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HUMAN AS A MAIN RISK DRIVER: UNDECLARED DANGEROUS GOODS IN MARITIME TRANSPORT & AVIATION

Summary. Dangerous goods (DGs) not declared for transport as required by the regulations can give rise to risks, as they can endanger public safety or the environment. This study explains the risks posed by undeclared shipments by providing information about the most common undeclared DGs aboard aircraft and maritime ships, legal frameworks regulating the proper transportation of DGs, and key mechanisms for preventing the occurrence of undeclared DG shipments. This paper identifies the responsibilities of each stakeholder involved in the process of DG transportation. The main objective of this paper is to reveal human errors and dishonest techniques within the supply chain when DGs are transported by air and sea.

1. INTRODUCTION

Over the last three decades, world freight transportation has substantially increased. Globally, dangerous goods (DGs) represent a significant portion of shipments, as they are widely used in products and commodities. Gasoline, as well as other petroleum products, are likely to account for a large share of DGs. In addition, lithium battery usage has continued to grow, and these batteries have taken on a growing role in our daily lives worldwide. The transport of hazardous commodities creates considerable utility to society but carries a huge risk to safety, health, and the environment. Even when hazardous shipments are strictly regulated, there are situations when such shipments are not declared properly. Such a situation is called the mis/undeclaration or hidden DGs.

The undeclaration of hazardous goods is not new in maritime and aviation. The trend of undeclaration DGs has continued for years, especially in containerized shipments, for many reasons (lower freight rates, hiding the illegal nature of the goods, laxness and negligence).

Firstly, there is a large difference between the terms "misdeclared," "undeclared," and "hidden." In terms of the declaration of DGs, "misdeclared" refers to any DGs s not declared properly according to requirements of the IMDG Code or IATA DG Regulations. This may include incorrect or missing descriptions of DGs in documentation accompanying the shipment (or DG declaration in cases of maritime transport) or misleading placarding or marking. The term "undeclared" refers to situations when goods listed in regulations are declared by the shipper as DGs (intentionally, for various reasons). Finally, "hidden" DGs are household or commercial products, well-known by their general descriptions, containing dangerous substances. If undetected, these products may be erroneously offered as undeclared DGs for transportation by air.

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2. LITERATURE & METHODS

In this paper, the authors focused on research on DG shipment declarations aboard maritime vessels and cargo/passenger aircraft. The initial analysis shows that the human factor is generally the main cause of accidents in maritime and air transport [8, 9]. The scientific literature shows that various human errors contribute to accidents in port and maritime vessels [22, 10], especially in cases when DGs were not declared properly [1, 11].

Human failure is also the biggest hazard in aviation, as the scientific literature points to the problem with the transportation of lithium batteries [26, 21]. Moreover, the intentional undeclaration of DGs is the cause of many aviation accidents involving DGs [19].

In this paper, the authors point to the motives for the undeclaration of DGs, that results from the intentional (high transport rates) or unintentional (lack of skills or knowledge) behaviour of responsible persons. Moreover, authors provide an overview of maritime accidents caused by the undeclaration of DGs and its effects. Based on the comprehensive analysis of accidents involving undeclared DGs, the following research questions were posed:

1. In which part of the logistics chain do failures occur most often?
2. Are failures across the logistics chain intentional or unintentional?
3. How can the risk of error in the logistics chain be reduced?

After addressing these questions, the main objective of the study was given:

- to develop a comprehensive analysis of human failure along the logistic chain,
- to provide recommendations for increasing safety in maritime and air transportation of DGs.

3. BACKGROUND

3.1. Regulations for DGs carriage

3.1.1. Regulations for the transportation of DGs by sea

The transportation of DGs by sea must be carried out according to the International Maritime Dangerous Goods Code (IMDG Code), resulting from the International Convention for the Safety of Life at Sea (SOLAS) Chapter VII (Carriage of Dangerous Goods). This chapter contains mandatory provisions governing the carriage of DGs in packaged form.

International Maritime Organization Regulations – MARPOL (1973)

The International Convention for the Prevention of Pollutions from Ships [16] also extends the IMDG Code; specifically, in Annex III, there are mandatory provisions for the prevention of pollution by harmful substances carried by sea in packaged form. MARPOL also prohibits the carriage of some harmful substances in vessels. The code was initially adopted in 1965 as a recommendatory instrument. In 2002, the general assembly, at its seventeenth session, adopted resolution A.716(17) in the IMDG Code and decided to give it mandatory status under the umbrella of the SOLAS Convention starting on January 1, 2004. However, some parts of the code remain recommendatory.

International Maritime Dangerous Goods Code – IMDG Code

The IMDG Code, as the main regulation for the international maritime transportation of DGs in packaged form, is a tool for the improvement and harmonization of safe carriage and serves to prevent marine environment pollution. The code includes the details applicable for each individual substance, together with the specific requirements for packing, labeling, marking, placarding, stowing, consigning, and documenting DGs. The IMDG Code contains information about the maximum amount of each type of DG allowed on transport, packaged in cargo transport units on container and Ro-Ro ships.

3.1.2. Regulations for the air transportation of DGs

The international transport of DGs by air has been regulated since 1956 [17]. The main principles governing the international transport of dangerous shipments by air are defined in Annex 18 to the Chicago Convention – the Safe Transport of Dangerous Goods by Air. The ICAO Technical Instructions of the Safe Transport of DG by Air extend the basic provisions of Annex 18 and include detailed instructions necessary for the safe transportation of DGs by air.

The Technical Instructions (ICAO-TI) are divided into eight parts, including general provisions: DG classification, limitation, marking and packing requirements, shipper's and operator's responsibilities, and provisions concerning passengers and crewmembers. The requirements of ICAO are mandatory for all ICAO member countries.

The internationally agreed-upon rules for transporting DGs by air are also covered by the **International Air Transport Association (IATA) International Dangerous Goods Regulations**. The IATA DG Regulations are published by the IATA DG Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA member airlines [17]. Similar to the ICAO, the IATA DG Regulations are based on Annex 18 of the Chicago Convention (1944) and associated with the Technical Instructions for the Safe Transport of DG by Air adopted by the Council of ICAO.

IATA DG Regulations are divided into similar sections as the ICAO Regulations—namely, limitations, classification, packing, marking, labeling, documentation, handling, and general provisions about DG procedures. Packing, as the essential element for the safe transportation of DG by air, is also included in these regulations. The instructions explain proper packing for each type of DG acceptable for air transport and provide a wide range of options for inner, outer, and single packages. Moreover, the regulations include a list of all individual substances that specifies the UN classification of each substance and the acceptability and conditions for its transportation.

3.2. Problems in transportation & logistic chains

Despite existing regulations for DG transport and handling, serious accidents endangering life, the environment, and property still occur. In maritime transport, the undeclaration of dangerous shipments often starts a fire within the container, such as chemicals, batteries, and self-igniting charcoal. When undeclared, such hazardous commodities might be improperly packed and stowed onboard, which can result in ignition. In the past several years, many catastrophic fires have occurred in maritime transport due to undeclaration. The majority of these cases involved cargo damage, leakage, and fires resulting from mis/undeclared or poorly packaged containers. Container losses at sea significantly increased in 2020 and continued at a high level in 2021, disrupting supply chains and prolonging delivery times, which caused an increase in shipping costs and posed potential pollution and navigation risks. In recent years, there have been several high-profile fires on container and Ro-Ro ships involving DGs (APL Vancouver, Yantian Express, E.R. Kobe, Grande America, KMTC Hong Kong, APL Le Havre). A brief summary of some such accidents is provided in Table 1. The number of container losses was the highest in the past eight years. In 2020, more than 3,000 containers were lost at sea, while more than 1,000 alone fell overboard during the first three months of 2021 [2].

Annually, more than 60 million metric tons of goods are transported by aircraft, representing about 40% of global trade by value but less than 1% of world trade by volume. The pandemic increased demand for goods that were not available in brick-and-mortar stores, and cargo had to be transported as quickly as possible (i.e., by air). Since the COVID-19 crisis began, air cargo has been a vital partner in delivering much-needed medicines and medical equipment (including spare parts and repair components), as well as in keeping global supply chains functioning for the most time-sensitive materials.

In 2021, 62.2 million metric tons of goods were transported by aircraft, which is 0.7 million metric tons more than in 2019, the last year before the Covid pandemic[3] (IATA, 2022). The growth in air

[3] In comparison, in 2015, there were "only" 52.5 million metric tons of goods transported by air (IATA, 2022).

cargo demand shows potential in the growth of DGs air freight demand. DGs classified as special shipments need to follow special, strictly regulated, handling processes. Despite this, situations often arise in which DGs are not declared, and un/misdeclaration is the factor that contributes the most to aviation accidents involving DGs (40%[4]).

Table 1

Maritime accidents involving DGs in recent years

Vessel name	Date of Accident	Undeclared cargo	Description of Accident	Consequences
Mærsk Honam	2018-03-6	54 containers with sodium dichloroisocyanurate dihydrate (SDID) declared as household goods	Fire occurred in the cargo hold, with containers stowed incorrectly in the forepart of the vessel.[5]	5 fatalities, total loss of $500m (total loss of ship and cargo)
Yantian Express	2019-01-03	Coconut charcoal declared as coconut pellets	Fire broke out in one of the onboard containers	Total loss of 198 containers
E. R. Kobe	2019-02-14	Charcoal	Double fire on board	No injuries, six containers on fire
KMTC Hongkong	2019-05-25	5 tank containers loaded with liquid paraffin, 13 containers loaded with calcium hypochlorite	A fire broke out on board the ship in port when discharging 35 containers remaining on board Fire and burning chemicals caused noxious smoke and acidic ashes to rain down	25 workers suffering from smoke inhalation and other injuries; 130 people hospitalized
COSCO Pacific	2020-01-04	Container loaded with lithium batteries (declared as spare parts)	Fire in the cargo hold, spontaneous combustion of a lithium battery not properly declared	Damage unknown (at least three containers with undeclared DGs)

Source: Authors according to Shipping and Freight Resource & Safety4Sea

4. HUMAN FAILURE, ERRORS, AND MOTIVES FOR UNDECLARATION

The analysis shows that the human factor is the factor that contributes the most to transportation accidents. In this chapter, attention is given to the transportation of DGs and failures resulting from errors in the supply chain.

4.1. Undeclaration in maritime transport

Human failure within the supply chain

DG transportation is a multifaceted problem involving multiple stakeholders. Errors and mistakes can occur everywhere along the logistic chain, from shipper to consignee [6]. Human error strongly depends on the position and type of work performed by each stakeholder. For example, an agent could

[4] Passenger error (package, declaration) causes 25% of aviation accidents, handling failure represents 15% of accidents, and spillage and packaging failure each account for 10% of accidents [17].
[5] SDID was stowed under-deck; the main fixed firefighting means in this area was CO_2, which is ineffective for fires associated with such materials.

wrongly read the UN number from the dangerous goods document (DGD), or a forklift could accidentally penetrate a steel drum filled with a highly hazardous substance. This analogy can be applied to each stakeholder in the chain. Everyone at every position in the chain must take responsibility and ensure that the proper declarations have been made. Ensuring safe processes should be logical and natural when distributing information between various stakeholders.

Furthermore, human characteristics significantly influence safety during operations across the entire logistics chain. Humans are not able to maintain the same level of concentration throughout the day, which leaves room for failure. Physical conditions such as fatigue and sickness contribute to lost concentration. Fatigue is considered one of the most important causes of human mistakes [8]. A study on fatigue in maritime transport [9] also stated that failures of comprehension or interpretation among stakeholders can be attributed to a lack of experience or inadequate training.[6] As a result, the human factor can be positively influenced by high-quality education, training, and knowledge of the use of modern equipment.

Stakeholders involved in the process of handling and carrying DGs can be divided into two groups: stakeholders involved in logistic flow and those involved in governance, the functions of which are to issue legislation governing the proper transport and declaration of DGs and supervise processes.

Stakeholders involved in logistic flow

1. A **shipper/consignor** is any person, organization, or government that prepares a consignment for transport [15]. The shipper is the first element in the supply chain. According to Nyquist [21], the shipper is the initial source of information. This statement is confirmed by the fact that the shipper creates the DGD, which is subsequently to every stakeholder in the supply chain. The shipper's declaration represents the statement of the shipper (consignor) that all information on the DGD is complete and follows all relevant regulations. The statement is signed and dated by the shipper [15, p. 5.4.1.6.1]. Hence, the shipper has an undeniable responsibility and liability.
2. A **freight forwarder** is a person or company specializing in the arrangement of cargo on behalf of shippers and providing various services, including maritime and air freight transportation. In comparison with freight forwarders, a freight consolidator takes the shipment (too small for exclusive container use) from various shippers and loads it into one container, thus taking on the role of container stuffer.[7]
3. A **carrier**[8] is any person, organization, or government undertaking the transport of DGs by any means. The term includes both carriers for hire or reward (known as common or contract carriers in some countries) and carriers on their own account (known as private carriers in some countries) [15]. A carrier can reveal undeclared dangerous consignment. Carriers may report to the flag state, port state of departure, or port state of arrival. According to IMDG Code Compliance Centre (2022), there are three possibilities for identifying undeclared (or misdeclared) shipments for carriers:
   - when subject to random inspection initiated by the carrier,
   - when the consignment is involved in an incident,
   - when subject to random inspection by port authorities.
4. **Ports and terminal operators** assume some responsibility, even when shipping lines are responsible for carrying DGs and suffering the consequences of any accidents on board. Based on new regulations, "The Dangerous Goods in Harbour Areas Regulations 2016" (DGHAR) [6], that came into force in 2016, safety provisions aimed at safeguarding ports against serious accidents

[6] The training requirements of the IMDG Code became mandatory for shore side personnel on January 1, 2010 (Amendment 34-08).
[7] A person who is signing the container packing certificate.
[8] A local representative of the carrier is an agent (a broker, commission merchant, resident buyer, sales agent, or manufacturer's representative).

involving DGs when transiting through ports and their areas were set. The objective of the regulations is to provide measures to reduce the risk of a serious incident occurring.[9] Based on DGHAR, the main provisions for safeguarding port areas against chemical incidents are:

- anyone bringing DGs into a port must pre-notify the arrival of DGs to the berth operator and/or port master;
- the port master is responsible for regulating the movement of DGs within the port area in the case of risks to health and safety;
- port authorities must create their own emergency plans – scenarios for incidents involving DGs;
- berth operators must provide emergency arrangements to masters of vessels;
- port areas where explosives are to be brought or handled must be licensed[10];
- port management should provide associated safety and security requirements for explosives in port areas
- improper stowage processes (missing cargo manifest).

Many ports and harbors have local legislation governing safe navigation and other matters. Even with new regulations and a high level of protection in maritime ports, the number of accidents with DGs is still high (42% of accidents occur in ports during loading and unloading processes) [17].

5. **Authorities and regulatory bodies -** the general transportation of goods requires licenses and declarations from authorities, particularly in the case of the transportation of DGs. Shipments require declarations to various governmental agencies, such as port authorities, waste regulating agencies, and customs. Different stakeholders have a responsibility to declare goods to governmental agencies. If the port authorities identify a consignment that does not comply with the IMDG Code (most often during random inspections), they may report the case to respective authorities within their jurisdiction; competent authorities may then notify other competent authorities from whose territory the cargo originated (see IMDG Code 1.1.1.8). Furthermore, when a port authority observes any infringement of provisions of the IMDG Code, they penalize the master of the vessel under SOLAS and MARPOL conventions.

Motives for the intentional undeclaration of DGs

The freight rate is the most frequent motive for the undeclaration of DGs [11]. For comparison, the freight rate for a container carrying DGs is 50–100% higher than the rate for a container carrying general goods. Moreover, if general cargo is carried in a refrigerated container, the rates are 150–200% lower than the rates for the transportation of DGs in the same container. For this reason, some shippers and agents decide to undeclare or hide DGs and transport them as general cargo.

In the case of the unintentional misdeclaration of DGs, a lack of experience and skills play a significant role [22]. On the other hand, with the rapid development of the global chemical industry, the amount and variety of chemical products have increased rapidly. Some new hazardous substances still cannot be listed in the IMDG Code.

Another reason for undeclaration is transport prohibitions of certain types of DGs. For example, class 1 explosives could not be imported to the United States after the 9/11 terrorist attacks, while lighters are forbidden from being imported in some European countries. In this case, the shipper has no choice but to change the name of forbidden or provide false information. According to a survey about the misdeclaration of DGs [16], the wilful default represents 33.10% of all incidents with misdeclared dangerous shipments. The most frequent reasons for the wilful undeclaration of DGs are:

1. goods restricted or prohibited by shipping lines, but which have high demand in the market (29%),

[9] DGHAR replaced the Dangerous Substances in Harbour Areas Regulations 1987 (DSHAR), along with its associated Approved Code of Practice, thereby removing superseded, redundant, and duplicated provisions.
[10] By HSE or, in certain cases, the Office for Nuclear Regulation (ONR).

2. higher freight imposed by the shipper (28%),
3. goods restricted by the shipper (19%),
4. goods prohibited by the shipper (14%),
5. goods prohibited by the country of destination (10%) [16].

Up to 25% of all serious incidents and fires on board containerships are attributable to misdeclared cargo (Cargo Incident Notification System). In 2018, there were 174 reported fire incidents.[11] The mis/undeclaration of DGs often results in delays or the confiscation of goods, the invalidation of export licenses, duty payments, and regulatory investigations. Even when no physical loss or damage occurs, each situation represents adverse financial implications. Between 2000 and 2015, 56 containership fires damaged 8,252 containers, resulting in insurance payouts of over 1 billion USD. Furthermore, between 2000 and 2019, hull insurers paid out approximately 189 million USD for hull claims related to containership fires, most of which were supposedly caused by undeclared goods. Speculations state that the increasing size of the containership industry is also expected to see an increase due to the cost to insurers.

Inspections

Less than four of every 100,000 containers are routinely checked (ICHCA, 2017 IMO Submission). Routine inspections of containers show a high level of non-compliance, including improper stowage. In 2018, there were more than 32,000 DG container inspections provided by ports in the USA; 7.9% of the inspected units (2,569 containers) were non-compliant due to poor stowage/securing, misdeclared cargo, and other related issues [20].

About 6 million containers involving DGs are shipped annually, and nearly 1.3 million of them are improperly packed, labeled, or identified. The National Cargo Bureau recently initiated a Container Inspection Safety Initiative for the inspection of 500 containers from cooperating carriers. These inspections involved shipments of dangerous and normal shipments imported from Europe, Latin America, Asia, and the Middle East, as well as export shipments, including shippers that had not previously been exposed to container inspections. The main goal of this initiative was to quantify the stage of danger on every voyage caused by undeclared or insufficiently secured cargoes.

This initiative is assumed to be a catalyst for increased container inspections, enhancing the safety awareness and regulatory compliance of shippers, cargo consolidators, and export container packers. Ultimately, it will contribute to reducing shipping incidents due to non-compliance with DG regulations. The current state of non-compliance shows a system prone to extreme and unacceptable disasters that the industry is not ready for. This situation will continue unless a comprehensive approach is adopted by the whole transport industry to address the root of the problem and reduce non-compliance by all supply chain participants.

4.2. Undeclaration in aviation

When DGs are not properly packaged and labelled for air transport, they can pose significant risks because there is little room for error when problems arise during flight. The main purpose of the present study was to find weak spots within the supply chain of DG transportation.

Human failure in air transport

A human failure, in terms of aviation, is mainly related to shippers. The first type of adverse situation occurs when a shipper declares dangerous shipments as non-hazardous. Secondly, shippers may declare DGs but provide inaccurate descriptions. For example, the quantity of goods stated by a

[11] A Mærsk Honam fire accident (2018) resulted in the loss of five crewmembers and an estimated financial loss of 430 million USD. Even when the cause was not confirmed, the Mærsk shipping company believed that dangerous goods were implicated in the severity of the fire onboard [1].

shipper may be lower than the actual weight so that the goods will be loaded onto passenger aircraft even though they should be loaded onto cargo aircraft.

The unintentional misdeclaration of DGs and the improper identification of shipments lead to errors, such as inappropriate packaging, mishandling, and improper storage. Thus, the misdeclaration of DGs can lead to catastrophic consequences during the process of handling, transporting, and storing DGs.

1. A **freight forwarder** is a person or organization who arranges the transport of cargo by air (ICAO-TI). The freight forwarder may assume some or all of the shipper's responsibilities as the shipper's agent.
2. A **Shipper** is a person, organization, or enterprise undertaking any of the shipper's responsibilities (ICAO-TI). The shipper has the elementary responsibility of ensuring the safety of DG shipments. The shipper has many responsibilities and duties, such as DG identification; supervising to ensure the proper packaging, labeling, and marking of DGs; and accompanying the shipment with a dangerous goods transport document (also known as the shipper's declaration for DGs) in compliance with the ICAO-TI.
3. An **air operator (or carrier)** is a person, organization, or enterprise engaged in or offering to engage in an aircraft operation (ICAO-TI). Carriers must ensure that all regulations will be followed before accepting DGs for transport. Carriers share the responsibility for the safe transportation of DGs, as they must utilize a checklist to ensure proper documentation and quantity limits and to certify proper shipping names and numbers, among other duties. Carriers also accept, load, and shore DG shipments. Carriers can perform inspections to ensure compliance with the ICAO-TI and must respond when incidents occur.

Hidden DGs in civil aviation

Many consumer goods are not generally thought of as hazardous materials. Nevertheless, because these items can pose a potential risk to health and safety, it is important to carry them safely and responsibly. In fact, there are many incidents with hidden or undeclared DGs in civil aviation. According to the CAAS list of commonly hidden DGs [4], many common household products may contain substances that are classified as DGs, for example:

- thermometers (containing mercury),
- breathing apparatuses with compressed air or oxygen, camping equipment (propane, flammable liquid, matches, and portable gas burners;
- any product packed in dry ice (e.g., fruits and vegetables).

There is a substantial range of items that are classed as DGs, and passengers often do not have the slightest idea that they are carrying DGs. It is important to understand how common hazardous materials can be. Helium tanks and lighter fluid are obvious items on the list, but everyday products like nail polish remover and mothballs can also be dangerous if transported in large quantities [24]. Furthermore, lithium batteries may be integrated into a variety of electronic goods, making them a hidden danger.

5. RECOMMENDATIONS FOR INCREASING COMPLIANCE AND SAFETY

5.1. Maritime transport and handling

The first step toward the safer transportation of DGs is to establish an automatic system for monitoring receiving shipments to provide a display of container marking and placarding in order to avoid errors and violations, increase the speed of the receiving gate process, and increase compliance (for example, using RFID tags). The in-gate receiving process should involve physical inspections of containers for signs of leakage, as well as marks, labels, and proper placards. Real data and booking

data about marks and placards should be compared to ensure they match. If an inspection reveals that the container does not match the booking data or documentation, the container should be placed on hold, responsible parties should be informed, and defects should be fixed before the container is accepted.

Each shipping company should consider a risk-based matrix to determine the type of hazards for containers filled with various DGs. Based on the risk analysis and evaluation, the list of the most dangerous substances should be developed, and those shipments should be checked, with attention given to the possible existence of damage, leaks of hazardous substances, or potential undeclared DGs. Moreover, shipping companies should develop inspection programs for containers involving DGs to ensure the integrity and proper placarding of containers. This program can also ensure that substances are properly secured within containers, revealing the possible existence of damage, leaks of hazardous substances or potential undeclared DGs. Every shipping company and shipper should consider a risk-based matrix to determine type hazards for containers, located and filled with various DGs.

Inspection procedures based on the prepared database of the most dangerous substances (or shippers that had issues with a declaration in the past) should be applied to provide a standard of quality control, capture inspection information for analysis, and ensure the efficient use of resources.

Stowage plans for dangerous shipments should be compared with actual condition prior to the commencement of operations, as well as during loading, to review shipments for any updates and upon completion to ensure that final stowage and segregation comply with requirements. Physical loading operations should be supervised and monitored to ensure containers involving DGs are stowed in assigned positions. Planners of handling should be alerted of any changes, and the DGs manifest should be updated accordingly. The DGs manifest should be reviewed, any discrepancies should be corrected, and the final manifest should be signed by designated vessel personnel to acknowledge correctness.

Recommendations increasing the safety of monitoring dangerous shipments in maritime transport are supported by Directive 2002/59/EC, which established a community vessel traffic monitoring and information system. The purpose of this directive is to establish in the community a vessel traffic monitoring and information system to enhance the safety and efficiency of maritime traffic; improve the response of authorities to incidents, accidents, or potentially dangerous situations at sea, including search and rescue operations; and contribute to preventing and detecting pollution by ships.

1. Carriers

The carrier should properly identify the relevant transportation documentation provided by the shipper. The carrier's employers responsible for the operation should be familiar with the correct names for and information about hazardous substances. Using the cargo database is a useful approach for preventing undeclared DGs by the shipper. When the bill of lading is entered, the system will provide an alert, which helps maintain consistency between the cargo and its transport documents and prevent the occurrence of undeclared DGs effectively.

Owing to the large number of accidents involving undeclared DGs, some carriers recently announced that they impose levy penalties on shippers for undeclared cargo, as the fires from such cargo come at a great expense to the carriers and put all on-board cargo, as well as the integrity of the ship, at risk. Effective September 15, 2019, Hapag-Lloyd, which shipped nearly half a million DGs last year, began fining shippers $15,000 for undeclared or misdeclared hazardous cargo. HMM fines the same amount, while Evergreen announced a penalty of $35,000. Other carriers should follow their example and impose high sanctions on irresponsible shippers.

Moreover, to minimize risks, Hapag-Lloyd developed an advanced cargo screening software called Cargo Patrol, which scans the booking documents of all cargo that has not been declared as DGs twice daily. The company also has a team of five experts who perform further investigations on these bookings. Every suspicious booking that investigators place on hold is not to be transported further until investigations are complete. If, after further investigation, Hapag-Lloyd finds evidence that documentation is fraudulent, it refuses the shipment and leaves the container behind.

2. Ports

Several ports have started to implement penalties to reduce undeclared DGs. Based on an analysis of 50 world port authorities, only two authorities located in New Zealand are implementing penalties:

- the Port of Napier has announced the implementation of a DG handling charge of $630 for misdeclared cargo and cargo with an incorrect placard [27].
- the Port of Auckland is charging a fee of $1,081.01 + GST for misdeclared cargo [28].

We recommend that other ports follow their example. Ports must ensure that the proportion of undeclared consignments and containers carrying DGs is reduced to increase the safety of their personnel. Ports should implement policies sanctioning persons who wilfully carry undeclared DGs.

3. Authorities

Maritime administration plays a crucial role in checking for undeclared DGs during transportation. Firstly, maritime administration should strengthen the declaration checking of containers carrying DGs via verbal questioning methods or on-site inspections.

Secondly, improvements to the management of shipping companies and agents are crucial. Generally, the declaration for the DGs is the responsibility of the native agent (or the delegate of shipping companies); thus, the processes of managing the agent and delegating are very important for checking undeclared DGs. There is a blacklist system[12] with which the maritime administration can open and exchange the information of shipping companies undeclaring containers carrying DGs. Such companies can be investigated and punished according to the IMDG Code and national legislation. The containers from blacklisted companies should then be tracked closely.

Thirdly, the port state should implement legislation to punish the shipment of undeclared DGs in containers. Furthermore, the administration may use an information system to improve the management of undeclared DGs in containers. For example, the Port of Shanghai developed the EDI system to declare containers carrying DGs. The maritime administration can inquire about the information related to declaration and pre-booking on exports, track suspicious shipments at any moment, and open the container to inspect the cargo inside. In addition, public tip-offs are encouraged for the safety management of containers carrying DGs.

5.2. Aviation

This chapter includes recommendations for the elimination of transport of undeclared, hidden, and misdeclared DGs.

1. Handling of shipments marked with GHS pictograms

As we recommended for maritime transport, an automatic monitoring system for received shipments should be implemented. Placards and marks involving GHS pictograms should be reviewed based on the booking information and documentation. If a container carrying DGs does not match the booking data, it will not be shipped until the deficiencies are rectified.

2. Training

It is crucial to provide training for employees included in the process of DG handling to ensure the safe transportation of DGs by air. For example, service providers appointed to handle DGs on behalf of the shipper should be trained. Initial and repetitive training must be maintained by the following stakeholders involved in the carriage of DGs by air:

- shippers of DGs, including packers and persons undertaking the shipper's responsibilities,
- aircraft operators,
- ground handling agencies performing (on behalf of the operator) accepting, handling, transferring, and other processes involving DGs,

[12] System of Port State Control.

- ground handling agencies located at airports that perform (on behalf of the operator) the act of processing passengers,
- agencies not located at an airport that perform (on behalf of the operator) checking in passengers,
- every public postal operator.

The content of DG training programs should comply with the requirements specified in the technical instructions (ICAO).

Recommendations for safe carriage of lithium batteries

The current information on regulations and standard operating procedures for the shipment of lithium batteries should be immediately given to all parties involved in the transportation of lithium batteries. Lithium battery shipments must be strictly supervised to minimize the probability of mishandling and accidents.

When undeclared lithium batteries are detected, cargo staff should make a clear decision regarding the cargo based on whether the lithium batteries meet requirements. If the batteries do not meet requirements, the staff should call the shipper immediately upon the rejection of the cargo, or the conditions shipper must make adjustments so that the cargo can be accepted. When an incident caused by lithium batteries occurs, an emergency response should be carried out.

5.3. Recommendations for the maritime and aviation industries

For both the aviation and maritime industry, we recommend creating a centralized DG database that can be accessed and updated on an ongoing basis. The data may be derived from DG incident information, booking rejection details, and confirmed mis/undeclared DGs hits resulting from cargo screening. The database can also include a list of trusted shippers that are subject to fewer inspections than other shippers, a target list of repeat offenders for follow-up and increased investigations, and information regarding more detailed training for identified employee functions.

6. CONCLUSION

The undeclaration or misdeclaration of DGs occurs when a hazardous substance or item is not properly described, weighed, measured, or counted. When a dangerous item or substance is hidden, this situation is perceived as a case of intentional concealment of a consignment with dangerous properties due to a reduction of freight or other (mostly financial) reasons. There are four main motives for the undeclaration of a dangerous shipment:

1. the desire to avoid increased freight charges or circumvent rules on the carriage of certain DGs;
2. a lack of adequate enforcement and adherence to regulations and instructions for handling and transporting DGs;
3. a lack of adequate training or awareness regarding the proper packaging process or the compatibility of various cargo types in cargo holds; and
4. the difficulty in properly filling out various forms for DG documentation and the variations in this process depending on the IMDG Code and jurisdiction.

Measures that can be taken by regulatory bodies and authorities involve introducing changing inspection frequencies, changes in regulations, and setting and assessing penalties for non-compliance with the regulations. Carriers may act individually to improve their own procedures and programs for identifying undeclared DGs and implementing disincentive measures, such as fines, for non-compliance. Carriers may also act collectively through associations to share information and lobby for change.

As expected, each stakeholder involved in the process of DG transport is implementing strategies to improve safety and compliance in order to reduce accidents involving undeclared and misdeclared DGs. Hazardous substances can be safely transported by sea and air through proper declarations in

transport documents, the correct packaging and handling of DGs in accordance with regulations, and the provision of the necessary training and information to employees and service providers.

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