

## FOAMING PROCESSES IN AMINE GAS PURIFICATION

**Sardor Toshboev**

*Independent researcher, Bukhara Institute of Engineering and Technology,  
Uzbekistan, Bukhara*

**Erali Panoev**

*Doctor of Philosophy in Technical Sciences (PhD), Bukhara Engineering and  
Technological institute, Uzbekistan, Bukhara.*

**Abstract:** *Amine solutions foam because normal froth is stabilized into foam by contaminating surfactants. Since pure amines do not form stable foams, one or more components must be present in the treating solution in order to form. Possible contaminants include not only liquid hydrocarbons and iron sulphide, but well treating fluids, amine degradation products, and other finely divided solids.*

*The goal of foaming control should be to minimize the level of contaminants in the amine solution. This article explains how to defoam and lists a number of causes of amine foaming.*

**Keywords:** *Amine, foaming, amine system, hydrogen sulphide, carbon dioxide.*

### INTRODUCTION


Amine gas treating, also known as amine scrubbing, gas sweetening and acid gas removal, refers to a group of processes that use aqueous solutions of various alkyl amines to remove hydrogen sulphide (H<sub>2</sub>S) and carbon dioxide (CO<sub>2</sub>) from gases.

During operation of an amine unit, degradation of the solvent occurs due to reaction with contaminants like oxygen, sulphur dioxide, and acids in the feed gas. Some of the tertiary amine oxidation products lead to a number of operational problems in the amine units. Amine gas scrubbing can experience problems with solvent degradation for many reasons, including conditions that allow for ingress of contaminants. This article provides information on foam formation and fading.

Amine gas cleaning is also known as amine cleaning, gas sweetening, and acid gas stripping. It is also used in oil and gas processing plants in chemical plants and other industries.

Amine has a natural affinity for CO<sub>2</sub> and H<sub>2</sub>S, allowing it to be a very efficient and effective removal process.





Foaming in alkanolamine solutions is the most common problem in these Liquefaction plants. Mostly it occurs in the absorber, can also be observed in the stripper. Impurities in the feed gas such as hydrocarbon liquid, organic acids, well chemicals, foam reducing agents and amine degradation products all have an effect on the ability for the amine to foam. Pure amine solutions do not form stable foams. In order to form stable foam, some other components must be present in the treatment solution. There are two Categories of contaminants, those that are added to the solution, and those that are formed within the solution. Each contaminant can have an impact on foaming tendency and foaming stability.

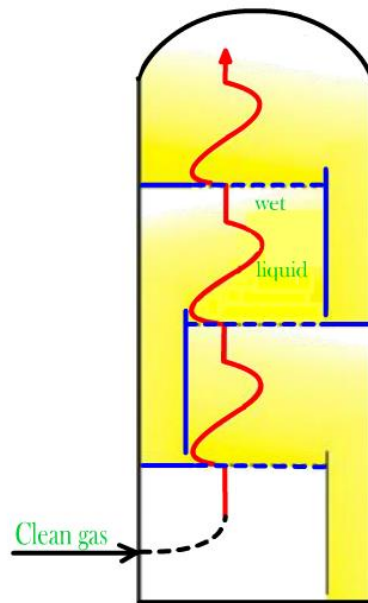
Foaming is a common problem in gas absorption processes and gas processing plants due to the use of aqueous alkanolamine solutions. Foaming is considered negative because its presence has serious effects on the industrial plant, such as loss of absorption capacity, reduction of mass transfer area and efficiency, as well as transfer of amine solution to the downstream plant.

In the 20th century, scientists discovered that a variety of chemical contaminants, such as suspended solids, condensed hydrocarbons, amine breakdown products, corrosion inhibitors, oil or water contaminants, and fine particles can form foam. Many measures have been used to prevent or reduce this foaming problem, including mechanical filtration, carbon adsorption, solution distillation, and antifoam additives.

***Factors leading to the foaming process are as follows.***

- Sudden increase in the column's differential pressure.
- Foaming reduces the vapour-liquid contact area, generating a reduced effective mass transfer zone and hence less acid gas is picked up by the amine. Unexpectedly high H<sub>2</sub>S content indicates possible foaming.
  - Amine carryover to downstream equipment.
  - Loss or reduction in the rich-amine flow rate is accompanied by an abnormal level indication in the absorber column's bottom section.
  - Abnormal absorber column's temperature profile can be another indicator. During foaming, the bulge temperature normally shifts from the lower trays to the upper trays, if foaming was caused by contaminated sour gas.





**Figure 2. Scheme of formation of foam in an absorber device.**

***To prevent the formation of foam, it is necessary to do the following.***

- Problems with foaming can usually be minimized by limiting the external pollutants like oil from compressors, well chemicals and rust inhibitors entering the system.

- A combination of a slug catcher, inlet filter/separator, and a gas-liquid coalescer installed in a series in the feed gas line is the best way to prevent external contaminants from entering the system.

- Conventional separators have difficulty removing aerosols 3 microns or less in diameter, while specialized high-efficiency gas-liquid coalescers can remove compressor lubricating oil droplets as small as 0.001 micron.

- Amine contactors and regenerators should be supplied with a differential pressure indication and alarm to provide an early warning of foaming problems.

A common method of foam destruction is the addition of chemical antifoaming agents. Antifoam or an anti-foaming agent or de-foamer is a chemical additive that reduces and hinders the formation of foam in industrial process liquids. Commonly used agents are insoluble oils, poly-dimethyl silanes and other silicones, certain alcohols, stearates and glycols. The additive is used to prevent formation of foam or is added to break a foam already formed. Many types of antifoams are commercially available with a range of properties and varied foam destruction efficiency.

Types of antifoams:

- Oil based antifoams



- Water based antifoams
- Silicone based antifoams
- EO / PO based antifoams
- Alkyl poly acrylates

Properties of antifoams:

- Antifoams are insoluble in the foaming medium and has surface active properties.
- Antifoam product is a low viscosity and a facility to spread rapidly on foamy surfaces.
- It has affinity to the air-liquid surfaces where it destabilizes the foam lamellas. This causes rupture of the air bubbles and breakdown of surface foam.
- Entrained air bubbles are collect, and the larger bubbles rise to the surface of the bulk liquid more quickly.

### **RESEARCH PROCESS**

Before entering the absorber gas is pass through an inlet separator where entrained droplets or sludge of liquid are removed from the gas stream by impaction devices. Baffles remove a portion of liquids. Mist eliminator pads located near the gas outlet of the tank, trap the rest. Typical contaminates in natural gas streams may be liquid hydrocarbons salt water, sand well treating compounds, pipeline treating chemicals and compressor oils.

The sour gas, freed of entrained liquids by the inlet separator, enter the bottom of the absorber. Usually the absorber is a tray column; although packed columns are also used. In either case, the objectives is to provide intimate contact between the gas and the amine solvent so that the  $H_2S$  and  $CO_2$  molecules can transfer from the gas phase to the solvent liquid phase. In tray columns, a liquid level is maintained on each tray by a weir usually 2 or 3 inches high.

As already described, antifoams work by penetrating and destroying the foam lamellas. The first barrier to be overcome when penetrating is the pseudo emulsion film. If the pseudo emulsion film is too stable, antifoam droplet cannot penetrate the surface and de-foaming is not possible. Once the antifoam droplet has overcome the pseudo emulsion film and penetrated the lamella. It describes the force equilibrium between the three phases the liquid to be de-foamed, antifoam and air The antifoam droplet may spread after penetrating the lamella. If the antifoam can spread on the surface, it forms an antifoam lens at the lamella surface and displaces the surfactants at this location. As a result, the stability and flexibility of the lamella are impaired and it may collapse. The spreading process leads to flow of the lamella liquid along the direction of spreading. This





phenomenon, also known as Marangoni flow, causes a local thinning of the lamella at the location of the spreading antifoam droplet and leads to further destabilization of the lamella. The penetration and spreading of antifoam droplet is illustrated.

If the antifoam droplet has penetrated both sides of the lamella, a subsequent dewetting or stretching mechanism can lead to rupture of the lamella.

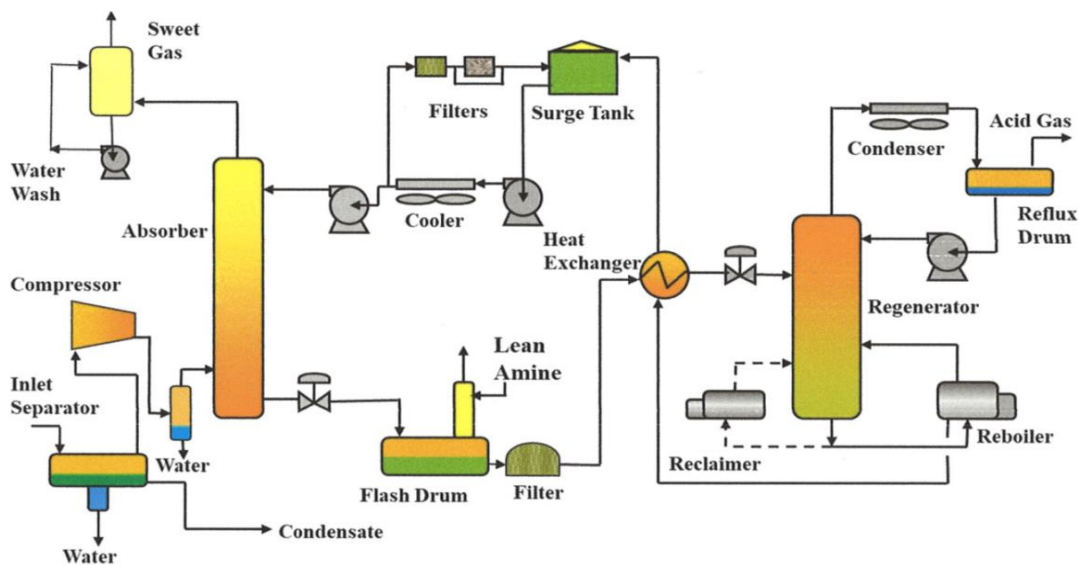
**Table No. 1. Physical properties of absorber column working**

| Information                    | Chemical absorption                                                                                                                           |                                                   |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
|                                | Alkanolamine                                                                                                                                  | Inorganic carbonate                               |
| Types of absorbents            | Primary Amines: MEA, DGA<br>Secondary Amines: DEA, DIPA<br>Tertiary Amines: MDEA, TEA<br>Mixed Amines<br>Formulated Amines: UCARSOL, FLEXSORB | $K_2CO_3$ , $K_2CO_3$ -MEA, $K_2CO_3$ -DEA        |
| Selectivity $CO_2$ , $H_2S$    | Only MDEA selective for $H_2S$                                                                                                                | May be selective for $H_2S$                       |
| $CO_2$ absorption mechanism    | $2RNH_2 + CO_2 + H_2O \leftrightarrow (RNH_3)_2CO_3$<br>$(RNH_3)_2CO_3 + CO_2 + H_2O \leftrightarrow 2RNH_3HCO_3$                             | $Na_2CO_3 + CO_2 + H_2O \leftrightarrow 2NaHCO_3$ |
| Operating Temp., °C            | 37.78-204.44                                                                                                                                  | 93.33-121.11                                      |
| Absorbent recovery             | Reboiled stripper                                                                                                                             | Stripper                                          |
| Operating gauge pressure, mmHg | Insensitive to pressure                                                                                                                       | >10,337.76                                        |

### Advantages of Amine Gas Treating System

- Reduces  $CO_2$  and  $H_2S$  levels to the required specifications
- Modular, skid-mounted system
- Reduced manufacturing and commissioning times
- Standardized and proven designs
- New equipment only
- Guaranteed performance
- Lower installation and removal cost
- Built in liquid containment to reduce environmental hazards.





**Figure 2. Technological scheme of amine purification of gases from acidic components.**

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### **CONCLUSION**

Amine solutions foam because gas bubbles are stabilized into foam by contaminating surfactants. The most common way to control foaming has been injecting antifoaming chemicals into the recirculating solution level breaking the foam. The efficiency of antifoams can be reduced in a variety of ways; therefore, are unreliable as a long term control solution. The only way to actually control amine foaming over the long term is to remove the foam causing surfactants.

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