# Removal and Disposal of BTEX Components from Amine Plant Acid Gas Streams

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**ABSTRACT**

The amine process will absorb heavy hydrocarbons and aromatics from gas streams in addition to the acid components. Whether the acid gas is to be vented or fed to a sulfur plant, it is highly desirable to remove these compounds from the acid gas. A new, economical process has been developed to greatly reduce the aromatics and heavy hydrocarbons in the amine plant acid gas stream. In the test facility, the new BTEX-T. rex process decreased the level of aromatics in the acid gas stream by more than three quarters. The process utilizes the plant fuel gas as a stripping agent and the aromatics and heavy hydrocarbons which are removed are incinerated in the amine plant reboiler heater. Plant data collected before and after implementing the BTEX-T. rex process compare favorably with the results estimated using a recent version of TSWEET regarding BTEX concentration results.

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## INTRODUCTION

The Clean Air Act limits the amounts of heavy hydrocarbons (Volatile Organic Compounds) which may be emitted from a facility to 250 tons per year. Aromatic compounds such as benzene are further classified as Hazardous Air Pollutants and are limited to 25 tons per year total aromatics and 10 tons per year of any individual aromatic.

The BTEX (benzene, toluene, ethylbenzene, xylene) regulations obviously have little effect on small amine systems; however, units as small as 200 gpm circulation treating gas containing aromatics may well be above the allowable amounts of aromatics in the vent stream.

The deleterious effects of heavy hydrocarbons and particularly aromatics in a sulfur plant feed is well documented.[1,2,3] Catalyst coking has been tied to aromatics with toluene shown to be the primary contributor to coking. Benzene was shown by mass balance to pass through the catalyst beds unchanged and could therefore remain in the vent gas stream for a split flow plant.[2]

The test case for this paper will center around a current amine treating application in which the level of BTEX components absorbed into the amine stream is above the legal limits. The gas stream being treated is 150 MMscfd and has above 600 ppmv BTEX components. Of the BTEX components in the inlet gas, the amine process absorbs approximately 14 lb/hr of BTEX components. This paper will discuss current methods of treating off-spec vent streams, a new method for removing BTEX components from vent gas streams, and cost comparisons of the options available.

Henry's Law may be used to understand the absorption and desorption of aromatic compounds in an amine system. Since the BTEX compounds are present at very low levels, the vapor phase concentration leaving a stage is related to the liquid phase concentration leaving that stage by the ratio of the Henry's Law Constant for the compound divided by the system pressure. The aromatic compounds are transferred into the liquid phase under absorber conditions of moderate temperature and high pressure. They transfer into the vapor phase in the amine regenerator under conditions of high temperature and low pressure.

## CURRENT BTEX REMOVAL OPTIONS

Currently, two main options exist for the removal of BTEX components from vent gas streams: carbon bed adsorption and vent gas incineration. Carbon bed adsorption involves the use of activated carbon to adsorb BTEX components. By contrast, vent gas incineration heats the vent stream to temperatures in excess of 1200$^{o}$F, changing the chemical composition of the vent gas to an environmentally neutral mixture.

### Carbon Bed Adsorption

Carbon bed adsorption is a process in which a bed of activated carbon is used to adsorb BTEX components onto the surface of the carbon molecules. Activated carbon possesses a very high surface area with a capacity of about half its weight. Prior to carbon treating, the vent gas stream containing BTEX components must be partially dehumidified to make the allowable adsorption area available to the aromatics rather than being occupied by water. Since the vent stream from an amine plant is water saturated at about 120$^{o}$F and 15 psig, the mass of water in the vent gas stream may easily exceed that of the BTEX components by 25 times. The bed is partially regenerable with high pressure superheated steam. Eventually, when the carbon bed becomes saturated and loses its economic ability to remove further BTEX components, the spent carbon must be disposed of as a hazardous solid waste. The energy required to dehumidify the vent gas stream along with the difficulties in disposing of solid hazardous waste make this a capital as well as labor intensive process.

### Vent Gas Incineration

Vent gas incineration is a thermal oxidation process in which the BTEX components are combusted at temperatures in excess of 1200$^{o}$F. An incinerator exposes the vent gas stream to a direct flame that is produced by igniting fuel gas and providing excess air via a forced draft fan. The products of combustion are carbon dioxide and water vapor, which are environmentally acceptable alternatives to BTEX emissions. Since most of the vent gas stream is water saturated $CO_2$, a considerable amount of fuel is required for this operation. Design of incineration equipment is critical to allow complete combustion of the BTEX compounds as well as minimizing CO generation. Vent gas incineration solves the problem of removing and disposing of BTEX components in the vent gas stream, but can be cost prohibitive from both an initial investment and fuel usage standpoint, which will be discussed in a later section of this paper.

 

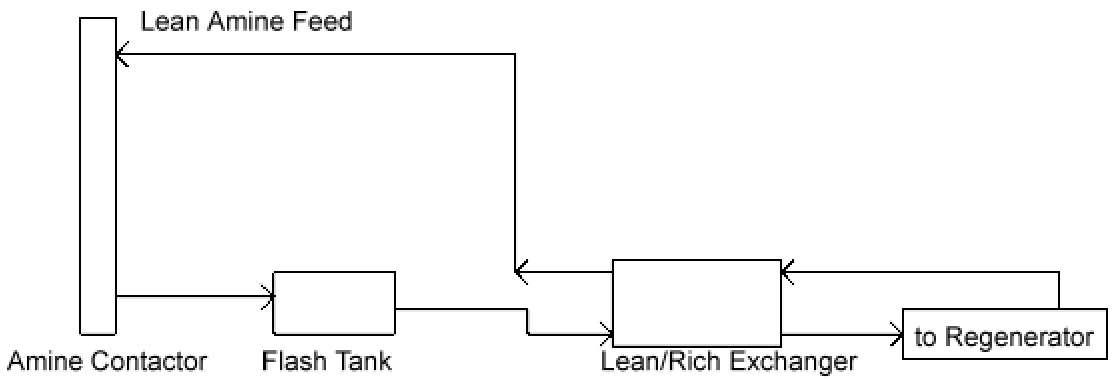


Figure 1. Current amine treating loop without BTEX-T.rex process.

## BTEX-T.REX PROCESS

The BTEX-T.rex process is a newly developed, patented method for removing BTEX components from acid gas streams. The BTEX-T.rex process uses the fuel gas for the heater (hot oil, cabin, boiler) to strip BTEX components from the amine at low pressure and moderate temperature (80 psig, 100$^{o}$F) downstream of the flash tank. The BTEX-T.rex process is carried out in a packed vertical column, which countercurrently mixes the rich amine stream and the fuel gas for the heating medium. Figure 1 shows a graphical representation of the amine treating process before the BTEX-T.rex process, and Figure 2 represents the addition of the process. Additional process modifications may be made which allow a 20-25 fold reduction in the quantity of aromatics in the amine plant vent gas vs. that absorbed in the rich amine.

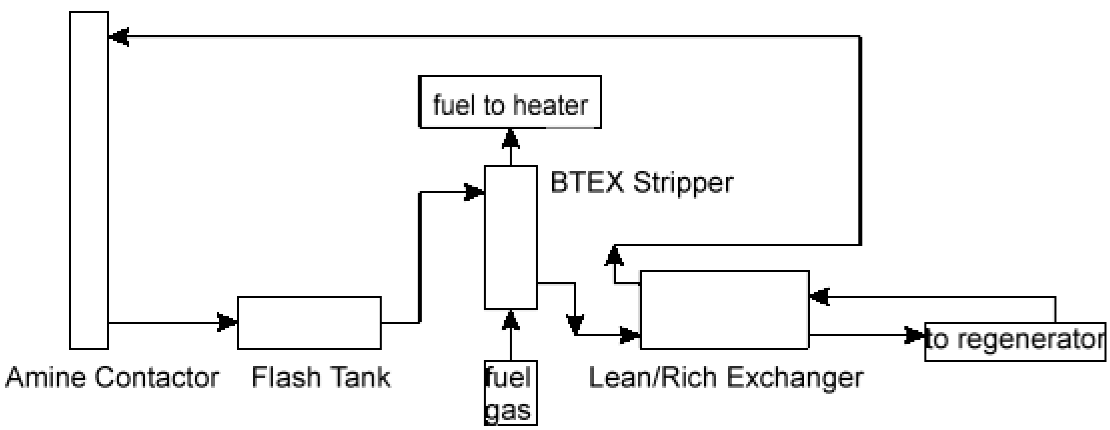


Figure 2. Amine treating loop with BTEX-T.rex process.

### Simulation Results vs. test data for the BTEX-T.rex Process

As previously mentioned, the test case for the BTEX- T.rex process is an amine unit (600 gpm) designed to treat 150 MMscfd that has above 600 ppmv BTEX components. According to a Bryan Research simulation (96.0 version), the amine would absorb approximately 14 lb/hr of BTEX components at the 1,000 psig treating pressure. Based on the simulation results, the amine leaving the BTEX-T.rex stripper contains only 4.03 lb/hr of BTEX components, which is well within the 5.7 lb/hr limit. Table I below shows the simulation results for all of the streams entering and leaving the BTEX-T.rex stripper.

**Table I**

 

**Simulation BTEX stripper stream summaries**

| | Measured test case | Predicted test case |
|---|---|---|
| Benzene in rich amine (lb/hr) | 5.68 | 6.125 |
| Other BTEX in rich amine (lb/hr) | 7.20 | 9.605 |
| Benzene in plant vent (lb/hr) | 2.17 | 2.035 |
| Other BTEX in plant vent (lb/hr) | 2.56 | 3.129 |
| Vent gas rate in MMscfd | 4.238 | 4.238 |
| VOC in rich amine (lb/hr) | nd | 1.513 |
| VOC in plant vent (lb/hr) | 0.788 | 0.618 |

## ECONOMIC COMPARISONS OF BTEX REMOVAL OPTIONS

The best way to compare the three options for BTEX component removal (activated carbon, vent gas incineration, BTEX-T.rex Process) is to discuss the installation and operating costs involved for the same conditions. Table II below shows economic comparisons for the three options as applied to the test case of this paper, which is a 600 gpm amine treating plant designed for 150 MMscfd with over 600 ppmv BTEX components.

**Table II**
**Economic comparison of BTEX removal options***

| | Activated carbon | Incineration | BTEX-T.rex |
|---|---|---|---|
| Est. installed cost | $1,900,000 | $500,000 | $150,000 |
| Est. fuel cost (annual) | $13,000 | $235,000 | $0 |
| Est. materials (annual) | $17,000 | $10,000 | $2,500 |
| Est. labor (annual) | $35,000 | $15,000 | $10,000 |
| Monthly cost (36 mo. payout) | $58,195 | $35,555 | $5,208 |

*Does not include licensing fees for any of the cases.

Table II illustrates the savings advantage that the BTEX- T.rex has over activated carbon and incineration treatment for BTEX components in an amine stream, not to mention the maintenance advantages (no moving parts or regeneration necessary).

## CONCLUSIONS

The absorption of BTEX components from natural gas streams at higher amine treating pressures poses an environmental problem in the vent stream as well as operating and catalyst life problems in any downstream sulfur plant equipment. Regeneration of the amine takes place at low pressure and high temperature, which removes the BTEX components from the amine and sends them to the atmosphere or to a sulfur plant with the vent stream. Current options for removal of BTEX components from vent streams include activated carbon treatment and vent gas incineration, both of which are labor and capital intensive. The BTEX-T.rex process uses fuel gas to strip the BTEX components prior to regeneration and uses the process heater to burn the BTEX components with the fuel gas. The burning of stripped BTEX components then reduces the amount of BTEX emissions in the vent stream to an acceptable limit. The BTEX T-Rex process also has economic advantages over activated carbon treatment and incineration, from both an installation and a maintenance standpoint.

 

## REFERENCES

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