



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

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AIRWORTHINESS CIRCULAR

**AIRWORTHINESS CERTIFICATION REQUIREMENTS FOR LITHIUM BATTERIES
IN APPLICATIONS OTHER THAN SAFETY OF FLIGHT BACKUP POWER**

1. Purpose. This United States Air Force (USAF) airworthiness (AW) circular (AC) clarifies and provides an acceptable means to show compliance to the AW certification requirements for lithium batteries in applications other than safety of flight (SOF) backup power.

2. Scope. This AC applies to all air systems the USAF owns, leases, operates, uses, designs, or modifies.

3. Cancellations. Not applicable. This is the first issuance of this AC.

4. Referenced Documents.

4.1. USAF Documents.

AFMAN 24-204, *Preparing Hazardous Materials for Military Air Shipments*, 24 July 2018

AFPD 62-6, *USAF Airworthiness*, 16 January 2019

AWB-120A, *Modification Airworthiness, Relatedness and Reportability Determination*, 2 June 2021

AWB-150B, *Airworthiness Risk Assessment and Acceptance*, 30 September 2020

AWB-360, *Commercial Derivative Aircraft Airworthiness*, 1 September 2021

4.2. Federal Aviation Administration Documents.

AC 20-184, *Guidance on Testing and Installation of Rechargeable Lithium Battery and Battery Systems on Aircraft*, 15 October 2015

AC 20-192, *Guidance on Testing and Installation of Non-rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft*, DRAFT

4.3. Department of Defense Specifications, Standards, and Handbooks.

MIL-HDBK-516C, *Department of Defense Handbook, Airworthiness Certification Criteria*, 12 December 2014

MIL-HDBK-704, *Guidance for Test Procedures for Demonstration of Utilization Equipment Compliance to Aircraft Electrical Power Characteristics*, 9 April 2004

MIL-PRF-29595A, *General Specification for Aircraft Rechargeable Lithium Batteries and Cells*, 24 October 2016

MIL-PRF-32271A, *General Specification for Aircraft Non-Rechargeable Lithium Batteries*, 09 July 2014

MIL-PRF-32383, *General Specification for Sealed Rechargeable Batteries*, 16 June 2011

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MIL-PRF-49471B, *High Performance Non-rechargeable Batteries*, 30 November 2000

MIL-STD-704F, *Aircraft Electrical Power Characteristics*, 5 December 2016

MIL-STD-810H, *Environmental Engineering Considerations and Laboratory Tests*, 31 January 2019

NAVSEA S9310-AQ-SAF-010, *Technical Manual for Navy Lithium Battery Safety Program Responsibilities and Procedures*, Third Revision, 03 November 2020

4.4. Commercial Standards.

IEC 60086-4, *Primary Batteries – Safety of Lithium Batteries*, Fifth Edition, May 2020

IEC 62133-2:2017, *Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*, 1.1 Edition, July 2021

RTCA DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, 8 December 2010

RTCA DO-227A, *Minimum Operational Performance Standards (MOPS) for Non-Researchable Lithium Batteries*, 21 September 2017

RTCA DO-311A, *Minimum Operational Performance Standards for Rechargeable Lithium Battery Systems*, 19 December 2017

RTCA DO-347, *Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems*, 18 December 2013

UL 1642, *Standards for Safety for Lithium Batteries, Fifth Edition*, 13 March 2012

UL 2054, *Standards for Safety for Household and Commercial Batteries*, Second Edition, 14 September 2011

5. Background.

5.1. Non-rechargeable (primary) and rechargeable (secondary) lithium batteries (to include button/coin cells) are increasingly being installed in various USAF aircraft in applications other than SOF backup power. Some applications are, but not limited to:

5.1.1. Primary power for carry-on equipment; temporary equipment; and non-essential, non-required equipment

5.1.2. Hold up or backup power for avionics (installed internal to line replaceable unit [LRU])

5.2. Current lithium batteries have high energy density and have the potential for thermal instability. Consequently, lithium batteries can present a safety hazard if improperly designed, tested, used, and/or integrated into DoD systems. Lithium battery failures can result in a thermal runaway event (self-sustaining uncontrolled increase in pressure and temperature leading to the possible rupture of the battery shell) and the possible venting of hazardous gases from the battery. The high temperatures caused by a thermal runaway may ignite the

flammable gases vented from the battery and result in an aircraft fire. As such, it is imperative that program offices installing lithium batteries understand the associated AW certification requirements to minimize the associated hazards.

5.3. Depending on the overall AW approach, use of lithium batteries on commercial derivative aircraft may be assessed to either Federal Aviation Administration (FAA) or USAF AW certification requirements (refer to AWB-360, *Commercial Derivative Aircraft Airworthiness*, for additional details). FAA Advisory Circulars 20-184, *Guidance on Testing and Installation of Rechargeable Lithium Battery and Battery Systems on Aircraft*, and 20-192, *Guidance on Testing and Installation of Non-rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft*, (draft) communicate FAA certification guidance for rechargeable and non-rechargeable lithium batteries respectively. USAF AW certification requirements are established in MIL-HDBK-516C, *Department of Defense Handbook, Airworthiness Certification Criteria*. This AC is limited to USAF AW certification requirements.¹

6. Discussion. MIL-HDBK-516C, paragraph 12.1.6.1 establishes the USAF AW criterion, standards, and methods of compliance (MoCs) for lithium batteries (to include button/coin cells) used in applications other than SOF backup power.² AW certification is addressed from two (2) perspectives: battery safety (to include the end item/LRU it is installed within) and installation safety.

6.1. Battery Safety. MIL-HDBK-516C, paragraph 12.1.6.1, standards (a), (e), and (f), and MoCs (a), (e), and (g) addresses battery safety. The following subparagraphs provide additional guidance in meeting these standards and methods of compliance.

6.1.1. Standard (a) and MoC (a): Show that the battery complies with one or more of the following standards to ensure safe battery cell temperatures and pressures are maintained during charging and discharging. Standard (e) and MoC (e): For rechargeable batteries, show that the battery meets the requirements of one of the following standards to ensure the battery charging system is designed to safety charge the battery.

6.1.1.1. For rechargeable batteries:

6.1.1.1.1. MIL-PRF-29595A, *General Specification for Aircraft Rechargeable Lithium Batteries and Cells*

6.1.1.1.2. MIL-PRF-32383, *General Specification for Sealed Rechargeable Batteries*

6.1.1.1.3. RTCA DO-347, *Certification Test Guidance for Small and Medium*

¹ AFD 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, AFD 62-6 requires the USAF to obtain and maintain FAA type certification to the maximum extent practical. As such, CDA program offices should plan to obtain FAA certification for lithium batteries.

² This AC is limited to MIL-HDBK-516C, criterion 12.1.6.1. Other MIL-HDBK-516C criteria may also be applicable to lithium battery installation (e.g., fire protection/flammability, crashworthiness, electromagnetic interference, etc.)

Sized Rechargeable Lithium Batteries

6.1.1.1.4. RTCA/DO-311A, *Minimum Operational Performance Standards for Rechargeable Lithium Battery Systems*

6.1.1.1.5. UL 1642, *Standards for Safety for Lithium Batteries*

6.1.1.1.6. UL 2054, *Standards for Safety for Household and Commercial Batteries*

6.1.1.1.7. IEC 62133-2:2017, *Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

6.1.1.2. For non-rechargeable batteries:

6.1.1.2.1. MIL-PRF-32271A, *General Specification for Aircraft Non-Rechargeable Lithium Batteries*

6.1.1.2.2. MIL-PRF-49471B, *High Performance Non-rechargeable Batteries*

6.1.1.2.3. DO-227A, *Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries*

6.1.1.2.4. UL 1642, *Standards for Safety for Lithium Batteries*

6.1.1.2.5. UL 2054, *Standards for Safety for Household and Commercial Batteries*

6.1.1.2.6. IEC 60086-4, *Primary Batteries – Safety of Lithium Batteries*

6.1.1.3. Proof of independent certifications may be submitted in lieu of providing qualification data to establish compliance with this standard if it matches the design and intended use for which it was certified (e.g., FAA Technical Standard Order Approval, Underwriter Laboratory Listed).

6.1.2. Standard (f) and MoC (g): relies on satisfying battery safety requirements in NAVSEA S9310-AQ-SAF-010, *Technical Manual for Navy Lithium Battery Safety Program Responsibilities and Procedures*, which establishes general requirements for battery selection, design, and safety assessment testing. Safety assessment testing evaluates a battery's response to failure scenarios.

6.1.2.1. Show that the battery meets one of the following:

6.1.2.1.1. NAVSEA S9310-AQ-SAF-010, Chapter 6 (Lithium Battery System Design) and Chapter 13 (Safety Assessment Testing).³ Analysis may be acceptable to show similarity with another tested battery.

6.1.2.1.2. Exception in NAVSEA S9310-AQ-SAF-010, Chapter 4 (Exceptions to Testing, Review, and Certification Requirements).

³ Commercial off-the-shelf batteries may be qualified to DO-347 (secondary batteries 2-300 watt-hours), DO-311 (for secondary batteries greater than 300 watt-hours), or DO-227 (for primary batteries greater than 2 watt-hours). Additional analysis or testing may be required to meet NAVSEA S9310-AQ-SAF-010.

6.1.2.1.3. A certification letter issued IAW NAVSEA S9310-AQ-SAF-010 may be submitted in lieu of providing data to show compliance with this standard if the battery is used in the same device and environment.

6.2. Installation Safety. MIL-HDBK-516C, paragraph 12.1.6.1, standards (b), (c), (d), and (g) and MoCs (b), (c), (d), and (f) address installation safety.

6.2.1. Standard (b) and MoC (b):

6.2.1.1. Show that the explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the battery subsystem, does not accumulate in hazardous quantities within the aircraft. A probable malfunction is considered a short circuit failure. Utilize the results from the NAVSEA S9310-AQ-SAF-010 battery safety testing that characterized the battery's response to a short circuit.³ If explosive or toxic gases are emitted, conduct a toxicity analysis considering the concentrations of these byproduct gases that are immediately dangerous to life and health (IDLH), or similar chemical exposure guidelines, and aircraft integration (e.g., environmental control system).

6.2.1.2. For batteries that meet the NAVSEA S9310-AQ-SAF-010 Chapter 4 exception criteria, compliance to standard (f) is an acceptable means to demonstrate compliance to standard (b).

6.2.2. Standard (c) and MoC (c):

6.2.2.1. Show that corrosive fluids or gases, which escape from the battery, do not damage surrounding structures or adjacent essential equipment, to include wiring, fuel lines, and hydraulic lines. Utilize the results from the NAVSEA S9310-AQ-SAF-010 battery safety testing.³

6.2.2.2. For batteries that meet the NAVSEA S9310-AQ-SAF-010 Chapter 4 exception criteria, compliance to standard (f) is an acceptable means to demonstrate compliance to standard (c).

6.2.3. Standard (d) and MoC (d):

6.2.3.1. Show that heat generated by the battery during a short circuit does not create a hazardous effect on structure or adjacent essential equipment, to include wiring. Utilize the results from the NAVSEA S9310-AQ-SAF-010 battery safety testing that characterized the battery's most severe response to a short circuit.³

6.2.3.2. For batteries that meet the NAVSEA S9310-AQ-SAF-010 Chapter 4 exception criteria, compliance to standard (f) is an acceptable means to demonstrate compliance to standard (d).

6.2.4. Standard (g) and MoC (f):

6.2.4.1. For rechargeable batteries, show that the battery complies with MIL-STD-704, *Aircraft Electrical Power Characteristics*, power quality, utilizing the test

procedures in MIL-HDBK-704F, *Guidance for Test Procedures for Demonstration of Utilization Equipment Compliance to Aircraft Electrical Power Characteristics*.⁴

6.2.4.2. For non-rechargeable batteries, show that there is a means to prevent charging of the battery (e.g., device schematics, device component description, etc.), or any cell, from any aircraft power.

6.3. Risk Assessment. Batteries that do not comply with MIL-HDBK-516C, criterion 12.1.6.1 Standards require a risk assessment in accordance with AWB-150, *Airworthiness Risk Assessment and Acceptance*. Risk assessments should consider the following:

6.3.1. Chemistry. Chemistries that have a higher energy density can have a more volatile failure reaction compared to chemistries of a lower energy density. In addition, temperatures contributing to a thermal runaway failure vary depending on the chemistry used.

6.3.2. Installation location. A failed battery may burst into flames, emit toxic gases, or leak corrosive fluids. Close proximity to personnel or installation near essential/flight critical equipment or flammable fluids may increase the severity of the hazard. Ambient temperature of the installation location also effect performance, and could induce a battery thermal runaway failure. If battery safety assessment testing (ref. para 6.1.2) is unavailable to determine if explosive or toxic gas is emitted, assume that all potential gas will be released during a failure when conducting a toxicity analysis.

6.3.3. Size. Typically, the larger the battery capacity, the higher the energy density, and the more chemicals present within the battery. In the event of a failure, this may lead to a greater quantity of emitted toxic gases or leaked corrosive fluids. Extinguishing a large battery fire may be problematic as it may require specialized firefighting equipment.

6.3.4. Qualification/Safety/Environmental testing results and analyses. Qualification, safety, and relevant environmental test results should be analyzed to determine if there are shortcomings. Failure Mode and Effects Analysis should be reviewed to give guidance on probabilities of failure modes. The usage and how the battery is operated should also be understood.

7. Recommendations.

7.1. Program offices should use the guidelines herein to select and show compliance for each non-SOF lithium battery application.

7.2. Delegated technical authorities should consider lithium batteries, or lithium battery systems, that are rated greater than 200 watt-hours to be reportable when determining the reportability in accordance with AWB-120, *Modification Airworthiness, Relatedness and Reportability Determination*. Based on the experience of previous technical reviews, batteries or battery systems rated greater than 200 watt-hours are considered to have increased complexity, and may result in a more severe failure category.

⁴ Commercial off-the-shelf batteries may be qualified to DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment*. Additional analysis or testing may be required to meet MIL-STD-704.

7.3. For non-reportable modifications, program offices should inform the office of primary responsibility (OPR) for this AC of completed battery safety activities to facilitate sharing of battery-level safety data between USAF and DoD programs.

8. Point of Contact. The OPR for this AC is Air Vehicle Subsystems Branch (AFLCMC/EZFA). Comments, suggestions, or questions on this AC should be directed to: Mr. Christopher Kusak, DSN 312-785-1722, commercial 937-255-1722, or email at christopher.kusak@us.af.mil. General AW questions should be emailed to the USAF AW Office mailbox at USAF.Airworthiness.Office@us.af.mil.

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