Welcome

- Commitment to safety
- 787 systems
- Event details
- Comprehensive solution set
- Go-forward plan
Our Commitment to Safety

- The safety of passengers and crew members is our highest priority.

- Working together with customers, suppliers and global regulators, we have made air travel the safest form of transportation in the world.

- We stand behind the integrity of every Boeing product.

Every Boeing Employee Is Focused on Safety
Batteries Perform Limited Functions

Main Battery

- Ground maintenance operations:
  - Refueling.
  - Brake power while towing.
  - Navigation lights while towing.

- Backup power.

Auxiliary Power Unit Battery

- APU start
  - APU provides ground power and serves as backup power in flight.

Primarily Ground Operations, Not Flight Critical
Lithium-Ion Provides an Advantage

- High power for ground operations
- Less weight / less volume
- Improved charging characteristics
- No memory effect
- Improved storage life

The Right Technology for Peak Performance
System Design Objectives

- Prevent failure but be capable of handling one if it occurs.
- Redundancy provides multiple layers of protection.
- Ensure that no single failure will endanger the airplane or occupants.

Continued Safe Flight and Landing Assured
Facts About Battery Events

- No major airplane structure was damaged
- Minor damage within 20 inches of battery
- Two three-inch flames at connector outside of the battery box (Boston)
- No fire in Takamatsu event
- Cells vented, which is a protective feature of the battery
- Airplane systems functioned as intended

Electrical equipment bay – Boston event
Facts About Battery Events

- The only possible cause for thermal runaway at an airplane level is overcharging.

- The 787 has four independent protections against overcharging.

- Following detailed review no evidence of overcharging was found in either event.

Propagation of Overheating and Venting

*Boston battery*
Boeing Responded Immediately

- Teams deployed to support investigations
- Technical team activated to analyze potential faults
- Development team gathered to create solutions
- Industry experts reviewed work, concurred with findings and solution

+ 200,000 Engineering Hours Applied
Event Analysis Led to Causal Factors

- Causal Factors
  - Internal Cell Heating
  - Single Cell Venting
  - Cell-to-Cell Propagation

Battery Event

Rigorous Process Focused Development of Solution
Three Layers of Protection

- Prevent initiation of event
- Prevent propagation of event
- Prevent impact to airplane

Causal Factors Addressed
Comprehensive Solution

- Enhanced cell and battery build processes
- Enhanced production tests for cells and batteries
- Tightened voltage range
- Battery design improvements
- Charger design improvements
- Added battery enclosure

Multiple Layers of Improvements
Comprehensive Set of Solutions: Battery

Wire Harness
Heat and chafe resistant sleeving

Cells
Wrapped in electrical isolation tape

Battery Monitoring Unit
Tightened voltage range

Insulation
Improved for electrical isolation

Frame
Drain holes address moisture

Terminals
Locking fasteners

Spacer
Improved for thermal and electrical isolation

Insulation
Improved for thermal and electrical isolation

Prevent Issues, Reduce Impact of Issues
Comprehensive Set of Solutions: Charger

- Reduced maximum charging levels
- Increased minimum charging levels = increased maximum discharge level
- Softened charging sequence

Decreases Workload on the Battery
Comprehensive Set of Solutions: Enclosure

- Eliminates potential for fire
- Vented electrolyte released safely within enclosure
- Heat and pressure released safely within enclosure
- Dedicated vent line
- All vapors and odors vented immediately overboard
Safeguarding Your 787 Flight

- **Prevent Initiation**
  - Enhanced manufacturing controls
  - Enhanced post-production testing
  - Protection limits strengthened
  - Improved design features

- **Prevent Propagation**
  - Design changes increase cell isolation (thermal and electrical)
  - Vapors controlled by dedicated vent system
  - Vapors immediately released overboard

- **Prevent impact to airplane**
  - Enclosure prevents fire from occurring

---

**Consistent with Boeing Design Philosophy**
Go-Forward Plan

- Complete certification testing and analysis
- Certification
- Fleet installations
- Airlines return to flight
- Resume Boeing production test flights
- Resume deliveries
Your Safety Is Our Priority

- We have applied vast resources to understand the battery events.

- Our focus has been on developing a comprehensive set of solutions that addresses causal factors.

- We look forward to flying with you on the 787 soon.

The 787 Continues the Proud Boeing Legacy of Safety