

Exploration and Production Emission Calculator II (EPEC II) User's Guide

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SECOND EDITION, JANUARY 2007



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Exploration and Production Emission Calculator II (EPEC II) User's Guide

Regulatory and Scientific Affairs Department

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1. INTRODUCTION

The Exploration and Production Emission Calculator Version 2.0 (EPEC II) is a software tool that can be used to estimate emissions for exploration and production (E&P) facilities. EPEC II integrates user inputs, emission calculations, and data summaries for many equipment types common to E&P facilities. The calculation techniques and emission factors utilized by the EPEC II software were, in most cases, established by the U.S. Environmental Protection Agency (EPA), the American Petroleum Institute (API), and the Gas Research Institute (GRI). Published references that provide background information for the calculation methods used in EPEC II are given for each equipment type in both the software and in each section of this User's Guide. EPEC II can be used to estimate emissions of criteria pollutants (carbon monoxide [CO], nitrogen oxides [NO_x], sulfur oxides [SO_x], particulate matter under 10 µm [PM₁₀], and volatile organic compounds [VOCs]), hydrogen sulfide (H₂S), greenhouse gases (GHGs—carbon dioxide [CO₂], methane, and ethane), and hazardous air pollutants (HAPs), such as benzene, toluene, ethylbenzene, xylenes, 1,3-butadiene, n-hexane, 2,2,4-trimethylpentane, formaldehyde, and acetaldehyde. The types of equipment addressed by the EPEC II software include amine units, cooling towers, diesel/gasoline internal combustion (IC) engines, external combustion emission units, fixed-roof storage tanks, flares, fugitive emissions, glycol dehydrators, loading operations, natural gas engines, natural gas turbines, and vents. The user also has the flexibility to include emissions from additional equipment types, or to use alternative means to calculate emissions.

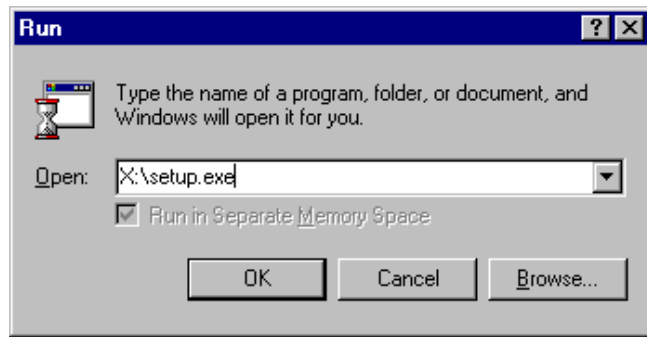
1.1 PRINCIPLES OF USE AND SYSTEM REQUIREMENTS

EPEC II operates as a stand-alone program under the Microsoft® Windows 95/NT™ operating environment. At a minimum, a 486DX2 Windows 95 platform with 16 Mbyte RAM and 30 Mbytes of available hard disk storage space is needed to operate the EPEC II. The EPEC II user should possess a modest familiarity with the Windows operating environment and should understand a few of its common features, such as point-and-click, copy-and-paste, and text editing. EPEC II accepts user inputs, calculates emissions, generates emissions summaries as text files, and saves any user-input data and calculated results to a Microsoft Access™ data file. As an alternative to using EPEC II's text file reports, users can take advantage of Access's automated report generation features to create customized reports.

1.2 INSTALLATION

The EPEC II distribution pack includes this User's Guide and an Installation Disk. Complete the following steps to install EPEC II:

1. Insert the Installation Disk into the x:\ compact disk (CD) drive (where "x" is the CD drive).
2. Click  from the Windows Taskbar, then select .
3. Type x:\setup and click .



4. Follow the instructions that appear on each successive screen: (1) close down any programs that may running; (2) select the destination directory where the program files will be installed; and (3) provide a name for the program group where a shortcut to EPEC II will be placed on the Windows taskbar.
5. Remove the Installation Disk from the CD drive. Store the Installation Disk in a safe place.

2. USING EPEC II

2.1 STARTING EPEC II AND CREATING A NEW FACILITY DATA FILE

To start EPEC II, click  **Start** from the Windows taskbar, then select **Programs** ► **EPEC II**. Upon starting EPEC II, the Welcome screen will appear (**Figure 2-1**).

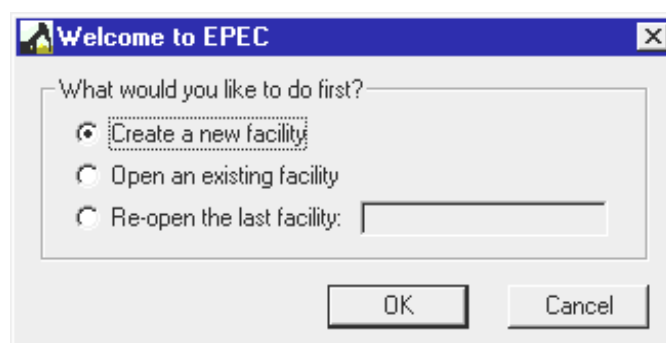
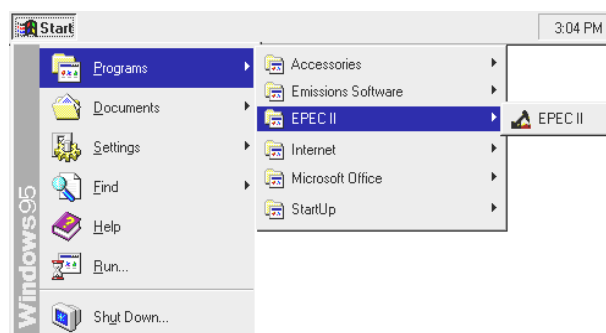


Figure 2-1. EPEC Welcome screen.

On the Welcome screen, click ☒ **Create a new facility** and **OK**. Enter the name of a file that will store the new facility's data and click **Save**. The General Facility Information screen will appear (**Figure 2-2**).

EPEC - General Facility Information

Facility/Well Name:		Facility Permit #:	
Facility/Well ID:		Nearest Town:	
Field Name:		Dist. To Nrst. Rcpt. (mi.):	0
Company:		County/Parish:	
Street Address:		EPA Region:	Region I
Mailing Address:		Facility Type:	
City:		SIC Code Description:	
State:		SIC Code:	
Street Zip:		Dun & Bradstreet No:	
Mailing Zip:		Principal Business:	
Telephone:		Latitude:	0
Fax:		Longitude:	0
Other (1):		UTM Northing:	0
Other (2):		UTM Easting:	0
Other (3):		UTM Zone:	0

Operating Info Contact Info OK Cancel

Figure 2-2. General Facility Information screen.

On the General Facility Information screen, enter any desired descriptive information and click **OK**. (Note that the Facility/Well ID is required.) The EPEC Control Panel will appear (**Figure 2-3**).

EPEC - Control Panel

File Edit View Help

Current Facility

Facility Name: **Open New**

Facility File Name: **Edit**

Number of Units: **View Summary**

Units at this Facility

Select Unit Type: **Add New**

Select Unit ID: **Edit**

Units of this Type: **View Summary** **Copy** **Delete**

Exit

Figure 2-3. EPEC Control Panel.

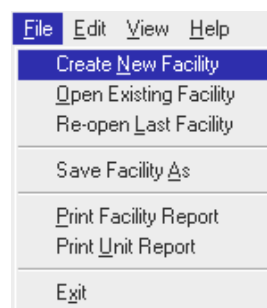
From the EPEC Control Panel, the EPEC user may perform the following tasks.

- Create new or open existing facility data files.
- Save the current facility data file under a different file name.
- Edit general information for the current facility.
- Create new, edit existing, copy, or delete equipment units for the current facility.
- View and print emissions summary reports for facilities or equipment units.
- Exit EPEC II.

2.2 WORKING WITH FACILITIES

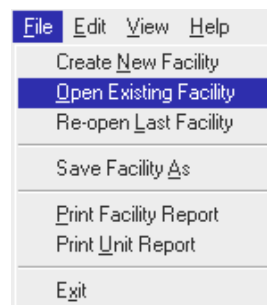
2.2.1 Create a New Facility

Select File | Create New Facility from the Control Panel menu. Enter a file name where the new facility's data will be stored and click **Save**. The General Facility Information screen will appear (Figure 2-2). On the General Facility Information screen, enter any desired descriptive information and click **OK**. (Note that the Facility/Well ID is required.) The EPEC Control Panel will appear with the new facility's file name identified as current.



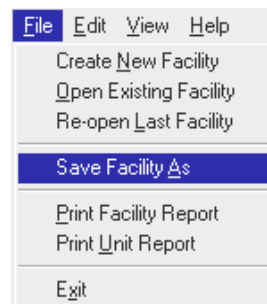
2.2.2 Open an Existing Facility

Select File | Open Existing Facility from the Control Panel menu. Select the file name where the facility's data was previously stored and click **Open**. The EPEC Control Panel will reappear with the selected facility's file name identified as current.



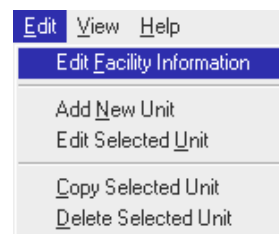
2.2.3 Save the Current Facility Under a New File Name

Select File | Save Facility As from the Control Panel menu. Enter a file name where the facility's data will be stored and click **Save**. The EPEC Control Panel will reappear with the new file name identified as current.



2.2.4 Edit General Information for the Current Facility

Select Edit | Edit Facility Information from the Control Panel menu. The General Facility Information screen will appear (Figure 2-2). On the General Facility Information screen, enter or change any descriptive information and click **OK**. (Note that the Facility/Well ID is required.)

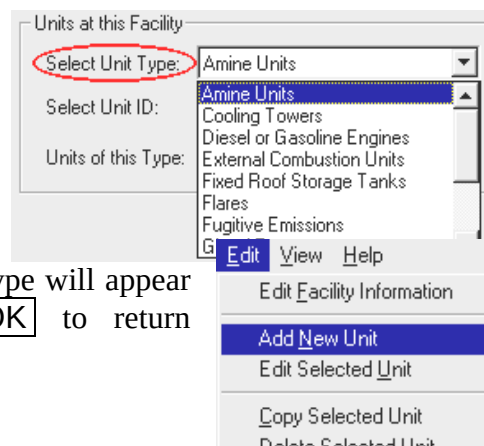


2.3 WORKING WITH EQUIPMENT UNITS

2.3.1 Adding New Equipment Units to the Current Facility

First, a facility must be created or opened from an existing file (see Section 2.2). Select the type of new equipment to be added from the Select Unit Type drop-list on the Control Panel.

From the Control Panel menu, select Edit | Add New Unit. The data entry screen for the selected equipment type will appear (Figure 2-4). Enter the information and click **OK** to return to the Control Panel. (Note that the Unit ID is required.)

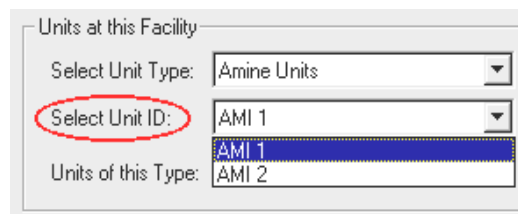


The 'EPEC - Amine Units' data entry screen is shown. The 'Unit ID' field is circled in red and labeled 'Required'. The 'Unit Description' is 'Primary amine sweetening unit'. The 'Emission Calculation Method' is 'Stack Testing'. The 'Stack Gas Flow Rate' is '100 (scf/min)'. The 'Gas Conc. (@ STP)' is 'mg/m3'. The 'Molecular Wt. (lb/bl-mol)' is '50'. The 'VOC' is '200'. The 'n-Hexanes' is '60'. The 'Benzene' is '30'. The 'Toluene' is '100'. The 'Ethyl Benzene' is '10'. The 'Xylenes' is '0'. The 'Hydrogen Sulfide' is '5'. The 'Design Gas Flow Rate' is '1000 (MMscfd)'. The 'Actual Gas Flow Rate' is '650 (MMscfd)'. The 'Amine Recirculation Rate' is '45 (gal/min)'. The 'Control Technology' is 'None (Vent Only)'. The 'Hydrocarbon Control Efficiency' is '0 (%)'. The 'H2S Control Efficiency' is '0 (%)'. The 'Potential Run Time' is '8760 (h/y)'. The 'Actual Run Time' is '720 (h/y)'. The screen includes buttons for 'View Summary', 'References', 'User Notes', 'Print Report', 'OK', and 'Cancel'.

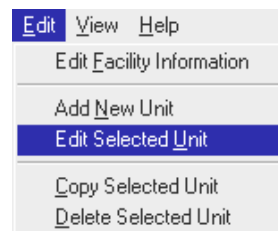
Figure 2-4. Data entry screen for an amine gas sweetening unit.

2.3.2 Editing Existing Equipment Units

Select the type of equipment to be edited from the Select Unit Type drop-list on the Control Panel. Then, select the unit to be edited from the Select Unit ID drop-list.



From the Control Panel menu, select Edit | Edit Selected Unit. The data entry screen for the selected equipment unit will appear. Enter or change the existing data and click **OK** to return to the Control Panel.



2.3.3 Selecting Alternative Emission Factors

Within EPEC II, the user may enter or select alternative emission factors for use in estimating emissions from the following equipment types.

- Cooling towers
- Diesel/gasoline engines
- External combustion units
- Flares
- Natural gas engines
- Natural gas turbines

For each of these equipment types, EPEC II determines which emission factors are applicable from parameters entered on the equipment data entry screen. For example, the determining parameters for diesel/gasoline engines are Fuel Type, Emission Factor Units, Make, and Model. Click the **Emission Factors** button



to display and edit currently selected emission factors (**Figure 2-5**). EPEC II defaults to emission factors that are published in the EPA's document, *Compilation of Air Pollutant Emission Factors (AP-42)*, where available. If none are published in AP-42, EPEC II defaults to factors published by the Gas Research Institute or provided by engine manufacturers.

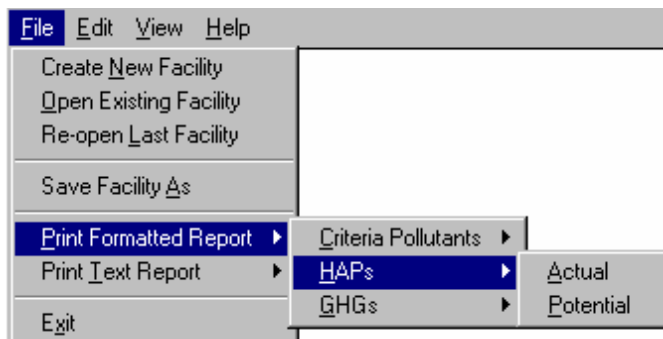
Figure 2-5. Emission factors display screen for diesel/gasoline engines.

If no published emission factors are available for a particular pollutant, the user must enter an emission factor in order to estimate emissions. Select “Other/Test” or “Manufacturer” as the Data Source and enter an emission factor in the space provided.

2.4 WORKING WITH EMISSIONS REPORTS AND SUMMARIES

2.4.1 View, Print, or Save Formatted Reports

To create tabulated reports of emissions from all equipment units at a facility (or Formatted Reports), select File | Print | Formatted Report | ... from the Control Panel menu. Then, select from the menu the pollutant type of interest (Criteria Pollutants, HAPs, or GHGs), and the emissions type of interest (Actual or Potential). A print preview of the Formatted Report will appear (**Figure 2-6**).



EPEC - drFacRepActY (DataReport)

Zoom 75%

Facility Report: Actual Emissions (TPY)

Facility Name: An example facility

UnitID	UnitDesc:	Tons per Year					
		NOx	SOx	CO	VOC	PM10	
EquipmentType: Diesel/Gasoline IC Engine							
DE1	An Example Diesel	61.27	4.04	13.17	4.31	4.35	
Number of Units: 1		SubTotal:	61.27	4.04	13.17	4.31	4.35
EquipmentType: External Combustion Unit							
EC1	Example External	9.55	0.23	16.04	1.05	1.45	
Number of Units: 1		SubTotal:	9.55	0.23	16.04	1.05	1.45
EquipmentType: Flare							
2	example	15.25	0.00	83.05	11.67	2.42	
3		0.00	0.00	0.00	0.00	0.00	
Number of Units: 2		SubTotal:	15.25	0.00	83.05	11.67	2.42
Total Number of Units: 4		Grand Total:	86.08	4.27	112.26	17.04	8.22

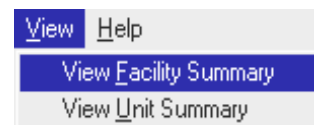
Pages: 1

Figure 2-6. Formatted Report of actual criteria pollutant emissions – print preview screen.

To send a Formatted Report to the printer or to export it to a file, click the printer  or export  buttons from the print preview screen. Formatted Reports may be exported as HTML or text files.

2.4.2 View and Print Facility Summaries

First, a facility must be created or opened from an existing file (see Section 2.2). To view the Facility Summary, select View | View Facility Summary from the Control Panel menu or click the **View Summary** button in the Current Facility area, or the top half, of the EPEC II Control Panel. A summary of the total criteria pollutant, HAP, and CO₂ emissions for the current facility will appear in the Facility Summary viewer screen (**Figure 2-7**). To print, click the **Print** button on the Facility Summary viewer screen.



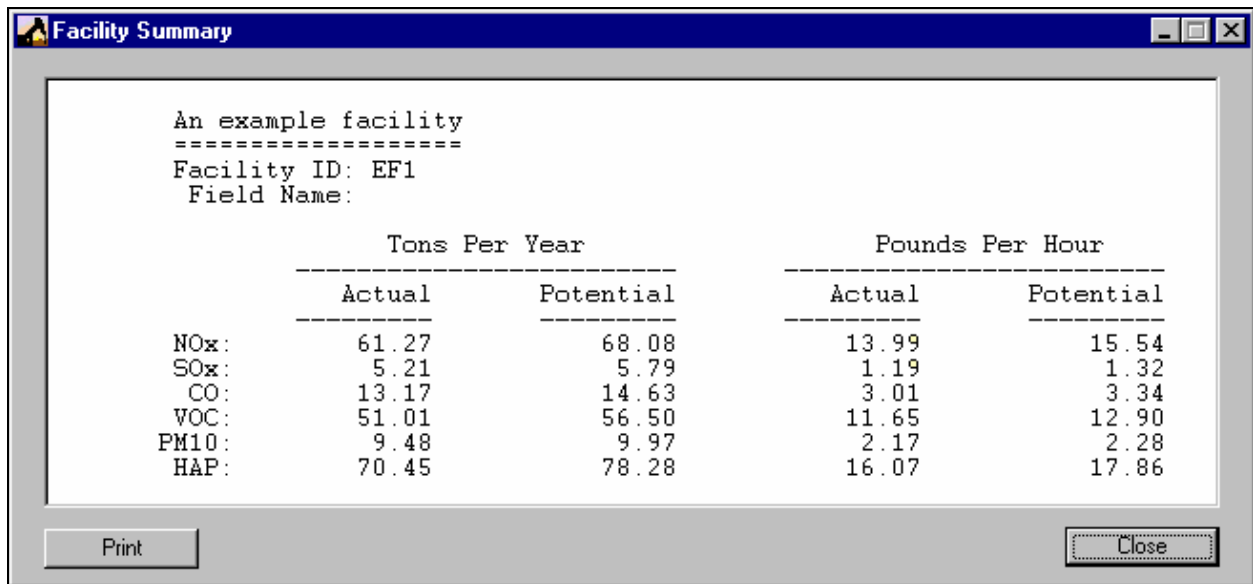
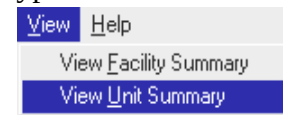


Figure 2-7. Facility Summary viewer screen.

2.4.3 View and Print Equipment Emissions Summaries

To view an Equipment Emissions Summary, select the equipment type of interest from the Select Unit Type drop-list on the Control Panel. Then, select the desired unit from the Select Unit ID drop-list. Select View | View Unit Summary from the Control Panel menu or click the View Summary button in the Units at Facility area, or the bottom half, of the Control Panel. A summary of the total criteria pollutant, HAP, and CO₂ emissions for the selected equipment unit will appear in the Equipment Summary viewer screen (Figure 2-8). To print, click the Print button on the Equipment Summary viewer screen.



Amine Unit Summary				
Amine Unit (Generator Off-Gas)				
=====				
Unit ID: AU1				
Unit Desc: Example Amine Unit 1				

	Tons Per Year		Pounds Per Hour	
	Actual	Potential	Actual	Potential
	-----	-----	-----	-----
SOx:	1.17	1.30	0.27	0.30
VOC:	1.32	1.46	0.30	0.33
n-Hexanes:	0.13	0.15	0.03	0.03
Benzene:	0.07	0.07	0.02	0.02
Toluene:	0.07	0.07	0.02	0.02
Ethyl Benzene:	0.03	0.04	0.01	0.01
Xylenes:	0.03	0.03	0.01	0.01
Total HAP:	0.32	0.36	0.07	0.08
Hydrogen Sulfide:	0.03	0.04	0.01	0.01

Figure 2-8. Equipment Summary viewer screen.

2.5 QUITTING EPEC II

Exiting EPEC II is only permitted from the Control Panel. Use one of the following techniques to exit EPEC II from the Control Panel: (1) click File | Exit from the menu, (2) click the ☐ symbol in the upper right corner, or (3) click the button in the lower right corner.

2.6 BACKING UP DATA FILES

It is very important to periodically back up data files created using EPEC II in order to minimize the risk of data loss. Back up data files using Windows Explorer by browsing to the location and file where data are stored and copying the data file to a secure location, such as a floppy disk or zip drive. Or, use the File | Save Facility As option from the Control Panel and save the data file to a secure location (see Section 2.2.3). EPEC II data files are usually stored with an *.mdb file name extension.

3. METHODS USED BY EPEC II TO CALCULATE EMISSIONS

This section describes the calculation methods available to the EPEC user for amine units, cooling towers, diesel/gasoline IC engines, external combustion emission units, fixed-roof storage tanks, flares, fugitive emissions, glycol dehydrators, loading operations, natural gas engines, natural gas turbines, vents, and other emission units. Methods to customize facility-specific emission estimates are also described. Appendix A contains data for an example facility.

Whenever possible, the most recently available calculation techniques and emission factors from published literature have been integrated into EPEC II. In most cases, these methods have gained past acceptance by the EPA, and are recommended in literature published by the EPA, API, GRI, or the Emission Inventory Improvement Program (EIIP). EPEC also offers the flexibility to input emission factors which are facility-specific or have been updated since the release of EPEC II.

Features that are common to many equipment types include potential and actual emission calculations, HAPs speciation calculations, applications of control efficiencies, facility-specific emission calculations, and the inclusion of default input values.

- Potential emissions are calculated assuming maximum operating time, maximum fuel usage, maximum rated horsepower, etc. Potential emissions are meant to reflect the maximum capacity of the facility to create airborne emissions, while actual emissions are meant to reflect actual operating conditions.
- In EPEC II, HAP emissions are usually calculated as a percent of VOC emissions.
- Emission reductions due to control technologies are included such that:

$$\text{Reduced Emissions} = \text{Emissions} \times (1 - \text{Control efficiency \%} / 100\%) \quad (3-1)$$

- At many points within EPEC, emission factors or speciation profiles are blank because these data are not currently available. However, the appropriate equations have been integrated into the EPEC spreadsheets for calculating emissions, therefore, users are encouraged to provide their own facility-specific or more recently updated published factors.
- Many of the data entry fields contain default values from published literature. Users are encouraged to enter more applicable or timely data as it becomes available.

3.1 AMINE UNITS

Process

Amine units are used for removal of H₂S and CO₂ from natural gas, a process called “gas sweetening.” These compounds must be removed from natural gas prior to pipeline injection because they are corrosive.

The key components of the process are the amine contact tower and the amine regenerator. The H₂S and CO₂ are absorbed from the natural gas stream via contact with a lean amine solution. The spent amine (or enriched amine) is then recycled in an amine regenerator. The regeneration process involves heating the amine in order to volatilize the absorbed H₂S and CO₂. Hydrocarbons also can be absorbed from the gas stream and can be volatilized as a by-product of this process. Without a control device, such as a flare, the by-product hydrocarbons are emitted to the atmosphere.

Emissions

The amine unit emissions may be associated with three gaseous streams: (1) the regenerator off-gas, (2) the regenerator burner exhaust, and possibly (3) flash tank gas. Several options are available to dispose of the flash tank gas. It may be flared, used to power a combustion emission unit, or vented. Using EPEC II, flash tank emissions should be assigned to an appropriate equipment unit category, according to the disposal method. Emissions from the burner are best included with external combustion emission units. The off-gas from the amine regenerator is typically vented or flared. If flared, emissions may be included with flares or they may be calculated using the Atmospheric Rich-Learn or NG Balance Methods (discussed below) with “Combustion” selected as the Control Technology. If vented, emissions may be calculated using the GRI HAPCalc™ program (Ferry et al., 1996), or any of the estimation techniques included in EPEC II (discussed below). Note that EPEC II also permits direct entry of actual emission rates (lb/hr) estimated using GRI HAPCalc (select “HAPCalc” as the Emission Calculation Method).

Atmospheric Rich-Learn Calculation Option (Amine Balance)

The atmospheric rich-learn calculation method requires laboratory analyses of enriched and lean amine samples for the emission components of interest [H₂S and reduced sulfur compounds, VOCs, and benzene, ethyl benzene, toluene, and xylenes (BTEX)]. It is possible that the lean analyses may be eliminated since concentrations in the lean amine stream tend to be negligible.

Emissions (E) for each analyte in tons per year are calculated according to the following equation:

$$E = (C_{\text{Rich}} - C_{\text{Lean}}) \times Q_{\text{Recirc}} \times t \times 3.785 \text{ L/gal} \times 60 \text{ min/hr} \times \text{lb/453,600 mg} \times \text{ton/2000 lb} \quad (3-2)$$

where:

- E = Emissions in tons per year
 $C_{\text{Rich}}, C_{\text{Lean}}$ = Concentration of the analyte of interest in the rich and lean samples (mg/L)
 Q_{Recirc} = Amine recirculation rate (gal/min)
 t = Annual time of operation (hr/yr)

NG Balance Calculation Option

The NG Balance method requires laboratory analyses of the natural gas stream at the inlet to the amine unit with results corrected to standard temperature and pressure (60°F, 1 atm). Emissions (E) for each analyte, in tons/year, are calculated according to the following equation:

$$E = C \times \frac{EF_c}{100\%} \times Q \times t \times m_c \times \frac{\text{ton}}{2000 \text{ lb}} \times \frac{\text{day}}{24 \text{ hr}} \times \frac{\text{lb-mol}}{379.4 \text{ scf}} \quad (3-3)$$

where:

- E = Emissions in tons per year
 C = Concentration of analyte c in the natural gas, measured at the inlet to the amine unit (ppm)
 EF_c = Percent of analyte c emitted (%)
 Q = Volumetric natural gas throughput rate (MMscfD)
 t = Amine unit run time (hr/year)
 m_c = Molecular weight of analyte c (lb/lb-mol)

Stack Testing Option

Emissions may be calculated using the stack testing option if the volumetric exhaust rate of the amine unit is known, and laboratory analyses of stack gas samples are available. Ideally, the exhaust rate and natural gas process rate should be measured simultaneously as the stack gas samples are collected. This method assumes that the stack gas samples are collected downstream from any pollutant control devices. (No additional emissions reductions will be applied if this option is selected.)

Emissions (E) for each analyte in tons per year are calculated according to one of the following equations, depending upon the concentration units.

$$E = C_{\text{ppmv}} \times 10^{-6} \times \frac{\text{lb} \cdot \text{mol}}{379 \text{ scf}} \times \text{mwt}_c \times Q_{\text{stack}} \times 60 \frac{\text{min}}{\text{hr}} \times t \times \frac{\text{ton}}{2000 \text{ lb}} \quad (3-4)$$

$$E = C_{\text{mg/m}^3} \times \frac{\text{lb}}{454,000 \text{ mg}} \times \frac{\text{m}^3}{35.3 \text{ scf}} \times Q_{\text{stack}} \times 60 \frac{\text{min}}{\text{hr}} \times t \times \frac{\text{ton}}{2000 \text{ lb}} \quad (3-5)$$

where:

E = Emissions in tons per year

C_{ppmv} = Concentration of the analyte of interest in the stack gas (ppmv)

$C_{\text{mg/m}^3}$ = Concentration of the analyte of interest (c) in the stack gas (mg/m³)

mwt_c = Molecular weight of analyte c (lb/lb-mol)

t = Amine unit run time (hr/yr)

Emissions from Claus Sulfur Recovery Units

Claus sulfur recovery units (SRU) reclaim sulfur from the amine regenerator off-gas stream. However, some residual amount of sulfur is lost as air emissions. When a sulfur recovery unit is present, EPEC II calculates residual emissions of H₂S and SO_x according to the EIIP's guidance documents. EPEC II reduces H₂S emissions as follows.

$$E_{\text{H}_2\text{S}, \text{SRU}} = E_{\text{non-SRU}} \times \frac{2}{3} \times \left(1 - \frac{\% \text{RE}}{100}\right) \quad (3-6)$$

where:

$E_{\text{H}_2\text{S}, \text{SRU}}$ = H₂S emissions from an amine unit that is equipped with a SRU (tons per year)

$E_{\text{non-SRU}}$ = The H₂S emission rate that would exist if the amine unit were not equipped with a SRU (tons per year)

%RE = The sulfur recovery efficiency of the Claus SRU (percent)

Note that the factor $\frac{2}{3}$ is a stoichiometric ratio associated with the Claus sulfur recovery process.

SO_x emissions can arise from two processes associated with Claus SRUs: (1) the sulfur recovery process itself and, (2) if the SRU is equipped with a tail gas flare, the combustion of H₂S → SO₂. The following equation accounts for both processes.

$$E_{\text{SO}_2, \text{SRU}} = \left[\left(E_{\text{H}_2\text{S}, \text{SRU}}^{\text{vent}} \times \frac{1}{2} \right) + \left(E_{\text{H}_2\text{S}, \text{SRU}}^{\text{flare}} \times \frac{\% \text{Eff}_{\text{H}_2\text{S}}}{100 - \% \text{Eff}_{\text{H}_2\text{S}}} \right) \right] \times \frac{64 \text{ lb/lb} \cdot \text{mol}}{34.1 \text{ lb/lb} \cdot \text{mol}} \quad (3-7)$$

where:

$E_{\text{SO}_2, \text{SRU}}$ = SO_x emissions from an amine unit that is equipped with a SRU (tons per year)

$E_{\text{H}_2\text{S}, \text{SRU}}^{\text{vent}}$ = H₂S emissions that would be emitted from an amine unit that is equipped with a SRU but is not equipped with a tail gas flare (tons per year)

$E_{\text{H}_2\text{S}, \text{SRU}}^{\text{flare}}$ = H₂S emissions that would be emitted from an amine unit that is equipped with a SRU and a tail gas flare (tons per year)

%Eff_{H₂S} = The combustion efficiency of the tail gas flare, or the combustion conversion rate of H₂S → SO₂.

The first term enclosed in parentheses accounts for sulfur emissions due to the sulfur recovery process. The second term accounts for the combustion of H₂S → SO₂. Note that the factor $\frac{1}{2}$ is a stoichiometric ratio associated with the Claus sulfur recovery process.

Control Technology Options for Amine Units

The following control options are available to the EPEC II user. (Note that these choices are not available if the Stack Testing or HAPCalc options are selected as the Emission Calculation Method.)

- None (vent only) – Emissions are uncontrolled.
- Condenser – Hydrocarbon emissions are reduced by 80 percent.
- Combustion – Hydrocarbon emissions are reduced by 98 percent. Also, 95 percent of H₂S is converted to SO_x (%Eff_{H₂S} = 95 percent).
- Condenser + Combustion – Hydrocarbon emissions are reduced by 99 percent. Also, 95 percent of H₂S is converted to SO_x (or, %Eff_{H₂S} = 95 percent).
- SRU + vent – Hydrocarbon emissions are uncontrolled. Sulfur emissions are calculated as discussed above.
- SRU + tail gas flare – Hydrocarbon emissions are reduced by 98 percent. Sulfur emissions are calculated as discussed above.
- Other – The user must input a percent reduction of hydrocarbon emissions and percent conversion of H₂S → SO₂.

Amine Unit Worksheet Inputs

Critical user inputs for the amine unit worksheet are listed below. All other data are for informational or reporting purposes, but are not necessary to calculate emissions.

Always needed

- Unit ID
- Emission Calculation Method (select Amine Balance, GRI HAPCalc™, NG Balance, or Stack Testing)
- Design Gas Flow Rate (MMscf/day)
- Actual Gas Flow Rate (MMscf/day)
- Potential Run Time (hours/yr)
- Actual Run Time (hours/yr)

Only needed for Atmospheric Rich-Lean Method (Amine Balance)

- Amine Recirculation Rate (gal/min)
- Inputs for the Amine Balance Method: rich and lean amine constituent concentrations (mg/L)

Only needed for NG Balance Method

- Inputs for the NG Balance Method, including natural gas constituent concentrations (ppm), emissions factors (% emitted), and average molecular weight (MW) of emitted VOCs (lb/lb-mol)

Needed for either Atmospheric Rich-Lean or NG Balance Method

- Control Technology (select from those listed in the section above)
- Hydrocarbon Control Efficiency (percent; defaults are based on the selection of Control Technology)
- H₂S Control Efficiency (percent; defaults are based on the selection of Control Technology)

Only needed for Stack Testing Option

- Stack testing results, including stack gas constituent concentrations (ppmv or mg/m³), stack gas flow rate (scf/min), and average molecular weight of emitted VOCs (lb/lb-mol)

Only needed for GRI HAPCalc Option

- Actual emission rates (lb/hr) estimated using GRI HAPCalc

References

1. Emission Inventory Improvement Program (1998) *EIIP Guidance Document Series: Volume II*, Chapter 10 “Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processing Operations.” Report prepared for the Point Sources Committee of the Emission Inventory Improvement Program by Eastern Research Group, Inc., Morrisville, North Carolina. EPA-454/R-97-004 a-g. External Review Draft. February 1998. <http://www.epa.gov/ttn/chief/eiip/techrep.htm>
2. Ferry K.R., Hong T.K., Beitler C.A.M., and Thompson P.A. (1996) *Technical reference manual for GRI-HAPCalc™ Version 2.0 and GRI-HAPData™ Version 1.0: software for estimating emissions of hazardous air pollutants and criteria air pollutants from natural gas industry operations*. Technical report prepared for Gas Research Institute, Chicago, IL by Radian Corp., Austin, TX.
3. Skinner D.F., McIntush K.E., and Murff M.C. (1995) *Amine-based gas sweetening and Claus sulfur recovery process chemistry and waste stream survey*. Technical report prepared for Gas Research Institute, Chicago, IL by Radian Corp., Austin, TX.
4. Skinner D.F., Reif D.L., and Wilson A.C. (1996) *BTEX and other VOC emissions from a natural gas amine treater*. Technical report prepared for Gas Research Institute, Chicago, IL by Radian Corp., Austin, TX.

3.2 COOLING TOWERS

Process

Cooling towers are used to dissipate large heat loads. Cooling tower designs vary with several factors: the type of heat transfer medium (wet or dry), the type of the airstream draft (natural or induced), the orientation of the draft relative to the cooling water, the geometry of draft-water contact, and the type of water distribution system. Because wet (or evaporative) cooling towers are the most common type, and because dry towers do not tend to produce particulate emissions, AP-42 (U.S. Environmental Protection Agency, 1996a) only addresses emissions from wet towers. Most wet cooling towers are designed to recirculate cooling water, exploiting water's latent heat of evaporation in order to transfer heat to the atmosphere.

Emissions

Emissions from wet cooling towers include particulate matter of aerodynamic diameter 10 microns or less (PM₁₀) and fugitive VOCs. PM₁₀ emissions originate from cooling water droplets that are entrained in the escaping airstream. (These entrained droplets are termed *liquid drift*.) The dissolved solids in the cooling water contribute to airborne particulate emissions. VOC emissions arise from fugitive compounds that leak into the cooling water from heat exchangers and condensers. These compounds are released to the atmosphere when the cooling water comes into contact with air.

Calculations

EPEC uses the following equations to calculate PM₁₀ emissions (tpy).

$$E_{PM10} = EF_{PM10} \times Q \times t \times \frac{\text{ton}}{2000\text{lb}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{\text{MM}}{10^6} \quad (3-8)$$

$$EF_{PM10} = L \times TDS_{\text{circ}} \times \frac{10^{-6}}{\text{ppm}} \times \frac{1000}{\text{M}} \quad (3-9)$$

where:

EF_{PM10} = Calculated factor for PM₁₀ emissions (lb/MMgal)

Q = Circulating water flow rate (gal/min)

t = Cooling tower run time (hr/yr)

L = Liquid drift factor, or mass of liquid drift per volume of cooling water recirculation (lb/1000 gal), specified in AP-42. This factor varies according to the type of airstream draft: natural or induced.

TDS_{circ} = Denotes the user-input total dissolved solids fraction in the circulation water (ppm)

This emission estimate is conservatively high because it assumes that none of the dissolved solids in the liquid drift contribute to the larger size fraction of particulate matter.

If TDS_{circ} is unknown, it may be approximated using the dissolved solid concentration in the makeup water (TDS_{make}) and the ratio of a selected physical parameter (p) between the

circulation water and the makeup water. AP-42 suggests several applicable parameters such as calcium, chloride, or phosphate concentration or conductivity. The equation below illustrates.

$$\text{TDS}_{\text{circ}} \cong \text{TDS}_{\text{make}} \times \frac{\text{P}_{\text{circ}}}{\text{P}_{\text{make}}} \quad (3-10)$$

If the above approximation is not possible, AP-42 suggests that for induced draft towers, the product $L \times \text{TDS}_{\text{circ}}$ is set approximately equal to 0.019 lb/1000 gal, which corresponds to TDS_{circ} which is approximately equal to 11,500 ppm. No equivalent estimate is currently available for natural draft towers.

VOC emissions (tpy) are calculated according to the following equation.

$$\text{E}_{\text{VOC}} = \text{EF}_{\text{VOC}} \times Q \times t \times \frac{\text{ton}}{2000\text{lb}} \times \frac{60\text{min}}{\text{hr}} \times \frac{\text{MM}}{10^6} \quad (3-11)$$

where:

- EF_{VOC} = Emission factor (lb/MMgal), which varies according to whether inspection-and-maintenance control measures are in place for fugitive emissions from condensers and heat exchangers on the cooling tower
- Q = Circulating water flow rate (gal/min)
- t = Cooling tower run time (hr/yr)

Cooling Tower Worksheet Inputs

Critical user inputs for the cooling tower worksheet are listed below. All other data are for informational or reporting purposes, but are not necessary to calculate emissions.

- Unit ID
- Tower Type (select Unclassified, Induced Draft, or Natural Draft)
- Control Type (select Minimize Hydrocarbon Leaks and Monitor Hydrocarbons in water, or None)
- Tower Run Time (hours/yr)
- Circulating Water Flow (gal/min)
- Total Dissolved Solids Concentration in Water (ppm)
- Additional Control Efficiency (%) - The estimated effectiveness of any installed control devices. (See emission factors worksheet, criteria pollutants only.)

Reference

U.S. Environmental Protection Agency (1996a) Compilation of air pollutant emission factors. Vol. 1: stationary point and area emission units. **Sections 5.1 and 13.4, AP-42, 5th ed. (January 1996); Supplements A and B (November 1996)** Report prepared by Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC.

3.3 DIESEL OR GASOLINE ENGINES

Process

Exploration and production facilities use diesel- and gasoline-fueled internal combustion engines to power generators, pumps, and cranes. This emission unit class only includes stationary industrial engines. It is not necessary to estimate emissions from mobile emission units such as diesel trucks or gasoline-powered boats.

Emissions

EPEC II calculates combustive emissions from diesel and gasoline engines. Emissions are calculated using emission factors and either the annual engine fuel consumption (MMBtu) or power output (hp-hr). Emission factors were obtained from AP-42 (U.S. Environmental Protection Agency, 1996b), and from some manufacturers for specific engine makes/models. However, the user may input other manufacturers' factors or the results of independent emission tests.

Calculations

EPEC uses one of the following equations to calculate emissions (tpy), depending on user-selected options.

To calculate emissions based on fuel use:

$$E = EF_{(lb/MMBtu)} \times U \times H \times \frac{\text{ton}}{2000\text{lb}} \times \frac{\text{MM}}{10^6} \quad (3-12)$$

To calculate emissions based on power output:

$$E = EF_{(g/hp-hr)} \times HP \times t \times \frac{\text{lb}}{453.6\text{g}} \times \frac{\text{ton}}{2000\text{lb}} \quad (3-13)$$

where:

- E = Emissions in tons per year
- EF = Emission factor (units are shown in parentheses)
- U = Fuel usage (lb/yr)
- H = Fuel heating value (BTU/lb)
- HP = Engine horsepower (hp)
- t = Engine operating time (hr/yr)

HAPs can be calculated using equations similar to those shown above. Alternately, a speciation profile may be used for HAPs. If the default HAPs speciation is used for gasoline, it should be noted that it was obtained directly from the EPA's *Air Emissions Species Manual* (1990) rather than from the SPECIATE database because the appropriate profile (#1011) was not included in the most recent version of SPECIATE (Version 1.5). It should also be noted that the speciation fraction for n-hexane is conservatively high because it was taken to be equal to that for the total of all isomers of hexane, in lieu of a better estimate.

Diesel or Gasoline Engine Worksheet Inputs

Critical user inputs for the diesel or gasoline engine worksheet are listed below. All other data are for informational or reporting purposes, but are not necessary to calculate emissions.

Always needed:

- Unit ID
- Engine Potential Horsepower (hp) - The maximum rated engine horsepower
- Engine Operating Horsepower (hp) - The actual operating horsepower
- Potential Run Time (hours/yr)
- Actual Run Time (hours/yr)
- Fuel Type (select Gasoline or Diesel)
- Fuel Sulfur Content (% by mass); only needed for diesel engines larger than 600hp
- Fuel Gas Heating Value (Btu/lb)
- Emission Factor Units (select lb/MMBtu or g/hp-hr) - Determines which set of emission factors and equations will be used. The lb/MMBtu selection indicates that emissions will be based on the engine fuel usage, while the g/hp-hr selection indicates that emissions will be based on engine power output.
- Additional Control Efficiency (%) - The estimated effectiveness of any installed control devices. (See emission factors worksheet, criteria pollutants only.)

Only needed when Emission Factor Units are lb/MMBtu:

- Average Fuel Consumption (Btu/hp-hr) and Fuel Gas Heating Value (Btu/lb)
OR
- Fuel Usage Rate (lb/hp-hr)
- Estimated Actual Fuel Usage (lb/yr)
- Estimated Potential Fuel Usage (lb/yr)

Only needed when default manufacturer's emission factors will be used to estimate emissions:

- Make – The name of the engine manufacturer
- Model – The model number of the engine

References

1. U.S. Environmental Protection Agency (1990) *Air emission species manual. Vol. 1: volatile organic compound species profiles. 2nd ed.* Report prepared by U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-450/2-90-001a.
2. U.S. Environmental Protection Agency (1996b) *Compilation of air pollutant emission factors. Vol. 1: stationary point and area emission units. Section 3.3, AP-42, 5th ed. (January 1996); Supplements A and B (November 1996).* Report prepared by Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC.
3. Brooks, G. W.; Waddell, J. T.; Butler, W. A. 1990. *Air Emissions Species Manual. Volume 1. Volatile Organic Compound Species Profiles.* Second Edition. Radian Corp., Research Triangle Park, NC. Environmental Protection Agency, NTIS Accession Number: PB90-185844/XAB EPA/450/2-90/001A 640p.

3.4 EXTERNAL COMBUSTION UNITS

Process

External combustion units include burners which may be used as line heaters, reboilers for glycol dehydrator and amine gas sweetening units, steam generators, etc. Typically, natural gas is used as the fuel for these units at oil and gas production facilities; therefore, EPEC II assumes natural gas for the fuel type.

Emissions

EPEC II calculates combustive emissions for external combustion units. These emissions are calculated using emission factors and annual fuel consumption (MMscf). Default emission factors were obtained from AP-42 (U.S. Environmental Protection Agency, 1996c). These emission factors vary with the size of the unit (as indicated by the hourly fuel consumption rate) and emissions control technologies. The user may also input factors obtained from the manufacturer or independent emission testing. Note that AP-42 should be consulted to select the proper NO_x and CO emission factors for tangentially fired external combustion units.

Calculations

EPEC II uses the following equation to calculate emissions (tpy).

$$E = EF \times HI \div H \times t \times \frac{\text{ton}}{2000\text{lb}} \quad (3-14)$$

where:

- E = Emissions in tons per year
- EF = Emission factor (lb/MMscf)
- HI = Design heat input (MMBtu/hr)
- H = Fuel gas heating value (Btu/scf)
- t = Run time (hr/yr)

This equation is slightly modified for SO_x emission estimates, as follows

$$E = EF \times HI \div H \times t \times \frac{\text{ton}}{2000\text{lb}} \times \frac{C_s}{3.18\text{ppm}} \quad (3-15)$$

where:

- C_s = Sulfur content of the fuel in ppm. AP-42 factors assume a sulfur content of 3.18 ppm (or 2000 grains/MMscf); however, SO_x emissions vary proportionally with sulfur content

HAPs can be calculated using Equation 3-14, or a speciation profile can be used. It should be noted that the speciation fraction for n-hexane is conservatively high because it was taken to be equal to that for the total of all isomers of hexane, in lieu of a better estimate. Additionally, it should be noted that total organic compounds (TOC) were approximated as total hydrocarbons (THC).