

Status of (1) Cell-Level AIAA S-144-201X Qualification, (2) the New AIAA Battery-Level Qualification Standard, and (3) Upcoming Changes to US Government Regulatory Requirements for Space Cells/Batteries

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AIAA Li-ion Space Cell Commoditization Committee on Standards (CoS): AIAA S-144- 201X

- AIAA CoS Includes **51 Organizations (47 Active)**
 - Government Customers
 - Prime Contractors
 - Battery Assemblers
 - Cell Manufacturers
 - Range Safety (East and West)
- **Standardize** cell design (approximately 6.5"x3"x2") produced by multiple cell vendors, 18650, 26650, 21700
- Issue: **Stockpiles of heritage NCA, LCO and MCMB will be exhausted in 1-2 years**
- Solution: **Test programs on four (4) Li-ion chemistry variants through two organizations using S-144-201X: domestic NCA/MCMB, domestic LCO/MCMB, Vector, and "ZeroVolt"; DLA Stockpile new materials – already used**
- **Tailorable standard** to enable quicker new technology introduction
- AIAA S-144-201X modified to industry standard operating procedure



AIAA CoS Participants

- Government
 - USAF Space and Missile Systems Center – AEHF, SBIRS, GPS, Launch Wing, Chief Engineer’s Office, Advanced Development (Science)
 - NASA – Ames, Glenn (ISS), Glenn (Orion), Goddard (Space Science), Johnson (Planetary Missions), Marshall (Launch Vehicle)
 - Missile Defense Agency
 - NSWC Crane
 - Defense Logistics Agency
 - OGA
- Prime Contractors
 - Boeing, Firefly, Lockheed-Martin, Mitsubishi Electric, Northrop-Grumman, Northrop-Grumman Innovation Systems (Orbital/ATK), Space Systems Loral, SpaceX, Thales-Alenia, United Launch Alliance
- Battery Assemblers
 - Enersys (ABSL)
- Cell Manufacturers
 - EaglePicher, GS Yuasa, Enersys (Quallion), Saft, EaglePicher Yardney Division, Space Information Laboratories
- Range Safety
 - USAF Kennedy (45th Space Wing), NASA Kennedy, USAF Vandenberg (30th Space Wing), NASA Wallops
- FFRDCs, Consultants
 - Aerospace Corporation, Airbin, Hazmat Safety Consulting, Jet Propulsion Laboratory, Johns Hopkins University/APL, NREL, Quandry Solutions LLC, Salim, Voltaiq
- Academic
 - Kyushu Institute of Technology, PES University, Texas A&M

Nine AIAA S-144-201X Features

- Reduce Program Office Costs Due to Schedule Delays
 - Provide COTS drop-in alternatives from multiple manufacturers – 18650, 26650, 21700, 5781173 cells
- Minimize Prime Contractor Costs for Specialty Engineering
 - Make batteries modular and scalable, reducing the need for changes in mission-specific battery design assembly, NRE, documentation, and requalification
- Reduce Costs of Qualification
 - Standardize qualification and acceptance tests based on international requirements
- Reduce Sole-Source, Single-Source, and Foreign-Source Cost Risks to Production
 - Encourage dual-source parts to reduce sole-source, single-source, and foreign-source risks

Nine AIAA S-144-201X Features (cont'd)

- Reduce Cell Manufacturer Costs: Commoditization
 - **Standardize Qualification and Acceptance reports and reporting formats, improving customer awareness of alternatives for new missions**
 - **Require manufacturer transparency to resolve any issues that affect parts, materials, and processes, or form, fit, and function**
 - **Establish standardized cells in the market, stimulating an economy of scale for these products**
- Reduce Issues Due to Proprietary Information
 - **Preserve trade secrets**
- Stimulate Technology Development
 - **Enable quick, new technology transitions into the space market**

USAF/SMC Rapid Innovation Fund Battery/Cell Characterization Qualification Program

- \$2.9M Program:
 - Implements Cell-Level AIAA S-144-201X Qualification Tests for
 - 5781173 cells
 - 18650 cells
 - Implements Battery-Level SMC S-017 Qualification Tests to a Program of Record
 - Characterizes a specific chemistry

The New AIAA Space Battery-Level Qualification Standard

- Applied in November for new Battery-Level Qualification Document through AIAA Li-ion Space Cell Commoditization Committee
- Complements Cell-Level AIAA S-144-201X Qualification Document
- Seed Document Based on USAF RIF Program Battery Qualification Requirements

CoS Addressed Ongoing Industry Focus: AFSPCMAN 91-710 and NASA 8719.24 Process Update

- Update of AFSPCMAN 91-710 and NASA 8719.24 State of Practice and Range Safety processes – prime contractors previously bid on unseen launch practices
 - Through AIAA coordination, NASA and USAF harmonizing NASA 8719.24 and AFSPCMAN 91-710
 - Items currently being addressed:
 - NASA-advised COTS MEOP, Proof Pressure, Vent Operation tests implemented -- white paper produced to address topics
 - AFSPCMAN 91-710 requiring compliance with Code of Federal Regulations Title 49: Transportation, Subtitle B, Chapter I, Subchapter C, Part 173, Subpart E, §173.185 Lithium cells and Batteries. This CFR requires adherence to UN 38.3 and documentation of same. The certification of UN 38.3 occurs as a function of the overall systems level certification.
 - NASA 8719.24 implements elements of AFSPCMAN 91-710
 - AFSPCMAN 91-710 being updated
 - The 2004 version of AFSPCMAN 91-710 addressed battery chemistries prevalent and in use at that time (e.g., Ni-H, Lithium primary and NiCad). The manual DID NOT address emerging Li-ion chemistries. The joint 30th/45th policy letter, published in 2005, specifically addressed li-ion battery chemistry and operational safety requirements.
 - **Interim changes to range safety procedures based on experience with Li-ion chemistries have been accumulated and are practiced at both Vandenberg and Kennedy. These practices are being incorporated into the revised versions of AFSPCMAN 91-710 and 8719.24, including the required compliance with CFR (UN 38.3) and new NASA-advised COTS MEOP, Proof Pressure, and Vent Operation Tests.**

CoS Addressing Ongoing Industry Issues: UN 38.3 Issues

- UN 38.3 changed once every two years – next opportunity 2020. AIAA has started the process of change for the following **four issues**:
- (1) **“Disassembly” issue**: Solids are always ejected by and in the vent stream during a thermal runaway event, so “disassembly” always occurs during venting. Under the current writing, venting is expected in tests T5, T6, T7, and T8 but disassembly is disallowed, which represents an impossible requirement for most or all Li-ion cells.
- (2) **Large cells cannot pass test T7 “Overcharge”**: the current UN Manual of Tests is written to address “overcharge” on small COTS cells only. Large capacity space cells are constructed differently than small COTS cells; the test requires twice the charge current and twice the charge voltage on the cell.
- (3) **Large sample size on test T8 “Forced Discharge**: 20 samples required. COTS cells are typically \$10 per unit, resulting in a \$200 sample cost. Large cells are typically \$10K per unit, resulting in a \$200K sample cost.

CoS Addressing Ongoing Industry Issues: USDOT/UN 38.3 Discrepancies

- (4) **Differences between UN 38.3 and CFR Title 49 Language:**
 - **United Nations** - Recommendations on the Transport of Dangerous Goods: Model Regulations, Volume I, Nineteenth revised edition. Within this document, in the Annex: Model Regulations on the Transport of Dangerous Goods, on page 317, Part 3, Chapter 3.3 - Special Provisions Applicable to Certain Articles or Substances, Section 310, it states "The testing requirements in the Manual of Tests and Criteria, part III sub-section 38.3 do not apply to production runs consisting of not more than 100 cell and batteries, or to pre-production prototypes of cells and batteries when these prototypes are transported for testing when packaged in accordance with packing instruction P910 of 4.1.4.1'.
 - **United States** - CFR 49(B)(I)(C)173(E)173.185 Code of Federal Regulations Title 49: Transportation, Subtitle B, Chapter I, Subchapter C, Part 173, Subpart E, §173.185 Lithium cells and batteries. "Low production runs (i.e., annual production runs consisting of not more than 100 lithium cells or batteries), or prototype lithium cells or batteries, including equipment transported for purposes of testing, are excepted from the testing and record keeping requirements of paragraph (a) of this section"
- Two problems highlighted by difference between UN and US language:
 - "Cells" and "batteries of cells" are different - which standard should be followed?
 - What is the standard - annual production runs, runs from a single production lot, or production runs of a single product?
- **USAF and NASA are requiring UN 38.3 compliance at the launch ranges. USDOT advises AIAA that way-forward for compliance is to submit "special permit" requests for each cell or battery in a system delivered to the range**

Summary

- Final Draft of Cell-Level AIAA S-144-2018 Qualification protocol to be released in December
- New Draft of AIAA Battery-Level Qualification released in January
- AFSPCMAN 91-710 and NASA 8719.24 Harmonized
 - COTS MEOP issue addressed
 - UN 38.3 Required
- UN 38.3 Large-Cell Revisions Proposed to USDOT
- How can you help?
 - Review AIAA S-144-2018
 - Provide input for change to UN 38.3
- Contact Brad Reed for further information