



Engineering Procedure

SAEP-340

21 December 2005

Air Quality Impact Analysis and Assessment

Environmental Standards Committee Members

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Anazi, Khalaf Saddah, Vice Chairman

Bokhedaim, Yahya Shaheen

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Ngao, Joseph Owuor

Said, Mohammed Madan

Rehm, Thomas E.

Sharif, Amira Abdullah

Worrall, Martin Edward

Abed Hezam, Mohammad Hamzah

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1 Scope

This document, SAEP-340, contains technical procedures for air dispersion modeling and emission estimates. This document also supports the design requirements of SAES-A-102, "Air Emissions Control".

2 Applicable Documents

- Saudi Government Documents and Standards

Document No. 1409-01 and revisions, "Environmental Protection Standards", Presidency of Meteorology and the Environment (PME)

The most recent Royal Commission environmental standards.

3 Air Dispersion Modeling

3.1 Air Dispersion Model Version

Air dispersion models shall be the latest versions of the following modeling software approved or recommended by the USEPA. However, EED shall have the final decision as to which modeling application will be used for the EIA study. Other modeling applications may be acceptable to EED, if supporting data is presented to EED at least 30 days prior to the commencement of the modeling study showing the merits or advantages of the particular model.

- CALPUFF, latest non-steady state model
- AERMOD, latest steady state model

Before an air dispersion modeling study is conducted, EED shall review and approve, within 15 business days of submittal, the following details:

- a. Meteorological and air quality data
- b. Background ambient air quality levels
- c. Modeling assumptions
- d. Input modeling parameters
- e. Sensitive receptors

Input modeling parameters shall include but not be limited to the following:

- a. Selection of emission sources
- b. Type of modeling grid and receptors selected
- c. Any sensitive discrete receptors selected by EED

- d. Wind speed profile exponents and temperature gradients
- e. Source and number of years of meteorological data
- f. Use of rural or urban conditions
- g. Treatment of calms
- h. Use of downwash calculations where applicable using Prime BPIP
- i. Use of seasonal emission variability
- j. Type of report outputs

The Tables in the Appendix show the required emissions input data components of the modeling study.

Note:

Where this section does not address specific modeling input requirements, the model shall adhere to the procedures set forth in the USEPA document "Guidelines on Air Quality Models" and 40 CFR, Chapter 1, Part 51, Appendix W.

3.2 Modeling Basis

For modeling purposes, the maximum design load conditions shall be used to predict the worst-case short-term ambient air quality impacts of 1-hour and 24-hour duration. Anticipated normal operating conditions shall be used for assessing long-term impacts (annual or longer periods).

Process upsets shall not be considered part of routine worst-case conditions unless, for example, flaring is the normal and continuous method of disposing of excess products or wastes at the facility.

Stacks height shall comply with Good engineering Practice (GEP) and shall be modelled having a maximum height of 91.4 meters (300 feet).

AERMOD and CALPUFF modelling results shall be based on actual meteorological data collected for five (5) years and one (1) respectively. The appropriate modelling data shall include hourly mixing heights and atmospheric stability classes for all years selected. EED shall provide the available hourly data for the modeling and/or the technical guidance for conducting a proper modeling study.

Where there are missing hours in the meteorological data to be used for the model, one of two USEPA recommended options shall be applied to the missing data. These techniques are outlined in the referenced USEPA documents "Guideline on Air Quality Models" and "On-Site Meteorological Program

Guidance for Regulatory Modeling Applications." Alternatives for missing upper air data can be substituted by using prognostic data for the same year.

Modeling results shall include background ambient air quality levels that are based on actual ambient air quality levels collected from the area, preferably those collected by the Saudi Aramco AMMNET program. Where such data are not available, a baseline source emission inventory shall be used to predict existing ambient pollutant levels. Appendix Table 2 shall be used to record the background pollutant concentration data values. Building dimension shall be used as listed in the Appendix Table 3. Prime building down wash algorithms shall be in all modeling applications, where appropriate. Appendix Table 4 shall be used to record the input and output data for the air dispersion modeling study.

3.4 Final Report

The final report shall include to the following but not limited to:

- Maps detailing the area(s) modeled;
- Existing and proposed facility emission sources;
- Locations of other significant sources that emit the same pollutants within 50 km radius;
- The location of sensitive receptors;
- Elevations of the surrounding terrain, where applicable;
- The location and dimensions of any significant obstacles, such as buildings or hills, which could affect dispersion of the air pollutants under study;
- An estimate of the significant population groups within 50 km radius of the facility (including local residents, facility employees, and other workers), along with the approximate locations of these groups;
- Provide predicted ground-level concentrations (GLC) summaries for the 1 and/or 24 hour AAQS pollutant with the highest, 2nd-highest, and 3rd-highest values, their location coordinates and corresponding date/hour for these values;
- Predicted GLC isopleths superimposed on a current area map of the facility and its environs, showing all emission sources and identified sensitive receptors;
- Modelling options used shall be presented in a table along with Control and List files; and,
- Process flow diagram(s) showing existing facilities and proposed changes, additions, or modifications.

4 Emission Inventory

4.1 General

An emission inventory can be used as a basis for air dispersion modeling studies, demonstrate compliance with environmental standards, and minimize waste. Tables are provided in the Appendix as an aid in developing a comprehensive air emission inventory.

4.2 Emission Inventory Basis

The quantities of each pollutant emitted shall be based on one or more of the following methods, and the method(s) used shall be stated in the inventory:

- Measurements obtained by stack testing, continuous emission monitoring, or process gas sampling providing the sample analyses are quality-assured;
- Process-related engineering calculations;
- Manufacturer's emissions data – based on performance testing with the installed equipment;
- Emission factors based on the latest USEPA AP-42, API, CMA, or other recognized governmental or industry source(s);
- SAES-A-112 for meteorological conditions; and/or,
- Saudi Aramco product specifications for hydrocarbon properties.

5 Definitions, Abbreviations and Acronyms

5.1 Definitions

Actual Emissions: Based on actual or normal throughput (not based on design capacity).

Air Dispersion Modeling: The technique of predicting ground-level concentrations by mathematical relationships that govern the dispersion and diffusion of gaseous pollutants in the atmosphere.

Air Quality: Ambient air pollutant concentrations with temporal and spatial distribution.

Air Pollutant: Any substance emitted to the atmosphere that causes or has the potential to produce adverse impacts on human health or the environment.

Ambient Air: The portion of the atmosphere external to defined industrial areas (facility plot limits).

Ambient Air Quality Standards (AAQS): The maximum concentration limits of criteria pollutants permitted in air which, allowing for a degree of safety, present no hazard to human health or the environment.

Area Source: A two-dimensional emission source that releases pollutants, such as a storage pile, slag dump, or wastewater lagoon.

Averages: (as applied to the interpretation of air dispersion modeling predictive results) -

- **1-Hour Average:** the smallest discrete concentration averaging period used to determine the other concentration averages such as 8-hour, 24-hour, and 1-year.
- **8-Hour Average:** computed as a running 8-hour average; any exceedances will be determined based on running CO averages which do not overlap (do not share the same hours). Note that this standard only applies to carbon monoxide.
- **24-Hour Average:** computed as the daily average only and not as a running 24-hour average.
- **Annual Average:** computed on a non-running 12-month Gregorian calendar (January – December).

Background Concentration: The ambient pollutant concentration caused by a) natural sources; b) nearby sources other than the ones currently under consideration; and c) unidentified sources. All predicted (modeled) results must include the established background concentration values before a determination can be made as to whether an exceedance or violation has occurred.

Calms: A term used in air dispersion modeling to indicate wind speeds of less than 1.0 meters per second.

Continuous Emission Monitoring (CEM): The system(s) that are used to sample, condition, and analyze in-stack gas streams, and provide a permanent record of emissions or process parameters.

Criteria Pollutant: An air pollutant for which an air quality standard with a specific set of ambient air concentration limits has been established by the Saudi Arabian government based on specific health criteria (i.e., SO₂, O₃, NO₂, CO, Particulates).

Downwash: This is a term used in air dispersion modeling to describe the effect of turbulence from buildings and other structures on the laminar and dispersive flow of stack emissions. Downwash considerations are important when

modeling sources in close proximity to buildings, hills, trees, and other obstructions to air flow.

Emission Source: Any facility, process, or operation that releases air pollutants to the atmosphere.

Emission Standard: The maximum amount or rate of a specified pollutant permitted in airborne discharges.

Exceedance: A Ground Level Concentration (GLC) value greater than the limit specified by the government for a specified averaging time (i.e., 1-hour, 3-hour, 8-hour, 24-hour, monthly, 3-month, or annual)

Facility: Any installation or industrial activity that is expected to be a source of pollution or cause an adverse environmental impact.

Fugitive (Non-Point) Emissions: Emissions to the atmosphere from such sources as pumps, valves, flanges, seals, and other process locations not vented through discrete openings. Also includes emissions from area-wide sources such as settling ponds, wastewater lagoons, landfills, cooling towers, and piles of stored material.

Good Engineering Practice (GEP) Stack: The stack height (as measured from the ground-level elevation at the base of the stack) below which emissions from the source are influenced by the aerodynamic downwash of nearby buildings or other structures. The GEP stack height, H_s , is calculated as follows: $H_s = H + 1.5L$ where H is the height of the nearby structure and L is the lesser dimension of the height or width of the nearby structure. "Nearby" means that distance up to 5 times " L " but not greater than 0.8 kilometer ($\frac{1}{2}$ mile). It should be noted that compliance with this condition does not relieve the PMT or Facility from ensuring ambient air quality standards are also met. For determining compliance of these standards, stack height is capped at 91.4 meters (300 feet) for air dispersion modeling purposes. This limits the effect of height and the subsequent dilution of stack emissions alone in meeting the ambient air quality standards. For safety purposes, H_s must also meet the requirements of SAES-B-055, Appendix F-1 which states that "the top of the furnace stack shall be at least 3 meters higher than any working platform within 60 meters horizontally of the stack."

Ground-Level Concentration (GLC): The actual measured ambient concentration of the specified pollutant at ground level, or the predicted concentration based on air dispersion modeling techniques in parts per million (ppm) or equivalent micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) referenced to STP conditions.

Industrial Area: The area within the property line or recognized border limits of a facility from which the public is restricted.

Inhalable Particulates: Any particle dispersed to the atmosphere in solid or liquid form that has an aerodynamic size of 10 microns or less. Realistic determination particle behavior in any environment must consider the size, shape, and density of the particle. The technique best able to accomplish this is called aerodynamic sizing. The aerodynamic diameter of a particle is defined as the diameter of a sphere having the same resistance to motion as the particle.

Insolation: The rate of delivery of all direct solar energy per unit of horizontal surface, measured as solar radiation.

Isopleth: In modeling, a continuous line (or contour) drawn on a map that connects locations having equal ground-level concentrations.

Load Capacity Factor: The output of a device (boiler, process heater, furnace, etc.) expressed as a percentage of the maximum rated design capacity of the device (Example: a 0.5 load capacity factor indicates the device is operating at 50% of the maximum rated capacity of the device).

PME / Royal Commission Limit: The 1-hour, 8-hour, 24-hour, or 12-month (annual or yearly) GLC for the specified pollutant.

PME / Royal Commission Standard: The allowable number of exceedances within a specified measurement period for the pollutant.

Mixing Height: The depth at which atmospheric pollutants are typically mixed by dispersive processes.

Modified (Upgraded) Facility: See definition of Upgraded Facility.

New Facility: Any facility designed and constructed as a wholly new facility. All new facilities must meet all current and anticipated environmental standards and regulations.

Non-Criteria Pollutant: Any air pollutant that does not have a specific ambient air concentration limit but must be controlled because of other environmental considerations such as toxicity or contribution to increased levels of other regulated pollutants.

Opacity: The degree to which emissions reduce the transmission of light and obscure the view of an object in the background; the percent of opaqueness of the exhaust gas of a stack or flare; the higher the opacity number, the darker the emissions.

Particulate Matter: Any finely divided solid or liquid material, other than uncombined water, as measured by the USEPA reference or equivalent measurement method.

Pasquill Gifford Stability Category: A six-category classification of atmospheric stability in which the heating or cooling of the surface is used to establish a net radiation index that, in turn, is tabulated against wind speed to form a table of comparable mixing categories. The categories range from "A" to "F" with "A" representing very unstable conditions, "F" representing very stable conditions, and "D" representing neutral stability of the atmosphere.

Potential Emissions: Based on design capacity of the unit.

Receptor: For modeling purposes, it is any physical location that is impacted by the release of air pollutants. Environmental Engineering Division (EED) is responsible for defining receptor grids and locations. Receptors located in remote areas shall be handled on a case-by-case basis with respect to assessing ambient air quality impacts. (See: Sensitive Receptors)

Reid Vapor Pressure: The absolute vapor pressure of a volatile crude oil or volatile non-viscous petroleum liquids (except liquefied petroleum gases) as determined by the American Society for Testing and Materials (ASTM).

Royal Commission for Jubail (RCJ) and Yanbu (RCY): The jurisdictional authority that administers activities within the Madinat Jubail Al-Sinaiyah and Madinat Yanbu Al-Sinaiyah areas.

Sensitive Receptors: a component of the environment that has a physical location outside of the industrial area that may receive adverse impacts from the emission(s). these include but not limited to, hospitals, Schools, National Reverse Areas, Residential complexes, Farming Land, sensitive aquatic areas, etc.

Sigma Theta (σ_θ): The standard deviation of the horizontal wind direction over a 1-hour period, in degrees. A value used to determine the stability classification of the atmosphere.

Source Emission Standards: The maximum rate of a particular pollutant that can be discharged from a source. Source emission limits are used to limit adverse ambient air quality impacts. Source emission standards are given for specific pollutants and specific sources and can specify technologies and/or strategies to control the quantity and/or release rate of air pollutants from a facility.

Stack: Any specific opening used directly or indirectly for discharging pollutants to the atmosphere.

Stack Testing: The manual sampling of stack gases during normal operation to determine the emission rates of specific pollutant. Stack testing is part of the performance testing required at the initial start-up of a new process. Stack testing may also be required periodically thereafter if mandated by the regulatory agency.

Standard Limit: The 1-hour, 8-hour, 24-hour, or 12-month GLC of the specified air pollutant (see also PME / Royal Commission Limit).

Standard: The allowable number of GLC exceedances of the Standard Limit (see also PME / Royal Commission Limit).

Structure: Referred to as a downwash structure. A building or group of buildings determined to be important in downwash considerations. Structures within 5L of the modeled source (where L is the lesser of the height or width of the structure) are considered to cause downwash effects.

Sulfur Plant Efficiency: The amount of sulfur recovered as a percent of the total sulfur that could be incinerated and released to the atmosphere in the form of sulfur dioxide (SO₂). The minimum PME sulfur recovery efficiency is 95% however, the final sulfur recovery efficiency figure may be higher if ambient air quality standards are violated at the 95% level. Air dispersion modeling is used to determine the AAQS impacts.

True Vapor Pressure: The equilibrium partial pressure exerted by a liquid as defined by the ASTM. For storage tanks, the TVP is based on the highest operating temperature.

Upgraded (or Modified) Facility: Any modification or addition to an existing facility that directly or indirectly increases air pollutant emissions to the atmosphere from the facility. Upgraded or modified facilities must meet all current and anticipated environmental standards and regulations.

Violation (of a Standard): A number of exceedances greater than the allowable number of exceedances specified in the standard. For example, three (3) exceedances of the sulfur dioxide 1-hour PME limit within any 30-day period (i.e., day 1-30, 2-31, 3-32, etc.) constitutes a violation of the PME standard for sulfur dioxide for that period; five (5) exceedances in the same period would result in three violations if no other exceedances outside of the same 30-day period have contributed to additional violations. It is also assumed that the same three exceedances can not be used together a subsequent time to determine additional violations. In other words, one of the three exceedances

must be new when determining any additional violation. For a second example, three (3) exceedances of the Royal Commission for Jubail and Yanbu ozone standard results in a violation of this standard, since the standard allows only one 1-hour ozone exceedance per year rather than any 30-day period.

Volatile Organic Compound (VOC): Any organic compound that contributes to atmospheric photochemical reactions and subsequent air quality degradation.

Volume Source: An emission source that releases pollutants from a three-dimensional source such as a building, multiple vents, conveyor belts, or fugitive emissions from a chemical processing plant or refinery.

Worst-Case: With respect to air dispersion modeling, the highest ambient pollutant concentrations based on actual meteorological data collected over a specified period of time, generally five years or more; with respect to process operations, operational conditions that produce the greatest atmospheric emission rates.

5.2 Abbreviations and Acronyms

AMMNET	Air Quality Monitoring & Meteorology Network
AAQS	Ambient Air Quality Standard
ACMM	Actual Cubic Meters per Minute
AQ	Air Quality
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
Btu	British thermal unit
CMA	Chemical Manufacturers Association
CGT	Combustion Gas Turbine
DAQER	Detailed Air Quality Engineering Report
DBSP	Design Basis Scoping Paper
dscf	dry standard cubic foot
dscm	dry standard cubic meter
EIA	Environmental Impact Assessment
EED	Environmental Engineering Division

EPD	Environmental Protection Department
ES	Environmental Statement
FCCU	Fluidized Catalytic Cracking Unit
GEP	Good Engineering Practice
GI	Saudi Aramco General Instruction
GLC	Ground Level Concentration
HAP	Hazardous Air Pollutant
HS	GEP Stack Height
IP	Inhalable particulates (same as PM10)
kJ / w-hr	kilojoule per watt-hour
kkg	1000 kilograms (1 metric tonne)
kPa	kilopascals
LHV	Lower heating value; also called net heating value
M	1,000
MW	Molecular Weight
MTPY	Metric Tons Per Year
µg/m ³	micrograms per cubic meter
mg/m ³	milligrams per cubic meter
MMBtu/hr	Million Btu's per hour
mps	meters per second
mt	metric tonne (1000 kg)
MSL	Mean Sea Level
MW	Mega-Watts
Ng/J	nanograms per Joule
NMHC	Non-Methane Hydrocarbons
PAQER	Preliminary Air Quality Engineering Report
PGSA	Pasquill Gifford Stability Category
PM10	Particulate matter < 10 microns diameter
PMT	Project Management Team
PME	Presidency of Meteorology and Environment

ppm	Parts per million, by volume
q	Gross heat release
RCY	Royal Commission of Yanbu
RCJ	Royal Commission of Jubail
RVP	Reid Vapor Pressure
SAEP	Saudi Aramco Engineering Procedure
SAES	Saudi Aramco Engineering Standard
SES	Source Emission Standard
scf	Standard cubic foot
scm	Standard cubic meter
SRU	Sulfur Recovery Unit
STP	Standard Temperature & Pressure conditions of 25°C (298°K) and 1 standard atmosphere (760 mm Hg)
TOC	Total Organic Compounds
TSP	Total Suspended Particulates < 100 microns in aerodynamic diameter
TVP	True Vapor Pressure
USEPA	United States Environmental Protection Agency
UHC	Unburned Hydrocarbons
UTM	Universal Transverse Mercator Coordinate System
VOC	Volatile organic compounds

6 Reference Documents

6.1 Saudi Government Documents and Standards

"Royal Commission Environmental Regulations, "Royal Commission for Jubail and Yanbu "Directorate General for Jubail Project, Health Services Department, September 1999

"Environmental Protection Manual" and revisions, Directorate General for Yanbu Project, Madinat Yanbu Al-Sinaiyah, Royal Commission for Jubail and Yanbu, January 1991

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6.2 Industry Documents

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"Fugitive Emissions from Equipment Leaks II: Calculation Procedures for Petroleum Industry Facilities," American Petroleum Institute (API), Publication 343, May 1998

"Guide for Pressure Relieving and Depressuring Systems," American Petroleum Institute (API), Recommended Practice 521, Fourth Edition, Washington, D.C., March 1997

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"Evaporative Loss from Floating-Roof Tanks," Draft of API Manual of Petroleum Measurement Standards, Chapter 19.2, (combined API Publications 2517 and 2519, Fourth Edition, 1996), Draft of January 24-25, 1996

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"Evaporative Loss from Fixed-Roof Tanks," American Petroleum Institute (API) Manual of Petroleum Measurement Standards, Chapter 19.1 (API Publication 2518, Second Edition), Washington, D.C., October 1991

"Guidance for Estimating Fugitive Emissions from Equipment," Chemical Manufacturer's Association (CMA), Order # 018026, Arlington, Va., 1988

Evaporative Loss from Internal Floating-Roof Tanks," American Petroleum Institute (API), Publication 2519, Third Edition, Washington, D.C., June 1983

6.3 Other Reference Documents

"Guidelines on Air Quality Models," U. S. Code of Federal Regulations (CFR), 40 CFR, Chapter 1, Part 51, Appendix W, July 2003

"A User's Guide for the CALPUFF Dispersion Model (Version 5)". Scire, J.S., D.G. Strimaitis, and R.J. Yamartino: Earth Tech, Inc. Concord, MA, 2000a.

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"Air Quality Modeling Guidelines," Texas Natural Resource Conservation Commission (TNRCC), Publication No. RG-025, Austin, TX. February 1999

"Storage Tank Emissions (TANKS4, Version 4.07 or later)," User's Guide, USEPA, Office of Air Quality Planning & Standards, Sept. 30, 1999

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"On-Site Meteorological Program Guidance for Regulatory Modeling Applications," EPA-450/4-87-013, NTIS No. PB 87-227542, USEPA Office of Air Quality Planning and Standard, Research Triangle Park, NC, 1987

"Standards of Performance for Petroleum Refineries," U.S. Code of Federal Regulations (CFR), 40 CFR, Part 60, Subpart J

"Standards of Performance for New Stationary Sources, Test Methods and Procedures," U.S. Code of Federal Regulations (CFR), 40CFR, Part 60, Appendix A

"Locating and Estimating Air Toxics Emissions from Organic Liquid Storage Tanks," Chapter 7.1 of AP-42, U.S. Environmental Protection Agency, Research Triangle Park, N.C.

"Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries," U.S. Code of Federal Regulations (CFR), 40 CFR, Part 60, Subpart GGG

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Revision Summary

21 December 2005

Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.

APPENDIX

Table 1 – Mean Background Concentration Data Sheet

SAUDI ARAMCO FACILITY: LOCATION: DATA BASED ON: YEAR: AMMNET STATION: YEAR:	
POLLUTANT	MEAN BACKGROUND CONCENTRATION ($\mu\text{g}/\text{m}^3$ / ppm)
1-Hour	
8-Hour (CO only)	
24-Hour	
Annual	

Table 2 – Building Dimensions Information used for PRIME BPIP

Building name	
Number of Tiers for the building	
Base elevation (m)	
Length (m)	
Width (m)	
Height (m)	
Tier corner , UTM (km)	X= Y=
Total number of Building	
Total number of stacks	

APPENDIX

Table 3 – Stack Emission Estimation Worksheet and Modeling Results

POINT SOURCE EMISSION DATA	Albedo
Average Fuel Gas Used (MMSCFD):	Bowen Ratio
Design Fuel Gas (MMSCFD):	Surface Roughness Length
Fuel Gas Heating Value (Btu/SCF):	
Fuel Gas H ₂ S (ppmv):	MODELING RESULTS
Liquid Fuel Type:	1-HOUR (for SO ₂ , H ₂ S, O ₃ , NO ₂ , and CO)
Average Liquid Fuel Used (Bbl/day):	Max. 1-hr Conc.:
Design Liquid Fuel Used (Bbl/day):	Location (X, Y): X = Y =
Liquid Fuel Heating Value (MMBtu/bbl):	2nd Highest 1-hr Conc.:
Liquid Fuel Sulfur Content (wt%) :	Location (X, Y): X = Y =
Stack ID #:	3rd Highest 1-hr Conc.:
Unit Type (Manufacturer/Model):	Location (X, Y): X = Y =
Maximum Design Heat Input (MMBtu/hr):	8-HOUR (for CO only)
Source Location (X, Y): X = Y =	Max. 8-hr Conc.:
Source Elevation (Above M.S.L.) (m):	Location (X, Y): X = Y =
Stack Height (m):	2nd Highest 8-hr Conc.:
Stack Inner Diameter (m):	Location (X, Y): X = Y =
Average Stack Gas Exit Temp. (°C):	3rd Highest 8-hr Conc.:
Average Stack Gas Exit Velocity (m/s):	Location (X, Y): X = Y =
Average Stack Gas Volumetric Flow Rate (m ³ /min.):	24-HOUR (for SO ₂ , H ₂ S, and PM-10)
Emissions rate (g/s):	Max. 24-hr Conc.:
Average Excess O ₂ (%):	Location (X, Y): X = Y =
Low NO _x Burners (Y/N) :	2nd Highest 24-hr Conc.:
METEOROLOGY DATA	Location (X, Y): X = Y =
Surface (i.e. AMMNET) Station(s) I.D.	Annual (for SO ₂ , NO ₂ , and PM-10)
Year(s) used:	Annual Conc.:
Station(s) Location (X, Y): X = Y =	Location (X, Y): X = Y =
File Format:	
Type of Prognostic Data used:	DOMAIN & GRID SIZE INFORMATION
Year(s) used:	Center of Domain
Upper Air Station(s) I.D.	Domain grid points and Grid Cell
Year(s) used:	Domain resolution (course/fine, km)
Station(s) Location (X, Y): X = Y =	Prognostic Grid Size:
File Format (If using FSL specify format & wind unit):	CALMET Grid Size:
	Computational Grid Size:
MODELING OPTIONS USED (where appropriate)	CALPUFF Grid Size
List in separate table, CALPUFF & CALMET options	AERMAP Grid Size:
List in separate table, MM5 prognostics options	

APPENDIX

Table 4 – Fugitive Emissions Estimation Worksheet

General Fugitive Emissions Estimation Worksheet						
Pollutant(s) (check type) : VOC _____ SO ₂ _____ H ₂ S _____				Note: Use a separate worksheet for each type of pollutant emitted.		
Other Pollutant (specify) _____						
Facility: _____ Location: _____						
Coordinates (UTM): _____						
Unit Name, if applicable: _____						
Number of Compressors in Gas/Vapor Service						
Source	Items per Compressor	Number of Items	Emission Factor, kg/hr	Total Emission Rate		
Item	(Note 1)	(Note 2)	(Note 3)	g/s	kg/hr	mt/yr
Valves						
Flanges						
Compressor Seals						
Depressure/Relief Valves						
Open-Ended Lines						
Number of Pumps in Light Liquid Services						
Source	Items per Pump	Number of Items	Emission Factor, kg/hr	Total Emission Rate		
Item	(Note 1)	(Note 2)	(Note 3)	g/s	kg/hr	mt/yr
Valves						
Flanges						
Pump Seals						
Open-Ended Lines						
Number of Pumps in Heavy Liquid Service						
Source	Items per Pump	Number of Items	Emission Factor, kg/hr	Total Emission Rate		
Item	(Note 1)	(Note 2)	(Note 3)	g/s	kg/hr	mt/yr
Valves						
Flanges						
Pump Seals						
Open-Ended Lines						
Miscellaneous Source Item (Specify)		Number of Items	Emission Factor, kg/hr.	Total Emission Rate		
				g/s	kg/hr	mt/yr
Depressure/Relief Valves on Vessels						
Total Fugitive Emissions Release Rate:						

Notes:

- 1) For VOCs, component estimation factors taken from "Guidance for Estimating Fugitive Emissions from Equipment," by Chemical Manufacturer's Association (CMA);
- 2) Number of Items = Number of compressors or pumps times number of items per compressor or pump;
- 3) Emission factors from "Compilation of Air Pollution Emission Factors, AP-42" USEPA. Note that this source includes API factors.

APPENDIX

Table 5 – Bulk Loading Emissions & Product Transfer Emissions Worksheet

Bulk Loading and Product Transfer Facility Evaporative Emissions Estimation Worksheet						
Bulk Loading Operations			Emission Rate			
Storage Tanks (All Types)			mg/L Throughput	kg/ML Throughput		
Loading/Unloading of Product From Storage Tanks Operations						
Breathing Losses of Storage Tanks						
Yearly throughput, Q = _____ ML/yr						
Product Transfer Operations			Annual Average			
Source			lb/yr	kg/yr		
Vehicle Refueling Operations						
Displacement Losses (uncontrolled)						
Spillage						
General Losses from Fueling Operations						
Total Product Transfer Losses						
Input the following parameters: 1. Number of Vehicles: N = _____ (dimensionless) 2. Average Vehicle Usage: U = _____ km/year/vehicle 3. Average Vehicle Fuel Efficiency: E = _____ km/liter						
Pollutant	Emission Factor, (g/km)	Total Vehicle Kilometers/ Year	One Hour Peak Flow (g/s) (kg/hr)		Annual Average (kg/yr) (mt/yr)	
Carbon Monoxides (CO)						
Volatile Organic Compounds (VOC)						
Nitrogen Oxides (as NO ₂)						

Reference for emission factors is US EPA Publication AP-42.

APPENDIX

Table 6 –Tank Emissions Worksheets

External Floating Roof Tank

Facility Name:
Environmental Coordinator:

	Tank ID# _____
	Tank Contents Description: _____
	Diameter (ft): _____
	Tank Volume (bbl): _____
	Average Net Throughput (bbl/day): _____
	Internal Shell Condition: _____
	Paint Color (White/Sliver/Black): _____
	Paint Condition (Good/Bad): _____
	<u>Roof Characteristics:</u>
	Roof Type: _____
	Tank Construction (riveted/welded): _____
	Primary Seal Type: _____
	Secondary Seal Type: _____

Internal Floating Roof Tank

Facility Name:
Environmental Coordinator:

	Tank ID#:
	Tank Contents Description:
	Diameter (ft): _____
	Tank Volume (bbl): _____
	Average Net Throughput (bbl/day): _____
	Self Supporting Roof (Y/N): _____
	Number of columns: _____
	Effective Column Diameter: _____
	Internal Shell Condition: _____
	External Shell Color (White/Sliver/Black): _____
	External Shell Condition (Good/Bad): _____
	Roof Color: _____
	Roof Condition (Good/Bad): _____
	Floating Roof Seal Type: _____

APPENDIX

Table 6 – Tank Emissions Worksheets ...continued

Cone Roof Tank

Facility Name:

Environmental Coordinator:

	Tank ID#: _____ Tank Contents Description: _____ Shell Height (ft): _____ Shell diameter: (ft): _____ Maximum Liquid Height (ft): _____ Average Liquid Height (ft): _____ Working volume (bbl): _____ Average Net Throughput (bbl/day): _____ Shell Color (White/Sliver/Black): _____ Shell Condition (Good/Bad): _____ <u>Roof Characteristics</u> Color (White/Sliver/Black): _____ Condition (Good/Bad): _____ Height (ft): _____ <u>Breather Vent</u> Vacuum Setting (psig): _____ Pressure Setting (psig): _____
--	---

Table 7 – Emissions Inventory Format Table

Stack ID #	Emission Source	Pollutants (i.e. SO ₂ , NO _x , PM, VOC)					
		Fuel Gas Emission Factor	Actual Emissions		Potential Emissions		Emissions in Reg Unit
		(lb/MMft ³)	Kg/hr	MT/Yr	Kg/hr	MT/Yr	(ng/Joule)

APPENDIX

Table 8 – VOC Emissions from Gasoline Transfer and Dispensing Operations

Emission Source	Emission Rate (lb VOC / 1,000 gal throughput)	Throughput ¹ (gal)	Annual VOC Emissions ² (lb/yr)	Annual VOC Emissions ³ (tons/yr)
Tank Truck Loading ⁴				
Aboveground Tank Filling, Breathing & Emptying ⁵				
Vehicle Refueling Operations ⁴ Displacement Losses				
Spillage ⁶				

Footnotes:

- 1 - Assume annual throughput
- 2 - $\text{VOC Emissions (lb / yr)} = \text{Emission Rate (lb VOC / 1,000 gal throughput)} \times \text{Throughput (gal)} / 1,000$.
- 3 - $\text{VOC Emissions (tons / yr)} = \text{VOC Emissions (lb/yr)} / 2,000$
- 4 - Emission rate for tank truck loading, or loading loss (L1), calculated using the following equation:

$$\text{L1 (lb/1000 gal)} = (12.46 \times S \times P \times M / T)$$

where:

Saturation Factor (S) = 0.60 (Submerged loading, dedicated vapor balance service - USEPA, AP-42 (Fifth Edition), p. 5.2 – 4, Equation (1) and Table 5.2 – 1)

True Vapor Pressure, psia (P) = 11.0 (Gasoline RVP 11 @ 100°F - USEPA, AP-42 (Fifth Edition), p. 7.1-83, Table 7.1-2)

Mol. Wt. of Vapor, lb/lb-mol (M) = 62 (Gasoline RVP 13 @ 100°F - USEPA, AP-42 (Fifth Edition), p. 7.1-83, Table 7.1-2)

Bulk Liquid Temperature, °R (T) = 560.00 (based on estimate of 100°F, on average)
- 5 - Calculated for tanks using USEPA TANKS4.1 program (or latest version).
- 6 - USEPA, AP-42 (Fifth Edition), p. 5.2 – 15, Table 5.2-7 – Stage II controlled displacement losses; spillage

APPENDIX

Table 9 – Marine Vessel Emission Factors

Pre-Loading Emissions = Compartment Treatment Factor X Prior Cargo Ratio Factor
Compartment Treatment Factor

Vessel Type	Prior Cargo	Compartment Treatment*	Factor kg/m ³ Loaded
Tanker Ocean Barge	Volatile	Uncleaned	0.10305
		Ballasted	0.05512
		Cleaned	0.03954
		Gas Freed	0.03954 **
	Non-Volatile	Uncleaned	0.10305
		Ballasted	0.05512

* Compartment treatment during the ballast voyage, prior to loading.

** Assume value is constant for all volatile products.

	Product in Prior Cargo	Factor Ratio
Volatile	Crude Oil	1.0000
	Tops	1.3780
	Gasoline	1.1510
	Lt. Naphtha	1.1510
	Naphtha	1.3170
	Jet Naphtha	1.3170
Non-Volatile***	Jet Fuel / Kerosene	0.0381
	Gas Oil	0.0424
	Bunker Oil	0.0525

*** Use for only uncleaned or ballasted cargo holds. Assume the hold would not be cleaned or gas freed under normal operating procedures. If the hold had been cleaned and/or gas freed, assume 0.03954 x prior cargo.

Definitions

Ocean Barge	Draft of approximately 12 meters
Volatile	True vapor pressure, greater than 0.1 bar
Uncleaned	No compartment treatment of any kind, except routine heel washing
Ballasted	An uncleaned compartment which has been filled with ballast water
Cleaned	Compartment has been water washed
Gas Freed	Compartment has been cleaned and air-blown, so that it is suitable for entry and hot work.

APPENDIX

Table 10 – Marine Facility Data Sheet

Date of Site Visit:						
Location :				Representative Time Period:		
PRODUCT DATA						
Product Type	Density Kg/L	RVP kg/cm ² or PSI	Average Loading	Temp. °C Discharge	Total Volume m ³ or bbls	
					Loaded	Discharged
Arabian Light (AL) Crude						
Arabian Super Light (ASL) Crude						
Arabian Extra Light (AXL) Crude						
Diesel Oil						
Heavy Fuel Oil (HFO)						
Gas Oil						
JP-4						
Kerosene						
LPG						
Lube Oil						
Naphtha						
Premium Gasoline						
Reformatted Gasoline						
Other						
1) Type of Vessel & Cargo Size, DWT	Tanker T	Ocean Barge O	Barge B	Super Tanker S		
2) Typical Prior Cargo:	Volatile V	Non-Volatile N	If Discharging Cargo, Omit			
3) Typical Compartment Treatment Prior to Loading	Uncleaned U	If Discharging Cargo, Omit				
	Ballasted W					
	Cleaned C					
	Gas Freed G					
4) Cargo Direction:	Loading L	Discharging D & Ullage (# meters) on Arrival				
As examples of vessel characterization, assume an ocean barge, previously filled with volatile material which had been gas-freed, is being loaded: Vessel Characterization is OVGL Assume a Tanker, carrying gasoline, arrives in port with an Ullage of 3 meters: Vessel Characterization is TD (3) Note: For tankers that use main Diesel engine exhaust to inert their tanks, assume that the volume of Diesel exhaust displaced by the product being loaded has a negligible impact on ambient air quality						

APPENDIX

CONVERSIONS AND FORMULAS

1. Conversion from a concentration measured in weight per unit volume to a volume ratio:

$$C_{\text{ppm}} = C_{\mu\text{g}/\text{m}^3} \left[\frac{24.45}{1000(\text{MW})} \right]$$

where

C_{ppm} = Concentration in parts per million

$C_{\mu\text{g}/\text{m}^3}$ = Concentration in micrograms/cubic meter, 24.45 = Molar gas volume at STP

MW = Molecular weight of the gas

2. Calculating the Total Net Heating Value (LHV) of a Gas to be Combusted in a Flare:

$$\text{LHV} = K \sum_{i=1}^n C_i (\text{LHV}_i)$$

where

LHV = Net heating value of the gas mixture (MJ/SCM)

C_i = Concentration of the i th sample gas component, ppm

LHV_i = Net heat of combustion of the i th sample gas component at 25°C and 760 mm Hg. pressure, kcal/g-mole

K = 1.74×10^{-7} g-mole MJ/ (ppm SCM kcal) (constant)

3. Calculating the Exit or Tip Velocity Limits of a Flare (for air dispersion modeling purposes):

The exit or tip velocity of a steam-assisted or non-assisted flare shall be a maximum of 18.3 m/s if the net heating value of the waste gas is less than 37.3 MJ/scm (1000 Btu/scf).

If the net heating value of the waste gas is over 37.3 MJ/scm, the maximum tip velocity shall be determined from the applicable formulas below that calculate tip velocities, subject to the absolute maximum of 122 m/s.

The tip velocity for an air-assisted flare shall be calculated based on the applicable formula below, subject to the same absolute maximum velocity of 122 m/s.

CONVERSIONS AND FORMULAS (Cont'd)

- a. For steam-assisted and non-assisted flares: $\log_{10} (V_{\max}) = (\text{LHV} + 28.8) / 31.7$, where 28.8 and 31.7 are constants
- b. For air-assisted flares: $V_{\max} = 8.706 + 0.7084 (\text{LHV})$, where 8.706 and 0.7084 are constants

$V_{\max}$ = tip velocity in m/s, not to exceed a maximum value of 122 m/s

LHV = Net heating value of the gas mixture being combusted, MJ/scm

4. Determining the Effective Stack Diameter of a Flare for modeling as a point source:

Since combustion occurs at or beyond the tip of a flare in the atmosphere, appropriate values for stack exit temperature and velocity cannot be accurately determined. To predict dispersion for flare type sources, the point source algorithm can be used with arbitrary values assigned for stack exit velocity of 20 mps (65.6 ft/sec) and stack exit temperature of 1,273°K (1,000°C). A stack height equal to the height of the flare tip is recommended for flares. The effective stack diameter, D , in meters, is determined using the following equations:

$$D = \sqrt{(10^{-6} q_n)}$$

where

$$q_n = q [1 - 0.048 \sqrt{\text{MW}}] \text{ and}$$

q = gross heat release in cal/sec

Note:

To convert a heating value in Btu/scf to cal/sec, use the following:

$$[(\text{Btu/scf}) \times (252 \text{ cal/Btu}) \times (\text{scfm})] / 60 \text{ sec/min}$$

MW = weighted average molecular weight of the mixture being burned, by volume

Note:

The diameter of the pipe leading to the flare tip is not considered a factor in determining plume rise. Also note that q_n accounts for heat loss due to radiation. Enclosed vapor combustion units shall not be modeled with the above parameters, but with stack parameters that reflect the physical characteristics of the unit. For additional information, contact the Air Quality Engineering Specialist, EPD/EED.