NATURAL GAS PROCESSING

WHITE PAPER

SOUR GAS TREATING:

DEVELOPING SOUR GAS ASSETS WITH CONFIDENCE: HOW A GAS SWEETENING FEED STUDY DE-RISKS TECHNOLOGY SELECTION, COST, AND EXECUTION

CANUSA EPC

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SUMMARY

Gas sweetening – the process of removing foul-smelling mercaptans, toxic hydrogen sulfide (H2S), and carbon dioxide (CO2) from hydrocarbon streams – has become critical for natural gas development, but yet its execution is becoming increasingly complex. As producers contend with increasingly sour reservoirs and stricter environmental requirements, selecting the appropriate fit-for-purpose gas sweetening system while considering a system-wide engineering approach is key to achieving project success.

This success is charted long before construction begins. Engaging in a gas sweetening study allows an owner to take a tactical approach towards evaluating and selecting the best solution that balances integration, operability, and long-term flexibility. In doing so, owners can gain clarity on capital efficiency, lifecycle performance, and understanding project risk.

Keep reading to learn how CANUSA EPC's technology agnostic approach can support your gas sweetening initiatives.

HIGHLIGHTS

- **Understand Technologies -** review the current gas processing technology options for sour gas treatment
- **Analysis of a Case Study** - real numbers and real decisions that an operator could act on

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Market Context

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Natural gas has emerged as a preferred energy source, displacing other carbon intensive fuel sources such as coal and fuel oils. As the market share of natural gas grows, the expectations around its quality and environmental footprint are also increasing. Pipeline specifications across North America and global LNG markets are enforcing lower allowable sulfur limits for both H2S and mercaptans, and this trend is pronounced in applications where precious downstream catalysts are prone to sulfur poisoning, such as for hydrogen production and petrochemical processing.

Regulatory pressure on sulfur emissions and flaring is intensifying, with operators being expected to demonstrate more stringent control over acid gas handling, often necessitating integrated sulfur recovery and tail gas treatment systems. Consequently, the gas sweetening scope is no longer treated as an isolated processing step, but rather, an integral part of the broader emissions management strategy.

Feedstock variability adds complexity. Mercaptan, H2S, and CO2 concentrations are known to fluctuate – sometimes dramatically – in the gas produced from unconventional reservoirs not only between fields, but commonly over the life of a single asset. Being ill-prepared for these fluctuations can risk underperformance, increased operating costs, and premature shut-in.

Some operators are also placing greater emphasis on energy efficiency, carbon intensity, and their overall carbon strategy. Regenerative solvent-based systems can represent a significant portion of a facility's energy demand, and as a result, there is growing pressure for process optimization, heat integration, and operational configurations that maintain performance and reduce energy consumption. In some cases, CO2 removal from natural gas streams may align with CCUS strategies, particularly where concentrated CO2 stream can be sequestered or utilized.

On the backdrop of this dynamic landscape, gas sweetening projects continue to be driven by the underlying need to mitigate acid gas corrosion risks in downstream infrastructure, elevate the heating value of gas, and prevent freezing in liquefied states.

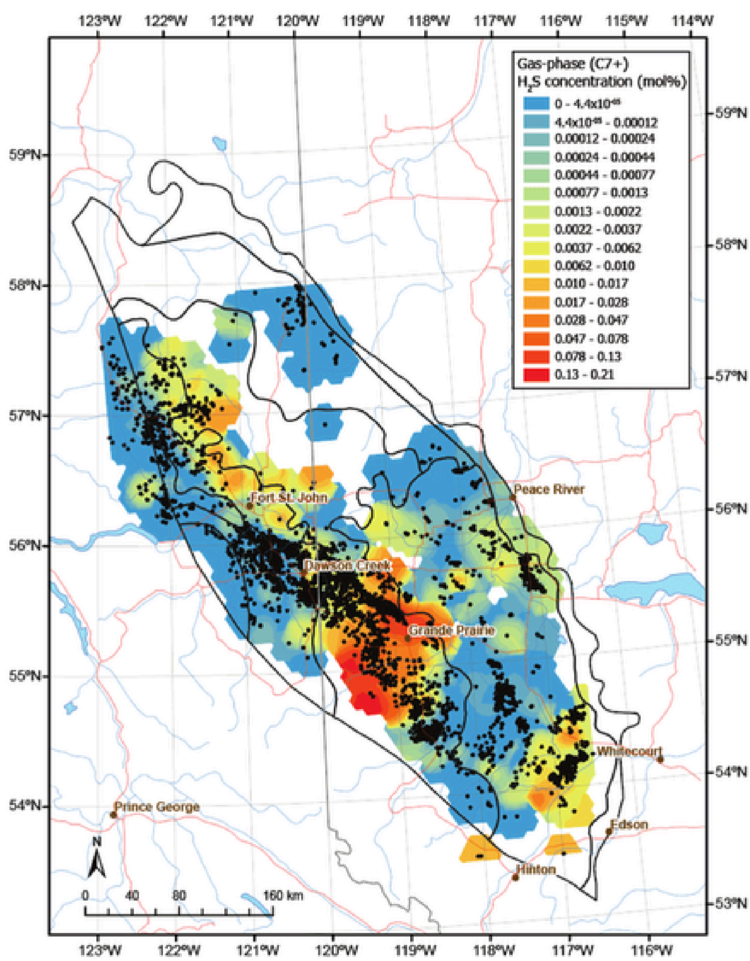

FIGURE 1: HYDROGEN SULFIDE (H2S) DISTRIBUTION IN THE MONTNEY FORMATION (SOURCE: NATURAL RESOURCES CANADA)

Technology Overview

Amines

Aqueous amine-based absorption systems are the dominant technology for H2S/CO2 removal due to their reliability, scalability, and regenerable solvents. Solvent selection – whether monoethanolamine (MEA), diethanolamine (DEA), or other selective formulations such as methyldiethanolamine (MDEA) – is based on gas composition, desired removal efficiency, energy consumption, and H2S/CO2 selectivity. Although widely deployed, amine systems require thoughtful engineering to mitigate regeneration duty, solvent degradation, and corrosion.

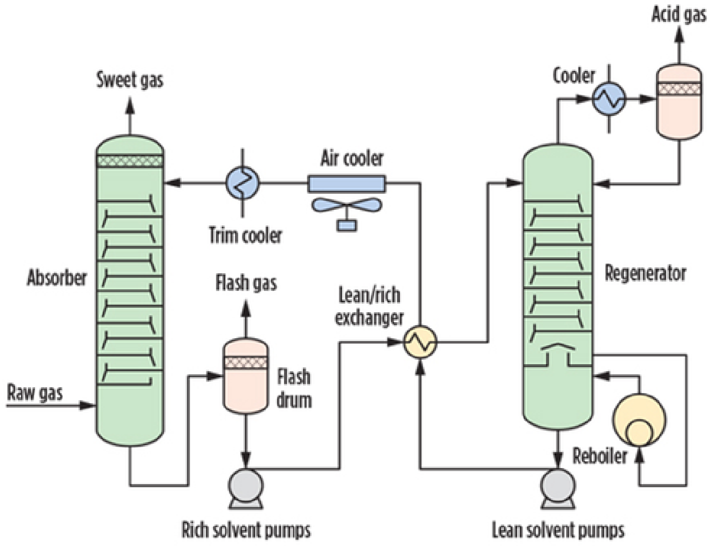

FIGURE 2: REGENERATIVE ACID GAS REMOVAL PROCESS (SOURCE: GAS PROCESSING & LNG)

TECHNOLOGIES

Amine Absorption

Membrane Separation

PSA with Molecular Sieve

Chemical Adsorption (Regenerative or Consumable)

Membranes

Membrane separation systems, working under the principles of selective permeation through porous and non-porous barriers, may be considered for continuous flow applications with large volumes and lower purity requirements. Membranes can be sensitive to fouling and in large volumes can require substantial horsepower to operate.

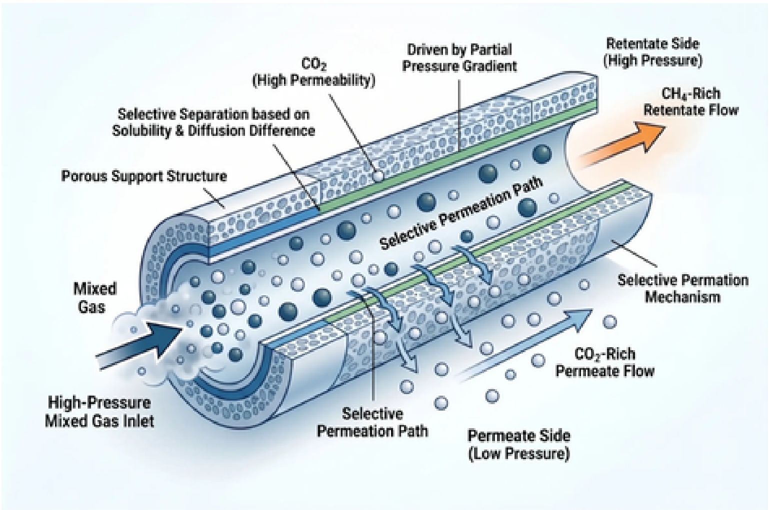

FIGURE 3: MEMBRANE SEPARATION FOR GAS SWEETENING - CO2 REMOVAL (SOURCE: JALON)

Pressure Swing Adsorption (PSA)

Meanwhile, molecular sieves operated in a pressure swing adsorption system make use of zeolites to selectively capture impurities at high pressure and release at low pressure. The molecular sieve meets the niche of handling high gas purities for relatively lower output capacities.

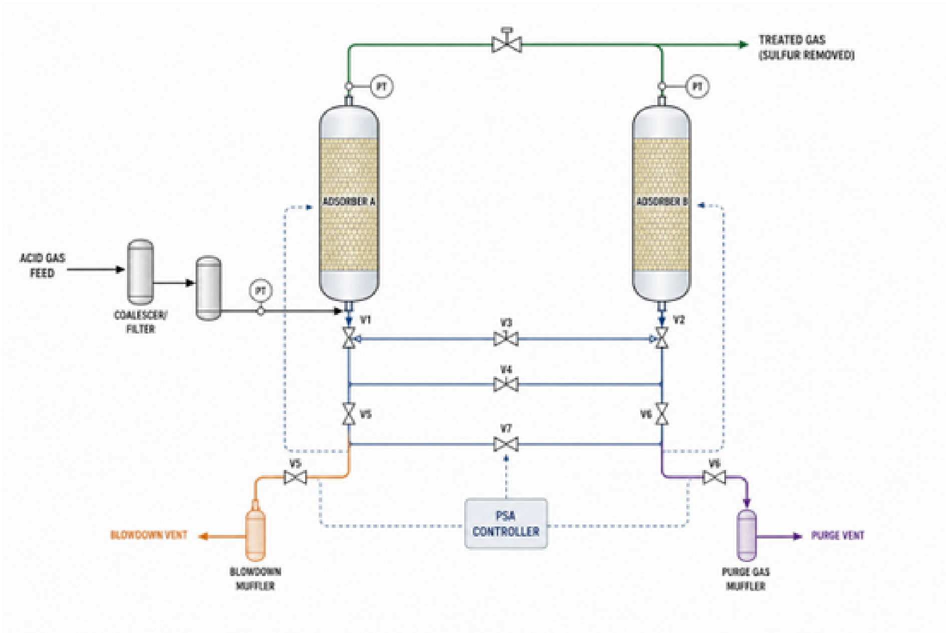

FIGURE 4: MOLECULAR SIEVE PSA SYSTEM FOR SULFUR REMOVAL

Chemical and Caustic Treatment

Unlike H2S, mercaptans are less reactive and often require additional treatment steps beyond conventional absorption techniques. Mercaptan removal may entail the use of caustic treating systems, catalytic oxidation processes, or adsorption-based polishing units. The challenge lies not only in achieving removal targets, but doing so consistently at extremely low concentrations where odor and product specifications become critical, all while protecting the project economics. Chemical treatment can be developed in a consumable deployment for low flow or concentration applications or regenerative systems that extend the life of the chemical bulk material.

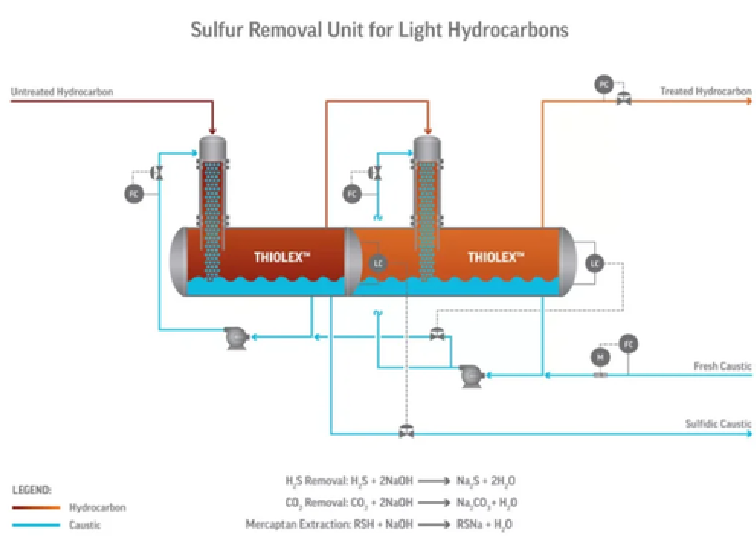

FIGURE 5: CHEMICAL AND CAUSTIC TREATMENT (SOURCE: MERICHEM)

CANUSA EPC INSIGHT

- ***Combinations of technology can often compliment the advantages of both.***
- ***Various technologies can be used to compliment each other such as initial bulk removal of contaminants through absorption or membrane processes with final polishing by a PSA to meet specification and reduce losses.***

Claus Sulfur Recovery

For larger or more concentrated sour applications, the integration of sulfur recovery (Claus) processes and tail gas treatment may become essential. The Claus process is the primary industrial technology for desulfurization in oil refining and natural gas processing and is used when there are high concentrations of H2S. The Claus process treats H2S gas into harmless, commercial-grade elemental sulfur using high heat and multiple catalytic stages with alumina or titania catalysts. Operating at standard recovery rates of 95–97%, it serves as the benchmark bulk sulfur-recovery technology for high-concentration gas streams.

TECHNOLOGY	EFECTIVE SPECIES REMOVAL	CONSTRAINTS	APPLICABLE PHASES
Amines (Amine Scrubbing)	H2S, CO2	Mercaptans (minimal/poor removal due to low acidity)	Gas & Liquids (natural gas, LPG, NGLs)
Membranes	CO2 (primary), H2S (secondary)	Mercaptans (poor selectivity; risk of membrane swelling/degradation)	Gas Only
PSA with Molecular Sieve	H2S, CO2	Mercaptans (poor trace removal; causes severe bed fouling/irreversible poisoning)	Gas Only
Chemical & Caustic Adsorption (Scrubbing / Scavengers)	H2S, Mercaptans	CO2 (not for bulk removal; reacts preferentially and consumes caustic reagent rapidly)	Gas & Liquids (gas, refined fuels, LPG, crude)
Claus Process	H2S	CO2 (inert through furnace/catalysts), Mercaptans (causes operational issues/sooting if unburned)	Gas Only

How to Evaluate Technology Options

These technologies each offer distinct advantages and constraints that make choosing the correct solution challenging. Selection must account for gas composition, contaminant variability, lifecycle treatment and development plans. To align economics, operability, and facility performance, operators often will engage a Front-End Engineering and Design (FEED) study to compare viable options on a common basis and narrow down the field of solutions.

Gas Sweeting FEED Study

A gas sweetening FEED study sits at the intersection of technical theory and executable, practical design. Its informs whether to proceed with a project with confidence and if risks and cost escalations can be avoided. The study involves several key steps designed to identify the best path forward before large capital expenditures are approved.

Clarifying Project Parameters

The first critical step is to document all project objectives, specifications, assumptions, and concerns. CANUSA EPC takes the time to align expectations with project owners and gain a clear understanding of the context, project drivers, evaluation criteria, and constraints.

Understanding the Gas Stream Characteristics

The study must consider the composition of the gas stream, including what contaminants are present and in what quantities. The variability of feed contaminants over the asset life must also be considered along with a thorough understanding of any forecast production decline. Understanding the gas characteristics – for example, mercaptan type - is critical to selecting a suitable gas sweetening technology, as the contaminant loading and feed conditions will impact the efficacy or operability of different systems.

Evaluation of Gas Sweetening Technologies

Factors to consider include a cost-benefit analysis, evaluating both the initial capital expenditures and ongoing operational costs associated with each technology. A detailed operability review should also be undertaken in a gas sweetening study to assess how existing personnel might manage the new system. Equipment and consumables sourcing strategies should be examined, especially if dealing with proprietary chemicals/components.

Integration with upstream and downstream systems is equally critical. Gas sweetening can tie-in to inlet separation, dehydration, compression, and sulfur recovery. Poor integration can create bottlenecks, increase energy demand or compromise product quality.

At this stage, the project execution approach can be conceptualized with an evaluation of modular vs. stick-built solutions being undertaken, based on the project scale and location.

CANUSA EPC INSIGHT

- ***Engaging an engineering firm with a preferred technology partner will often lead to the most concise and efficient analysis for a FEED study. This requires aligning both parties on the goal of the FEED study to ensure that proper definition can be determined for performance and installation costs.***

Decision-Making Transparency

Selecting the right gas sweetening technology often involves trade-offs between cost, efficiency, and future expandability. Detailed studies identify potential risks, allowing owners to confidently choose the right technology, avoiding unexpected costs and delays later in the project. Beyond the technology, developing a fit-for-purpose solution that considers an owner's commercial flexibility is equally important. For example, the commercial approach towards managing a single isolated sour gas asset may differ drastically from an asset that falls within a broader portfolio with existing integrated operations and multiple receipt points.

Transparency and alignment are paramount in these studies, providing a complete view of each option's advantages and disadvantages. Combining CANUSA EPC's technology agnostic approach and commitment to transparency enables project owners to walk away with an unbiased evaluation that provides clarity on critical aspects like project budget, timeline, and risks mitigation.

Case Study: Sour Gas Well

H_2S and Mercaptan Removal

CANUSA EPC recently supported a customer's gas sweetening project through a technology evaluation study.

The customer operates a mature, low decline gas field that produces 200 mscf/d of lean sweet gas. After acquiring the asset, the customer drilled and completed a new gas well that is awaiting tie-in and expected to ramp the total field production to 1,000 mscf/d. The production from the new well is sour and will comingle with existing production.

To meet gas specifications at the delivery point, the customer asked CANUSA EPC to scope and evaluate options for the design and supply of a gas sweetening unit for the removal of H_2S and mercaptans. When initially tested, the inlet H_2S concentration was stated at 700 ppm and the inlet mercaptan concentration was stated at 150 ppm. The customer required outlet H_2S concentration of <1 ppm and outlet mercaptan concentration of <10 ppm.

The customer's production forecast indicated plans to choke the new production well to supply 30,000 sm^3/d of flat comingled production for 3.5 years before declining into the mid 2030s.

Upon initial evaluation, CANUSA EPC identified relatively lower flow rates and high turn down requirements as critical project considerations. CANUSA EPC consulted with the customer who agreed to evaluate non-regenerative options to minimize upfront capital investment and maximize the lifetime economics from the field.

CANUSA EPC started with a technology market assessment, evaluating solutions providers from multiple jurisdictions. The initial findings from the assessment are provided below.

	Solution 1	Solution 2	Solution 3	Solution 4
Provider Location	Canada	USA	USA	China
Solution Type	Sacrificial media: activated carbon	Type 1 scavenger: proprietary mixed metal oxide adsorbent (lead/lag configuration) Type 2 scavenger: proprietary mixed metal oxide nanowire-based catalytic	Pelletized iron-based adsorbent using 2 equal sized vessels in series	PSA equipment with molecular sieve
Capital Investment (Excluding First Fill Of Consumables)	2-vessel lead/lag configuration: CAD 640,000 +/-50% 1 vessel configuration: CAD 280,000 +/-50%	USD 1,000,000 +/-40% (excludes required HEX) USD 1,300,000 +/-40% (includes required HEX)	USD 600,000 +/-40%	USD 250,000 +/-30%
Consumables Cost	USD 2.10/lb USD 55,000/yr	Type 1 scavenger: USD 5/kg Type 2 scavenger: USD 50/kg	USD 1.60/lb USD 325,000 for first fill of both vessels	USD 600,000
Changeout Frequency	2 weeks	6 months	Vessel 1: 328 days Vessel 2: 8 days	2-3 years
Considerations	2-vessel lead/lag configuration allows changeout 1-vessel configuration requires gas bypass/flare during changeout and higher consumptions	Hydrogen is required and not provisioned	Vessel 1 is for H2S removal, Vessel 2 is for mercaptans removal	Desulfurization requires upstream gas dehydration, a combined dehydration and desulfurization solution was proposed

Technology Selection Findings

The gas sweetening study entailed a detailed economic comparison of the identified technologies, inclusive of an evaluation of geographic sourcing risks and analysis of consumables cost escalations. Additional analyses considered changeout frequency, operability, safety, turndown, plot space requirements, constructability aspects, and salvage value. For completeness, a similar evaluation was performed for a regenerative system, which confirmed it was the least economic option given the relatively lower produced gas volumes and high maturity of the gas field.

After the review of the findings, the customer felt that operational cost associated with gas processing should be evaluated at the individual wellhead based on production plan declines versus at a central facility.

Success with Sour Gas

Completing a gas sweetening study before assembling the project team is vital. The study not only guides technology selection, but it also provides the project team of the technical challenges, operational requirements, and risk factors. Starting with a solid understanding of the gas sweetening requirements and technologies allows project managers to set realistic budgets, timelines, and performance targets. Get the data you need to make technology solutions confidently – connect with our team for a consultation.

After selecting the gas treatment technology, what is next to consider?

Compression systems and strategies for vent capture and material selection. CANUSA EPC has completed sour gas compression systems for production gas systems and has helped customers evaluate the cost impact per landed horsepower of compression and additional emissions considerations.

Metering is another challenge to consider ensuring that the system can identify, record and report on containments for custody transfer. Depending on the species of contaminants, analyzer sensitivity needs to be considered.