Density Measurement and Vapour Elimination Systems

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INTRODUCTION

LPG Measurement Technology & LPG Engineering have been manufacturing LPG Dispensers since 1983. In the years that followed, research into the performance of LPG dispensers (particularly in the areas of vapour elimination systems and measurement accuracy) uncovered areas where performance and reliability could be improved. More specifically, two key needs were identified as most important in the development of a more precise and reliable LPG dispensing system:

1. All vapour elimination systems currently in use in LPG dispensers did not remove vapour reliably in at least some of the situations in which vapour can occur. In addition, all current systems were mechanical in nature and suffered from mechanical wear and tear.
2. OIML guidelines for the required accuracy of LPG dispensers could not be met when delivering varying ratios of propane and butane because the mixture has temperature compensations dependent on mixture. These compensations are too dependent on density for a single fixed density to be assumed and still meet the OIML guidelines. So (if possible) a way of measuring LPG density in-line should be developed in order to meet the OIML guidelines in anticipation of their soon introduction as an international standard.

The outcome of the extensive research and development that followed was the LPG Measurement Technology Density Sensing (and Vapour Elimination) System. It is an entirely electronic device that has no moving parts and answers both needs in one unit. It acts as the central component for vapour elimination and is also able to measure the density (and, therefore the mixture) of propane/butane mixes that make up standard automotive LPG.

This document describes the old mechanical vapour elimination systems and compares and contrasts them with the LPG Measurement Technology Density Sensing (and Vapour Elimination) System.

Traditional Vapour Elimination Systems

A vapour eliminator is defined as:

"A device installed upstream of the measuring device to avoid measuring vapour."

The use of a vapour eliminator is mandatory in LPG dispensers.

The two most widely used types are, the *float type* and the *constant bleed type* vapour eliminator.

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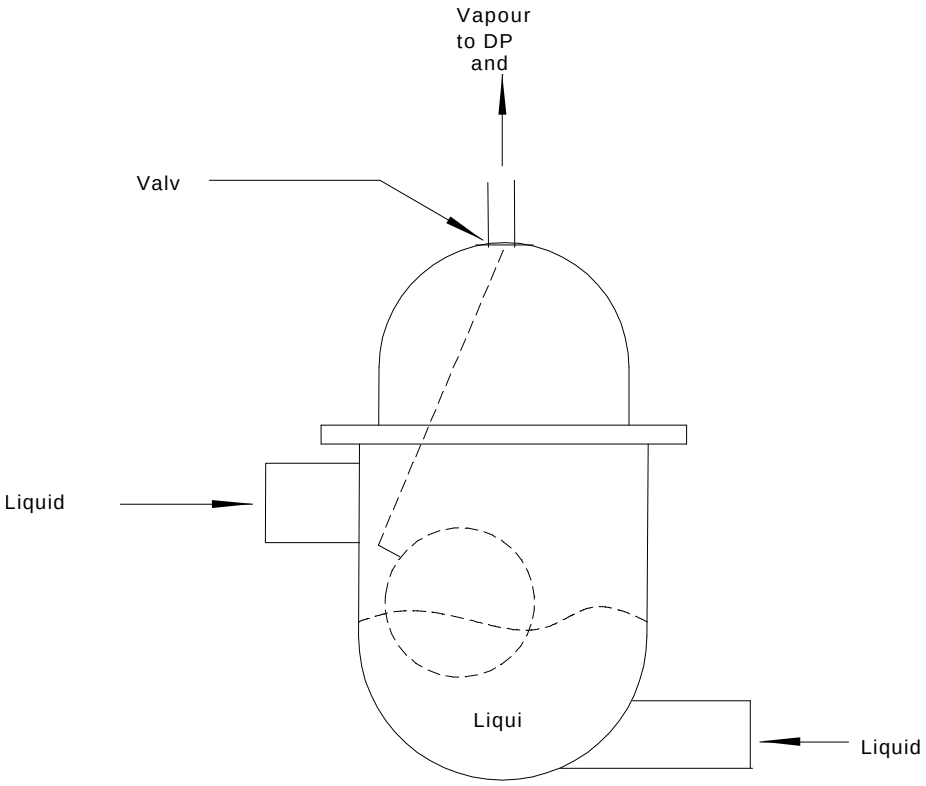
Float type vapour eliminators



If a large amount of vapour is present in the system, the float will fall and the vapour will exit through the top of the vapour eliminator. This vapour will return to the tank and may be used to provide high pressure to the Differential Pressure (DP) valve to stop delivery while the vapour is being cleared.

When the vapour eliminator is full of liquid the valve in the top of the chamber will close and flow is resumed to the meter.

These types of systems are currently used by many LPG dispenser manufacturers, including:

1. Liquid Controls (USA)
2. Neptune (USA)
3. Tatsuno (Japan)
4. Tokiko (Japan)

These types of systems have the following advantages and disadvantages:

Advantages

1. Will detect and eliminate vapour when it exists in large quantities.
2. Provides higher pressure to DP valve when vapour is detected compared to constant bleed vapour eliminators.

Disadvantages

1. Large size.

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2. Many moving parts.
3. Will not detect unsaturated liquid (bubbles).
4. With time and wear in the moving parts, it will fail to function.

The float type vapour eliminator is used widely in the petroleum industry. It's principles of operation are well understood. The adaptation of this system to LPG has been quite effective and produces an acceptable result for elimination of bulk quantities of LPG, but struggles to eliminate LPG bubbles.

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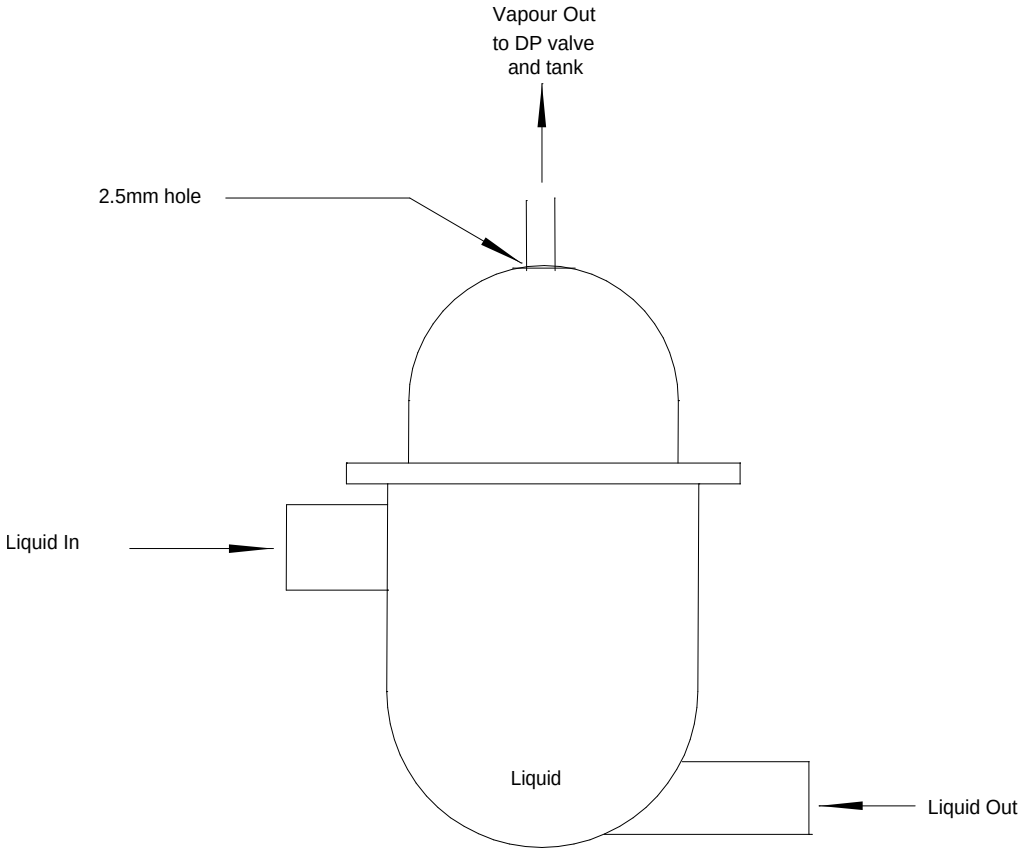
Constant bleed type vapour eliminators



This system relies on a 2.5mm hole in the top of the eliminator to return a constant flow of liquid back to the tank. If vapour is present, it is expected that it will return to the tank. It does provide a small increase in pressure in the return line when vapour is present which can cause the D P valve to close off the delivery while vapour is present. However, this design requires a DP valve that is much more sensitive than that required for float type vapour eliminators.

These types of systems are currently used by many LPG dispenser manufacturers, including:

1. Schwelm (Germany).
2. Nuovo Pignone (Italy).
3. Migas (Italy).
4. Batchen (Australia)

These types of systems have the following advantages and disadvantages:

Advantages

1. No moving parts.
2. Usually more compact than float type vapour eliminators.

Disadvantages

1. Does not reliably detect or eliminate large or small amounts of vapour.

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2. Will not detect unsaturated liquid (bubbles).
3. Moderately large size.
4. Does not provide a strong high pressure signal to DP valve.
5. Wastes pump energy bypassing approximately 10 lit./min back to tank through a 2.5mm hole.

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LPGMT Density Sensing and Vapour Elimination System
NEW TECHNOLOGY – HIGH PERFORMANCE

In order to provide a more reliable vapour elimination system, Mr John Clark researched an electronic vapour detection system. This system was developed over a period of two years and was approved by the Australian National Standards Commission in March 1991 and has been patented in Australia, New Zealand, Canada, USA, Korea and other countries. This system is now acknowledged as the most precise means of detecting unsaturated liquid and/or vapour to ensure that absolute accuracy is maintained. LPG Engineering & LPG Measurement Technology have been manufacturing dispensers using this system and licensing the technology to other manufacturers since approval was obtained in 1991.

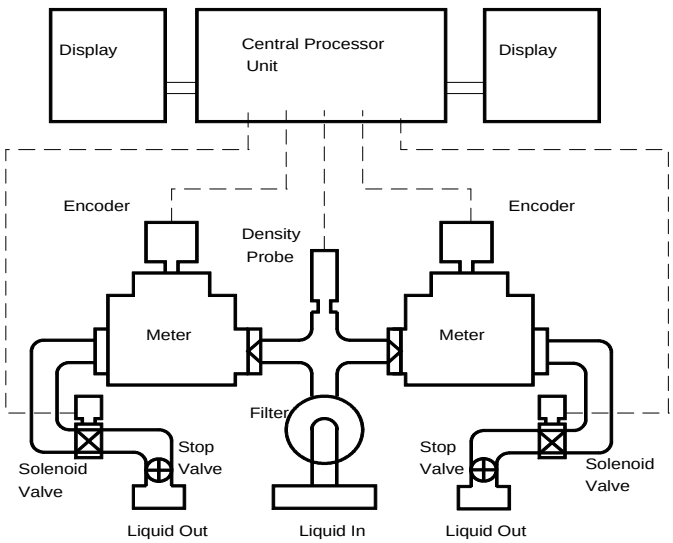
Since then, over 2,500 units have been successfully incorporated into LPG dispensers around the world. Their ability to perform (and outperform previous systems) has been well demonstrated.

Use of this advanced technology has not only provided a highly reliable vapour elimination system, but has also brought a range of additional benefits:

1. Real-time measurement of LPG density
2. Simplified, streamlined, hydraulic design resulting in simpler manufacture and higher peak flow rates.
3. Real-time liquid temperature measurement built-in.
4. No moving parts – high reliability.
5. No DP valve required.
6. Return line is not used.

Typical system configuration and operation

The following diagram describes the basic components of an LPG dispenser and how they are arranged in a system utilising the LPG Measurement Technology Density Sensing and Vapour Elimination System.



Liquid enters the dispenser through the filter and then passes over the vapour sensing probe and enters the meter through a soft seat back check valve. The liquid leaves the meter and passes through a delivery control solenoid valve, a manual stop valve, excess flow valve, hose, line break and dispensing nozzle.

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If unsaturated liquid or vapour is present at the meter inlet, then the delivery control solenoid valve will close, the pressure from the pump will re-saturate the liquid and once this is detected the delivery control solenoid valve will open and allow the delivery to proceed. (This is patented technology).

The system hydraulics to implement this are greatly simplified when compared to other systems. This allows for a reduced manufactured cost, less maintenance, ease of maintenance and more accurate metering.

The key component in this system is the electronic sensor. This sensor measures the dielectric constant of the LPG. If unsaturated liquid is present, then it is easily detected because there is a very large change in dielectric constant. The sensing probe is so sensitive that it can detect the difference between Propane and Butane and can be used to measure the density of the LPG mixture.

This system overcomes the problems with existing vapour elimination systems. The key advantages of the system are as follows:

1. Will detect and eliminate any amount of vapour (large or small).
2. Will detect and eliminate unsaturated liquid (bubbles).
3. Provides a signal to CPU to stop delivery when vapour is detected.
4. Small size.
5. Simplifies hydraulic manufacture and improves peak flow rate ability.
6. Can be used to detect Propane/Butane ratio.
7. Easy to incorporate into existing electronic counters (via standard serial communications).
8. Sophisticated built-in processor calculates the temperature correction factors for the particular mixture measured.
9. No moving parts – improved reliability.

The LPG Measurement Technology Density Sensing and Vapour Elimination System in LPG MT dispensers and under licence in Australia and around the world. Licensees include:

1. Gilbarco (Australia).
2. Dong Hwa (Korea).
3. Mid West Pump (Canada).

For more information on this new technology, or for information about licensing, please contact John K Clark:

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PROPANE/BUTANE BLENDS AND DENSITY

The LPG Measurement Technology Density Sensing and Vapour Elimination System is capable of detecting the propane/butane ratio of a blend.

As LPG must be temperature compensated, the Density at 15°C of the LPG must be known to apply appropriate temperature compensation for that density.

The density sensing system developed and patented by this company is the only means available to ensure that the correct temperature compensation is provided over the range of 100% propane to 100% butane or any intermediate mix.

There is now an international standard governing the accuracy of LPG dispensers. This is the OIML R 117 standard. This standard was adopted in Australia by the National Standards Commission on January 1 1996, and is being adopted in other countries around the world.

To be able to comply with the class of accuracy designated for LPG it is necessary to be able to determine both the temperature AND the density of the LPG to provide the appropriate temperature correction.

LPG dispensers are a class 1 device. This means that the Maximum Permissible Error (MPE) for the meter is 0.6% and the total MPE is 1%. This means that the temperature compensating device must be accurate to within 0.4%. The only way that this can be achieved is to measure both the temperature and density. (See NSC Doc. 100 - OIML R 117 clause 2.5 table 2 and clause 2.7.2 table 4).

The following chart shows the different correction factors applicable to Propane and Butane:

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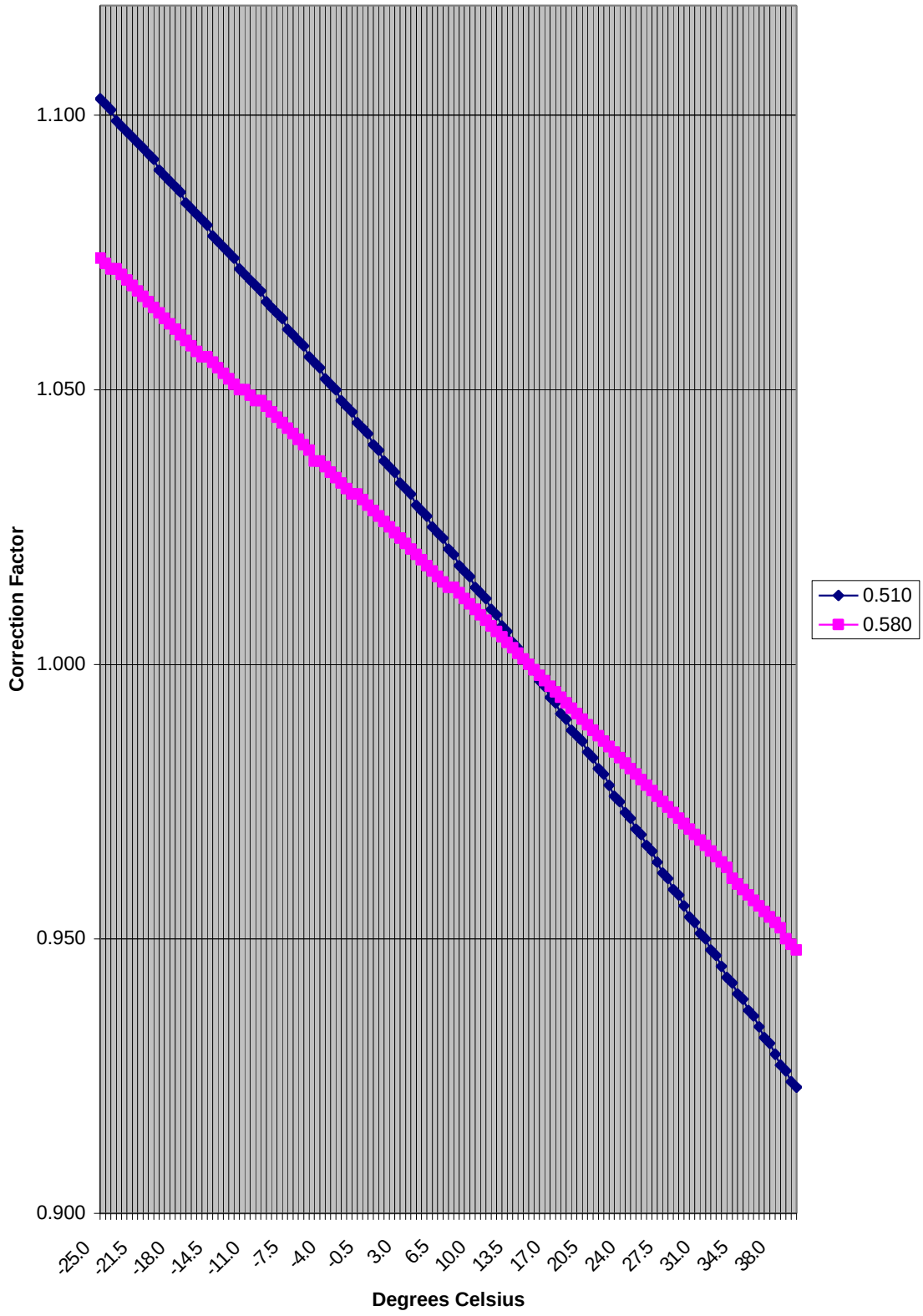

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Example

If we deliver 60 litres (uncompensated) at a temperature of 27°C with the compensator programmed for a density of 545 kg/m3 , (the typical density of 50/50 autogas) the corrected delivery would be 58.26 litres. (correction factor of 0.971) If the true density of the LPG was found to be 508 kg/m3 (the typical density of propane) then the true corrected volume would be 57.81 liters. The error induced by not knowing the true density is 0.78%. Note that the total error allowed for the compensator is only 0.4%. The temperature can only be measured to within ±0.5°C, so we must allow approx 0.15% for temperature error, therefore we can only tolerate an error produced by density measurement of 0.25%.

This means that we must be able to measure the temperature to within ±0.5°C and the density to ±2.0 kg/m3. (As per OIML R117 2.7.2 table 4).

Summary

The only way to achieve this is by using electronic density sensing.

More advantages

Because the probe provides all the information necessary for LPG dispensing, it is possible to use standard petrol pump/dispenser electronics (with hardware interface) for an LPG dispenser with only a small software change. This minimises inventory, production and service costs.

LPG Measurement Technology Density Sensing and Vapour Elimination Systems
The Future in LPG delivery.

visit us at http://www.lpgmt.com

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