BENEFITS OF USING DELIQUESCING DESICCANTS FOR GAS DEHYDRATION

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ABSTRACT

Deliquescing desiccants have been used for gas dehydration for over 40 years. Historically this technology had limited applications due to poor desiccant quality and integrity, equipment design problems, operational difficulty, and limited drying ability. Recent advances in dry material blending and tableting, formulation, and equipment design have greatly expanded the application range of deliquescing desiccants. Deliquescing desiccants are now used to dry sales gas, fuel gas, sour gas, excess or "peak" gas, and for hydrate control. Operating and capital costs compare favorably to traditional TEG systems. Field data verifies the drying ability and performance of deliquescing desiccant systems. Because of the operational simplicity and closed system design, deliquescing desiccants offer many advantages over traditional drying methods such as triethylene glycol, including: no VOC or BTEX emissions, no ground contamination, no fire hazard, low capital expense, low maintenance, no "turn down" concerns, and simple operation. Used for hydrate control in gathering systems, desiccants offer a simple and inexpensive method to dry below pipeline dewpoint thereby allowing trouble free gas flow from wellhead to processing plant. At the plant, gas is further dehydrated to meet pipeline requirements. Desiccants have substantial advantages for drying sour gas both for hydrate control and pipeline sales. There are no emissions, odors, or glycol contamination, and vessels can be over-sized to extend service interval to only several times per year, greatly reducing employee exposure to hydrogen sulfide. Because of it's simplicity and small footprint, desiccant drying of fuel gas yields increased revenues by using suction gas, not sales gas for compressor fuel. The entire compressor throughput capacity can be sold, instead of a portion being used for fuel. Desiccant dehydration is well suited for remote, unmanned locations, which are not visited daily. Because operation is simple and service intervals long, operators can schedule maintenance and service weekly or even monthly. This reduces total operating costs and labor requirements.

INTRODUCTION

Calcium chloride has been used to dehydrate natural gas and air since the 1920's and 1930's. Since many salts are hygroscopic, they have the ability to attract and remove water vapor from the surrounding environment. The ability of each salt to remove water vapor is based on the vapor pressure difference between the hydrate of that salt and the vapor pressure of water in the environment'. Combinations of several salts may produce vapor pressures lower than any of the original salts. Originally, calcium chloride chips or chunks were simply placed in an empty vessel on a support screen. Channeling, bridging and plugging were common problems due to non-uniform gas flow through the calcium chloride bed. As gas flowed through the calcium chloride, it would find the easiest path, and bypass the rest of the bed. Once started, this process would accelerate the calcium chloride consumption in this flow zone, and a channel would form through the calcium chloride bed. The drying process would stop since wet gas no longer contacted salts. The operator would have to mechanically break up the bed, which was not easy, as the non-used calcium chloride tended to fuse together. Calcium chloride has limited hygroscopic properties, and so while effective in hydrate control, it is not usually a viable technique for drying to pipeline specifications. Because calcium chloride was used in a loose, granular, chip or briquette form, it's shape was irregular and when partially consumed, became more irregular. This irregularity also led to non-uniform flow. Calcium chloride was formed into briquettes, and while an improvement over chips and chunks, briquettes are soft, crumbly and porous. Gas may penetrate the briquette, causing it to hydrate internally. This caused the briquette to expand and "bloom".

New salt formulations enable deliquescing desiccants to dry to pipeline specifications in many cases, while using these grades in series to minimize operating costs[2]. Our new approach offers an integrated system, where piping, gas flows, dryer design and desiccant performance are all considered. New technology enables us to dry gas at nearly two feet per second, compared with traditional velocities of 0.5 - *0.75* ft/s while at the same time greatly increasing the amount of water removed per pound of desiccant (referred as "dilution rate"). Flowing through a low grade, low cost desiccant first removes most of the water vapor. Then gas is further dried using higher grade (more hygroscopic) desiccants. New dry tabletting technology also produces a hard, non-porous, low permeability tablet. Hydration can only occur on the outside of the tablet, which helps to maintain its general shape as it is consumed. Flow efficiency remains relatively constant as the tablet bed is consumed.

ADVANTAGES

Since deliquescing desiccant systems are closed, there are no volatile organic carbon (VOC) or aromatic hydrocarbon (BTEX) emissions. With new EPA Clean Air Act regulations[3] now in place this advantage alone often makes desiccants a better choice over triethylene glycol (TEG). Ground contamination by TEG spills from surge tanks and leaky pumps is a major industry problem. Contaminated soil must usually be excavated and hauled to approved landfills, which can be very costly. Deliquescents are very "environmentally friendly", as there are no emissions and no costly fluid disposal. Since brine water (the only byproduct of desiccant dehydration) is simply piped to a storage tank, spill liability is minimized. Since there is no regeneration with deliquescing desiccant dehydration, there is no fire or heat source. This obviously has substantial safety advantages for offshore and petrochemical plant applications. Since equipment is relatively simple compared to glycol systems, capital cost is normally less than that of TEG systems. This is especially true if emission control systems are required with the TEG unit. Deliquescent desiccant dryers have a distinct advantage over glycol systems at higher pressures, as there is less water in the inlet gas, and cheaper desiccants can be used to achieve the required water specification in the gas. Desiccant units are very simple to operate and require minimal maintenance. There are no moving parts other than a motor valve to discharge fluids. 100% turndown is possible with desiccant dehydration. This is particularly beneficial for peak-shaving, variable flow, or storage locations.

PROCESS DESCRIPTION

Desiccant tablets are placed in a vertical vessel through service openings in the vessel top. Support and diffusion plates are located several feet up from the vessel bottom. Inlet gas enters the vessel below the support plate, and free liquid drop out in the sump (Fig. 1). As wet gas flows upward it is diffused by the plates, then encounters tablets resting immediately on the plates. These tablets hydrate, removing water vapor from the gas stream. This water accumulates on the tablet surface, and drips off the tablet into the sump as the hygroscopic brine on the tablet surface continues to remove water vapor from the gas. This process, known as "deliquescing", causes desiccant salts to dissolve into the fresh water accumulating on the tablet. Tablets are hence consumed' at a rate based on the dilution factor of each formulation. One pound of each desiccant will remove a certain mass of water vapor from gas. A higher dilution rate indicates that each pound of desiccant removes more water. Generally, more hygroscopic desiccants have higher dilution rates.

Gas exiting the vessel top has been dried to a point consistent with the equilibrium point of each desiccant. Selection of the correct grade is based on the inlet gas conditions and the required outlet moisture content. If higher grades (more hygroscopic) are needed, it is normally more economic to use several grades in series, flowing from lowest grade to highest in separate vessels, rather than simply using a high grade desiccant in one vessel'. An exception is for very low flow rates such as instrument gas where operating cost savings per thousand cubic feet (mcf) may not offset additional equipment costs incurred by using multiple vessels.

As tablets are consumed new tablets must be added periodically by isolating and depressurizing the vessel, removing the top service closure, and pouring tablets into the vessel' (Fig. 2). This interval is predictable, and if necessary, the vessel is simply oversized to provide a longer interval between service operations.

Water removed from the gas combines with salts in the tablets to form brine water, which accumulates in the sump. This brine is removed (typically by automatic controllers) to brine storage where it can normally be disposed of as common oilfield brine. There are no other byproducts or emissions. Tablets are typically not affected by high BTU gas, however inlet gas should flow through standard fluid knock-outs, filters, or separators as required in any dehydration process design. The brine byproduct is not corrosive unless oxygen is present in the gas. No additional corrosion allowance is required for gas streams without oxygen[6].

HYDRATE CONTROL

Hydrate control was the first, and is now the most widely used application for deliquescing desiccant drying. Gas is typically dried with a single vessel using the lowest grade desiccant. Therefore both equipment and operating costs are very low, Gas must only be dried to a dewpoint below the minimum expected pipeline temperature to prevent free water and hence hydrate formation'. For surface lines, the minimum gas temperature is the coldest ambient air temperature, but for lines buried below frost level the lowest gas temperature is typically 35°F.

As an example, assume saturated wellhead gas (100% methane) being dried at 600 psig and 60°F, and the gathering pipeline operates at 450 psig and 35°F in the winter. Inlet gas contains approximately 24#/MMCF water vapor[4]. To dry to a dewpoint of 30°F at 450 psig, resultant moisture content must be 11.7#/MMCF. Drying this gas with a single vessel filled with the lowest grade desiccant yields 7#/MMCF gas at an operating cost of approximately one cent per mcf[5]. Gas can be flowed to a central plant for further processing and dehydration, without hydrates in the gathering system.

This technology offers an alternative to traditional TEG wellhead drying units, which are often difficult to operate consistently and efficiently especially with remote or variable flow wells. Most operators prefer to check TEG units daily, which reduces the number of wells each operator can manage. However daily service is not always possible, especially in winter. If a burner or pump fails and the operator does not visit the site, wet gas flows into the gathering system and free liquids precipitate after cooling. This may lead to hydrate formation and pipeline blockages. Consequently, methanol injection is frequently used with TEG in the event a TEG unit malfunctions (burner, pump, filter, etc.). Desiccant dehydration is much simpler than TEG and is typically more reliable, so methanol injection can be eliminated.

SOUR GAS DEHYDRATION

Regardless of the application, desiccant dehydration offers substantial benefits for drying sour gas. Desiccant tablets react only with water and their performance is unaffected by gas composition. Tablets do not react with hydrogen sulfide, carbon dioxide, oxygen or other gases. Service interval can be extended by simply over-sizing the vessel, or by using several vessels in parallel. Unlike TEG systems, there is no continuous odor, and the operator does not have to dispose of contaminated TEG. The only emission is gas used to blow brine to storage, which is typically treated with a small sweetening pot located on the water tank vent. Most systems include a sweet gas purge system using either city gas or bottled nitrogen. After vessels are depressurized sweet gas is purged through the vessels, normally several times, before the vessels are opened. Naturally the operator should still wear proper safety equipment as if he were working in a hydrogen sulfide environment. Reducing employee exposure to hydrogen sulfide can be a valuable benefit of desiccant dehydration.

FUEL GAS

Desiccant dehydration is well suited for drying fuel gas for heaters. and treaters. This equipment is often remote and frequently experiences fuel line freezing in the winter months. Drying fuel through a single desiccant vessel typically prevents fuel line problems at very low net costs. Because fuel flow is normally low, most fuel gas systems can economically provide very long service intervals, reducing labor expenses.

Perhaps the best use for drying fuel gas with desiccants is at field compressor sites (gathering stations). These sites often operate at capacity and are unable to move more gas or lower suction pressure. If compressing wet gas, the operator must use sales gas that has been dehydrated (typically with TEG) for compressor fuel. This effectively reduces throughput and sales by “robbing” discharge gas for fuel. It is typically not economic to dry suction gas (which is normally low pressure and cool) with TEG for fuel. However a single desiccant vessel can dry gas taken from the inlet separator for fuel use. So instead of using discharge gas for fuel the operator uses suction gas, freeing up the entire compressor capacity for sales.

Economic benefits of drying suction gas for fuel are substantial. A typical 3000 hp compressor may bum 500 mcfpd for fuel. If the compressor is operating at capacity and there is more gas to be moved if more horsepower were available, using suction gas instead of discharge gas for fuel allows the operator to sell the entire compressor capacity, an additional 500 mcfpd in this case.

REMOTE OR UNMANNED LOCATIONS

In an effort to reduce labor costs, companies are designing, installing and operating more and more unmanned facilities. These require expensive automation controls and remote monitoring. However automatic control of TEG units is difficult and relatively expensive. Desiccant dehydration is ideal for remote or unmanned locations since it is very simple and requires very little maintenance.

One company in West Virginia installed two unmanned sites, one flowing *2.5* MMCFPD at 230 psig and the other flowing 0.50 MMCFPD at 660 psig. The first dryer is refilled every other week, and the second dryer is refilled monthly (or longer). The company’s field employee is responsible for several unmanned locations, which are separated by considerable distance. Because of the minimum service required for the dryers, he **is** able to reduce the time he spends at each site, thereby effectively operating more facilities.

CONCLUSION

Desiccant dehydration is a viable technology and offers an alternative to traditional dehydration methods such as TEG contactors. It eliminates VOC and BTEX emissions which are now regulated by the Clean Air Act. There is no fire hazard, making it safer for offshore applications. Simple operation and extended service interval reduces labor and operating cost. Capital equipment costs are generally less than TEG. New technology has eliminated many of the problems traditionally associated with deliquescing desiccants.

Nomenclature

ft/s = feet per second
mcf = thousand cubic feet
mcfpd = thousand cubic feet per day
MMCF = million cubic feet
MMCFPD = million cubic feet per day
psia = pounds per square inch absolute
psig = pounds per square inch gauge

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SI Metric Conversion Factors

°F	x (to -32)/1.8		= °C
ft/s	x 3.048 000	E-01	= m/s
ft^3	x 2.831 685	E-02	= m^3
in	x 2.540 000	E-02	= m
pounds	x 4.535 924	E-01	= kg
psi	x 6.894 757	E+03	= Pa

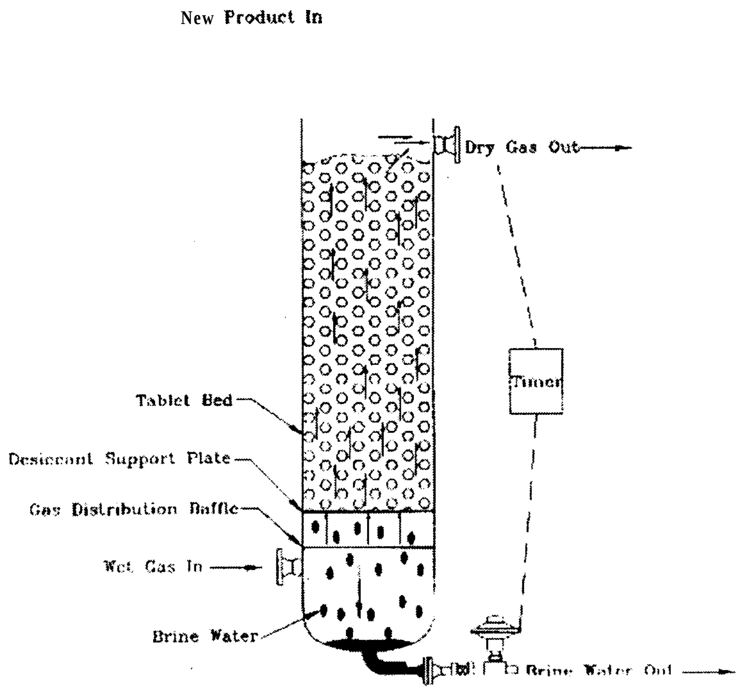

Figure 1 – Operation of Deliquescing Desiccant System

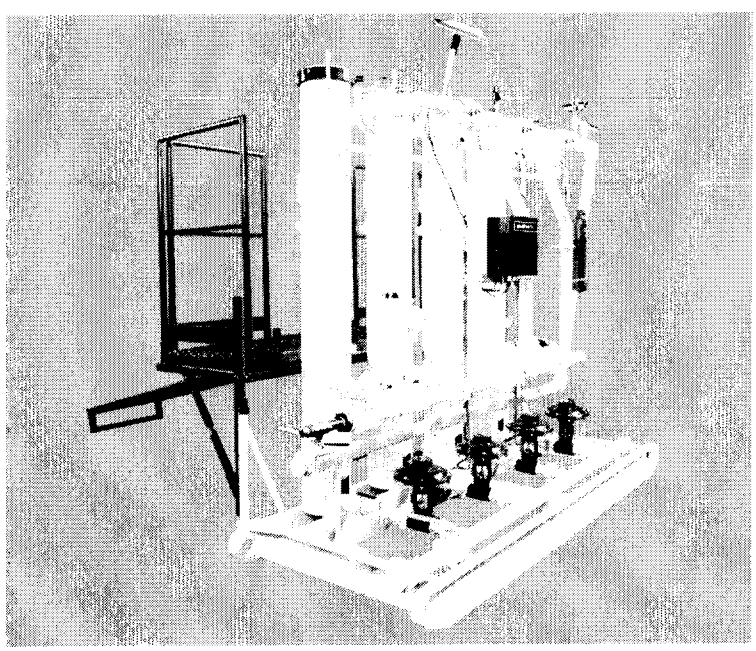

Figure 2 – Four Stage DESI-DRI Desiccant System