

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Preliminary Draft Staff Report

Proposed Rule 1177 – Liquefied Petroleum Gas Transfer and Dispensing

August 2011

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EXECUTIVE SUMMARY

Fugitive Volatile Organic Compound (VOC) emissions associated with the transfer and dispensing of liquefied petroleum gas (LPG) are currently not accounted for or regulated by the South Coast Air Quality Management District (District) or the California Air Resources Board (CARB). The fugitive VOC emissions inventory from the transfer of LPG is conservatively estimated to be as low as 2.5 tons per day depending on assumptions made, and as high as 10.8 tons per day. Because LPG, which is a gas at atmospheric conditions, is stored under pressure to maintain its liquid state, reducing fugitive VOC emissions during the transfer and dispensing of LPG equate to reducing product loss and therefore, in addition to the air quality benefits, it would also result in potential cost-savings for industry and the consumer.

Proposed Rule (PR) 1177 will reduce fugitive emissions of VOCs from the transfer and dispensing of LPG. The processes contributing to these emissions include delivery and transfer of LPG to residential, industrial and commercial users, fueling stations and cylinder refueling. The proposed rule applies to the transfer of LPG to and from stationary storage tanks and cargo tanks, including bobtails, tanker trucks and rail tank cars, and into portable refillable cylinders. The proposed rule requires the following:

- Installation of smaller orifice fixed liquid level gauges (FLLGs) on applicable receiving tanks and cylinders in accordance with the installation schedule of the proposed rule beginning July 1, 2012 and ending July 1, 2016.
- Use of properly installed low-emission connectors that minimize loss of LPG during disconnection, effective July 1, 2012.
- Routine LPG transfer equipment and component leak detection and repair by trained personnel, effective January 1, 2012.
- Associated recordkeeping and reporting to demonstrate compliance with the proposed rule requirements.

The estimated emission reductions range from 0.9 tons per day to 6.7 tons per day of fugitive VOC emissions upon full implementation. PR 1177 will partially implement Control Measure CM #2007 MCS-07 – Application of All Feasible Measures from the 2007 Air Quality Management Plan (AQMP).

Currently, only a subset of the LPG transfer and dispensing industry is being evaluated for VOC emissions reductions and controls in this proposed rule. Staff will continue to study other industry processes and potential control technology, and may pursue future amendments in an effort to procure greater emission reductions from this source category.

Pursuant to the California Environmental Quality Act (CEQA) and the AQMD's Certified Regulatory Program (Rule 110), AQMD staff will be reviewing PR 1177

and will determine if the proposed project will result in any potential adverse environmental impacts. Appropriate CEQA documentation for PR 1177 will be prepared based on the analysis. Comments received at the public workshop and CEQA scoping meeting will be considered when preparing the CEQA document.

Lastly, staff plans to conduct a comprehensive socioeconomic analysis for the proposed rule and will discuss the overall cost-effectiveness of the proposal in the draft staff report.

BACKGROUND

In May 1992, the California Air Resources Board (CARB) conducted a study to determine the usage patterns of LPG and to estimate emissions resulting from the transfer operations for the entire state of California. This effort was the first attempt to quantify LPG transfer emissions in California and the study found that total emissions were estimated to be 1,131 tons per year (3.11 tons per day) or the equivalent of 464,000 gallons of LPG. These emissions were based on 722 million gallons of LPG transferred in California. The report also concluded that emissions from the FLLG emissions were as significant as emissions from filling line disconnections.

Subsequently, under CARB's Innovative Clean Air Technologies (ICAT) grant program, in 2006, the Adept Group Inc. evaluated and recommended methods to reduce fugitive VOC emissions from open vent valves during LPG tank filling operations.

Starting in 2005, the Propane Educational Research Council (PERC), a non-profit organization created to enhance consumer and employee safety and also provide research and development for clean and efficient propane utilization equipment, initiated a rebate program, subsidizing 75 percent of the cost of retrofitting LPG transfer and dispensing equipment with low-emission connector technology. Based on data presented by the Western Propane Gas Association (WPGA) the program has funded approximately \$500,000, resulting in an estimated 25 percent penetration of low-emission connectors into the inventory of components eligible for retrofit.

The District rule making process was initiated in August 2010 and has consisted of meetings with industry, including the WPGA and its membership. There have been a total of three (3) working group meetings and five (5) field visits to bulk loading and dispensing facilities. Staff has had numerous telephone and electronic mail communications with CARB, the National Fire Protection Association (NFPA) and local fire agencies to fully evaluate the LPG transfer and dispensing process, as well as existing applicable local and federal fire code requirements and practices.

In June 2011, a report authored by Life Cycle Associates, LLC and prepared for WPGA, estimating the quantity of LPG fugitive emissions in California and the District by examining the value chain of LPG, the associated activity and potential

VOC fugitive emissions events. The report also included potential strategies for VOC reductions.

Introduction

LPG is a petroleum product composed predominantly of any of the following hydrocarbons or mixtures thereof: propane, propylene, butanes (normal or isobutane) and to a lesser extent butylenes, and is classified as a VOC. Although consisting mainly of propane and butane, in some parts of the country, propane itself is commonly referred to as LPG. Unlike gasoline, which is a liquid under normal or standard conditions, LPG is a vapor under similar conditions, and must be stored and transported in closed containers under pressure to retain its liquefied state.

LPG is colorless and odorless and about 1.5 times as heavy as air in the vapor state. Therefore, it is necessary, as a fire and safety precaution, to add an artificial odorant to warn users of its presence in the event of leaks. Organosulfur compounds are usually used for this purpose with the most common odorant being ethyl mercaptan. Most states require a minimum of 1 pound of odorant to be injected into 10,000 gallons of LPG loaded. Appendix A contains additional details on LPG properties, transfer methods and uses.

Table 1 below indicates the LPG consumption categories and the specific uses in each category.

Table 1 – LPG Sales Categories

Category	Description
Residential	Private homes (heating and cooking), recreational vehicles
Commercial	Motels (space heating and cooking), restaurants (space heating & cooking), laundries
Chemical	Raw material for chemical processing industry
I.C.E. Fuel	Highway vehicles, forklifts, oil field drilling production equipment
Agricultural	Tractor fuel, irrigation equipment engine fuel, building space heating, cooking, crop drying, tobacco curing and flame cultivation
Sales to Retail	Cylinder filling and exchange
Industrial	Standby fuel for manufacturing plants, space heating, flame cutting, metallurgical furnaces

LPG Transfer and Dispensing

When material is transferred from storage containers it is done under atmospheric conditions, but at pressures much higher than atmospheric through the use of pumps or vapor compressors. In order for the material to remain in its liquid state when

transferred, it is important that delivery occurs within a closed system where compression is not compromised. Another important reason for maintaining a closed system under compression is because LPG is sold as a liquid and therefore metered and typically paid for on a per volume basis. Maintaining a closed system ensures that the customer is paying for product that is actually transferred rather than paying for lost product, as required by the Bureau of Weights and Measures.

The main value of LPG products lies in the fact that they can be stored in a liquid state and used in their gaseous state. The advantage obtained from reduced transportation cost is sufficient to offset the cost of liquefying these products. Also, in order to use LPG in most commercial and industrial applications it must be converted back to a gaseous state which can be accomplished by returning it to atmospheric temperature and pressure.

Based on discussions with LPG operators and field observations, product transfer practices seem to vary relative to the period of time the FLLG is left open. Currently, NFPA 58; 7.3.1 (3) indicates that the venting of LPG gas where necessary, shall be permitted by the use of FLLGs or bleeder valves. As such, per event activities are significantly different depending on the operator. Staff research indicates that NFPA 58 requires that the FLLG be open for the entire duration of LPG transfer mainly to address fire and safety concerns associated with overfills and possible release of large quantities of LPG. Based on staff research, numerous members of the industry maintain this practice when transferring fuel to a storage tank equipped with a FLLG.

LPG Fugitive Emissions

From the point of LPG production either from natural gas processing or crude oil refining to where the product reaches the end user, LPG is bought, sold, transported or distributed by wholesalers and refiners, retail bulk plants and other functions within the value chain as detailed in Appendix A. During transfer of LPG within the value chain there are fugitive emissions associated with each exchange.

LPG fugitive emissions from transfer and dispensing operations result from three main areas: volatilization of entrapped product from the housing of various hoses, dispensing nozzles and interconnections during disconnection, leaks in the equipment used for transfer and dispensing, and venting through FLLGs used as a safety device to ensure that pressurized receiving containers, cylinders and tanks are not overfilled.

The FLLG is usually found on bobtail truck tanks, stationary tanks and portable storage tanks and is a dip tube that extends into the LPG storage container. The tube is inserted to be at the maximum level to which a receiving tank is to be filled and this level is set to 80 percent of the tank's capacity with the remainder as vapor space to account for impacts of fluctuating temperature. The connection outside of the tank is a bleed valve. When the valve is opened during filling, LPG vapor is pushed through the FLLG and when the desired volume is reached, liquid LPG is ejected, thereby providing the operator with a visual indication that the tanks has reached its capacity and filling is complete.

Affected Industry

The facilities and operations affected by PR 1177 are represented by two Standard Industrial Classification (SIC) codes, which are 4925 (Mixed Manufacturing or LPG Production and/or Distribution) and 5984 LPG (Bottled Gas) Dealers.

Sales Distribution

The chart below indicates the distribution of LPG sales in the District according to market sector. The residential sector consumes approximately 40 percent of the total LPG sales in the basin followed by the chemical sector which uses approximately 20 percent.

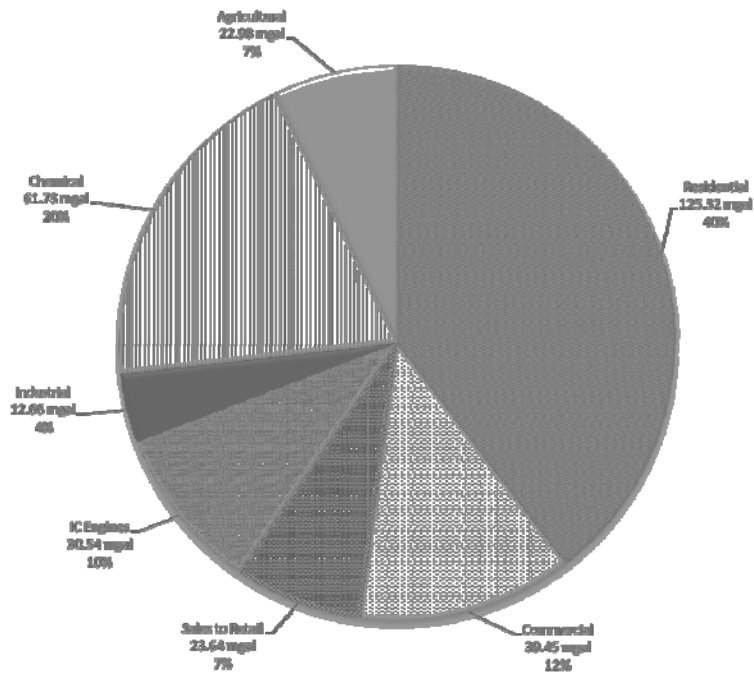


Figure 1. SCAQMD 2009 LPG Sales Distribution

EMISSION CONTROL TECHNOLOGY ASSESSMENT

In this section, control techniques for reducing fugitive VOC emissions from LPG transfer and dispensing activities are described below.

Fixed Liquid Level Gauge

This gauge is also referred to as the “bleeder” valve and depicts the level of propane in a tank. The bleeder valve is designed so that during the filling process, when the propane going into the tank reaches the 80 percent mark, liquid will flow out of the opened valve. This lets the delivery operator know that the tank has reached its maximum filling capacity. The valve is connected to what is called the dip tube that goes into the container. The dip tube is fixed and is typically set at a length equal to 80 percent liquid level tank capacity and filling level is dependent upon external conditions that would affect the expansion of LPG in the tank vapor space.

Currently, No. 54 orifice drill size is used on most tanks and cylinders, although some tank owners have already retrofitted tanks with No. 72 orifice drill size, which by virtue of its smaller orifice size, results in a reduced amount of LPG emitted during the filling process. There are several manufacturers that have produced and distributed these small orifice FLLGs.

Low Emission/Dry Break Transfer System

Low emission connectors are designed for various uses within the LPG transfer and dispensing industry. These products are designed to transfer LPG in bobtail, transport, railcar and bulk applications. Relative to this specific application, manufacturers’ claims include up to a 99.6% reduction in fugitive emissions compared to standard valves in use today, as well as a minimum saving of \$350 per 1,000 transfers of LPG. Other low emission connectors are used for the dispensing of LPG into cylinders as well.

In addition to an equipment and component leak detection and repair program, PR 1177 requires facility operators to: 1) replace existing FLLG valves with a smaller orifice (0.025 inch) No. 72 fixed liquid level gauge that reduces fugitive LPG vapors and 2) install low-emission connectors that result in reduced emissions upon disconnection.

The FLLGs and low emission connectors (components) are relatively inexpensive and are currently in place on several of the tanks, cylinders and lines that store and facilitate the transfer of LPG in the District. There are several companies that manufacture and distribute these components. The component retrofit costs have been subsidized through a rebate program that is sponsored by the Western Propane Educational Research Council (WPERC). The program provides a 75 percent rebate on new components and to date the WPGA has claimed that 25 percent of existing inventory of components have been retrofitted as a result of the rebate program. Staff will continue to assess and verify the retrofitted component inventory.

SUMMARY OF PROPOSED RULE 1177

PR 1177 is being proposed to reduce fugitive emissions of VOC from the transfer and dispensing of LPG. The processes contributing to these emissions include delivery to residential, industrial and commercial users, fueling stations and cylinder refueling. The proposed rule applies to the transfer of LPG to and from stationary storage tanks and cargo tanks, including bobtails, tanker trucks and rail tank cars, and into portable refillable cylinders. The proposed rule is divided into the following sections:

- (a) Purpose
- (b) Applicability
- (c) Definitions
- (d) Equipment and Operation Requirements
- (e) Operator Check and Inspection Program Requirements
- (f) Reporting Requirements
- (g) Recordkeeping Requirements
- (h) Exemptions

In summary, PR 1177 requires:

- Installation of smaller orifice FLLGs on applicable receiving tanks and cylinders in accordance with the installation schedule of the proposed rule, beginning July 1, 2012 and ending July 1, 2016.
- Use of properly installed low-emission connectors that minimize loss of LPG during disconnection, effective July 1, 2012.
- Routine LPG transfer equipment and component leak detection and repair by trained personnel, effective January 1, 2012.
- Associated recordkeeping and reporting to demonstrate compliance with the proposed rule requirements.

EMISSION INVENTORY

The emissions inventory is comprised of fugitive VOC emissions released from the LPG transfer and dispensing operations within the AQMD. The fugitive emissions can be released by the following actions:

- Disconnection of liquid line
- Disconnection of vapor line
- Vapor released from the FLLG
- Liquid released from the FLLG

- Disconnection of the jump line

Table 2 below lists the emissions associated with each market sector and also the reductions resulting from the use of control technology. The overall fugitive VOC emissions are estimated to range from 2.5 to 10.8 tons per day. The reason for the range is because of varying operator practice relative to the time the FLLG is left opened during the tank filling process, during which time VOC emissions in the form of propane vapor is released. Based on discussions with industry and observations in the field, there seems to be a significant difference in the practice of venting LPG from the receiving tank's FLLG to allow for gas expansion during transfer. In some cases the FLLG was left open for approximately one (1) minute, while in other cases the FLLG was left open for as long as the entire duration of the filling process, which can vary between 4 minutes for a 5 gallon container to 30 minutes for a bobtail truck tank or large residential/commercial storage tank.

EMISSIONS ESTIMATION METHODOLOGY

The proposed rule will address fugitive emissions released from each transfer shown in the value chain in Figure A-1 of Appendix A. Also, for each transfer activity there are specific emissions associated depending on whether it involves: (a) filling or (b) offloading. When emissions data from each transfer activity are combined with the 2009 sales volume data (see Table 2) the result is a mass emission value.

Liquefied Petroleum Gas (LPG) Sales

Historical American Petroleum Industries (API) sales data combined residential and commercial sales, but as of 2003, sales data for these two categories were reported separately. Table 2 below shows California LPG sales data from 1999 to 2009, while Figure 2 shows the sales distribution for 2009.

Due to the lack of region-specific LPG sales data for the District, a proportionality factor of 0.455, based on the District's population compared to total California state population was used to estimate the sales data for the four-county region. This data is based on 2009 API-reported sales, which is the most recently compiled.

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Table 2. Historical California LPG Sales (mgal), API sales data provided by Western Propane Gas Association

Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residential and Commercial	302,715	288,766	199,223	240,791							
Residential	-----	-----	-----	-----	204,167	246,420	252,807	259,285	287,581	283,711	275,256
Commercial	-----	-----	-----	-----	109,912	146,220	104,266	88,015	101,518	108,513	86,639
Sales to Retailers	N/A	N/A	N/A	N/A	64,663	61,665	65,854	56,938	56,905	65,358	51,941
ICE Fuel	44,297	66,678	80,660	64,717	53,829	62,773	73,137	73,498	with-held	with-held	67,077
Chemical	89,212	180,861	135,075	N/A	N/A	N/A	N/A	N/A	N/A	N/A	135,576
Industrial	37,950	36,791	37,813	45,300	33,331	22,994	44,788	46,512	with-held	with-held	27,806
Agricultural	25,421	17,255	39,874	65,056	30,373	49,588	55,509	66,216	74,321	59,409	50,466
Total CA Sales	499,415	590,361	492,644	415,864	496,276	589,480	573,904	590,464	651,139	633,053	694,761
SCAQMD Sales *	227,234	268,614	224,153	189,136	225,806	268,259	261,126	268,661	296,268	288,039	316,116

(*) South Coast Air Basin sales is estimated at 45.5 percent of California sales based on population

Although sales in California fluctuated during this period of time, there has been an overall increase in LPG sales of almost 40 percent with LPG sales increasing from almost 500 million gallons in 1999 to almost 695 million gallons in 2009.

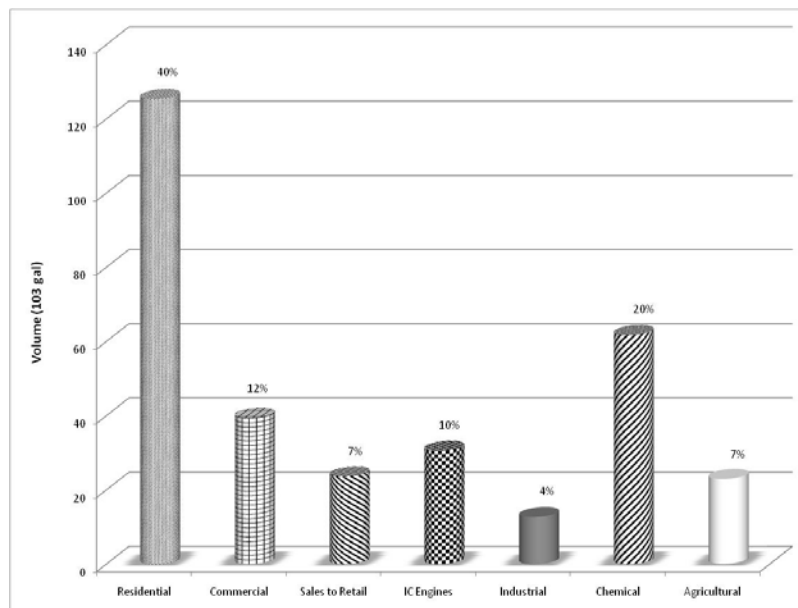


Figure 2. SCAQMD 2009 LPG Sales Distribution

LPG Emission Factor Determination

In November 2008, the District conducted VOC testing at the Mutual Propane facility in Gardena, California. Thirty-three (33) pound LPG (propane) forklift storage tanks were filled using the gravity filling system with the objective of the test being to determine the amount of propane lost to the atmosphere during the filling process. The results obtained from the District tests were compared with the results obtained by the Adept Group which conducted their testing separately, but on the same day as the District. The tanks in both the District and the Adept Group tests were equipped with a No. 54 gauge (0.055-inch orifice) FLLG. The results of both sets of testing are shown below:

Table 3. LPG Test Data

		Gaseous Propane Emissions Rate (g/s)	Liquid Propane Emissions Rate (g/s)
Gravity Filling	SCAQMD	2.26	8.94
	Adept Group	2.5	N/A
Pressure Filling	SCAQMD	N/A	N/A
	Adept Group	3.0	10.9

In addition to the District and the Adept Group’s testing, Battelle also conducted source testing in September 2009 to compare the fluid flow rate through a No. 54 orifice drill size FLLG and a No. 72 orifice drill size (0.025 inch) FLLG, as well as to evaluate the smaller gauge with respect to susceptibility to blocked flow due to particle obstruction. The Battelle source test was evaluated by District source testing staff and found to be conditionally acceptable, however, staff may consider additional follow-up on the overall control efficiency and potential obstruction issue.

The current estimated emissions inventory from the transfer of LPG range from 2.5 tpd – 10.8 tpd depending on activity level and assumptions pertaining to the length of time the FLLG is left open during the LPG transfer process. In contrast, the WPGA estimates VOC emissions of 1.71 tpd. Lastly, based on the Adept Group’s estimates the VOC emissions inventory may be as high as 68 tpd.

Emission Reductions

Table 4 summarizes emissions and potential emission reductions data collected by the WPGA, as well as estimates based on staff research, including feedback provided by stakeholders during the working group meetings, and during site visits conducted by staff.

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Table 4. SCAQMD VOC Emissions Reductions (tons per day)

Sector	WPGA Criteria		Criteria Under Review	
	Emissions (tons/day)	Reductions (tons/day)	Emissions (tons/day)*	Reduction (tons/day)*
Residential	0.15	0.05	0.3 – 5.9	0.10 – 4.0
Commercial	0.05	0.02	0.1 – 1.9	0.02 – 1.3
Sales to Retail	0.91	0.27	1.2 – 1.9	0.34 – 0.9
IC Engines	0.47	0.26	0.81	0.48
Industrial, Chemical Agricultural	0.01	< 0.01	0.04 - 0.07	<0.01 - 0.03
Distribution Facilities	0.12	<0.01	0.2 – 0.3	< 0.01
Total:	1.71	0.60	2.5 – 10.8	0.9 – 6.7
			68 †	

Range Primarily Driven by Variation of FLLG use from 60-90 Seconds up to 100% of LPG Transfer Time. Worse case criteria does not adjust WPGA assumed market distribution of fill by weight transfers. Assumptions: 4 gpm – BBQ / Forklift Tanks; 30 gpm – Commercial / Residential Tanks; 150 gpm – Bobtail/Mobile Fueler Loading

† Adept Group Estimate, 2009.

PR 1177 will reduce the overall VOC emissions by 0.9 to 6.7 tons per day based on the control efficiency claims of the manufacturers of the FLLG and the low emissions connectors. The Battelle source testing helps to support the FLLG VOC emissions reduction claims, but the actual test data and report for the low emissions connectors have not been provided.

COST AND COST-EFFECTIVENESS

New low-emission valves and other transfer and dispensing components for the LPG transfer and dispensing industry are already manufactured by various companies. Some operators have already retrofitted equipment with these components and in some cases have taken advantage of the WPERC Fugitive Emission Reduction Program which subsidizes 75 percent of the low-emission component cost on a first-come, first-serve basis.

Based on data supplied by the WPGA, the cost of components can range from as low as \$2 for a self-cleaning, 72 orifice drill size FLLG to as much as \$2,250 for the retrofit of a loading arm system for bobtail and transport trucks.

Fugitive VOC emission reductions resulting from the implementation of PR 1177 are estimated to range from 0.9 to 6.7 tons per day.

Staff will continue to assess cost and emissions estimates, in conjunction with the WPGA and other stakeholders, and will provide additional detailed analysis in the

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draft staff report, including an estimated cost-effectiveness of PR1177, as well as an incremental cost-effectiveness of control options.

COMPARATIVE ANALYSIS

There are no existing local, state or federal rules and regulations that control the fugitive VOC emissions from the transfer and dispensing of LPG.

COMMENTS AND RESPONSES

Comments from Public

All comments received with regards to the public workshop conducted on August 25, 2011 will be noted with corresponding staff response in the draft staff report.

SOCIOECONOMIC ASSESSMENT

A socioeconomic analysis of the proposed rule will be available no later than 30 days prior to the hearing.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Pursuant to the California Environmental Quality Act (CEQA) and the AQMD's Certified Regulatory Program (Rule 110), AQMD staff will be reviewing PR 1177 and will determine if the proposed project will result in any potential adverse environmental impacts. Appropriate CEQA documentation for PR 1177 will be prepared based on the analysis. Comments received at the public workshop and CEQA scoping meeting will be considered when preparing the CEQA document.

DRAFT FINDINGS UNDER CALIFORNIA HEALTH AND SAFETY CODE SECTION 40727

Health and Safety Code Section 40727 requires that prior to adopting, amending or repealing rules, the AQMD Governing Board shall make findings of necessity, authority, clarity, consistency, non-duplication and reference, based on relevant information presented at the hearing. The draft findings are as follows:

Necessity: The AQMD Governing Board has determined that a need exists to adopt Rule 1177 - Liquefied Petroleum Gas Transfer and Dispensing, to partially implement Control Measure CM #2007 MCS-07 – Application of All Feasible Measures from the 2007 AQMP and help AQMD attain the National Ambient Air Quality Standard for ozone.

Authority: The District obtains its authority to adopt, amend or repeal rules and regulations from California Health and Safety Code Sections 39002, 39650, 40000,

40001, 40440, 40441, 40463, 40702, and 40725 through 40728, 41508, 41700, and 42300.

Clarity: Rule 1177 - Liquefied Petroleum Gas Transfer and Dispensing as proposed to be adopted, is written or displayed so that its meaning can be easily understood by the persons directly affected by it.

Consistency: Proposed Rule 1177 - Liquefied Petroleum Gas Transfer and Dispensing is in harmony with, and not in conflict with or contradictory to, existing statutes, court decisions, or federal or state regulations.

Non Duplication: Rule 1177 - Liquefied Petroleum Gas Transfer and Dispensing, as proposed to be amended, does not impose the same requirements as any existing state or federal regulations, and the amendments are necessary and proper to execute the powers and duties granted to, and imposed upon, the District. The proposed amendment consolidates existing state and federal requirements.

Reference: This regulation would implement, interpret or make specific the provisions of: Health and Safety Code Sections 40001 (rules to achieve ambient air quality standards), 40440(a) and (c) (rules to carry out the Air Quality Management Plan and rules which are also cost-effective and efficient), 40702 (rules to execute duties necessary to preserve original intent of rule), 40910 et seq., (California Clean Air Act), and Federal Clean Air Act §111 (New Source Performance Standards).

REFERENCES

1. AQMD (2008) VOC Emissions During the Gravity Filling of a Forklift Propane Tank – Mutual Propane, Gardena, California, November 2008
2. Adept Group, Inc. (2008) LP Gas Emissions Through Outage Gauge During Cylinder Refilling – Mutual Propane, Gardena, California, November 2008
3. Battelle (2009) Research Investigation on Testing and Evaluation of New Low Emission Fixed Maximum Liquid Level Gauges for Use in LP-Gas Containers, prepared for PERC, September 2009
4. CARB (1992) Determination of Usage Patterns and Emissions for Propane/LPG in California, May 1992
5. Life Cycle Associates, LLC (2011) Inventory of Fugitive Emissions from LPG Transfers in California, prepared for WPGA, June 2011 (**CONFIDENTIAL**)

APPENDIX A. LPG INDUSTRY SUMMARY

- **LPG PROPERTIES**
- **LPG VALUE CHAIN AND MODES OF DISTRIBUTION**
- **LPG USAGE AND SALES**
- **LPG TRANSPORT METHODS, STORAGE AND DISPENSING**

The following information has been extracted from the June 2011 Life Cycle Associates, Inc. report that was prepared for the WPGA and supplemented by staff's research.

Liquefied Petroleum Gas (LPG) is derived from two large energy industries; natural gas processing and crude oil refining. LPG is a group of hydrocarbon-based gases that include ethane, ethylene, propane, propylene, n-butane, butylene, isobutane and isobutylene.

Raw natural gas that comes from wells primarily comes from any of three sources: crude oil wells, gas wells and condensate wells. Natural gas that comes from crude oil wells is typically referred to as associated gas. This gas could have existed as a gas cap above the crude oil in the underground formation or could have dissolved in the crude oil. Natural gas that comes from gas wells and from condensate wells, in which there is little or no crude oil is termed non-associated gas.

When natural gas is drawn from the earth, it is a mixture of several gases and liquids. Natural gas which is sold by gas utilities consists of about 90 percent methane. Of the remaining 10 percent, 5 percent is propane and 5 percent is other gases such as ethane and butane. Before natural gas can be transported or used, the LPG (which is slightly heavier than methane, the major component of natural gas) is separated out.

Some LPG is also trapped in crude oil and in order to stabilize crude oil for pipeline or tanker distribution, the associated gases" are further processed into LPG. Worldwide, gas processing is a source of approximately 60 percent of LPG produced, while crude oil refining is the source of the other roughly 40 percent of LPG supplies although the ratio between gas processing and refining varies depending on geographic location.

During the crude oil refining process LPG is the first product produced on the way to making the heavier fuels such as diesel, jet fuel, fuel oil, and gasoline. Roughly 3 percent of a typical barrel of crude oil is refined into LPG, although as much as 40 percent of a barrel could be converted into LPG. Although tied to the production of natural gas and crude oil, LPG has its own distinct marketing advantages and can perform nearly every fuel function of the primary fuels from which it is derived. It is estimated that approximately 37 percent of propane consumed in the United States is consumed as raw material in the petrochemical industry with demand being regional and concentrated in the Gulf Coast region. Since propane is one of many possible raw material options, the petrochemical industry can switch to other commodities when the price of propane becomes too high.

LPG PROPERTIES

LPG is a petroleum product composed predominantly of any of the following hydrocarbons or mixtures thereof: propane, propylene, butanes (normal or isobutane) and to a lesser extent butylenes. Although consisting mainly of propane and butane, in some parts of the country, propane itself is commonly referred to as LPG. Propane

and butane have vapor pressures (at 60 degrees F) of 100 psig and 12 psig, respectively compared to gasoline which ranges from approximately 3.5 psig to 7 psig at the same temperature (see Table A-1).

Unlike gasoline, which is a liquid under normal or standard conditions, LPG is a vapor under similar conditions. The heating value of LPG is in the range of 22 to 26 percent less than that of natural gas. Also, the temperatures required to liquefy LPG products can be produced by refrigeration or by use of storage containers that are designed to securely hold vapors at pressures significantly in excess of the vapor pressures of LPG within normal temperature ranges. It is mainly for this reason that LPG is stored and transported in closed containers under pressure.

LPG is colorless and odorless and about 1.5 times as heavy as air in the vapor state. Therefore, it is necessary, as a fire and safety precaution, to add an artificial odorant to warn users of its presence in the event of leaks. Organosulfur compounds are usually used for this purpose with the most common odorant being ethyl mercaptan. Most states require a minimum of 1 pound of odorant to be injected into 10,000 gallons of LPG loaded.

When material is transferred from storage containers it is done under atmospheric conditions, but at pressures much higher than atmospheric through the use of pumps. In order for the material to remain in its liquid state when transferred, it is important that delivery occur within a closed system where compression is not compromised. Another important reason for maintaining a closed system under compression is because LPG is sold as a liquid and therefore metered and typically paid for on a per volume basis. Maintaining a closed system ensures that the customer is paying for product that is actually transferred rather than paying for lost product.

The main value of LPG products lies in the fact that they can be stored in liquid state and used in their gaseous state. The advantage obtained from reduced transportation cost is sufficient to offset the cost of liquefying these products. Also, in order to use LPG in most commercial and industrial applications it must be converted back to a gaseous state which can be accomplished by returning it to atmospheric temperature and pressure.

Table A-1. Fuel Properties Comparison

Property	Vapor Pressure (psig)		Boiling Point (°F)	BTUs per gallon	BTUs per cubic foot
	@ 60 °F	@ 100 °F			
Propane	100	172	-44	91,690	2,500
Butane	12	38	32	102,032	3,200
Gasoline	3.5 – 7			⁽¹⁾ 114,000 – 125,000	
Natural Gas					1,030

(1): BTU content depends on the grade and blend of the gasoline

A high proportion of the energy contained in LPG is converted into heat through combustion. LPG also has multiple uses in numerous applications ranging from cooking, heating, air conditioning and transportation, as well as industrial uses where LPG can be used as a fuel in metallurgical plants or as a standby fuel. In some cases LPG is used as a chemical feedstock at manufacturing plants, and is also available for use in motor vehicles, where it is commonly referred to as autogas.

LPG burns relatively cleanly, resulting in lower greenhouse gas emissions than any other fossil fuel when measured on a total fuel cycle. However, there are many transfer points in the supply chain that are inefficient, resulting in product loss, the correction of which could translate directly into overall cost savings.

LPG VALUE CHAIN AND MODES OF DISTRIBUTION

Liquefied Petroleum Gas (LPG) Value Chain

From the point of LPG production either from natural gas processing or crude oil refining to where the product reaches the end user, LPG is bought, sold, transported or distributed by wholesalers and refiners, retail bulk plants and other functions within the value chain as shown in Figure A-1. During transfer of LPG within the value chain there are fugitive emissions associated with each exchange.

Terminals

After production, LPG is typically held in storage at its production facility and then transported to a terminal via rail tank cars or tanker trucks, but LPG may also be sent directly to a retail bulk plant. However, most of the LPG produced within the state is sent to terminals which do not sell directly to the public, but caters predominantly to high volume transfers. At a terminal, LPG is transferred from rail tank cars which have an approximate capacity of 33,000 gallons and the terminal has the equipment necessary to load and unload tanker trucks which have a capacity of about 10,000 gallons. Typically, pumps are used to facilitate the tanker truck loading process,

while compressors are used during the tanker truck unloading process. In some cases terminals also facilitate the loading of bobtail trucks which have a capacity in the range of 2,500 to 3,000 gallons.

Retail Bulk Plants

A retail bulk plant can be viewed as a distribution center for retail type transactions. LPG is usually delivered to a retail bulk plant either directly from the LPG production/storage facility via rail and tanker trucks or from terminals via tanker trucks. Bulk storage tanks have a much greater water capacity than most customer tanks. They typically range in size from 6,000 to 60,000 gallons, but may be as large as 120,000 gallons.

Bobtail trucks usually fill up at bulk plants and then distribute LPG to multiple users, including retail sales facilities, residential, commercial and fueling stations. The residential sector consumes approximately 40 percent of the LPG sold in the South Coast Basin followed by the chemical sector and the commercial sector which consume 20 percent and 12 percent, respectively.

Another significant sector includes usage in internal combustion engines (I.C.Es.) which accounts for 10 percent of total LPG sales. Of this 10 percent, the majority (94 percent) of LPG in this category is used in the operation of forklifts while the remaining 6 percent is used in on-road vehicles.

The retail sales sector accounts for approximately 7 percent of the overall LPG market and consists of both onsite cylinder refilling operations, as well as a (20-pound) cylinder exchange program. Although no statistical data have been collected, the Western Propane Gas Association (WPGA) estimated that the cylinder exchange program has grown from approximately 7 percent of the retail sales sector (based on a 2005 Keatley report) to approximately 50 percent of total retail sales currently. This approximation points to a shift in consumer habits from refilling 20 - pound barbecue tanks at a retail filling station to participation in the more convenient tank exchange programs which can be done at hardware stores like Home Depot.

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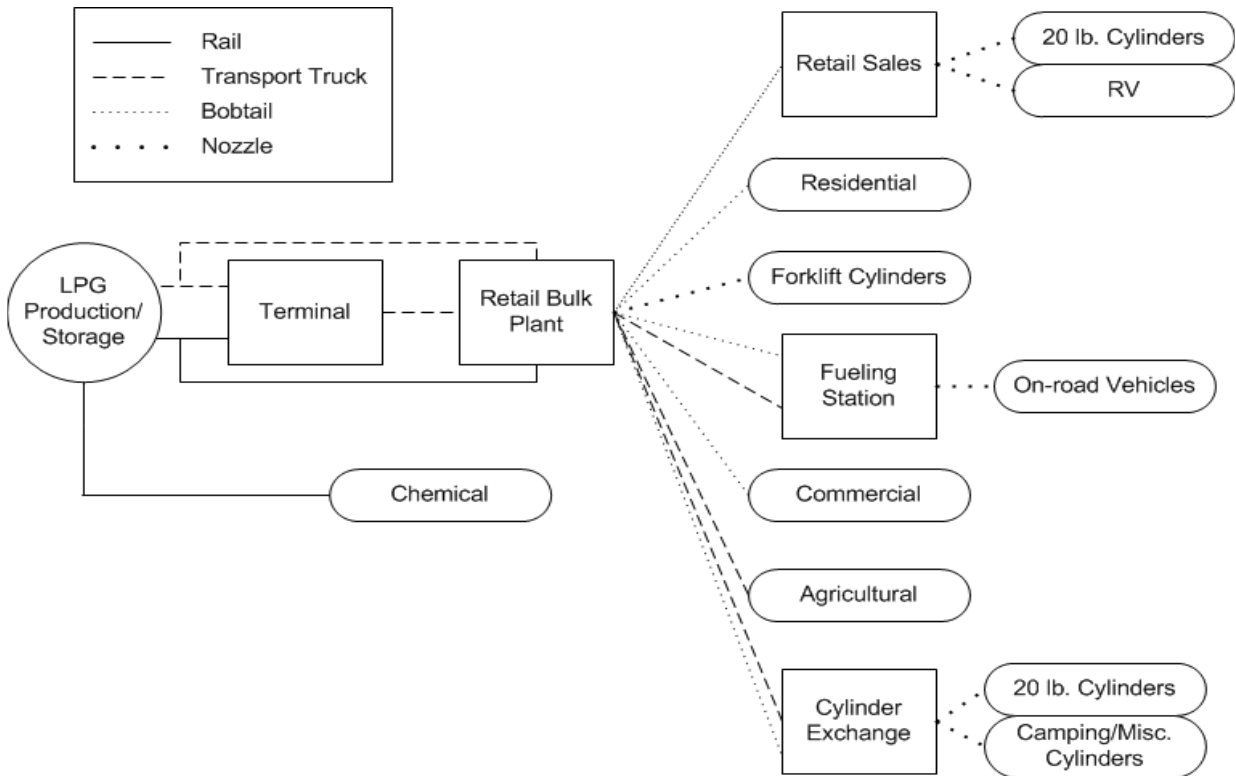


Figure A-1. Value Chain of LPG Distribution [Life Cycle Associates, LLC]

LIQUEFIED PETROLEUM GAS (LPG) USAGE

Propane sales are divided into seven (7) categories as shown in Table A-2 below.

Table A-2. Propane Sales Categories

Category	Description
Residential	Private homes (heating and cooking), recreational vehicles
Commercial	Motels (space heating and cooking), restaurants (space heating & cooking), laundries
Chemical	Raw material for chemical processing industry
I.C.E. Fuel	Highway vehicles, forklifts, oil field drilling production equipment
Agricultural	Tractor fuel, irrigation equipment engine fuel, building space heating, cooking, crop drying, tobacco curing and flame cultivation
Sales to Retail	Cylinder filling and exchange
Industrial	Standby fuel for mfg. plants, space heating, flame cutting, metallurgical furnaces

Residential

In California and the South Coast Basin, residential LPG usage accounted for the largest market share of LPG sales. Typically, residential LPG is distributed in areas where there is a lack of natural gas distribution infrastructure. Residential customers use LPG for space heating, indoor and outdoor cooking, water heating, swimming pool heating, clothes drying, lighting and cooling. Recreational vehicle (RV) fueling is also included in the residential market category and LPG is used in RVs for power generation, heat and refrigeration.

Commercial

LPG is used commercially at facilities such as motels and restaurants. These facilities utilize LPG for space heating, water heating, cooking and for laundering. This category also includes sales to bottle fillers, campgrounds, and hardware stores.

Chemical

The chemical market segment in the South Coast Basin accounts for only 20 percent of total LPG sales. LPG is sold to the petrochemical industry where it is used as raw material in chemical processes. Some typical products manufactured include ethylene, benzene, toluene, xylene, and methanol which are the starting points for many polymers and specialty chemicals.

Internal Combustion Fuel

In this category propane is utilized for fueling highway vehicles, forklifts, and oil field drilling and production equipment. Forklifts in the South Coast Basin are widely used in warehouses because VOC emissions from propane combustion are much less than that from diesel or gasoline combustion. The majority of LPG in this category is used as forklift fuel. However, electric and hydrogen fuel cell forklifts have recently been replacing LPG-fueled forklifts.

While only 0.1 percent of all LPG nationwide in 2005 was used for on-road transportation, California accounted for approximately 12 percent of the nation's LPG transportation usage.

Agricultural

Farm use accounts for about 7 percent of total sales in the South Coast Basin. LPG is used in the farming industry for fueling tractors, irrigation engines, standby electric generators, space heating in buildings (including farm houses), cooking, crop drying, tobacco curing, poultry, and other applications.

Sales to Retail

LPG is sold to locations where 20-pound cylinder filling takes place and these include dispensing stations or hardware stores which conduct LPG cylinder sales as

part of exchange programs. Exchange program cylinders are filled by weight or mass at bulk loading facilities using an automated system and then delivered by trucks to exchange sites.

Industrial Uses

LPG usage in manufacturing plants includes fuel for standby equipment, space heating, and flame cutting and metallurgical furnaces.

LIQUEFIED PETROLEUM GAS (LPG) SALES

Table A-3 below shows California LPG sales data from 1999 to 2009. Although sales in California have fluctuated during this period of time, there has been an overall increase in LPG sales of almost 40 percent with LPG sales increasing from almost 500 million gallons in 1999 to almost 695 million gallons in 2009. Prior to 2003, American Petroleum Industries (API) sales data combined residential and commercial sales, but as of 2003, sales data for these two categories were reported separately.

Due to the lack of region-specific LPG sales data for the District, a proportionality factor of 0.455, based on the District's population compared to total California state population was used to estimate the sales data for the four-county region. This data is based on 2009 API reported sales, which is the most recent compiled. A breakdown of LPG sales data for the District according to market sector also shown in Table A-3 below, and the distribution by sector is highlighted in Table A-4.

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Table A-3. Historical California LPG Sales (mgal), API sales data provided by Western Propane Gas Association

Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residential and Commercial	302,715	288,766	199,223	240,791							
Residential	-----	-----	-----	-----	204,167	246,420	252,807	259,285	287,581	283,711	275,256
Commercial	-----	-----	-----	-----	109,912	146,220	104,266	88,015	101,518	108,513	86,639
Sales to Retailers	N/A	N/A	N/A	N/A	64,663	61,665	65,854	56,938	56,905	65,358	51,941
ICE Fuel	44,297	66,678	80,660	64,717	53,829	62,773	73,137	73,498	with-held	with-held	67,077
Chemical	89,212	180,861	135,075	N/A	N/A	N/A	N/A	N/A	N/A	N/A	135,576
Industrial	37,950	36,791	37,813	45,300	33,331	22,994	44,788	46,512	with-held	with-held	27,806
Agricultural	25,421	17,255	39,874	65,056	30,373	49,588	55,509	66,216	74,321	59,409	50,466
Total CA Sales	499,415	590,361	492,644	415,864	496,276	589,480	573,904	590,464	651,139	633,053	694,761
SCAQMD Sales *	227,234	268,614	224,153	189,136	225,806	268,259	261,126	268,661	296,268	288,039	316,116

(*) South Coast Air Basin sales is estimated at 45.5 percent of California sales based on population

Table A-4. 2009 SCAQMD LPG Sales

Market Sector	Market Subsector	Volume (mgal)	Percent Share (%)
Residential	Heating	122.01	97.36
	RVs	3.31	2.64
Subtotal:		125.32	
Commercial		39.45	
Sales to Retail	Exchange	11.82	50
	On-site Refill	11.82	50
Subtotal:		23.64	
IC Engines	Forklift	28.76	94.17
	On-road Vehicles	1.78	5.83
Subtotal:		30.54	
Industrial		12.66	
Chemical		61.73	
Agricultural		22.98	
Total:		316.27	

LPG TRANSPORT METHODS, STORAGE AND DISPENSING

Liquefied Petroleum Gas (LPG) Transport Methods

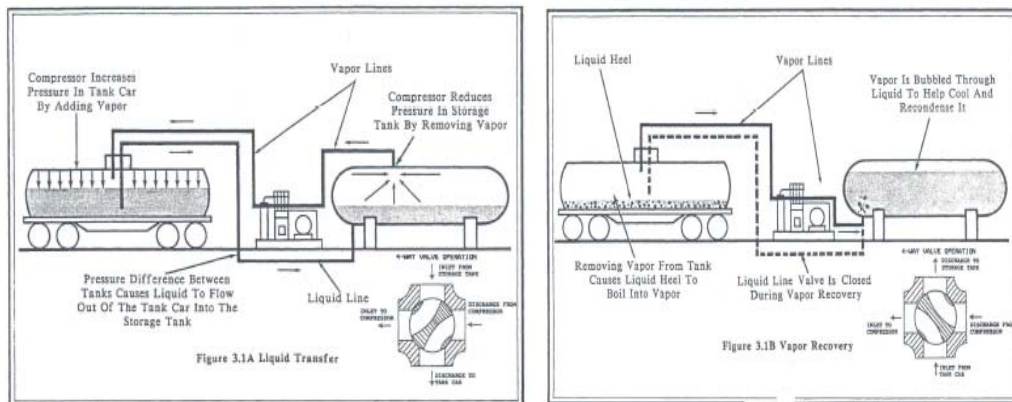
Railroad Tank Cars

Railroad tank cars deliver propane to bulk plant unloading stations in very large quantities. Railroad tank cars are by far the largest DOT tanks that transport LPG, ranging in size from 4,000 – 45,000 gallons water capacity and equipped with fittings and valves enclosed in a protective dome that is located on the top of the cargo tank. The tank cars observed in the AQMD are in the range of 30,000 – 34,000 gallons water capacity and can be emptied in 45 minutes to an hour with the use of a compressor.

Unloading stations have a ladder and platform that provide access to a manway on the railroad tank car which provides access to the valves within the dome. There are also liquid and vapor hose connections and emergency shutoff valves that connect to the plant piping system. Multiple cars may be loaded or unloaded without moving the cars.

Railroad tank cars do not have their own transport pump and therefore the bulk plant compressor is used to facilitate the transfer of LPG from the rail tank car to the bulk plant storage. The compressor forces vapors from the bulk plant tank into the vapor space of the tank car and enables the movement of liquid LPG through the liquid valves and into the plant piping. In some cases compressed natural gas from the city supply or other suitable gases are forced into the tank car vapor space to assist in pushing the liquid out of the tank car and into the bulk plant pipeline system.

After all the possible liquid has been transferred in this manner, there is still some liquid remaining in the tank car, in addition to some valuable vapors. To remove the remaining liquid and the residual vapors, the compressor valves are adjusted to reverse the direction of flow through it. After the liquid sections of the two tanks are closed, the remaining liquid in the tank car vaporizes and can then be drawn off of the tank car and into the liquid section of the bulk storage where it condenses.



Tanker Truck

Tanker trucks (or truck transports) will usually have a water capacity of approximately 10,000 gallons.

When a tanker truck is being unloaded its liquid line is connected to that of the storage tank liquid line. Similarly, vapor lines from the tanker truck and the storage tank are connected, thereby forming a closed loop vapor return/equalization system that promotes the transfer of LPG.

Tanker trucks are also equipped with either a pump or a compressor that is used during the offloading process. Using a compressor is more efficient and facilitates the transfer of liquid LPG from the tanker truck and the transfer lines. However, when a pump is used the hose of the liquid line will still have residual liquid.

Bobtail Truck

A bobtail truck has a water capacity in the range of 2,500 – 3,000 gallons and is used to transport LPG to residential, commercial and retail sales facilities. These facilities will usually store relatively smaller amounts (less than 10,000 gallons) of LPG. On a typical delivery route a bobtail truck can make multiple deliveries since a most residential tank is about 150 gallons and a commercial tank can be as large as 1,000 gallons.

Unlike a tanker truck, a bobtail truck does not have a vapor return/equalization line. However, a bobtail truck has a hose which is extended to the customer's storage tank, in addition to a pump which helps to transfer LPG. Upon completion of the transfer process, the hose is rolled back onto a spool and the driver makes the necessary preparation for another delivery.

Unlike a tanker truck, when a bobtail truck is filled it utilizes a fixed liquid level gauge (FLLG) which may be opened either intermittently or completely depending on operator practice. Opening of the FLLG ensures that the tank vapor pressure remains at a safe level during filling. The bobtail truck's cargo tank usually has a gauge that indicates the LPG volume, but an operator will usually determine that a tank is filled when liquid level is somewhere in the range of 80 to 87 percent capacity depending on season, temperature or the period of time that the LPG is allowed to remain in the cargo tank before delivery.

Liquefied Petroleum Gas (LPG) Storage Vessels

Propane cylinders are the most common type of LPG storage vessels. All cylinders used for LPG services are manufactured according to the Department of Transportation (DOT) specifications. Twenty (20) pound barbecue cylinders are by far the most common cylinders followed by forklift cylinders which are used predominantly at industrial facilities. In addition to cylinders, LPG storage containers also include storage tanks that are used at residential and commercial facilities.

Barbecue Cylinders

The 20-pound cylinders are typically used in gas grills, but are also used to fuel the type of space heaters that can be found at outdoor restaurants. These cylinders have a water capacity of 4.7 gallons and can be refilled at a local retailer or exchanged at a cylinder exchange station. Cylinders are usually filled at a bulk plant and then delivered to the exchange site. According to the Western Propane Gas Association (WPGA), over the last few years there has been a shift from refilling these tanks at a retail station to replacing an empty cylinder by going through an exchange program.

Forklift Cylinders

Thirty-three pound LPG cylinders are usually used to power most of the forklifts used at industrial sites, however, larger forklifts use 40 pounds LPG cylinders. These cylinders can be used either indoors or outdoors. LPG for forklift usage is usually in liquid form and cylinders are mounted horizontally on the back of the forklift. The tank gauge for this application may be designed to accurately indicate LPG levels when the tank is in either a horizontal or a vertical position.

LPG forklift cylinder delivery service is offered by many companies, but some companies also fill their forklift tanks onsite. Forklift cylinders can be filled either by weight or by volume, but cylinders that are filled offsite and are transported are required to be filled by weight according to DOT regulations.

Residential and Commercial Storage Tanks

Residential storage tanks can range from 150 -500 gallons and commercial tanks from 250 –1,100 gallons. These tanks are filled by bobtail trucks and may be filled up to levels ranging from 80 – 87 percent of total capacity depending on the ambient temperature. Some tanks have more than one (1) FLLG to facilitate the different fill levels. During the summer months operators are more likely to fill these tanks to the 80 percent level because the tank vapor pressure is proportional to its temperature and pressure build up may trigger fugitive emission releases from the pressure relief valve. Also, during the filling process operators have been observed to intermittently open the FLLG to reduce the storage tank pressure.

Liquefied Petroleum Gas (LPG) Fuel Dispensing/Delivery

Figure 3-1 below represents a simplified version of an LPG dispensing system. There are four (4) essential functional components which make up the system and they are 1) a storage tank; 2) a pump; 3) a metering unit and 4) the piping (including valves and other control elements) that connects these components and leads from the metering unit to the discharge nozzle.

The design of the system must also reflect its use in a specific delivery application. In situations where transfers are made from bulk loading facility storage tanks to tanker trucks, transfer are typically completed at rates of 100 gallons per minute

(gpm) or higher. When these tanker trucks make deliveries to retail facilities, discharge rates are approximately 50 to 60 gpm. Residential deliveries are made at discharge rates which are even lower and typically at about 30 gpm.

The system is closed and must not allow the leak of either liquid or vapor. In addition, the system is usually designed to withstand high pressures and specifications regarding operating pressures that the system must be capable of withstanding have been developed by the American Society of Mechanical Engineers (ASME) Pressure Vessel Code, Section 8 and have been adopted by the State Fire and Safety Codes. The system must be capable of minimizing the production of vapor within the system, eliminate small amounts of vapor that are produced and must also be equipped with pressure relief valves, which are designed to permit a controlled venting of the product to the atmosphere when internal pressures exceed safe limits.

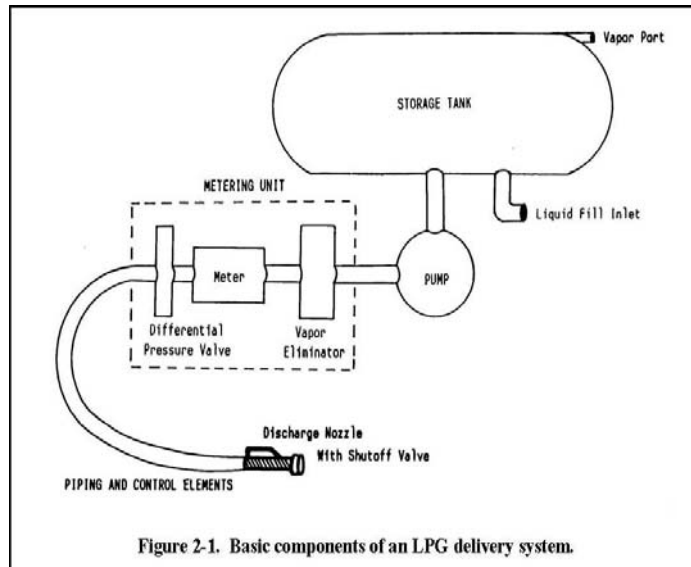


Figure A-3. Basic Components of an LPG Delivery System

Storage Tank and Pump

As shown in the Figure A-3 above an LPG storage tank is designed with a liquid fill inlet for supplying product and a discharge line with an outlet for delivery. A storage tank also has a vapor port that accommodates the insertion of a pressure equalization line to increase delivery efficiency under certain circumstances. The vapor port also allows for volumetric testing or system calibration.

The pump provides pressure to move product from the storage tank to the receiving tank and its design and operating characteristics are based on its application. Also, the discharge rate and pressure of the dispensing system have to be appropriate for the system to which it delivers product.

Metering Unit

Liquid LPG is measured as it passes through the metering unit. There is also an indicating unit which is designed to register the quantity of liquid as it passes through the meter. Measuring and registration occur simultaneously, thereby allowing the system operator and customer to monitor the amount of liquid that is being delivered continuously throughout the delivery.

Vapor Eliminator and Differential Pressure Valve

As shown in Figure A-3, above, the metering unit includes the vapor eliminator and the differential pressure valve. The function of these devices is to prevent vapor from entering the meter and being measured along with liquid product. The vapor eliminator separates any vapor that is produced from the liquid flow before it reaches the meter and returns it to the vapor space of the storage tank. The differential pressure valve maintains the product in its liquid state as it passes through the meter by restricting flow on the discharge side of the meter and thus maintaining a uniform pressure in the piping and metering element upstream that is at or above the product vapor pressure.

As liquid is drawn from the storage tank the liquid pressure drops causing some of the liquid product to boil since its boiling point is -44 degrees Fahrenheit and increasing vapor in the tank vapor space. This is typical of any liquid LPG delivery system.

Receiving Vessels

Both the receiving vessel and the delivery system contain a combination of vapor and liquid at all times. As the liquid is pumped into the receiving tank and the level rises the vapor becomes compressed thereby causing the pressure and temperature in the receiving vessel to rise. When equilibrium is eventually established and vapor condenses and returns to the liquid phase.

Previously, older vapor return systems were designed to alleviate the pressure build-up problem by connecting a vapor line between the vapor spaces of the two tanks. This would allow for equilibrium in both the delivery and the receiving tanks. However, this is not beneficial to the purchaser because product that was being purchased was being returned to the seller in the form of vapor.

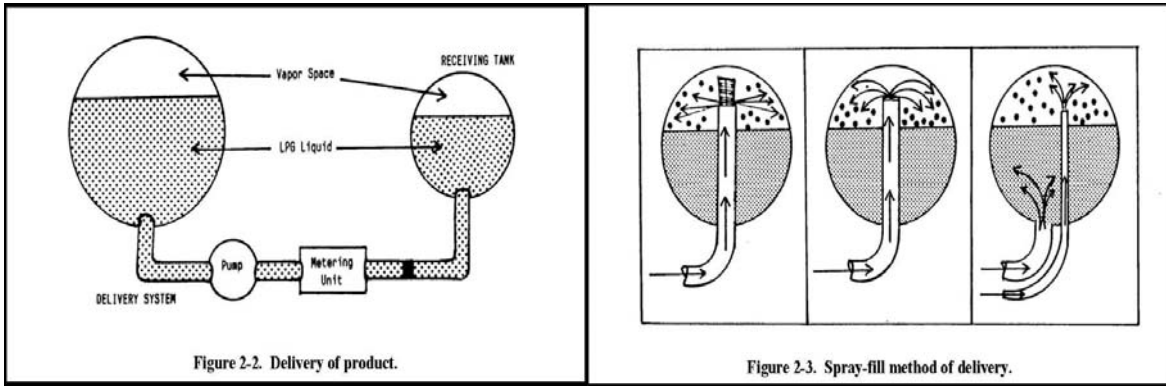


Figure A-4. Delivery of Product and Spray Fill Method

Spray Fill

Delivery systems now consist of a pipe from the receiving tank that is extended into the vapor space and is designed in such a way that the incoming liquid product is sprayed upward toward the top of the tank as shown in Figure A-4. As cooler liquid droplets descend they condense the vapor, thereby lowering the pressure in the receiving tank and allowing the system to pump to deliver liquid product more efficiently.

LPG Motor Fuel Dispensing

The construction of an LPG filling station appears to be quite similar to a gasoline filling station. LPG filling stations/dispensers offer a range of services depending on customer demand. A dispenser can be a simple unit consisting of basic elements of pumping and metering or a sophisticated state-of-the-art data collection and processing module equivalent to that of a gasoline dispenser. A typical fill rate of a motor vehicle using LPG is about 10 gallons per minute.