Dangerous Cargo Operations Systematics in Container Terminal Gate Operations and a Study on Turkish Container Terminals

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Abstract: The transportation of dangerous cargo by sea has become increasingly prevalent in recent years, largely due to the economic advantages offered by maritime shipping. The principal advantages of maritime transport are its affordability, safety and high load-carrying capacity. In recent times, containerised cargo has become a prominent feature of maritime transport, eclipsing other forms of freight transportation. Containers, the transport units used in container transport, are in high demand compared to other types of transport due to their durability and robustness. Additionally, containers allow for multi-storey stacking, which is a significant advantage in terms of space efficiency. It is possible to integrate container transports not only by sea but also by road, railway and, to a lesser extent, by air. Consequently, this represents a highly advantageous mode of transport in the context of multimodal logistics. The proportion of dangerous cargo transported in containers is on the rise, with international and national regulations governing the process. Despite the fact that the majority of dangerous cargoes are transported by container from warehouses and other facilities on the land side, the highest level of inspections and controls are typically conducted at the ports of gate. Containers transported by road or rail from the landside are prohibited from entering the port if they pose a risk to the safety of the port. Consequently, the gate procedures of ports represent a crucial aspect of security management.

This study aims to examine the security management practices employed in the gate operations of container terminals in Turkey that handle containers carrying dangerous cargo. In this study, the regulatory criteria obtained by scanning international and national legal regulations and the security management systems applied in ports were compared. The importance ranking of the determined criteria was attempted to be determined by analysing the AHP method with the data obtained from the surveys conducted in the ports. The results demonstrated that the ports assign different priorities to the criteria determined in the gate operations.

Key Words: Marine Transport Engineering, Maritime Management Dangerous Cargo, Safety Management.

1. INTRODUCTION

A container terminal is defined as a location where the transport modes of containers are altered. Given that one leg of the terminal is the sea route, it can be stated with certainty that one of the modes is the sea route. The container is transported to the terminal by sea, by land or by rail, where it is handled by the terminal's handling equipment and subsequently continues the logistics process by sea, by land or by rail. It is at this juncture that terminals assume a pivotal role, with the crucial distinction that they represent a pivotal point of transition between maritime and other modes of transportation.

Container terminals serve as pivotal nodes in global supply chains, facilitating the transportation of goods across international borders. The efficiency and effectiveness of these terminals are of paramount importance, as they directly impact the costs associated with transportation, the time required for delivery, and the overall performance of the supply chain. It is imperative to gain a comprehensive understanding of the various factors affecting container terminal operations in order to enhance their productivity and sustainability.

The principal function of container terminals is to serve as interim storage facilities for containers, facilitating the segregation and subsequent loading of containers from ships onto trucks or trains. This operational flexibility is of great consequence for the maintenance of the flow of goods in the supply chain, as it enables terminals to manage fluctuations in cargo volume without the necessity for synchronised schedules between different modes of transport (Caserta et al., 2011). The strategic position of container terminals within global logistics networks serves to increase their importance, as they are required to adapt to the demands of international trade, which is characterised by an increasing volume and complexity (Mar-Ortiz et al., 2016).

In the contemporary era, container terminals represent the primary locations where fundamental logistics operations are conducted. As is the case with all logistics centres, container ports can be divided into two basic categories in terms of the flows that occur within them. These can be classified as physical flow and information flow. The term 'information flow' refers to the processing of all the administrative data associated with the ship and its cargo. The physical flow refers to the movement of cargo within the port and/or terminal.

The principal logistics functions performed by container terminals can be broadly classified into three categories. The following section provides a brief overview of the aforementioned basic logistics functions.

The transport function of containers is as follows: Cargoes arriving at or departing from the port by sea are conveyed by main and feeder lines, respectively. In general terms, maritime services are provided on a regular basis. While railway transport is less prevalent than maritime transport, it is more common in land transport. Road transport is the only remaining mode of transport that carries less cargo than the others. This mode of transport is more suited to the movement of individual cargo.

The function of containers in storage: Given the scheduled nature of maritime and rail operations, cargoes must adhere to the specified timeframe for loading and unloading. It is an uncommon occurrence for cargo to be loaded directly onto a ship as it departs from port or loaded directly onto a ship as it arrives. In particular, cargo transported by road can be loaded on a ship with minimal delay, or cargo discharged from a ship can leave the port by road with minimal delay.

The handling function of containers is as follows: Ports typically employ two distinct handling operations. The first type of handling service is provided to the container itself. This encompasses the transfer of the container from the ship to the land, from the land to the ship, from the port to the land vehicle, or from the land vehicle to the port. The other handling service is provided to the cargo. Containers are transported to areas designated as Container Freight Stations (CFS), where both the loading of cargo into containers and the unloading of cargo from containers are conducted. One of the primary reasons for the preference of CFS services is the desire to load cargo within the port area without removing containers from the premises.

One of the principal factors influencing the efficacy of container terminals is the dependability of the service provided. In consequence, the reliability of the agreed voyage time (ETD), the efficiency of customs declarations, the efficiency of loading and unloading, port tariffs and berth availability are the five most important service attributes for shipping lines and agents (Lu et al., 2011).

The transportation of dangerous goods represents a significant area of concern, given the inherent risks associated with such activities. This area is subject to a complex regulatory framework, the objective of which is to reduce the potential for adverse effects on human health, property and the environment. The regulations governing the transport of dangerous goods vary depending on the mode of transport in question, including road, rail and air. These regulations are influenced by a number of factors, including international agreements and national legislation (Kołdys, 2016; Fabiano et al., 2005).

The transportation of dangerous goods represents a critical area of concern due to the inherent risks associated with such activities. The United Nations has classified dangerous goods as a diverse range of substances, including explosives, flammable liquids, toxic substances, and corrosive substances. Each of these presents unique challenges during transport (Eski and Tavacıoğlu, 2021). The safe transport of these materials is governed by a set of rigorous regulations and guidelines, including the International Maritime Dangerous Goods Code (IMDG) and the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) (Sabar and Hammoumi, 2020; Kołdys, 2016). The objective of these regulations is to mitigate the risks to human health, safety and the environment by ensuring that dangerous goods are correctly classified, packaged and handled throughout the transport process (Vojinović et al., 2021).

One of the most significant challenges in the transportation of dangerous goods is the accurate identification and segregation of these materials from non-hazardous cargo. The difficulty in identifying undeclared dangerous goods can result in significant adverse consequences if these materials are not properly managed (Zhao et al., 2018; Ellis, 2010). Moreover, the physical and chemical properties of dangerous goods must be rigorously considered during the course of transport operations, as factors such as temperature, pressure and environmental conditions have the potential to significantly impact safety outcomes (Medvedev et al., 2018).

The risks associated with the transportation of dangerous goods are not limited to accidents that occur during transit; they also encompass the potential for exposure to chemicals during loading and unloading operations. A substantial proportion of cargo containers have been found to be contaminated with toxic chemicals, which presents a risk to workers handling these materials (Pedersen et al., 2014).

Moreover, the design and maintenance of vehicles utilised for the transportation of dangerous goods are of paramount importance in ensuring safety. It has been demonstrated that the structural integrity of road tankers and other transport vehicles must comply with rigorous design standards in order to prevent the occurrence of leaks and spills (Chondros et al., 2019).

It is imperative to acknowledge the environmental consequences of the transportation of hazardous materials. The potential for spillage and leakage represents a significant threat to ecosystems, particularly in areas of environmental sensitivity such as waterways and urban environments. The efficacy of regulatory frameworks in mitigating these risks is contingent upon compliance and enforcement at both the national and local levels (Sabar & Hammoumi, 2020).

Furthermore, contingency planning and response strategies are essential elements in the management of risks associated with the transportation of dangerous goods. Such strategies must encompass comprehensive risk assessments and contingency plans that consider a range of potential scenarios, including those pertaining to accidents and natural disasters (Fabiano et al., 2005).

2. GENERAL STRUCTURE OF CONTAINER TERMINALS AND GATE OPERATIONS OF DANGEROUS CARGOES

The growth in international trade has led to a significant rise in demand for maritime transportation. Turkey's consistently rising import and export figures have facilitated the country's ability to procure a greater volume of goods from overseas markets and facilitate their export. This expansion in trade has led to a corresponding increase in the number of vessels arriving in Turkey or traversing the transit straits (Arıcan, 2024a)

It would be appropriate to mention the most appropriate basic criteria to be used during the general design and planning of container terminals. These criteria are safety, simplicity, flexibility and cost efficiency.Container terminals play a pivotal role in global trade, functioning as vital nodes for the transfer of goods between maritime and land transportation. The development of container terminals has been significantly influenced by advances in automation technology, which have been implemented with the dual objective of increasing operational efficiency and reducing labour costs (Wang, 2023; Knatz et al., 2022).

The design and equipment of container terminals are of significant consequence with regard to the operational efficiency of such facilities. Factors such as layout, equipment selection and technology integration are of critical importance in ensuring that container terminals are able to cope with the increasing complexity of container movements. The introduction of automated systems, including robotic technologies, has been shown to enhance the efficiency of terminal operations by reducing the necessity for manual handling and increasing the accuracy of container movements (Malyshev and Korovyakovskiy, 2020). Additionally, the design of terminal infrastructure, including pavements and stacking areas, must accommodate the substantial loads and dynamic operations inherent to container handling (Schnabel, 2020).

The management of container delivery and collection operations is also of great importance with regard to terminal efficiency. The effective planning and coordination of truck arrivals and departures can have a significant impact on turnaround times and overall terminal throughput (Zhao et al., 2020). The implementation of advanced management systems utilising real-time data can facilitate more effective decision-making and resource allocation, which in turn can lead to improved service levels and greater customer satisfaction (Lun et al., 2023).

The operation of container terminals, in particular the management of gates, is a complex and multifaceted process that has a significant impact on overall terminal efficiency. Gate operations represent a pivotal point of interaction between landside and waterside operations, where trucks are admitted to and depart from the terminal to deliver or retrieve containers. This interaction is of critical importance in the minimisation of delays and the optimisation of throughput, as gate congestion has the potential to result in significant operational inefficiencies and cost increases for shipping companies and logistics providers (Moszyk et al., 2021; Li et al., 2022). The lack of basic training for personnel working in coastal facilities was identified and the requirements for proper training were defined. In particular, the shortcomings of the port areas designated as bonded areas in the ISPS are among the unacceptable shortcomings for the border entry points (Arıcan, 2024b).

In container ports, the gate operations of cargoes designated as export cargoes, which are brought from outside to be loaded onto the ship, or the exit operations of full containers designated as import cargoes, which arrive by ship, or open cargoes designated as open cargoes, which are removed from the container and discharged in the CFS area, are collectively referred to as container door operations. Gate operations encompass the physical management of cargo and the input and approval of data into the system. In container gate operations, the use of terminal gates provides an effective means of controlling the entry and exit of cargo.

A customs control unit has been established in close proximity to the gate, specifically for the use of port customs personnel. The vehicles transporting cargo into the port are first required to complete the requisite customs controls and procedures at this unit, after which they proceed towards the port gate. Similarly, vehicles laden with cargo from the port first undergo customs controls and other requisite procedures in this unit and subsequently depart from the port.

In addition, there are designated areas, referred to as "clearing areas," situated in close proximity to certain terminal gates. These areas are utilized for the transfer of cargo originating from external sources into the port, as well as for the removal of cargo originating from within the port. In these areas, full export containers or export open cargo brought from outside by vehicles transfer their cargo to the YTTs sent from the terminal, or full import containers or import open cargo brought by YTTs are transferred to the vehicle coming from outside. The utilisation of this clearing area is contingent upon the prohibition of vehicles originating from external sources from entering the terminal zone. This is implemented to prevent any disruption to the established traffic patterns within the port. The utilisation of this clearing area is an extremely secure method. It is inadvisable for vehicles arriving from outside to enter terminal areas without prior familiarity with the established traffic patterns. In particular, the transportation of containers carrying dangerous cargo presents a significant risk of accidents. It is not only possible that vehicles coming from outside may be involved in an accident themselves, but also that they may be involved in accidents with other handling vehicles and transfer vehicles used in the port. Such circumstances have the potential to result in significantly more catastrophic outcomes.

It is a requirement that all export cargoes loaded onto ships at ports undergo inspection at the terminal entrance. Furthermore, containers are also subject to this procedure. It is incumbent upon all export open cargoes and export containers at the terminal entrances to have the requisite information available in order to be reflected in the port's operating system. The cargo is subject to both an entrance control and an in-terminal movement planning procedure, the latter of which entails the input of relevant information into the system.

Subsequently, the container must be returned to the terminal for loading purposes. The input of accurate and complete information about the container into the terminal operating system facilitates the smooth processing of the container. It is imperative that the aforementioned information entries are completed accurately and in a timely manner. The data is sourced from the container agency responsible for the loading of the container. The aforementioned information is received by container agents from the customer or customers, as well as freight forwarding companies. The information provided by container agents is transmitted via EDI files and email from the internet environment.

In consideration of the data transmitted regarding the container, the planning department determines the storage location for the container prior to its arrival and transmits the pertinent information to the terminal gate. It is of the utmost importance that the aforementioned information is entered prior to the arrival of the container and that the requisite storage location is prepared. In the event that the requisite information is not provided in a timely manner, the container will not be permitted to enter the terminal, as the gate entry system will lack the necessary data. In certain instances, the resolution of disruptions resulting from the delayed entry of information or the delayed entry of the relevant data into the system is achieved through the collaboration of container agencies and port management. In such instances, the container is admitted into the terminal but is held in designated areas until the requisite information is entered into the system. Upon the arrival of the requisite information, the location for the storage of the container is determined, and the operational process continues.

In the event of an error or deficiency in the information provided during the verification process, a problem document is prepared for the container in question and the container is directed to the designated problem desk. The aforementioned situation is duly communicated to the container agent, who is then requested to implement the necessary corrections. The container agency is responsible for rectifying any errors or deficiencies that it has caused. In the event that the error or deficiency is determined to have been caused by the customer, the customer or freight forwarding companies are promptly contacted and corrective action is initiated. In certain instances, this process may be quite time-consuming. Consequently, the officials at the terminal gate take the vehicle into the terminal with the knowledge of the terminal management, but are unable to receive the container on the vehicle. In certain instances, vehicles are not permitted to enter the premises and are instead left to wait in the parking area outside. Once the requisite information has been supplied or the requisite corrections have been made, the vehicle is permitted to enter and deliver the container, after which it is permitted to exit the premises following the completion of the requisite control procedures.

In the event of an overflow in the export container, an alternative process is initiated. An overflow of containers occurs when the cargo carried by the container extends beyond the designated areas within the container, according to the physical structure of the container itself. The contents of the container may overflow from the top, sides, front or back. In such a scenario, it is not feasible to place another container in proximity to the original container, whether in front of, behind, or on top of it. In the event of an overflow of the container to be entered, a document is printed which indicates that there is no space allocated in the field. The document also contains information regarding the overflow of the container. This document is provided at the gate. The aforementioned issue is conveyed to the designated problem desk in conjunction with the container in question, which is transported on the aforementioned vehicle. The information pertaining to the overflow of a container is duly conveyed to the designated problem desk by the respective field operation officers, who are responsible for ascertaining the dimensions of the overflowing container. The problem desk enters the relevant overflow information into the system and prepares an 'Overflow Container Record', which is then sent to the container. The Planning Department then assigns the container a suitable location by providing the vehicle with the necessary documentation on the computer.

It should be noted that terminal gates are not solely operated via an operating system. Additionally, the gate operation officer performs a visual inspection of the container. In the event of any damage to the container, this is duly recorded in the appropriate report. As responsibility for the container transfers to the terminal upon its arrival, it is crucial to ascertain and document the extent of any damage that may have occurred prior to this transfer. In order to fulfil this function, the damage is duly recorded and referred to the relevant department, namely the one responsible for addressing such issues. This process is conducted by the gate operation unit.

In the event that the documents and the bill of lading indicate that the container is carrying dangerous cargo, a label denoting one of the nine dangerous cargo classes specified by the IMD Code must be affixed to the container. It is the responsibility of the gate operation officer to ascertain that the aforementioned label is affixed in a location that is readily visible and in accordance with the prescribed standard dimensions. In some ports, an Optical Character Reader (OCR) system is in operation. The system in question automates the operations that would otherwise be performed at the terminal gates.

It is common practice for container terminal gates to utilise barcode-based or OCR-based systems. In a barcode-based system, upon arrival of the container vehicle at the gate, the driver is required to identify both the vehicle and the container through the barcode system, after which he receives information pertaining to the work order. Nevertheless, the deployment of a barcode system is often a lengthy process, and the integrity of the barcodes can be compromised, potentially leading to errors. An OCR-based system employs a video classifier to identify trucks and containers. However, this also frequently gives rise to issues, as it necessitates manual operation. To address these issues, research has been conducted into the potential use of Radio Frequency Identification (RFID) technology at the container terminal entrance. The RFID-based system has enabled the automatic identification of trucks and containers; however, it is not currently possible to automatically communicate information about the work pattern to the driver. Consequently, the process of access management remains partially manual, necessitating that the vehicle halt at the entrance gate to obtain a paper slip detailing the work order (Günay, 2012).

The initial operation undertaken by dangerous cargo containers upon their entry into a port is that of dangerous cargo gate operations at container terminals. As the containers are closed due to their structure during dangerous cargo gate operations, port personnel are able to perform the requisite gate operations by checking the relevant documentation. Furthermore, an external visual inspection is conducted to ascertain the physical condition of the container. It is not permitted for port personnel to open and examine the interior of the container for security reasons during the course of gate operations.

The intricate nature of container terminal operations necessitates a multifaceted approach that integrates technological advancement, efficacious queue management, and well-defined operational policies. By addressing the challenges associated with gate operations, terminal operators can enhance the quality of their service, reduce costs and increase the overall efficiency of their operations. The ongoing advancement of container terminal design and management practices will be pivotal in addressing the increasing demands of global trade and logistics.

The following section outlines the conditions that must be considered when entering dangerous cargoes at container terminals.

2.1. Type of Container

It is a requirement that any dangerous cargo containers arriving at the container terminal comply with the rules set out in the International Convention for Safe Containers (CSC), 1972. It is imperative that containers are intact, undamaged, labelled, and that the label is readable.

It is imperative that any dangerous cargoes brought to the container terminal area for handling in containers are properly packaged, and that the packages or containers are labelled accordingly. All relevant information pertaining to the cargo must be prepared in accordance with internationally recognised standards and regulations.

The variety of container types that may be admitted to the terminal includes standard, open-top, ventilated, refrigerated, platform and flatrack containers. It is imperative that dangerous cargoes on flatrack and platform containers be safeguarded against external factors. It is imperative that open-top containers be safeguarded against the ingress of sea and rainwater. Containers of the 20-foot and 40-foot sizes are accepted. The container must be marked with a number and any other relevant information.

The solid nature of the majority of dangerous cargoes results in standard container transportation being a relatively costly and infrequent occurrence. Tank containers are employed for the transportation of liquid and gaseous cargoes. A refrigerated container is employed for the transportation of chemical substances, as it allows for the maintenance of a specific temperature. The remaining container types are employed less frequently.

2.2. Dangerous Class

Any dangerous cargo brought to the terminal by land or sea must fall within the scope of cargoes that have been authorised for export or import under the relevant customs legislation. It is imperative that the cargo in question be included among those declared under the customs regime, and that the relevant declaration be made in an accurate and complete manner.

In the event that the cargoes arriving at the container terminal by road, rail or ship are classified as dangerous cargo of classes 1 and 7, the decision regarding their entry is made by the port authorities. Furthermore, port administrations are required to obtain approval from port authorities prior to accepting any cargo. It is not permissible to accept any cargo without the requisite approval. Such cargo is permitted to remain in the port for a limited period, subject to the implementation of specific safety measures.

It is also crucial to consider the status of the labels used to identify the dangerous cargo. It is imperative that the labels affixed to the container are both legible and free from contamination. The cargo within the container and the label displayed on the exterior of the container must correspond to the same cargo classification. It is imperative that the process of label and document control be conducted at the terminal gate. From the point of entry to the port, personnel will undertake intervention operations based on an examination of the labels affixed to the containers. This is particularly pertinent in the event of an emergency, and it is therefore imperative that the labels are both legible and accurate.

It is standard practice for container terminals to decline the acceptance of Class 1 explosives and Class 7 radioactive materials. Port management will accept these cargoes when the requisite conditions have been met. Furthermore, both class 2 gases and class 3 liquids present a risk of fire and potential for dissemination within the terminal area. Furthermore, specific measures must be taken to ensure the safe transportation of Class 6 infectious and toxic substances. It is not the policy of the port to prohibit the entry or departure of cargoes classified as Class 8 or Class 9. However, it is incumbent upon all parties involved in the handling of such cargo to exercise the utmost care and caution.

2.3. Stacking Condition

The stacking of cargoes of a dangerous nature into containers represents a significant undertaking. In this country, the responsibility for undertaking the stacking operation of dangerous cargoes into containers is borne by the cargo owners. The stacking of dangerous cargoes for containers is not conducted at ports. Consequently, the port does not exercise control over the manner in which cargoes in containers are stacked upon arrival. The improper stacking of dangerous cargo, undertaken without the requisite precautions, may result in damage to the cargo itself, as well as to other containers and personnel situated outside the container.

It is imperative that any dangerous cargo conditions or container defects that may potentially impact the safety of the port and the vessel, as well as any circumstances that may pose a risk to personnel or equipment, are promptly communicated. In the case of packaged dangerous cargo, the quantities and additional information should be communicated to the port management in accordance with the requirements set forth in section 5.4 of the IMDG Code for classes or divisions of goods. It is inadvisable to pack dangerous cargoes into cargo transport units with incompatible cargoes.

Cargoes that require ventilation must be stacked correctly in the designated ventilation areas and must not obstruct the ventilation openings. In the event that dangerous cargo is to be carried in limited quantities within the container, it shall be labelled accordingly and stacked in close proximity to the doors. No other cargo that is prohibited from being loaded into containers will be loaded into this container.

It is imperative that in-container loads are correctly labelled, and that carrier vehicles are appropriately placarded. In the event that cooling is conducted within the container using carbon dioxide, labels or warning signs must be affixed to the doors, and the following warning must be displayed: It is imperative that containers in which dangerous goods are transported are secured by locking or sealing mechanisms.

When dangerous cargoes are stacked in a container, they should be stacked in accordance with the instructions provided by the relevant dangerous cargo experts, with due consideration to the packaging and securing of the cargoes in question. It is imperative that packages containing dangerous cargoes undergo a visual inspection prior to being loaded into the container. In the event that any damage, leakage or discolouration is identified, the package in question must be rejected and removed from the container. In the event that packages exhibit indications of discolouration, it is imperative that they are not stored within the container until such time as a determination has been made as to their safety and acceptability.

2.4. Quantity of Cargo

The specific types and number of packages, package groups, quantities, and any additional information required by section 5.4 of the IMDG Code for packaged dangerous cargoes at the entrances to the terminal must be communicated to the port management. It is essential to obtain precise information from the shipper regarding the nature of the dangerous cargoes, including the quantity and characteristics of the cargoes. It is imperative that the technical name, cargo class, UN number and packing group, as well as the total quantity, be requested from the shipper.

It is imperative that the dangerous cargoes are packed, marked, labelled, placarded and equipped with the necessary labels at the entrance of the containers to the terminal, in accordance with the legal legislation currently in force. The declaration attesting to the completion of these operations may be appended to the transport documents or alternatively, it may be demonstrated and documented through photographic evidence.

In accordance with the SOLAS Convention, it has become mandatory to declare the weight of containers entering container terminals in our country as of 1 July 2016. The quantity of cargo entering the port can be compared with the quantity declared on the document. This will ensure that dangerous cargo is transported in accordance with the relevant legislation. The circumstances surrounding an incident resulting from the storage of a greater quantity of hazardous materials than is permitted will be subject to alteration. In particular, in the event of fire or the spread of fire, it will prove more challenging to control the cargo. Furthermore, the facilities of the port will prove inadequate in such circumstances.

The retention of a substantial quantity of Class 1 cargo may result in the occurrence of explosions with a considerable degree of destructive potential. The interaction of Class 2 and Class 3 cargoes with heat, due to external factors, can result in significantly more powerful and destructive explosions and spills. The control of Class 5 and Class 8 cargoes is likely to prove challenging in the event of their dispersion, with the potential for significant harm to the port and its personnel. Class 7 cargoes are of particular concern in this regard, given their elevated risk profile. In the event of a radioactive accident, there is a risk of contamination affecting personnel in the vicinity and the general population.

2.5. Cargo Combustion

The combustion of dangerous cargoes presents a significant hazard due to their inherent flammability. The fire risk posed by dangerous cargoes is heightened when they are exposed to various heat sources, particularly during the process of stacking. The degree of flammability of each dangerous cargo class is distinct, and the port should be apprised of this information separately.

Class 1 cargoes, which include explosives, will continue to burn until they reach their explosion points. Such explosions have the potential to cause significant damage to the site. Class 1.1 and class 1.5 cargoes, which are subclasses of class 1 cargoes, are characterised by a high risk of mass explosion and combustion. It can be stated that there is no risk of a mass explosion for the aforementioned subclasses of Class 1, namely Class 1.2, Class 1.3, Class 1.4 and Class 1.6. Furthermore, class 2 gases may be flammable, toxic, or corrosive and may be transported to ports in a liquefied, filled, or compressed state. An explosive atmosphere may result from the leakage of gas cargoes, potentially leading to a fire. In enclosed spaces, the occurrence of a leakage due to the presence of cargo may result in the formation of an explosive atmosphere as a consequence of gas compression, despite the absence of any effective means of preventing such an occurrence.

Class 3 flammable liquids, when separated from their packaging, may pose a risk of spreading over the water, potentially creating an explosive atmosphere. In the event of a fire involving the same cargoes and an intact container, the pressure generated may result in a rupture and subsequent explosion due to the effects of the fire. The category of flammable solids, as defined by the relevant regulatory bodies, encompasses a range of substances that, when in contact with water, can undergo an exothermic chemical reaction, leading to the generation of considerable heat and the potential for an explosive outcome. This includes substances that are water-soaked explosives or self-reactive substances. Flammable solids are readily ignited by heat sources. Class 4.2 loads, which are a subclass of Class 4, are defined as spontaneously combustible materials that present a fire risk in the event of contact with hot air from heat sources or self-heating. Class 4.3 loads, which are a subclass of Class 4, present a fire risk due to their tendency to burn when in a moist state.

Class 5.1 loads increase the oxygen content of the surrounding environment by extracting oxygen, thereby creating an environment conducive to combustion. Class 5.2 loads, organic peroxides, burn rapidly, thereby facilitating the rapid spread of fire. In contrast, Class 6 toxic substances can damage their packaging in the event of a fire, mix with the surrounding air, and present a significant risk of adverse health effects if inhaled by personnel. Radioactive substances belonging to Class 7 are transported in specially designed packaging. However, in the event of an intense fire, these substances may pose a significant risk to the civilian population in the vicinity, particularly port personnel, due to the potential for leakage of the cargo and subsequent deterioration of the package structure. Corrosive substances classified as Class 8 may generate considerable quantities of corrosive vapour when subjected to combustion, contingent on the structural characteristics of the substance in question.

Dangerous cargoes are stored in designated areas within port facilities, with access restricted to authorized personnel. It is imperative that these specialised areas are safeguarded from all forms of heat sources in the event of a delay or interruption to the arrival of the cargo. Furthermore, the cargo itself should be kept under observation until it has been fully unloaded. Dangerous cargoes have the potential to either instigate a fire during the process of container transportation or to prolong and intensify an existing fire. It is of the utmost importance at the entrance to the port to provide accurate and sufficient cargo quantity information regarding the risks associated with the cargo types in question in terms of fire.

2.6. Cargo Spreading

The risk of load spread is greatest for dangerous cargoes, particularly class 2 gas and class 3 liquid cargoes, due to the inherent structural characteristics of these materials. The potential risks associated with dangerous cargoes are significant, particularly given their propensity to spread through mixing with the surrounding air, thereby creating an atmosphere within their immediate environment. Furthermore, gaseous cargoes have the potential to mix with the air, resulting in the formation of atmospheres that may be suffocating, poisonous, or flammable for personnel. Furthermore, liquid cargoes have the potential to spread over the surface area, thereby creating a fire risk for personnel and other containers.

It is of paramount importance to ensure the safety of personnel and the port as a whole with regard to Class 1 explosives. The ignition of even a small quantity of cargo spillage has the potential to cause injury or death to personnel.

Class 2.1 flammable gases have the potential to vaporise and cause a vapour cloud explosion. For an explosion to occur, it is necessary for the vapour of the cargo to mix with air and form a cloud. Furthermore, class 2.2 flammable and non-hazardous gases have the potential to create a suffocation hazard for personnel in confined spaces by replacing oxygen in the surrounding environment. Class 2.3 toxic gases have the potential to create a toxic atmosphere by filling the enclosed space or compartment in which they are located.

Class 3 flammable liquids have the potential to induce anaesthetic effects in personnel at high concentrations and may also cause short-term lethal or poisonous effects at severe concentrations. Class 4.1 flammable solids present the least significant risk of combustion and spread, yet they remain a notable hazard due to their rapid combustion characteristics in the event of such occurrences. The spontaneous combustion of Class 4.2 cargoes results in a chemical reaction, thereby increasing the risk of fire. Class 4.3 solids that burn when wet present a significant risk of fire initiation in any water source in the event of their spread.

Class 5.1 oxidising loads have the capacity to alter the atmosphere by emitting oxygen at a level that increases the risk of combustion in the presence of other flammable materials in the event of dispersion. Class 5.2 organic peroxides, which are highly flammable, may cause an uncontrolled fire if they spread. The release of Class 6.1 toxic cargoes may result in significant adverse effects on personnel exposed to their effects, including serious discomfort. The release of infectious substances (Class 6.2) has the potential to cause serious epidemics through the contamination of personnel and their immediate environment.

The dissemination of Class 7 radioactive materials may occur in the form of solid, liquid, or gaseous substances, and the intervention and prevention of this dissemination by personnel can be exceedingly risky and potentially fatal. It is imperative that Class 7 cargoes are stored in designated areas with specific conditions. The aforementioned risks will manifest if the cargoes are released from the port entrances. In the case of Class 8 corrosive cargoes, which encompass both solid and liquid substances, the potential exists for irreversible damage to the skin of personnel. The inhalation of corrosive cargo vapour can result in significant lung damage and, in extreme cases, may prove fatal.

In the context of port gate operations, it is essential to possess accurate and comprehensive information regarding the extent of cargo contamination within dangerous cargo containers. It is of significant importance that these containers enter ports with robust structural integrity, particularly given the heightened risk of dispersion associated with gaseous cargoes. It is of significant importance to ascertain the structural soundness of tank containers during the course of port gate operations, and to conduct a thorough examination of the pertinent documentation to verify that the containers have been duly filled and inspected in accordance with the established legal and regulatory requirements.

3. LITERATURE

In the context of the national and international literature review, the studies that examine issues closely related to the subject matter were examined and explained in brief below.

Zorba (2009), Safety management of dangerous cargoes in international maritime trade: International Maritime Dangerous Goods Transport Standards (IMDG Code) and its applications in Turkey, laid the first foundations for the implementation of dangerous cargoes in Turkey.

Ünal & Usluer (2015) emphasised the importance of dangerous cargo training in Turkish ports in their study on the necessity and importance of dangerous cargo handling training in port enterprises.

Ünal, Güler & İncaz (2016), A study on dangerous cargo operatıons and safety management ın contaıner termınals study describes the dangerous cargo operations carried out in the container terminals of the ports and examines the results of the study on the safety management of dangerous cargo transport in the ports included in the study.

Chu & Lyu (2018), Critical assessment on dangerous goods storage container yard of port: Case study of lpg tank container study, discussed a case study to evaluate the critical storage of dangerous goods storage container using the event tree technique.

Xie, Lu, Wang & Lin, (2021), in a study on research on safety risk, prevention and control in port dangerous goods container yard, found that dangerous cargoes should be stored less and security measures should be increased.

Chen, Cheng, Wang, Ma, Y., & Deng, D. (2023) Multi-objective Planning and Solution of Port Dangerous Cargo Container Yard Location Based on NSGA-II, in their study Multi-objective Planning and Solution of Port Hazardous Cargo Container Yard Location Based on NSGA-II. This study is intended to provide decision support to businesses to increase the handling capacity of dangerous cargo containers and reduce costs.

Yeğin & Yorulmaz (2023) examined the risks that occur in the handling of dangerous cargoes in their study titled 'Fuzzy multi-criteria integrated model examination of the risks related to dangerous cargo operations in ports and the measures to be taken.

Ünal & Alkan (2023), in a study on the approaches of container terminals operating in the Marmara region to dangerous cargo operations and cargo structures, the approaches of container terminals to dangerous cargo operations and the priorities they give to cargo types were examined.

Chen, Cheng, Wang, Xue, Yu, & Deng (2024), Factors analysis and safety risk assessment of port dangerous cargo container yard location selection and constructs a multi-level and multi-dimensional risk assessment index system. AHP is adopted to assign the weights of the evaluation index system, fuzzy comprehensive evaluation rules are proposed, fuzzy matching relationship is established, fuzzy matrix and weight vector are used to calculate the evaluation vector to achieve the quantitative evaluation result, and a risk evaluation method combining AHP and fuzzy comprehensive evaluation is established for the port dangerous cargo container yard.

As evidenced by the above studies, comprehensive research has been conducted on the subject of dangerous cargoes. The studies demonstrate that the focus of risk and security management of dangerous cargoes in ports and terminals is a significant area of concern. This study examines the priorities and approaches of terminals in relation to six criteria identified in the gate operations of those terminals handling containers of dangerous cargo.

4. METHOD

In the course of the research, the 20 container terminals operating in Turkey were invited to contribute their views on the six gate operation priorities that had emerged from the literature review. The questions were posed in the form of a questionnaire, and the resulting data were subjected to comparative analysis. The research method employed was the Analytical Hierarchy Process (AHP). The Analytic Hierarchy Process (AHP) is a decision-making process based on the principle of operating the managerial decision mechanism by assigning relative importance values to decision alternatives and criteria in complex decision problems. Many decision-making problems are characterised by the presence of both objective and subjective elements. AHP is a more realistic solution method than many other decision-making methods because it incorporates both objective and subjective elements into its solution structure. (Timor, 2011)

The Analytic Hierarchy Process (AHP) is a structured technique for organising and analysing complex decisions, based on mathematics and psychology. The AHP was developed by Thomas L. Saaty in the 1970s and allows decision-makers to model a problem in a hierarchical structure and break it down into smaller, more manageable parts, which may include objectives, criteria, sub-criteria and alternatives (Sipahi & Timor, 2010). This method is particularly useful in multi-criteria decision-making (MCDM) contexts, where it facilitates the comparison of various options according to multiple criteria, thus enabling a more comprehensive evaluation of alternatives (Amorocho-Daza et al., 2019; Yazdani-Chamzini et al., 2013; Subramanian & Ramanathan, 2012).

The Analytic Hierarchy Process (AHP) is a decision-making process based on the principle of operating the managerial decision mechanism by assigning relative importance values to decision alternatives and criteria in complex decision problems (Timor, 2011).

The following section outlines the steps that should be followed in this process.

The steps followed in this process are given below:

Step 1. Making a list of objectives

Step 2. Listing the criteria necessary to realise the objectives,

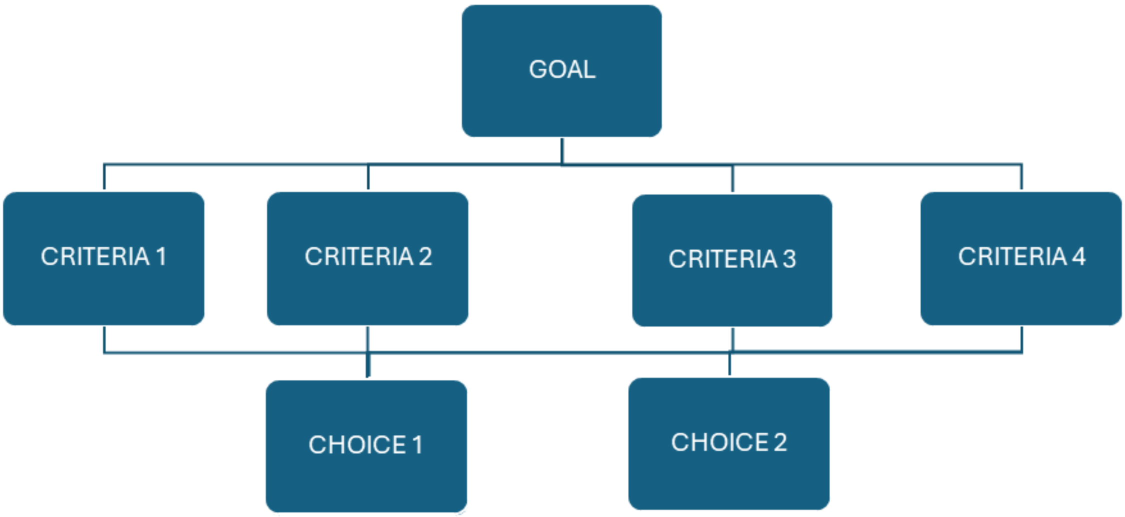
Step 3. Identification of (n) possible decision alternatives for each criterion,

Step 4. Determining the Hierarchical Model.

The Analytic Hierarchy Process (AHP) employs a pairwise comparison methodology, wherein decision-makers assess the relative importance of various criteria and alternatives by contrasting them in pairs. This method facilitates the decision-making process by converting qualitative assessments into quantitative values that can be processed mathematically (Balali et al., 2014; Petroutsatou and Sifiniadis, 2016). The utilisation of pairwise comparisons guarantees the consistency of the decisions made and permits the aggregation of individual preferences into a collective decision (Yazdani-Chamzini et al., 2013; Soam et al., 2023). Moreover, AHP is capable of accommodating both qualitative and quantitative data, rendering it a versatile tool in a multitude of fields, including project management, resource allocation, and risk assessment (Lin et al., 2022; Sirshar et al., 2019).

One of the key benefits of AHP is its capacity to address uncertainty and ambiguity in the decision-making process. While the traditional AHP method is capable of addressing these issues, adaptations such as fuzzy AHP (FAHP) have been developed to enhance its applicability in scenarios where information is incomplete or imprecise (Janjić et al., 2016; Torabi-Kaveh et al., 2016). The incorporation of fuzzy logic into FAHP enables a more accurate representation of the subtleties of human judgement, thereby enhancing the precision of the decision-making process in uncertain contexts (Khademalhoseiny et al., 2017; Cheng, 2013). This adaptability has resulted in its extensive utilisation across a range of industries, including renewable energy project selection, construction risk management and supplier selection (Yazdani-Chamzini et al., 2013; Kurniawan et al., 2022; Ghorbani et al., 2022).

Figure 1**:** Analatic Hierarchy Process



The first step in AHP is the creation of the hierarchical structure. After the creation of the hierarchical structure, the following stages are applied:

- In order to perform the operations in AHP, firstly a 'Comparison Matrix' must be created.

- This matrix is then transformed into a 'Priority Vector'.

- ''Concordance Ratio'' is calculated.

In AHP, relative or absolute measurements are used to obtain pairwise comparisons. According to the information obtained in this way, judgements in AHP are transformed into a 'Comparison Matrix' (Timor, 2011).

A_{ij} represent the pairwise comparison value between the i-th feature and the j-th feature, and a_{ji} represent the pairwise comparison value between the j-th feature and the j-th feature. According to the non-reciprocal property;

$a_{ji} - 1 / a_{ij}$.

The general form of the pairwise comparison matrix is given below.

$$A=\begin{bmatrix} a11 & a12 \ldots a1n \\ a21 & a22 \ldots a2n \\ \ldots & \ldots \;\ldots\; \ldots \\ an1 & an2 \ldots ann \end{bmatrix} = \begin{bmatrix} a11 & a12 \ldots a1n \\ 1/a12 & a22 \ldots a2n \\ \ldots & \ldots \;\ldots\; \ldots \\ 1/an1 & 1/a2 \ldots ann \end{bmatrix}$$

From the pairwise comparison matrix, the priority (eigenvalue vector) W is obtained.

It is denoted by W = (w_1 w_2, ... w_n). Wi is defined as the priority (eigenvalue).

Basic properties of the pairwise comparison matrix:

1. A pairwise comparison matrix is a square matrix of positive values,

2. If the pairwise comparison matrix is fully consistent, the following threshold is satisfied:

$$\sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} aij.ajk = aik \quad (i, j, k = 1, \ldots, n)$$

$$|aij|.\,|ajk| = (wi / wj) . (wj.wk) = (wi / wk) = aik$$

3. If matrix A is fully consistent, all other elements of the matrix can be easily obtained from any row,

4. It is equal to a 2-way combination of n, the total number of comparisons to be made,

5. The eigenvector matrix corresponding to the largest eigenvalue of this matrix is called the weight (priorities vector) in AHP,

5. The diagonal values of matrix A are equal to 1 (Saaty, 2000).

After the creation of the hierarchical structure, the following steps are applied respectively when solving problems with AHP:

Step 1. In order to perform the operations in AHP, a 'Comparison Matrix' must first be created.

Step 2. This matrix is then transformed into a 'Priority Vector'.

Step 3. The 'Concordance Ratio' is calculated (Saaty and Vargas, 1987).

The Consistency Ratio, which shows the consistency between the comparisons, is calculated as follows. Consistency ratio less than 0.1 is called good. For ratios greater than 0.1, re-evaluation should be made (Hafeez, Zhang and Malak, 2002).

Steps to be followed in the calculation of the Compliance Ratio:

Step 1. For each row of the Comparison Matrix, the sum of the weights of the elements in the columns is calculated.

Step 2. The Normalised Matrix is calculated by dividing the element in each column of the Comparison Matrix by the total column weight.

Step 3. The Priority Vector is calculated by averaging each row of the Normalised Matrix.

Step 4. After the Priorities Vector is calculated, the vector obtained is multiplied by the Comparison Matrix given at the beginning, and the All Priorities Matrix, which takes into account the Comparison Matrix, is created.

Step 5. Consistency index is calculated using the following formula:

$CI= (\lambda_{maks} – n) / (n – 1)$

The following formulations are used to calculate the Consistency Ratio (CR):

$CR = CI / RI$

The maximum value between the eigenvalues of a square matrix is expressed by λ_{max}. (To calculate λ_{max}, each element of the All Priorities Matrix is divided by the elements of the Priorities Vector and the new matrix elements are averaged).

RI It represents the Random Value Index and is used in the operations by selecting the appropriate value from the table given (Timor, 2011).

The questionnaires returned from the terminals were evaluated in the package programme named superdecision and the analysis results were obtained. The results obtained are tabulated and presented in detail. The average weights of the priorities given by the terminals to the gate operations are also presented graphically.

5. RESULTS

The initial operation undertaken by dangerous cargo containers upon their entry into a port is that of dangerous cargo gate operations at container terminals. As the containers are closed due to their structure during dangerous cargo gate operations, port personnel are able to perform the requisite gate operations by checking the relevant documentation. Furthermore, an external visual inspection is conducted to ascertain the physical condition of the container. It is not permitted for port personnel to open and examine the interior of the container for reasons pertaining to security.

On 3 March 2015, the 29284th edition of the Official Gazette, prepared by the Ministry of Transport, Maritime Affairs and Communications, was published. This edition contains the 'Regulation on the Transport of Dangerous Goods by Sea', which sets out the rules and procedures for the transportation of dangerous cargo containers by sea. It also covers the gate procedures for road and rail vehicles carrying such containers.

In accordance with the stipulations set forth in this regulation, ships and marine vessels are obliged to submit a document containing comprehensive details about the dangerous cargoes they are transporting at least twenty-four hours prior to entering the port boundaries to the port authority to which the port is connected. This must be done in writing through the relevant personnel. In the event that the duration of the voyage of ships and marine vessels is less than twenty-four hours, the requisite notifications must be made immediately upon departure from the port of departure.

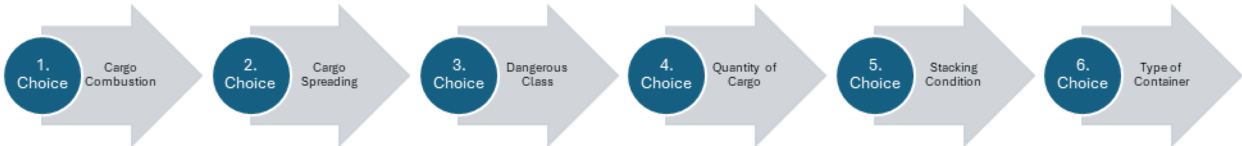
In the notifications, the following information must be provided: the amount of cargo, the stowage status, the packaging types, the degree of combustion if flammable, the amount of cargo to be transported to other ports, the class of dangerous cargoes according to IMDG Code rules, together with the ship arrival petition, the ship notification chart and the dangerous cargo notification chart.

In accordance with the aforementioned regulation, any dangerous cargo arriving by land or rail is required to notify the relevant port authority at least three hours prior to entering the port. The specifics of the notification are defined by the General Directorate of Dangerous Goods and Combined Transport Regulation. In the event that notifications are not submitted or that the submitted notifications do not include the declared information, administrative actions will be taken against the notifiers. Ships and marine vessels that are not notified or that have been incorrectly notified will lose their berthing, departure and passage orders, if any.

Dangerous cargo operations are of significant importance, as they represent the initial stage of the container's journey within the terminal area. In these operations, the requisite container documentation for the entry of the containers, transmitted either by the vehicle drivers or electronically, is subjected to scrutiny. It is of the utmost importance that personnel at the terminal exercise the utmost care during this initial operation. It is imperative that not only the documents be subjected to meticulous scrutiny, but that a visual inspection be conducted with equal care and attention during the gate operations.

A review of the literature on gate operations reveals six key criteria, with the relative importance of these criteria illustrated in Figure 2.

Figure 2: Prioritisation of Criteria in Gate Operation



In the context of gate operations, the primary objective is to prioritise according to the degree of combustion risk posed by the cargo. The level of combustion risk associated with a given dangerous cargo directly correlates with the fire risk posed by that cargo within the terminal area. A fire involving dangerous cargo within the terminal area would present a significant hazard. It is of significant importance to consider the potential for combustion of the dangerous cargo at the terminal entrance, and to implement the necessary precautions in accordance with the identified risks. A fire is a chemical reaction, and the majority of dangerous cargoes can rapidly ignite as a consequence of contact with a heat source and oxygen. The occurrence of a fire involving dangerous cargo represents a significant challenge in terms of firefighting operations.

The second criterion is the cargo spreading. The cargo spreading is a significant risk for liquid and gaseous loads. In the event of the spread of a gas type load, a flammable and toxic atmosphere is formed in the surrounding environment. In the event of liquid spillage, the liquids in question come into contact with the heat sources present in the field, thereby increasing the risk of fire. Furthermore, significant explosions and incidents may occur when dangerous cargoes come into contact with one another, particularly when there is cargo spreading and reactions between cargo classes.

The third criterion pertains to the dangerous class. In the context of dangerous classes, there are certain cargoes that are prohibited from entering the terminals. Such classes are not accepted, given the considerable risk they pose to the safety of the terminal and the fact that their entry is not approved by the port authorities. In particular, cargoes classified as Class 1 and Class 7 are not permitted due to the elevated risks they present. It is imperative that specific security measures be implemented within terminal areas to ensure the safety and security of these cargoes. Accordingly, these cargoes are transported to terminal areas with the express permission of the port authorities.

The fourth criterion is the quantity of cargo. The legal limits for the quantity of cargo vary for each class of dangerous goods. The amount of cargo that can legally be transported is specified in the IMDG and can be referred to if necessary. It is important for terminals to check the legal limits for the amount of cargo. The loading capacity of the existing container and the amount of cargo it can hold are standardised and these limits vary for different container types. It is important for terminals to check that the declared cargo quantities are within the legal limits. It is important for the terminals to check the official documents declared as evidence in this audit and it is important that the documents produced are checked by declaring the weights of the containers.

The fifth criterion is the stacking condition. Dangerous cargoes enter the terminals in sealed standard containers. It is the responsibility of the cargo owner or loader to ensure that the cargo is properly stowed in the container. Failure to do so may result in containers being struck and cargo being damaged during terminal operations. Terminals are not authorised to control the stowage of cargo in containers. Legal regulations have been prepared for the proper stowage of dangerous cargoes and documents are prepared in case of proper stowage by the shipper or cargo owner. These documents should be checked for completeness and compliance with legal requirements and should be allowed to enter the terminal gate.

The final criterion is the type of container. The type of container is contingent upon the class of dangerous cargo being conveyed and is of paramount importance for safety considerations. It is imperative that the container type selected is appropriate for the class of dangerous cargo in question. The lower transportation costs associated with standard containers have consistently prompted shippers and cargo owners to opt for this type of container, given its cost-effectiveness. It is of significant importance to ascertain the type of container that is being transported at the point of entry to the terminal, and to ensure that the container in question has been selected in accordance with the load class.

The questionnaires were verbally presented to the terminals in order to ascertain the criteria pertaining to the dangerous cargo gate operations that had been previously outlined. The responses of 20 terminals were subjected to analysis in the program named Superdecision.

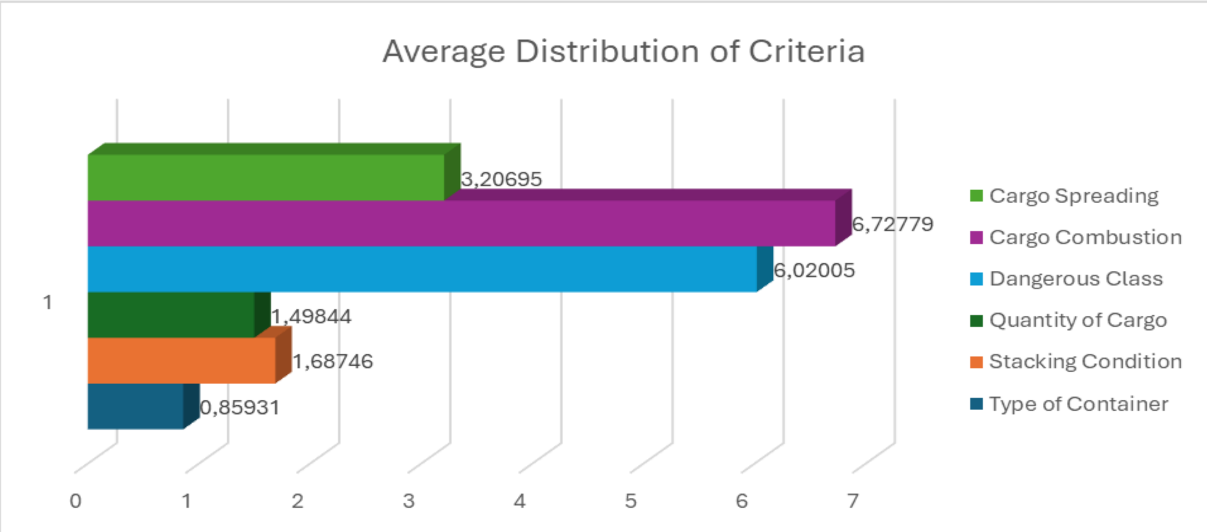
The data obtained after analysing the answers given by the terminals in the Superdecision software are presented in Table 1 below. The table shows the distribution of the order of importance given by each terminal to the criteria for container gate operations. The names of the terminals are code-named and will not be disclosed for reasons of confidentiality.

Table 1: Container Terminal Entrance Operation Criteria Distributions

Ports	Type of Container	Stacking Condition	Quantity of Cargo	Dangerous Class	Cargo Combustion	Cargo Spreading
Port A	0,03145	0,05960	0,01648	0,52376	0,23943	0,12928
Port B	0,03838	0,05846	0,04678	0,43878	0,28661	0,13099
Port C	0,01848	0,05930	0,07768	0,42692	0,26991	0,14771
Port D	0,02495	0,07936	0,04481	0,13906	0,35591	0,35591
Port E	0,03353	0,12578	0,05244	0,30845	0,34480	0,13500
Port F	0,04606	0,03220	0,04141	0,29305	0,42475	0,16253
Port G	0,12165	0,02928	0,01724	0,25058	0,46982	0,11143
Port H	0,03773	0,02694	0,03616	0,20391	0,50102	0,19424
Port I	0,01745	0,08484	0,08484	0,59012	0,15718	0,06557
Port K	0,07046	0,11026	0,17511	0,23490	0,20606	0,20321
Port L	0,05937	0,03280	0,01657	0,13299	0,52599	0,23228
Port M	0,01155	0,09540	0,11965	0,26750	0,37051	0,13539
Port N	0,03699	0,08363	0,12562	0,22803	0,46533	0,06040
Port O	0,08281	0,20351	0,22521	0,35752	0,09379	0,03716
Port P	0,01868	0,07045	0,11601	0,03341	0,26904	0,49241
Port R	0,01934	0,12509	0,04331	0,59756	0,10735	0,10735
Port S	0,01426	0,11617	0,03030	0,26068	0,51350	0,06509
Port T	0,10788	0,15887	0,13164	0,24748	0,31403	0,04010
Port U	0,03154	0,09226	0,04962	0,33751	0,31465	0,17442
Port Z	0,03675	0,04326	0,04756	0,14784	0,49811	0,22648

As can be seen from the table above, terminals prioritise different criteria. It can be seen that the terminals give first priority to the risk of dangerous cargo burning. This is related to the ignition temperature of the cargo and the reaction time to the fire event. The averages of the criteria priorities of the data collected from 20 terminals across Turkey are shown in Figure 3 below.

Figure 3: Distributions of Gate Operation Criteria in Terminal Preferences.



As can be seen from the above distribution, terminals prefer the cargo combustin as the first priority. This first priority is an expected result. Terminals have ranked dangerous cargo classes as second priority. Although this situation should be further behind in the priority ranking of gate operations, the approach of the terminals was different. Terminals ranked the cargo spreading as the third priority. This prioritisation was an expected result. Terminals preferred the stacking condition as the fourth priority. This priority is more important for terminals, while it is in the background in the general evaluation. The fifth priority of the terminals is the quantity of the cargo. While the general evaluation gives priority to this priority, the terminals keep it in the background. The last priority for terminals is the type of container. This priority is an expected preference according to the general evaluation.

In general, when looking at the priorities of the terminals, it can be seen that preferences are made outside the general evaluation. It can also be seen that there are differences of opinion within the terminals themselves on the criteria for gate operations outside the general assessment. Although the instructions and recommendations issued by the international maritime regulatory authorities contain general approaches, it can be seen that ports and terminals have different approaches within themselves. This may be due to different approaches to security management and different security cultures. The fact that ports operate in different regions with different cultures leads personnel to give different priorities to the same type of operation with different approaches.

6. CONCLUSION

Container terminal gate operations are important to the safety and efficiency of the entire terminal. Addressing issues such as cargo congestion, queue management and the integration of automation technologies are essential to optimising these operations. In addition, understanding the economic context and implementing effective management practices can lead to significant improvements in operational efficiency. As the global supply chain continues to evolve, continued research and innovation will be critical to overcoming the challenges faced at container terminal gates.

This study analyses the security management practices of container terminals in Turkey in relation to the entry of dangerous goods. Data obtained through literature review and surveys were analysed using the Analytic Hierarchy Process (AHP) and valuable insights into the security priorities of the terminals were revealed.

The survey results show that terminals consider the 'Cargo Combustion' of dangerous cargoes as the most important safety criterion. This is understandable given the potentially devastating consequences of fires and the flammability of dangerous goods. The 'Cargo Spreading' is also recognised as a major concern by terminals, highlighting in particular the serious dangers posed by the uncontrolled release of gaseous and liquid cargoes.

The study also shows that terminals prioritise the classification of dangerous goods. This is in line with the high risks associated with certain classes of cargo (particularly Class 1 and Class 7) and the need for special safety measures when handling such cargo. 'Stacking Condition' has also emerged as an important factor in the safety assessments of terminals, indicating that improper stowage can lead to cargo damage and potentially dangerous situations.

However, other criteria such as 'quantity of cargo' and 'type of container' appear to have a relatively lower priority in terminal security management practices. This may be explained by the perception that these factors pose less immediate risks or are adequately addressed by existing regulatory frameworks and standard operating procedures.

Overall, this study provides valuable insights into the security management of dangerous cargo gate operations at container terminals in Turkey. The results show differences in the security priorities of the terminals and some deviations from the overall assessment. These differences can be attributed to various factors such as different geographical locations, operational characteristics and security culture. The results of this research have important implications for policy makers, terminal operators and other stakeholders, which can help them to improve existing security protocols and regulations to ensure the safe and secure handling of dangerous cargoes.

Future research could extend the scope of this study by covering a wider range of terminals and comparing the security management practices of dangerous goods transport modes. It would also be useful to include additional factors that may influence security performance (e.g. staff training, contingency plans and use of technology). Such research will contribute to the development of evidence-based strategies and policies to further improve the security and efficiency of dangerous cargo operations at container terminals.

Note: The plain and summary version of this study was presented as a paper at the IBANESS Economics, Business and Management Sciences Congresses Series-Ohrid/Republic of North Macedonia Congress (12/13 October 2024). Paper title: A Study on Operation Priorities in the Entry Operations of Dangerous Cargo Containers into Port Terminals

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