

# **The Sorbead™ Quick-Cycle Process For Simultaneous Removal of Water, Heavy Hydrocarbons and Mercaptans from Natural Gas**

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## **Abstract**

Used for decades, BASF Sorbead™ oil-drop silica gel is a premium silica gel-based adsorbent that allows the single step removal of both heavy hydrocarbons and water from natural gas ('quick-cycle units') as well as for natural gas dehydration.

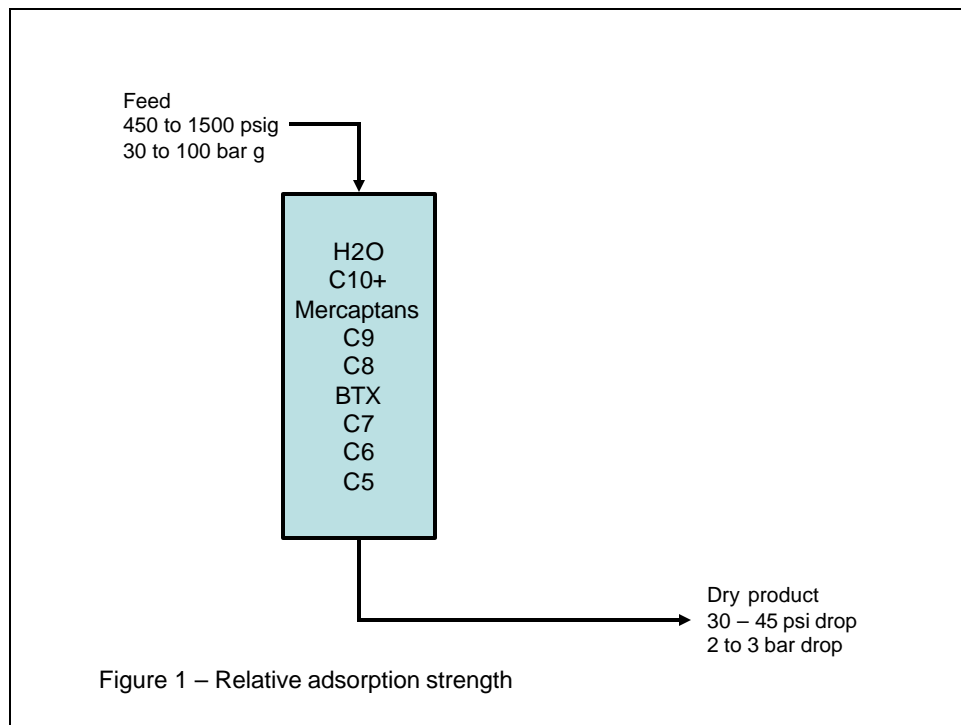
Recent developments in the quick-cycle process allow the removal of heavy hydrocarbons, mercaptans, water and, through integration with amine treating, enables H<sub>2</sub>S / CO<sub>2</sub> removal without an additional dehydration unit. The benefits of the improved quick-cycle process can include amine plant operations with reduced foaming, improved sulfur recovery rates, longer Claus catalyst lifetimes, simplification of propane and LPG mercaptan treating, and the ability to integrate non-regenerable mercury traps at an earlier stage of processing and the production of dehydrated product. The integrated process can be attractive for gas conditioning, LNG and GTL facilities.

## Introduction

Natural gas always contains contaminants or other unacceptable components that can include heavy hydrocarbons, water, mercaptans, mercury and the acid gases of H<sub>2</sub>S and CO<sub>2</sub>. Conditioning natural gas for pipeline, LNG or GTL generally requires the removal of these contaminants. Historical arrangements of the process units for their removal are optimized on an individual plant basis but fundamentally removal of the contaminants as early as possible in the processing train is desirable.

BASF Sorbead™ oil-drop silica gel has been applied for decades to remove water and heavy hydrocarbons from natural gas in "quick-cycle" units. These units operate on the basis that water and heavy hydrocarbons are attracted through molecular scale forces to the surface of the Sorbead adsorbent with a higher adsorption capacity than that of lighter hydrocarbons.

As a general rule, the adsorption capacity is directly related to the molecular weight and boiling point of the gas adsorbed (with the exception that water is very strongly adsorbed). This means water and higher molecular weight components are adsorbed more strongly than lighter components. In this manner, BASF Sorbead adsorbents act much like a giant gas chromatograph with the adsorption strength as demonstrated in *Figure 1*.



Examination of *Figure 1* indicates that the flow is downward, which is typical, and, after C<sub>5</sub>, the C<sub>6</sub> component is nearest the product discharge side of the bed. This means that if additional feed were sent into the adsorbent bed the C<sub>5</sub> components would be the first to appear in the product gas followed by C<sub>6</sub>. Note that water is most strongly adsorbed and that it is removed at the entrance to the bed of adsorbent. The mercaptan species are also removed and are adsorbed more strongly than C<sub>6</sub>. As with the other components the higher molecular weight mercaptans are removed first.

Once saturated with the targeted impurities, the bed is thermally regenerated by passing a hot stream of feed gas through the bed which upon heating causes a decrease in the adsorbent affinity for the impurities and they are released into the regeneration stream. This heating step is followed by cooling and the cycle repeats.

## The Quick-Cycle Process for the Removal of Hydrocarbons and / or Mercaptans

Most process engineers, in the natural gas industry, have at least a passing familiarity with thermal swing adsorption (TSA) systems used for dehydration. These systems generally consist of two or more vessels of adsorbent where, at any point in time, one vessel is removing vapor phase water from the wet natural gas feed stream while the second vessel is first heated and then cooled - often with the product gas. Adsorbents used in this service include BASF Sorbead oil-drop silica gels, granular gels, aluminas and molecular sieves. While many configurations and adsorbents are used, they mostly share the trait of long adsorption and regeneration times, often in excess of 8 hours each. Long regeneration times allow the vessels to use external insulation.

Given that the quick-cycle process must remove not only the strongly adsorbed water components but also some of the C5+ hydrocarbons as well as heavy components, long cycle times of 8 hours are economically impractical due to the adsorbent quantity required. Instead, the system is held to an economical cost by operating in a quick-cycle mode with typical adsorption time of 0.5-2 hours.

This quick-cycle imposes several design constraints on the system. First, and most importantly, the adsorbent will see many times the number of adsorption and regeneration cycles experienced as compared to conventional TSA dehydration. Since adsorbent life is related to the number of cycles, it is imperative to employ an adsorbent that can withstand the large number of cycles without premature deactivation. It has been demonstrated, at many plants, that conventional silica gels can rapidly deactivate requiring recharges, in some cases within weeks of start-up. However, the oil-drop manufacturing process used in the Sorbead production imparts a higher strength and easy regeneration that allows years of operation, generally 3-5 years or more with some units in operation for over 10 years.

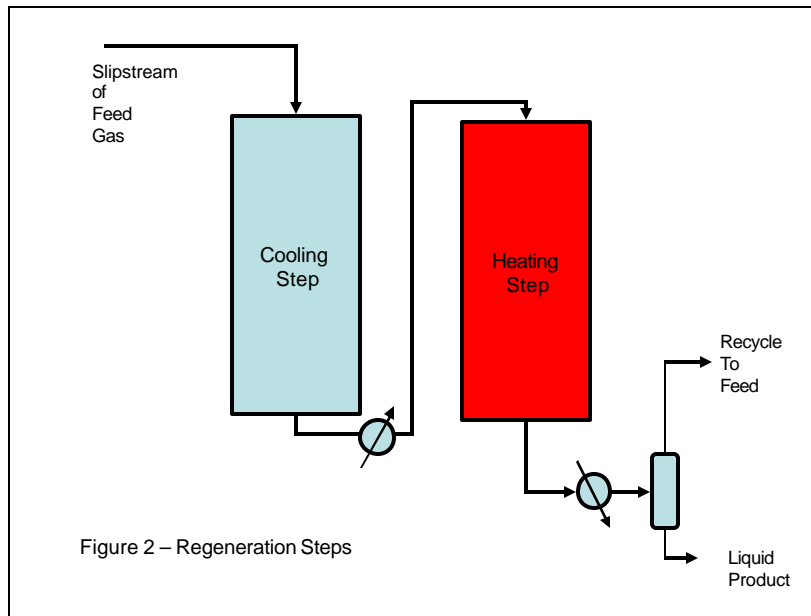
The quick-cycle design also requires that the vessels be internally insulated. This internal insulation allows the rapid heating and cooling of the adsorbent beds without having to heat and cool the entire vessel with the associated demand for excessive levels of regeneration gas and the dilution of the heavy hydrocarbon concentration in the regeneration stream. Internal insulation also reduces mechanical stresses due to the thermal temperature swings on the adsorber vessels.

The quick-cycle design consists of three basic steps and generally at least three adsorber vessels (more typically four adsorber vessels) - all with a down flow direction and all from the feed end of the vessel. The first step is the adsorption step as demonstrated in *Figure 1*. The saturated vessel is then regenerated in two steps - first by heating and then by cooling. The bed that has terminated heating is cooled with raw feed gas by passing a slipstream through the bed in the same direction as feed. This cooling step lowers the adsorbent temperature and also transfers heat from the adsorbent bed to the regeneration stream. Since the regeneration effluent from this vessel is partially heated, a higher heating efficiency results.

The partly heated effluent is then further heated, often with a gas fired heater, to about 500°F (260°C) and passed in the same direction as feed into the vessel to be heated. This heating is the initial step of regeneration and is directed into a bed saturated with the previously adsorbed heavy components. It is during this heating step that the heavy components desorb into the regeneration stream and are enriched in concentration. By cooling and condensing this effluent stream a liquid product is recovered.

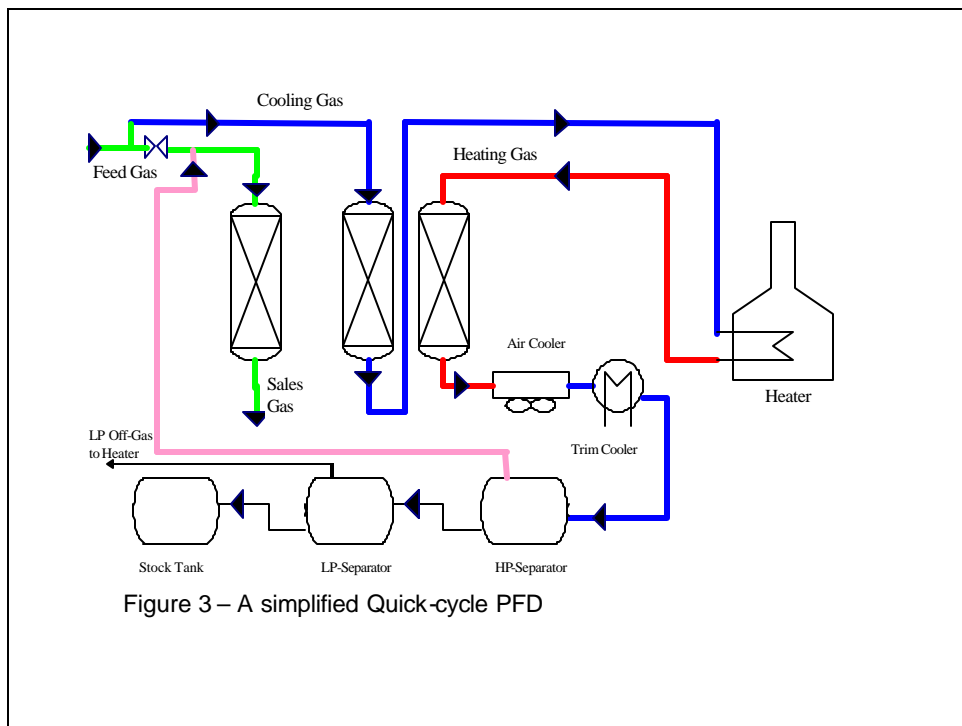
After heavy components are condensed, the uncondensed regeneration vapor stream is now wet and contains a residual amount of heavy hydrocarbons and is recycled back to the raw feed. In general, this recycle rate is 15-30% of the raw feed rate and the system must be sized to accommodate this recycle flow.

The regeneration steps are demonstrated in *Figure 2*, on the following page.



The adsorption and regeneration of the quick-cycle unit is typically from 450 to 1500 psig (30 to 100 bar g) with product at about 30 – 45 psi (2-3 bar) lower than the feed pressure. The regeneration is also at high pressure and no compression is required in the system (the penalty being the 2-3 bar g pressure drop).

A typical simplified PFD is in *Figure 3* and a photo of a 4-vessel design is shown in *Figure 4*.





**Figure 4** – A typical 4-vessel Sorbead Quick-Cycle Unit Oil-Drop Silica Gel

BASF Sorbead silica gel adsorbent is unique among silica gels and other adsorbents in that the manufacturing process consists of forming the spherical silica gel beads through an oil bath. Subsequent treatment results in spherical beads of a high surface area with unique and adjustable properties. The oil bath and manufacturing conditions allow the modification of the material such as adjustments in pore size and capacity with targeting for specific separations.

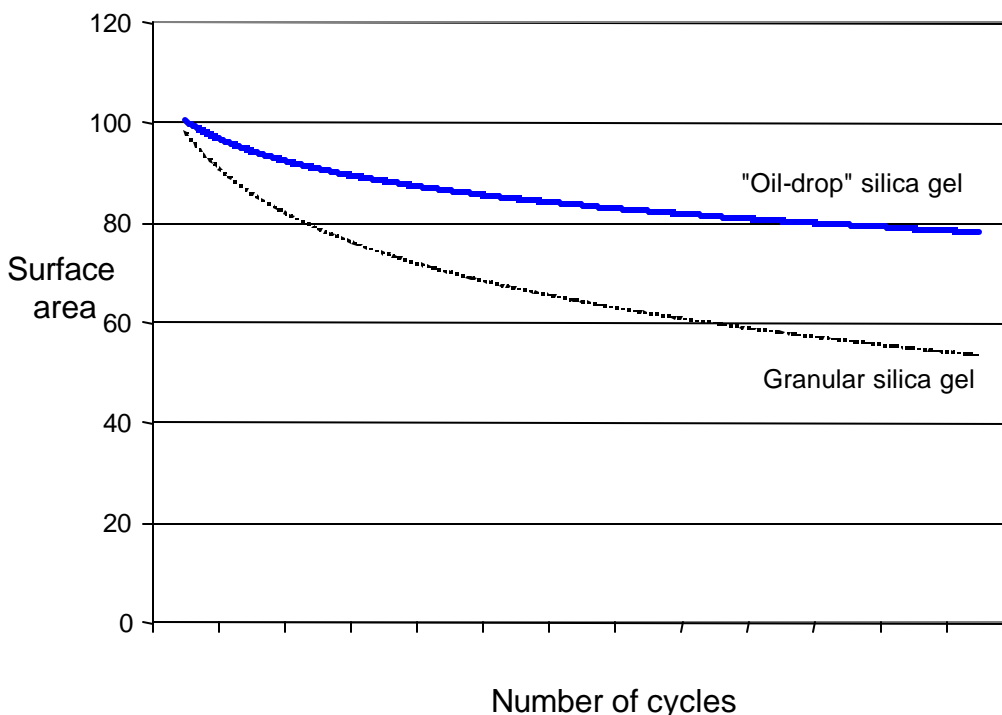
Liquid water in gas processing applications can be carried over from the feed stream or “rained” down into the adsorbent when the concentrated water in the regeneration stream condenses should it contact any cool points in the vessel head or piping. In production of BASF Sorbead WS (water stable) adsorbent, the manufacturing conditions are modified to produce a material that is resistant to liquid water without using calcination (excessive heating that reduces a materials capacity). By avoiding calcination, a material with both high capacity and liquid water resistance is produced that is sometimes used to protect the main bed of adsorbent (whether silica gel or molecular sieves).

Conventional granular silica gel is manufactured by mixing the raw materials in a tub and washing to remove impurities. Such production steps and raw materials allows low cost production but at the compromise of a material that is physically damaged by liquid water and one that can be damaged by the stresses of thermal swing adsorption.

One reason that adsorbents have a high capacity for water and heavy hydrocarbons is that within the pores of the adsorbent the impurity turns to liquid in a physical phenomenon termed “capillary condensation”. While the in-pore condensation allows high capacity, it exposes the adsorbent to liquid water and upon heating the expansion due to evaporation can cause physical damage to the adsorbent. BASF Sorbead oil-drop silica gel is highly resistant to such damage.

To determine the impact of the numbers of cycles on a water saturated feed stream on an analytical basis, hydrothermal stability testing has been conducted using pilot plant facilities. In the test, Sorbead oil-drop adsorbent and granular silica gel were exposed to a saturated stream until breakthrough was observed. Once

water saturated, the adsorbent bed was regenerated with flow of hot gas and the cycle repeated. The results showed a decrease in the Sorbead oil-drop adsorbent capacity with the first few cycles followed by a flattening of the capacity to relatively stable capacity. The granular silica gel started at similar capacity but quickly dropped about twice the level of the Sorbead adsorbent followed by continual capacity loss. The relative performance is shown in *Figure 5*.



**Figure 5** - Stability study of Sorbead oil-drop silica gel

Acid gases (CO<sub>2</sub> and H<sub>2</sub>S) are commonly removed using amine solvents. In the process, the acid gases react to form weak chemical bonds with the amine solvent at high pressure, in which these chemical bonds permit the removal of the acid gas while the natural gas passes through the solvent, and are available as a product reduced in these undesirable components. The rich solvent is regenerated by pressure reduction and heating which liberates the acid gases into a stripper overhead stream

Typical pipeline specifications for H<sub>2</sub>S are less than 4 ppm (v) and 2% (mol) for CO<sub>2</sub>. LNG facilities require the near complete removal of CO<sub>2</sub> since it will freeze at the temperatures of LNG.

Heavy hydrocarbons in natural gas can cause foaming of the amine solvent (1) and rich amine can contain considerable amounts of heavy hydrocarbons (2). This operation problem leads to reduced capacity in the amine plant and can lead to turndown of the entire natural gas processing train. While always difficult to quantify the throughput losses, they could rapidly mount to significance.

Use of a quick-cycle unit before the amine plant removes the heavy hydrocarbons and can eliminate the foaming caused by the heavy hydrocarbons (1). This single benefit may be enough to justify the addition of the unit but there are further peripheral benefits that are discussed in this paper.

## Reduced Amine Plant VOC emissions in CO<sub>2</sub> Removal Amine Plants

BTX and other heavy components have a small but definite solubility in amine solvents (2). Because of this, the amine plant stripper overhead will contain a quantity of heavy hydrocarbons that can include BTX and other heavy hydrocarbon VOC's. In an amine plant for CO<sub>2</sub> removal that treats a feed without H<sub>2</sub>S, the vented CO<sub>2</sub> rich stream from the amine stripper can quickly exceed VOC permitting levels dependent on the solubility of the heavy hydrocarbons in the particular amine solvent.

Addressing the co-absorbed VOC's can be a major permitting issue and fuel gas assisted flares or catalytic incineration has been used in operating facilities. In such plants, the fuel required for the VOC destruction represents a significant loss of natural gas and has a significant cost.

Thus, using a quick-cycle unit to remove the heavy hydrocarbons before they reach the amine plant can not only reduce foaming but can eliminate concerns with VOC emissions. It is also possible that the VOC's must be combusted and this can require the cost for fuel assist or other means for their destruction. (3)

## Removal of BTX from Claus Plant Feeds

The destruction of BTX in a Claus plant furnace can require temperature levels that cannot be achieved for a particular sulfur plant feed stream and this is especially the case where the natural gas contains relatively low H<sub>2</sub>S concentrations. While the use of H<sub>2</sub>S selective amine formulations can help enrich the H<sub>2</sub>S, low H<sub>2</sub>S concentrations in the Claus plant feed is still common for feeds where the H<sub>2</sub>S concentration is low relative to the CO<sub>2</sub> level or in LNG plants where complete CO<sub>2</sub> removal is required (leading to dilute H<sub>2</sub>S concentrations). If the temperature in the Claus plant furnace is insufficient for BTX destruction, the unconverted BTX will carryover into the Claus plant catalyst beds and cause coking and deactivation leading to shortened catalyst life (4).

Because BTX adsorbs strongly in the quick-cycle units placement of the quick-cycle unit at the upfront point of the purification train before the amine plant means BTX is not present in the feed to the Claus plant and the downstream catalyst deactivation is mitigated.

Certain Claus plant designs also take advantage of a split flow design wherein a portion of the feed is routed to the furnace and a portion bypassed directly to the Claus catalyst beds. These "split-flow" designs reduce the capital and operating cost of the Claus plant and are attractive for certain ranges of H<sub>2</sub>S concentration. Where the Claus feed contains BTX such split flow designs are not often chosen since the direct introduction of BTX (present in the stream bypassed around the Claus furnace) causes rapid catalyst degradation. By removing the BTX before the amine plant such a split flow design can be reconsidered.

## Mercaptan Removal

Commercial unit field data on the removal of mercaptans with Sorbead quick-cycle units is limited but studies have shown easy removal. Data from Advantica (5) is repeated in *Table 1* along with the fundamental conclusions. Since Sorbead quick-cycle units are used to remove C5+ with feed concentrations of C5+ typically 7000 ppm, the mercaptans will have a co-adsorption impact but it is relatively minor in most cases. This is because the mercaptan concentrations are typically lower and the mercaptans have a higher loading. In this study a range of feeds were evaluated and typical heavy compositions in the test are presented in *Table 1*.

**Table 1**

	Feed composition
Operating pressures	725 – 1015 psig (50 – 70 bar g)
Temperature	95 F (35 C)
Pentane, ppm	4000
Hexane, ppm	1500
Heptane, ppm	300
Octane, ppm	150
Methyl Mercaptan, ppm	5 – 20
Ethyl Mercaptan, ppm	11 – 33
Isopropyl Mercaptan, ppm	4 – 12
Tertiary-Butyl Mercaptan, ppm	1 - 3

## Test Results

- Mercaptans were removed without breakthrough.
- No significant impact of mercaptans on C5+ removal.
- Mercaptans end up in the heavy hydrocarbon condensate.
- A portion of the mercaptans flash from the condensate and are recycled to the feed.
- When treating higher levels of mercaptans, they are expected to be removed but recycle will increase.

As mercaptan levels increase, the amount of mercaptans that flash from the condensate also increase. Since this flash gas stream is recycled back to the feed of the Sorbead quick-cycle unit the amount of recycle can become significant in the overall drive to remove mercaptans. For this reason, using all or part of this flash gas as field fuel, rather than recycling back to the feed of the unit, can be desirable. As an alternative the recycle flash gas, enriched in mercaptans, can be separately treated for mercaptan removal.

The studies conducted by Advantica were in support of a Sorbead quick-cycle unit they designed for the Karachaganak gas field in the Caspian basin since their previous experience was limited to a feed with 10 ppm of mercaptans. While the raw feed can contain up to 2000 ppm, at this site mixed-solvent amine treating precedes the quick-cycle unit and the mercaptan level is 50 ppm at the inlet to the quick-cycle unit. The unit operates at this site though field data is limited.

## Mercaptan Free LPG and COS Formation

Mercaptans are commonly present in natural gas, especially in some of the Middle East and FSU fields that are currently subject to high levels of interest. Mercaptans, if permitted into the amine plant, are partially removed due to their solubility in the amine solvent and, thus are present in both the natural gas overhead product and the acid gas stream.

When the quick-cycle unit removes mercaptans with the water and heavy hydrocarbons before the amine plant, the removed mercaptans are present in the liquid condensate from the quick-cycle unit and thus sour condensate results. Such a condensate can be added to the sour field condensate for treatment.

If not removed upfront, the bulk of the mercaptans permitted into the amine plant is present in the residue natural gas stream, however, due to their solubility in the amine solvent a portion of the mercaptans are also present in the amine plant stripper overhead with the  $\text{CO}_2$  and  $\text{H}_2\text{S}$ . This requires that the mercaptans be converted in the Claus furnace.

The residue natural gas after amine treatment is generally processed for the removal of the higher value LPG components. While a range of mercaptans may be present in the raw natural gas, they tend to concentrate in the LPG liquids extracted and in traditional facilities where these liquid products often require further treatment for the removal of these mercaptans. If mercaptans are largely removed upfront, the downstream treatment can be reduced or potentially eliminated. It is also noteworthy that silica gels causes less COS formation than molecular sieves and dehydration using SORBEAD adsorbent can have advantages in this regard (6).

While this paper does not address the considerations for acid gas removal solvent selection, the removal of mercaptans and heavy hydrocarbons upfront of the amine plant can influence the solvent selected since mercaptan and heavy hydrocarbon solubility in the acid gas treating solvent will be less of an issue. Thus removal of mercaptans and heavy hydrocarbons can affect the selection between the use of chemical amine solvents or mixed chemical/physical solvents.

## Mercaptan Free Acid Gas Enrichment Units Vent Stream

In cases where the  $\text{H}_2\text{S}$  concentration of the stripper overhead is lean in  $\text{H}_2\text{S}$  for a Claus plant feed, as is the case with many LNG and other natural gas plants, an acid gas enrichment unit (AGE) can be used to treat the amine plant acid gases to remove the  $\text{H}_2\text{S}$  from the  $\text{CO}_2$ , thus providing a highly enriched  $\text{H}_2\text{S}$  stream as feed to

the Claus plant. The benefit of the AGE unit is a much higher H<sub>2</sub>S concentration as feed to the Claus plant leading to capital savings in the Claus plant and operation cost reductions.

While this extra processing step can have advantages, the solubility of the heavy hydrocarbons and mercaptans in the AGE solvent will leave a level of these components in the AGE stripper overhead (CO<sub>2</sub> rich stream). This overhead will lower the overall sulfur recovery rate if the mercaptans are not removed and incineration of the CO<sub>2</sub> rich vent can also be required which simply routes sulfur to the atmosphere as SO<sub>2</sub>. Further if this CO<sub>2</sub> rich stream requires incineration expensive fuel spiking to combust the mercaptans and heavy hydrocarbons in the stream may be required.

Thus, where an AGE unit is applied, the removal of the heavy hydrocarbons and mercaptans in a quick-cycle unit before the amine treater not only has advantages for the main amine plant but also keeps the heavy hydrocarbons and mercaptans from the AGE stripper overhead and incinerator.

## **Mercury Removal**

Sorbent adsorbents do not have a high affinity for mercury and it mostly passes into the natural gas product stream. When a quick-cycle is placed at the plant inlet, the fact that the product is dry and reduced in heavy hydrocarbons provides advantages to conventional mercury removal arrangement.

Mercury is commonly present in natural gas and, especially in LNG facilities, must be removed to maintain the mechanical integrity of downstream low temperature equipment. While a number of technologies are available for mercury removal, sulfur impregnated activated carbon is commonly used where the mercury is removed onto the bed of adsorbent in a non-regenerable mode where it adsorbs the mercury and is periodically replaced. While activated carbon can treat feeds containing water vapor, the carbon will perform better with a dry feed and the placement of the carbon beds immediately after the quick-cycle system and before the amine plant eliminates the mercury in an early stage of the gas plant.

Removal of the mercury by placing the mercury trapping adsorbent directly after the quick-cycle removal of water and heavy hydrocarbons and before the amine acid gas removal system offers advantages over traditional processing trains because this early removal limits the number of streams into which the mercury fractionates.

Where mercury is not removed upfront of the amine plant it will be present in both the amine plant residue natural gas and the stripper overhead. In a traditional arrangement, where glycol drying of the residue natural gas is used after the amine plant, the mercury will be present in both the dry gas from the glycol unit as well as in the vent stream from the regenerated glycol. Where conventional molecular sieve beds are used for drying the natural gas, mercury can be present in the natural gas product, regeneration stream and the condensed water.

Since mercury is also present in the amine plant stripper overhead, it is also present in the stream that is vented to the atmosphere (where H<sub>2</sub>S is not present) and also found in the sulfur product where H<sub>2</sub>S is removed and treated to produce a sulfur product.

Mercury removal upfront is important since it keeps the mercury from splitting in the various process streams resulting from downstream treatment. Please refer to references (7, 8) regarding the discussion on the various points at which mercury is found if it is not removed upstream.

## **Integrated Dehydration**

Placement of the quick-cycle unit near the inlet to the gas conditioning facility has the advantages described. However, it also has an undesirable issue; in that the water dry, heavy hydrocarbon reduced stream sent to the amine plant will be re-saturated with water by the amine solvent.

Conventional approaches to dealing with this water saturated stream include another Sorbent or other adsorbent dryer or glycol dehydration. While Sorbent units deliver lower dew points than conventional glycol units and do not achieve the dew points reached by molecular sieve beds, the fact that a quick-cycle unit exists

before the amine plant can allow a cost-effective solution. The water from the amine plant is removed onto an adsorbent bed that has completed its treatment of the raw feed but before it is regenerated. This integration can be best understood by the cycle shown in *Figure 6*.

Adsorption Raw Feed	Dehydration After Amine	Heat	Cool
Cool	Adsorption Raw Feed	Dehydration After Amine	Heat
Heat	Cool	Adsorption Raw Feed	Dehydration After Amine
Dehydration After Amine	Heat	Cool	Adsorption Raw Feed

**Figure 6** – Integrated drying quick-cycle

The cycle is designed such that a first adsorption step "*Adsorption Raw Feed*" removes water and heavy hydrocarbon from the natural gas and routes the dehydrated and reduced heavy hydrocarbon stream to the amine plant (or an intermediate mercury removal bed followed by the amine plant). The first adsorption step is followed by a second adsorption step "*Dehydration after Amine*" where the wet natural gas from the amine plant is routed back into a vessel that has completed the initial treatment of the raw feed stream.

Since water adsorbs strongly and the heavy hydrocarbons have already been removed from this stream, only a small incremental amount of adsorbent is required for the removal of the water vapor introduced by the amine plant. The adsorbed water from the second adsorption step will also displace some C5+ into the product stream but the quantity is small since the amount of adsorbent required for the water is small. Note that any displaced C5+ will not have any impact on the amine plant, since the amine plant treats the effluent from the first adsorption step such that effectively the C5+ is bypassed around the amine plant.

Since the integrated heavy hydrocarbon removal requires only one additional vessel, the added cost for the dehydration after the amine plant is roughly 20 percent of the installed cost of the system. However, no units yet operate in this manner and there is a design consideration that the beds will contain a small quantity of H<sub>2</sub>S and CO<sub>2</sub> during the initial "*Adsorption Raw Feed*" step that can be displaced into the product end by the second "*Dehydration after Amine*" step and thus bypassing the amine system. This concern can require recycle of this second effluent stream to the amine plant or treatment by a small slipstream of lean amine.

## Sorbead™ System Size

For the overall integrated system the size of the quick-cycle unit is driven by the amount of heavy hydrocarbons in the feed and most critically the dew point requirements. For example if a low hydrocarbon dew point were required after both the initial adsorption step and also after the second adsorption step (removing the water that is reintroduced by the amine system) the system would be larger than if a level of hydrocarbons were permitted to slip into the product stream from the second adsorption step.

It is also notable that the breakthrough of the heavy hydrocarbons is initially low and progressively increases as the adsorption step progresses. This results in an initially lower hydrocarbon dew point that gradually increases. To compensate for this dew point variation multiple beds of adsorbent are often placed on

the adsorption step in a staggered manner that leads to an averaging of the product heavy hydrocarbons and limiting the hydrocarbon dew point changes over the cycle. A typical design material balance is shown in *Table 2*.

**Table 2**

Flow, MM SCFD (nm <sup>3</sup> /hr)	150 (167,500)
Pressure, psig (bar a)	1000 (70)
Inlet Temperature, F (C)	86 (32)
Composition, Mol %	
C1	90.107
N2	1.000
CO2	3.000
C2	3.400
C3	1.500
C4	0.100
C5	0.400
C6	0.200
C7	0.100
C8	0.020
C9	0.020
Mercaptans	0.010
C10	0.020
Benzene	0.040
Toluene	0.010
Water	0.083

With the design basis above a 6-bed system was designed to meet a hydrocarbon dew point of 23 Deg F (-5 Deg C) at the end of the cycle (highest breakthrough of hydrocarbons). This design would use vessels of 7.5 ft diameter by 24 ft (2.3 M x 7.4 M).

## LNG Facilities

The process advantages and integrations described above are applicable directly to natural gas conditioning for pipeline purposes. However, though water is strongly adsorbed, quick-cycle units do not generally achieve the water dew points typically required in LNG plants (0.1 ppmv). Typical water levels achieved by quick-cycle units are 10-20 ppmv (roughly -20 to -40 Deg F or -4 to -40 Deg C dew points at 800 psig or 55 bar g) with feed gas regeneration.

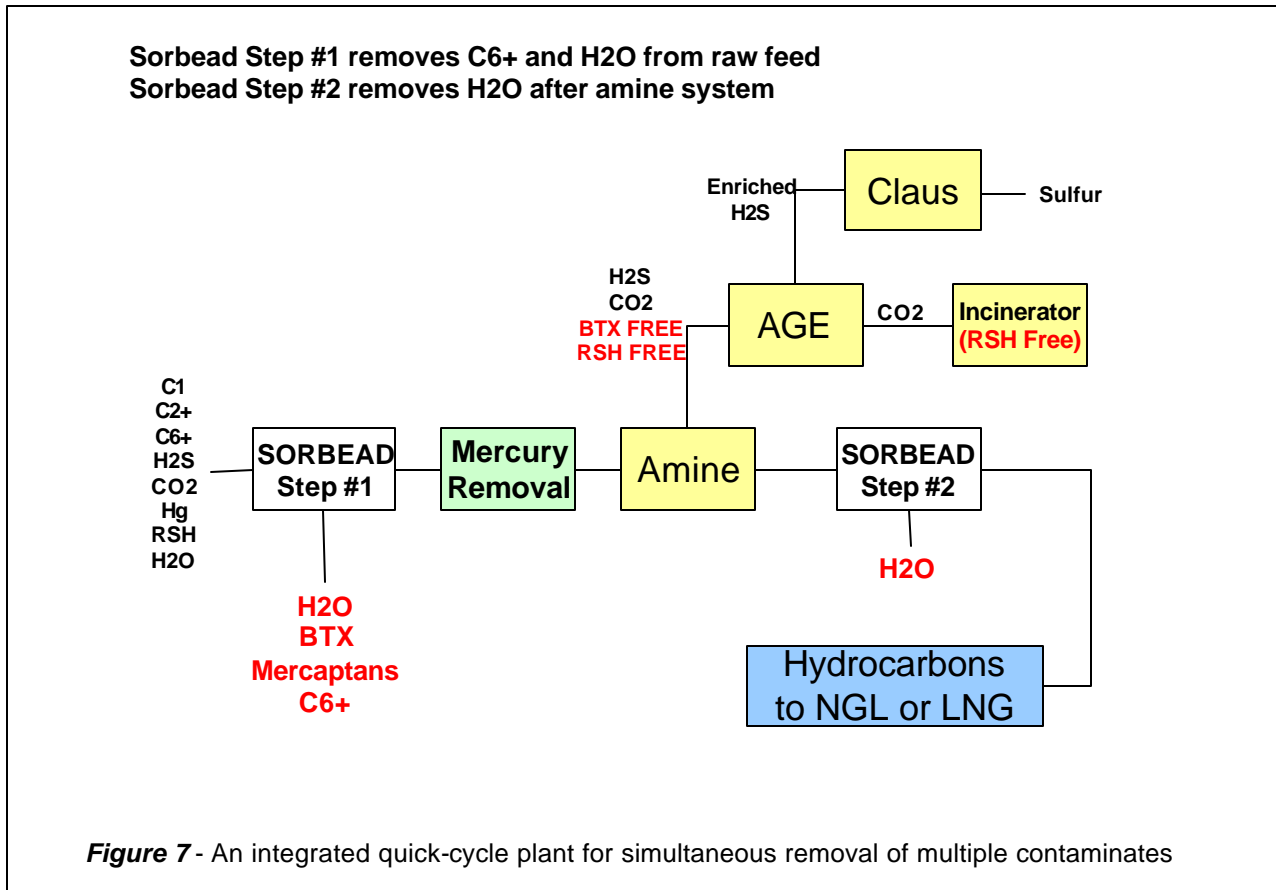
Though trim layers of molecular sieve in the quick-cycle unit could be considered, the large number of cycles would impose a challenge for molecular sieve. A more practical approach is to add a small TSA molecular sieve polishing dryer downstream of the quick-cycle unit to remove the residual ppm levels of water. This trim unit would require a relatively small adsorbent inventory and can run on an extended cycle time and thus the cost would be relatively small.

Two further integrations between the quick-cycle and molecular sieve trim unit exist. The quick-cycle unit and molecular sieve unit would regenerate at the same temperature of about 500°F (260°C), thus the quick-cycle units furnace could be designed with an extra tube bundle to heat the molecular sieve unit regeneration stream. This design will avoid another furnace and would be highly desired to reduce cost, operations and permitting issues. Secondly, the relatively small regeneration stream of the molecular sieve unit can be recycled back to the feed inlet of the quick-cycle unit to reduce hydrocarbon losses.

## Conclusion

In summary, the advantages of upfront quick-cycle treatment using BASF Sorbead™ adsorbent can include the point below which are graphically illustrated in *Figure 7*.

- Reduced foaming in the amine plant.
- BTX free Claus plant feeds leading to longer catalyst life.
- Mercaptan-free Claus plant feed.
- Improved sulfur recovery since mercaptans are not present in the incinerator.
- Elimination of incineration of the amine plant stripper overhead.
- Improved sulfur recovery rates since mercaptans are not incinerated in the AGE overhead.
- Simplification of the treating of liquid products.
- Earlier removal of mercury and avoidance of having mercury split into multiple streams.
- Simplified dehydration.
- A downstream molecular sieve unit would be required to meet very low dew points.



The quick-cycle process has been used for decades to dehydrate and remove heavy hydrocarbons from natural gas. The integrated quick-cycle process using Sorbead™ adsorbent placed in the front of natural gas conditioning plants eliminates contaminates at the earliest part of the processing train and offers operating advantages throughout the downstream processing train.

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## About BASF

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