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## INVENTORY MEASUREMENT MODEL FOR LIQUEFIED PETROLEUM GAS OF PETROCHEMICAL COMPANIES IN THAILAND.

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### ABSTRACT

This research is qualitative research. The purpose of this research is to study the work pattern for setting up operational procedures and developing a method for measuring petroleum gas levels of a petrochemical company in Thailand. It is research in the field of actual operations with the population with special reference to workers in gas warehouses in all 5 regions in the country. Interview forms validated by qualified experts and calculation forms were used as tools for data collection.

The research results showed that: the measurement of the gas level started from measuring the depth of the gas water; measuring the temperature of gas water; measuring the temperature of the gas vapor; and measuring the gas pressure and gas molar mass. After that a calculation was done to find the true volume from the developed calculation model. Table constants in Table 54 was compared to find the Density at 15°C and Table Tank table to find the total gas volume, after which it was then calculated in the developed calculation which made the gas volume increase by 20% than the previous model.

**KEYWORDS:** measurement, Inventory, petroleum gas.

### 1. INTRODUCTION

According to the Department of Energy Business issued a letter No. Phor. 0402/Wor. 10707 dated October 12, 2021, regarding the determination of types and rates, criteria, methods and conditions for calculating fuel reserves: this was effective from 1st January 2022 to oil traders under Section 7, the Department of Energy Business issued an announcement on the type and rate determination, rules, procedures and conditions for calculating fuel reserves (Version 3) 2021 became effective from 1st January 2022 which allowed oil traders under Section 7 to acknowledge the change in fuel reserves of which crude oil reserve rate 4% increased to 5%; liquid petroleum reserve rate from 1% to 2%; and petroleum gas to come into effect from 1st January 2022 onwards.



The announcement of the Department of Energy Business resulted in oil traders under Section 7 to hold a meeting on 24th August 2021, in which oil traders under Section 7 submitted a letter to the Department of Energy Business. And there were comments of each of them as follows: PTT Public Company Limited submitted a letter to the Department of Energy Business on 26th October 2021 regarding comments on increasing gas reserves for the year for liquid petroleum of 2 percent effective from 1st January 2022 according to the Department of Energy Business. There was a letter requiring the reserve rate of liquefied petroleum gas to increase from 1 percent to 2 percent, increasing the cost burden for oil traders under Section 7, which was considered a higher cost and not suitable for the current economic situation. The companies attending the meeting gave interesting comments as follows:

(1) PTT had an opinion to maintain the reserve rate at 1%; and PTT had the ability to import liquefied petroleum gas by ship from abroad This is in line with long-term import contracts from foreign traders, and thus enabling PTT to import in a timely manner. Therefore, PTT viewed that the reserve rate of liquefied petroleum gas is 1 percent.

(2) As for Uno Gas Co., Ltd., it was seen that increasing the reserve by 2 percent would incur some cost for entrepreneurs. The burden of this cost and the high oil price factor would be the consumer's liability. While for PAP Gas Co., Ltd., Atlas Energy Co., Ltd., Orchid Gas Co., Ltd., Big Gas Technology Co., Ltd., Unique Gas and Petro Co., Ltd. Trochemicals Public Company Limited, and Siam Gas and Petrochemicals Public Company Limited had some opinions on increasing the reserve rate of liquefied petroleum gas to 2 percent, which is in line with most oil traders under section 7 that the reserve of 1 percent was appropriate and in line with current economic conditions. Increasing the reserve rate of liquefied petroleum gas to 2 percent is an increase in protection for oil traders under Section 7, which represents a higher cost and not suitable for current economic conditions.

As a result of the enactment of the aforementioned law, liquefied petroleum gas warehouse operators have to adjust the form of measuring inventory to be more efficient. Such methods cannot determine the true value of liquefied petroleum gas. In the correct measurement, it must be measured in the liquid and vapor gas values and then added together. Therefore, it will get the actual amount of liquefied petroleum gas. The aforementioned problems of liquefied petroleum gas warehouse operators pointed to some interest in studying the measurement of liquefied petroleum gas inventory of a petrochemical company in Thailand that required a study of model inventory calculations to increase the accuracy of inventory measurements and effectively forecast inventory storage.

## **2. RESEARCH OBJECTIVES**

1. To study the work style of inventory storage of liquefied petroleum gas of a petrochemical



company in Thailand.

2. To prepare the process of measuring the level of liquefied petroleum gas of a petrochemical company in Thailand.
3. To create a suitable inventory level measurement model for efficient gas stock preparation.

### 3. LITERATURE REVIEW

Petroleum gas and gas theory

NFPA 58 (2004) defines liquefied petroleum gas as liquefied hydrocarbon gases: propane, propylene, normal butane, isobutane, or butylene. This is generally called liquefied petroleum gas as gas, gas, liquefied gas or cooking gas in trade and industry. The name that is known well is LP Gas (LP GAS) or LPG (LPG), which is an abbreviation from Liquefied Petroleum Gas, so for convenience, hereinafter the study calls it “LPG” or “Petroleum Gas” or “fluid”.

Ministry of Energy (2011) defines liquefied petroleum gas as liquefied petroleum gas that consists of propane, propylene, normal butane, and isobutane or butylene. One or more mixtures that are mainly packed into LPG cylinders or gas storage and distribution tanks.

The Institute of Gas Processors Association (GPA) has set up the standard of LPG with a method for checking the standard name GPA Standard 2140-97. Liquefied Petroleum Gas Specifications and Test Methods can be divided LPG into 4 groups as follows:

- (1) Commercial Propane: The main constituents are propane and/or Propylene.
- (2) Commercial Butane: The main component is butane and/or butylene.
- (3) Commercial B-P Mixture: The main ingredient is a mixture of propane and/or propylene and butane and/or butylene.
- (4) Propane HD-5: Contains propane not less than 90% by volume and propylene not more than 5% by volume.

The gas laws (the gas laws) over the centuries involve the behavior of gas under conditions of pressure, temperature, volume and number of moles has been studied.

- (1) Boyle’s law (1622). Robert Boyle studied the relationship between pressure and volume of gas at constant temperature, which concluded that the pressure of the gas was inversely proportional to the volume of gas at constant temperature ( $P \propto 1/V$ )
- (2) Charles’s law (1787). Jacques-Alexandre-César Charles studied the relationship between the volume and temperature of a gas at constant pressure, which concluded that the volume of a certain amount of gas was proportional to the absolute temperature of the gas at constant pressure ( $V \propto T$ ).
- (3) Gay-Lussac’s law (1807). Joseph-Louis Gay-Lussac studied the relationship between the pressure



and temperature of a gas when the volume of the gas was constant. It was concluded that the pressure of the gas varied with the Kelvin temperature when the volume and the mass of the gas was constant ( $P \propto T$ ).

- (4) Avogadro's law (1856). Amaedeo Avogadro studied the relationship between the volume of gas and the number of moles of this gas at constant gas pressure and temperature. It was concluded that the volume of the gas varied with the number of moles of gas when constant temperature and pressure ( $V \propto n$ ).
- (5) The ideal gas is the combination of Boyle's law and Charles' law to form the combined gas law which can be written as  $PV = nRT$ .

#### **Laws, standards and theories about LPG warehouse management**

The Ministerial Regulation on Liquefied Petroleum Gas Storage (2021) gives the meaning of Liquefied petroleum gas depot in accordance with the Ministerial Regulation on Prescribing Criteria, Procedures, and Conditions Regarding Notifications, Permissions, and Rates of Fees Related to Fuel Business Operations.

The Ministerial Regulation on liquefied petroleum gas containers (2017) explains that liquefied petroleum gas storage and distribution tanks must have the following characteristics:

LPG storage and distribution tanks with a volume not exceeding 500,000 liters must be designed and manufactured. Or constructed according to ASME Boiler and Pressure Vessel Code Section VIII Division 1 using a design pressure of not less than 1.65 MPA.

Liquefied petroleum gas storage and distribution tanks with a volume of more than 500,000 liters, the tank must be designed or built in accordance with ASME Boiler and Pressure Vessel Code Section VIII Division 1 or ASME Boiler and Pressure Vessel Code Section VIII Division 2 standards, using a design pressure of not less than 1.25 times of The pressure of liquefied petroleum gas to be stored at 42°C.

Liquefied petroleum gas storage and distribution tanks Only propane, propylene, normal butane, isobutane, or butylene storage tanks must be designed, manufactured, or constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII standards Division 1 or ASME Boiler and Pressure Vessel Code Section VIII Division 2 or other standards announced by the Minister by using the design pressure to handle the pressure of liquefied petroleum gas that will be stored at 42 °C.

There was an announcement of the Department of Energy Business on Specify types and rates, criteria, methods and conditions for calculation (Fuel reserves, 2020) that the amount of crude oil used to calculate the reserves shall be calculated from the following equation:

Amount of crude oil used to calculate reserves =

The annual trade volume of refined crude oil X The total amount of refined oil refined or produced for sale The total amount of refined oil refined or produced as fuel in the Kingdom

Unique Gas and Petrochemicals (2022) divides LPG warehouses into 3 popular formats: Pressurized Gas Tankers is a form of LPG storage inside a container under a high pressure of about 6 – 13 bar. In designing a pressure tank, it must be designed to be able to support a pressure of not less than about 18 bar and able to withstand LPG transfers in and out of the reserve tank at 45°C, resulting in the size of this type of storage tank not exceeding 1,000 m3.

Semi-Refrigerated/Semi-Pressurized Gas Carriers is a form of storing LPG gas under a temperature lower than the boiling point of LPG gas, in which the boiling point of LPG gas is about -50 ° C, and thus the pressure inside the tank is only 2.8 - 7.0 bar, resulting in the size of this type of reserve tank not exceeding 12,000 m3.

Fully Refrigerated Gas Carriers are a form of gas storage with conditions inside the storage tank that are equal to or close to atmospheric pressure by controlling the temperature inside the reserve tank to be equal to or close to the boiling point temperature of that gas. For storage of propane gas, the temperature inside this reserve tank is kept to the boiling point of propane gas, which is -42°C or slightly lower, i.e. -45°C. Butane is stored at -2°C. C, therefore, with this gas storage system, storage at a minimum storage temperature of -50 °C and a working pressure of approximately 250 millibar, resulting in the size of the storage tank This type has a size between 5,000 - 75,000 m3.

According to the literature review, past papers and relevant research, the study proposed the research framework as follows:

#### 4. CONCEPTUAL FRAMEWORK OF THE RESEARCH

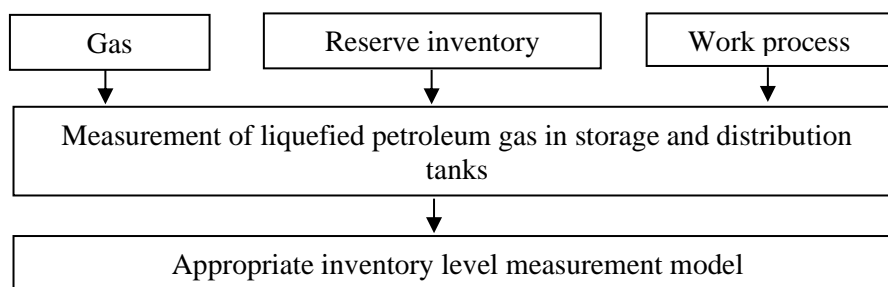


Figure 1 Conceptual Framework of the Research



## **5. RESEARCH METHODOLOGY**

This research on the liquefied petroleum gas inventory measurement model of a petrochemical company in Thailand is qualitative research which studied the operational procedures and tools used to solve the problem of inventory management. A petrochemical company in Thailand to be studied in the real area, which consisted of Bang Pakong gas depot, Sathupradit branch gas depot Gas Depot, Khon Kaen Branch Suksawat gas depot and gas depot, Surat Thani branch. The tools used in this research consisted of an interview form and an inventory record form. Data collected in this research can be divided into 2 types: (1) Primary data is information that enables the study to understand the procedures for working in the warehouse. The study used an interview form that was verified for accuracy and content consistency to interview 5 heads of the receiving-paying operations about work procedures and inventory data recording procedures; (2) Secondary data are data were collected through measuring the level of liquefied petroleum gas and calculating the amount of gas in both the original form and the newly developed form and compare them to see the differences that occurred.

## **6. DATA ANALYSIS**

The study used the newly developed model to analyze the inventory to compare the actual inventory to reveal the improvement in inventory storage efficiency expressed as a percentage that compares the actual inventory and the original stock measure versus the newly developed stock measure.

## **7. RESEARCH RESULTS**

1. The results of interviews with 5 heads of receiving and distributing operations from 5 areas of liquefied petroleum gas depots can be summarized as follows.

(1) General information of interview respondents - Most of the chiefs of the receiving-disbursement operations were male, aged between 35 and 50 years old, and had more than 10 years of work experience in gas storage.

(2) Knowledge about liquefied petroleum gas - Most of the respondents gave the meaning of liquefied petroleum gas as LPG which is a mixture of propane and butane that comes from marine and natural gas platforms. Onshore Gas Separation Plant for Household Use transportation and industry, etc.

(3) Knowledge of liquefied petroleum gas storage and distribution tanks - Most of the interviewees did not describe the meaning of containers, but instead explained that liquefied petroleum gas storage and distribution tanks were designed to store liquefied petroleum gas. This must be in accordance with the Department of Energy Business's requirements, which can be divided into Bulk or Bullet tanks and Sphere tanks.



(4) Knowledge about the storage process of liquefied petroleum gas - The interviewees divided the storage process into 2 forms: the first form is the incoming gas from ships while for the second model, only for the warehouse in Khon Kaen, will be the form of receiving inbound from transportation vehicles. For the gas supply from the depot, most of them will be dispensed from the depot by car only. In receiving incoming gas, the stock will be measured before receiving and compared with the stock after receiving gas every time and every evening will be measured to summarize the stock balance.

(5) Daily measurement of liquefied petroleum gas storage - Most of the interviewees explained the gas calculation process in the same direction starting from: measuring the depth of the gas water; measuring the temperature of gas water; measuring the temperature of the gas vapor; measuring the gas pressure level and fill in the data in the computer record form which the computer will process to get the weight out as the daily gas stock.

(6) LPG Stock Control Technique - Interview respondents gave information in the same direction, that is, stock calculations will be compared before receiving and after receiving gas, while controlling is using the Loss / Gain criterion to control. If the gas is lost (Loss), no one will not receive prize money Gas stock must be gain only to receive rewards.

2. The results of fieldwork at 5 areas of liquefied petroleum gas depots, which include Bang Pakong gas depots, Sathupradit branch gas depot Gas Depot, Khon Kaen Branch Suksawat gas depot and gas depot, and Surat Thani branch. To study the work process, the flow process for liquefied petroleum gas storage management can be established as follows:

Operation Flow chart

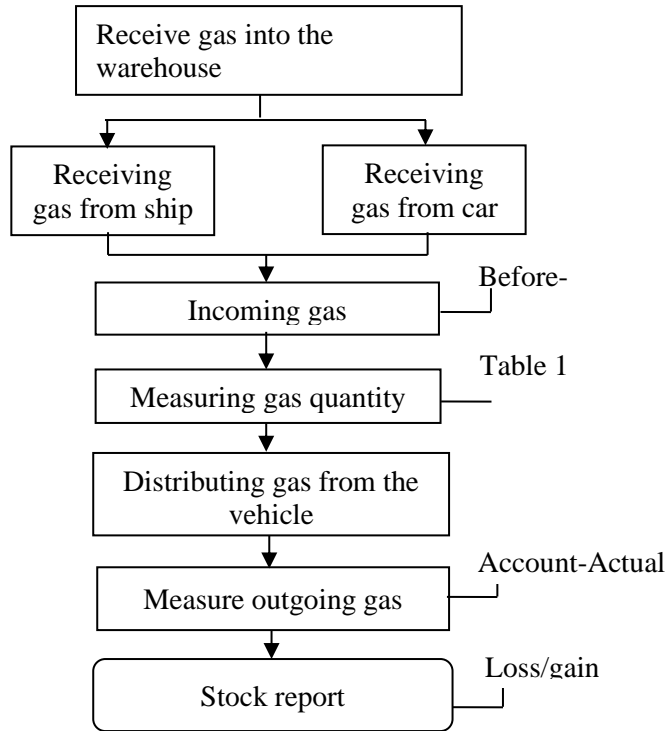


Figure 2. Flow process for managing liquefied petroleum gas storage

3. From the field visits, the study and the interviewees improved the gas quantity calculation model, resulting in more accurate values, resulting in efficiency in stock forecasting, which can be shown in the Table 1.

Table 1 Form for calculating the amount of gas in the gas storage tank.

Before						
Sounding	Temp. Liquid	Temp. Vapor	Pressure	MW	Density	Den 15 °C
Calculated item		Liquid + Vapor		MT.		
After						
Sounding	Temp. Liquid	Temp. Vapor	Pressure	MW	Density	Den 15 °C
Calculated item		Liquid + Vapor		MT.		
Compare						
Before	MT.	After	MT.	Loss/Gain	MT.	





From Table 1, it can be explained that measurement of the gas level starts from measuring the depth of the gas water; measuring the temperature of gas water; measuring the temperature of the gas vapor; measuring the gas pressure and gas molar mass. After that some calculation was performed to find the true volume from the developed calculation model by comparing the table constants in Table 54 to find the Density at 15 °C and Table Tank table to find the total gas volume in metric tons.

## 8. DISCUSSION

A Study of Petroleum Gas Inventory Measurement of a Petrochemical Company in Thailand to study the work pattern that established a process for measuring liquefied petroleum gas levels and creating a form for measuring inventory levels. The results showed that the measurement of liquefied petroleum gas storage began from measuring the depth of gas water; measuring the temperature of gas water; measuring the temperature of the gas vapor; measuring the gas pressure level and fill in the computer record, in which the computer will process to obtain the weight of the daily gas stock, in accordance with Boyle's law (1622) and Charles's law (1787). Two theories were introduced which are relationship between pressure (P) and the volume of the gas (V) and the relationship between the volume (V) and temperature (T) of the gas that can be combined to form the gas law.

The process of measuring the level of liquefied petroleum gas and the form of measuring the level of inventory found that the operation process started from receiving the gas into the warehouse; incoming gas measurement; the calculation of the amount of gas from the table; distributing gas by the truck; outgoing gas measurement, comparison of the levels and doses and report of daily results. The calculation of the water-gas level in this process is consistent with Avogadro's law (1856) which states that the volume of a gas varies with the number of moles of gas at constant temperature and pressure, and Unique Gas and Petrochemicals (2022) which states that the arrangement gas storage model, semi-Refrigerated/semi-pressurized gas carriers, resulting in the size of this type of storage tank not exceeding 12,000 m<sup>3</sup>.

## 9. SUGGESTIONS FOR THIS RESEARCH

This research contributes to the development of a warehouse management model, especially for dangerous goods warehouses, in particular, the development of a new inventory level calculation model. The results of this research can explain that accurate forecasting of inventory quantities from the gas water quantity calculation model in storage and distribution tanks will greatly reduce the cost of warehouse management, whether it is the cost of ordering savings. and costs resulting from storage.

## 10. SUGGESTIONS FOR FUTURE RESEARCH

It is worth noting that the research on hazardous warehouses in the country has very few people conducting research on this topic. The value of dangerous goods warehouses is relatively high, which

can be well applied to the concept of Activity Based Costing (ABC). The study will be that the development of a petroleum gas inventory measurement model will be an extension for those who are interested in logistics management to extend their knowledge in the future.

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