Paper 16:

Experience with Installation of Sampling System in special Application

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1. INTRODUCTION

At the Kårstø Gas Terminal, LPG and NGL products are loaded to ships via three different jetties. These products are propane, ISO-Butane, normal-Butane and Naphtha or Condensate C5+.
Propane is loaded via jetty no. 1 and 2, ISO-Butane can be loaded via all jetties, normal-Butane can be loaded via jetty no.1 and 2 and Naphtha can be loaded via all jetties.
There are two metering stations for propane and both can meter to jetty 1 and jetty 2. One of the stations has been in operation since start up of the Kårstø Gas Terminal in 1985. The second one was put in operation in 2000. They are both based on turbine meters and equipped with a piston prover and a compact prover respectively.
In addition there is one metering station for ISO-butane, one for normal-butane, one for condensate and two metering stations for Naphtha.

Not only is it required to meter the quantity in terms of mass, it is also required to check the quality of the products. Therefore all the metering stations are equipped with product samplers. Since a number of the quality checks have to be done at the laboratory, it has been decided not to install on-line analysers.
It is therefore of outmost importance that the sampling systems are reliable and provide samples representing the average of the loads.

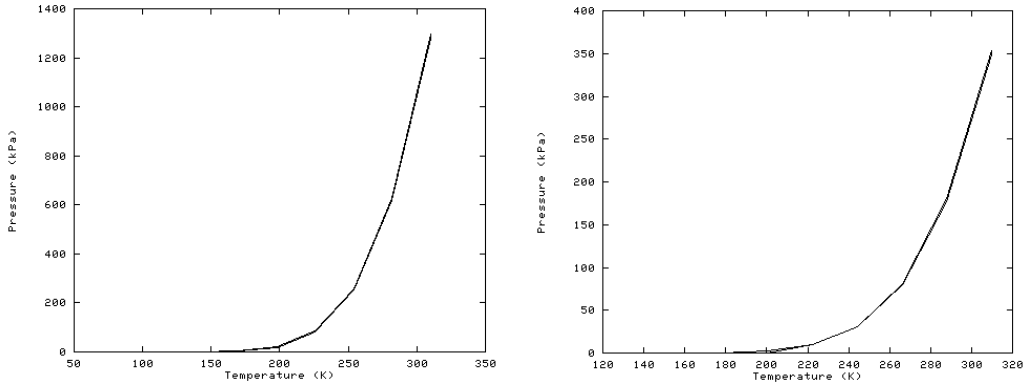
This paper deals with problems experienced by sampling liquid propane for laboratory use, and how these problems were solved.

2 BACKGROUND

Both the regulations from Norwegian Petroleum Directorate (NPD) as well as Transport and Sales Agreement require flow proportional sampling. If this is not possible for one reason or another, the fallback procedure is to take spot samples after 25 %, 50 % and 75 % during the ship loading. It is also a requirement that a part of the sample should be stored in case disputes between parties arise afterwards.

The propane metering station set in operation in 1985 was equipped with a flow proportional sampler. However, despite many efforts from the vendor and the operating personnel, this system never functioned properly. So spot sampling has been the regular procedure ever since.
In connection with the installation of a new propane metering station in 1999, it was decided to look for solutions for a successful sampling system.

The phase envelope of propane is special, relative to the other products. Examples are shown in fig. 1.



a. Phase envelope for Propane Product *b. Phase envelop for n-Butane*

Fig. 1
a. Phase envelope for Propane product: 0.8 mol % C2, 99 mol % C3, 0.2 mol % iC4
b. Phase envelope for n-Butane product: 0.8 mol % C3, 98 mol % nC4, 1 mol % iC4, 0.2 mol % C5.

It appears from the phase envelopes from propane that at atmospheric pressure (100 kPa), the temperature has to be lower than ~231 K (-42°C) to be in liquid phase. On the other hand, at a normal ambient temperature of 17°C (290 K), the pressure has to be higher than 800 kPa (8 bar) to be in liquid phase.
For n-Butane the temperature has to be lower that ~273 K (0°C) at atmospheric pressure to be in liquid phase, and at a normal ambient temperature of 17°C (290 K), the pressure has to be higher than 200 kPa (2 bar) to be in liquid phase.

The line pressure of propane (at the metering stations) is approximately 8 bar and the operational temperature is ~231 K (-42°C). The problem experienced with the "old" sampling system arises from these conditions: Samples were taken at line pressure, but as soon as the temperature started to increase toward ambient, the liquid propane went to gas phase and apparently no liquid were sampled at all.

So the "trick" with the new sampler system was to increase the pressure sufficiently to keep it at sufficient pressure in all parts of the sampling system to remain in the liquid phase.

So, a rugged system was designed to sample the propane at a higher pressure than the line pressure, so high that it should not be a problem to maintain it in liquid phase all the way to the laboratory.
Not only should the system be flow proportional, but the samples should also be maintained homogeneous since the amount of product used in the analysers is only a small part of the total sample.
To achieve this, a liquid grab sampler together with a sampling system for transport and storing the samples of the load is necessary.

3. FUNCTIONAL DESCRIPTION OF THE PROPANE SAMPLER

A Sample system for liquid propane sampling is designed to extract a sample of the propane from a pipeline and store it in a sample container under fixed conditions. The sampler system consists of a grab sampler, transport tubing and a sample container with mixer.
The sampling frequency is proportional to the flow rate. The sample container has a volume of 10 liters. With about 80 % of the container volume to fill and a cup volume at 4 ml, it will take 2000 samples to achieve 8 litters. If a load takes about 12 hours, the sampler takes a sample every 21 second. .
The sample container is a piston cylinder with a pressure from an external gas bank to keep the piston forced at a pressure of 30 barg to keep the sample in liquid form. Included is also a mixer system. The mixer ensures homogeneous mix of the sample in the container.

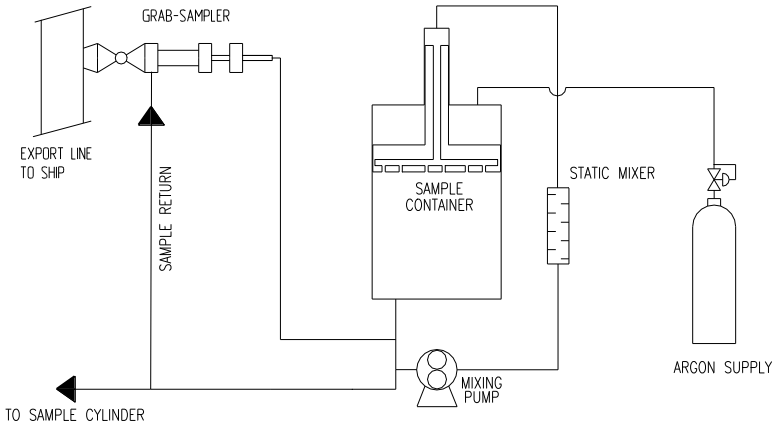


Fig. 2 A simple schematic drawing of the sampling system

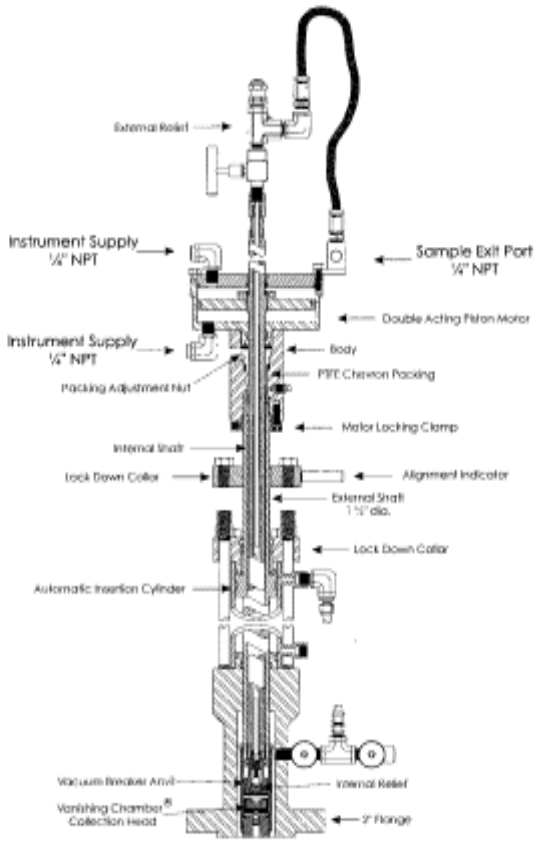
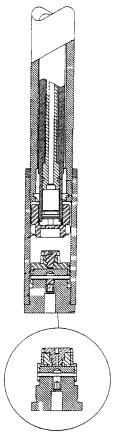


Fig. 3 Grab sampler type Welker model LSSM-1F



The grab sampler used is the type Welker model LSSM-1F. A drawing is shown in figure 3.
The grab sampler itself is actually in the pipe. (See drawing of the grab) This grab captures a fixed volume of propane, and an automatic pneumatic driven unit operates the grab in and out of the pipeline under full process conditions, and allows this volume of the product to be forced into the sampler system at 43 barg to the container. This provides the user to get a representative and accurate sample of his product.

Fig. 4 Detail of the grab sampler

The sampler is flow proportional. During the load, 2.000 samples will be taken. This ensures a good average measurement of the load.

Fig 5 Installation of the grab sampler at Kårstø

The sample container and the mixing system are located inside a cabinet. Between the grab sampler and the sample container, is 10m tubing with inside diameter of 3 mm.

Fig. 6 Sampler cabinet

The sampler cabinet consists of the sample container with piston and level monitoring, a mixing system with pump, and valves and gauges for operating the system when lab. samples are taken. It contains also equipment for operating the grab sampler, and for control of the backpressure on the piston in the sample container.
To get sample from the grab sampler to the container, a higher pressure must be maintained on the sample than the backpressure in the system. Sample pressure can be read at the respective gauges. See fig.7.
Grab sample pressure is read at the left gauge. This increases by the operation of the grab sampler until it reaches the set pressure of the relief valve, which is set to 43 bar in this case. At the picture, the sampler is not in operation and therefor the pressure is equal to line pressure.
The gauge in the middle shows the backpressure. This is always set to 30 bar.

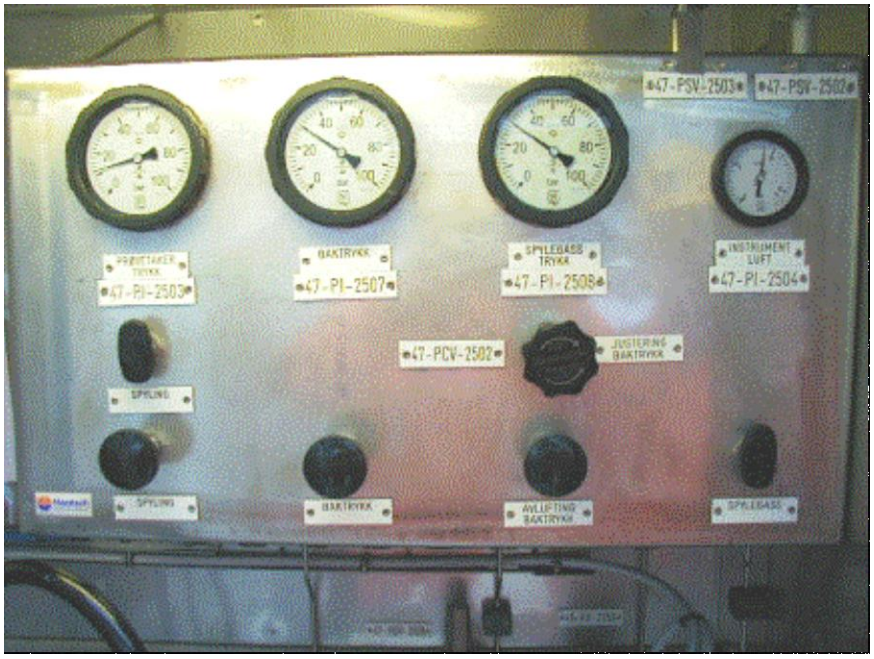


Fig.7 gauge panel

The mixing system consists of a pump, a static mixer and a jet mixer. The propane is forced in a closed loop by the pump through the static mixer, through the piston and then through the sample in the container.

The cabinet is also constructed with facilities to purge the excessive propane from the container back to the pipeline.

4. PROCEDURES

Procedures have been established to ensure that the propane is kept at required homogeneous liquid phase conditions.
Once the loading to ship starts, the sampler system starts to grab samples. The filling level (i.e. the position of the piston) is monitored continuously during the loading. Before lab-samples are taken to be analyzed in the laboratory, the filling level is checked and the mixing system is started. Normally, lab-samples from the 10-l sample containers are extracted when the ship is 90 % filled up. Three samples each of 300 ml are filled up after a careful purging of the tubing between the large sample container and the small sampler cylinder. Approximately 1.5 – 2 litters are taken out in this action. The remaining propane in the 10-litre cylinder is then returned into the line. This is possible because the pressure in the container is far above the line pressure.

When sampling starts for a new load, the pressure in the tubing is kept at this high pressure so the sample provided from the 43 bar part over to the sample tubing will continue in liquid phase. No amount of propane from the new load is needed to pressurize the system for reaching its equilibrium pressure.

The continuous piston position monitoring, quickly reveals any leakage or malfunction. Also, the final level will reveal problems with the grab sampler itself.

5. EXPERIENCES

The new installation was not put into operation without some start-up problems. The experience showed that the cup size is one of the keys to success. The first cup installed had a volume of 1ml. This volume was not enough to reach the necessary level in the sample container, and this forced the grab sampler to exceed its maximum frequency. The result was incomplete movements of the sampler.
A cup size of 4 ml was installed last July, and no problem with the operation of the system has occurred later.

The filling level when lab samples are taken for the laboratory at 90 % finished loading, should ideally be 7.2 litres. The recorded level has steadily been 6 litres. This means that the effective grab size is 3.3 ml instead of theoretically 4 ml. This is regarded as fully acceptable.

The only complaint so far has been that the operation of the system by the laboratory personnel is inconvenient due to bad positioning of the cabinet.

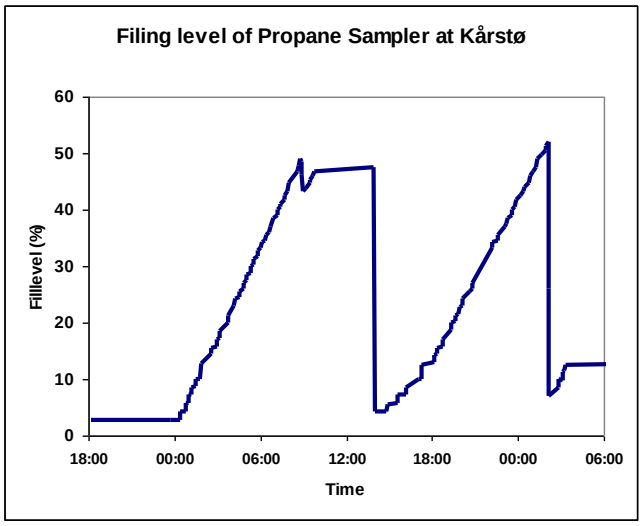


Fig. 8 shows how the filling level develops during the loading.

6. CONCLUTION

The former sample system for propane at Kårstø did not operate properly. Therefor a routine with manually sampling three times during a load was established. This was not according to the agreement between the partners.

When a new export line for propane was built, a sampling system from FMC Kongsberg Metering was selected. The goal was to establish a flow proportional sampling system according to the regulations from The Norwegian Petroleum Directorate (NPD) and The Transport and Sales Agreement.

The challenge was to keep the sample in liquid phase, and present a reliable result representing the average of the load. This was achieved with the application of the pressure above the piston in the sample container and correct size of the sample cup in the grab sampler.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.