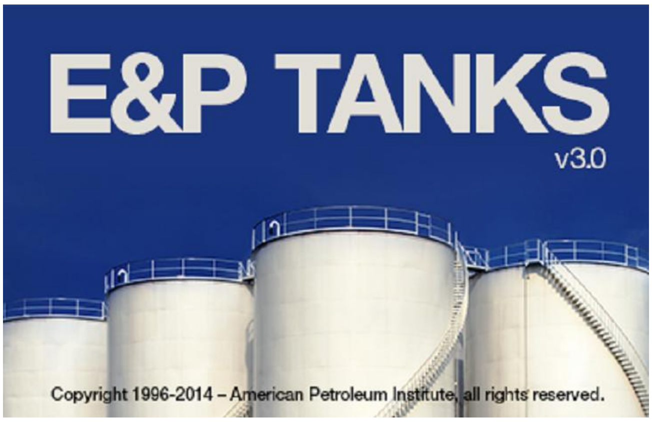
AMERICAN PETROLEUM INSTITUTE



# Production Tank Emissions Model,
# E&P TANK Version 3.0

# User’s Manual

# Chapter 1: Introduction

## Welcome

Welcome to E&P TANK Version 3.0, a software program that predicts hydrocarbon emissions from production oil tanks. This version of E&P TANK is compatible with both 32-bit and 64-bit Windows 7 as well as Windows 2000/XP/Vista.

## What's New in This Version

The new capabilities and functions of E&P TANK v3.0 include:

### 1. Plus Fraction Characterization Algorithm

A flexible plus fraction ($C_n$+) characterization algorithm has been implemented in this version. Users have the option of inputting inlet streams containing $C_7$+, $C_8$+, $C_9$+, or $C_{10}$+ component groups depending on the data availability from the lab analysis. The fluid is characterized by employing an exponential distribution function to estimate the composition profile of the heaviest components and a re-grouping and averaging process to generate the critical properties for five (5) pseudo-components to represent the plus fraction with carbon number greater than 7.

### 2. Updated with the Stream Input Algorithm

Modifications have been made on the existing four (4) options of the stream input.

- Low Pressure Oil – This option is used as direct input for emission calculations. In this case, the low pressure oil from the separator is passed through a flash valve in which the pressure is reduced. The flash loss is estimated based on the conditions of the separator as well as the ambient temperature and pressure. A pressure-enthalpy (P-H) flash calculation is used to take into account the pressure drop. In addition, the separator temperature and pressure are also required for the calculation of the specific gravity of flash oil. The characterization of $C_n$+ fraction as described above is performed prior to the flash calculation.
- High Pressure Oil – This option has been updated. An initial calculation is performed to estimate the composition of low pressure oil. The estimated composition of the low pressure oil is used in the algorithm for low pressure oil input as described above to calculate the flash loss and the specific gravity of flash oil.
- Low Pressure Gas – This option has been revised. Molar ratios ($C_7$:$C_8$:$C_9$:$C_{10}$) are no longer required as inputs. Instead, the gas-oil ratio (GOR) is a required input to

generate the composition of high pressure oil through iterative calculations. Once the high pressure oil composition is obtained, the program uses the procedures described in the "High Pressure Oil" section are used to estimate the flash losses and specific gravity of the flash oil.

- Geographic Database – This option is used in the cases where lab analysis is not available. The existing database remains unchanged from v2.0 and contains 103 cases divided into four geographic regions and classified by sales oil properties (API and RVP) and separator conditions (temperature and pressure).

### 3. Mass Balance and Green House Gas Emission Calculations

A mass balance routine is used to calculate and display the emission results for the flash gas loss, the W/S gas losses, and total emission. The report also displays the uncontrolled emissions of $CO_2$ and $CH_4$ separately in addition to total HAPs, total HC, and VOCs (both controlled and uncontrolled).

### 4. Monthly Reports

An option has been added to display the results of emission calculations for the production tanks on a monthly basis to reflect differences in ambient and tank operating conditions from month to month during the year. Input stream composition and separator conditions are assumed to be constant and cannot be varied on a monthly basis.

Both the RVP Distillation Column model and the AP-42 model can be used to perform monthly calculations. If the RVP Distillation Column model is chosen, the required monthly inputs are ambient temperatures, ambient pressures, and average daily production rates for sales oil. If the AP-42 model is chosen, the additional inputs required include the monthly average highest and lowest ambient daily temperatures and the solar insolation factor for each month based on meteorological data. The emission results based on the selected months as well as the total emission for the selected time period are displayed in a table format and can be exported to an Excel file or a text file and plotted for comparison.

### 5. Modifications to the Graphical User Interface (GUI)

The GUI has been significantly improved to include the new functions and calculation routines. Specifically, the major improvements include:

- Compatibility with 32-bit and 64-bit Windows 7, and Windows XP operating systems.
- Measurement unit system options – The user may select either English or SI units or create his/her own unit system by mixing the two unit systems (for example, bar for pressure and °C for temperature).
- A choice of either monthly or yearly report display options.

- The ability to export input / output results to MS Excel spreadsheet.

### 6. Compatibility between Version 2.0 and Version 3.0

The program v3.0 can open a case created by v2.0 and re-save it as v3.0 case which will be indicated as .ept3 as compared to .ept in v2.0. However, cases saved in v3.0 (.ept3) cannot be opened or processed by v2.0 software.

# About E&P TANK Version 3.0

Petroleum production tank batteries are prevalent within the petroleum industry's exploration and production (E&P) sector. Tank operators are required to quantify and report certain tank emissions. These may include both Hazardous Air Pollutants (HAPs) and Volatile Organic Compounds (VOCs). The following table shows the types of HAPs and VOCs considered in this program.

| *HAPs* | *VOCs* | |
|---|---|---|
| Benzene | Methane | Octanes |
| Toluene | Ethane | Nonanes |
| Ethyl-Benzene | Propane | Benzene |
| Xylenes | n-Butane | Toluene |
| n-Hexane | i-Butane | Ethyl-Benzene |
| | n-Pentane | Xylenes |
| | i-Pentane | Heptanes+ |
| | n-Hexane | Octanes+ |
| | Hexanes | Nonanes+ |
| | Heptanes | Decanes+ |

A study previously undertaken by the API evaluated alternatives for quantifying the hydrocarbon emissions from petroleum production tanks [1]. The study concluded that direct field sampling and analysis from each production tank were deemed not feasible from economic and technical viewpoints. Therefore, development of a computer-based simulator for estimating emissions was recommended.

The calculation algorithm of this software follows the recommendation of a previous API study [1]. A steady-state model is used to simulate petroleum production tank operations. The contribution by flash losses to the total vent from the tanks is calculated rigorously according to thermodynamic principles. The working and standing losses are simulated differently depending upon the nature of the tank. For oil production tanks, the working and standing losses are represented by a distillation column operation, either of which will generate a certain amount of vaporization so that the characteristics of the produced liquid matches the sales oil specifications such as Reid Vapor Pressure (RVP). In addition, a modified AP-42 method may be used instead of the distillation column method for calculating working and standing losses from oil production tanks. For storage tanks containing stable oil or sales oil, the work and standing losses are calculated by a modified AP-42 method.

# Chapter 2: Installation and Security Methods

## System Requirements

Standalone PC Edition

- 70 MB free hard disk space
- Printer (optional)
- Microsoft Windows 7/XP/2000/Vista
- Microsoft Excel (for option to export)

Network Edition

- Microsoft Network TCP/IP

## Installing E&P TANK v3.0

1. Find the .msi file and double click it to start the installation
2. Change the default E&P TANK directory if desired

After installation, the E&P TANK program group will be created. The default installation directory is: C:\Program Files\API\ EP Tank 3.0.

For further details please refer to the document EP_TanksV3_Installtion_Guide.pdf. Which is can be downloaded by clicking the link.

**Note:** *If there is already a version (including demos) of E&P TANK on your system, please uninstall the existing version first. For further information on uninstalling, refer to your Microsoft Windows Help system. Please ensure the regional language settings are English (US or Canada) otherwise some features will not be accessible.*

# Chapter 3: Getting Started

## Starting and Exiting E&P TANK Version 3.0

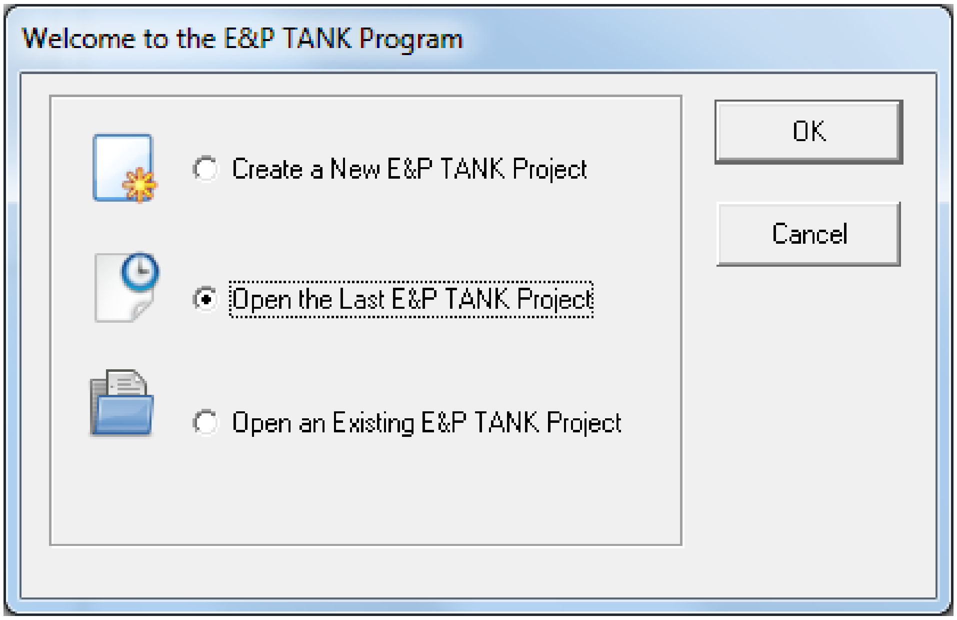
### To Start E&P TANK v3.0

1. Select E&P TANK from Program in the Start menu of the Windows Taskbar,

   -or-

   Double-click EPTANK.exe file in the installation folder through Windows Explorer.

An introductory screen followed by the welcome window appears.



○ Create a New E&P TANK Project
● Open the Last E&P TANK Project
○ Open an Existing E&P TANK Project

*Welcome to the E&P TANK Program*

2. In the **Welcome to the E&P TANK Program** dialog, select appropriate option to open a new project, the last project, or an existing project and click **OK**.

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***Note:*** *The security method must be properly configured to run E&P Tank. To see how to setup security method, please refer to Chapter 2.*

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### To Exit E&P TANK v3.0

Do one of the following:

- Click **Exit** from the **File** menu.
- Click on the **Close Box** on the E&P TANK title bar.
- Right click on the E&P TANK title bar and select **Close**.

## Basic Steps to Generate an E&P TANK Project

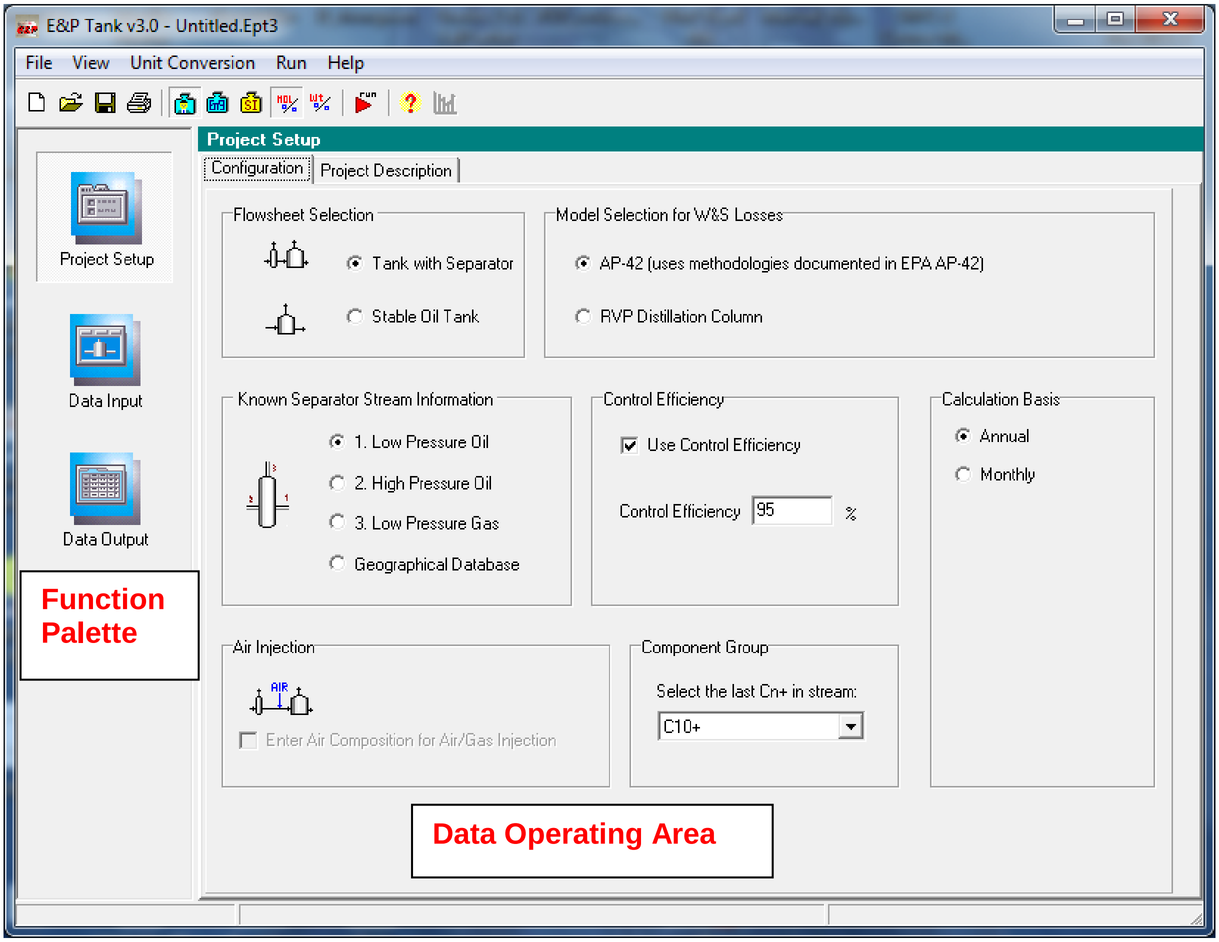
The basic steps to create a project using E&P TANK v3.0:

1. Open a new project.
2. In the Project Setup window:
    - Select a flowsheet and a calculation model
    - Specify necessary setup information
    - Provide the project information if available
3. In the Data Input window, provide inputs via hotspots (devices or flow lines) on the input flowsheet.
4. Execute calculations.
5. View and print results.
6. Save the project.

## Working Environment

The application window of E&P TANK v3.0 can be divided into two main areas:

- Function Palette
- Data Operating Area



**Project Setup**

Configuration | Project Description

Flowsheet Selection
● Tank with Separator
○ Stable Oil Tank

Model Selection for W&S Losses
● AP-42 (uses methodologies documented in EPA AP-42)
○ RVP Distillation Column

Known Separator Stream Information
● 1. Low Pressure Oil
○ 2. High Pressure Oil
○ 3. Low Pressure Gas
○ Geographical Database

Control Efficiency
☑ Use Control Efficiency
Control Efficiency 95 %

Calculation Basis
● Annual
○ Monthly

Air Injection
☐ Enter Air Composition for Air/Gas Injection

Component Group
Select the last Cn+ in stream: C10+

*The E&P TANK Application Window*

Located in the left pane, the Function Palette consists of navigating buttons. Upon clicking on a navigating button, the Data Operating Area to the right of the Function Palette displays the corresponding window. There are three operating windows in E&P TANK:

- Project Setup
- Data Input
- Data Output

The Data Operating Area occupies the right pane of the application window. It displays the corresponding worksheet that you select from the Button Palette. The Data Operating Area is the main working area where you can input data and view calculation results.

# Default Unit System Selection

The Default Unit System Selection allows the option to work with the English units, the SI Units or the Customized Units.

Default Unit System Selection
○ English Units ○ SI Units ● Customized Units

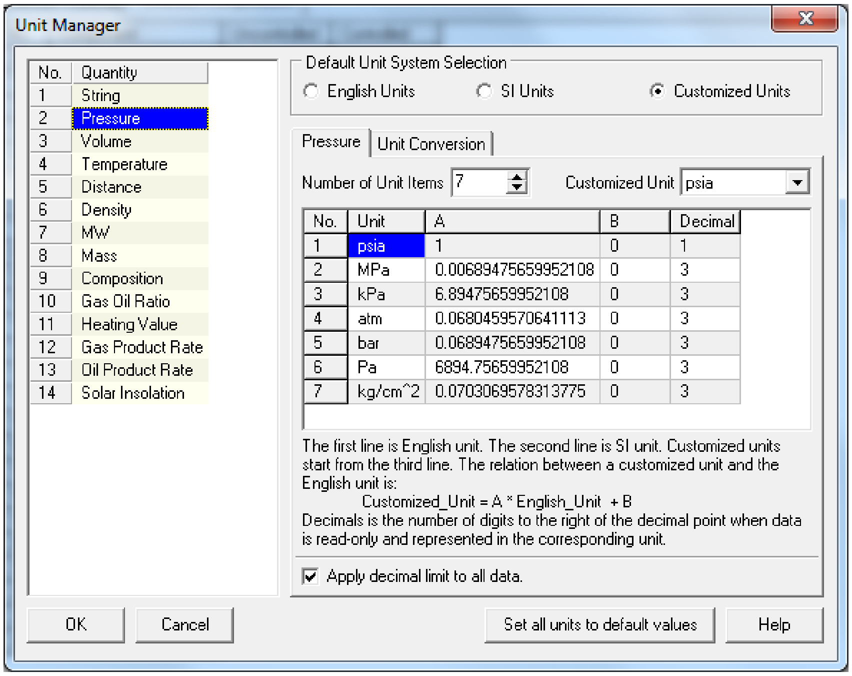
*Default Unit System Selection*

# Unit Manager

Select “Unit Conversion” on the primary menu and then “Start Unit Manager…”. The Unit Manager window is composed of three main sections:

- The default unit system selection
- The parameter tab
- The parameter selection on the left corner

The parameter (Pressure, Volume, Temperature etc.) tab, displays the number of Unit Items, customized units and also a data area where all the conversion parameter values are listed.



| No. | Quantity |
|---|---|
| 1 | String |
| 2 | Pressure |
| 3 | Volume |
| 4 | Temperature |
| 5 | Distance |
| 6 | Density |
| 7 | MW |
| 8 | Mass |
| 9 | Composition |
| 10 | Gas Oil Ratio |
| 11 | Heating Value |
| 12 | Gas Product Rate |
| 13 | Oil Product Rate |
| 14 | Solar Insolation |

Default Unit System Selection
○ English Units ○ SI Units ● Customized Units

Pressure

Number of Unit Items 7

Customized Unit psia

| No. | Unit | A | B | Decimal |
|---|---|---|---|---|
| 1 | psia | 1 | 0 | 1 |
| 2 | MPa | 0.00689475659952108 | 0 | 3 |
| 3 | kPa | 6.89475659952108 | 0 | 3 |
| 4 | atm | 0.0680459570641113 | 0 | 3 |
| 5 | bar | 0.0689475659952108 | 0 | 3 |
| 6 | Pa | 6894.75659952108 | 0 | 3 |
| 7 | kg/cm^2 | 0.0703069578313775 | 0 | 3 |

The first line is English unit. The second line is SI unit. Customized units start from the third line. The relation between a customized unit and the English unit is:

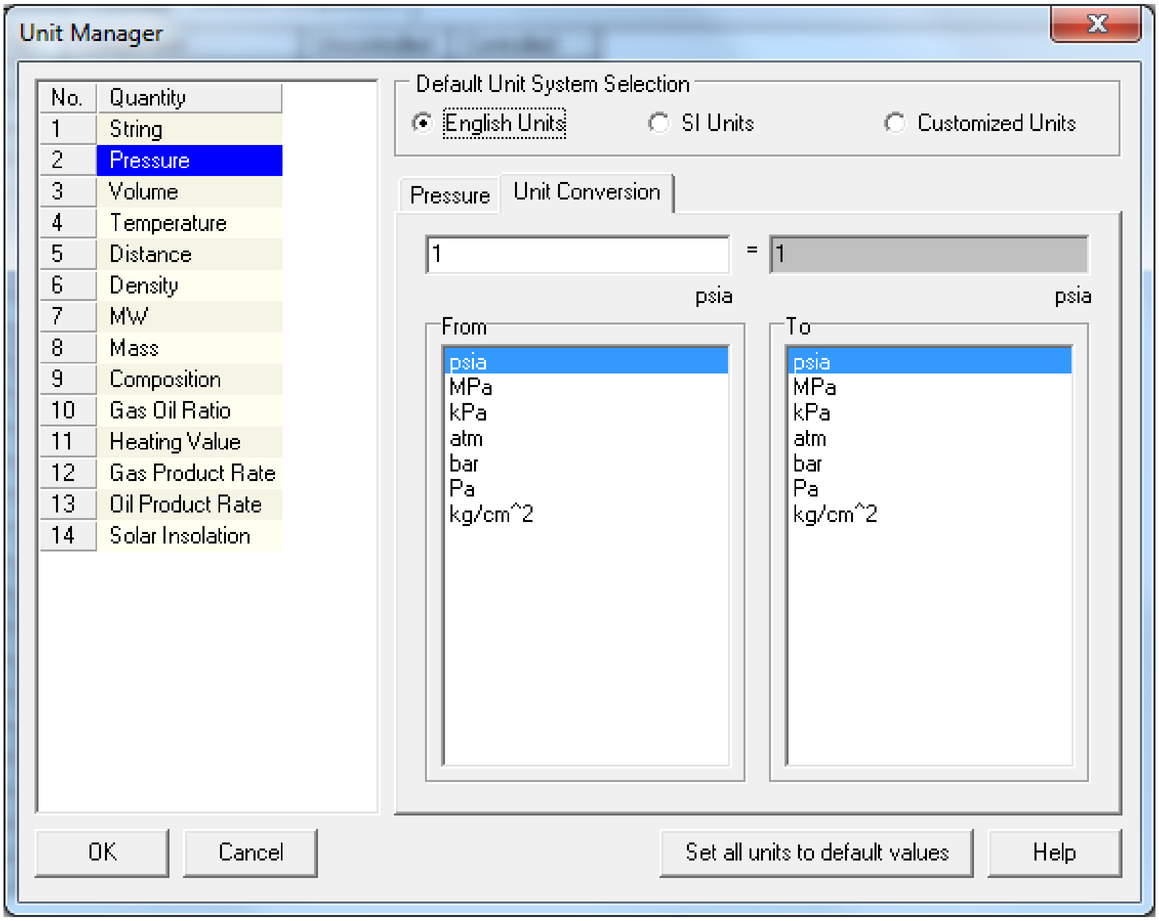
Customized_Unit = A * English_Unit + B

Decimals is the number of digits to the right of the decimal point when data is read-only and represented in the corresponding unit.

☑ Apply decimal limit to all data.

*Conversion Parameters Tab*

There are two unit systems available in E&P TANK: **English** and **SI** units. Users may choose to view data and print projects in either of the units, regardless of which system was used in data input. To select a unit system, click on the appropriate unit buttons on the toolbar or select from the **Unit Conversion** menu. Besides selecting the unit system, users may select mol % or wt % from the toolbar or the Unit Conversion menu.



| No. | Quantity |
|---|---|
| 1 | String |
| 2 | Pressure |
| 3 | Volume |
| 4 | Temperature |
| 5 | Distance |
| 6 | Density |
| 7 | MW |
| 8 | Mass |
| 9 | Composition |
| 10 | Gas Oil Ratio |
| 11 | Heating Value |
| 12 | Gas Product Rate |
| 13 | Oil Product Rate |
| 14 | Solar Insolation |

Default Unit System Selection
● English Units ○ SI Units ○ Customized Units

1 psia = 1 psia

From: psia, MPa, kPa, atm, bar, Pa, kg/cm^2

To: psia, MPa, kPa, atm, bar, Pa, kg/cm^2

*Unit Conversion*

To perform unit conversions:

- Select the unit to be converted "from", by scrolling through the list of units in the "from" field.
- Select the unit to be converted "to", by scrolling through the list of units in the "To" window.
- Input the Value to be converted in the white blank area.

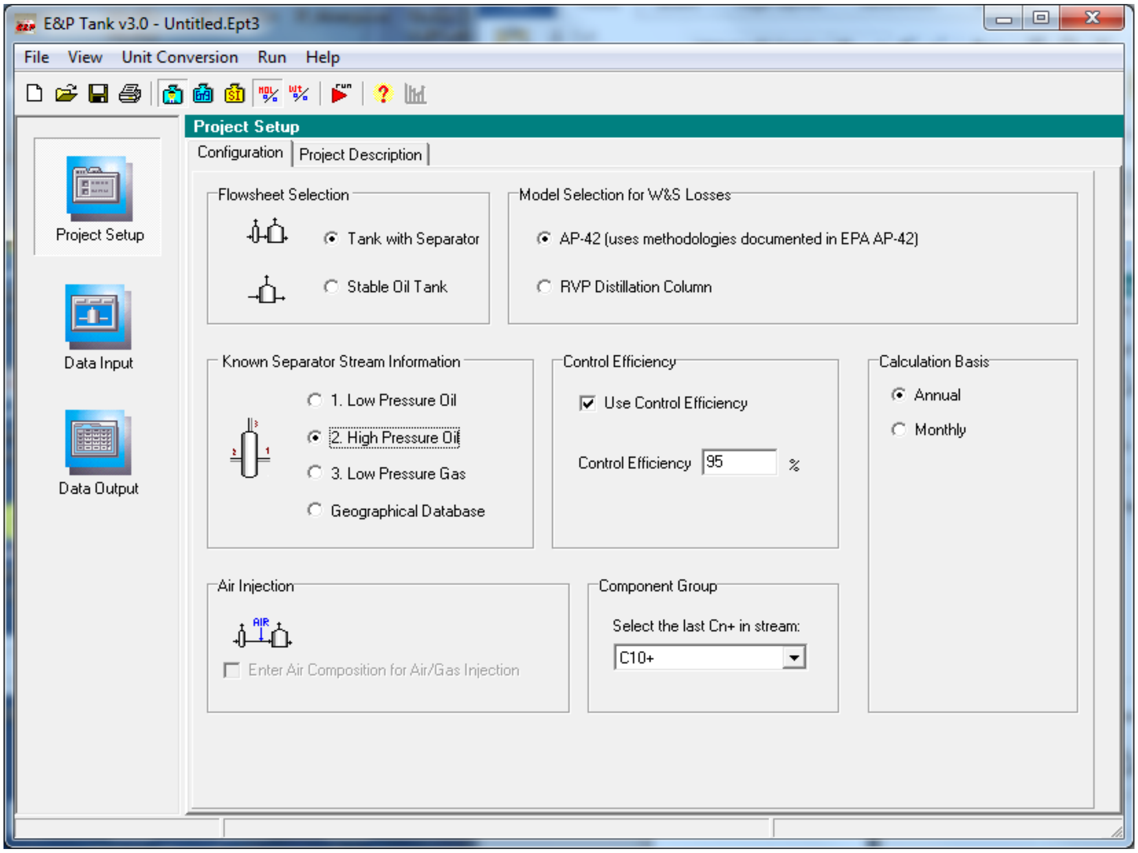
# Chapter 4: Using E&P TANK Version 3.0

## Creating a New Project

When you are starting E&P TANK v3.0:

In the welcome window, select **Create a New E&P TANK Project** and click OK.
-or-
While you are working on another project, click on the **New Project** button on the toolbar or select New from the File menu.

## Project Setup



Flowsheet Selection
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Known Separator Stream Information
○ 1. Low Pressure Oil
● 2. High Pressure Oil
○ 3. Low Pressure Gas
○ Geographical Database

Control Efficiency
☑ Use Control Efficiency
Control Efficiency 95 %

Calculation Basis
● Annual
○ Monthly

Air Injection
☐ Enter Air Composition for Air/Gas Injection

Component Group
Select the last Cn+ in stream:
C10+

*Project Setup*

## To Setup a Project

1. On the **Configuration** tab in the Project Setup window:
   a. Make a **Flowsheet Selection**
   b. Select a model to calculate **Working and Standing (W&S) losses**. Regardless of which model you select in step 2, E&P TANK uses the Peng-Robinson equation of state to calculate flash loss.
   c. If the flowsheet with separator was selected in Step 1a, select a **Separator Stream** for which compositional information is known.
   d. Click to select **Control Efficiency** and specify the percentage, if desired.
   e. Select **Calculation Basis**. If "**Monthly**" is selected, specify which month(s) to calculate.
   f. Make a **Component Group** selection from the drop-down menu reflecting the last $C_n$+ in the input stream analytical data.
   g. If you select flowsheet with separator in Step 1a and RVP as calculation model in Step 1b, the **Air Injection** option will be available for you to specify the daily air injection.
2. Switch to the **Project Description** tab to enter details about the facility. This information will help identify the project.

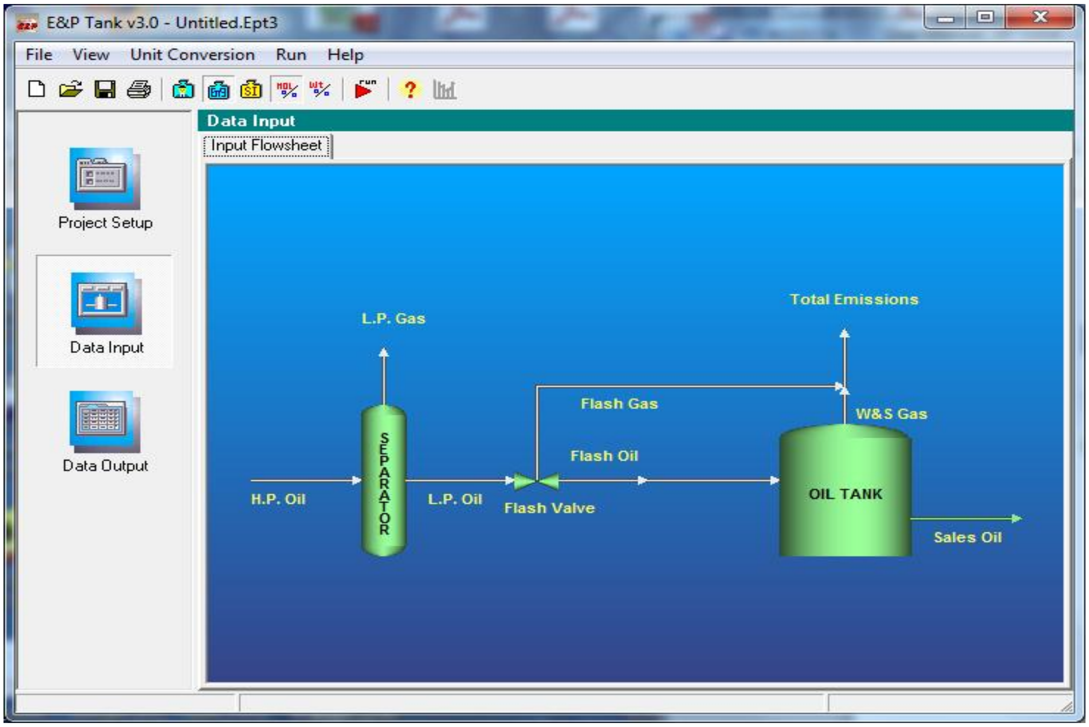
***Note:*** *Once a $C_n$+ group is selected and the characterization is completed, the component group selection option will be dimmed and changes in the $C_n$+ group will not be allowed.*

# Data Input

The Data Input flowsheet is object oriented. The flowsheet changes according to your project setup. Hotspots are colored green in the flowsheet.

Some but not all of the following inputs are required for each project:

- Separator
- Stable Oil Tank
- Stable Oil and Sales Oil
- Flash Valve Inputs
- Air Injection



*Input Flowsheet: Tank with Separator*

## Separator

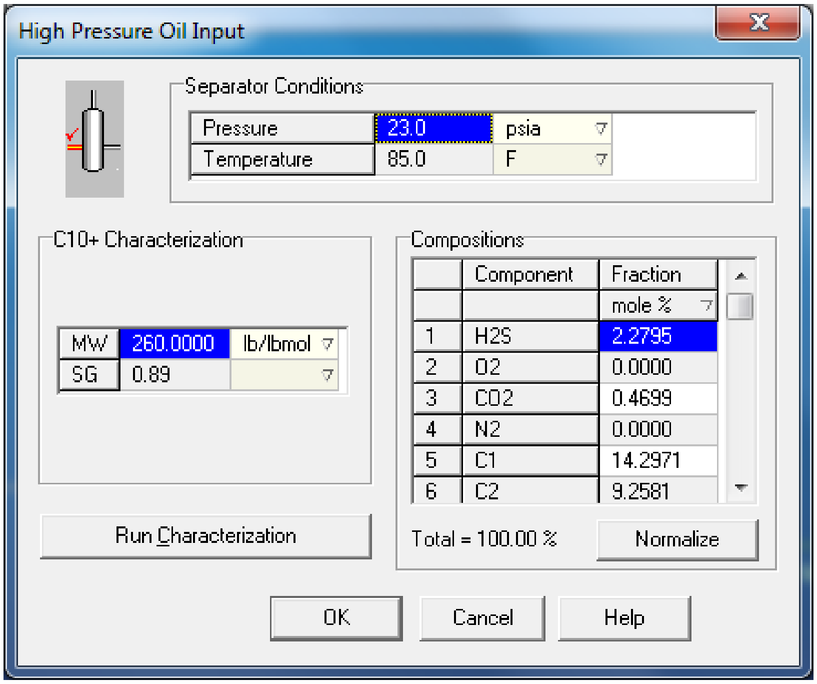
Users enter the input data such as separator conditions and detailed compositional data for separator oil or gas. The input varies according to your selection of **Known Separator Stream Information** in the Project Setup window.

### Data Input for Low Pressure or High Pressure Oil

If Low Pressure Oil or High Pressure Oil is selected as the known separator stream in Project Setup, an input dialog similar to the one shown in the following will appear when you click on the **Separator** hotspot.

To input data for the LP/HP Oils:

1. Click on the **Separator** hotspot on the Input Flowsheet. The input dialog appears.



Separator Conditions

| | | |
|---|---|---|
| Pressure | 23.0 | psia |
| Temperature | 85.0 | F |

C10+ Characterization

| | | |
|---|---|---|
| MW | 260.0000 | lb/lbmol |
| SG | 0.89 | |

Compositions

| | Component | Fraction |
|---|---|---|
| | | mole % |
| 1 | H2S | 2.2795 |
| 2 | O2 | 0.0000 |
| 3 | CO2 | 0.4699 |
| 4 | N2 | 0.0000 |
| 5 | C1 | 14.2971 |
| 6 | C2 | 9.2581 |

Total = 100.00 %

*Separator: High Pressure Oil Input*

2. Provide **Separator Conditions**: **Pressure** and **Temperature**.

   *(Note: clicking on the triangular icon adjacent to the unit values allows the user to modify the units for the associated inputs)*

3. Enter the **Composition** of the low-pressure or high-pressure oil.

4. Provide the characterization properties of molecular weight (**MW**) and specific gravity (**SG**) for the $C_n$+ fraction where n equals 7, 8, 9, or 10 based on the selection made during **Project Setup**.

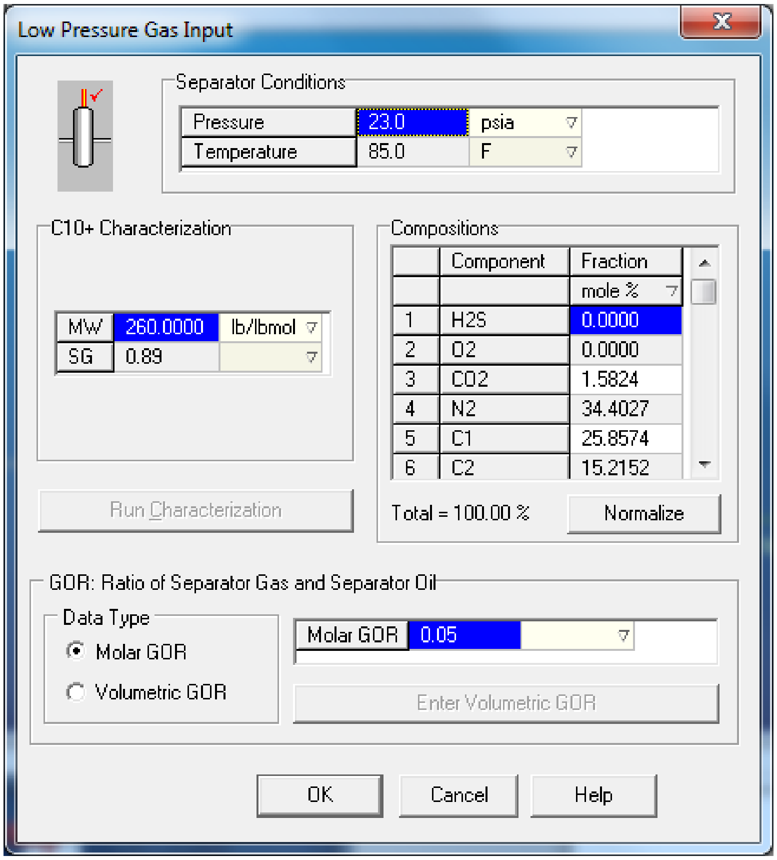
5. Click **OK** to exit the dialog.

## Low Pressure Gas Input

If Low Pressure Gas is selected as the known separator stream in Project Setup, the Low Pressure Gas Input dialog will appear when you click on the **Separator** hotspot.

To specify low pressure gas:

1. Click on the **Separator** hotspot on the Input Flowsheet. The **Low Pressure Gas Input** dialog appears.



Separator Conditions

| | | |
|---|---|---|
| Pressure | 23.0 | psia |
| Temperature | 85.0 | F |

C10+ Characterization

| | | |
|---|---|---|
| MW | 260.0000 | lb/lbmol |
| SG | 0.89 | |

Compositions

| | Component | Fraction |
|---|---|---|
| | | mole % |
| 1 | H2S | 0.0000 |
| 2 | O2 | 0.0000 |
| 3 | CO2 | 1.5824 |
| 4 | N2 | 34.4027 |
| 5 | C1 | 25.8574 |
| 6 | C2 | 15.2152 |

Total = 100.00 %

GOR: Ratio of Separator Gas and Separator Oil

Data Type

● Molar GOR

○ Volumetric GOR

Molar GOR 0.05

*Separator: Low Pressure Gas Input*

2. Provide **Separator Conditions**: **Pressure** and **Temperature**.
3. Enter **Compositional** data for each component.
4. Provide the characterization properties of molecular weight (**MW**) and specific gravity (**SG**) for the $C_n$+ fraction where n equals 7, 8, 9, or 10, based on the selection made during **Project Setup.**
5. Select **Molar GOR** or **Volumetric GOR**:

   If **Molar GOR** is selected, enter the value in the **Molar GOR** box.

   If **Volumetric GOR** is selected, click **Enter Volumetric GOR** and then **Enter GOR** dialog appears. Enter volumetric GOR, oil density and MW. Click **Convert to Molar GOR**. You will return to the **Low Pressure Gas Input** dialog.
6. Click **OK** to exit the **Low Pressure Gas Input** dialog.

---

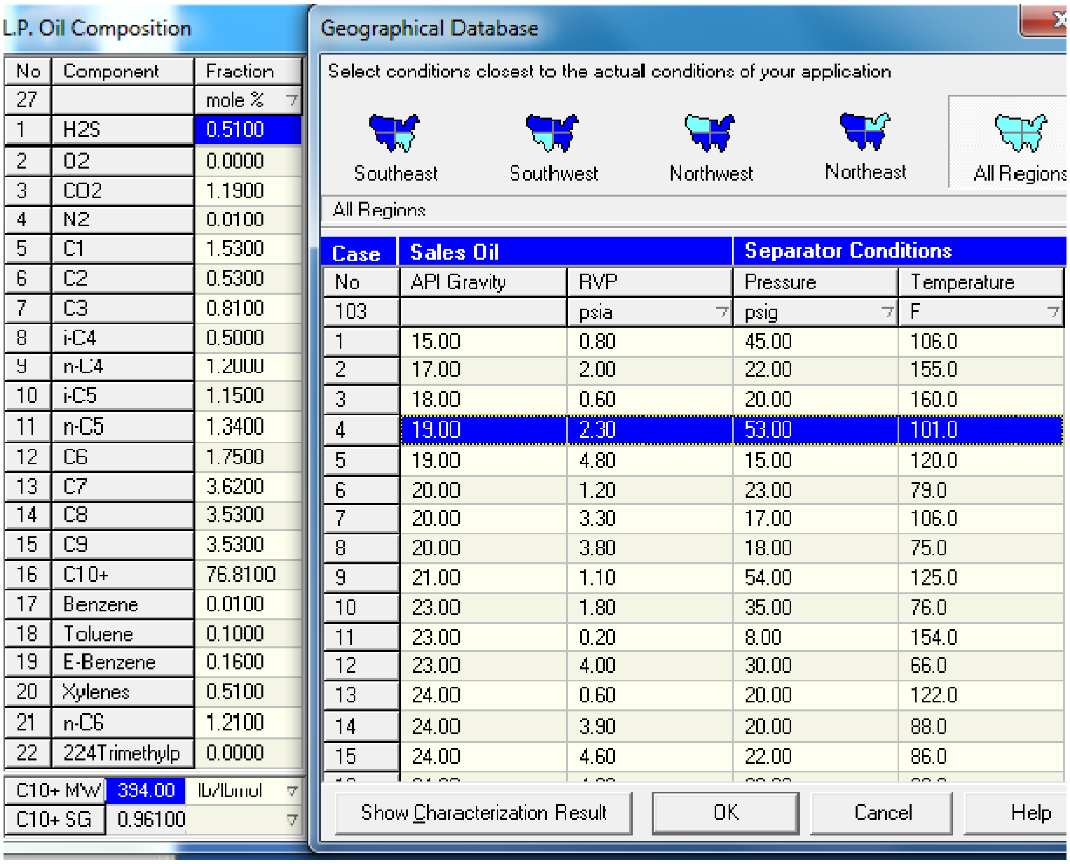
***Note:*** *If the separator pressure data are in units of psig, the user should convert to psia. Since the local ambient pressure varies with elevation and meteorological conditions, the program requires the user to enter pressure in absolute units.*

## Geographical Database

If you do not have any stream data on the separator, you may select the **Geographical Database** option in the **Project Setup** window. This option offers a selection of 103 cases that are stored in a database sorted according to their geographical regions, sales oil, and separator conditions. The parameters for each case are taken from actual field data. The separator oil compositions are also associated with the selection of these cases. Hence, the separator compositions are automatically fixed upon the selection of a geographical site and a specific case.

To select a case from the database:

1. Click on the **Separator** hotspot on the Input Flowsheet. The **Geographical Database** dialog appears.



| No | Component | Fraction |
|---|---|---|
| 27 | | mole % |
| 1 | H2S | 0.5100 |
| 2 | O2 | 0.0000 |
| 3 | CO2 | 1.1900 |
| 4 | N2 | 0.0100 |
| 5 | C1 | 1.5300 |
| 6 | C2 | 0.5300 |
| 7 | C3 | 0.8100 |
| 8 | i-C4 | 0.5000 |
| 9 | n-C4 | 1.2000 |
| 10 | i-C5 | 1.1500 |
| 11 | n-C5 | 1.3400 |
| 12 | C6 | 1.7500 |
| 13 | C7 | 3.6200 |
| 14 | C8 | 3.5300 |
| 15 | C9 | 3.5300 |
| 16 | C10+ | 76.8100 |
| 17 | Benzene | 0.0100 |
| 18 | Toluene | 0.1000 |
| 19 | E-Benzene | 0.1600 |
| 20 | Xylenes | 0.5100 |
| 21 | n-C6 | 1.2100 |
| 22 | 224Trimethylp | 0.0000 |

C10+ MW 394.00 lb/lbmol
C10+ SG 0.96100

Select conditions closest to the actual conditions of your application

All Regions

| Case | Sales Oil | | Separator Conditions | |
|---|---|---|---|---|
| No | API Gravity | RVP | Pressure | Temperature |
| 103 | | psia | psig | F |
| 1 | 15.00 | 0.80 | 45.00 | 106.0 |
| 2 | 17.00 | 2.00 | 22.00 | 155.0 |
| 3 | 18.00 | 0.60 | 20.00 | 160.0 |
| 4 | 19.00 | 2.30 | 53.00 | 101.0 |
| 5 | 19.00 | 4.80 | 15.00 | 120.0 |
| 6 | 20.00 | 1.20 | 23.00 | 79.0 |
| 7 | 20.00 | 3.30 | 17.00 | 106.0 |
| 8 | 20.00 | 3.80 | 18.00 | 75.0 |
| 9 | 21.00 | 1.10 | 54.00 | 125.0 |
| 10 | 23.00 | 1.80 | 35.00 | 76.0 |
| 11 | 23.00 | 0.20 | 8.00 | 154.0 |
| 12 | 23.00 | 4.00 | 30.00 | 66.0 |
| 13 | 24.00 | 0.60 | 20.00 | 122.0 |
| 14 | 24.00 | 3.90 | 20.00 | 88.0 |
| 15 | 24.00 | 4.60 | 22.00 | 86.0 |

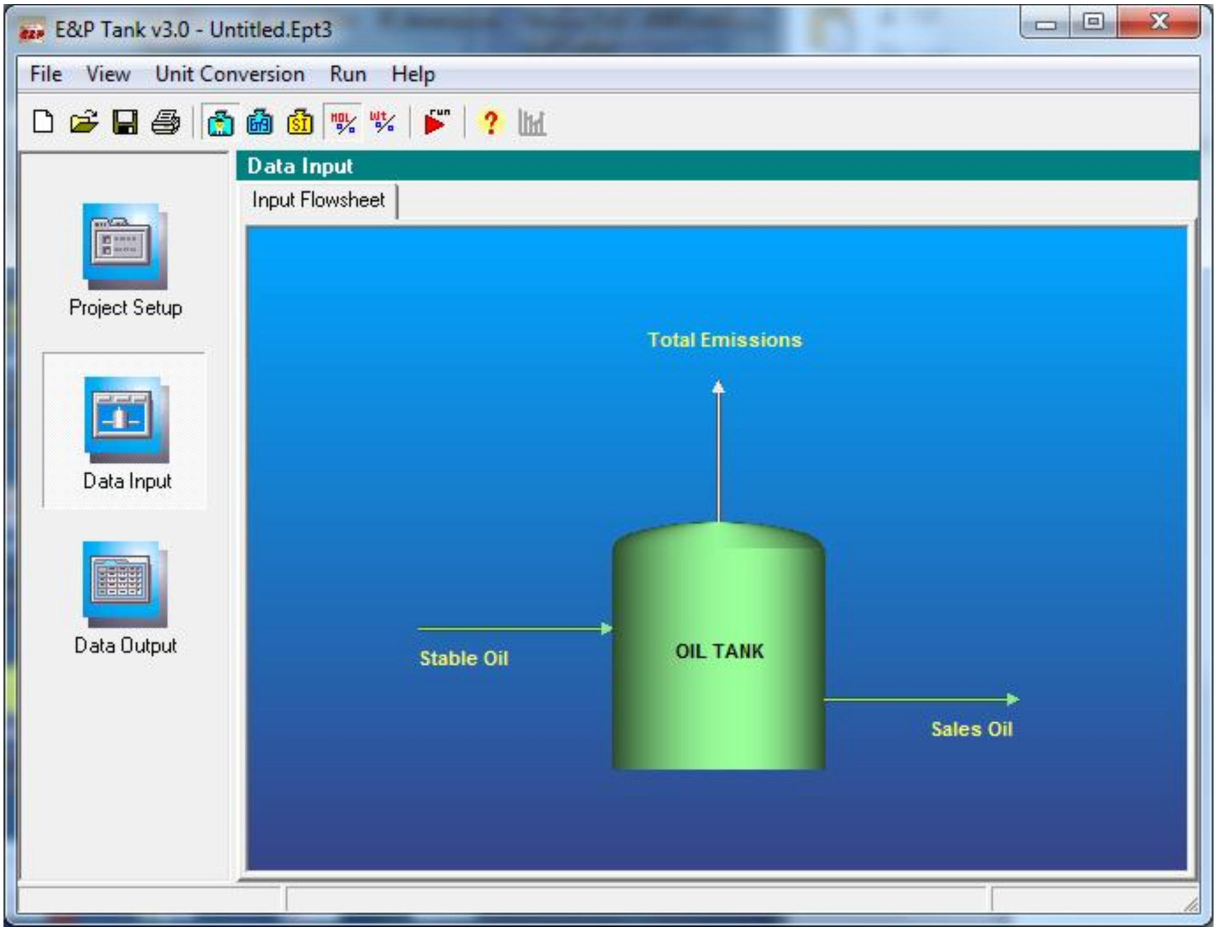
*Separator: Geographical Database*

2. Select a region closest to the actual geographical location of your facility.
3. Select a case closest to the actual sales oil data and separator conditions.

4. After the selections made in Step 2 and Step 3, the composition of the low-pressure oil is automatically displayed in the left pane.
5. Click **OK** to accept selection and exit the dialog.

## Stable Oil Tank

If you select the Stable Oil Tank flowsheet, the program will calculate only the working and standing losses from the storage tank for stable oil.



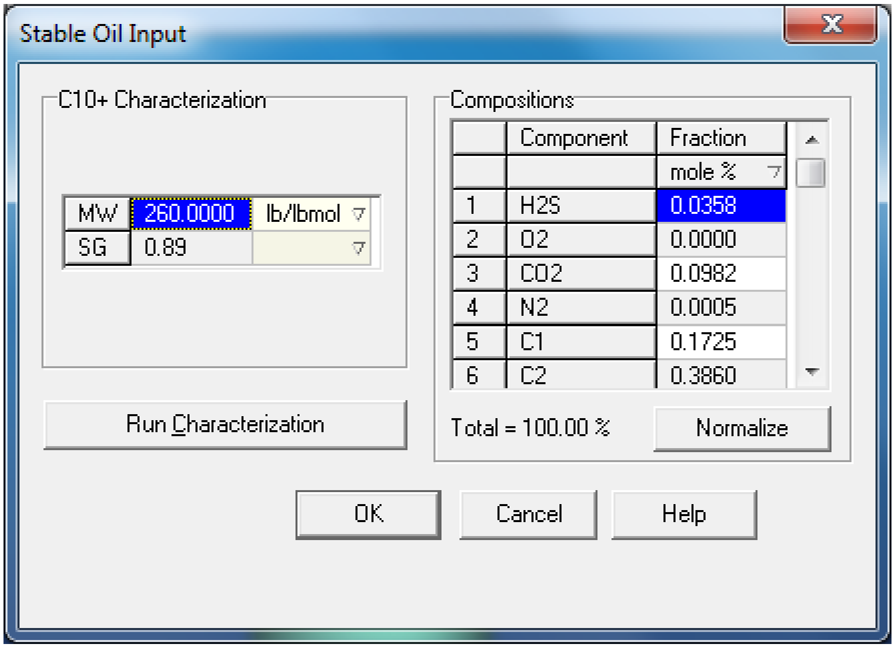
*Data Input Flowsheet: Stable Oil Tank*

### Stable Oil

This input is required if you select the Stable Oil Tank flowsheet. In order to execute the stand-alone AP-42 calculations, users must provide the compositions of the stable oil entering the storage tank.

To specify stable oil:

1. Click on the **Stable Oil** hotspot in the input flowsheet.



| | | |
|---|---|---|
| MW | 260.0000 | lb/lbmol |
| SG | 0.89 | |

| | Component | Fraction |
|---|---|---|
| | | mole % |
| 1 | H2S | 0.0358 |
| 2 | O2 | 0.0000 |
| 3 | CO2 | 0.0982 |
| 4 | N2 | 0.0005 |
| 5 | C1 | 0.1725 |
| 6 | C2 | 0.3860 |

Total = 100.00 %

*Stable Oil Input*

2. Enter the stable oil **Compositions**.

3. Enter the $C_n$+ characterization properties.

4. Click **OK** to return to the Input Flowsheet.

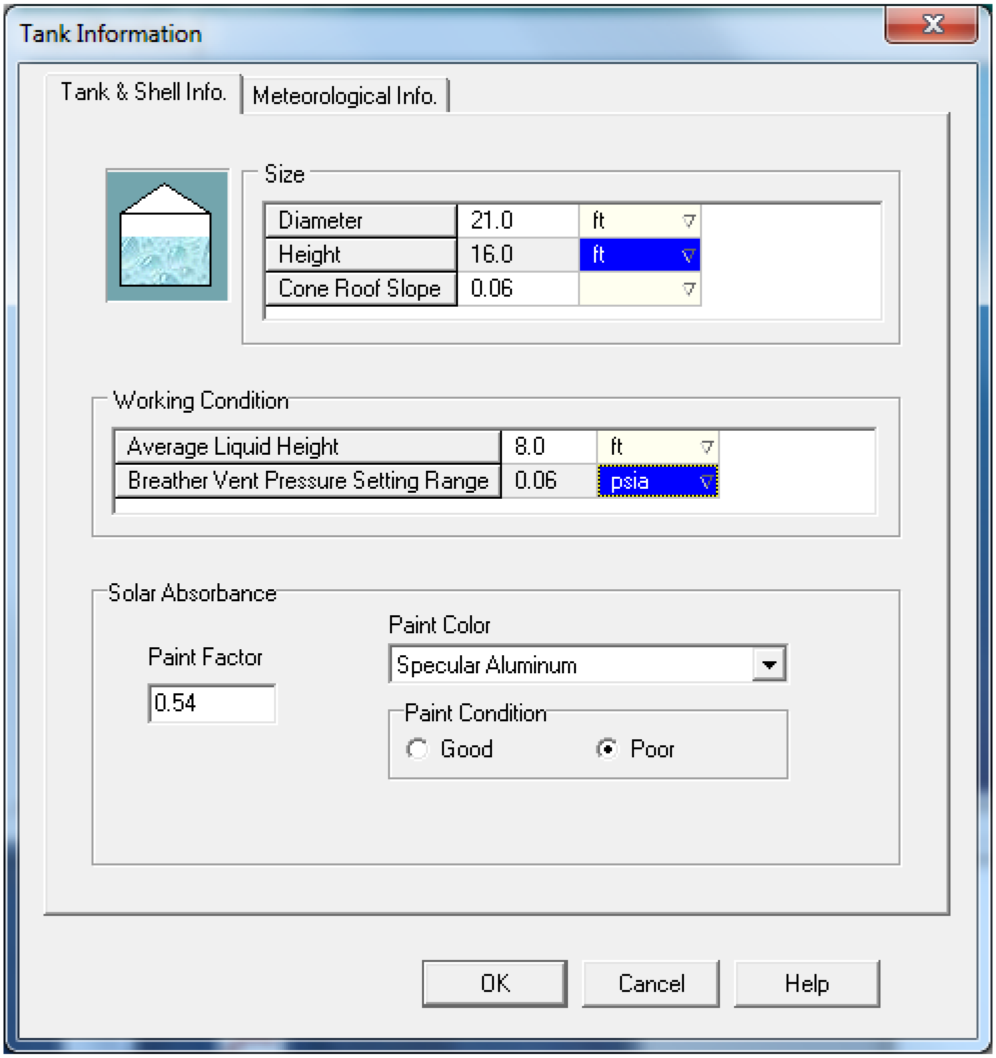
## Tank Information Input

If the AP-42 method is selected for W&S losses during project setup the Oil Tank is presented as a hotspot in the **Data Input** window. Otherwise (RVP Distillation Column Method selected) tank information is not required to estimate the losses and the oil tank is greyed out and disabled as a hotspot.23.

To provide oil tank information:

1. Click on the Oil Tank hotspot to activate the **Tank Information** dialog. There are two tabs in the dialog: **Tank & Shell Info** and **Meteorological Info**.

2. Click on the **Tank & Shell Info.** tab.



Size

| | | |
|---|---|---|
| Diameter | 21.0 | ft |
| Height | 16.0 | ft |
| Cone Roof Slope | 0.06 | |

Working Condition

| | | |
|---|---|---|
| Average Liquid Height | 8.0 | ft |
| Breather Vent Pressure Setting Range | 0.06 | psia |

Solar Absorbance

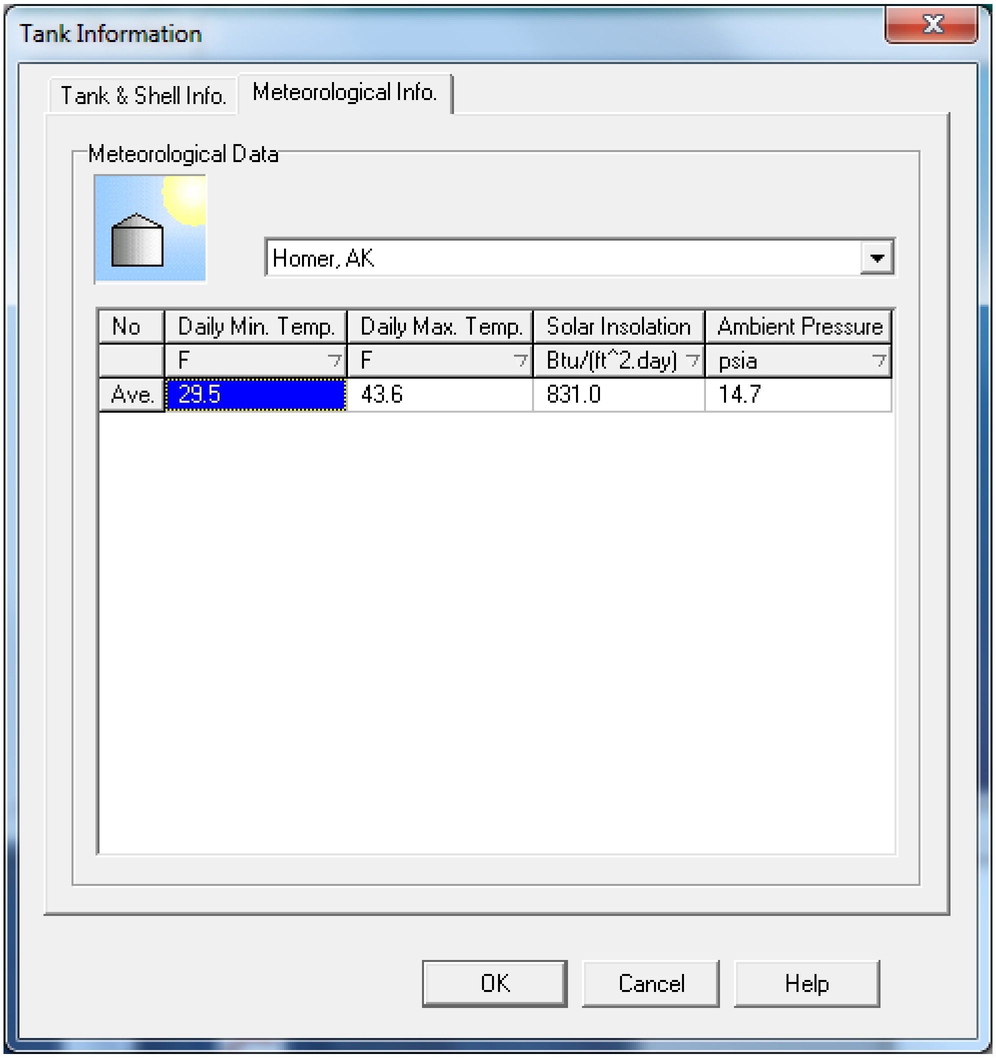
Paint Factor: 0.54

Paint Color: Specular Aluminum

Paint Condition: ○ Good ● Poor

*Oil Tank: Tank & Shell Information*

3. Provide the tank dimensions.
4. Enter normal working conditions such as **Average Liquid Height** and **Breather Vent Pressure Setting Range**.
5. In the **Solar Absorbance** section, select a color from the **Paint Color** box. Click to assign the paint condition. The program will adjust the paint factor accordingly. Otherwise, simply enter the factor, if known, into the **Paint Factor** box directly.
6. Click on the **Meteorological Info.** tab.



Homer, AK

| No | Daily Min. Temp. | Daily Max. Temp. | Solar Insolation | Ambient Pressure |
|---|---|---|---|---|
| | F | F | Btu/(ft^2.day) | psia |
| Ave. | 29.5 | 43.6 | 831.0 | 14.7 |

*Oil Tank: Meteorological Information*

7. Select a city closest to the geographical location of the facility.

8. Upon selecting a US location, the program automatically displays the **Daily Minimum and Maximum ambient temperatures** as well as the **Daily Solar Insolation**. These values may be edited to reflect actual location data, if available. Editing these values is recommended where significant climate differences from the nearest geographical location may exist because of elevation differences or other meteorological factors.

9. Enter the **Ambient Pressure**. This pressure value may have already been updated from the Flash Valve Inputs dialog but may be adjusted here, if necessary.

10. Click **OK** to return to the Input Flowsheet.

---

***Note:*** *The solar absorbance factors of paint are taken from an AP-42 publication [8] based on the conditions of the tank.*

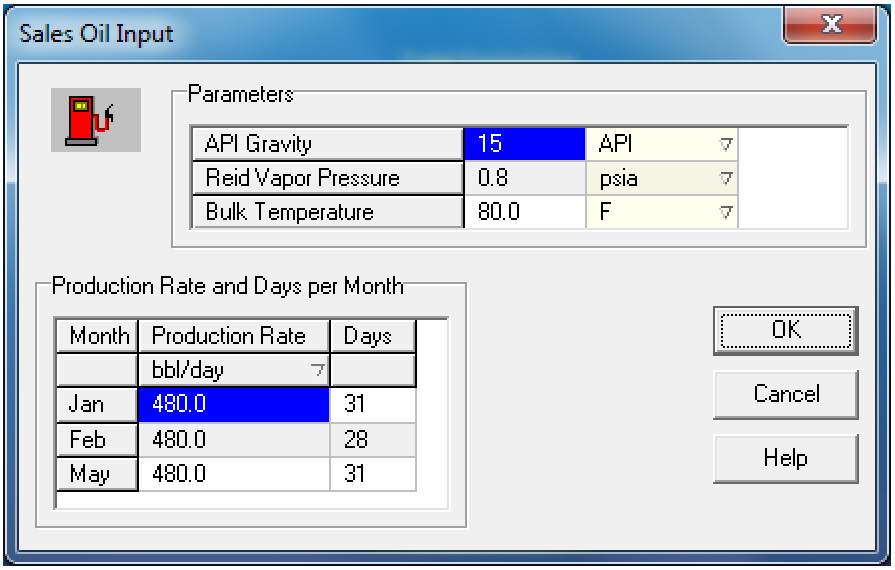
---

## Sales Oil

If the RVP Distillation Column method is selected, the sales oil properties required as inputs in the Sales Oil dialog are production rate, days of annual operation, API gravity, and Reid vapor pressure. If the AP-42 method is selected the bulk temperature of the sales oil is an additional parameter required to be input. These data are commonly available. If the calculation is on the monthly basis, the production rate and actual number of operating days in each month should be entered.

To specify sales oil:

1. Click on the **Sales Oil** hotspot in the Data Input flowsheet.



| | | |
|---|---|---|
| API Gravity | 15 | API |
| Reid Vapor Pressure | 0.8 | psia |
| Bulk Temperature | 80.0 | F |

| Month | Production Rate | Days |
|---|---|---|
| | bbl/day | |
| Jan | 480.0 | 31 |
| Feb | 480.0 | 28 |
| May | 480.0 | 31 |

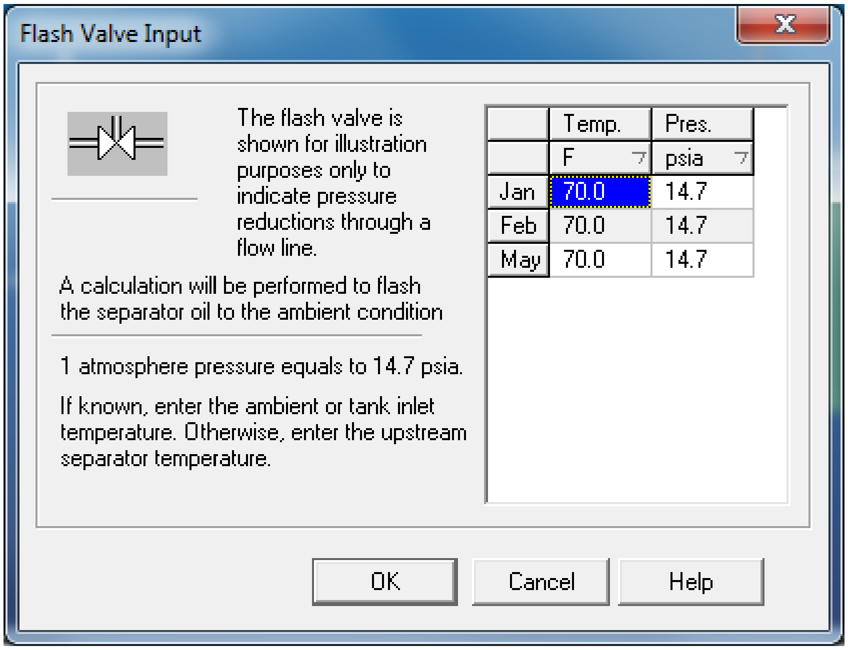
*Sales Oil Input*

2. Enter the sales oil properties in the appropriate boxes.
3. Click **OK** to return to the Input Flowsheet.

## Flash Valve

To specify the flash valve inputs:

1. Click on the **Flash Valve** hotspot in the Data Input flowsheet.



The flash valve is shown for illustration purposes only to indicate pressure reductions through a flow line.

A calculation will be performed to flash the separator oil to the ambient condition

1 atmosphere pressure equals to 14.7 psia.

If known, enter the ambient or tank inlet temperature. Otherwise, enter the upstream separator temperature.

| | Temp. | Pres. |
|---|---|---|
| | F | psia |
| Jan | 70.0 | 14.7 |
| Feb | 70.0 | 14.7 |
| May | 70.0 | 14.7 |

*Flash Valve Inputs*

2. Enter the **Ambient Pressure** and **Ambient Temperature**. If the ambient temperature is unavailable, use temperature of the upstream separator.

3. Click **OK** to return to the Input Flowsheet window.

---

***Note:*** *The flash valve is not a physical piece of equipment. It simply illustrates pressure reduction in a flow line.*

---

## Air Injection

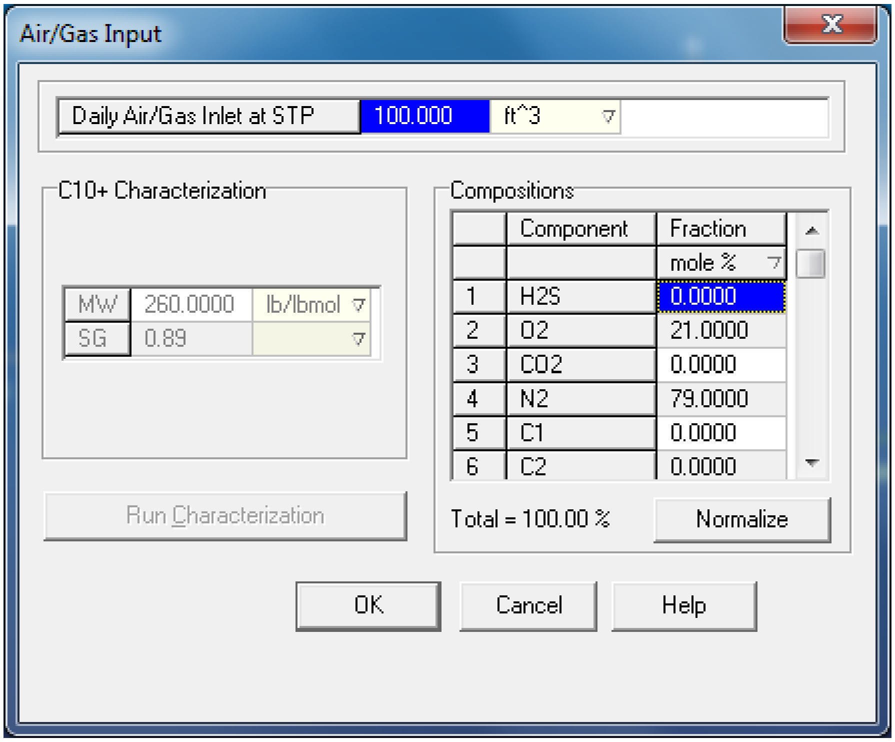
Air or gas injection is optional. It is introduced into the system as an air and/or gas blanket. This option is available to RVP Distillation method only.

To specify an air injection:

1. In Project Setup, select the **Air Injection** box in the **Configuration** tab.

2. Proceed to the Data Input window.

3. Click on the **Air Injection** hotspot on the Input Flowsheet. The **Air/Gas Input** dialog appears.



Daily Air/Gas Inlet at STP 100.000 ft^3

| | | |
|---|---|---|
| MW | 260.0000 | lb/lbmol |
| SG | 0.89 | |

| | Component | Fraction |
|---|---|---|
| | | mole % |
| 1 | H2S | 0.0000 |
| 2 | O2 | 21.0000 |
| 3 | CO2 | 0.0000 |
| 4 | N2 | 79.0000 |
| 5 | C1 | 0.0000 |
| 6 | C2 | 0.0000 |

Total = 100.00 %

*Air Injection*

4. Enter the daily air/gas injection volume.
5. Provide the air/gas **Compositions**.
6. Click **OK** to return to the Input Flowsheet.

# Data Output

Predicted results are viewed in the Data Output window. The program will advance to the Data Output window once the calculations have converged.

## Viewing Calculation Results

The calculated results are presented in the Data Output window. The outputs are shown in four tabs:

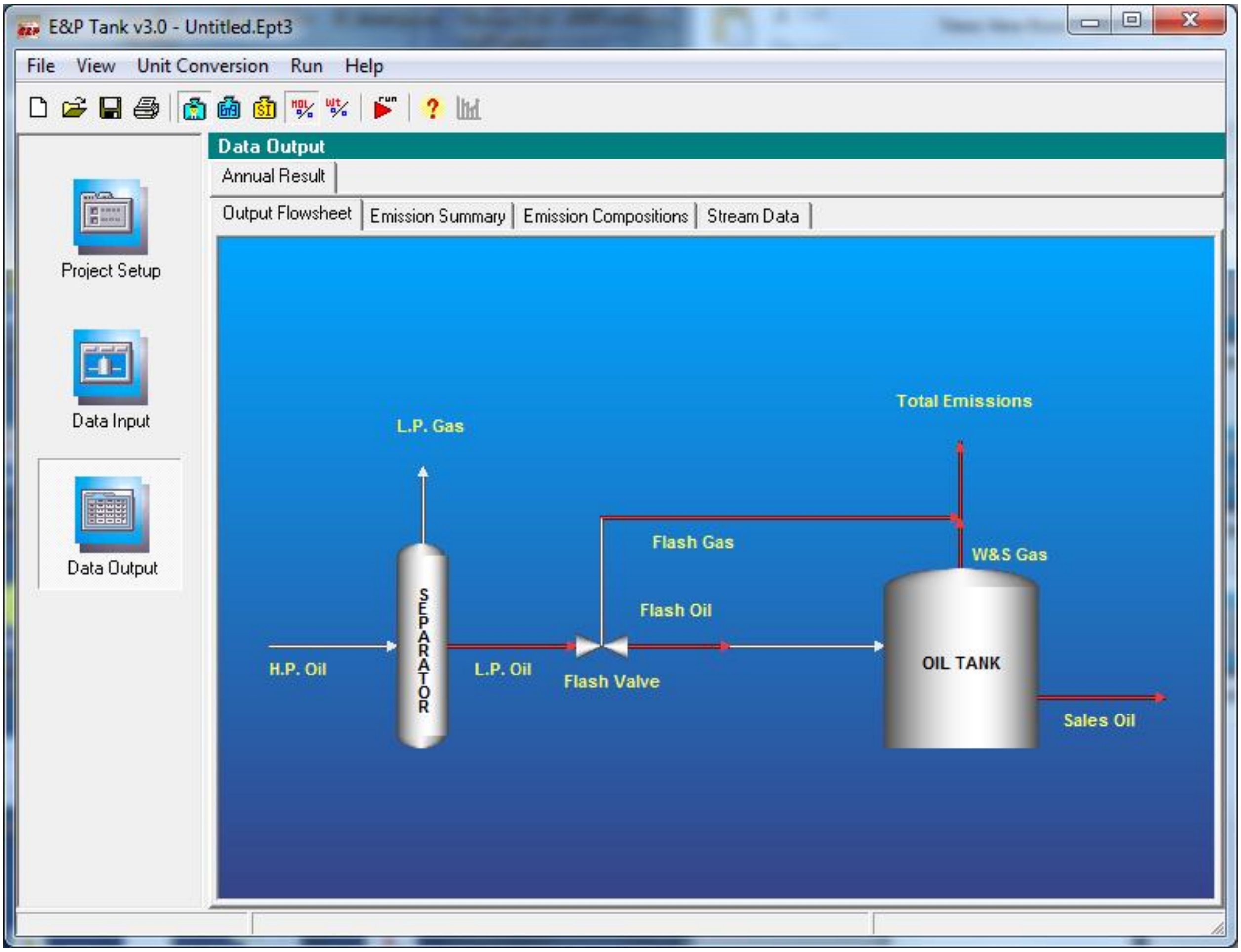
- Output Flowsheet
- Emission Summary
- Emission Compositions
- Stream Data

If monthly calculations are selected, Total HAPs, Total HC, VOCs, and emissions of $CO_2$ and $CH_4$ are tabulated for comparison on a monthly basis and monthly plots are available by clicking on the 'chart' icon on the toolbar.

## Output Flowsheet

Clicking on a hotspot (colored red) in the Output Flowsheet activates a pop-up dialog that consists of compositional information and stream properties for the selected hotspot.

***Note:*** Output flowsheet is not available when running monthly calculations.

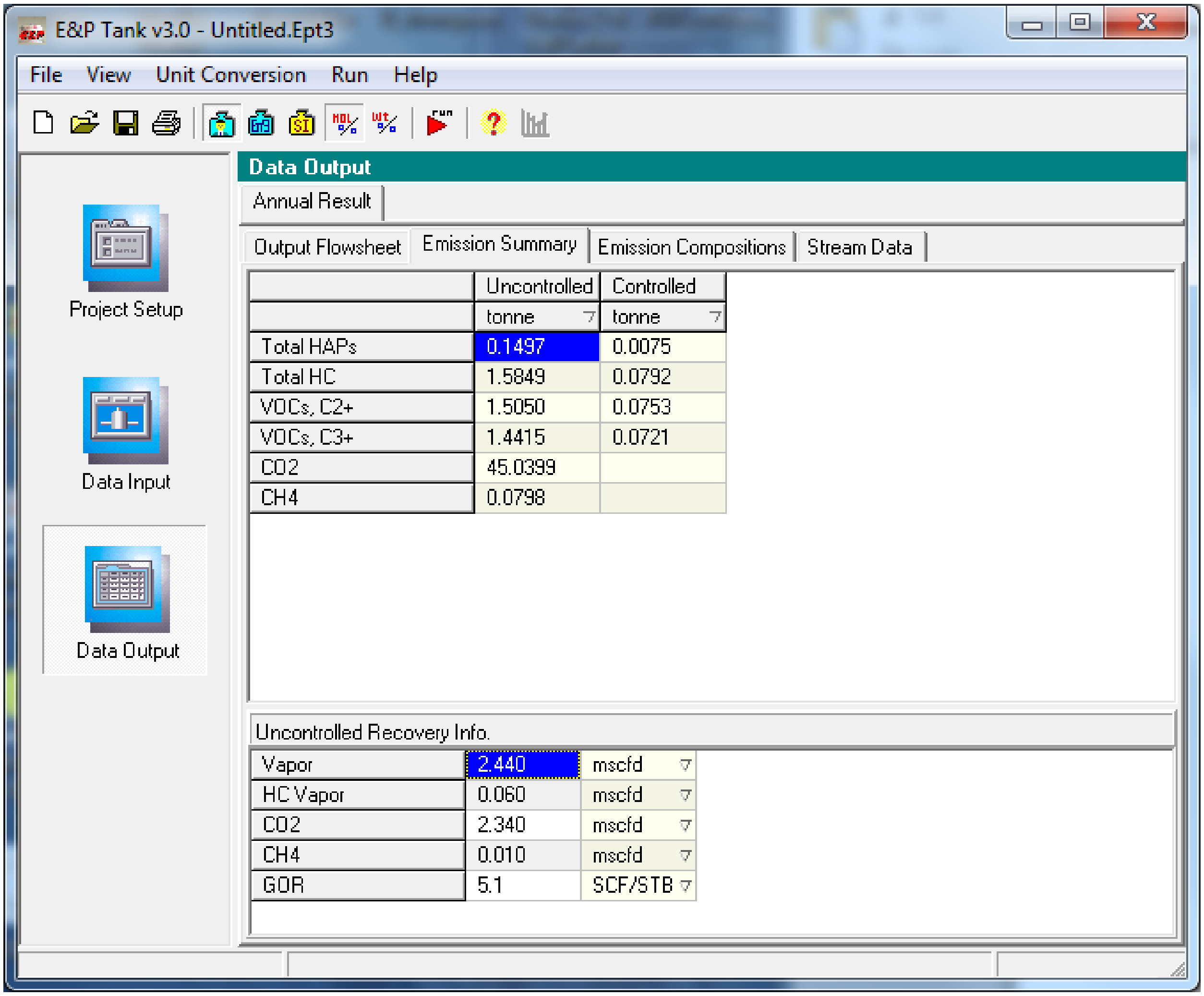


*Output Flowsheet*

## Emission Summary

This tab contains the controlled and uncontrolled emissions for components of specific interest. They are the Total HAPs, Total HC, VOCs, $C_2$+, VOCs, $C_3$+, $CO_2$, and $CH_4$. Note that because emissions of Greenhouse Gases (GHG), specifically $CO_2$, will depend on the control strategy (i.e. combustion vs. vapor recovery), controlled emissions of GHG are left to the user to calculate on a facility-specific basis.

This tab also lists the uncontrolled recovery for Vapor, HC Vapor, $CO_2$, $CH_4$, and GOR from the oil storage tank.



| | Uncontrolled | Controlled |
|---|---|---|
| | tonne | tonne |
| Total HAPs | 0.1497 | 0.0075 |
| Total HC | 1.5849 | 0.0792 |
| VOCs, C2+ | 1.5050 | 0.0753 |
| VOCs, C3+ | 1.4415 | 0.0721 |
| CO2 | 45.0399 | |
| CH4 | 0.0798 | |

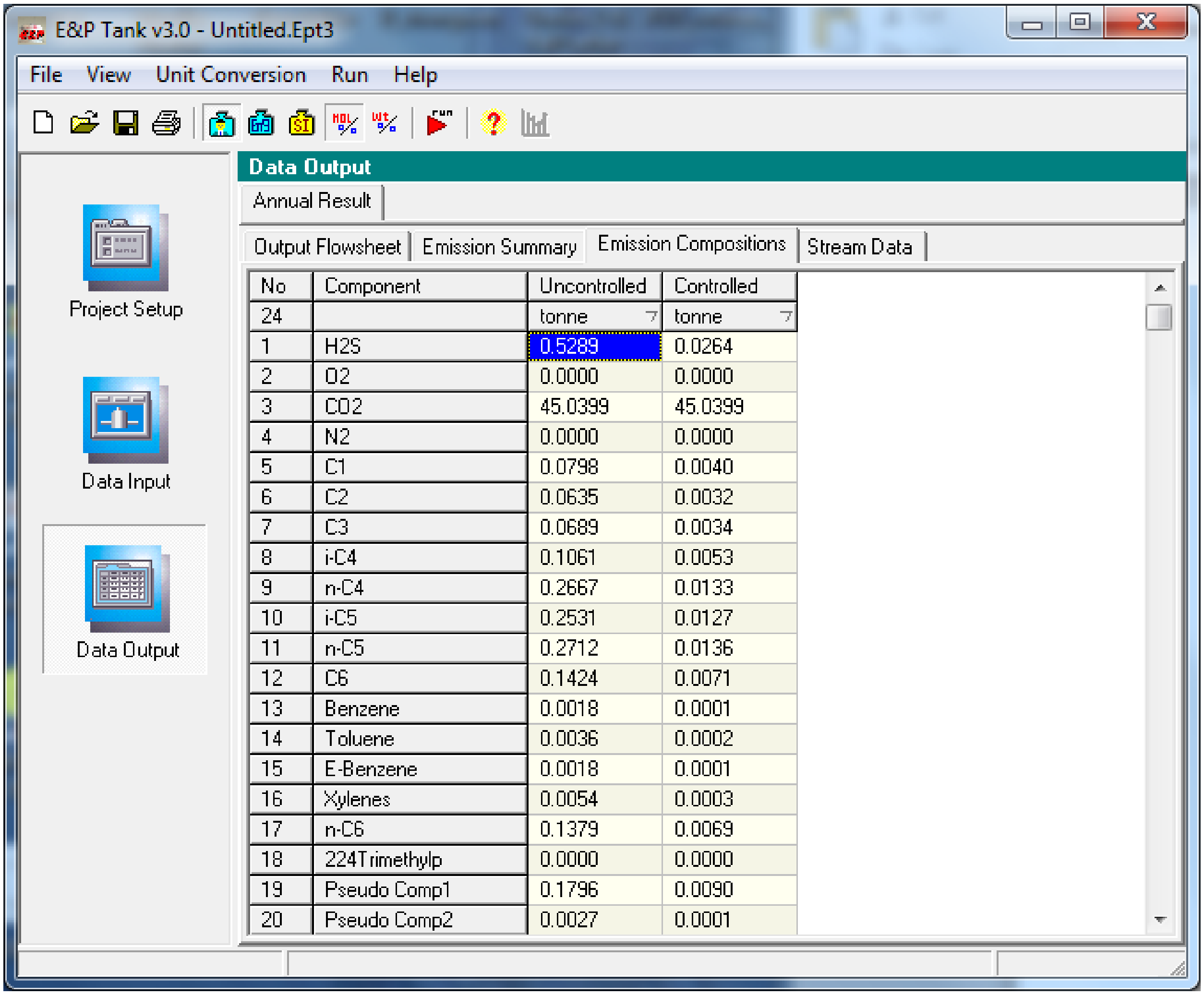
Uncontrolled Recovery Info.

| | | |
|---|---|---|
| Vapor | 2.440 | mscfd |
| HC Vapor | 0.060 | mscfd |
| CO2 | 2.340 | mscfd |
| CH4 | 0.010 | mscfd |
| GOR | 5.1 | SCF/STB |

*Emission Summary*

## Emission Compositions

Similar to the **Emission Summary** tab, this tab presents the controlled and uncontrolled emissions for all the components in your system. In this list, control efficiency is applied to the combustible components and the non-combustible components pass through unaltered by the control efficiency factor. However, since control strategies vary combustion products are NOT calculated by the program so that $CO_2$ emissions must be calculated via other methods.

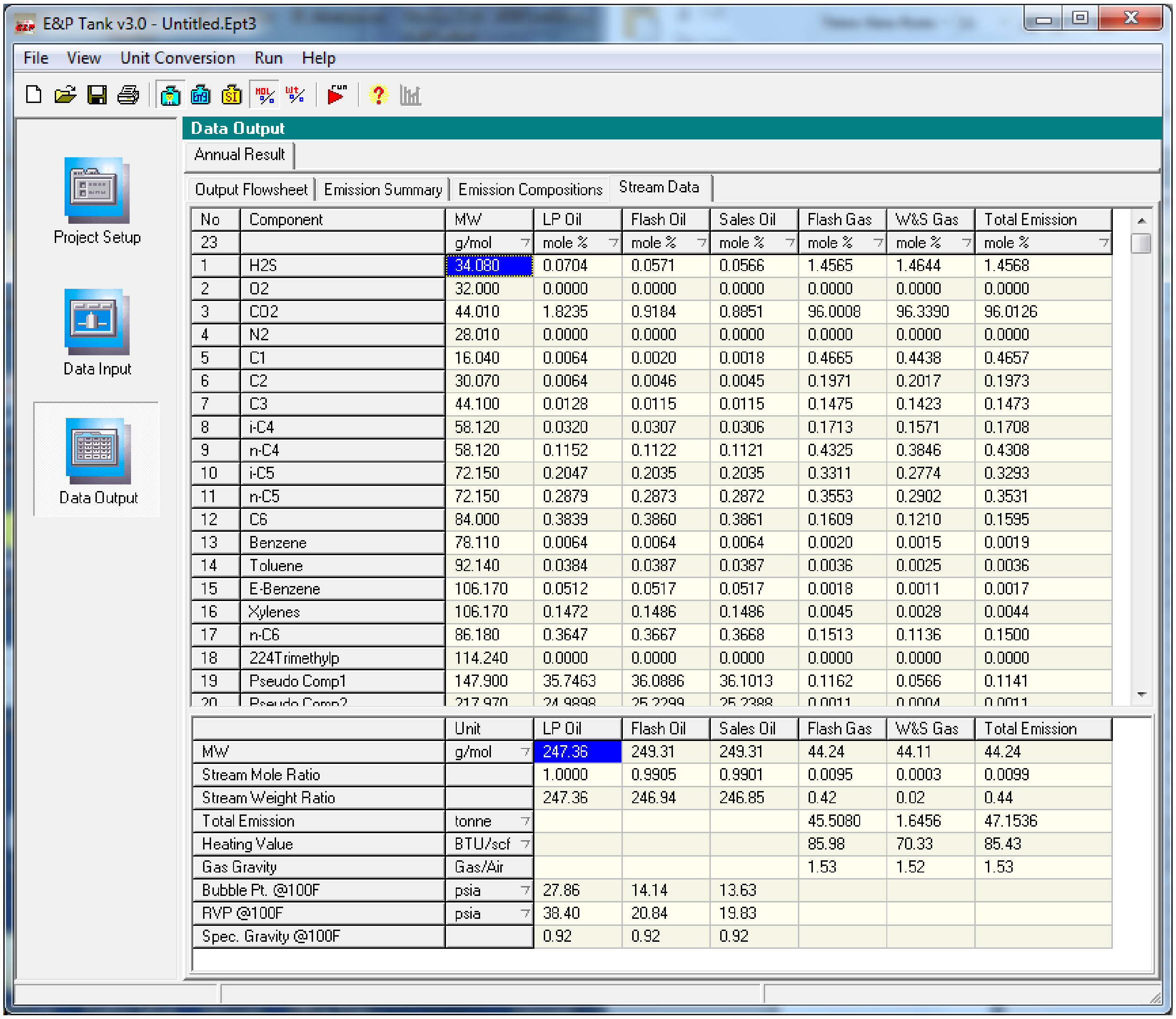


| No | Component | Uncontrolled | Controlled |
|---|---|---|---|
| 24 | | tonne | tonne |
| 1 | H2S | 0.5289 | 0.0264 |
| 2 | O2 | 0.0000 | 0.0000 |
| 3 | CO2 | 45.0399 | 45.0399 |
| 4 | N2 | 0.0000 | 0.0000 |
| 5 | C1 | 0.0798 | 0.0040 |
| 6 | C2 | 0.0635 | 0.0032 |
| 7 | C3 | 0.0689 | 0.0034 |
| 8 | i-C4 | 0.1061 | 0.0053 |
| 9 | n-C4 | 0.2667 | 0.0133 |
| 10 | i-C5 | 0.2531 | 0.0127 |
| 11 | n-C5 | 0.2712 | 0.0136 |
| 12 | C6 | 0.1424 | 0.0071 |
| 13 | Benzene | 0.0018 | 0.0001 |
| 14 | Toluene | 0.0036 | 0.0002 |
| 15 | E-Benzene | 0.0018 | 0.0001 |
| 16 | Xylenes | 0.0054 | 0.0003 |
| 17 | n-C6 | 0.1379 | 0.0069 |
| 18 | 224Trimethylp | 0.0000 | 0.0000 |
| 19 | Pseudo Comp1 | 0.1796 | 0.0090 |
| 20 | Pseudo Comp2 | 0.0027 | 0.0001 |

*Emission Compositions*

## Stream Data

This tab shows the compositions for all the different streams as well as their physical and thermodynamic properties.



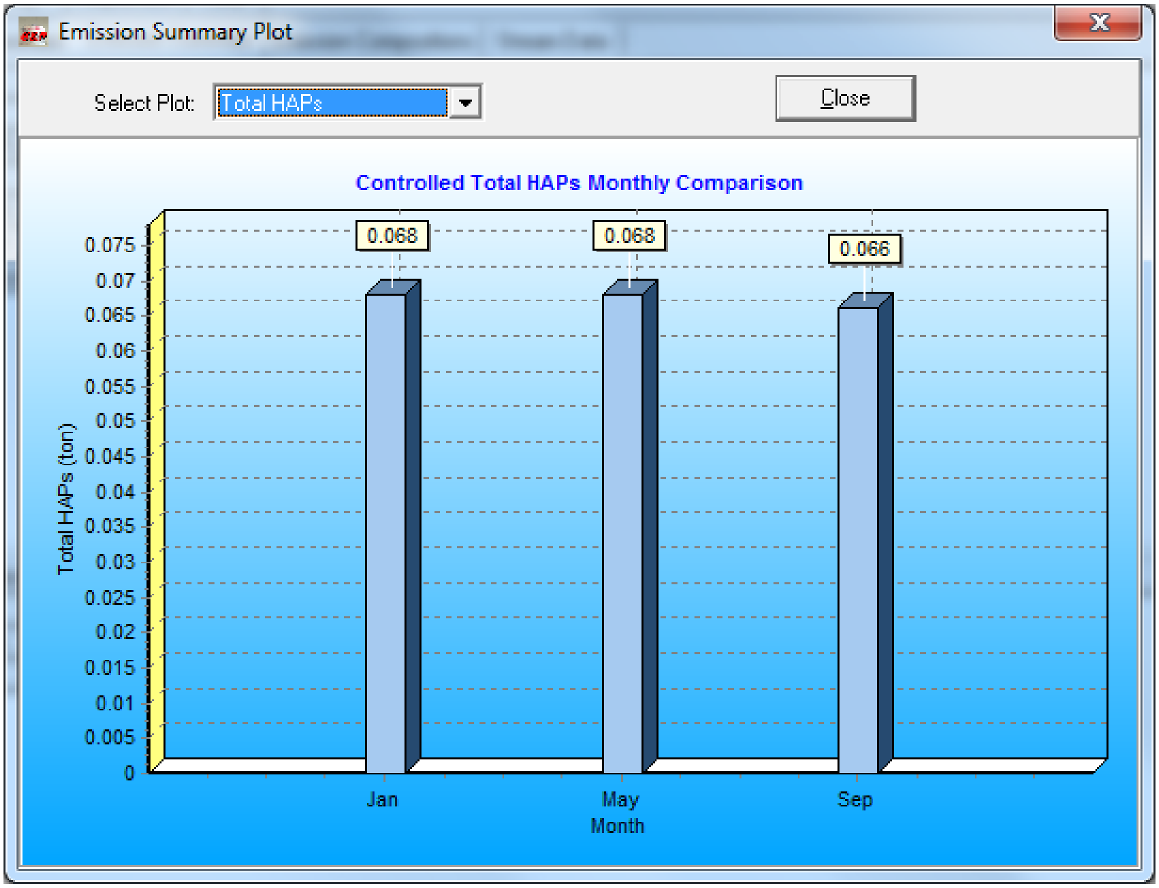
| No | Component | MW | LP Oil | Flash Oil | Sales Oil | Flash Gas | W&S Gas | Total Emission |
|---|---|---|---|---|---|---|---|---|
| 23 | | g/mol | mole % | mole % | mole % | mole % | mole % | mole % |
| 1 | H2S | 34.080 | 0.0704 | 0.0571 | 0.0566 | 1.4565 | 1.4644 | 1.4568 |
| 2 | O2 | 32.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | CO2 | 44.010 | 1.8235 | 0.9184 | 0.8851 | 96.0008 | 96.3390 | 96.0126 |
| 4 | N2 | 28.010 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | C1 | 16.040 | 0.0064 | 0.0020 | 0.0018 | 0.4665 | 0.4438 | 0.4657 |
| 6 | C2 | 30.070 | 0.0064 | 0.0046 | 0.0045 | 0.1971 | 0.2017 | 0.1973 |
| 7 | C3 | 44.100 | 0.0128 | 0.0115 | 0.0115 | 0.1475 | 0.1423 | 0.1473 |
| 8 | i-C4 | 58.120 | 0.0320 | 0.0307 | 0.0306 | 0.1713 | 0.1571 | 0.1708 |
| 9 | n-C4 | 58.120 | 0.1152 | 0.1122 | 0.1121 | 0.4325 | 0.3846 | 0.4308 |
| 10 | i-C5 | 72.150 | 0.2047 | 0.2035 | 0.2035 | 0.3311 | 0.2774 | 0.3293 |
| 11 | n-C5 | 72.150 | 0.2879 | 0.2873 | 0.2872 | 0.3553 | 0.2902 | 0.3531 |
| 12 | C6 | 84.000 | 0.3839 | 0.3860 | 0.3861 | 0.1609 | 0.1210 | 0.1595 |
| 13 | Benzene | 78.110 | 0.0064 | 0.0064 | 0.0064 | 0.0020 | 0.0015 | 0.0019 |
| 14 | Toluene | 92.140 | 0.0384 | 0.0387 | 0.0387 | 0.0036 | 0.0025 | 0.0036 |
| 15 | E-Benzene | 106.170 | 0.0512 | 0.0517 | 0.0517 | 0.0018 | 0.0011 | 0.0017 |
| 16 | Xylenes | 106.170 | 0.1472 | 0.1486 | 0.1486 | 0.0045 | 0.0028 | 0.0044 |
| 17 | n-C6 | 86.180 | 0.3647 | 0.3667 | 0.3668 | 0.1513 | 0.1136 | 0.1500 |
| 18 | 224Trimethylp | 114.240 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 19 | Pseudo Comp1 | 147.900 | 35.7463 | 36.0886 | 36.1013 | 0.1162 | 0.0566 | 0.1141 |
| 20 | Pseudo Comp2 | 217.970 | 24.9898 | 25.2299 | 25.2388 | 0.0011 | 0.0004 | 0.0011 |

| | Unit | LP Oil | Flash Oil | Sales Oil | Flash Gas | W&S Gas | Total Emission |
|---|---|---|---|---|---|---|---|
| MW | g/mol | 247.36 | 249.31 | 249.31 | 44.24 | 44.11 | 44.24 |
| Stream Mole Ratio | | 1.0000 | 0.9905 | 0.9901 | 0.0095 | 0.0003 | 0.0099 |
| Stream Weight Ratio | | 247.36 | 246.94 | 246.85 | 0.42 | 0.02 | 0.44 |
| Total Emission | tonne | | | | 45.5080 | 1.6456 | 47.1536 |
| Heating Value | BTU/scf | | | | 85.98 | 70.33 | 85.43 |
| Gas Gravity | Gas/Air | | | | 1.53 | 1.52 | 1.53 |
| Bubble Pt. @100F | psia | 27.86 | 14.14 | 13.63 | | | |
| RVP @100F | psia | 38.40 | 20.84 | 19.83 | | | |
| Spec. Gravity @100F | | 0.92 | 0.92 | 0.92 | | | |

*Stream Data*

### Emission Summary Plot

When running monthly calculations, the emission results (controlled Total HAPs, Total HC, VOCs, $C_2$+, VOCs, $C_3$+, and uncontrolled $CO_2$ and $CH_4$) based on the selected months are plotted for comparison by selecting the 'chart' icon on the toolbar.



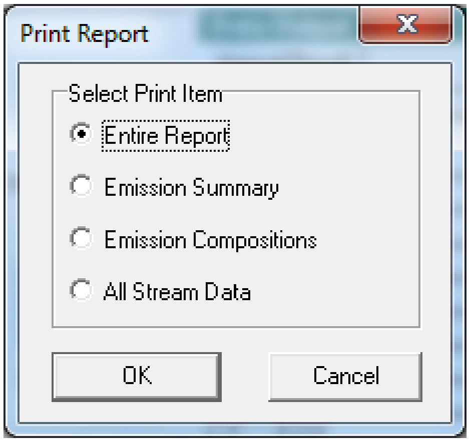
Select Plot: Total HAPs

*Emission Plot*

## Printing Calculation Results

To print calculation results:

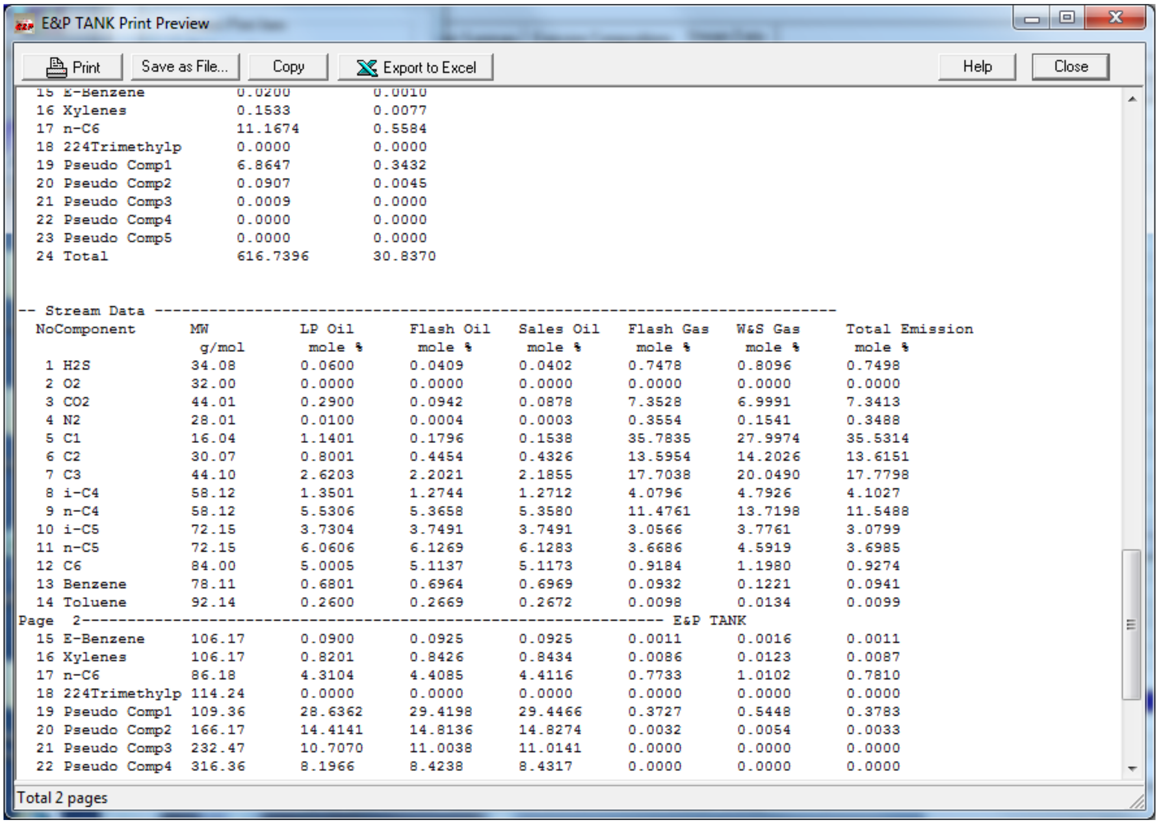
1. Select **Print** from the toolbar or from the **File** menu. The **Print Report** dialog appears.



● Entire Report
○ Emission Summary
○ Emission Compositions
○ All Stream Data

*Selecting a Print Item*

2. Select an item to print. Click **OK**. The **E&P TANK Print Preview** dialog appears.



```
  15 E-Benzene          0.0200         0.0010
  16 Xylenes            0.1533         0.0077
  17 n-C6               11.1674        0.5584
  18 224Trimethylp      0.0000         0.0000
  19 Pseudo Comp1       6.8647         0.3432
  20 Pseudo Comp2       0.0907         0.0045
  21 Pseudo Comp3       0.0009         0.0000
  22 Pseudo Comp4       0.0000         0.0000
  23 Pseudo Comp5       0.0000         0.0000
  24 Total              616.7396       30.8370


-- Stream Data ---------------------------------------------------------------------------
  NoComponent      MW          LP Oil      Flash Oil   Sales Oil   Flash Gas   W&S Gas     Total Emission
                    g/mol       mole %      mole %      mole %      mole %      mole %      mole %
   1 H2S           34.08       0.0600      0.0409      0.0402      0.7478      0.8096      0.7498
   2 O2            32.00       0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
   3 CO2           44.01       0.2900      0.0942      0.0878      7.3528      6.9991      7.3413
   4 N2            28.01       0.0100      0.0004      0.0003      0.3554      0.1541      0.3488
   5 C1            16.04       1.1401      0.1796      0.1538      35.7835     27.9974     35.5314
   6 C2            30.07       0.8001      0.4454      0.4326      13.5954     14.2026     13.6151
   7 C3            44.10       2.6203      2.2021      2.1855      17.7038     20.0490     17.7798
   8 i-C4          58.12       1.3501      1.2744      1.2712      4.0796      4.7926      4.1027
   9 n-C4          58.12       5.5306      5.3658      5.3580      11.4761     13.7198     11.5488
  10 i-C5          72.15       3.7304      3.7491      3.7491      3.0566      3.7761      3.0799
  11 n-C5          72.15       6.0606      6.1269      6.1283      3.6686      4.5919      3.6985
  12 C6            84.00       5.0005      5.1137      5.1173      0.9184      1.1980      0.9274
  13 Benzene       78.11       0.6801      0.6964      0.6969      0.0932      0.1221      0.0941
  14 Toluene       92.14       0.2600      0.2669      0.2672      0.0098      0.0134      0.0099
Page  2---------------------------------------------------------------- E&P TANK
  15 E-Benzene     106.17      0.0900      0.0925      0.0925      0.0011      0.0016      0.0011
  16 Xylenes       106.17      0.8201      0.8426      0.8434      0.0086      0.0123      0.0087
  17 n-C6          86.18       4.3104      4.4085      4.4116      0.7733      1.0102      0.7810
  18 224Trimethylp 114.24      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
  19 Pseudo Comp1  109.36      28.6362     29.4198     29.4466     0.3727      0.5448      0.3783
  20 Pseudo Comp2  166.17      14.4141     14.8136     14.8274     0.0032      0.0054      0.0033
  21 Pseudo Comp3  232.47      10.7070     11.0038     11.0141     0.0000      0.0000      0.0000
  22 Pseudo Comp4  316.36      8.1966      8.4238      8.4317      0.0000      0.0000      0.0000
```

*Print Preview*

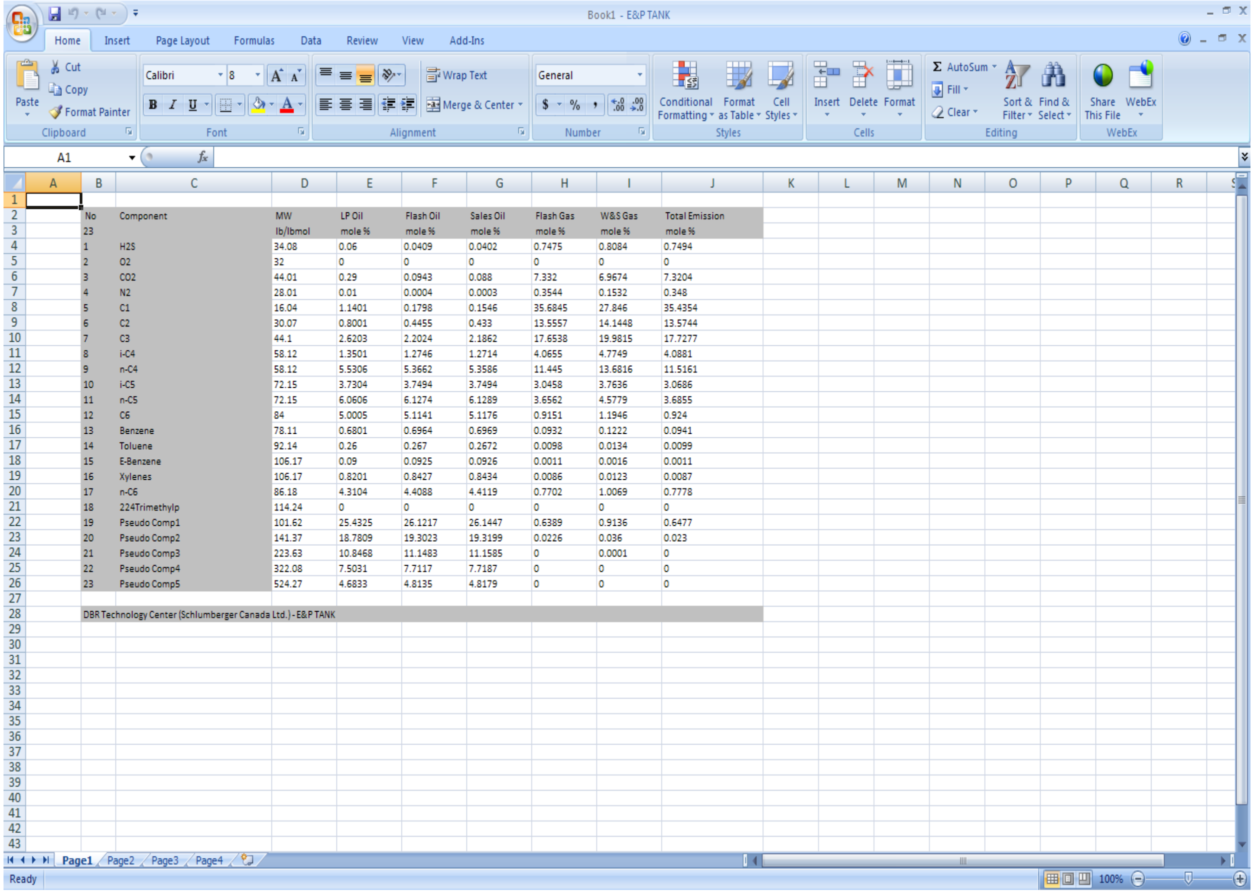
3. Click **Print** to start printing. Alternatively, you can save the report to a file or copy the report to another location or Export to excel.

To copy results from Print Preview:

1. While you are in the **E&P TANK Print Preview** dialog, select contents to copy by highlighting the selection.
2. Click **Copy**.
3. Proceed to the destined location or application and click **Paste** from within the application.

## To Export Results to Excel

1. Right-click the mouse (or use 'Ctrl+E' shortcut) and select **Send to MS Excel** on the toolbar. This will automatically export the current screen to Excel.
2. Select **Print** from the toolbar or from the **File** menu. The **Print Report** dialog appears. Select an item to print. Click **OK**, then click **Export to excel,** it allows the user to export current data or the whole project.



| No | Component | MW | LP Oil | Flash Oil | Sales Oil | Flash Gas | W&S Gas | Total Emission |
|---|---|---|---|---|---|---|---|---|
| 23 | | lb/lbmol | mole % | mole % | mole % | mole % | mole % | mole % |
| 1 | H2S | 34.08 | 0.06 | 0.0409 | 0.0402 | 0.7475 | 0.8084 | 0.7494 |
| 2 | O2 | 32 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | CO2 | 44.01 | 0.29 | 0.0943 | 0.088 | 7.332 | 6.9674 | 7.3204 |
| 4 | N2 | 28.01 | 0.01 | 0.0004 | 0.0003 | 0.3544 | 0.1532 | 0.348 |
| 5 | C1 | 16.04 | 1.1401 | 0.1798 | 0.1546 | 35.6845 | 27.846 | 35.4354 |
| 6 | C2 | 30.07 | 0.8001 | 0.4455 | 0.433 | 13.5557 | 14.1448 | 13.5744 |
| 7 | C3 | 44.1 | 2.6203 | 2.2024 | 2.1862 | 17.6538 | 19.9815 | 17.7277 |
| 8 | i-C4 | 58.12 | 1.3501 | 1.2746 | 1.2714 | 4.0655 | 4.7749 | 4.0881 |
| 9 | n-C4 | 58.12 | 5.5306 | 5.3662 | 5.3586 | 11.445 | 13.6816 | 11.5161 |
| 10 | i-C5 | 72.15 | 3.7304 | 3.7494 | 3.7494 | 3.0458 | 3.7636 | 3.0686 |
| 11 | n-C5 | 72.15 | 6.0606 | 6.1274 | 6.1289 | 3.6562 | 4.5779 | 3.6855 |
| 12 | C6 | 84 | 5.0005 | 5.1141 | 5.1176 | 0.9151 | 1.1946 | 0.924 |
| 13 | Benzene | 78.11 | 0.6801 | 0.6964 | 0.6969 | 0.0932 | 0.1222 | 0.0941 |
| 14 | Toluene | 92.14 | 0.26 | 0.267 | 0.2672 | 0.0098 | 0.0134 | 0.0099 |
| 15 | E-Benzene | 106.17 | 0.09 | 0.0925 | 0.0926 | 0.0011 | 0.0016 | 0.0011 |
| 16 | Xylenes | 106.17 | 0.8201 | 0.8427 | 0.8434 | 0.0086 | 0.0123 | 0.0087 |
| 17 | n-C6 | 86.18 | 4.3104 | 4.4088 | 4.4119 | 0.7702 | 1.0069 | 0.7778 |
| 18 | 224Trimethylp | 114.24 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | Pseudo Comp1 | 101.62 | 25.4325 | 26.1217 | 26.1447 | 0.6389 | 0.9136 | 0.6477 |
| 20 | Pseudo Comp2 | 141.37 | 18.7809 | 19.3023 | 19.3199 | 0.0226 | 0.036 | 0.023 |
| 21 | Pseudo Comp3 | 223.63 | 10.8468 | 11.1483 | 11.1585 | 0 | 0.0001 | 0 |
| 22 | Pseudo Comp4 | 322.08 | 7.5031 | 7.7117 | 7.7187 | 0 | 0 | 0 |
| 23 | Pseudo Comp5 | 524.27 | 4.6833 | 4.8135 | 4.8179 | 0 | 0 | 0 |

DBR Technology Center (Schlumberger Canada Ltd.) - E&P TANK

Print to MS Excel

## Copy and Paste

E&P TANK is equipped with a copy and paste feature that allows tedious compositional data to be transferred from external spreadsheets such as Microsoft Excel worksheets.

### To copy data from a Windows application

1. Select and copy cells in the external spreadsheets.
2. Start E&P TANK 3.0 and select destination cells in the E&P TANK Worksheet.
3. Select **Paste** from the Pop-up menu.

### To copy data to a Windows application

1. Select data from an E&P TANK worksheet.
2. Right-click the mouse and select **Copy** and **Copy ALL** from the pop-up menu.
3. Go to the Windows application and select destination cells in the spreadsheet.
4. Perform the **Paste** command while in the Windows application.

# Chapter 5: Managing Projects

E&P TANK Projects can be created, saved, printed in the text file format or from the Microsoft Excel environment (for terminals with Microsoft Excel), and deleted.

## To Create a New Project

When you are starting E&P TANK v3.0:

In the welcome window, select **Create a New E&P TANK Project** and click OK.

-or-

While you are working on another project:

Click on the **New Project** button on the toolbar or select **New** from the **File menu**.

## To Open an Existing Project

1. When you are starting E&P TANK v3.0:

   Select **Open an existing E&P TANK project and** click **OK**

   -or-

   While you are working on another project:

   Click on the **Open E&P TANK Project File** button on the toolbar or select **Open...** from the **File** menu.

   The **Open E&P TANK** dialog appears.
2. Specify the file path and the file name.
3. Click **Open**.

## To Print a Project

To print a project in text file format (if Microsoft Excel is not installed in your computer):

1. Click on the **Print** button on the toolbar or select **Print...** from the **File** menu.
2. In the **Print Report** dialog, select an item to print and click **OK**.
3. In the **E&P TANK Print Preview** dialog, click **Print** to start printing.

While you are in the E&P TANK Print Preview dialog, you can also save the calculation results to a file for future review or copy the results into another location for editing.

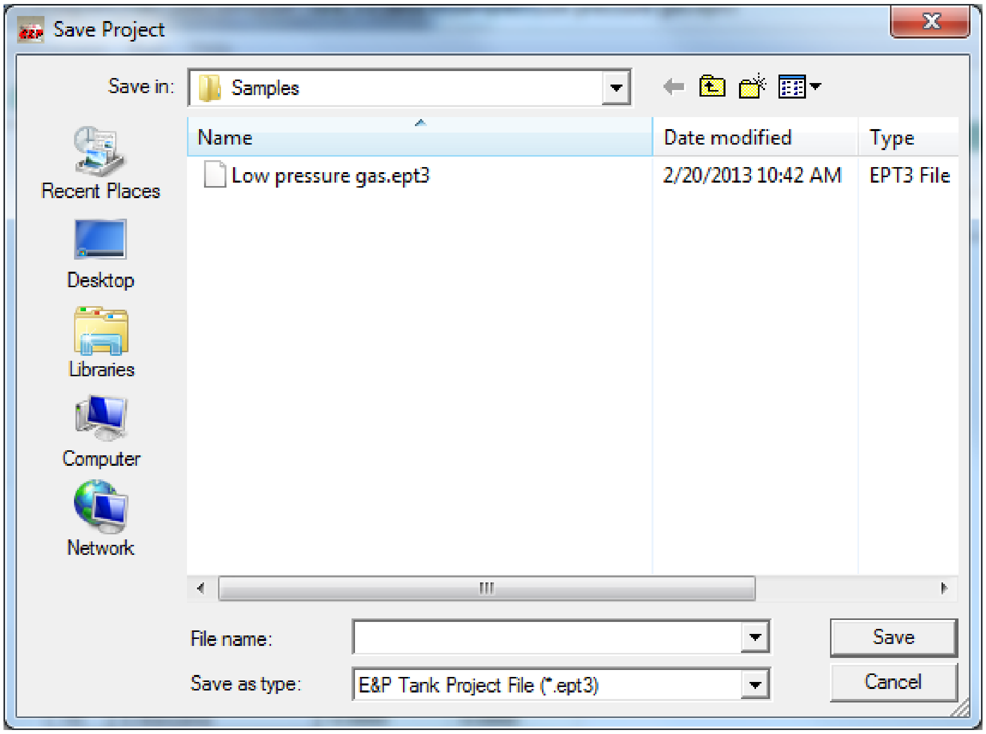
If Microsoft Excel is installed in your computer, refer to "**To Export Results to Excel"** to obtain a hard copy of the project in the Excel format.

## To Save a Project

Click on the **Save** button on the toolbar or select **Save** from the **File** menu.

## To Save a Project into Another File Name

1. Select **Save As...** from the **File** menu. The **Save E&P TANK Project File** dialog appears.
2. Specify the file path and file name.
3. Click **Save**.



Save in: Samples

| Name | Date modified | Type |
|---|---|---|
| Low pressure gas.ept3 | 2/20/2013 10:42 AM | EPT3 File |

Save as type: E&P Tank Project File (*.ept3)

*Saving a Project*

## To Delete a Project

In Windows Explorer, select the project file click **Delete.**

# Annex A: Technical Background

A simplified flow diagram of a typical oil production tank system is illustrated in Figure 1. The liquid oil from a low pressure (LP) separator, after passing through a pressure reducing valve, is charged into the production tank where it may be stored for a period of time before being shipped as sales oil. The emission losses from the tank can be classified into three categories: flash, working, and standing (also called breathing) losses. Flash losses occur when the pressure of the saturated oil is reduced from some moderate pressure in the LP separator to atmospheric pressure in the storage tank. For a typical production tank, the flash loss forms a major contribution to its overall emissions. Working losses are vapors displaced from the tank during the filling cycle, and standing losses are vapors generated through diurnal and seasonal temperature changes.

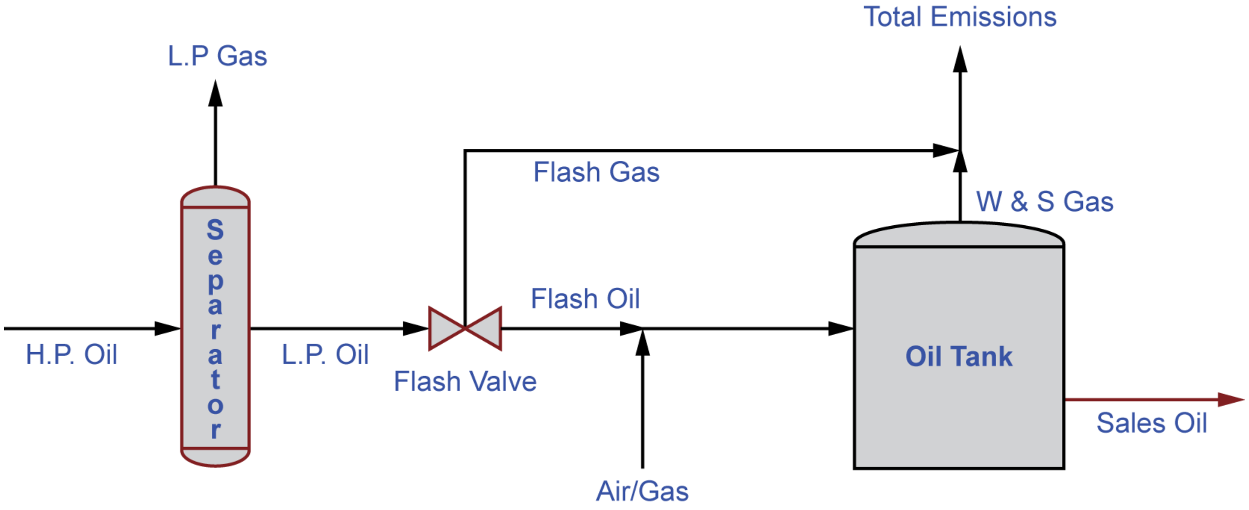


**Figure 1—Oil Production Storage System**

It is important to note the relationship between the LP separator and the flash calculation performed at the entrance to the storage tank. Currently, the Oil Tank module completes the flash calculation at a user specified ambient temperature. This temperature is necessary as it will produce the most accurate representation of the losses at the flash valve. However, if this ambient temperature is not available, the user can provide the previously recorded separator temperature for the most conservative estimate of the flash losses.

Following the inlet flash calculation are the tank operations. The operation of the fixed roof tank is simulated by a distillation column with four trays operation. Similarly to the flash valve, the produced vapor also contributes to the total tank emissions, while the liquid phase from the fixed roof tank represents the sales oil.

Working and standing losses are highly dynamic in nature and cannot be described solely by steady-state models. However, since most of the dynamic information, such as meteorological and daily liquid level data, is cumbersome to use, an inference method was designed to circumvent this difficulty [1]. The method imposes a constraint that the characteristics of the liquid effluent from the storage tank should match the sales oil characteristics (e.g., RVP and API gravity). This inference method ensures that all effects of dynamic parameters are suitably represented by the simulator. The shortcoming of using this inference method is that the model may artificially adjust some operating parameters of the tank to reflect the effects of dynamic parameters. For example, the model may be forced to raise the operating temperature of the storage tank beyond that actually encountered to compensate for the elevated emission level resulting from extended residence times of the sales oil.

In E&P TANK, two different alternatives for estimating flashing, working, and standing losses are provided. The first alternative estimates the flash loss using rigorous thermodynamic flash calculations and estimates working and standing losses with a fixed roof tank simulation. Here, a four-tray distillation column representation is attempted. In this case, detailed information such as tank characteristics and site meteorological data are not necessary to estimate emissions. The minimum information requirements for this method are:

- Separator Pressure and Temperature
- Separator Oil Composition
- Reference Pressure
- RVP of Sales Oil
- Sales Oil Production Rate
- API Gravity of Sales Oil

The second alternative estimates the flash losses using the same rigorous thermodynamic flash calculations as in the first method. However, working and standing losses are estimated using the modified AP-42 equations which require details on tank characteristics and site meteorological data. In addition to the information requirements listed above for the first approach, at a minimum, the second approach requires the following input data:

- Stock Oil Bulk Temperature
- Tank Diameter
- Tank Shell Height
- Average Stock Liquid Height
- Cone Roof Slope
- Tank Solar Absorbency
- Daily Minimum Ambient Temperature
- Daily Maximum Ambient Temperature
- Daily Solar Insulation
- Breather Vent Pressure Setting Range

Both approaches are available to the user, thereby allowing emission estimates to be made depending upon data availability and user needs. In general, the first approach will yield more conservative (i.e. higher) emission estimates than the second approach.

## Influent Specifications

There are several modes for users to specify influent data for the model (i.e. the model is able to accept different types of compositional input data). Each of the options that follow either accepts or completes a calculation to generate the LP separator oil composition. It is this fluid that undergoes flashing, working and standing losses to produce emissions.

### Input Option 1: LP Separator Oil

The first input option is to directly specify the LP separator oil composition of the liquid discharged from the final LP separator. This is the preferred option and a sampling protocol is given in Annex C to ensure proper oil sample collection. This is a commonly available analysis and provides the simplest operation of the model.

### Input Option 2: HP Separator Oil

A second option is to enter the composition of a high pressure fluid stream and allows the model to complete a flash calculation through the low pressure separator.

## Input Option 3: LP Separator Gas

The third option is to enter the composition of a separator gas sample with a measured Gas-Oil Ratio (GOR). With these data, the software will complete a recombination calculation to determine the composition of the LP separator oil.

## Input Option 4: Geographical Database

Finally, it is possible to obtain compositional input data from the Database option. This database contains 103 example cases (containing both fluid compositions and tank operating conditions) obtained from API. These cases are taken from actual tank sites across the US. These example cases may be selected by geographical location or by oil physical properties. The geographical criteria are useful in providing conditions based on location while the oil selection capability aids in the comparison of emission losses from oils with different physical characteristics. It is also important to note that these example cases may be manipulated and adjusted based on any measured data that are available.

In terms of compositional data requirements, the model has been designed to accept C7+, C8+, C9+, C10+ analyses with a detailed breakdown of the HAP and VOC components. A flexible plus fraction characterization has been implemented. The characterization is performed by employing an exponential distribution function and a process of critical properties estimate for pseudo-components to represent the fractions with carbon number greater than 7. The characterization procedure from the literature [2] is adapted and it involves the following steps:

1. Generate molecular weight and density for each component using exponential extrapolation.
2. Generate critical properties and interaction parameters for each component using the property correlation.
3. Group or lump components and generate pseudo-components properties that are required in the EOS calculations.

The corresponding C7+, C8, C9+, C10+ molecular weight and specific gravity are required to characterize the pseudo-component in the model. The case studies show that the predicted emission results after implementing the new charateriztion algorithm  are an improvement over the previous version predictions.

## Modified AP-42 for Non-Flash Tank Emissions

The AP-42 method has been generally accepted for estimating working and standing (non-flashing) losses for stabilized hydrocarbon products with an RVP of 12 psia or less. The AP-42 method cannot distinguish between HAPs and VOCs for crude oil. The E&P TANK modifications have remedied this shortcoming.

The documented AP-42 method [3] uses empirical correlations for estimating evaporative (non-flash) losses from fixed-roof tanks. The data required to use the AP-42 method can be classified into three categories:

1. Tank Characteristics
2. Meteorological Information
3. Oil Specifications

Tank characteristics include tank shape and size, paint color, average liquid height, and breather vent pressure setting. Meteorological information includes daily maximum and minimum ambient temperature, solar insolation on a horizontal surface, and reference ambient pressure. Oil specifications include oil RVP and throughput. Separate empirical correlations are applied for both working and standing losses in a specified time period and results are presented in units of emission (for example, ton or lb).

The modification of the AP-42 method in this package is focused on oil specifications. Rigorous thermodynamic calculations based on the Peng-Robinson EOS [4] have been introduced to characterize oils whenever necessary. A summary of changes is provided as follows:

- Oil RVP is calculated by the Peng-Robinson EOS according to the composition specifications.
- The AP-42 method is deemed unsuitable if the oil vapor pressure at the specified average tank temperature equals or exceeds the reference ambient pressure.
- The evaporated oil composition is calculated from a hypothetical flash at 90 percent of the saturation pressure.

# Technical Basis of E&P TANK

E&P TANK is built upon rigorous thermodynamic calculations. All components and phases are assumed to be in equilibrium throughout the entire system. For most hydrocarbon processes, this assumption is a fairly good approximation. Also, the Peng-Robinson EOS [4] has been chosen for property-related calculations because it is one of the most widely accepted models in the hydrocarbon processing industry.

When vapor and liquid phases are in equilibrium, the fugacity of each component in the vapor ($f_i^V$) is equal to its fugacity in the liquid ($f_i^L$). The fugacities in the liquid and vapor are defined by:

$$f_i^L = \Phi_i^L x_i P$$

$$f_i^V = \Phi_i^V y_i P$$

where

$P$ is the system pressure,

$x_i$ is the mole fraction of species $i$ in liquid,

$y_i$ is the mole fraction of species $i$ in vapor,

$\Phi_i^L$ is the fugacity coefficient of species $i$ in liquid,

$\Phi_i^V$ is the fugacity coefficient of species $i$ in vapor.

One advantage of using an EOS model is that the fugacity coefficients in both the vapor and liquid phases are treated uniformly by the following relation:

$$ln\,\Phi_i^\alpha = \frac{1}{RT}\int_V^\infty \left[\left(\frac{P}{n_i}\right) - \frac{RT}{V}\right] dV - ln\left(\frac{PV}{RT}\right)$$

where

$\alpha$ is the either V for vapor or L for liquid phase'

$P$ is the system pressure'

$V$ is the system volume at the specified condition'

$T$ is the system temperature on an absolute scale'

R is the universal gas constant'

$n$ is the number of moles of species $i$.

The above thermodynamic relationships, in conjunction with material and energy balances, are used extensively in the program to solve for vapor-liquid-equilibrium (VLE) conditions. Detailed discussions about the calculation schemes for convergence are covered in standard thermodynamic textbooks such as the one by Smith and Van Ness [5].

In particular cases where the VLE separation is achieved through column distillations, the simulation of the column is accomplished using the Ishii-Otto [6] algorithm. The Ishii-Otto algorithm is fairly stable and fast in reaching convergent solutions for most hydrocarbon applications.

# Annex B: Technical References

[1] Choi, M., *API Tank Vapors Project,* Paper (SPE 26588) presented at the meeting of 68th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers. Houston, Texas: October 3-6, 1993.

[2] Pedersen, K.S., Thomassen P. and Fredenslund Aa., paper presented at the AICHE Spring National Meeting New Orleans LA, 6-10 March, 1988.

[3] Gas Research Institute, *Technical Reference Manual for GRI-GlyCalc™: A Program for Estimating Emissions from Glycol Dehydration of Natural Gas*, Prepared by Radian International LLC, 1996.

[4] Peng, D.Y. and Robinson, D.B., *A New Two-Constant Equation of State*, Industrial and Engineering Chemistry Fundamentals, 15(1):59-64, 1976.

[5] Smith, J.M. and Van Ness, H.C., *Introduction to Chemical Engineering Thermodynamics*, 3rd Edition, McGraw-Hill, New York, NY, 1975.

[6] Ishii, Y. and Otto, F.D., *A General Algorithm for Multistage Multicomponent Separation Calculations*, Canadian Journal of Chemical Engineering. 51: 601-606, 1973.

[7] Radian International LLC, *Evaluation of a Petroleum Production Tank Emission Model*, API Publication No. 4662 American Petroleum Institute, Washington, D.C., 1997

[8] US Environmental Protection Agency, *Compilation of Air Pollutant Emission Factors. Vol. 1*, Stationary Point and Area Emission Units, Section 7, AP-42, Fifth Edition (January 1996); Supplements A and B (November 1996). Report prepared by Office of Air Quality Planning and Standards, US Environmental Protection Agency, Research Triangle Park, NC. 1996.

# Annex C: Sampling Protocol

## Surface Fluid Sampling of Black Oil Reservoirs

### Separator Liquid Collection

The separator liquid sample collection point should be upstream of any metering device or flow restriction to ensure single phase flow. There is often a temperature reduction on the separator liquid flowline, but this does not alter the sample integrity. Conversely, if the flowline temperature is in excess of the operating temperature of the separator, it is advisable to sample directly from the sight gauge on the separator.

Care must be taken when sampling from the separator sight gauge. The upper and lower values installed on sight gauges have restricted flow orifices and check valves. Therefore, as fluids are removed through sight gauge valves, there is a preferred flow of the gas phase through the top valve. One must maintain the liquid level above the bottom sight glass valve while collecting the separator liquid samples. If the liquid level is allowed to decrease to the point of sample collection, excess gas will be drawn into the cylinder with the separator liquid, voiding the validity of the separator liquid sample.

Flexible lines used to connect the sample source to the sample cylinder should be as short as possible. One should check for entrained water in the liquid source stream.

Water and any other contaminant must be removed completely prior to the collection of any separator liquid samples. It is advisable to re-check the sampling points and line for contaminants after completing the sampling procedure to ensure proper samples have been collected.

### Separator Liquid Collection: Evacuated Cylinder Method

1. The cylinders should be evacuated by the laboratory before being sent to the field.
2. Select a sample point from which a representative first stage separator liquid sample can be collected.
3. Compare the pressure and temperature of the sample source to the maximum operating pressure and the current temperature of the sample cylinder to ensure that the cylinder will safely contain the liquid sample. The cylinder temperature should not be more than

10 °F (6 °C) lower than the source temperature. If it is, this technique should not be used. Low cylinder temperatures often cause the cylinder to fill completely with liquid, thus resulting in a serious hazardous situation when the cylinder is allowed to warm. To prevent the hazardous situation, an alternate technique, such as the Liquid Displacement Method, should be used. The cylinder must be an approved type with a current certification date for sample transport to the laboratory. In the United States, the cylinder must be an approved type with a current certification date for sample transportation to the laboratory. In the United States, the cylinder must be approved by the U.S. Department of Transportation, while transporting a cylinder in many international locations requires certification by Lloyd's Register Industrial Services.

4. Connect the sampling line to the liquid source and the sample cylinder in the manner shown in Figure C-1, leaving the fitting on the cylinder end of the connector line finger tight.

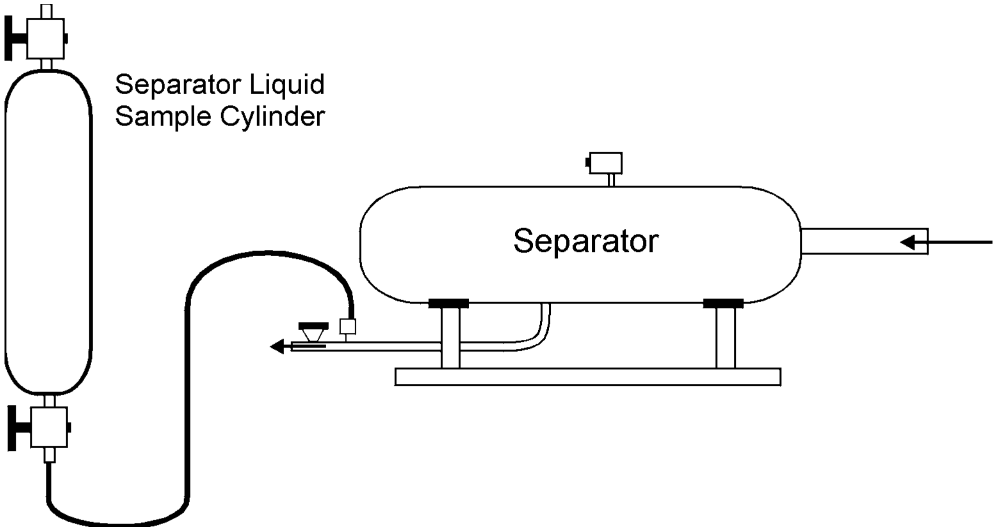


Figure C-1. Evacuated Cylinder Method

5. Slowly purge the sample line to displace air and to vent sufficient liquid to clean the sample point and sampling system.
6. With a wrench, properly tighten the connecting line fitting to the cylinder fitting.
7. With the sample line purged and full of liquid and the separator liquid source valve fully open, hold cylinder in a vertical position with the inlet valve at the bottom and slowly (but fully) open the lower cylinder valve to admit liquid into the container. Refer to Figure C-1.

8. When the liquid stops flowing into the cylinder, close the inlet valve before moving the cylinder out of the vertical position. The sample collected in this manner will be in two phases, gas and liquid. The sample cylinder will have some portion of its volume as gas cap, which can safely accommodate any liquid expansion if the cylinder temperature increases during shipment to the laboratory.
9. Close the valves from the sample source and de-pressurize the connect line. Dismantle the sampling assembly and install the blow plug in the sample cylinder valve used for sample entry.
10. Fill in information on the sample tag as completely and accurately as possible and attach the tag to the sample cylinder. Also on a separate sheet of paper, make a list of all of the information recorded on the cylinder tag along with the cylinder number. Prepare the information for all cylinders involved in the sample collection on the sheet of paper for separate mailing to the laboratory.
11. Repeat the above procedures using all separator liquid cylinders provided.

**Notes (Item 8):**

The (safe) situation of having a two phase system in the container will not change to an unsafe single liquid phase situation unless one or more of the following is allowed to occur:

- Sample container is agitated while filling.
- Containers being filled are much colder than the separator.
- Containers are left on the pressure source for an extended length of time. It is not important to have the container completely full of sample. The representative liquid has been admitted to the cylinder and is not altered in composition; it merely has been flashed to a two phase condition for transport to the laboratory. When this sample is received in the laboratory, it is pressured up to considerably above the source pressure by mercury injection prior to removal of any portion of the contents. During the re-pressurization, the saturation pressure is measured to check the validity of the sample contained. If the saturation pressure obtained does not approximate the separator conditions, any subsequent analysis performed using the sample will be in error.

Medium gravity, 20 to 27 API crude oils are particularly susceptible to foaming and, if sampled directly into an evacuated cylinder, could result in obtaining a cylinder virtually full of gas with a small amount of foamy oil. The procedure of sampling a liquid by gas displacement is used to overcome this potential foaming problem. The description of this procedure begins below.

## Separator Liquid Collection: Gas Displacement Method

1. Select a sample point from which a representative first stage separator liquid sample can be collected.
2. Compare the pressure of the sample source to the maximum operating pressure of the sample cylinder to ensure that the cylinder safely contains the liquid sample. The cylinder must be an approved type with a current certification date for sample transport to the laboratory. In the United States, the cylinder must be approved by the U.S. Department of Transportation, while transporting a cylinder in many international locations requires certification by Lloyd's Register Industrial Services.
3. Fill the cylinder to be used for collecting separator liquid sample with equilibrium separator gas as per the procedure outlined in Separator Gas Collection - Evacuated Cylinder Method.
4. Connect the sampling line to the liquid sample source and to the gas filled liquid sample cylinder in the conventional manner shown in Figure C-1 leaving the fitting on the cylinder end of the connecting line finger tight.
5. Slowly purge the sample line to displace air and to vent enough liquid to clean the sample point and sampling system.
6. With a wrench, properly tighten the connecting line fitting to the cylinder fitting.
7. With the sample line purged and full of liquid and the sample source valve fully opened, hold the cylinder in a vertical position as indicated in Figure C-1, with inlet valve at the bottom and fully open the lower cylinder valve.
8. Holding the cylinder vertical, slowly open the top valve of the cylinder to bleed gas at a very low rate. The low bleeding rate is necessary so no appreciable pressure drop occurs in the sampling system, thus maintaining the separator liquid in one phase while it enters the sample cylinder.
9. When separator liquid flows from the top valve, close first the top valve and second the bottom valve of the cylinder. Close the valve from the source and depressurize the sampling system.
10. Disconnect the sample cylinder from the sampling hose.
11. Holding the cylinder vertical, in a single motion quickly release a small amount of liquid from the bottom valve. This will relieve the dangerous situation of having a cylinder completely filled with liquid for transport to the laboratory, without altering the sample. Creating a gas cap in this manner can easily alter the sample composition. In order to

prevent the alteration of the sample composition, the liquid must be taken in one quick motion.

12. Install blow plugs securely in both valves.
13. Fill in information on the sample tag as completely and accurately as possible and attach to the sample cylinder.
14. On a separate sheet of paper, list the cylinder number with all of the information recorded on the sample cylinder tag. Include this information for all cylinders involved in the sample collection on this same sheet of paper. Send this information under separate cover to the laboratory.
15. Repeat the above procedure using all separator liquid cylinders provided.

**Notes:**

Medium gravity, 20 to 27 API, crude oils are particularly susceptible to foaming and if sampled directly into an evacuated cylinder, could result in obtaining a cylinder virtually full of gas with a small amount of foamy oil. The procedure of sampling a liquid by gas or liquid displacement is used to overcome this potential foaming problem.

## Separator Liquid Collection: Liquid Displacement Method

1. Fill the cylinder with a suitable liquid which is more dense than, and immiscible with the separator liquid. Suitable liquids for use are displacement media which are: mercury, brine, glycol/water mixtures and water. The latter three should not be used in sour systems.
2. Select a sample point from which a representative first stage separator sample can be collected.
3. Compare the pressure of the sample source to the maximum operating pressure of the sample cylinder to ensure that the cylinder will safely contain the liquid sample. The cylinder must be an approved type with a current certification date for sample transport to the laboratory. In the United States, the cylinder must be approved by the U.S. Department of Transportation, while transporting a cylinder in many international locations requires certification by Lloyd's Register Industrial Services.
4. Connect the sample line to the separator liquid source and to the sample cylinder in a manner as shown in Figure C-2, leaving the fitting on the cylinder end of the connector line finger tight.

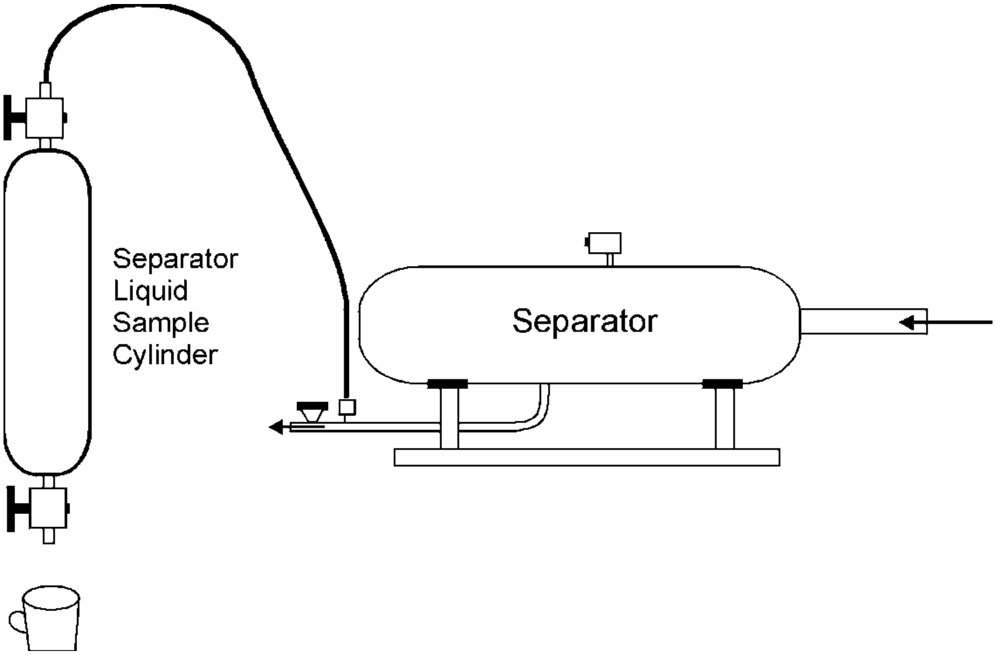


**Figure C-2. Liquid Displacement Method**

5. Partially open the separator liquid source valve, allowing a slow displacement of air from the connecting line. Continue venting sufficient liquid to clean the sample point and sampling system.
6. With a wrench, properly tighten the connecting line to the cylinder fitting.
7. Fully open the separator liquid source valve.
8. Maintain the cylinder in a vertical position with the inlet valve at the top throughout the sample collection procedure.
9. Fully open the upper cylinder valve.
10. With the cylinder perfectly vertical, slowly open the bottom valve of the cylinder to allow a slow (small) stream of displacement liquid to drain into a graduated cup.
11. Maintain the slow rate of displacement liquid removal so that no appreciable pressure drop occurs in the sampling system. One must not rush this procedure.
12. When 90 percent of the sample cylinder volume has been collected, close first the bottom valve and then the top valve of the sample cylinder.
13. With the top valve of the cylinder closed, slowly drain from the bottom of cylinder the remaining 10 percent of the displacement liquid. Close the bottom valve of the sample cylinder immediately when the separator liquid appears. Creating a gas cap in this manner is easily accomplished, perfectly safe and of very little risk to the integrity of the sample.

14. Close the valve from sample source and depressurize the sampling system.
15. Disconnect the sample cylinder from the sampling hose.
16. Securely install blow plugs into both sample cylinder valves.
17. Fill in information on the sample tags as completely and accurately as possible and attach to the sample cylinder.
18. On a separate sheet of paper, list the cylinder number with all of the information recorded on the sample cylinder tag. Include this information for all cylinders involved in the sample collection on this same sheet of paper. Send this information under separate cover to the laboratory.
19. Repeat the above procedure using all separator liquid cylinders provided.

**Notes:**

The Liquid Displacement sampling technique is generally utilized when collecting LPG and NGL samples. This procedure ensures a good gas cap inside the cylinder. Samples of these products can be extremely dangerous if the cylinder is absolutely liquid filled and allowed to warm while in transport to the laboratory.

## Separator Gas Collection

The gas sampling method is important for accurate modeling results. The separator gas sample is typically collected from the gas line at the low pressure separator outlet. Operators have sampled separator gas for years by attaching a canister or high pressure cylinder directly to the separator's gas sampling port. The GRI-GlyCalc manual (GRI, 1996) recommends employing a manifold to remove entranced liquids from the sample probe when collecting the sample from the gas line. The manifold is necessary when measuring low concentration components such as HAPs (benzene, toluene, ethyl-benzene, xylenes and x-hexane). The manual recommends the Gas Processors Association (GPA) standard 2166 as a gas sampling reference. Also, the manual indicates a modified EPA method T0-14, normally used for ambient air sampling, as a satisfactory method for gas sampling.

# Index