SIGMA THERMAL

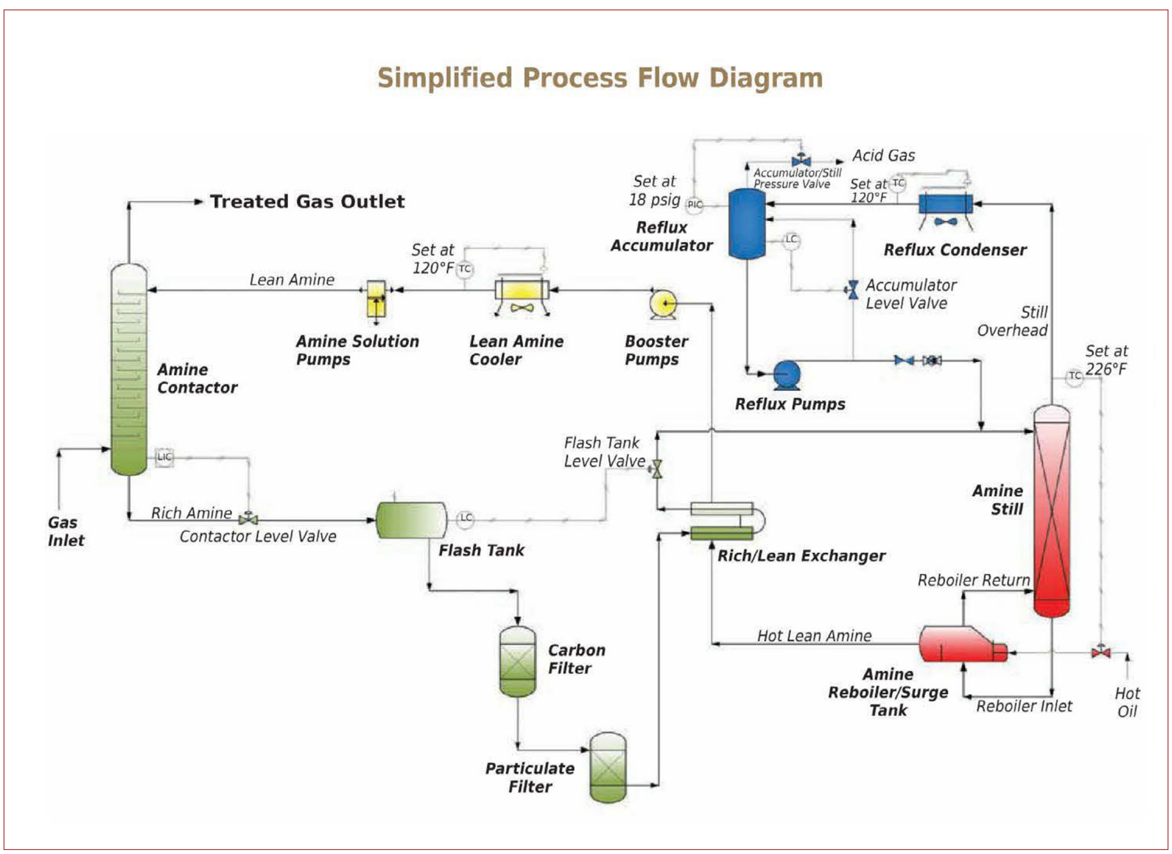
Effective Heating Helps Amine Plants Purify Natural Gas

by Zane Rhodes

Some gas sweetening plants utilize thermal fluid heaters to help remove carbon dioxide and hydrogen sulfide from natural gas, purifying the product for market.

Improved shale oil and gas extraction technologies have led to a renewal in the energy industry in North America, and thermal fluid heaters are used in many processes to help bring these products to market. One of these processes is amine gas treating. Sometimes called gas sweetening plants, an amine plant is used to remove carbon dioxide ($C0_2$) and hydrogen sulfide (H_2S) from natural gas so that it can be put into pipelines and used by customers. Collectively, $C0_2$ and H_2S are known as acid gases, and an amine plant uses a water-based, heat regenerable solvent or amine to remove these impurities from the natural gas.

This 200 gal/min amine plant has the thermal fluid heater separated from the rest of the system for safety.



Natural gas is introduced into the bottom of the absorber while the amine is introduced in the top. The gas and amine are brought into contact with one another using trays or packing. The amine absorbs the CO_2 and H_2S, and the purified natural gas exits the top of the absorber. The amine is then sent to the regeneration system, where it is filtered to remove particulates and any heavy hydrocarbons that have been entrained.

During the process, the natural gas is introduced into the bottom of a tall vertical vessel called an absorber, and the amine is introduced into the top of the vessel. The gas and amine are brought into contact with one another using trays or packing. The ammo absorbs the $C0_2$ and H_2S, and the purified natural gas exits the top of the absorber. This is an exothermic reaction, and a properly designed system will ensure that the temperature is not excessive, which can prevent the amine from absorbing the contaminants. Then, the amine is sent to the regeneration system. In the regeneration system, the amine is filtered to remove particulates and any heavy hydrocarbons that have been entrained in the amine. The actual regeneration of the amine occurs in two pieces of equipment: the still and the reboiler. The still is a tall vertical vessel filled with packing or trays. The amine is introduced into the top of the still, where it comes into contact with steam that is produced in the reboiler. In the still, the steam provides the heat necessary to reverse the reaction and dilutes the $C0_2$ and H_2S released during regeneration. The high temperatures and dilution move the equilibrium point of the amine regeneration to higher amine purities. The amine flows into the reboiler, which is a shell and tube exchanger heated with steam or thermal fluid. In this exchanger, thermal fluid or steam is used to provide the heat to vaporize a portion of the water contained in the amine solution. In some smaller plants, the reboiler is a direct-fired heater where a fire tube is submerged in the amine to produce the stripping steam necessary for the regeneration of the amine. The thermal fluid or steam temperature must be maintained to prevent thermal degradation of the amine. Common practice is to limit the thermal fluid temperature to less than 360°F (182°C) with a return temperature of approximately 280°F (138°C) and steam systems to 50 psig saturated steam. The use of steam is limited to systems that are installed in some refineries or where a surplus of low pressure, saturated steam is available. For the balance of the installations, thermal fluid systems are used.

Controlling the Regeneration Temperature

In thermal fluid systems, the most prevalent flow scheme is to vary the flow through the reboiler exchanger using a control valve and a bypass valve to maintain a constant flow through the thermal fluid heater and a constant temperature set point. Because there is boiling in the reboiler, changing the heat input does not change the temperature of the reboiler by an appreciable amount. To control the reboiler, some systems are set to control the overhead temperature. This is the temperature of the non-condensed steam and acid gases exiting the top of the still. There are a few problems with this strategy. First, there is a significant time delay between increasing the heat input into the reboiler and when the overhead temperature changes. This delay can lead to the control valve fully opening and closing and never settling down to steady state operation. However, this can be mitgated to some degree by reducing the operating range of the thermal fluid control valve to ±10 percent of the nominal set point.

Second, another issue that can arise when using this control scheme is that the ambient temperature can greatly affect the measured overhead temperature. This occurs because the temperature transmitter often is placed in piping close to the ground for ease of access for maintenance and not at the top of an 80 foot tower. The gas will cool as the acid gases flow through the pipe to the temperature measurement, and this cooling will vary based on ambient temperature. Third, because a cool reflux stream is injected periodically into the top of the still, it can cause a sudden drop in overhead temperature. This can wreak havoc on the control system and destabilize it if not properly accounted for in control scheme design.

The Role of Operators in Regeneration Control

Even though most systems are designed and programmed to control using the overhead temperature, operators often disable this and manually set the flow of hot oil through the reboiler. The advantage to this is that the control system does not have to be tuned for various operating scenarios. The disadvantage to this is that operators generally use a conservative setting that ensures the treated gas meets the specifications. This conservative setting wastes energy that could have been avoided. This problem is exacerbated when the inlet gas conditions vary because the operator then has to choose a setting that works for all scenarios even if that heat load is only required a few minutes a day. This results in much higher energy costs than should be required.

The general specifications for a thermal fluid system for an amine plant will include:

- To maximize the run time, there should be 100 percent backup on the pumps.
- No yellow metals (copper alloys) should be used in any valves or piping due to the possible presence of H_2S and corrosion issues that can result.
- Class I, Division 2 burner, motors and electronics should be used due to the possible presence of natural gas.
- The heater should be separated from the high pressure gas streams by at least 50 feet.

The requirements of the thermal fluid systems are further complicated if other users are added to the thermal fluid system. For instance, a molsieve dehydration system can require up to 600°F (315°C) thermal fluid for the regeneration of the mol sieve. The molsieve regeneration is an intermittent process, which must be taken into consideration when designing the overall system. In installations such as these, the amine plant can be put into a secondary loop to prevent oil at 600°F (315°C) being introduced into the reboiler. Likewise, TEG dehydration units require thermal fluid at approximately 460°F (238°C), and stabilizer and fractionation trains require oil at various temperatures and flow rates. Therefore, it is important to work with a thermal fluid system supplier that has experience with natural gas applications so the various needs of each system are addressed in a robust, efficient and cost-effective manner.