



Department of Transportation  
**Federal Aviation Administration**  
Aircraft Certification Service  
Washington, D.C.

**TSO-C142a**

Effective  
Date: 08/7/06

# Technical Standard Order

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**Subject: NON-RECHARGEABLE LITHIUM CELLS and BATTERIES**

1. **PURPOSE.** This technical standard order (TSO) is for manufacturers and designers of non-rechargeable lithium cells and batteries applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your lithium cells and batteries must first meet for approval and identification with the applicable TSO marking.

2. **APPLICABILITY.** This TSO affects new applications submitted after its effective date.

a. All prior versions of this TSO are no longer effective. Generally we will not accept applications after the effective date of this TSO. However, we may do so up to six months after its effective date, if we know that you were working against the earlier MPS before the new change became effective.

b. Lithium sulfur dioxide (LiSO<sub>2</sub>) batteries approved under TSO-C97, *Lithium Sulfur Dioxide Batteries*, dated September 26, 1979, may still be manufactured under the provisions of their original approval, but new applications for non-rechargeable lithium sulfur dioxide batteries must meet the MPS of this TSO.

c. Major design changes to lithium cells and batteries approved under previous versions of TSO-C142 and TSO-C97 require a new authorization under this TSO. Future major design changes to lithium cells and batteries approved under this TSO will require a new authorization. See Title 14 of the Code of Federal Regulations (14 CFR) § 21.611(b).

3. **REQUIREMENTS.** New models of non-rechargeable lithium cells and batteries identified and manufactured on or after the effective date of this TSO must meet the MPS in RTCA, Inc. document RTCA/DO-227, *Minimum Operational Performance Standards for Lithium Batteries*, dated June 23, 1995, Section 2.0, as amended by appendix 1 of this TSO. RTCA/DO-227 contains requirements and guidance on chemical composition, quantity of potentially hazardous substances, cell size, cell construction, interconnection of cells into batteries, fusing, venting, current limiting and testing. RTCA/DO-227 also covers operational and storage environments, packaging, handling and battery disposal that affect the use of these articles in aircraft.

**a. Functionality.** This TSO's standards apply to non-rechargeable lithium cells and batteries intended to provide power for aircraft equipment including emergency and standby systems. Non-rechargeable cells and batteries are also called primary.

**b. Failure Condition Classification.** Failure of the function defined in paragraphs 3 and 3.a of this TSO is a *major* failure condition. Develop cells and batteries to, at least, the design assurance level equal to this failure condition classification.

**c. Functional Qualification.** Demonstrate the required performance under the test conditions in RTCA/DO-227, Sections 2.2 and 2.4, as amended by appendix 1 of this TSO.

**d. Environmental Qualification.** Test the equipment according to RTCA/DO-227, Section 2.3, as amended by appendix 1 of this TSO.

**e. Deviations.** We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under 14 CFR § 21.609 before submitting your data package.

#### **4. MARKING.**

**a.** Mark each cell or battery permanently and legibly with all the information in 14 CFR § 21.607(d) and RTCA/DO-227, Section 1.4.6.

**5. APPLICATION DATA REQUIREMENTS.** As a TSO manufacturer-applicant, you must give the FAA aircraft certification office (ACO) manager responsible for your facilities a statement of conformance, as specified in 14 CFR § 21.605(a)(1), and one copy each of the following technical data to support our design and production approval. (Under 14 CFR § 21.617(a)(2), LODA applicants submit the same data through their civil aviation authority:)

**a.** Operating instructions and equipment limitations in an installation/instruction manual (IM), sufficient to describe the cell or battery's operational capability. Describe any deviations in detail. If needed, identify cell or battery by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

**b.** Installation procedures and limitations in an IM, sufficient to ensure that the cells and batteries, when installed according to the installation procedures, still meet this TSO's requirements. The limitations must identify any unique aspects of the installation. Finally, the limitations must include a note with the following statement:

The conditions and tests for TSO approval of this article are minimum performance standards. Those installing this article, on or in a specific type or class of aircraft, must determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an

aircraft. The article may be installed only according to 14 CFR part 43 or the applicable airworthiness requirements. Lithium cell and battery safety concerns include the possibility of fire and venting of toxic gases.

- c. Schematic drawings of the installation procedures.
- d. Wiring diagrams of the installation procedures.
- e. List of components, by part number, that make up the cells or batteries complying with the standards in this TSO. Include vendor part number cross-references, when applicable.
- f. A component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed cells or batteries. Instructions should include recommended inspection intervals and service life. Describe the details of deviations granted, as noted in paragraph 5.a of this TSO.
- g. Material and process specifications list.
- h. The quality control system (QCS) description required by 14 CFR §§ 21.143 and 21.605(a)(3) including functional test specifications. The QCS should ensure that you will detect any change to the equipment that could adversely affect compliance with the TSO MPS, and reject the item accordingly. (Not required for LODA applicants.)
- i. Manufacturer's TSO qualification test report.
- j. Nameplate drawing with the information required by paragraph 4 of this TSO.
- k. A list of all drawings and processes (including revision level), to define the article's design. For a minor change, you only need to make the revision to the list available on request.
- l. An environmental qualifications form for the cells or batteries describing the environmental tests conducted.

**6. MANUFACTURER DATA REQUIREMENTS.** Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

- a. The functional qualification specifications for qualifying each production article to ensure compliance with this TSO.
- b. Equipment calibration procedures.
- c. Corrective maintenance procedures within 12 months after TSO authorization.

- d. Schematic drawings.
- e. Wiring diagrams.
- f. Material and process specifications.
- g. The results of the environmental qualification tests conducted per RTCA/DO-227, Section 2.3, as modified by appendix 1 of this TSO.

**7. FURNISHED DATA REQUIREMENTS.** If furnishing one or more articles to one entity (such as an operator or repair station), send one copy of the data in paragraphs **5.a** through **5.f** plus **5.i** for each article manufactured under this TSO.

**8. HOW TO GET REFERENCED DOCUMENTS.**

**a.** Order RTCA documents from RTCA Inc., 1828 L Street, N.W., Suite 805, Washington, DC 20036-4001. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies from the RTCA Internet website at [www.rtca.org](http://www.rtca.org).

**b.** Order copies of 14 CFR part 21, Subpart O, and 14 CFR part 43 from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh PA 15250-7954. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies from the Government Printing Office (GPO) Internet website at [www.access.gpo.gov](http://www.access.gpo.gov). Select "Access," then "Online Bookstore." Select "Aviation," then scroll to "Code of Federal Regulations."

**c.** You can find a current list of technical standard orders on the FAA Internet website Regulatory and Guidance Library at [www.airweb.faa.gov/rgl](http://www.airweb.faa.gov/rgl). You will also find the TSO Index of Articles at the same site.

*/s/ David W. Hempe*

David W. Hempe  
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**APPENDIX 1. MINIMUM PERFORMANCE  
STANDARD FOR LITHIUM BATTERIES**

**1. PURPOSE.** This appendix prescribes the MPS for lithium batteries as modified by the FAA for reference in this TSO.

**2. REQUIREMENTS.** The standards applicable to this TSO are set forth in the industry standard, RTCA/DO-227, *Minimum Operational Performance Standard for Lithium Batteries*, dated June 23, 1995. We modified the standard, as follows:

**Table 1. FAA Modifications to RTCA/DO-227**

<i>RTCA/DO-227 section and title:</i>	<i>FAA modification:</i>
<b>1.5.11, Design Life</b>	<b>ADD at the end of the paragraph</b>  “Equipment manufacturers are responsible for ensuring that the integrity of date coding systems used by the cell/battery supplier(s) will support design life criteria.”
<b>1.7.3, Lot Acceptance Test Goals</b>	<b>ADD at the end of the paragraph</b>  “We recommend that the manufacture's lot acceptance testing include the discharge tests described by paragraph 2.4.1.1 Capacity-Verification Test.”
<b>2.1.2 b., Performance Requirements</b>	<b>ADD at the end of the paragraph</b>  “If the battery is required to operate in temperatures outside this envelope, test the battery using the more severe temperatures.”
<b>Table 2-1, CELL EVALUATION CRITERIA</b>	<b>DELETE</b> the superscript "4" on the Internal Short-Circuit Test row under the "FIRE" column. The superscript "4" is only used under the Forced-Discharge, External Short-Circuit, and Charging tests, and then only under the "LEAK" and "VENT" columns.
<b>2.1.8.2, Test Tolerances</b>	<b>ADD new paragraphs after 2.1.8.2</b>  <b>Rated Capacity and Current</b>  Except as otherwise specified in the test methods in subsections 2.3 and 2.4, the rated capacity and current must be the same for all testing in this standard.

	<p><b>Warning - Hazards of Testing</b></p> <p>When subjected to electrical testing specified in this document, cells or batteries may leak or vent hazardous materials, burn, or in exceptional cases, vent violently.</p>
<p><b>2.3.1, Vibration Test</b> Figure 2-3</p>	<p><b>REPLACE</b> Figure 2-3 with the modified STANDARD RANDOM VIBRATION Figure 2-3 in appendix 1 of this TSO. This revised figure depicts different limit lines.</p>
<p><b>2.3.1, Vibration Test</b> Figure 2-4</p>	<p><b>REPLACE</b> Figure 2-4 with the modified STANDARD RANDOM VIBRATION Figure 2-4 in appendix 1 of this TSO. This revised figure depicts different limit lines.</p>
<p><b>2.3.1, Vibration Test</b></p>	<p><b>ADD</b> before the last sentence in the eighth paragraph</p> <p>“Measure the open circuit voltage (OCV) before, during, and after the tests.”</p>
<p><b>2.3.2, Shock Test</b></p>	<p><b>REPLACE</b> the wording with</p> <p>“For the battery shock test, mount samples in the equipment in which they will be used.</p> <p>Perform this test using undischarged sample cells or batteries. Secure the sample to a shock table by a mechanically secured device. The shock test machine must be capable of imparting a series of calibrated shock impulses to the sample. The shock impulse waveform distortion at any point on the waveform may not be greater than 15 percent of the peak value of the shock pulse. The duration of the shock pulse is specified with reference to the zero points of the wave. The shock forces are specified in terms of peak amplitude g values.</p> <p>Measure the shock impulse using a calibrated accelerometer and associated instrumentation having a 3db response over a range of at least 5 to 250 Hz. Mount the sample on the shock test machine so that the shock impulses can be applied in both directions of the three orthogonal axes.</p> <p>For general purposes, use the following test parameters. Apply a 75 g saw tooth wave shock impulse with a duration of 11 ±2 ms in both directions of the three orthogonal axes. Measure the open circuit voltage before and after the test. Examine each sample to determine if it meets the requirements of <u>Table 2-1</u> and <u>2-2</u>.</p>

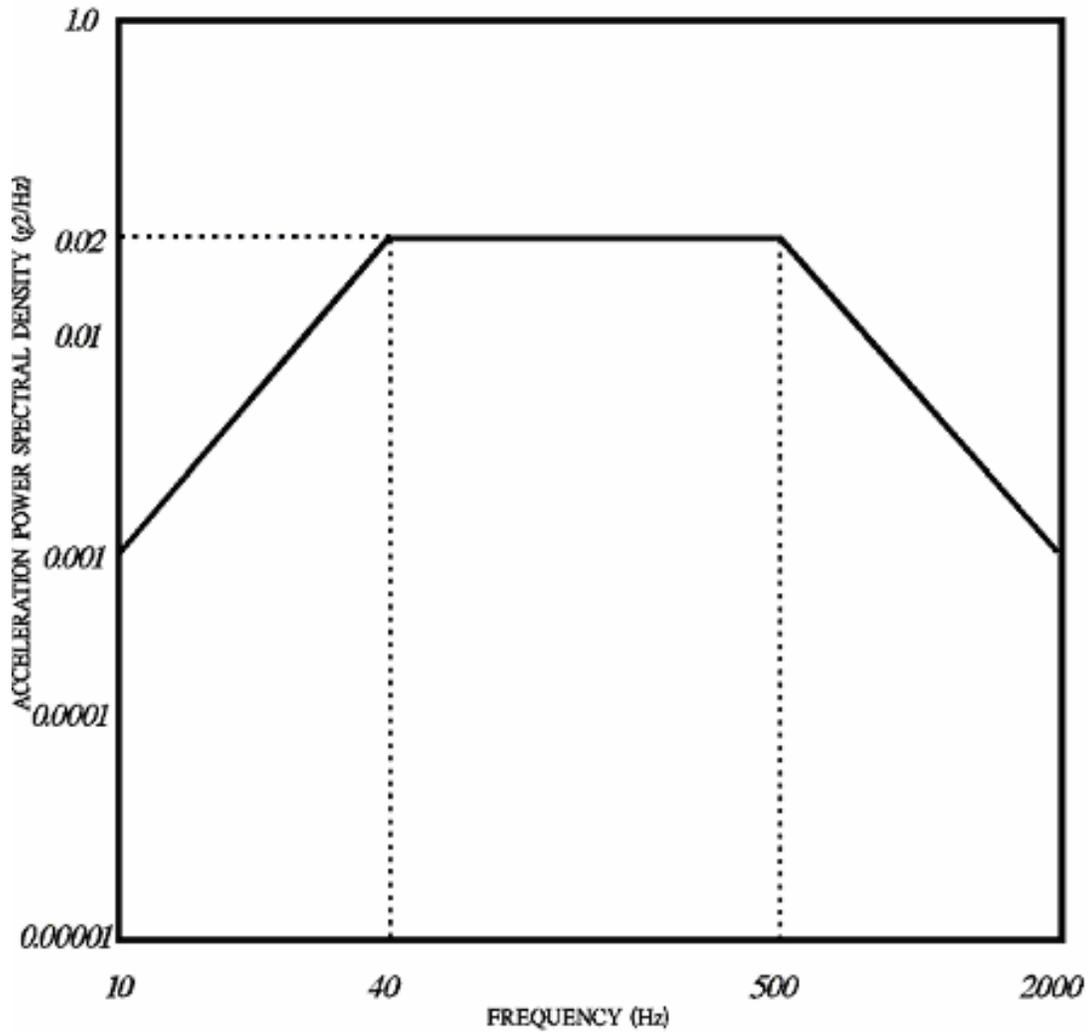
	For applications with shock requirements in excess of the general test (that is, where crashworthiness, ELTs, or survivability is an issue), use the following more stringent requirements. Apply a 100 g half sine wave shock impulse with a duration of 23 $\pm$ 2 ms in both directions of the three orthogonal axes. Measure the open circuit voltage (OCV) before, during and after the test. Examine each sample to determine if it meets the requirements of <u>Table 2-1</u> or <u>Table 2-2</u> .”
<b>2.3.3, Temperature Cycling Test</b>	<b>CHANGE</b> 10 times to 9 times
<b>2.3.3, Temperature Cycling Test</b>	<b>ADD</b> to the end of the paragraph,  “...for either method.”
<b>2.4.1.2, Discharge Test</b>	<b>ADD</b> after the second sentence in the first paragraph,  “Set the DC power supply to a voltage limit equal to the number of cells per series string in the battery times the OCV of an individual cell.”
<b>2.4.1.2, Discharge Test</b>	<b>ADD</b> to the end of the first paragraph  “If the sample contains one or more protective devices, set the test current to just below (by no more than 10 percent) the current at which any protective device will activate during the forced discharge test.”
<b>2.4.1.3, Forced Discharge Test</b>	<b>DELETE</b> the fourth sentence: If the sample contains one or more protective devices, the test current is just below (by no more than 10%) that at which any protective device will activate during the forced discharge test.
<b>2.4.1.3, Forced Discharge Test</b>	<b>ADD</b> to the end of the paragraph  “This test is not required for single cell batteries. Test the cells up to and (possibly) including the maximum rate of discharge specified by the manufacturer. Rate any protective device at or below the discharge rate specified by the manufacturer. Perform all testing according to this rating.”
<b>2.4.2.1, Internal Short-circuit Test</b>	<b>REPLACE</b> the first paragraph with  “This test is designed to determine the effects of an internal short circuit in undischarged cells. At 24° C, deform the

	<p>sample between a rod with a hard insulating surface and an insulated plate. Each cell is deformed until the open circuit voltage drops abruptly or is reduced to at least one third. At the point where the cell voltage drops, remove the applied force. Allow the sample to cool to 24° C and then hold for a minimum of 24 hours. Examine each sample to determine if it meets the requirements of <u>Table 2-1.</u>”</p>
<p><b>3.4, Test Procedures for Installed Equipment Performance</b></p>	<p><b>ADD</b> new paragraph after 3.4</p> <p><b>Toxic Gas Venting Precautions</b></p> <p>Do not install or use batteries that can vent toxic gases in the aircraft cockpit, because of an increased probability of immediate flight crew impairment. Batteries that can vent toxic gases may be installed or used in an aircraft passenger compartment, if the installer shows that this would not create a safety hazard.</p> <p>You can prevent a safety hazard by:</p> <ol style="list-style-type: none"> <li>a. Installing a system for overboard venting, absorption, or containment, or</li> <li>b. Showing that, if venting occurs, permissible exposure limits do not exceed those maintained by safety-standard organizations (Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists, Inc.).</li> </ol>
<p><b>3.4, Test Procedures for Installed Equipment Performance</b></p>	<p><b>ADD</b> new paragraph after 3.4</p> <p>(a) Because lithium batteries have ignited, vented gas or exploded, we require additional performance standards governing the use of lithium batteries or equipment incorporating lithium cells or batteries on airplanes. Airplane and equipment manufacturers incorporating lithium cells or batteries must ensure that if there is a fire within a single cell of the battery, the equipment unit will contain the fragments and debris (but not smoke/gases/vapors) from a battery explosion and fire. Fire within the equipment, such as from wires and electrical components, must self-extinguish.</p> <p>(b) See Table 2, appendix 1 of this TSO for tests to ensure that the manufacturer has met the fire safety requirements for equipment incorporating lithium cells or batteries.</p>



**APPENDIX 1. MINIMUM PERFORMANCE  
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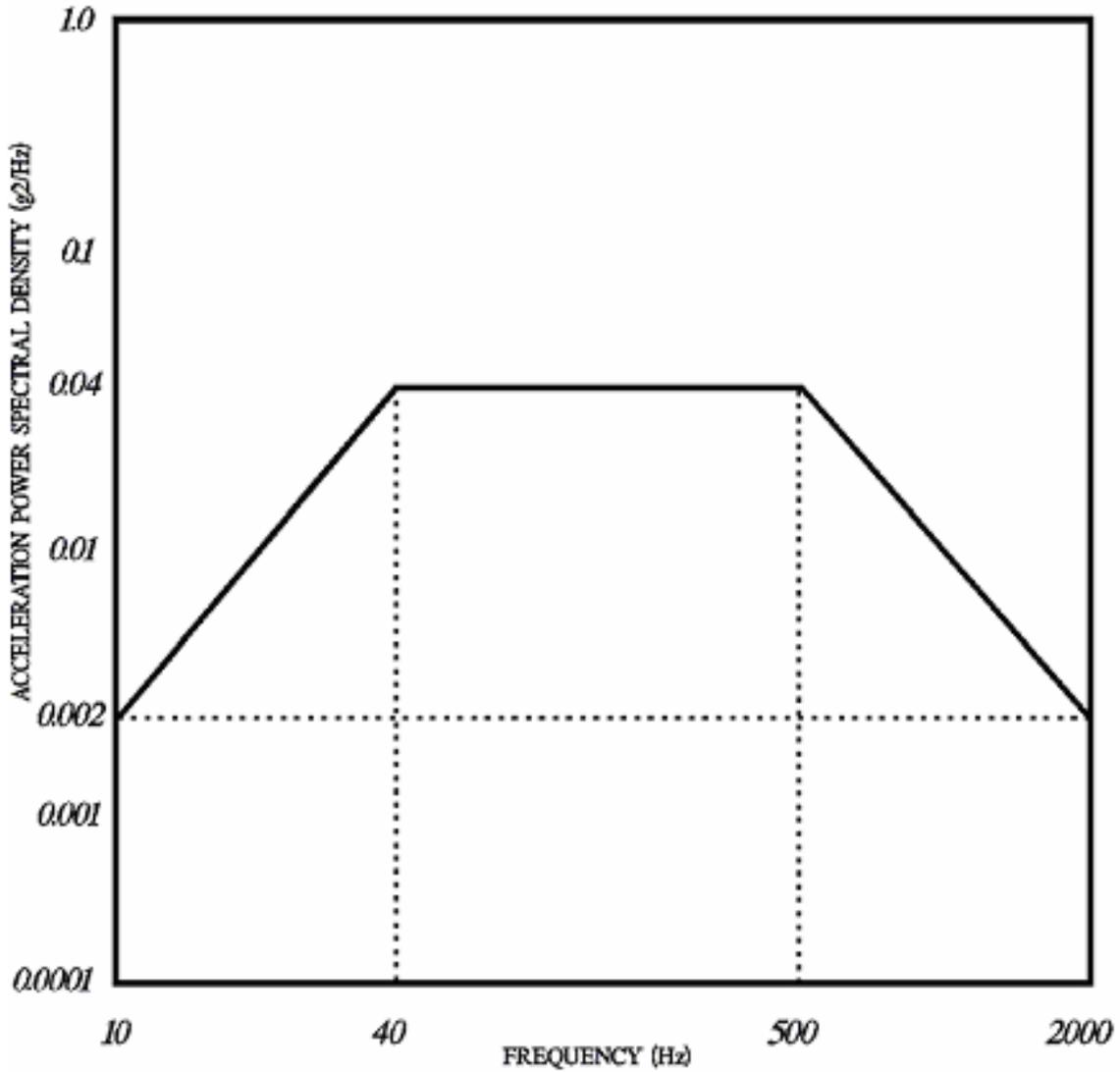
**Figure 2-3. Standard Random Vibration Test Curves for Equipment Installed in Fixed Wing Aircraft With Turbojet Engines**



*NOTE: All slopes are ±6 dB/Octave and the cumulative spectral power density is 4.12 g (rms).*

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(Continued)**

**Figure 2-4. Robust Random Vibration Test Curves for Equipment Installed in Fixed Wing Aircraft with Turbojet Engines**



*NOTE: All slopes are  $\pm 6$  dB/Octave and the cumulative spectral power density is 6.08 g (rms).*

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(Continued)**

<b>Table 2. TESTS FOR FIRE SAFETY REQUIREMENTS</b>		
<b>Test</b>	<b>Procedures</b>	<b>Criteria to Pass</b>
External Short Circuit	Measure direct connection between terminals through electric wire with resistance of 2m-ohm.  State of Charge (SoC) of a cell : 100%	No venting of gases/vapors. No smoke produced. No ignition or fire. No explosion.
Crush	Test battery by dropping an iron ball (9.1 kg) from the height of 61cm  SoC of a cell : 50%	No venting of gases/vapors. No smoke produced. No ignition or fire. No explosion.
Over discharge	Test battery by discharging with a current of 1C for 1 hour (or to the maximum discharge time for the battery operation).  SoC of a cell : 0%	No venting of gases/vapors. No smoke produced. No ignition or fire. No explosion.
Overheat	Test battery by heating up to 115 degrees C in the oven.  SoC of a cell : 100%	No venting of gases/vapors. No smoke produced. No ignition or fire. No explosion.
Fire	Test equipment unit with battery in place for fire penetration by igniting a single unit.  SoC of a cell : 100%	Unit must contain the fragments/debris from explosion but not gases/vapors/smoke. Fire within the unit must self-extinguish. Note that the presence of a fire extinguishing or suppression system outside the battery (such as in the equipment compartment) may be used to provide this feature if the system is designed to handle this fire threat.