



Transportation of Lithium Batteries by Air

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Why Focus On Lithium Batteries?

- ▶ Billions Transported By Air Each Year
- ▶ Unique Hazard Set
 - Thermal Runaway Propagation
 - ▶ Self Igniting
 - ▶ Flammable
 - ▶ Explosive Gas Evolution
- ▶ Fire Protection Systems Ineffective
 - Don't Suppress Lithium Metal Fires
 - Don't Stop Thermal Runaway Propagation
 - Overwhelmed By Explosive Gas Generation

Lithium Battery History

- ▶ Accidents/Incidents
- ▶ FAA Tests
- ▶ Safety Recommendations
 - ICAO
 - FAA
 - NTSB
 - EASA
 - ICCAIA, Boeing, Airbus



Pilots Perspective

► Aircraft Fires Must Be Prevented

- Flight Control Loss Begins In Less than 5 Minutes
- Minimum Diversion Time From Cruise 15-20 Minutes
- 360 Minutes ETOPS Maximum
- 150 Minutes ETOPS Common



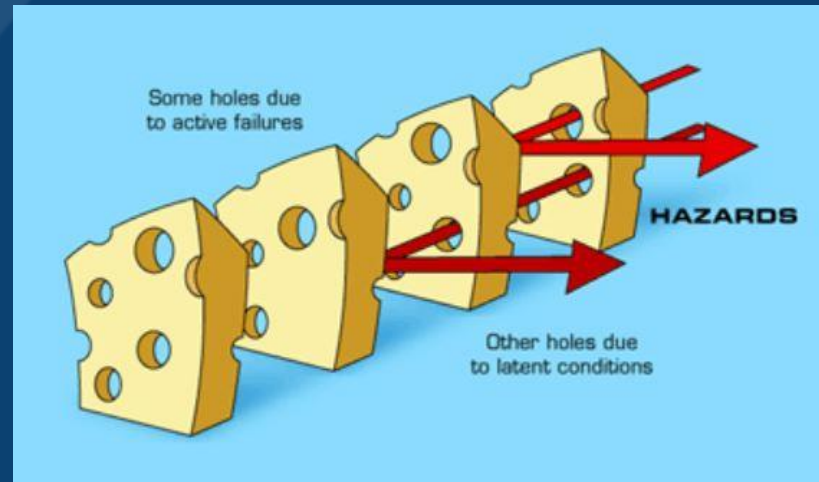
Batteries on Aircraft

- ▶ Operator Equipment
- ▶ Passenger Carry On
- ▶ Passenger Checked Baggage
- ▶ Cargo Shipments



Layered Approach

- ▶ Design
- ▶ Package
- ▶ Container
- ▶ Compartment
- ▶ Aircraft



Cargo Hold Fire Suppression

- ▶ Halon (Passenger And Freighter)- Class C
 - Belly
- ▶ Depressurization (Freighter)- Class E
 - Main Deck
- ▶ Oxygen Starvation (Freighter)- Class D
 - Belly
- ▶ None Effective On Lithium Batteries

Additional Cargo Fire Mitigation

- ▶ **Compartment Level**
 - Fire Suppression System
 - Segregation
 - Density Limits
- ▶ **Container Level**
 - Fire Resistant Containers
 - Fire Containment Covers
 - In Container Suppression Systems
- ▶ **Package Level**
 - Gel Packs
 - Other Packaging



Detection Issues

► UPS 6, Asiana 991

- Flight Control Loss Within 5 minutes Of Fire Detection
- Cockpit Warning Not Until Fire Already Near Maximum Intensity
- Layered Containers



► Detection Systems Need Improvement

ICAO Cargo Regulations

- ▶ Batteries as Cargo Banned From International Passenger Flights
- ▶ No Quantity Limits In/With Equipment
- ▶ No Quantity Limits On All-Cargo Flights
- ▶ Most Shipments Subject To Limited Regulations

ICAO Process

- ▶ SAE Output Is Known Hazard
- ▶ How will ICAO Incorporate Result?
 - Applicability
 - One Part Of Mitigation System?
 - One Means Of Compliance?

SAE Approach

- ▶ Develop Standards To Prevent Propagation Between Packages Following Thermal Runaway

- ▶ Design A Test To Show Package Contains:
 - Hazardous Flames
 - Hazardous Fragments
 - Hazardous Heat
 - Flammable Gas

SAE Issues

- ▶ What Is Hazardous Flame
- ▶ What Is Hazardous Fragment
- ▶ Demonstrated Containment Time
- ▶ Repeatability
- ▶ External Fire Threat
- ▶ Low Hazard Batteries



Passenger Issues

- ▶ Hoverboards And Galaxies
- ▶ Regulatory Complexity
- ▶ Non-Compliant/Undeclared DG

Conclusion

- ▶ Any Ban Represents System Failure
- ▶ Goal-Safe Transportation Of All Cargo
- ▶ Effective Solution Is Multilayered

Questions?