



WORKING PAPER

**DANGEROUS GOODS PANEL (DGP)
WORKING GROUP MEETING (DGP-WG/26)**

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Agenda Item 2: Managing air-specific safety risks and identifying anomalies (REC-A-DGS-2029)

**LIMITING THE CARRIAGE OF PORTABLE ELECTRONIC DEVICES (PEDS) CONTAINING
LITHIUM BATTERIES IN PASSENGER CHECKED BAGGAGE**

(Presented by D. Schlichting)

SUMMARY

This working paper addresses a safety concern regarding the carriage of portable electronic devices (PEDs) containing lithium batteries in passenger checked baggage. A lithium battery within such a device may enter thermal runaway, providing an ignition source for surrounding baggage, and generating intense heat and flames that can interact with other dangerous goods permitted in passenger baggage. These interactions can result in rapid fire escalation, significant pressure rise and explosive events, potentially creating conditions that exceed the design and certification criteria of Class C cargo compartment fire protection systems.

Action by the DGP-WG is in paragraph 2.

1. INTRODUCTION

1.1 The average airline passenger routinely carries multiple lithium battery-powered devices both in carry-on baggage and checked baggage. Historically, personal electronic device (PED) transport safety has primarily been focused on limiting the battery energy storage capacity, preventing inadvertent activation of PEDs in checked baggage, and allowing spare batteries only in carry-on baggage. These measures were based upon the assumption that thermal runaway events involving a single PED within checked baggage would remain contained and that the resulting fire could be effectively controlled by existing aircraft cargo compartment fire protection systems. This approach, however, did not take into account the operational aspects of cargo fire events or PED fires involving other dangerous goods.

1.2 Research done by the United States Federal Aviation Administration (FAA) William J. Hughes Technical Center demonstrated that previous assumptions regarding PED fires were incomplete. Although a single lithium battery fire inside a suitcase could normally be contained, testing showed that when a thermal runaway event occurred in the presence of otherwise permitted dangerous goods such as aerosols or flammable liquids, the consequences changed fundamentally. Instead of a conventional

Class A baggage fire, the interaction produced rapidly developing fire conditions, explosive gas ignition and secondary fuel involvement capable of overwhelming existing cargo compartment fire protection systems. These findings prompted extensive discussion within a multidisciplinary Cargo Safety Group (CSG) established to address the potential safety impact from security measures that had been implemented by various Member States prohibiting the carriage of certain portable electronic devices (PEDs) in aircraft cabins on flights over certain routes and the twenty-sixth meeting of the Dangerous Goods Panel (DGP/26).

1.3 The Cargo Safety Group concluded that combining PEDs with other dangerous goods could lead to an explosion in a Class C cargo compartment before sufficient halon concentration had been established. While the halon system might eventually suppress the secondary fire, the initial explosion and resulting fire development could compromise the effectiveness of the aircraft fire protection system. Additional concern was expressed regarding aircraft equipped with Class D cargo compartments, where no active halon suppression system is installed. These conclusions led to a worldwide survey of States (see State letter M16/1-18/2) concerning PED carriage, incidents and aircraft cargo compartment configurations (see paragraphs 6.1.1, 6.3. and Appendix D to the Report on Agenda Item 6 of the DGP/26 report for details).

1.4 In response to these developments, the 2018 meeting of the Dangerous Goods Panel Working Group (DGP-WG/18) reviewed the available scientific evidence together with data collected through ICAO State Letter M16/1-18/2. DGP-WG/18 considered the status of the identified risks and supported the establishment of Air Navigation Commission Job Card DGP.006.01 to undertake a comprehensive review of lithium batteries carried and used by passengers, crew members and operators. The work recognized that passenger-carried lithium batteries represent a distinct safety issue requiring consideration beyond the existing provisions contained within the Technical Instructions.

1.5 Responses from fifty-eight States identified more than one thousand reported PED-related events occurring in aircraft cabins, checked baggage and airport environments, confirming that lithium battery incidents are neither isolated nor theoretical occurrences. The survey also showed that significant numbers of passenger aircraft remained equipped with cargo compartment configurations presenting varying levels of protection against lithium battery fires. ICAO subsequently established a recommendation to remove PEDs from checked luggage. These findings have been backed up by data received from the International Air Transport Association (IATA) and more recently by the Underwriters Laboratories Standards and Engagement (ULSE) Thermal Runaway Incident Program (TRIP).

1.6 Since completion of the DGP-WG/18 work programme, substantial additional research has been undertaken through projects sponsored by the European Union Aviation Safety Agency (EASA). These include the LOKI-PED programme and the AIRPED research, both of which have advanced understanding of the effectiveness of existing mitigation measures.

1.7 While LOKI-PED primarily examined events occurring within the passenger cabin, the research confirms the rapid development of thermal runaway events, the production of large quantities of flammable and toxic gases, and the limitations of existing mitigation techniques when multiple cells become involved. These findings reinforce the conclusions previously reached by FAA testing regarding the importance of early detection and immediate crew intervention. These capabilities are unavailable when PEDs are carried within checked baggage. The EASA project AIRPED confirmed the earlier FAA Tech Center findings of the incompatibility of PEDs and other dangerous goods in checked luggage. The EASA LOKI-PED project effectively demonstrated the effectiveness of current firefighting methods available in transport category airplanes passenger cabins when fighting lithium battery fires of 100 Wh or less.

1.8 The fire protection strategy for Class C cargo compartments is based on a layered defense concept. The primary objective is to prevent cargo compartment fires from occurring through the application of dangerous goods regulations, packaging standards, loading procedures, and operational controls. Smoke detection and fire suppression systems are intended to mitigate the consequences if prevention fails. Cargo compartment fire protection should therefore be regarded as the last line of defense, not the primary means of managing cargo compartment fire risk.

1.9 The ICAO CSG in 2017 was presented with data that indicated that, prior to widespread advent of lithium battery-powered PEDs, the number of cargo compartment fire events per year was one to two globally. Recent, 2025 data from the UL Standards and Engagement TRIP indicates that the total number of cargo compartment fires is at least five per year. The TRIP data from 2025 is based on incident data received from forty-nine air operators and most likely does not include events that were fully contained in checked baggage. The actual number of PED fires in checked baggage can therefore be substantially higher.

1.10 Cargo compartment fire suppression systems represent the final engineered barrier within the aviation safety framework. Once smoke is detected, flight crews have very limited options available:

- a) activate the fire suppression system;
- b) isolate ventilation in accordance with aircraft procedures;
- c) declare an emergency;
- d) divert to the nearest suitable aerodrome; and
- e) land before the suppressant concentration can no longer be maintained.

1.11 Unlike a fire occurring within the passenger cabin, a fire in checked baggage is inaccessible throughout the flight. Cabin crew cannot cool the source of thermal runaway, remove surrounding combustible materials, isolate adjacent baggage or monitor the progression of the event. The aircraft therefore becomes entirely dependent upon the performance of the cargo compartment fire suppression system.

1.12 Class C cargo compartments do not have a fire detection system. Instead, the system is based on optical smoke detectors. These smoke detectors react to any optical obscuration including the fire suppressant. There is no visibility from the flight deck on the progress of the cargo fire or any information about whether the fire is contained or not. This is a major operational risk as the flight crew are forced to make decisions with limited information.

1.13 Consequently, the effectiveness of the cargo fire safety strategy depends primarily on preventing ignition, rather than relying on installed fire suppression systems after ignition has occurred. Therefore, potential ignition sources should be removed from the cargo hold as much as possible.

2. ACTION BY THE DGP-WG

2.1 The DGP-WG is invited to:

- a) review the safety information contained in this paper and the safety risk assessment presented in Appendix A to this working paper;

- b) agree that the current provisions for portable electronic devices in checked baggage no longer provide an acceptable level of safety;
- c) agree to proposed amendments to Part 8 of the Technical Instructions presented in Appendix B to this working paper; and
- d) recommend adoption of revised passenger provisions for incorporation into the next edition of the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284).

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APPENDIX A

SAFETY RISK ASSESSMENT

Hazard identification

The primary hazard addressed in this paper is: An uncontrolled thermal runaway event involving a lithium battery installed in a portable electronic device (PED) carried in passenger checked baggage.

Accident sequence

The accident sequence associated with PEDs in checked baggage can be described as follows:

1. A lithium battery within a PED enters thermal runaway.
2. Heat causes ignition of surrounding baggage contents.
3. Battery vent gases and high temperatures rupture containers causing the release of flammable materials.
4. Flammable vapours from aerosols or liquids ignite.
5. Fire intensity increases rapidly beyond that expected for a conventional baggage fire.
6. Pressure pulse from ignition can compromise fire suppression system integrity.
7. Pressure rise and secondary explosions may occur before the aircraft fire suppression system reaches effective concentration.
8. Cargo compartment temperatures continue to increase.
9. Structural components, electrical systems or flight control systems may become exposed to excessive heat.
10. Continued fire growth threatens the continued safe flight and landing of the aircraft.

This sequence differs fundamentally from the certification scenarios used for conventional cargo compartment fire protection systems because the fire develops more rapidly and involves additional energy sources beyond ordinary baggage combustibles.

Existing safety barriers

Current regulations rely upon several preventive measures intended to reduce the likelihood of a thermal runaway event.

These include:

- requiring PEDs to be switched completely off before being placed in checked baggage;
- requiring protection against inadvertent activation;
- compliance with United Nations lithium battery design testing requirements (UN 38.3);
- operator acceptance procedures (for 100-160 Wh batteries)
- prohibition of Lithium Batteries above 160 Wh; and
- passenger education.

Aircraft certification additionally provides several mitigating barriers after a fire has developed, including:

- cargo compartment smoke detection;
- flight crew warning systems;
- halon fire suppression systems in Class C cargo compartments;
- fire-resistant cargo liners; and
- emergency procedures leading to diversion and landing.

These measures remain effective for many conventional cargo compartment fires. However, research indicates that they are less effective where thermal runaway interacts with other dangerous goods because the initiating event develops faster than anticipated and may produce phenomena not addressed during original cargo compartment certification.

Limitations of existing mitigations

Several inherent limitations reduce aircraft cargo compartments fire detection and suppression systems effectiveness against lithium battery thermal runaway events.

First, the fire detection system in Class C cargo compartments is based on optical smoke detection. The time between smoke generation and detection can be substantial due to diffusion resistances caused by packaging, plastic wrapping around packages, Unit Load Device air tightness, and possible wrapping of ULD's.

Second, halon suppresses flame propagation but provides little cooling to battery cells. Consequently, adjacent cells may continue entering thermal runaway despite successful suppression of visible flames.

Third, lithium battery thermal runaway produces hydrogen and other flammable gases capable of accumulating within baggage before ignition. Ignition of some of these mixtures is not suppressed by aircraft cargo compartment fire suppression systems. If ignition occurs in a gas mixture on which Halon is effective, but before the required halon concentration has been established, a pressure event may develop that could render the fire suppression system ineffective. This was not considered during certification of the cargo compartment fire protection system. FAA research identified this mechanism as a principal contributor to catastrophic fire scenarios involving PEDs packed with aerosols.

Fourth, flight crews have no opportunity to intervene directly. Unlike cabin events, where smoke or flames can be observed and the device cooled immediately, checked baggage remains inaccessible throughout the flight.

Finally, passengers frequently carry multiple lithium battery-powered devices within the same suitcase, increasing the potential for thermal runaway propagation and substantially increasing the available fire load. According to UL TRIP data from 2025, between 25% and 37% of passengers pack power banks and e-cigarettes in their checked baggage. The data set does not include other PEDs such as laptops, tablets, phones, etc.

Risk evaluation

Applying the *Safety Management Manual (SMM)* (Doc 9859) methodology, the hazard may be assessed using the standard safety risk framework.

Severity

The credible worst-case outcome includes:

- uncontrollable cargo compartment fire;
- structural damage;
- damage to aircraft systems;
- loss of smoke control capability;
- emergency diversion;
- hull loss; and
- multiple fatalities.

Accordingly, the severity is assessed as:

Catastrophic (Severity A).

Likelihood

Although individual lithium battery failures remain relatively infrequent, the exposure to the hazard continues to increase because:

- passengers routinely travel with increasing number of PEDs;
- lithium battery energy density continues to increase;
- the electronics surrounding batteries continues to shrink, providing less buffer between batteries;
- passenger numbers continue to grow;
- many passengers continue checking electronic devices;
- protection against inadvertent activation of PEDs is difficult to verify; and
- spare batteries, Power Banks and e-cigarettes are still commonly found in checked luggage.

The TRIP data demonstrates that lithium battery incidents occur regularly in aviation operations, indicating that the initiating event cannot be considered extremely remote.

Risk index

Using the ICAO safety risk matrix:

Hazard	Severity	Likelihood	Risk
PED thermal runaway alone	Major	Remote	Medium
PED + flammable aerosols	Catastrophic	Remote	High
PED + multiple permitted DG	Catastrophic	Remote (credible exposure)	High

Risk Control Options

Prevention remains the most effective control

The aviation safety system is built upon the principle that hazards should be eliminated or controlled before they develop into emergencies. Cargo compartment fire suppression systems are designed to mitigate the consequences of prevention failures and not to compensate for an increasing frequency of ignition events. To put this into context, the Class C cargo compartments on aircraft operating today were developed decades ago to address fires likely to occur. At that time, lithium battery thermal runaway was not considered. Lithium batteries have changed both the type of fire and the frequency of fires that are likely to occur.

For this reason, cargo hold fire safety should be viewed through the hierarchy of controls:

1. Prevent cargo compartment fires from occurring.
2. Detect abnormal conditions as early as possible.
3. Suppress fires that nevertheless develop.
4. Land the aircraft before the suppression capability is exhausted.

From a systems safety perspective, relocating portable electronic devices from checked baggage to the passenger cabin strengthens the first layer of defense by reducing the likelihood of an inaccessible cargo compartment fire. In the cabin, any thermal runaway event is likely to be detected immediately, allowing trained cabin crew to apply established firefighting procedures and cooling techniques before significant fire growth occurs.

Several mitigation strategies have been considered

Maintaining the existing provisions would rely upon aircraft fire protection systems despite increasing evidence that these systems were not certificated for the existing and now understood combined hazard.

Strengthening passenger education may reduce inadvertent activation but cannot eliminate latent battery defects or thermal runaway. Education is the least effective mitigation strategy in the hierarchy of effective mitigations.

Prohibiting other Dangerous Goods such as aerosols and other flammable consumer products would impose inconvenience on passengers while failing to eliminate other combustible materials present within baggage. This would also not address the risk of the increased number of cargo fire events.

The most effective mitigation is to remove the initiating hazard from the inaccessible cargo compartment. Requiring PEDs containing lithium batteries to be carried in the passenger cabin enables immediate detection, rapid crew intervention, cooling of affected devices, and implementation of established cabin fire procedures. This measure removes the dependency on passive cargo compartment protection and restores multiple active safety barriers.

Increasing the cabin fire risk

The increased risk of PED fire in the cabin in the event PEDs are removed from the checked baggage has also been considered. While the total number of Lithium Battery related incidents may increase the presence of several control mechanisms effectively mitigate the increased risk. Location of the PEDs in the cabin should be considered so that they are easily monitored and readily accessible. This will effectively allow detection of inadvertent activation and enable prompt and effective firefighting methods.

Conclusion

The accumulated evidence demonstrates that the risk associated with PEDs in checked baggage is not adequately represented by earlier safety assessments. The hazard arises from the increase of the total number of cargo fire events, preventing effective crew intervention, and combination of lithium battery thermal runaway with otherwise permitted dangerous goods, creating accident sequences capable of exceeding cargo compartment fire protection assumptions.

From a Safety Management perspective, the current provisions do not satisfy the objective of reducing risk to a level that is as low as reasonably practicable (ALARP). Relocating PEDs to the passenger cabin represents a practicable, proportionate, and highly effective risk control measure that significantly reduces the likelihood of catastrophic consequences while imposing only minimal operational burden on passengers and operators.

Accordingly, the safety assessment supports the introduction of a prohibition on portable electronic devices containing lithium batteries in passenger checked baggage as the most effective means of reducing this identified safety risk.

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APPENDIX B

PROPOSED AMENDMENT TO PART 8 OF THE TECHNICAL INSTRUCTIONS

Part 8

PROVISIONS CONCERNING PASSENGERS AND CREW

Chapter 1

PROVISIONS FOR DANGEROUS GOODS CARRIED BY PASSENGERS AND CREW

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1.1 DANGEROUS GOODS CARRIED BY PASSENGERS AND CREW

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Table 8-1. Provisions for dangerous goods carried by passengers and crew

Dangerous Goods	Location		Approval of the operator(s) is required	Restrictions
	Checked baggage	Carry-on baggage		
Batteries				
1) Lithium batteries (including power banks) and portable electronic devices	Yes (except h), i) and No (except for j))	Yes	(see c) and d))	a) each battery must be of a type which meets the requirements of each test in the UN <i>Manual of Tests and Criteria</i>, Part III, subsection 38.3; b) each battery must not exceed the following: — for lithium metal batteries, a lithium content of 2 g; or — for lithium ion batteries, a Watt-hour rating of 100 Wh; c) each battery may exceed a Watt-hour rating of 100 Wh but not exceed a Watt-hour rating of 160 Wh for lithium ion with the approval of the operator; d) each battery may exceed a lithium content of 2 g but not exceed a lithium content of 8 g for lithium metal for portable medical electronic devices with the approval of the operator; e) no more than two spare batteries meeting the requirements of c) or d) may be carried per person; f) for portable electronic devices containing batteries: — measures must be taken to prevent unintentional activation and to protect the devices from damage; — the devices should be carried as carry-on baggage; however, if carried as checked baggage, the devices must be completely switched off (not in sleep or hibernation mode) if the batteries exceed: — for lithium metal batteries, a lithium content of 0.3 g per device; or — for lithium ion batteries, a Watt-hour rating of 2.7 Wh per device;

	Location		Approval of the operator(s) is required	Restrictions
	Checked baggage	Carry-on baggage		
Dangerous Goods				g) batteries and heating elements must be isolated in portable electronic devices capable of generating extreme heat, which could cause a fire if activated, by removal of the heating element, battery or other components; h) spare batteries: — must be carried as carry-on baggage; and — must be individually protected so as to prevent short circuits (by placement in original retail packaging or by otherwise insulating terminals, e.g. by taping over exposed terminals or placing each battery in a separate plastic bag or protective pouch); i) power banks: — must be carried as carry-on baggage; — must not be recharged while on board the aircraft; — should not be used to recharge a portable electronic device while on board the aircraft; — no more than two power banks may be carried per person; and — must be individually protected so as to prevent short circuits when not in use (by placement in original retail packaging or by otherwise insulating terminals, such as by taping over exposed terminals or placing each power bank in a separate plastic bag or protective pouch); j) <u>portable electronic devices and</u> baggage equipped with a lithium battery(ies) exceeding: — for lithium metal batteries, a lithium content of 0.3 g; or — for lithium ion batteries, a Watt-hour rating of 2.7 Wh must be carried as carry-on baggage unless the battery(ies) is removed from the baggage, in which case the battery(ies) must be carried in accordance with h); <i>Note.— The restrictions in a) and the applicable limits in b), c), d) or e) apply to all batteries under this item, that is those contained in portable electronic devices, spare batteries, power banks and baggage equipped with lithium batteries.</i>

— END —