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PRODUCTION TANK EMISSIONS MODEL

E&P TANK VERSION 2.0
USER'S MANUAL

A PROGRAM FOR ESTIMATING EMISSIONS FROM HYDROCARBON PRODUCTION TANKS

REGULATORY AND SCIENTIFIC AFFAIRS
SOFTWARE NUMBER 4697
APRIL 20000

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ABSTRACT

For regulatory purposes, the petroleum industry's exploration and production (E&P) sector may be required to estimate and report certain emissions for petroleum production tank batteries currently in service. As a consequence, the American Petroleum Institute (API) and GRI jointly supported the development of a comprehensive software package for the estimation of emissions from hydrocarbon production tanks. The foundation of the software package, entitled *Production Tank Emissions Model (E&P TANK Version 2.0)*, is based upon rigorous thermodynamic principles or, in some cases, upon kinetic models well accepted by industry and the U.S. Environmental Protection Agency (USEPA). This version of E&P TANK uses a 32-bit user-friendly graphic interface to complement the established functionalities of the previous version. Special attention has been paid to the program interface design, making it user-friendly and easily understandable to those with a basic knowledge of Windows™. Validation of the models in E&P TANK Version 2.0 has been completed with good agreement between model predictions and field data.

Table of Contents

Chapter 1 Introduction

Welcome

Welcome to E&P TANK Version 2.0, a software program that predicts hydrocarbon emissions from production oil tanks. This version of E&P TANK uses a 32-bit user-friendly graphic interface to complement the established functionalities of the previous version.

About E&P TANK Version 2.0

There are approximately one-quarter million petroleum production tank batteries currently in service for the petroleum industry's exploration and production (E&P) sector. Tank operators may be 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	Heptanes
Toluene	Ethane	Octanes
Ethyl-Benzene	Propane	Nonanes
Xylenes	n-Butane	Benzene
n-Hexane	i-Butane	Toluene
	n-Pentane	Ethyl-Benzene
	i-Pentane	Xylenes
	n-Hexane	Decanes+
	Hexanes	

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 or a flash 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.

The calculation accuracy of E&P TANK Version 2.0 has been confirmed by comparing its predictions with HYSIM®, a commercially available simulator from Hyprotech Ltd., Calgary. This comparison confirmed the calculation procedures and algorithms of the program. In addition, plant data measurements conducted by Radian International L.L.C. further validated the accuracy of the E&P TANK program as the field data were compared with E&P TANK predictions.

Chapter 2 Installation

Installing E&P TANK Version 2.0 is a simple process. This chapter explains everything you need to know regarding installation of E&P TANK Version 2.0.

Installation Requirements

Hardware Requirements

- 486 or Higher PC Compatibles (Pentium recommended)
- 8 MB RAM
- 2 MB Free Hard Disk Space
- Printer (optional)

Software Requirements

- Microsoft Windows 95/98/NT 4.0 (or later)

Installing E&P TANK Version 2.0

Note: *If you want to install E&P TANK Version 2.0 and there is already a previous version 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.*

To install E&P TANK Version 2.0

1. Insert the E&P TANK Version 2.0 Disk 1 into a floppy disk drive.
2. Click **Start** on the Microsoft Windows Taskbar and then click **Run**.
3. At the **Run** dialog, type **a:\Setup32** or **b:\Setup32** to execute the automatic installation process.
4. Follow the installation instructions on the screen.

After the installation process is complete, the E&P TANK program group will be created.

Technical Support

DB Robinson Research Ltd. provides technical support for E&P TANK Version 2.0. Should you have technical problems that cannot be solved using the on-line help or the user's manual, please contact our software technical support staff at:

Telephone:	**(780) 463-8638**
Fax:	**(780) 450-1668**
E-mail:	**support@dbra.com**

Before contacting DB Robinson Research Ltd., it is suggested that the following information pertaining to the problem be gathered in order to identify the problem as quickly as possible.

If the problem is related to **installing E&P TANK Version 2.0**, record:

- the product version number
- the hardware configuration of your computer (e.g., Pentium 200 MHz)
- the operating system and version number (e.g., Windows 95)
- the exact wording of any error messages (if applicable)

If the problem is related to **running E&P TANK Version 2.0**, record:

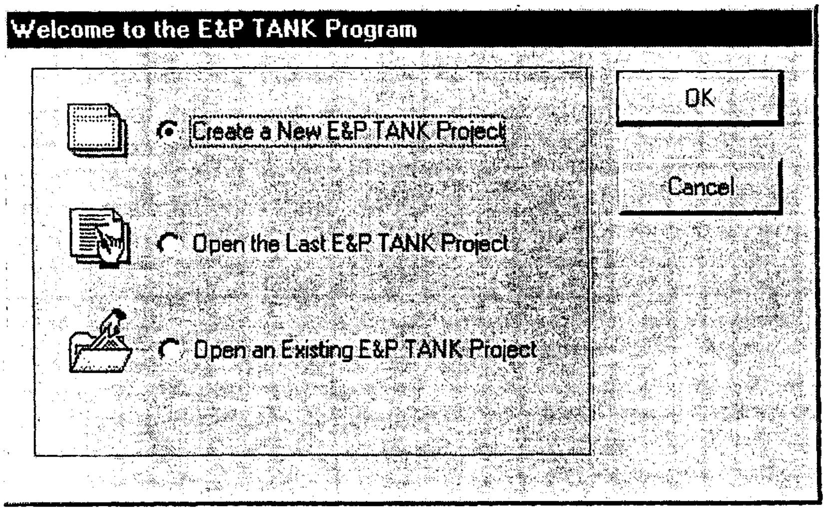
- the exact wording of any error messages (if applicable)
- the input data used
- what you were doing when the problem occurred
- your attempt in solving the problem

Chapter 3 Getting Started

Starting and Exiting E&P TANK Version 2.0

To start E&P TANK

1. From the Windows **Start** Taskbar, click **Program** and select **E&P TANK Version 2.0**.



Welcome to the E&P TANK Program

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

To exit E&P TANK

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**.

Accessing Online Help

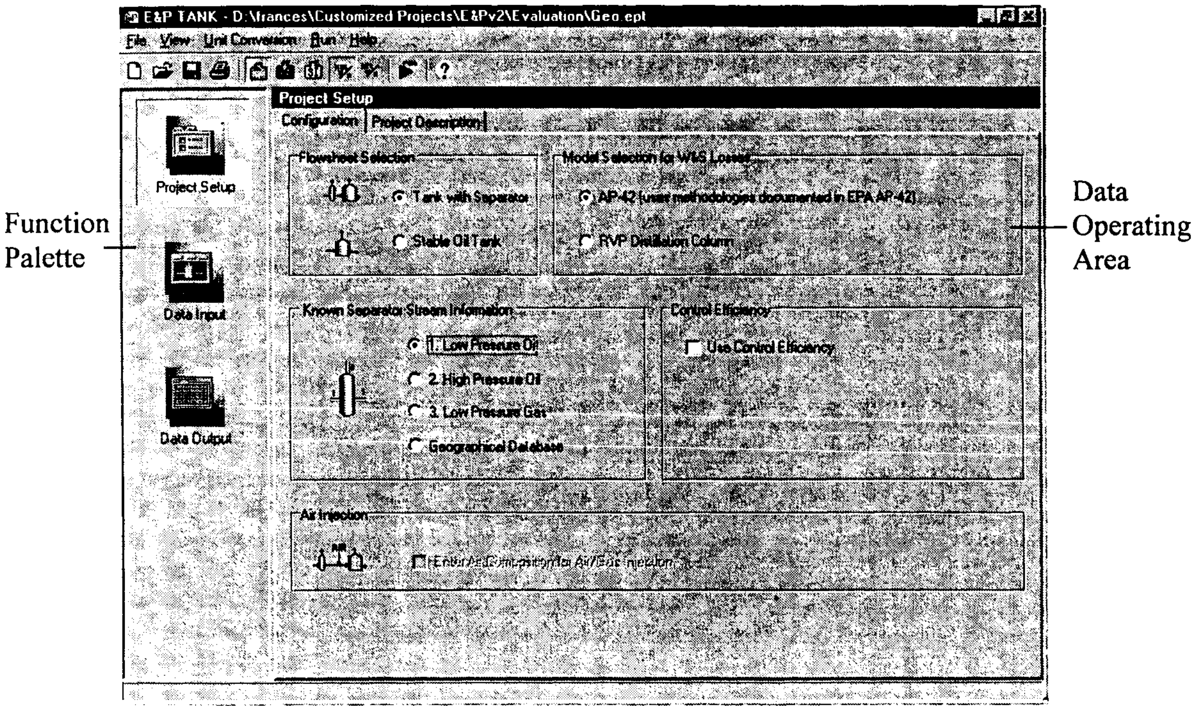
You can access the online help from the E&P TANK Help system:

- From the **Help** menu, select **Contents** or **Index**.
- Click **Help for Current Screen** on the E&P TANK toolbar.
- From within a dialog, click the **Help** button.

Application Window

There are two main working areas in the E&P TANK application window:

- Function Palette
- Data Operating Area



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

Unit Conversions

There are two unit systems in E&P TANK: Engineering and SI units.

The two unit systems are convertible in any display windows in E&P TANK. Users can choose to view and enter data as well as to print calculation results in either of the units, regardless of which system was used in data input. Besides selecting the unit system, users may select mol % or wt % from the toolbar or the Unit Conversion menu.

Selecting & Converting Units

To select a unit system

Click on the appropriate unit buttons on the toolbar or select desired unit system from the Unit Conversion menu.

To perform unit conversions

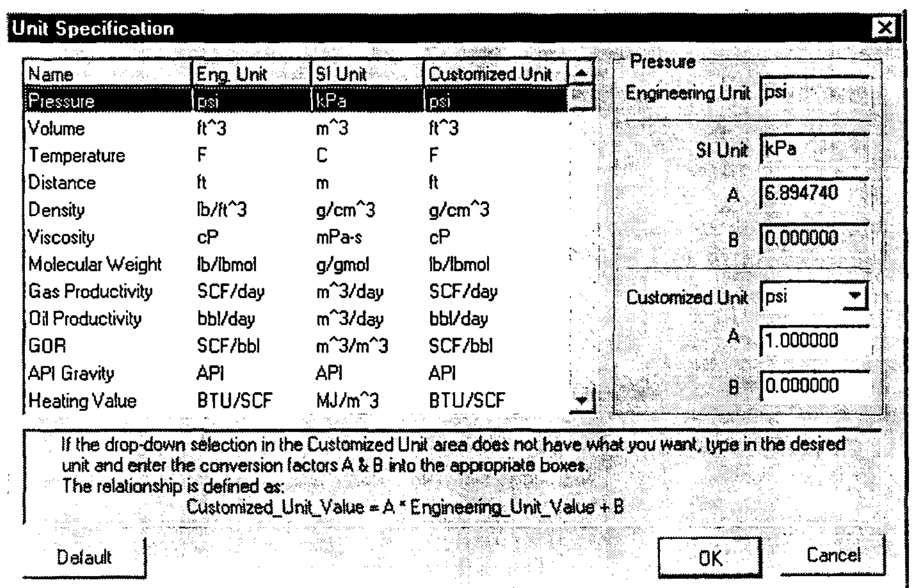
Switch the unit systems from one unit system to another by clicking on the appropriate unit button on the toolbar. Results of unit conversions are displayed instantly upon the switch of the unit system.

Customizing a Unit System

The E&P TANK program allows you to customize your own unit combinations and save the combinations as the Customized unit.

To define a new unit in the Customized Unit systems

1. Select **Options...** from the **Unit Conversion** menu. A dialog appears.



Customized Units

2. In the **Unit Specification** dialog, click to select a unit name from the left pane.
3. Click on the down arrow next to the **Customized Unit** box to select a unit. If the desired unit is not listed, create it by typing the new unit over any existing unit in the list.
4. If it is a created unit, enter the conversion factors A and B in the appropriate boxes.
5. Click **OK** to exit the dialog.

Chapter 4 Using E&P TANK Version 2.0

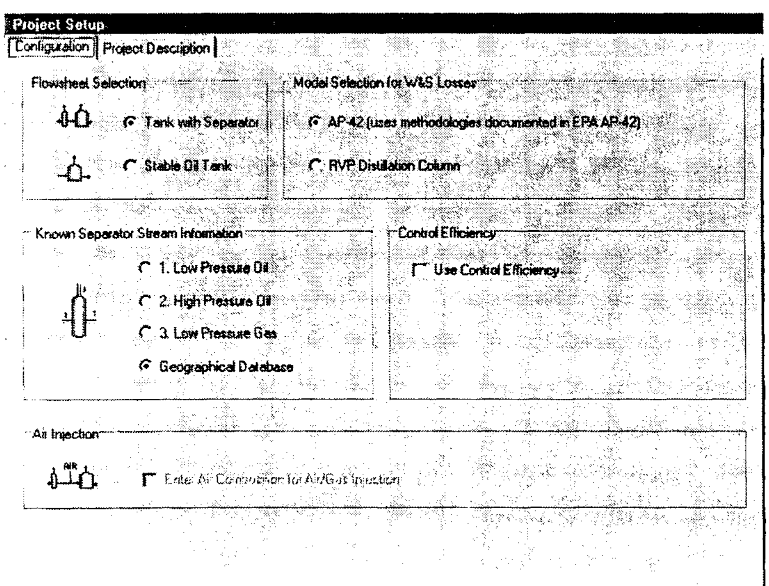
This chapter will assist users in starting and setting up a new project, providing input data, as well as viewing and printing calculation results.

E&P TANK Basic Steps

The basic steps to create a project using E&P TANK 2.0 are as follows:

1. Open a new project.
2. In the Project Setup window:
    - Select a flowsheet and a calculation model
    - Specify necessary setup information
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.

Project Setup



Project Setup

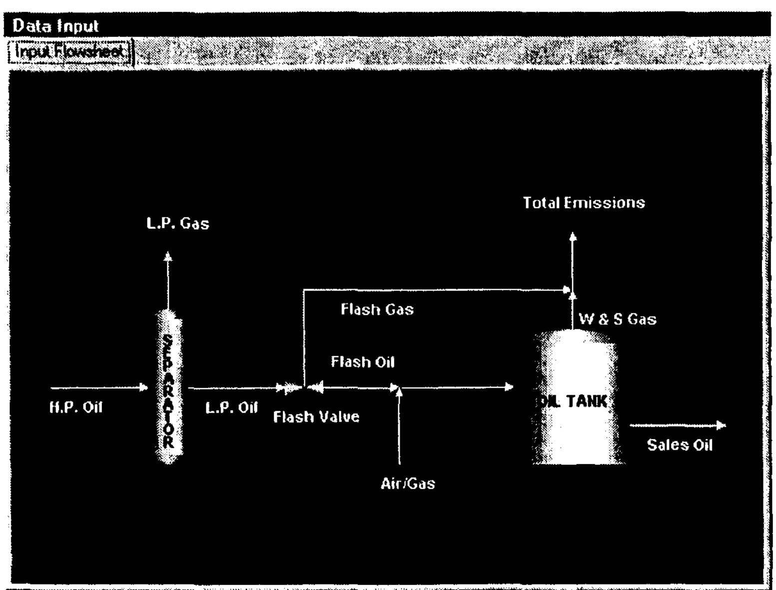
To setup a project

1. In the Project Setup window, select the flowsheet type from the **Configuration** tab.
2. 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.
3. If the flowsheet with separator was selected in Step 1, select a separator stream in which compositional information is known.
4. Click to select **Control Efficiency** and specify the percentage, if desired.
5. If you select flowsheet with separator and RVP as calculation model, the Air Injection option will be available for you to specify the daily air injection.
6. Provide project description in the **Project Description** tab, if desired.

Note:	*If Distillation Column is selected in step 2, E&P TANK will by default use multi-stage distillation to estimate W&S losses. Only when the multi-stage distillation method fails, the program switches to single-stage distillation.*

Data Input

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



Input Flowsheet: Tank with Separator

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

Separator

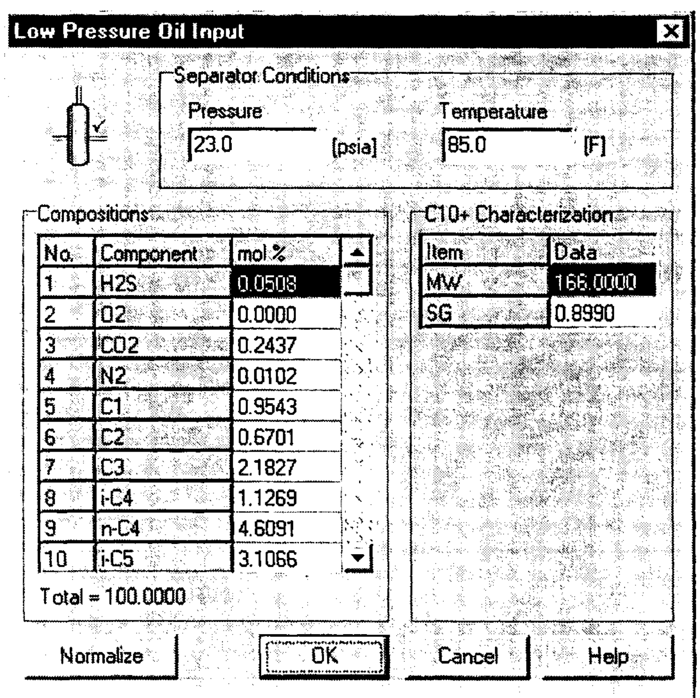
Users enter the input data such as separator conditions and detailed compositional data for separator oil or gas. The input varies according to your selection of **Known Separator Stream Information** in the Project Setup window.

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: Low Pressure Oil Input

2. Provide separator pressure and temperature.
3. Enter the compositions for the low-pressure or high-pressure oil.

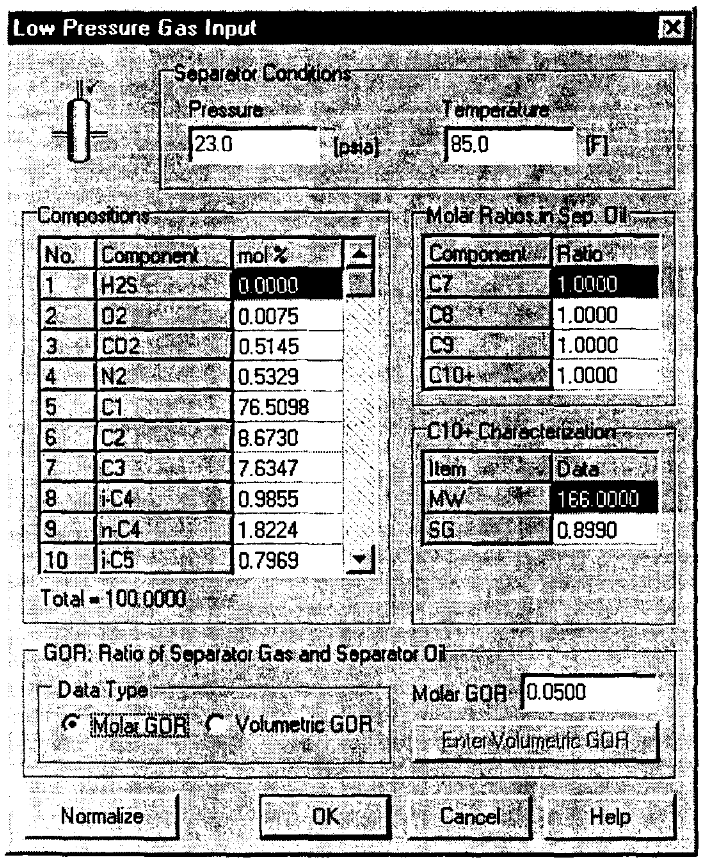
4. Provide characterization properties such as molecular weight (MW) and specific gravity (SG) for the C10+ fraction.
5. Click **OK** to exit the dialog.

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: Low Pressure Gas Input

2. Provide separator pressure and temperature.
3. Enter compositional data for each component. Provide the C7:C8:C9:C10+ molar ratios and the C10+ characterization properties for the separator oil.
4. 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.** The **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.

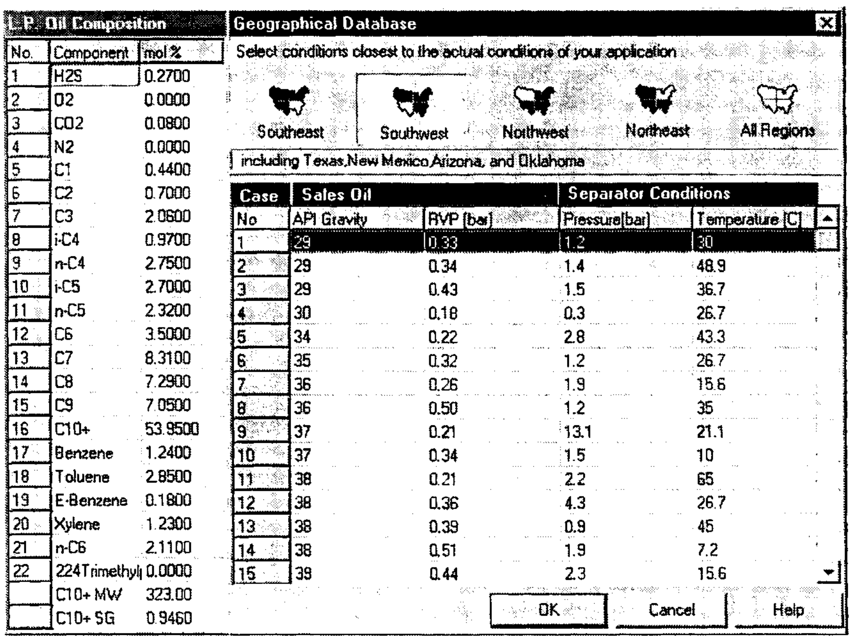
5. Click **OK** to exit the **Low Pressure Gas Input** dialog.

Geographical Database

If you do not have any stream data on the separator, you may select the geographical information option. 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 test tanks. The separator oil compositions are also associated with the selection of these cases. Hence, the separator compositions are automatically fixed upon the selections 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.

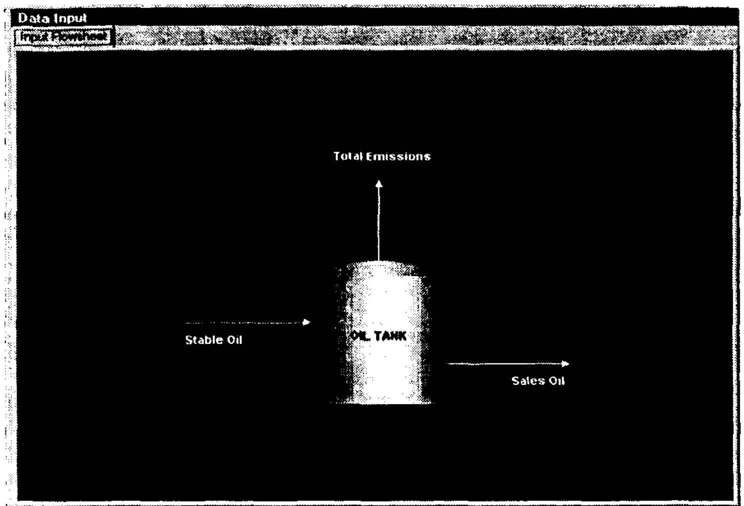


Separator: Geographical Database

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.



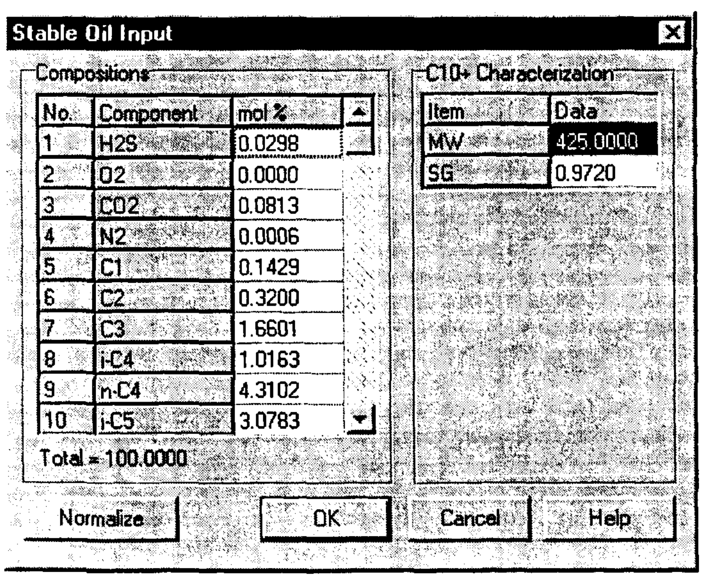
Data Input Flowsheet: Stable Oil Tank

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.



Stable Oil Input

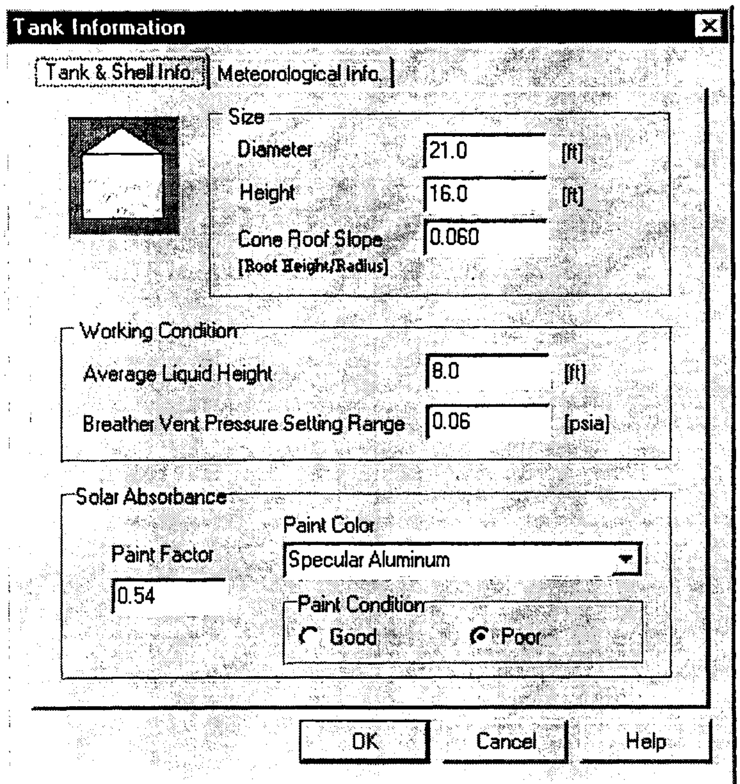
2. Enter the stable oil compositions.
3. Enter the C10+ characterization properties as well.
4. Click **OK** to return to the Input Flowsheet.

Oil Tank

There are two tabs in the Tank Information dialog: **Tank & Shell Info.** and **Meteorological Info.**

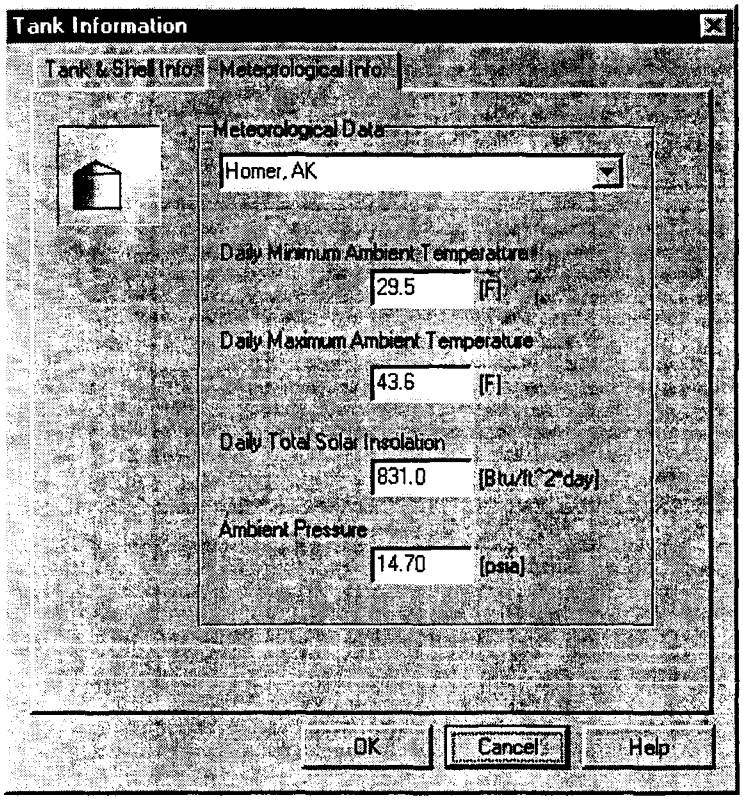
To provide oil tank information

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



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.



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.
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.

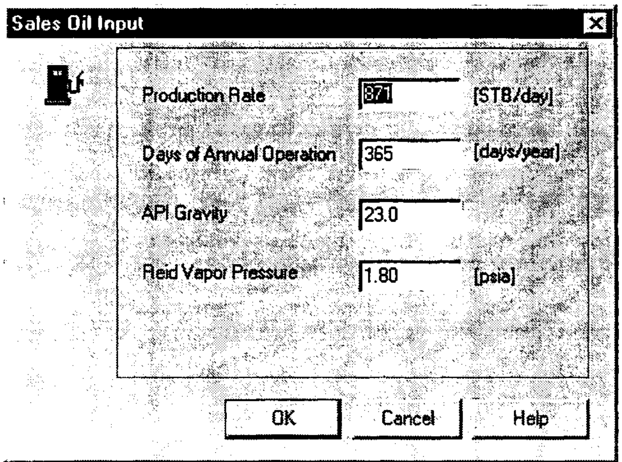
Note: *The solar absorbance factors of paint are taken from an AP-42 publication [7] based on the conditions of the tank.*

Sales Oil

If the RVP Distillation method is selected, sales oil properties such as production rate, API gravity, and Reid vapor pressure, are required to be entered in the Sales Oil Input dialog. These data are commonly available.

To specify sales oil

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



Sales Oil Input

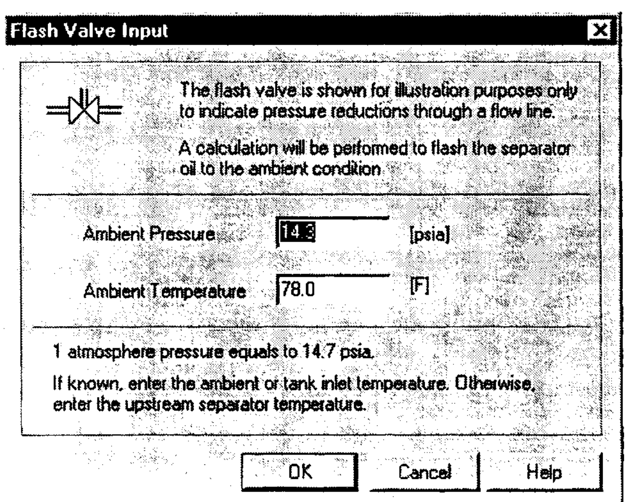
2. Enter the sales oil properties in the appropriate boxes.
3. Click **OK** to return to the Input Flowsheet.

Note: The RVP Distillation method uses a four-stage distillation column to simulate working and standing losses by matching sales oil RVP specifications. If a convergence problem exists in this calculation, the program automatically recalculates the working and standing losses using a more conservative, single-stage approach.

Flash Valve

To specify the flash valve inputs

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



Flash Valve Inputs

2. Enter the ambient pressure and temperature. If the ambient temperature is unavailable, use temperature of the upstream separator.
3. Click **OK** to return to the Input Flowsheet window.

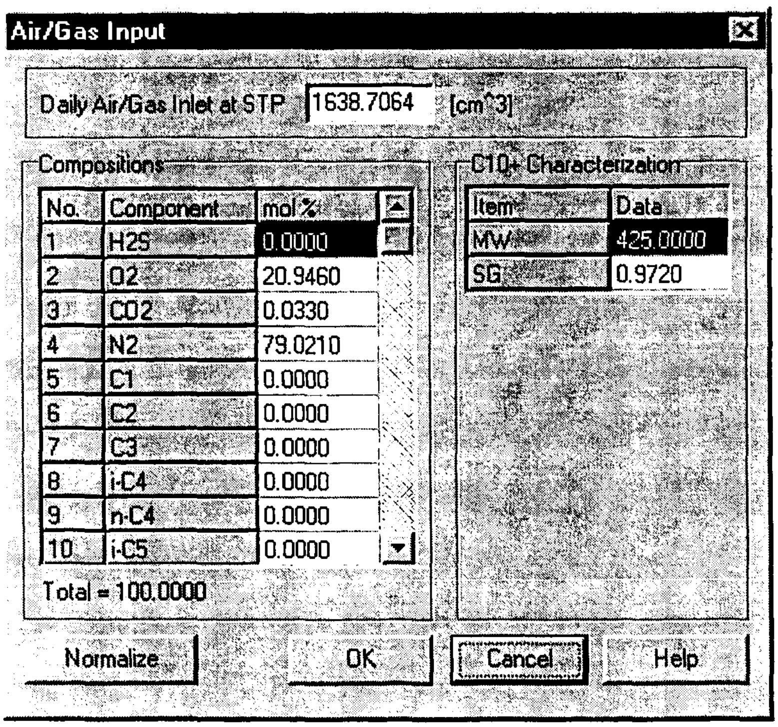
Note: *The flash valve is not a physical piece of equipment. It simply illustrates pressure reduction in a flow line.*

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.



Air Injection

4. Enter the daily air/gas injection volume.
5. Provide the air/gas compositions.
6. Enter C10+ characterization, if applicable.

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

Data Output

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

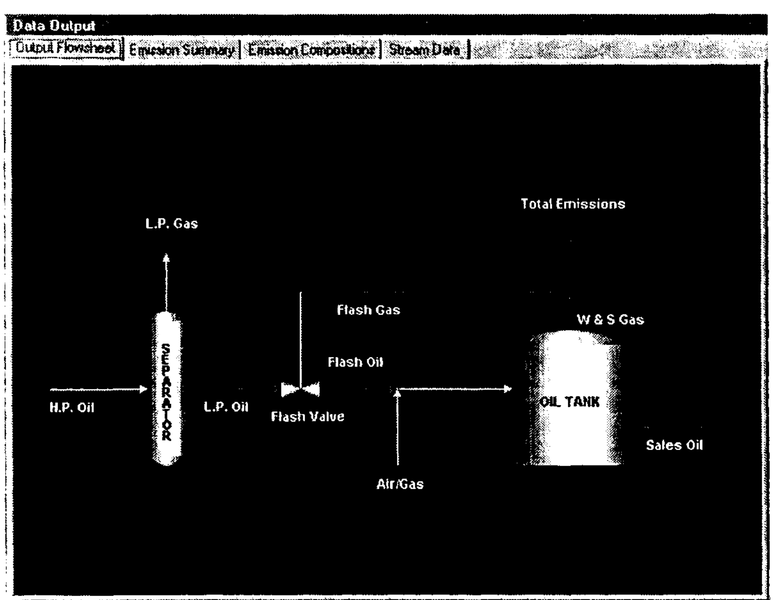
Viewing Calculation Results

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

Output Flowsheet

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



Output Flowsheet

Emission Summary

This tab contains the controlled and uncontrolled emissions for components of specific interest. They are the total HAPs, individual HAP, total HC, C2+, and C3+. This tab also presents the uncontrolled recovery for total vapor and HC vapor from the oil storage tank.

Data Output

Output Flowsheet | Emission Summary | Emission Compositions | Stream Data

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
Total HAPs	12.090	2.760	0.605	0.138
Total HC	686.156	156.657	34.308	7.833
VOCs, C2+	577.798	131.917	28.890	6.596
VOCs, C3+	498.049	113.710	24.902	5.685
Uncontrolled Recovery Info.				
Vapor	40.9200	[MSCFD]		
HC Vapor	37.8200	[MSCFD]		
GOR	20.46	[SCF/bbl]		

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.

Data Output

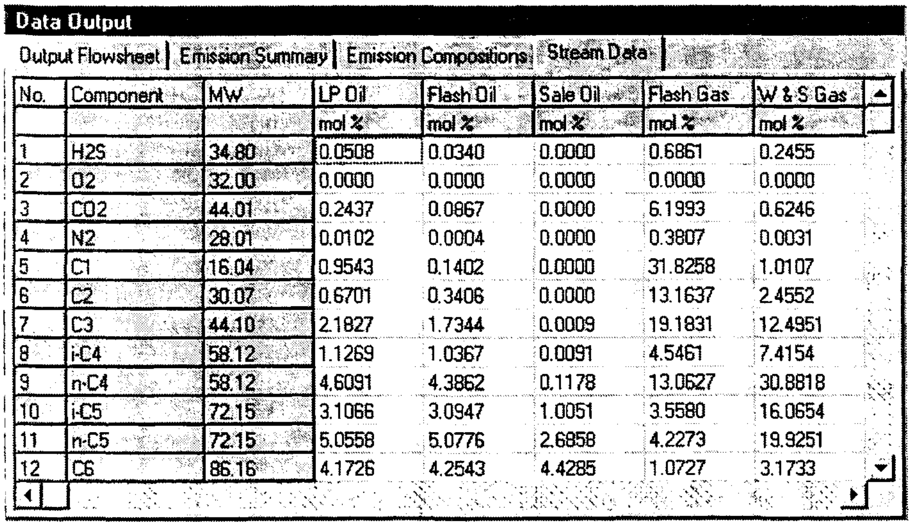
Output Flowsheet | Emission Summary | Emission Compositions | Stream Data

No	Component	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
1	H2S	6.986	1.595	0.349	0.080
2	O2	0.000	0.000	0.000	0.000
3	CO2	43.283	9.882	43.283	9.882
4	N2	1.153	0.263	1.153	0.263
5	C1	61.782	14.105	3.089	0.705
6	C2	81.314	18.565	4.066	0.928
7	C3	388.278	88.648	19.414	4.432
8	i-C4	262.518	59.936	13.126	2.997
9	n-C4	1057.897	241.529	52.895	12.076
10	i-C5	658.937	150.442	32.947	7.522
11	n-C5	815.856	186.268	40.793	9.313
12	C6	154.751	35.331	7.738	1.767
13	C7	132.378	30.223	6.619	1.511

Emission Compositions

Stream Data

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



Data Output

Output Flowsheet | Emission Summary | Emission Compositions | Stream Data

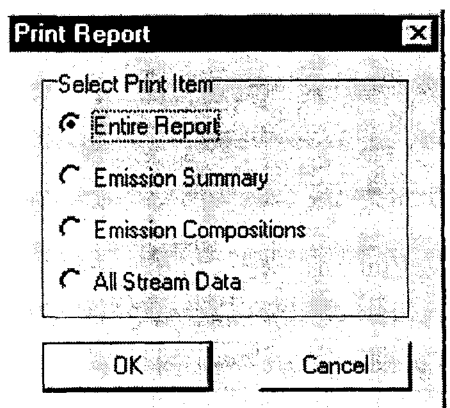
No.	Component	MW	LP Oil mol %	Flash Oil mol %	Sale Oil mol %	Flash Gas mol %	W & S Gas mol %
1	H2S	34.80	0.0508	0.0340	0.0000	0.6861	0.2455
2	O2	32.00	0.0000	0.0000	0.0000	0.0000	0.0000
3	CO2	44.01	0.2437	0.0867	0.0000	6.1993	0.6246
4	N2	28.01	0.0102	0.0004	0.0000	0.3807	0.0031
5	C1	16.04	0.9543	0.1402	0.0000	31.8258	1.0107
6	C2	30.07	0.6701	0.3406	0.0000	13.1637	2.4552
7	C3	44.10	2.1827	1.7344	0.0009	19.1831	12.4951
8	i-C4	58.12	1.1269	1.0367	0.0091	4.5461	7.4154
9	n-C4	58.12	4.6091	4.3862	0.1178	13.0627	30.8818
10	i-C5	72.15	3.1066	3.0947	1.0051	3.5580	16.0654
11	n-C5	72.15	5.0558	5.0776	2.6858	4.2273	19.9251
12	C6	86.16	4.1726	4.2543	4.4285	1.0727	3.1733

Stream Data

Printing Calculation Results

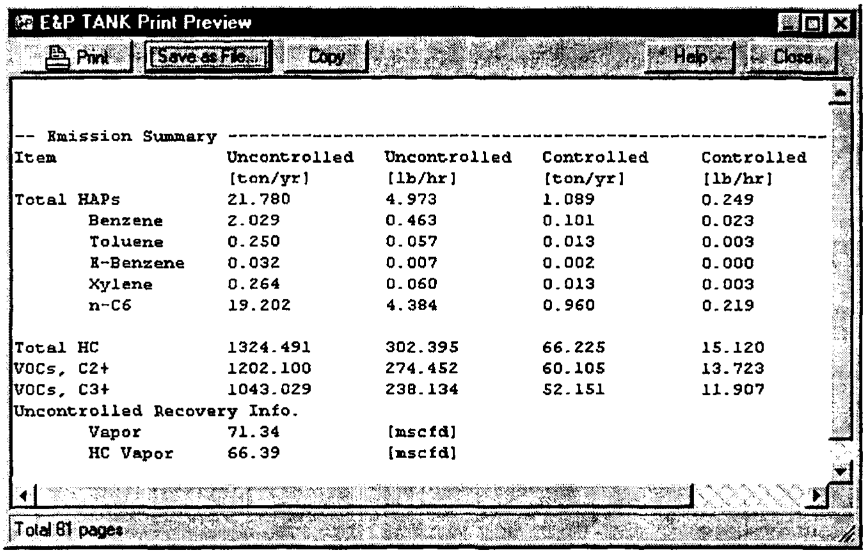
To print calculation results

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



Selecting a Print Item

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



-- Emission Summary --

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
Total HAPs	21.780	4.973	1.089	0.249
Benzene	2.029	0.463	0.101	0.023
Toluene	0.250	0.057	0.013	0.003
E-Benzene	0.032	0.007	0.002	0.000
Xylene	0.264	0.060	0.013	0.003
n-C6	19.202	4.384	0.960	0.219
Total HC	1324.491	302.395	66.225	15.120
VOCs, C2+	1202.100	274.452	60.105	13.723
VOCs, C3+	1043.029	238.134	52.151	11.907
Uncontrolled Recovery Info.				
Vapor	71.34	[mscfd]		
HC Vapor	66.39	[mscfd]		

Print Preview

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

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.

Chapter 5 Managing Projects

Creating a New Project

To create a new project

1. Click on the **New Project** button on the toolbar or select **New** from the **File** menu. The Project Setup window appears.
2. Configure the project in the **Configuration** tab.
3. Enter project descriptions in the **Project Description** tab, if desired.

Opening a Project

To open a new project

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

To open an existing project

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

Printing a Project

To print a project

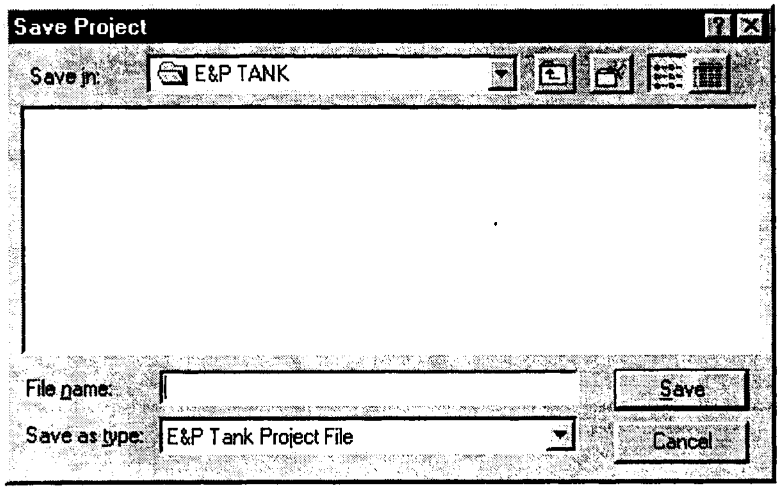
1. Click on the **Print** button on the toolbar or select **Print...** from the **File** menu.
2. In the **Print Report** dialog, select an item to print and click **OK.**
3. In the **E&P TANK Print Preview** dialog, click **Print** to start printing.

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.

Saving a Project

To save a project

1. Simply click on the **Save Project** button on the toolbar or select **Save** or **Save As** from the **File** menu.



Saving a Project

2. In the **Save Project** dialog, specify the path and the project file name.
3. Click **Save**.

Deleting a Project

To delete an E&P TANK project

Using Windows Explorer, delete the E&P TANK project file.

Appendix A Technical Aspects

Technical Background of E&P TANK

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.

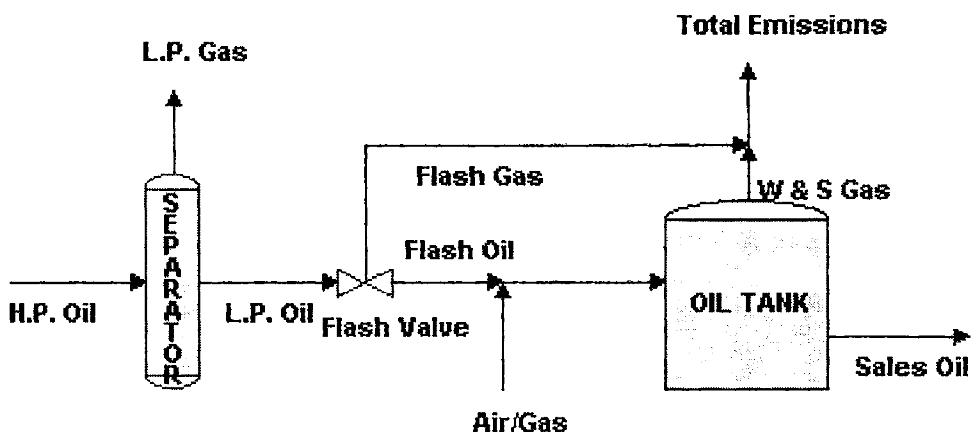


Figure 1. Oil Production Storage System

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 either a distillation column with four trays or a single-stage flash 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 first attempted and if column convergence problems arise, it is automatically followed by a more conservative single-stage flash operation. This transition is transparent to the user although a notation is provided as to which method was used in the output report. In either 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 Absorbancy
- Daily Minimum Ambient Temperature
- Daily Maximum Ambient Temperature
- Daily Solar Insolation
- 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 follows 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 Appendix 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 C10+ analyses with a detailed breakdown of the HAP and VOC components. Since these components must be specified to the model so that their contribution to the emissions may be calculated, a less detailed analysis such as a C6+ or C7+ would not be appropriate. Should these be the only compositional data available, the most reasonable solution would be to select an oil with similar average properties (and C6- composition) from the database and use that fluid as an estimate of the emissions expected from the reference crude. Of course, this method would only provide a rough approximation and should be used with the appropriate considerations.

Similarly, the C10+ molecular weight and specific gravity are required to characterize that pseudo-component in the model. If only a C6+ or C7+ analysis is available, these C10+ values are not provided. Again, in lieu of obtaining the necessary C10+ analysis, a prohibitive solution would be to select a similar oil from the database and use its C10+ characterization values. These properties would likely be more representative of the reference oil (as oils with similar API gravity and RVP often have similar C10+ properties) and as such, could be used with more confidence than the HAP concentrations discussed in the previous paragraph.

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 [7] 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 rates (for example, pounds per year).

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

Composition of stable oil is required.

- Oil RVP is calculated by the Peng-Robinson equation of state 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 = system pressure

x_i = mole fraction of species i in liquid

y_i = mole fraction of species i in vapor

Φ_i^L = fugacity coefficient of species i in liquid

Φ_i^V = 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:

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

where:

α = either V for vapor or L for liquid phase

P = system pressure

V = system volume at the specified condition

T = system temperature on an absolute scale

R = universal gas constant

n = 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 [6].

In particular cases where the VLE separation is achieved through column distillations, the simulation of the column is accomplished using the Ishii-Otto [3] algorithm. The Ishii-Otto algorithm is fairly stable and fast in reaching convergent solutions for most hydrocarbon applications.

Program Validation

There are two aspects in the program validation. The first is to assume the accuracy of program algorithms and calculated results. The second is to verify program predictions against field data. Validation of the first aspect was to compare the OIL TANK module predictions with another commercial simulator, called HYSIM®. The two sets of predictions agreed well. The second aspect was verified by the good agreement between the E&P predictions and field data. A detailed report of these comparisons is available from the American Petroleum Institute [5].

Program Limitations

The program has a fixed process configuration and is dedicated to estimating the emissions from petroleum production tanks. There are no explicit limitations in the program applicability. The API gravity of the sales oils (and condensate) tested ranged from 15 to 68, with RVP from 0.2 to 13.1 psia. Program testing has indicated that when the working and standing losses become extremely low, either because of a low oil volatility or a short residence time in the tank, the column or flash simulations may not match specified RVP values. This is particularly true in the case where the multi-stage column is selected to simulate the tank. As a result, if the four stage distillation column method does not converge to a solution, the software automatically recalculates the working and standing losses using the more conservative single-stage flash operation.

Appendix 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] 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.

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

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

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

[7] 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.

[8] Vasquez, M. and Beggs, H.D., *Correlations for Fluid Physical Property Predictions*, Journal of Petroleum Technology. June: 968-970, 1980.

Appendix 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. 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.

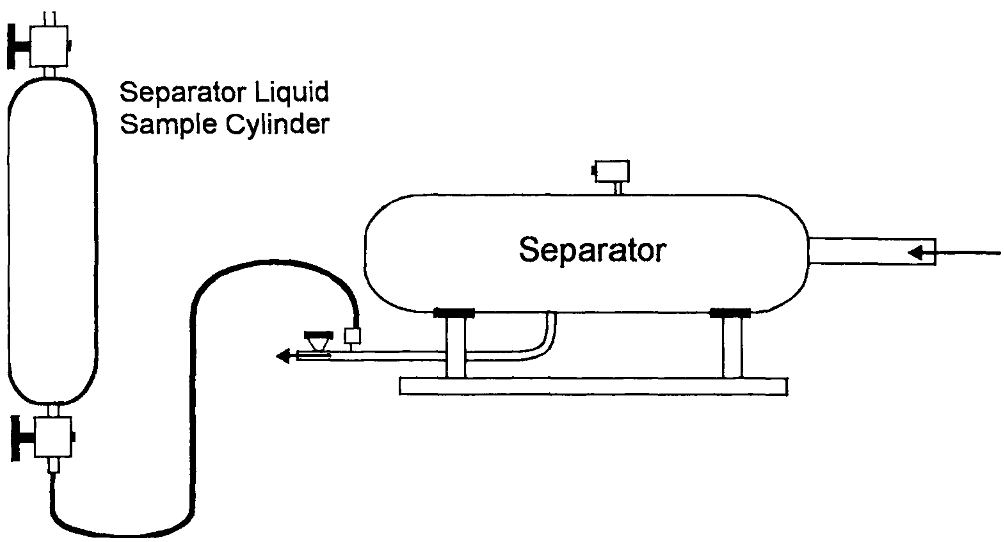


Figure C-1. Evacuated Cylinder Method

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 <u>unless</u> 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 repressurization, 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.
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.

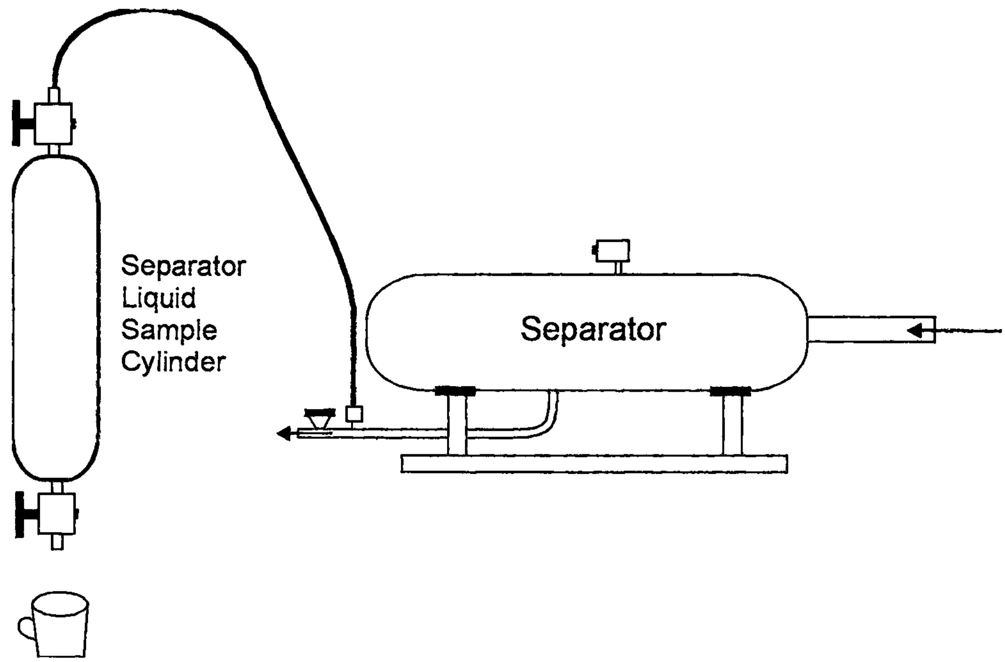


Figure C-2. Liquid Displacement Method

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.

Appendix D Examples

Shown in this appendix are the printouts of the following simulations:

- Oil Tank Prediction (Low Pressure Separator Oil Option)
- Oil Tank Prediction (Low Pressure Separator Gas Option)
- Stable Oil Tank Prediction

Example 1

Oil Tank Prediction (Low Pressure Separator Oil Option)

```
******************************************************************************************
*     Project Setup Information                                                          *
******************************************************************************************
Project File                : F:\Customized Projects\E&P Tank v2.0\Examples\Oil Tank (LP Oil).ept
Flowsheet Selection         : Oil Tank with Separator
Calculation Method          : RVP Distillation
Control Efficiency          : 95.0%
Known Separator Stream      : Low Pressure Oil
Entering Air Composition    : No

Date                        : 1999.04.27


******************************************************************************************
*     Data Input                                                                         *
******************************************************************************************


Separator Pressure          : 23.00[psig]
Separator Temperature       : 85.00[F]
Ambient Pressure            : 14.70[psia]
Ambient Temperature         : 70.00[F]
C10+ SG                     : 0.8990
C10+ MW                     : 166.00

-- Low Pressure Oil -----------------------------------------------------------------------
   No.    Component              mol %
   1      H2S                    0.0508
   2      O2                     0.0000
   3      CO2                    0.2437
   4      N2                     0.0102
   5      C1                     0.9543
   6      C2                     0.6701
   7      C3                     2.1827
   8      i-C4                   1.1269
   9      n-C4                   4.6091
   10     i-C5                   3.1066
   11     n-C5                   5.0558
   12     C6                     4.1726
   13     C7                    10.3655
   14     C8                    10.8426
   15     C9                     5.5127
   16     C10+                  45.9695
   17     Benzene                0.5685
   18     Toluene                0.2132
   19     E-Benzene              0.0711
```

20	Xylenes	0.6802
21	n-C6	3.5939
22	224Trimethylp	0.0000

-- Sales Oil --

Production Rate : 2000[bbl/day]

Days of Annual Operation : 365 [days/year]

API Gravity : 46.0

Reid Vapor Pressure : 7.70[psia]

****

* Calculation Results *

****

-- Emission Summary ---

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
Total HAPs	21.780	4.973	1.089	0.249
Total HC	1324.491	302.395	66.225	15.120
VOCs, C2+	1202.100	274.452	60.105	13.723
VOCs, C3+	1043.029	238.134	52.151	11.907

Uncontrolled Recovery Info.

Vapor	71.3400	[MSCFD]
HC Vapor	66.3900	[MSCFD]
GOR	35.67	[SCF/bbl]

-- Emission Composition ---

No	Component	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
1	H2S	12.137	2.771	0.607	0.139
2	O2	0.000	0.000	0.000	0.000
3	CO2	85.667	19.559	85.667	19.559
4	N2	2.284	0.521	2.284	0.521
5	C1	122.391	27.943	6.120	1.397
6	C2	159.072	36.318	7.954	1.816
7	C3	415.158	94.785	20.758	4.739
8	i-C4	96.442	22.019	4.822	1.101
9	n-C4	261.360	59.671	13.068	2.984
10	i-C5	82.901	18.927	4.145	0.946
11	n-C5	97.357	22.228	4.868	1.111
12	C6	28.130	6.422	1.407	0.321
13	C7	26.984	6.161	1.349	0.308
14	C8	10.294	2.350	0.515	0.118

15	C9	2.081	0.475	0.104	0.024
16	C10+	0.544	0.124	0.027	0.006
17	Benzene	2.029	0.463	0.101	0.023
18	Toluene	0.250	0.057	0.013	0.003
19	E-Benzene	0.032	0.007	0.002	0.000
20	Xylenes	0.264	0.060	0.013	0.003
21	n-C6	19.202	4.384	0.960	0.219
22	224Trimethylp	0.000	0.000	0.000	0.000
	Total	1424.579	325.246	71.229	16.262

-- Stream Data ---

No.	Component		MW	LP Oil	Flash Oil	Sale Oil	Flash Gas	W&S Gas	Total
Emissions									
				mol %	mol %	mol %	mol %	mol %	mol %
1	H2S		34.80	0.0508	0.0358	0.0065	0.6793	1.4580	1.0368
2	O2		32.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	CO2		44.01	0.2437	0.0950	0.0002	6.4933	4.6923	5.6664
4	N2		28.01	0.0102	0.0005	0.0000	0.4189	0.0235	0.2374
5	C1		16.04	0.9543	0.1553	0.0000	34.5319	7.6894	22.2079
6	C2		30.07	0.6701	0.3661	0.0087	13.4456	17.7009	15.3993
7	C3		44.10	2.1827	1.7950	1.0502	18.4760	37.9263	27.4061
8	i-C4		58.12	1.1269	1.0530	0.9606	4.2332	5.5332	4.8301
9	n-C4		58.12	4.6091	4.4328	4.2283	12.0182	14.3518	13.0896
10	i-C5		72.15	3.1066	3.1043	3.0959	3.2018	3.5131	3.3447
11	n-C5		72.15	5.0558	5.0864	5.1064	3.7713	4.1125	3.9280
12	C6		86.16	4.1726	4.2496	4.3162	0.9366	1.0199	0.9748
13	C7		100.20	10.3655	10.5937	10.7945	0.7742	0.8517	0.8098
14	C8		114.23	10.8426	11.0945	11.3173	0.2563	0.2861	0.2700
15	C9		128.28	5.5127	5.6428	5.7580	0.0450	0.0543	0.0492
16	C10+		166.00	45.9695	47.0631	48.0331	0.0087	0.0106	0.0095
17	Benzene		78.11	0.5685	0.5803	0.5906	0.0723	0.0795	0.0756
18	Toluene		92.13	0.2132	0.2181	0.2224	0.0075	0.0084	0.0079
19	E-Benzene		106.17	0.0711	0.0728	0.0743	0.0008	0.0009	0.0009
20	Xylenes		106.17	0.6802	0.6962	0.7104	0.0068	0.0077	0.0072
21	n-C6		86.18	3.5939	3.6646	3.7261	0.6222	0.6798	0.6486
22	224Trimethylp		114.24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	MW			123.89	125.93	127.59	37.91	45.66	41.47
	Stream Mole Ratio			1.0000	0.9768	0.9570	0.0232	0.0197	0.0430
	Heating Value		[BTU/SCF]				2001.39	2458.73	2211.37
	Gas Gravity		[Gas/Air]				1.31	1.58	1.43
	Bubble Pt. @ 100F		[psia]	56.28	20.19	8.70			
	RVP @ 100F		[psia]	18.38	11.68	7.71			
	Spec. Gravity @ 100F			0.800	0.803	0.806			

Example 2

Oil Tank Prediction (Low Pressure Separator Gas Option)

```
************************************************************************************
*     Project Setup Information                                                    *
************************************************************************************
Project File                : F:\Customized Projects\E&P Tank v2.0\Examples\Oil Tank (LP Seprator
Gas).ept
Flowsheet Selection         : Oil Tank with Separator
Calculation Method          : AP42
Control Efficiency          : 95.0%
Known Separator Stream      : Low Pressure Gas
Entering Air Composition    : No

Date                        : 1999.04.27


************************************************************************************
*     Data Input                                                                   *
************************************************************************************

Separator Pressure          : 23.00[psig]
Separator Temperature       : 85.00[F]
Molar GOR                   : 0.0500
Ambient Pressure            : 14.70[psia]
Ambient Temperature         : 70.00[F]
C10+ SG                     : 0.8990
C10+ MW                     : 166.00

-- Low Pressure Gas -----------------------------------------------------------------
   No.    Component           mol %
   1      H2S                 0.0000
   2      O2                  0.0075
   3      CO2                 0.5145
   4      N2                  0.5329
   5      C1                 76.5098
   6      C2                  8.6730
   7      C3                  7.6347
   8      i-C4                0.9855
   9      n-C4                1.8224
   10     i-C5                0.7969
   11     n-C5                1.3635
   12     C6                  0.2318
   13     C7+                 0.6783
   14     Benzene             0.0262
   15     Toluene             0.0273
   16     E-Benzene           0.0051
   17     Xylenes             0.0108
```

18	n-C6	0.1798
19	224Trimethylp	0.0000

C7+ Molar Ratio: C7 : C8 : C9 : C10+
1.0000 1.0000 1.0000 1.0000

-- Sales Oil --

Production Rate : 2000[bbl/day]
Days of Annual Operation : 365 [days/year]
API Gravity : 46.0
Reid Vapor Pressure : 7.70[psia]
Bulk Temperature : 80.00[F]

-- Tank and Shell Data --

Diameter : 21.00[ft]
Shell Height : 16.00[ft]
Cone Roof Slope : 0.06
Average Liquid Height : 8.00[ft]
Vent Pressure Range : 0.06[psi]
Solar Absorbance : 0.54

-- Meteorological Data --

City : Homer, AK
Ambient Pressure : 14.70[psia]
Ambient Temperature : 70.00[F]
Min Ambient Temperature : 29.50[F]
Max Ambient Temperature : 43.60[F]
Total Solar Insolation : 831.00[Btu/ft^2*day]

****

* Calculation Results *

****

-- Emission Summary --

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
Total HAPs	3.840	0.877	0.192	0.044
Total HC	299.957	68.483	14.998	3.424
VOCs, C2+	203.638	46.493	10.182	2.325
VOCs, C3+	159.332	36.377	7.967	1.819

Uncontrolled Recovery Info.

Vapor	21.5100	[MSCFD]
HC Vapor	21.3300	[MSCFD]

GOR	10.76	[SCF/bbl]

-- Emission Composition --

No	Component	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
1	H2S	0.000	0.000	0.000	0.000
2	O2	0.010	0.002	0.001	0.000
3	CO2	3.013	0.688	3.013	0.688
4	N2	0.421	0.096	0.421	0.096
5	C1	96.319	21.991	4.816	1.100
6	C2	44.306	10.116	2.215	0.506
7	C3	66.610	15.208	3.331	0.760
8	i-C4	11.469	2.618	0.573	0.131
9	n-C4	21.046	4.805	1.052	0.240
10	i-C5	11.110	2.537	0.556	0.127
11	n-C5	18.690	4.267	0.935	0.213
12	C6	3.538	0.808	0.177	0.040
13	C7	15.311	3.496	0.766	0.175
14	C8	5.529	1.262	0.276	0.063
15	C9	2.111	0.482	0.106	0.024
16	C10+	0.077	0.018	0.004	0.001
17	Benzene	0.368	0.084	0.018	0.004
18	Toluene	0.425	0.097	0.021	0.005
19	E-Benzene	0.087	0.020	0.004	0.001
20	Xylenes	0.182	0.042	0.009	0.002
21	n-C6	2.777	0.634	0.139	0.032
22	224Trimethylp	0.000	0.000	0.000	0.000
	Total	303.399	69.269	15.170	3.463

-- Stream Data --

No.	Component	MW	LP Oil	Flash Oil	Sale Oil	Flash Gas	W&S Gas	Total Emissions
			mol %	mol %	mol %	mol %	mol %	mol %
1	H2S	34.80	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	O2	32.00	0.0000	0.0000	0.0000	0.0031	0.0023	0.0031
3	CO2	44.01	0.0172	0.0098	0.0095	0.6602	0.6815	0.6610
4	N2	28.01	0.0019	0.0002	0.0002	0.1475	0.0872	0.1452
5	C1	16.04	0.9593	0.3046	0.2816	58.2283	51.5579	57.9768
6	C2	30.07	0.6032	0.4479	0.4412	14.1828	15.3967	14.2286
7	C3	44.10	1.8190	1.6740	1.6672	14.5006	16.7864	14.5868
8	i-C4	58.12	0.5776	0.5626	0.5618	1.8914	2.2650	1.9055
9	n-C4	58.12	1.5287	1.5065	1.5053	3.4685	4.2122	3.4966
10	i-C5	72.15	1.6642	1.6664	1.6663	1.4732	1.8410	1.4870
11	n-C5	72.15	3.8362	3.8517	3.8520	2.4765	3.1368	2.5014
12	C6	86.16	1.8110	1.8271	1.8277	0.4021	0.5254	0.4067

13	C7	100.20	20.4562	20.6728	20.6812	1.5042	2.0369	1.5243
14	C8	114.23	20.4870	20.7158	20.7248	0.4738	0.6658	0.4810
15	C9	128.28	20.4968	20.7293	20.7385	0.1629	0.2372	0.1657
16	C10+	166.00	20.5023	20.7366	20.7459	0.0044	0.0071	0.0045
17	Benzene	78.11	0.3130	0.3160	0.3162	0.0450	0.0594	0.0455
18	Toluene	92.13	1.1033	1.1154	1.1159	0.0440	0.0605	0.0446
19	E-Benzene	106.17	0.5968	0.6035	0.6038	0.0078	0.0111	0.0079
20	Xylenes	106.17	1.4405	1.4568	1.4574	0.0163	0.0233	0.0166
21	n-C6	86.18	1.7861	1.8030	1.8036	0.3075	0.4062	0.3112
22	224Trimethylp	114.24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	MW		114.65	115.63	115.63	29.20	31.93	29.30
	Stream Mole Ratio		1.0000	0.9887	0.9883	0.0113	0.0004	0.0117
	Heating Value	[BTU/SCF]				1694.95	1841.19	1700.47
	Gas Gravity	[Gas/Air]				1.01	1.10	1.01
	Bubble Pt. @ 100F	[psia]	40.91	18.69	17.90			
	RVP @ 100F	[psia]	86.71	58.20	57.51			
	Spec. Gravity @ 100F		0.725	0.727	0.727			

Example 3

Stable Oil Tank Prediction

```
******************************************************************************************
*     Project Setup Information                                                          *
******************************************************************************************
Project File              : F:\Customized Projects\E&P Tank v2.0\Examples\Stable Oil Tank.ept
Model                     : Stable Oil Tank
Calculation Method        : AP42
Control Efficiency        : 95.0%

Date                      : 1999.04.27


******************************************************************************************
*     Data Input                                                                         *
******************************************************************************************


Separator Pressure        : 23.00[psig]
Separator Temperature     : 85.00[F]
Ambient Pressure          : 14.70[psia]
Ambient Temperature       : 70.00[F]
C10+ SG                   : 0.8990
C10+ MW                   : 166.00

-- Stable Oil ---------------------------------------------------------------------------
   No.    Component              mol %
   1      H2S                    0.0298
   2      O2                     0.0000
   3      CO2                    0.0813
   4      N2                     0.0006
   5      C1                     0.1429
   6      C2                     0.3200
   7      C3                     1.6601
   8      i-C4                   1.0163
   9      n-C4                   4.3102
   10     i-C5                   3.0783
   11     n-C5                   5.0568
   12     C6                     4.2584
   13     C7                    10.6399
   14     C8                    11.1525
   15     C9                     5.6739
   16     C10+                  47.3307
   17     Benzene                0.5815
   18     Toluene                0.2191
   19     E-Benzene              0.0732
   20     Xylenes                0.6999
   21     n-C6                   3.6746
```

22 224Trimethylp 0.0000

-- Sales Oil --

Production Rate : 2000[bbl/day]

Days of Annual Operation : 365 [days/year]

API Gravity : 46.0

Reid Vapor Pressure : 7.70[psia]

Bulk Temperature : 80.00[F]

-- Tank and Shell Data --

Diameter : 21.00[ft]

Shell Height : 16.00[ft]

Cone Roof Slope : 0.06

Average Liquid Height : 8.00[ft]

Vent Pressure Range : 0.06[psi]

Solar Absorbance : 0.54

-- Meteorological Data --

City : Homer, AK

Ambient Pressure : 14.70[psia]

Ambient Temperature : 70.00[F]

Min Ambient Temperature : 29.50[F]

Max Ambient Temperature : 43.60[F]

Total Solar Insolation : 831.00[Btu/ft^2*day]

****

* Calculation Results *

****

-- Emission Summary ---

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]	Controlled [ton/yr]	Controlled [lb/hr]
Total HAPs	0.490	0.112	0.024	0.006
Total HC	22.340	5.100	1.117	0.255
VOCs, C2+	19.935	4.551	0.997	0.228
VOCs, C3+	17.696	4.040	0.885	0.202

Uncontrolled Recovery Info.

Vapor	1.1800	[MSCFD]
HC Vapor	1.1000	[MSCFD]
GOR	0.59	[SCF/bbl]

-- Emission Composition ---

No Component Uncontrolled Uncontrolled Controlled Controlled

		[ton/yr]	[lb/hr]	[ton/yr]	[lb/hr]
1	H2S	0.128	0.029	0.006	0.001
2	O2	0.000	0.000	0.000	0.000
3	CO2	1.464	0.334	1.464	0.334
4	N2	0.039	0.009	0.039	0.009
5	C1	2.405	0.549	0.120	0.027
6	C2	2.240	0.511	0.112	0.026
7	C3	5.190	1.185	0.260	0.059
8	i-C4	1.703	0.389	0.085	0.019
9	n-C4	4.953	1.131	0.248	0.057
10	i-C5	1.726	0.394	0.086	0.020
11	n-C5	2.070	0.473	0.104	0.024
12	C6	0.627	0.143	0.031	0.007
13	C7	0.624	0.142	0.031	0.007
14	C8	0.246	0.056	0.012	0.003
15	C9	0.050	0.011	0.003	0.001
16	C10+	0.015	0.003	0.001	0.000
17	Benzene	0.046	0.011	0.002	0.001
18	Toluene	0.006	0.001	0.000	0.000
19	E-Benzene	0.001	0.000	0.000	0.000
20	Xylenes	0.006	0.001	0.000	0.000
21	n-C6	0.433	0.099	0.022	0.005
22	224Trimethylp	0.000	0.000	0.000	0.000
	Total	23.972	5.473	1.199	0.274

-- Stream Data --

No.	Component	MW	Stable Oil mol %	Sales Oil mol %	Total Emissions mol %
1	H2S	34.80	0.0508	0.0294	0.6586
2	O2	32.00	0.0000	0.0000	0.0000
3	CO2	44.01	0.2437	0.0772	5.8362
4	N2	28.01	0.0102	0.0004	0.2461
5	C1	16.04	0.9543	0.1242	26.2991
6	C2	30.07	0.6701	0.3109	13.0672
7	C3	44.10	2.1827	1.6465	20.6481
8	i-C4	58.12	1.1269	1.0134	5.1418
9	n-C4	58.12	4.6091	4.3026	14.9518
10	i-C5	72.15	3.1066	3.0775	4.1973
11	n-C5	72.15	5.0558	5.0568	5.0331
12	C6	86.16	4.1726	4.2605	1.3096
13	C7	100.20	10.3655	10.6467	1.1283
14	C8	114.23	10.8426	11.1602	0.3894
15	C9	128.28	5.5127	5.6779	0.0710
16	C10+	166.00	45.9695	47.3645	0.0154
17	Benzene	78.11	0.5685	0.5818	0.1025

18	Toluene	92.13	0.2132	0.2192	0.0111
19	E-Benzene	106.17	0.0711	0.0733	0.0013
20	Xylenes	106.17	0.6802	0.7004	0.0106
21	n-C6	86.18	3.5939	3.6766	0.8815
22	224Trimethylp	114.24	0.0000	0.0000	0.0000
	MW		126.33	126.33	42.06
	Stream Mole Ratio		1.0000	0.9993	0.0007
	Heating Value	[BTU/SCF]			2241.38
	Gas Gravity	[Gas/Air]			1.45
	Bubble Pt. @ 100F	[psia]	18.82	17.95	
	RVP @ 100F	[psia]	75.59	73.99	
	SG @ 100F		0.804	0.804	

Index

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