, appendix D.

Background

The FAA derived the current regulations governing installation of batteries in transport category airplanes from the Civil Air Regulations (CAR) 4b.625(d) as part of the recodification of CAR 4b that established 14 CFR part 25 in February 1965. This recodification basically reworded the CAR 4b battery requirements, which are currently in § 25.1353(b)(1) through (4). Non-rechargeable lithium batteries are novel and unusual with respect to the state of technology considered when these requirements were codified.

Recent events involving rechargeable and non-rechargeable lithium batteries prompted the FAA to initiate a broad evaluation of these energy storage technologies. In January 2013, two

independent events[1] involving rechargeable lithium-ion batteries revealed unanticipated failure effects. On July 12, 2013, an event[2] involving a non-rechargeable lithium battery in an emergency locator transmitter installation demonstrated additional unanticipated failure effects.

The FAA has been issuing SCs for certification projects involving the installations of non-rechargeable lithium batteries. At this time, all of the published SCs have been the same. These SCs are listed below.

In lieu of title 14, Code of Federal Regulations (14 CFR) 25.1353(b) (1) through (4) at amendment 25-123 or § 25.1353(c) (1) through (4) at earlier amendments, each non-rechargeable lithium battery installation must:

:

1. Be designed to maintain safe cell temperatures and pressures under all foreseeable operating conditions to prevent fire and explosion.
2. Be designed to prevent the occurrence of self-sustaining, uncontrollable increases in temperature or pressure.
3. Not emit explosive or toxic gases, either in normal operation or as a result of its failure, that may accumulate in hazardous quantities within the airplane.
4. Meet the requirements of § 25.863.
5. Not damage surrounding structure or adjacent systems, equipment, or electrical wiring from corrosive fluids or gases that may escape in such a way as to cause a major or more severe failure condition.
6. Have provisions to prevent any hazardous effect on airplane structure or systems caused by the maximum amount of heat it can generate due to any failure of it or its individual cells.
7. Have a failure sensing and warning system to alert the flightcrew if its failure affects safe operation of the airplane.
8. Have a means for the flightcrew or maintenance personnel to determine the battery charge state if the battery's function is required for safe operation of the airplane.

Note: A battery system consists of the battery and any protective, monitoring, and alerting circuitry or hardware inside or outside of the battery. It also includes vents (where necessary) and packaging. For the purpose of these special conditions, a "battery" and "battery system" are referred to as a battery.

[1] National Transportation Safety Board Accident Report AIR-14-01, dated November 21, 2014

[2] United Kingdom's Air Accidents Investigation Branch Bulletin S4/2014

Appendix D. Guidance for installing non-rechargeable lithium batteries on Transport Airplanes

For the purpose of this appendix, we refer to a battery and battery system as a battery. A battery system consists of the battery and any protective, monitoring, and alerting circuitry or hardware inside or outside of the battery. It also includes vents (where necessary) and packaging.

The Federal Aviation Administration (FAA) has issued several special conditions (SCs) for non-rechargeable lithium battery installations on transport category airplanes. These SCs are provided in Appendix C of this AC.

This appendix provides an acceptable method of compliance with the non-rechargeable lithium battery SCs in Appendix C of this AC and related 14 CFR part 25 requirements. It also provides guidance related to the applicability statements in previously issued non-rechargeable lithium battery SCs.

D.1 Methods of Compliance with SCs

RTCA/DO-227A, *Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries,* sections 1 *Purpose and Scope* and 2 *Equipment Performance Requirements and Test Procedures,* provide design requirements and guidelines that are pertinent to designing safe batteries and to meeting part 25 installation requirements and these SCs. Consider each of these requirements and guidelines when designing cells and batteries.

Special Conditions 1 and 2 below are intended to ensure that the cells and battery are *designed* to eliminate the potential for uncontrollable failures. However, a certain number of failures will still occur due to various factors many of which are beyond the control of the designer. Therefore, these SCs as a whole are intended to protect the airplane and its occupants even when a failure occurs.

These SCs are independent of each other. Demonstrating compliance with one of these SCs does not constitute compliance with the other SCs. The methods of compliance are as follows:

D.1.1 Method of Compliance (MOC) for SC 1

Show that the individual cells meet the requirements in RTCA/DO-227A, section 2.2.1 *Cell Functional and Safety Requirements*. Use the test procedures in RTCA/DO-227A, section 2.4.1 *Cell Test Procedures and Criteria* and show that the associated evaluation criteria are met.

D.1.2 Method of Compliance for SC 2

Whereas, SC 1 requires that each individual cell within a non-rechargeable lithium battery be designed to maintain safe temperatures and pressures, SC 2 addresses these same issues but for the entire battery. Special Condition 2 requires that the battery be designed to prevent propagation of a thermal event, such as self-sustained, uncontrollable increases in temperature or pressure from one cell to adjacent cells.

Show that the battery installation meets the requirements in RTCA/DO-227A, sections 2.2.2 *Battery Functional and Safety Requirements* and 2.2.3 *End Item Functional and Safety Requirements*. Use the test procedures in RTCA/DO-227A, sections 2.4.2 *Battery Test Procedures and Criteria* and 2.4.3 *End Item Test Procedures and Criteria* and show that the associated evaluation criteria are met.

RTCA/DO-227A, section 2.2.2 states, "If a single-cell battery is identical to the cell being tested for qualification, then the battery tests in this section shall be conducted unless they are identical to the cell tests." In these cases, where the battery tests are identical to the cell tests, show that the cell tests are met in lieu of the battery tests to support demonstrating compliance with SC 2.

D.1.3 Method of Compliance for SC 3 - 6

Use the worst case test data from the MOCs for SCs 1 and 2 to support demonstrating compliance with SCs 3 - 6. The FAA considers that the RTCA/DO-227A, section 2.4.3.2.2 *End Item Thermal Runaway Containment Test* usually provides these worst case data.

D.1.4 Method of Compliance for SC 3

RTCA/DO-227A, appendix A, section A.5 *Battery Emission Hazard* discusses potential gas emissions from batteries and their effects. An acceptable MOC with SC 3 includes using the tests required under SCs 1 and 2 to demonstrate that all emitted gases are contained or vented overboard (i.e., vented outside the airplane) through designed ports. Section D.2.1 *System Safety Assessment* of this policy statement provides guidance for conducting a system safety assessment for a design that vents these gases overboard.

Special Condition 3 does allow explosive and toxic gases to be uncontained and not vented overboard, provided they do not accumulate in hazardous quantities within the airplane. Consider the gases emitted from not only the cells but also the battery materials (e.g., insulation separators) when demonstrating compliance by this means.

D.1.5 Method of Compliance for SC 4

The amendment level of § 25.863 is determined by 14 CFR 21.17 or § 21.101, as appropriate. The amendment level is not determined by the issuance or effective date of the special conditions.

The Aviation Rulemaking Advisory Committee (ARAC) draft Advisory Circular (AC) 25.863-1, *Flammable Fluid Fire Protection*[3] gives acceptable guidance on § 25.863. Section 25.863 is a "fail-safe" regulation that requires means to minimize the likelihood of a fire and the resultant hazards if fire does occur. When applying § 25.863 to a battery installation, as explicitly required by SC 4, conduct a hazard assessment assuming that a battery failure ignites any resultant flammable fluids or gases, and provide provisions to address the associated hazards. This may result in the need to provide a battery enclosure that vents overboard.

D.1.6 Method of Compliance for SC 5

Show that when fluid escapes the battery, it is not corrosive or it is managed in a way (e.g., contained, isolated, or vented overboard) to protect the surrounding structure and adjacent systems, equipment and electrical wiring.

D.1.7 Method of Compliance for SC 6

Show that the effects of the heat, and any related effects, from the tests performed under SCs 1 and 2 do not constitute a hazard to the structure or systems of the airplane.

If the effects of the heat or any related effects constitute a hazard to the structure or systems of the airplane, design mitigation at the airplane level may be applied to bring the design into compliance with this SC.

D.1.8 Method of Compliance for SC 7

Pursuant to § 25.1309(c), SC 7 requires flightcrew alerting when the failure of a battery installation, in itself or in relation to a system that performs an airplane-level function, could result in "unsafe system operating conditions" as stated in § 25.1309(c). The alert must meet the applicable paragraphs of § 25.1322. The applicant should refer to the current AC 25.1309-1A *System Design and Analysis* for guidance. The ARAC recommended draft AC 25.1309-Arsenal, *System Design and Analysis*, dated June 10, 2002, also provides guidance that may be applied to a project if the applicant receives an equivalent level of safety finding to §§ 25.1301 and 25.1309(c) in accordance with FAA Policy Statement PS-ANM-100-00-113-1034, dated January 4, 2001.

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[3] Aviation Rulemaking Advisory Committee (ARAC) draft Advisory Circular (AC) 25.863-1 http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEpihT5-9231998.pdf[4]
Aviation Rulemaking Advisory Committee (ARAC) draft Advisory Circular (AC) 25.863-1 http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEpihT5-9231998.pdf

D.1.9 Method of Compliance for SC 8

The following are examples of "means" by which the flightcrew or maintenance personnel to determine the battery charge state:

- A manually activated system (e.g., push button) that displays the available charge of each battery unit
- An automatic system that records the available charge of each battery unit on an appropriate interval and makes it available to maintenance personnel before the next flight
- Physical access that allows a maintenance person to measure the battery charge state

The above "means" are acceptable only when the Instructions for Continued Airworthiness (ICA) include a requirement for a person to check the battery charge state within an interval that will ensure sufficient charge for the entire flight and to replace the battery when the charge is not sufficient.

D.1.10 Method of Compliance for Very Small, Button/Coin Non-Rechargeable Lithium Batteries

An acceptable MOC with SCs 1 through 6 for button/coin non-rechargeable lithium battery installations that have less than 2 watt-hours of energy is showing these batteries meet Underwriters Laboratories (UL) 1642.

D.2 Part 25 Compliance

Non-rechargeable lithium battery installations must comply with these SCs and all applicable part 25 and part 26 requirements. The following provides methods of compliance and other information for pertinent part 25 requirements:

D.2.1 System Safety Assessment

Pursuant to §§ 25.1301, 25.1309 and 25.1709, and these SCs requirements for specific functionalities and capabilities, address certain critical failure modes of non-rechargeable lithium batteries and their installations, the applicant must also meet the requirements of §§ 25.1301, 25.1309 and 25.1709, when applicable, in addition to these SCs. To date, in-service experience has shown that non-rechargeable lithium battery thermal/pressure runaway conditions are not extremely improbable. Assume such failures could occur sometime during the life of the battery installation when demonstrating compliance with § 25.1309 except for button/coin batteries that have less than 2 watt-hours of energy and meet UL 1642. For button/coin batteries that have less than 2 watt-hours of energy and meet UL 1642, use the data from UL 1642 to support demonstrating compliance with § 25.1309. For other non-rechargeable lithium batteries, use the worst case test data from section D.1.1 *Method of Compliance for SC 1* and section D.1.2 *Method of Compliance for SC 2* to support demonstrating compliance with § 25.1309.

As part of showing compliance with § 25.1309, the applicant is to demonstrate that particular risks, as identified in SAE ARP 4761, *Guidelines and Methods for Conducting Safety Assessment Process on Civil Airborne Systems and Equipment*, such as an uncontained rotor burst, tire debris, fire, lightning or bird strike, will not compromise continued safe flight and

landing. The applicant is to consider the effects of particular risks both internal and external to non-rechargeable lithium battery installations. For example, the applicant is to consider the effects of particular risks on any containment and venting provisions for a non-rechargeable lithium battery.

Application of § 25.1309(b) and (c) may result in required periodic maintenance actions or flightcrew alerting features. For example, an over-temperature warning system may be necessary to allow the flightcrew to manage potentially unsafe system operating conditions. Provide rationale for alerting requirements (or for why an alert is not needed) in the system safety assessment of the battery installations to demonstrate compliance with § 25.1309(c). Such alerts, when provided, must meet § 25.1322. Refer to AC 25.1309-1A, AC 25.1322-1 *Flight Crew Alerting*, AC 25.1581-1 *Airplane Flight Manual*, and AC 25.1701-1 *Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes* for further guidance.

> **Note**: In addition to the current AC 25.1309-1A, the FAA has allowed the use of ARAC recommended AC 25.1309-Arsenal, *System Design and Analysis*, dated June 10, 2002, if the applicant receives an equivalent level of safety finding to §§ 25.1301 and 25.1309 in accordance with FAA Policy Statement PS-ANM-100-00-113-1034, dated January 4, 2001.

Venting toxic and explosive gases from a non-rechargeable lithium battery failure through designed ports that lead outside of the airplane is a MOC with SC 3 as discussed in section D.1.4 *Method of Compliance for SC 3*. Pursuant to § 25.1309, consider the hazards of exposure of these gases to ground personnel, air conditioning in-take and engine in-takes.

D.2.2 Section 25.1353 Electrical Equipment and Installations

Pursuant to §§ 25.1353(b) and (c), each SC states that it applies to all non-rechargeable lithium battery installations in lieu of § 25.1353(b)(1) through (4) at amendment 25-123 or § 25.1353(c)(1) through (4) at earlier amendments. This statement does not relieve an applicant from demonstrating compliance to the other paragraphs of § 25.1353.

D.2.3 Section 25.1529 Instruction for Continued Airworthiness (ICA)

Pursuant to § 25.1529, include in the ICA the following to show compliance with the regulation:

1. Maintenance requirements to replace each non-rechargeable lithium battery within an interval that will ensure there is sufficient charge to power equipment.
2. A requirement to only replace non-rechargeable lithium batteries with batteries from the same manufacturer with the same part number or to obtain a new FAA approval for installing a different battery. Refer to the battery original equipment manufacturer maintenance manual.
3. Procedures to ensure that each non-rechargeable lithium battery has not:
   a. Experienced degraded charge retention ability or other damage during storage.

b. Been damaged from environmental or physical impacts such as mechanical shock, vibration, heat and possible abuses encountered during storage, transportation prior to their installation or maintenance activities on or around them.

4. Precautions to prevent mishandling of replacement non-rechargeable lithium batteries prior to their installation which could result in short-circuit or other unintentional damage.

Acceptable procedures for item 3.b. may include a quality control process for packaging, storing, maintaining and transporting non-rechargeable lithium batteries, including reporting of dropped or damaged batteries.

D.2.4 Section 25.1729 Electrical Wiring Interconnection Systems (EWISs) ICA

Pursuant to § 25.1729, Electrical Wiring Interconnection Systems (EWISs) maintenance and inspection tasks required are to ensure that EWIS components associated with non-rechargeable lithium batteries are sufficient to prevent degradation of any EWIS component that is designed and installed to support compliance with these SCs.

D.2.5 Sections 25.903(d) and 25.1309 Uncontained Engine or Auxiliary Power Unit (APU) Rotor Failures

Pursuant to § 25.1309, the FAA expects the applicant to demonstrate that a foreseeable event originating from outside of a non-rechargeable lithium battery, such as an uncontained rotor burst, will not compromise continued safe flight and landing. An applicant may propose fail-safe design features that encase and safely vent the hazardous byproducts of a failure originated from within the battery to show compliance with the non-rechargeable lithium battery SCs. However, a rotor failure could defeat such safety features depending on the location of the battery installation. If an applicant proposes to install a non-rechargeable lithium battery in a rotor burst zone, the applicant must ensure the means of compliance to the SCs remain effective considering potential rotor failures that could damage the battery.

Regarding compliance to § 25.903(d)(1) turbine engine rotor failures, AC 20-128A *Design Considerations for Minimizing Hazards caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure* provides guidance on fragmentation characteristics and the boundaries of the locations in which applicants are expected to evaluate the effects of impact damage following an uncontained rotor burst. If an applicant proposes to install a non-rechargeable lithium battery in a rotor burst zone, the applicant must assess the rotor burst induced damage to the battery to show compliance with § 25.903(d)(1) in conjunction with showing compliance with the non-rechargeable lithium battery SCs. In this case, provide a proposed method of compliance to the FAA. Alternatively, locate the battery outside of the rotor burst zone.

D.3 Special Condition Applicability Exclusion Criteria

As explained in Appendix C, the FAA determined from non-rechargeable lithium battery incidences that part 25 does not contain adequate safety standards for installing these batteries on transport category airplanes. The FAA addressed this issue on new certification projects for

transport category airplanes by requiring changes involving non-rechargeable lithium batteries to comply with special conditions. However, the FAA previously approved many non-rechargeable lithium battery installations that were not shown to comply with special conditions. Therefore, to improve the safety of follow-on airplanes that are delivered with these installations, the FAA included a paragraph in the applicability section of non-rechargeable lithium battery special conditions similar to the following:

> *These special conditions are not applicable to changes to previously certified non-rechargeable lithium battery installations where the only change is either cosmetic or to relocate the installation to improve the safety of the airplane and occupants. Previously certified non-rechargeable lithium battery installations, as used in this paragraph, are those installations approved for certification projects applied for on or before the effective date of these special conditions. A cosmetic change is a change in appearance only, and does not change any function or safety characteristic of the battery installation. These special conditions are also not applicable to unchanged, previously certified non-rechargeable lithium battery installations that are affected by a change in a manner that improves the safety of its installation. The FAA determined that these exclusions are in the public interest because the need to meet all of the special conditions might otherwise deter these design changes that improve safety.*

This statement is intended to allow the FAA or type certificate holders to identify approved lithium battery installations that are a fire safety concern, which are not necessarily unsafe such that the FAA would issue an airworthiness directive, and implement a design change that improves the safety of it on follow-on airplane deliveries without having to show compliance with the special conditions. The FAA considered that requiring new substantiation data for meeting the special conditions may prevent type certificate holders from implementing these improvements.

The special condition applicability exclusion, which relates to improving the safety of previously approved installations, only applies to the below conditions and each condition must be met:

- A change to a baseline airplane type certificated on or before the effective date of the special condition. That is, the follow-on airplane change must be compared to a single, baseline airplane (i.e., a distinct serial number airplane). Other changes between the follow-on airplane and baseline airplane may exist, but all of those changes must be approved as part of the follow-on airplane changes. Otherwise, the proposed baseline airplane is not actually the baseline airplane.
- Previously approved non-rechargeable lithium battery installations on baseline airplanes where a fire safety concern, which may not be considered unsafe such that the FAA would issue an airworthiness directive, is identified. This exclusion does not cover a situation where a battery is moved to an arguably better location, but either location is considered fine in terms of fire safety.
- A change that provides a substantial, fire safety improvement.
- For minor software changes to avionics devices that contain non-rechargeable lithium batteries, where the software functional changes have no effect on and are not affected by an existing installed battery. Applicants should demonstrate that the change has no effect on the battery or the associated special conditions.

Applicants, who propose to use this special condition applicability exclusion statement, should provide the FAA information to show how their proposal meets each of the above conditions. This includes providing a detailed assessment of the battery installation on the baseline airplane and the improvement due to the proposed change considering a battery thermal runaway failure for both installations. The assessment should:

- Consider the battery thermal runaway effects of heat, explosive energy, projecting debris and toxic gases.
- Address the proximity of the battery to occupants, critical systems and equipment, structure, and any other installations that could be a hazard if exposed to a battery thermal runaway (e.g., oxygen bottles/lines, fuel lines).

Appendix E. Safety Objectives and MOC for installation of Non-Rechargeable Lithium Batteries on Rotorcrafts

This appendix establishes an approach to show compliance for non-rechargeable lithium batteries and their installation to the safety objectives listed in this appendix. It is also intended to ensure, as required by §§ 27/29.601 and 27/29.1309, that the installation does not represent a hazard to the rotorcraft and its occupants.

Regulatory Basis from parts 27 and 29

Pursuant to §§ 27/29.601, the design must not have features or details that experience has shown to be hazardous or unreliable.

Pursuant to §§ 27/29.863, provide a means of minimizing the probability of ignition of flammable fluids or vapors that might leak from flammable liquid sources, and the resultant hazards in the event of ignition.

Pursuant to §§ 27/29.1301, ensure each system is appropriate for its intended function, and is labeled and installed according to its limitations and function.

Pursuant to §§ 29.1309, ensure all systems perform their intended function under any foreseeable operating conditions, systems must be designed to prevent hazards to the rotorcraft in the event of a probable malfunction or failure.

Pursuant to §§ 27.1309, all systems must perform their intended function under any foreseeable operating conditions, systems must be designed to prevent hazards to a multiengine rotorcraft in the event of a probable malfunction or failure and minimize hazards to a single engine rotorcraft.

Pursuant to §§ 29/27.1353, storage batteries must be designed and installed to maintain safe cell temperatures and pressures that no explosive or toxic gases can accumulate in hazardous quantities, and that corrosive fluids or gases cannot damage surrounding structures or essential systems.

Pursuant to §§ 27/29.1529, requires that Instructions for Airworthiness be prepared that are acceptable to the Administrator.

Advisory Material

RTCA/DO-227A, *Minimum Operations Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries*.

AC 29-2C, *Certification of Transport Category Rotorcraft*.

E.1 Safety Objectives (SO's)

Eight Safety Objectives are identified as critical for safe installation of non-rechargeable lithium batteries on rotorcrafts. Each non-rechargeable lithium battery installation must show compliance with the following Safety Objectives:

E.1.1 Safety Objective 1:

The battery shall be designed to maintain safe cell temperatures and pressures under all foreseeable operating conditions to prevent fire and explosion.

E.1.2 Safety Objective 2:

The battery shall be to prevent the occurrence of self-sustaining, uncontrollable increases in temperature or pressure.

E.1.3 Safety Objective 3:

The battery shall not emit explosive or toxic gases, either in normal operation or as a result of its failure, that may accumulate in hazardous quantities within the rotorcraft.

E.1.4 Safety Objective 4:

The battery must meet the flammable fluid fire protection requirements of §29.863.

E.1.5 Safety Objective 5:

The battery and installation must be designed to prevent corrosive fluids or gases that may escape from damaging surrounding structure or adjacent systems, equipment, or electrical wiring.

E.1.6 Safety Objective 6:

The battery and installation must be designed to prevent any hazardous effect on rotorcraft structure or systems caused by the maximum amount of heat generated from any battery or individual cell failure.

E.1.7 Safety Objective 7:

The battery and installation must have a failure sensing and warning system to alert the flight crew if a failure affects safe operation of the rotorcraft.

E.1.8 Safety Objective 8:

The battery and installation must provide a means for the flight crew to determine the battery charge state (for required battery systems).

Note: A battery system consists of individual battery cell(s), a battery assembly, and any protective, monitoring and alerting circuitry or hardware inside or outside of the battery. It may also include vents (when necessary) and packaging. For the purpose of this guidance, a battery and battery system are referred to as a battery.

A battery may also be an integral component of an end item assembly. The battery supplies energy to the end item. A battery may also be an end item.

E.2 Method of Compliance (MOC)

The following MOC have been accepted to ensure that the battery meets Safety Objectives 1 through 8 discussed in the paragraphs above. Some failures may still occur due to various factors beyond the control of the battery and battery system OEM; these MOCs are also intended to address the occurrence of these unexpected failures.

RTCA/DO-227A provides a MOC acceptable to the FAA for installation of non-rechargeable lithium batteries on rotorcraft. General design and construction requirements necessary to reliably and consistently produce lithium batteries appropriate for installation into the expected rotorcraft environment are found in paragraph 2.1, *General Requirements and Design Guidelines*. Paragraph 2.2, *Functional and Safety Requirements*, defines the minimum functional requirements for battery cells, batteries, and end items. Each subparagraph in paragraph 2.2 references a specific test procedure found in paragraph 2.4. Test procedures and evaluation criteria specifically for cells, batteries and end items are outlined in paragraph 2.4 corresponding to each of the functional and safety requirements. Test conditions are defined in paragraph 2.3.

E.2.1 MOC for Safety Objective 1 –

Show that the individual cells meet the requirements in RTCA/DO-227A, section 2.2.1. by successfully performing the test procedures in section 2.4.1 and judging the test results against the associated evaluation criteria.

E.2.2 MOC for Safety Objective 2 –

Safety Objective 1 requires that each individual cell within a non-rechargeable lithium battery be designed to maintain safe temperatures and pressures. Safety Objective 2 requires that the battery and end item installation be designed to prevent propagation of a thermal event, such as self-sustained, uncontrollable increases in temperature or pressure from one cell to adjacent cells.

Show that the battery installation meets the requirements in RTCA/DO-227A, sections 2.2.2 *Battery Functional and Safety Requirements* and 2.2.3 *End Item Functional and Safety*

Requirements. Successfully perform the test procedures in sections 2.4.2 and 2.4.3. Judge the test results against the associated evaluation criteria for successful showing.

E.2.3 Safety Objectives 3 through 6 –

Use the worst case test data from the MOCs for Safety Objectives 1 and 2 to support demonstrating compliance with SO 3 through 6. The FAA considers that the RTCA/DO-227A, section 2.4.3.2.2 *End Item Thermal Runaway Containment Test* usually provides these worst case data.

i. MOC for Safety Objective 3 –

RTCA/DO-227A, appendix A, section A.5 discusses potential gas emissions from batteries and their effects. An acceptable means of complying with Safety Objective 3 includes using the tests required under Safety Objectives 1 and 2 to demonstrate that all emitted gases are contained or vented overboard (i.e., vented outside the rotorcraft) through designed ports. Pursuant to §29.1309, when the design has ports to vent gases overboard, show that there are means to protect ground personnel from exposure to these gases and to prevent re-ingestion, for example through engine in-take or air conditioning in-take.

Safety Objective 3 allows explosive and toxic gases to be uncontained and not vented overboard if they do not accumulate in hazardous quantities within the rotorcraft. Consider the gases emitted from not only the cells but also the battery materials (e.g., insulation separators) when demonstrating compliance by this means.

ii. MOC for Safety Objective 4 –

The amendment level of §25.863 is determined by 14 CFR § 21.17 or § 21.101, as appropriate. The amendment level is not determined by the issuance or effective date of the special conditions. The Aviation Rulemaking Advisory Committee (ARAC) draft Advisory Circular (AC) 25.863-1, *Flammable Fluid Fire Protection*[4] gives acceptable guidance on §25.863.

iii. MOC for Safety Objective 5 –

Show that if fluid escapes the battery, it is not corrosive or it is managed in a way (e.g., contained, isolated, or vented overboard) to protect the surrounding structure and adjacent systems, equipment and electrical wiring.

iv. MOC for Safety Objective 6 –

Show that the effects of the heat, and any related effects, from the tests performed under Safety Objectives 1 and 2 do not constitute a hazard to the structure or systems of the rotorcraft.

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[4] Aviation Rulemaking Advisory Committee (ARAC) draft Advisory Circular (AC) 25.863-1 http://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEpihT5-9231998.pdf

If the effects of the heat or any related effects constitute a hazard to the structure or systems of the rotorcraft, design mitigation at the aircraft level may be applied to bring the design into compliance with Safety Objective 6.

E.2.4 MOC for Safety Objective 7 –

Pursuant to §29.1322, Safety Objective 7 requires flight crew alerting for unsafe operating conditions. Flight crew alerting is required when a battery installation failure affects continued safe flight and landing. The effect of the battery failure on other systems that perform functions required for safe flight and landing must also be considered. The alert must meet the applicable paragraphs of §29.1322. The applicant should refer to the current AC 29-2C for guidance on §29.1322.

E.2.5 MOC for Safety Objective 8 –

The following are examples of "means" for flight crew or maintenance personnel to determine the battery charge state:

(a) A manually activated system (e.g., push button) that displays the available charge of each battery unit.

(b) An automatic system that records the available charge of each battery unit on an appropriate interval and makes it available to maintenance personnel before the next flight.

(c) Physical access that allows a maintenance person to measure the battery charge state

The above "means" are acceptable only when the Instructions for Continued Airworthiness (ICA) include a requirement for a person to check the battery charge state within an interval that will ensure sufficient charge for the entire flight considering the worst case scenario, and to replace the battery when the charge is not sufficient.

After completing all the required test and validation based on the MOC for each safety objectives, provide a summary of all the evaluation criteria and reportable items listed in each test. Compliance to one safety objective does not constitute compliance to any other safety objectives.

E.3 Part 27 and 29 Compliance

Pursuant to part 29, non-rechargeable lithium battery installations should satisfy each of the MOCs identified in this document. The following provides means of compliance and other information on other important part 29 requirements.

E.3.1 System Safety Assessment

Pursuant to §§ 27, 29.1301 and .1309, hazard conditions require specific functionalities and capabilities, and address certain critical failure modes of non-rechargeable lithium batteries and

their installations, to date however, in-service experience has shown that non-rechargeable lithium battery thermal/pressure runaway conditions are not extremely improbable. Assuming such failures will occur sometime during the life of the battery installation when demonstrating compliance, periodic maintenance actions or flight crew alerting features such as, an over-temperature warning system may be necessary to allow the flight crew to manage potentially unsafe system operating conditions. Provide rationale for alerting requirements (or for why an alert is not needed) in the system safety assessment of the battery installations to demonstrate compliance with §27.1309 and §29.1309. Such alerts, when provided, must meet §27.1322 and §29.1322.

E.3.2 (2) The ICA should include the following provisions to comply with §27.1529 and §29.1529:

(a) Maintenance requirements to replace each non-rechargeable lithium battery within an interval that will ensure there is sufficient charge to power equipment.

(b) A requirement to only replace non-rechargeable lithium batteries with batteries from the same manufacturer with the same part number or to obtain a new FAA approval for installing a different battery. Refer to the battery Original Equipment Manufacturer's maintenance manual.

(c) Procedures to ensure that each non-rechargeable lithium battery has not:

(i) Experienced degraded charge retention ability or other damage during storage.

(ii) Been damaged from environmental or physical impacts such as mechanical shock, vibration, heat and possible abuses encountered during storage, transportation prior to their installation or maintenance activities on or around them.

(iii) Precautions to prevent mishandling of replacement non-rechargeable lithium batteries prior to their installation which could result in short-circuit or other unintentional damage.

Note: Acceptable procedures for paragraph (2)(b) above may include a quality control process for packaging, storing, maintaining and transporting non-rechargeable lithium batteries, including reporting of dropped or damaged batteries.

E.3.3 Uncontained Engine or APU Rotor Failures: Sections 27.903(b), 29.903(d) and 27/29.1309

In general, as part of showing compliance with §§ 27/29.1309, the FAA expects the applicant to demonstrate that a foreseeable event originating from outside of a non-rechargeable lithium battery, such as an uncontained rotor burst, will not compromise continued safe flight and landing. While you may use failsafe design features that encase and safely vent the hazardous

byproducts of a failure originated from within the battery to show compliance with the non-rechargeable lithium battery **Safety Objectives,** depending on the location of the battery installation, a rotor failure could defeat such safety features. If you propose to install a non-rechargeable lithium battery in a rotor burst zone, you must ensure the means of compliance to the SO's remains effective considering potential rotor failures that could damage the battery.

Regarding compliance to § 29.903(d)(1) turbine engine rotor failures, AC 20-128A provides guidance on fragmentation characteristics and the boundaries of the locations in which applicants are expected to evaluate the effects of impact damage following an uncontained rotor burst. If you propose to install a non-rechargeable lithium battery in a rotor burst zone, you must assess the rotor burst induced damage to the battery in your plan for showing compliance with § 29.903(d)(1) in conjunction with complying with the non-rechargeable lithium battery SO's. Clearly state your method of compliance in your response to this issue paper. Alternatively, the battery is to be located outside of the rotor burst zone.

Appendix F. Certification considerations of Non-Rechargeable Lithium Batteries on Small Airplanes

This appendix provides guidance to Aircraft Certification Offices (ACOs) regarding the risk-based certification considerations for the installation of non-rechargeable lithium batteries, or equipment that uses non-rechargeable lithium batteries on Title 14 of the Code of Federal Regulations (14 CFR) part 23 airplanes.

The regulations applicable to the subject include §§ 23.2510 and 23.2525 amendment 23-64, or §§ 23.1309 and 23.1353 with an earlier amendment level.

Section 23.1309 requires installed equipment perform its intended function and that it is designed to mitigate the hazard severity accordingly.

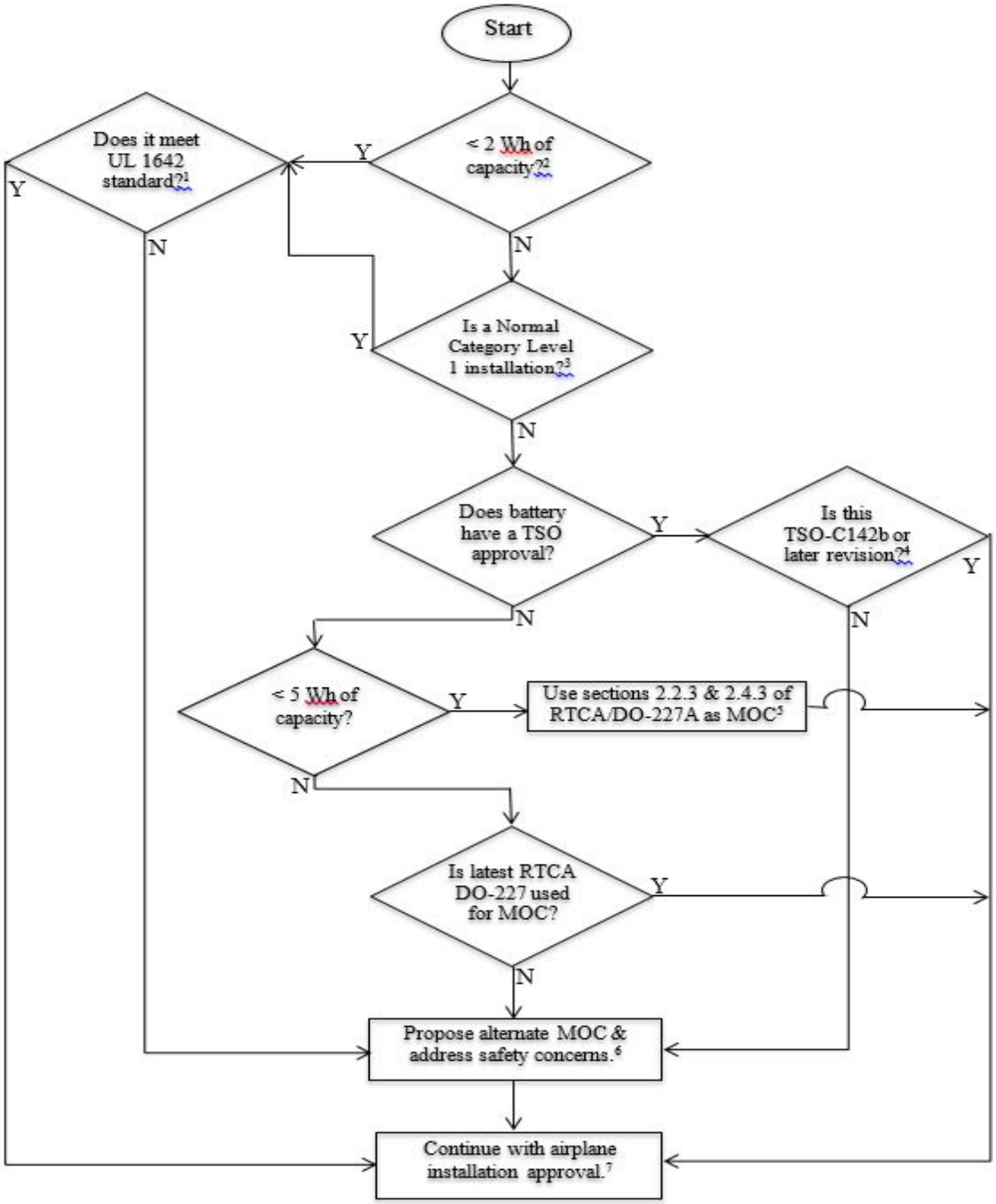
Section 23.1353 requires that storage batteries be designed and installed to maintain safe cell temperatures and pressures that no explosive or toxic gases can accumulate in hazardous quantities, and that corrosive fluids or gases cannot damage surrounding structures or essential systems.

Section 23.2510 requires the probability and failure conditions of installed system or equipment remain an acceptable inverse relationship.

Section 23.2525 requires the power supply is adequate for intended operations that a single failure cannot stop power supply to essential loads for safe flight and landing, and has enough power storage capacity of duration to continue safe flight and landing.

The following depiction, figure 1, identifies applicable evaluations for installing equipment using non-rechargeable lithium batteries in part 23 airplanes.

Figure 1. Non-Rechargeable Lithium Battery Certification Considerations



Footnotes:

1. Other than meeting the UL 1642 Standard, the appropriate regulatory authority that governs Hazardous Materials Transportation will regulate the carriage of uninstalled lithium batteries. For example, the UN regulations (e.g., UN 38.3, etc.) established guidance for safe transportation of lithium batteries.
2. A Watt-hour (Wh) is defined as the rated capacity (in ampere-hours, Ah) times the nominal battery voltage. Evaluate the energy of the entire battery capacity for 2 Wh threshold.
3. Section 23.2005(b) (1), amendment 23-64, defines a Normal Category Level 1 airplane. Certification basis with earlier amendments should use a Class I airplane, as defined in AC 23.1309-1E for this evaluation.
4. The following is applicable to this footnote:
    a. New installations with TSO-C142a approved articles should present data (e.g., test reports, quantitative and qualitative analysis, etc.) to show that there are no performance gaps in meeting TSO-C142b requirements. One example is substantiation of thermal runaway containment.
    b. TSO-C142b-7 marking (i.e., marking requirements of "-7" described in paragraph 4.b of TSO-C142b) is an acceptable means of compliance for installation.
5. The following items are applicable to this footnote:
    a) Battery (or cell) must meet at a minimum UL1642 and UN 38.3 requirements. RTCA document, DO-227A, section 2.2.3 and 2.4.3 can be used as a MOC for the end item that the battery (or cell) provides power to.
    b) If RTCA document, DO-227A, sections 2.2.3 and 2.4.3 are not used as a MOC, then the applicant must propose alternate methods to show compliance.
6. The following items are applicable to this footnote:
    a) New installations that use earlier version of RTCA/DO-227 as a MOC must perform adequate analysis and present additional data to meet the latest standards.
    b) Coordinate with the small airplane standards branch for proposed alternate MOC, or any analysis used to justify deviations from latest DO-227 required tests.
    c) Identified safety concerns must be addressed. Examples are risk assessment and mitigation of internal failures, overheat conditions, flammability, and gas emission.
7. Continue the certification process. For example, §23.2510 (or §23.1309) compliance includes System Safety Assessment (SSA) process. Location related hazards (e.g. designated fire zones etc.), with respect to where an equipment is to be installed, should be addressed by SSA zonal safety analysis (ZSA), particular risk analysis (PRA), and failure modes and effects analysis (FMEA).

Appendix G. Advisory Circular Feedback Information

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) emailing this form to 9-AWA-AVS-AIR-DMO@faa.gov or (2) faxing it to (202) 267-1813.

Subject: AC 20-192-Guidance on Testing and Installation of Non-rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _____ on page _____.

☐ Recommend paragraph _____ on page _____ be changed as follows:

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

☐ Other comments:

☐ I would like to discuss the above. Please contact me.

I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____

Telephone Number: _____ Email Address: _____