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Implementing New Technology at TransCanada Meter Stations -- Better, Faster, Cheaper

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Abstract

TransCanada is a recognized leader in successfully developing and applying new technologies and engineering solutions in response to business needs. This paper highlights recent examples of new technology and innovative approaches that have been implemented at TransCanada's custody transfer meter stations. They include high differential pressure measurement, perforated plate flow conditioners, ultrasonic flow meters, automatic sour gas return systems, and automated check measurement systems. As a result of this new technology, TransCanada and its customers have been provided with more timely, reliable measurement information, improved service, and reduced capital and operating costs. These and other benefits are also presented.

TransCanada PipeLines

TransCanada is a leading North American energy company, operating one of the most technological advanced and highly automated pipeline systems in the world. With nearly five decades of experience and strong roots in the Canadian and U.S. pipeline industry, TransCanada is the largest volume carrier of natural gas in North America. Its 38,000 km (23,600 miles) of pipelines offer connections between the Western Canada Sedimentary Basin and major Canadian and U.S. markets. TransCanada moves nearly 80 per cent of Canada's natural gas production to market, with 60 per cent of the total volume delivered to the U.S.

TransCanada's Metering Capabilities

The TransCanada pipeline system at January 1st, 2001 included 1363 custody transfer meter stations – 962 receipt and 401 delivery. A total of 1125 stations are located on TransCanada's Alberta system with an additional 227 stations on the Mainline system, extending from Saskatchewan to Quebec, and 11 stations on the BC system. Alberta system throughput in 2000 totaled 4.51 tcf.

A variety of primary measurement devices are in use, including orifice, turbine, positive displacement, ultrasonic, and vortex meters. Metering applications are primarily for receipt and delivery custody transfer measurement, including large border and sales stations (interconnections to LDC's, industrial loads) and gas storage facilities. In addition there are applications for small sales facilities (taps, utility gas), compressor fuel gas, and mainline measurement. All TransCanada custody transfer stations are equipped with electronic flow measurement and remote communications capabilities. With system-wide implementation of this technology, access to key measurement and operating information is available to TransCanada and its customers 24 hours a day, 365 days of the year.

TransCanada's meter station design and operating practices also comply with Measurement Canada custody transfer measurement requirements and Gas Transportation Tariff agreements with its customers. TransCanada is committed to satisfying customer expectations for providing high performance measurement and service while maximizing operating and cost efficiency.

Technology Management

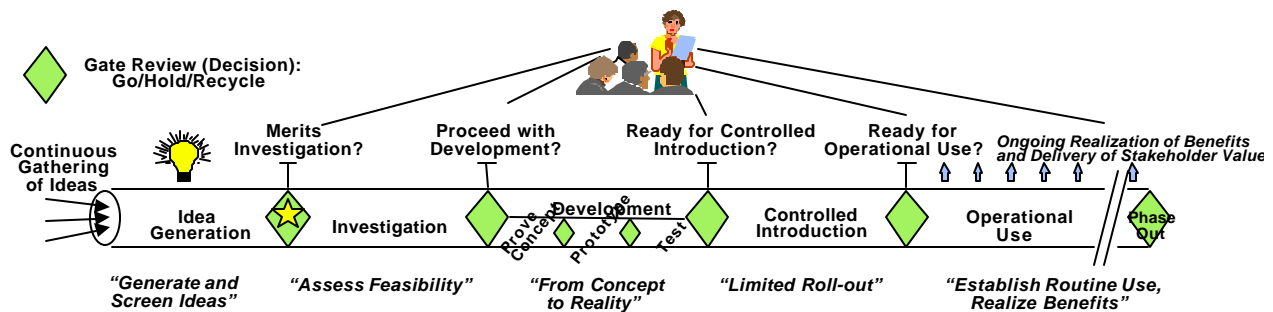
Technology development at TransCanada is business driven – responding to both short-term operational and long-term strategic goals. Gas flow measurement is one of the important areas in TransCanada's technology management portfolio. Research and development activities are proposed, reviewed, prioritized, and managed each year. They are evaluated based on strategic leverage, business alignment, technical and business risk, sponsorship, and expected rewards. Developing and introducing new measurement-related technologies are expected to enable:

- Flexible gas metering – through new technology metering and gas quality analysis
- Improved capital and operating cost efficiencies – using traditional and advanced metering technologies, achieving measurement accuracy consistent with or better than today's standards
- Information availability to meet business demands – providing TransCanada and its customers with gas management data and information when and where it's needed
- Simple and flexible customer transactions – allowing customers to select the information they need and to make electronic requests for integrated transportation services

Earlier research by TransCanada in the gas measurement area has focused on quantifying the effects of various installation arrangements on meter accuracy. Projects undertaken have determined the influence of imperfect orifice plates, liquid contamination, pulsating flow, and various piping configurations. More recent research and evaluation is focused on investigating new measurement technologies and other approaches to drive out further operating efficiencies and extend metering capacities.

TransCanada follows a "value pipeline" process that involves stage gates where "go/no go" decisions are made as part of managing the research and development cycle for each project.

If a new technology passes the rigor of investigation and concept proving and then through prototype evaluation and field testing (and the business case remains sound), a recommendation to advance to the next stage of controlled introduction is proposed. Following this limited roll-out phase and further evaluation of the new technology in the field, the next stage gate is operational use. At this point, new engineering and maintenance standards along with required business process changes are developed and implemented. This includes transition plans for the base of installed equipment and systems that the new technology may ultimately replace. Further details in the value pipeline process are shown below.



New Measurement Technologies and Innovation

The technologies and innovations highlighted in this paper are all in full operational use today at TransCanada. Three technologies have matured directly from TransCanada’s technology management efforts and in collaboration with industry partners. These are high differential pressure measurement, perforated plate flow conditioners, and ultrasonic flow meters. Automated sour gas return systems and automated check measurement systems have been implemented at TransCanada by selecting technologies available in the marketplace and integrating them to meet specific business needs.

Each section below describes how each new technology or systems work, the research and development effort in bringing it to operational use, the scope and current application on the TransCanada system, the benefits received, and impacts to customers.

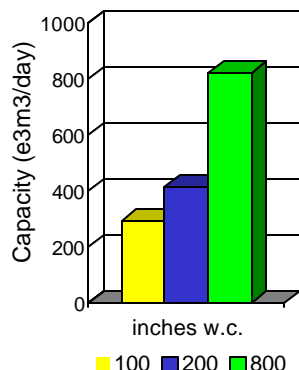
High Differential Pressure Measurement

High differential pressure (DP) measurement is available for use at all TransCanada orifice meter stations. The advent of electronic measurement in the late 1980’s is the technology that has enabled users of orifice meters to measure beyond 200 inches w.c. which is the limit of most mechanical dry flow meters. High DP measurement substantially increases the metering capacity of orifice meters, reducing the cost of building new meter stations and expanding existing facilities, by allowing the DP range to exceed 200 inches w.c. About 75% of TransCanada’s custody transfer stations contain orifice meters and over 10% of these stations are now taking advantage of high DP measurement.

TransCanada has conducted research work and field tests with high DP measurement. This led to chairing an American Gas Association (AGA) – Transmission Measurement Committee Task Group, which in 1998 released an Engineering Technical Note. This document provides guidelines for use of high DP orifice flow measurement and addresses several technical issues when using differential pressures greater than 100 inches w.c. Effects of plate deflection,

discharge coefficient equation, expansion factor, change in tap hole location, and seal ring leakage are covered in the Technical Note. When referenced with AGA Report No. 3, users should be able to confidently operate orifice meters at differential pressures up to 1000 inches w.c., depending on plate geometry.

Higher differential pressures, however, do result in higher meter run gas velocities and greater permanent pressure losses. TransCanada evaluates these gas velocities on an individual installation basis for such things as noise, erosion, and thermowell vibration to confirm that high DP measurement is acceptable and that the gas velocities through the yard piping and meter run are within design limits.

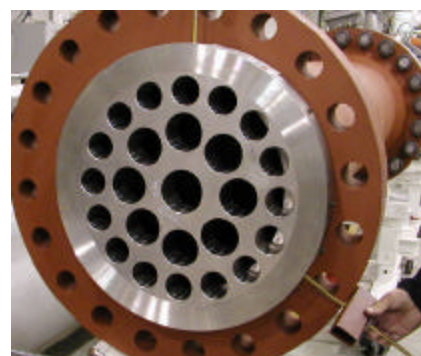


The benefits of high DP measurement can be explained using a typical 4 inch orifice meter run. The initial design capacity of a new meter station is based on a 100 inch w.c. range and assuming a 6000 kPa line pressure and maximum 0.6 beta ratio plate, it can measure 294 e3m3/day. This rises to 415 e3m3/day (+41%) when the DP range is increased to 200 inches w.c. In the past, a further increase in flow rate would have required a change out to a 6 inch meter run. Today, the DP range can be extended up to 800 inches w.c. (based on review of yard piping gas velocity design limits) providing an ultimate meter run capacity of 824 e3m3/day (+180%).

With high DP measurement, TransCanada is able to accommodate customer requests for most contract volume increases much more quickly (typically only a few days notice to schedule a technician to re-range the existing DP transmitter or install a new higher range DP transmitter). In these cases, customers are able to avoid the capital cost for replacing the meter run.

Perforated Plate Flow Conditioners

TransCanada has played a leading role in the development and introduction of perforated plate flow conditioners. The NOVA 50E flow conditioners used by TransCanada consists of a steel plate 0.125D to 0.15D in thickness with two concentric rings of circular holes around a central hole. The holes account for about 50% of the area of the plate. The spacing and design of this flow conditioner is intended to produce a fully developed flow profile downstream of the plate. The thickness of the plate also eliminates swirl which may exist upstream of the meter.



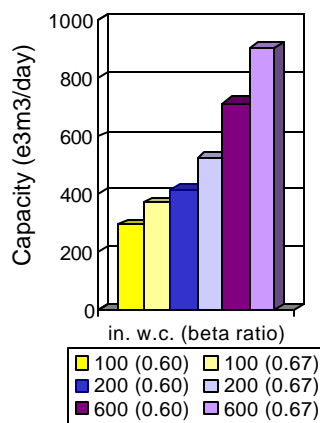
Benefits of perforated plate flow conditioners include reduced measurement uncertainty and bias error, increased metering capacity, lower permanent pressure loss, reduced meter station expansion costs, and compliance with new standards. These benefits offset the higher capital cost of these flow conditioners compared to conventional straightening vanes.

Measurement accuracy is directly impacted by the performance of these flow conditioners. Perforated plates are isolating flow conditioners intended to reduce flow disturbances in natural gas caused by upstream piping design configurations such as one elbow, two or more elbows in and out of plane, flow tees, and headers. They effectively remove swirl from a flowing gas stream while redistributing the stream to produce flow conditions that accurately replicate the

orifice plate coefficient of discharge database values. Conventional tube bundle flow straighteners may have limited ability to produce the same desired flow conditions generated by isolating flow conditioners.

TransCanada has worked extensively with the NOVA Research and Technology Center (NRTC) to develop and evaluate the NOVA 50E isolating flow conditioner. Today, this flow conditioner is commercially available for use in orifice, turbine, ultrasonic and vortex meter installations. The application and performance requirements of flow conditioners is contained in the revised April 2000 AGA Report No. 3/API 14.3 which provides manufacturers with installation criteria and performance acceptance tests to develop, evaluate, and introduce this new technology to the gas industry. While tube bundle flow straighteners remain an acceptable flow conditioning device the new AGA/API standard specifies more stringent requirements for their construction and the requirement for longer upstream meter run piping lengths.

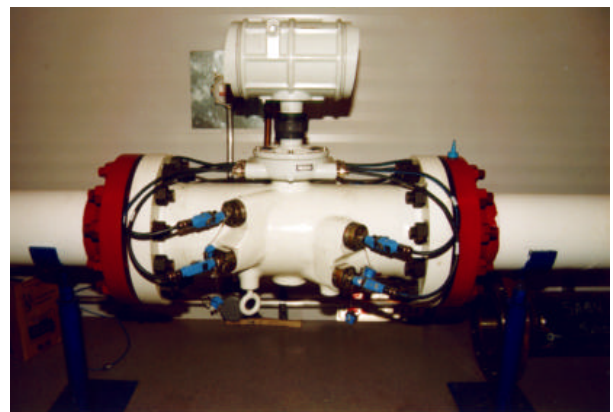
TransCanada has been installing perforated plate flow conditioners at all new orifice and ultrasonic meter stations since 2000. All ultrasonic meter stations on the Alberta system have had these flow conditioners originally installed. At existing orifice stations, they are being installed when required to replace straightening vanes that are rejected as part of scheduled Measurement Canada meter run inspections.



Perforated plate flow conditioners also enable use of larger size orifice plates at TransCanada, beyond the 0.6 beta ratio used as a company standard to minimize measurement uncertainty. Installation of perforated plates has allowed the beta ratio limit to increase to 0.67 without a loss in accuracy providing additional metering capacity at minimal cost. Referencing the example above, the capacity of a NPS 4 meter run increases to 372 e3m3/day (+27% at 100 inches w.c.) with use of a larger plate.

Ultrasonic Flow Meters

TransCanada has been a leader in the successful development and implementation of ultrasonic meters. These devices measure gas velocity by determining the difference in time for sound waves to travel upstream and downstream between pairs of transducers.



TransCanada's leadership role includes ultrasonic metering research, evaluating longer-term field performance, developing standards and specifications, and successfully installing and operating these new types of meters.

Research work for several years with NRTC focused on comprehensive evaluation programs for multi-path custody transfer ultrasonic meters as well as single-path mainline measurement ultrasonic meters. Installation effects and longer-term field performance test results were obtained. This knowledge and experience contributed to AGA Report No. 9 – Measurement of Gas by Ultrasonic Meters and Measurement Canada's Provisional Specifications for Ultrasonic Meters. TransCanada chaired both AGA and CGA task groups that were responsible for

bringing together manufacturers, user companies, and Measurement Canada in developing these specifications.

Since 1994, TransCanada has installed more than 60 ultrasonic meters. Multi-path custody transfer applications include new receipt and delivery meter stations starting at NPS 8 up to a 60,000 e3m³/day three run NPS 30 installation. Several NPS 12 turbine meter stations have also been upgraded with multi-path ultrasonic meters. Mainline measurement capabilities include three locations where multi-path insertion ultrasonic meters have been installed on pipelines ranging in size from NPS 16 to NPS 42.

The primary reason for installations to date has been the significant reduction in capital costs compared to conventional orifice or turbine meter installations. These savings have ranged from about \$100,000 Cdn for a new NPS 12 installation up to \$5 million Cdn for the three-run NPS 30 ultrasonic station. There is also a significant reduction in operating costs through reduced maintenance requirements such as plate inspections and turbine spin tests. At multi-run locations, there is a further reduction in transmitter calibration requirements due to the higher capacity of the ultrasonic meters which means less meter runs and fewer transmitters.

TransCanada's operating experience with this new technology has been very positive – ultrasonic meters have met expectations in terms of delivering high measurement performance and reliability combined with lower capital and operating costs. Ultrasonic meters are the metering design standard at new, large volume receipt, delivery, and gas storage facilities (typically NPS 12 or larger). With some in-service custody transfer meters now approaching the six year re-certification period, longer-term arrangements are now in place to have these meters re-calibrated at the TransCanada Calibrations high pressure testing facility located near Winnipeg. This avoids the higher cost of returning meters to facilities in Europe for re-calibration.

Automatic Sour Gas Return Systems

Automatic Sour Return (ASR) is an innovative engineering solution introduced in 1999 that reduces service interruptions for gas production plants due to the inadvertent release of sour natural gas into the pipeline system. There are about 240 sour meter stations on TransCanada's Alberta system today – 25 of these stations have ASR capabilities. The ASR system integrates a number of available technologies including station control systems, electronic flow measurement, and gas quality monitoring equipment. ASR enables gas production to resume much faster after a sour shut-in condition has occurred.

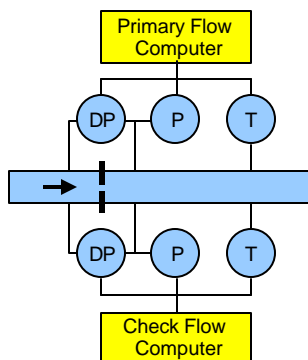
Typically, after sour gas at a receipt meter station is detected by the on-site H₂S analyser and is found to exceed contract limits, an RTU initiates automatic closure of the station block valve. The plant then pulls back the sour gas that is contained in the sour bottle piping through the return run. At this point, a TransCanada field technician would have been dispatched to the station to verify the H₂S concentration levels and to manually re-open the block valve.

However, with ASR installed, this manual intervention is no longer required. The time period that the block valve remains closed is determined by the RTU based on the H₂S level it receives from the analyser and the return run volume as calculated by the on-site flow computer. After the plant has completed its corrective action and the system detects no further sour gas, the RTU instructs the block valve to open automatically, allowing sweet gas to re-enter the pipeline.

The benefits of this new system for TransCanada and its customers are significant, especially for sour stations located in remote isolated areas in Alberta where travel time to site can be a number of hours even under ideal conditions. As a result of fewer call-outs and associated travel expenses and overtime hours, lower operating costs are achieved. In addition to these savings, the producer is able to substantially reduce their lost production while waiting to come back on-line. ASR also contributes to reduced flaring at the plant leading to lower greenhouse gas emissions.

Automated Check Measurement Systems

TransCanada employs automated check measurement systems at its orifice meter stations on the Alberta system. At these stations, one set of pressure transmitters is connected to each of the two pressure taps located on each side of the orifice meter. The transmitters in turn are



connected to their own flow computer to perform independent flow calculations. This information is communicated hourly to TransCanada's central Gas Management System where comparisons are performed to validate energy, volume, pressure, temperature and differential pressure values from the primary and check flow computers. Other validation checks are performed at the

station and run level. A comparison that exceeds acceptable limits will trigger an alarm that is acknowledged by field technicians at the start of each workday. The priority for taking corrective action is based on the size of the energy comparison difference.



The benefits of this automated check measurement system include:

- Reduced transmitter calibration frequency from monthly to annual at all orifice stations based on use of primary to check measurement to detect operating problems
- Ability to finalize custody transfer information daily based on validation of measurement data.
- Quicker response time to correct potential measurement errors, minimizing the duration, size, and uncertainty of measurement corrections and their impact to customers.

Implementing this check measurement system has relied on integrating electronic flow measurement, telecommunications, and information system technologies and as well as developing and introducing new business processes. TransCanada's Gas Management System collects, validates, corrects and reports the custody transfer measurement. This information is then fed into Customer Management Systems which allocates the quantities measured at each custody transfer location to the participating customers. The information is then used to track and manage each customer's supply/demand inventory position. Collectively, these systems and other technologies also contribute to improved management of the measurement variance on the TransCanada system.

Conclusion

TransCanada has been successful in selectively applying new beneficial measurement technology and introducing innovative engineering solutions to meet business needs. This technology is now incorporated into standard meter station design and operating practices.

The examples presented in this paper demonstrate that high measurement performance and service can be achieved while delivering lower capital and operating costs to benefit TransCanada and its customers – we are doing it better, faster, cheaper.



The development and introduction of technology also needs a well managed implementation plan to provide confidence in new measurement equipment, systems, and operating procedures and ultimately the quality of the custody transfer metering information. Developing and implementing required business process changes to effectively exploit new technology is critical.

TransCanada views technology as a strategic investment in the future and a source of competitive advantage. The company will continue to provide industry leadership in technology development and offer great value to its customers, shareholders, employees and the communities in which it operates.

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