BY DANA MARSHALL, PEMBINA PIPELINE

KNOWLEDGE

WWW.micromotion.com

Micro Motion® Coriolis Meters Simplify Multi-product Liquid Transport

Custody transfer proving holds constant with varying density and viscosity

Switching to Coriolis meters in a multi-product pipeline with custody transfer requirements reduced the cost of hardware, installation, maintenance, proving and operating, and also maximized process flexibility.

Pembina Pipeline has been transporting petroleum products in Alberta and British Columbia, Canada, for more than 40 years.

A few years ago, it became evident that excess production liquids were available in the northeastern part of British Columbia and Northwestern part of Alberta. Pembina augmented part of its existing pipeline systems to build a new pipeline system to transport crude oil, condensate, ethane plus other carbon compounds (C2+) and pentane plus other carbon compounds (C3+) to customers south of their origination points. Approximately one-third of the new system already existed.

The products are sent down a pipeline consisting of 8-inch, 10-inch and 12-inch pipes in batches that have no plugs or other devices to separate them. Care must be observed not to inject one product into another product. Upon arrival at their destination, the batches must be separated.

Having different products in the pipeline presented a challenge to Pembina to separate the batches. Additionally, Pembina personnel wanted to measure the mass of the light products (C2+ & C3+) and the volume of the heavy products (crude oil and condensate), based on the density corrected for temperature and pressure.

The problem was compounded by the fact that the light products are not pure components, but blends. The molecules of some of the substances, especially C2, are so small they can easily combine and blend with other products.

To visualize this concept, consider a full container of rocks into which sand can still be added. The container was full before sand was added and the container volume has not changed but the mass or amount of material has changed. In a similar way, the smaller C2 molecules can blend with other hydrocarbon components without significantly changing the volume.

The operational constraints narrowed the options of metering the products. The guidelines for the metering system were as follows:

- Custody transfer approval standard required at all receipt and delivery points;
- Viscosities vary from 0.1 to 1 centipoise;
- Densities vary from 0.475 kilogram (kg) per cubic meter (approximately 0.475 specific gravity) for ethane to more than 0.85 for crude;
- Must measure mass and volume;
- Project must be cost-effective.

Expensive traditional approach

The traditional approach to a multi-product pipeline had extremely high installation costs, as well as operational, maintenance and proving costs (Figure 1).

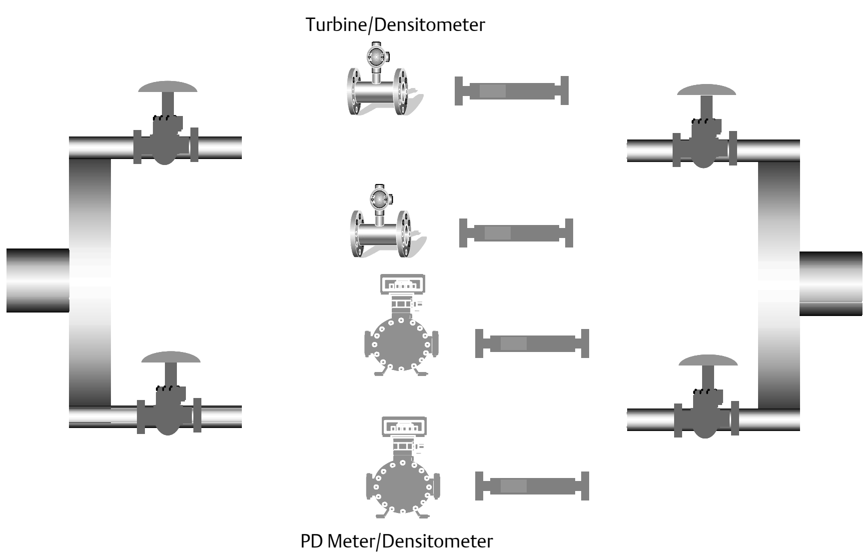

Figure 1. The traditional approach to a multi-product pipeline has extremely installation high costs, as well as operational, maintenance and proving costs.

Micro Motion Coriolis meters simplified multi-product pipeline instrumentation. The three meters in the foreground measure product from Taylor, British Columbia and the three in the background measure product from Dunvegan, Alberta.

In the background are three Coriolis meters at the end of one of Pembina's pipeline at Fort Saskatchewan, Alberta, just prior to the pipeline entering a customer's facility.

The light hydrocarbons were measured by a turbine meter, which used an impeller or multi-bladed fan to measure volume, and a densitometer to measure density. To measure crude and condensate, a valving system switched to a positive displacement (PD) meter and densitometer. A PD meter has one or more rotating gears or impellers that fit snugly in the meter body to minimize slippage. Multiplying the measured volume by the density determines the mass. Although product mass is not required, the density measurement is used for batch tracking, or to keep the batches segregated.

With two sets of metering systems, one for the lighter products and the other for the heavier products, the complexity of the valving arrangements and automatic switching in a control scheme caused increased costs, especially maintenance and proving costs. The turbine and PD meters have many moving parts that require maintenance.

Proving two sets of meters on each product was a cost obstacle for the facility, especially trying to coordinate with batches flowing through the line. Proving is a complex and expensive process, because a contract operator does the proofs. Multiple proofs are required for the two different meters. Many meters are not linear for the wide flow ranges of operations.

The old system presented another problem: It was difficult to have someone available to prove the meters at the appropriate time for all batches. Pembina has attempted to prove multiple batches; the cost to prove five sites with a contract operator could amount to $20,000 to $30,000 per month.

Coriolis simplifies system

For a multi-product pipeline, there is an advantage to using a single flow measurement system that can measure all required variables for all products. In 1999, Pembina installed in parallel three Micro Motion® Coriolis meters, which simplified the measurement system. Systems were installed later at four other sites.

In addition to simplifying the instrumentation system, Pembina management chose three meters in parallel to reduce pressure drop and pumping costs, which are significant. The product stream is split into three equal lines before the Coriolis meters.

The Coriolis meters measure mass, volume and density, substantially reducing the amount of hardware needed. The estimated hardware savings were several hundred thousand dollars (U.S.).

Use of Coriolis meters also has resulted in a significant reduction in operating costs. Both of the two major cost factors, maintenance and proving costs, saw dramatic cost reductions over previous metering methods. There are no dual metering systems, densitometers or complex valving systems to operate: there is only one set of identical meters. The extra densitometer was eliminated. There are no extra automatic switching valves requiring maintenance.

Experience has shown that the Coriolis meters require virtually no maintenance, because they have no moving parts and only vibrate. Maintenance personnel check the electronics for a zero once or twice a year.

The reduction in proving costs has been significant, because proofs are now much easier to obtain. Multiple proofs at multiple flows for different products are not required; a single meter can perform many of those functions.

Proofs for custody transfer are required once each month by custody transfer agreement, which is an industry standard. Proving is conducted using either a ball prover or a compact piston prover. The proving factor for the Coriolis meters stays very stable. If one proof for one product is obtained in a month, the pipeline measurement specialist is certain that the meter is functioning for other products as well.

Table 1 shows typical results of some test proofs at one site for two days. The cubic meters per hour can be converted to barrels per hour by multiplying by 6.3. Dividing kilopascals by 7 to convert to pounds per square inch (psi) shows the typical pressures are 600 to 700 psi. For the two days the densities were 0.506 and 0.475. Three proofs were obtained for each flow rate. Each proof consisted of 5 runs. The meter factors were very consistent, averaging 1.005 in all cases. Thus, the repeatability was excellent.

The same results were obtained with changing density and viscosity. The same meter was installed in another station and tested on different products with an agent's portable ball prover. During the test, the ball was tight in the prover, causing the flow to drop to 28 cubic meters per hour. Even under those conditions, repeatability was excellent. The meter was proved on a lighter condensate, lighter crude, heavier crude, a different condensate, C2 and C3. Densities varied from 0.5 to 0.835. The factor did not change significantly.

The one instance when repeatability went out of spec occurred during the passing of an interface, when density increased. There was a blend of crude and condensate at that site. It is unrealistic to expect a good proof under those circumstances.

Project success

In summary, Pembina Pipeline was able to achieve success with the Coriolis installation project in many ways:

- Minimized hardware costs,
- Minimized installation costs,
- Minimized maintenance costs,
- Minimized proving costs,
- Minimized operating costs,
- Maximized process flexibility.

The installation of Coriolis meters reduced hardware capital costs as much as Pembina management had hoped, thus reducing installation costs. Turbine meters require extra meter runs and strainers. Because PD meters are more sensitive to pipeline rouge, grit and other contaminants, double sets of strainers are required for PD meters. The extra valving and piping for those two sets of meters were avoided by using Coriolis meters.

Maintenance costs on the Coriolis meters are virtually zero, whereas with other types of meters, those costs can be significant, especially after several years of service.

Proving costs were minimized because only one proof once a month on any one product is required. As long as the meter is working well, it will be with specifications. If approved by customers, proving less frequently may be considered.

The less expensive installation cost allowed an extra meter to be installed. The use of three Coriolis meters in parallel reduced pressure drop and subsequently reduced pump

Table 1. Typical results of some test proofs at one site for two days show the repeatability of Coriolis meters.

Date	Time	Rate m3/hr	Meter Pres (kPA)	Density (Kg.m3)	Run Repeat (%)	Meter Factor	Avg. MF	MF Repeat (%)	Comments
27-Aug-99	8:51	50	4905	506.6	0.00	1.005			Plenum pressure = 1900
	9:08	50	4913	506.5	0.02	1.0049			
	9:13	50	4915	506.4	0.02	1.0049	1.0049	0.01	
	9:20	75	4886	506.3	0.03	1.0052			
	9:23	75	4887	506.2	0.02	1.0052			
	9:28	75	4886	506.2	0.03	1.0052	1.0052	0	
	9:39	100	4860	506.1	0.02	1.005			
	9:42	100	4855	506.1	0.02	1.0052			
	9:46	100	4836	506	0.04	1.0051	1.0051	0.02	
	9:54	125	4812	505.9	0.03	1.0051			
	9:58	125	4810	505.8	0.01	1.0052			
	10:01	125	4808	505.7	0.02	1.0051	1.0051	0.01	
	10:11	150	4770	505.8	0.04	1.0054			
	10:15	150	4768	505.8	0.05	1.0054			
	10:18	150	4766	505.8	0.01	1.0054	1.0054	0	Plenum pressure had dropped to 1800
		Meter electronics "zeroed" before proves							
31-Aug-99	10:50	175	4251	473.8	0.04	1.0048			
	10:54	175	4288	474	0.01	1.0046			
	10:56	175	4339	474.4	0.04	1.0047	1.0047	0.02	
	11:06	160	4351	474.3	0.04	1.0046			
	11:09	160	4352	474.7	0.06	1.0045			
	11:12	160	4351	474.5	0.03	1.0046	1.0046	0.01	Plenum pressure = 1680
	11:27	150	4469	475	0.07	1.0049			
	11:30	150	4464	474.8	0.05	1.0048			
	11:32	150	4465	475	0.03	1.0048	1.0048	0.01	
	11:39	125	4505	475.3	0.03	1.0047			
	11:42	125	4507	475.3	0.03	1.0047			
	11:45	125	4510	475.2	0.04	1.0047	1.0047	0	
	11:50	100	4513	475.2	0	1.0046			
	11:54	100	4509	475.5	0.03	1.0046			
	11:59	100	4510	475.6	0.03	1.0044	1.0045	0.02	

Proving with 12” 60 liter Small Volume Prover

horsepower and pumping costs. Three meters also allow for the repair of one meter without shutting down the system, if maintenance is required.

The Coriolis meter maximizes process flexibility because a single meter provides not only volume and mass, but also density for batch tracking. Pembina can do online crude and condensate API temperature-pressure correction that feeds into a flow computer. Pembina can measure accurately any product at any flow rate with one meter, using one meter factor.

About the author

Dana Marshall has been a pipeline measurement technologist for Pembina Pipeline in Sherwood Park, Alberta, Canada, for 16 years. Prior to that, Marshall worked in other petroleum measurement positions for nine years.

Micro Motion, Inc. USA
Worldwide Headquarters
7070 Winchester Circle
Boulder, Colorado 80301
T (303) 530-8400
(800) 522-6277
F (303) 530-8459
www.micromotion.com

Micro Motion Europe
Emerson Process Management
Wiltonstraat 30
3905 KW Veenendaal
The Netherlands
T +31 (0) 318 549 549
F +31 (0) 318 549 559

Micro Motion Japan
Emerson Process Management
Shinagawa NF Bldg. 5F
1-2-5, Higashi Shinagawa
Shinagawa-ku
Tokyo 140-0002 Japan
T (81) 3 5769-6803
F (81) 3 5769-6843

Micro Motion Asia
Emerson Process Management
1 Pandan Crescent
Singapore 128461
Republic of Singapore
T (65) 6 777-8211
F (65) 6 770-8003