Cavern inventory management feeds fractionation plant and pipeline products

Chevron's Fort Saskatchewan, Alberta, Canada facility (Figure 1) includes a fractionation process and storage caverns that handle light hydrocarbon products in dense phase or liquid form. The feedstock to the fractionation process is a propane (C3) mixture containing other products (called C3+). The mixture is 50 to 60 percent propane. The process produces approximately 5,000 cubic meters (31,445 barrels) per day of C3, butane (C4) and a light grade condensate.

Pipeline infrastructure enables the transportation of ethane (C2) mixture containing other products (called C2+), C3, C4, and pentane (C5) spec products into the facility for storage purposes.

Ten caverns

A major portion of the facility’s business is cavern storage; approximately one million cubic meters of outside C3 was stored in the caverns in 2000.

The cavern storage consists of ten underground caverns mined in the Lotsberg Salt formation, which is a layer of salt about 250 feet thick located between five and six thousand feet below the surface. The combined storage capacity is 1.1 million cubic meters (6.9 million barrels). The caverns vary in size from approximately 75,000 cubic meters to 180,000 cubic meters.

What is called the product pad rides on top of the brine that is at the bottom of each cavern. Somewhere in the cavern is an interface between the product and brine.

The caverns are called “single hole” caverns because there is one drilled bore from surface down into the cavern (Figure 2). A typical cavern wellhead consists three kinds of piping infrastructure: product, brine and fresh water piping (Figure 3).

The product piping, or outer 9 5/8 inch line, comes into what is called the Y-spool of the wellhead. Multistage high-pressure injection pumps push product down this pipe and forces brine from near the bottom of the cavern up through a 7-inch pipe inside the outer pipe in the center of the wellhead and into two

Figure 1. Chevron’s Fort Saskatchewan, Alberta, Canada facility handles light hydrocarbon products. It includes contract storage facilities and a facility for the fractionation of incoming products.
open holding ponds, where it is stored. The deeper the cavern, the higher the pressure required to overcome the head of the saturated brine. Conversely, brine is pumped in to force the product out so that it can be sold.

The freshwater from high-pressure triplex pumps is used to correct salting problems. Salt particulates will build up if not much product is moved or the brine concentration is too close to the saturation point. If particulates build up in a valve, the freshwater will wash and dissolve the salt. In the event of a salt plug in the inner pipe, operators will block the brine system and wash down into the cavern.

Emergency shutdown valves are located on the product and brine wellhead spooling. Transmitters measure redundant product and brine pressure, and an orifice plate and differential pressure transmitter measure brine flow. Other instrumentation is used for gas detection.

One major concern is overfilling a cavern and potentially bringing high-pressure (approximately 2,400 psi) product back to the atmosphere on top of the holding ponds through the brine piping, which operates at less than 50 psi.

To safeguard against this, there are automatic shutdowns for high brine pressure or high brine flow, as well as slots near the bottom of the brine tubing. The plant monitors surface pressure on both the product and brine.

**Audit of custody transfer**

The facility handles about 40 custody transfer points, which are monitored by the measurement coordinator. The custody transfer points include incoming pipeline receipts, outgoing sales and the fractionation plant production streams (Photo 1). Chevron operates 11 meters, while pipeline operators handle the remainder of the meters. The facility tracks proofs of all the meters through what is called the facility’s quality assurance measurement program (QAMP).

Data is logged, such as meter correction factor deviation from the previous prove and flowrate at which the meter prove was performed. The logs provide valuable information for internal and external auditing and for adjustment detail when metering errors occur.

For auditing purposes, the measurement coordinator can show meter performance on any one of the custody transfer points and show how diligently it has been calibrated.

Cavern inventory measurement was done by balancing custody transfer receipts against sales. Because the pressure exceeds 2,000 psi and product piping is rated ANSI 1500 (an American National Standards Institute standard for piping), metering the
product at each cavern presents a challenge. The meters must be bi-directional, being able to measure flow into the cavern and out of the cavern through the same device. The inventory measurement must also agree with custody transfer instrumentation.

The facility originally installed bi-directional turbine meters with stand-alone mechanical totalizers. Pulses from the rotor of the turbine would advance a mechanical reading device. Operations people would record that number, which became the inventory balance for the day.

Because these turbine meters were only used for product balance, the volumes were not corrected for temperature or pressure. Proving was done strictly by comparisons against custody meters, as the high pressure prevented portable proving.

There were problems with the turbine meters, including unacceptable tolerance in balance error and high maintenance due to salt particulates affecting the turbine meters’ mechanical internals. Interface material and brine would destroy the bearings and accumulate in the turbines when the facility voided the caverns or depressurized them.

**Coriolis project**

In 1993, the facility undertook a project to upgrade the cavern inventory (Photo 2). The Coriolis mass meter was chosen because it has no internal moving parts that would require maintenance.

The stand-alone mechanical totalizers were replaced by automated measurement software embedded in the facility’s distributed control system (DCS). Initially, only one meter was purchased and installed on a single C3+ cavern. Over the next three years, the remaining nine caverns were converted to Coriolis meters.

The measurement upgrade project yielded significant improvements. The error between the inventory and custody transfer measurement was reduced from between 1.5 and 2% to approximately 0.5% (Figure 4).

Product balancing, which was not good until the early 1990s, also was affected by the upgrade. In 1997, after the measurement upgrade project was completed, tolerance of inventory measurement versus custody transfers receipts and sales improved significantly.

It is important to note that any metering error is carried with the cavern until that cavern can be completely voided, which is why the product balances return to zero at regular intervals.

Some of the peaks in Figure 4 are called cavern voidances. A cavern voidance provides the opportunity to empty the cavern and zero the volume. If the meters introduce an error, it widens with time. Even if corrections are made, until the facility zeros out or empties
the cavern, the amount of error is unknown. Then, the facility writes off that error from the production accounting books and brings it back to zero error.

Benefits

Significant benefits were realized when the facility began using Micro Motion® Coriolis meters. Improving the balance between inventory and accounting enabled the facility to find and correct custody meter errors sooner. Meter maintenance was also considerably reduced.

The facility realized an intangible benefit from this project that the engineers did not realize at the start, something that was not part of the original project or its objectives. Because the density variable is available from the mass meter, a meter is able to detect a density tolerance for each specific product in each cavern and subsequently alert the operator with high- and low-density alarms.

Without the alarms, an error made by the operator had the potential of contaminating huge volumes in a cavern with another product, which would cost the company a great deal of money in reprocessing, penalties in sales contracts, and so forth.

Additional benefits included automatic reporting of all measurement streams from the DCS and online balance software that provides real-time error tracking for each product. The facility is continuing to improve; the goal is to further tighten the balance tolerance to less than 0.5%

About the author

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