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Liquefied Natural and Petroleum Gas Carriers: An Analysis of the Potential Dangers, Safety Measures and Risk Factors

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المستخلص:

يستخدم الغاز الطبيعي المسال وغاز البترول المسال على نطاق واسع كمصادر طاقة صديقة للبيئة وفعالة للغاية. ومع ذلك، فإن نقل هذه المنتجات عن طريق البحار ينطوي على أخطار متأصلة على البيئة ورفاهية الإنسان. يحقق هذا البحث في المخاطر المحتملة وتدابير السلامة والمتغيرات التي تزيد من احتمالية الضرر المرتبط بتداول الناقلات للغاز الطبيعي المسال والغاز البترولي المسال، حيث تسعى هذه الدراسة أيضًا إلى التحقق من وجهات نظر وأحكام القائمين والعاملين في مجال تداول الغاز الطبيعي المسال وغاز البترول المسال حول المخاطر المحتملة وتدابير السلامة وعوامل الخطورة المرتبطة بسفن الغاز الطبيعي المسال والغاز البترول المسال. وتم إجراء استطلاع على عينة مختلفة مكونة من ١٠٠ شخص من مختلف قطاعات الصناعة. وكشفت النتائج أن غالبية المشاركين أعربوا عن قلقهم بشأن المخاطر المحتملة المرتبطة بنقل الغاز الطبيعي المسال والغاز البترول المسال. ومع ذلك، فقد حافظوا أيضًا على اقتناعهم بأن إجراءات السلامة والبروتوكولات والتدريب والتقدم التكنولوجي الحالية تعتبر فعالة في التخفيف من المخاطر. وأعرب المشاركون عن رضاهم عن مستوى الشفافية والتواصل والعمل الجماعي والمعايير المتخذة في الصناعة، فضلاً عن كفاية عمليات التأمين والضمانات. وتشير نتائج الدراسة إلى أن تصور الجموع العام لنقل الغاز الطبيعي المسال والغاز البترول المسال كان إيجابيًا في الغالب ومتوافقًا مع تدابير السلامة التي تم وضعها.

Abstract

Liquefied natural gas (LNAG) and liquefied petroleum gas (LPG) are extensively used as environmentally friendly and highly efficient energy sources. Nevertheless, the movement of goods by water has inherent risks to both the environment and human well-being. This study examines the potential hazards, safety precautions, and risk factors related with the transportation of Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG) carriers. This research also aims to examine the perspectives and opinions of individuals working in the LNG and LPG business on the possible hazards, safety precautions, and risk elements related with LNG and LPG carriers. A survey was performed among a heterogeneous sample of 100 individuals from various areas of the business.The analysis reveals that a huge part of individuals expresses problem approximately ability risks associated with LNG and LPG transportation. While self belief in present day safety measures is extraordinary, there are dissenting evaluations, suggesting regions for improvement. Safety protocols, emergency reaction approaches, and the qualifications of personnel also showcase numerous perceptions. Environmental impact emerges as a chief

challenge, highlighting the need for similarly research. Transparency and communique within the industry show blended responses, emphasizing potential regions for enhancement. Participants generally well known the fantastic impact of technological advancements, but neutrality suggests various views. Insurance and liability mechanisms are perceived positively, however dissenting critiques underscore areas of skepticism. International cooperation and requirements garner combined responses, indicating ability possibilities for global collaboration. The take a look at concludes by exploring the alignment between public notion and actual protection measures. While a massive component is glad, dissenting and impartial responses indicate room for development in aligning public belief with enterprise protection realities. Overall, this research contributes valuable insights for stakeholders, guiding future safety enhancements and coverage concerns in the LNG and LPG transportation area.

Keywords: LNG, LPG, transportation, safety, risk, perception, attitude, survey.

1. INTRODUCTION

Liquefied natural gas (LNG) and liquefied petroleum gas (LPG) are substantial sources of energy that are transported on a global scale using specialised carriers. The marine industry is witnessing a growing prominence of liquefied gas utilisation on account of its potential to serve as a more environmentally friendly and effective alternative to conventional fuels (Pitblado and Woodward, 2011). The transportation of these gases has inherent dangers; thus, it is critical to understand the safety standards and potential dangers associated with their transportation. Dedicated boats are utilised to transport LNG and LPG while maintaining the gases in a liquefied state at exact temperature and pressure parameters. These boats play a vital role in enabling the global transit of petroleum products and natural gas. However, there are inherent dangers associated with the shipping of LNG and LPG, including the potential for leaks, burns, and explosions. It is critical to ensure the security of these carriers to prevent accidents and preserve lives and the environment.

A number of countries, including Japan, South Korea, and some European countries, lack the capability to acquire undersea or terrestrial pipelines in order to tap the natural gas reserves of their neighbouring countries. Given the continuing Ukraine War (2022) and the situation concerning fixed gas connections and the oppressive Russian government, which has affected practically every EU member state (Khujadze and Janužytė, 2023), the crucial importance of LNG transit becomes evident. Comparable conditions pertain to the need for LPG; certain enterprises are significantly apprehensive regarding the accessibility of supplies via maritime transportation. Constantly, ensuring the safety of liquefied gas transport at sea has been of the utmost importance. Precautions are implemented to mitigate the effect of any incidents that do transpire and to increase the probability of their occurrence by decreasing their probability. By adhering to the most stringent industry standards for risk assessment and management, these safeguards supplement technological measures that are consistent with crew training requirements. Due to the Intentional Maritime Organization's (IMO) attention on it in a number of gas code issues and professional organisations, important players are quite informed (such as SIGTTO or OCIMF). The likelihood of an accident or incident is also never zero. Engineers must thus possess a comprehensive comprehension of past incidents in order to devise effective responses (Gucma & Mou, 2022).

Questionnaire about potential dangers, preventative measures, and risk factors associated with LNG and LPG transporters is the objective of this research. This study has the potential to offer valuable insights into the safety of LNG and LPG transportation for regulatory authorities and stakeholders in the energy and transportation industries by examining these facets.

2. RESEARCH OBJECTIVE

This research aims to:

1) Examine the potential hazards, precautionary measures, and factors that contribute to the risk of injury in the transportation of LNG and LPG carriers
2) Examine the perspectives and assessments of persons working in the LNG and LPG business about the possible hazards, safety precautions, and risk factors linked to LNG and LPG vessels.

3. RESEARCH QUESTIONS

1) What are the perceived risks connected with the transportation of LNG and LPG carriers, as indicated by those employed in the LNG and LPG industries?
2) What safety measures do staff often use while transporting LNG and LPG carriers to reduce possible risks and hazards?
3) Which elements have industry specialists recognized as important contributors to the risk of harm in the transportation of LNG and LPG carriers?

4. REVIEW OF LITERATURE

4.1. LNG/LPG Safety

In contrast to other industries involved in petroleum and processing, the LNG industry has an exceptional safety record. This is demonstrated by the rare mistakes and catastrophes that have transpired since the first LNG facility in West Virginia was established in 1912. Foss (2003) highlighted several aspects that contribute to the safety performance of the LNG industry in his research. An element contributing to this is the sector's dedication to ensuring secure operations, a goal that has been accomplished via technical and operational progress. There are several facets to technological and operational advancements, including the engineering discipline that supports LNG facilities, operational processes, and employee technical expertise. In addition, the technology and processes have been designed with the physical and chemical properties of LNG, along with the related risks and dangers, in mind. The stringent requirements and restrictions that are implemented within the LNG sector (Forte and Ruf, 2017).

The absence of intolerable levels of risk or severe bodily injury constitutes safety. Facilities and carriers engaged in the transportation and storage of LNG and LPG are subject to various dangers that have the capacity to impact their operations (Narayanasamy et al., 2018). A hazard is a physical situation or situation that, whether present alone or in combination, is capable of causing harm to human life, property, the environment, or property damage. Risk avoidance and mitigation strategies are implemented across the whole LNG value chain. Risk prevention techniques are used with the intention of proactively averting the occurrence of hazards and its adverse effects, whilst risk mitigation tactics are utilised to lessen the severity of hazards. Risk can be conceptualised as the product of the probability of an unfavourable incident transpiring and the gravity of its

repercussions, or as the amalgamation of the probability of its transpiration and the scale of its potential affects (Wang and Trbojevic, 2007).

Despite the implementation of many safety protocols, incidents of an unanticipated nature may occur throughout the LNG/LPG value chain. An incident that transpires within a segment of the LNG/LPG value chain has the potential to impact other segments as well. For instance, an incident or mishap associated with the functioning of LNG carriers when loading or unloading LNG might potentially impact the LNG storage tanks through the pipelines (Briouig, 2014). One approach to identify operational hazards associated with LNG/LPG carriers is to employ a brainstorming process that examines the safety characteristics of the various components of the LNG/LPG value chain. Five primary operations comprise the LNG value chain: production of natural gas, transportation of LNG, liquefaction of natural gas, re-gasification, and distribution. In order to facilitate the uninterrupted flow of natural gas from the well to the liquefaction plant, a number of procedures must be executed. These encompass the activities of drilling and completion of a natural gas well, casing the well bore for reinforcement, evaluating the formation's pressure and temperature, and installing the necessary equipment (Naturalgas Online, 2010).

By transforming natural gas into a liquid state, liquefaction plants enable the transfer of LNG via LNG carriers. The liquefaction facility has a range of safety protocols, such as fire alarm systems, secondary containment of LNG storage tanks to ensure gas separation in the event of an accident, and automated shutdown mechanisms. Carriers for LNG and LPG are utilised to move fuel between several containment tanks. The safety risks linked to the transportation of LNG and LPG are escalating as a result of the expanding distribution and demand for these fuels, a development that is garnering more and more scholarly interest (Nwaoha et al., 2016).

To safeguard the LNG, LNG carriers are outfitted with double-hull systems and containment systems comprising over four layers, respectively, to limit the possibility of gas leakage. Vaporizers are utilised in the regasification process to transform LNG from its liquid state to gaseous state. For the purpose of preventing environmental contamination and safeguarding workers, rigorous compliance with occupational safety and health regulations (HSE) and standards is upheld (Varagka, 2015). Through pipelines, the natural gas generated by the re-gasification process is transported to ultimate consumers. To guarantee the integrity of natural gas transmission, regular checks are conducted on these pipes. Pipeline inspection serves to disclose the safety status of the pipelines, so enabling timely intervention or correction in the case of any complications. An assortment of internal procedures, including ultrasonic, eddy current, geometry/calliper, and magnetic flux leakage, are utilised to check the pipeline. Furthermore, diver inspection, remote-operated towing vehicles (ROTVs), and remote-operated vehicles (ROVs) are all examples of exterior inspection techniques (Nwaoha et al., 2016).

4.2. LNG & LPG Hazards

Combustibility of liquid gas vapours is the greatest danger. However, the health implications of a medicine are of equal importance. Hydrogen, biodiesel, liquefied natural gas (LNG), methanol, and ethanol are all considered viable alternatives to traditional fuels. LNG is utilised to propel LNG carrier boats; due to its higher hydrogen-to-carbon ratio compared to traditional marine fuels, this fuel type effectively mitigates NOx and CO2 emissions. LPG, an ecologically acceptable

replacement for petroleum in cars, is a gasohol blend composed of butane and propane. By employing steam-methane reform and electrolysis, it is possible to extract hydrogen from various substances in order to generate an emission-free propellant. The purpose of ethanol, a gasoline alternative derived from corn and sugarcane, was to serve as a replacement for petroleum. Despite having unique physicochemical properties, these fuels emit fewer pollutants due to their simple molecular structures as compared to traditional fuels. Significantly lower particulate and hydrocarbon emissions result from the use of these fuels. The properties of diesel fuel and alternative fuels that were investigated in this study are summarised in Table 2. A comparison of LNG delivered in bulk by ship with LPG, gasoline, and VCM demonstrates if LNG is extremely hazardous cargo (Table 1). (Djermouni and Ouadha, 2021).

Table (1): Comparison of LNG with LPG, VCM and gasoline (Djermouni and Ouadha, 2021).

Characteristics	LNG	LPG
Temperature of the flame (K at 100 kPa)	2233	2243.15
Limits on flammability (vol.% air)	4–16	2.2-9.5
Evaporation heat (kJ/kg)	479	428
Molar Mass (kg/kmol)	18	51
Boiling point °C	-162	-40
The temperature of autoignition in Kelvin	810	727.6-783.15
LFL % (in air)	5	2
Flash point °C	-175	-105
UFL % (in air)	15	9
Value of net thermal (MJ/kg)	46–50.2	46.3

Liquid gas vapors' flammability is the major risk. the toxicity, carcinogenicity, oxygen shortage, and other unique characteristics of chemicals constitute health dangers. The issue with liquefied gases, specifically LNG, is the incredibly low temperature. Comparison of LNG with LPG, gasoline, and VCM, transported in bulk by ship, reveals if LNG is very dangerous cargo (Table 1) (Starosta, 2007).

4.3. 2019 Kerch Strait liquified gas tanker fire

When two ships, Kandy and Maestro, caught fire while transporting liquefied gas from one vessel to another in the Kerch Strait on January 21, 2019, it resulted in a significant crisis. During the event, six crew members—including Libyan, Turkish, and Indian sailors—went missing, and fourteen people perished. The Russian Navy was able to save twelve men who dove into the ocean. Maestro had fifteen crew members, whereas Kandy had seventeen crew members. 4,500 metric tons of gasoline were being carried by both ships at the time of the accident.

Turkish ships Maestro and Kandy, flying the Tanzanian flag, were involved in the ship-to-ship fuel transfer that culminated in the fire explosion and spread to both ships (Bosneagu, 2022). The effort to put out the fire was spearheaded by the Russian multipurpose salvage vessel Spasatel Demidov;

however, despite dousing both ships, the fire raged on for five more days. Ten ships, one of which was a Soviet rescue ship, participated in the crew rescue mission (Bosneagu, 2022).

4.4. Risk Assessment of the Gas Carriers

Accidents involving flammable goods, such as LNG, can have disastrous effects, including fire and explosions. Asset managers are obligated to design safety measures in compliance with regulatory regulations in order to mitigate such effects. Risk analysis has become a very effective tool for this purpose in safety-critical sectors to help guide choices on asset design, production, installation, operation and maintenance (O&M), and decommissioning (Animah & Shafiee, 2020).

Risk analysis is a relatively new topic, having only been studied scientifically for roughly 30 to 40 years, according to Aven (2016). Although a relatively new field of study, risk analysis has been used in a variety of fields, including medicine, engineering, transportation, security, and the military, as well as social and legal issues, to identify the best possible technological, safety, economic, and environmental solutions (Aven, 2016). Risk analysis may have its origins in the nuclear business of the past (Pasman, 2015).

The first probabilistic risk assessment (PRA) approach was created for a nuclear power plant in the 1970s, according to information from the United States Regulatory Commission, and several more techniques and tools have since been created. In order to help decision-makers continually handle operational, safety, economic, and environmental concerns in safety-critical sectors, Villa et al. (2016) highlighted that risk analysis methodologies are transitioning from conventional approaches to more dynamic ones.

4.5. Previous studies

Multiple scholars have contributed to the enhancement of safety measures for LNG/LPG carrier operations through the use of risk assessments. Significant volumes of LNG/LPG or its vapour emission are the principal safety threat for LNG/LPG carriers (Crolius et al., 2021). It is imperative to quantify and mitigate the hazards associated with LNG/LPG, including potential injury to human life, damage to carrier systems, and environmental hazards. A quantitative risk assessment approach was implemented on a generic LNG/LPG carrier using the formal safety assessment (FSA) paradigm (Vanem et al., 2008). The FSA determined the consequences of a collision, grounding, contact, fire, explosion, or loading or unloading of LNG or LPG carriers using Event Tree Analysis (ETA). The idea of As Low as Reasonably Practical (ALARP) identified the greatest potential for collisions. The dangers connected with LNG carrier systems and LNG terminals have been investigated qualitatively and quantitatively by a number of studies. Pitblado et al. (2004), Östvik et al. (2005), Kim et al. (2005), Bubbico et al. (2009), Moon et al. (2009), and Nwaoha et al. (2009) have all contributed to these investigations (2011a, 2012b, 2013). In their study, Bublico et al. conducted a preliminary risk assessment of LNG/LPG vessels approaching the Panigaglia maritime port (2009).

Intentional damage to the containment systems of the LNG tankers due to terrorism caused pool fires. The analysis of the results indicated that harmful thermal consequences were anticipated within a 700–1500 m radius in the region under examination. The impacts of both the residential population and the anchoring were negligible. In a similar vein, Pitblado et al. (2004) examined the potential hazards and repercussions associated with inadvertent malfunctions, such as terrorist

assaults, that may occur on LNG vessels at an ordinary LNG terminal in the United States. The research undertaken by Kim et al. (2005) involved the application of fault tree analysis (FTA) to evaluate the quantitative risk associated with the onshore LNG storage tank in Korea. The study determined that loading and unloading LNG carriers constituted one of the six potential disaster scenarios that may lead to an LNG spill from the onshore LNG storage tank in Korea. A number of FTA diagrams were generated for the six accident categories that were identified, and the failure probability of each were evaluated. Additionally, a study conducted by Stvik et al. (2005) elaborated on the utilisation of a qualitative risk assessment methodology to compute the potential dangers linked to the 138,000 m3 membrane-type LNG carriers presently under construction by Navantia. During the process of risk identification and estimation, many operating stages of LNG tankers were considered.

Moon et al. (2009) conducted research that underscored the significance of risk assessment in evaluating various gas turbine propulsion system designs for LNG carriers. The primary objective was to identify potential hazards associated with each design and ascertain the primary contributors to these hazards. Further investigation was conducted into the origins of gas discharge, with a particular focus on the novel attributes of gas turbine propulsion systems, in order to identify potential remedies for mitigating the hazards and causes of gas emissions. Nwaoha et al. (2011a) conducted a probabilistic risk assessment (PRA) on LNG carrier systems utilising an FTA. Utilizing the FSA methodology, the research presents a novel fuzzy evidential reasoning (FER) model to handle the failure mode uncertainty of the LNG containment system and transfer arm. Suggested in the work by Nwaoha et al. (2013) are sophisticated computational techniques for dealing with unpredictable conditions. A risk-based evaluation of LNG carrier hazards was conducted in this study utilising a combination of FER and a risk matrix.

5. METHODOLOGY

A mixed-methods approach was utilized in this study to obtain a comprehensive understanding of the potential hazards, safety measures, and risk factors associated with the transportation of these gases. This approach incorporated both quantitative and qualitative methods.

5.1. Data Collection

The data collection procedure proceeded with the distribution of a **Likert scale questionnaire** to a sample of **100 individuals** who were employed in the transportation and energy sectors (Appendix 1). The questionnaire was created to evaluate the participants' perspectives of the possible hazards, safety precautions, and risk factors linked to LNG and LPG transporters. The participants were chosen based on their proficiency and background in the industry, guaranteeing a thorough comprehension of the topic. In addition, a thorough examination of relevant literature and case studies was conducted to get qualitative perspectives on the safety of LNG and LPG transporters.

5.2. Sample Size

The survey sample comprises 100 individuals who are employed in the transportation and energy sectors. The current sample size is deemed sufficient for capturing a wide array of viewpoints and experiences pertaining to the transportation of LNG and LPG. The participants include of experts engaged in the operation and regulation of LNG and LPG carriers, together with those with knowledge in the safety and risk management of these specialized vessels.

5.3. Data Analysis

A statistical analysis was conducted on the data acquired from the Likert scale questionnaire with the purpose of identifying trends and patterns in the viewpoints of the participants. Software applications, including SPSS (Statistical Package for the Social Sciences), were utilised to process the quantitative data in order to provide descriptive statistics and inferential analyses. Thematic analysis was used to the qualitative data obtained from the literature review and case studies with the purpose of identifying recurrent patterns and obtaining significant insights into the safety of LNG and LPG carriers.

5.4. Ethical Consideration

The participants were provided with informed consent documents that detailed the aims of the study, the intended use of their responses, and their rights as subjects of research. Thorough precautions were used to ensure the preservation of confidentiality and anonymity. The collected data will be utilised solely for the intended purposes of this research. In addition, to protect the rights and welfare of the participants, the research adheres rigorously to ethical guidelines and standards set out by regulatory bodies and pertinent institutional review boards. Furthermore, the study focuses increased importance on guaranteeing the ethical management of any confidential data obtained throughout the inquiry. Every potential conflict of interest has been duly disclosed, and the research has been conducted in an entirely transparent and truthful manner.

6. RESULTS AND DISCUSSION

6.1 An Examination of the Questionnaire

A) Age

Table 2. Age of participants.

Age	Frequency	Percent (%)
Less than 25 years old	5	5
25-35 years old	35	35
36-45 years old	40	40
Above 45 years old	20	20
Total	100	100

The age distribution mentioned inside the furnished information offers treasured insights into the demographic composition of the surveyed members, shedding light on the generational perspectives contributing to the observe on LNG and LPG transportation.

The largest cohort within the sample is individuals aged between 36 and 45 years, constituting forty% of the members. This age organization possibly represents specialists with a massive amount of revel in and know-how, doubtlessly presenting a pro and nicely-knowledgeable attitude on the situation depend. Their insights can be shaped through a aggregate of early-career experiences and a extra mature information of enterprise dynamics.

The 25-35 age organization accommodates 35% of the sample, representing a large part of mid-profession professionals. This demographic can also bring a stability of contemporary insights, having skilled the evolution of enterprise practices and technology at some stage in their careers.

Participants above 45 years vintage make up 20% of the pattern, representing a set with significant revel in and doubtlessly imparting historic context and insights into the long-time period adjustments in the enterprise.

The age organization much less than 25 years old, constituting five%, represents the perspectives of early-career experts. While a smaller cohort, their inclusion is essential for capturing sparkling viewpoints and expertise the concerns and expectancies of the rising group of workers within the subject.

In conclusion, the age distribution inside the take a look at reflects a numerous representation of experts across exceptional levels in their careers. This range in age companies enriches the study by way of incorporating numerous perspectives shaped by way of unique profession ranges, reports, and ancient contexts. It highlights the want for a comprehensive information of generational dynamics within the enterprise, spotting that each age institution can also make contributions precise insights to discussions surrounding LNG and LPG transportation.

B) Gender

Table 3. Gender of participants.

Gender	Frequency	Percent (%)
Male	80	80
Female	20	20
Total	100	100

The gender distribution presented in the provided data indicates the representation of male and female participants within the surveyed population. This categorization is essential for understanding the diversity of perspectives and experiences brought to the study on LNG and LPG transportation.

The majority of participants, 80%, identify as male. This imbalance in gender representation is a notable aspect of the sample and raises considerations about the potential impact on the study's findings. It underscores the importance of promoting greater gender diversity and inclusivity in future research endeavors within the energy and transportation sectors.

The female representation at 20% highlights the presence of women in the field, albeit in a minority. Recognizing and amplifying the voices of women in industries traditionally dominated by men is crucial for fostering diversity of thought and experience. The perspectives of female professionals may bring unique insights and considerations to the forefront, enhancing the overall richness of the study.

In conclusion, while the gender distribution in this study may reflect existing gender imbalances within certain industries, it also emphasizes the need for concerted efforts to promote inclusivity

and diversity in research samples. Future studies should strive for more balanced gender representation to ensure a more comprehensive understanding of perspectives and challenges within the context of LNG and LPG transportation.

C) Level of Education

Table 4. Level of Education.

Level of Education	Frequency	Percent (%)
High school or equivalent	6	6
Bachelor's degree	24	24
Master's degree	40	40
Doctorate's degree	20	20
Total	100	100

The breakdown of individuals' stage of education within the provided records elucidates the academic qualifications of the surveyed populace. This categorization is instrumental in comprehending how people with varying instructional backgrounds understand and have interaction with the difficulty matter related to LNG and LPG transportation.

The largest organization in the pattern accommodates people with a Master's diploma, representing forty% of the individuals. This indicates a sizable proportion of individuals who have pursued superior schooling, potentially bringing a deeper expertise of the technical, environmental, and safety elements associated with LNG and LPG transportation. Their perspectives may be knowledgeable by way of specialized know-how received through postgraduate research.

Bachelor's diploma holders constitute 24% of the sample, presenting a good sized representation of specialists with foundational academic qualifications. This group in all likelihood brings a diverse set of abilties and understanding, contributing to a well-rounded view of the challenge depend. The inclusion of participants with a excessive school or equal education (6%) acknowledges those with sensible industry revel in who may also offer particular insights based on their fingers-on involvement.

Participants with Doctorate's ranges make up 20% of the pattern, reflecting a great presence of people with the best level of academic achievement. This subgroup can also contribute a specialized and research-oriented attitude, including depth to the overall analysis of LNG and LPG transportation-associated problems.

In summary, the educational distribution amongst participants famous a diverse and well-balanced illustration of professionals with varying levels of instructional attainment. This variety complements the breadth of perspectives in the study, encompassing insights from people with specific educational backgrounds and areas of understanding. Understanding this range is crucial for interpreting the nuanced responses to the survey questions, because it permits for a extra comprehensive knowledge of the way schooling impacts perceptions in the context of LNG and LPG transportation.

D) Current occupation

Table 5. Current occupation.

Occupation	Frequency	Percent (%)
Energy industry professional	45	45
Transportation industry professional	30	30
Regulatory authority representative	15	15
Other	10	10
Total	100	100

The breakdown of player occupations within the provided records furnishes a complete know-how of the various professional backgrounds contributing to the survey. This categorization enables a nuanced analysis of the way people from diverse sectors and roles in the industry perceive and respond to the have a look at's attention on LNG and LPG transportation.

The preeminent class is Energy Industry Professionals, representing 45% of the surveyed populace. This widespread representation underscores the significance of perspectives from the ones directly engaged inside the electricity region. Their insights, fashioned by means of arms-on enjoy and enterprise-unique expertise, possibly preserve large weight in evaluating the protection measures, dangers, and precautionary components related to LNG and LPG transportation.

The Transportation Industry Professionals class, comprising 30% of the sample, brings a crucial angle to the take a look at. These people, with their direct involvement within the transportation region, contribute treasured insights into the operational intricacies and challenges faced within the real motion of LNG and LPG.

The inclusion of Regulatory Authority Representatives at 15% guarantees a regulatory perspective within the study. Their presence is critical for knowledge how industry regulations, requirements, and compliance elements have an effect on perceptions of safety and hazard control in LNG and LPG transportation

The "Other" category, representing 10%, provides a layer of variety, acknowledging experts with roles outside the explicitly referred to sectors. This inclusivity broadens the scope of the have a look at, shooting insights from a variety of roles that may have indirect but sizeable connections to the challenge count number.

In summary, the occupational distribution reflects a properly-balanced and diverse illustration of specialists with varied understanding and duties in the electricity and transportation industries. This variety enhances the richness of the records, imparting a holistic view of perceptions and attitudes toward LNG and LPG transportation from multiple vantage points. Understanding these professional backgrounds is pivotal for interpreting and making use of the have a look at's findings correctly across one of a kind aspects of the industry.

E) Years of experience

Table 6. Years of experience.

Years of experience	Frequency	Percent (%)
Less than 6 years	14	14
6-10	26	26
11-20	45	45
More than 20	15	15
Total	100	100.0

The provided records on years of revel in within a positive domain presents a clear distribution of the surveyed population, providing insights into the professional tenure of the members. The frequency distribution illustrates the variety of enjoy stages within the pattern, offering a precious context for deciphering different survey responses.

Notably, the majority of members fall in the mid-variety of expert enjoy, with 45% reporting 11 to twenty years of revel in. This suggests a substantial portion of the pattern with a large amount of time spent in their respective fields. It shows that a full-size variety of respondents own a wealth of knowledge and information, potentially influencing their perspectives and responses to questions related to the difficulty be counted.

The distribution additionally highlights a balanced representation across distinct revel in brackets, which includes those with much less than 6 years (14%) and those with 6 to 10 years (26%). This blend guarantees a diverse variety of insights, incorporating the views of each early-career experts and those who have had a more considerable exposure to the sphere.

The inclusion of a class for individuals with extra than two decades of enjoy (15%) recognizes the precious contributions of seasoned professionals who carry a wealth of enterprise know-how and ancient context to the observe. Their perspectives can offer unique insights into the evolution of practices and modifications in the industry over an prolonged duration**.**

6.2. Questionnaire Questions

Table 7. Results of questionnaire questions.

	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	**I am concerned about the potential dangers associated with the transportation of LNG and LPG.**	20%	40%	16.7%	13.3%	10%
2	**I believe that current safety measures for LNG and LPG carriers are effective in mitigating potential risks.**	30%	40%	13.3%	10%	6.7%
3	**Safety protocols and emergency response procedures for LNG and LPG carriers are adequate.**	20%	43.3%	20%	3.3%	13.3%
4	**I believe that the training and qualifications of personnel involved in the operation of LNG and LPG carriers are sufficient to ensure safety.**	13.3%	50%	26.7%	6.7%	3.3%
5	**The potential environmental impact of LNG and LPG transportation is a major concern.**	13.3%	46.7%	30%	6.7%	3.3%
6	**I am satisfied with the level of transparency and communication regarding the safety of LNG and LPG carriers within the industry.**	23.3%	43.3%	3.3%	16.7%	13.3%
7	**I believe that technological advancements have significantly improved the safety of LNG and LPG carriers.**	16.7%	40%	20%	10%	13.3%
8	**I feel that the potential risks associated with LNG and LPG carriers are adequately covered by insurance and liability mechanisms.**	16.7%	36.7%	23.3%	13.3%	10%
9	**I am satisfied with the level of international cooperation and standards in place for the safety of LNG and LPG carriers.**	10%	46.7%	13.3%	16.7%	13.3%
10	**I believe that the public perception of LNG and LPG transportation accurately reflects the actual safety measures in place.**	13.3%	33.3%	23.3%	16.7%	13.3%

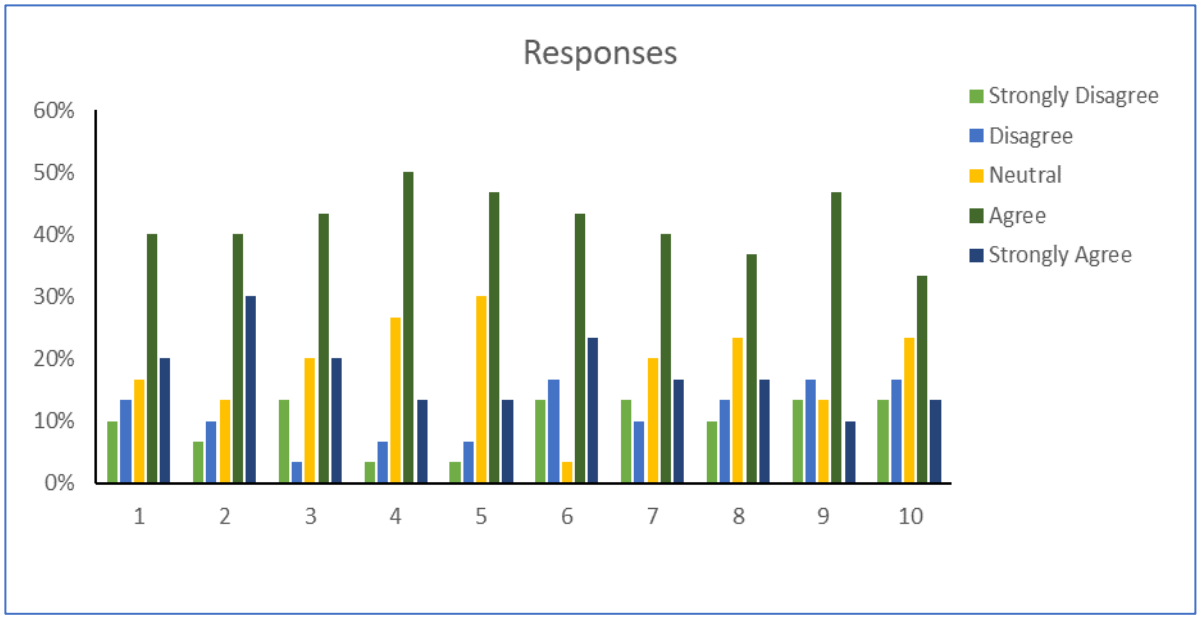

Figure 1. Participants Responses

The aim of this study is to investigate the capability hazards, precautionary measures, and danger factors related to the transportation of LNG and LPG. The individuals had been supplied with a series of statements, and their responses had been categorised into five stages: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. Each class's percentage become calculated primarily based at the responses to provide an insightful analysis of the perceptions inside the sample.

The first query examined the members' concerns about the ability risks of LNG and LPG transportation. Notably, forty% of respondents agreed, indicating a giant level of challenge, at the same time as 20% strongly agreed. This suggests a heightened awareness and acknowledgment of the capability risks associated with the shipping of these gases.

Moving on to the effectiveness of contemporary protection measures, 70% (30% Strongly Agree + 40% Agree) of contributors expressed confidence in the present protection protocols for LNG and LPG providers. However, it's far noteworthy that 16.7% disagreed or strongly disagreed, highlighting a portion of the sample which could understand inadequacies inside the present day safety measures.

Concerning protection protocols and emergency response tactics, 63.3% of individuals (20% Strongly Agree + forty three.3% Agree) taken into consideration them adequate. The presence of a neutral response at 20% suggests a part of the pattern remains not sure or neutral in this matter.

The qualifications of personnel worried within the operation of LNG and LPG carriers had been typically perceived definitely, with 50% agreeing that the training and qualifications are sufficient

for making sure safety. However, it's miles critical to word the ten% who strongly disagreed or disagreed, indicating some skepticism inside the sample.

The potential environmental effect of LNG and LPG transportation emerged as a major concern for forty six.7% of members, signaling a considerable stage of apprehension in the pattern. Moreover, 30% expressed neutrality, suggesting a need for in addition investigation into public sentiment in this element.

Transparency and communication in the enterprise acquired combined responses. While 43.Three% agreed and 23.3% were impartial, 30% expressed dissatisfaction. This indicates a capacity place for development in terms of information dissemination and communication techniques.

Technological advancements were generally perceived undoubtedly, with 56.7% (16.7% Strongly Agree + forty% Agree) expressing notion in their advantageous effect on protection. However, it's far vital to address the 23.Three% who have been neutral, likely indicating a lack of consensus or data in this subject matter.

Regarding insurance and liability mechanisms, fifty three.Four% (sixteen.7% Strongly Agree + 36.7% Agree) believed that capacity risks are competently blanketed. However, the 23.Three% who disagreed or strongly disagreed imply a subset of individuals with reservations about the present day coverage and liability measures in place.

International cooperation and standards for protection garnered a effective reaction from 46.7% of individuals. However, the 16.7% who disagreed and 13.3% who had been neutral highlight potential areas in which international collaboration and standardization can be more desirable.

Finally, the look at explored the alignment between public belief and actual protection measures. Notably, forty six.6% expressed pleasure or settlement, but the 30% who disagreed or had been impartial suggest room for improvement in aligning public belief with the industry's safety reality.

In end, this analysis gives a complete evaluate of the participants' perceptions on diverse aspects of LNG and LPG transportation protection. The findings highlight areas of consensus, as well as points of competition and uncertainty, imparting precious insights for stakeholders in the enterprise to address worries and give a boost to protection measures.
The desk supplied herein encapsulates the responses accumulated via a meticulous survey designed to attain a profound understanding of perceptions surrounding the transportation of Liquified Natural Gas (LNG) and Liquified Petroleum Gas (LPG). The overarching goal of this examine is to delve into the potential dangers, precautionary measures, and danger elements related to the shipping of those critical electricity resources. By scrutinizing participants' attitudes and evaluations, we aim to get to the bottom of the intricacies of their worries, ideals, and checks touching on the protection protocols, environmental influences, and average safety landscape related to LNG and LPG carriers.

In pursuit of this objective, the survey administered a sequence of ten questions, each addressing awesome aspects of the transportation technique. The responses have been meticulously categorized into 5 tiers, starting from Strongly Agree to Strongly Disagree, presenting a nuanced and unique exploration of members' views. Through this systematic approach, our have a look at endeavors to make a contribution valuable insights that can tell stakeholders within the LNG and LPG transportation enterprise, fostering a much better and responsive protection framework.

The principal recognition of the studies lies in unraveling the nuanced tapestry of perceptions in the surveyed cohort, losing mild on regions of consensus, divergence, and capacity areas for development. As we navigate thru the tabulated facts, we purpose to determine patterns, identify key tendencies, and offer a complete understanding of the triumphing sentiments surrounding protection measures, environmental issues, technological advancements, and global cooperation within the realm of LNG and LPG transportation.

By aligning player responses with the wider goal of scrutinizing dangers, precautionary measures, and risk elements, this table serves as a crucial device in unlocking insights that may guide destiny safety improvements and policy considerations. The observe aspires to make contributions no longer only to the instructional discourse but also to the sensible evolution of protection practices within the LNG and LPG transportation industry, ultimately promoting a safer and greater sustainable destiny for the worldwide energy landscape.

7. CONCLUSION

In conclusion, the complete evaluation of player responses inside the presented table gives precious insights into the perceptions surrounding the transportation of Liquified Natural Gas (LNG) and Liquified Petroleum Gas (LPG). The overarching purpose of this look at become to examine ability risks, precautionary measures, and danger factors related to those vital energy sources' transport.

The findings screen a nuanced panorama of views inside the surveyed cohort. While a vast portion of participants expresses concerns approximately ability dangers related to LNG and LPG transportation, there is a widespread level of self-belief in contemporary safety measures. However, it's miles noteworthy that positive respondents harbor reservations and uncertainties, especially concerning the adequacy of protection protocols, personnel qualifications, and the capability environmental impact.

Environmental concerns come to be a distinguished subject, with a enormous percentage of participants highlighting the need for in addition scrutiny and mitigation techniques. Transparency and communication in the industry additionally warrant interest, as a noteworthy percent of respondents express dissatisfaction with the current ranges.

The wonderful perceptions regarding technological advancements and insurance mechanisms imply a foundation for boosting protection practices, whilst the regions of problem offer clean signposts for targeted upgrades. The examine underscores the importance of worldwide cooperation and requirements, suggesting ability avenues for collaborative efforts to reinforce the protection framework on a global scale.

In mild of these observations, stakeholders within the LNG and LPG transportation enterprise are encouraged to remember the numerous views uncovered on this look at as they work towards refining protection measures. By addressing issues, fostering transparency, and leveraging technological improvements, the enterprise can similarly enhance its dedication to safety and environmental stewardship.

This look at serves now not simplest as an educational exploration but additionally as a practical manual for industry experts, policymakers, and applicable stakeholders. As we flow forward, non-stop engagement with these insights can be instrumental in shaping a safer, greater sustainable, and resilient destiny for the worldwide LNG and LPG transportation landscape.

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Appendix 1

Questionnaire

A) Demographic Questions

1. What is your age?

- Under 25
- 25-35
- 36-45
- Over 45

2. What is your gender?

- Male
- Female

3. What is your highest level of education?

- High school or equivalent
- Bachelor's degree
- Master's degree
- Doctoral degree

4. What is your current occupation?

- Energy industry professional
- Transportation industry professional
- Regulatory authority representative
- Other (please specify)

5. How many years of experience do you have in the energy or transportation industry?

- Less than 6 years
- 6-10 years
- 11-20 years
- Over 20 years

B) Likert Scale Questions

6. I am concerned about the potential dangers associated with the transportation of LNG and LPG.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

7. I believe that current safety measures for LNG and LPG carriers are effective in mitigating potential risks.
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

8. Safety protocols and emergency response procedures for LNG and LPG carriers are adequate.
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

9. I believe that the training and qualifications of personnel involved in the operation of LNG and LPG carriers are sufficient to ensure safety.
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

10. The potential environmental impact of LNG and LPG transportation is a major concern.
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

11. I am satisfied with the level of transparency and communication regarding the safety of LNG and LPG carriers within the industry.
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

12. I believe that technological advancements have significantly improved the safety of LNG and LPG carriers.
- Strongly Agree
- Agree

- Neutral
- Disagree
- Strongly Disagree

13. I feel that the potential risks associated with LNG and LPG carriers are adequately covered by insurance and liability mechanisms.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

14. I am satisfied with the level of international cooperation and standards in place for the safety of LNG and LPG carriers.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

15. I believe that the public perception of LNG and LPG transportation accurately reflects the actual safety measures in place.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree