

Proper and Safe Handling Lithium Battery Affect to Flight Safety

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Abstract. The purpose of this journal is to minimize the risk of flight accident caused by lithium batteries on scheduled flight (Airlines) and Cargo Aircraft Only (CAO). Lithium batteries often used as a main energy source for many electronic devices. In aviation, many accidents or incidents happened because of the blast, short circuit, et cetera caused by lithium batteries. The biggest factor that can trigger accidents related to transporting lithium batteries is from human factors, because almost all dangerous goods handling activities are still done manually by human power. The two most influential parties in the safety of transporting lithium batteries are shipper and airline. Each party has an equally important responsibility and role for flight safety. This journal will review and analyze the procedure of handling shipment that included lithium battery based on IATA Dangerous Goods Regulations 59th Edition of 2018, PP No. 03 Year 2001, PM No.58 Year 2016, Law 01 year 2009 and other related journal about the regulation of lithium battery handling. In this journal the author also describes all regulations, procedures and requirements that must be met by all relevant parties in accordance with applicable regulations. This journal using Descriptive Explorative method, and the secondary data is obtained from IATA DGR, national laws, and journal that already written and authors discussion.

Keyword: lithium battery, safety, handling

1. Introduction

The growth of shipments of goods through air transportation is increasing every year [1]. Rapid progress in technology, new electronic products are being continuously developed. This results in an increasing number of styles and types of dangerous goods (DG) in international trade, threatening airfreight safety (Zheng, 2014) in [2]. A wide range of content is transported through air transport from both individuals and organizations or companies. Airfreight can be categorized into 3 classifications, namely General Cargo, Special Cargo, and Dangerous Goods. This research will discuss the air charge associated with Dangerous Goods which has 9 Class, namely Explosive, Gas, Liquid, Flammable Solid, Oxidizing Substances & Organic Peroxides, Toxic, Radioactive, Corrosive and Miscellaneous.

Dangerous goods are articles or substances which are capable of posing risk to health, safety, property or the environment and which are classified according to these regulations (DGR Section 1.0). One item categorized as dangerous goods is lithium battery classified into dangerous goods Class 9 – Miscellaneous. Miscellaneous is articles and substances which, during air transport present a danger not covered by other classes (IATA DGR). Lithium batteries are characterized by high specific energy, high efficiency, and long life. These unique properties have made lithium batteries the power sources of choice for the consumer electronics market with a production of the order of billions of units per year[3].

In the world of aviation, there were several incidents such as the burning of the B747-400F cargo plane owned by UPS Airline in Dubai at 2010 due to carrying loads containing more than 81.000 lithium batteries and "other combustible materials". Flight safety was determined by various factors related to human factors, both preflight and in-flight service [4]. On January 3, 2019 there was also an incident related to the explosion of a lithium battery at Royal Brunei

Airlines flight RB BI636 which was on its way from Hong Kong to Bandar Seri Begawan. Another incident also occurred due to the explosion of cellphones on October 6, 2016 on the Southwest Airlines plane before taking off from Louisville to Baltimore. There are plenty of activities when handling and transporting DG that are considered incidents but do not necessarily lead to accidents [5]. An investigation of the accident indicated that the cargo aircraft was carrying a total of 58 tons of newly developed electronic products, including mobile phones and lithium batteries, which are classified as dangerous goods [6].

To reduce the potential risk of explosions or fire hazards caused by lithium batteries the Ministry of Air Transportation has also circulated regulations related to the transport of lithium batteries in air transportation in Indonesia written in PM No. 58 of 2016 [7]. Aviation safety is a condition that is realized from the smooth operation of flights in accordance with the operating procedures and requirements for the technical feasibility of aviation facilities and infrastructure along with the support of PP No. 03 of 2001 [8]. the perspective of the government and air carriers, ensuring the safety and minimizing the risk and potential losses caused by such incidents is highly important [6]. Therefore, regulations concerning conducting DG are also regulated in Law 1 of 2009 article 136 [8] concerning the transportation of special and dangerous goods, which contain: (1) Transportation and processes and dangerous must meet the requirements of flight safety and security. (2) Special goods as intended in the form of goods which because of nature, type, and size require special handling. (3) Dangerous goods as may take the form of liquid material, fuel or gas material which may endanger health, life safety, property, and flight safety and security. (4) Dangerous goods as intended, namely Explosive, gas, liquid, solids, oxidizing substances, toxic and infectious substances, radioactive materials, corrosive substances, liquids, and miscellaneous. (5) Commercial air business that violate provisions in paragraph 1 administrative sanctions are imposed in the form of warnings and / or revocation of licenses.

The purpose of this research is intended as a reference for airlines and cargo companies in handling lithium batteries in order to minimize the potential incidents that can be caused by lithium batteries.

2. Method

The author uses this method with the aim to summarize and describe every lithium battery handling activities start from identification to handling to be easily understood and expected to be no more incidents that occur due to a faulty lithium battery. The method used in this research is descriptive explorative. The method used in this research is descriptive explorative. Descriptive research is a study that aims to describe things, for example circumstances, conditions, situations, events, activities and others (Suharsimi, 2010) in [9]. Suharsimi Arikunto (2010: 14) in [9] suggests that explorative research is research that seeks to explore the causes or things that influence the occurrence of something. Explorative research also seeks to explore new knowledge to find out about a problem.

3. Discussion and Result

All airlines or logistics companies engaged in air cargo shipping use IATA DGR as an SOP to handle dangerous goods, although they differ slightly between companies because they are adjusted to company policies and laws. IATA DGR also actually refers to ICAO ANNEX 18 which was created at the Chicago Convention and is renewed annually. Very specific is the transport of dangerous goods, which are different from other modes of transport and are updated in a more frequent period [10]. When exporting or importing lithium batteries internationally through air cargo, the TDG Regulations Part 12 requires to meet the requirements listed in ICAO technical directive and some additional regulations from TDG Regulations.

The International Civil Aviation Organization (ICAO) is prohibited the shipment of LIBs as cargo on passenger airplanes. State Of Charge (SOC) must be less than 30% [11]. Lithium

batteries classified as Dangerous Goods class 9 (miscellaneous) also contain the potential of hidden dangerous goods, meaning that lithium batteries are not visible because they have been installed in their devices, but the potential hazards that can be caused remain the same. The battery must meet the UN test requirement and criteria to be transported. And for lithium metal batteries the weight may be above 2g but may not exceed 8g. And for the battery is calculated based on power, which is above 100wh / hour but should not be more than 160wh / hour.

Personal electronic items such as cellphones, laptops, power banks, cameras, or medical devices containing lithium batteries should not be loaded in the luggage compartment and must be carried into the passenger cabin baggage. Each backup battery must also be protected individually to avoid short-circuit by storing it in the original packaging obtained when purchasing or closing open terminals with solutions to avoid touching each other and can also store each battery in a bag over different packaging (IATA 2018). IATA also issued a ban on the transport of lithium batteries in luggage compartments with passenger aircraft until the discovery of new fire and explosion resistant packaging standards specifically designed for battery shipment.

3.1 Identification and Classification

All incidents related to lithium batteries that cause explosions must occur because they do not follow applicable rules or carelessness in classifying the type of battery. There are 4 types of batteries namely Lithium metal batteries (UN 3090), Lithium metal contained in equipment Lithium metal or lithium metal batteries packed in equipment (UN3091), Lithium-ion batteries (UN3480), contained in equipment Lithium-ion batteries or Lithium batteries packed with equipment (UN3481).

Some batteries may be carried on the passenger and cargo aircraft and some may only be on air cargo craft only. Lithium-ion batteries (UN3480), lithium metal batteries (UN3090) and contained in equipment Lithium metal or lithium metal batteries packed in equipment (UN3091) may only be on cargo air craft only may not be carried into a passenger and cargo aircraft, whereas Lithium batteries packed with equipment (UN3481) may be in a passenger and aircraft cargo and may also be on air cargo craft only. If the officer incorrectly identifies the type of battery, it can trigger an explosion which is believed to be due to the placement of lithium batteries not in accordance with the applicable rules.

Lithium battery packed with the equipment means the battery is located inside the package but not installed to the equipment, while lithium battery contained in equipment means the battery is installed in it [12]. Lithium battery is also can be identified based on the type. For Lithium ion batteries are typically rechargeable, and power devices such as laptop computers, mobile phones and portable music players, while for non rechargeable lithium metal batteries , for power devices including cameras, flashlights and Automatic External Defibrillators. [13].

Batteries are divided into three general classes: primary batteries are used once and are immediately discarded; secondary, a rechargeable battery that can be charged and then recover to its original state by reversing the current flow through the cell; and special batteries designed for specific purposes (Winter,2004:Ralph, 2004) in [1]. Dangerous goods class 9 category for other materials, potentially hazardous in air transport: magnetized materials which could affect the aircraft's navigational systems, Genetically Modified Micro-Organisms (GMMOs), Genetically Modified Organisms (GMOs) [14]. Lithium batteries are classified into a dangerous goods class 9 because lithium batteries present a safety risk since they can generate a great deal of heat if short circuited. Short circuits are the batteries have been improperly charged / discharged or used. If the batteries are not designed, tested, manufactured, and prepared for transport in accordance with regulations, various hazard conditions are possible [15]

Shippers are also responsible for the process of identifying dangerous goods shipments. The shipper is required to fill the shipper declaration containing the specifications of the item to be sent. In IATA DGR subsection 1.3 it is explained that 4 shipper obligations must be fulfilled:

- 1) Shipper must fulfill all requirements regarding dangerous goods shipments arranged by IATA members and all participating airlines. Besides, the shipper must also fulfill all regulations made by the authorized party in the sending country, transit country, and destination country.
- 2) The regulation is fully bound by ICAO Technical Instruction. A shipper who violates will be indicated as being punished.
- 3) In the regulation, the words "shall" and "must" are used for regulations that must be followed. And the words "should" and "may" are used for preferences and are not mandatory.
- 4) The shipper is fully responsible for ensuring the goods to be shipped meet the requirements.

3.2 Packing

One of the biggest risks associated with sending lithium batteries is the short circuiting of the battery caused by the battery terminal coming into contact with another battery terminal. Battery packs must be separated from each other to prevent short circuits and damage to the battery terminals must be packed with strong outer packing, unless the battery is installed in the device.

Each type of lithium battery has a difference in packing instruction. Packing instruction loaded with PI 965, PI968 [16] Lithium ion battery and lithium metal battery must not be packed in the same outer packaging and not be placed in an overpack with dangerous goods classified in Class 1 (Explosive), Class 2 (Gases), Class 3 (Liquids), Class 4 (Solids) and Class 5 (Oxidizers).

Apart from having to be separated from the classes above the outer packaging and inside the lithium battery must also be shock resistant, made of non-conductive material (plastic or cardboard) so that the battery in the packaging does not move when it drops or falls. If the packing has followed the rules, there will be no event that can trigger an explosion.

3.3 Marking and Labelling

After identification and packing, the next step is marking and labeling. In the marking process and labeling, an error will occur if at the time of identifying the sender is wrong in the determination. If it is wrong in the marking and labeling there will be a wrong handler related to the lithium battery.

In general, marking and labeling are regulated in the IATA DGR which contains methods for handling when marking and labeling: The labeling and marking placement must be following label class 9 on IATA and obtain entry into security and only aircraft only or only aircraft cargo only if it can only be on cargo aircraft only a label cargo aircraft only is required without any errors in handling and other labels needed regarding lithium batteries.

The special marking and labeling for lithium batteries is loaded on the IATA DGR:

1. Packages containing lithium cells or batteries prepared in accordance with Section II of Packing Instructions 965 to 970 and Section 18 of Packing Instructions 965 and 968 must be marked as shown in (Figure 1). The mark must be in the form of a rectangle with hatched edging. The symbol (group of batteries, one damaged and emitting flame, above the UN number for lithium ion or lithium metal batteries or cells) must be black on white or suitable contrasting background.
2. The "Lithium Battery" Class 9 hazard label (Figure 2).

3. The "Cargo Aircraft Only" label (Figure 3) must be used on packages containing dangerous goods that are permitted only on cargo aircraft.

However, where the packing instruction number and the permitted quantity per package are identical for passenger and cargo aircraft, the "Cargo Aircraft Only" label should not be used. The "Cargo Aircraft Only" label must not be used for packages packed according to Passenger Aircraft limitations (Subsection 4.2) even when included on a Shipper's Declaration marked "Cargo Aircraft Only" because of other packages in the shipment.

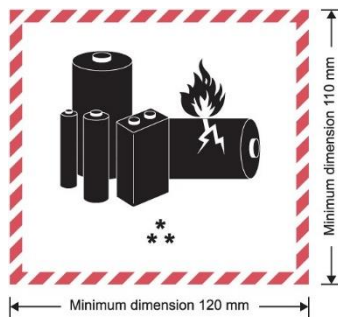


Figure 1



Figure 2



Figure 3

Sumber : IATA DGR

According to the IATA DGR in subsection 7.1.1 the responsibility of the shippers in the marking process is check that any relevant mark on the package or overpack already on the package is the correct location and meets the quality and specification requirements of the Regulations, remove or obliterate any irrelevant mark already on the package or overpack, ensure that each outer or single packaging used for dangerous goods, for which specification packaging is required in Section 5, bears the specification marks as specified in 6.0.4, apply any appropriate new mark in the correct location and ensure that it is of durable quality and correct specification, ensure that their responsibilities for marking are completely fulfilled when the package or overpack is presented to the operator for shipment.

According to the IATA DGR in subsection 7.2.1, the responsibility of the shippers in labelling process is remove or obliterate any irrelevant labelling already on the package or overpack, use only labels of durable quality and correct specification, inscribe on each label, in a durable manner, any required additional information, affix the appropriate label(s) in the correct location(s) and in a secure manner, ensure that the responsibilities for labeling are completely fulfilled when the package or overpack is presented to the operator for shipment.

3.4 Documentation

Air waybill(s) accompanying dangerous goods consignment(s) for which a dangerous goods declaration is required must include the following statements, as applicable, in the "handling Information" box: "Dangerous Goods as per attached Shipper's Declaration" or "Dangerous Goods as per attached DGR", and "Cargo Aircraft Only" or "CAO"

Shipper's Declaration: The declaration form must be in the same format and language (US English) , Declaration forms can be printed with black and red ink on white paper, but can also only be printed using red ink and size for the ISO standard shipper declaration printed on A3 (297 x 420mm) and A4 (297 x 210mm) paper. For North America use Ledger paper (280mm x 430 mm) and Letter (280 x 215mm)

4. Handling

Regulations concerning handling lithium batteries are made by the laws of each country and are also made by IATA contained in the Dangerous Goods Regulation IATA book. In Indonesia, handling the shipment of other lithium and dangerous batteries is regulated by the Directorate General of Civil Aviation and refers to the IATA DGR as its basic framework. International export and import regulations from and to Indonesia are contained in sub-section 2.8.2 on IDG-01 and IDG-02:

Air operators wishing to carry dangerous goods into, transiting or out of Indonesia must be obtain a dangerous goods permit from Directorate General of Civil Aviation c.q Directorate of Aviation Security. All applications are to be made on prescribed forms and addressed to the Indonesian Authority for Dangerous Goods Transported by Air. Air operators wishing to carry dangerous goods class 1 (explosive), except devicion 6.2 (infectious subtaces) and class 7 (radioactive) overflying of Indonesia must notify to the National Authority for Dangerous Goods Transported by Air in Indonesia

The Shippent of lithium batteries can be done using passenger and cargo aircraft and cargo aircraft only differentiated according to the type of lithium battery as listed in the table below.

Tabel 4.2
List of Dangerous Goods

UN/ ID no.	Proper Shipping Name/Description	Passenger and Cargo Aircraft				Cargo Aircraft Only	
		Ltd Qty					
		Pkg Inst	Max Net Qty/Pkg	Pkg Ins	Max Net Qty/Pkg	Pkg Inst	Max Net Qty/Pkg
3480	lithium ion batteries (including lithium ion polymer batteries)	Forbidden		Forbidden		See 965	
3481	Lithium ion batteries contained in equipment (Including lithium ion polymer batteries)	Forbidden		968	5kg	967	35kg
3081	Lithium batteries packed with equipment (including lithiium ion polymer batteries)	Forbidden		966	5kg	966	35kg
3090	Lithium metal batteries (Including lithium alloy batteries)	Forbidden		Forbidden		See 968	
3091	Lithium metal batteries contained in equipment (including lithium alloy batteries)	Forbidden		970	5kg	970	35kg
3091	Lithium metal batteries packed with equipment (Lithium lithium alloy batteries)	Forbidden		969	5kg	969	35kg

Sumber : IATA Dangerous Goods Regulation

In table 4.2 above described what type of batteries can be transported by the passenger and cargo aircraft and what type of battery can only be transported by cargo aircraft only. Types of lithium batteries that are allowed to be transported using passenger and cargo aircraft only types of lithium-ion batteries which are in one package with either not installed or installed in devices. As for the type of lithium-ion battery without a device and lithium metal batteries may only be transported using cargo aircraft only. The capacities allowed to be transported have also been regulated by the IATA, that is, they may not exceed 100wh / unit with the amount of free quantity.

Tabel 2.3A
Provisions for Dangerous Goods Carried by Passenger or Crew

The pilot-in-command must be informed of the location				
Permitted in or as carry-on baggage				
Permitted in or as checked baggage				
The approval of the operator is required				
Lithium Batteries: Security-type equipment containing lithium batteries (see 2.3.2.)	YES	YES	NO	NO
Lithium Batteries: Portable electronic devices (PED) containing lithium metal or lithium ion cells or batteries	NO	YES	YES	NO
Lithium batteries, spare/loose, including power banks, see batteries, spare/loose	YES	YES	YES	NO
Lithium battery-powered electronic devices	YES	NO	YES	NO
Lithium batteries, spare/loose	YES	NO	YES	NO

In table 2.3. A also describes the permissions that must be obtained to send lithium batteries based on the IATA DGR 59th edition. To ensure the safety and security of aviation using airplanes, all flight safety requirements must be met, such as carrying a lithium battery capacity in accordance with applicable regulations. (S, 2011) [17]. Especially for Powerbank, passengers must carry it in cabin baggage and be personally responsible and subject to the regulations that have been set. As for the following is the Circular Director General of Air Transportation Number 15 of 2018 [18]. Concerning the provisions of carrying a portable battery charger (power bank) and Backup lithium battery on aircraft. Air Transport Business Entities and Foreign Air Transport Companies are an intrusion for:

- 1) Ask the passenger to have a Power Bank or a backup lithium battery or no
- 2) Ensuring that passengers and porcelain aircraft fulfill the applicable provisions such as not connected with other electronic devices, power banks are only placed in cabin and are prohibited from being recorded, Power bank can only have 100Wh if you want to carry more than 100Wh but still not more than 160Wh also can the approval of the air transport business entity for foreign air transport companies may only carry a maximum of 2 units per passenger, Power bank more than 160Wh may not be taken to boarding and for foreign air transport companies may only carry a maximum of 2 units per passenger, the power bank must be A description of the information regarding the number of Wh.
- 3) Responsible for storing power banks that do not comply with the provisions.
- 4) Prohibiting passengers from charging during flight.

And also the airline must provide instructions at check-in for passengers carrying a power bank or a spare battery and ensure the power bank is not in use or in a dangerous condition such as charging. The airline must also be responsible for power bank storage that is not professionally qualified (cannot be transported). If an incident occurs due to an explosion or burning of a power bank, the first step that must be taken is to provide a larger container from the dimension of the power bank that contains water and soaks the power bank in the container until it is safe.

5. Conclusion

Lithium batteries are categorized as IATA class 9 dangerous goods because all companies or airlines that provide Dangerous Goods shipping services must comply with the IATA regulations contained in the IATA - Dangerous Goods Regulations. In the book IATA has written detailed regulations regarding the handling, labeling, marking, and documentation of lithium batteries and other dangerous goods. Lithium batteries can be categorized into several types, but widely lithium batteries can be identified to be 2 types, namely lithium-ion battery (rechargeable) and lithium metal battery (non-rechargeable).

There is a handling difference between the lithium battery loaded in the cabin baggage and cargo baggage, in the passenger cabin baggage is responsible for packing and handling their luggage. Airport security officers only appeal and check when boarding enters. Whereas the entire compartment baggage is responsible for identification, handling, labeling, and marking, the complete documentation is carried out by the relevant officer. Lithium batteries can only be sent with Country and Country approvals that will receive the charge of the lithium battery

Common errors that can trigger factors that cause accidents on flights are usually caused by misidentification and handling of lithium batteries and other dangerous goods. Flight safety is determined by several factors related to human factors, both in preflight and in-flight. To ensure flight safety and security, all regulations related to security and safety must be met. If in the event of an incident caused by faulty handling of lithium batteries, generally airlines or logistics companies will form investigations to trace the exact cause of the incident. If it is found that any party is negligent, the sanctions imposed can be in the form of exclusion, revocation of license, and criminal punishment in accordance with the applicable local law.

Incidents related to lithium batteries that endanger flight occurs due to human factors, both shipper and handling officer, the shipper responsible for filling out the declaration is sometimes negligent in identifying the type of battery. The incident related to lithium batteries can be minimized to a minimum and even zero accident if all parties involved are not negligent in carrying out their duties

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