Comparison of Emission Calculation Methodologies for the Oil and Gas Industry

Presented by:
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Trinity Consultants, Inc.

- Founded 1974
- 30+ offices nationwide with over 400 employees
- Environmental and business solutions for industry
  - Expertise in air permitting, modeling, and regulatory compliance
  - Overall environmental management support
  - EMIS Systems
Presentation Agenda

• Background
• Atmospheric Storage Tanks
• Glycol Dehydrators
• Amine Treaters
• Conclusions
• Questions
Section 1

Background
Purpose of This Study

• Used various methodologies/programs using the same real-world field data to compare results
• Varied throughputs to show response of simulations
• You have choices!
• Important to understand each method and the inputs required
Important Reminders for Emission Calculations

• Several methodologies available for each source
• Each methodology has limitations
  • Input data ranges
  • Sensitivities
• Build in flexibility and be able to re-create calculations
• Use extended gas analyses where available
Section 2

Atmospheric Storage Tanks
Calculation Methodologies

• Programs Addressed
  • Vasquez-Beggs
  • US EPA TANKs 4.09d
  • GOR Sampling
  • GRI-HAPCALC 3.0
  • Environmental Consultants Research Algorithm (EC/R Method)
  • E&P Tanks v2.0
  • ProMax ®

• Other Methods
  • ChemCAD
  • AspenTech HYSYS 2006.5
  • Valko and McCain – Stock Tank Gas-Oil Ratio
  • Direct Measurement Method
Vasquez-Beggs

• PROS
  • Simple equation with eight (8) common inputs (i.e. API gravity, separator pressure, temperature, gas specific gravity, hydrocarbon production, etc.)
  • No program or simulation required and can be set-up in Excel
  • Most appropriate for use on stock tanks at wellheads, oil and gas production batteries and for “black oil”
Vasquez-Beggs

**CONS**

- Does not calculate standing or working losses from storage tanks
- Underestimates or overestimates flashing emissions depending on inputs
- Method is very rudimentary
- Many limitations in the data ranges
Vasquez-Beggs

• Data limitations:
  • Stock Tank Liquid Relative Density: 16-58 °API
  • Separator Pressure: 50-5250 psia
  • Separator Temperature: 70-295 °F
  • Separator Gas SG: 0.56-1.18
  • Solution Gas Oil Ratio (GOR): 20-2070 scf/bbl
US EPA TANKS 4.09d

• PROS
  • Free from EPA website
  • Designed by EPA to use software instead of algorithms provided in AP-42 Chapter 7.1
  • User-friendly interface with customizable materials list
  • Requires common tank physical characteristics parameters (i.e. tank dimensions, tank color, heated, throughput, etc.)
  • Requires storage chemical properties if you do not use a chemical from the database
US EPA TANKS 4.09d

• PROS CONTINUED
  • Uses AP-42 site-specific meteorological data
  • Is able to calculate emissions from different types of storage tanks (i.e. fixed or floating-roof)
  • Can distinguish the types of fittings located on the tanks (i.e. access hatches or slotted guide poles)
US EPA TANKS 4.09d

• CONS
  • Flash emissions cannot be calculated
  • Complex emission methods for calculating short-term emissions
  • Adding in mixtures can require additional chemical properties to be added to the database
US EPA TANKS 4.09d

TANKS 4.09d – Comparison - Annual

Annual Emission Rate (tpy)

Annual Throughput (gal/yr)

Crude Oil RVP 5 (W & B Losses)
Gasoline (W & B Losses)
Condensate Sample (W & B Losses)
Gas Oil Ratio (GOR) Sampling

• This is a direct laboratory analysis of the flash gas emitted from a pressurized oil/condensate sample
• Sample must be taken to a lab and be analyzed
• GOR is the volume of flash gas produced (scf) per barrel of liquid
• Conditions at site are recreated and flash gas is measured
Gas Oil Ratio (GOR) Sampling

• PROS

• Performed in laboratory setting with specific protocols to ensure repeatability

• Generally provides the most representative flash emission estimate

• Analysis will usually include speciation of compounds

• Simple equation with four (4) inputs needed (i.e. measured GOR, oil production, stock tank molecular weight, and speciation profile)
Gas Oil Ratio (GOR) Sampling

• CONS
  • Does not calculate standing or working losses from storage tanks
  • Can be difficult to obtain a pressurized liquid sample
Environmental Consultants Research Algorithm (EC/R) Method

- Calculates flash emissions based on pressure drop of stream from process vessel to a storage vessel
- Equation derived from the behavior of the liquid stream based on changes in stream compositions and pressure (Akin and Battye, 1994)
- Primarily intended to estimate BTEX emissions
- Equation is suitable if composition does not deviate significantly from the assumed composition
EC/R Method

• PROS
  • Simple equation that can be setup in a spreadsheet
  • Inputs are fairly common

• CONS
  • Only calculates flash emissions
  • Valid for vapor pressure of liquid streams entering the storage tank between 1.6 atm and 5.1 atm
  • The assumed composition on which the equation was formulated does not generally follow actual compositions
GRI-HAPCALC 3.0

• Software program which uses the Vasquez-Beggs correlation equation to determine flash emissions

• PROS
  • Calculates flash, working, and standing
  • Free software to download
  • Common inputs required (annual throughput, tank capacity, separator conditions, specific gas gravity, etc.)
GRI-HAPCALC 3.0

• CONS
  • Only allows specific range of inputs or will not compute (API is limited to 58 API)
  • Program assumes parameters about the tank to calculate working and standing losses
  • If the user attempts to input a variable outside the appropriate range, the program will prevent the user from running the program
E&P Tanks

- Software is used to determine flashing, working and standing emissions from tanks
- Two options to run simulations:
  - AP-42
  - RVP Method
E&P Tanks

• PROS

• Provides flashing, working, and standing losses
• Free program and user-friendly interface
• Provides Options to enter one of three different streams entering and leaving the separator (e.g. gas inlet composition, pressurized liquid sample, or separator gas sample)
• Common inputs needed (i.e. gas or liquid composition, separator conditions, API gravity, Reid Vapor Pressure, daily throughput, etc.)
E&P Tanks

• CONS
  • Not always compatible with all versions of Windows
  • Does not consider whether tanks are fixed or floating roof
  • Cannot distinguish types of fittings inside the tanks
  • Data Limitations:
    • API Gravity of the sales oils and condensate: 15 – 68
    • Cannot accurately estimate working and standing losses when the oil has low oil volatility or a short residence time in the tank
ProMax ®

• Versatile software can be used to determine flash, working, and standing emissions
• Developed by Bryan Research and Engineering
• Can be customized to fit site using sample and analysis
ProMax ®

• PROS
  • Provides an accurate simulation of actual emissions
  • Can be customized to be very site specific
  • Customer service is provided with software as well as training
  • Software includes various packages which can be used for several types of oil and gas applications
  • Includes software updates
ProMax ®

• CONS
  • Must understand how to use software to get accurate results
  • Software is expensive
  • Does not consider whether tanks are fixed or floating roof
  • Cannot distinguish types of fittings inside the tanks
All Tank Comparison

Combined Methods Comparison - Annual (W&B Only)

Annual Emission Rate (tpy)

Daily Throughput (bbl/day)

- ProMax Method
- TANKS 4.09d (Condensate Analysis)
- TANKS 4.09d (Crude Oil RVP 5)
- TANKS 4.09d (Gasoline)
Comparison of Methods

• The following methods were not used in the comparison because the ranges were outside reliable limits or the data was not sufficient for an accurate comparison

• Vasquez-Beggs: Our analysis is outside following ranges:
  • Stock tank Liquid Density is 112.5 API (Range is 16-58)
  • GOR was calculated to be 9,505.27 scf/bbl based on flash gas (Range of 20-2070 scf/bbl)

• GOR Method (Flash Gas Analysis): The flash gas analysis was flashed at 940 psig which does not represent real conditions

• GOR Method (Liquid Analysis): The liquid analysis factor is not based on the flash gas, but instead on the gas entrained in the liquid
Comparison of Methods

- The following methods were still considered in the comparison but are not the most reliable results:
  - EC/R Method: Our analysis has a vapor pressure of 1.381 psia = 0.09397 atm (Range is 1.6 atm - 5.1 atm)
  - HAPCalc: The API gravity was forced to be the maximum the program would need to run (58 API). The sample API gravity is actually 112.5 API
All Tank Comparison

All Methods Comparison - Annual
(W & B & Flash)
Conclusions

• It is important to understand the acceptable ranges and limitations of programs/equations.
• Permitting levels and federal applicability (i.e. NSPS OOOO) could be reached at different throughputs depending on the method chosen.
• Throughput has a direct correlation to emissions with all programs used in this study.
• Choosing the “lowest” option is not always best.
Section 3

Glycol Dehydrators
Calculation Methodologies

• Programs Addressed
  • GRI-GLYCalc
  • ProMax ®

• Other Programs
  • Aspen HYSIS ® Simulator
  • Dow Simulation
GRI-GLYCalc v4.0

• A windows based program for estimating air emissions from glycol units using triethylene glycol (TEG), diethylene glycol (DEG) or ethylene glycol (EG)

• Provides speciated emissions including uncontrolled regenerator, controlled regenerator, and flash tank emissions
GRI-GLYCalc v4.0

• PROS
  • Emissions can be used to estimate meeting BACT requirements for glycol dehydrators
  • Results are site specific since input stream require compositions
  • A variety of different options exist making results site-specific
  • Inputs are common and some defaults exist in the program for easy setup
  • Specifically referenced by federal regulations
GRI-GLYCalc v4.0

• CONS
  • Price (as of August 13, 2013) is about $295.00 per copy
  • Defaults that can over-simplify approach
  • Very sensitive to certain inputs
ProMax ®

• Same general Pros and Cons as Atmospheric storage tanks

• Pros
  • Customizable
  • Software includes a variety of calculations options and configurations

• Cons
  • Price
  • More complex and more time consuming to setup
All Dehydrator Comparison

Dehydrator - VOC

Uncontrolled Annual Emissions (tpy)

Throughput (MMscf / day)

ProMax Output

GRI-GLYCalc Output
Conclusions

• ProMax provides lower emissions in our case
• Throughput is not the main contributing factor to emissions
• Lean glycol circulations rates and temperature/pressure settings have a greater impact on emissions
• MACT HH/HHH applicability could be more dependent on operating parameters instead of throughput
Section 4

Amine Treaters
Calculation Methodologies

• Program Addressed
  • AMINECalc
  • ProMax ®

• Other Programs
  • Aspen HYSIS ® Simulator
  • Dow Simulation
AMINECalc

• A Windows-based software program that estimates hydrocarbon emissions from amine-based sour gas and natural gas liquid sweetening units.

• Performs three types of calculation options
  1. Mass balance calculation
  2. Gas process [gas feed] simulation
  3. NGL process [liquid feed] simulation
AMINECalc

• PROS
  • Provides speciated emissions based on gas inlet composition
  • Provides flash tank and acid gas stream emissions

• CONS
  • Simplified program
  • Contains defaults
  • Must be run as administrator
ProMax ®

• Same general Pros and Cons as Atmospheric storage tanks

• Pros
  • Customizable
  • Software includes a variety of calculations options and configurations

• Cons
  • Price
  • More complex and more time consuming to setup
All Amine Treater Comparison

Amine - VOC

Throughput (MMscf / day)

Uncontrolled Annual Emissions (tpy)

ProMax Output

AMINECalc Output
Conclusions

- AMINECalc provided lower emissions in our case
- Throughput is not the main contributing factor to emissions
- Lean amine circulations rates and temperature/pressure settings have a greater impact on emissions
- Greenhouse Gas (GHG) permitting could be mainly dependent on operating parameters instead of throughput
Section 5

Conclusions of Study
Conclusions

• Atmospheric Storage Tanks
  • TANKS 4.09d + ProMax provided the most reliable and lowest emissions
  • Permitting and federal applicability (i.e. NSPS OOOO) could be reached at different throughputs for different methods

• Dehydrators
  • ProMax provided lower emissions in our case
  • MACT HH/HHH applicability could be different depending on what program is used, however, these regulations specifically mention GRI-GlyCalc

• Amine Treaters
  • AMINECalc provided lower emissions in our case
  • CO₂ emissions for GHG reporting could be impacted depending on the program chosen
Conclusions Cont.

• Process Simulators (such as ProMax) allow you to run all units in one setup file but the results may not always be the lowest achievable.
• Other stand alone programs are easier to setup but you must run them individually.
• Permitting options can change depending on what programs are chosen.
• You have choices, choose wisely!
Questions?

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