# Sweetening of Sour Gas

A practical guide to sweetening of sour gas, covering the reader intent, the relationship to sweetening of sour gas, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next step.

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In the oil and gas industry, the term "sour gas" refers to natural gas that contains significant amounts of acidic contaminants, primarily hydrogen sulfide (H2S) and carbon dioxide (CO2). The process of removing these components is known as the sweetening of sour gas. This treatment is essential not only for meeting environmental regulations and safety standards but also for preventing the catastrophic corrosion of pipelines and processing equipment.

For process engineers and plant operators, the efficiency of a sweetening unit depends heavily on precise level control within absorption and regeneration columns. Failure to maintain accurate levels can lead to amine carryover, gas blow-through, or inefficient chemical usage, all of which increase operational costs and risk equipment damage.

## Principles of the Gas Sweetening Process

The most common method for the sweetening of sour gas is the amine treatment process, also known as amine scrubbing. This process relies on a reversible chemical reaction between the acid gases and an aqueous amine solution (such as MEA, DEA, or MDEA).

## The Absorption Stage

In the contactor or absorber tower, sour gas enters at the bottom and flows upward, while a "lean" amine solution is pumped into the top and flows downward. As they contact each other on trays or packing, the amine chemically absorbs the H2S and CO2. The "sweetened" gas exits the top of the tower. The level at the bottom of the absorber is a critical process variable; it must be high enough to provide a liquid seal to prevent gas from entering the liquid outlet, but low enough to maximize the contact volume.

## The Regeneration Stage

The "rich" amine (now saturated with acid gases) is sent to a flash tank to remove dissolved hydrocarbons and then to a regenerator (stripper) column. In the regenerator, heat is applied via a reboiler to break the chemical bonds between the amine and the acid gases. The acid gases are stripped out and sent for further processing (such as a Claus unit for sulfur recovery), while the "lean" amine is cooled and recirculated back to the absorber.

## Level Measurement Principles in Sweetening Units

Selecting the correct instrumentation for the sweetening of sour gas requires an understanding of the physical and chemical environment. The fluids involved are often corrosive, prone to foaming, and subject to high pressures.

## Guided Wave Radar (GWR)

Guided Wave Radar operates on the principle of Time Domain Reflectometry (TDR). A low-energy microwave pulse is sent down a probe (waveguide). When the pulse hits the surface of the amine solution, a portion of the energy is reflected back to the transmitter. Since the speed of light is constant, the time taken for the pulse to travel is used to calculate the distance. GWR is highly effective in amine units because it is relatively unaffected by changes in pressure, temperature, or vapor space composition.

## Magnetic Level Gauges (MLG)

MLGs utilize a float containing a high-intensity magnet that moves within a non-magnetic bypass chamber. As the liquid level in the vessel changes, the float moves accordingly, flipping magnetic flags on an external indicator. For electronic integration, a magnetostrictive transmitter can be mounted to the chamber. This provides a robust, visual, and electronic measurement solution that isolates the instrument electronics from the process fluid.

## Differential Pressure (DP) Transmitters

DP transmitters measure the hydrostatic head of the liquid column. By comparing the pressure at the bottom of the vessel to the pressure in the vapor space, the liquid level can be inferred. While common, DP measurement in the sweetening of sour gas can be complicated by changes in the specific gravity of the amine solution as its concentration or temperature fluctuates.

## Technology Selection for Amine Units

Choosing the right level sensor depends on the specific vessel and the characteristics of the amine solution being used. The following table provides a comparison of common technologies used in these applications.

| Technology | Accuracy | Suitability for Foam | Maintenance Requirement | Best Application |
|---|---|---|---|---|
| Guided Wave Radar | High (±3 mm) | Good (measures through foam) | Low | Absorbers, Flash Tanks |
| Non-contact Radar | High (±2 mm) | Moderate (can be affected) | Very Low | Storage Tanks, Sumps |
| Magnetic Level Gauge | Moderate | Excellent | Medium | High-pressure Strippers |
| Hydrostatic (DP) | Variable | Poor | High | General level monitoring |
| Ultrasonic | High | Poor (not for high pressure) | Low | Atmospheric chemical tanks |

For a comprehensive range of industrial measurement tools suitable for these processes, engineers can Review product options and application support to find the specific configuration required for their facility.

## Critical Challenges in Sour Gas Sweetening

## Foaming Management

Foaming is one of the most prevalent issues in the sweetening of sour gas. It occurs when contaminants, such as condensed hydrocarbons or particulates, stabilize the bubbles created by the gas-liquid contact. Foam can create a false high-level reading in some instruments (like non-contact radar or ultrasonic sensors) and can lead to amine carryover into the gas stream. Guided Wave Radar is often preferred here because it can usually detect the true liquid level beneath the foam layer.

## Corrosion and Material Compatibility

H2S and CO2 are highly corrosive, particularly in the presence of water. Furthermore, amines themselves can be aggressive toward certain elastomers and metals. All level measurement components in contact with the process must comply with NACE MR0175/ISO 15156 standards. Typical materials include 316L Stainless Steel, Monel, or Hastelloy for probes and chambers.

## High Pressure and Temperature

Absorber towers often operate at high pressures (up to 70-100 bar), while regenerators operate at elevated temperatures to facilitate stripping. Instruments must be rated for these extremes. For instance, magnetic level gauges used in these applications require high-pressure float designs to prevent collapse.

## Installation Considerations

To ensure reliable performance during the sweetening of sour gas, proper installation is as important as technology selection.

1. Stilling Wells and Bypass Chambers: For radar and magnetic gauges, using a stilling well or an external bypass chamber helps to minimize turbulence and foam at the measurement point. It also allows for the instrument to be isolated for maintenance without shutting down the process.

2. Nozzle Dimensions: For non-contact radar, the nozzle height and diameter must be carefully selected to avoid internal interference from the vessel walls or internal structures (like trays).

3. Venting and Draining: Bypass chambers should always include vent and drain valves to allow for safe cleaning and calibration. In sour gas service, these vents must be piped to a flare or vapor recovery system due to the toxicity of $H_2S$.

4. Heat Tracing: In colder climates, or for highly concentrated amine solutions that may become viscous, heat tracing and insulation on the measurement chamber may be necessary to prevent crystallization or sluggish response.

## Limitations of Common Technologies

While modern instrumentation is highly advanced, every technology has its constraints in a sour gas environment:

Ultrasonic Sensors: These are generally unsuitable for pressurized vessels because the speed of sound changes significantly with gas density and composition.

Displacers: Older displacer technology is prone to mechanical failure due to the buildup of "black powder" (iron sulfide) common in sour gas systems, which can jam moving parts.

Non-contact Radar: While excellent for many applications, heavy steam or extremely dense foam in a regenerator can attenuate the signal, leading to "loss of echo" conditions.

## Frequently Asked Questions (FAQs)

Q: How does $H_2S$ affect the selection of level sensor materials?

A: $H_2S$ causes sulfide stress cracking (SSC) in many high-strength steels. Sensors must use materials certified to NACE MR0175, which typically limits the hardness of the metal and specifies particular alloys like 316 SS or nickel-based alloys.

Q: Can I use a single level technology for both the absorber and the regenerator?

A: While Guided Wave Radar is versatile enough for both, the regenerator often requires higher temperature ratings and may benefit from a Magnetic Level Gauge for visual redundancy in the high-heat reboiler area.

Q: What is the impact of "black powder" on level measurement?

A: Black powder is primarily iron sulfide scale. It is magnetic and can interfere with Magnetic Level Gauges by coating the float or the chamber walls. In such cases, GWR or high-frequency non-contact radar is often a better choice as they have no moving parts to jam.

Q: Why is interface measurement important in gas sweetening?

A: In the flash tank, liquid hydrocarbons (condensate) often separate from the amine solution. Measuring the interface between the amine and the hydrocarbon layer is necessary to ensure that only the amine is sent to the regenerator, preventing hydrocarbon contamination of the stripping process.

By understanding these technical nuances, plant engineers can ensure that the sweetening of sour gas remains a safe and efficient component of their midstream or downstream operations. Selecting reliable level instrumentation is the first step in achieving stable process control.