

**Boeing 787-8,
ET-AOP**

**Stand 592 London
Heathrow**

12 July 2013

Serious Incident

Investigation Synopsis

On the afternoon of Friday 12 July 2013 the Air Accidents Investigation Branch (AAIB) was notified of a ground fire in a parked and unoccupied Boeing 787-8 on Stand 592 at London Heathrow Airport. The circumstances surrounding the occurrence did not fall within the definitions of an accident or serious incident as defined in ICAO Annex 13, however, the Chief Inspector, in exercise of his powers under the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996, initiated an investigation, treating the occurrence as a serious incident and invoking the protocols of ICAO Annex 13 with regard to the participation of other interested States.

The aircraft suffered extensive heat damage in the upper portion of the aircraft's rear fuselage, in an area coincident with the location of the Emergency Locator Transmitter (ELT). The absence of any other aircraft systems in this area containing stored energy capable of initiating a fire, together with evidence from forensic examination of the ELT, led the investigation to conclude that the fire originated within the ELT.

The ground fire on ET-AOP was initiated by the uncontrolled release of stored energy from the lithium-metal battery in the ELT. It was identified early in the investigation that ELT battery wires, crossed and trapped under the battery compartment cover-plate, probably created a short-circuit current path which could allow a rapid, uncontrolled discharge of the battery. Root Cause testing performed by the aircraft and ELT manufacturers confirmed this latent fault as the most likely cause of the ELT battery fire, most probably in combination with the early depletion of a single cell.

Neither the cell-level nor battery-level safety features prevented this single-cell failure, which propagated to adjacent cells, resulting in a cascading thermal runaway, rupture of the cells and consequent release of smoke, fire and flammable electrolyte.

The trapped battery wires compromised the environmental seal between the battery cover plate and the ELT, providing a path for flames and battery decomposition products to escape from the ELT. The flames directly impinged on the surrounding thermo-acoustic insulation blankets and on the composite aircraft structure in the immediate vicinity of the ELT. This elevated the temperature in the fuselage crown to the point where the resin in the composite material began to decompose, providing further fuel for the fire. As a result, a slow-burning fire became established in the fuselage crown and this fire continued to propagate from the ELT location, even after the energy from the battery thermal event was exhausted.

Fourteen Safety Recommendations have been made during the course of the investigation. In addition the ELT manufacturer carried out several safety actions and is redesigning the ELT unit taking into account the findings of this investigation. Boeing and the FAA have also undertaken safety actions.

Safety Recommendation 2013-016

Safety Recommendation 2013-016

It is recommended that the Federal Aviation Administration initiate action for making inert the Honeywell International RESCU406AFN fixed Emergency Locator Transmitter system in Boeing 787 aircraft until appropriate actions can be completed.

Date Safety Recommendation made: 08 July 2013

LATEST RESPONSE

Response received: 17 April 2014

The FAA issued Airworthiness Directive (AD) 2013-15-07 (Docket No. FAA- 2013-0628), which became effective July 26, 2013. The AD required, within 10 days of the effective date, either removal or inspection of the Honeywell fixed EL T and corrective action if necessary. The AD was issued to prevent a fire in the aft crown of the airplane, or to detect and correct discrepancies within the ELT that could cause such a fire. As a result, the FAA believes it has effectively addressed the intent of Safety Recommendation 14.008 and considers its actions complete.

Safety Recommendation Status Closed

AAIB Assessment Adequate

RESPONSE HISTORY

N/A

(SRIS Reference: GB.SIA-2013-0016)

Safety Recommendation 2013-017

Safety Recommendation 2013-017

It is recommended that the Federal Aviation Administration, in association with other regulatory authorities, conduct a safety review of installations of Lithium-powered Emergency Locator Transmitter systems in other aircraft types and, where appropriate, initiate airworthiness action.

Date Safety Recommendation made: 08 July 2013

LATEST RESPONSE

Response received: 17 February 2021

The FAA grouped together a number of AAIB Recommendations because each applies to certain aspects of 'previously approved' aircraft equipment powered by non-rechargeable lithium batteries. These were AAIB Safety Recommendations 2013-017, 2015-014, -015 and -019.

In their letter of 30 September 2019 to the AAIB, the FAA stated that they were still evaluating certain non-rechargeable lithium battery installations on transport aircraft and that the review of existing non-rechargeable lithium battery installations on small airplanes and rotorcraft was complete. For small airplanes and rotorcraft, they determined corrective actions mandated by airworthiness directive (AD) were not necessary and continue to hold this position.

In a letter dated 11 February to the AAIB, the FAA confirmed that they have now completed evaluation of existing non-rechargeable lithium battery installations on transport category airplanes and coordinated this evaluation with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil, and Transport Canada Civil Aviation, as the responsible civil airworthiness authorities for the states of design of transport category airplanes. This has resulted in airworthiness AD (Airworthiness Directive) action on a number of Airbus types.

The coordinated evaluation of existing non-rechargeable lithium battery installations on transport category aircraft did not result in other mandatory corrective actions. The review of installations of non-rechargeable lithium battery installations, including those in ELTs, is now complete for all aircraft types. The examination of these hazards included thermal energy release and toxic gas release.

Earlier in the process, in the aftermath of the event on the B787, ET-AOP, at London Heathrow, the FAA had issued AD 2014-17-02, which required inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies.

The FAA considers it has effectively addressed the Safety Recommendations referring to 'previously approved' installations and considers their actions complete.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

Feedback rationale

The AAIB acknowledges the depth of work undertaken by the FAA, and other agencies, in their reviews of 'previously approved' installations and closes this Recommendation. (EU Regulation 996/2010 article 18 refers).

RESPONSE HISTORY

Response received: 01 October 2019

At this time (Sept 2019) the FAA are still evaluating certain installations on transport aircraft to determine whether mandatory AD actions are necessary. The FAA are in the process of issuing a Special Airworthiness Information Bulletin (SAIB) to advise owners, operators, original equipment manufacturers, and mechanics of small airplanes, transport category airplanes and rotorcraft having non-rechargeable lithium battery installations of the potential for the batteries to overheat, explode, or emit toxic gases. The SAIB provides recommendations, but not mandatory requirements, for non-rechargeable lithium battery installations, addressing both general safety concerns as well as specific concerns with certain chemistries of lithium battery installations. The FAA have coordinated their results with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the state of design of small airplanes, transport category airplanes, and rotorcraft.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

As previously mentioned, the FAA has completed a safety risk assessment, associated with all of these related AAIB recommendations, and it indicated additional corrective actions mandated by airworthiness directive (AD) is not warranted for non-rechargeable lithium batteries installations on small airplanes or rotorcraft. However, at this time we are still evaluating certain installations on transport aircraft to determine if mandatory AD actions are necessary. Currently, we are in the process of issuing a :Special Airworthiness Information Bulletin (SAIB) to advise owners, operators, original equipmen manufacturers, and mechanics of small airplanes. transport category airplanes, and rotorcraft having non-rechargeable lithium battery installations of the potential for the batteries to overheat, explode, or emit toxic gases. The SAIB provides recommendations, but not mandatory requirements for non-rechargeable lithium battery installations; addressing both general safety concerns, as well as specific concerns with certain chemistries of lithium battery installations. We have coordinated our results with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the state of design of small airplanes, transport category airplanes, and rotorcraft.

AAIB Assessment – Partially Adequate Open

Response received: 20 July 2018

As indicated in our letter, dated August 17, 2017, the FAA requested data from foreign and domestic design approval holders on lithium battery installations in transport airplanes. We coordinated with the European Aviation Safety Agency (EASA), the Agencia Nacional de Avia<yao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the State of Design of transport airplanes, to obtain this data from foreign design approval holders.

The FAA reviewed this data and conducted tests of certain non-rechargeable lithium batteries, including those installed in Emergency Locator Transmitter (ELI) systems, to determine if certain installation would be an explosive or toxic gas hazard on transport airplanes. Our tests included forcing non-rechargeable lithium batteries of different chemistries and sizes into thermal runaway and assessing the results in relation to their location on the airplane.

The information gathering and testing phase of our review is complete and we made recommendations to EASA, ANAC, and TCCA at the working level, our corrective actions for certain EL T system non-rechargeable lithium battery installations. Our recommendations considered battery size and chemistry, location of installation on the airplane, a intensity of the failure mode, and toxicity of the by-products.

Furthermore, we are conducting a risk assessment to decide whether we should mandate these recommendations by airworthiness directive.

If we determine it is appropriate to mandate these corrective actions, the FAA will coordinate with foreign authorities and release a notice of proposed rulemaking to allow public comment. We expect to provide an updated response by June 2019.

AAIB Assessment – Adequate Closed

Response received: 11 June 2018

As mentioned in our previous correspondence, the FAA requested data from foreign and domestic design approval holders on lithium battery installations in transport airplanes. We coordinated with the European Aviation Safety Agency (EASA), the Agência Nacional de Aviação Civil (ANAC) and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the State of Design of transport airplanes, to obtain this data from foreign design approval holders. The FAA has reviewed this data and conducted tests of certain non-rechargeable lithium batteries, including those installed in Emergency Locator Transmitter (ELT) systems, to determine if certain installation would be an explosive or toxic gas hazard on transport airplanes. Our tests included forcing non rechargeable lithium batteries of different chemistries and sizes into thermal runaway and assessing the results in relation to their location on the airplane.

The information gathering and testing phase of our review is complete and we have made recommendations to EASA, ANAC and TCCA at the working level, for corrective actions on certain ELT system non-rechargeable lithium battery installations. The recommendations considered battery size and chemistry, where it is installed in the airplane, the intensity of the failure mode, and toxicity of the by-products. We are currently conducting a risk assessment for use in deciding if these recommendations for corrective action should be mandated by airworthiness directive (AD).

If a mandatory corrective action is determined to be appropriate, the FAA will coordinate with foreign authorities and release a notice of proposed rulemaking (NPRM) to allow public comment prior to issuance of an AD.

We expect to provide an updated response by December 28, 2018.

AAIB Assessment – Adequate Closed

Response received: 18 August 2017

As indicated in our previous response, the FAA requested a complete list of lithium battery installations (including installations of ELTs with lithium batteries) on transport category airplanes from several Type

Certificate (TC) and Supplemental Type Certificate (STC) design approval holders. For each lithium battery installation, we requested each TC or STC holder to describe its cell type, size, chemistry, power capacity, location, intended function, and installation characteristics intended to protect the airplane from battery failure hazards. The FAA also requested specific information regarding the safety assessments conducted in accordance with Title 14, Code of Federal Regulations Section 25.1309, Equipment, Systems, and Installations that were required for TC and STC approval.

The FAA is reviewing this information on existing non-rechargeable lithium battery installations and conducting tests on certain lithium batteries to determine if any of the non-rechargeable lithium battery installations, including those installed in ELTs, would be an explosive or toxic gas hazard. Furthermore, our tests include forcing non-rechargeable lithium batteries of different characteristics into thermal runaway and then further assessing the results in relation to their location on the airplane.

Pending the results of our testing, if a mandatory corrective action is determined to be appropriate for a domestic product, the FAA, as the state of design, will coordinate with foreign authorities and release a notice of proposed rulemaking to allow public comment prior to issuance of an airworthiness directive. Additionally, if the findings involve a foreign product, the FAA will work with the responsible civil airworthiness authority for the state of design to determine appropriate corrective measures. We expect to provide an updated response to this recommendation by March 31, 2018.

AAIB Assessment – Partially Adequate Open

Response received: 23 July 2015

The FAA requested a complete list of lithium battery installations (including installations of ELTs with lithium batteries) on transport category airplanes from several Type Certificate (TC) and Supplemental Type Certificate (STC) design approval holders. For each lithium battery installation, the FAA requested each TC or STC holder to describe its cell type, size, chemistry, power capacity, location, intended function, and installation characteristics intended to protect the airplane from battery failure hazards. The FAA also requested specific information regarding the safety assessments conducted in accordance with Title 14, Code of Federal Regulation Section 25.1309, Equipment, Systems, and Installations, that were required for TC and STC approval. The FAA will use the data to determine if airworthiness directives need to be issued.

The FAA expect to provide an updated response to FAA Safety Recommendation 14.009 (AAIB 2013-017) by July 31, 2016.

AAIB Assessment – Partially Adequate Open

Response received: 17 April 2014

The FAA is currently conducting a safety review of Lithium-powered ELT systems with other regulatory authorities to identify any unsafe conditions in other aircraft types. The FAA expects to provide an update on the status of the safety review by March 31, 2015. As a result, Safety Recommendation 14.009 will remain classified as open.

AAIB Assessment – Adequate Closed

(SRIS Reference: GB.SIA-2013-0017)

Safety Recommendation 2014-020

Safety Recommendation 2014-020

It is recommended that the Federal Aviation Administration develop enhanced certification requirements for the use of lithium-metal batteries in aviation equipment, to take account of current industry knowledge on the design, operational characteristics and failure modes of lithium-metal batteries.

Date Safety Recommendation made: 18 June 2014

LATEST RESPONSE

Response received: 17 February 2016

The FAA has developed special conditions for non-rechargeable lithium batteries. On November 20, 2015, the FAA published a notice of proposed special conditions, titled "Special Conditions: Gulfstream Aerospace Corporation, Gulfstream GVI Airplane; Non Rechargeable Lithium Battery Installations" (enclosed). The notice is applicable to non-rechargeable lithium batteries on Gulfstream G-VI airplanes. The FAA will issue similar special conditions to address other airplane models. These special conditions take into account current industry knowledge of design, operational characteristics, and modes of failure. The FAA has also established acceptable methods for complying with these special conditions. The current methods of compliance accepted by the FAA include a combination of published tests:

- RTCA (Radio Technical Commission for Aeronautics) DO-227, Minimum Operational Performance Standards for Lithium Batteries;
- RTCA DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems; and
- FAA Technical Standard Order TSO-C142a, Non-Rechargeable Lithium Cells and Batteries.

In demonstrating compliance to the proposed special conditions developed by the FAA, applicants will have to meet all applicable tests, including the performance and design-abuse certification tests conducted in the parent equipment. Additionally, applicants must demonstrate that their batteries and equipment design protect against hazardous effects of propagation of single-cell thermal runaway to other cells, and the release of electrolyte, fire, or explosive debris.

The FAA considers this has effectively addressed this safety recommendation and consider their actions complete.

Safety Recommendation Status Closed

AAIB Assessment Partially Adequate

RESPONSE HISTORY

Response received: 31 October 2014

The FAA has assigned the Safety Recommendation to the Aircraft Certification Office. The FAA expects to provide an updated response by November 30, 2014

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2014-0020)

Safety Recommendation 2014-021

Safety Recommendation 2014-021

It is recommended that the Federal Aviation Administration require that electrical performance and design-abuse certification tests for lithium-metal batteries are conducted with the battery installed in the parent equipment, to take account of battery thermal performance.

Date Safety Recommendation made: 18 June 2014

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries. The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, 'Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft', aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries'. DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and the FAA anticipate publication of the final AC by December 2019. After the AC is published, the FAA will propose closure of these safety recommendations.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 14 September 2018

In its previous letter dated December 5, 2017, the FAA provided an overall description and plan of action to establish special conditions (SC) and the means of compliance for installations involving non-rechargeable lithium batteries. Included in our response were four actions that directly pertained to answering these safety recommendations. The first three actions describe the process the FAA uses to certify installations involving non-rechargeable lithium batteries on transport category aircraft. The fourth action concerned its work with RTCA Special Committee 235 to revise RTCA/DO 227, Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries.

Since our last response, the RTCA published revision A to DO-227. The new DO-227A directly addresses recommendations 14.102 and 14.104 through the inclusion of:

- Electrical performance and design-abuse certification testing conducted on the end item (eg, parent equipment such as the Emergency Locator Transmitter or Underwater Locating Beacon). These tests establish and demonstrate safe operating margins under environmental and operational stresses of both the battery itself and the overall battery system, taking into account battery thermal performance;

- Design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing; and
- Evaluation criteria for the thermal runaway containment test of the parent equipment to ensure that the design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire, or explosion debris.

The FAA accepts DO-227A standards as part of a method of compliance with the airworthiness requirements of the SCs for new non-rechargeable battery installations, for batteries that exceed energy capacities of 2-watt-hours: For small batteries that fall below this threshold, the FAA will accept batteries that meet the Underwriters Laboratories 1642 standard.

The FAA plans to publish guidance in an Advisory Circular (AC) that will reference the methods of compliance incorporated in DO-227 A for non-rechargeable lithium battery and battery systems, and will add guidance for safe integration of MOPS-compliant battery systems into aircraft. The FAA expected to release the draft AC by June 2018, but due to unforeseen delays, now expects to release the draft AC in late 2018. The FAA anticipates providing an updated response to these recommendations by February 2019.

AAIB Assessment – Partially Adequate Open

Response received: 05 December 2017

Appendix 1 (enclosed) provides an overall description and plan of actions taken by the FAA to establish special conditions (SC) and the means of compliance for installations involving non-rechargeable lithium batteries.

The following actions address recommendations 14.102 and 14.104:

CD The FAA has issued SCs to establish safety standards for installation of non-rechargeable lithium batteries on in-production transport category airplanes;

o Applicants show compliance to the SCs for installation approval by accounting for battery-level and equipment-level failure modes and effects, as well as protecting the airplane from excessive heat that the battery may produce;

o The FAA has developed an acceptable means of compliance to the SCs to ensure that applicants consider the effect of a battery cell(s) going into thermal runaway, and currently applies these means of compliance on a project-by-project basis through the issue paper process; and

o The FAA completed its work with RTCA Special Committee 235, Non-Rechargeable Lithium Batteries, to revise RTCA/DO-227 on September 21, 2017. The revised standard (RTCA/DO-227A) includes design-abuse testing demonstration requirements. The FAA plans to release a new Advisory Circular (AC) based on RTCA/DO-227A as one means of compliance to the SCs by June 2018.

Regarding recommendation 14.102, RTCA/DO-227A includes electrical performance and design-abuse certification tests to be conducted on the end item (e.g., parent equipment such as the Emergency Locator Transmitter or Underwater Locating Beacon). These tests establish and demonstrate safe operating margins under environmental and operational stresses of both the battery itself and the overall battery system, taking into account battery thermal performance.

To address recommendation 14.104, RTCA/DO-227A includes design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing. Evaluation criteria of RTCA/DO-227A for the thermal runaway containment test of the parent equipment ensures that the design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire, or explosion debris.

By July 31, 2018, we will provide an update on the actions we have taken to address recommendations 14.102 and 14.104 for transport category airplanes. As part of that update, we will provide the status of the new AC.

AAIB Assessment – Partially Adequate Open

Response received: 17 February 2016

On June 18, 2015, the RTCA initiated special committee SC-235, Non-Rechargeable Lithium Batteries, in response to the FAA's request to incorporate the AAIB recommended actions into RTCA DO-227.

The FAA expect to provide an updated response to these safety recommendations by December 2016.

AAIB Assessment – Partially Adequate Open

Response received: 31 October 2014

We plan to request that the Radio Technical Commission for Aeronautics (RTCA) task Special Committee 225, Rechargeable Lithium Batteries and Battery Systems, to revise and update RTCA Document Number DO-227, Minimum Operational Performance Standards for Lithium Batteries, for non-rechargeable lithium metal batteries. The revision would include methods to force lithium metal cells within a lithium metal battery to thermal runaway conditions.

The Tasking would include exploring the mitigation of the worst possible effects of this condition during certification testing. We plan to include evaluation criteria to ascertain pass/fail criteria under these test conditions.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2014-0021)

Safety Recommendation 2014-022

Safety Recommendation 2014-022

It is recommended that the Federal Aviation Administration work with industry to determine the best method to force a lithium-metal cell into thermal runaway and develop a design-abuse test that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing.

Date Safety Recommendation made: 18 June 2014

LATEST RESPONSE

Response received: 05 December 2017

The RTCA Special Committee 235 finalized the update to RTCA DO-227 A on September 21, 2017. A copy of this document is available at the following Web site: <https://www.rtca.org/content/documents>. The update determined the best methods to force a lithium-metal cell into thermal runaway and developed design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing. The updated document also provides certification performance guidance for non-rechargeable batteries permanently installed in aircraft. Additionally, the revised Minimum Operational Performance Standards incorporate the latest understanding of lithium battery technology, including battery testing.

I believe the FAA has effectively addressed this safety recommendation and consider our action complete.

Safety Recommendation Status Closed

AAIB Assessment Partially Adequate

RESPONSE HISTORY

Response received: 31 October 2014

We plan to request that the Radio Technical Commission for Aeronautics (RTCA) task Special Committee 225, Rechargeable Lithium Batteries and Battery Systems, to revise and update RTCA Document Number DO-227, Minimum Operational Performance Standards for Lithium Batteries, for non-rechargeable lithium metal batteries. The revision would include methods to force lithium metal cells within a lithium metal battery to thermal runaway conditions.

The Tasking would include exploring the mitigation of the worst possible effects of this condition during certification testing. We plan to include evaluation criteria to ascertain pass/fail criteria under these test conditions.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2014-0022)

Safety Recommendation 2014-023

Safety Recommendation 2014-023

It is recommended that the Federal Aviation Administration require equipment manufacturers wishing to use lithium-metal batteries to demonstrate (using the design-abuse testing described in Safety Recommendation 2014-022) that the battery and equipment design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire or explosive debris.

Date Safety Recommendation made: 18 June 2014

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries. The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, 'Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft', aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries'. DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and the FAA anticipate publication of the final AC by December 2019. After the AC is published, the FAA will propose closure of these safety recommendations.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 14 September 2018

In its previous letter dated December 5, 2017, the FAA provided an overall description and plan of action to establish special conditions (SC) and the means of compliance for installations involving non-rechargeable lithium batteries. Included in our response were four actions that directly pertained to answering these safety recommendations. The first three actions describe the process the FAA uses to certify installations involving non-rechargeable lithium batteries on transport category aircraft. The fourth action concerned its work with RTCA Special Committee 235 to revise RTCA/DO 227, Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries. Since our last response, the RTCA published revision A to DO-227. The new DO-227A directly addresses recommendations 14.102 and 14.104 through the inclusion of:

- Electrical performance and design-abuse certification testing conducted on the end item (eg, parent equipment such as the Emergency Locator Transmitter or Underwater Locating Beacon). These tests establish and demonstrate safe operating margins under environmental and operational stresses of both the battery itself and the overall battery system, taking into account battery thermal performance;
- Design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing; and
- Evaluation criteria for the thermal runaway containment test of the parent equipment to ensure that the design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire, or explosion debris.

The FAA accepts DO-227A standards as part of a method of compliance with the airworthiness requirements of the SCs for new non-rechargeable battery installations, for batteries that exceed energy capacities of 2-watt-hours: For small batteries that fall below this threshold, the FAA will accept batteries that meet the Underwriters Laboratories 1642 standard.

The FAA plans to publish guidance in an Advisory Circular (AC) that will reference the methods of compliance incorporated in DO-227 A for non-rechargeable lithium battery and battery systems, and will add guidance for safe integration of MOPS-compliant battery systems into aircraft. The FAA expected to release the draft AC by June 2018, but due to unforeseen delays, now expects to release the draft AC in late 2018. The FAA anticipates providing an updated response to these recommendations by February 2019.

AAIB Assessment – Partially Adequate Open

Response received: 05 December 2017

Appendix 1 (enclosed) provides an overall description and plan of actions taken by the FAA to establish special conditions (SC) and the means of compliance for installations involving non-rechargeable lithium batteries.

The following actions address recommendations 14.102 and 14.104:

CD The FAA has issued SCs to establish safety standards for installation of non-rechargeable lithium batteries on in-production transport category airplanes;

o Applicants show compliance to the SCs for installation approval by accounting for battery-level and equipment-level failure modes and effects, as well as protecting the airplane from excessive heat that the battery may produce;

o The FAA has developed an acceptable means of compliance to the SCs to ensure that applicants consider the effect of a battery cell(s) going into thermal runaway, and currently applies these means of compliance on a project-by-project basis through the issue paper process; and

o The FAA completed its work with RTCA Special Committee 235, Non-Rechargeable Lithium Batteries, to revise RTCA/DO-227 on September 21, 2017. The revised standard (RTCA/DO-227A) includes design-abuse testing demonstration requirements. The FAA plans to release a new Advisory Circular (AC) based on RTCA/DO-227A as one means of compliance to the SCs by June 2018.

Regarding recommendation 14.102, RTCA/DO-227A includes electrical performance and design-abuse certification tests to be conducted on the end item (e.g., parent equipment such as the Emergency Locator Transmitter or Underwater Locating Beacon).

These tests establish and demonstrate safe operating margins under environmental and operational stresses of both the battery itself and the overall battery system, taking into account battery thermal performance.

To address recommendation 14.104, RTCA/DO-227A includes design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing. Evaluation criteria of RTCA/DO-227A for the thermal runaway containment test of the parent equipment ensures that the design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire, or explosion debris.

By July 31, 2018, we will provide an update on the actions we have taken to address recommendations 14.102 and 14.104 for transport category airplanes. As part of that update, we will provide the status of the new AC.

AAIB Assessment – Partially Adequate Open

Response received: 17 February 2016

On June 18, 2015, the RTCA initiated special committee SC-235, Non-Rechargeable Lithium Batteries, in response to the FAA's request to incorporate the AAIB recommended actions into RTCA DO-227.

The FAA expect to provide an updated response to these safety recommendations by December 2016.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2014-0023)

Safety Recommendation 2014-024

Safety Recommendation 2014-024

It is recommended that the Federal Aviation Administration review whether the Technical Standard Order (TSO) process is the most effective means for the certification of lithium-metal batteries installed in aircraft equipment, the actual performance of which can only be verified when demonstrated in the parent equipment and the aircraft installation.

Date Safety Recommendation made: 18 June 2014

LATEST RESPONSE

Response received: 31 October 2014

The FAA believes a Technical Standard Order (TSO) is effective in approving the design and production of an article to meet the Minimum Performance Standards. A TSO alone is not sufficient for certification approval. In order to complete a certification of a lithium metal battery installed in aircraft equipment, an airworthiness regulation approval is required. The airworthiness regulation must be complied with during the Type certification, and Supplemental Type certification (including their respective amendments).

Safety Recommendation Status Closed

AAIB Assessment Partially Adequate

RESPONSE HISTORY

N/A

(SRIS Reference: GB.SIA-2014-0024)

Safety Recommendation 2015-014

Safety Recommendation 2015-014

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, conduct an assessment of the circuit protection offered by the existing Honeywell RESCU 406AF and 406AFN ELT battery, to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to mitigate against external short-circuits and unbalanced discharge.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 17 February 2021

The FAA grouped together a number of AAIB Recommendations because each applies to certain aspects of 'previously approved' aircraft equipment powered by non-rechargeable lithium batteries. These were AAIB Safety Recommendations 2013-017, 2015-014, -015 and -019.

In their letter of 30 September 2019 to the AAIB, the FAA stated that they were still evaluating certain non-rechargeable lithium battery installations on transport aircraft and that the review of existing non-rechargeable lithium battery installations on small airplanes and rotorcraft was complete. For small airplanes and rotorcraft, they determined corrective actions mandated by airworthiness directive (AD) were not necessary and continue to hold this position.

In a letter dated 11 February to the AAIB, the FAA confirmed that they have now completed evaluation of existing non-rechargeable lithium battery installations on transport category airplanes and coordinated this evaluation with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil, and Transport Canada Civil Aviation, as the responsible civil airworthiness authorities for the states of design of transport category airplanes. This has resulted in airworthiness AD (Airworthiness Directive) action on a number of Airbus types.

The coordinated evaluation of existing non-rechargeable lithium battery installations on transport category aircraft did not result in other mandatory corrective actions. The review of installations of non-rechargeable lithium battery installations, including those in ELTs, is now complete for all aircraft types. The examination of these hazards included thermal energy release and toxic gas release.

Earlier in the process, in the aftermath of the event on the B787, ET-AOP, at London Heathrow, the FAA had issued AD 2014-17-02, which required inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies.

The FAA considers it has effectively addressed the Safety Recommendations referring to 'previously approved' installations and considers their actions complete.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status**Planned Action Completed****Feedback rationale**

The AAIB acknowledges the depth of work undertaken by the FAA, and other agencies, in their reviews of 'previously approved' installations and closes this Recommendation. (EU Regulation 996/2010 article 18 refers).

RESPONSE HISTORY

Response received: 30 September 2019

As previously mentioned, the FAA has completed a safety risk assessment, associated with all of these related AAIB recommendations, and it indicated additional corrective actions mandated by airworthiness directive (AD) is not warranted for non-rechargeable lithium batteries installations on small airplanes or rotorcraft. However, at this time we are still evaluating certain installations on transport aircraft to determine if mandatory AD actions are necessary. Currently, we are in the process of issuing a :Special Airworthiness Information Bulletin (SAIB) to advise owners, operators, original equipment manufacturers, and mechanics of small airplanes, transport category airplanes, and rotorcraft having non-rechargeable lithium battery installations of the potential for the batteries to overheat, explode, or emit toxic gases. The SAIB provides recommendations, but not mandatory requirements for non-rechargeable lithium battery installations; addressing both general safety concerns, as well as specific concerns with certain chemistries of lithium battery installations. We have coordinated our results with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the state of design of small airplanes, transport category airplanes, and rotorcraft.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

In our previous response, we indicated we would evaluate the circuit protection of the Honeywell RESCU 406AF and 406AFN emergency locator transmitter. We also indicated we would conduct a more comprehensive review of potential hazards resulting from a battery failure (i.e. thermal runaway) for existing non-rechargeable lithium batteries generally installed in aircraft equipment on all transport category airplanes. We coordinated with the European Aviation Safety Agency (EASA), Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the State of Design of transport category airplanes, to obtain the data from the foreign design approval holders. Our review of the data, in combination with tests of certain non-rechargeable lithium batteries, assesses whether such battery installations are unsafe by considering the types of failures that could result in a battery thermal runaway (i.e., thermal runaway due not only to inadequate circuit protection, but also to overheating, manufacturing flaw, damage, etc.). The review also included consideration of potential unsafe conditions resulting from toxic gases on airplane occupants.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and

406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source.

These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2015-0014)

Safety Recommendation 2015-015

Safety Recommendation 2015-015

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, conduct a review of installed aircraft equipment on transport category aircraft powered by lithium-metal batteries, which have been approved under TSO-C142 /C142A or by equivalent means, to ensure that the design of such batteries incorporates an acceptable level of circuit protection to mitigate against known failure modes including, but not limited to, external short-circuits and unbalanced discharge.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 17 February 2021

The FAA grouped together a number of AAIB Recommendations because each applies to certain aspects of 'previously approved' aircraft equipment powered by non-rechargeable lithium batteries. These were AAIB Safety Recommendations 2013-017, 2015-014, -015 and -019.

In their letter of 30 September 2019 to the AAIB, the FAA stated that they were still evaluating certain non-rechargeable lithium battery installations on transport aircraft and that the review of existing non-rechargeable lithium battery installations on small airplanes and rotorcraft was complete. For small airplanes and rotorcraft, they determined corrective actions mandated by airworthiness directive (AD) were not necessary and continue to hold this position.

In a letter dated 11 February to the AAIB, the FAA confirmed that they have now completed evaluation of existing non-rechargeable lithium battery installations on transport category airplanes and coordinated this evaluation with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil, and Transport Canada Civil Aviation, as the responsible civil airworthiness authorities for the states of design of transport category airplanes. This has resulted in airworthiness AD (Airworthiness Directive) action on a number of Airbus types.

The coordinated evaluation of existing non-rechargeable lithium battery installations on transport category aircraft did not result in other mandatory corrective actions. The review of installations of non-rechargeable lithium battery installations, including those in ELTs, is now complete for all aircraft types. The examination of these hazards included thermal energy release and toxic gas release.

Earlier in the process, in the aftermath of the event on the B787, ET-AOP, at London Heathrow, the FAA had issued AD 2014-17-02, which required inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies.

The FAA considers it has effectively addressed the Safety Recommendations referring to 'previously approved' installations and considers their actions complete.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status**Planned Action Completed****Feedback rationale**

The AAIB acknowledges the depth of work undertaken by the FAA, and other agencies, in their reviews of 'previously approved' installations and closes this Recommendation. (EU Regulation 996/2010 article 18 refers).

RESPONSE HISTORY

Response received: 30 September 2019

As previously mentioned, the FAA has completed a safety risk assessment, associated with all of these related AAIB recommendations, and it indicated additional corrective actions mandated by airworthiness directive (AD) is not warranted for non-rechargeable lithium batteries installations on small airplanes or rotorcraft. However, at this time we are still evaluating certain installations on transport aircraft to determine if mandatory AD actions are necessary. Currently, we are in the process of issuing a :Special Airworthiness Information Bulletin (SAIB) to advise owners, operators, original equipment manufacturers, and mechanics of small airplanes, transport category airplanes, and rotorcraft having non-rechargeable lithium battery installations of the potential for the batteries to overheat, explode, or emit toxic gases. The SAIB provides recommendations, but not mandatory requirements for non-rechargeable lithium battery installations; addressing both general safety concerns, as well as specific concerns with certain chemistries of lithium battery installations. We have coordinated our results with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the state of design of small airplanes, transport category airplanes, and rotorcraft.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.108, 15.109, and 15.113 together because each one applies to certain aspects of previously-approved aircraft equipment powered by non-rechargeable lithium batteries.

In our previous response, we indicated we would evaluate the circuit protection of the Honeywell RESCU 406AF and 406AFN emergency locator transmitter. We also indicated we would conduct a more comprehensive review of potential hazards resulting from a battery failure (i.e. thermal runaway) for existing non-rechargeable lithium batteries generally installed in aircraft equipment on all transport category airplanes. We coordinated with the European Aviation Safety Agency (EASA), Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the State of Design of transport category airplanes, to obtain the data from the foreign design approval holders. Our review of the data, in combination with tests of certain non-rechargeable lithium batteries, assesses whether such battery installations are unsafe by considering the types of failures that could result in a battery thermal runaway (i.e., thermal runaway due not only to inadequate circuit protection, but also to overheating, manufacturing flaw, damage, etc.).

The review also included consideration of potential unsafe conditions resulting from toxic gases on airplane occupants.

We are conducting a safety risk assessment to determine if airworthiness corrective actions are necessary.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Not Adequate Open

(SRIS Reference: GB.SIA-2015-0015)

Safety Recommendation 2015-016

Safety Recommendation 2015-016

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require equipment manufacturers intending to use lithium-metal batteries in aircraft equipment to demonstrate that the battery design incorporates an acceptable level of circuit protection to mitigate against known failure modes including, but not limited to, external short-circuits and unbalanced discharge.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries. The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft, aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries.

DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and we anticipate publication of the final AC by December 2019. After the AC is published, we will propose closure of these safety recommendations.

We anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.110, 15.111, 15.112, and 15.114 together because each one applies to certain aspects related to future installations of aircraft equipment powered by non-rechargeable lithium batteries.

On September 21, 2017, the RTCA published DO-227A, "Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries." DO-227A identifies battery failure modes and requires testing to provide data for determining the effects at the battery, equipment, and airplane level. It also requires abuse tests that include the following:

- Short circuit tests of a battery system with protection enabled and disabled (recommendation 15.110);
- Tests to determine the effectiveness of containing a thermal runaway event (recommendation 15.111);
- Tests to determine the maximum heat that would be generated during a thermal runaway failure (recommendation 15.111);

- Tests to determine the effectiveness of the battery case to contain the ignition of vapors and/or electrolyte in the battery (recommendation 15.111); and
- Tests to evaluate the venting system (recommendation 15.114).

The FAA is now accepting new non-rechargeable lithium battery installations that meet the standards of either DO-227A or DO-347 (discussed in our previous response to these recommendations), which ensures the effects of battery failures will not be a hazard to the airplane or occupants. We note that these standards do not apply to very small batteries (i.e. 2 watt-hours or less) that meet the Underwriters Laboratories 1642 standard.

Additionally, guidance for a new advisory circular is being drafted. It will outline the methods of compliance incorporated by DO-227A standards for non-rechargeable lithium battery and battery systems. Also, the FAA's Aircraft Certification Service, Transport Airplane Directorate continues its planned activities related to the subject safety recommendations. We expect to provide an updated response to these safety recommendations by March 31, 2019.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2015-0016)

Safety Recommendation 2015-017

Safety Recommendation 2015-017

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require manufacturers intending to use lithium metal batteries in aircraft equipment, to quantify the heat produced by the battery over a range of discharge conditions and demonstrate that the battery and equipment design can adequately dissipate the heat produced.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries. The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, 'Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft', aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries'. DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and the FAA anticipate publication of the final AC by December 2019. After the AC is published, the FAA will propose closure of these safety recommendations.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.110, 15.111, 15.112, and 15.114 together because each one applies to certain aspects related to future installations of aircraft equipment powered by non-rechargeable lithium batteries.

On September 21, 2017, the RTCA published DO-227A, "Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries." DO-227A identifies battery failure modes and requires testing to provide data for determining the effects at the battery, equipment, and airplane level. It also requires abuse tests that include the following:

- Short circuit tests of a battery system with protection enabled and disabled (recommendation 15.110);
- Tests to determine the effectiveness of containing a thermal runaway event (recommendation 15.111);
- Tests to determine the maximum heat that would be generated during a thermal runaway failure (recommendation 15.111);
- Tests to determine the effectiveness of the battery case to contain the ignition of vapors and/or electrolyte in the battery (recommendation 15.111); and
- Tests to evaluate the venting system (recommendation 15.114).

The FAA is now accepting new non-rechargeable lithium battery installations that meet the standards of either DO-227A or DO-347 (discussed in our previous response to these recommendations), which ensures the effects of battery failures will not be a hazard to the airplane or occupants. We note that these standards do not apply to very small batteries (i.e. 2 watt-hours or less) that meet the Underwriters Laboratories 1642 standard.

Additionally, guidance for a new advisory circular is being drafted. It will outline the methods of compliance incorporated by DO-227A standards for non-rechargeable lithium battery and battery systems. Also, the FAA's Aircraft Certification Service, Transport Airplane Directorate continues its planned activities related to the subject safety recommendations. We expect to provide an updated response to these safety recommendations by March 31, 2019.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2015-0017)

Safety Recommendation 2015-018

Safety Recommendation 2015-018

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require the manufacturers of lithium-metal batteries and manufacturers of aircraft equipment powered by lithium-metal batteries, to conduct battery-level and equipment level 'failure mode and effects analyses' to identify failure modes and their effects.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries.

The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, 'Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft', aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries'. DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and the FAA anticipate publication of the final AC by December 2019. After the AC is published, the FAA will propose closure of these safety recommendations.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.110, 15.111, 15.112, and 15.114 together because each one applies to certain aspects related to future installations of aircraft equipment powered by non-rechargeable lithium batteries.

On September 21, 2017, the RTCA published DO-227A, "Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries." DO-227A identifies battery failure modes and requires testing to provide data for determining the effects at the battery, equipment, and airplane level. It also requires abuse tests that include the following:

- Short circuit tests of a battery system with protection enabled and disabled (recommendation 15.110);
- Tests to determine the effectiveness of containing a thermal runaway event (recommendation 15.111);

- Tests to determine the maximum heat that would be generated during a thermal runaway failure (recommendation 15.111);
- Tests to determine the effectiveness of the battery case to contain the ignition of vapors and/or electrolyte in the battery (recommendation 15.111); and
- Tests to evaluate the venting system (recommendation 15.114).

The FAA is now accepting new non-rechargeable lithium battery installations that meet the standards of either DO-227A or DO-347 (discussed in our previous response to these recommendations), which ensures the effects of battery failures will not be a hazard to the airplane or occupants. We note that these standards do not apply to very small batteries (i.e. 2 watt-hours or less) that meet the Underwriters Laboratories 1642 standard.

Additionally, guidance for a new advisory circular is being drafted. It will outline the methods of compliance incorporated by DO-227A standards for non-rechargeable lithium battery and battery systems. Also, the FAA's Aircraft Certification Service, Transport Airplane Directorate continues its planned activities related to the subject safety recommendations. We expect to provide an updated response to these safety recommendations by March 31, 2019.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Partially Adequate Open

(SRIS Reference: GB.SIA-2015-0018)

Safety Recommendation 2015-019

Safety Recommendation 2015-019

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, review all previously-approved aircraft equipment powered by lithium-metal batteries to determine whether they comply with the intent of the 'Toxic Gas Venting Precautions' described in TSO-C142 / TSO-C142a Appendix 1.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 17 February 2021

The FAA grouped together a number of AAIB Recommendations because each applies to certain aspects of 'previously approved' aircraft equipment powered by non-rechargeable lithium batteries. These were AAIB Safety Recommendations 2013-017, 2015-014, -015 and -019.

In their letter of 30 September 2019 to the AAIB, the FAA stated that they were still evaluating certain non-rechargeable lithium battery installations on transport aircraft and that the review of existing non-rechargeable lithium battery installations on small airplanes and rotorcraft was complete. For small airplanes and rotorcraft, they determined corrective actions mandated by airworthiness directive (AD) were not necessary and continue to hold this position.

In a letter dated 11 February to the AAIB, the FAA confirmed that they have now completed evaluation of existing non-rechargeable lithium battery installations on transport category airplanes and coordinated this evaluation with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil, and Transport Canada Civil Aviation, as the responsible civil airworthiness authorities for the states of design of transport category airplanes. This has resulted in airworthiness AD (Airworthiness Directive) action on a number of Airbus types.

The coordinated evaluation of existing non-rechargeable lithium battery installations on transport category aircraft did not result in other mandatory corrective actions. The review of installations of non-rechargeable lithium battery installations, including those in ELTs, is now complete for all aircraft types. The examination of these hazards included thermal energy release and toxic gas release.

Earlier in the process, in the aftermath of the event on the B787, ET-AOP, at London Heathrow, the FAA had issued AD 2014-17-02, which required inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies.

The FAA considers it has effectively addressed the Safety Recommendations referring to 'previously approved' installations and considers their actions complete.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

Feedback rationale

The AAIB acknowledges the depth of work undertaken by the FAA, and other agencies, in their reviews of 'previously approved' installations and closes this Recommendation. (EU Regulation 996/2010 article 18 refers).

RESPONSE HISTORY

Response received: 30 September 2019

As previously mentioned, the FAA has completed a safety risk assessment, associated with all of these related AAIB recommendations, and it indicated additional corrective actions mandated by airworthiness directive (AD) is not warranted for non-rechargeable lithium batteries installations on small airplanes or rotorcraft. However, at this time we are still evaluating certain installations on transport aircraft to determine if mandatory AD actions are necessary. Currently, we are in the process of issuing a :Special Airworthiness Information Bulletin (SAIB) to advise owners, operators, original equipment manufacturers, and mechanics of small airplanes, transport category airplanes, and rotorcraft having non-rechargeable lithium battery installations of the potential for the batteries to overheat, explode, or emit toxic gases. The SAIB provides recommendations, but not mandatory requirements for non-rechargeable lithium battery installations; addressing both general safety concerns, as well as specific concerns with certain chemistries of lithium battery installations. We have coordinated our results with the European Aviation Safety Agency (EASA), the Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the state of design of small airplanes, transport category airplanes, and rotorcraft.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.108, 15.109, and 15.113 together because each one applies to certain aspects of previously-approved aircraft equipment powered by non-rechargeable lithium batteries.

In our previous response, we indicated we would evaluate the circuit protection of the Honeywell RESCU 406AF and 406AFN emergency locator transmitter. We also indicated we would conduct a more comprehensive review of potential hazards resulting from a battery failure (i.e. thermal runaway) for existing non-rechargeable lithium batteries generally installed in aircraft equipment on all transport category airplanes. We coordinated with the European Aviation Safety Agency (EASA), Agencia Nacional de Aviacao Civil (ANAC), and Transport Canada Civil Aviation (TCCA), as the responsible civil airworthiness authorities for the State of Design of transport category airplanes, to obtain the data from the foreign design approval holders. Our review of the data, in combination with tests of certain non-rechargeable lithium batteries, assesses whether such battery installations are unsafe by considering the types of failures that could result in a battery thermal runaway (i.e., thermal runaway due not only to inadequate circuit protection, but also to overheating, manufacturing flaw, damage, etc.). The review also included consideration of potential unsafe conditions resulting from toxic gases on airplane occupants.

We are conducting a safety risk assessment to determine if airworthiness corrective actions are necessary.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies.

These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Not Adequate Open

(SRIS Reference: GB.SIA-2015-0019)

Safety Recommendation 2015-020

Safety Recommendation 2015-020

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, review whether the 'Toxic Gas Venting Precautions' described in TSO-C142 / TSO-C142a Appendix 1 should be applied to portable aircraft equipment powered by lithium-metal batteries.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 26 April 2022

The FAA has worked with Lithium-metal (Li-metal) battery technology experts through RTCA, Inc. (RTCA) to develop industry consensus standards that capture the lessons learned in the development and early application of this technology and enhance the safety of Li-metal batteries and their installation on aircraft. As a result of the FAA's collaboration with Li-metal battery technology experts, RTCA updated DO-227, Minimum Operational Performance Standards (MOPS) for Lithium Batteries, to DO-227A, MOPS for Non-Rechargeable Lithium Batteries. The FAA followed this by issuing Technical Standard Order C142b, Non-Rechargeable Lithium Cells and Batteries, effective March 26, 2018, to reflect DO-227A as a basis for FAA approval of such batteries.

DO-227A has been implemented on all aircraft certification projects that utilize non-rechargeable lithium cells, batteries, and batteries within end items on aircraft. This process addresses all concerns and issues raised by the AAIB's safety recommendations.

Finally, the FAA has decided to manage lithium battery installations using our issue paper process and working with industry standard bodies, rather than issue Advisory Circular 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, mentioned in our previous letter. The FAA's issue paper process utilizes DO-227A as a method of compliance to the special conditions. This approach allows the FAA to address any real time changes in current and future safety requirements and battery technology improvements. Furthermore, the usage of issue papers on a project-by-project basis enables the FAA to take into account all the safety recommendations with respect to specific installation hazard and mitigation.

Safety Recommendation Status Closed

AAIB Assessment Adequate

Action Status Planned Action Completed

RESPONSE HISTORY

Response received: 17 February 2021

The FAA grouped together a number of Safety recommendations because each applies to aspects related to 'future installations' of aircraft equipment powered by non-rechargeable lithium batteries. The AAIB Safety Recommendations in this group are 2014-021 and -023, 2015-016, -017, -018 and -020.

The FAA's draft Advisory Circular (AC) 20-192, Guidance on Testing and Installation of Non-Rechargeable Lithium Cells, Batteries and Batteries within End Items on Aircraft, was released for public comment on October 11, 2018; however, the FAA have not yet published the final AC. The draft AC previously released for public comment is being restructured to maintain the desired clarity of differing requirements for various aircraft categories. The transport airplane requirements in the draft AC are not changing.

The AC contains the methods of compliance incorporated within DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries. This document, DO-227A, identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The AC includes compliance material for all categories of aircraft, including those with differently structured, and in some aspects less stringent, requirements when viewed in comparison to transport category airplanes. The revised and clarified AC will address the AAIB's safety recommendations pertaining to future installations of aircraft equipment powered by non-rechargeable lithium batteries. The FAA anticipate publishing the updated AC by summer 2021.

The FAA expects to update the AAIB on these safety recommendations by December 31, 2021.

AAIB Assessment – Partially Adequate Open

Response received: 30 September 2019

A draft Advisory Circular (AC) 20-192, 'Guidance on Testing and Installation of Non-Rechargeable Lithium cells, Batteries and Batteries within End Items on Aircraft', aimed at addressing the AAIB's recommendations, was released for public comment on October 11, 2018. The AC contains the methods of compliance incorporated within DO-227A, 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries'. DO-227A identifies non-rechargeable lithium battery failure modes and requires testing to provide data for determining the effects at the battery, equipment and airplane level. The public comment period for the draft AC closed on November 17, 2018 and the FAA anticipate publication of the final AC by December 2019. After the AC is published, the FAA will propose closure of these safety recommendations.

The FAA anticipate providing an updated response to these recommendations by November 2020.

AAIB Assessment – Partially Adequate Open

Response received: 11 June 2018

We have grouped recommendations 15.110, 15.111, 15.112, and 15.114 together because each one applies to certain aspects related to future installations of aircraft equipment powered by non-rechargeable lithium batteries.

On September 21, 2017, the RTCA published DO-227A, "Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries." DO-227A identifies battery failure modes and requires testing to provide data for determining the effects at the battery, equipment, and airplane level. It also requires abuse tests that include the following:

- Short circuit tests of a battery system with protection enabled and disabled (recommendation 15.110);
- Tests to determine the effectiveness of containing a thermal runaway event (recommendation 15.111);
- Tests to determine the maximum heat that would be generated during a thermal runaway failure (recommendation 15.111);
- Tests to determine the effectiveness of the battery case to contain the ignition of vapors and/or electrolyte in the battery (recommendation 15.111); and
- Tests to evaluate the venting system (recommendation 15.114).

The FAA is now accepting new non-rechargeable lithium battery installations that meet the standards of either DO-227A or DO-347 (discussed in our previous response to these recommendations), which ensures the effects of battery failures will not be a hazard to the airplane or occupants. We note that these standards do not apply to very small batteries (i.e. 2 watt-hours or less) that meet the Underwriters Laboratories 1642 standard.

Additionally, guidance for a new advisory circular is being drafted. It will outline the methods of compliance incorporated by DO-227A standards for non-rechargeable lithium battery and battery systems. Also, the FAA's Aircraft Certification Service, Transport Airplane Directorate continues its planned activities related to the subject safety recommendations. We expect to provide an updated response to these safety recommendations by March 31, 2019.

AAIB Assessment – Partially Adequate Open

Response received: 23 December 2015

The FAA issued Airworthiness Directive (AD) 2014-17-02, Honeywell ASCa Inc. Emergency Locator Transmitters Installed on Various Transport Category Airplanes, effective September 9, 2014, which supersedes AD 2013-18-09. AD 2014-17-02 requires the inspection of Honeywell RESCU 406AF and 406AFN ELT batteries to detect and correct possible wiring discrepancies. These discrepancies, if not detected, could lead to an electrical short and create a possible ignition source. These AD-required actions, in concert with related Boeing 787-8 AD 2013-15-07, Boeing Company Airplanes, address the immediate safety vulnerability associated with the referenced ELT batteries. This also allows the FAA to continue its investigative work with Boeing and Honeywell to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to protect against external short-circuits and unbalanced discharge. The current efforts include evaluations to determine if the ELT needs additional circuit protection, and to determine if the ELT battery will benefit from additional insulation to suppress cell thermal runaway.

The FAA has been working with aircraft manufacturers and the RTCA (Radio Technical Commission for Aeronautics) Special Committee 235, Non-Rechargeable Lithium Batteries, which is composed of industry experts as well as experts from the European Aviation Safety Agency, Transport Canada, and other foreign regulatory agencies, to develop improved design and certification standards for lithium-metal batteries used in aircraft equipment. While these improved standards are in development, the FAA is applying Special Conditions, as prescribed in Title 14, Code of Federal Regulations Section 21.16, to all new transport airplane certification projects that include lithium-metal battery installations. Additionally, the FAA is working with design approval holders to identify potential safety issues associated with lithium-metal batteries.

We expect to provide an updated response to Safety Recommendations 15.108 through 15.114 by November 17, 2016.

AAIB Assessment – Not Adequate Open

(SRIS Reference: GB.SIA-2015-0020)

Safety Recommendation 2015-021

Safety Recommendation 2015-021

It is recommended that Boeing expedite the modelling of the B787 Environmental Control System, to examine the distribution of ELT battery combustion products through the aircraft cabin, and demonstrate the results of this modelling to the Federal Aviation Administration.

Date Safety Recommendation made: 19 August 2015

LATEST RESPONSE

Response received: 29 October 2015

Boeing has completed its modeling of the B787-8 Environmental Control System (ECS) using the release of combustion products from a Honeywell Rescue 406 ELT battery pack. Boeing has notified the relevant FAA individuals on the completion of the modelling activity, with the intention of demonstrating the results to the FAA.

Safety Recommendation Status Closed

AAIB Assessment Adequate

RESPONSE HISTORY

N/A

(SRIS Reference: GB.SIA-2015-0021)