Determining Emissions from Produced Water Storage Tanks

Disclaimer

Guidance presented within this document is ONLY applicable to the Barnett Shale, Phase Two Special Inventory and is not intended for permitting, demonstrating compliance, or other agency purposes, including annual point source emissions inventory reporting.

The following guidance was developed specifically for the Barnett Shale Phase Two Special Inventory to determine emissions from produced water tanks specific to the Barnett Shale formation(s).

Definition

For the purposes of this inventory, produced water storage tanks are defined as tanks that do not report a liquid hydrocarbon product volume to the Texas Railroad Commission. Note produced water is also commonly referred to as saltwater. There are alternate calculation methods that may be equally acceptable if they are based upon, and adequately demonstrate, sound engineering assumptions and data. For additional guidance regarding the acceptability of a given emissions determination method for the purposes of the Barnett Shale Phase Two Special Inventory, contact Julia Knezek at (512) 239-1424, Miles Whitten at (512) 239-5749, or the Emissions Inventory Help Line at (512) 239-1773.

Produced Water Operations

Site operations determine emissions from produced water tanks. Working, breathing, and flash losses are all considerations. Atmospheric storage tanks located at oil and gas exploration and production activities that receive liquids from a separator are a common type of produced water tank. Atmospheric storage tanks located at saltwater disposal sites that store produced water in preparation for disposal are another type. The emissions determination methodologies for each of the operation types will be addressed in this document. Skim oil/condensate tanks are also addressed but are considered condensate tanks for Barnett Shale special inventory purposes.

Produced Water Tanks at Oil and Gas Production Sites

In a typical tank battery, the well stream is passed through a separator or a heater treater where liquid hydrocarbons (i.e., oil or condensate), gas, and water are separated. The reduction in pressure in the separator relative to the inlet gas pressure releases gases dissolved in the liquids. Gases are collected and routed for further processing. Separated liquids – oil, condensate, and/or produced water – are stored in a tank battery. If hydrocarbons are present in the produced water, these compounds could flash when placed into the atmospheric pressure storage tanks. If the hydrocarbons remain in liquid form, these compounds contribute to increased vapor phase concentrations in the tank headspace and thus increased working and breathing losses.

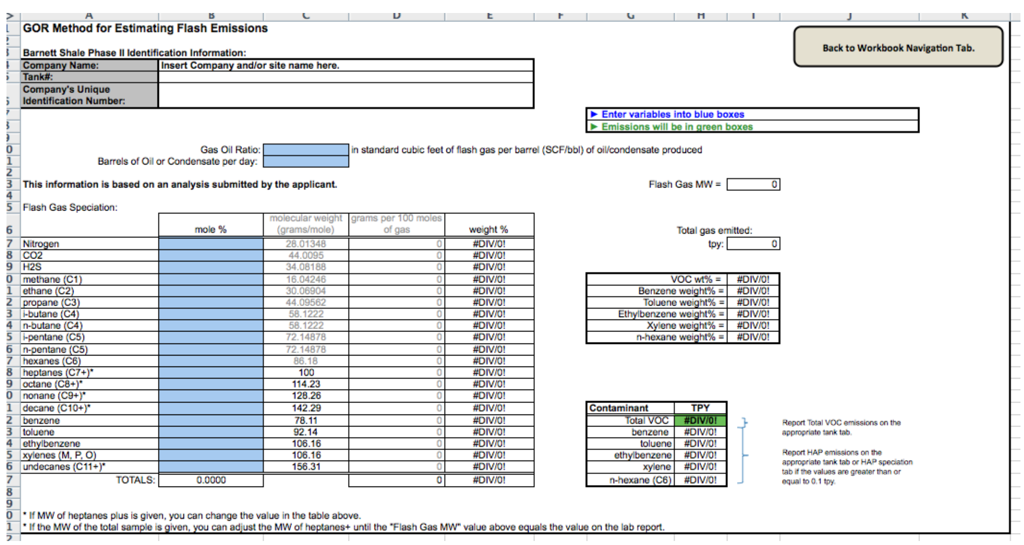
Determining Flash Losses

If volatile organic compounds (VOC) are entrained in water produced during oil and gas exploration and production activities, VOC could flash when placed in atmospheric pressure tanks due to pressure differentials. For the purposes of this inventory, produced water storage tanks are defined as tanks that do not report a liquid hydrocarbon product volume to the Texas Railroad Commission. To determine the flash losses, direct measurement of emissions or measurement of the amount of flash gas from a pressurized sample of produced water (similar to the gas/oil ratio (GOR) method) are the preferred emissions determination methods.

Pressurized sample method

Pressurized separator liquid samples (i.e., before the hydrocarbon liquid has been allowed to flash) for each produced water tank battery site using GPA Standard 2174-93 (Obtaining Liquid Hydrocarbon Samples for Analysis by Gas Chromatography) should be taken using a constant pressure cylinder. The samples should be collected from the low pressure separator liquids stream. As indicated in the GPA Standard 2174-93 document, "Care must be exercised when sampling liquids having a vapor pressure higher than atmospheric pressure to prevent flashing of lighter components when transferring product from the source to a sample cylinder, or from a primary sample cylinder to a secondary cylinder." The produced water samples should be flashed in the laboratory and the gas analyzed using GPA Method 2286. Note that the compositions should be calculated on an air-free basis (i.e., excluding oxygen) as it is the correct representation of vapors from liquid stored in the tank.

Once the gas/oil ratio and composition are determined from the sampling data, choose the GOR method in the Barnett Shale Emissions Calculator to determine the total VOC, benzene, toluene, ethylbenzene, xylene (BTEX), and n-hexane emissions. Figure 1 below shows the calculator screen. The gas/oil ratio and the mole percent composition are required information. Input these data into the Barnett Shale Emissions Calculator; emission rates are calculated and displayed in the lower right hand corner.


GOR Method for Estimating Flash Emissions

Back to Workbook Navigation Tab.

Barnett Shale Phase II Identification Information:

Company Name:	Insert Company and/or site name here.
Tank#:	
Company's Unique Identification Number:	

► Enter variables into blue boxes
► Emissions will be in green boxes

Gas Oil Ratio: [ ] in standard cubic feet of flash gas per barrel (SCF/bbl) of oil/condensate produced
Barrels of Oil or Condensate per day: [ ]

This information is based on an analysis submitted by the applicant.

Flash Gas MW = 0

Flash Gas Speciation:

	mole %	molecular weight (grams/mole)	grams per 100 moles of gas	weight %
Nitrogen		28.01348	0	#DIV/0!
CO2		44.0095	0	#DIV/0!
H2S		34.08188	0	#DIV/0!
methane (C1)		16.04246	0	#DIV/0!
ethane (C2)		30.06904	0	#DIV/0!
propane (C3)		44.09562	0	#DIV/0!
i-butane (C4)		58.1222	0	#DIV/0!
n-butane (C4)		58.1222	0	#DIV/0!
i-pentane (C5)		72.14878	0	#DIV/0!
n-pentane (C5)		72.14878	0	#DIV/0!
hexanes (C6)		86.18	0	#DIV/0!
heptanes (C7+)*		100	0	#DIV/0!
octane (C8+)*		114.23	0	#DIV/0!
nonane (C9+)*		128.26	0	#DIV/0!
decane (C10+)*		142.29	0	#DIV/0!
benzene		78.11	0	#DIV/0!
toluene		92.14	0	#DIV/0!
ethylbenzene		106.16	0	#DIV/0!
xylenes (M, P, O)		106.16	0	#DIV/0!
undecanes (C11+)*		156.31	0	#DIV/0!
TOTALS:	0.0000		0	#DIV/0!

Total gas emitted:
tpy: 0

VOC wt% =	#DIV/0!
Benzene weight% =	#DIV/0!
Toluene weight% =	#DIV/0!
Ethylbenzene weight% =	#DIV/0!
Xylene weight% =	#DIV/0!
n-hexane weight% =	#DIV/0!

Contaminant	TPY
Total VOC	#DIV/0!
benzene	#DIV/0!
toluene	#DIV/0!
ethylbenzene	#DIV/0!
xylene	#DIV/0!
n-hexane (C6)	#DIV/0!

Report Total VOC emissions on the appropriate tank tab.

Report HAP emissions on the appropriate tank tab or HAP speciation tab if the values are greater than or equal to 0.1 tpy.

* If MW of heptanes plus is given, you can change the value in the table above.
* If the MW of the total sample is given, you can adjust the MW of heptanes+ until the "Flash Gas MW" value above equals the value on the lab report.

Figure 1. GOR Method Emission Calculator

Emission factor method

When direct measurement or pressurized samples of produced water are not available or a feasible option, the TCEQ has developed the following factors in Table 1 to determine produced water flash emissions for Barnett Shale Special Inventory Phase Two purposes only. These produced water flash emissions factors are categorized into two subsets based on the type of product the site produces. The “Gas Production Only Sites” factors are for produced water tanks located at sites where only gas was produced and reported to the Texas Railroad Commission. The “Liquid Hydrocarbon and Gas Production Sites” factors are for produced water tanks located at sites where gas and a liquid hydrocarbon product, such as condensate, is produced and reported to the Texas Railroad Commission.

Examples

1. If a tank battery consists of two condensate tanks and one produced water tank, the “Liquid Hydrocarbon and Gas Production Sites” factor should be used to determine flash emissions from the one produced water tank since the site produces hydrocarbon liquids as well as water.

- Working and breathing losses from the one produced water tank can be determined using TANKS 4.09D as outlined in the “Determining Working and Breathing Losses” section below.
- Flash, breathing, and working losses from the two condensate tanks can be determined as detailed in the “Skim Oil/Condensate Tanks” section below.

2. However, if a tank battery consists of only two produced water tanks, then “Gas Production Only Sites” factor would be used to determine flash emissions from the two produced water tanks. Working and breathing losses from the two produced water tanks can be determined using TANKS 4.09D as outlined below.

NOTE: If any of the tanks store a liquid hydrocarbon product, then these factors do not apply. See the skim oil/condensate tanks section below for how to determine emissions for these types of tanks.

Table 1. Produced Water Storage Tank Flash Loss Emissions Factors for Barnett Shale Special Inventory Purposes ONLY

Pollutant	Average Produced Water Emission Factor (lb/bbl)	
	Gas Production Only Sites	Liquid Hydrocarbon and Gas Production Sites
VOC	0.01	0.0402
Benzene	0.0001	0.000054
Toluene	0.0003	0.000130
Ethylbenzene	0.000006	0.000003
Xylene(s)	0.00006	0.000049
n-Hexane	NA	0.000987

Produced Water Tanks at Saltwater Disposal Well Sites

Saltwater/produced water at saltwater disposal well sites commonly contains oil or condensate. Therefore, emissions associated with the produced water storage tanks at these sites should be evaluated for the special inventory. Flash losses (emissions) occur when a liquid with entrained gases experiences a pressure drop or a temperature increase. Flash losses from produced water storage tank at saltwater disposal sites can be considered negligible, provided the saltwater/produced water experiences no pressure or temperature changes before it enters the storage tank. If a pressure or temperature change is experienced, treat the saltwater/produced water tank as a water tank at an oil or gas production site and determine the flash losses by applying an approved methodology discussed above. Working and breathing losses would need to be determined using the same method described below for produced water storage tanks at oil and gas production sites.

Skim Oil and Condensate Tanks

Storage tanks with water where liquid hydrocarbons are removed (skimmed) from the tanks are considered condensate tanks for the purposes of the Barnett Shale special inventory. Most hydrocarbons have a lower specific gravity than water. Without agitation, oil separates from the water and floats to the surface. Normally oil bonds more tightly to itself and other materials than it does to water. This affinity and differences in surface tension between oil and water cause oils to adhere to a skimming medium. Oil skimmers rely on specific gravity, surface tension and a moving medium to remove floating oil from a fluid's surface. Floating oil and grease cling to skimming media more readily than water, and water has little affinity for the media.

The emissions from skim oil tanks as well as condensate tanks can be determined by applying the emission factors from the Houston Advanced Research Center (HARC) 51C project entitled *VOC Emission from Oil and Condensate Storage Tanks*. Apply the HARC 51C emission factor to the total liquid hydrocarbon volume during the reporting period. The HARC 51C factor accounts for working, breathing, and flash losses. Therefore, additional emission calculations using TANKS 4.09D are not necessary.

See Table 2 below for the applicable HARC 51C factor based on the hydrocarbon properties. Condensate is defined as a liquid hydrocarbon with an API gravity of greater than 40 degrees while crude oil is defined as heavy, low-volatility oil approximated by an API gravity less than 40 degrees.

Table 2. HARC 51C Total VOC Emission Factors

Condensate VOC Emissions Factor (lb/bbl liquid hydrocarbon produced)	Crude Oil Total VOC Emissions Factor (lb/bbl liquid hydrocarbon produced)
33.3	1.6

Determining Working and Breathing Losses

Emissions from storage tanks also occur because of evaporative losses of the liquid during storage (breathing losses) and as a result of changes in liquid level (working losses). Breathing and working loss emissions from produced water tanks can be determined using the current version of the TANKS program, the EPA's free software, available for download at <www.epa.gov/ttn/chief/software/tanks/index.html>. The recommended methodology is to create a mixture in the EPA TANKS 4.09D similar to the composition of the produced water stored in the tanks (e.g., a mixture of 95 percent water and 5 percent condensate) to determine the emissions. See *Using EPA TANKS 4.09D to Estimating Working and Breathing Losses from a Mixture* below for an example on how to create a mixture using the software.

Using EPA TANKS 4.09D to Estimate Working and Breathing Losses from a Mixture

This specific example uses Environmental Protection Agency (EPA) TANKS 4.0 program to estimate the working and breathing losses from a produced water tank containing 95 percent water and 5 percent condensate. Actual site specific and mixture composition data should be used when applying this methodology to determine the emissions for a produced water tank. Remember the EPA TANKS 4.09D program does not estimate flash losses. Flash loss must be accounted for using the procedures detailed in this document as well as the *Barnett Shale Special Inventory, Phase II Frequently Asked Questions* document available at <http://www.tceq.state.tx.us/implementation/air/industei/psei/psei.html#barnett2>.

The EPA TANKS 4.09D program is available for download at <http://www.epa.gov/ttn/chief/software/tanks/.> In addition to the software, there is also a *User's Manual for TANKS 4.0* that should be downloaded for future reference.

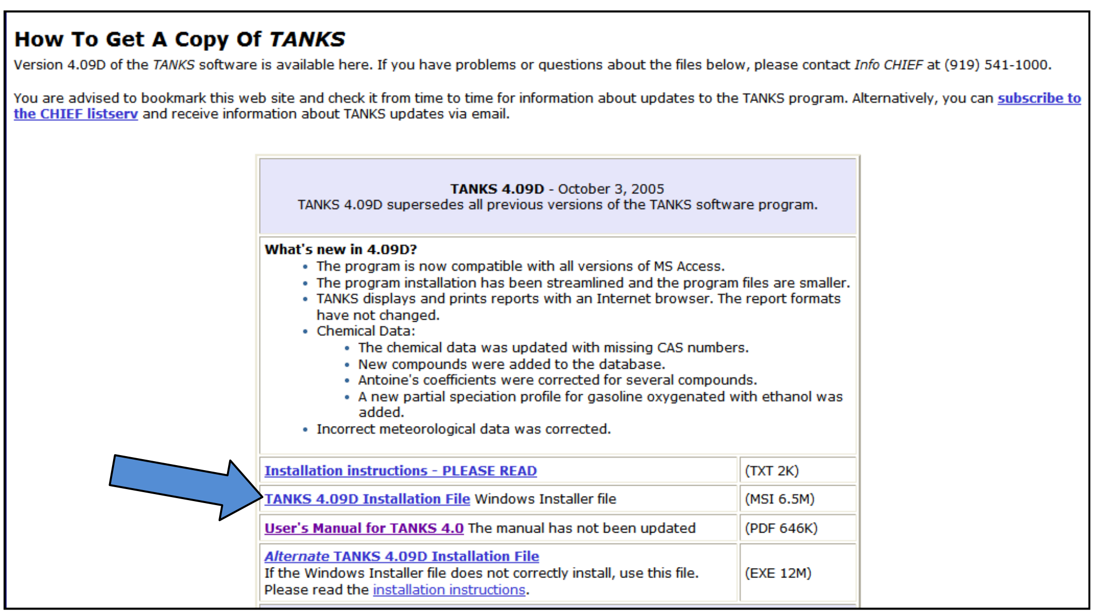


Figure 2. EPA TANKS 4.09D Webpage Screenshot

The EPA TANKS 4.09D program is designed with a chemical database that includes many chemicals including crude oil (RVP 5) and gasoline at various vapor pressures. However, the chemical database does not include water, which is required for our example. Therefore we will need to add this chemical to the database. Note: The same procedure can be used to add site-specific chemicals or mixtures such as condensate to the TANKS 4.09D database.

Adding Chemical Information to Database

To add a new chemical or mixture to the database, choose the "Data\Chemical\Edit Database" path in the software window from the TANKS main menu as shown below in Figure 3.

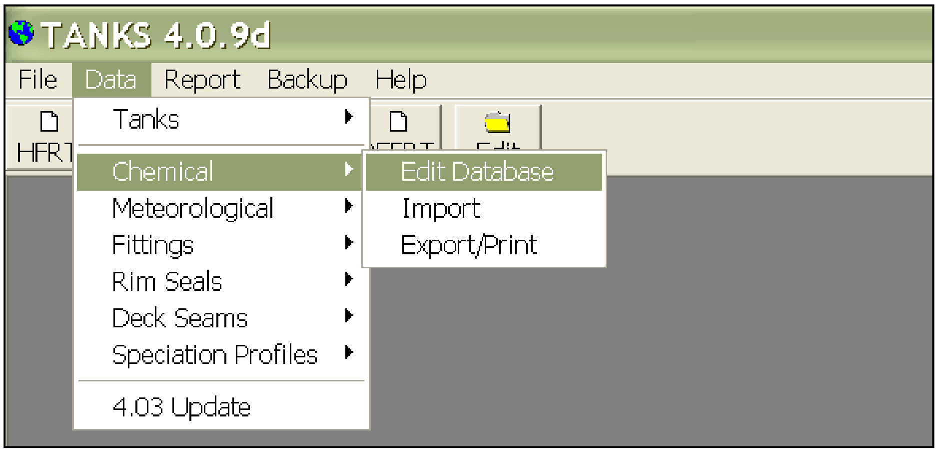


Figure 3. Accessing the Chemical Database in EPA TANKS 4.09D

This will bring up the chemical database window. Select the "Add New" button at the bottom of the window to add a new chemical.

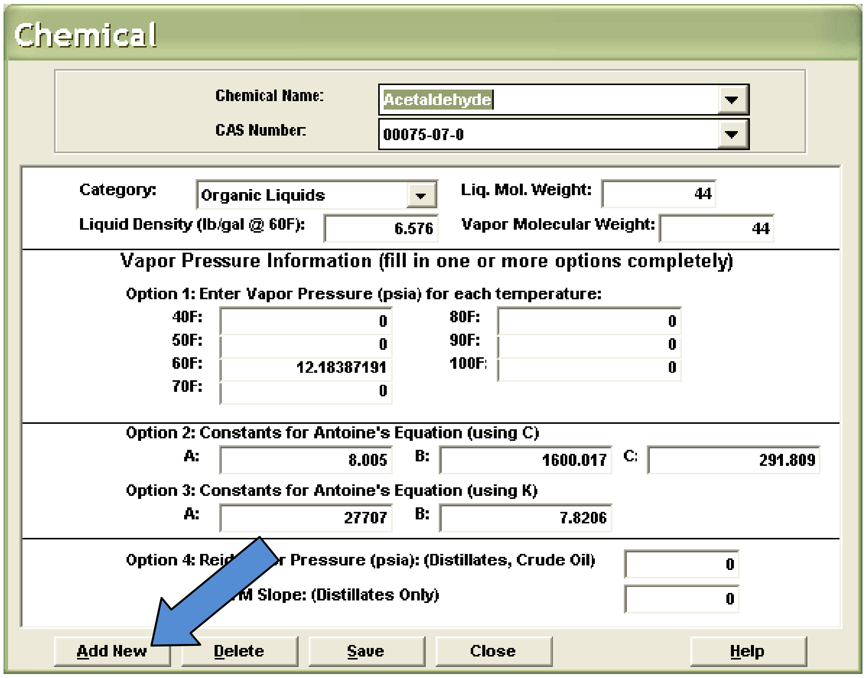


Figure 4. Chemical Database Welcome Screen

Complete the Chemical Name field at the top of the page with the chemical you would like to add (in this example case “Water”). Note the CAS number is not a required field.

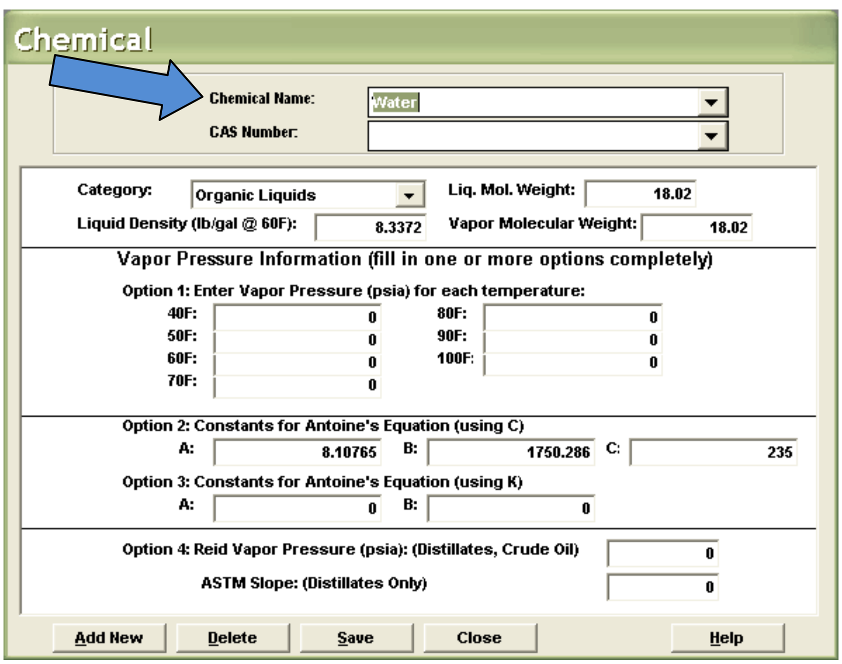


Figure 5. Adding Water to Chemical Database

Complete the top of this form by filling in the category, liquid and vapor molecular weight, and the liquid density. The category we chose for water was organic liquids for lack of a more applicable category. For water, the liquid molecular weight and vapor molecular weight is 18.02. The liquid density of water at 60°F in pounds per gallon is 8.3372 pounds per gallon. In addition you will need to choose a vapor pressure information option to complete. Using option 2 from the vapor pressure information options, the constants for Antoine's Equation are: A: 8.10765, B: 1750.286, and C: 235. By choosing the save button, you will have saved the new chemical "Water" into the chemical database.

Creating a Mixture Using TANKS 4.09D

The welcome screen for EPA TANKS 4.09D program gives you two options: either create a new tank record or open an existing record. Under the "Create a New Tank Record" dropdown menu, choose the appropriate type of tank. For our example, our tank is a vertical fixed roof tank. Note you can access a tank that you previously saved in the TANKS program by choosing the "Open an Existing Tank Record" option.

Figure 6. Welcome to TANKS screen

Complete the site and tank specific information in the identification, physical characteristics, and site selection tabs. Use the tabs at the top of the screen to navigate between screens to complete all the required information. Figures 7 through 9 show each of these particular tabs with our example case information completed.

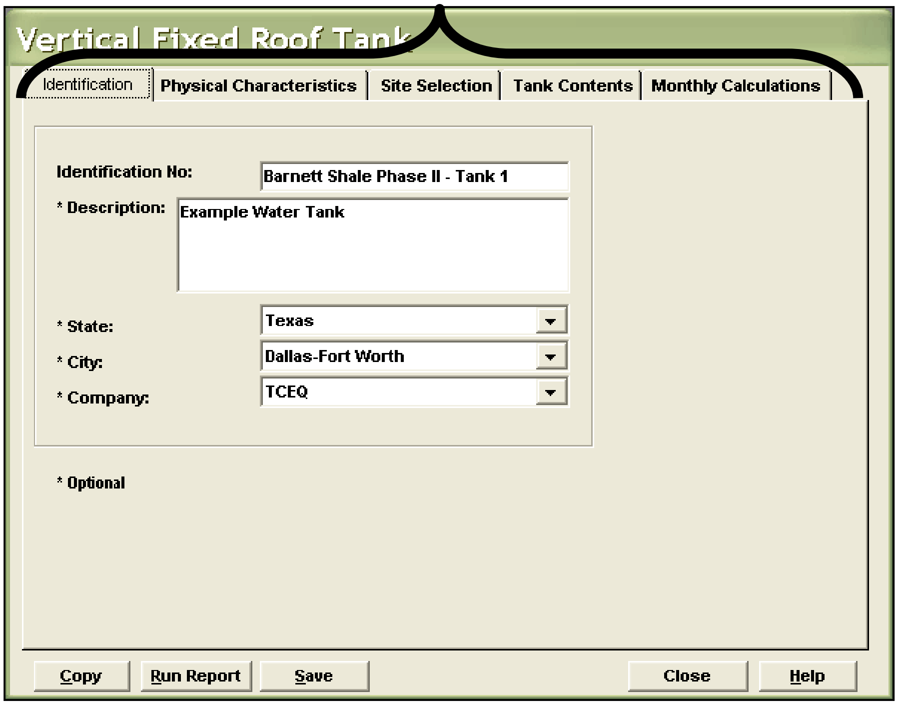


Figure 7. Identification Information

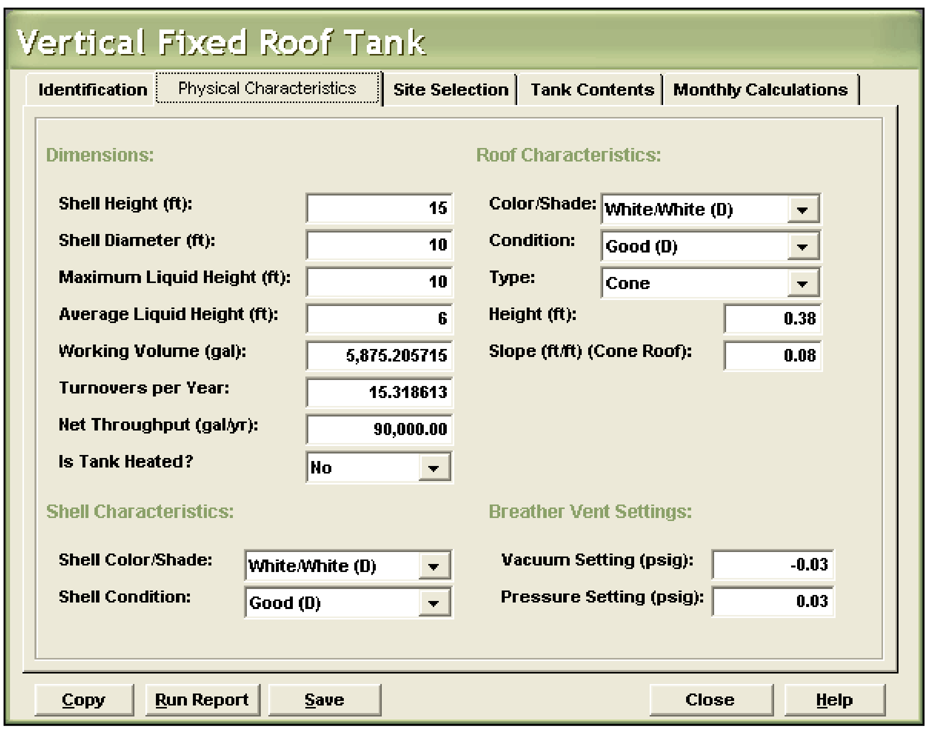


Figure 8. Physical Characteristics Information

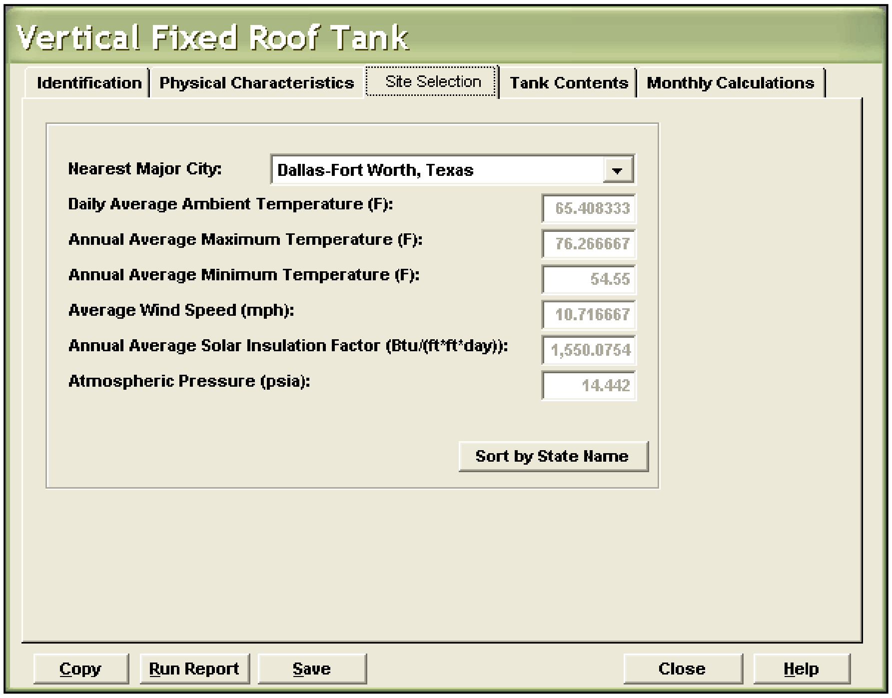


Figure 9. Site Selection Information

The tank contents tab is where to add the mixture properties to TANKS 4.09D. For our example case, the produced water is 5 percent condensate and 95 percent water. We will use gasoline RVP 15 to model the condensate portion of the mixture because no site-specific information is available for the condensate. For this example, “petroleum distillates” is selected as the chemical category of liquid. Choose “Multiple” for the single or multi-component liquid and “Full Speciation” for the speciation option. Enter a mixture name for the new mixture; in this case we used “Produced water” as the mixture name. Once all the above information is completed, click the “View/Add Components” button as indicated by the blue arrow in Figure 10 below.

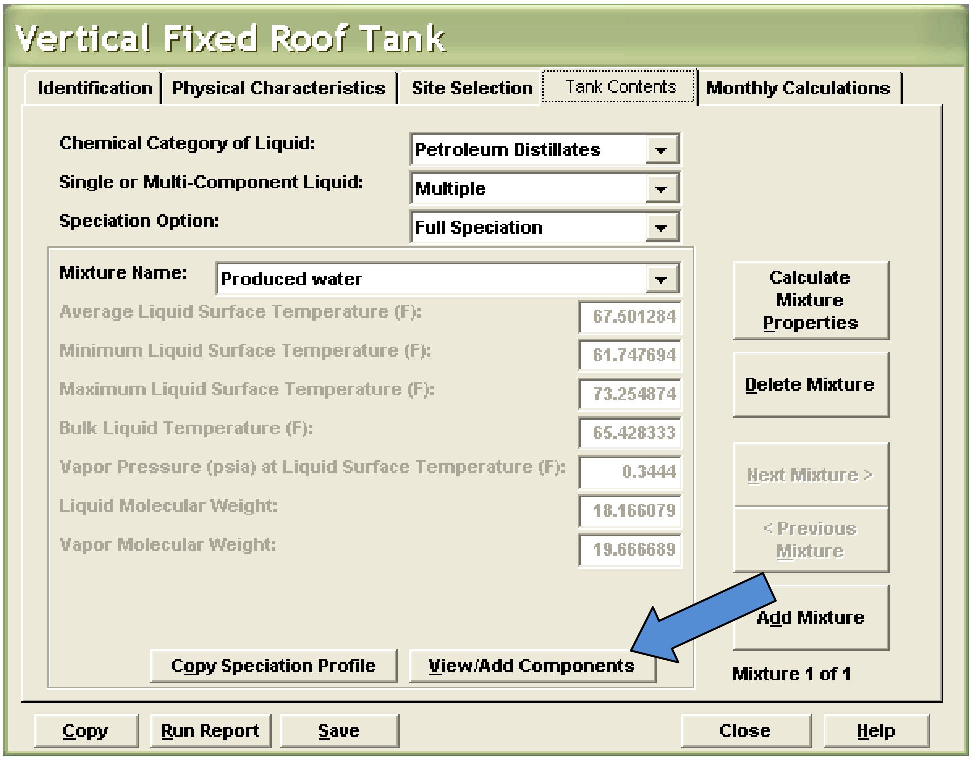


Figure 10. Tank Contents

The “View/Add Components” button will bring up the “Specify Components” window. In this window specify the components of your mixture and the total liquid weight breakdown. For our example, gasoline RVP 15 makes up 5 percent and water makes up 95 percent of the mixture. So our first component, gasoline RVP 15, is selected from the chemical name dropdown menu and five percent is entered for the percent of total liquid weight. By selecting the “Add” button, a blank form will appear to allow the addition of the second component.

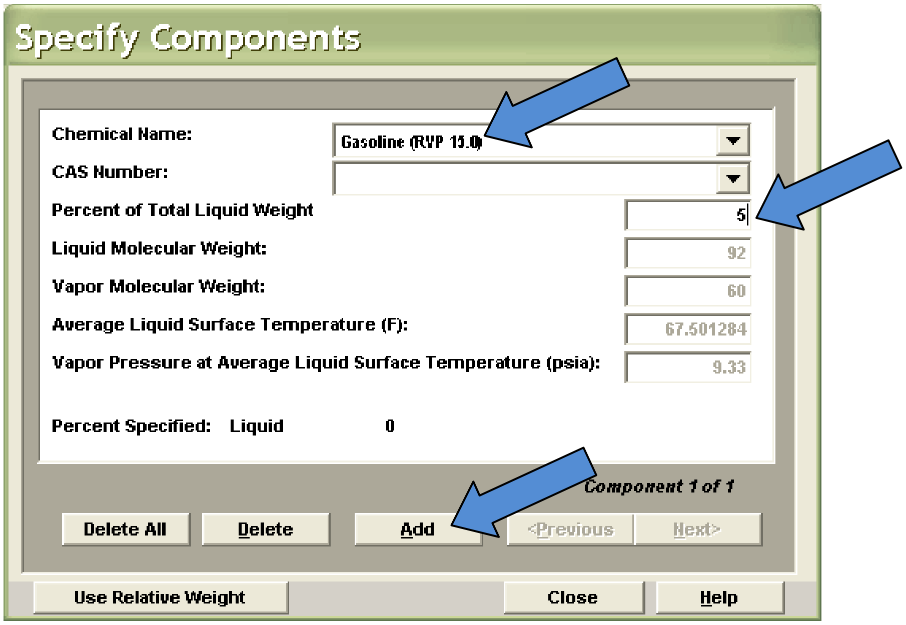


Figure 11. Specifying Component 1 of 1

For our example, the second component of the mixture, water, can be entered by selecting "Water" from the "Chemical Name" dropdown menu; 95 percent is entered for the percent of total liquid weight. Once all components are completed, select the "Close" button to save and close the window.

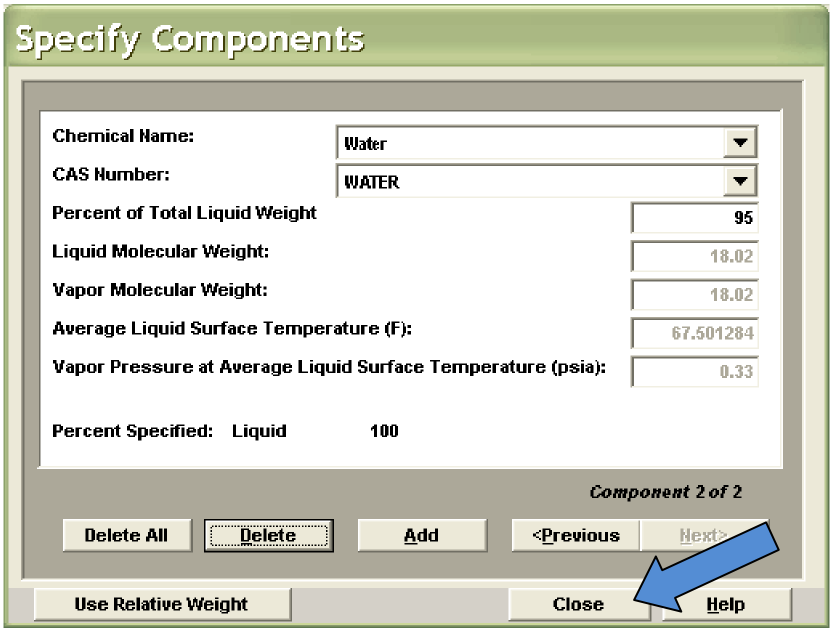


Figure 12. Specifying Component 2 of 2

The monthly calculations are completed by the TANKS program by calculating an average monthly throughput and applying it to the entire year. However, the "Monthly Calculations" tab allows you to modify the monthly throughputs to be more accurate. For the example site, there was no modification to the monthly throughput as shown in Figure 13 below.

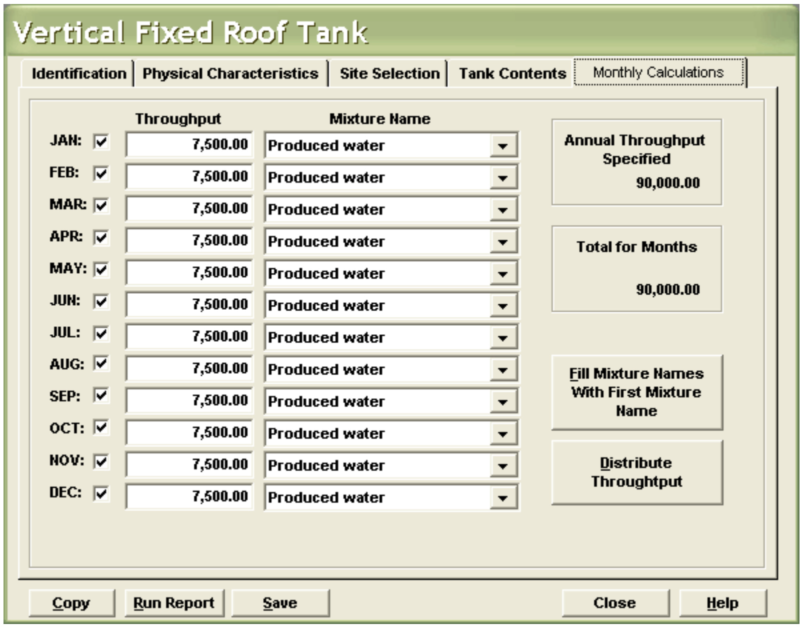


Figure 13. Monthly Calculations TANKS tab

Once all the tabs in the EPA TANKS 4.09D software program have been completed, select the "Save" button to save your tank record. Next, select the "Run Report" button found at the bottom of the software window as shown in Figure 14.

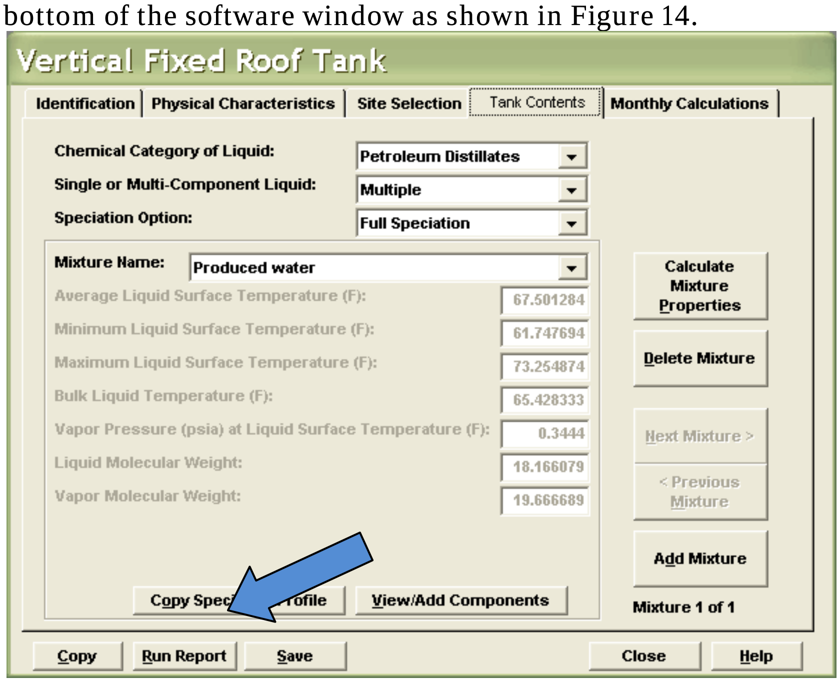


Figure 14. Running the TANKS 4.09D report

This will bring up the "Report Type" window. Select "Detail" for the report type and "Annual" for the time basis to run the emissions report as detailed in Figure 15 below.

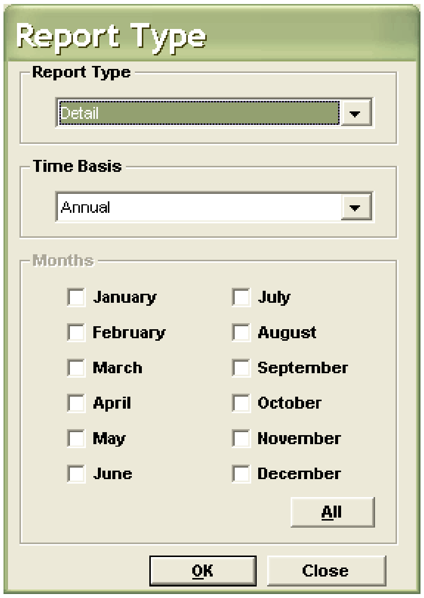
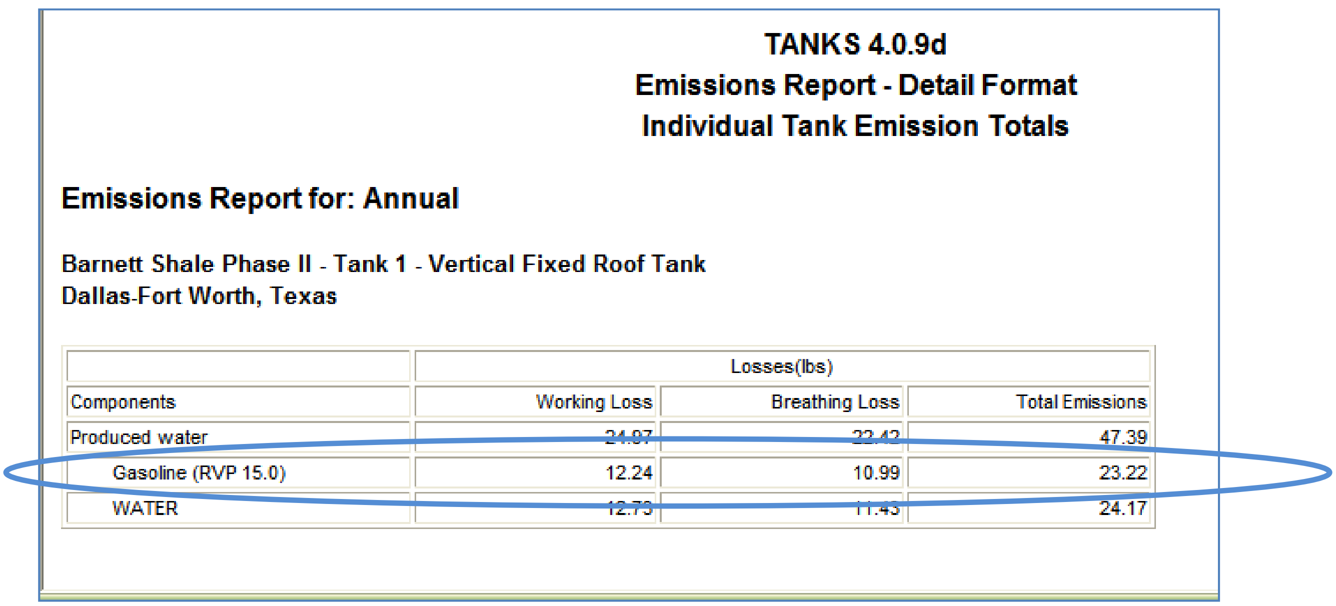


Figure 15. EPA TANKS 4.09D Report Type Window

Running the report using the window/printer option will allow you to view the results in a user friendly format. The last page of the detail report details the emissions calculated by the EPA TANKS 4.09D program.



TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

Barnett Shale Phase II - Tank 1 - Vertical Fixed Roof Tank
Dallas-Fort Worth, Texas

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Produced water	24.97	22.42	47.39
Gasoline (RVP 15.0)	12.24	10.99	23.22
WATER	12.73	11.43	24.17

Figure 16. TANKS Emissions Report Example

Referring to the Annual Emissions Report, read the hydrocarbon liquid emission rate. For our example that is the gasoline RVP 15. Please be aware that the TANKS 4.09D software program calculates emission losses in pounds. Therefore the calculated emission rate should be divided by 2000 pounds to get the emissions in tons per year (tpy) to be reported in the Barnett Shale Special Inventory Phase II workbook. For our specific example, TANKS 4.09D calculated 23.22 pounds that corresponds to 0.0116 tpy.