

A COMPREHENSIVE ANALYSIS ON MARKING AND LABELLING PRACTICES FOR DANGEROUS GOODS IN THE AIR CARGO INDUSTRY

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Abstract: The Global trade relies heavily on the air cargo industry for the transport of high-value, hazardous, and time-sensitive goods. The safe transport of Dangerous Goods (DG) is accompanied by international regulations such as IATA DGR (International Air Transport Association – Dangerous goods regulation) and ICAO TI (International Civil Aviation organization – Technical Instructions) that need to be followed. This study looks into the marking and labelling of DG air freight, including the industry's barriers, legal challenges, technological solutions, and practices. The improper dg marking and labelling leads to serious risk of danger, fines and penalties, environmental impact, and operational delays. This project showcases the key operational hurdles and gaps regarding compliance to international DG regulations utilizing a descriptive research design approach with data from a shipping specialist at a Freight Forwarder Company. It addresses issues such as non-uniform training and increasing compliance costs, variations in regulatory enforcement, impact of modern technologies and language barrier.

Through practical suggestions for better labelling practices, investment automation tools, and aligned regulations for the standardization of policies, this research aims to enhance safety in air cargo hazardous materials.

Keywords: Dangerous Goods (DG), Air cargo industry, Marking and labelling practices, Hazard label, Handling label, International regulation (IATA DGR & ICAO TI), Freight Forwarding Operations.

I. INTRODUCTION

The air logistics and cargo sector enables global and domestic trade flow through timely movement of goods. This incorporates Airlines and Air Freight Operators, Airports and Cargo Hubs, cargo handling businesses, freight forwarding companies, and regulatory agencies all working collaboratively to ensure that the supply chain functions efficiently. The category of cargo transported on aircraft includes Dangerous goods, or HAZMAT. These goods include aerosol whipped cream, paint, perfume, and even lithium batteries which are heavily utilized. They are dangerous because of their hazardous content and as such require special handling. Marking and labelling is the part where specific symbols, texts, and danger warnings are affixed to the pack containing dangerous goods, and it is an important component of dangerous goods description. The air transport of Dangerous Goods (DG), markings is essential for identifying packaging compliance. Correspondingly, DG labelling comprises Hazard Labels indicating the nature of the risk, and Handling Labels that provide critical handling instructions.

The strict regulations must be followed because, compared to other modes of transportation, carrying hazardous materials by air is more dangerous due to the high pressure and temperature, which ranges from -50°C to -70°C at altitudes of 35,000 to 40000 feet. The IATA Dangerous Goods Regulations (DGR) is the global standard for shipping dangerous goods, aligning with the International Civil Aviation Organization (ICAO) who created the rules and regulations and including extra airline-specific regulations. IATA also requires training for all those involved with DG handling, including shippers, freight forwarders, and airline staff to ensure compliance with safety guidelines.

Furthermore, IATA collaborates with regulatory bodies, airlines, and industry stakeholders to improve the safe transport of hazardous materials while reducing risks for passengers, crew, and environment.

This research analyses existing packaging and labelling practices for dangerous goods transport by air, focusing on their effectiveness and compliance with international standards. The report examines operational challenges, regulatory gaps, and the potential of emerging technology to enhance safety and compliance requirements and utilizes survey and operational data to identify priority concerns that must be addressed, as well as explore significant areas that require improvement.

II. STATEMENT OF THE PROBLEM

The stakeholder such as Shippers, freight forwarders and airline operators usually encounter difficulties in determining and implementing the marking and labelling requirements specified in the IATA DGR and ICAO TI guidelines. The ambiguity of that regulation may result in accidental non-compliance, which can be dangerous and costly. The constantly evolving nature of Dangerous Goods regulations further complicates compliance, especially for small and medium-sized operators with limited training resources. Poor labelling practices—either not using weatherproof labels or counterfeit ones—can cause labels to peel, fade or become unreadable in transit, making it easier for goods to be misclassified and mistreated. Also, incorrect marking or mislabelling can quickly result in rejected shipments, product hold, or ask leave to origin, ultimately affecting service and financials with significant penalties.

III. REVIEW OF LITERATURE

Joachim G. Schäfer 2023 explores the challenges and risks in airfreight post-2008, looking at the extent to which they influence shippers, airlines, and freight forwarders, as well as how supply chain design under these conditions can be conducted under contemporary air cargo dynamics.

Emmy Arsonval Maniriho (2022) contains valuable training information for air cargo-handlers and shippers focusing on good practice in cargo warehouse and consignment management.

Brylka, Robert (2021) study indicated that a YOLO based AI detection system was created to identify DG labels and barcodes with accuracy and speed for real warehousing and transportation applications.

Ruwantissa Abeyratne (2018) identifies regulatory and carriage of goods (mainly air cargo) legal issues related to hazardous goods, Handbook of Air Cargo Law including contract, liability, regulatory and governance roles of ICAO and IATA in relation to cargo.

Anne DeMasi, Harry Elston, Neal Langerman (2022) researched the creation of SDS is a significant cost and compliance issue for manufacturers. Evolving global regulations challenge the manufacturer in assessing the accuracy and communication of hazard data sheets.

Anna Jodejko-Pietruczuk (2025) reported that AR technology may assist with the DG acceptance process at airports; by allowing operators to visualize legal requirements, and improve the accuracy of inspections but still has shortcomings.

Indumathy Jagadeeswaran & Harini Sriram (2022) found that the EU CLP regulation regulates classification, labelling, and packaging of hazardous substances, and ensures chemical safety across member states, through the standard Safety Data Sheet (SDS), and compliance practices.

Maternová Andrea (2022) stated that the use of undeclared DGs in air and maritime transport heightens safety risks. The research expands on the causes, legislative frameworks, and preventive measures to lessen safety risks by focusing on human error and regulatory compliance.

IV. OBJECTIVE OF THE STUDY

- To review current procedures for marking and labelling of dangerous goods in air cargo.
- To identify both the main challenges and safety implications facing the businesses involved in DG handling.
- To assess global standards and identify any inconsideration with terms of DG marking and labelling.
- To look into technological solutions that provides more compliance or operational efficiency.

V. RESEARCH METHODOLOGY

This research will take a systematic approach to examine marking and labelling practices for Dangerous Goods (DG) in the air cargo sector. It incorporates survey data from the research project and the literature to highlight compliance barriers and opportunities for improvement.

RESEARCH DESIGN

A descriptive research design is used to systematically study current DG labelling practices without manipulating variables. By systematically analysing actual information from primary and secondary data sources, descriptive designs make it easier to observe trends, stakeholder responsibilities in compliance, and regulatory compliance.

DATA COLLECTION METHOD

The research employed both primary and secondary data collection methods to review the marking and labelling practices for Dangerous Goods (DG) in the air cargo sector. Primary data was collected using a structured questionnaire, via Google Forms, sent to people involved in the DG shipping industry, focusing specifically on issues related to regulatory compliance, shipping documentation, packaging and transportation issues, and communication issues. Secondary data collection involved the analysis of past shipment records to see if there were patterns in mislabelling, the classes of DG that were shipped most often, and the most common export destinations of DG.

DATA ANALYSIS TOOLS

The gathered data was processed and analysed using SPSS (Statistical Package for the Social Sciences) software. Statistical instruments used include the following:

- **Correlation analysis:** measures the strength and direction of the relationship between two or more variables.
- **Percentage Analysis:** To understand the demographic distribution of variables and key operational practices.

VI. SIGNIFICANCE OF THE STUDY

This study draws attention to the importance of correct marking and labelling for Dangerous Goods (DG) in the air cargo industry, which is essential for safety, compliance, and a smooth operation. It achieved this by identifying and analysing current barriers to successful air cargo Dangerous Goods operations, an assessment of the various stakeholders and their involvement in current practice, as well as technological advancements in the transportation of Dangerous Goods. The study identified valuable findings regarding the standards for handling Dangerous Goods at a global level. The aim was to help airlines, cargo agents, and regulatory entities mitigate risk, reduce delays, and promote compliance in Dangerous Goods logistics shipping.

FINDINGS

The investigation determined most participants were typically compliant with the IATA Dangerous Goods Regulations manual demonstrating compliance with a global standard. Manual inspections were the widely used method to identify labelling errors suggesting compliance issues were more a human error rather than systems-approached to automation. Multilingual labelling, often synonymous with international shipments, may distinguish like-seeming data content. Noteworthy, underlying compliance issues remain such as incorrect UN numbers and missing hazard label information. For example, Class 9 goods such as lithium-ion batteries dominate the air cargo industry and represent a major commitment to dangerous goods processes. Dangerous Goods packaging is mainly specialists; Dangerous Goods professionals are specialists (freight forwarders), with the incorrect packaging issue of dangerous goods belonging to the packaging teams. Confusion at all levels is typically caused by speed and inconsistency in convention with real goods. Technology in Dangerous Goods is being considered, such as artificial intelligence and tracking. However, they are not mature to capture circular advantages to make processing easier and implement and assimilate into policy/legislation-based processes.

PERCENTAGE ANALYSIS:

- 28% of respondents are Dangerous Goods Specialists, Freight Forwarders (26%) and Warehouse/Logistics Managers (24%).
- 40% have 1–3 years of experience, while 28% have less than 1 year.
- 80% of respondents indicates that they use the current IATA DGR manual for correct marking and labelling
- 64% of respondents are using manual inspecting by trained staff instead of an automated systems, indicating a reliance on human input

- 72% of respondents use multi-lingual labelling to be consistent through multiple international destinations
- The most often reported labelling issues were incorrect UN numbers or class identification (42% and the second issue was missing hazard labels (34%).
- Of the Dangerous Goods Specialists (28%) and Freight Forwarders (26%), were key job functions for DG compliance
- 62% of respondents reported that inconsistent national regulation was a challenge to correct DG marking and labelling, while 30% were challenged by so frequent changes to the DG Guidelines
- 42% citing improper marking and labelling contributed to the Canadian government's risk of a hazardous incident occurring.
- Only 42% had negligible variances between international standards like IATA DGR, ICAO TI and national rules
- 38% of respondents would prefer using technological tools, such as automatically barcode/RFID tracking tools, and 30% would consider AI verification system.

CORRELATION ANALYSIS

		Correlations	
		Experience in handling DG	Frequency of inconsistency in regulations
How many years of experience do you have in handling Dangerous Goods (DG)?	Pearson Correlation	1	-.293*
	Sig. (2-tailed)		.039
	N	50	50
How frequently do you face inconsistencies between IATA DGR, ICAO TI, and national regulations?	Pearson Correlation	-.293*	1
	Sig. (2-tailed)	.039	
	N	50	50

*. Correlation is significant at the 0.05 level (2-tailed).

INFERENCE

The results showed a statistically significant negative relationship between Dangerous Goods handling experience and frequency of perceived regulatory inconsistencies ($r = -0.293$, $p = 0.039$). This means that professionals with more Dangerous Goods (DG) handling experience are less likely to perceive the regulations as incoherent. One possible explanation is maybe the most experience Dangerous Goods professionals are better informed of regulatory updates and changes and are thus better positioned to adapt to them. Comparatively, less experience individuals likely find this constant state of change confusing leading to greater perceived inconsistency.

VII. DISCUSSION

The recommendations for the practice of Dangerous Goods (DG) provided through this study include digital facilities utilize digital technologies decreasing human errors in Dangerous Goods handling, through automating document checks and combining error and flag concepts in handling and procedures. In clarity and durability we would see meaningful advantage through standardization of multilingual labelling and high-performance weather-resistant exterior labels. Important for reducing human errors, the documentation of completed training for freight forwarders, packaging teams and third-party handlers is paramount in demonstrating DG marks and labels. Consideration of mandatory references to globally accepted standards such as IATA DGR and ICAO TI, along with national standards and regulations would assist with harmonization of a practice. Following an organizations formation of compliance teams, it is recommended that compliance teams develop central databases specifying country-specific requirements and consideration is given to implementing a combination of digital/human inspection schemes. Pertaining to the process of DG marking and/or labelling, peer review, explicit communications regarding agreed DG markings/labels with shippers and visual representations of Standard Operating Procedures of marking and/or labelling concepts were deemed advantageous to project consistency and efficiency to support DG compliance. with the objective of reducing operational errors and improving safety to support the compilation of global air cargo operations.

VIII. CONCLUSION

In conclusion, the study focused on Dangerous Goods (DG) marking and labelling with an air freight perspective. Specifically, it examined issues of compliance with international regulations, operational and technical issues. The

study indicates that while the IATA DGR and ICAO TI provide excellent recommendations, poor regulation enforcement, national variations in regulations, and poor communications systems often lead to non-compliance. The risks associated with improperly marked dangerous goods include potential medical expenses, delays in shipping, and potentially unsafe conditions for employees or the public. Technology has potential to help, as indicated by the recommendation of various forms of automated verification systems and digital documentation tools. The study advocates for further development of training resources for stakeholders involved in all stages of the DG export process. The study concludes that the DG transport/movement industry must make a conscious effort to invest in and improve the practical side of using and working with modern technologies.

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