Control Valve Sourcebook — Chemical Unit Operations

Absorption

EMERSON

Absorption

I. How It Operates

Absorbers, also knowns as gas scrubbing or gas washing, are part of the chemical unit operation group called mass transfer.

Absorbers typically consist of trays or packed column beds where liquid absorbent is passed counter currently to absorb the soluble vapors from the impure feed or vent gas. The efficiency of an absorber depends on factors such as column design, column pressure, and the amount of contact between vapor rising and liquid falling down. Control of the absorption process is accomplished by absorbent flow rate and residence time, so correct sizing and selection of the control valve package is crucial. Figure 1 shows the typical layout of an absorption column with associated critical control valves.

The absorption process starts with a gas mixture entering the bottom of the absorption column, and a lean amine solution entering the column from the top flowing counter-currently to the feed gas mixture. As mentioned previously, the absorber column either consists of trays or packed beds under specific pressure, which are used to maximize the surface area contact between the amine solution and feed gas mixture. This minimizes the amount of amine solution required while still allowing for optimal absorption of soluble vapors from feed gas mixture.

Purified gas exits the top of the column for further downstream processing and the amine solution enriched with soluble vapor exits the bottom through a level control valve to be regenerated and reused. The fluid passes through a heat exchanger where it picks up heat from the regenerated lean amine solution and then enters the regenerator to further separate the amine solution from the entrained soluble vapors. The regenerator is essentially a distillation or separation column that physically separates the gas and liquid based on their volatility. The fluid enters the regenerator and the higher volatile gas will exit the top of the unit while regenerated amine, now known as lean amine, will exit the bottom to be reused in the absorption process.

II. Where Absorbers are Used

The absorption process removes undesired product from gas mixtures, so it is used in a variety of process industries such as:

- Ammonia plant - To remove carbon dioxide from the feed gas to the reactor, where it will poison the catalyst if not removed.
- Ethylene plant - To remove carbon dioxide and hydrogen sulfide from the feed/cracked gas.
- Phosgene plant - To remove residual phosgene from vent gas.
- Refinery - To remove hydrogen sulfide from liquid hydrocarbons.

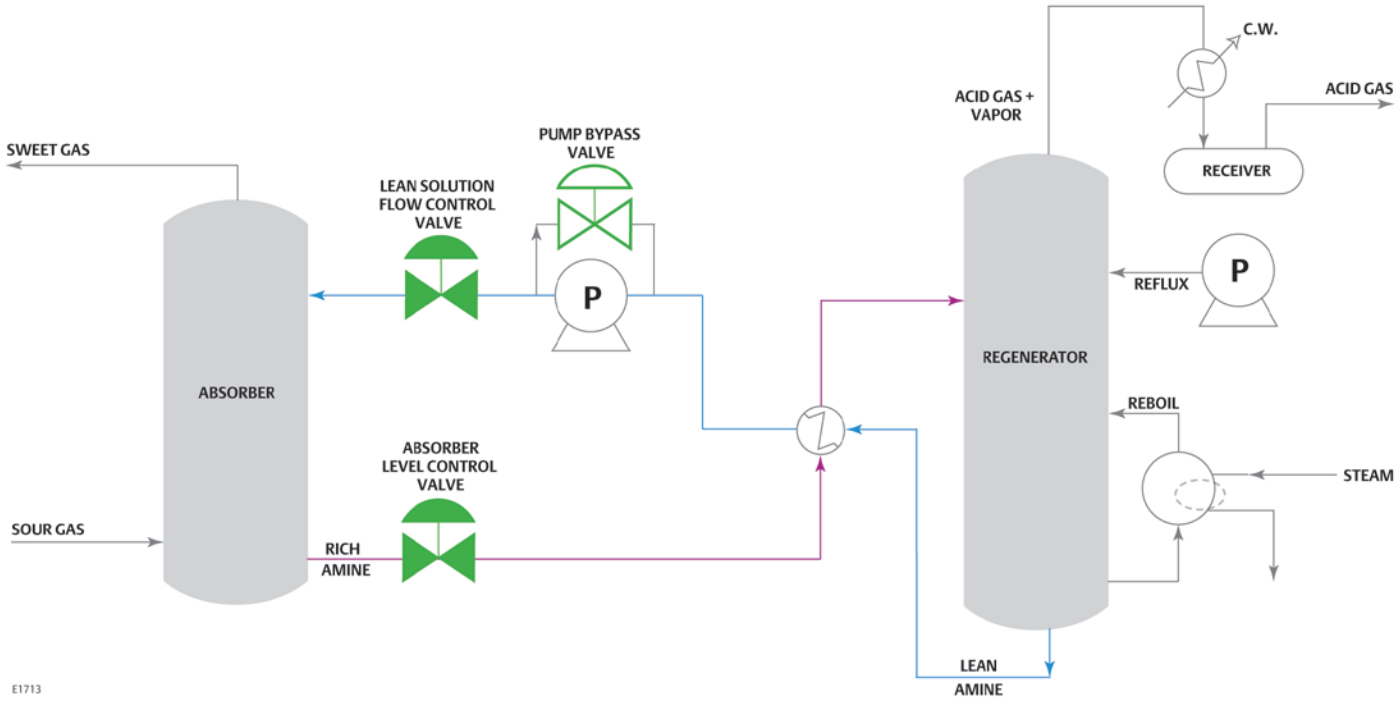

Figure 1. Absorption Column Process Diagram

III. Absorbers Application Review

An efficient process is accomplished by optimum flow rate control and residence time, hence correct sizing and selection of control valve packages becomes very crucial.

1. Absorber Level Control Valve

The rich amine solution exits the bottom of the absorption column and flows through a level control valve as shown in Figure 1. At the reduced downstream pressure, some of the entrained gas is released from the solution, while some of the gases remain dissolved in the amine solution. At the exit of the valve, the process fluid consists of a two-phase flow (gas and liquid with entrained gas).

Major concerns with level letdown control valve:

- If the valve opens too far, residence time decreases and less acid gas is absorbed. If operating with limited or restricted capacity, flooding of the tower becomes a concern.
- Vibration and damages due to the release of entrained gases as a pressure drop occurs through the valve.
- Under or over compensation for gas expansion resulting in incorrect sizing.

- **Typical Process Conditions:**
  - Fluid: Amine liquid enriched with gas
  - Pressure and temperature are dependent on process design
- **Typical Valve Selection:**
  - Fisher™ easy-e™ and EW valves
  - Customizable Trim Solution: Hardened Fisher Whisper Trim™ cages or trim parts based on various pressure drops
  - Custom plug or stem design if excessive vibration causes breakage
  - Materials of Construction: CF8M or as otherwise specified

2. Lean Amine Flow Control Valve

As shown in Figure 1, lean amine solution exiting the bottom of the regeneration column passes through the lean amine flow control valve to the absorber column to repeat its cycle.

Major concerns with lean amine letdown control valve:

- If the valve opens too far, flooding of the tower becomes a concern. If operating with limited capacity or restricted capacity, retention time decreases therefore less acid gas is absorbed.
- Cavitation damages due to high pressure drop.
- **Typical Process Conditions:**
  - Fluid: Lean amine liquid
  - Pressure and temperature are dependent on process design
- **Typical Valve Selection:**
  - Fisher easy-e and EW valves
  - Customizable Trim Solution: Hardened standard, Fisher Cavitrol™ trim, Fisher NotchFlo™ DST, Fisher Dirty Service Trim, and/or solid parts based on various pressure drops
  - Materials of Construction: Carbon steel or as otherwise specified

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