Texas Commission on Environmental Quality
Air Permits Division

New Source Review (NSR) Emission Calculations

This information is maintained by the Chemical NSR Section and is subject to change. Last update was made **October 2006**. These emission calculations represent current NSR guidelines and are provided for informational purposes only. The emission calculations are subject to change based on TCEQ case by case evaluation. Please contact the appropriate Chemical NSR Section management if there are questions related to the emission calculations.

Calculations for Absorbers
The represented calculation methods are intended as an aid in the completion of acceptable submittals; alternate calculation methods may be equally acceptable if they are based on, and adequately demonstrate, sound engineering assumptions or data.

A Table 14 is required to be submitted in each permit application for each absorber handling gas streams that will result in emissions. Certain absorbers, such as an amine unit, may not be required to have a Table 14 submitted (engineers discretion) if they do not directly result in air emissions. The following are sample calculations that a permit engineer will often use to verify an adequate circulation rate of solvent liquid and adequate inventory replenishment for a batch operation. These calculations are designed for absorbers that utilize either a chemical reactive material such as caustic or an absorbing solvent.

Example 1
The following example illustrates a method of determining if there is adequate caustic sodium hydroxide (NaOH) at 10% by weight) being circulated in a countercurrent packed bed absorber to remove gaseous HCl that is present in a gas stream (HCl present at 5% by weight).

Consider the following at standard conditions:
Inlet gas = 1000 ft^3/min (5% HCl stream)
Minimum circulation rate of caustic= 12 gallons/min of 10% NaOH, 90% H_2O

The pounds (lb) of HCl gas entering the absorber can be determined at standard conditions (70^o F, 14.7 psia):

$$\left(\frac{1000\,ft^3}{\min}\right)\left(\frac{60\min}{hr}\right)\left(\frac{1\,lb\,mole}{387\,ft^3}\right)\left(\frac{37\,lb}{lb\,mole}\right)\left(\frac{0.05\,lb\,HCl}{lb\,gas}\right) = 287\,lb\;HCl/hr$$

The chemical reaction in stoichiometric form is as follows:

$$NaOH + HCl \rightarrow NaCl + H_2O$$

For every lb mole of HCl that enters the absorber, 1 lb mole of NaOH is needed to form the NaCl salt. The lb mole/hr of HCl entering the absorber can be calculated as follows:

$$\left(\frac{287\, lb\, HCl}{hr}\right)\left(\frac{1 lbmole\, HCl}{37\, lb\, HCl}\right) = 7.75\, lb\ mole/hr$$

The lb mole/hr of NaOH entering the absorber is determined below:

$$\left(\frac{12\, gal}{\min}\right)\left(\frac{60 \min}{hr}\right)\left(\frac{8.96\, lb\ NaOH\ solution}{gal}\right)\left(\frac{0.10\, lb\ NaOH}{lb\, solution}\right)\left(\frac{1\ lbmole\ NaOH}{40\, lb\ NaOH}\right) = 16.1\ lb\, moles\, of\ \ NaOH/hr$$

The example illustrates that there is enough caustic per hour to complete the reaction. Although the water being circulated in the absorber will directly absorb some of the HCL, the water in a caustic absorber normally is not given credit for removing gases. This is because absorbers designed to use caustic are not properly designed for water absorption.

Example 2
This example illustrates how often the caustic batch will need to be changed out. Consider a 15,000 gallon inventory of the above mentioned 10% NaOH and water solution.

The lb moles of NaOH available can be determined:

$$(15000\, gal)\left(\frac{0.10\, lb\ NaOH}{lb\, solution}\right)\left(\frac{8.96\, lb\ NaOH\ solution}{gal}\right)\left(\frac{1\, lb\, mole\ NaOH}{40\, lb\ NaOH}\right) = 336\, lb\, moles\ NaOH\ available$$

7.75 lb mole of NaOH/hr is needed to create the NaCl. This means that the batch should be changed out every:

$$\frac{336\ lb\ moles}{7.75\ lb\ moles\ \ NaOH/hr} = 43.35\, hours\, or\, 1.8\ days\, of\ \ continuous\, operation$$

Since this is a batch operation, the incoming caustic/water solvent will, in essence, dilute the batch and reduce available absorbing capacity. A safety factor of two is usually added to account for this. This means that the batch should be changed out every 0.9 days (1.8 days/2) of operation. A permit may allow a longer time interval between batch change-outs if the applicant is required to perform regularly scheduled titration tests of the caustic batch.

Example 3
This example illustrates a method of determining if there is adequate solvent (in this case water) being circulated in a countercurrent packed bed absorber to remove gaseous ammonia (NH_3) present in a gas stream (NH_3 present at 10% by weight).

Consider at standard conditions:
Inlet gas = 1500 ft^3/min (10% NH_3 stream)
Minimum circulation rate of the solvent (water) = 15 gallons/minute

The lb of NH_3 gas entering the absorber can be determined at standard conditions (70 ^{o} F, 14.7 psia):

$$\left(\frac{1500\ ft^3}{\min}\right)\left(\frac{60\ \min}{hr}\right)\left(\frac{1\ lb\ mole}{387\ ft^3}\right)\left(\frac{17\ lb}{lb\ mole}\right)\left(\frac{0.10\ lb\ NH_3}{lb\ gas}\right) = 395\ lb/hr$$

Referencing solubility data for ammonia in water, it is determined that at standard conditions, 53 parts of NH_3 will be absorbed per 100 parts of H_2O.

The amount of water entering the absorber is determined as follows:

$$\left(\frac{15\ gal}{\min}\right)\left(\frac{60\ \min}{hr}\right)\left(\frac{1\ ft^3}{7.48\ gal}\right)\left(\frac{62.4\ lb}{ft^3}\right) = 7508\ lb\ H_2O/hr$$

The amount of ammonia absorbed in any given hour is determined as follows:

$$\left(\frac{7508\ lb\ H_2O}{hr}\right)\left(\frac{53\ lb\ NH_3}{100\ lb\ H_2O}\right) = 3979\ lb\ NH_3/hr$$

This example illustrates that on an instantaneous basis there is more than an adequate supply of water being circulated to remove the ammonia.