Technology transfer

By Sarah Kimpton, Senior Consultant for DNV GL Oil and Gas explains how the natural gas industry is transporting knowledge to the carbon dioxide industry

A natural gas transmission system is a combination of the assets (pipelines, valves, etc.) and measurement systems for flow control, line pack calculations, and custody transfer billing. Energy measurement facilities are installed at all custody transfer stations, such as beach reception terminals, LNG export-to-grid, interconnectors and city gate/transmission off-take points. Experience from the mature natural gas industry can be used to apply technology transfer methods to CO₂ transport and experimental testing.

CUSTODY TRANSFER

Custody transfer refers to the transfer of ownership of a fluid from one operator to another. This includes transferring raw and refined products between tanks and tankers, tankers and ships, ships and pipelines and from one pipeline to another. Custody transfer in fluid measurement is defined as a metering point (location) where the fluid is being measured for sale. As part of the custody transfer, the quality of the fluid may be checked and measured to ensure that it complies with the custody transfer contract or with local regulations. Quality checking often occurs at international boundaries and at entry points to transmission pipelines to protect the end-users and to ensure the integrity of the transmission assets. There are four drivers for custody transfer measurement (Figure 1): statutory regulations, commercial/legal agreements, taxation, and protection of the transmission assets. All four are achieved by measurement of fluid quantity and quality according to:

• Industry standards (ISO, EN, etc.)
• Contracts between two operators for billing
• Government regulation for safety reasons
• Government regulation for taxation including emissions trading

The contracts between the operators will also specify uncertainties and errors of measurement to define the type of instrumentation that should be used. Custody transfer measurements are often required to be traceable through the metrology chain to national and international standards.

CUSTODY TRANSFER FOR NATURAL GAS

The custody of natural gas is transferred a number of times throughout the journey from production to utilisation. An example of where custody transfer measurements are made on a natural gas network is shown in Figure 2. The points in the journey at which the gas passes from one party to another are outlined in red. In recent times, non-conventional gases, such as biomethane, may enter the network at lower pressure tiers. These ‘grid injection’ points have become custody transfer entry points to a network. The transport and energy measurement of natural gas is well developed for flow control, custody transfer, line pack and billing purposes. Energy measurement facilities are installed at all custody transfer stations such as beach reception terminals, LNG export to grid, interconnectors and city gate/transmission off-take points. These energy measurement facilities comprise

• Volume or mass flow measurement (meters)
• Gas quality instrumentation (analysers)
• Pressure and temperature measurement
• Flow computers implementing equations of state and international standards

At entry points to national transmission networks, further expensive gas quality measurements are made to ensure compliance with statutory and contractual requirements. Fluid phase behaviour is checked to ensure transportation in the gas phase with no liquid dropout, this is achieved by determining the natural gas hydrocarbon and water dew points from detailed compositional analysis and an appropriate equation of state. Also, gas properties are checked to ensure safe combustion and to protect the integrity of the pipelines and other assets during transportation. Equations of state and international standards are implemented on flow computers and these are agreed in the metering contract. Natural gas is usually transported and compressed from a high-pressure source to a lower-pressure tier at the point of use and measured to ensure that it

CUSTODY TRANSFER FOR CARBON DIOXIDE

Custody transfer during the transport of CO₂ from production to its point of use or storage also occurs at a number of different locations. A schematic showing custody transfer points for a CO₂ transmission system is shown in Figure 3.

As a general rule, the transport of CO₂ for carbon capture and storage (CCS) is in the reverse direction to the transport of natural gas; CO₂ transport usually starts onshore at low pressure and is compressed to above 150bar before storage offshore. For CCS applications, the CO₂ is produced by the combustion of a fossil fuel at, for example, a power station and the flue gas is then processed to capture a CO₂-rich fluid. After leaving the clean-up plant, the custody of the CO₂ is likely to be passed to a pipeline company which transports the CO₂-rich fluid to the reception terminal at the storage facility. At the storage facility, the fluid may be compressed further to increase the pressure and pumped to an underground storage location.
quantity and purity of the CO₂ sent to storage may need to be reported to a statutory body to ensure compliance with regulations such as the European Union Emissions Trading Scheme (EU-ETS).

**TECHNOLOGY TRANSFER FROM NATURAL GAS TO CO₂**

CO₂-rich fluids behave very differently to natural gas in terms of phase behaviour and thermophysical properties. Natural gas transmission systems are largely designed to operate at the local ground or ambient temperatures, for example between -20 and 50°C, and at pressures between 40 and 85bar. The density of natural gas at these conditions varies from 25 to 100kg/m³. The natural gas is processed by the producers to ensure no liquid dropout during transmission and that the combustion and other physical properties are suitable and safe at the point of use.

The phase diagrams of natural gas and CO₂ have been plotted together in Figure 4.

The operating domain for a typical natural gas transmission system is shown by the red box – in this region, natural gas is well away from its two-phase region and the system is operating in the gas or supercritical fluid region of the phase diagram.

Unfortunately for CO₂, this operating domain would be unsuitable because the vapour pressure curve, which is the transition between the gas and liquid phases, passes right through the middle of the red box. Additionally, whereas the maximum density of transmission natural gas is about 100kg/m³, the corresponding densities of CO₂ range from 100 to 1,000kg/m³. When impurities are added to CO₂, the two-phase region goes from a line to a loop as shown in Figure 5; this makes the transport of CO₂ at conditions familiar to the natural gas industry even more challenging. A comparison between the measurements required for the custody transfer of natural gas and those likely for CO₂ is given in Figure 5.

**CONCLUSION**

The transport and energy measurement of natural gas is well understood. ISO standards and best practice specifications and procedures to facilitate transport and custody transfer are widely available and under constant improvement and review.

Knowledge and experience of the transportation of CO₂ is currently limited. Understanding of technology transfer from the mature natural gas industry can be applied to the CO₂ sector as a starting point to develop a full-scale prototype custody transfer system. DNV GL is now actively working in this area. This will ensure that risks and benefits can be fully measured and analysed in a controlled environment through experimental testing.

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