RAGASCO
A BUSINESS OF WORTHINGTON ENTERPRISES

Ragasco Composite Propane Cylinders

Part 1 - Design and Properties

If you have questions or need technical assistance, please contact cylinders@wthg.com

WORTHINGTON ENTERPRISES

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1 Summary and Background

This document outlines Ragasco Composite Propane Cylinders, highlighting their unique design and properties compared to traditional metallic cylinders. The insights provided aim to help users maximize the benefits of these cylinders.

2 The Company

Ragasco, a division of Worthington Enterprises, is the leading global provider of composite liquefied petroleum gas (LPG) cylinders for residential, leisure, and commercial applications. Our product line offers key advantages such as enhanced safety, lightweight design, rust-resistant materials, and translucency.

Since 2000, Ragasco has manufactured and sold over 25 million cylinders worldwide. The Ragasco cylinders meet a broad spectrum of international standards and certifications and are approved in more than 95 countries.

3 Product Properties

Ragasco composite cylinders have set the benchmark for user-friendly LPG solutions, offering numerous benefits that distinguish them from traditional metal cylinders:

- Lightweight: Easy to transport and handle.
- Translucent: Allows users to easily check LPG levels.
- BLEVE-free: Designed to prevent Boiling Liquid Expanding Vapor Explosions (BLEVE).
- Rust-free: Made from durable, corrosion-resistant materials.
- Ergonomic and stackable: Engineered for user comfort and efficient storage.
- Protected valve: Impact-resistant design safeguards the valve.
- Easy to clean: Requires minimal maintenance.

Additionally, the material is UV-stable with a robust design to resist the effects of sunlight, rain, temperature fluctuations, and everyday handling.

4 Product Design Details

4.1 General Description

Inner Liner:

- Made from High-Density Polyethylene (HDPE).
- Blow-molded for strength.
- Functions as a gas barrier.
- Highly ductile material.

Boss (interface between liner and valve):

- Features a threaded, HDPE over-molded, brass insert.
- Brass insert is interlocked with the reinforcing fibers for strength.
- Hotplate welded to the liner for a secure bond.

Composite:

- Fully wrapped continuous glass fibers.
- High-performance resin.

Valves:

- Available in all common valve outlet types.
- Special RAGASCO design featuring parallel threads and an O-ring seal, unlike metal cylinders, which

typically have tapered threads, and require a thread seal and high torque.
- The parallel thread and O-ring seal design allow for low-torque valve mounting, reducing the risk of damage to the joint between the metal and plastic in the boss.

Outer casing:
- Made from injection-molded HDPE.
- Designed for stacking, ergonomic handling, and cylinder impact protection.
- Protects the valve from external impacts.

Manufacturing:
- Fully automated production line.
- Extensive number of manufacturing and testing parameters are collected for each cylinder.

Additional features:
- Unintended rotation of the cylinder inside the casing is prevented by friction between the cylinder and the casing.

4.2 General Description

All Viking cylinders are marked in compliance with the DOT/TC regulations in effect at the time of manufacturing. Examples of such markings are presented in figures 4.1, 4.2 and 4.3.

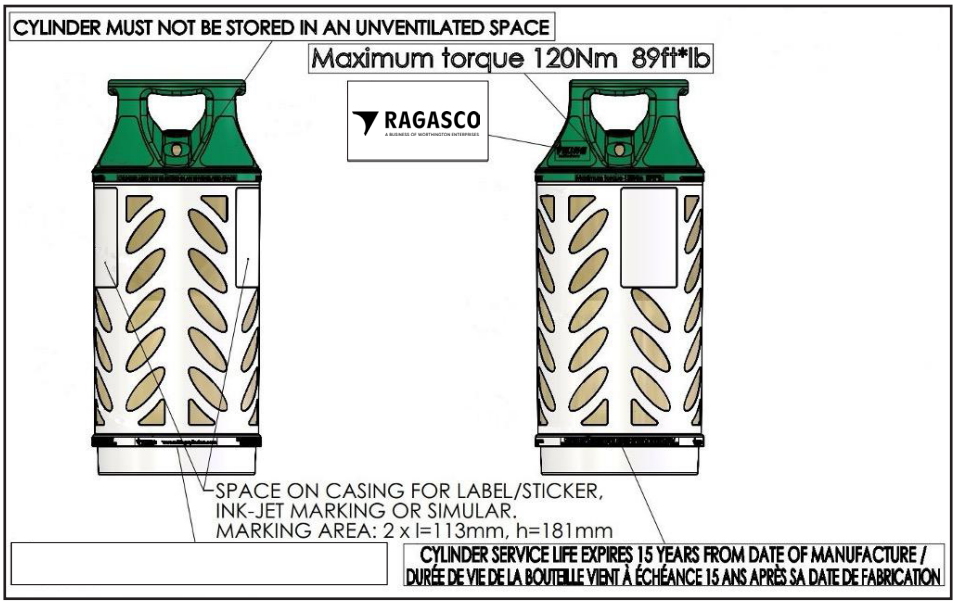

Figure 4-1 - Example casing markings

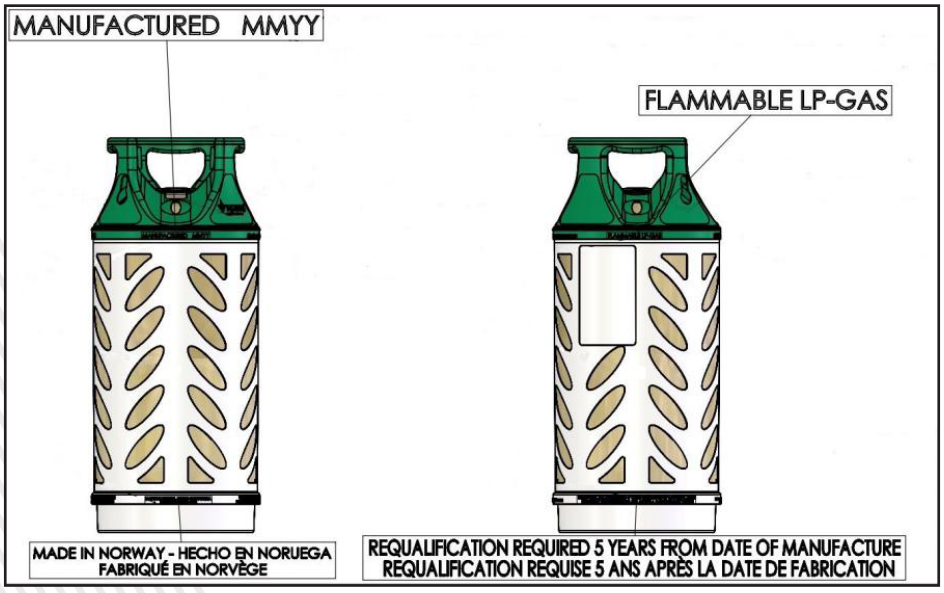

Figure 4-2 - Example casing markings

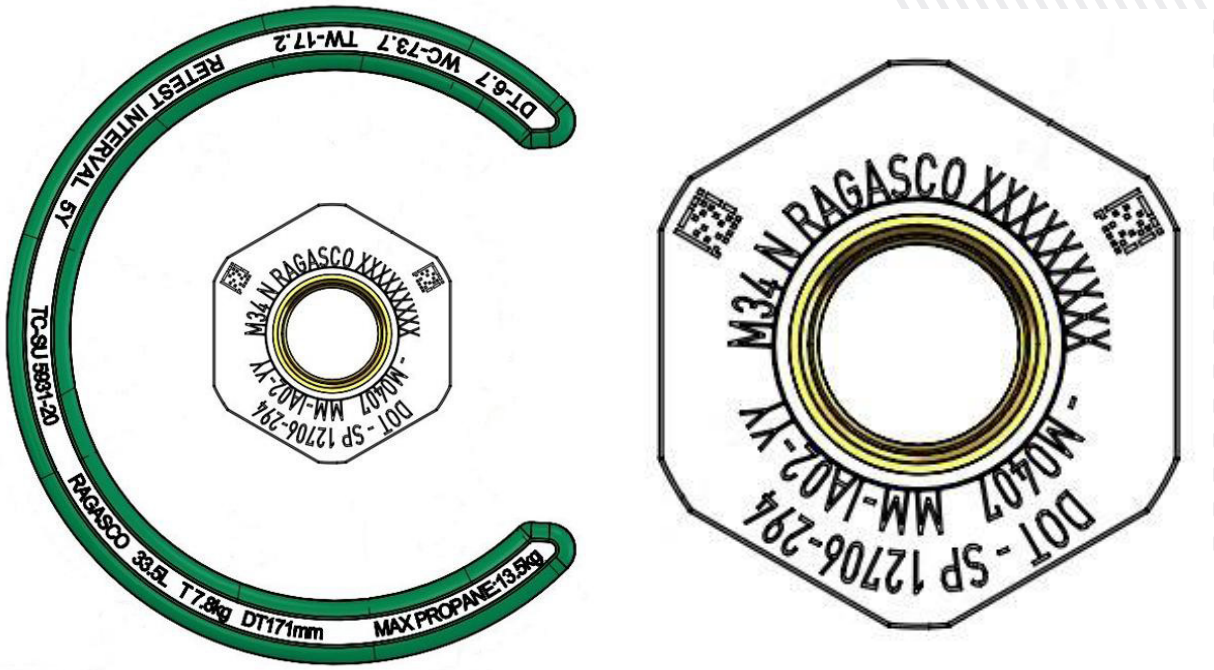

Figure 4-3 - Example marking on top ring and boss

Marking on top ring (starting top right, going counterclockwise):

DOT SP12706 markings:
- Dip tube length in inches [DT-X.X]
- Water capacity in lb [WC-X.X]
- Tare weight in lb [TW-X.X]

TC SU 5931 markings:
- Retest interval [5Y]
- Equivalency certificate number and max service pressure
- Manufacturers mark [RAGASCO]
- Water capacity in liters [XX.XL]
- Tare weight in kg [X.Xkg]
- Dip tube length in mm [DTXXXmm]
- Maximum allowed propane weight in kg [XX.Xkg]

Markings on boss starting with the "inner ring":
- M34: Cylinder thread
- N: country of manufacture
- RAGASCO. Manufacturers mark
- XXXXX: unique cylinder serial number
- M0407: CA approval number
- MM-IA02-YY: Month and year of manufacturing with the independent inspection agency number in between

Outer ring (at the bottom of the picture):
- DOT-SP 12706-294: Special permit number and maximum service pressure in psi

5 Ragasco Compared to Steel Cylinders

4.1 General Description

Traditional steel LPG cylinders are approved to the corresponding DOT specification as specified in 49 CFR Part 178, (e.g. DOT4BA, DOT240ET, etc.) which includes how to calculate the steel wall thickness and design many of the cylinder components, whilst composite LPG cylinders are certified based on performance testing of prototype cylinders. Composite LPG cylinders on the other hand are designed in accordance with Special Permits, which are normally based on internationally recognized cylinder design standards.

Ragasco is adapted particularly for the US and Canada market and are manufactured in accordance with DOT Special Permit 12706 and Equivalency certificate TC-SU 5931-20. These permits/standards base the cylinder design on very stringent testing of sample cylinders - it is a performance-based standard. Both types of permits/standards can lead to the production of high-quality cylinders, but the composite cylinder production is dependent on high quality repeatable production methods only deliverable by companies like Ragasco with an excellent quality assurance system.

5.2 Volumetric Expansion

When steel cylinders are pressurized, the steel expand under the stress and the design standard for typical steel cylinders allow around 20% volumetric expansion before the cylinder bursts under extreme pressure. Composites are different and do not stretch very much under extreme stress and pressure. Why does this matter? The liquid LPG expands considerably as it heats up, so if a cylinder is overfilled and the temperature rises, the entire internal space will be filled with liquid, and any further expansion of the LPG will cause the pressure inside to rise very rapidly as the liquid has nowhere to go. A steel cylinder will deform to increase the space inside, but a composite cylinder will deform less and may reach the nominal burst pressure earlier than a steel cylinder. But Viking Cylinders composite LPG cylinders have an average pressure resistance approximately double that of steel cylinders. If care is taken when filling the cylinder, this situation will never arise, but if there is doubt, or if the cylinder is filled by an unauthorized person, the Viking Cylinders are fitted with a relief device in the cylinder valve, which will prevent over-pressurization. Either of the cylinder types, if not fitted with a relief device, will fail when they reach their burst pressure. The composite cylinder has a much higher burst pressure and when it bursts there is less energy released than in the case of a steel cylinder, as the material has not the same elasticity.

5.3 Performance in a fire situation

When exposed to a fire, steel LPG cylinders eventually reach a temperature where the steel is no longer strong enough to hold the internal pressure of the hot LPG. At this point a BLEVE[1][2] (**B**oiling **L**iquid **E**xpanding **V**apor **E**xplosion) occurs in which the steel ruptures and with the release in pressure the liquid LPG in the cylinder boils rapidly giving off large amounts of gas which expands through the rupture in the steel and blows the cylinder apart. Projectile pieces of the cylinder can travel hundreds of yards and the pressure wave from the explosion can demolish buildings and cause serious injuries or death. In the case of the Viking cylinder a fire simply melts the casing and liner and burns the resin in the composite, causing the composite to become porous and release the LPG. Additional highly flammable LPG is added to the fire but there is no explosion or fragmentation of the cylinder.

*[1] A **b**oiling **l**iquid **e**xpanding **v**apor **e**xplosion (**BLEVE**, is an explosion caused by the rupture of a vessel containing a pressurized liquid above its boiling point.*

[2] If the fitted pressure relief valve (PRV) functions as intended, and the cylinder is not positioned in a group of cylinders, the PRV may help avoid a BLEVE, however this is not always the case.

5.4 Corrosion

Corrosion of steel cylinders is one of the main causes of failure in service. Contact with water, and in particular contaminated water, can cause rapid corrosion of the steel and leakage or complete failure of the cylinder. In addition, steel cylinders must be periodically re-coated with a protective medium such as paint to prevent corrosion and maintain the appearance and markings on the cylinder. Composite cylinders are not corroded by water and maintain their appearance over many years of service. They can be washed with water and detergent and rinsed clean. The cylinders can be pressure washed and RAGASCO recommends an alkaline detergent. They must not be in prolonged contact with solvents such as acetone, which can dissolve the resin in the composite exposing the reinforcement.

5.5 Impact Damage and Repair

If you drop a steel cylinder from some height the probability is that you will bend the foot ring or the shroud or dent the cylinder. With a composite cylinder you may crack the outer casing or in severe cases cause some de-lamination of the composite if the cylinder strikes a hard edge. In some cases, a steel cylinder can be repaired by welding on a new shroud or foot ring or straightening either of these. With a composite cylinder the outer case can be replaced if damaged, but damage to the pressure vessel beyond the limits described in RAGASCO document **Appendix 1 – Criteria for cylinder inspection** must result in scrapping of the cylinder.

5.6 Static Electricity and Bonding

During all LPG cylinder filling, equipotential ESD bonding to earth must be provided, to prevent any static electricity produced by the flow of gas or movement of the cylinder. Where care is taken to ensure that filling heads, conveyor tracks and filling machine weighing scales are bonded, the connection to the cylinder is always the weakest link. Failure to provide this bond can result in stray currents which may cause a spark and ignite any gas release. Whilst steel cylinders conduct electricity, composite cylinders do not. Charges accumulate on the cylinder surface and RAGASCO recommends adding small amounts of water to the cylinder outer surface and/or using other means to discharge the polymer surface just before filling. It is important that extra care is taken on all electrical bonding, and that earthing, or bonding does not use the cylinder as part of the grounding system.

5.7 Vacuum

It is common practice to reduce the pressure in steel cylinders to a significant vacuum to purge the cylinder of air before filling. This should be avoided in the case of composite cylinders with a liner, as the result could be to collapse the liner, pulling it away from the composite cylinder walls. The composite cylinders are designed to withstand all pressure conditions incurred during the storage of any LPG mixture[3] or air within any likely ambient conditions, i.e., at very low temperatures there may be a vacuum condition with any LPG mixture but not low enough to cause any problem for the cylinder.

5.8 Operating Temperature

The Viking Cylinders operating temperature range is -40 °C up to +65 °C.

5.9 Evaporation Rates (valid only for vapor withdrawal)

Different LPG cylinders can deliver different rates of gas flow. The end user will need a cylinder large enough to deliver the maximum gas demand of the device connected to the cylinder. The process of converting liquid LPG in the cylinder to gas requires the transfer of heat from the atmosphere and more heat can be transferred through the larger surface area of a larger cylinder and hence lead to a higher gas flow rate. The material of manufacture of the cylinder and the shape of the cylinder also influences the evaporation rate. Table 1 below provides some indicative values for gas consumption; it must be noted however that ambient temperature,

[3] *Including pure propane and pure butane.*

whether demand is continuous or intermittent, the level of liquid in the cylinder and the type of gas regulator used will all influence the gas flow rate. It is therefore advised to use the next largest cylinder size or connect 2 or more cylinders in parallel, if in doubt. Liquid withdrawal of the LPG will not limit the gas flow, as vaporization does not affect the amount of liquid possible to withdraw.

Note: When using Viking Cylinders as motor fuel on e.g. forklift trucks, the cylinder is equipped with a dip tube that will draw liquid LPG. In these instances, the vaporization capacity is not a limitation.

Table 1 shows typical applications for LPG equipment, and the suitability of Viking Cylinders, compared to steel cylinders.

TABLE 1 - RECOMMENDED USE FOR COMPOSITE AND STEEL LPG CYLINDERS

GAS	CONSUMPTION		TYPICAL EQUIPMENT	CYLINDER TYPE	SHORT DURATION (<60 MINUTES)	MEDIUM DURATION (60MIN<X<120MIN)	LONG DURATION (>120 MIN)
PROPANE	HIGH	> 14kW	Very large grills, weed burners, industry heaters	**Composite**	Efficient	Gradually reduction of effect. OK.	Limited ability
				Steel	Recommended.	Efficient	Limited ability.
	MEDIUM	3kW - 14kW	Patio heaters, normal grills, cabinet heaters, domestic cooking, etc	**Composite**	Efficient	Recommended.	Reduced effect.
				Steel	Recommended.	Efficient. Recommended.	Reduced effect.
	LOW	<3kW	Normal/small grills, cabinet heaters low effect, refrigerators etc.	**Composite**	Efficient. Recommended.	Efficient. Recommended.	Efficient. Recommended.
				Steel	Efficient. Recommended.	Efficient. Recommended.	Efficient. Recommended.
BUTANE	HIGH	> 14kW	Very large grills, weed burners, industry heaters	**Composite**	Efficient. Recommended.	Efficient. Recommended.	Limited ability
				Steel	Efficient. Recommended.	Reduced effect.	Limited ability.
	MEDIUM	3kW - 14kW	Patio heaters, normal grills, cabinet heaters, domestic cooking, etc.	**Composite**	Efficient. Recommended.	Reduced effect.	Reduced effect.
				Steel	Efficient. Recommended.	Efficient. Recommended.	Reduced effect.
	LOW	<3kW	Normal/small grills, cabinet heaters low effect, refrigerators etc.	**Composite**	Efficient. Recommended.	Efficient. Recommended.	Efficient. Recommended.
				Steel	Efficient. Recommended.	Efficient. Recommended.	Efficient. Recommended.

6 Usage of Ragasco Composite LPG Cylinders

The Ragasco composite LPG cylinders can generally be used for the same applications as standard steel LPG cylinders or LPG cylinders made from other materials.

We have, however provided some recommendations for using the Ragasco composite LPG cylinders or introducing the product to end-users.

Below you find some comments for vapor usage and liquid service usage respectively.

6.1 Vapor Usage

The Ragasco composite LPG cylinders can be recommended for all kinds of vapor usage such as cooking, water heating, room heating, outdoor space heating, fueling of small-scale LPG engines (that don't require liquid service) and gas grilling.

The specific advantages of composite LPG cylinders (light weight, no corrosion and translucent cylinder wall) make them especially attractive for camping cars, cooking and water heating on boats

ILLUSTRATIONS OF TYPICAL VAPOUR APPLICATIONS:

• Barbecue

• Cooking

• Floor polishing

• Gardening

• Heating

• Landscaping

• Lawn mowing

• Marine

• RV / Mobile home

6.2 Liquid Service Usage

The Viking cylinders are widely used for fueling engines on small vehicles such as Forklift Trucks as well as for outboard engines on smaller boats. The light weight of the composite LPG cylinders allows for significant ergonomic improvements compared to steel LPG cylinders.

ILLUSTRATIONS OF TYPICAL VAPOUR APPLICATIONS:

- Forklift trucks

- Marine

The Viking cylinders for liquid service come with many different valve solutions and it is important that the cylinders are orientated correctly to fully extract the liquid content (position of the emersion pipe for liquid extraction.

Here are some figures showing how the cylinder should be orientated depending on valve type:

FORKLIFT TRUCK MULTIVALVE US

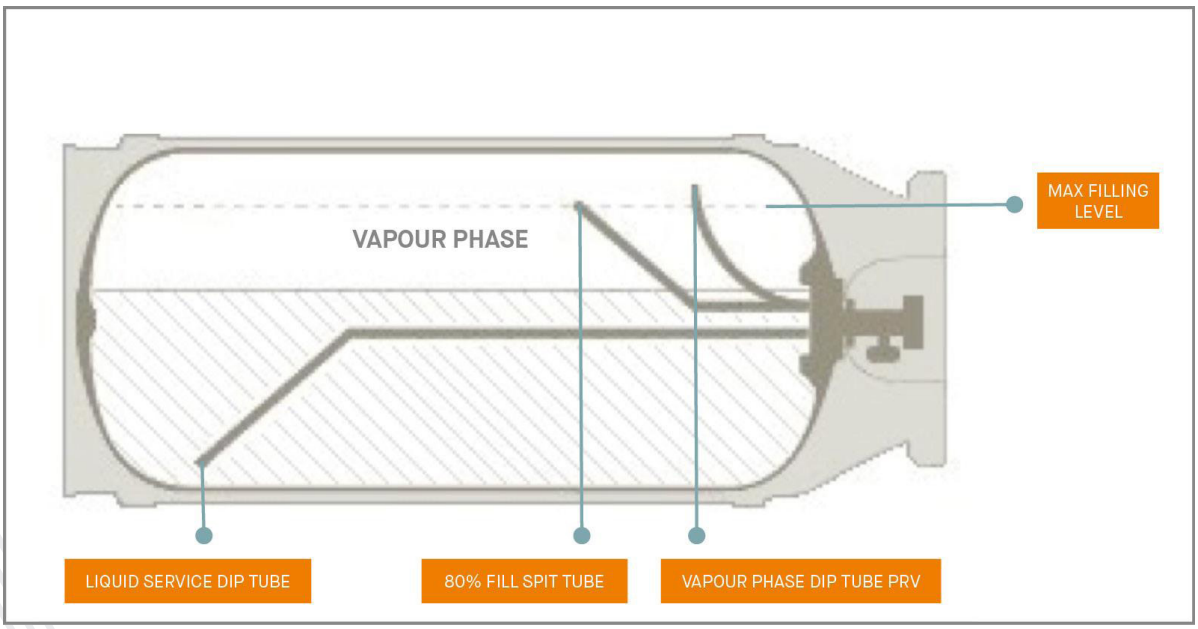

Figure 6-1 Principal sketch of multivalve. The "80% Fill Spit tube" is formally called a Fixed Maximum Liquid Level Gauge (FMLL gauge).

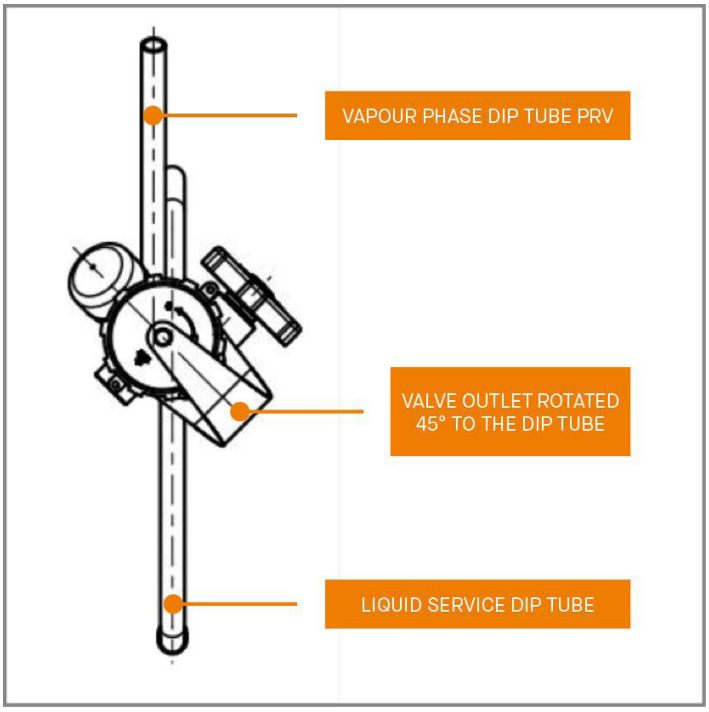

Figure 6-2 - FLT multivalve orientation - 45°. When the valve outlet is oriented 45 ° downward, the liquid withdrawal dip tube is oriented straight down, staying in the liquid phase during all operation, and the tubes for the FMLL gauge and the pressure relief valve points straight upwards into the vapor phase.

Figure 6-3 - FLT multivalve. The pin hole or keyhole shall be oriented so that the locator pin on the forklift truck is positioned in the pin hole. This ensures liquid withdrawal of the LPG.

7 Revisions

Revision	Date	Author	Change Description
01	September 4, 2024	Geir Vethe	Created
02	September 18, 2024	Mustafa Stanikzai	Changed the document template
03	October 30, 2024	Jonas Berglund	Updated and adapted text to North American market
04	November 25, 2025	Jacqueline Barber	Updated to reflect Ragasco/Worthington Enteprirses branding