

**DEPARTMENT OF TRANSPORTATION****Federal Aviation Administration****14 CFR Part 25**

[Docket No. NM375 Special Conditions No. 25-359-SC]

**Special Conditions: Boeing Model 787-8 Airplane; Lithium Ion Battery Installation****AGENCY:** Federal Aviation Administration (FAA), DOT.**ACTION:** Final special conditions.

**SUMMARY:** These special conditions are issued for the Boeing Model 787-8 airplane. This airplane will have novel or unusual design features when compared to the state of technology envisioned in the airworthiness standards for transport category airplanes. The Boeing Model 787-8 airplanes will use high capacity lithium ion battery technology in on-board systems. For these design features, the applicable airworthiness regulations do not contain adequate or appropriate safety standards. These special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing standards. Additional special conditions will be issued for other novel or unusual design features of the Boeing Model 787-8 airplanes.

**DATES:** *Effective Date:* November 13, 2007.

**FOR FURTHER INFORMATION CONTACT:** Nazih Khaouly, FAA, Airplane and Flight Crew Interface, ANM-111, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue, SW., Renton, Washington 98057-3356; telephone (425) 227-2432; facsimile (425) 227-1149.

**SUPPLEMENTARY INFORMATION:****Background**

On March 28, 2003, Boeing applied for an FAA type certificate for its new Boeing Model 787-8 passenger airplane. The Boeing Model 787-8 airplane will be an all-new, two-engine jet transport airplane with a two-aisle cabin. The maximum takeoff weight will be 476,000 pounds, with a maximum passenger count of 381 passengers.

**Type Certification Basis**

Under provisions of 14 Code of Federal Regulations (CFR) 21.17, Boeing must show that Boeing Model 787-8 airplanes (hereafter referred to as "the 787") meet the applicable provisions of 14 CFR part 25, as amended by

Amendments 25-1 through 25-117, except §§ 25.809(a) and 25.812, which will remain at Amendment 25-115. If the Administrator finds that the applicable airworthiness regulations do not contain adequate or appropriate safety standards for the 787 because of a novel or unusual design feature, special conditions are prescribed under provisions of 14 CFR 21.16.

In addition to the applicable airworthiness regulations and special conditions, the 787 must comply with the fuel vent and exhaust emission requirements of 14 CFR part 34 and the noise certification requirements of 14 CFR part 36. The FAA must also issue a finding of regulatory adequacy pursuant to section 611 of Public Law 92-574, the "Noise Control Act of 1972."

The FAA issues special conditions, as defined in 14 CFR 11.19, under § 11.38, and they become part of the type certification basis under § 21.17(a)(2).

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same or similar novel or unusual design feature, the special conditions would also apply to the other model under § 21.101.

**Novel or Unusual Design Features**

The 787 will incorporate a number of novel or unusual design features. Because of rapid improvements in airplane technology, the applicable airworthiness regulations do not contain adequate or appropriate safety standards for these design features. These special conditions for the 787 contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

The 787 design includes planned use of lithium ion batteries for the following applications:

- Main and Auxiliary Power Unit (APU) Battery/Battery Charger System.
- Flight Control Electronics.
- Emergency Lighting System.
- Recorder Independent Power Supply.

Large, high capacity, rechargeable lithium ion batteries are a novel or unusual design feature in transport category airplanes. This type of battery has certain failure, operational, and maintenance characteristics that differ significantly from those of the nickel-cadmium and lead-acid rechargeable batteries currently approved for installation on large transport category airplanes. The FAA issues these special

conditions to require that (1) all characteristics of the lithium ion battery and its installation that could affect safe operation of the 787 are addressed, and (2) appropriate maintenance requirements are established to ensure the availability of electrical power from the batteries when needed.

**Background**

The current regulations governing installation of batteries in large transport category airplanes were derived from Civil Air Regulations (CAR) part 4b.625(d) as part of the recodification of CAR 4b that established 14 CFR part 25 in February, 1965. The new battery requirements, 14 CFR 25.1353(c)(1) through (c)(4), basically reworded the CAR requirements.

Increased use of nickel-cadmium batteries in small airplanes resulted in increased incidents of battery fires and failures. This led to additional rulemaking affecting large transport category airplanes as well as small airplanes. On September 1, 1977, and March 1, 1978, respectively, the FAA issued 14 CFR 25.1353c(5) and c(6), governing nickel-cadmium battery installations on large transport category airplanes.

The proposed use of lithium ion batteries for the emergency lighting system on the 787 has prompted the FAA to review the adequacy of these existing regulations. Our review indicates that existing regulations do not adequately address several failure, operational, and maintenance characteristics of lithium ion batteries that could affect the safety and reliability of the 787's lithium ion battery installations.

At present, there is limited experience with use of rechargeable lithium ion batteries in applications involving commercial aviation. However, other users of this technology, ranging from wireless telephone manufacturing to the electric vehicle industry, have noted safety problems with lithium ion batteries. These problems include overcharging, over-discharging, and flammability of cell components.

**1. Overcharging**

In general, lithium ion batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (thermal runaway) than their nickel-cadmium or lead-acid counterparts. This is especially true for overcharging, which causes heating and destabilization of the components of the cell, leading to formation (by plating) of highly unstable metallic lithium. The metallic lithium can ignite, resulting in

a self-sustaining fire or explosion. Finally, the severity of thermal runaway from overcharging increases with increasing battery capacity, because of the higher amount of electrolytes in large batteries.

### 2. Over-Discharging

Discharge of some types of lithium ion batteries beyond a certain voltage (typically 2.4 volts) can cause corrosion of the electrodes of the cell, resulting in loss of battery capacity that cannot be reversed by recharging. This loss of capacity may not be detected by the simple voltage measurements commonly available to flightcrews as a means of checking battery status. This is a problem shared with nickel-cadmium batteries.

### 3. Flammability of Cell Components

Unlike nickel-cadmium and lead-acid batteries, some types of lithium ion batteries use liquid electrolytes that are flammable. The electrolytes can serve as a source of fuel for an external fire, if there is a breach of the battery container.

These problems experienced by users of lithium ion batteries raise concern about use of these batteries in commercial aviation. The intent of these special conditions is to establish appropriate airworthiness standards for lithium ion battery installations in the 787 and to ensure, as required by 14 CFR 25.601, that these battery installations are not hazardous or unreliable. To address these concerns, these special conditions adopt the following requirements:

- Those sections of 14 CFR 25.1353 that are applicable to lithium ion batteries.
- The flammable fluid fire protection requirements of 14 CFR 25.863. In the past, this rule was not applied to batteries of transport category airplanes, since the electrolytes used in lead-acid and nickel-cadmium batteries are not flammable.

- New requirements to address the hazards of overcharging and over-discharging that are unique to lithium ion batteries.

- New maintenance requirements to ensure that batteries used as spares are maintained in an appropriate state of charge.

These special conditions are similar to special conditions adopted for the Airbus A380 (71 FR 74755; December 13, 2006).

### Discussion of Comments

Notice of Proposed Special Conditions No. 25-07-10-SC for the 787 was published in the **Federal**

**Register** on April 30, 2007 (72 FR 21162). We received comments from the Air Line Pilots Association, International, which are discussed below.

The Air Line Pilots Association (ALPA) conditionally supports the FAA's proposal for special conditions for lithium ion batteries on the 787 aircraft, but "strongly maintains that there need to be adequate protections and procedures in place to ensure that concerns regarding lithium ion batteries are fully addressed and protected against." Appended to the ALPA comments was a copy of FAA report DOT/FAA/AR-06/38, September 2006, Flammability Assessment of Bulk-Packed, Rechargeable Lithium-Ion Cells In Transport Category Aircraft. With the knowledge of the safety hazards described in the appended report and by others, ALPA requested that the FAA consider the specific concerns discussed below.

- *ALPA Comment re Special Condition (3)*: The commenter requested that paragraph 3 of the special conditions be revised to ensure that the certification design of the 787 prevents explosive or toxic gases emitted by a lithium ion battery from entering the cabin. The commenter also requested that the FAA ensure that flightcrew procedures and training are adequate to protect both passengers and crew, if explosive or toxic gases do enter the cabin.

*FAA Response*: 14 CFR 25.857 prohibits hazardous quantities of smoke, flames, or extinguishing agents from cargo compartments from entering any compartment occupied by the crew or passengers. Paragraph (3) of these special conditions specifies that

No explosive or toxic gases emitted by any lithium ion battery in normal operation, or as the result of any failure of the battery charging system, monitoring system, or battery installation not shown to be extremely remote, may accumulate in hazardous quantities within the airplane.

The special conditions require that any explosive or toxic gases emitted by a lithium ion battery be limited to less than hazardous quantities everywhere on the airplane. The FAA does not expect the need for additional training above and beyond the training that crews receive today. We made no change to these special conditions as a result of this comment.

- *ALPA Comment re Special Condition (4)*: The commenter stated,

We are very concerned with a fire erupting in flight, and being able to rapidly extinguish it. The Special Conditions should require that there be a means provided to apply extinguishing agents by the flight (cabin

crew instead of promoting it as an option in managing the threat posed by the use of lithium-ion batteries. ALPA maintains that the petitioner must provide means for extinguishing fires that occur vs. listing it as an option in § 25.863.

ALPA clarified this comment in the following communication, sent by e-mail on August 10, 2007.

The intent of our comments submitted to the Docket for question [Special Condition] Number 4 (see below) is to assure that the FAA includes language or makes it clear in the Special Conditions directing the OEM or a potential STC applicant that a fire from these devices, in any situation, is unacceptable. ALPA requests the FAA reiterate that preventing a fire and not reacting to one, if one occurs, is critical. The last sentence of our comments in this Question [Special Condition] refers to the potential for an "equivalent level of safety" being introduced or referenced in the document that would negate the prevention of a fire; ALPA finds this "option" unacceptable.

*(4) Installations of lithium ion batteries must meet the requirements of 14 CFR 25.863(a) through (d).*

The proposal states that the certification requirements of § 25.283 [§ 25.863] must be complied with; however, the FAA report (FAA report DOT/FAA/AR-06/38, September 2006) indicates that a relatively small fire source is sufficient to heat the lithium-ion cell above the temperature required to activate the pressure release mechanism in the cell. This causes the cell to forcefully vent its electrolyte through the relief ports near the positive terminal. The electrolyte is highly flammable and easily ignites when exposed to an open flame or hot surface. Fully charged cells released small white sparks along with the electrolyte.

*FAA Response*: The FAA shares the commenter's concern over a fire erupting in flight. The regulations and the rigid requirements defined in these special conditions are intended to prevent lithium battery fires on board the aircraft. We have made no change as a result of this comment.

- *ALPA Comment re Special Condition (7)*: The commenter suggested that the special conditions address means to ensure that the lithium ion batteries do not overheat or overcharge in the event of failure or malfunction of the automatic disconnect function, when a means of disconnecting the batteries from the charging source is not available.

*FAA Response*: The FAA agrees with the commenter. Special Condition (7) requires means to prevent overheating or overcharging of lithium ion batteries in the event of failure or malfunction of the automatic disconnect function. The issue of failure modes of the lithium ion batteries is covered by Special Conditions (1), (2), and (6). We made no change as a result of this comment.

• *ALPA Comment re Special Condition (8)*: Finally, ALPA commented on monitoring and warning features that will indicate when the state-of-charge of the batteries has fallen below levels considered acceptable for dispatch of the airplane. The commenter suggested that the special conditions address the location of the warning indication; whether it is displayed to the captain, the crew, or both; and the training to be incorporated in the crew training programs.

*FAA Response*: Flight deck warning indicators associated with the state-of-charge of the lithium ion battery and appropriate training of the crew will be addressed during certification as part of the flight deck evaluation. As required by § 25.1309(c), this evaluation will ensure that the warning indication is effective and appropriate for the hazard. We made no change as a result of this comment.

These special conditions are issued as proposed.

#### Applicability

As discussed above, these special conditions are applicable to the 787. Should Boeing apply at a later date for a change to the type certificate to include another model on the same type certificate incorporating the same novel or unusual design features, these special conditions would apply to that model as well.

#### Conclusion

This action affects only certain novel or unusual design features of the 787. It is not a rule of general applicability.

#### List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The authority citation for these special conditions is as follows:

**Authority:** 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

#### The Special Conditions

■ Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for the Boeing Model 787–8 airplane.

In lieu of the requirements of 14 CFR 25.1353(c)(1) through (c)(4), the following special conditions apply. Lithium ion batteries on the Boeing Model 787–8 airplane must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any foreseeable charging or discharging condition and during any failure of the

charging or battery monitoring system not shown to be extremely remote. The lithium ion battery installation must preclude explosion in the event of those failures.

(2) Design of the lithium ion batteries must preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure.

(3) No explosive or toxic gases emitted by any lithium ion battery in normal operation, or as the result of any failure of the battery charging system, monitoring system, or battery installation not shown to be extremely remote, may accumulate in hazardous quantities within the airplane.

(4) Installations of lithium ion batteries must meet the requirements of 14 CFR 25.863(a) through (d).

(5) No corrosive fluids or gases that may escape from any lithium ion battery may damage surrounding structure or any adjacent systems, equipment, or electrical wiring of the airplane in such a way as to cause a major or more severe failure condition, in accordance with 14 CFR 25.1309(b) and applicable regulatory guidance.

(6) Each lithium ion battery installation must have provisions to prevent any hazardous effect on structure or essential systems caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(7) Lithium ion battery installations must have a system to control the charging rate of the battery automatically, so as to prevent battery overheating or overcharging, and,

(i) A battery temperature sensing and over-temperature warning system with a means for automatically disconnecting the battery from its charging source in the event of an over-temperature condition, or,

(ii) A battery failure sensing and warning system with a means for automatically disconnecting the battery from its charging source in the event of battery failure.

(8) Any lithium ion battery installation whose function is required for safe operation of the airplane must incorporate a monitoring and warning feature that will provide an indication to the appropriate flight crewmembers whenever the state-of-charge of the batteries has fallen below levels considered acceptable for dispatch of the airplane.

(9) The Instructions for Continued Airworthiness required by 14 CFR 25.1529 must contain maintenance requirements for measurements of battery capacity at appropriate intervals to ensure that batteries whose function

is required for safe operation of the airplane will perform their intended function as long as the battery is installed in the airplane. The Instructions for Continued Airworthiness must also contain procedures for the maintenance of lithium ion batteries in spares storage to prevent the replacement of batteries whose function is required for safe operation of the airplane with batteries that have experienced degraded charge retention ability or other damage due to prolonged storage at a low state of charge.

**Note:** These special conditions are not intended to replace 14 CFR 25.1353(c) in the certification basis of the Boeing 787–8 airplane. These special conditions apply only to lithium ion batteries and their installations. The requirements of 14 CFR 25.1353(c) remain in effect for batteries and battery installations of the Boeing 787–8 airplane that do not use lithium ion batteries.

Issued in Renton, Washington, on September 28, 2007.

**Ali Bahrami,**

*Manager, Transport Airplane Directorate, Aircraft Certification Service.*

[FR Doc. E7–19980 Filed 10–10–07; 8:45 am]

**BILLING CODE 4910–13–P**

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## DEPARTMENT OF TRANSPORTATION

### Federal Aviation Administration

#### 14 CFR Part 25

[Docket No. NM366 Special Conditions No. 25–348–SC]

#### Special Conditions: Boeing Model 787–8 Airplane; Composite Wing and Fuel Tank Structure—Fire Protection Requirements

**AGENCY:** Federal Aviation Administration (FAA), DOT.

**ACTION:** Final special conditions.

**SUMMARY:** These special conditions are issued for the Boeing Model 787–8 airplane. This airplane will have novel or unusual design features when compared to the state of technology envisioned in the airworthiness standards for transport category airplanes. These novel or unusual design features are associated with composite materials chosen for the construction of the fuel tank skin and structure. For these design features, the applicable airworthiness regulations do not contain adequate or appropriate safety standards for wing and fuel tank structure with respect to postcrash fire safety. These special conditions contain the additional safety standards that the Administrator considers necessary to