



Summary of the 33rd Plenary Special Committee 235 - Non-Rechargeable Lithium Batteries

Meeting Summary:

The 33rd Plenary Meeting of Special Committee 235 (SC-235) was held on March 5-7, 2024. The meeting was conducted at the RTCA Facility in Washington, DC with in-person and virtual attendees participating via WebEx.

John Trela (Chairman)

Norman Pereira (Government Authorized Representative)

Jeff Densmore (Secretary)

Karan Hofmann (Program Director)

Antonio Chiesa **
Jim Dellinger
Tom Jaeger **
Maria Jose **
Nazih Khaouly **
Frederic Menard
Paul Pfeifer

Fernando Menedez Rodriguez **

Jim Russell **
Adrian Sfetcu **
Greg Smith

Clayton Vondrasek **

The Boeing Company

Federal Aviation Administration Radiant Power Corporation

RTCA, Inc. Transport Canada

National Institute for Aviation Research

American Airlines

Airbus

Federal Aviation Administration

Safran Electronics and Defense Beacons

Textron EASA

The Boeing Company (retired)

Bell Helicopter U.S. Air Force Garmin Ltd

Opening Plenary

- The 33rd Plenary meeting of SC-235 was convened on March 5, 2024 at 9:00am EDT by Chair John Trela (Boeing). Jeff Densmore (Radiant Power) was the SC-235 Recording Secretary.
- Norman Pereira was introduced as the Government Authorized Representative.
- An RTCA overview, including RTCA's Proprietary References Policy was read by Karan Hofmann, the Program Director.
- Welcoming remarks were made by John Trela. Each person in attendance was invited to introduce themselves.
- The meeting agenda was reviewed.

^{**} Attended Virtually



- The Meeting Summary for SC-235 Plenary #32 was reviewed and approved as written. The meeting summary has been posted on AerOpus.
- All documents and presentation material reviewed during Plenary #33 have been uploaded and are available
 in the RTCA AerOpus documents folder for this meeting.

Plenary #32 Action Item Review

There were no open Action Items following Plenary #32

DO-227B Final Review and Comment

During Plenary #31, the committee approved a change to the Terms of Reference (ToR) which updated the FRAC Completion Date from March 2023 to June 2024 as shown.

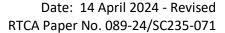
| Product | Description | FRAC Completion Due Date* | Change |
|---------|---|---------------------------------|---------------|
| DO-227B | Minimum Operational Performance Standard for Non-Rechargeable Lithium Batteries | JuneMarch 20243 | March 2022202 |

The ToR Update was presented and approved during the PMC December 2023 meeting.

DO-227B Final Review and Comment

Plenary #33 was the first plenary of SC-235 following the second Final Review and Comment (FRAC) process for DO-227B. The second FRAC comment period closed on January 12, 2024 with the following summary of comments received.

| Comment Type | Quantity | Percentage |
|---------------------|----------|------------|
| Non-Concur | 15 | 4.3% |
| High | 35 | 10.1% |
| Medium | 104 | 29.9% |
| Low | 81 | 23.3% |
| Editorial | 113 | 32.4% |
| | 348 | |





Comments were received from the following organizations:

- EASA
- FAA
- Transport Canada
- The Boeing Company
- Radiant Power Corp
- SAFRAN Electronics and Defense Beacons SAS
- Airbus
- Textron
- NIAR

Following the close of the second FRAC comment period, several Working Group meetings were conducted to discuss the comments and resolve those possible (mostly editorial). During those discussions, a few additional comments were entered into the register and some comments were reclassified with concurrence of RTCA and the committee leadership.

Of most significance, all of the comments from NIAR were reclassified from "Non-Concur" to "Medium". The original comment classifications were in error due to a misunderstanding of the category definitions. NIAR provided written concurrence of the reclassification of their comments.

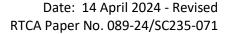
Entering Plenary #33, the status of all comments were as follows:

| Comment Type | Total | Resolved | Percentage | Unresolved | Percentage |
|---------------------|-------|----------|------------|------------|------------|
| Non-Concur | 1 | 0 | 0% | 1 | 100% |
| High | 35 | 3 | 8.6% | 32 | 91.4% |
| Medium | 119 | 19 | 16% | 100 | 84% |
| Low | 95 | 9 | 9.5% | 86 | 90.5% |
| Editorial | 100 | 64 | 64% | 36 | 36% |
| | 350 | 95 | 27.1% | 225 | 72.9% |

The primary purpose of Plenary #32 was to discuss and resolve the last remaining comments and proceed to a second Final Review And Comment (FRAC) process. The follow two items were discussed:

- 1. Battery external short circuit with protections disabled.
- 2. Thermal Runaway Chamber Sizing Discussion

Several Working Group meetings were held to review these items prior to Plenary #32.





Comment Discussion and Resolution

Non-Concurs

As mentioned above, there were fourteen *Non-Concur* comments from NIAR. After reviewing them during the Working Group meetings, all of these were reclassified to *Medium* due to a misunderstanding of the category definitions.

This left only one (1) Non-Concur comment from Radiant Power which reads as follows:

During the Dec 2023 PMC Meeting, Hette Hoekema from EASA stated that once DO-227B is adopted, EASA will require all future NRLB installations to be compliant with the latest standard (DO-227B). This is a significant cause for concern as MANY conversations have occurred during the drafting of DO-227B regarding the acceptability of products qualified to DO-227A. Per FAA (Pereira) and TCCA (Chiesa), products previously qualified to DO-227A will continue to be deemed acceptable for new installation as long as an incident or other issue does not arise / occur that would deem DO-227A unacceptable. If EASA's position is as stated above, Radiant Power is concerned that previously qualified products will have to be re-qualified to the new standard to be approved for installation. This is a significant impact to equipment manufacturers and installers. If this is EASA's position regarding DO-227A, then Radiant will issue a "Non-concur" to the release of DO-227B.

Discussing this comment during the Plenary meeting, Jeff Densmore from Radiant Power acquiesced that the Non-Concur is not directly applicable to DO-227B, but rather more directed towards the adoption of DO-227B such as an Advisory Circular, Special Condition Guidance, etc. However, given EASA's comments during the December PMC, it appears that EASA has already decided that future installation approvals will no longer accept DO-227A compliant equipment. This would require currently compliant equipment to be requalified to DO-227B which is an impactful (9-12 month) proposition. Underwater Locating Devices (ULDs) and Portable Emergency Locator Transmitter (ELTs) would be particularly impacted as they are often subject to new installations.

Fernando Menedez Rodriguez from EASA stated that he was not aware of a "pre-determined" position regarding the adoption of DO-227B and that this would not occur until after the document was released. Additionally, it was stated that a "RevA" to "RevB" comparison table would assist in the regulators' assessment of the changes and applicability of the current DO-227A to installation requirements.

Jeff Desmore from Radiant Power concluded the discussion by stating that the Non-Concur will be withdrawn and appreciated everyone's attention to this impactful issue.

High, Medium, and Low Comments

The following table summarizes the comments reviewed and resolved during the Plenary meeting.



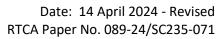


| Id | Category | Section | Subject | Comment | Disposition | Resolution |
|-------|----------------|-----------|---|---|-------------|--|
| 68185 | Non- Concur | General | DO-227A Acceptability for Future Installations. | During the Dec 2023 PMC Meeting, Hette HOEKEMA from EASA stated that once DO-227B is adopted, EASA will require all future NRLB installations to be compliant with the latest standard (DO-227B). This is a significant cause for concern as MANY conversations have occurred during the drafting of DO-227B regarding the acceptability of products qualified to DO-227A. Per FAA (Pereira) and TCCA (Chiesa), products previously qualified to DO-227A will continue to be deemed acceptable for new installation as long as an incident or other issue does not arise / occur that would deem DO-227A unacceptable. If EASA's position is as stated above, Radiant Power is concerned that previously qualified products will have to be re-qualified to the new standard to be approved for installation. This is a significant impact to equipment manufacturers and installers. If this is EASA's position regarding DO-227A, then Radiant will issue a "Non-concur" to the release of DO-227B. | Withdrawn | Comment does not address the MOPS content. The question of applicability is at a higher level. |
| 68060 | High | 2.4.2 | Missing information | Missing information regarding passivation of battery pack (as established for cell in paragraph 2.4.1) | Accepted | Copied the txt from the 2.4.1 cell section here to allow depassivation of the cells in batteries. |
| 68061 | High | 2.4.2.1.2 | Not clear | Temperature monitoring not required | Accepted | Removed temperature measurements from batteries because any internal flaw that would cause heating would also be detected by the OCV measurements. |
| 68062 | High | 2.4.2.2.2 | Missing information | "Instrument the battery for surface temperature measurements." -> number of probes and location not defined | Accepted | Added test setup to provide means of measuring cell warming. |
| 68063 | High | 2.4.2.2.3 | Missing information | "Instrument the two batteries for temperature measurement> number of probes and location not defined | Accepted | Added definition of ways to measure temperature |
| 68064 | High | 2.4.2.2.3 | Remove information | "Maximum cell and battery temperatures reached during the post-impact test period." -> highly difficult to perform for cells embedded in battery pack | Accepted | Removed cell temperature from the reportables because it is difficult to instrument. |
| 68068 | High | 2.4.1.2.1 | Harmonization | difference between method and Reportable Items: "once per second or faster" "a. Sample rate shall be at least 1 / minute." | Accepted | The common term is aligned as "at least 1 / minute." |
| 68069 | High | 2.4.2.2.5 | Harmonization | refers to the battery discharge when it is the cell that is discharged | Accepted | Cells may have a large increase in impedance at very low SOC, leading to very long discharge times to reach the target. Consider ways to reword the criteria that include capacity, impedance changes, and current capability. |
| 68128 | High | 2.4.1.1.2 | Test setup | Line 1024 and 1041 require an APSD analysis for the response of the cell. There is no requirement to instrument the cell for vibration (only the control input). If we require analysis of the response it will require instrumenting accelerometers on all 45 cells which is more than the available inputs on most vibration table setups. Our lab has 8 inputs currently and upgradeable to 16. Additionally the data would be of little or no value. Any change in the APSD response would mean an internal cell failure which would be observed with the OCV measurement currently required on each cell. | Accepted | Clarified there are two accelerometers to measure the input driving spectrum as well as the fixture response. |





| Id | Category | Section | Subject | Comment | Disposition | Resolution |
|-------|---------------------------|------------------------------------|--------------------------|--|--------------------|--|
| 68129 | High | 2.4.1.1.3 | Test setup | Shock test should only require instrumenting the control. No reason to instrument all 45 cells for shock (DO-160G does not require instrumenting the test article). Doing so will be above the inputs available for many shock/vibe tables requiring multiple test runs. Additionally the data would be of little or no value. | Accepted | Shock measurements will be at the table and the fixture locations. |
| 68134 | High | h 2.4.1.2.6 Reportable requirement | | Reportable item b. requires data from a thermal runaway. I believe (not explicitly clear) that a thermal runaway would be considered a failure in which case data documentation is not needed. | Accepted | Removed reportable b, as after a Tr there is no need for additional condition data. |
| 68140 | High 2.4.2.1.2 Test setup | | Test setup | Line 1408 and 1021 require an APSD analysis for the response of the battery. There is no requirement to instrument the battery for vibration (only the control input). If we require analysis of the response it will require instrumenting accelerometers on all 36 batteries which is more than the available inputs on most vibration table setups. Our lab has 8 inputs currently and upgradeable to 16. Additionally the data would be of little or no value. Any change in the APSD response would mean an internal battery failure which would be observed with the OCV measurement currently required on each battery. | Partially Accepted | Clarified that the APSD is for the fixture response, not the test article. |
| 68362 | High | 2.1.4 c | Need to be clear | End Items shall use batteries that meet this MOPS. (DO-227A or later revision. 270 Batteries may be qualified as End Items.). | Partially Accepted | Deleted items b and c. Updated the provisos in the battery (2.2.2) and end item (2.2.3) introductory sections. |
| 68364 | High | 2.4.1.1.2 | clarification | This test is to be performed on a set of 45 sample cells. This is a generic comment that applies to cells within the batteries and end item. | Clarified | Provision to use undischarged cells is mention at the start of the section 2.4.1. |
| 68375 | High | 2.1.2 | Airworthiness in MOPS | As an ETSO approval is normally different installations and as the installation architecture is not known at the time of the ETSO authorization, it is impossible to provide all the necessary information. Therefore this requirement is not verifiable and as such not valid. Airworthiness title and references inside the text are not adequate. Title should be more adequate when referencing Installation, Maintenance and Operation. | Partially Accepted | Airworthiness is part of the RTCA template and should be preserved. The required aspects were changed to guidance. |
| 68378 | High | 2.1.3 | clarify responsibilities | The current formulation allows that either the cell or the battery manufacturer is defining the intended functions. | Accepted | Rewrote the requirement to apply to all components. |
| 68391 | High | 2.1.15 | requirement unverifiable | it is still an unverifiable requirement at end item level. | Partially accepted | The requirement for warning was changed to guidance. |
| 68394 | High | 2.2 | means of compliance | Normally section 2.4 should only include a possible means but not the only means to show compliance to the requirements of sections 2.1 and 2.2. This change from will to shall makes all of section 2.4 something that has to be reassessed. Linked with paragraph 1.6. | Rejected | Not required for clarification of 1.6 and 2.2 |
| 68398 | High | 2.2.1.2.1 | removal to be justified | Please provide the ELOS (equivalent level of safety) or a justification for the removal of the following: "Another fundamental aspect is the ability to partially discharge at maximum current capability without residual negative effects." | Accepted | Returned the sentence to the rationale. |
| 68070 | Medium | 2.4.2.2.5 | Harmonization | "Step g." does not exist. | Superseded | |
| 68071 | Medium | 2.4.2.2.6 | Harmonization | reference to "Figure 2-19." not relevant | Superseded | |
| 68131 | Medium | 2.2.1 | Test order | Requirement to follow the specific test order in figure 2-26 seems unneeded and puts additional burden on the tester. Allowing alternate order will provide greater ability to schedule available lab resources. | Rejected | The order of testing may have an effect due to compounding effects |



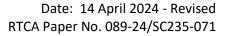


| Id | Category | Section | Subject | Comment | Disposition | Resolution |
|-------|------------------------------------|-----------|--|--|--------------------|--|
| 68215 | Medium 2.4.2.2.2 Battery Drop Test | | Battery Drop Test | Battery OCV measurement was not required in 227A. The P/F criteria table for batteries had a "blank" in this category. Discussing during WG and FRAC concluded that it should be NA ("-"). Reference Plenary #13. Why has it be added? | Accepted | Comments from Plenary 33: DO-227 did not contain cell and battery drop tests. When the Battery Drop Test was added in DO-227A, Table 2-4 "Battery Test Evaluation Criteria" had a blank entry for OCV and OCV was not measured in the test procedure. Table 2-4 was modified to show a "-" in the OCV column (meaning N/A) in the first FRAC DO-227B version and did not receive any comments during FRAC 1. However, while in Plenary 27 in March 2023 the "-" was changed to "F1" and test procedure steps to measure OCV prior to and following the drop were added. This happened during a discussion of the Pass / Fail criteria for the Drop Test with respect to Distortion. The rationale for making the OCV change was not documented in the FRAC 1 spreadsheet or Plenary 27 Meeting Minutes. During Plenary 33, the status of this OCV pass / fail criteria was discussed and the majority of the committee felt that the OCV measurement was not needed since this is an abusive test that needs to meet the other requirements of Table 2-5: Leakage, Venting, Distortion, Fire, and Rupture. |
| 68251 | Medium | 2.4.1.1.2 | precision | Cells mounted in spring-type holders may not experience the vibration correctly. | Accepted | Added text to specify regid cell-holding. |
| 68255 | Medium | 2.4.1.2.1 | Correct data | There is no specification in the standard as to where in the discharge circuit the voltage measurement leads should be connected. The connection location can make quite a difference and should be stated. | Accepted | Accepted and added a comment to survey other tests for consistent wording on voltage connection points. |
| 68271 | Medium | 2.4.2.2.4 | Procedural | There is no setup step for adding the voltage measurement wiring. | Superseded | |
| 68272 | Medium | 2.4.2.2.4 | Procedural | There is no preliminary step to measure the loop resistance. | Accepted | Added a set up step to measure the end-to-end loop resistance |
| 68346 | Medium | 2.4.2.2.4 | Battery External Short Circuit | instrumentation/equipment. | Partially Accepted | Added setup for imagery, voltage / current. |
| 68347 | Medium | 2.4.2.2.4 | Circuit | Suggest changing test procedure item a as proposed on the right column. | Superseded | |
| 68349 | Medium | 2.4.2.2.5 | Battery Single Cell Short Circuit with | Test Procedure item e calls for video recording while Reportable Item e calls for still images. | Accepted | Resolved as "e. Still images from the video of the battery" |
| 68376 | Medium | 2.1.3 | clarify responsibilities | The current formulation allows that either the cell or the battery is not providing the intended functions, which is not what is stipulated in the rational. | Accepted | Rewrote the requirement to apply to all components. |
| 68377 | Medium | 2.1.3 | shall in rationale | The rational shall not contain requirements, therefore the use of the word "must" was correct. "Must" states, that somewhere else this is formulated as a requirements. | Accepted | Removed "shall" |
| 68388 | Medium | 2.1.9 | Calibration | "When appropriate" is not an adequate way to propose a requirement. Calibration shall be a topic covered by means beyond this MOPS. | Accepted | Removed from 2.1.9 and augmented 2.3.2 to address calibration sources. |
| 68392 | | 2.1.16 | identification of test to be repeated to be explicitly mentioned | Add that the change impact analysis shall also identify all the tests that have to repeated after the design change has been implemented. | Accepted | Add that the change impact analysis shall also identify all the tests that have to repeated after the design change has been implemented. |
| 68127 | Low | 2.4.1.1.2 | Incorrect reference | Section 2.4.1.1.2 is Cell Vibration testing, but the cross reference in line 1015 points to DO-160G 7.3.1 which is Crash Safety. | Accepted | Suggest pointing to DO-160G section 8.3 |
| 68130 | Low | 2.4.1.1.3 | reference | The referenced section 7.3.1 in DO-160G is for Crash Safety. | Superseded | |





| Id | Category | Section | Subject | Comment | Disposition | Resolution |
|-------|----------|----------------------|--------------------------------------|---|------------------------------|--|
| 68132 | Low | 2.4.1.2.1 | sample rate | Sample rate in step a. does not align with the data requirements in the Reportable Items starting on line 1215. | Superseded | |
| 68139 | Low | 2.4.1.1.2 test setup | | Section 2.4.2.1.2 for the battery vibe test details using a fast response voltage sensor in the setup section. This is absent from the Cell vibe test setup (ref line 1399 for battery setup). | Rejected | Cells do not have the same vibration damage effects as battery, so there is no need for fast OCV during cell vibration testing. |
| 68146 | Low | 2.4.2.2.2 | test setup | Adding instrumentation to the battery for temperature measure will likely have a negative impact on the test especially when trying to test specific orientations | Superseded | |
| 68152 | Low | 2.4.1.1.2 | test procedure | Procedure allows running two bands of 10 to 500 Hz and 500 to 2000 Hz. DO-160 Section 8 allows two bands, but uses 10 to 600 and 600 to 2000. Is the difference intentional or simply a typo? Question also applies to lines 1397 and 1940 | Accepted | Removed the specific frequency bands and instead refer the reader to the DO-160 standard. |
| 68182 | Low | 2.4.1.1.2 | Redundant step | Measuring post test OCV is already in Step a (line 1010) | Accepted in previous comment | |
| 68183 | Low | 2.4.2.2.5 | incomplete setup statement | Step a. has you instrument the battery, but the data requirement is for cell temps. | Partially accepted | Suggest clarifying test setup step a. to specify that battery cells are to be instrumented. |
| 68198 | Low | 2.4.1.2.1 | Cell Discharge Test | Sample Rate clarification. | Superseded | |
| 68203 | Low | 2.4.1.2.6 | Cell Pressure Control (Venting) Test | requiring a linear control of the chamber temperature (procedure step b) drives testing to a traditional environmental chamber. As such obtaining video evidence of this test has become more difficult as environmental chambers offer much smaller viewing windows with multiple layers of glass which provides poor viewing of the test article. | Accepted | Change to read: Increase the temperature at a rate not exceeding 10°C every 30 minutes until evidence of venting is observed visually, or the samples burn or rupture. |
| 68207 | Low | 2.4.2.1.2 | Battery Vibration Test | Reportable item f states: All other measured data that was recorded during the test. This is vague and should be removed. If specific reportables are required, they should be explicitly listed | Superseded | |
| 68214 | Low | 2.4.2.2.2 | Battery Drop Test | Test setup step a discusses the instrumentation of the battery test articles for temperature. Adding thermocouples to the batteries prior to dropping may (and do) affect the orientation of the batteries as they are dropped. Suggest ability to apply thermocouples to batteries after they are dropped | Superseded | |
| 68273 | Low | 2.4.2.2.4 | consistency | Some sections just say compliance to Table criteria but this says including reportable conditions | Acknowledged | be consistent |





During Plenary #33, the committee successfully reviewed and resolved 47 comments. The resulting status of all comments is shown below.

| Comment Type | Total | Resolved | Percentage | Unresolved | Percentage |
|---------------------|-------|----------|------------|------------|------------|
| Non-Concur | 1 | 1 | 100.0% | 0 | 0.0% |
| High | 35 | 21 | 60.0% | 14 | 40.0% |
| Medium | 119 | 34 | 28.6% | 85 | 71.4% |
| Low | 95 | 22 | 23.2% | 73 | 76.8% |
| Editorial | 100 | 64 | 64.0% | 36 | 36.0% |
| | 350 | 142 | 40.6% | 208 | 59.4% |

Requirements Rationale

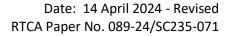
During the working group meetings, Antonio Chiesa from Transport Canada identified inconsistencies with the requirements rationale throughout the document. As a result, he submitted a proposal of suggested changes to improve the document.

An action was assigned during the Plenary to add each of these comments to the master spreadsheet and review during the Working Group meetings.

DO-227B Final Review and Comment (FRAC) Schedule Update

John Trela reviewed the schedule progress towards closure of the FRAC process as summarized below:

Second FRAC Start: 14 Nov 23
FRAC Comments Due: 12 Jan 24
Plenary #33 (WDC): 3-7 Mar 24
Plenary #34 (WDC) – planned: 14-16 May 24
FRAC Closure – planned: 26 Jun 24
DO-227B Transmitted to RTCA: Early July 2024
RTCA PMC Approval: Sep 2024





Action Item Summary

There were no new actions generated during Plenary #32:

- 1) Consult with Cell and Battery OEM's regarding transient OCV variation (timing and characteristics) as a result of the vibration environment. These inputs will help shape the monitoring requirements.
 - a. Assigned to: Jim Russell
 - b. Status: OPEN
- 2) Delegate resolution of the requirements rationale changes proposed by Antonio Chiesa
 - a. Assigned to: Jim Russell
 - b. Status: OPEN
- 3) Create a DO-227A vs DO-227B comparison Table for Insertion into the document
 - a. Assigned to; Jeff Densmore and John Trela
 - b. Status: OPEN

Working Group Meetings

Working Group meetings will continue on Mondays and Wednesdays from 10:00am to 11:30am (Eastern).

Next Plenary

Plenary #34 was scheduled for 14-16 May 2024 at RTCA's facility in Washington, DC.

-S-Jeff Densmore Secretary

CERTIFIED as a true and accurate summary of the meeting.

-S-John Trela Chairman