

The Challenge & Solution - Inventory Management of NGLs in 1.3m x 500m Horizontal Vessels

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Abstract:

Storage and reconciling inventory of Natural Gas Liquids (NGLs) present different challenges depending on where this is done in the value chain. This paper is about a central storage facility where NGLs are piped in from several gas plants (single owner), trucked in liquids from diverse owners as well as liquids piped in from a third party. This centralized storage and truck terminal then supplies the market feeding into existing midstream infrastructure. While there are traditional metering points of custody transfer at each receiving and the final delivery point it's important to have visibility on the stored inventory and with that a balancing challenge to ensure the fluids on hand reconcile with all the receipts and deliveries.

Did we mention that the storage capacity we are referring to is approximately 3,500 m³. Factor in the fact that the NGL is a high vapour pressure liquid where a change in temperature of 10°C can result in an expansion/shrinkage of +/-3% or more. By not having corrected volumes in the tubes there is a risk that the daily and monthly balancing could cause over or under reporting of the inventory.

As we alluded to in the title of this paper the, the challenge is the inventory management of a storage system using multiple 1.30m (diameter) x 500m (length) horizontal vessels, essentially a tube storage system buried below the frost line. The challenges get a little more complex as the horizontal vessels are on a 1 degree slope resulting in one end of the vessel being essentially 5m above the other end.

Please read on to understand how in collaboration an Energy Company as the Operator, faced with a challenging problem and the Solution Provider challenged with delivering the solution came together with successful project.

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As the Cutbank Ridge assets, a collection of new construction natural gas liquids (NGL) projects, come online and approach name plate the requirement to collect and store the produced NGLs meant that the Veresen Midstream Tower Centralized Liquids Storage (TCLS) facility project would start construction. An Inventory Management System would be one of the assets requirements in order to manage and reconcile the inventory and to satisfy the Measurement Accounting requirements imposed by the Regulator and contracts with the different stakeholders. Figure 1 is a simplified measurement schematic for the TCLS facility showing the multiple inventory inputs and single output and why storage and reconciliation would be critical for the project's operation.

The accounting procedure approved by the British Columbia Oil and Gas Commission (OGC) and the British Columbia Ministry of Finance (MOF) required Veresen Midstream to equalize:

- 1) the pipeline LACT sales volumes at a component level plus/minus tube inventory to,
- 2) the CLS receipt meters, both flow-lined and trucked production and to,
- 3) the gas plant meters plus/minus the NGL inventory at the gas plants

Due to potential metering differences the equalization would be made through the application of proration factors.

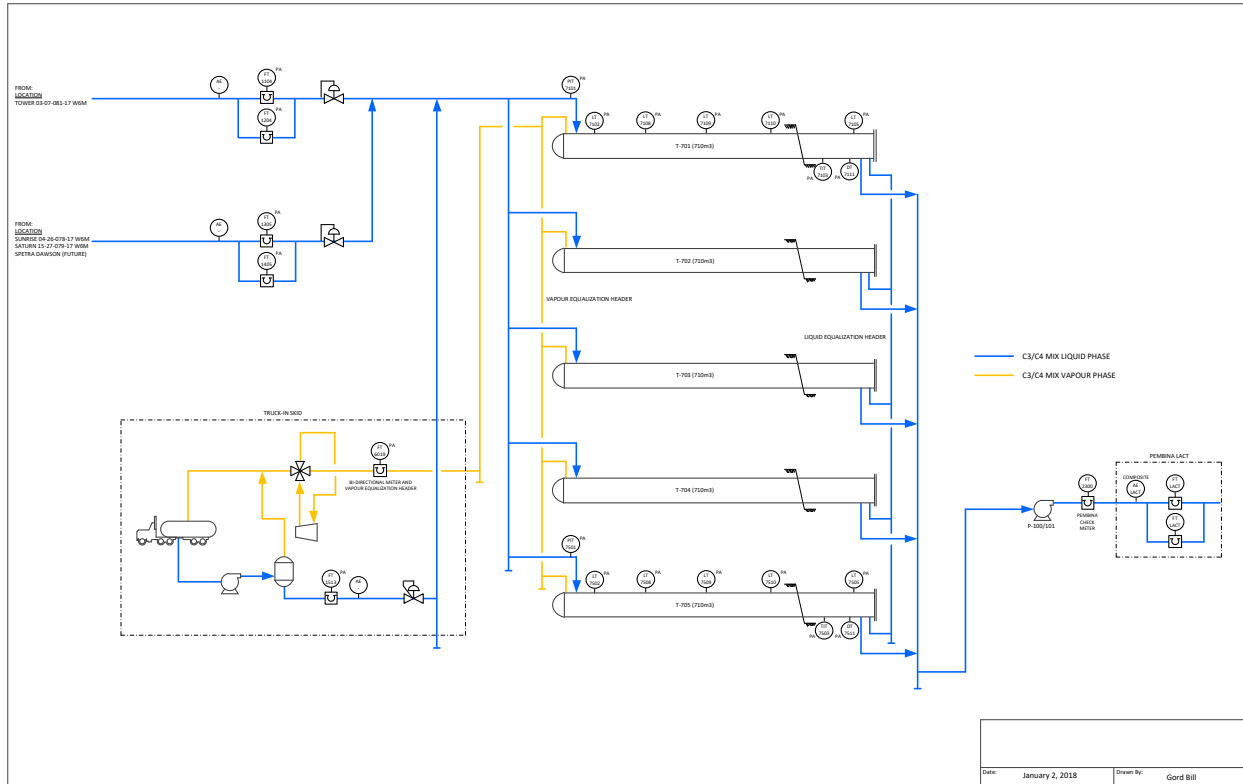


Figure 1- Tower Central Liquids Storage Schematic (simplified)

As dictated by the accounting requirements, all of the measurement systems were required to comply with the OGC Measurement Guidelines for Upstream Operations and the liquid metering systems need to have an installed total volumetric measurement uncertainty of 0.5%.

Since the NGL meter volumes at the gas plants' outlets, CLS inlet and pipeline LACT are being pressure and temperature compensated to API 11.2.2 and GPA TP-27 it is also important to perform the same compensation on the volumes inside the tubes because of the large volume. Altogether, the CLS has a combined capacity of 3,550m³ and since the NGL is high vapour pressure liquid a change in temperature of 10°C can result in an expansion/shrinkage of +/-3% or more. By not having corrected volumes of the inventory there would be a risk to the daily and monthly balancing that could cause over or under reporting of the inventory.

The equipment required to accomplish this were:

- Level transmitters
- Temperature transmitters
- Pressure transmitters
- Density measurement transmitters
- Tank Capacity (Strapping) Tables
- Tank volume corrector

Since temperature changes pose a huge influential factor on the inventory the key in the project design was to minimize the impact of temperature. One could imagine that 3,550m³ of high

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vapour pressure liquids would mean a significant tank farm of bullet tanks that would be exposed to the varying temperatures in North Eastern British Columbia, where the CLS is located in Canada. This is precisely why the best solution was to store the fluids below the frost line in five (5) five hundred meter (500m) long tubes with a diameter of 1300 mm each. The influence of temperature is thereby significantly minimized without the need for costly temperature controlled bullet tanks. Other design factors that influenced the decision to use buried tubes where:

- Estimated lower cost of ~25-40%
 - Lower construction/material costs
- Beneficial topography and lease space
- Regulatory viability – design accepted by the OGC
- Influence and experience from joint venture partners
- Simpler inlet/outlet header design
- Allowed for increased NPSH on sales pumps, reducing their size

Now you can understand some of the of reasoning behind storing the NGLs in a so-called Tube Storage facility.

To add to the inventory measurement, challenge the design required that the storage tubes be installed on a 1° slope. In theory measuring the level in a tube that is horizontally level would be fairly simple. The 1° slope and the length of the storage tubes (500m) meant that the inlet would be 5m higher in elevation than the outlet of the storage tube (see Figure 2), here in lies the challenge. Suffice it to say this paper will further identify the challenges of measuring inventory in these non-conventional storage vessels.

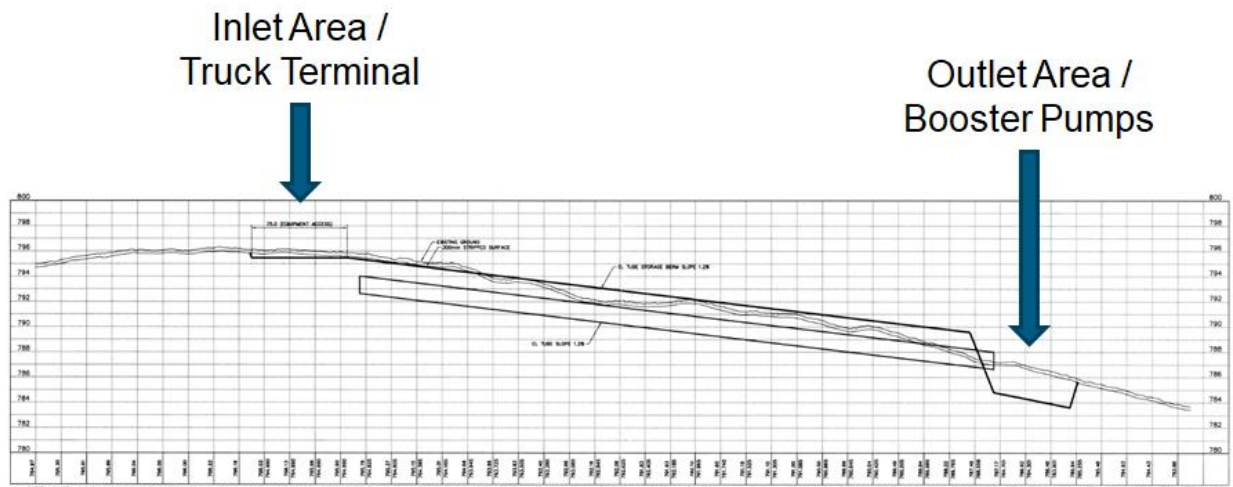


Figure 2 - Topography and Design Profile

The process of evaluating the storage vessel(s) Net Standard Volume for the purpose of accounting and reconciliation of the facilities inventory meant that we need to determine the vessels liquid level and temperature in combination with a tank capacity (strapping) table which produces the Total Observed Volume. While factoring in various other calculations and volume correction factors as defined by the American Petroleum Institute (API) and as required by the OGC we are able to determine the inventory. The Tankvision Inventory Management System provides this function for the CLS. Figure #3 is a simplified flow chart describing a volume assessment similar to that utilized at the CLS.

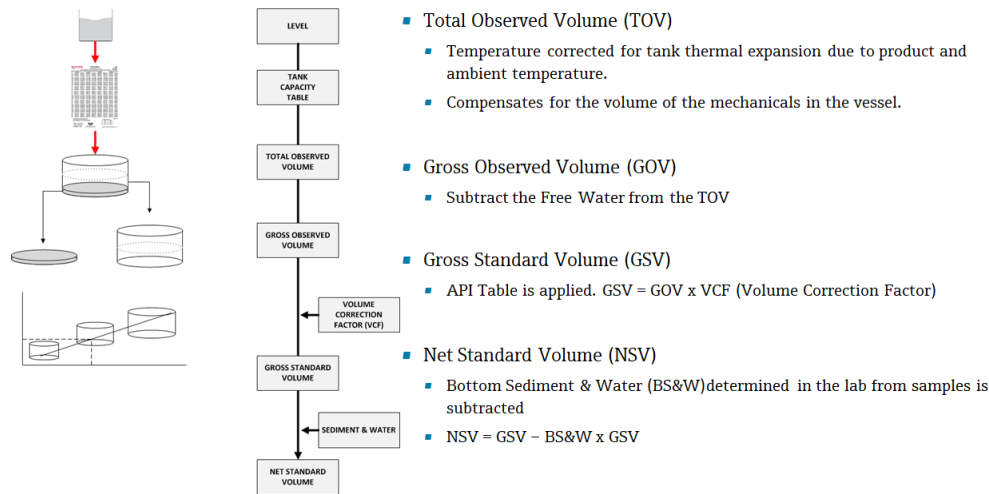


Figure 3- Simplified explanation of Volume Assessment for an Inventory Management System

So how exactly would the level measurement be performed in a 500m long storage tube on a 1° slope? By utilizing five (5) guided wave radar transmitters equally spaced 125m apart we were able to cover the necessary range of level measurement. Figure #4 shows how the five (5) Levelflex transmitters were installed in order to solved the challenge of measuring the level.

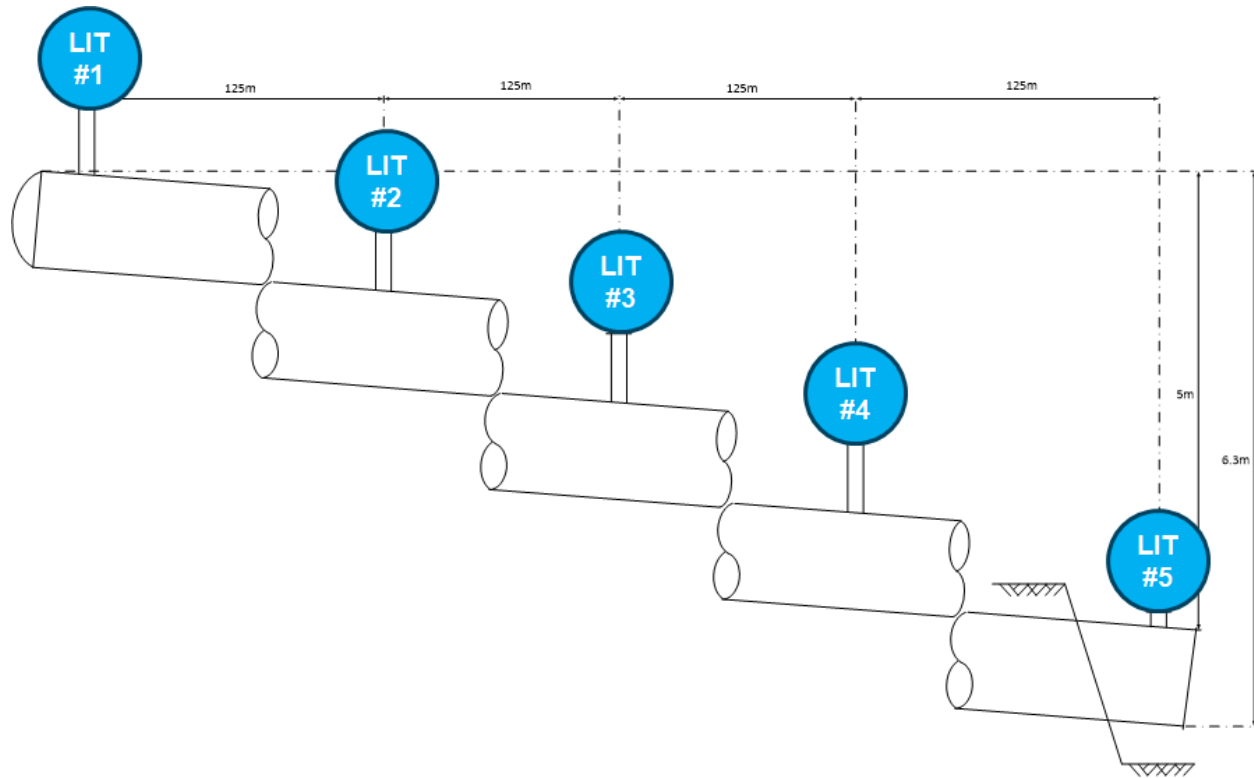


Figure 4 - Measuring the Level and the 1° challenge.

As detailed in Figure #3 in order to determine the inventory a tank capacity table (aka strapping table) is required. Determining the tank capacity table in a conventional tank commonly utilizes a surveying laser setup in the vessel. The challenge these storage tubes presented due to the 1° slope was that for each tube five (5) tank capacity tables (TCT) are required each TCT referenced for each of the five (5) level transmitters (LIT) as shown in Figure #4. We solved this challenge leveraging one of the required construction steps, the hydrotest. During the hydrotest a spare Coriolis was used to measure the corrected volume of hydrotest fluid as the tubes were being filled. Onsite Endress+Hauser Technicians utilizing a data acquisition system called Memograph monitored the in flowing volumetric flow and the level measurement of each of the five (5) Levelflex transmitters. Determining the tank capacity tables this way ensured that the level at each on the level transmitters versus volume would be known. This approach had minimal impact on the construction plan as we utilized an already planned step in the project, the hydrotest, in order to get determine the volume. One phase of construction yielded two results, hydrotest & tank capacity tables, the resulting TCT is shown in Figure #5.

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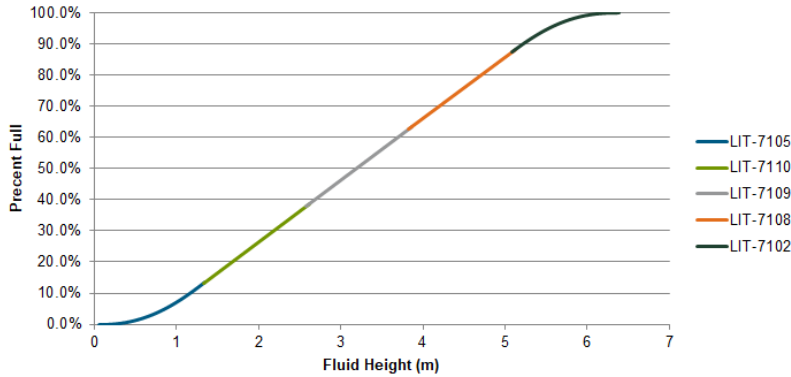


Figure 5 - Tank Capacity Table accounting for the 1° slope of the storage tube

The desired operational philosophy coupled with the complexity of distance (500m) meant that the project would utilize a Rockwell Automation ControlLogix Control System at the Inlet Terminal and at the Outlet Terminal interconnected over fiber optics as shown in Figure #6. To minimize wiring costs some of the instrumentation would be wired to each of the two control systems (Inlet & Outlet). In order to minimize rounding and resolution errors commonly expected with analogue 4...20mA technology the project's mandate was to utilize a digital technology, HART protocol. This means that all of the instruments would output utilizing HART protocol which is interpreted by the control systems smart input modules. By utilizing HART all measurements and calculations leverage 32 bit all digital values and this helps to satisfy the project requirement for an installed total volumetric measurement uncertainty of 0.5%. In order to maximize availability and minimize life cycle operating costs Veresen Midstream preferred an inventory management system that would directly determine the Net Standard Volume and output to the Terminal Control System without the need special software installed on application servers. Here enters the inventory management system, Tankvision. Tankvision interfaced to the ControlLogix to collect the different measurements all digitally leveraging the local area network based on EtherNet/IP. Tankvision then performs the required calculations satisfying OGC and MOF requirements by correcting the C3/C4+ volume to equilibrium vapour pressure and 15°C using GPA TP-27 / API MPMS 11.2 Table 54E. The results are then returned to the control system and operations over EtherNet/IP. To be specific the inventory system leveraged all digital and open interfaces minimizing the integration effort by not requiring custom interfaces that would prove to be a challenge to maintain over the operating life cycle.

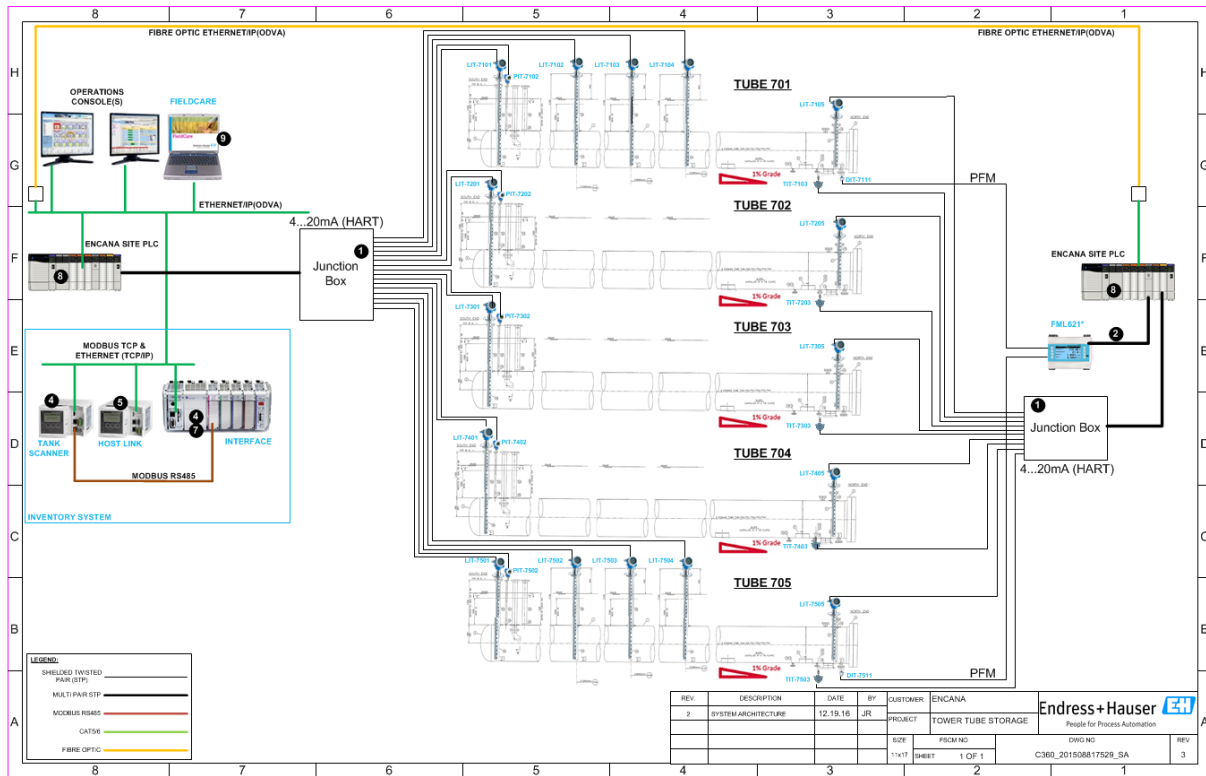


Figure 6 - Inventory System integrates with the ControlLogix PLCs without custom interfaces

One of the life cycle and maintenance requirements was the ability to verify and document the level instruments performance instu without the need to take the instrumentation offline or without interrupting the inventory measurement. Heartbeat Technology integrated into the guided wave radar transmitters selected offering instu verification traceable to the level instrument’s original multi-point factory calibration. The distinct documented test can be initiated from the level device display or remotely with FieldCare software tunneling through the ControlLogix system providing Technicians a simple guided test procedure, and automatically generated test protocol, providing proof that by means of supporting documentation, that the device measurement can be counted on. The tube design furthermore allows for the different level transmitters to overlap another providing further confidence by comparing one device to another as the tube inventory changes.

Our paper demonstrates how a challenging inventory measurement requirement can be solved through collaboration though-out the various phases (eg. design, construction, commisioning and operation) of an NGL Storage facility.

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References:

[Memograph is a product of Endress+Hauser.](#)

[Levelflex is a product of Endress+Hauser.](#)

[Liquiphant is a product of Endress+Hauser.](#)

[Tankvision is a product of Endress+Hauser.](#)

[FieldCare is a product of Endress+Hauser.](#)

[Heartbeat Technology™ is a trademarked technology of Endress+Hauser.](#)

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MOF is the Ministry of Finance of British Columbia
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