Mercury treatment options for natural gas plants

Removing mercury as close as is practicable to the front end of a natural gas processing system is the best choice

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Mercury in natural gas and natural gas liquids is most likely to be in the elemental state. Although mercury has a high boiling point (357°C), it also has a high vapour pressure, which makes it very mobile. Mobility presents a challenge for today's gas processors as mercury can disperse throughout gas plant assets, making it difficult to determine how and where it should be removed. Left unchecked, mercury will deposit on surfaces including those common to pipelines and plant assets. Mercury can then desorb back into gas streams, passing through contaminated pipelines. Because of this, long periods of time can elapse between the installation of an upstream mercury removal unit (MRU) and the complete purging of a pipeline. How best to remove mercury has consumed a lot of thought on behalf of processors and treatment companies alike. Industry experts suggests that removing mercury as close to the front end of a natural gas processing or gas transmission system as is practicable is the best choice.

Mercury removal process options

The market has a number of approaches to treatment for mercury removal. These options can be categorised as regenerative adsorbent and non-regenerative adsorbent solutions for mercury contaminant removal.

Non-regenerative adsorbent for mercury removal

A non-regenerative MRU is sulphur impregnated on carbon or metal sulphide beds. The common and traditional approach to mercury removal has been through the use of sulphur impregnated carbon beds. Existing sulphur impregnated activated carbon options tend to be less effective at positions upstream of molecular sieve drying systems or glycol injection due to the risk of capillary condensation of water and heavier hydrocarbons in the micropores of the carbon sub-structure. Sulphur impregnated carbon products are thus not a product of choice, particularly where MRU locations have been in the 'up-front' position, where raw gas is often at or close to its dew point and entrained liquids are common. This is where fixed bed, metallic based MRU products find greatest success in their ability to treat 'wet' gas streams in 'up-front' positions.

UOP's non-regenerative metal sulphides (UOP GB series of products) are a set of versatile non-regenerative mercury removal adsorbents. They are operationally flexible and can be used to process gas that is at or close to its dew point in a variety of process locations.

Gas and liquid streams containing thousands of micrograms or parts per billion levels of mercury can be treated to extremely low effluent levels using GB adsorbents. These high capacity mercury adsorbents are engineered using a copper based active component finely dispersed across an alumina substrate. This high capacity leads to infrequent change-outs and a longer lifespan, reducing the cost of mercury removal over time. GB adsorbents can be supplied in their oxidised form or in their sulphided form, which offers flexibility, and they can be pre-sulphided or sulphided *in situ*.

Mercury is reactively adsorbed from the gas/liquid hydrocarbon stream by reaction with cupric sulphide. As Figure 1 shows, cupric sulphide is the product of choice for mercury

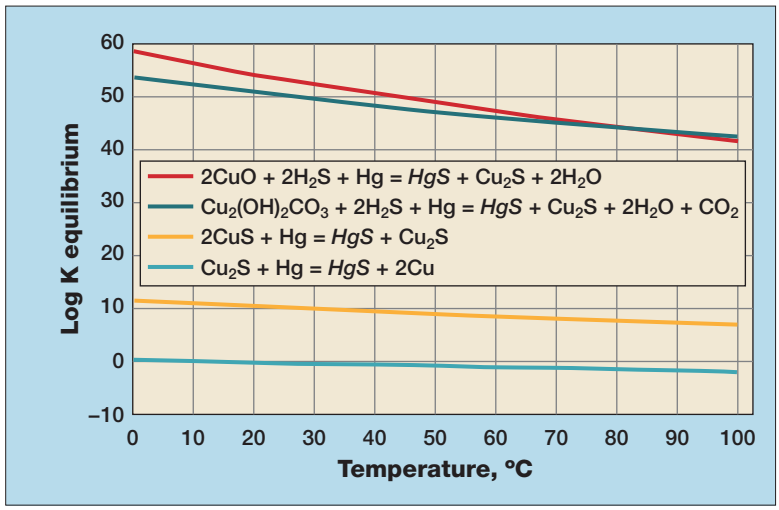

Figure 1 Thermodynamic driving force favours cupric sulphide over cuprous sulphide for reaction with mercury

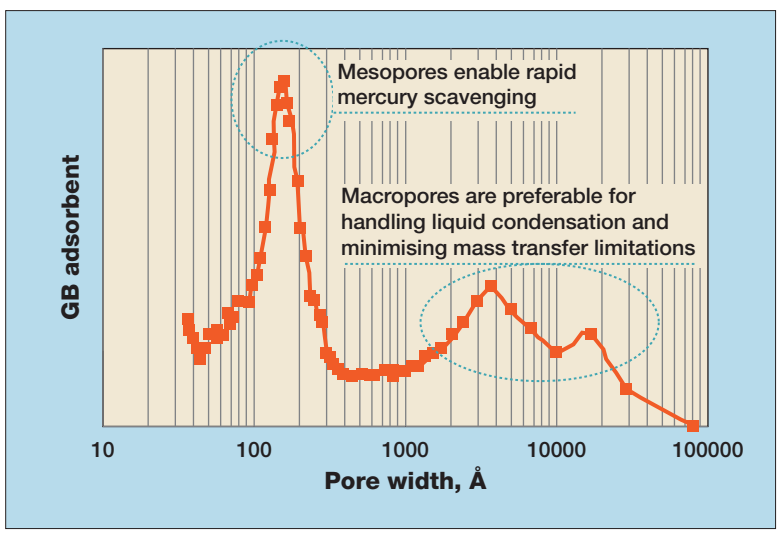

Figure 2 Pore features of UOP GB products

removal over cuprous sulphide.

Careful selection of the carrier substrate is essential for maximising mercury adsorption as these beds are designed to operate effectively at short contact times and are exposed to hydrocarbons close to their dew point. Therefore it is critical to specifically engineer the pore distribution of the adsorbent. As Figure 2 shows, an engineered mix of micro- and mesoporous structures ensures rapid mercury adsorption with the ability to withstand liquid condensation and minimise mass transfer limitations.

Regenerative adsorbent for mercury removal

UOP HgSIV adsorbents are regenerative molecular sieve products that contain silver on the outside surface of the molecular sieve pellet or bead. Mercury from the process fluid (either gas or liquid) amalgamates with the silver and a mercury-free dry process fluid is obtained at the bed outlet. An additional layer of HgSIV adsorbent, to an existing dryer configuration, results in removal of design water load and the mercury from feed gas. Mercury and water are both regenerated from the HgSIV adsorbents using conventional gas dryer techniques where the mercury-silver amalgam on the molecular sieve is regenerated thermally. The mercury desorption profile from the HgSIV adsorbent is similar to a typical water regeneration profile, except that mercury is completely removed from the HgSIV adsorbent well before the full regeneration temperature is reached (for water removal).

Mercury exits the bed during the regeneration step along with the spent regeneration gas. Plants have the option to consider installation of a smaller, non-regenerative guard bed to treat the mercury laden, spent regeneration gas. This ensures removal of mercury from the gas processing section of the plant.

Physically, UOP HgSIV adsorbents have a similar appearance to conventional molecular sieves. These HgSIV adsorbents are loaded into an adsorption vessel in the same way as are conventional molecular sieves. There is no need for special care such as the use of nitrogen blanketing during the installation. For unloading, only the same precautions need to be taken as when unloading conventional molecular sieves.

Regenerative adsorbents for mercury removal, such as HgSIV adsorbents, can be used to treat mercury laden gas in plants which were not originally designed for mercury from feed gas. These

adsorbents can be installed in the existing dehydration beds without capital expenditure of installing non-regenerative MRUs. This also helps users avoid additional pressure drop upstream of cryogenic separation.

HgSIV adsorbents also help users treat their gas in situations where their non-regenerative guard beds are either out of service or are under performing.

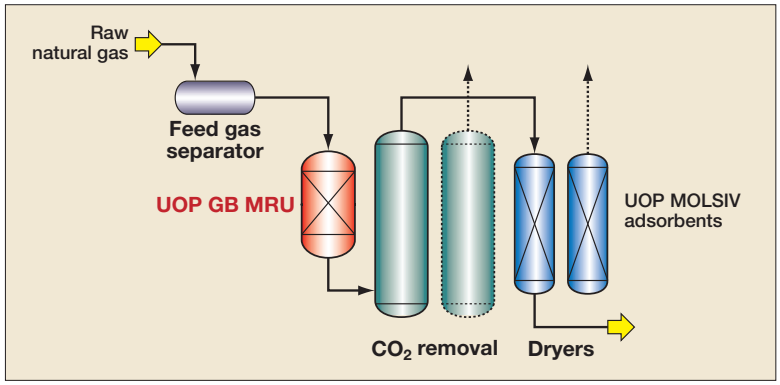

Figure 3 MRU upstream of the acid gas removal section and dehydrators

Mercury removal schemes

Non-regenerative bed for upstream mercury removal

UOP's GB range of non-regenerative metal sulphide adsorbents can remove mercury from the raw gas, upstream of the amine unit and the dehydration vessels (see Figure 3). Using larger MRU vessels protects the brazed aluminum heat exchanger and significantly reduces mercury contamination in and around the process plant. This option has become increasingly popular since it minimises the total mercury present before there is any opportunity for mercury to migrate to various locations within a gas processing plant and avoid the risk of subsequent partitioning into processed natural gas and condensate streams. This option also avoids subsequent adsorption onto any pipeline asset or piece of equipment downstream.

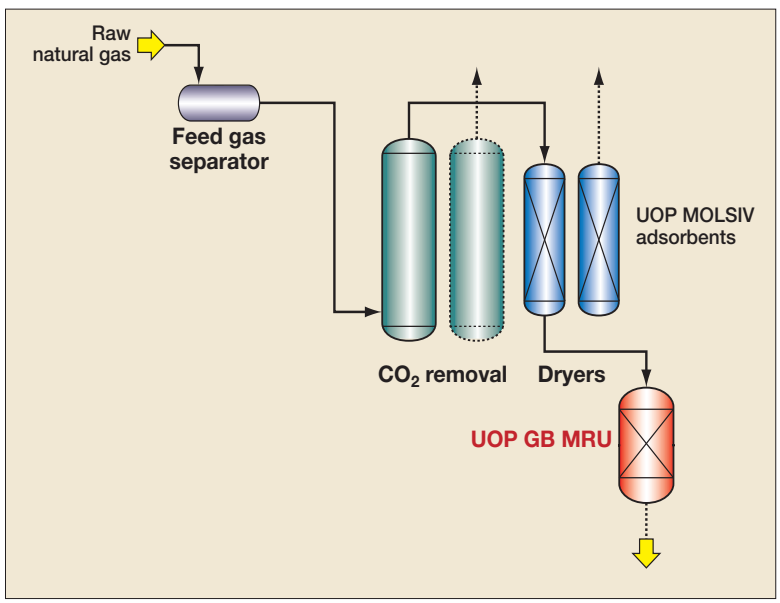

Figure 4 MRU downstream of the acid gas removal section and dehydrators

While the recommendation to position the MRU upstream of the acid gas removal units remains the ideal solution for natural gas plants, there are many operating facilities with MRU vessels downstream of the dryers (see Figure 4).

Placement of the MRU downstream of the dehydrator might not appear to be a logical choice for a user. However, when plant operations decides to use sulphur impregnated carbon as the adsorbent for mercury removal from gas, the MRU location becomes critical. Sulphur impregnated carbon based mercury adsorbents are highly sensitive to moisture and thus need dry gas to effectively remove mercury. This forces the location of the MRU to be downstream of the dryers.

However, this is not the preferred MRU location for most natural gas plants. Because the mercury removal occurs just upstream of the cold section, there will be mercury in the acid gas removal system as well as in the molecular sieve regeneration gas. Additionally, this option requires separate vessels and adds to pressure drop upstream of the cryogenic section.

Regenerative adsorbents for mercury removal

For a regenerative mercury removal option, HgSIV adsorbent can be loaded with the dehydration molecular sieve. This helps protect the

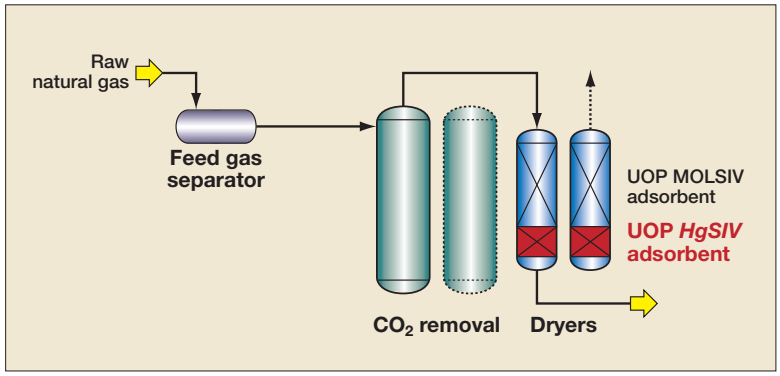

Figure 5 Regenerative mercury removal along with dehydration

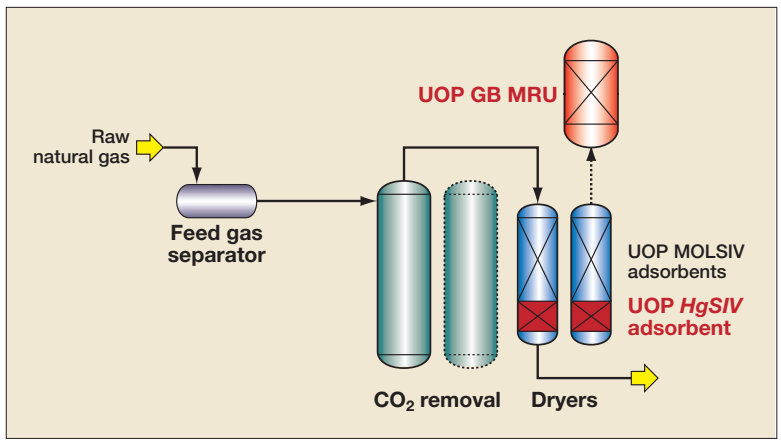

Figure 6 Configuration showing regeneration gas mercury removal

brazed aluminum cold box in the cryogenic section. HgSIV adsorbents can be used in natural gas plants to meet the processing requirements of a mercury content of less than 10ng/Nm^3 for the treated gas.

Handling mercury contamination of spent regeneration gas

UOP receives frequent enquiries regarding use of HgSIV adsorbent and handling of spent regeneration gas. There are two practical approaches to handling spent regeneration gas from a dryer installed with HgSIV adsorbent. Some plants choose to route the mercury laden spent regeneration gas to the fuel gas header of the plant or into a larger volume of pipe gas where the contribution from the spent regeneration gas is relatively minor, thereby reducing any concerns about reliability in the downstream hardware.

The second option is to treat the spent regeneration gas with a GB non-regenerative adsorbent.

Spent regeneration gas treatment to enable recycle to feed gas

UOP offers design and know-how support for mercury removal from spent regeneration gas. The design incorporates the use of a small bed of GB adsorbent (non-regenerative mercury removal adsorbent). One such scheme is shown in Figure 6. The spent regeneration gas, after being cooled and passed through a separator, is sent through a small GB adsorbent bed. Since regeneration gas flow is relatively small compared to the feed gas, the GB adsorbent requirement is relatively small when compared to the requirement for feed gas adsorbent.

Natural gas liquids treatment

C_4, C_4+ and in some instances even C_3 streams from the cryogenic section of a natural gas plant exhibit mercury contamination. This mercury contamination can be high in situations where upstream mercury treatment is either ineffective or not present. Mercury treatment from these liquid streams is done principally in the same way as for feed gas treatment. Options for mercury removal are the non-regenerative or regenerative adsorbent beds designed for liquid treatment.

Summary

UOP offers various reliable mercury treatment options and arrangements. The decision for using one or more of these schemes would generally depend on the operational and capital requirements of the user. However, for addressing health, safety and environmental concerns, the scheme involving upstream mercury removal offers maximum insurance.

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Adsorbents portfolio to the natural gas and petrochemical industry. Satyam holds a bachelor's degree in chemical engineering from India's Maharaja Sayajirao University of Baroda and has been involved with the oil and gas industry for the last 15 years.

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