Acid Gas Injection – A Primer

By John J. Carroll

With more than 45 projects in Western Canada, acid gas injection has become a viable method for dealing with small quantities of acid gas. The unwanted gas is compressed and transported by pipeline where it enters a disposal well, travelling down the well into a suitable subsurface formation, typically an aquifer or a depleted producing zone (it has been successfully injected into both sandstone and carbonate formations).

Acid gas, separated from the desired hydrocarbon components in natural gas, is composed mostly of H_2S and CO_2; their combined mole fractions are in excess of 95% on a water-free basis and the stream is saturated with water.

At Wayne-Rosedale, a successful injection project in Alberta, the Leduc "C," an aquifer, is the disposal zone (about 1 900 metres). Here they inject a mixture of 17.39% H_2S, 82.53% CO_2 and 0.08% methane (on a water-free basis). Injected at a rate of 21 x 10_ Sm_/d, the acid gas, saturated with water, comes from an amine sweetening unit at 43°C and 37 kPa[g].

Proper design of the injection scheme is only one part of the picture, however. Operation of the compressor is also crucial. Operators should avoid the temptation to reduce the compressor discharge pressure so that it is merely sufficient for injection. This may lead to problems with the formation of an aqueous phase or a hydrate.

Only when fluid density is determined can an accurate injection pressure be achieved. Initially, at Wayne-Rosedale, the design scheme called for a surface pressure of 22 000 kPa – greater than the required bottom-hole pressure, but once injection started pressure was only about 6 500 kPa, which is more in line with fluid density predictions.

From the plant compressor, acid gas, now a fluid, is transported to the injection well via a pipeline, which needs sufficient discharge pressure for injection (calculated using conventional techniques). Ideally, the pipeline should be as short as possible. In the event of a pipeline failure, this will minimize the release of deadly H_2S. At Wayne-Rosedale, the carbon steel pipeline is 60.3 mm OD and only 100 metres in length.

Percy Marshall Will Return.

As a rule of thumb, to compress an acid gas mixture from 50 to 7 000 kPa[g] requires approximately 7.5 W per Sm_/d. So the compression of 25 x 10_ Sm_/d requires about 190 kW of compression power.

Because of the overestimation of injection pressure, the compressor at Wayne-Rosedale was over-designed, calling for a five-stage reciprocating compressor with a discharge pressure of 22 715 kPa. In the normal operation of this compressor, the fifth stage is essentially not in use.

Contrary to Light Hydrocarbons

A secondary effect in the design of an acid gas compressor is removing water from the stream.

Water knockout using compression is possible because of a unique property of acid gas. Unlike sweet gas, where water content is a continuously decreasing function of the pressure, acid gas exhibits a minima. Furthermore, the solubility of water in liquefied acid gas is greater than in the vapour at approximately the same conditions. Again, this is contrary to light hydrocarbons. The effect is significantly larger with mixtures rich in H_2S rather than with CO_2.

Acid gas can be dehydrated using one of three means: TEG dehydrator, molecular sieve and additional cooling.

At Wayne-Rosedale, a TEG dehydration unit is used after the third stage. By doing so operators are assured that a water-rich phase will not form. As a result, carbon steel can be used safely for the pipeline.

But this question arises: Could the designers at Wayne-Rosedale achieved sufficient water removal with compression alone? Preliminary analysis says yes.

In the overall design of an acid gas scheme, it's important to establish the phase envelope of the injection gas. This is done to avoid unwanted condensation, which might lead to significant operational problems, especially in the compression of the gas, but it might also lead to problems injecting the fluid.

Proper design of the injection scheme is only one part of the picture, however. Operation of the compressor is also crucial. Operators should avoid the temptation to reduce the compressor discharge pressure so that it is merely sufficient for injection. This may lead to problems with the formation of an aqueous phase or a hydrate. Remember, the discharge pressure is set to achieve both near optimal water knockout and injection of the stream.

In addition, operators should avoid the temptation to over-cool on the interstage, especially during cold winters. This may lead to hydrate formation in the coolers, but worse, it may lead to condensation of the acid gas. This liquefied acid gas would be removed in the interstage scrubbers and set with the water for further processing.

If the water is sent to a sour water plant, this will surely overload this unit. If the water is recycled to the suction of the compressor, this will add additional load to the compressor, which it may not be able to handle.

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