Tronox LLC, Columbus

General Information

ID	Branch	SIC	County	Basin	Start	End
1696	Chemical	2491	Lowndes	Tombigbee River	10/27/1992	

Address

Physical Address (Primary)	Mailing Address
2300 14th Avenue North Columbus, MS 39701	PO Box 268859 Oklahoma City, OK 731268859

Telecommunications

Type	Address or Phone
Work phone number	(405) 775-5129

Alternate / Historic AI Identifiers

Alt ID	Alt Name	Alt Type	Start Date	End Date
2808700020	Tronox LLC, Columbus	Air-AIRS AFS	10/12/2000	06/01/2002
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Construction	06/12/1998	
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Synthetic Minor Operating	06/06/1997	06/01/2002
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Synthetic Minor Operating	06/12/1998	06/01/2002
MSR220010	Kerr McGee Chemical Corporation, Columbus	GP-Wood Treating	10/27/1992	07/13/1997
MSD990866329	Kerr McGee Chemical Corporation, Columbus	Hazardous Waste-EPA ID	10/12/2000	
MSD990866329	Kerr McGee Chemical Corporation, Columbus	Hazardous Waste-TSD	06/11/2001	04/12/2006
MSD990866329	Tronox LLC, Columbus	Hazardous Waste-TSD	04/13/2006	05/31/2011
1696	Kerr McGee Chemical Corporation	Historic Site Name	10/27/1992	04/10/2006
1696	Tronox, LLC	Official Site Name	04/10/2006	
MSP090021	Kerr McGee Chemical Corporation, Columbus	Water-Pretreatment	10/11/1994	10/10/1999
MSP090021	Kerr McGee Chemical Corporation, Columbus	Water-Pretreatment	08/23/2000	07/31/2005
MSP090021	Kerr McGee Chemical Corporation, Columbus	Water-Pretreatment	10/31/2005	04/12/2006
MSP090021	Tronox LLC, Columbus	Water-Pretreatment	04/13/2006	09/30/2010

Regulatory Programs

Program	SubProgram	Start Date	End Date
Air	NSPS Subpart Dc	09/12/1990	06/01/2002
Air	SM	06/06/1997	06/01/2002
Hazardous Waste	Large Quantity Generator	04/01/1997	
Hazardous Waste	TSD - Not Classified	06/11/2001	
Water	PT CIU	10/11/1994	09/01/2003
Water	PT CIU - Timber Products	10/11/1994	09/01/2003

	Processing (Subpart 429)		
Water	PT NCS	09/01/2003	
Water	PT SIU	10/11/1994	

Locational Data

Latitude	Longitude	Metadata	S / T / R	Map Links
33 ° 30 ' 38 .51 (033.510697)	88 ° 24 ' 34 .02 (088.409450)	**Point Desc:** PG - Plant entrance (General) Data collected by Louis Crawford on 7/11/00. PG - Plant Entrance (General) Data collected by Clift Jeter on 6/13/02. LAT 33deg 30min 36.6sec LON 88deg 24min 35.1sec **Method:** GPS Code (Psuedo Range) Differential **Datum:** NAD83 **Type:** MDEQ	Section: Township: Range:	SWIMS TerraServer Map It

10/13/2006 10:29:50 AM

Kerr McGee Chemical Corporation, Columbus

General Information

ID	Branch	SIC	County	Basin	Start	End
1696	Chemical	2491	Lowndes	Tombigbee River	10/27/1992	

Address

Physical Address (Primary)	Mailing Address
2300 14th Avenue North Columbus, MS 39701	2300 14th Avenue North Columbus, MS 39701

Telecommunications

Type	Address or Phone
Work phone number	(662) 328-7551

Alternate / Historic AI Identifiers

Alt ID	Alt Name	Alt Type	Start Date	End Date
08700020	Kerr McGee Chemical Corporation, Columbus	Air-AIRS AFS	10/12/2000	
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Construction	06/12/1998	
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Synthetic Minor Operating	06/06/1997	06/01/2002
168000020	Kerr McGee Chemical Corporation, Columbus	Air-Synthetic Minor Operating	06/12/1998	06/01/2002
MSR220010	Kerr McGee Chemical Corporation, Columbus	GP-Wood Treating	10/27/1992	07/13/1997
MSD990866329	Kerr McGee Chemical Corporation, Columbus	Hazardous Waste-EPA ID	10/12/2000	
MSD990866329	Kerr McGee Chemical Corporation, Columbus	Hazardous Waste-TSD	06/11/2001	05/31/2011
1696	Kerr McGee Chemical Corporation	Official Site Name	10/27/1992	
MSP090021	Kerr McGee Chemical Corporation, Columbus	Water-Pretreatment	10/11/1994	10/10/1999
MSP090021	Kerr McGee Chemical Corporation, Columbus	Water-Pretreatment	08/23/2000	07/31/2005

Regulatory Programs

Program	SubProgram
Air	SM

Hazardous Waste	TSD - Not Classified
Water	PT CIU
Water	PT CIU - Timber Products Processing (Subpart 429)
Water	PT SIU

Locational Data

Latitude	Longitude	Method	Datum	S / T / R	Map Links
33° 30' 38.51 (033.510697)	88° 24' 34.2 (088.409450)	GPS Code (Psuedo Range) Differential	NAD83	Section: Township: Range:	SWIMS TerraServer Map It

Report Date: 1/28/2005 2:22:45 PM

Coded

CLEAN AIR ACT
TITLE V OPERATING PERMIT APPLICATION

VOLUME 2

RECEIVED
APR -6 1995
DEQ-OPC

Prepared for:

KERR-MCGEE CHEMICAL CORPORATION
FOREST PRODUCTS DIVISION
Columbus, Mississippi

Prepared by:

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AquAeTer, Inc.
215 Jamestown Park, Suite 204
Brentwood, Tennessee

March 1995

optimizing environmental resources
water, air, earth

LIST OF APPENDICES

Appendix No.	**Description**
Appendix 1	Mississippi Instructions for Application for Title V Air Pollution Control Permit
Appendix 2	Mississippi Air Operating Permit
Appendix 3	Site Visit Field Notes
Appendix 4	Support Calculations
Appendix 5	Data Evaluations
Appendix 6	USEPA WATER 8 Model and USEPA TANK 2.0 Program Model
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Appendix 9	Weather Data

APPENDIX 1

MISSISSIPPI INSTRUCTIONS FOR APPLICATION FOR TITLE V AIR POLLUTION CONTROL PERMIT

FOR OFFICIAL USE ONLY

APPLICATION RECEIPT DATE: ____________

APPLICATION NO.: ____________

FOR MODIFICATION:
MINOR ____________
SIGNIFICANT ____________

STATE OF MISSISSIPPI
DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF POLLUTION CONTROL
AIR DIVISION

P.O. BOX 10385
JACKSON, MS. 39289-0385
PHONE NO.: (601) 961 - 5171

APPLICATION FOR TITLE V AIR POLLUTION CONTROL PERMIT TO OPERATE AIR EMISSIONS EQUIPMENT

Data Coded

PERMITTING ACTIVITY:

____________ INITIAL APPLICATION
____________ MODIFICATION
____________ RENEWAL OF OPERATING PERMIT

NAME: ____________

CITY: ____________

COUNTY: ____________

FACILITY No. (if known): ____________

APPLICATION FOR TITLE V PERMIT TO OPERATE AIR EMISSIONS EQUIPMENT

CONTENTS

DESCRIPTION **SECTION**

OPERATING PERMIT APPLICATION REQUIREMENTS

All applications must be submitted on the form supplied by the Permit Board. Insignificant activities which are specified in Section VII.A. of Regulation APC-S-6 and listed herein need not be included in permit applications. For insignificant activities which are specified in Section VII.B. of Regulation APC-S-6, a list must be included in the application. An application may not omit information needed to determine the applicability of, or to impose, any applicable requirement, or to evaluate the fee amount required under the schedule pursuant to Section VI. of Regulation APC-S-6. The forms and attachments shall include the elements specified as follows:

A. Identifying information, including company name and address (or plant name and address if different from the company name), owners name and agent, and telephone number and names of plant site manager/contact;

B. A description of the sources process and products by Standard Industrial Classification Code including any associated with any alternate scenario identified by the source;

C. Emission-related information as follows:

1. All emissions of pollutants for which the source is major, and all emissions of regulated air pollutants. Fugitive emissions from individual components within a facility may be determined collectively based on their relationship to the associated process unless individual emission rates are needed to determine the applicability of an applicable requirement such as NSPS, NESHAPS, a MACT standard, etc. or to determine air quality impacts. A permit application shall describe all emissions of regulated air pollutants emitted from any emissions unit, except those emissions resulting from insignificant activities listed on pages 6-8 of this application. The Permit Board shall require additional information related to the emissions of air pollutants sufficient to verify which requirements are applicable to the source, and other information necessary to collect any permit fees owed under the fee schedule pursuant to Section VI. of Regulation APC-S-6;

2. Identification and description of all points of emissions described in item C.1. of this section in sufficient detail to establish the basis for fees and applicability of requirements of the Federal Act;

3. Emission rates in TPY and in such terms as are necessary to establish compliance consistent with the applicable standard reference test method;

4. To the extent it is needed to determine or regulate emissions, the information that follows: fuels, fuel use, raw materials, production rates, and operating schedules;

5. Identification and description of air pollution control equipment and compliance monitoring devices or activities;

6. Limitations on source operation affecting emissions or any work practice standards, where applicable, for all regulated pollutants at the Title V source;

7. Other information required by any applicable requirement (including information related to stack height limitations developed pursuant to Section 123 of the Federal Act); and

8. Calculations on which the information requested in this section is based;

D. Air pollution control requirements as follows:

  1. Citation and description of all applicable requirements, and

  2. Description of or reference to any applicable test method for determining compliance with each applicable requirement;

E. Other specific information that may be necessary to implement and enforce other applicable requirements of the Federal Act or of these regulations or to determine the applicability of such requirements;

F. An explanation of any proposed exemptions from otherwise applicable requirements;

G. Additional information as determined to be necessary by the Permit Board to define alternative operating scenarios identified by the source pursuant to Section III.A.9. of Regulation APC-S-6 or to define permit terms and conditions implementing 40 CFR 70.4(b)(12) or Section III.A.10. of Regulation APC-S-6;

H. A compliance plan for all Title V sources that contains all of the following:

  1. A description of the compliance status of the source with respect to all applicable requirements;

  2. A description as follows:

    a. For applicable requirements with which the source is in compliance, a statement that the source will continue to comply with such requirements;

    b. For applicable requirements that will become effective during the permit term, a statement that the source will meet such requirements on a timely basis;

    c. For requirements for which the source is not in compliance at the time of permit issuance, a narrative description of how the source will achieve compliance with such requirements;

  3. A compliance schedule as follows:

    a. For applicable requirements with which the source is in compliance, a statement that the source will continue to comply with such requirements;

    b. For applicable requirements that will become effective during the permit term, a statement that the source will meet such requirements on a timely basis. A statement that the source will meet in a timely manner applicable requirements that become effective during the permit term shall satisfy this provision, unless a more detailed schedule is expressly required by the applicable requirements;

    c. A schedule of compliance for sources that are not in compliance with all applicable requirements at the time of permit issuance. Such a schedule shall include a schedule or remedial measures, including an enforceable sequence of actions with milestones, leading to compliance with any applicable requirements for which the source will be in noncompliance at the time of permit issuance. This compliance schedule shall resemble and be at least as stringent as that contained in any judicial consent decree or administrative order to which the source is subject. Any such schedule of compliance shall be supplemental to, and shall not sanction noncompliance with, the applicable requirements on which it is based;

4. A schedule for submission of certified progress reports, to be submitted no less frequently than every 6 months for sources required to have a schedule of compliance to remedy a violation;

5. The compliance plan content requirements specified in this paragraph shall apply and be included in the acid rain portion of a compliance plan for an affected source, except as specifically superseded by regulations promulgated under Title IV of the Federal Act with regard to the schedule and method(s) the source will use to achieve compliance with the acid rain emissions limitations;

I. Requirements for compliance certification, including the following:

1. A certification of compliance with all applicable requirements by a responsible official consistent with Section II.E of Regulation APC-S-6 and Section 114(a)(3) of the Federal Act;

2. A statement of methods used for determining compliance, including a description of monitoring, recordkeeping, and reporting requirements and test methods;

3. A schedule for submission of compliance certifications during the permit term, to be submitted no less frequently than annually, or more frequently if specified by the underlying applicable requirement or by the Permit Board;

4. A statement indicating the sources compliance status with any applicable enhanced monitoring and compliance certification requirements of the Federal Act; and

J. The use of nationally-standardized forms for acid rain portions of permit applications and compliance plans, as required by regulations promulgated under Title IV of the Federal Act.

INSIGNIFICANT ACTIVITIES AND EMISSIONS

I. The following activities/emissions sources are not required to be included in a Title V permit application:

A. New or modified pilot plants, subject to temporary source regulations located in Section III.E of regulation APC-S-6.

B. Maintenance and upkeep:

1. Maintenance, structural changes, or repairs which do not change the capacity of such process, fuel-burning, refuse-burning, or control equipment, and do not involve any change in quality, nature, or quantity of potential emissions of any regulated air pollutants; and

2. Housekeeping activities or building maintenance procedures;

C. Air conditioning or ventilation: comfort air conditioning or comfort ventilating systems which do not transport, remove, or exhaust regulated air pollutants to the atmosphere;

D. Laboratory equipment:

1. Laboratory equipment used exclusively for chemical or physical analysis for quality control or environmental monitoring purposes; or

2. Non-production laboratory equipment used at non-profit health or non-profit educational institutions for chemical or physical analyses, bench scale experimentation or training, or instruction;

E. Hot water heaters which are used for domestic purposes only and are not used to heat process water;

F. Fuel use related to food preparation by a restaurant, cafeteria, residential cooker or barbecue grill where the products are intended for human consumption;

G. Clerical activities such as operating copy machines and document printers, except operation of such units on a commercial basis;

H. Hand held equipment used for buffing, polishing, carving, cutting, drilling, machining, routing, sanding, sawing, surface grinding, or turning of ceramic art work, precision parts, leather, metals, plastics, fiber board, masonry, carbon, glass, or wood;

I. Equipment for washing or drying fabricated glass or metal products, if no VOCs are used in the process and no oil or solid fuel is burned;

J. Water cooling towers (except at nuclear power plants); water treatment systems for process cooling water or boiler feed water; and water tanks, reservoirs, or other water containers not used in direct contact with gaseous or liquid process streams containing carbon compounds, sulfur compounds, halogens or halogen compounds, cyanide compounds, inorganic acids, or acid gases;

K. Domestic sewage treatment facilities (excluding combustion or incineration equipment, land farms, storage silos for dry material, or grease trap waste handling or treatment facilities);

L. Stacks or vents to prevent escape of sewer gases through plumbing traps;

M. Vacuum cleaning systems for housekeeping, except at a source with hazardous air pollutants;

N. Alkaline/phosphate washers and associated cleaners and burners;

O. Mobile sources;

P. Livestock and poultry feedlots and associated fuel burning equipment other than incinerators;

Q. Outdoor kerosene heaters;

R. Equipment used for hydraulic or hydrostatic testing;

S. Safety devices, excluding those with continuous emissions; and

T. Brazing, soldering, or welding equipment that is used intermittently or in a non-continuous mode.

II. The following activities/emissions sources must be listed in the application but emissions from these activities do not have to be quantified.

A. All gas fired, #2 oil fired, infrared, electric ovens with no emissions other than products of fuel combustion;

B. Combustion units with rated input capacity less than 10 million Btu/hr that are fueled by:

1. Liquified petroleum gas or natural gas supplied by a public utility; or

2. Commercial fuel oil #2 or lighter;

C. Equipment used for inspection of metal products;

D. Equipment used exclusively for forging, pressing, drawing, spinning, or extruding metals;

E. Equipment used exclusively to mill or grind coatings and molding compounds where all materials charged are in paste form;

F. Mixers, blenders, roll mills, or calendars for rubber or plastics for which no materials in powder form are added and in which no organic solvents, diluents, or thinners are used;

G. All storage tanks used exclusively to store fuel oils, kerosene, diesel, jet fuel, crude oil, natural gas, or liquified petroleum gas (the application must list the size of the tank, date constructed and/or modified, type tank, and material stored);

H. Space heaters utilizing natural or LPG gas and used exclusively for space heating;

I. Back-up or emergency use generators, boilers or other fuel burning equipment which is of equal or smaller capacity than normal main operating equipment, cannot be used in conjunction with normal main operating equipment, and does not emit, have or cause the potential to emit of any regulated air pollutant to increase;

J. Blast cleaning equipment using a suspension of abrasives in water;

K. Die casting machines;

L. Foundry sand mold forming equipment to which no heat is applied and from which no organics are emitted.

M. Bark and wood - waste storage and handling;

N. Log wetting areas;

P. Log flumes;

Q. Sodium hydrosulfide storage tank;

R. Smelt dissolving tank view ports;

S. Spout cooling water storage;

T. Effluent drains;

U. White water chest;

V. Repupler vents;

W. Clay storage tank;

X. Alum storage tank;

Y. Starch storage tank;

Z. Steam vents and leaks;

AA. Deaerator vents;

AB. Mill air and instrument air system;

AC. Demineralizer water storage tank;

AD. Acid storage tank;

AE. Process water tank;

AF. Air purification system vents;

AG. Effluent neutralizing tank/system;

AH. Dregs washer;

AI. Lime silo;

AJ. Lime mud mix tank;

AK. H_2O_2 storage tank;

AL. Green liquor tank; and

AM. Tall oil storage tank.

III. Notwithstanding I. and II. above, the applicant shall include all emissions sources and quantify emissions if needed to determine major source status, to determine compliance with an applicable requirement and/or the applicability of any applicable requirement such as NSPS, NESHAP, MACT standard, etc. as such term is defined in Section I. of Regulation APC-S-6 or collect any permit fee owed under the approved fee scheduled.

IV. Notwithstanding I. and II. above, the applicant shall include all emission sources with a potential to emit:

1. greater than 1 pound per hour of any regulated pollutant that is not a hazardous air pollutant;

2. greater than 0.1 pound per hour of any hazardous air pollutant.

V. The permittee does not have to report the addition of any insignificant activity listed in Section I. above unless the addition is a Title I modification or requires a permit to construct. If a Title I permit or a Permit to Construct is required, then the modification procedures outlined in Section IV.E. of Regulation APC-S-6 shall be followed.

IV. The addition of any insignificant activity listed in Section II. above, shall be handled as an administrative amendment, as defined in Section IV.D. of Regulation APC-S-6 unless the addition is a Title I modification or requires a Permit to Construct. If a Title I permit or Permit to Construct is required, then the modification procedures outlined in Section IV.E. of Regulation APC-S-6 shall be followed.

REGULATED AIR POLLUTANTS

Total suspended particulate matter
PM$_{10}$
Sulfur dioxide
Nitrogen oxides
Carbon monoxide
Volatile organic compounds(see note 1)
Lead
Dioxin/Furan
Fluorides
Hydrogen chloride
Hydrogen sulfide
Sulfuric acid mist
Total reduced sulfur
Reduced sulfur compounds
Arsenic
Asbestos
Beryllium
Benzene
Mercury
Radionuclides
Vinyl chloride
Carbon tetrachloride
Chlorofluorocarbon-11
Chlorofluorocarbon-12
Chlorofluorocarbon-13
Chlorofluorocarbon-111
Chlorofluorocarbon-112
Chlorofluorocarbon-113
Chlorofluorocarbon-114
Chlorofluorocarbon-115
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Hydrochlorofluorocarbon-253
Hydrochlorofluorocarbon-261
Hydrochlorofluorocarbon-262
Hydrochlorofluorocarbon-271
Halon-1211
Halon-1301
Halon-2402
Methyl chloroform

Note 1 - Volatile organic compounds (VOC) includes any compound of carbon, excluding carbon monoxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate, which participates in atmospheric photochemical reactions. This includes any such organic compound other than the following which have been determined to have negligible photochemical reactivity: Methane; ethane; methylene chloride; 1,1,1-trichloroethane; CFC-113; CFC-11;CFC-12; CFC-22; FC-23; CFC-114; CFC-115; HCFC-123; HFC-134a; HCFC-141b; HCFC-142b; HCFC-124; HFC-125; HFC-134; HFC-143a; HFC-153a; and perfluorocarbon compounds which fall into these classes: (i) Cyclic, branched, or linear, completely fluorinated alkanes; (ii) Cyclic, benched, or linear, completely fluorinated ethers with no unsaturations; (iii) Cyclic, branched, or linear completely fluorinated tertiary amines with no unsaturations; and (iv) Sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine. **For the purposes of this application hazardous air pollutants that are volatile organic compounds should be included as VOCs for reflection of total VOCs from the facility but need to be identified separately as well.**

HAZARDOUS AIR POLLUTANTS

CAS No.	CHEMICAL NAME
75070	Acetaldehyde
60355	Acetamide
75058	Acetonitrile
98862	Acetophenone
53963	Acetylaminofluorene(2)
107028	Acrolein
79061	Acrylamide
79107	Acrylic Acid
107131	Acrylonitrile
107051	Allyl Chloride
92671	Aminodipheyl(4)
62533	Aniline
90040	Anisidine(o)
7440360	Antimony Compounds
7440382	Arsenic Compounds (inorganic including arsine)
1332214	Asbestos
71432	Benzene
92875	Benzidine
98077	Benzotrichloride
100447	Benzyl Chloride
7440417	Beryllium Compounds
192524	Biphenyl
117817	Bis(2-ethhylhexyl)phthalate(DEHP) (Dioctyl Phthalate)
542881	Bis(chloromethyl)ether
75252	Bromoform
106990	Butadiene(1,3)
7440439	Cadmium Compounds
156627	Calcium Cyanamide
105602	Caprolactam
133062	Captan
63252	Carbaryl
75150	Carbon Disulfide
56235	Carbon Tetrachloride
463581	Carbonyl Sulfide
120809	Catechol
133904	Chloramben
57749	Chlordane
7782505	Chlorine
79118	Chloroacetic Acid
532274	Chloroacetophenone(2)
108907	Chlorobenzene
510156	Chlorobenzinate
67663	Chloroform
107302	Chloromethyl methyl ether
126998	Chloroprene (Neoprene; 2-Chloro-1,3-Butadiene)
7440473	Chromium Compounds (IV)
10210681	Cobalt Carbonyl (as Co)
7440484	Cobalt Compounds (metal, dust, and fumes as Co)
16842038	Cobalt Hydrocarbonyl (as Co)

HAZARDOUS AIR POLLUTANTS

CAS No.	CHEMICAL NAME
65996818A	Coke Oven Emissions
1319773	Cresols/Cresylic acid
108394	Cresol(m)
95487	Cresol(o)
106445	Cresol(p)
98828	Cumene (Isopropylbenzene)
---	Cyanide Compounds (NOTE # 1)
3547044	DDE
334883	Diazomethane
132649	Dibenzofurans
96128	Dibromo-3-chloropropane(1,2)
84742	Dibutylphthalate
106467	Dichlorobenzene(1,4)(p)
91941	Dichlorobenzidene(3,3)
111444	Dichloroethyl ether (Bis(2-chloroehtyl)ether)
542756	Dichloropropene(1,3)
62737	Dichlorvos
111422	Diethanolamine
121697	Diethyl aniline (N,N) (dimethylaniline (N,N))
64675	Diethyl Sulfate
119904	Dimethoxybenzidine(3,3')
60117	4 - Dimethyl aminoazobenzene
119937	Dimethyl benzidine (3,3')
79447	Dimethyl carbamoyl chloride
68122	Dimethyl formamide
57147	Dimethyl hydrazine(1,1)
131113	Dimethyl phthalate
77781	Dimethyl sulfate
534521	Dinitro-o-cresol(4,6), and salts
51285	Dinitrophenol(2,4)
121142	Dinitrotoluene(2,4)
123911	Dioxane(1,4) (1,4-diethyleneoxide)
122667	Diphenylhydrazine(1,2)
94757	d(2,4), salts and esters
106898	Epichlorohydrin (Chloro-2,3-epoxypropane(1))
106887	Epoxybutane(1,2) (1,2-Butylene oxide)
140885	Ethyl acrylate
100414	Ethyl benzene
51796	Ethyl carbamate (Urethane)
75003	Ethyl chloride (Chloroethane)
106934	Ethylene dibromide (1,2-Dibromoethane)
107062	Ethylene dichloride (1,2-Dichloroethane)
107211	Ethylene glycol
151564	Ethylene imine (Azridine)
75218	Ethylene oxide
96457	Ethylene thiourea
75343	Ethylidene dichloride (1,1-Dichloroethane)
50000	Formaldehyde
---	Glycol ethers (NOTE #2)
76448	Heptachlor

HAZARDOUS AIR POLLUTANTS

CAS No.	CHEMICAL NAME
118741	Hexachlorobenzene
87683	Hexachlorocyclopentadiene
67721	Hexachloroethane
822060	Hexamethylene-1,6-diisocyanate
680319	Hexamethylphosphoramide
110543	Hexane
302012	Hydrazine
7647010	Hydrochloric acid
7664393	Hydrogen Fluoride (Hydrofluoric acid)
123319	Hydroquinone
78591	Isophorone
7439921	Lead Compounds
58899	Lindane (all isomers)
108316	Maleic anhydride
7439965	Manganese Compounds
7439976	Mercury Compounds
67561	Methanol
72435	Methoxychlor
74839	Methyl bromide (Bromomethane)
74873	Methyl chloride (Chloromethane)
71556	Methyl chloroform (1,1,1-Trichloroethane)
78933	Methyl ehtyl ketone (2-Butanone) (MEK)
60344	Methyl hydrazine
74884	Methyl iodide (Iodomethane)
108101	Methyl isobutyl ketone (Hexone)
624839	Methyl isocyanate
80626	Methyl methacrylate
1634044	Methyl tert butyl ether
101144	Methylene bis(2-chloroaniline)(4,4) (MOCA)
75092	Methylene chloride (Dichloromethane)
101688	Methylene diphenyl diisocynate (MDI)
101779	Methylenedianiline(4,4')
---	Mineral fibers (NOTE #3)
91203	Naphthalene
7440020	Nickel Compounds
7440020	Nickel, refinery dust
12035722	Nickel, subsulfide
98953	Nitrobenzene
92933	Nitrodiphenyl(4)
100027	Nitrophenol(4)
79469	Nitropropane(2)
62759	Nitrosodimethylamine(N) (Dimethylnitrosoamine)
59892	Nitrosomorpholine(N)
684935	Nitroso-N-methylurea(N)
56382	Parathion
82688	Pentachloronitrobenzene (Quintobenzene)
87865	Pentachlorophenol
108952	Phenol
106503	Phenylenediamine(p)
75445	Phosgene

HAZARDOUS AIR POLLUTANTS

CAS No.	CHEMICAL NAME
7803512	Phosphine
7723140	Phosphorus
85449	Phthalic anhydride
1336363	Polychlorinated biphenyls (Arochlors)
---	Polycylic Organic Matter (NOTE #5)
1120714	Propane sultone(1,3)
57578	Propiolactone(beta)
123386	Propionaldehyde
114261	Propoxur (Baygon)
78875	Propylene dichloride (1,2 dichloropropane)
75558	Propylene imine(1,2) (2-methyl aziridine)
75569	Propylene oxide
91225	Quinoline
106514	Quinone (1,4-Cyclohexadienedione)
---	Radionuclides (including radon) (NOTE #4)
7782492	Selenium Compounds
100425	Styrene
96093	Styrene oxide
1746016	Tetrachlorodibenzo-p-dioxin(2,3,7,8) (TCDD) (Dioxin)
79345	Tetrachloroethane(1,1,2,2)
127184	Tetrachloroethylene (Perchloroethylene)
7550450	Titanium Tetrachloride
108883	Toluene
95807	Toluene diamine(2,4) (2,4-diaminotoluene)
584849	Toluene diisocyanate(2,4)
95534	Toluidine(o)
8001352	Toxaphene (Chlorinated camphene)
120821	Trichlorobenzene(1,2,4)
79005	Trichloroethane(1,1,2)
79016	Trichloroethylene
95954	Trichlorophenol(2,4,5)
88062	Trichlorophenol(2,4,6)
121448	Triethylamine
1582098	Trifluralin
540841	Trimethylpentane(2,2,4)
75014	Vinyl Chloride
108054	Vinyl Acetate
593602	Vinyl Bromide
75354	Vinylidene chloride (1,1-Dichloroethylene)
1330207	Xylenes (mixed)
108383	Xylene(m)
95476	Xylene(o)
106423	Xylene(p)

NOTE # 1: X'CN where X = H' or any other group where a formal dissociation may occur, for example: KCN or $Ca(CN)_2$.

NOTE # 2: Includes mono- and di- ethers of ethylene glycol, dietheylene glycol and triethylene glycol R-(OCH_2CH_2)n-OR' where:

n = 1,2,3
R = alkyl or arl groups
R' = R,H, or group which, when removed, yield glycols
ethers with the structure: R-(OCH_2CH_2)n-OH. Polymers
are excluded from the glycol category

NOTE # 3. Includes glass microfibers, glass wool fibers, rock wool fibers, and slag wool fibers, each characterized as "respirable" (fiber diameter less then 3.5 micrometers) and possessing an aspect ratio (fiber length divided by fiber diameter) greater than 3.

NOTE # 4: A type of atom which spontaneously undergoes radioactive decay.

NOTE # 5. Includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100 Celsius.

Owners Information

Section B

1 Name, Address & Contact for the Owner/Applicant

A. Company Name: ____________________

B. Mailing Address:

1. Street Address or P.O. Box: ____________________
2. City: ____________________ 3. State: ____________________
4. Zip Code: ____________________
5. Telephone No.: (   ) ____________________

C. Contact:

1. Name: ____________________
2. Title: ____________________

2. Name, Address, Location and Contact for the Facility:

A. Name: ____________________

B. Mailing Address:
1. Street Address or P.O. Box: ____________________
2. City: ____________________ 3. State: ____________________
4. Zip Code: ____________________
5. Telephone No.: (   ) ____________________

C. Site Location:
1. Street: ____________________
2. City: ____________________ 3. State: ____________________
4. County: ____________________ 5. Zip Code: ____________________
6. Telephone No.: (   ) ____________________

Note: If the facility is located outside of the City limits, please attach a sketch or description to this application showing the approximate location of the site.

D. Contact:

1. Name: ____________________
2. Title: ____________________

3. SIC Code(s)(including any associated with alternate operating scenarios): ____________________

____

APPENDIX 2

MISSISSIPPI AIR OPERATING PERMIT

INTERNAL CORRESPONDENCE

KMCC-FPD

(UNIT)

TO J. H. Bull

DATE April 22, 1992

FROM J. J. Getz

SUBJECT Air Operating Permit

Enclosed please find a copy of the new Air Operating Permit issued to the Columbus facility on April 14, 1992. The permit is in effect for 5 years, unless we change or install new equipment.

The original is on file here at Columbus.

Please let me know if you have any questions.

JJG:tjj

Joe Getz

STATE OF MISSISSIPPI
DEPARTMENT OF ENVIRONMENTAL QUALITY
JAMES I. PALMER, JR.
EXECUTIVE DIRECTOR

RECEIVED
APR 21 1992
KERR-McGEE CORP.
FOREST PRODUCTS DIV.

April 16, 1992

Certified Mail No. P 165 464 921

Mr. John Gertz, Plant Manager
Kerr-McGee Chemical Corporation
Forest Products Division
P.O. Box 906
Columbus, MS 39704

Dear Mr. Getz:

Re: Operating Permit
No. 1680-00020
14th Avenue & 20th Street
Columbus, Mississippi

Enclosed please find Operating Permit No. 1680-00020 issued for the operation of air emissions equipment. Operation of the air emissions equipment at the facility shall be in accordance with the terms, conditions, and limitations of the permit.

Any significant modification to this process or facility which will alter the rate or composition of air pollutant emissions will cause this permit to become invalid. Should you wish to make such a modification, it will be necessary to submit a new application for a construction permit.

This permit expires on April 1, 1997. A new permit application must be submitted one hundred and eighty (180) days prior to this date in order to renew this permit.

Any appeal of this permit action must be made within the 30 day period provided for in Section 49-17-29(4)(b) Mississippi Code of 1972.

If you have any questions or if we can be of service, please let me know.

Very truly yours,

J. Dewayne Headrick

J. Dewayne Headrick
Stationary Source Compliance Section

JDH:sr
Enclosure

OFFICE OF POLLUTION CONTROL, P. O. BOX 10385, JACKSON, MS 39289-0385, (601) 961-5171

STATE OF MISSISSIPPI
AIR POLLUTION CONTROL PERMIT

TO OPERATE AIR EMISSIONS EQUIPMENT

THIS CERTIFIES THAT

Kerr-McGee Chemical Corporation
Forest Products Division
14th Avenue & 20th Street
Columbus, Mississippi

has been granted permission to operate air emissions equipment in accordance with emission limitations, monitoring requirements and conditions set forth herein. This permit is issued in accordance with the provisions of the Mississippi Air and Water Pollution Control Law (Section 49-17-1 et. seq., Mississippi Code of 1972), and the regulations and standards adopted and promulgated thereunder.

Issued this 14th day of April, 1992

Effective Date: April 14, 1992

MISSISSIPPI ENVIRONMENTAL QUALITY PERMIT BOARD

Charles Chisolm

HEAD, OFFICE OF POLLUTION CONTROL
MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

Expires 1st day of April, 1997

Permit No. 1680-00020

PART I
GENERAL CONDITIONS

1. All emissions authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any air pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions or modifications which will result in new, different, or increased emission of air pollutants must be reported by submission of a new application.

2. The permittee shall at all times maintain in good working order and operate as efficiently as possible all air pollution control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

3. Solids removed in the course of control of air emissions shall be disposed of in a manner such as to prevent the solids from becoming windborne and to prevent the materials from entering state waters without the proper environmental permits.

4. Any diversion from or bypass of collection and control facilities is prohibited except (i) where unavoidable to prevent loss of life or severe property damage or (ii) when approved by the Mississippi Environmental Quality Permit Board.

5. Whenever any emergency, accidental or excessive discharge of air contaminants occurs, the Mississippi Department of Environmental Quality Office of Pollution Control shall be notified immediately of all information concerning cause of the discharge, point of discharge, volume and characteristics, and whether discharge is continuing or stopped.

6. Should the Executive Director of the Mississippi Department of Environmental Quality declare an Air Pollution Control Episode, the permittee will be required to operate in accordance with the permittee's previously approved Emissions Reduction Schedule.

7. The permittee shall allow the Mississippi Department of Environmental Quality Office of Pollution Control and the Mississippi Environmental Quality Permit Board and/or their authorized representatives, upon the presentation of credentials:

    a. To enter upon the permittee's premises where an air emission source is located or in which any records are required to be kept under the terms and conditions of this permit, and

    b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any air emission.

8. After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to:

   a. Violation of any terms or conditions of this permit.

   b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

   c. A change in any condition that required either a temporary or permanent reduction or elimination of authorized air emissions.

9. For renewal of this permit the applicant shall make application not less than one-hundred eighty (180) days prior to the expiration date of the permit substantiated with current emissions data, test results or reports or other data as deemed necessary by the Mississippi Environmental Quality Permit Board.

10. Except for data determined to be confidential under the Mississippi Air & Water Pollution Control Law, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Mississippi Department of Environmental Quality Office of Pollution Control.

11. The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

12. Nothing herein contained shall be construed as releasing the permittee from any liability for damage to persons or property by reason of the installation, maintenance, or operation of the air cleaning facility, or from compliance with the applicable statutes of the State, or with local laws, regulations, or ordinances.

13. This permit may only be transferred upon approval of the Mississippi Environmental Quality Permit Board.

14. This permit is for air pollution control purposes only.

15. This permit is not a Federally approved operating permit under Title V of the Federal Clean Air Act as amended in 1990. This permit is a transitional operating permit to satisfy the requirements of State Law only. After new State operating permit regulations are developed and adopted to satisfy the conditions of Title V of the Federal Act, the permittee will be required to submit an updated application to comply with said regulations and this permit may be modified, suspended, or revoked as necessary to comply with said regulations.

PART II
EMISSION LIMITATIONS AND MONITORING REQUIREMENTS

Beginning April 14, 1992, and lasting until April 1, 1997, the permittee is authorized to operate air emissions equipment and emit air contaminants from Emission Point AA-001, the CB D-6 Boiler.

Such emissions shall be limited by the permittee as specified below:

EMISSION LIMITATIONS

Particulate Matter	16.6 lbs/hr
Sulfur Dioxide	163.2
Opacity	40% Maximum

PART II
EMISSION LIMITATIONS AND MONITORING REQUIREMENTS

Beginning April 14, 1992, and lasting until April 1, 1997, the permittee is authorized to operate air emissions equipment and emit air contaminants from Emission Point AA-002, the Vogt 14435 Woodwaste Boiler.

Such emissions shall be limited by the permittee as specified below:

EMISSION LIMITATIONS

Particulate Matter	31.3 lbs/hr
Sulfur Dioxide	68.6
Opacity	40% Maximum

PART II
EMISSION LIMITATIONS AND MONITORING REQUIREMENTS

Beginning April 14, 1992, and lasting until April 1, 1997, the permittee is authorized to operate air emissions equipment and emit air contaminants from Emission Point AA-003, two (2) wood processing cyclones.

Such emissions shall be limited by the permittee as specified below:

EMISSION LIMITATIONS

Cyclone #1:

Particulate Matter	9.1 lbs/hr

Cyclone #2:

Particulate Matter	15.1 lbs/hr

PART II
EMISSION LIMITATIONS AND MONITORING REQUIREMENTS

Beginning April 14, 1992, and lasting until April 1, 1997, the permittee is authorized to operate air emissions equipment and emit air contaminants from Emission Point AA-004, the 57,000 gallon creosote storage tank controlled by a scrubber.

Such emissions shall be limited by the permittee as specified below:

EMISSION LIMITATIONS

Volatile Organic Compounds (VOC) 0.8 lbs/hr and 3.5 tons/year and reduction of control equipment inlet VOC by 95% as set forth by 40 CFR 60.112b(a)(3).

REPORTING & RECORDKEEPING

The permittee shall provide notices and reports, and maintain records as required by 40 CFR 60, Section 60.115b.

TESTING & PROCEDURES

The permittee shall demonstrate compliance with the required control efficiency for VOC emissions as required by 40 CFR 60.113b.

PART III
OTHER REQUIREMENTS

(1) The operator of the equipment covered by this permit shall operate and maintain this equipment to assure that the emission rates will not, at any time, exceed the rates allowed by the Mississippi Air Emission Regulations.

(2) The permittee is required to meet all applicable conditions and requirements contained in New-Source Performance Standards (NSPS), Subpart Kb.

(3) The NSPS tank must be controlled by a closed vent system and scrubber. The closed vent system shall be designed to collect all VOC vapors and gases discharged from the storage vessel and operated with no detectable emissions as indicated by an instrument reading of less than 500 ppm above background. The control device shall be designed and operated to reduce inlet VOC emissions by 95% or greater.

(4) The permittee is allowed to store only creosote in the storage vessel. The amount of creosote stored must be recorded at all times. The maximum true vapor pressure of the stored creosote must be recorded at all times.

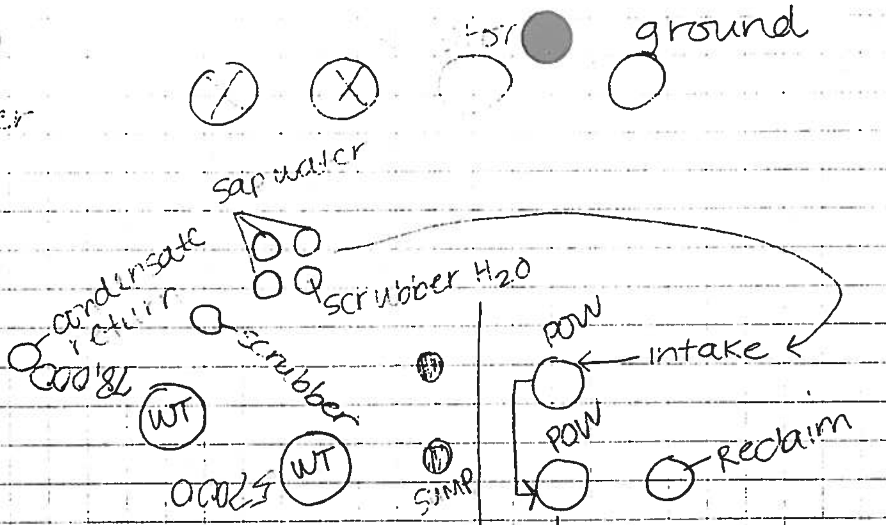
APPENDIX 3

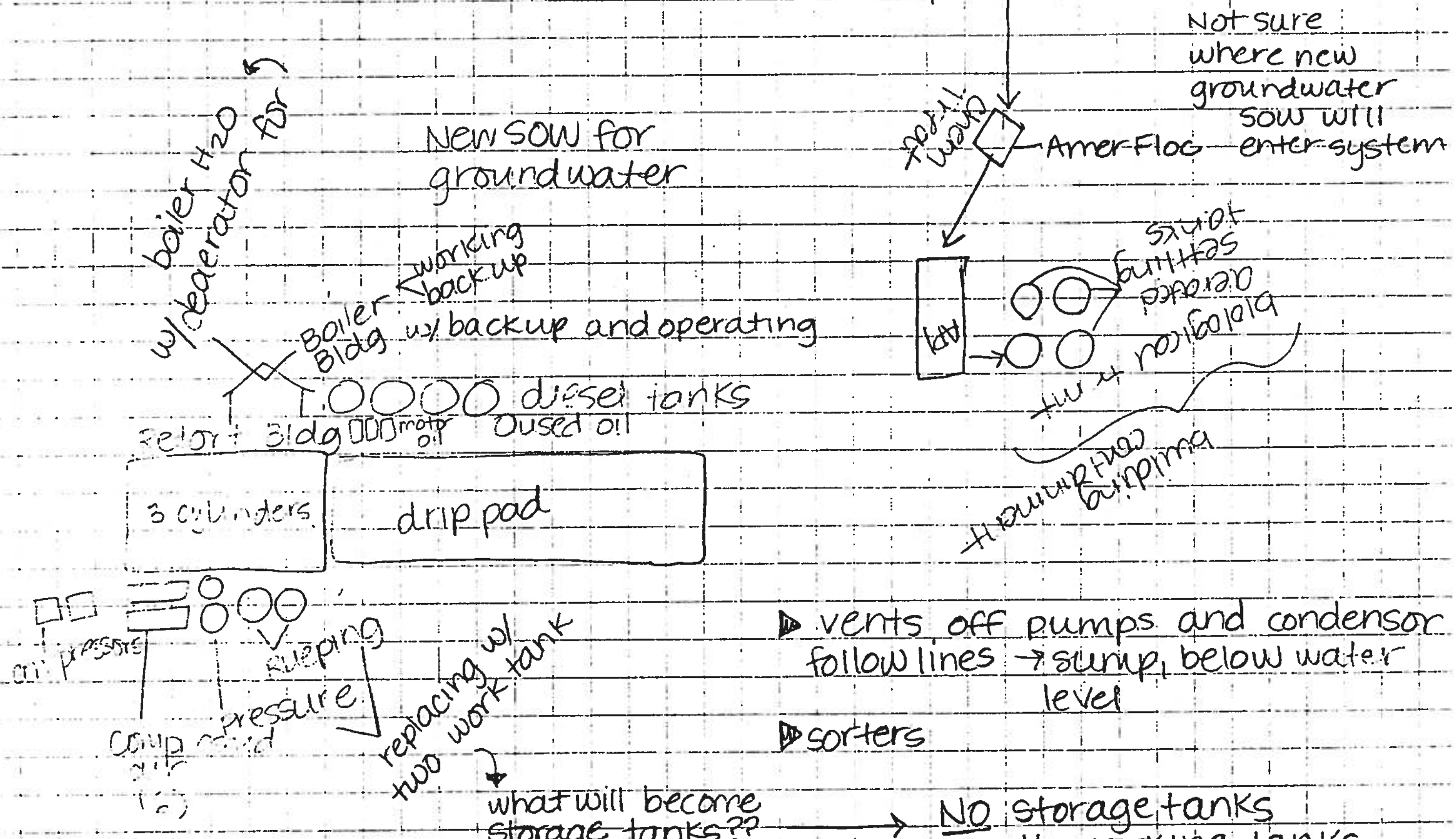
SITE VISIT FIELD NOTES

Aug. 3

WTS containment area
- sumps - rainwater
being concreted

sap tanks - fill a volume
vs Madison where count
number of fills





Not sure where new groundwater SOW will enter system

New SOW for groundwater

Boiler Bldg w/ backup and operating

replacing w/ two work tank

what will become ~~storage tanks~~?? → NO storage tanks all working tanks

- vents off pumps and condensor follow lines → sump, below water level
- sorters

- Product Yard
  Diesel tank 1,000 g
  and Dispenser

- look out window at vacuum pump sump to sap tank

Varec 2500 Liquid Level Gage

Jan. 9, 1995
agitating aerators
shaft dia ?
hp ?
rpm ?

		Avg	Max
influent BOD			
phenols		32.6 lb/day	48.8
O&G			
pH			

52 ppm 78 ppm

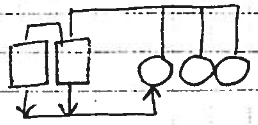
in future, new

8-29-94 ②

▶ Work Tanks
80% capacity -avg
black in color
fixed roof
[illegible]Vs to atmosphere

cylinders [illegible])
rueping tanks
→ work tanks
↓
scrubber

3 cylinders → 1 tank → scrubber



2 Rueping tanks have pressure - negative
vented to work tanks

max. hrs of operation on vacuum pumps - all yr / 3 cylinders

▶ 4 diesel tanks 25,348 g
1 1,000 g tank in pine yard (across street)
2 inch vent to atmosphere
80% avg capacity
1 pump for boiler or vehicles

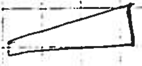
▶ wood dust
3,000 ties / 8 hr shift max.
sorter - open to atmosphere
sweep daily
15 ft conveyor belt length
getting cyclones on both
open top BFI container

(1) switchties
(1) cross ties

▶ Framing Mill
line 1 2½" dia x 1" deep 11 holes / tie 100,000 ties/yr
2 cutters 11/16" dia x 10" 6 holes / tie 400/day
17/tie

line 2 30% bored = 5,000 ties / yr 300 ties / day
12 variations 8 holes/ panel
of full length cuts 11/16" x 2 or
3/8" x 1¼
+ 2½" counter bore

line 3 100 ties/day
dap



bridge

bevelled on 2 lines 45°
1½ in from bottom then 45° cut up

2 end cuts / tie at least

→ 2-3 trailer loads / wk saw dust only max = 4
30 yard vans

cyclone - 95% efficient
all saws are blown to cyclone

sweep, vacuum daily
enclosed building
11 hydraulic oil pumps 30-40 gals

8-29-94 ③

▷ Road Dust
ChemLoc 103 Dust suffacant + H_2O applied daily
$CaCl_2$ applied once/yr.

een charges 3/day (3 cylinders) max
trend is to do more green
currently 50:50

59 ties/ trams
649 ties/cylinder 11 trams/cylinder

710,655 pieces
use cubic feet of pieces to estimate

10% switch ties

Additional sources
PRVs on cylinders → sump
2 hrs/cycle for green pump
1 3/4 hrs/cycle for dry pump
1 hr out of 24 hr on condensor
Vent on condensor → floor

Switch tie sorter
saw only
No grading bays

Prentice 210 on truck
conveyor belt to container

Switch tie cutbacks
cut rejects

no controls

Cross tie sorter
↓
incisor
↓
german stacker

vibrator, blocks to truck for community
conveyor belt to container

sump outside door to retort bldg next to cylinder doors

TOU COLUMBUS

① Aug 29

switch
framing / bridge
3rd in production
80 acres
160 - 270,000 ft^3 wood / yr
oak - 10-12 mo.s dry
Norfolk Southern
50/50 green : dry
7 days / wk
Birmingham Northern
1 yr appl CaCl2
H_2O appl. daily
25,000 / mo treat
10,000 / mo ship
250,000 max BT storage

Tony - PM
Chuck - ~~Assistant~~
Supv. Treating oper.
Keith - Maintanence
Super

retort 100' 22-25 ft^3/ charge

sorter for switch ties
sorter crossties

B&N across road storage yd incld in 80 acres

60-70,000 BT store today

rdwood changes color more quickly

2-4 hrs final vaccuum use initial air 60 lbs

notched pieces across road
small crossings - bt notched ties

4 / 8 ft section NS single timber crossings - bevelled

P1 - Pine highest grade
P2 - else less refined

Chuck - Reid Vapor Press
Miss St. University
Forest Product
Dr. Terry Ambergy
wood science
and products

vibrator across wire screen - conveyor to vibrator
suction system w/ cyclone
dust comes out back of saw ∴ collection point
1/4" ~ 5/16" 0.256"
sweep dust daily

204 7x9 in stack : 4 high

ties / tram

maintanence - 2 furnaces

parts cleaner - hot H_2O + caustic like drip pad can be put into WTS

TOUR- OLUMBUS

② Aug 29

10%. limestone
90%. washed river gravel

Endplaters : (1) before treatment
(1) after (squeezes all 4 sizes)

~~65~~ 85 employees
treating 7 days/wk
Framing
single timber crossing - line 1 hole
panels 2
bridge 3

dust collection system to cyclone in framing

WTS
POW (2)
chemical treatment
SSW (1) before aeration - new (1) after
aeration basins (3)
POTW
25-75,000 gals/day avg 35
15-20,000 groundwater recovery → POTW
→ once a week from bottom to WTS

2 work tanks → scrubber PRVs - containment
2 rueping tanks } replace w/2 additional work
2 pressure tanks }

sump in tank farm

4 tanks : (1) stormwater
(2) groundwater

8' ft dia x 100' long

rueping - dry wood process

pine - steam for 8-10 hrs instead of Boulton 2 charges/wk avg
cycle time basically same 104 charge/yr

surge tanks for treatment - make sure ~~tanks~~ cylinders are full
blowback 5,600 gals

laim sump at door

20,000 lb/hr boiler - gas

TOUR COLUMBUS

Aug
29

③

rueping - round (2)   next to retort bldg
cylinders - pressure (2)

don't have storage tanks - work tanks act as storage
work out of one of the work tanks

phenol - daily   colorimetric   48.8 lbs/day based on 30,000 g/day
pH - daily   ~6-10 ppm
other analyses sent to lab   ↑ permit phenol limit

groundwater recovery trench 800 ft

internal monitoring pt. - also NPDES   + 5 stormwater monitoring pts

BTS - Charles' idea
poles vs ties

grtr space bt poles allows a more efficient final vacuum ∴ maybe drier out of retort

8-29-94 ①

SUMPS -
2 work tank containment
1 Primary separator
Air receiver tanks
1 door
1 vacuum seal H_2O in retort bldg
2 new, where SOW - concrete being pored
1 storage across road, tanks for stormwater

1 SOW (for solids)
1 stormwater tank

FLANGES 84
VALVES 102

PUMPS #s will decrease due to new work tanks
3 pressure
1 fill
2 unloading
3 vacuum
11 water
20

min. of ~~2~~ seals/pump
assume ~~3~~ seals/pump
∴ ~~60~~ seals

SPACE HEATERS - (2) Maintanence
(2) Framing
(1) office CHA/gas

OIL PUMPS (2) unloader
at each Prentice - mobile and stationary
at each endplater (6)
capacity ____

PRVs vented back to work tanks - MS

2 gravity fed POWs
intake - sap tanks
rainwater from containment
seal water
groundwater going to back end
currently vented to atmosphere
piping in place, but not in use b/c permit mod

pumps - 3

SOW (1) before aeration basins
3 have biological treatment, vented to atmosphere; 0 pumps
1 for return of cell water
(1) new, bt POW and existing SOW
vented to atmosphere
1 pump

capacity on list

32,000 gals

surge gwater 1,000 g
holding gwater 78,000 g

1 surge tank - list

stormwater: 1 - big 78,000 g
1 - little 1,000 g pumps pick up here

5 stormwater monitoring pts.
outfalls 1, 2, 5, 9, 11

510 lbs creosote

APPENDIX 4

SUPPORT CALCULATIONS

JOB 940168/E 3

SHEET NO. 1 OF

CALCULATED BY STM DATE 2-20-95

CHECKED BY DATE

SCALE

AquAeTer

215 Jamestown Park, Suite 204
Brentwood, TN 37027
(615) 373-8532 FAX (615) 373-8512

KMCC - COLUMBUS

EMISSIONS CALCULATIONS

For emissions in terms of Naphthalene,

For every 77.4 lbs Naphthalene, there will also be
15.0 lbs Dibenzofuran
7.5 lbs Quinoline
0.1 lbs Biphenyl

▶ RETORT DOOR

As estimated in EPA tests at the Avoca, PA facility and measured by Mostardi-Platt at the Madison, IL site,

Average Naphthalene emissions = 0.180 lbs/hr

To account for the 15 minute limit that the door is open per charge,

$$\frac{0.180 \text{ lb Naph}}{1 \text{ hr}} * \frac{1 \text{ hr}}{60 \text{ mins}} * \frac{15 \text{ mins}}{\text{charge}} = 0.045 \text{ lbs/charge Naph}$$

Therefore,

$$\frac{77.4 \text{ lbs Naph}}{15.0 \text{ lbs Dbf}} = \frac{0.045 \text{ lbs Naph}}{x \text{ lbs Dbf}} \qquad x = \frac{(15.0 \text{ lbs Dbf})(0.045 \text{ lbs Naph})}{(77.4 \text{ lbs Naph})}$$

$$x = 0.0087 \text{ lbs/charge Dbf}$$

$$\frac{77.4 \text{ lbs Naph}}{7.5 \text{ lbs Quin}} = \frac{0.045 \text{ lbs Naph}}{x \text{ lbs Quin}} \qquad x = \frac{(7.5 \text{ lbs Quin})(0.045 \text{ lbs Naph})}{(77.4 \text{ lbs Naph})}$$

$$x = 0.0044 \text{ lbs/charge Quin}$$

$$\frac{77.4 \text{ lbs Naph}}{0.1 \text{ lbs Biph}} = \frac{0.045 \text{ lbs Naph}}{x \text{ lbs Biph}} \qquad x = \frac{(0.1 \text{ lbs Biph})(0.045 \text{ lbs Naph})}{(77.4 \text{ lbs Naph})}$$

$$x = 5.81 \times 10^{-5} \text{ lbs/charge Biph}$$

JOB 940165:3 B
SHEET NO. 2 OF
CALCULATED BY STM DATE 2-20-95
CHECKED BY DATE
SCALE

AquAeTer
215 Jamestown Park, Suite 204
Brentwood, TN 37027
(615) 373-8532 FAX (615) 373-8512

KMCC- COLUMBUS
EMISSIONS CALCULATIONS

D RETORT DOOR (continued)
summary,

Retort door losses	0.045	lbs/charge Naphthalene
	0.0087	lbs/charge Dibenzofuran
	0.0044	lbs/charge Quinoline
	5.81×10^{-5}	lbs/charge Biphenyl

Totals,
Retort door losses for 3 retort doors, 3 dry charges per day per retort

$\frac{0.045 \text{ lbs Naph}}{\text{charge}} * \frac{3 \text{ charges}}{\text{day}} * 3 \text{ retorts} = 0.405$ lbs/day Naph

$\frac{0.0087 \text{ lbs Dbf}}{\text{charge}} * \frac{3 \text{ charges}}{\text{day}} * 3 \text{ retorts} = 0.0783$ lbs/day Dbf

$\frac{0.0044 \text{ lbs Quin}}{\text{charge}} * \frac{3 \text{ charges}}{\text{day}} * 3 \text{ retorts} = 0.0396$ lbs/day Quin

$\frac{5.81 \times 10^{-5} \text{ lbs Biph}}{\text{charge}} * \frac{3 \text{ charges}}{\text{day}} * 3 \text{ retorts} = 0.0005$ lbs/day Biph

Short-term emissions in lbs/day,

0.405	lbs/day	Naphthalene
0.0783	lbs/day	Dibenzofuran
0.0396	lbs/day	Quinoline
0.0005	lbs/day	Biphenyl

JOB 940165/3

SHEET NO. 3 OF

CALCULATED BY STM DATE 2-20-95

CHECKED BY DATE

SCALE

KMCC - COLUMBUS
EMISSIONS CALCULATIONS

▶ RETORT DOOR (Continued)
Long-term emissions in tons/yr.

$$\frac{0.405\ \text{lbs Naph}}{\text{day}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{365\ \text{days}}{1\ \text{yr}} = 0.0739\ \text{tons/yr Naph}$$

$$\frac{0.0783\ \text{lbs Dbf}}{\text{day}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{365\ \text{days}}{1\ \text{yr}} = 0.0143\ \text{tons/yr Dbf}$$

$$\frac{0.0396\ \text{lbs Quin}}{\text{day}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{365\ \text{days}}{1\ \text{yr}} = 0.0072\ \text{tons/yr Quin}$$

$$\frac{0.0005\ \text{lbs Biph}}{\text{day}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{365\ \text{days}}{1\ \text{yr}} = 9.1 \times 10^{-5}\ \text{tons/yr Biph}$$

As measured in EPA tests of the Avoca, PA facility
Average Creosote emissions = 5.917 lbs/hr
Creosote emissions are considered as VOCs
Therefore

$$\frac{5.917\ \text{lbs Creo}}{\text{hr}} * \frac{1\ \text{hr}}{60\ \text{mins}} * \frac{15\ \text{mins}}{\text{charge}} = 1.4793\ \text{lbs/charge Creosote or VOCs}$$

Short-term emissions.

$$\frac{1.4793\ \text{lbs Creo}}{\text{charge}} * \frac{3\ \text{charges}}{\text{day}} * 3\ \text{retorts} = 13.3137\ \text{lbs/day Creosote or VOCs}$$

Long-term emissions.

$$\frac{13.3137\ \text{lbs Creo}}{\text{day}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{365\ \text{days}}{1\ \text{yr}} = 2.4298\ \text{tons/yr Creosote or VOCs}$$

Pumps

0.0186 lbs/hr N = 0.4464 lbs/day N = 0.0815 tpy

$\frac{77.4\ N}{15.0\ Dbf} = \frac{0.4464\ N}{x\ Dbf}$ x = 0.0865 lbs/day Dbf or 0.0158 tpy

$\frac{77.4\ N}{7.5\ Q} = \frac{0.4464\ N}{x\ Q}$ x = 0.0433 lbs/day Q or 0.0079 tpy

$\frac{77.4\ N}{0.1\ B} = \frac{0.4464\ N}{x\ B}$ x = 0.0006 lbs/day B or 0.0001 tpy

$\frac{0.4464\ N}{0.42}$ = 1.0629 lbs/day VOCs or 0.1940 tpy

25% – E/M
45% – VS
25% – SC

Retorts – V

0.0030 lbs/hr N = 0.072 lbs/day N or 0.0131 tpy

$\frac{77.4\ N}{15.0\ Dbf} = \frac{0.072\ N}{x\ Dbf}$ $x = 0.0140$ lbs/day Dbf or 0.0026 tpy

$\frac{(15.0)(0.072)}{(77.4)}$

$\frac{77.4\ N}{7.5\ Q} = \frac{0.072\ N}{x\ Q}$ $x = 0.0070$ lbs/day Quin or 0.0013 tpy

$\frac{77.4\ N}{0.1\ B} = \frac{0.072\ N}{x\ B}$ $x = 9.3 \times 10^{-5}$ lbs/day Biphenyle or 1.7×10^{-5} tpy

$\frac{0.072}{0.42} = 0.1714$ lbs/day VOC or 0.0313 tpy

JOB 940163/3 B
SHEET NO. 1 OF
CALCULATED BY STM DATE 2-26-95
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KMCC- COLUMBUS
EMISSION CALCULATIONS

▷ WORK TANK NO. 1
Assumptions,
1. Work tanks are closed.
2. Work tanks are equipped with PVRVs.
3. Breathing losses are from atmospheric, natural air temperature changes and barometric pressure changes.
4. Working losses are from tank filling and emptying.
5. Overpressurization is not accounted for; Reuping losses are calculated separately.
6. The USEPA Tanks 2.0 Program is used for confirmation.
7. AP42 calculation procedures for breathing losses and working losses are from section 4.3 Storage of organic Liquids (USEPA, September, 1985)
8. Avoca- and Susquehanna data are used to confirm AP42 calculations.
9. Tank temperatures are 180°F or 82.2°C

JOB 940168/3 B

SHEET NO. 2 OF

CALCULATED BY STM DATE 2-26-95

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KMCC-COLUMBUS
EMISSIONS CALCULATIONS

▷ WORKTANK NO. 1 (continued)

There are two significant types of emissions from fixed roof tanks, breathing and working loss.

Breathing Loss, L_B

$$L_B = (2.26 \times 10^{-2})(M_V)\left(\frac{P}{P_A - P}\right)^{0.68}(D)^{1.73}(H)^{0.51}(\Delta T)^{0.50}(F_P)(C)(K_C)$$

where,

L_B = fixed roof breathing loss (lb/yr)

M_V = molecular weight of vapor in work tank (lb/lb mole)

$$M_V = M_a\left(\frac{P_a x_a}{P_t}\right) + M_b\left(\frac{P_b x_b}{P_t}\right)$$

M_a = molecular weight of pure component (lb/lb mole)

P_a = vapor pressure of pure component (psia)

x_a = mole fraction of component in the liquid (psia)

$P_t = P_a x_a + P_b x_b$ by Raoult's Law (psia)

P_A = average atmospheric pressure at tank location (psia)

P = true vapor pressure at bulk liquid conditions (psia)

D = tank diameter (ft)

H = average vapor space height (ft)

ΔT = average ambient diurnal temperature change (°F)

F_p = paint factor (dimensionless)

C = adjustment factor for small diameter tanks (dimensionless)

K_C = product factor (dimensionless)

Therefore, for Naphthalene

$$M_V = M_a\left(\frac{P_a x_a}{P_t}\right)$$

M_a = 128 lb/lb mole

P_a = 0.141 psia from GERG; refer to Appendix 5

x_a = 0.157 from GERG; refer to Appendix 5

P_t = 0.068 psia from Allied Signal; refer to Appendix 5

JOB 94068/3 B

SHEET NO. 3 OF

CALCULATED BY STM DATE 2-26-95

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SCALE

KMCC - COLUMBUS
EMISSIONS CALCULATIONS

▶ WORK TANK NO. 1 (continued)

$M_V = 128\ \text{lb/lb mole}\left(\frac{0.141\ \text{psia} * 0.157}{0.068\ \text{psia}}\right) = 41.6696\ \text{lb/lb mole}$

P_A = 14.09 psia; from NOAA Tupelo, MS; refer to Appendix 9

P = 0.068 psia from Allied Signal; refer to Appendix 5

D = 18.0 ft from KMCC-Columbus

H = 3.0 ft from KMCC-Columbus

ΔT = 23.10 °F from NOAA Tupelo, MS; refer to Appendix 9

F_P = 1.58 from AP42 Table 4.3-1

C = 1.00 from AP42 Table 4.3-4

K_C = 0.10 as per AWPI

$$L_B = (2.26 \times 10^{-2})(41.67\ \text{lb/lb mole})\left(\frac{0.068\ \text{psia}}{14.09\ \text{psia} - 0.068\ \text{psia}}\right)^{0.68}(18\ \text{ft})^{1.73}(3\ \text{ft})^{0.51}$$

$$(23.10\ °\text{F})^{0.50}(1.58)(1.00)(0.10)$$

$$= (2.26 \times 10^{-2})(41.67)(0.0267)(148.4641)(1.7512)(4.8062)(1.58)(1.00)(0.10)$$

= 4.9643 lbs/yr Naphthalene

JOB 940168/3 B

SHEET NO. 4 OF

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KMCC- COLUMBUS
EMISSION CALCULATIONS

WORK TANK 110.1 (continued)

Working Loss, L_W

$$L_W = (2.40 \times 10^{-5})(M_V)(P)(V)(N)(K_N)(K_C)$$

where,

L_W = fixed roof working loss (lb/yr)

M_V = molecular weight of vapor in storage tank (lb/lbmole)
see L_B for determination

P = true vapor pressure at bulk liquid temperature (psia)

V = tank capacity (gal)

N = number of turnovers per year

$$N = \frac{\text{total throughput per year (gal)}}{\text{tank capacity, V (gal)}}$$

K_N = turnover factor (dimensionless)

K_C = product factor (dimensionless)

Therefore, for Naphthalene

M_V = 41.6696 lb/lb mole

P = 0.068 psia from Allied Signal; refer to Appendix 5

V = 57,000 gal from KMCC - Columbus

$$N = \frac{\text{amount of creosote purchased + pumpback volume (gal)}}{\text{total tank capacity (gal)}}$$

$$= \frac{(1.5 \times 10^{6}\ \text{gal/yr}) + (17{,}443\ \text{gal/pb} * 3\ \text{retorts} * 1\ \text{Boulton/retort/day} * 2\ \text{pb/Boulton} * 365\ \text{days/yr}}{(57{,}000\ \text{gal} * 1\ \text{tank}) + (78{,}000\ \text{gal} + 1\ \text{tank})}$$

$$= \frac{39{,}700{,}170\ \text{gals/yr}}{135{,}000\ \text{gals}} = 294.0753\ \text{turnovers/yr}$$

Note: 1,500 pumpbacks per year are entered into the AP42 spreadsheet. This maximum number of pumpbacks results in 399 turnovers per year.

JOB 940168/3 B
SHEET NO. 5 OF
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KMCC - COLUMBUS
EMISSION CALCULATIONS

▶ WORK TANK NO. 1 (continued)

Note: Turnovers are calculated as the sum of the volume of creosote purchased (1993 SARA) and pumpback volumes derived from the number of Boulton charges and cylinder void volumes. Further, this number is calculated as an average number of turnovers per tank.

K_N = 0.24 from AP42 Figure 4.3-7
K_C = 0.10 as per AWPI

$L_W = (2.40\times10^{-5})$(41.66 lb/lbmole)(0.068 psia)(57,000 gal)(399)(0.24)(0.10)

= 37.1106 lbs/yr Naphthalene

JOB 940168/3
SHEET NO. 6 OF
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KMCC- COLUMBUS
EMISSIONS CALCULATIONS

WORK TANK NO. 1 (continued)

For an AP42 derived working loss, Lw = 37.11 lbs/yr Naphthalene there will also be

$$\frac{77.4 \text{ lbs/yr N}}{15.0 \text{ lbs/yr Dbf}} = \frac{37.11 \text{ lbs/yr N}}{x \text{ lbs/yr Dbf}} \qquad x = \frac{(15.0 \text{ lbs/yr Dbf})(37.11 \text{ lbs/yr N})}{(77.4 \text{ lbs/yr N})}$$

$x = 7.1919$ lbs/yr Dibenzofuran

$$\frac{77.4 \text{ lbs/yr N}}{7.5 \text{ lbs/yr Q}} = \frac{37.11 \text{ lbs/yr N}}{x \text{ lbs/yr Q}} \qquad x = \frac{(7.5 \text{ lbs/yr Q})(37.11 \text{ lbs/yr N})}{(77.4 \text{ lbs/yr N})}$$

$x = 3.5959$ lbs/yr Quinoline

$$\frac{77.4 \text{ lbs/yr N}}{0.1 \text{ lbs/yr B}} = \frac{37.11 \text{ lbs/yr N}}{x \text{ lbs/yr B}} \qquad x = \frac{(0.1 \text{ lbs/yr B})(37.11 \text{ lbs/yr N})}{(77.4 \text{ lbs/yr N})}$$

$x = 0.0479$ lbs/yr Biphenyl

Summary of HAP Lw,

37.11 lbs/yr Naphthalene
7.19 lbs/yr Dibenzofuran
3.60 lbs/yr Quinoline
0.05 lbs/yr Biphenyl

Totals,

4.96 lbs/yr N L_B + 37.11 lbs/yr N Lw = 42.07 lbs/yr Naphthalene
0.9612 lbs/yr Dbf L_B + 7.19 lbs/yr Dbf Lw = 8.15 lbs/yr Dibenzofuran
0.4802 lbs/yr Q L_B + 3.60 lbs/yr Q Lw = 4.08 lbs/yr Quinoline
0.0062 lbs/yr B L_B + 0.05 lbs/yr B Lw = 0.06 lbs/yr Biphenyl

JOB 940168/3

SHEET NO. 7 OF

CALCULATED BY STM DATE 3-19-95

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SCALE

KMCC- COLLUMBUS
EMISSIONS CALCULATIONS

▶ WORK TANK NO. 1 (continued)

Short-term emissions in lbs/day,

42.07 lbs/yr N * 1 yr/365 days = 0.1153 lbs/day Naphthalene
8.15 lbs/yr Dbf * 1 yr/365 days = 0.0223 lbs/day Dibenzofuran
4.08 lbs/yr Q * 1 yr/365 days = 0.0112 lbs/day Quinoline
0.06 lbs/yr B * 1 yr/365 days = 0.0002 lbs/day Biphenyl

Long-term emissions in tons/yr,

42.07 lbs/yr N * 1 ton/2,000 lbs = 0.0210 tons/yr Naphthalene
8.15 lbs/yr Dbf * 1 ton/2,000 lbs = 0.0041 tons/yr Dibenzofuran
4.08 lbs/yr Q * 1 ton/2,000 lbs = 0.0020 tons/yr Quinoline
0.06 lbs/yr B * 1 ton/2,000 lbs = 3.0×10^{-5} tons/yr Biphenyl

Naphthalene emissions are equivalent to 42 percent of creosote or VOC emissions as determined by GERG analytical data. Creosote emissions are equivalent to total VOC emissions.

Therefore, short-term creosote emissions in lbs/day

$$\frac{0.1153 \text{ lbs/day N}}{0.42} = 0.2745 \text{ lbs/day creosote or VOCs}$$

Long-term creosote emissions in tons/yr,

$$\frac{0.0210 \text{ tons/yr N}}{0.42} = 0.05 \text{ tons/yr creosote or VOCs}$$

JOB KMCC 940168-3
SHEET NO. 1 OF
CALCULATED BY MRL DATE 3/7/95
CHECKED BY STM DATE 3-8-95
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A factor of 0.10 has been used to adjust AP-42 & SOCMI emission factors for volatile constituents to a representative emission factor for relatively non volatile creosote.

Creosote falls out of the pressure definition for NSPS because of its low volatility (see attached sheet)

In early discussions with the U.S. EPA on air emissions from creosote wood treating operations, Mr Jeffrey Bull of KMCC postulated that this factor should be 10% or 0.10. This factor has since been incorporated into the AWPI's SARA emissions cookbook and is widely referred to in the industry as the "Bull" factor.

The basis for the "Bull" factor of 0.10 for low volatile creosote can be assessed by comparing the vapor pressure of a high volatile constituent such as benzene with the most volatile component of creosote, which is, naphthalene.

vapor pressure @ 180°F of benzene = 760 mm Hg
of naphthalene = 7.29 mm Hg

$\therefore$ 7.29 / 760 = 0.0096 = 1%

for NSPS considerations for low volatility creosote vapor pres = 0.467 kPa
NSPS volatile cutoff VP = 3.5 kPa

0.467/3.5 kPa = 0.133 = 13.3%

Note: 3.5 kPa @ standard temperature

Use 0.10 as factor to correct for low-volatile creosote

COLUMBUS

Work Tank No. 1 Nephthelene Emissions

Breathing Loss, Lb, Emissions	**Unit**	**Symbol**
1. Molecular Weight of Vapor	41.66 lb/lb mole	Mv
2. Average Atmospheric Pressure	14.09 psia	Pa
3. True Vapor Pressure at Bulk Liquid Conditions	0.07 psia	P
4. Tank Diameter	18.00 ft	D
5. Average Vapor Space Height	3.00 ft	H
6. Average Ambient Diurnal Temperature Change	23.10 oF	T
7. Paint Factor	1.58 NA	Fp
8. Adjustment Factor for Small Tanks	1.00 NA	C
9. Product Factor	0.10 NA	Kc

Lb (lb/yr) = (2.26x10^-2) x (Mv) x ((P/Pa-P)^0.68) x (D^1.73) x (H^0.51) x (T^0.50) x Fp x C x Kc

Therefore, the Lb = 4.96 lb/yr
0.0025 ton/yr

Working Loss, Lw, Emissions	**Unit**	**Symbol**
1. Molecular Weight of Vapor	41.66 lb/lb mole	Mv
2. True Vapor Pressure at Bulk Liquid Conditions	0.07 psia	P
3. Tank Capacity	57,000.00 gal	V
4. Number of Turnovers per Year	399.47 NA	N
5. Turnover Factor	0.24 NA	Kn
6. Product Factor	0.10 NA	Kc

Lw (lb/yr) = (2.40x10^-5) x Mv x P x V x N x Kn x Kc

Therefore, the Lw = 37.15 lb/yr
0.0186 ton/yr

Molecular Weight of Vapor Determination	**Unit**	**Symbol**
1. Molecular Weight of Pure Component	128 lb/lb mole	Ma
2. Vapor Pressure of Pure Component	0.1410 psia	Pa
3. Mole Fraction of Pure Component	0.157	Xa
4. Vapor Pressure of Bulk Liquid	0.068 psia	Pt

Mv (lb/lb mole) = Ma(PaXa)/Pt + Mb(PbXb)/Pt

Therefore the Mv for Naphthalene = 41.665 lb/lb mole

Process Equipment Data for Turn Over Calculations		
Cylinder Length	100	
Diameter	8	
Cylinder Volume	5,024.00	
Volume per tie (ft3)	3.72	i
No. Ties/tram	59	ii
No. Trams/charge	11	iii
Wood Volume (ft3)/Charge	2,414.28	Ap = iii*ii*i
Cylinder Void Volume (ft3)/Charge	2,609.72	Bp
Gals. Creosote to Cylinder/Charge based on cylinder void	19,523.32	Cp = Bp*7.481
Lbs Creosote/ft3 of Wood	8.00	Dp
Lbs Creosote Retained in Wood	19,314.24	Ep = Dp*Ap
Gals. Creosote Retained in Wood (@ d = 9.3 lbs/gal)	2,080.55	Fp = Ep/9.3lbs/gal
Gals. of Creosote Pumped Back to Work Tank	17,442.77	Gp = Cp-Fp
Average No. of Cycles	1,105	Hp
Maximum No. of Cycles	1,500	Ip

Number of Turnovers		
Annual Purchases of Creosote	1,600,000	a
Maximum No. of Cycles; Assume all Boulton	1,500	Ip
No. of Pump Backs per Cycle	2	b
No. of Total Annual Pump Backs	3,000	c = b*Ip
Gals. of Creosote Pumped Back per Cycle	17,442.77	Gp
Annual Gals. Creosote Pumped Back	52,328,306.98	d = Gp*c
Total Annual Gals Creosote Throughput	53,928,306.98	e = a+d
Total Work Tank Capacity	135,000	
Annual Tank Turnovers	399.47	

Tank Capacities (gal)	
Tank 1	57,000
Tank 2	78,000
Total Tank Capacity	135,000

Assumptions
1. Cylinders and tanks are interconnected as a closed loop vapor recovery system.
2. The calculation of a turnover factor for working losses considers the volume of creosote recycled as pumpbacks.
   Additionally, the total throughput per year for a work tank considers the volume of creosote recycled as pumpbacks.
3. Evaporative emissions as loading losses are incorporated into the breathing and working losses for large storate tanks.
   (Section 4.4, Transportation and Marketing of Petroleum Liquids, refers to Section 4.3, Storage of Organic Liquids, for large storage tanks.)

References
1. AP-42 4.3
2. GERG
3. Allied Signal

COLUMBUS

Work Tank No. 1 HAP and VOC Emissions

For emissions in terms of naphthalene, there are	15.0 lbs Dibenzofuran 7.5 lbs Quinoline 0.1 lbs Biphenyl
for every	77.4 lbs Naphthalene

Therefore, for AP-42 derived Naphthalene breathing losses of 4.96 lbs/yr

$$\text{Dibenzofuran losses} = \frac{\text{(15 lbs of Dibenzofuran x 4.96 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.96 \text{ lbs/yr}$$

$$\text{Quinoline losses} = \frac{\text{(7.5 lbs of Quinoline x 4.96 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.48 \text{ lbs/yr}$$

$$\text{Biphenyl losses} = \frac{\text{(0.1 lbs of Biphenyl x 4.96 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.01 \text{ lbs/yr}$$

Summary,

Total losses	Naphthalene	42.11 lbs/yr
	Dibenzofuran	8.16 lbs/yr
	Quinoline	4.08 lbs/yr
	Biphenyl	0.05 lbs/yr
	HAPS	54.41 lbs/yr
Short-term emissions	Naphthalene	0.12 lbs/day
	Dibenzofuran	0.02 lbs/day
	Quinoline	0.01 lbs/day
	Biphenyl	0.0001 lbs/day
	HAPS	0.15 lbs/day
Long-term emissions	Naphthalene	0.02 tons/yr
	Dibenzofuran	0.00 tons/yr
	Quinoline	0.00 tons/yr
	Biphenyl	0.0000 tons/yr
	HAPS	0.03 tons/yr

Therefore, for AP-42 derived Naphthalene working losses of 37.15 lbs/yr

$$\text{Dibenzofuran losses} = \frac{\text{(15 lbs of Dibenzofuran x 37.15 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 7.20 \text{ lbs/yr}$$

$$\text{Quinoline losses} = \frac{\text{(7.5 lbs of Quinoline x 37.15 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 3.60 \text{ lbs/yr}$$

$$\text{Biphenyl losses} = \frac{\text{(0.1 lbs of Biphenyl x 37.15 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.05 \text{ lbs/yr}$$

Naphthalene emissions are equivalent to 42 percent of creosote emissions as determined by the EPA tests at the Avoca, PA facility. Creosote emissions are considered as VOCs.

Therefore,

$$\text{Short-term creosote/VOC emissions} = \frac{\text{0.0687 lbs/day Naphthalene}}{0.42}$$

$$= 0.27 \text{ lbs/day creosote/VOCs}$$

$$\text{Long-term creosote/VOC emissions} = \frac{\text{0.0125 tons/yr Naphthalene}}{0.42}$$

$$= 0.05 \text{ tons/yr creosote/VOCs}$$

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COLUMBUS

Work Tank No. 1 Naphthalene Emissions

Process Unit Data

No. of Cylinders	1
No. of rueping cycles per cylinder	2
No. of total annual rueping cycles	308
Cylinder length (ft)	100
Diameter (ft)	8
Wood Charge Volume (ft^3)	5,036.48
Cylinder Volume (ft^3)	2,414.28
Cylinder Void Volume (ft^3)	2,622.20
Cylinder Void Volume (liters)	74,260.70 V
Operating Temperature K	355.37 K
Venting Temperature K'	293.15 K'
Operating Pressure P (atm)	5.00 P
Venting Pressure P' (atm)	1.00 P'
Rueping Air (Venting) Volume	V'

PV=nRT
PV/T = nR
P'V'/T' = nR

V' = (PV/T)(T'/P')	306,293.80 liters
Rueping (venting) Air	10,818.30 ft^3

Air is 8% Naphthalene	
MW Naphthalene (g/mole)	128.00
density of air g/mole	28.96
density of 8% Naphthalene Air (g/mole)	36.88
density of Naphthalene (lb/ft^3)	0.0001

Naphthalene Rueping Air Emissions	1.11 lb/cycle
	342.76 lb/yr
	0.17 ton/yr

Summary,

Total losses	Naphthalene	342.76 lbs/yr
	Dibenzofuran	66.43 lbs/yr
	Quinoline	33.21 lbs/yr
	Biphenyl	0.44 lbs/yr
	HAPs	442.85 lbs/yr
Short-term emissions	Naphthalene	0.0391 lbs/hr
	Dibenzofuran	0.0076 lbs/hr
	Quinoline	0.0038 lbs/hr
	Biphenyl	0.0001 lbs/hr
	HAPs	0.0506 lbs/hr
Long-term emissions	Naphthalene	0.1714 tons/yr
	Dibenzofuran	0.0332 tons/yr
	Quinoline	0.0166 tons/yr
	Biphenyl	0.0002 tons/yr
	HAPs	0.2214 tons/yr

HAP Emissions

For emissions in terms of Naphthalene, there are 15.0 lbs Dibenzofuran
7.5 lbs Quinoline
0.1 lbs Biphenyl

for every 77.4 lbs Naphthalene

Therefore, for Naphthalene Rueping losses of 342.76 lbs/yr

Dibenzofuran losses = (15 lbs Dibenzofuran x 185.83 lbs/yr Naphthalene) / (77.4 lbs Naphthalene)

= 66.43 lbs/yr

Quinoline losses = (7.5 lbs Quinoline x 185.83 lbs/yr Naphthalene) / (77.4 lbs Naphthalene)

= 33.21 lbs/yr

Biphenyl losses = (0.1 lbs Quinoline x 185.83 lbs/yr Naphthalene) / (77.4 lbs Naphthalene)

= 0.44 lbs/yr

Naphthalene emissions are equivalent to 42 percent of creosote emissions as determined by analytical measurements. Creosote emissions are considered as VOCs.

Therefore,
Short-term creosote/VOC emissions = 0.02 lbs/hr Naphthalene / 0.42

= 0.09 lbs/hr creosote/VOCs

Long-term cresoste/VOC emissions = 0.09 tons/yr Naphthalene / 0.42

= 0.41 tons/yr creosote/VOCs

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COLUMBUS

Work Tank No. 2 Nephthelene Emissions

Breathing Loss, Lb, Emissions		Unit	Symbol
1.	Molecular Weight of Vapor	41.66 lb/lb mole	Mv
2.	Average Atmospheric Pressure	14.09 psia	Pa
3.	True Vapor Pressure at Bulk Liquid Conditions	0.07 psia	P
4.	Tank Diameter	22.00 ft	D
5.	Average Vapor Space Height	3.00 ft	H
6.	Average Ambient Diurnal Temperature Change	23.10 oF	T
7.	Paint Factor	1.58 NA	Fp
8.	Adjustment Factor for Small Tanks	1.00 NA	C
9.	Product Factor	0.10 NA	Ko

Lb (lb/yr) = (2.26x10^-2) x (Mv) x ((P/Pa-P)^0.68) x (D^1.73) x (H^0.51) x (T^0.50) x Fp x C x Kc

Therefore, the Lb for 1 Work Tank = 7.02 lb/yr
0.0035 ton/yr

Working Loss, Lw, Emissions		Unit	Symbol
1.	Molecular Weight of Vapor	41.66 lb/lb mole	Mv
2.	True Vapor Pressure at Bulk Liquid Conditions	0.07 psia	P
3.	Tank Capacity	78,000.00 gal	V
4.	Number of Turnovers per Year	399.47 NA	N
5.	Turnover Factor	0.24 NA	Kn
6.	Product Factor	0.10 NA	Kc

Lw (lb/yr) = (2.40x10^-5) x Mv x P x V x N x Kn x Kc

Therefore, the Lw for 1 Work Tank = 50.84 lb/yr
0.0254 ton/yr

Molecular Weight of Vapor Determination		Unit	Symbol
1.	Molecular Weight of Pure Component	128 lb/lb mole	Ma
2.	Vapor Pressure of Pure Component	0.1410 psia	Pa
3.	Mole Fraction of Pure Component	0.157	Xa
4.	Vapor Pressure of Bulk Liquid	0.068 psia	Pt

Mv (lb/lb mole) = Ma(PaXa)/Pt + Mb(PbXb)/Pt

Therefore the Mv for Naphthalene = 41.655 lb/lb mole

Process Equipment Data for Turn Over Calculations		
Cylinder Length	100	
Diameter	8	
Cylinder Volume	5,024.00	
Volume per tie (ft3)	3.72	i
No. Ties/tram	59	ii
No. Trams/charge	11	iii
Wood Volume (ft3)/Charge	2,414.28	Ap = iii*ii*i
Cylinder Void Volume (ft3)/Charge	2,609.72	Bp
Gals. Creosote to Cylinder/Charge based on cylinder void	19,523.32	Cp = Bp*7.481
Lbs Creosote/ft3 of Wood	8.00	Dp
Lbs Creosote Retained in Wood	19,314.24	Ep = Dp*Ap
Gals. Creosote Retained in Wood (@ d = 9.3 lbs/gal)	2,080.55	Fp = Ep/9.3lbs/gal
Gals. of Creosote Pumped Back to Work Tank	17,442.77	Gp = Cp-Fp
Average No. of Cycles	1,105	Hp
Maximum No. of Cycles	1,500	Ip

Number of Turnovers		
Annual Purchases of Creosote	1,600,000	a
Maximum No. of Cycles; Assume all Boulton	1,500	Ip
No. of Pump Backs per Cycle	2	b
No. of Total Annual Pump Backs	3,000	c = b*Ip
Gals. of Creosote Pumped Back per Cycle	17,442.77	Gp
Annual Gals. Creosote Pumped Back	52,328,306.98	d = Gp*c
Total Annual Gals Creosote Throughput	53,928,306.98	e = a+d
Total Work Tank Capacity	135,000	
Annual Tank Turnovers	399.47	

Tank Capacities (gal)	
Tanks 1	57,000
Tank 2	78,000
Total Tank Capacity	135,000

Assumptions

1. Cylinders and tanks are interconnected as a closed loop vapor recovery system.
2. The calculation of a turnover factor for working losses considers the volume of creosote recycled as pumpbacks.
   Additionally, the total throughput per year for a work tank considers the volume of creosote recycled as pumpbacks.
3. Evaporative emissions as loading losses are incorporated into the breathing and working losses for large storate tanks.
   (Section 4.4, Transportation and Marketing of Petroleum Liquids, refers to Section 4.3, Storage of Organic Liquids, for large storage tanks.)

References

1. AP-42 4.3
2. GERG
3. Allied Signal

F:\DATA\0168\COLUMBUS\EXWT2_N.WK3
16-Mar-95
12:48 PM

COLUMBUS

Work Tank No. 2 HAP and VOC Emissions

For emissions in terms of naphthalene, there are	15.0 lbs Dibenzofuran 7.5 lbs Quinoline 0.1 lbs Biphenyl
for every	77.4 lbs Naphthalene

Therefore, for AP-42 derived Naphthalene breathing losses of 7.02 lbs/yr

$$\text{Dibenzofuran losses} = \frac{\text{(15 lbs of Dibenzofuran} \times \text{7.02 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 1.36 \text{ lbs/yr}$$

$$\text{Quinoline losses} = \frac{\text{(7.5 lbs of Quinoline} \times \text{7.02 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.68 \text{ lbs/yr}$$

$$\text{Biphenyl losses} = \frac{\text{(0.1 lbs of Biphenyl} \times \text{7.02 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.01 \text{ lbs/yr}$$

Therefore, for AP-42 derived Naphthalene working losses of 50.84 lbs/yr

$$\text{Dibenzofuran losses} = \frac{\text{(15 lbs of Dibenzofuran} \times \text{50.84 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 9.85 \text{ lbs/yr}$$

$$\text{Quinoline losses} = \frac{\text{(7.5 lbs of Quinoline} \times \text{50.84 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 4.93 \text{ lbs/yr}$$

$$\text{Biphenyl losses} = \frac{\text{(0.1 lbs of Biphenyl} \times \text{50.84 lbs/yr Naphthalene)}}{\text{(77.4 lbs Naphthalene)}}$$

$$= 0.07 \text{ lbs/yr}$$

Summary,

Total losses	Naphthalene	57.86 lbs/yr
	Dibenzofuran	11.21 lbs/yr
	Quinoline	5.61 lbs/yr
	Biphenyl	0.07 lbs/yr
	HAPS	74.75 lbs/yr
Short-term emissions	Naphthalene	0.16 lbs/day
	Dibenzofuran	0.03 lbs/day
	Quinoline	0.02 lbs/day
	Biphenyl	0.0002 lbs/day
	HAPS	0.20 lbs/day
Long-term emissions	Naphthalene	0.03 tons/yr
	Dibenzofuran	0.01 tons/yr
	Quinoline	0.00 tons/yr
	Biphenyl	0.0000 tons/yr
	HAPS	0.04 tons/yr

Naphthalene emissions are equivalent to 42 percent of creosote emissions as determined by the EPA tests at the Avoca, PA facility. Creosote emissions are considered as VOCs.

Therefore,

$$\text{Short-term creosote/VOC emissions} = \frac{\text{0.0946 lbs/day Naphthalene}}{0.42}$$

$$= 0.38 \text{ lbs/day creosote/VOCs}$$

$$\text{Long-term creosote/VOC emissions} = \frac{\text{0.0173 tons/yr Naphthalene}}{0.42}$$

$$= 0.07 \text{ tons/yr creosote/VOCs}$$

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16-Mar-95
12:48 PM

COLUMBUS

Work Tank No. 2 Naphthalene Emissions

Process Unit Data

No. of Cylinders	1
No. of rueping cycles per cylinder	2
No. of total annual rueping cycles	422
Cylinder length (ft)	100
Diameter (ft)	8
Wood Charge Volume (ft^3)	5,036.48
Cylinder Volume (ft^3)	2,414.28
Cylinder Void Volume (ft^3)	2,622.20
Cylinder Void Volume (liters)	74,260.70 V
Operating Temperature K	355.37 K
Venting Temperature K'	293.15 K'
Operating Pressure P (atm)	5.00 P
Venting Pressure P' (atm)	1.00 P'
Rueping Air (Venting) Volume	V'
PV=nRT	
PV/T = nR	
P'V'/T' = nR	
V' = (PV/T)(T'/P')	306,293.80 liters
Rueping (venting) Air	10,818.30 ft^3

Air is 8% Naphthalene	
MW Naphthalene (g/mole)	128.00
density of air g/mole	28.96
density of 8% Naphthalene Air (g/mole)	36.88
density of Naphthalene (lb/ft^3)	0.0001

Naphthalene Rueping Air Emissions	1.11 lb/cycle 469.09 lb/yr 0.23 ton/yr

Summary,

Total losses	Naphthalene	469.09 lbs/yr
	Dibenzofuran	90.91 lbs/yr
	Quinoline	45.45 lbs/yr
	Biphenyl	0.61 lbs/yr
	HAPs	606.05 lbs/yr
Short-term emissions	Naphthalene	0.0535 lbs/hr
	Dibenzofuran	0.0104 lbs/hr
	Quinoline	0.0052 lbs/hr
	Biphenyl	0.0001 lbs/hr
	HAPs	0.0692 lbs/hr
Long-term emissions	Naphthalene	0.2345 tons/yr
	Dibenzofuran	0.0455 tons/yr
	Quinoline	0.0227 tons/yr
	Biphenyl	0.0003 tons/yr
	HAPs	0.3030 tons/yr

HAP Emissions

For emissions in terms of Naphthalene, there are 15.0 lbs Dibenzofuran
7.5 lbs Quinoline
0.1 lbs Biphenyl
for every 77.4 lbs Naphthalene

Therefore, for Naphthalene Rueping losses of 469.09 lbs/yr

Dibenzofuran losses = <u>(15 lbs Dibenzofuran x 254.35 lbs/yr Naphthalene)</u>
(77.4 lbs Naphthalene)

= 90.91 lbs/yr

Quinoline losses = <u>(7.5 lbs Quinoline x 254.35 lbs/yr Naphthalene)</u>
(77.4 lbs Naphthalene)

= 45.45 lbs/yr

Biphenyl losses = <u>(0.1 lbs Quinoline x 254.35 lbs/yr Naphthalene)</u>
(77.4 lbs Naphthalene)

= 0.61 lbs/yr

Naphthalene emissions are equivalent to 42 percent of creosote emissions as determined by analytical measurements. Creosote emissions are considered as VOCs.

Therefore,
Short-term creosote/VOC emissions = <u>0.03 lbs/hr Naphthalene</u>
0.42

= 0.13 lbs/hr creosote/VOCs

Long-term creosote/VOC emissions = <u>0.13 tons/yr Naphthalene</u>
0.42

= 0.56 tons/yr creosote/VOCs

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15-Mar-95
04:34 PM

PLANT: Columbus
PROCESS UNIT: Framing Mill (Crossings, Panels, Bridge)
EMISSION: Maximum Particulates: PM, PM-10

Wood Waste Emission Factor

The variety of cuts, all to customer specifications, made at each of the three saw mills, precludes any wood waste estimates based on saw cuts. Therefore, wood waste will be quantified by the number of 30 yard containers filled and removed weekly.

	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	6	8	8.5
2. Weight of tie (lb)	175		
3. Cubic feet of tie (ft3)	2.83		
4. Pound per cubic foot (lb/ft3)	61.76		
5. Weight of cubic foot of sawdust (lb/ft3)	31.185		
6. Weight of cubic yard of sawdust (lb/yd3)	842.00		

Maximum Emissions

based on what? # shifts, # hrs, need supporting plant data.

		Unit		
Number of units	1			
Maximum number of 30-CuYd bins filled	4	bins/week		
	208	bins/yr		
Maximum volume of wood waste produced	5,254,049	lb/yr		14394.65 lb/day
	2,627.02	ton/yr		
Maximum pounds of wood waste/container	25,259.85	lbs/bin	=	90% of wood waste Collected By Cyclone
Maximum pounds of PM/container	2,525.99	lbs/bin		PM is assumed to be 10 percent of wood w
Maximum pounds of PM-10/container	1,262.99	lbs/bin		PM-10 is assumed to be 50 percent of PM
Fugitive PM loss from Container	25.26	lbs/bin		1 percent emission rate from AP-42
Fugitive PM-10 loss from Container	12.63	lbs/bin		1 percent emission rate from AP-42
PM Collected By Cyclone	2,806.65	lbs/bin	=	PM Cyclone Collects per bin
PM-10 Collected By Cyclone	1,403.33	lbs/bin		
Fugitive PM loss from Cyclone	**280.67**	lbs/bin		of Fugitive PM from Cyclone per bin
Fugitive PM-10 loss from Cyclone	**140.33**	lbs/bin		of Fugitive PM-10 from Cyclone per bin
Total PM Generated By Framing Mill Building	2,954.37	lbs/bin	=	Cyclone Collects 95% PM Framing Mill Buildi
Total PM-10 Generated By Framing Mill Building	1,477.18	lbs/bin		
PM Uncollected from Building by Cyclone	147.72	lbs/bin	=	5% Building PM Uncollected by Cyclone
PM-10 Uncollected from Building by Cyclone	73.86	lbs/bin		
Building Fugitive PM	**1.48**	lbs/bin	=	Building Controls 99% of 5% Fugitive PM
Building Fugitive PM-10	**0.74**	lbs/bin		
Total Fugitive PM from Framing Mill	**307.40**	**lbs/bin**		
Total Fugitive PM-10 from Framing Mill	**153.70**	**lbs/bin**		
Annual Number of Bins	208			
Total Annual Fugitive PM	**31.97**	**ton/yr**		
	175.18	lbs/day		
Total Annual Fugitive PM-10	**15.98**	**ton/yr**		
	87.59	lbs/day		

01:56 PM 15-Mar-95

Assumptions

1. Pound per cubic foot of tie is based on a 6 x 8 tie at 175 lb.

References

1. Emission factors for wood waste were found in AP-42 10.4.3

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PLANT:	Columbus
PROCESS UNIT:	Framing Mill (Crossings, Panels, Bridge)
EMISSION:	Actual Particulates: PM, PM-10

Wood Waste Emission Factor

The variety of cuts, all to customer specifications, made at each of the three saw mills, precludes any wood waste estimates based on saw cuts. Therefore, wood waste will be quantified by the number of 30 yard containers filled and removed weekly.

	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	6	8	8.5
2. Weight of tie (lb)	175		
3. Cubic feet of tie (ft3)	2.83		
4. Pound per cubic foot (lb/ft3)	61.76		
5. Weight of cubic foot of sawdust (lb/ft3)	31.185		
6. Weight of cubic yard of sawdust (lb/yd3)	842.00		

Maximum Emissions

2 Cyclones in series?

	Unit		
Number of units	1		
Maximum number of 30-CuYd bins filled	2	bins/week	
	104	bins/yr	
Maximum volume of wood waste produced	2,627,024	lb/yr	7197.327 lb/day
	1,313.51	ton/yr	
Maximum pounds of wood waste/container	25,259.85	lbs/bin	= 90% of wood waste Collected By Cyclone
Maximum pounds of PM/container	2,525.99	lbs/bin	PM is assumed to be 10 percent of wood w
Maximum pounds of PM-10/container	1,262.99	lbs/bin	PM-10 is assumed to be 50 percent of PM
Fugitive PM loss from Container	25.26	lbs/bin	1 percent emission rate from AP-42
Fugitive PM-10 loss from Container	12.63	lbs/bin	1 percent emission rate from AP-42
PM Collected By Cyclone	2,806.65	lbs/bin	= PM Cyclone Collects per bin
PM-10 Collected By Cyclone	1,403.33	lbs/bin	
Fugitive PM loss from Cyclone	**280.67**	lbs/bin	of Fugitive PM from Cyclone per bin
Fugitive PM-10 loss from Cyclone	**140.33**	lbs/bin	of Fugitive PM-10 from Cyclone per bin
Total PM Generated By Framing Mill Building	2,954.37	lbs/bin	= Cyclone Collects 95% PM Framing Mill Buildi
Total PM-10 Generated By Framing Mill Building	1,477.18	lbs/bin	
PM Uncollected from Building by Cyclone	147.72	lbs/bin	= 5% Building PM Uncollected by Cyclone
PM-10 Uncollected from Building by Cyclone	73.86	lbs/bin	
Building Fugitive PM	**1.48**	lbs/bin	= Building Controls 99% of 5% Fugitive PM
Building Fugitive PM-10	**0.74**	lbs/bin	
Total Fugitive PM from Framing Mill	**307.40**	**lbs/bin**	
Total Fugitive PM-10 from Framing Mill	**153.70**	**lbs/bin**	
Annual Number of Bins	104		
Total Annual Fugitive PM	**15.98**	**ton/yr**	
	87.59	lbs/day	
Total Annual Fugitive PM-10	**7.99**	**ton/yr**	
	43.79	lbs/day	

?. AP-42 says 1.0 lb/ton or 2.0 lb/ton.

$\frac{2525.99}{.9}$

2525.99 + 280.67

? should be $\frac{25259.85}{.95} = 26,589.32$

01:18 PM 15-Mar-95

Assumptions

1. Pound per cubic foot of tie is based on a 6 x 8 tie at 175 lb.

References

1. Emission factors for wood waste were found in AP-42 10.4.3

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PLANT: Columbus
PROCESS UNIT: Switch tie Unloader
EMISSION: PM

Wood Waste Emission Factor

Saw Cut - 7x9 tie	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	7	9	8.5
2. Weight of tie (lb)	200		
3. Cubic feet of tie (ft3)	3.72		
4. Pound per cubic foot (lb/ft3)	53.78		
5. Saw cut (in)	0.25		
6. Cubic feet of saw cut (ft3)	0.0091		
7. Pounds of wood waste per cut (lb/cut)	0.49		
8. Pounds of wood waste per tie (lb/tie)	0.98		

Maximum By-Product	Unit
Number of units	1
Maximum number of ties processed	5,000 ties/day
	1,825,000 ties/yr
Maximum volume of wood waste produced	4,902 lb/day
	895 ton/yr
Maximum volume of PM produced	49.02 lb/day
	8.95 ton/yr
Typical By-Product	
Number of units	1
Typical number of ties processed	3,000 ties/day
	1,095,000 ties/yr
Typical volume of wood waste produced	2,941 lb/day
	537 ton/yr
Typical volume of PM produced	29.41 lb/day
	5.37 ton/yr

Saw Cut - 6x8 tie	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	6	8	8.5
2. Weight of tie (lb)	175		
3. Cubic feet of tie (ft3)	2.83		
4. Pound per cubic foot (lb/ft3)	61.76		
5. Saw cut (in)	0.25		
6. Cubic feet of saw cut (ft3)	0.0069		
7. Pounds of wood waste per cut (lb/cut)	0.43		
8. Pounds of wood waste per tie (lb/tie)	0.86		

Maximum By-Product	
Number of units	1
Maximum volume of wood waste produced	4,205 lb/day
	2.10 ton/yr
Maximum volume of PM produced	42.05 lb/day
	0.02 ton/yr
Typical By-Product	
Number of units	1
Typical volume of wood waste produced	939,338 lb/day
	469.67 ton/yr
Typical volume of PM produced	9,393.38 lb/day
	4.70 ton/yr

Spike	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	5
2. Cubic feet of spike (ft3)	0.0007	
3. Pounds of wood waste per spike (lb/spike)	0.0444	
4. Pounds of wood waste per tie (lb/tie)	0.36	

Maximum By-Product	
Number of units	1
Maximum volume of wood waste produced	648,088 lb/day
	324.04 ton/yr
Maximum volume of PM produced	6,480.88 lb/day
	3.24 ton/yr
Typical By-Product	
Number of units	1
Typical volume of wood waste produced	388,853 lb/day
	194.43 ton/yr
Typical volume of PM produced	3,888.53 lb/day
	1.94 ton/yr

Bore - 7x9 tie	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	7
2. Cubic feet of bore (ft3)	0.00101	
3. Pounds of wood waste per bore (lb/bore)	0.05411	
4. Pounds of wood waste per tie (lb/tie)	0.43	

Maximum By-Product	
Number of units	1
Maximum volume of wood waste produced	790,051 lb/day
	395.03 ton/yr
Maximum volume of PM produced	7,900.51 lb/day
	3.95 ton/yr
Typical By-Product	
Number of units	1
Typical volume of wood waste produced	474,030 lb/day
	237.02 ton/yr
Typical volume of PM produced	4,740.30 lb/day
	2.37 ton/yr

Bore - 6x8 tie	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	6
2. Cubic feet of bore (ft3)	0.00086	
3. Pounds of wood waste per bore (lb/bore)	0.05327	
4. Pounds of wood waste per tie (lb/tie)	0.43	

Maximum By-Product	
Number of units	1
Maximum volume of wood waste produced	777,706 lb/day
	388.85 ton/yr
Maximum volume of PM produced	7,777.06 lb/day
	3.89 ton/yr
Typical By-Product	
Number of units	1
Typical volume of wood waste produced	466,624 lb/day
	233.31 ton/yr
Typical volume of PM produced	4,666.24 lb/day
	2.33 ton/yr

Assumptions

1. The width of the saw cut or bit cut is equivalent in mass to the amount of sawdust produced.
2. As spikes are invariable drilled at 5 inches, the heavier pound per cubic foot value for 6x8 ties was used.
3. Although the Switch tie Unloader may cut various sizes of ties, the number of 7x9 ties used for this estimation will more than compensate for larger cuts made on fewer ties.

References

1. AP-42 10.4

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15-Mar-95
01:59 PM

PLANT: Columbus
PROCESS UNIT: Switch tie Unloader
EMISSION: PM-10

Maximum Emissions		To Control	To Atmosphere	Portion that is PM-10	Unit
1. Maximum volume of PM produced	8.95				tons/yr
2. Saw to capture system		8.50			tons/yr
a. to atmosphere from cyclone			0.85	0.43	tons/yr
b. into bin		7.65			tons/yr
c. to atmosphere from bin - fugitive			0.08	0.04	tons/yr
3. Saw to building		0.45			tons/yr
Total Emittable to Atmosphere			0.93	0.46	tons/yr
Typical Emissions					
1. Typical volume of PM produced	5.37				tons/yr
2. Saw to capture system		5.10			tons/yr
a. to atmosphere from cyclone			0.51	0.26	tons/yr
b. into bin		4.59			tons/yr
c. to atmosphere from bin - fugitive			0.05	0.02	tons/yr
3. Saw to building		0.27			tons/yr
Total Emittable to Atmosphere			0.56	0.28	tons/yr

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PLANT: Columbus
PROCESS UNIT: Cross tie Unloader
EMISSION: PM

Wood Waste Emission Factor

Saw Cut - 7x9 tie	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	7	9	8.5
2. Weight of tie (lb)	200		
3. Cubic feet of tie (ft3)	3.72		
4. Pound per cubic foot (lb/ft3)	53.78		
5. Saw cut (in)	0.25		
6. Cubic feet of saw cut (ft3)	0.0091		
7. Pounds of wood waste per cut (lb/cut)	0.49		
8. Pounds of wood waste per tie (lb/tie)	0.98		

Maximum By-Product		Unit
Number of units	1	
Maximum number of ties processed	9,000	ties/day
	3,285,000	ties/yr
Maximum volume of wood waste produced	8,824	lb/day
	1,610	ton/yr
Maximum volume of PM produced	88.24	lb/day
	16.10	ton/yr
Typical By-Product		
Number of units	1	
Typical number of ties processed	7,500	ties/day
	2,737,500	ties/yr
Typical volume of wood waste produced	7,353	lb/day
	1,342	ton/yr
Typical volume of PM produced	73.53	lb/day
	13.42	ton/yr

Saw Cut - 6x8 tie	Width (in)	Depth (in)	Length (ft)
1. Dimensions of tie (W x L x D)	6	8	8.5
2. Weight of tie (lb)	175		
3. Cubic feet of tie (ft3)	2.83		
4. Pound per cubic foot (lb/ft3)	61.76		
5. Saw cut (in)	0.25		
6. Cubic feet of saw cut (ft3)	0.0069		
7. Pounds of wood waste per cut (lb/cut)	0.43		
8. Pounds of wood waste per tie (lb/tie)	0.86		

Maximum By-Product		
Number of units	1	
Maximum volume of wood waste produced	7,569	lb/day
	3.78	ton/yr
Maximum volume of PM produced	75.69	lb/day
	0.04	ton/yr
Typical By-Product		
Number of units	1	
Typical volume of wood waste produced	2,348,346	lb/day
	1,174.17	ton/yr
Typical volume of PM produced	23,483.46	lb/day
	11.74	ton/yr

Spike	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	5
2. Cubic feet of spike (ft3)	0.0007	
3. Pounds of wood waste per spike (lb/spike	0.0444	
4. Pounds of wood waste per tie (lb/tie)	0.36	

Maximum By-Product		
Number of units	1	
Maximum volume of wood waste produced	1,166,559	lb/day
	583.28	ton/yr
Maximum volume of PM produced	11,665.59	lb/day
	5.83	ton/yr
Typical By-Product		
Number of units	1	
Typical volume of wood waste produced	972,133	lb/day
	486.07	ton/yr
Typical volume of PM produced	9,721.33	lb/day
	4.86	ton/yr

Bore - 7x9 tie	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	7
2. Cubic feet of bore (ft3)	0.00101	
3. Pounds of wood waste per bore (lb/bore)	0.05411	
4. Pounds of wood waste per tie (lb/tie)	0.43	

Maximum By-Product		
Number of units	1	
Maximum volume of wood waste produced	1,422,091	lb/day
	711.05	ton/yr
Maximum volume of PM produced	14,220.91	lb/day
	7.11	ton/yr
Typical By-Product		
Number of units	1	
Typical volume of wood waste produced	1,185,076	lb/day
	592.54	ton/yr
Typical volume of PM produced	11,850.76	lb/day
	5.93	ton/yr

Bore - 6x8 tie	Diameter (in)	Depth (in)
1. Dimensions of bit	0.5625	6
2. Cubic feet of bore (ft3)	0.00086	
3. Pounds of wood waste per bore (lb/bore)	0.05327	
4. Pounds of wood waste per tie (lb/tie)	0.43	

Maximum By-Product		
Number of units	1	
Maximum volume of wood waste produced	1,399,871	lb/day
	699.94	ton/yr
Maximum volume of PM produced	13,998.71	lb/day
	7.00	ton/yr
Typical By-Product		
Number of units	1	
Typical volume of wood waste produced	1,166,559	lb/day
	583.28	ton/yr
Typical volume of PM produced	11,665.59	lb/day
	5.83	ton/yr

Assumptions

1. The width of the saw cut or bit cut is equivalent in mass to the amount of sawdust produced.
2. As spikes are invariable drilled at 5 inches, the heavier pound per cubic foot value for 6x8 ties was used.

References

1. AP-42 10.4

F:\DATA\0168\COLUMBUS\XSORTER.WK3
27-Feb-95
06:08 PM

PLANT: Columbus
PROCESS UNIT: Cross tie Unloader
EMISSION: PM-10

Maximum Emissions		**To Control**	**To Atmosphere**	**Portion that is PM-10**	**Unit**
1. Maximum volume of PM produced	16.10				tons/yr
2. Saw to capture system		15.30			tons/yr
a. to atmosphere from cyclone			1.53	0.76	tons/yr
b. into bin		13.77			tons/yr
c. to atmosphere from bin - fugitive			0.14	0.07	tons/yr
3. Saw to building		0.81			tons/yr
Total Emittable to Atmosphere			1.67	0.83	tons/yr
Typical Emissions					
1. Typical volume of PM produced	13.42				tons/yr
2. Saw to capture system		12.75			tons/yr
a. to atmosphere from cyclone			1.27	0.64	tons/yr
b. into bin		11.47			tons/yr
c. to atmosphere from bin - fugitive			0.11	0.06	tons/yr
3. Saw to building		0.67			tons/yr
Total Emittable to Atmosphere			1.39	0.69	tons/yr

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JOB 940168/3 B

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KMCC - COLUMBUS

EMISSIONS CALCULATIONS

▶ PRIMARY AND STANDBY BOILERS

The boilers are operated as a primary heat generator and a stand-by or alternative heat generator.

Emission factors for Fuel Oil and Natural Gas are given by AP42.

The maximum capacity for the boilers is rated at 34 and 14.3 million BTU/hr Natural Gas and 100 gallons/hr Fuel Oil.

The boilers are fired with low sulfur (< 0.5% wt) No.2 Oil only when necessary.

According to the AP42, boilers can be approximately classified by gross heat rate. The boilers at Columbus are therefore classified as Industrial for 10×10^6 to 100×10^6 BTU/hr.

Uncontrolled Emission Factors for Natural Gas Combustion

Emission factors are expressed as weight per volume fuel fired.

Emission		lb/MM ft³
Particulates:	PM	2.5
	PM-10	2.5
SO_2		0.6
NOx		140
CO		35
VOCs		2.8

1,000 BTU/ft³ of Natural Gas

Therefore,

Particulates: PM, PM-10

$$\frac{2.5 \text{ lb}}{\text{MMft}^3} * \frac{\text{ft}^3}{1{,}000 \text{ BTU}} * \frac{34 \text{ MMBTU}}{\text{hr}} = 0.085 \text{ lbs/hr PM, PM-10}$$

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KMCC-COLUMBUS
EMISSION CALCULATIONS

▶ BOILERS (continued)

$SO_2 = \frac{0.6 \text{ lb}}{MMft^3} * \frac{ft^3}{1{,}000 \text{ BTU}} * \frac{34 \text{ MMBTU}}{hr} = 0.0204 \text{ lbs/hr } SO_2$

$NOx = \frac{140 \text{ lb}}{MMft^3} * \frac{ft^3}{1{,}000 \text{ BTU}} * \frac{34 \text{ MMBTU}}{hr} = 4.76 \text{ lbs/hr NOx}$

$CO = \frac{35 \text{ lb}}{MMft^3} * \frac{ft^3}{1{,}000 \text{ BTU}} * \frac{34 \text{ MMBTU}}{hr} = 1.19 \text{ lbs/hr CO}$

$VOCs = \frac{2.8 \text{ lb}}{MMft^3} * \frac{ft^3}{1{,}000 \text{ BTU}} * \frac{34 \text{ MMBTU}}{hr} = 0.0952 \text{ lbs/hr VOC}$

Summary,
Short-term emissions in lbs/hr
Particulates: PM, PM-10 = 0.085 lbs/hr
SO_2 = 0.0204 lbs/hr
NOx = 4.76 lbs/hr
CO = 1.19 lbs/hr
VOCs = 0.0952 lbs/hr

Long-term emissions in tons/yr

$PM, PM\text{-}10 = \frac{0.085 \text{ lbs}}{hr} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{yr} = 0.3723 \text{ tons/yr PM, PM-10}$

$SO_2 = \frac{0.0204 \text{ lbs}}{hr} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{yr} = 0.0894 \text{ tons/yr } SO_2$

$NOx = \frac{4.76 \text{ lbs}}{hr} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{yr} = 20.8488 \text{ tons/yr NOx}$

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KMCC-COLUMBUS
EMISSION CALCULATIONS

▶ BOILERS (continued)

$$CO = \frac{1.19\ lbs}{hr} * \frac{1\ ton}{2{,}000\ lbs} * \frac{8760\ lbs}{yr} = 5.2122\ tons/yr\ CO$$

$$VOCs = \frac{0.0952\ lbs}{hr} * \frac{1\ ton}{2{,}000\ lbs} * \frac{8760\ lbs}{yr} = 0.4170\ tons/yr\ VOC$$

Uncontrolled Emission Factors for Fuel Oil - Distillate Oil
All emission factors are expressed as weight per volume fuel fired.

Emission		$lb/10^3\ gal$
Particulates:	PM	2
	PM-10	2
SO_2		(142)(weight % of sulfur in the oil)
NOx		20
CO		5
VOCs		0.2

Particulates: PM, PM-10

$$\frac{2\ lb}{1{,}000\ gal} * \frac{100\ gal}{hr} = 0.2\ lbs/hr\ PM, PM\text{-}10$$

$$SO_2 = \frac{(142)(0.5)\ lb}{1{,}000\ gal} * \frac{100\ gal}{hr} = 7.1\ lbs/hr\ SO_2$$

$$NOx = \frac{20\ lb}{1{,}000\ gal} * \frac{100\ gal}{hr} = 2.0\ lbs/hr\ NOx$$

$$CO = \frac{5\ lb}{1{,}000\ gal} * \frac{100\ gal}{hr} = 0.5\ lbs/hr\ CO$$

JOB 940168/3 B

SHEET NO. 4 OF

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KMCC-COLUMBUS
EMISSION CALCULATIONS

▶ BOILERS (continued)

$$\text{VOCs} = \frac{0.2\ \text{lb}}{1{,}000\ \text{gal}} * \frac{100\ \text{gal}}{\text{hr}} = 0.02\ \text{lbs/hr VOCs}$$

Summary

Short-term emissions in lbs/hr,

Particulates: PM, PM-10 = 0.2 lbs/hr

SO_2 = 7.1 lbs/hr

NO_x = 2.0 lbs/hr

CO = 0.5 lbs/hr

VOCs = 0.02 lbs/hr

Long-term emissions in tons/yr,

$$\text{PM, PM-10} = \frac{0.2\ \text{lbs}}{\text{hr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{8760\ \text{hrs}}{\text{yr}} = 0.876\ \text{tons/yr PM, PM-10}$$

$$SO_2 = \frac{7.1\ \text{lbs}}{\text{hr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{8760\ \text{hrs}}{\text{yr}} = 31.098\ \text{tons/yr } SO_2$$

$$NO_x = \frac{2.0\ \text{lbs}}{\text{hr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{8760\ \text{hrs}}{\text{yr}} = 8.76\ \text{tons/yr } NO_x$$

$$\text{CO} = \frac{0.5\ \text{lbs}}{\text{hr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{8760\ \text{hrs}}{\text{yr}} = 2.19\ \text{tons/yr CO}$$

$$\text{VOCs} = \frac{0.02\ \text{lbs}}{\text{hr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} * \frac{8760\ \text{lbs}}{\text{yr}} = 0.0876\ \text{tons/yr VOC}$$

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KMCC-COLUMBUS
EMISSIONS CALCULATIONS

▶ BOILERS (continued)

Assume 3 months operation with Fuel Oil and 9 months operation with Natural Gas

$$PM, PM\text{-}10 = \frac{0.876 \text{ tons}}{yr} * \frac{3 \text{ mo.s}}{12 \text{ mo.s}} + \frac{0.3723 \text{ tons}}{yr} * \frac{9 \text{ mo.s}}{12 \text{ mo.s}} = 0.4982 \text{ tons/yr } PM, PM\text{-}10$$

$$SO_2 = \frac{31.098 \text{ tons}}{yr} * \frac{3 \text{ mo.s}}{12 \text{ mo.s}} + \frac{0.0894 \text{ tons}}{yr} * \frac{9 \text{ mo.s}}{12 \text{ mo.s}} = 7.8416 \text{ tons/yr } SO_2$$

$$NOx = \frac{8.76 \text{ tons}}{yr} * \frac{3 \text{ mo.s}}{12 \text{ mo.s}} + \frac{20.8488 \text{ tons}}{yr} * \frac{9 \text{ mo.s}}{12 \text{ mo.s}} = 17.8266 \text{ tons/yr } NOx$$

$$CO = \frac{2.19 \text{ tons}}{yr} * \frac{3 \text{ mo.s}}{12 \text{ mo.s}} + \frac{5.2122 \text{ tons}}{yr} * \frac{9 \text{ mo.s}}{12 \text{ mo.s}} = 4.4567 \text{ tons/yr } CO$$

$$VOC = \frac{0.0876 \text{ tons}}{yr} * \frac{3 \text{ mo.s}}{12 \text{ mo.s}} + \frac{0.4170 \text{ tons}}{yr} * \frac{9 \text{ mo.s}}{12 \text{ mo.s}} = 0.3347 \text{ tons/yr } VOC$$

JOB 940168B

SHEET NO. 5 OF 5

CALCULATED BY MRC DATE 2/28/95

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SCALE

For maximum emissions, the emission rates that resulted in the maximum emissions was used. For example, natural gas is typically used continuously with oil being used about 1 month per year due to natural gas curtailment. TDS would use natural gas continuously if it was available. Therefore, for max emissions, the natural gas emission rates were used for NO_x, CO & VOC, since this results in the highest emissions. Oil is used about 1 month per year due to gas curtailment. The max anticipated gas curtailment has been estimated at 3 months. For PM, PM_{10} and SO_2, oil emission rates are the highest, therefore, for these 3 constituents, a 9 month natural gas and a 3 month oil emission calculation was assumed.

$$PM, PM_{10} = \overset{\text{oil}}{0.7884} \frac{\text{tons}}{\text{yr}} * \frac{3\text{ mo}}{12\text{ mo}} + \overset{\text{gas}}{0.3066} \frac{\text{tons}}{\text{yr}} * \frac{9\text{ mo}}{12\text{ mo}} = 0.4271 \frac{\text{tons}}{\text{yr}}$$

$$SO_2 = \overset{\text{oil}}{27.9882} \frac{\text{tons}}{\text{yr}} * \frac{3\text{ mo}}{12\text{ mo}} + \overset{\text{gas}}{0.0736} \frac{\text{ton}}{\text{yr}} * \frac{9\text{ mo}}{12\text{ mo}} = 7.0523 \frac{\text{tons}}{\text{yr}}$$

$$NO_x = \overset{\text{gas}}{17.1696} \frac{\text{ton}}{\text{yr}} * \frac{12\text{ mo}}{12\text{ mo}} = 17.1696 \frac{\text{tons}}{\text{yr}}$$

$$CO = 4.2924 \frac{\text{tons}}{\text{yr}} * \frac{12\text{ mo}}{12\text{ mo}} = 4.2924 \frac{\text{tons}}{\text{yr}}$$

$$VOCs = 0.3434 \frac{\text{tons}}{\text{yr}} * \frac{12\text{ mo}}{12\text{ mo}} = \overset{0.3434}{\cancel{0.1056}}\ \text{tons/yr}$$

Plant	**Columbus**		
Process Unit	**Primary Boiler**		
Emissions	**Criteria Pollutants**		Abbreviation
Boiler Size (MMBTU/Hr)	34.0		A
BTU's per cubic ft of Natural Gas	1,000		B
Annual Hours of Production	8,760		C
Maximum Annual BTUs Capacity	297,840	D = A*C	D
Burning Capacity ft3 NG/Hr	34,000	E = A/B	E
Maximum Annual MMCubic ft of NG	298	F = C*E	F
No. 2 Fuel Oil Capacity; gal/hr	100.00		G
Weekly Fuel Oil Cap. gal/week	16,800.00	H = G *24*7	H
Monthly Fuel Oil Cap. gal/month	72,000.00	I = G*24*30	I
Annual Fuel Oil Cap. gal/yr	873,600.00	J = H * 52	J

Emission Factors for Uncontrolled Natural Gas Combustion

Boiler Type	Particulates PM lbs/MMcuft	Particulates PM10 lbs/MMcuft	Sulfur Dioxide lbs/MMcuft	Nitrogen Oxides lbs/MMcuft	Carbon Monoxide lbs/MMcuft	Volatile Non-Methane Organics lbs/MMcuft
Industrial Boilers (a)	2.5	2.5	0.6	140	35	2.8

Emission Factors for Uncontrolled Fuel Oil Combustion

Boiler Type	Particulates PM lb/1000 gal	Particulates PM10 lb/1000 gal	Sulfur Dioxide lb/1000 gal	Nitrogen Oxides lb/1000 gal	Carbon Monoxide lb/1000 gal	Volatile Non-Methane Organics lb/1000 gal
Industrial Boilers (a)	2	2	142(S)	20	5	0.2

Maximum Annual Emissions Based on BTU Combustion Capacity Burning Natural Gas

Emission Rate	PM	PM10	Sulfur Dioxide	Nitrogen Oxides	Carbon Monoxide	Volatile Non-Methane Organics	Total Criteria Pollutants TPY
Lbs per Hour	0.085	0.085	0.020	4.760	1.190	0.095	6.236
Tons Per Year	0.372	0.372	0.089	20.849	5.212	0.417	27.312

Maximum Annual Emissions Based on BTU Combustion Capacity Burning No. 2 Fuel Oil

Emission Rate	PM	PM10	Sulfur Dioxide	Nitrogen Oxides	Carbon Monoxide	Volatile Non-Methane Organics	Total Criteria Pollutants
Lbs per Hour	0.200	0.200	7.100	2.000	0.500	0.020	10.02
Tons Per Year	0.876	0.876	31.098	8.76	2.19	0.0876	43.8876

Emission Rate	PM	PM10	Sulfur Dioxide	Nitrogen Oxides	Carbon Monoxide	Volatile Non-Methane Organics	Total Criteria Pollutants
Tons Natural Gas Emissions per 9 Months	0.279	0.279	0.067	15.637	3.909	0.313	20.484
Tons No. 2 Fuel Oil Emissions per 3 Months	0.219	0.219	7.775	2.190	0.548	0.022	10.972
Combined Tons per Year	0.498	0.498	7.842	17.827	4.457	0.335	31.456

Notes:
(a) Industrial boilers are classifed as having a heat input of 10 - 100 million BTUs (MMBTU) per hour.

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Plant	**Columbus**		
Process Unit	**Secondary Boiler**		
Emissions	**Criteria Pollutants**		Abbreviation
Boiler Size (MMBTU/Hr)	14.3		A
BTU's per cubic ft of Natural Gas	1,000		B
Annual Hours of Production	8,760		C
Maximum Annual BTUs Capacity	125,268	D = A*C	D
Burning Capacity ft3 NG/Hr	14,300	E = A/B	E
Maximum Annual MMCubic ft of NG	125	F = C*E	F
No. 2 Fuel Oil Capacity; gal/hr	100.00		G
Weekly Fuel Oil Cap. gal/week	16,800.00	H = G *24*7	H
Monthly Fuel Oil Cap. gal/month	72,000.00	I = G*24*30	I
Annual Fuel Oil Cap. gal/yr	873,600.00	J = H * 52	J

Emission Factors for Uncontrolled Natural Gas Combustion

Boiler Type	Particulates PM lbs/MMcuft	Particulates PM10 lbs/MMcuft	Sulfur Dioxide lbs/MMcuft	Nitrogen Oxides lbs/MMcuft	Carbon Monoxide lbs/MMcuft	Volatile Non-Methane Organics lbs/MMcuft
Industrial Boilers (a)	2.5	2.5	0.6	140	35	2.8

Maximum Annual Emissions Based on BTU Combustion Capacity Burning Natural Gas

Emission Rate	PM	PM10	Sulfur Dioxide	Nitrogen Oxides	Carbon Monoxide	Volatile Non-Methane Organics	Total Criteria Pollutants TPY
Lbs per Hour	0.036	0.036	0.009	2.002	0.501	0.040	2.623
Tons Per Year	0.157	0.157	0.038	8.769	2.192	0.175	11.487

Notes:
(a) Industrial boilers are classifed as having a heat input of 10 - 100 million BTUs (MMBTU) per hour.

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KMCC-COLLUMBUS
EMISSIONS CALCULATIONS

- SAPTANKS

water8 derived emissions in terms of Naphthalene were modeled at 207.2947 lbs/yr

Short-term emissions in terms of lbs/day.

207.2947 lbs/yr * 1 yr/365 days = 0.5679 lbs/day Naphthalene

$$\frac{77.4 \text{ lbs N}}{15.0 \text{ lbs Dbf}} = \frac{0.5679 \text{ lbs N}}{x \text{ lbs Dbf}} \qquad x = \frac{(15.0 \text{ lbs Dbf})(0.5679 \text{ lbs N})}{(77.4 \text{ lbs N})}$$

x = 0.1101 lbs/day Dibenzofuran

$$\frac{77.4 \text{ lbs N}}{7.5 \text{ lbs Q}} = \frac{0.5679 \text{ lbs N}}{x \text{ lbs Q}} \qquad x = \frac{(7.5 \text{ lbs Q})(0.5679 \text{ lbs N})}{(77.4 \text{ lbs N})}$$

x = 0.0550 lbs/day Quinoline

$$\frac{77.4 \text{ lbs N}}{0.1 \text{ lbs B}} = \frac{0.5679 \text{ lbs N}}{x \text{ lbs B}} \qquad x = \frac{(0.1 \text{ lbs Q})(0.5679 \text{ lbs N})}{(77.4 \text{ lbs N})}$$

x = 0.0007 lbs/day Biphenyl

$$\text{VOC} = \frac{0.5679 \text{ lb N}}{0.42} = 1.3521 \text{ lbs/day VOC}$$

This total is for all 3 tanks. This number was divided by 3 to find emissions for each individual tank.

WASTEWATER TREATMENT EMISSION COMPUTATIONS - COLUMBUS
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SOURCE	QUANTITY	WATER8 MODEL EMISSIONS	AP-42 FACTOR (c)		OPERATION TIME			FLOW RATE				NAPH-THALENE EMISSIONS	ANNUAL CREOSOTE/ VOC EMISSIONS	ANNUAL CREOSOTE/ VOC EMISSIONS
		(lb naph./yr)	Factor	Units	(hr/day)	(days/yr)	(hr/yr)	(gpm)	(mgd)	(Kgal/yr)	(Mgal/yr)	(lb/yr)	(lb/yr)	(tons/yr)
1. COOLING TOWERS (a)	2	-	0.6	lb VOC/Mgal	24	365	8,760	200	0.288	105,120	105.1	-	0.0	0.00
2. PRIMARY OIL/WATER SEPARATOR TANKS (b)	2	74.4	-	-	24	365	8,760	20	0.029	10,438	10.4	74.4	177.1	0.09
3. SECONDARY OIL/WATER SEPARATOR (b)														
PROCESS WATER	1	323.2	-	-	24	365	8,760	20	0.029	10,438	10.4	323.2	769.6	0.38
4. SURGE TANK (b)	1	96.3	-	-	24	365	8,760	20	0.029	10,438	10.4	96.3	229.3	0.11
5. AERATED TANKS (b)	3	474.8	-	-	24	365	8,760	20	0.029	10,438	10.4	474.8	1,130.5	0.57
6. GROUNDWATER OIL/WATER SEPARATOR	1	32.3	-	-	24	365	8,760	15	0.022	8,042	8.0	201.0	478.6	0.
										Totals		1,170	2,785	1.

Notes:
(a) Under Mississippi regulations cooling towers are considered insignificant sources.
(b) Emissions estimated from EPA's Water7 Air Emission Model for Wastewater Treatment. The annual poundage is divided by 42.0% (0.42) in order to obtain annual creosote emissions.
(c) AP-42 emission factors were developed for the petroleum industry. A factor of 0.10 times the AP-42 factors has been used to determine low-volatility emissions.

Calculations:

Operation Time (hr/yr)	= [hr/day] * [# days/yr]
Flow Rate (mgd)	= [Flow Rate, gpm] * [60 min/hr] * [24 hr/day] / [1000000 gal/Mgal]
Flow Rate (Kgal/yr)	= [Flow Rate, gpm] * [60 min/hr] * [Operation time, hr/yr] / [1000 gal/Kgal]
Flow Rate (Mgal/yr)	= [Flow Rate, gpm] * [60 min/hr] * [Operation time, hr/yr] / [1000000 gal/Mgal]
Process Drains	= [Operation time, hr/yr] * [AP-42 Factor, lb/hr-source] * [# of sources]
Total Emissions, lb/yr (cooling tower)	= [Flow Rate, Mgal/yr] * [AP-42 Factor, lb/hr-flow basis] * [# of units]
Annual Emissions, tons/yr	= [Total Emissions, lb/yr] / [2000 lb/ton]

EMISSIONS FROM WASTEWATER SOURCES BY INDIVIDUAL HAP

SOURCE	HAP EMISSIONS (tons/yr)				UNCONTROLLED EMISSIONS		
	Quinoline 7.5%	Biphenyl 0.1%	Naphthalene 77.4%	Dibenzofuran 15.0%	TOTAL HAPS (tons/yr)	NON-HAP VOC (tons/yr)	TOTAL VOC/ CREOSOTE (tons/yr)
1. Cooling Towers	0.00	0.00000	0.00	0.00	0.00	0.00	0.00
2. Primary Oil/Water Separator Tanks	0.00	0.00005	0.04	0.01	0.05	0.04	0.09
3. Secondary Oil/Water Separator							
Process Water	0.02	0.00021	0.16	0.03	0.21	0.18	0.38
4. Surge Tank	0.00	0.00006	0.05	0.01	0.06	0.05	0.11
5. Aerated Tanks (No Controls)	0.02	0.00031	0.24	0.05	0.31	0.26	0.57
6. Groundwater Oil/Water Separator	0.01	0.00013	0.10	0.02	0.13	0.11	0.24
Totals	0.06	0.00076	0.58	0.11	0.76	0.64	1.39

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KMCC-COLUMBUS
EMISSIONS CALCULATIONS

▷ MISCELLANEOUS FUGITIVE EMISSIONS

Fugitive VOC emissions in the Synthetic Organic Chemicals Manufacturing Industry (SOCMI) are reduced by a factor of 10 to account for the lower volatility of creosote as compared to petroleum products (as per AWPI).

Heavy Liquid Valves
121 valves * 0.000507 lbs/hr VOC * 0.1 = 0.0061 lbs/hr VOC

Pressure Relief Valves
3 valves * 0.2293 lbs/hr VOC * 0.1 = 0.0688 lbs/hr VOC

Heavy Liquid Pump Seals
20 pump seals * 0.0472 lbs/hr VOC * 0.1 = 0.0944 lbs/hr VOC

Flanges
88 flanges * 0.00183 lbs/hr VOC * 0.1 = 0.0161 lbs/hr VOC

Summary
Short-term emissions in lbs/day VOC
Heavy Liquid Valves = 0.0061 lbs/hr * 24 hrs/day = 0.1464 lbs/day
Pressure Relief Valves = 0.0688 lbs/hr * 24 hrs/day = 1.6512 lbs/day
Heavy Liquid Pump Seals = 0.0944 lbs/hr * 24 hrs/day = 2.2656 lbs/day
Flanges = 0.0161 lbs/hr * 24 hrs/day = 0.3864 lbs/day

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KMCC - COLUMBUS
EMISSIONS CALCULATIONS

➢ MISCELLANEOUS FUGITIVE EMISSIONS (continued)
Long-term emissions in tons/yr VOC
Heavy Liquid Valves

$$\frac{0.0061 \text{ lbs}}{\text{hr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{1 \text{ yr}} = 0.0267 \text{ tons/yr}$$

Pressure Relief Valves

$$\frac{0.0688 \text{ lbs}}{\text{hr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{1 \text{ yr}} = 0.3013 \text{ tons/yr}$$

Heavy Liquid Pump Seals

$$\frac{0.0944 \text{ lbs}}{\text{hr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{1 \text{ yr}} = 0.4135 \text{ tons/yr}$$

Flanges

$$\frac{0.0161 \text{ lbs}}{\text{hr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} * \frac{8760 \text{ hrs}}{1 \text{ yr}} = 0.0705 \text{ tons/yr}$$

From analytical measurements of an industry composite creosote, Naphthalene is equivalent to 42 percent of creosote or VOC emissions.
Therefore
Short-term emissions in lbs/day Naphthalene
Heavy Liquid Valves
0.1464 lbs/day * 0.42 = 0.0615 lbs/day

Pressure Relief Valves
1.6512 lbs/day * 0.42 = 0.6935 lbs/day

JOB 940168/3 B
SHEET NO. 3 OF
CALCULATED BY STM DATE 2-26-95
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SCALE

KMCC - COLUMBUS
EMISSIONS CALCULATIONS

▶ MISCELLANEOUS FUGITIVE EMISSIONS (continued)

Heavy Liquid Pump Seals
2.2656 lbs/day * 0.42 = 0.9516 lbs/day

Flanges
0.3864 lbs/day * 0.42 = 0.1623 lbs/day

Long-term emissions in tons/yr Naphthalene

Heavy Liquid Valves
0.0267 tons/yr * 0.42 = 0.0112 tons/yr

Pressure Relief Valves
0.3013 tons/yr * 0.42 = 0.1265 tons/yr

Heavy Liquid Pump Seals
0.4135 tons/yr * 0.42 = 0.1737 tons/yr

Flanges
0.0705 tons/yr * 0.42 = 0.0296 tons/yr

FUGITIVE EMISSION COMPUTATIONS - COLUMBUS
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SOURCE	QUANTITY	EMISSION FACTOR (a) (lb/hr-source)	OPERATION TIME			NAPH-THALENE EMISSIONS (lb/yr)	ANNUAL CREOSOTE/ VOC EMISSIONS (lb/yr)	ANNUAL CREOSOTE/ VOC EMISSIONS (T/yr)
			(hrs/day)	(days/yr)	(hrs/yr)			
1. HEAVY LIQUID PIPELINE VALVES	121	0.0000507	24	365	8,760	-	53.74	0.03
2. OPEN ENDED VALVES	0	0.000374	24	365	8,760	-	0.00	0.00
3. PRESSURE VENT RELIEF VALVES (b)	3	0.02293	24	365	8,760	-	602.60	0.30
4. FLANGES	88	0.000183	24	365	8,760	-	141.07	0.07
5. PUMP SEALS								
LIGHT LIQUIDS	0	0.01089	24	365	8,760	-	0.00	0.00
HEAVY LIQUIDS	20	0.00472	24	365	8,760	-	826.94	0.41
6. DRIP PAD (c)	1	0.00784	24	365	8,760	68.69	163.54	0.08
7. TANK CONTAINMENT FIELD (c)	1	0.00410	24	365	8,760	35.92	85.51	0.04
8. PROCESS DRAINS (d)	11	0.007	24	365	8,760	-	674.52	0.34
9. "HOT" SUMP (e)	1	-	24	365	8,760	20.6	49.05	0.02
					Totals	125.20	2,597	1.30

(a) Per AWPI, the SOCMI factor is multiplied by 0.1 due to less volatility for this plant than at a SOCMI facility.
(b) One Pressure Vent Relief Valve (PVRV) was assumed per retort. PVRV's on condensers were observed to be inoperative and were calculated as pipeline valves.
(c) The Drip Pad and Tank Containment Area emissions were derived by multiplying factors of 0.1 for thin films and 0.1 for affected areas by the SOW emissions as shown below.
(d) The AP-42 factor for process drains was multiplied by 0.1 due to less volatility for this plant than for a refinery.
(e) A "hot" sump was calculated from Water 8 to account for hot discharge to a central sump receiving direct process water.

Calculations:

Annual Emissions (tons/yr)	= [Quantity] * [Emission Factor, lb/hr-source] * [Operation Time, hrs/yr] / [2,000 lb/ton]
Drip Pad Annual Emissions (tons/yr)	= [SOW Emissions, lb/yr] / [SOW Area, sq ft] * [0.1, Thin Films] * [0.1, Area of Drips] * [Area of Drip Pad, sq ft] / [0.42] / [2,000 lb/ton]
Tank Containment Annual Emissions (tons/yr)	= [SOW Emissions, lb/yr] / [SOW Area, sq ft] * [0.1, Thin Films] * [0.1, Area of Drips] * [Area of Tank Field, sq ft] / [0.42] / [2,000 lb/ton]

FUGITIVE EMISSIONS BY INDIVIDUAL HAP

SOURCE	HAP EMISSIONS (tons/yr)				TOTAL HAPS (tons/yr)	TOTAL NON-HAP VOC (tons/yr)	TOTAL CREOSOTE (tons/yr)
	Quinoline 7.5%	Biphenyl 0.1%	Naphthalene 77.4%	Dibenzofuran 15.0%			
1. HEAVY LIQUID PIPELINE VALVES	0.0011	0.00001	0.011	0.0022	0.015	0.01	0.03
2. OPEN ENDED VALVES	0.0000	0.00000	0.000	0.0000	0.000	0.00	0.00
3. PRESSURE VENT RELIEF VALVES	0.0123	0.00016	0.127	0.0245	0.163	0.14	0.30
4. FLANGES	0.0029	0.00004	0.030	0.0057	0.038	0.03	0.07
5. PUMP SEALS							
LIGHT LIQUIDS	0.0000	0.00000	0.000	0.0000	0.000	0.00	0.00
HEAVY LIQUIDS	0.0168	0.00022	0.174	0.0337	0.224	0.19	0.41
6. DRIP PAD	0.0033	0.00004	0.034	0.0067	0.044	0.04	0.08
7. TANK CONTAINMENT FIELD	0.0017	0.00002	0.018	0.0035	0.023	0.02	0.04
8. PROCESS DRAINS	0.0137	0.00018	0.142	0.0275	0.183	0.15	0.34
9. "HOT" SUMP	0.0010	0.00001	0.010	0.0020	0.013	0.01	0.02
Totals	0.0528	0.0007	0.5454	0.1057	0.70	0.59	1.30

COLUMBUS - ESTIMATED NAPHTHALENE EMISSIONS FROM A BLACK TIE STORAGE YARD

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Facility	Kerr-McGee Chemical Corporation			
Location	Columbus, MS			
Max. Ties On Site	138,500			
Min. Ties On Site	27,700			
Ties/Unit	27,700			Equivalent Annual Production is 332400 ties/yr.
S.A. of Six 49-tie Bundles	1,212 ft^2			Most conservative surface area from reply to EPA.
Diameter of Test Pole	11 in			
Length of Test Pole	40 ft			
No. of Test Poles	6 poles			
S.A. of Test Poles	699 ft^2			
Emissions (mg/hr):	N1(t) =	18,104	* exp (	0.46683 * t), t <= 0.25 days
(Based on 6 poles with a	N2(t) =	36,697	* exp (	-2.43497 * t), 0.25 < t <= 1.0 day
699 ft^2 surface area)	N3(t) =	3,347	* exp (	-0.04358 * t), t > 1.0 day
Emissions (lb/day/ft^2):	N1(t) =	1.370E-03	* exp (	0.46683 * t), t <= 0.25 days
(Based on 6 poles with a	N2(t) =	2.777E-03	* exp (	-2.43497 * t), 0.25 < t <= 1.0 day
699 ft^2 surface area)	N3(t) =	2.533E-04	* exp (	-0.04358 * t), t > 1.0 day
Calculated 24-hr Average California Pole Test Temperature =				80 °F
Temperature Correction Factor for Other Geographic Locations = exp[-11,161.25*(1/(T, °F+460)-1/(80+460)]				
Assumes 30 days/month				

Month	Black Tie Units on Site	No. of Black Ties	No. of 294-Tie Stacks	Total Yard Surface Area (ft^2)	Percent of Ties __ Months Old					Tram Emissions			Yard Emissions * Percent of Ties __ Months Old Rate N3(t) Emissions (lb naphthalene/ft^2 treated surface area)							Columbus, MS Average Temperature (°F)	Temperature Correction Factor	Total Naphthalene Emissions (lb)
					0 mo.	1 mo.	2 mo.	3 mo.	4 mo.	Surface Area (27700 ties/mo) (ft^2/month)	N1 Rate (lb/ft^2) 0-0.25 d	N2 Rate (lb/ft^2) 0.25-1.0 d						Tram Sum	Yard Sum			
					0-30 d	30-60 d	60-90 d	90-120 d	120-150 d				1.0-30 d	30-60 d	60-90 d	90-120 d	120-150 d					
1	3	83,100	283	342,576	33.3	33.3	33.3			103,047	3.63E-04	5.21E-04	1.33E-03	3.82E-04	1.03E-04			8.84E-04	1.82E-03	41.2	0.202	144
2	4	110,800	377	456,767	25.0	25.0	25.0	25.0		103,047	3.63E-04	5.21E-04	9.98E-04	2.87E-04	7.76E-05	2.10E-05		8.84E-04	1.38E-03	44.9	0.238	172
3	5	138,500	471	570,959	20.0	20.0	20.0	20.0	20.0	103,047	3.63E-04	5.21E-04	7.99E-04	2.29E-04	6.21E-05	1.68E-05	4.54E-06	8.84E-04	1.11E-03	52.6	0.331	240
4	4.43	122,671	417	505,707	22.6	22.6	22.6	22.6	9.7	103,047	3.63E-04	5.21E-04	9.02E-04	2.59E-04	7.01E-05	1.90E-05	2.20E-06	8.84E-04	1.25E-03	62.6	0.502	364
5	3.86	106,843	363	440,454	25.9	25.9	25.9	22.2		103,047	3.63E-04	5.21E-04	1.04E-03	2.97E-04	8.05E-05	1.87E-05		8.84E-04	1.43E-03	70.4	0.688	496
6	3.29	91,014	310	375,202	30.4	30.4	30.4	8.7		103,047	3.63E-04	5.21E-04	1.22E-03	3.49E-04	9.45E-05	7.30E-06		8.84E-04	1.67E-03	77.7	0.915	656
7	2.71	75,186	256	309,949	36.8	36.8	26.3			103,047	3.63E-04	5.21E-04	1.47E-03	4.23E-04	8.17E-05			8.84E-04	1.98E-03	80.9	1.035	728
8	2.14	59,357	202	244,697	46.7	46.7	6.7			103,047	3.63E-04	5.21E-04	1.86E-03	5.35E-04	2.07E-05			8.84E-04	2.42E-03	80.1	1.004	686
9	1.57	43,529	148	179,444	63.6	36.4				103,047	3.63E-04	5.21E-04	2.54E-03	4.17E-04				8.84E-04	2.96E-03	74.1	0.796	495
10	1	27,700	94	114,192	100.0					103,047	3.63E-04	5.21E-04	3.99E-03					8.84E-04	3.99E-03	62.3	0.496	272
11	1	27,700	94	114,192	100.0					103,047	3.63E-04	5.21E-04	3.99E-03					8.84E-04	3.99E-03	51.1	0.311	170
12	2	55,400	188	228,384	50.0	50.0				103,047	3.63E-04	5.21E-04	2.00E-03	5.74E-04				8.84E-04	2.57E-03	44.1	0.229	[illegible]
														Emissions for maximum on-site storage of 138500 ties is:							Total (lb/yr)	4,578
														Annual Production is 332400 ties/yr							Total (tons/yr)	2.29

INDIVIDUAL HAP EMISSIONS (tons/yr)					TOTAL
HAP	Quinoline	Biphenyl	Naphthalene	Dibenzofuran	HAPs
Percentage	7.5%	1.5%	77.4%	15.0%	(tons/yr)
Totals (tons/yr)	0.22	0.04	2.29	0.44	3.00

Note: Black tie storage yard emissions were based on measured naphthalene emissions only. The additional three HAPs will therefore be additive.

PARTICULATE EMISSIONS - COLUMBUS VEHICULAR TRAFFIC COMPUTATION SHEET
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VEHICLE	QTY	AVERAGE DISTANCE TRAVELED			MEAN VEHICLE SPEED (mph)	MEAN VEHICLE WEIGHT (tons)	MEAN NUMBER OF WHEELS (#)	EMISSION FACTOR (b) (lb/VMT)	EMISSIONS (b) (lb/day)	ANNUAL EMISSIONS (b) (tons/yr)
		NO. OF TRIPS (trips/vehicle/day)	AVG RUN (ft/trip)	VEHICLE MILES TRAVELED (VMT in miles/day (b)						
1. DELIVERY TRUCKS, (WOOD - INBOUND)	12	1	7,920	18.00	5	27.5	18	0.8691	15.6446	2.8473
2. DELIVERY TRUCKS, (OUTBOUND)	4	1	2,640	2.00	5	27.5	18	0.8691	1.7383	0.3164
3. FORK TRUCKS, TAYLOR TEH-300L,	7	50	500	33.14	5	15.0	4	0.2681	8.8842	1.6169
4. FORK LIFT, WINHAM W-8	1	25	100	0.47	5	8.0	4	0.1726	0.0817	0.0149
5. FORK LIFT, NASCO DF-8	1	25	100	0.47	5	8.0	4	0.1726	0.0817	0.0149
6. FORK LIFT, NISSAN WF 30A35V	1	25	100	0.47	5	3.8	4	0.1016	0.0481	0.0088
7. FORK LIFT, JOHN DEERE 644B	2	50	500	9.47	5	17.0	4	0.2926	2.7708	0.5043
8. MOBILE DIESEL, PRENTICE KNUCKLEBOOM (210	3	4	1,400	3.18	5	6.0	4	0.1411	0.4491	0.0817
9. MOBILE DIESEL, PRENTICE KNUCKLEBOOM (210	4	4	1,400	4.24	5	6.0	4	0.1411	0.5988	0.1090
10. TIMBERJACK SKIDDER, 230D (a)	1	5	500	0.47	5	6.0	4	0.1411	0.0668	0.0122
11. BACKHOE, FORD 455C	1	10	1,100	2.08	5	6.3	4	0.1452	0.3026	0.0551
12. 1/2 TON PICKUPS	9	10	1,350	23.01	5	2.5	4	0.0765	1.7598	0.3203
									Total (tons/yr)	5.9016

(a) The Timberjack is only driven on a concrete drip pad, therefore, there are no dust emissions.
(b) Calculations:

Vehicle Miles Traveled/Day (VMT/day) = [# of Vehicles] * [Trips/Day/Vehicle] * [Avg. Trip Length, ft] / [5,280 ft/mile]
Emission Factor (lb/VMT) = [(Particle Size, μm)*5.9] * [% Silt/12] * [(Speed, mph)/30] * [((Vehicle Wt., tons)/3)^0.7] * [(# Wheels/4)^0.5] * [(365 - # Wet Days)/365]
Emissions (lb/day) = [Emission Factor, lb/VMT] * [Miles Traveled, VMT/day]
Annual Emissions (tons/yr) = [Emissions, lb/day] * [7 days/week] * [52 weeks/yr] / [2,000 lb/ton]

VARIABLES
Particle Size Multiplier

SIZE	X
<= 30 μm	0.8
<= 15 μm	0.5
<= 10 μ	0.36
<= 5 μm	0.2
<= 2.5 μ	0.095

selection
0.36

Road Type	% silt	selection
Gravel	5	5
Dirt	28.5	
C Limestone	9.6	

Rain Days (by Site) AP-42	p	selection
Madison, Illinois	115	110
Avoca, Pennsylvania	130	
The Dalles, Oregon	165	
Columbus, Mississippi	110	
Texarkana, Texas	100	
Springfield, Illinois	115	
Indianapolis, Indiana	125	

Precipitation/Evapotranspiration Data for Columbus

Month	Precip (in)	Evap (in)	Surplus/(Deficit)	Wet days
Jan	5.65	0.85	4.80	30
Feb	4.63	1.76	2.87	30
Mar	6.94	3.63	3.31	30
Apr	5.66	6.08	(0.42)	0
May	5.22	7.75	(2.53)	0
Jun	3.72	8.41	(4.69)	0
Jul	4.59	8.10	(3.51)	0
Aug	2.84	7.31	(4.47)	0
Sep	3.64	5.79	(2.15)	0
Oct	2.99	4.47	(1.48)	0
Nov	4.63	2.51	2.12	30
Dec	5.61	1.21	4.40	30
			Wet days	150

Assumptions
1. Assumes 52 wks/yr, 7 days/wk, 24 hrs/day operation
2. The greater number of Wet (or Rain) Days from the AP-42 or Weather Data was used.

APPENDIX 5

DATA EVALUATIONS

EVALUATIONS OF EMISSIONS MONITORING REPORTS FROM THE KERR-McGEE PLANT IN AVOCO, PA AND MADISON, IL AND THE KOPPERS PLANT IN SUSQUEHANNA, PA

INTRODUCTION

The Kerr-McGee Chemical Corporation (KMCC) owns and operates creosote wood treating plants in Avoca, PA and Madison, IL, as well as facilities in other states. One emissions data report for organic emissions is available from the EPA for tests performed at the Avoca, PA plant. Two emissions reports are available from Industrial Hygiene Resources (IHR), Ltd. and one from Mostardi-Platt Associates (MPA), Inc. for testing at the Madison, IL plant. The purpose of this report is to compare and contrast the available emissions data as well as determining the relative usefulness of these reports for use in determining emissions factors.

EPA EMISSIONS REPORT

EPA Emissions Testing - Avoca, Pennsylvania Facility

EPA conducted emissions testing of carbon from a creosote charge at the KMCC Avoca plant in order to determine hazardous air pollutants (HAPs) emissions from a wood treating operation. EPA calibrated their carbon analyzers to propane and then converted to creosote and then to naphthalene, the representative HAP for the wood treating process. The goal was to calculate the pounds of naphthalene released to the atmosphere each year in order to compare against the maximum HAPs emission rate of 10 tons/year.

The results of EPA's emission testing for the Avoca, PA plant are shown in Table 1. There were six steps monitored during a creosote charge at the plant. The following calculations refer to the first part of the cycle, the 12-hour Boulton (moisture removal) phase of the wood treatment cycle, as shown in Table 1 and Equation (1).

$$Operation\left(\frac{hrs}{charge}\right) = 12\left(\frac{hrs}{charge}\right) \tag{1}$$

The other five cycles were calculated identically to this example for the Boulton phase.

The "EMISSION LOADING Propane lbs/hr" quantity in Equation (2) represented the amount of total hydrocarbons emitted expressed in terms of the propane calibration gas for the flame ionization analyzer/detector (FIA/FID).

$$\mathit{EMISSION\ LOADING\ Propane}\left(\frac{lbs}{hr}\right) = 1.22\left(\frac{lbs}{hr}\right) \quad (measured) \tag{2}$$

Conversations with EPA at Research Triangle Park, NC indicated that EPA Method 25A was most likely used for this measurement (40 CFR § 60, Appendix A, Method 25A). Method 25A explains only the method for operating the flame ionization analyzer and does not contain the calculational procedures for converting emissions in terms of a calibration gas (propane) to actual emissions in terms of creosote.

The "Mass Propane lbs/charge" quantity was calculated based on the length of the operation, as presented in Equation (3).

$$\mathit{Mass\ Propane}\left(\frac{lbs\ propane}{charge}\right) = 12\left(\frac{hrs}{charge}\right) * 1.22\left(\frac{lbs\ propane}{hrs}\right) = 14.64\left(\frac{lbs\ propane}{charge}\right) \tag{3}$$

The quantity labeled "MW RATIO lbs carbon/lb propane" was inappropriately called a molecular weight (MW) ratio. Instead, it represented the mass fraction of carbon (MFC) ratio in the propane (C_3H_8) molecule, as shown by Equation (4).

$$\mathit{MFC\ RATIO}\left(\frac{lbs\ carbon}{lb\ propane}\right) = \frac{C_3}{C_3H_8} = \frac{(3 * 12)}{(3 * 12) + (8 * 1)} = \frac{36}{44} = 0.818\left(\frac{lbs\ carbon}{lb\ propane}\right) \tag{4}$$

The "MW RATIO CREOSOTE TO CARBON 128/120" column was also incorrectly labeled and the given ratio is incorrect since the 128 is the molecular weight of naphthalene rather than creosote. "128/120" was actually the ratio of the total mass of a naphthalene molecule ($C_{10}H_8 = (10 * 12) + 8 = 128$ lbs/lb-mole) to the mass of carbon in the naphthalene molecule ($C_{10} = 10 * 12 = 120$). It may be that this column was mislabeled, but the quantity "lb carbon/lb creosote" was necessary in order to convert the measured propane emission rate to a creosote emission rate.

Because creosote is composed of many polynuclear aromatic compounds (compounds composed of two or more benzene rings that are joined through a common edge or common C—C bond), a single molecular weight for creosote was not available. However, Table 2 shows a breakdown of some of the most abundant compounds in creosote and their percentage of occurrence. This information was used to calculate an estimated molecular weight for creosote, and the result was approximately 172 lbs/lb-mole. The fraction of carbon in creosote was found to be about 0.933 lbs carbon/lb creosote, and the inverse of this ratio was 1.071 lbs creosote/lb carbon. Coincidentally, the 1.071 ratio is very close to the 1.0667 ratio used in the EPA calculations, which are shown in Equation (5).

$$MFC\ RATIO\left(\frac{lbs\ creosote}{lb\ carbon}\right) = \frac{128}{120} = 1.0667\left(\frac{lbs\ creosote}{lb\ carbon}\right) \qquad (5)$$

The conversion from emissions in terms of propane to emissions in terms of creosote is given by Equation (6). This required multiplying the "EMISSION LOADING Propane lb/hr" value by the two "MFC RATIO" conversion factors to arrive at a creosote emission rate.

$$EMISSION\ LOADING\ Creosote\left(\frac{lbs\ creosote}{hr}\right)$$
$$= 1.22\left(\frac{lbs\ propane}{hr}\right)*0.818\left(\frac{lbs\ carbon}{lb\ propane}\right)*1.0667\left(\frac{lbs\ creosote}{lb\ carbon}\right) = 1.0645\left(\frac{lbs\ creosote}{hr}\right) \qquad (6)$$

"Mass Creosote lb/charge" was calculated by multiplying the creosote emission rate by the length of the charging operation as shown in Equation (7).

$$Mass\ Creosote\left(\frac{lbs\ creosote}{charge}\right) = 12\left(\frac{hrs}{charge}\right)*1.0645\left(\frac{lb\ creosote}{hr}\right) = 12.774\left(\frac{lbs\ creosote}{charge}\right) \qquad (7)$$

The "Average Propane" and "Average Naphthalene" emissions in pounds per hour were calculated only for the "Boulton Total" part of the cycle, and not for each process step; that is, a gross number for the total 14-hour, 6-step process was calculated. It is not yet understood why this was done. Conversations with KMCC personnel revealed that the quantity "Mass of Naphthalene lb/charge" was calculated by multiplying an assumed 3 percent of naphthalene in creosote by the quantity "Mass Creosote lb/charge" calculated by Equation (7).

The "Average Propane lb/hour" rate was a division of the pounds of propane per charge by the length of the charge as shown in Equation (8). The calculations shown below use the corresponding length of time in hours for that part of the wood treatment cycle.

$$Average\ Propane\left(\frac{lbs\ propane}{hr}\right) = \frac{16.305\left(\frac{lbs\ propane}{charge}\right)}{14\left(\frac{hrs}{charge}\right)} = 1.165\left(\frac{lbs\ propane}{hr}\right) \qquad (8)$$

The "Average Naphthalene lb/hour" and "Average Creosote lb/hour" were calculated in a manner similar to Equation (8). These calculations are shown in Equations (9) and (10).

$$Average\ Naphthalene\left(\frac{lbs\ naphthalene}{hr}\right) = \frac{0.43\left(\frac{lbs\ naphthalene}{charge}\right)}{14\left(\frac{hrs}{charge}\right)} = 0.030\left(\frac{lbs\ naphthalene}{hr}\right) \qquad (9)$$

$$Average\ Creosote\left(\frac{lbs\ creosote}{hr}\right) = \frac{12.774\left(\frac{lbs\ creosote}{charge}\right)}{12\left(\frac{hrs}{charge}\right)} = 1.064\left(\frac{lbs\ creosote}{hr}\right) \tag{10}$$

The title "HYPOTHETICAL POUNDS/YEAR" was meant to estimate the yearly emissions based on 500 retort charges per year, as given by Equation (11).

$$Production\ Rate\left(\frac{charges}{yr}\right) = 500 \tag{11}$$

Finally, the estimated yearly emissions of propane, creosote, and naphthalene were calculated as presented in Equations (12), (13), and (14), respectively.

$$Mass\ Propane\left(\frac{lbs\ propane}{yr}\right) = 14.640\left(\frac{lbs\ propane}{charge}\right) * 500\left(\frac{charges}{yr}\right) = 7{,}320\left(\frac{lbs\ propane}{yr}\right) \tag{12}$$

$$Mass\ Creosote\left(\frac{lbs\ creosote}{yr}\right) = 12.774\left(\frac{lbs\ creosote}{charge}\right) * 500\left(\frac{charges}{yr}\right) = 6{,}387\left(\frac{lbs\ creosote}{yr}\right) \tag{13}$$

$$Mass\ Naphthalene\left(\frac{lbs\ naphthalene}{yr}\right) = 0.38\left(\frac{lbs\ naphthalene}{charge}\right) * 500\left(\frac{charges}{yr}\right) = 192\left(\frac{lbs\ naphthalene}{yr}\right) \tag{14}$$

Table 3 is a recalculation of EPA's test results. This recalculation checks the basic math of the EPA table, and includes the derived molecular weight for creosote from Table 2. The revised results differ less than two percent from EPA's values. Although the EPA table appears to use several terms incorrectly, the mathematical process by which EPA arrived at an estimated annual creosote emission rate is basically sound. This conclusion is based on the assumption that the propane measurements in pounds per hour are valid and representative. Additional information about the test procedures, conditions, and data would be helpful.

CONCLUSIONS

The EPA report for the Avoca, PA site presented the propane emissions in pounds per hour, without any supporting data (i.e. propane concentrations in ppmv, flow rates, test conditions, etc.). Until the supporting data is provided, the validity of the calculated emission rates is in question, because all subsequent calculations were based on the propane measurements.

The emission report showed an average emission rate of 0.211 lb/hr as naphthalene for a 15 hour Boulton cycle.

REPORTS BY INDUSTRIAL HYGIENE RESOURCES, LTD.

IHR REPORT #1 - MADISON, ILLINOIS FACILITY

INTRODUCTION

In a report incorrectly dated January 24, 1990 (should have been 1991), Industrial Hygiene Resources (IHR), Ltd. presented three emissions reports from tests performed at the KMCC's Madison, IL facility. The dates of the work were December 17-21, 1990 and January 2-5, 1991. The first study was done before without a scrubber control device. When it was determined that the Illinois Environmental Protection Agency (IEPA) maximum emission rate of 8 lb/hr was being exceeded, Boulton processes were suspended until an interim scrubber was installed. Two emission studies were done after the scrubber was installed. The final scrubber design was to be a packed tower scrubber.

ANALYSIS OF DATA - ALL TESTS

The molecular weight (MW) of creosote was assumed by IHR to be 108 g/g-mole. Appendix A of the IHR report contains information on cresol, not creosote. The molecular weight of cresol is given as 108 g/g-mole in the appendix. Calculations by **AquAeTer** show the MW to be near 172 g-gmole, and conversations with Kerr-McGee indicate that the MW of creosote falls in the 170-180 g/g-mole range.

Method 25A (total gaseous organics) and Method 2A (measurement of gas volumes) were both used in December 1990 study. Both of these methods are found in 40 CFR § 60, Appendix A. A flame ionization detector (FID) calibrated with propane was used for the detection of organics. Volumetric flow rate measured with a gas turbine meter down to about 75 cfm. A Kurz mass flow sensor (hot-wire anemometer) was used to measure lower flows. At 75 cfm, the correlation between these two flow monitoring was reported as "good."

Condensable hydrocarbon crystal growth (i.e. naphthalene) clogged the turbine meter with time, making data for the later hours of the cycle "unusable." A heated wire anemometer (Kurz probe) was also used, and the combination of both the turbine meter and anemometer gave good flow information, although significant monitoring problems were encountered because of the naphthalene-like crystal growth in the piping. No indication of naphthalene-like crystal growth was apparent during the January 1991 study in either metering device after the installation of the interim water scrubber.

Data Tables I and II (Run #1 - No Scrubber)

The data points chosen for emissions measurement seem to have been chosen at arbitrary intervals, from periods as short as 2 minutes to as long as 175 minutes. The concentrations did not have units (except for ppmv), and it was not shown if this value is corrected to a dry concentration. Only one concentration was shown for each of the unequal measurement periods. It is unknown if these concentrations were the only measurement taken for that period, the average for that period, etc. Temperature, pressure, and moisture content of flow not given. These quantities are normally needed for air flow calculations to report the results in dry standard conditions. **AquAeTer** believes the correct method for calculating air flows and concentrations and correcting them to dry, standard conditions is shown in Attachment 1. The IHR data and other calculations are presented in Table 4.

The emission rate equation was presented as shown below in Equation (15). No derivation was given for this equation.

$$\text{Emission Rate}\left(\frac{lb}{hr}\right) = 1.655*10^{-5} \; * \; [C\ (ppmv)] \; * \; [Q\ (cfm)] \tag{15}$$

Table II showed that the Boulton cycle was 16.25 hours long, but the data shows a cycle time of only 16 hours. The Boulton TWA emission rate was given as 3.66 lb/hr. **AquAeTer** recalculated the TWA by two different methods: 1) a time-weighted average, and 2) by calculating the area under the emission curve using trapezoids. These methods yielded values of 3.63 lb/hr and 3.76 lb/hr respectively, indicating that the IHR method for calculating the TWA was correct. Numerical integrations of this type would normally be calculated using either Simpson's Rule or the Trapezoid Rule, but these numerical integration methods require evenly-spaced time intervals, which these tests lacked.

At the bottom of this table, IHR attempted to correct the air flow data due to artificially high values caused by vent line restrictions. Since heating the sample line prevented restrictions at VOC sampler, it is logical that a similar method should have been used at the air flow meter to prevent line restriction buildup.

Finally, IHR used time-weighted concentrations and air flows to get emission rates, then time-weighted these emission rates to get a Boulton TWA. Ideally, the entire set of raw data should be time-weight averaged to get a value for the entire process. IHR effectively did a double time-weighted average.

Data Tables III and IV- Run #1 (With Interim Scrubber)

Data points were taken at more regular intervals than previous test, even though the sampling periods ranged from a low of 15 minutes to a high of 240 minutes. Tables III and IV include the Final Vacuum Pressure Treatment after the Boulton cycle, but Table II does not. Therefore, only measurements from the Boulton cycle were considered. This Boulton cycle lasted 15.9 hours, as compared to 16 hours from the previous test. In Table III, concentrations were given as ranges for specific time intervals, and the average concentration for that range was used in the emission calculations. Emission rates were again calculated using Equation (15). The Boulton TWA was calculated as 1.775 lb/hr. **AquAeTer** calculated emission rates of 1.93 lb/hr (TWA method) and 2.05 lb/hr (trapezoid method). The emission rates appear to have been time-weight averaged twice as previously discussed. The IHR data and additional calculations are shown in Table 5.

Data Tables V and VI - Run #2/#3 Cylinder (With Interim Scrubber)

Table V, like Table III, contains data on the Pressure Treatment Final Vacuum cycle. In order to make good comparisons, only measurements from the Boulton cycle are being considered. In Table V, concentrations were given as ranges for specific time intervals, and the average concentration for that range was used in the emission calculations.

The Boulton TWA was given as 1.051 lb/hr in Table VI. **AquAeTer** calculated 0.81 (trapezoidal method) and 1.03 (TWA) from the IHR numbers. The disparity was due to the fact that there were only four data points from which to calculate an area under the curve. More data points give a more accurate curve area. Equation (15) was used once again to calculate the emission rates. The emission rates appear to have been time-weight averaged twice as previously discussed. Table 6 shows the data from this test run.

CONCLUSIONS

Significant emission reductions were observed after the interim scrubber installation. The scrubber reduced VOC emissions to a maximum level of 3.8 lb/hr (Table IV) from the readings of 8 lb/hr and above reported before the scrubber installation (Table II). The time-weighted average (TWA) values were 3.66 lb/hr without the scrubber, and 1.775 lb/hr and 1.051 lb/hr with the scrubber. A packed tower scrubber was scheduled for installation in Spring 1991.

IHR provided no data on test conditions such as air flow temperature and humidity, and repeatedly used an incorrect molecular weight for creosote. Additionally, Equation (15) was used for all of the emission rate calculations, but no derivation was given for this equation. Although IHR's calculations seemed correct, their methods and lack of background data produced questionable results. KMCC later found that IHR had incorrectly calculated the emission rates and independently confirmed this by consulting experts from KMCC, industry, and analytical laboratories. The correct emission rate equation was agreed to be the one shown in Equation (16).

$$\begin{aligned}\text{Emission Rate}\left(\frac{lb\ C_{10}}{hr}\right) &= \left[\left(\frac{C\ (ppmv\ C_3\ equivalents)}{(10^6\ liters\ flow)}\right) * \left(\frac{3\ liters\ C_{10}}{10\ liters\ C_3}\right)\right] \\ &* \left[\left(\frac{Q\ ft^3\ flow}{min}\right) * \left(\frac{28.316\ liters\ flow}{ft^3\ flow}\right) * \left(\frac{60\ min}{hr}\right)\right] \\ &* \left[\left(\frac{128.17\ g\ C_{10}}{24.47\ liters\ C_{10}}\right) * \left(\frac{1\ lb\ C_{10}}{453.59\ g\ C_{10}}\right)\right], \end{aligned} \tag{16}$$

where:

C = measured propane (C_3) concentration, parts per million by volume (ppmv), and

Q = measured air flow rate, cubic feet per minute, $\left(\frac{ft^3}{min}\right)$.

IHR REPORT #2 - MADISON, IL FACILITY

INTRODUCTION

In a report dated August 23, 1991, Industrial Hygiene Resources (IHR), Ltd. presented three sets of emission results from tests performed at the KMCC's Madison, IL facility. The dates of the work were May 2-4, 1991. Measurements for organics were taken after the air flow had passed through the permanent scrubber, but air flow measurements were taken prior to the scrubber. All measurements appear to have been taken on the combined vacuum exhaust of cylinders (retorts) #3 and #4.

PROCESS SCHEMATIC AND CALCULATION EXPLANATION

IHR provided supplemental information in this report which was absent from the first report. Figure I from this report showed a schematic of the general wood treating process and the location of the measuring devices. The calculation explanation was a handwritten attempt to provide the derivation of Equation (15). Several outside sources, as well as KMCC personnel, stated that Equation (15) was incorrectly used to calculate emission rates. Once again, 108 was incorrectly used as the MW for creosote, and flow rates and concentrations were not converted to dry standard conditions. Conversion of results to dry standard conditions is normally done in air emission calculations in order to compare emission rates from different sites on the same basis.

Data Table I - (Run #1 on Cylinders #3 and #4 - Boulton Cycle Only)

Air emissions testing included the combined emissions from Cylinders #3 and #4. The Boulton cycle from #3 was 14 hours long, and the #4 cycle was 15 hours long. Flow rate was measured before the scrubber, and the FID probe was placed after the scrubber. Ideally, both of these quantities should have been measured at the same point. Temperatures of the air flow were taken before and after the scrubber to correct for the fact that the FID probe and air flow meter were not in the same place. The form of this correction factor is shown in Equation (17).

$$Q_{(after\ scrubber)}\,(acfm) = Q_{(before\ scrubber)}\,(acfm) * \left(\frac{T_{after}(^{\circ}F) + 460}{T_{before}(^{\circ}F) + 460}\right)$$

$$\text{where}$$

$$T_{before} \geq T_{after} \quad \text{(due to the cooling effect of the scrubber)} \tag{17}$$

$$\text{and therefore}$$

$$\left(\frac{T_{after}(^{\circ}F) + 460}{T_{before}(^{\circ}F) + 460}\right) \leq 1 \quad \text{in most cases.}$$

In other words, the cooled air flow rate after the scrubber should have been lower than the warmer air flow rate before the scrubber. This air flow rate correction factor was calculated correctly in the handwritten data in Appendix C of the report. Additionally, there is still the consensus by various KMCC officials, vendors, and chemists that IHR again incorrectly used Equation (15) to calculate the emission rates.

The Boulton cycle TWA emissions as propane were calculated by **AquAeTer** were 0.92 lb propane/hr. Equation (18), which was derived from Equation (16), was used to calculate the propane emission mass rates in lb/hr. Calculations for this test run are shown in Table 7. Equation (18) is shown below.

$$\begin{aligned} \text{Emission Rate}\left(\frac{lb\ C_3H_8}{hr}\right) &= \left[\left(\frac{C\ (ppmv\ C_3H_8)}{(10^6\ liters\ flow)}\right)\right] \\ &* \left[\left(\frac{Q\ ft^3\ flow}{\text{min}}\right) * \left(\frac{28.316\ liters\ flow}{ft^3\ flow}\right) * \left(\frac{60\ \text{min}}{hr}\right)\right] \\ &* \left[\left(\frac{44\ g\ C_3H_8}{24.47\ liters\ C_3H_8}\right) * \left(\frac{1\ lb}{453.59\ g}\right)\right], \end{aligned} \tag{18}$$

where:

C = measured propane (C_3) concentration, parts per million by volume (ppmv), and

Q = measured air flow rate, cubic feet per minute, $\left(\frac{ft^3}{min}\right)$.

Data Table II - (Run #2 on Cylinders #3 and #4 - Boulton Cycle Only)

Air emissions testing included the combined emissions from Cylinders #3 and #4. The Boulton cycle for both cylinders was 13 to 14 hours long. Flow rate was measured before the scrubber, and the FID probe was placed after the scrubber. Ideally, both of these quantities should have been measured at the same point, as previously discussed. The temperature correction described in Equation (16) was also used in the Table II calculations in the report.

The IHR Boulton cycle TWA propane emissions were 0.78 lb/hr. Results from this test appear in Table 8.

Data Table III - (Run #3 on Cylinders #3 and #4 - Boulton Cycle Only)

Air testing included emissions from both Cylinders #3 and #4. The Boulton cycle for Cylinders #3 and #4 was 13.5 and 14.75 hours long, respectively. Flow rate was measured before the scrubber, and the FID probe was placed after the scrubber. As previously discussed, both of these quantities should have been measured at the same point. The temperature correction described in Equation (16) was again used in the calculations for this section of the report, although these calculations were performed by a method which industry officials have called incorrect.

The IHR Boulton TWA emissions were calculated as 0.80 lb/hr. The test data is shown in Table 9.

MOSTARDI-PLATT ASSOCIATES (MPA), INC. REPORT

In a May 24, 1988 report, Mostardi-Platt Associates (MPA), Inc. presented emission results from tests performed at KMCC's Madison, IL facility. The dates of the work were April 4-8, 1988. Tests were performed at the pump exhausts of Cylinders #2, #3 and #4 as well as the #6 and #7 heated creosote holding tanks (work tanks). No problems with the test equipment were reported.

MPA had the most comprehensive approach to measuring flow and concentrations. They performed the correct calculations to put the flow rates on a dry standard basis, and even provided some of the formulae used to do this. However, the emissions equation they used did not have a derivation shown, and emissions measurements were performed only for parts of the entire wood treating process. The measurements were not made with time during the duration of the Boulton process as was done in the IHR reports. Emissions were measured as Total Gaseous Non-Methane Organics (TGNMO). Despite the fact that MPA used a more rigorous and correct approach, their data is the least usable of all the reports reviewed. The emissions equation used by MPA is shown in Equation (18).

$$Emissions\left(\frac{lb}{hr}\right) = \left[TGNMO\ Conc.\left(\frac{mg\ C}{m^3}\right)\right] * \left[\frac{6.24 * 10^{-8}\left(\frac{m^3}{dscf}\right)}{\left(\frac{mg}{lb}\right)}\right] * dscfm * 60\left(\frac{min}{hr}\right) \tag{18}$$

where:

TGNMO = Total Gaseous Non-Methane Organics, $\left(\frac{mg\ C}{m^3}\right)$,
dscf = dry standard cubic feet, and
dscfm = dry standard cubic feet per minute.

The organic vapor analyzer (OVA) used by MPA had a scale of 1-10,000 ppm and was calibrated using 100 ppm and 9,210 ppm methane. There is a discrepancy between the scale limits and results which were listed as greater than 10,000 (+10,000).

The only Boulton cycle measured by MPA was on Cylinder #3 (4/6/88) and lasted about two and one-half hours. The average emissions from the cylinder during that time period were calculated to be 7.67 lb carbon/hr of TGNMO. **AquAeTer** calculated the average emissions to be 8.72 lb carbon/hr based on the MPA results table, although all other average emissions on the table appear to have been averaged correctly. However, when the MPA values were substituted into Equation (16), the average result was 0.91 lb naphthalene/hr. Table 10 contains the MPA test results.

CHESTER ENVIRONMENTAL REPORT FOR KOPPERS INDUSTRIES, INC.

In an April 22, 1994 report, which was a corrected and reissued version of work performed during the period of May 24-25, 1990, Chester Environmental presented emission results from tests performed at Koppers Industries, Inc. Susquehanna Wood Treating Facilities. The work was conducted by Keystone Environmental Resources, Inc., which was a subsidiary of Chester Environmental at that time. The testing program involved sampling the gases emitted from a retort during each step of the wood treatment cycle. This report is a revision of an August, 1990 report which was intended to provide emission factors for calculating SARA Title III releases and to document the emissions of creosote components from the treating process. The compounds on interest in this report were polynuclear aromatic hydrocarbons (PAHs).

Tests that were conducted include Boultonizing in two cylinders, Boultonizing in one cylinder, vacuum pump emissions(assumed during blowback), and vacuum pump emissions during the final vacuum.

The Koppers facility uses three retorts which are 8 feet in diameter and 140 feet long. A 60/40 creosote/coal tar solution is used as the wood preservative. Green wood is treated for moisture removal by the Boulton process, followed by creosote treatment with the Rueping process. During the Rueping process, the cylinder containing the dried wood is pressurized, and creosote is added to displace the pressurized air and heat is added. Additional pressurization is added until the desired product retention is reached. A final vacuum step assists in removing excess creosote.

EPA methods were followed for the determination of gas velocities (Method 1), volumetric flow rates (Method 2), and moisture content (Method 4) in the retort exhaust gas. Modified EPA Method 5 was used for the determination of PAHs. Volumetric flow rates were reported in terms of ACFM, SCFM, and DSCFM. The calculated emission factors were presented as pounds of individual PAHs/ft^3 of wood treated.

EPA Modified Method 5 involved measuring the PAH compounds with an XAD collection medium in the sample train. Water portions from the sample train were extracted and combined with the XAD extract. The resulting sample was analyzed using EPA Method 610 for 18 PAHs. No problems with the testing equipment were reported.

Emissions (and emissions factors) were reported as the mass of a specific PAH per hour or cubic foot of wood treated, instead of reporting emissions in terms of an OVA calibration gas. The calculational procedure used is shown below and generally held true for Tables 1 through 5 in the Koppers report. The volumetric air flows were measured using the procedures shown in Attachment 1. The procedure began with the measured information shown in Equation (19).

The sample concentration was calculated by dividing the analytical results by the sample size and converting units, as presented in Equation (20).

From Table 1. Example Calculation for Naphthalene
Sample Size (ft^3) = 17.8
Air Flow (DSCFM) = 227
Wood Treated (ft^3) = 5,852 **(19)**
Hours of Operation (hr) = 17.9
Sample Number = *SUS-FC1-1*

$$\text{Analytical Results for Naphthalene}\left(\frac{\text{mg naphthalene}}{\text{total sample}}\right) = 24.7$$

$$\text{Sample Concentration}\left(\frac{\text{lb naphthalene}}{ft^3}\right) = \left[\frac{\left(\frac{24.7\ \text{mg naphthalene}}{\text{total sample}}\right) * \left(\frac{1\ g}{1{,}000\ mg}\right) * \left(\frac{1\ lb}{453.59\ g}\right)}{17.8\ \frac{ft^3}{\text{total sample}}}\right] \tag{20}$$

$$= 3.06 * 10^{-6}\left(\frac{\text{lb naphthalene}}{ft^3}\right)$$

The Process Mass Emission of each compound in pounds per hour was calculated by multiplying the sample concentration by the air flow a shown in Equation (21).

$$\text{Process Mass Emission}\left(\frac{\text{lb naphthalene}}{hr}\right) = \left(3.06 * 10^{-6}\ \frac{lb}{ft^3}\right) * \left(227\ \frac{\text{dry standard } ft^3}{\text{min}}\right) * \left(\frac{60\ \text{min}}{hr}\right) \tag{21}$$

$$= 4.16 * 10^{-2}\left(\frac{\text{lb naphthalene}}{hr}\right)$$

The Calculated Emission Factor was calculated as the product of the Process Mass Emission and the hours of operation, divided by the volume of wood treated, as displayed in Equation (22).

$$\text{Calculated Emission Factor}\left(\frac{\text{lb naphthalene}}{ft^3\ \text{treated wood}}\right) = \left[\frac{\left(4.16 * 10^{-2}\ \frac{lb}{hr}\right) * (17.9\ hr)}{(5{,}852\ ft^3\ \text{treated wood})}\right] \tag{22}$$

$$= 1.27 * 10^{-4}\left(\frac{\text{lb naphthalene}}{ft^3\ \text{treated wood}}\right)$$

Equations (20) through (22) were used to calculate the Sample Concentrations, Process Mass Emissions, and Calculated Emission Factors for the remaining 17 PAHs in Table 1 of the report and in Tables 2 through 4 of the report.

Table 1 of the report presented the vacuum pump emissions from Boultonizing in two cylinders. Table 2 showed the vacuum pump emissions from a single Boulton cycle. Vacuum pump emissions from air releases during the Rueping process were given in Table 3, while Table 4 contained vacuum pump emissions from the final vacuum step. Table 5 of the report was a summary of emission factors from the wood conditioning, air release, and final vacuum steps of the wood treatment process.

The totals of these emission factors were $1.45*10^{-4}$ lb/ft^3 for wood conditioning, $7.60*10^{-5}$ lb/ft^3 for air releases, and $4.66*10^{-6}$ lb/ft^3 for the final vacuum. Emission factors for the wood conditioning step were averages of the values for each compound from Tables 1 and 2 of the report. Air release and final vacuum emission factors came directly from Tables 3 and 4 of the report, respectively.

The total of the wood conditioning, air release, and final vacuum emission factors was $2.25*10^{-4}$ lb of "creosote"/ft^3 of wood treated (assuming that the 18 compounds analyzed form the majority of creosote constituents). Actually, 10 of the 18 compounds investigated in the Koppers report appear in Table 2 of this report, indicating that they are among the most prevalent compounds found in creosote. Assuming that the sum of the compounds analyzed in each test is representative of creosote, Table 2 of the report listed $5.92*10^{-3}$ lb creosote/hr for Boultonizing in one cylinder.

Although Table 1 of the report showed emissions for two cylinders and Table 2 showed results from one cylinder, the average ratio of the two-cylinder values to the one-cylinder values was about 6.7, instead of being doubled, as might be expected.

The Chester/Keystone/Koppers report provided field data sheets which documented the tests well and provided process information in a straightforward manner. The wood treatment production forms were included in the documentation. The report had the most correct and verifiable calculations for converting actual flow to DSCFM and, using concentrations, to obtain emission rates in units of mass per time. However, the IHR, MPA, and EPA reports presented emissions in terms of the calibration gas (which were converted totally to naphthalene emissions), whereas the Chester report presented emissions in terms of individual compounds. This made comparisons with the other emissions reports difficult.

CONCLUSIONS

All the reports reviewed presented their results in different units, measured under different conditions (actual vs. dry standard, with and without scrubber, etc.), and used different measurement techniques, intervals, calculational methods. However, all reports followed the EPA Methods 2A and 25A from 40 CFR § 60, Appendix A. It was difficult to compare the results in more than a general way due to these differences. Whenever possible, the test results were put into standard units of pounds of naphthalene per hour by the use of Equation (16). The comparison of these results is presented in Table 11, which presents the process conditions under which each set of tests was performed. The Avoca, PA data table from EPA was excluded from the comparison due to the lack of adequate background information. The result of this exclusion was that only results from tests done during Boulton cycles at the Madison, IL plant were compared.

EMISSION FACTORS

The results reviewed in this report may be suitable for computing emission factors at other KMCC plants which have nearly identical processes. No standard methods were found for the calculation or reporting of such results, although the draft emission factor document for the wood preserving industry for AP-42 provided some guidance. However, the conversion of the available emissions data to units of naphthalene, and converting emissions rates measured with scrubbers to rates measured without them, suitable emission factors might be calculated.

Table 12 shows an example emission factor calculation. The basis for this calculation was the liquid surface area in a 7 ft diameter cylinder with 6 in of headspace. The resulting liquid surface area is 541 ft^2. It was assumed that the scrubber was 75 percent efficient, as it will probably be necessary to convert scrubbed emissions to an unscrubbed basis. It was also assumed that the wood preserving operations were continuous throughout the year (8,760 hr/yr). Other factors upon which an emissions factor may be based include: the volume of wood treated, the volume of the retort, or the volume of preservative in the retort, etc. The method is to obtain a representative factor of the form (lb naphthalene emitted/time/process characteristic) which can be used to predict emissions at other KMCC facilities.

ABLE 1. EST RESULTS FOR THE AVOCA, PA FACILITY

RESULTS OF EPA'S TEST DATA
AVOCA, PA

YCLE	Operation Hours	EMISSION LOADING Propane lb/hour	Mass Propane lb/charge	MW RATIO lb carbon/ lb propane .818	MW RATIO CREOSOTE TO CARBON 128/120	EMISSION LOADING Creosote lb/hour	Mass Creosote lb/charge	POUNDS/HOUR Average Propane lb/hour	Average Naphthalene lb/hour	Average Creosote lb/hour
oulton	12	1.2200	14.640	0.8180	1.0667	1.0645	12.774			1.064
st Blowback	0.25	0.7700	0.193	0.8180	1.0667	0.6719	0.168			0.672
ressurization	0.5	0.1200	0.060	0.8180	1.0667	0.1047	0.052			0.105
nd Blowback	0.25	0.7700	0.193	0.8180	1.0667	0.6719	0.168			0.672
inal Vacuum	1	1.2200	1.220	0.8180	1.0667	1.0645	1.064			1.064
3oulton Total	14		16.305				14.227	1.165	0.030	1.01
Retort Door	1	6.7500	6.750	0.8180	1.0667	5.8896	5.890	6.750	0.177	5.890
Charge Total	15		23.055				20.116	7.915	0.207	6.906

CYCLE	Operation Hours	Propane lb/hour	POUNDS/CHARGE Mass Propane lb/charge	Mass Creosote lb/charge	Mass Naphthalene lb/charge	HYPOTETHICAL POUNDS/YEAR Mass Propane lb/year 500 charges	Mass Creosote lb/year 500 charges	Mass Naphthalene lb/year 500 charges
Boulton	12	1.22	14.64	12.77	0.38	7320	6387	192
1st Blowback	0.25	0.77	0.19	0.17	0.01	96	84	3
Pressurization	0.5	0.12	0.06	0.05	0.002	30	26	1
2nd Blowback	0.25	0.77	0.19	0.17	0.01	96	84	3
Final Vacuum	1	1.22	1.22	1.06	0.03	610	532	16
Boulton Total	14		16.31	14.23	0.43	8153	7113	213
Retort Door	1	6.75	6.75	5.89	0.18	3375	2945	88
Charge Total	15		23.06	20.12	0.60	11528	10058	302

TABLE 2. ESTIMATED MOLECULAR WEIGHT FOR CREOSOTE

Source: EVALUATION OF EMISSION SOURCES FROM CREOSOTE WOOD TREATMENT OPERATIONS PB89-224729

MIDWEST RESEARCH INSTITUTE
CARY, NC JUNE 89

Basis: 97.4 lb Creosote									
Creosote Component	Whole Creosote (a) (%)	Component Molecular Weight (lbs/lb-mole)	Mass of Component (lbs)	Moles of Component (lb-mole)	Mole Percent in Creosote (%)	Contribution to MW (lbs/lb-mole)	No. of Carbon Atoms in Molecule (#)	Mass Fraction of Carbon in Molecule (fraction)	Contribution to Carbon Mass Fraction (lbs C/lb Creosote)
Naphthalene (b)	10.0	128.2	10.0	0.078	13.8	17.7	10	0.94	0.129
2-Methylnaphthalene	1.2	142.2	1.2	0.008	1.5	2.1	11	0.93	0.014
1-Methylnaphthalene	0.9	142.2	0.9	0.006	1.1	1.6	11	0.93	0.010
Biphenyl	0.8	154.2	0.8	0.005	0.9	1.4	12	0.93	0.009
Dimethylnaphthalenes	2.0	156.2	2.0	0.013	2.3	3.5	12	0.92	0.021
Acenaphthene	9.0	156.2	9.0	0.058	10.2	15.9	12	0.92	0.094
Dibenzofuran	5.0	168.2	5.0	0.030	5.3	8.8	12	0.86	0.045
Fluorene	10.0	166.2	10.0	0.060	10.6	17.7	13	0.94	0.100
Methylfluorenes	3.0	180.2	3.0	0.017	2.9	5.3	14	0.93	0.027
Phenanthrene	21.0	178.2	21.0	0.118	20.8	37.1	14	0.94	0.196
Anthracene	2.0	178.2	2.0	0.011	2.0	3.5	14	0.94	0.019
Carbazole	2.0	167.2	2.0	0.012	2.1	3.5	12	0.86	0.018
Methylphenanthrenes	3.0	192.2	3.0	0.016	2.8	5.3	15	0.94	0.026
Methylanthracenes	4.0	192.2	4.0	0.021	3.7	7.1	15	0.94	0.034
Fluoranthene	10.0	202.3	10.0	0.049	8.7	17.7	16	0.95	0.083
Pyrene	8.5	202.3	8.5	0.042	7.4	15.0	16	0.95	0.070
Benzofluorenes	2.0	216.3	2.0	0.009	1.6	3.5	17	0.94	0.015
Chrysene	3.0	228.3	3.0	0.013	2.3	5.3	18	0.95	0.022
Total	97.4			0.566	100.0	172.0			0.9333

Average Molecular Weight of Creosote	172.0 lbs/lb-mole
Average Mass of Carbon in Creosote	160.6 lbs carbon/lb-mole creosote
Average Mass Fraction of Carbon in Creosote	0.9333 lbs carbon/lb creosote
Mass Ratio of Creosote/Carbon	1.0714 lbs creosote/lb carbon

(a) Assumes weight percent.
(b) The naphthalene percentage was increased from the literature value of 3% to 10% in order to more accurately reflect the Avoca plant operation.

TABLE 3. RECALCULATION OF EPA's TEST DATA FOR THE AVOCA, PA PLANT

					MFC (a)				CALCULATED EMISSIONS			
Cycle	Operation (hrs/charge)	Hydrocarbon Emissions as Propane (lbs/hr)	Mass of Propane (lbs/charge)	Mass of Naphthalene (lbs/charge)	Mass Ratio (lbs carbon/ lb propane)	Mass Ratio (lbs creosote lb carbon)	Calculated Creosote Emissions (lbs/hr)	Mass of Creosote (lbs/charge)	Average Propane (lbs/hr)	Average Naphthalene (lbs/hr)	Average Creosote (lbs/hr)	Average Creosote (lbs/15 min)
Boulton	12	1.22	14.64	0.38	0.818	1.0714	1.0695	12.834		0.032	1.069	0.267
1st Blowback	0.25	0.77	0.1925	0.01	0.818	1.0714	0.6750	0.169		0.040	0.675	0.169
Pressurization	0.5	0.12	0.06	0.002	0.818	1.0714	0.1052	0.053		0.004	0.105	0.026
2nd Blowback	0.25	0.77	0.1925	0.01	0.818	1.0714	0.6750	0.169		0.040	0.675	0.169
Final Vacuum	1	1.22	1.22	0.03	0.818	1.0714	1.0695	1.069		0.030	1.069	0.267
Boulton Total	14		16.305	0.43	0.818	1.0714		14.294	1.165	0.031	1.021	0.255
Retort Door	1	6.75	6.75	0.18	0.818	1.0714	5.9173	5.917	6.750	0.180	5.917	1.479
Charge Total	· 15		23.055	0.61	0.818	1.0714		20.211	7.915	0.211	6.938	1.735

							ESTIMATED ANNUAL EMISSIONS		
Cycle	Operation (hrs/charge)	Propane (lbs/hr)	Mass of Propane (lbs/charge)	Mass of Creosote (lbs/charge)	Mass of Naphthalene (lbs/charge)	Charges per Year (#)	Propane Emissions (lbs/yr)	Creosote Emissions (lbs/yr)	Naphthalene Emissions (lbs/yr)
Boulton	12	1.22	14.64	12.83	0.380	500	7,320	6,417	190
1st Blowback	0.25	0.77	0.19	0.17	0.010	500	96	84	5
Pressurization	0.5	0.12	0.06	0.05	0.002	500	30	26	1
2nd Blowback	0.25	0.77	0.19	0.17	0.010	500	96	84	5
Final Vacuum	1	1.22	1.22	1.07	0.030	500	610	535	15
Boulton Total	14		16.31	14.29	0.430	500	8,153	7,147	216
Retort Door	1	6.75	6.75	5.92	0.180	500	3,375	2,959	90
Revised Totals	15		23.06	20.21	0.610	500	11,528	10,105	306
EPA Totals							11,528	10,058	302
Percent Difference							0.0	-0.5	-1.3

(a) Mass Fraction of Carbon

TABLE 4. FIRST IHR REPORT- DECEMBER 19-20, 199
BOULTON CYCLE ONLY (NO SCRUBBER, #3 CYLINDER)
MADISON, IL

TABLE I

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Total Hydrocarbon Conc., C (ppmv)	Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emissions Rate by Eqn. (16) as Naphthalene (lb/hr)	Corrected Emissions TWA Rate by Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1	0	0	0.0	0	0	0.00	0.00	0.00	0.00	0.00	3.76	8
2	128	128	2.1	150	180	0.45	0.16	0.02	0.13	0.06	3.76	8
3	9	137	2.3	1,000	108	1.79	0.64	0.01	0.01	0.02	3.76	8
4	6	143	2.4	6,000	82	8.14	2.90	0.02	0.01	0.05	3.76	8
5	23	166	2.8	9,000	77	11.47	4.08	0.10	0.02	0.27	3.76	8
6	10	176	2.9	7,100	74	8.70	3.09	0.03	0.01	0.09	3.76	8
7	4	180	3.0	5,400	58	5.18	1.84	0.01	0.00	0.02	3.76	8
8	11	191	3.2	10,000	66	10.92	3.88	0.04	0.01	0.13	3.76	8
9	2	193	3.2	5,800	69	6.62	2.36	0.00	0.00	0.01	3.76	8
10	6	199	3.3	6,000	66	6.55	2.33	0.01	0.01	0.04	3.76	8
11	9	208	3.5	6,800	71	7.99	2.84	0.03	0.01	0.07	3.76	8
12	5	213	3.6	7,800	69	8.91	3.17	0.02	0.01	0.05	3.76	8
13	6	219	3.7	7,800	66	8.52	3.03	0.02	0.01	0.05	3.76	8
14	6	225	3.8	5,600	66	6.12	2.18	0.01	0.01	0.04	3.76	8
15	9	234	3.9	6,000	66	6.55	2.33	0.02	0.01	0.06	3.76	8
16	2	236	3.9	8,500	66	9.28	3.30	0.01	0.00	0.02	3.76	8
17	10	246	4.1	10,000	62	10.26	3.65	0.04	0.01	0.11	3.76	8
18	10	256	4.3	7,000	66	7.65	2.72	0.03	0.01	0.08	3.76	8
19	46	302	5.0	6,000	80	7.94	2.83	0.14	0.05	0.38	3.76	8
20	8	310	5.2	10,000	106	17.54	6.24	0.05	0.01	0.15	3.76	8
21	26	336	5.6	9,500	88	13.84	4.92	0.13	0.03	0.37	3.76	8
22	13	349	5.8	8,000	88	11.65	4.14	0.06	0.01	0.16	3.76	8
23	30	379	6.3	4,000	110	7.28	2.59	0.08	0.03	0.23	3.76	8
24	58	437	7.3	7,000	128	14.83	5.27	0.32	0.06	0.90	3.76	8
25	9	446	7.4	4,000	66	4.37	1.55	0.01	0.01	0.04	3.76	8
26	19	465	7.8	3,800	22	1.38	0.49	0.01	0.02	0.03	3.76	8
27	76	541	9.0	6,000	14	1.39	0.49	0.04	0.08	0.11	3.76	8
28	138	679	11.3	5,000	15	1.24	0.44	0.06	0.14	0.18	3.76	8
29	21	700	11.7	4,000	10	0.66	0.24	0.01	0.02	0.01	3.76	8
30	5	705	11.8	3,800	7	0.44	0.16	0.00	0.01	0.00	3.76	8
31	63	768	12.8	3,100	5	0.26	0.09	0.01	0.07	0.02	3.76	8
32	17	785	13.1	3,100	2	0.10	0.04	0.00	0.02	0.00	3.76	8
33	175	960	16.0	2,600	2	0.09	0.03	0.01	0.18	0.02	3.76	8

TWA (lb/hr)= 1.34 lb/hr

TABLE 5. FIRST IHR REPORT - JANUARY 2-5, 1991 TEST RUN #1
(WITH SCRUBBER, #3 CYLINDER, BOULTON CYCLE & FINAL VACUUM)
MADISON, IL

TABLE III

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Total Hydrocarbon Conc., C (ppmv)	Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Corrected TWA Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1	0	0	0.0	32	0.0	0.00	0.00	0.00	0.00	0.00	1.99	8
2	15	15	0.3	29	172.5	0.08	0.03	0.00	0.01	0.00	1.99	8
3	15	30	0.5	32	158.5	0.08	0.03	0.00	0.01	0.00	1.99	8
4	15	45	0.8	43	142.5	0.10	0.04	0.00	0.01	0.00	1.99	8
5	15	60	1.0	36	126.0	0.08	0.03	0.00	0.01	0.00	1.99	8
6	20	80	1.3	60	111.0	0.11	0.04	0.00	0.02	0.00	1.99	8
7	20	100	1.7	1,445	103.0	2.46	0.88	0.02	0.02	0.05	1.99	8
8	20	120	2.0	2,000	91.8	3.04	1.08	0.02	0.02	0.06	1.99	8
9	15	135	2.3	3,500	78.2	4.53	1.61	0.02	0.01	0.07	1.99	8
10	30	165	2.8	3,500	76.1	4.41	1.57	0.05	0.03	0.13	1.99	8
11	30	195	3.3	3,000	63.8	3.17	1.13	0.03	0.03	0.09	1.99	8
12	240	435	7.3	3,500	65.8	3.81	1.36	0.31	0.23	0.88	1.99	8
13	150	585	9.8	1,500	70.6	1.75	0.62	0.09	0.14	0.25	1.99	8
14	60	645	10.8	750	73.7	0.91	0.33	0.02	0.06	0.05	1.99	8
15	75	720	12.0	620	67.5	0.69	0.25	0.02	0.07	0.05	1.99	8
16	30	750	12.5	650	63.0	0.68	0.24	0.01	0.03	0.02	1.99	8
17	205	955	15.9	420	63.0	0.44	0.16	0.03	0.20	0.09	1.99	8
BEGIN PRESSURE TREATMENT												
18	30	985	16.4	300	166.0	0.82	0.29	0.01	0.03	0.02	1.99	8
19	15	1000	16.7	1,000	177.8	2.94	1.05	0.02	0.01	0.04	1.99	8
20	20	1020	17.0	900	117.8	1.75	0.62	0.01	0.02	0.03	1.99	8
21	25	1045	17.4	640	640.0	6.78	2.41	0.06	0.02	0.16	1.99	8
							TWA (lb/hr)=	0.71				

TABLE 6. FIRST IHR REPORT - JANUARY 2-5, 1991 TEST RUN #2
(WITH SCRUBBER, #3 CYLINDER, BOULTON CYCLE)
MADISON, IL

TABLE V

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Total Hydrocarbon Conc., C (ppmv)	Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Corrected TWA Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1	0	0	0.0	0	0.0	0.00	0.00	0.00	0.00	0.00	1.05	8
2	110	110	1.8	120	109.2	0.22	0.35	0.06	0.18	0.04	1.05	8
3	45	155	2.6	135	60.8	0.14	0.22	0.02	0.08	0.01	1.05	8
4	60	215	3.6	1,075	54.4	0.97	1.54	0.15	0.10	0.10	1.05	8
5	295	510	8.5	1,500	59.9	1.49	2.37	1.16	0.49	0.73	1.05	8
BEGIN PRESSURE TREATMENT												
6	15	525	8.8	975	140	2.26	3.59	0.09	0.03	0.06	1.05	8
7	75	600	10.0	920	60.0	0.91	1.45	0.18	0.13	0.11	1.05	8
							TWA (lb/hr)=	1.67 lb				
								lb/hr				

TABLE 7. SECOND IHR REPORT - MAY 2, 1991 TEST RUN #1
(WITH SCRUBBER, #3 & #4 CYLINDERS; BOULTON CYCLE, PRESSURE TREATMENT, & FINAL VACUUM)
MADISON. IL

TABLE I

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Avg. Hydrocarbon Conc., C (ppmv)	Temperature Corrected Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Corrected TWA Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1			0.0	0	0	0.00	0.00	0.00	0.00	0.00	2.27	8
2			1.0	1,650	201	5.49	1.95	0.10	0.05	0.29	2.27	8
3			2.0	2,687	98	4.36	1.55	0.08	0.05	0.23	2.27	8
4			3.0	18,079	20	5.98	2.13	0.11	0.05	0.31	2.27	8
5			4.0	19,291	15	4.79	1.70	0.09	0.05	0.25	2.27	8
6			5.0	8,300	15	2.06	0.73	0.04	0.05	0.11	2.27	8
7			6.0	8,962	15	2.22	0.79	0.04	0.05	0.12	2.27	8
8			7.0	8,712	10	1.44	0.51	0.03	0.05	0.08	2.27	8
9			8.0	7,567	13	1.63	0.58	0.03	0.05	0.09	2.27	8
10			9.0	7,107	14	1.65	0.59	0.03	0.05	0.09	2.27	8
11			10.0	7,070	16	1.87	0.67	0.04	0.05	0.10	2.27	8
12			11.0	6,917	17	1.95	0.69	0.04	0.05	0.10	2.27	8
13			12.0	6,698	14	1.55	0.55	0.03	0.05	0.08	2.27	8
14			13.0	6,508	15	1.62	0.57	0.03	0.05	0.09	2.27	8
15			14.0	5,363	14	1.24	0.44	0.02	0.05	0.07	2.27	8
16			15.0	4,558	25	1.89	0.67	0.04	0.05	0.10	2.27	8
BEGIN PRESSURE TREATMENT & FINAL VACUUM												
17			16	2999	35	1.74	0.62	0.03	0.05	0.09	2.27	8
18			17	2660	19	0.84	0.30	0.02	0.05	0.04	2.27	8
19			18	2254	13	0.48	0.17	0.01	0.05	0.03	2.27	8
20			19	1,867	8	0.25	0.09	0.00	0.05	0.01	2.27	8
							TWA (lb/hr)=	0.81				

TABLE 8. SECOND IHR REPORT - MAY 2, 1991 TEST RUN #2
(WITH SCRUBBER, #3 & #4 CYLINDERS, BOULTON CYCLE & FINAL VACUUM)
MADISON. IL

TABLE II

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Avg. Hydrocarbon Conc., C (ppmv)	Temperature Corrected Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emission Rate Eqn. (16) as Naphthalene (lb/hr)	Corrected TWA Emission Rate Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1			0.0	0	0	0.00	0.00	0.00	0.00	0.00	1.91	8
2			1.0	1,188	190	3.74	1.33	0.08	0.06	0.23	1.91	8
3			2.0	1,858	90	2.77	0.98	0.06	0.06	0.17	1.91	8
4			3.0	3,506	16	0.93	0.33	0.02	0.06	0.06	1.91	8
5			4.0	3,554	14	0.82	0.29	0.02	0.06	0.05	1.91	8
6			5.0	5,645	15	1.40	0.50	0.03	0.06	0.09	1.91	8
7			6.0	6,050	15	1.50	0.53	0.03	0.06	0.09	1.91	8
8			7.0	4,738	15	1.18	0.42	0.03	0.06	0.07	1.91	8
9			8.0	6,396	16	1.69	0.60	0.04	0.06	0.11	1.91	8
10			9.0	5,854	13	1.26	0.45	0.03	0.06	0.08	1.91	8
11			10.0	5,500	14	1.27	0.45	0.03	0.06	0.08	1.91	8
12			11.0	4,825	14	1.12	0.40	0.02	0.06	0.07	1.91	8
13			12.0	5,045	22	1.84	0.65	0.04	0.06	0.11	1.91	8
14			13.0	4,448	11	0.81	0.29	0.02	0.06	0.05	1.91	8
BEGIN PRESSURE TREATMENT & FINAL VACUUM												
15			14	9,017	17	2.54	0.90	0.06	0.06	0.16	1.91	8
16			15	6,995	60	6.95	2.47	0.15	0.06	0.43	1.91	8
17			16	4,737	9	0.71	0.25	0.02	0.06	0.04	1.91	8
			3.0				TWA (lb/hr)=	0.68				

TABLE 9. SECOND IHR REPORT - MAY 2, 1991 TEST RUN #3
(WITH SCRUBBER, #3 & #4 CYLINDERS, BOULTON CYCLE & FINAL VACUUM)
MADISON, IL

TABLE III

#	Run Time (min)	Elapsed Time (min)	Elapsed Time (hr)	Avg. Hydrocarbon Conc., C (ppmv)	Temperature Corrected Flow, Q (acfm)	Uncorrected Emission Rate (lb/hr) =1.655E-5(C)(Q)	Corrected Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Corrected TWA Emission Rate per Eqn. (16) as Naphthalene (lb/hr)	Time Weightings Sum=1.00	TWA Contribution (lb/hr)	TWA (lb/hr)	IEPA LIMIT (lb/hr)
1			0.0	0	0	0.00	0.00	0.00	0.00	0.00	1.96	8
2			1.0	776	162	2.08	0.74	0.04	0.06	0.12	1.96	8
3			2.0	3,238	68	3.64	1.30	0.07	0.06	0.20	1.96	8
4			3.0	6,993	27	3.12	1.11	0.06	0.06	0.17	1.96	8
5			4.0	7,203	14	1.67	0.59	0.03	0.06	0.09	1.96	8
6			5.0	7,829	13	1.68	0.60	0.03	0.06	0.09	1.96	8
7			6.0	9,881	15	2.45	0.87	0.05	0.06	0.14	1.96	8
8			7.0	9,775	17	2.75	0.98	0.05	0.06	0.15	1.96	8
9			8.0	9,150	17	2.57	0.92	0.05	0.06	0.14	1.96	8
10			9.0	8,433	16	2.23	0.79	0.04	0.06	0.12	1.96	8
11			10.0	7,383	18	2.20	0.78	0.04	0.06	0.12	1.96	8
12			11.0	6,983	19	2.20	0.78	0.04	0.06	0.12	1.96	8
13			12.0	5,979	17	1.68	0.60	0.03	0.06	0.09	1.96	8
14			13.0	5,338	17	1.50	0.53	0.03	0.06	0.08	1.96	8
15			14.0	4,621	15	1.15	0.41	0.02	0.06	0.06	1.96	8
PRESSURE TREATMENT AND FINAL VACUUM												
16			15	2,674	14	0.62	0.22	0.01	0.06	0.03	1.96	0
17			16	3,155	40	2.09	0.74	0.04	0.06	0.12	1.96	0
18			17	3,429	24	1.36	0.48	0.03	0.06	0.08	1.96	0
19			18	2,471	8	0.33	0.12	0.01	0.06	0.02	1.96	0
							TWA (lb/hr)=	0.70				

BLE 10. MOSTARDI-PLATT ASSOCIATES, INC. REPORT ON KMCC'S MADISON PLANT EMISSIONS RESULTS SUMMARY

Test	Location/Condition	Date	Time (hr)	Air Flow Range First (dscfm)	Air Flow Range Second (dscfm)	Air Flow Range Average (dscfm)	Temp (°F)	Moisture (%)	TGNMO as Carbon (mg C/cu m)
1	#2Cyl/Final Vacuum	4/5/88	0.55	59.7	29.4	44.6	90	4.8	11,521
2	#2Cyl/Final Vacuum	4/8/88	1.03	30.28	26.2	28.2	106	7.7	18,100
1	#3 Cyl/Final Vacuum	4/7/88	0.67	58.8	67.9	63.4	78	3.2	10,084
1	#4 Cyl-#3 Pump/Final Vac.	4/8/88	0.77	109.6	104.4	107.0	76	3.2	1,851
1	#3 Cyl/Boulton	4/6/88	0.75	60.81	42.98	51.9	126	13.7	82,235
2	#3 Cyl/Boulton	4/6/88	0.75	52.4	50.16	51.3	80	3.5	23,772
3	#3 Cyl/Boulton	4/6/88	0.72	51.07		51.1	70	2.5	13,061
			2.22						
1	#4 Cyl./Final Vacuum	4/6/88	0.90	91.53	39.03	65.3	125	13.3	5,791
2	#4 Cyl./Final Vacuum	4/7/88	0.80	51.51	47.06	49.3	90	4.7	8,731
1	#6 Tank/#3 Cyl. Pump Back	4/6/88	0.33	95.38		95.4	90	4.8	1,423
2	#6 Tank/#4 Cyl. Pump Back	4/6/88	0.28	95.24		95.2	90	4.8	1,423
1	#7 Tank/#3 Cyl. Pump Back	4/7/88	0.37	98.12		98.1	108	8.2	1,929

		Naphthalene (lb/hr)		
#3 Cylinder	Final Vacuum	0.45		
	Boulton	0.91		
	Blowback	0.04	Total Treatment	1.40

BLE 10. MOSTARDI-PLATT ASSOCIATES, INC. REPORT ON KMCC'S MADISON PLANT EMISSIONS RESULTS SUMMARY

Test	Location/Condition	Date	Time (hr)	Emissions Range (lb C/hr)	Emissions Range (lb C/hr)	Average Emissions Calculated (lb C/hr)	Average Emissions Reported (lb C/hr)	Average Emissions Difference (lb C/hr)
1	#2Cyl/Final Vacuum	4/5/88	0.55	2.58	1.27			
2	#2Cyl/Final Vacuum	4/8/88	1.03	2.05	1.78	1.92	1.92	0.00
1	#3 Cyl/Final Vacuum	4/7/88	0.67	2.22	2.56			
1	#4 Cyl-#3 Pump/Final Vac.	4/8/88	0.77	0.76	0.72	1.57	1.56	-0.01
1	#3 Cyl/Boulton	4/6/88	0.75	18.72	13.23			
2	#3 Cyl/Boulton	4/6/88	0.75	4.66	4.46			
3	#3 Cyl/Boulton	4/6/88	0.72	2.50		8.72	7.67	-1.05
			2.22		8.72			
1	#4 Cyl./Final Vacuum	4/6/88	0.90	1.98	0.85			
2	#4 Cyl./Final Vacuum	4/7/88	0.80	1.68	1.54	1.51	1.51	-0.00
1	#6 Tank/#3 Cyl. Pump Back	4/6/88	0.33	0.51				
2	#6 Tank/#4 Cyl. Pump Back	4/6/88	0.28	0.51				
1	#7 Tank/#3 Cyl. Pump Back	4/7/88	0.37	0.71		0.57	0.58	0.01

		Naphthalene (lb/hr)	
3 Cylinder	Final Vacuum	0.45	
	Boulton	0.91	
	Blowback	0.04	Total Treatment

ABLE 10. MOSTARDI-PLATT ASSOCIATES, INC. REPORT ON KMCC'S MADISON PLANT EMISSIONS RESULTS SUMMARY

Test	Location/Condition	Date	Time (hr)	Corrected to Naphthalene as per Eqn. (16)		FID Readings		
				First (lb/hr)	Second (lb/hr)	First (ppm)	Second (ppm)	Average (ppm)
1	#2Cyl/Final Vacuum	4/5/88	0.55	0.35	0.29	3,000	5,000	4,000
2	#2Cyl/Final Vacuum	4/8/88	1.03		0.51	+	10,000	NA
1	#3 Cyl/Final Vacuum	4/7/88	0.67	0.63	0.27	5,500	2,000	3,750
1	#4 Cyl-#3 Pump/Final Vac.	4/8/88	0.77	0.26	0.14	1,200	700	950
1	#3 Cyl/Boulton	4/6/88	0.75	0.00	0.84	+	10,000	NA
2	#3 Cyl/Boulton	4/6/88	0.75	0.00	0.98	+	10,000	NA
3	#3 Cyl/Boulton	4/6/88	0.72	0.00		+	10,000	NA
			2.22		0.91			
1	#4 Cyl./Final Vacuum	4/6/88	0.90	0.40	0.38	2,200	5,000	3,600
2	#4 Cyl./Final Vacuum	4/7/88	0.80	0.30	0.07	3,000	800	1,900
1	#6 Tank/#3 Cyl. Pump Back	4/6/88	0.33	0.04		200		200
2	#6 Tank/#4 Cyl. Pump Back	4/6/88	0.28	0.04		200		200
1	#7 Tank/#3 Cyl. Pump Back	4/7/88	0.37	0.04		200		200

		Naphthalene (lb/hr)	
#3 Cylinder	Final Vacuum	0.45	
	Boulton	0.91	
	Blowback	0.04	Total Treatment

TABLE 11. COMPARISON OF EMISSION RATES FROM KERR McGEE BOULTON CYCLES AT THE MADISON, IL FACILITY

Location	Source of Data	Dates of Testing	TWA Emission Rates			Pollution Control Device	Length of Boulton Cycle (hr)	Units in Which Air Flow Was Reported (b)	Averaging Method
			as Originally Reported (lb/hr)	Corrected to Naphthalene (a) (lb/hr)	Corrected to Naphthalene (a) (tons/yr)				
Avoca, PA	EPA	-	-	-	-	-	-	-	-
Madison, IL	IHR	Dec. 17-21, 1990	3.76	1.34	5.86	None	16.0	ACFM	Time-weighted
Madison, IL	IHR	Jan. 2-5, 1991	1.93	0.69	3.00	Interim Scrubber	15.9	ACFM	Time-weighted
Madison, IL	IHR	Jan. 2-5, 1991	1.03	1.64	7.20	Interim Scrubber	8.5	ACFM	Time-weighted
Madison, IL	IHR	May 2-4, 1991	2.65	0.94	4.13	Packed Tower Scrubber	15.0	ACFM	Time-weighted
Madison, IL	IHR	May 2-4, 1991	1.56	0.56	2.44	Packed Tower Scrubber	13.0	ACFM	Time-weighted
Madison, IL	IHR	May 2-4, 1991	2.10	0.75	3.28	Packed Tower Scrubber	15.0	ACFM	Time-weighted
Madison, IL	Mostardi-Platt	April 4-8, 1988	8.72	0.91	4.00	None	2.2	DSCFM	Arithmetic

(a) All values corrected to naphthalene. Tons/yr assumes 365 day/yr operation.

(b) ACFM = Actual Cubic Feet per Minute, DSCFM = Dry Standard Cubic Feet per Minute.

TABLE 12. EMISSION FACTORS FOR BOULTON CYCLES (INCLUDING PRESSURE TREATMENT & FINAL VACUUM) AT THE MADISON FACILITY

Based on Creosote Surface Area in 7' x 150' Retort

Creosote Surface Area @ 6" Headspace: 541 sq ft

Report	Naphthalene Emissions (lb/hr)	Emission Control Device ? (Y/N)	Type of Control Device	Control Device Efficiency (%)	Untreated Naphthalene Emissions (lb/hr)	Untreated Emission Factor (lb/yr/sq ft)	Emissions (tons/yr)	Madison Cylinder #	Assumed Cylinder Size (dia x length)
EPA	0.21	Y	Incinerator	99					
IHR #1	1.34	Y	Scrubber	75	5.36	86.75	23.5	#3	7'x150'
IHR #1	0.71	N	-	0	0.71	11.47	3.1	#3	7'x150'
IHR #1(a)	1.67	Y	Scrubber	75	6.67	108.09	29.2	#3	7'x150'
IHR#2 (c)	0.40	Y	Scrubber	75	1.61	26.10	7.1	#3 & #4	7'x150'
IHR#2 (c)	0.34	Y	Scrubber	75	1.36	21.97	5.9	#3 & #4	7'x150'
IHR#2 (c)	0.35	Y	Scrubber	75	1.40	22.62	6.1	#3 & #4	7'x150'
MPA	1.40	N	-	0	1.40	22.70	6.1	#3	7'x150'
				Avg (b)	1.97	31.93	8.6		

(a) May not be representative; test contained only 5 data points. All other IHR tests contained at least 14 data points.

(b) EPA and IHR#1(a) results not included in averages.

(c) These values represent one-half the reported emissions, because two cylinders were tested simultaneously.

LETTER TO HOLZSCHUH

KERR-McGEE CHEMICAL CORPORATION
KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

September 28, 1994

RECEIVED
OCT 4 1994

Mr. Dennis P. Holzschuh
Environmental Protection Agency
Emission Measurement Branch
Mail Drop 19
Research Triangle Park, NC 27711

Dear Mr. Holzschuh:

Kerr-McGee chemical Corporation (KMCC) permitted U.S. EPA contractor, Science Applications International Corporation (SAIC) to conduct emission tests at KMCC's Avoca, PA creosote wood treating facility for the purpose of determining emission factors from a creosote wood treating facility where an emission control device was in place. Emissions for the Avoca, PA facility were considered by EPA, AWPI, and KMCC as representative of uncontrolled emissions from a creosote wood treating facility.

The "Draft Emissions Testing Report" for the Avoca, PA wood treating facility dated August 3, 1994, as prepared by SAIC for Mr. Eugene Crumpler of the U.S. Environmental Protection Agency (U.S. EPA), has been reviewed. The report lacked much of the expected background detail, although the explanations of procedures and objectives were well presented. Detailed comments and report references are listed below.

CONCLUSIONS AND RECOMMENDATIONS

The draft report clarified the sampling locations, procedures, and objectives of the testing performed at the Avoca facility. Emission values were provided for three steps in the wood treating process, and these values agreed with the summary table originally provided by EPA/SAIC. It was assumed that proper methods and calculations were used to derive the emission values. However, the draft report lacked the raw test data, equations, and sample calculations necessary for Kerr-McGee or others to confirm the calculations and conclusions. Additionally, the test conditions were less than ideal due to unavoidable instances of both test equipment and process equipment failure.

Kerr-McGee is requesting the final report to include the raw test data, equations, and appropriate sample calculations used for data reduction to calculate the air emission values. The draft emissions report indicated that Kerr-McGee's wood treatment facility in Avoca, PA facility has an excellent thermal oxidizer system for odor control of the production process.

SPECIFIC COMMENTS

1. Direct measurements of vacuum pump emissions were not made (p. 2-2, Fig. 2-1). The emissions were measured at the incinerator inlet and include vacuum pump emissions, sap tank vapors, and creosote work tank vapors. Total emissions into the incinerator should therefore provide a conservative estimate of the Boulton cycle emissions. Therefore emissions levels determined by the report are expected to be higher than actual emission values from the vacuum pump as indicated by the report.

2. It appears that average total hydrocarbon (THC) concentrations and average air flow rates were used during each of the treatment steps to calculate emissions, rather than using time-weighted averages (TWA's). It is not clear at this time what effect this had on the calculated emissions (Table 3-2, p. 3-5). Clarification is needed on how, and from what raw data, these averages were calculated.

3. No calculations section was provided in the report. It was assumed that calculations were done accurately and with the appropriate equations. Kerr-McGee requests examples of all pertinent equations and a sample calculation done with each. Kerr-McGee may wish to make additional comments with regard to data reduction.

4. Raw test data values need to be included in the final report to show how DSCFM was calculated from ACFM, as well as how propane mass flow rates were calculated, etc. It was assumed that the calculations were done accurately using appropriate methods. However, there is currently no way to verify the data acquisition procedures, calculation methods, and results.

5. Kerr-McGee desires to verify which standard temperature and pressure (STP) values were used in the air flow calculations.

6. Emission values and durations for the Boulton cycle, first blowback, and pressurization steps from the Avoca draft report agree with those presented in the original Avoca data summary table (Table 1). The draft report gave no values or durations for the second blowback and final vacuum. It appears that the values for the second blowback and final vacuum were estimated from the first blowback and pressurization steps, respectively. The second blowback needs additional clarification.

7. The average flow rate during the Boulton cycle was presented as 14.0 DSCFM (p. 3-9, top). Neither an arithmetic average nor a time-weighted average of the flow rates listed in Tables 3-3 or 3-4 yield this number. Figure 3-3 (p. 3-10) claims to illustrate an average flow rate of 14.0 DSCFM, but shows instead a decreasing flow rate with time. The average flow rate cannot be represented by a line of decreasing slope, but would instead be a horizontal line. The derivation of this average Boulton cycle flow rate requires additional clarification.

8. As quoted in the Introduction (p. 1-1) of the draft report, "The incinerator may represent the MACT for new sources, and the results of the tests conducted at this facility may demonstrate the control efficiency that can be accomplished for new source MACT.", was not understood by KMCC as part of the original scope in determining emissions from the wood treating process at Avoca, PA.

    a. The final report needs more detailed documentation. Uncontrolled emissions as determined from the Avoca facility test data fell well below HAP thresholds.

    b. The incinerator efficiency results in Table 3-8 (p. 3-14) depend directly on the calculated emissions at the inlet and outlet of the incinerator. These propane emission calculations currently require clarification. The incinerator efficiency results depend on verification of the inlet and outlet conditions used to calculate them.

9. The molecular weight (MW) for creosote in the original summary table for this report was presented as 128 lb/lb-mole, as shown in Table 1. This value of 128 lb/lb-mole is the MW for naphthalene, not creosote. A derivation of the MW of creosote, based on the most prevalent of its many constituents, gave a value of 172 lb/lb-mole, as shown in Table 2.

10. Table 1 assumed that the retort doors at the Avoca facility were open for a duration of one hour. Kerr-McGee's operating policy mandates that the retort doors are open for no longer than fifteen minutes while loading or unloading charges. Untreated charges are preloaded onto trams and are thus ready for immediate placement in the retort. The one hour duration is therefore inappropriate from both operational and from emission calculations standpoints.

11. Table 3 presents a revision of the calculation scenario presented in Table 1. This revision incorporates the derived MW for creosote and the fifteen minute limitation on retort door openings. These changes produced air emission rates which were about 21 percent lower than those shown in Table 1.

Kerr-McGee recommends that EPA incorporates these comments into the final report on air emissions at KMCC's Avoca, PA wood treatment facility. I believe the joint efforts by EPA, AWPI, and KMCC provided a significant insight in regard to emissions from a creosote wood treating facility. Determination of production process emission factors at a creosote plant have permitted further refinement for emission estimates required by Form R under SARA and will provide a basis for emission estimates required under the auspices of the Clean Air Act Amendments of 1990.

Our joint efforts have provided the framework that demonstrates that cooperation is of mutual benefit. If I may be of further assistance please contact me at 405/270-2394.

Sincerely,

Nick Bock

Nicholas E. Bock
Kerr-McGee Chemical Corporation
Manager, Environmental & Regulatory Affairs

cc: Mr. Michael R. Corn, AquAeTer, Inc.
AWPI Clear Air Act Subcommittee

BLE 1, EST RESULTS FOR THE AVOCA, PA FACILITY

RESULTS OF EPA'S TEST DATA
AVOCA, PA

YCLE	Operation Hours	EMISSION LOADING Propane lb/hour	Mass Propane lb/charge	MW RATIO lb carbon/ lb propane .818	MW RATIO CREOSOTE TO CARBON 128/120	EMISSION LOADING Creosote lb/hour	Mass Creosote lb/charge	POUNDS/HOUR Average Propane lb/hour	Average Naphthalene lb/hour	Average Creosote lb/hour
oulton	12	1.2200	14.640	0.8180	1.0667	1.0645	12.774			1.064
st Blowback	0.25	0.7700	0.193	0.8180	1.0667	0.6719	0.168			0.672
ressurization	0.5	0.1200	0.060	0.8180	1.0667	0.1047	0.052			0.105
nd Blowback	0.25	0.7700	0.193	0.8180	1.0667	0.6719	0.168			0.672
inal Vacuum	1	1.2200	1.220	0.8180	1.0667	1.0645	1.064			1.064
oulton Total	14		16.305				14.227	1.165	0.030	1.01
Retort Door	1	6.7500	6.750	0.8180	1.0667	5.8896	5.890	6.750	0.177	5.890
Charge Total	15		23.055				20.116	7.915	0.207	6.906

CYCLE	Operation Hours	Propane lb/hour	POUNDS/CHARGE Mass Propane lb/charge	Mass Creosote lb/charge	Mass Naphthalene lb/charge	HYPOTETHICAL POUNDS/YEAR Mass Propane lb/year 500 charges	Mass Creosote lb/year 500 charges	Mass Naphthalene lb/year 500 charges
Boulton	12	1.22	14.64	12.77	0.38	7320	6387	192
1st Blowback	0.25	0.77	0.19	0.17	0.01	96	84	3
Pressurization	0.5	0.12	0.06	0.05	0.002	30	26	1
2nd Blowback	0.25	0.77	0.19	0.17	0.01	96	84	3.
Final Vacuum	1	1.22	1.22	1.06	0.03	610	532	16
Boulton Total	14		16.31	14.23	0.43	8153	7113	213
Retort Door	1	6.75	6.75	5.89	0.18	3375	2945	88
Charge Total	15		23.06	20.12	0.60	11528	10058	302

TABLE 2. DERIVATION OF A MOLECULAR WEIGHT FOR CREOSOTE

Source: EVALUATION OF EMISSION SOURCES FROM CREOSOTE WOOD TREATMENT OPERATIONS PB89-224729

MIDWEST RESEARCH INSTITUTE
CARY, NC JUNE 89

Basis: 97.4 lb Creosote Creosote Component	Whole Creosote (a) (%)	Component Molecular Weight (lbs/lb-mole	Mass of Component (lbs)	Moles of Component (lb-mole)	Mole Percent in Creosote (%)	Contribution to MW (lbs/lb-mole)	No. of Carbon Atoms in Molecule (#)	Mass Fraction of Carbon in Molecule (fraction)	Contribution to Carbon Mass Fraction (lbs C/lb Creosote)
Naphthalene (b)	10.0	128.2	10.0	0.078	13.8	17.7	10	0.94	0.129
2-Methylnaphthalene	1.2	142.2	1.2	0.008	1.5	2.1	11	0.93	0.014
1-Methylnaphthalene	0.9	142.2	0.9	0.006	1.1	1.6	11	0.93	0.010
Biphenyl	0.8	154.2	0.8	0.005	0.9	1.4	12	0.93	0.009
Dimethylnaphthalenes	2.0	156.2	2.0	0.013	2.3	3.5	12	0.92	0.021
Acenaphthene	9.0	156.2	9.0	0.058	10.2	15.9	12	0.92	0.094
Dibenzofuran	5.0	168.2	5.0	0.030	5.3	8.8	12	0.86	0.045
Fluorene	10.0	166.2	10.0	0.060	10.6	17.7	13	0.94	0.100
Methylfluorenes	3.0	180.2	3.0	0.017	2.9	5.3	14	0.93	0.027
Phenanthrene	21.0	178.2	21.0	0.118	20.8	37.1	14	0.94	0.196
Anthracene	2.0	178.2	2.0	0.011	2.0	3.5	14	0.94	0.019
Carbazole	2.0	167.2	2.0	0.012	2.1	3.5	12	0.86	0.018
Methylphenanthrenes	3.0	192.2	3.0	0.016	2.8	5.3	15	0.94	0.026
Methylanthracenes	4.0	192.2	4.0	0.021	3.7	7.1	15	0.94	0.034
Fluoranthene	10.0	202.3	10.0	0.049	8.7	17.7	16	0.95	0.083
Pyrene	8.5	202.3	8.5	0.042	7.4	15.0	16	0.95	0.070
Benzofluorenes	2.0	216.3	2.0	0.009	1.6	3.5	17	0.94	0.015
Chrysene	3.0	228.3	3.0	0.013	2.3	5.3	18	0.95	0.022
Total	97.4			0.566	100.0	172.0			0.9333

Average Molecular Weight of Creosote	172.0 lbs/lb-mole
Average Mass of Carbon in Creosote	160.6 lbs carbon/lb-mole creosote
Average Mass Fraction of Carbon in Creosote	0.9333 lbs carbon/lb creosote
Mass Ratio of Creosote/Carbon	1.0714 lbs creosote/lb carbon

(a) Assumes weight percent.

(b) The naphthalene percentage was increased from the literature value of 3% to 10% in order to derive a more conservative value of the molecular weight.

TABLE 3. REVISION OF EPA TEST DATA FOR THE AVOCA, PA PLANT

					MFC (a)				CALCULATED EMISSIONS		
Cycle	Operation (hrs/charge)	Hydrocarbon Emissions as Propane (lbs/hr)	Mass of Propane (lbs/charge)	Mass of Naphthalene (lbs/charge)	Mass Ratio (lbs carbon/ lb propane)	Mass Ratio (lbs creosote lb carbon)	Calculated Creosote Emissions (lbs/hr)	Mass of Creosote (lbs/charge)	Average Propane (lbs/hr)	Average Naphthalene (lbs/hr)	Average Creosote (lbs/hr)
Boulton	12	1.22	14.640	0.3850	0.818	1.0714	1.0695	12.834		0.032	1.069
1st Blowback	0.25	0.77	0.193	0.0051	0.818	1.0714	0.6750	0.169		0.020	0.675
Pressurization	0.5	0.12	0.060	0.0016	0.818	1.0714	0.1052	0.053		0.003	0.105
2nd Blowback	0.25	0.77	0.193	0.0051	0.818	1.0714	0.6750	0.169		0.020	0.675
Final Vacuum	1	1.22	1.220	0.0321	0.818	1.0714	1.0695	1.069		0.032	1.069
Boulton Total	14		16.305	0.4288	0.818	1.0714		14.294	1.165	0.031	1.021
Retort Door	0.25	6.75	1.688	0.0444	0.818	1.0714	5.9173	1.479	6.750	0.178	5.917
Charge Total	14.25		17.993	0.4732	0.818	1.0714		15.773	7.915	0.208	6.938

							ESTIMATED ANNUAL EMISSIONS		
Cycle	Operation (hrs/charge)	Propane (lbs/hr)	Mass of Propane (lbs/charge)	Mass of Creosote (lbs/charge)	Mass of Naphthalene (lbs/charge)	Charges per Year (#)	Propane Emissions (lbs/yr)	Creosote Emissions (lbs/yr)	Naphthalene Emissions (lbs/yr)
Boulton	12	1.22	14.64	12.83	0.385	500	7,320	6,417	192.51
1st Blowback	0.25	0.77	0.19	0.17	0.005	500	96	84	2.53
Pressurization	0.5	0.12	0.06	0.05	0.002	500	30	26	0.79
2nd Blowback	0.25	0.77	0.19	0.17	0.005	500	96	84	2.53
Final Vacuum	1	1.22	1.22	1.07	0.032	500	610	535	16.04
Boulton Total	14		16.31	14.29	0.429	500	8,153	7,147	214.40
Retort Door	0.25	6.75	1.69	1.48	0.044	500	844	740	22.19
Revised Totals	14.25		17.99	15.77	0.473	500	8,996	7,886	237
EPA Totals							11,528	10,058	302
Percent Difference							-22.0	-21.6	-21.7

(a) Mass Fraction of Carbon

FACSIMILE TRANSMISSION

KOPPERS INDUSTRIES INC.
436 Seventh Avenue, K-1800
Pittsburgh, PA 15219

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 10
To Mike Cain	From Steve Smith
Co.	Co.
Dept.	Phone # 412-227-2677
Fax # 615-373-8572	Fax #

DATE: November 22, 1994

TO: AWPI Regulatory Affairs Air Subcommittee

	FAX NO.
Jeff Smigel	912-964-1331
Nick Bock	405-270-3029
Ron Cauley	205-867-6882
Carleton Degges	205-877-3102
Charles Faulds	512-454-4221
Martin Rollins	601-832-1738
-- Janet Seaman	205-665-2545
Marty Wikstrom	703-893-8492

FROM: Stephen T. Smith Steve

NO. PAGES INCLUDING THIS PAGE: ~~[illegible]~~ 9

FACS NO.: (412)227-2423
VOICE NO.: (412)227-2677

Subject: Creosote Vapor Analysis

I discussion with Nick Bock yesterday, I offered to redo the creosote vapor pressure spread sheets to reflect the Industry Composite Creosote. Additionally, it has recently been necessary for me to prepare a complete emissions inventory for one of Koppers' plants and so I offer my work in this effort for your review and discussion.

Following are two vapor pressure analysis spreadsheets which are similar to ones I have shown you before, except that on these concentrations have been revised to match the Industry Composite Creosote results from the GERG testing. Sheet 1 includes all results reported. Any constituents which were below the reporting limit of 0.5% and, therefore were not reported, are shown as 0.

Sheet 2 includes additional estimated values for volitile constituents. Note that GERG has completed additional analyses with reporting limits down to about 0.1%, which could have a very significant impact on vapor pressure. As these two sheets show, the P1 creosote less water vp is 2.67 mmHg on sheet 1 and 6.93 mmHg on sheet 2, over two times as high. Dave Webb has called John Butala to attempt to get the test results.

Sheet 3 includes the same assumed volitiles, but with water reduced to 0 since we don't want it in the calculations. This sheet, with actual volitiles instead of assumed, is what I would recommend to use as a basis for estimating HAPs in creosote vapor, as from the cylinders and work tanks, etc., but not for yard emissions. The columns for "vapor mass fraction (%)" shown the percent of a given constituent as a percentage of the total vapor by weight. Thus, for P1, this would indicate that benzene would be 20%, naphthalene 20%, and biphenyl 0.17% of the total. If a plant estimated 5 tons per year of creosot emissions on the form R, 1 ton would be benzene, 1 ton naphthalene, and 17 pounds would be biphenyl. Of the 5 tons, 71% or 3.55 tons would be HAPs.

The next two sheets are spread sheets I prepared to estimate HAP emissions from yard inventory. I used my original method based on the Feather River test results, but borrowed from AquAeTer to calculate stacking factors based on exposed surface area for different age ranges. Each sheet applies to 1 million CF of treatment and is used to calculate an emission factor (pounds of HAP per cubic foot treated). The derivation of the stacking factors is shown on the next two sheets, 6 & 7. I expect that the final product from AquAeTer will allow a calculation similar to this, although probably more refined.

Finally, on sheet 8, creosote HAP emissions are calculated for a given plant using all the factors. This is an example of how this information could be used to make an emissions inventory for a plant. Process area emissions are calculated using Form R creosote emission figures and HAP vapor concentration estimates. Yard emissions are calculated using emission factors derived from the Feather River study, modified with stacking factors.

I think this is applicable to our planned conference call tomorrow morning. We can discuss any questions or comments you have at that time.

cc: Dave Webb

All concentrations per GERG (7/27/92).

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CALCULATION OF VAPOR PRESURES FOR INDUSTRY COMPOSITE CREOSOTES

22-Nov-94 File> vp-ind12.wk4

Creosote density (Kg/l) 1.09

Whole creosote MW is 187.8

				<--P1/P13 Creosote						<--P2 Creosote				-->	
	Constituent	MW C	Pure Component Vapor Press. at 180 F (mm Hg) D	Liquid Conc. In Creosote (%) F	Liquid Mole Fraction (moles) G=F*C4/100/C	Equilib. Vapor Concen. Pressure (mm Hg) H=D*G	Equil. Vapor Mole Mass I=C*H	Vapor Mass Fraction (%) J=100I/sumI	Vapor MW K=sumI/sumH	Liquid Conc. In Creosote (%) L	Liquid Mole Fraction (moles) M=L*C4/100/C	Equilib. Vapor Concen. Pressure (mm Hg) N=D*M	Equil. Vapor Mole Mass O=C*N	Vapor Mass Fraction (%) P=100*O/sumO	Vapor MW Q=sumO/sumN
	VOLITILE CONSTITUENTS (NON-PAH)														
	Water	18	4.00E+02	1.10E+00	1.15E-01	4.59E+01	8.3E+02	7.1E+01		2.00E-01	2.09E-02	8.35E+00	1.5E+02	3.0E+01	
H	Benzene	78	7.60E+02	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
H	Toluene	92	4.60E+02	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
H	Phenol	94	1.60E+01	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
H	Cresols	108	1.00E+01 *	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
H	P-Xylene	106	1.25E+02	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
	C2-Benzenes	106	1.25E+02 *	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
	SEMI-VOLITILE (PAH) CONSTITUENTS														
	Indene	116	3.00E+01 *	1.20E+00	1.94E-02	5.83E-01	6.8E+01	5.8E+00		9.90E-01	1.60E-02	4.81E-01	5.6E+01	1.1E+01	
	Indole	117	2.00E+00 *	7.60E-01	1.22E-02	2.44E-02	2.9E+00	2.4E-01		7.20E-01	1.16E-02	2.31E-02	2.7E+00	5.4E-01	
	Dihydroindene (Indan)	118	3.00E+01 *	5.90E-01	8.39E-03	2.87E-01	3.3E+01	2.8E+00		6.30E-01	1.00E-02	3.01E-01	3.5E+01	7.1E+00	
H	Napthalene	128	7.29E+00	1.04E+01	1.53E-01	1.12E+00	1.4E+02	1.2E+01		1.07E+01	1.56E-01	1.14E+00	1.5E+02	2.9E+01	
H	Quinoline	129	6.00E+00	1.06E+00	1.54E-02	9.26E-02	1.2E+01	1.0E+00		1.39E+00	2.02E-02	1.21E-01	1.6E+01	3.1E+00	
	Benzo(b)thiophene(thianaphthene)	134	7.29E+00	5.10E-01	7.15E-03	5.21E-02	7.0E+00	6.0E-01		4.90E-01	6.87E-03	5.01E-02	6.7E+00	1.3E+00	
	Methyl naphthalenes	142	4.00E+00	6.23E+00	8.24E-02	3.30E-01	4.7E+01	4.0E+00		5.98E+00	7.91E-02	3.16E-01	4.5E+01	9.0E+00	
	Acenaphthylene	152	1.09E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		5.24E+00	6.47E-02	7.06E-02	1.1E+01	2.1E+00	
H	Biphenyl	154	1.00E+00 *	6.60E-01	8.05E-03	8.06E-03	1.2E+00	1.1E-01		7.10E-01	8.66E-03	8.66E-03	1.3E+00	2.7E-01	
	Acenaphthene	154	5.27E-02	5.45E+00	6.65E-02	3.50E-03	5.4E-01	4.6E-02		5.24E+00	6.39E-02	3.37E-03	5.2E-01	1.0E-01	
	C2-Naphthalenes	156	5.00E+00 *	1.13E+00	1.38E-02	6.80E-02	1.1E+01	9.1E-01		1.23E+00	1.48E-02	7.40E-02	1.2E+01	2.3E+00	
	1,3-dimethyl naphthalene	156	5.00E+00 *	6.20E-01	7.46E-03	3.73E-02	5.8E+00	5.0E-01		6.50E-01	7.83E-03	3.91E-02	6.1E+00	1.2E+00	
	Fluorene	166	5.04E-01	3.29E+00	3.72E-02	1.88E-02	3.1E+00	2.7E-01		4.03E+00	4.56E-02	2.30E-02	3.8E+00	7.6E-01	
	Carbazole	167	4.00E-02	7.30E-01	6.21E-03	3.28E-04	5.5E-02	4.7E-03		7.00E-01	7.87E-03	3.15E-04	5.3E-02	1.0E-02	
	3-methyl biphenyl (3-phenyl toluene)	168	5.30E-02 *	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		6.10E-01	6.82E-03	3.61E-04	6.1E-02	1.2E-02	
H	Dibenzofuran	168	7.00E-01	3.65E+00	4.08E-02	2.86E-02	4.8E+00	4.1E-01		4.61E+00	5.15E-02	3.61E-02	6.1E+00	1.2E+00	
	C1-Acenaphthalenes	168	1.00E-01 *	7.30E-01	8.16E-03	8.16E-04	1.4E-01	1.2E-02		7.30E-01	8.16E-03	8.16E-04	1.4E-01	2.7E-02	
	Phenanthrene	180	1.71E-01	1.18E+01	1.23E-01	2.10E-02	3.8E+00	3.2E-01		1.25E+01	1.31E-01	2.23E-02	4.0E+00	8.0E-01	
	Anthracene	178	4.43E-02	1.28E+00	1.33E-02	5.89E-04	1.0E-01	9.0E-03		1.39E+00	1.47E-02	6.50E-04	1.2E-01	2.3E-02	
	Benzoquinoline-1	179	1.00E-03 *	6.70E-01	7.03E-03	7.00E-06	1.3E-03	1.1E-04		7.00E-01	7.34E-03	7.34E-06	1.3E-03	2.6E-04	
	C1-fluorenes	180	1.00E-03 *	4.90E-01	5.11E-03	5.11E-06	9.2E-04	7.9E-05		5.40E-01	5.63E-03	5.63E-06	1.0E-03	2.0E-04	
	C1-Dibenzofurans	182	1.00E-03 *	9.50E-01	9.80E-03	9.80E-06	1.8E-03	1.5E-04		1.03E+00	1.06E-02	1.06E-05	1.9E-03	3.9E-04	
	Dibenzothiophene	184	1.00E-03 *	8.20E-01	8.37E-03	8.37E-06	1.5E-03	1.3E-04		9.40E-01	9.59E-03	9.59E-06	1.8E-03	3.5E-04	
	4H-Cyclopenta[def]phenanthrene	190	1.00E-03 *	1.78E+00	1.76E-02	1.76E-05	3.3E-03	2.9E-04		1.74E+00	1.72E-02	1.72E-05	3.3E-03	6.5E-04	
	C1-Phenanthrenes	192	1.00E-03 *	1.00E+00	9.78E-03	9.78E-06	1.9E-03	1.6E-04		1.03E+00	1.01E-02	1.01E-05	1.9E-03	3.9E-04	
	2-Methyl phenanthrene	192	1.00E-03 *	1.10E+00	1.08E-02	1.08E-05	2.1E-03	1.8E-04		1.11E+00	1.09E-02	1.09E-05	2.1E-03	4.2E-04	
	C1-Benzoquinolines	190	1.00E-03 *	5.40E-01	5.25E-03	5.25E-06	1.0E-03	8.7E-05		5.70E-01	5.55E-03	5.55E-06	1.1E-03	2.1E-04	
	Fluoranthene	202	4.12E-04	6.16E+00	5.73E-02	2.36E-05	4.8E-03	4.1E-04		6.44E+00	5.99E-02	2.47E-05	5.0E-03	9.9E-04	
	Pyrene	202	2.06E-04	3.49E+00	3.24E-02	6.68E-06	1.4E-03	1.2E-04		3.64E+00	3.38E-02	6.97E-06	1.4E-03	2.8E-04	
	2-phenyl naphthalene	204	1.00E-04 *	5.00E-01	4.60E-03	4.60E-07	9.4E-05	8.0E-06		4.70E-01	4.33E-03	4.33E-07	8.8E-05	1.8E-05	
	C2-phenanthrenes	206	1.00E-04 *	4.70E-01	4.28E-03	4.28E-07	8.8E-05	7.6E-06		4.60E-01	4.19E-03	4.19E-07	8.6E-05	1.7E-05	
	C1-Fluoranthene/pyrenes	216	1.00E-04 *	1.30E+00	1.13E-02	1.13E-06	2.4E-04	2.1E-05		1.24E+00	1.08E-02	1.08E-06	2.3E-04	4.6E-05	
	1,2-Benzofluorene	218	1.00E-04 *	6.30E-01	7.22E-03	7.22E-07	1.6E-04	1.3E-05		7.30E-01	6.35E-03	6.35E-07	1.4E-04	2.7E-05	
	2,3-Benzofluorene	218	1.00E-04 *	7.60E-01	6.61E-03	6.61E-07	1.4E-04	1.2E-05		8.10E-01	7.04E-03	7.04E-07	1.5E-04	3.0E-05	
	Trihydrobenzoanthracenes	218	1.00E-04 *	1.94E+00	1.67E-02	1.67E-06	3.6E-04	3.1E-05		1.98E+00	1.69E-02	1.69E-06	3.7E-04	7.3E-05	
	CARCINOGENIC PAH'S														
c	Benzo(a)anthracene	228	1.89E-06	1.10E+00	9.06E-03	1.71E-08	3.9E-06	3.3E-07		1.25E+00	1.03E-02	1.95E-08	4.4E-06	8.8E-07	
c	Chrysene	228	5.19E-07	8.60E-01	7.08E-03	3.68E-09	8.4E-07	7.2E-08		1.04E+00	8.57E-03	4.45E-09	1.0E-06	2.0E-07	
c	Benzo(b)fluoranthene	252	4.12E-05	5.50E-01	4.10E-03	1.69E-07	4.3E-05	3.6E-06		5.10E-01	3.80E-03	1.57E-07	3.9E-05	7.9E-06	
c	Benzo(k)fluoranthene	252	4.20E-05	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Benzo(a)pyrene	252	4.61E-07	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Dibenz(a,h)anthracene	278	6.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Benzo(g,h,i)perylene	276	8.48E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Indano(1,2,3-cd)pyrene	276	8.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
	TOTALS:			76.50	0.97	48.57	1168.90	100.00	24.1	84.92	0.99	11.06	501.63	100.00	45.4
	TOTAL CREOSOTE LESS WATER					2.67		29.31				2.71		70.06	
	TOTAL VOLITILES LESS WATER					0.00		0.00				0.00		0.00	
	WATER VAPOR					45.91		70.69				8.35		29.94	
	TOTAL FOR SEMI-VOLITILE PAH					2.67		29.31				2.71		70.06	
	TOTAL FOR CARCINOGENIC PAH					1.90E-07		4.05E-08				1.80E-07		8.95E-08	
	TOTAL HAP					1.25		13.77				1.31		33.65	

* Vapor pressure guestimated. c=carcinogenic PAH H=Hazardous Air Pollutant (HAP)

(With assumed volitiles concentrations) 2

CALCULATION OF VAPOR PRESURES FOR INDUSTRY COMPOSITE CREOSOTES

22-Nov-94 File> vp-Ind12.wk4

Creosote density (Kg/l) 1.09
Whole creosote MW is 187.8

<----P1/P13 Creosote----> (columns F–J) <----P2 Creosote----> (columns L–P)

	Constituent	MW C	Pure Component Vapor Press. at 180 F (mm Hg) D	Liquid Conc. in Creosote (%) F	Liquid Mole Fraction (moles) G=F*C4/100/C	Equilib. Vapor Concen. Pressure (mm Hg) H=D*G	Equil. Vapor Mole Mass I=C*H	Vapor Mass Fraction (%) J=100I/sumI	Vapor MW K=sumI/sumH	Liquid Conc in Creosote (%) L	Liquid Mole Fraction (moles) M=L*C4/100/C	Equilib. Vapor Concen. Pressure (mm Hg) N=D*M	Equil. Vapor Mole Mass O=C*N	Vapor Mass Fraction (%) P=100*O/sumO	Vapor MW Q=sumO/sumN
	VOLITILE CONSTITUENTS (NON-PAH)														
	Water	18	4.00E+02	1.10E+00	1.15E-01	4.59E+01	8.3E+02	5.4E+01		2.00E-01	2.09E-02	8.35E+00	.5E+02	1.8E+01	
H	Benzene	78	7.60E+02	1.00E-01	2.41E-03	1.83E+00	1.4E+02	9.3E+00		1.00E-01	2.41E-03	1.83E+00	.4E+02	1.7E+01	
H	Toluene	92	4.60E+02	2.00E-01	4.08E-03	1.88E+00	1.7E+02	1.1E+01		2.00E-01	4.08E-03	1.88E+00	.7E+02	2.1E+01	
H	Phenol	94	1.60E+01	3.00E-01	5.99E-03	9.59E-02	9.0E+00	5.8E-01		2.00E-01	4.00E-03	6.39E-02	6.0E+00	7.2E-01	
H	Cresols	108	1.00E+01 *	1.00E-01	1.74E-03	1.74E-02	1.9E+00	1.2E-01		1.00E-01	1.74E-03	1.74E-02	.9E+00	2.3E-01	
H	P-Xylene	106	1.25E+02	1.00E-01	1.77E-03	2.21E-01	2.3E+01	1.5E+00		1.00E-02	1.77E-04	2.21E-02	2.3E+00	2.8E-01	
	C2-Benzenes	106	1.25E+02 *	1.00E-01	1.77E-03	2.21E-01	2.3E+01	1.5E+00		1.00E-02	1.77E-04	2.21E-02	2.3E+00	2.8E-01	
	SEMI-VOLITILE (PAH) CONSTITUENTS														
	Indene	116	3.00E+01 *	1.20E+00	1.94E-02	5.83E-01	6.8E+01	4.4E+00		9.90E-01	1.60E-02	4.81E-01	5.6E+01	6.7E+00	
	Indole	117	2.00E+00 *	7.60E-01	1.22E-02	2.44E-02	2.9E+00	1.9E-01		7.20E-01	1.16E-02	2.31E-02	2.7E+00	3.3E-01	
	Dihydroindene (Indan)	118	3.00E+01 *	5.90E-01	9.39E-03	2.82E-01	3.3E+01	2.2E+00		6.30E-01	1.00E-02	3.01E-01	3.5E+01	4.3E+00	
H	Napthalene	128	7.29E+00	1.04E+01	1.53E-01	1.12E+00	1.4E+02	9.3E+00		1.07E+01	1.56E-01	1.14E+00	.5E+02	1.8E+01	
H	Quinoline	129	6.00E+00	1.06E+00	1.54E-02	9.26E-02	1.2E+01	7.7E-01		1.39E+00	2.02E-02	1.21E-01	.6E+01	1.9E+00	
	Benzo(b)thiophene(thianaphthene)	134	7.29E+00	5.10E-01	7.15E-03	5.71E-02	7.0E+00	4.5E-01		4.90E-01	6.87E-03	5.01E-02	6.7E+00	8.1E-01	
	Methyl naphthalenes	142	4.00E+00	6.23E+00	8.24E-02	3.30E-01	4.7E+01	3.0E+00		5.98E+00	7.91E-02	3.16E-01	4.5E+01	5.4E+00	
	Acenaphthylene	152	1.09E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		5.24E+00	6.47E-02	7.08E-02	.1E+01	1.3E+00	
H	Biphenyl	154	1.00E+00 *	8.60E-01	8.05E-03	8.05E-03	1.2E+00	8.0E-02		7.10E-01	8.66E-03	8.66E-03	.3E+00	1.6E-01	
	Acenaphthene	154	5.27E-02	5.45E+00	6.65E-02	3.50E-03	5.4E-01	3.5E-02		5.24E+00	6.39E-02	3.37E-03	5.2E-01	6.2E-02	
	C2-Naphthalenes	156	5.00E+00 *	1.13E+00	1.36E-02	6.80E-02	1.1E+01	6.9E-01		1.23E+00	1.48E-02	7.40E-02	.2E+01	1.4E+00	
	1,3-dimethyl naphthalene	156	5.00E+00 *	6.20E-01	7.46E-03	3.73E-02	5.8E+00	3.8E-01		6.50E-01	7.83E-03	3.91E-02	6.1E+00	7.4E-01	
	Fluorene	166	5.04E-01	3.29E+00	3.72E-02	1.88E-02	3.1E+00	2.0E-01		4.00E+00	4.56E-02	2.30E-02	3.8E+00	4.6E-01	
	Carbazole	167	4.00E-02	7.30E-01	8.21E-03	3.28E-04	5.5E-02	3.6E-03		7.00E-01	7.87E-03	3.15E-04	5.3E-02	6.3E-03	
	3-methyl biphenyl (3-phenyl toluene)	168	5.30E-02 *	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		6.10E-01	6.82E-03	3.61E-04	6.1E-02	7.3E-03	
H	Dibenzofuran	168	7.00E-01	3.65E+00	4.08E-02	2.86E-02	4.8E+00	3.1E-01		4.61E+00	5.15E-02	3.61E-02	6.1E+00	7.3E-01	
	C1-Acenaphthalenes	168	1.00E-01 *	7.30E-01	8.16E-03	8.16E-04	1.4E-01	8.9E-03		7.30E-01	8.16E-03	8.16E-04	1.4E-01	1.7E-02	
	Phenanthrene	180	1.71E-01	1.18E+01	1.23E-01	2.10E-02	3.8E+00	2.5E-01		1.25E+01	1.31E-01	2.23E-02	4.0E+00	4.8E-01	
	Anthracene	178	4.43E-02	1.26E+00	1.33E-02	5.89E-04	1.0E-01	6.8E-03		1.39E+00	1.47E-02	6.50E-04	1.2E-01	1.4E-02	
	Benzoquinoline-1	179	1.00E-03 *	6.70E-01	7.03E-03	7.03E-06	1.3E-03	8.2E-05		7.00E-01	7.34E-03	7.34E-06	1.3E-03	1.6E-04	
	C1-fluorenes	180	1.00E-03 *	4.90E-01	5.11E-03	5.11E-06	9.2E-04	6.0E-05		5.40E-01	5.63E-03	5.63E-06	1.0E-03	1.2E-04	
	C1-Dibenzofurans	182	1.00E-03 *	9.50E-01	9.80E-03	9.80E-06	1.8E-03	1.2E-04		1.03E+00	1.06E-02	1.06E-05	1.9E-03	2.3E-04	
	Dibenzothiophene	184	1.00E-03 *	8.20E-01	8.37E-03	8.37E-06	1.5E-03	1.0E-04		9.40E-01	9.59E-03	9.59E-06	1.8E-03	2.1E-04	
	4H-Cyclopenta(def)phenanthrene	190	1.00E-03 *	1.76E+00	1.76E-02	1.76E-05	3.3E-03	2.2E-04		1.74E+00	1.72E-02	1.72E-05	3.3E-03	3.9E-04	
	C1-Phenanthrenes	192	1.00E-03 *	1.00E+00	9.76E-03	9.78E-06	1.9E-03	1.2E-04		1.03E+00	1.01E-02	1.01E-05	1.9E-03	2.3E-04	
	2-Methyl phenanthrene	192	1.00E-03 *	1.10E+00	1.08E-02	1.08E-05	2.1E-03	1.3E-04		1.11E+00	1.05E-02	1.00E-05	2.1E-03	2.5E-04	
	C1-Benzoquinolines	193	1.00E-03 *	5.40E-01	5.25E-03	5.25E-06	1.0E-03	6.6E-05		5.70E-01	5.56E-03	5.55E-06	1.1E-03	1.3E-04	
	Fluoranthene	202	4.12E-04	6.16E+00	5.73E-02	2.36E-05	4.8E-03	3.1E-04		6.44E+00	5.56E-02	2.47E-05	5.0E-03	6.0E-04	
	Pyrene	202	2.06E-04	3.49E+00	3.24E-02	6.68E-06	1.4E-03	8.8E-05		3.64E+00	3.30E-02	6.97E-06	1.4E-03	1.7E-04	
	2-phenyl naphthalene	204	1.00E-04 *	5.00E-01	4.60E-03	4.60E-07	9.4E-05	6.1E-06		4.70E-01	4.30E-03	4.33E-07	8.8E-05	1.1E-05	
	C2-phenanthrenes	206	1.00E-04 *	4.70E-01	4.28E-03	4.28E-07	8.8E-05	5.7E-06		4.60E-01	4.19E-03	4.19E-07	8.6E-05	1.0E-05	
	C1-Fluoranthene/pyrenes	218	1.00E-04 *	1.30E+00	1.13E-02	1.13E-06	2.4E-04	1.8E-05		1.24E+00	1.08E-02	1.08E-06	2.3E-04	2.8E-05	
	1,2-Benzofluorene	216	1.00E-04 *	8.30E-01	7.22E-03	7.22E-07	1.6E-04	1.0E-05		7.30E-01	6.35E-03	6.35E-07	1.4E-04	1.7E-05	
	2,3-Benzofluorene	216	1.00E-04 *	7.60E-01	6.61E-03	6.61E-07	1.4E-04	9.3E-06		8.10E-01	7.04E-03	7.04E-07	1.5E-04	1.8E-05	
	Trihydrobenzoanthracenes	218	1.00E-04 *	1.94E+00	1.67E-02	1.67E-06	3.6E-04	2.4E-05		1.96E+00	1.69E-02	1.69E-06	3.7E-04	4.4E-05	
	CARCINOGENIC PAH'S														
c	Benzo(a)anthracene	228	1.89E-06	1.10E+00	9.06E-03	1.71E-08	3.9E-06	2.5E-07		1.25E+00	1.00E-02	1.95E-08	4.4E-06	5.3E-07	
c	Chrysene	228	5.19E-07	8.60E-01	7.08E-03	3.68E-09	8.4E-07	5.4E-08		1.04E+00	8.57E-03	4.45E-09	1.0E-06	1.2E-07	
c	Benzo(b)fluoranthene	252	4.12E-05	5.50E-01	4.10E-03	1.69E-07	4.3E-05	2.8E-06		5.10E-01	3.80E-03	1.57E-07	3.9E-05	4.8E-06	
c	Benzo(k)fluoranthene	252	4.20E-05	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Benzo(a)pyrene	252	4.81E-07	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Dibenz(a,h)anthracene	278	8.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Benzo(g,h,i)perylene	276	8.48E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
c	Indeno(1,2,3-cd)pyrene	276	8.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	
	TOTALS:			77.40	0.99	52.84	1542.25	100.00	29.2	85.54	1.00	14.89	829.91	100.00	56.7
	TOTAL CREOSOTE LESS WATER					6.93		46.42				6.54		81.90	
	TOTAL VOLITILES LESS WATER					4.26		24.21				3.83		39.53	
	WATER VAPOR					45.91		53.58				8.35		18.10	
	TOTAL FOR SEMI-VOLITILE PAH					2.67		22.21				2.71		42.36	
	TOTAL FOR CARCINOGENIC PAH					1.90E-07		3.07E-06				1.80E-07		5.41E-06	
	TOTAL HAP					5.29		33.12				5.12		59.60	

* Vapor pressure guestimated. c=carcinogenic PAH H=Hazardous Air Pollutant (HAP)

[redacted]

CALCULATION OF VAPOR PRESURES FOR INDUSTRY COMPOSITE CREOSOTES

22-Nov-94 File> vp-ind12 wk4

Creosote density (Kg/l) 1.09
Whole creosote MW is 187.8

				<---P1/P13 Creosote				--->		<---P2 Creosote				--->	
	Constituent	MW C	Pure Component Vapor Press. at 160 F (mm Hg) D	Liquid Conc. In Creosote (%) F	Liquid Mole Fraction (moles) G=F*C4/100/C	Equilib. Vapor Concen. Pressure (mm Hg) H=D*G	Equil. Vapor Mole Mass I=C*H	Vapor Mass Fraction (%) J=100I/suml	Vapor MW K=suml/sumH	Liquid Conc. In Creosote (%) L	Liquid Mole Fraction (moles) M=L*C4/100/C	Equlib Vapo Concen Pressure (mm Hg N=D*M	Equil. Vapor Mole Mass O=C*N	Vapor Mass Fraction (%) P=100*O/sumO	Vapor MW Q=sumO/sumN
	VOLITILE CONSTITUENTS (NON-PAH)														
	Water	18	4.00E+02	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	1.0E+00	0.0E+00	
H	Benzene	78	7.60E+02	1.00E-01	2.41E-03	1.83E+00	1.4E+02	2.0E+01		1.00E-01	2.41E-03	1.83E+00	.4E+02	2.1E+01	
H	Toluene	92	4.60E+02	2.00E-01	4.08E-03	1.88E+00	1.7E+02	2.4E+01		2.00E-01	4.08E-03	1.88E+00	.7E+02	2.5E+01	
H	Phenol	94	1.60E+01	3.00E-01	5.89E-03	9.59E-02	9.0E+00	1.3E+00		2.00E-01	4.00E-03	6.39E-02	1.0E+00	8.8E-01	
H	Cresols	108	1.00E+01 •	1.00E-01	1.74E-03	1.74E-02	1.9E+00	2.6E-01		1.00E-01	1.74E-03	1.74E-02	.9E+00	2.8E-01	
H	P-Xylene	106	1.25E+02	1.00E-01	1.77E-03	2.21E-01	2.3E+01	3.3E+00		1.00E-02	1.77E-04	2.21E-02	.3E+00	3.5E-01	
	C2-Benzenes	106	1.25E+02 •	1.00E-01	1.77E-03	2.21E-01	2.3E+01	3.3E+00		1.00E-02	1.77E-04	2.21E-02	.3E+00	3.5E-01	
	SEMI-VOLITILE (PAH) CONSTITUENTS														
	Indene	116	3.00E+01 •	1.20E+00	1.94E-02	5.83E-01	8.8E+01	9.4E+00		9.90E-01	1.60E-02	4.81E-01	.6E+01	8.2E+00	
	Indole	117	2.00E+00 •	7.60E-01	1.22E-02	2.44E-02	2.9E+00	4.0E-01		7.20E-01	1.16E-02	2.31E-02	.7E+00	4.0E-01	
	Dihydroindene (Indan)	118	3.00E+01 •	5.90E-01	9.39E-03	2.82E-01	3.3E+01	4.6E+00		6.30E-01	1.00E-02	3.01E-01	1.5E+01	5.2E+00	
H	Napthalene	128	7.29E+00	1.04E+01	1.53E-01	1.12E+00	1.4E+02	2.0E+01		1.07E+01	1.56E-01	1.14E+00	.6E+02	2.1E+01	
H	Quinoline	129	6.00E+00	1.06E+00	1.54E-02	9.26E-02	1.2E+01	1.7E+00		1.39E+00	2.02E-02	1.21E-01	.6E+01	2.3E+00	
	Benzo(b)thiophene(thianaphthene)	134	7.29E+00	5.10E-01	7.15E-03	5.21E-02	7.0E+00	9.8E-01		4.90E-01	6.87E-03	5.01E-02	1.7E+00	9.9E-01	
	Methyl naphthalenes	142	4.00E+00	6.23E+00	8.24E-02	3.30E-01	4.7E+01	6.5E+00		5.98E+00	7.91E-02	3.16E-01	1.5E+01	8.6E+00	
	Acenaphthylene	152	1.09E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		5.24E+00	6.47E-02	7.06E-02	.1E+01	1.6E+00	
H	Diphenyl	154	1.00E+00 •	6.60E-01	8.06E-03	8.05E-03	1.2E+00	1.7E-01		7.10E-01	8.66E-03	8.66E-03	.3E+00	2.0E 01	
	Acenaphthene	154	5.27E-02	5.45E+00	6.66E-02	3.50E-03	5.4E-01	7.5E-02		5.24E+00	6.39E-02	3.37E-03	5.2E-01	7.6E-02	
	C2-Naphthalenes	156	5.00E+00 •	1.13E+00	1.36E-02	6.80E-02	1.1E+01	1.5E+00		1.23E+00	1.48E-02	7.40E-02	.2E+01	1.7E+00	
	1,3-dimethyl naphthalene	156	5.00E+00 •	6.20E-01	7.46E-03	3.73E-02	5.8E+00	8.1E-01		6.50E-01	7.83E-03	3.91E-02	1.1E+00	9.0E-01	
	Fluorene	166	5.04E-01	3.29E+00	3.72E-02	1.88E-02	3.1E+00	4.3E-01		4.03E+00	4.56E-02	2.30E-02	1.8E+00	5.6E-01	
	Carbazole	167	4.00E-02	7.30E-01	8.21E-03	3.28E-04	5.5E-02	7.7E-03		7.00E-01	7.87E-03	3.15E-04	5.3E-02	7.7E-03	
	3-methyl biphenyl (3-phenyl toluene)	168	5.30E-02 •	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		6.10E-01	6.82E-03	3.61E-04	6.1E-02	8.9E-03	
H	Dibenzofuran	168	7.00E-01	3.65E+00	4.08E-02	2.86E-02	4.8E+00	6.7E-01		4.61E+00	5.15E-02	3.61E-02	1.1E+00	8.9E-01	
	C1-Acenaphthalenes	168	1.00E-01 •	7.30E-01	8.16E-03	8.16E-04	1.4E-01	1.9E-02		7.30E-01	8.16E-03	8.16E-04	1.4E-01	2.0E-02	
	Phenanthrene	180	1.71E-01	1.18E+01	1.23E-01	2.10E-02	3.8E+00	5.3E-01		1.25E+01	1.31E-01	2.23E-02	1.0E+00	5.9E-01	
	Anthracene	178	4.43E-02	1.26E+00	1.33E-02	5.89E-04	1.0E-01	1.5E-02		1.39E+00	1.47E-02	6.50E-04	1.2E-01	1.7E-02	
	Benzoquinoline-1	179	1.00E-03 •	6.70E-01	7.03E-03	7.00E-06	1.3E-03	1.8E-04		7.00E-01	7.34E-03	7.34E-06	1.3E-03	1.0E-04	
	C1-fluorenes	180	1.00E-03 •	4.90E-01	5.11E-03	5.11E-06	9.2E-04	1.3E-04		5.40E-01	5.63E-03	5.63E-06	1.0E-03	1.5E-04	
	C1-Dibenzofurans	182	1.00E-03 •	9.50E-01	9.80E-03	9.80E-06	1.8E-03	2.5E-04		1.03E+00	1.06E-02	1.06E-05	1.9E-03	2.8E-04	
	Dibenzothiophene	184	1.00E-03 •	8.20E-01	8.37E-03	8.37E-06	1.5E-03	2.2E-04		9.40E-01	9.59E-03	9.59E-06	1.8E-03	2.6E-04	
	4H-Cyclopenta[def]phenanthrene	190	1.00E-03 •	1.78E+00	1.76E-02	1.76E-05	3.3E-03	4.7E 04		1.74E+00	1.72E-02	1.72E-05	3.3E-03	4.8E-04	
	C1-Phenanthrenes	192	1.00E-03 •	1.00E+00	9.78E-03	9.78E-06	1.9E-03	2.6E-04		1.00E+00	1.01E-02	1.01E-05	1.9E-03	2.8E-04	
	2-Methyl phenanthrene	192	1.00E-03 •	1.10E+00	1.08E-02	1.08E-05	2.1E-03	2.9E-04		1.11E+00	1.09E-02	1.09E-05	2.1E-03	3.1E-04	
	C1-Benzoquinolines	193	1.00E 03 •	5.40E-01	5.25E-03	5.25E-06	1.0E-03	1.4E-04		5.70E-01	5.56E-03	5.56E-06	1.1E-03	1.6E-04	
	Fluoranthene	202.	4.12E-04	6.16E+00	5.73E-02	2.36E-05	4.8E-03	6.7E-04		6.44E+00	5.99E-02	2.47E-05	5.0E-03	7.3E-04	
	Pyrene	202	2.06E-04	3.49E+00	3.24E-02	6.68E-06	1.4E-03	1.9E-04		3.64E+00	3.38E-02	6.97E-06	1.4E-03	2.1E-04	
	2-phenyl naphthalene	204	1.00E-04 •	5.00E-01	4.60E-03	4.60E-07	9.4E-05	1.3E-05		4.70E-01	4.33E-03	4.33E-07	9.8E-05	1.3E-06	
	C2-phenanthrenes	206	1.00E-04 •	4.70E-01	4.28E-03	4.28E-07	8.8E-05	1.2E-05		4.60E-01	4.19E-03	4.19E-07	9.8E-05	1.3E-06	
	C1-Fluoranthene/pyrenes	216	1.00E-04 •	1.30E+00	1.13E-02	1.13E-06	2.4E-04	3.4E-05		1.24E+00	1.08E-02	1.08E-06	2.3E-04	3.4E-06	
	1,2-Benzofluorene	216	1.00E-04 •	8.30E-01	7.22E-03	7.22E-07	1.6E-04	2.2E-05		7.30E-01	6.36E-03	6.35E-07	1.4E-04	2.0E-06	
	2,3-Benzofluorene	216	1.00E-04 •	7.60E-01	6.61E-03	6.61E-07	1.4E-04	2.0E-05		8.10E-01	7.04E-03	7.04E-07	1.5E-04	2.2E-06	
	Trihydrobenzoanthracenes	218	1.00E-04 •	1.94E+00	1.67E-02	1.67E-06	3.6E-04	5.1E-05		1.96E+00	1.69E-02	1.69E-06	3.7E-04	5.4E-06	
	CARCINOGENIC PAH'S														
c	Benzo(a)anthracene	228	1.89E-06	1.10E+00	9.06E-03	1.71E-08	3.9E-06	5.5E-07		1.25E+00	1.00E-02	1.95E-08	4.4E-06	6.5E-07	
c	Chrysene	228	5.15E-07	8.60E-01	7.08E-03	3.68E-09	8.4E-07	1.2E-07		1.04E+00	8.57E-03	4.45E-09	1.0E-06	1.5E-07	
c	Benzo(b)fluoranthene	252	4.12E-05	5.50E-01	4.10E-03	1.69E-07	4.3E-05	5.9E-06		5.10E-01	3.80E-03	1.57E-07	3.9E-05	5.8E-06	
c	Benzo(k)fluoranthene	252	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	.0E+00	0.0E+00	
c	Benzo(a)pyrene	252	4.61E-07	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	.0E+00	0.0E+00	
c	Dibenz(a,h)anthracene	278	8.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	.0E+00	0.0E+00	
c	Benzo(g,h,i)perylene	278	8.48E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	1.0E+00	0.0E+00	
c	Indeno(1,2,3-cd)pyrene	276	8.23E-09	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00		0.00E+00	0.00E+00	0.00E+00	1.0E+00	0.0E+00	
	TOTALS:			76.30	0.88	6.93	715.93	100.00	103.3	85.34	0.98	6.54	679.07	100.00	103.9
	TOTAL CREOSOTE LESS WATER					6.93		100.00				6.54		100.00	
	TOTAL VOLITILES LESS WATER					4.26		52.15				3.63		48.27	
	WATER VAPOR					0.00		0.00				0.00		0.00	
	TOTAL FOR SEMI-VOLITILE PAH					2.67		47.85				2.71		51.73	
	TOTAL FOR CARCINOGENIC PAH					1.90E-07		6.61E-06				1.80E-07		6.61E-06	
	TOTAL HAP					5.29		71.35				5.12		72.77	

• Vapor pressure guestimated c=carcinogenic PAH H=Hazardous Air Pollutant (HAP)

4

cr-pol-s.wk4

CREOSOTE WOOD TREATING PLANT EMISSIONS
FROM TREATED INVENTORY
BASED ON FEATHER RIVER PLANT
EMISSIONS STUDY RESULTS

Stacking Factors

POLES

Test No.	CF in test	Hours	On-Site	Stack Fac.
Fresh 2	163.8	24	100.00%	24.00%
Day 1(3)	163.8	72	100.00%	39.00%
Day 7	163.8	72	75.00%	19.00%
Day 12	163.8	240	40.00%	19.00%
Day 30	163.9	360	10.00%	19.00%

Volume of creosote wood treated(cf): (cf/year) 1,000,000

Constituent	MW	Pure Component Vapor Press. at 160 F (mm Hg)	Liquid Conc. In Creosote (%)	Liquid Mole Fraction (moles)	Equilib. Vapor Concen. Pressure (mm Hg)	Feather River Emission Rates: Measured Fresh 2 (mg/hr)	Calc'd Fresh 2 (mg/hr)	Volume Normal Fresh 2 (mg/hr/cf)	Measured Day 1(3) (mg/hr)	Calc'd Day 1(3) (mg/hr)	Volume Normal Day 1(3) (mg/hr/cf)	Measured Day 7 (mg/hr)	Calc'd Day 7 (mg/hr)	Volume Normal Day 7 (mg/hr/cf)
Creosote density (Kg/l)	1.07													
Whole creosote MW is	187.8													
NON-CARCINOGENIC PAHS														
Napthalene	128	7.29E+00	6.90E+00	1.012E-01	7.38E-01	2.00E+04		1.22E+02	2.80E+03		1.71E+01	2 13E+03		1.30E+01
Methyl naphthalenes	142	4.00E+00	5.40E+00	7.142E-02	2.86E-01	2.00E+04		1.22E+02	3.40E+03		2.08E+01	4 90E+03		3.01E+01
Acenaphthylene	152	1.09E+00	5.00E-01	6.178E-03	6.73E-03	3.20E+02		1.95E+00	6.21E+01		3.79E-01	7 73E+01		4.72E-01
Acenaphthene	154	5.27E-02	8.10E+00	7.439E-02	3.92E-03	9.41E+03		5.74E+01	1.60E+03		9.78E+00	1 87E+03		1.14E+01
Fluorene	166	5.04E-01	4.60E+00	5.204E-02	2.62E-02	4.45E+03		2.72E+01	1.09E+03		6.63E+00	1.16E+03		7.08E+00
Phenanthrene	180	1.71E-01	1.30E+01	1.356E-01	2.32E-02	4.17E+03		2.54E+01	1.68E+03		1.00E+01	1 32E+03		8.06E+00
Anthracene	178	4.43E-02	1.70E+00	1.794E-02	7.95E-04	8.84E+01		5.40E-01	1.44E+02		8.80E-01	3 48E+01		2.12E-01
Fluoranthene	202	4.12E-04	7.20E+00	6.694E-02	2.76E-05	2.14E+02		1.31E+00	1.14E+02		6.97E-01	8 13E+01		4.96E-01
Pyrene	202	2.06E-04	4.70E+00	4.370E-02	9.00E-06	3.86E+01		2.35E-01	3 05E+01		1.86E-01	2 45E+01		1.50E-01
	Total:		5.01E+01	5 69E-01			Total:	3.58E+02		Total:	6.67E+01		Total:	7.10E+01
CARCINOGENIC PAHS														
c Benzo(a)anthracene	228	1.89E-06	9.00E-01	7.413E-03	1.40E-08		6.00E-02	3.06E-04		4.75E-02	2.90E-04		3.81E-02	2.33E-04
c Chrysene	228	5.10E-07	1.00E+00	8.237E-03	4.27E-09		1.83E-02	1.12E-04		1.45E-02	8.85E-05		1.16E-02	7.10E-05
c Benzo(b)fluoranthene	252	4.12E-05	2.60E+00	1.938E-02	7.98E-07		3.42E+00	2.09E-02		2.71E+00	1.65E-02		2.17E+00	1.33E-02
c Benzo(k)fluoranthene	252	4.20E-05	3.40E+00	2.534E-02	1.06E-06		4.56E+00	2.78E-02		3.61E+00	2.20E-02		2 90E+00	1.77E-02
c Benzo(a)pyrene	252	4.81E-07	1.50E+00	1.118E-02	5.15E-09		2.21E-02	1.35E-04		1.75E-02	1.07E-04		1.40E-02	8.56E-05
c Dibenz(a,h)anthracene	278	8.23E-09	1.40E+00	9.458E-03	7.78E-11		3.33E-04	2.04E-06		2.84E-04	1.81E-06		2.12E-04	1.29E-06
c Benzo(g,h,i)perylene	276	8.48E-09	3.80E+00	2.586E-02	2.19E-10		8.39E-04	5.73E-06		7.43E-04	4.54E-06		6.97E-04	3.64E-06
c Indeno(1,2,3-cd)pyrene	276	8.23E-09	4.00E-01	2.722E-03	2.24E-11		9.59E-05	5.86E-07		7.59E-05	4.64E-07		6.10E-05	3.72E-07
	Total:		1.50E+01	1.10E-01			Total:	4.93E-02		Total:	3.90E-02		Total:	3.13E-02
OTHER CONSTITUENTS														
Carbazole (anthracene)	167	4.00E-02	4.00E-02	4.498E-04	1.80E-06		2.00E+00	1.22E-02		3 27E+00	1.99E-02		7.88E-01	4.81E-03
Benzene	78	7.60E+02	4.00E-01	9.631E-03	7.32E+00	26.02		1.59E-01	3.65		2.23E-02	2.78		1.70E-02
Toluene	92	3.25E+02		0.000E+00	0.00E+00	180		1.10E+00	130		7.94E-01	120		7.33E-01
Formaldehyde						569		3.47E+00	1218		7.44E+00	550		3.36E+00
						Total except. Formald..:		359 25			67.59			71.78

c Indicates carcinogenic PAH

Constituent	Feather River Emission Rates: Measured Day 12 (mg/hr)	Calc'd Day 12 (mg/hr)	Volume Normal Day 12 (mg/hr/cf)	Measured Day 30 (mg/hr)	Calc'd Day 30 (mg/hr)	Volume Normal Day 30 (mg/hr/cf)	Emissions from Treated Wood (mg/cf)	Emissions from Treated Wood (lb/cf)	Annual Emissions from Inventory (ton/yr)
NON-CARCINOGENIC PAHS									
Napthalene	1.61E+03		8.76E+00	9.83E+02		5.88E+00	1 57E+03	3.34E-03	1 67
Methyl naphthalenes	1.34E+03		7.30E+00	8.39E+02		5.12E+00	1 73E+03	3.80E-03	1.90
Acenaphthylene	2.95E+01		1.61E-01	1.65E+01		1.01E-01	2 97E+01	6.53E-06	0 03
Acenaphthene	6.71E+02		3 65E+00	4.54E+02		2.77E+00	7 89E+02	1.74E-03	0 87
Fluorene	3.84E+02		1.98E+00	2.51E+02		1.53E+00	4 51E+02	9.93E 04	0 50
Phenanthrene	5.26E+02		2.86E+00	3.30E+02		2.01E+00	5 70E+02	1.25E-03	0 63
Anthracene	1.48E+01		8.05E-02	1.51E+01		9.22E-02	3 15E+01	6.92E-06	0 03
Fluoranthene	3.09E+01		1.68E-01	9.35E+00		5.71E-02	3 62E+01	7.75E-06	0 04
Pyrene	2.15E+00		1.17E-02	3.03E+00		1.85E-02	8 33E+00	1.83E-05	0 01
		Total:	2.50E+01		Total:	1.76E+01	5 12E+03	1.14E-02	5 68
CARCINOGENIC PAHS									
c Benzo(a)anthracene		3.35E-03	1.82E-05		4.72E-03	2.88E-05	1.30E-02	2.85E-08	0 00
c Chrysene		1.02E-03	5.56E-06		1.44E-03	8.79E-06	3.96E-03	8.71E-09	0 00
c Benzo(b)fluoranthene		1.91E-01	1.04E-03		2.69E-01	1.64E-03	7.39E-01	1.63E-06	0 00
c Benzo(k)fluoranthene		2.54E-01	1.38E-03		3.58E-01	2.19E-03	9.85E-01	2.17E-06	0 00
c Benzo(a)pyrene		1.23E-03	6.70E-06		1.73E-03	1.06E-05	4.77E-03	1.05E-08	0 00
c Dibenz(a,h)anthracene		1.86E-05	1.01E-07		2.62E-05	1.60E-07	7.21E-05	1.59E-10	0 00
c Benzo(g,h,i)perylene		5.24E-05	2.86E-07		7.38E-05	4.51E-07	2.04E-04	4.48E-10	0 00
c Indeno(1,2,3-cd)pyrene		5.35E-06	2.91E-08		7.54E-06	4.60E-08	2 08E-05	4.57E-11	0 00
		Total:	2.45E-03		Total:	3.88E-03	1 75E+00	3.84E-06	1.92E-03
OTHER CONSTITUENTS									
Carbazole (anthracene)		3.36E-01	1.82E-03		3.42E-01	1.86E-03	7.14E-01	1.57E-06	0 00
Benzene	2.1		1.14E-02	1.2		6.53E-03	1 92E+00	4.23E-06	0 00
Toluene	330		1.80E+00	190		1.03E+00	6 89E+01	1.52E-04	0 08
Formaldehyde	187		1.02E+00	0		0.00E+00	2 82E+02	6.20E-04	0 31
Total except. Formald..:			24 99			18.63	5 19E+00	1.15E-02	5 76

Stacking Factors

TIES

5

cr-lle-s.wk4

CREOSOTE WOOD TREATING PLANT EMISSIONS
FROM TREATED INVENTORY
BASED ON FEATHER RIVER PLANT
EMISSIONS STUDY RESULTS

Test No.	CF in test	Hours	On-Site	Stack Fac.
Fresh 2	163.8	24	100.00%	18.00%
Day 1(3)	163.8	72	40.00%	18.00%
Day 7	163.8	72	20.00%	8.00%
Day 12	163.8	240	20.00%	8.00%
Day 30	163.8	360	10.00%	8.00%

Volume of creosote wood treated(cf): 1,000,000 (cf/year)

Creosote density (Kg/l) 1.07
Whole creosote MW is 187.8

Constituent	MW	Pure Component Vapor Press. at 180 F (mm Hg)	Liquid Conc. In Creosote (%)	Liquid Mole Fraction (moles)	Equilib. Vapor Concen. Pressure (mm Hg)	Feather River Emission Rates: Measured Fresh 2 (mg/hr)	Calc'd Fresh 2 (mg/hr)	Volume Normal Fresh 2 (mg/hr/cf)	Measured Day 1(3) (mg/hr)	Calc'd Day 1(3) (mg/hr)	Volume Normal Day 1(3) (mg/hr/cf)	Measured Day 7 (mg/hr)	Calc'd Day 7 (mg/hr)	Volume Normal Day 7 (mg/hr/cf)
NON-CARCINOGENIC PAHS														
Napthalene	128	7.29E+00	6.90E+00	1.012E-01	7.38E-01	2.00E+04		1.22E+02	2.80E+03		1.71E+01	2.13E+03		1.30E+01
Methyl naphthalenes	142	4.00E+00	5.40E+00	7.142E-02	2.86E-01	2.00E+04		1.22E+02	3.40E+03		2.08E+01	4.90E+03		3.01E+01
Acenaphthylene	152	1.09E+00	5.00E-01	6.178E-03	6.73E-03	3.20E+02		1.95E+00	6.21E+01		3.79E-01	7.73E+01		4.72E-01
Acenaphthene	154	5.27E-02	6.10E+00	7.439E-02	3.92E-03	9.41E+03		5.74E+01	1.60E+03		9.78E+00	1.87E+03		1.14E+01
Fluorene	166	5.04E-01	4.60E+00	5.204E-02	2.62E-02	4.45E+03		2.72E+01	1.09E+03		6.63E+00	1.16E+03		7.08E+00
Phenanthrene	180	1.71E-01	1.30E+01	1.356E-01	2.32E-02	4.17E+03		2.54E+01	1.68E+03		1.03E+01	1.32E+03		8.08E+00
Anthracene	178	4.43E-02	1.70E+00	1.794E-02	7.95E-04	8.84E+01		5.40E-01	1.44E+02		6.80E-01	3.48E+01		2.12E-01
Fluoranthene	202	4.12E-04	7.20E+00	6.694E-02	2.76E-05	2.14E+02		1.31E+00	1.14E+02		6.97E-01	8.13E+01		4.96E-01
Pyrene	202	2.06E-04	4.70E+00	4.370E-02	8.00E-06	3.86E+01		2.35E-01	3.05E+01		1.86E-01	2.45E+01		1.50E-01
		Total:	6.01E+01	5.69E-01			Total:	3.58E+02		Total:	6.87E+01		Total:	7.10E+01
CARCINOGENIC PAHS														
c Benzo(a)anthracene	228	1.69E-06	9.00E-01	7.413E-03	1.40E-08		6.00E-02	3.60E-04		4.75E-02	2.90E-04		3.81E-02	2.33E-04
c Chrysene	228	5.10E-07	1.00E+00	8.237E-03	4.27E-09		1.83E-02	1.12E-04		1.45E-02	8.85E-05		1.16E-02	7.10E-05
c Benzo(b)fluoranthene	252	4.12E-05	2.60E+00	1.938E-02	7.98E-07		3.42E+00	2.09E-02		2.71E+00	1.65E-02		2.17E+00	1.33E-02
c Benzo(k)fluoranthene	252	4.20E-05	3.40E+00	2.534E-02	1.06E-06		4.56E+00	2.78E-02		3.61E+00	2.20E-02		2.90E+00	1.77E-02
c Benzo(a)pyrene	252	4.61E-07	1.50E+00	1.118E-02	5.15E-09		2.21E-02	1.35E-04		1.75E-02	1.07E-04		1.40E-02	8.56E-05
c Dibenz(a,h)anthracene	278	8.23E-09	1.40E+00	9.458E-03	7.78E-11		3.33E-04	2.04E-06		2.64E-04	1.61E-06		2.12E-04	1.28E-06
c Benzo(g,h,i)perylene	276	8.48E-09	3.80E+00	2.586E-02	2.19E-10		9.35E-04	5.73E-08		7.43E-04	4.54E-08		5.97E-04	3.64E-08
c Indeno(1,2,3-cd)pyrene	276	8.23E-09	4.00E-01	2.722E-03	2.24E-11		8.59E-05	5.86E-07		7.59E-05	4.64E-07		6.10E-06	3.72E-07
		Total:	1.50E+01	1.10E-01			Total:	4.93E-02		Total:	3.90E-02		Total:	3.13E-02
OTHER CONSTITUENTS														
Carbazole (anthracene)	167	4.00E-02	4.00E-02	4.498E-04	1.80E-05		2.00E+00	1.22E-02		3.27E+00	1.99E-02		7.88E-01	4.81E-03
Benzene	78	7.60E+02	4.00E-01	9.631E-03	7.32E+00	26.02		1.59E-01	3.65		2.23E-02	2.78		1.70E-02
Toluene	92	3.25E+02		0.000E+00	0.00E+00	180		1.10E+00	130		7.94E-01	120		7.33E-01
Formaldehyde						569		3.47E+00	1218		7.44E+00	560		3.36E+00
						Total except. Formald..:		359 25			67.58			71 78

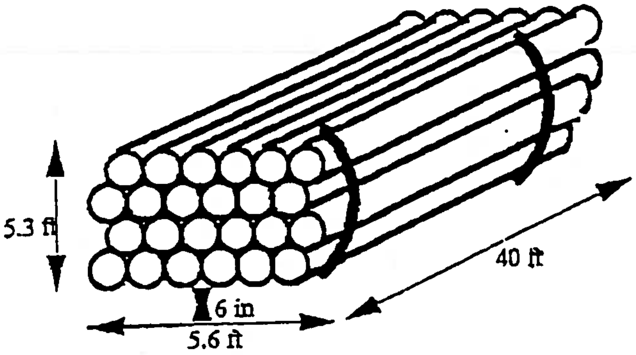
c Indicates carcinogenic PAH

Constituent	Feather River Emission Rates: Measured Day 12 (mg/hr)	Calc'd Day 12 (mg/hr)	Volume Normal Day 12 (mg/hr/cf)	Measured Day 30 (mg/hr)	Calc'd Day 30 (mg/hr)	Volume Normal Day 30 (mg/hr/cf)	Emissions from Treated Wood (mg/cf)	Emissions from Treated Wood (lb/cf)	Annual Emissions from Inventory (ton/yr)
NON-CARCINOGENIC PAHS									
Napthalene	1.61E+00		8.76E+00	9.63E+02		5.88E+00	8.22E+02	1.37E-03	0 68
Methyl naphthalenes	1.34E+00		7.30E+00	8.30E+02		5.12E+00	8.39E+02	1.41E-03	0 70
Acenaphthylene	2.96E+01		1.61E-01	1.65E+01		1.01E-01	1.08E+01	2.34E-05	0 01
Acenaphthene	6.71E+02		3.66E+00	4.54E+02		2.77E+00	2.98E+02	0.57E-04	0 33
Fluorene	3.64E+02		1.98E+00	2.51E+02		1.53E+00	1.54E+02	3.40E-04	0 17
Phenanthrene	5.26E+02		2.66E+00	3.30E+02		2.01E+00	1.71E+02	3.77E-04	0 19
Anthracene	1.48E+01		8.05E-02	1.51E+01		9.22E-02	7.19E+00	1.58E-05	0 01
Fluoranthene	3.09E+01		1.68E-01	9.35E+00		5.71E-02	9.85E+00	2.17E-05	0 01
Pyrene	2.15E+00		1.17E-02	3.03E+00		1.85E-02	2.09E+00	4.59E-06	0 00
		Total:	2.50E+01		Total:	1.76E+01	1.90E+03	4.21E-03	2 11
CARCINOGENIC PAHS									
c Benzo(a)anthracene		3.35E-03	1.82E-05		4.72E-03	2.88E-05	3.25E-03	7.15E-09	0 00
c Chrysene		1.02E-03	5.58E-06		1.44E-03	8.79E-06	9.91E-04	2.18E-09	0 00
c Benzo(b)fluoranthene		1.01E-01	1.04E-03		2.69E-01	1.64E-03	1.85E-01	4.07E-07	0 00
c Benzo(k)fluoranthene		2.54E-01	1.38E-03		3.58E-01	2.19E-03	2.47E-01	5.43E-07	0 00
c Benzo(a)pyrene		1.23E-03	6.70E-06		1.73E-03	1.06E-05	1.19E-03	2.63E-09	0 00
c Dibenz(a,h)anthracene		1.86E-05	1.01E-07		2.62E-05	1.60E-07	1.80E-05	3.07E-11	0 00
c Benzo(g,h,i)perylene		5.24E-05	2.85E-07		7.38E-05	4.51E-07	5.16E-05	1.14E-10	0 00
c Indeno(1,2,3-cd)pyrene		5.35E-06	2.91E-08		7.54E-06	4.60E-08	5.22E-06	1.15E-11	0 00
		Total:	2.45E-03		Total:	3.88E-03	4.37E-01	9.62E-07	4.81E-04
OTHER CONSTITUENTS									
Carbazole (anthracene)		3.35E-01	1.82E-03		3.42E-01	1.86E-03	1.64E-01	3.81E-07	0 00
Benzene	2.1		1.14E-02	1.2		6.53E-03	7.89E-01	1.74E-06	0 00
Toluene	330		1.60E+00	190		1.03E+00	1.61E+01	3.54E-06	0 02
Formaldehyde	187		1.02E+00	0		0.00E+00	5.07E+01	1.31E-04	0 07
	Total except. Formald..:		24.99			18.63	1.92E+03	4.25E-03	2 13

GEOMETRY of POLE STACKS

116.5 SF per pole

① TRAM



24-28 POLES per TRAM
4-5 TRAMS per CHARGE
MAX EMISSION RATES ON TRAM

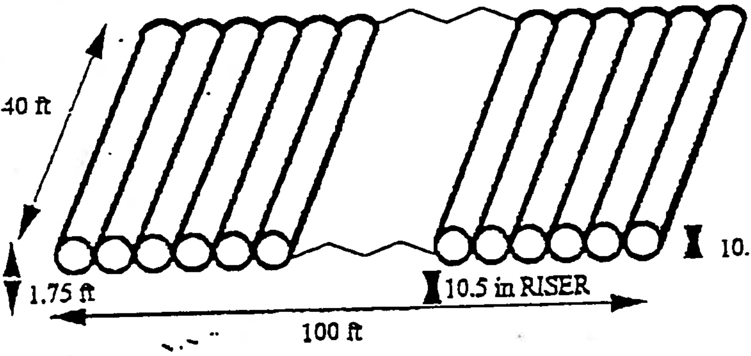
TIME ON TRAM	7-8 hours
TIME IN RAILTRUCK	16 hours

TOTAL TRAM SURFACE AREA =
709 ft²/TRAM

$\frac{709}{25 \times 116.5} = .24$

76 %

② 100 LAYOUT



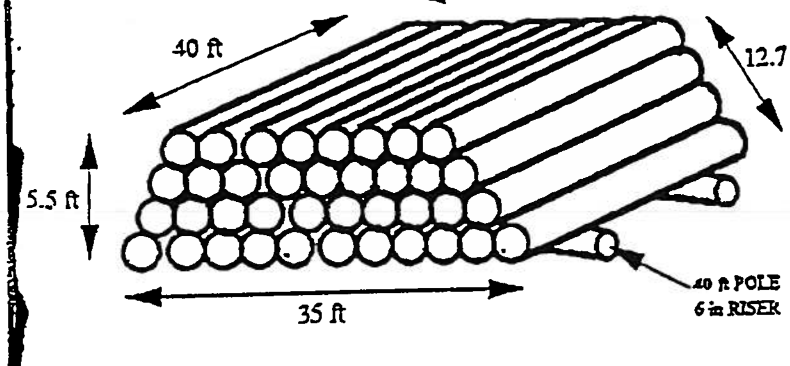
100 POLES - 100% ASSAY
1 LAYOUT AREA

TIME IN LAYOUT MAX 36 hours
SHIPPED OFF-SITE
LAYOUT SURFACE AREA =
4,496 ft²/LAYOUT

$\frac{4496}{100 \times 116.5} = 0.39$

61 %

③ YARD LAYOUT



80 POLES PER STACK
YARD AREA = 1,806 ft²/STACK

$\frac{1806}{80 \times 116.5} = 0.19$ 81 %

TIME IN YARD	3-4 months

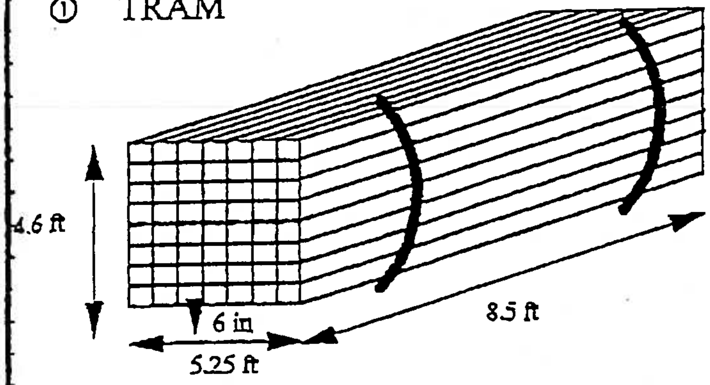
MAXIMUM INVENTORY =
2,000 POLES

AquAeTer

GEOMETRY OF TIE STACKS

ONE TIE SURFACE AREA (7 in x 9 in x 8.5 ft) = 23.55 ft²

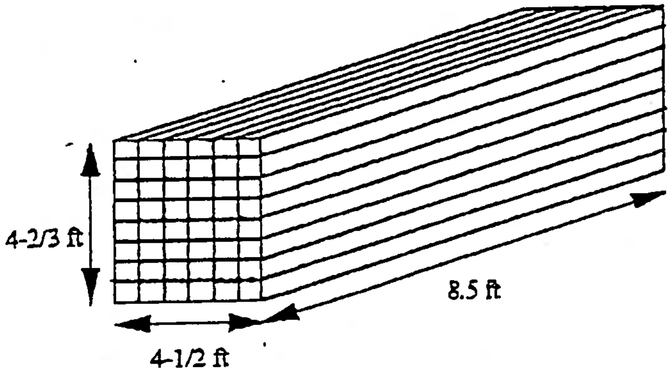
① TRAM



46 TIES PER TRAM
17 TRAMS PER CHARGE
TOTAL TRAM SURFACE AREA =
171 ft²

$\frac{171}{46 \times 23.55} = 0.16$

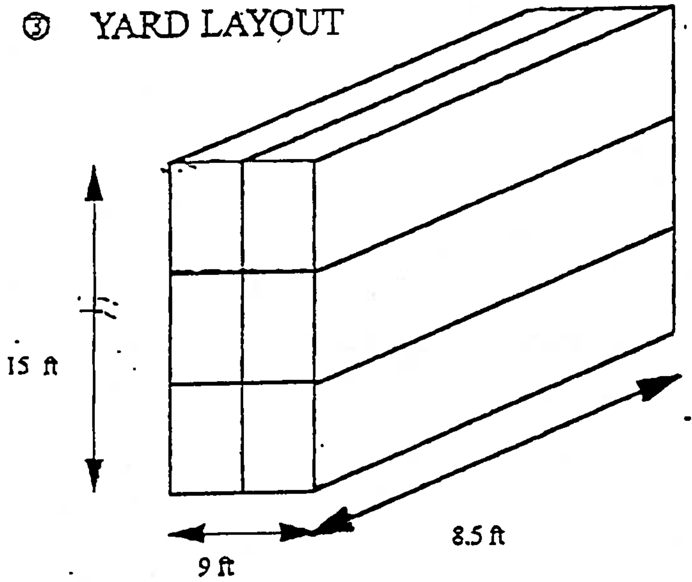
② BUNDLE



ASSUME 48 TIES = 1 BUNDLE
SURFACE AREA = 197.83 ft²

$\frac{198}{48 \times 23.55} = 0.18$

③ YARD LAYOUT



288 TIES IN 6 BUNDLES = 1 STACK
SURFACE AREA = 542.5 ft²

SURFACE AREA OF 288 STACKED TIES = SURFACE AREA OF INDIVIDUAL TIES

$$\frac{542.5 \text{ ft}^2}{(23.55 \text{ ft}^2)(288)} = \frac{542.5 \text{ ft}^2}{6{,}782.4} = 0.08$$

STACKING RESULTS IN 92%
REDUCTION IN SURFACE AREA
FROM SINGLE TIES

93,888 TIES PLACED IN 326 STACKS = 1 UNIT/MONTH PRODUCED
SURFACE AREA = SURFACE AREA OF ONE STACK * 326 STACKS

or

542.5 ft² * 326 STACKS = 176,855 ft²/UNIT

AquAeTer

WOOD PRESERVING PROCESSES

Pollutant	Emission Factor	Units	Basis	Estimated (tn/yr)	Emissions (lb/hr ave)
VOC(as Creosote)	N/A		Form R	15.37	3.50
HAPs contained in creosote:					
Benzene	22	% in vapor	Calculation	3.38	0.77
Biphenol	0.16	% in vapor	Calculation	0.02	0.01
Cresols	0.46	% in vapor	Calculation	0.07	0.02
Dibenzofurans	0.61	% in vapor	Calculation	0.09	0.02
Naphthalene	17	% in vapor	Calculation	2.61	0.60
P-Xylenes	4.5	% in vapor	Calculation	0.69	0.16
Phenol	1.4	% in vapor	Calculation	0.22	0.05
Quinoline	1.5	% in vapor	Calculation	0.23	0.05
Toluene	26	% in vapor	Calculation	4.00	0.91
TOTAL CREO. HAP	73.63	% in vapor		11.32	2.58
Pentachlorophenol (VOC)	N/A		Form R	0.015	0.00
TOTAL VOC				15.39	3.51

PRESERVATIVE TREATED WOOD STORAGE

Creosote Ties	1105226 C.F.
Creosote Poles	762209 C.F.
Oil/Penta. Poles	1638952 C.F.

Pollutant	Emission Factor	Units	Basis	Estimated (tn/yr)	Emissions (lb/hr ave)
Creosote Ties					
VOC(as Creosote)	4.25E-03	lb/cf	FR Test	2.35	0.54
Naphthalene	1.37E-03	lb/cf	FR Test	0.76	0.17
Benzene	1.74E-06	lb/cf	FR Test	0.00	0.00
Toluene	3.54E-05	lb/cf	FR Test	0.02	0.00
Creosote Poles					
VOC(as Creosote)	1.15E-02	lb/cf	FR Test	4.38	1.00
Naphthalene	3.34E-03	lb/cf	FR Test	1.27	0.29
Benzene	4.23E-06	lb/cf	FR Test	0.00	0.00
Toluene	1.52E-04	lb/cf	FR Test	0.06	0.01
Penta Poles					
VOC(from oil, est. as creo)	1.15E-02	lb/cf	FR Test	4.38	1.00
Pentachlorophenol	unk.	lb/cf	unk.	0.00	0.00

Totals					
VOC				11.11	tn/yr
Naphthalene				2.03	tn/yr
Benzene				0.00	tn/yr
Toluene				0.08	tn/yr
Pentachlorophenol				0.00	tn/yr
HAP Organics				2.11	tn/yr

Composite Creosote GC/MS Component Identity Determination - P1/P13 and Calculation of Partial (Pp) and Total (Pt) Vapor Pressures and Molecular Weight of Vapor (MV)

MW Calculation Basis: 76.5 lb creosote

A			B			B = GERG	C = B/A	D=Ci/Csum*10	F=Di/100*A	G =given	H = given	I=H*D	J=A(I/Pt)	K=A*D*H	L=Ki*100/Sum	M=MVi/SumMVi
MW (lb-mole)	Identity	CAS No	Mean Weight (%)	STD	% Var	Mass of Component (lb)	Moles of Component (lb-moles)	Mole % in Creosote (%) (Xi)	Contribution to MW (lb/lb-mole)	Pure VPi @ 180 mmHg	Pure VP @ 180 psia	Partial Press. Ppi @ 180 F psia	Component MVi @ Pp Sum	Equil Vapor Mole Mass	Vapor Mass Fraction %	%MVi of Creosote on MV 128
18	Water		1.10			1.1	0.061	11.8	2.1	40.0000	7.73E-01	9.10E-02	30.9174			
178	phenanthrene	85-01-8	11.78	1.15	9.80	11.78	0.066	12.7	22.7	0.0171	3.31E-04	4.21E-05	0.1415	7.50E-03	1.11E-01	0.11
128	**naphthalene - HAP**	91-20-3	10.44	1.06	10.10	10.44	0.082	15.7	20.1	7.2900	1.41E-01	2.21E-02	53.4785	2.83E+00	4.18E+01	41.77
202	fluoranthene	206-44-0	6.16	1.20	19.40	6.16	0.030	5.9	11.9	0.0004	7.97E-06	4.67E-07	0.0018	9.44E-05	1.39E-03	0.00
154	acenaphthene	83-32-9	5.45	0.83	15.20	5.45	0.035	6.8	10.5	0.0527	1.02E-03	6.94E-05	0.2018	1.07E-02	1.58E-01	0.16
142	2-methyl naphthalene	91-57-6	3.81	0.53	13.90	3.81	0.027	5.2	7.3	5.0000	9.67E-02	4.99E-03	13.3858	7.09E-01	1.05E+01	10.46
168	**dibenzofuran - HAP**	132-64-9	3.65	0.47	12.80	3.65	0.022	4.2	7.0	0.7000	1.35E-02	5.66E-04	1.7953	9.51E-02	1.40E+00	1.40
202	pyrene (benzo(def)phenanthrene)	129-00-00	3.49	0.73	21.00	3.49	0.017	3.3	6.7	0.0002	3.98E-06	1.32E-07	0.0005	2.68E-05	3.95E-04	0.00
166	fluorene	86-73-7	3.29	0.31	9.50	3.29	0.020	3.8	6.3	0.0504	9.74E-04	3.72E-05	0.1165	6.17E-03	9.10E-02	0.09
142	1-methyl naphthalene	90-12-0	2.42	0.27	11.00	2.42	0.017	3.3	4.7	4.0000	7.73E-02	2.54E-03	6.8018	3.60E-01	5.31E+00	5.31
218	trihydrobenzoanthracenes (m/z 218)		1.94	0.31	16.20	1.94	0.009	1.7	3.7	0.0001	1.93E-06	3.31E-08	0.0001	7.22E-06	1.06E-04	0.00
190	4H-cyclopenta(def)phenanthrene	203-64-5	1.78	0.41	23.20	1.78	0.009	1.8	3.4	0.0010	1.93E-05	3.49E-07	0.0013	6.62E-05	9.77E-04	0.00
216	C1-fluoranthrene/pyrenes		1.30	0.13	10.00	1.3	0.006	1.2	2.5	0.0001	1.93E-06	2.24E-08	0.0001	4.84E-06	7.14E-05	0.00
178	anthracene	120-12-7	1.26	0.24	18.90	1.26	0.007	1.4	2.4	0.0443	8.57E-04	1.17E-05	0.0392	2.08E-03	3.06E-02	0.03
116	indene	95-13-6	1.20	0.17	14.50	1.2	0.010	2.0	2.3	30.0000	5.80E-01	1.15E-02	25.2961	1.34E+00	1.98E+01	19.76
156	C2- naphthalenes		1.13	0.11	9.50	1.13	0.007	1.4	2.2	5.0000	9.67E-02	1.35E-03	3.9701	2.10E-01	3.10E+00	3.10
192	2-methyl phenanthrene	2531-84-2	1.10	0.18	15.90	1.1	0.006	1.1	2.1	0.0010	1.93E-05	2.13E-07	0.0008	4.09E-05	6.04E-04	0.00
228	benz(a)anthracene	56-55-3	1.10	0.16	14.70	1.1	0.005	0.9	2.1	1.80E-06	3.48E-08	3.23E-10	1.39E-06	7.37E-08	1.09E-06	0.00
129	**quinoline - HAP**	91-22-5	1.06	0.17	16.20	1.06	0.008	1.6	2.0	6.0000	1.16E-01	1.83E-03	4.4690	2.37E-01	3.49E+00	3.49
192	C1-phenanthrenes		1.00	0.10	10.40	1	0.005	1.0	1.9	0.0010	1.93E-05	1.94E-07	0.0007	3.72E-05	5.49E-04	0.00
182	C1-dibenzofurans		0.95	0.11	11.60	0.95	0.005	1.0	1.8	0.0010	1.93E-05	1.94E-07	0.0007	3.53E-05	5.21E-04	0.00
228	chrysene (benz(a)phenanthrene)	218-01-9	0.86	0.11	12.40	0.86	0.004	0.7	1.7	5.19E-07	1.00E-08	7.28E-11	3.14E-07	1.66E-08	2.45E-07	0.00
216	1,2-benzofluorene (benzo(a)fluorene)		0.83	0.13	15.20	0.83	0.004	0.7	1.6	0.0001	1.93E-06	1.43E-08	0.0001	3.09E-06	4.56E-05	0.00
184	dibenzothiophene	132-65-0	0.82	0.17	20.30	0.82	0.004	0.9	1.6	0.0010	1.93E-05	1.66E-07	0.0006	3.05E-05	4.50E-04	0.00
117	indole	120-72-9	0.76	0.08	11.10	0.76	0.006	1.3	1.5	2.0000	3.87E-02	4.83E-04	1.0681	5.66E-02	8.34E-01	0.83
216	2,3-benzofluorene	243-17-4	0.76	0.15	19.60	0.76	0.004	0.7	1.5	0.0001	1.93E-06	1.31E-08	0.0001	2.83E-06	4.17E-05	0.00
168	C1-acenaphthenes		0.73	0.11	14.50	0.73	0.004	0.8	1.4	0.0010	1.93E-05	1.62E-07	0.0005	2.72E-05	4.01E-04	0.00
167	carbazole	86-74-8	0.73	0.09	12.90	0.73	0.004	0.8	1.4	0.0400	7.73E-04	6.51E-06	0.0205	1.09E-03	1.60E-02	0.02
179	benzoquinoline-1 (7,8-benzoquinoline)	230-27-3	0.67	0.11	16.40	0.67	0.004	0.7	1.3	0.0010	1.93E-05	1.39E-07	0.0005	2.49E-05	3.68E-04	0.00
154	**biphenyl - HAP**	92-52-4	0.66	0.06	8.30	0.66	0.004	0.8	1.3	0.0010	1.93E-05	1.59E-07	0.0005	2.46E-05	3.62E-04	0.00
156	1,3-dimethyl naphthalene	575-41-7	0.62	0.07	11.40	0.62	0.004	0.8	1.2	5.0000	9.67E-02	7.39E-04	2.1783	1.15E-01	1.70E+00	1.70
118	dihydroindene (Indan)	496-11-7	0.59	0.06	10.50	0.59	0.005	1.0	1.1	30.0000	5.80E-01	5.58E-03	12.4372	6.59E-01	9.72E+00	9.72
252	benzo(b)fluoranthene	205-99-2	0.55	0.08	15.00	0.55	0.002	0.4	1.1	4.12E-05	7.97E-07	3.35E-09	1.59E-05	8.43E-07	1.24E-05	0.00
193	C1-benzoquinolines		0.54	0.08	15.30	0.54	0.003	0.5	1.0	0.0001	1.93E-06	1.04E-08	3.79E-05	2.01E-06	2.96E-05	0.00
134	benzo(b)thiophene (Thianaphthalene)	95-15-8	0.51	0.03	6.60	0.51	0.004	0.7	1.0	7.2900	1.41E-01	1.03E-03	2.6125	1.38E-01	2.04E+00	2.04
204	2-phenyl naphthalene		0.50	0.09	18.50	0.5	0.002	0.5	1.0	0.0001	1.93E-06	9.12E-09	3.51E-05	1.86E-06	2.74E-05	0.00
180	C1-fluorenes		0.49	0.07	14.60	0.49	0.003	0.5	0.9	0.0010	1.93E-05	1.01E-07	0.0003	1.82E-05	2.69E-04	0.00
206	C2-phenanthrenes		0.47	0.07	15.50	0.47	0.002	0.4	0.9	0.0001	1.93E-06	8.49E-09	3.30E-05	1.75E-06	2.58E-05	0.00
otals			76.50				0.5196	100	145.1			0.0530	128.0208	6.7791	100.00	100.00

Calculation of Molecular Weight of Vapor for Whole Creosote at Bulk Liquid Conditions

Molecular Weight of Vapor, MV = MWi(VPiXi)/Pt + MWii(VPiiXii)/Pt + MWiii(VPiiiXiii)/Pt
= MVi+MV Where MVi = MWi(Pi*Xi/Pt)

Vapor Pressure of Whole Creosote (100% of Partial Pressures) at Bulk Liquid Conditions (Allied Sig	0.068	psia
Vapor Pressure of Composite Creosote (Sum of Ppi) at Bulk Liquid Conditions (GERG) =	0.053	psia
Molecular Weight of Vapor of Creosote given by Vapor Pressure of Composite Creosote, 0.053 psia	128.021	psia

Emissions of HAPs from whole creosote are equivalent to 46.67% of total emissions.

* = Vapor Pressures for pure components are not registered and have not been determined and therefore were guestimated.

36 components comprising 0.5% or more mean weight account for 76.5% of whole creosote.

Only 77% of Creosote distills below 330C; the remaining 23% constituents cannot achieve the vapor phase and cannot contribule to Creosote Vapor Pressure; Ref. OHMTADS attached.

Only 0.4% of the GERG sample distilled below 210 F, see attached data.

The 22% differences in vapor pressures between the measured and the calculated could be due to underestimating the nonregistered(documented) VP.

Therefore, HAP emissions can be derived from the component-specific percent contribution to the molecular weight of vapor of whole creosote or the mole mass.

In every	**100.00**	**lb of Creosote Vapor there will be**
	41.77	**lbs of Naphthalene**
	1.40	**lbs of Dibenzofuran**
	3.49	**lbs of Quinoline**
	0.00	**lbs of Biphenyl**
	46.67	**lb/lb*mole of Total HAPS for Creosote Vapor**
	53.33	**lb/lb*mole Remaining as VOCs**

iedSignal PO Box 593. Fairfield, AL 35064

940183

FAX

Date: 10/25/94

Number of pages including cover sheet: 2

To: Shaleen McCormick
per John Utmore

Phone:

Fax phone: 615 373 8512

C:

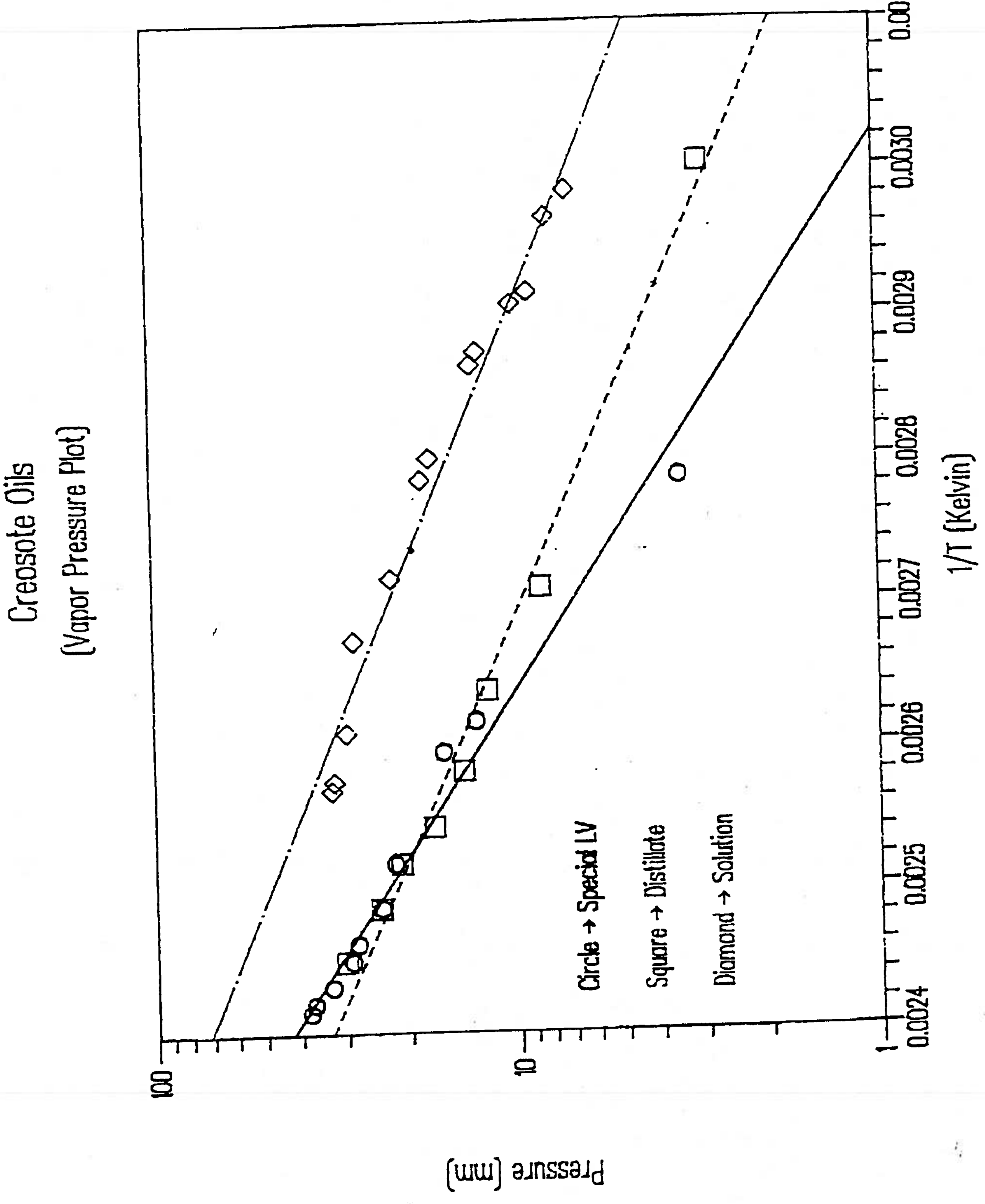
From: V. Cwynar
Allied Signal

Fairfield
205 787 8605

Ironton
Phone: 614 533 1040

Fax phone: (205) 783 0100

REMARKS: ☐ Urgent ☐ For your review ☐ Reply ASAP ☐ Please comment


Creosote Oils
(Vapor Pressure Plot)
Circle → Special LV
Square → Distillate
Diamond → Solution
1/T (Kelvin)
0.0024
0.0025
0.0026
0.0027
0.0028
0.0029
0.0030
0.0031
Pressure (mm)
100
10
1

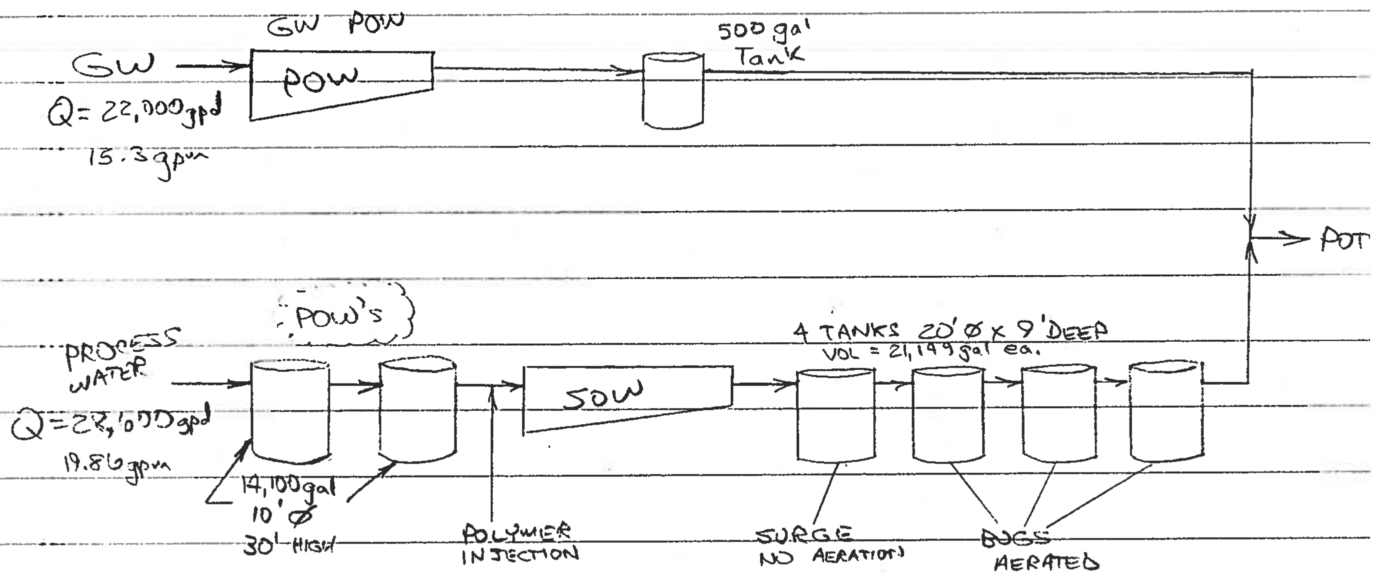
APPENDIX 6

USEPA WATER 8 MODEL AND USEPA TANKS 2.0 PROGRAM MODEL

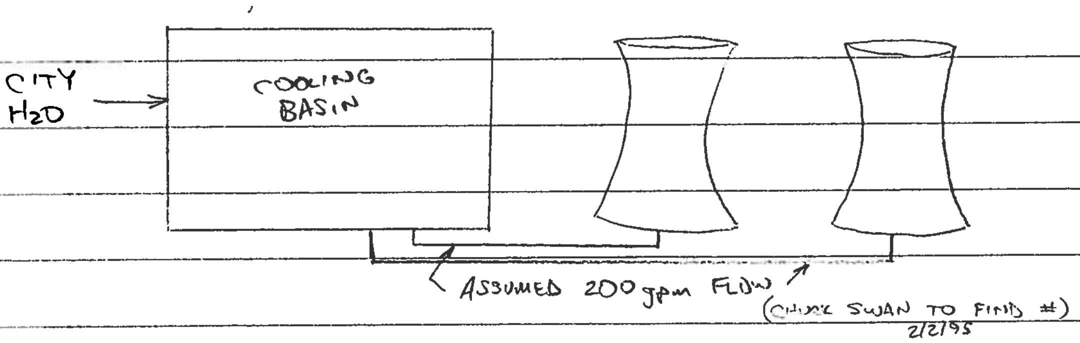
WATER 8

2/3/95 ABP

K-M COLUMBUS WW TREATMENT TRAIN



2 COOLING TOWERS / 1 BASIN NON-CONTACT



$$19.86\,\text{gal}/\cancel{\text{min}} \times \frac{\cancel{ft^3}}{7.48\,\text{gal}} \times \frac{28{,}320\,\cancel{cc}}{\cancel{ft^3}} \times \frac{m^3}{1\times10^6\,\cancel{cc}} \times \frac{\cancel{\text{min}}}{60\,\text{sec}} = 0.001253$$

.7027 E-3 59.93

$$\text{Area} = \frac{\pi D^2}{4} = \frac{\pi (20\,ft)^2}{4} = 314.16\,ft^2 \Rightarrow \sqrt{314} : 17.72\,ft\ (5.4\,m)$$

WATER 7 MODELING (FOR PROCESS WATER)

① MODELED 2 POW'S TOGETHER

② SOW BY ITSELF

③ SURGE TANK AND 1ST AERATED TANK

④ FINAL 2 AERATED TANK

```
    SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

    FILE: COLUMB8a.CwD                           02-16-1995


UNIT: General specifications_______________________
Wind velocity (cm/s at 10 m)                           224
Wastewater temperature   (C)                           60
Wastewater flow rate (m3/s)                            .001253
total dissolved organics in (mg/l)                     100
inlet suspended solids                                 500
Overall biorate (mg/g bio-hr)                          19

UNIT: equalization_POW Tanks_____________
number units equalization                              2
Wastewater temperature   (C)                           60
length of unit (m)                                     2.701
length of unit (m)                                     2.701
depth  of unit (m)                                     9.1449
Area of agitation (each aerator,m2)                    0
Total number of agitators in the unit                  0
Power of agitation (each aerator,HP)                   0
Impeller diameter (cm)                                 0
Impeller rotation (RPM)                                0
Agitator mechanical efficiency                         0
aerator effectiveness, alpha                           0
if there is plug flow, enter 1                         1
Overall biorate (mg/g bio-hr)                          0
Aeration  air flow (m3/s)                              0
active biomass,  (g/l)                                 0
If covered, then enter 1                               0
Recycle flow out of unit (m3/s)                        0

     INLET COMPOUND CONCENTRATIONS_________

    NAPHTHALENE                                    31 ppmw
```

```
INTERMEDIATE CALCULATIONS  COLUMB8a.CwD  02-16-1995


      SOURCE: equalization  SPRINGFIELD HOT SUMP       Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                         0.4857E-02
KL quiescent (m/s)                         0.2754E-05
KL OVERALL QUIESCENT (m/s)                 0.2746E-05
KL OVERALL (m/s)                           0.2746E-05
TOTAL FRACTION VOLATILIZED                 0.0276
FRACTION BIOLOGICALLY REMOVED              0.6153E-07
FRACTION ABSORBED                          0.2344
TOTAL AIR EMISSIONS  (g/s)                 0.1071E-02
                 (Mg/year)                 0.0338
EMISSION FACTOR  (g/cm2-s)                 0.1468E-07
UNIT EXIT CONCENTRATION (ppmw)            22.8797
```

```
   WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

 COLUMB8a.CwD  02-16-1995
      COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

      Type of compound       A  aromatic
      density  (g/cc)                                          1.14
      molecular weight                                         128.2
      diffusion coef. water (cm2/s)                            .0000075
      diffusion coef. air  (cm2/s)                             .059
      vapor pressure (mm Hg)                                   .23
      Henry's law constant (atm-m3/mol)                        .000483
      vapor pressure temp. coefficients                        7.3729
                                                                1968.36
                                                                222.61
      zero order biorate constant (mg/g-hr)                    42.47
      first order biorate constant (l/mg-s)                    1
      octanol water partition coefficient                      3.37
      UNIFAC code                                             28:2;000000000
      The estimated vapor diffusion coefficient is .0526  cm2/s
      The estimated vapor pressure is .26448  mm Hg.


   SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

 SOURCE                              RATE      Fraction   Fraction     est. conc
                                 (grams/sec)    Air      Remaining     (ng/m3)


 equalization      SPRINGF..    1.071029E-03 0.0276     0.7381       0.177E+06
 TOTALS, ALL UNITS              1.071029E-03 0.0276     0.7381
 total fraction absorbed                                 .2343717
```

g/s * 69,462.555 = lb/yr

= 74.3964 lb/yr

entered in CWW Table 2/22/95

```
    Version 2

        WASTEWATER TREATMENT SUMMARY  COLUMB8a.CwD  02-16-1995

 COMPOUND                                  RATE      Fraction  Fraction  Fraction
                                          (g/s)        Air       Bio      Remain
 NAPHTHALENE                           0.1071E-02  0.02757   0.00000   0.7381
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: colusow8.CwD 02-16-1995

UNIT: General specifications	
Wind velocity (cm/s at 10 m)	224
Wastewater temperature (C)	60
Wastewater flow rate (m3/s)	.00125
total dissolved organics in (mg/l)	100
inlet suspended solids	500
Overall biorate (mg/g bio-hr)	19

UNIT: equalization SOW	
number units equalization	1
Wastewater temperature (C)	60
length of unit (m)	3.66
length of unit (m)	18.29
depth of unit (m)	1.829
Area of agitation (each aerator,m2)	0
Total number of agitators in the unit	0
Power of agitation (each aerator,HP)	0
Impeller diameter (cm)	0
Impeller rotation (RPM)	0
Agitator mechanical efficiency	0
aerator effectiveness, alpha	0
if there is plug flow, enter 1	1
Overall biorate (mg/g bio-hr)	0
Aeration air flow (m3/s)	0
active biomass, (g/l)	0
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

INLET COMPOUND CONCENTRATIONS	
NAPHTHALENE	31 ppmw

```
INTERMEDIATE CALCULATIONS  colusow8.CwD  02-16-1995


      SOURCE: equalization  SPRINGFIELD HOT SUMP       Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                         0.4300E-02
KL quiescent (m/s)                         0.2754E-05
KL OVERALL QUIESCENT (m/s)                 0.2745E-05
KL OVERALL (m/s)                           0.2745E-05
TOTAL FRACTION VOLATILIZED                 0.1201
FRACTION BIOLOGICALLY REMOVED              0.1231E-06
FRACTION ABSORBED                          0.2220
TOTAL AIR EMISSIONS  (g/s)                 0.4653E-02
                 (Mg/year)                 0.1468
EMISSION FACTOR  (g/cm2-s)                 0.6952E-08
UNIT EXIT CONCENTRATION (ppmw)            20.3940
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

colusow8.CwD  02-16-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound       A  aromatic
     density  (g/cc)                                        1.14
     molecular weight                                       128.2
     diffusion coef. water (cm2/s)                          .0000075
     diffusion coef. air  (cm2/s)                           .059
     vapor pressure (mm Hg)                                 .23
     Henry's law constant (atm-m3/mol)                      .000483
     vapor pressure temp. coefficients                      7.3729
                                                             1968.36
                                                             222.61
     zero order biorate constant (mg/g-hr)                  42.47
     first order biorate constant (l/mg-s)                  1
     octanol water partition coefficient                    3.37
     UNIFAC code                                           28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

 SOURCE                             RATE      Fraction   Fraction    est. conc
                                (grams/sec)     Air      Remaining    (ng/m3)


 equalization      SPRINGF..   4.653458E-03 0.1201      0.6579      0.254E+06
 TOTALS, ALL UNITS             4.653458E-03 0.1201      0.6579
 total fraction absorbed                                 .2220399
```

g/s * 69,462,555 = lb/yr

= 323.2411 lb/yr

```
    Version 2

         WASTEWATER TREATMENT SUMMARY  colusow8.CwD  02-16-1995

COMPOUND                                   RATE      Fraction   Fraction   Fraction
                                          (g/s)        Air        Bio       Remain
NAPHTHALENE                             0.4653E-02  0.12009    0.00000    0.6579
```

```
SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLUMB8B.CwD                                02-16-1995

UNIT: General specifications_______________________
Wind velocity (cm/s at 10 m)                                  224
Wastewater temperature   (C)                                  60
Wastewater flow rate (m3/s)                                   .00125
total dissolved organics in (mg/l)                            100
inlet suspended solids                                        500
Overall biorate (mg/g bio-hr)                                 19

UNIT: equalization  SURGE TANK
number units equalization                                     1
Wastewater temperature   (C)                                  60
length of unit (m)                                            5.4
length of unit (m)                                            5.4
depth  of unit (m)                                            2.743
Area of agitation (each aerator,m2)                           0
Total number of agitators in the unit                         0
Power of agitation (each aerator,HP)                          0
Impeller diameter (cm)                                        0
Impeller rotation (RPM)                                       0
Agitator mechanical efficiency                                0
aerator effectiveness, alpha                                  0
if there is plug flow, enter 1                                1
Overall biorate (mg/g bio-hr)                                 0
Aeration  air flow (m3/s)                                     0
active biomass,  (g/l)                                        0
If covered, then enter 1                                      0
Recycle flow out of unit (m3/s)                               0

UNIT: aerated biotreatment AERATED TANK #1
number units aeration in parallel                             1
Wastewater temperature   (C)                                  60
length of aeration unit (m)                                   5.4
width of aeration unit (m)                                    5.4
depth of aeration unit (m)                                    2.743
Area of agitation (each aerator,m2)                           29
Total number of agitators in the unit                         1
Power of agitation (each aerator,HP)                          5
Impeller diameter (cm)                                        21
Impeller rotation (RPM)                                       1725
Agitator mechanical efficiency                                .83
aerator effectiveness, alpha                                  .83
if there is plug flow, enter 1                                0
Overall biorate (mg/g bio-hr)                                 19
Aeration  air flow (m3/s)                                     0
active biomass, aeration (g/l)                                2
If covered, then enter 1                                      0
Recycle flow out of unit (m3/s)                               0
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLUMB8B.CwD 02-16-1995

INLET COMPOUND CONCENTRATIONS__________

NAPHTHALENE	20.394 ppmw

```
INTERMEDIATE CALCULATIONS  COLUMB8B.CwD  02-16-1995


      SOURCE: equalization            Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                            0.4501E-02
KL quiescent (m/s)                            0.2754E-05
KL OVERALL QUIESCENT (m/s)                    0.2745E-05
KL OVERALL (m/s)                              0.2745E-05
TOTAL FRACTION VOLATILIZED                    0.0544
FRACTION BIOLOGICALLY REMOVED                 0.2338E-07
FRACTION ABSORBED                             0.2308
TOTAL AIR EMISSIONS  (g/s)                    0.1387E-02
                 (Mg/year)                    0.0437
EMISSION FACTOR  (g/cm2-s)                    0.4755E-08
UNIT EXIT CONCENTRATION (ppmw)               14.5769

      SOURCE: aerated biotreatment            Version 2
      COMPOUND: NAPHTHALENE

KG aerated (m/s)                              0.0460
KL aerated (m/s)                              0.9005E-02
KL OVERALL AERATED (m/s)                      0.4441E-02
KG quiescent (m/s)                            0.4501E-02
KL quiescent (m/s)                            0.2754E-05
KL OVERALL QUIESCENT (m/s)                    0.2745E-05
KL OVERALL (m/s)                              0.4416E-02
TOTAL FRACTION VOLATILIZED                    0.3741
FRACTION BIOLOGICALLY REMOVED                 0.6222
FRACTION ABSORBED                             0.9868E-04
TOTAL AIR EMISSIONS  (g/s)                    0.6816E-02
                 (Mg/year)                    0.2150
EMISSION FACTOR  (g/cm2-s)                    0.2338E-07
UNIT EXIT CONCENTRATION (ppmw)                0.0529
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

COLUMB8B.CwD  02-16-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound       A  aromatic
     density  (g/cc)                                         1.14
     molecular weight                                        128.2
     diffusion coef. water (cm2/s)                           .0000075
     diffusion coef. air  (cm2/s)                            .059
     vapor pressure (mm Hg)                                  .23
     Henry's law constant (atm-m3/mol)                       .000483
     vapor pressure temp. coefficients                       7.3729
                                                              1968.36
                                                              222.61
     zero order biorate constant (mg/g-hr)                   42.47
     first order biorate constant (l/mg-s)                   1
     octanol water partition coefficient                     3.37
     UNIFAC code                                            28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

SOURCE                               RATE      Fraction   Fraction    est. conc
                                  (grams/sec)    Air      Remaining    (ng/m3)


equalization                      1.386616E-03 0.0544      0.7148     0.115E+06
aerated biotreat.                 .0068162     0.3741      0.0036     0.564E+06
TOTALS, ALL UNITS                 8.202816E-03 0.3218      0.0026
total fraction absorbed                                     .2309115
```

g/s * 69,462.555 = lb/yr

SURGE = 96.3179 lb/yr

AER NO. 1 = 473.4707 lb/yr

```
    Version 2

          WASTEWATER TREATMENT SUMMARY  COLUMB8B.CwD  02-16-1995

COMPOUND                                          RATE     Fraction  Fraction  Fraction
                                                 (g/s)       Air       Bio      Remain
NAPHTHALENE                                   0.8203E-02  0.32177   0.44472   0.0026
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLUMB8C.CwD 02-16-1995

UNIT: General specifications

Wind velocity (cm/s at 10 m)	224
Wastewater temperature (C)	60
Wastewater flow rate (m3/s)	.00125
total dissolved organics in (mg/l)	100
inlet suspended solids	500
Overall biorate (mg/g bio-hr)	19

UNIT: aerated biotreatment AERATED TANK #2

number units aeration in parallel	1
Wastewater temperature (C)	60
length of aeration unit (m)	5.4
width of aeration unit (m)	5.4
depth of aeration unit (m)	2.743
Area of agitation (each aerator,m2)	29
Total number of agitators in the unit	1
Power of agitation (each aerator,HP)	3
Impeller diameter (cm)	21
Impeller rotation (RPM)	1725
Agitator mechanical efficiency	.83
aerator effectiveness, alpha	.83
if there is plug flow, enter 1	0
Overall biorate (mg/g bio-hr)	19
Aeration air flow (m3/s)	0
active biomass, aeration (g/l)	2
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

UNIT: aerated biotreatment AERAted TANK #3

number units aeration in parallel	1
Wastewater temperature (C)	60
length of aeration unit (m)	5.4
width of aeration unit (m)	5.4
depth of aeration unit (m)	2.743
Area of agitation (each aerator,m2)	29
Total number of agitators in the unit	1
Power of agitation (each aerator,HP)	1
Impeller diameter (cm)	14
Impeller rotation (RPM)	1725
Agitator mechanical efficiency	.83
aerator effectiveness, alpha	.83
if there is plug flow, enter 1	0
Overall biorate (mg/g bio-hr)	19
Aeration air flow (m3/s)	0
active biomass, aeration (g/l)	2
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLUMB8C.CwD 02-16-1995

INLET COMPOUND CONCENTRATIONS

NAPHTHALENE	.0529 ppmw

```
INTERMEDIATE CALCULATIONS  COLUMB8C.CwD  02-16-1995


      SOURCE: aerated biotreatment         Version 2
      COMPOUND: NAPHTHALENE

KG aerated (m/s)                           0.0375
KL aerated (m/s)                           0.5403E-02
KL OVERALL AERATED (m/s)                   0.3076E-02
KG quiescent  (m/s)                        0.4501E-02
KL quiescent  (m/s)                        0.2754E-05
KL OVERALL QUIESCENT (m/s)                 0.2745E-05
KL OVERALL (m/s)                           0.3059E-02
TOTAL FRACTION VOLATILIZED                 0.2922
FRACTION BIOLOGICALLY REMOVED              0.7025
FRACTION ABSORBED                          0.1224E-02
TOTAL AIR EMISSIONS  (g/s)                 0.1932E-04
                 (Mg/year)                 0.6093E-03
EMISSION FACTOR  (g/cm2-s)                 0.6626E-10
UNIT EXIT CONCENTRATION (ppmw)             0.2166E-03

      SOURCE: aerated biotreatment         Version 2
      COMPOUND: NAPHTHALENE

KG aerated (m/s)                           0.0281
KL aerated (m/s)                           0.1801E-02
KL OVERALL AERATED (m/s)                   0.1347E-02
KG quiescent  (m/s)                        0.4501E-02
KL quiescent  (m/s)                        0.2754E-05
KL OVERALL QUIESCENT (m/s)                 0.2745E-05
KL OVERALL (m/s)                           0.1340E-02
TOTAL FRACTION VOLATILIZED                 0.1533
FRACTION BIOLOGICALLY REMOVED              0.8417
TOTAL AIR EMISSIONS  (g/s)                 0.4152E-07
                 (Mg/year)                 0.1309E-05
EMISSION FACTOR  (g/cm2-s)                 0.1424E-12
UNIT EXIT CONCENTRATION (ppmw)             0.1063E-05
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

COLUMB8C.CwD  02-16-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound       A  aromatic
     density  (g/cc)                                         1.14
     molecular weight                                        128.2
     diffusion coef. water (cm2/s)                           .0000075
     diffusion coef. air  (cm2/s)                            .059
     vapor pressure (mm Hg)                                  .23
     Henry's law constant (atm-m3/mol)                       .000483
     vapor pressure temp. coefficients                       7.3729
                                                              1968.36
                                                              222.61
     zero order biorate constant (mg/g-hr)                   42.47
     first order biorate constant (l/mg-s)                   1
     octanol water partition coefficient                     3.37
     UNIFAC code                                            28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

SOURCE                                 RATE      Fraction   Fraction    est. conc
                                   (grams/sec)     Air      Remaining    (ng/m3)


aerated biotreat.                   1.932145E-05 0.2922     0.0041      0.160E+04
aerated biotreat.                   4.151799E-08 0.1533     0.0049      0.343E+01
TOTALS, ALL UNITS                   1.936297E-05 0.2928     0.0000
total fraction absorbed                                      1.224011E-03
```

g/s * 69,462.555 = lb/yr

AER NO. 2 = 1.3421 lb/yr

AER NO. 3 = 0.0029 lb/yr

```
    Version 2

        WASTEWATER TREATMENT SUMMARY  COLUMB8C.CwD  02-16-1995

COMPOUND                                      RATE      Fraction   Fraction   Fraction
                                              (g/s)       Air        Bio       Remain
NAPHTHALENE                                0.1936E-04  0.29282    0.70593    0.0000
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: colum8GW.CwD 02-16-1995

UNIT: General specifications

Wind velocity (cm/s at 10 m)	45
Wastewater temperature (C)	10
Wastewater flow rate (m3/s)	.00126
total dissolved organics in (mg/l)	20
inlet suspended solids	60
Overall biorate (mg/g bio-hr)	19

UNIT: equalization GROUNDWATER O/WS

number units equalization	1
Wastewater temperature (C)	10
length of unit (m)	3.658
length of unit (m)	15.24
depth of unit (m)	2.164
Area of agitation (each aerator,m2)	0
Total number of agitators in the unit	0
Power of agitation (each aerator,HP)	0
Impeller diameter (cm)	0
Impeller rotation (RPM)	0
Agitator mechanical efficiency	0
aerator effectiveness, alpha	0
if there is plug flow, enter 1	1
Overall biorate (mg/g bio-hr)	0
Aeration air flow (m3/s)	0
active biomass, (g/l)	0
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

INLET COMPOUND CONCENTRATIONS

NAPHTHALENE	31 ppmw

```
INTERMEDIATE CALCULATIONS  colum8GW.CwD  02-16-1995


      SOURCE: equalization          Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                              0.1026E-02
KL quiescent (m/s)                              0.2471E-05
KL OVERALL QUIESCENT (m/s)                      0.1769E-05
KL OVERALL (m/s)                                0.1769E-05
TOTAL FRACTION VOLATILIZED                      0.0741
FRACTION ABSORBED                               0.0309
TOTAL AIR EMISSIONS  (g/s)                      0.2894E-02
                 (Mg/year)                      0.0913
EMISSION FACTOR  (g/cm2-s)                      0.5191E-08
UNIT EXIT CONCENTRATION (ppmw)                 27.7463
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

colum8GW.CwD  02-16-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound       A  aromatic
     density  (g/cc)                                        1.14
     molecular weight                                       128.2
     diffusion coef. water (cm2/s)                          .0000075
     diffusion coef. air  (cm2/s)                           .059
     vapor pressure (mm Hg)                                 .23
     Henry's law constant (atm-m3/mol)                      .000483
     vapor pressure temp. coefficients                      7.3729
                                                             1968.36
                                                             222.61
     zero order biorate constant (mg/g-hr)                  42.47
     first order biorate constant (l/mg-s)                  1
     octanol water partition coefficient                    3.37
     UNIFAC code                                           28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

SOURCE                               RATE     Fraction   Fraction    est. conc
                                  (grams/sec)   Air      Remaining    (ng/m3)


equalization                       .0028939    0.0741    0.8950     0.861E+06
TOTALS, ALL UNITS                  .0028939    0.0741    0.8950
total fraction absorbed                                   3.086868E-02
```

= 201.0 lb/yr

```
    Version 2

        WASTEWATER TREATMENT SUMMARY  colum8GW.CwD  02-16-1995

  COMPOUND                                  RATE      Fraction  Fraction  Fraction
                                            (g/s)       Air       Bio      Remain
  NAPHTHALENE                           0.2894E-02  0.07409   -.00000    0.8950
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLSUMP8.CwD 02-16-1995

UNIT: General specifications

Wind velocity (cm/s at 10 m)	224
Wastewater temperature (C)	60
Wastewater flow rate (m3/s)	.00125
total dissolved organics in (mg/l)	100
inlet suspended solids	500
Overall biorate (mg/g bio-hr)	19

UNIT: equalization HOT SUMP

number units equalization	1
Wastewater temperature (C)	60
length of unit (m)	2
length of unit (m)	2
depth of unit (m)	1
Area of agitation (each aerator,m2)	0
Total number of agitators in the unit	0
Power of agitation (each aerator,HP)	0
Impeller diameter (cm)	0
Impeller rotation (RPM)	0
Agitator mechanical efficiency	0
aerator effectiveness, alpha	0
if there is plug flow, enter 1	1
Overall biorate (mg/g bio-hr)	0
Aeration air flow (m3/s)	0
active biomass, (g/l)	0
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

INLET COMPOUND CONCENTRATIONS

NAPHTHALENE	31 ppmw

```
INTERMEDIATE CALCULATIONS  COLSUMP8.CwD  02-16-1995


      SOURCE: equalization         Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                         0.5021E-02
KL quiescent (m/s)                         0.2754E-05
KL OVERALL QUIESCENT (m/s)                 0.2746E-05
KL OVERALL (m/s)                           0.2746E-05
TOTAL FRACTION VOLATILIZED                 0.7662E-02
FRACTION ABSORBED                          0.2370
TOTAL AIR EMISSIONS  (g/s)                 0.2969E-03
                 (Mg/year)                 0.9363E-02
EMISSION FACTOR  (g/cm2-s)                 0.7423E-08
UNIT EXIT CONCENTRATION (ppmw)            23.4164
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

COLSUMP8.CwD  02-16-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound       A  aromatic
     density  (g/cc)                                         1.14
     molecular weight                                        128.2
     diffusion coef. water (cm2/s)                           .0000075
     diffusion coef. air  (cm2/s)                            .059
     vapor pressure (mm Hg)                                  .23
     Henry's law constant (atm-m3/mol)                       .000483
     vapor pressure temp. coefficients                       7.3729
                                                              1968.36
                                                              222.61
     zero order biorate constant (mg/g-hr)                   42.47
     first order biorate constant (l/mg-s)                   1
     octanol water partition coefficient                     3.37
     UNIFAC code                                            28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

SOURCE                              RATE      Fraction   Fraction    est. conc
                                 (grams/sec)   Air       Remaining    (ng/m3)


equalization                     2.969024E-04 0.0077     0.7554      0.663E+05
TOTALS, ALL UNITS                2.969024E-04 0.0077     0.7554
total fraction absorbed                                   .2369708
```

g/s * 69,462.555 = lb/yr

= 20.6236 lb/yr

```
    Version 2

         WASTEWATER TREATMENT SUMMARY  COLSUMP8.CwD  02-16-1995
COMPOUND                                    RATE      Fraction  Fraction  Fraction
                                           (g/s)        Air       Bio      Remain
NAPHTHALENE                             0.2969E-03  0.00766   0.00000   0.7554
```

SELECTED PARAMETERS FOR THE WASTE WATER TREATMENT SYSTEM

FILE: COLSAP8.CWD 03-01-1995

UNIT: General specifications	
Wind velocity (cm/s at 10 m)	224
Wastewater temperature (C)	60
Wastewater flow rate (m3/s)	.00004
total dissolved organics in (mg/l)	200
inlet suspended solids	200
Overall biorate (mg/g bio-hr)	19

UNIT: equalization SAP TANKS 1,2,and 3	
number units equalization	3
Wastewater temperature (C)	60
length of unit (m)	2.7
length of unit (m)	2.7
depth of unit (m)	1.143
Area of agitation (each aerator,m2)	0
Total number of agitators in the unit	0
Power of agitation (each aerator,HP)	0
Impeller diameter (cm)	0
Impeller rotation (RPM)	0
Agitator mechanical efficiency	0
aerator effectiveness, alpha	0
if there is plug flow, enter 1	1
Overall biorate (mg/g bio-hr)	0
Aeration air flow (m3/s)	0
active biomass, (g/l)	0
If covered, then enter 1	0
Recycle flow out of unit (m3/s)	0

INLET COMPOUND CONCENTRATIONS	
NAPHTHALENE	100 ppmw

```
INTERMEDIATE CALCULATIONS  COLSAP8.CWD  03-01-1995


      SOURCE: equalization         Version 2
      COMPOUND: NAPHTHALENE

KG quiescent (m/s)                          0.4858E-02
KL quiescent (m/s)                          0.2754E-05
KL OVERALL QUIESCENT (m/s)                  0.2746E-05
KL OVERALL (m/s)                            0.2746E-05
TOTAL FRACTION VOLATILIZED                  0.7461
FRACTION BIOLOGICALLY REMOVED               0.1144E-06
FRACTION ABSORBED                           0.0540
TOTAL AIR EMISSIONS  (g/s)                  0.2984E-02
                 (Mg/year)                  0.0941
EMISSION FACTOR  (g/cm2-s)                  0.4094E-07
UNIT EXIT CONCENTRATION (ppmw)             19.9908
```

```
  WASTEWATER TREATMENT SUMMARY: NAPHTHALENE     Version 2

COLSAP8.CWD  03-01-1995
     COMPOUND PROPERTIES OF NAPHTHALENE at  25 deg. C

     Type of compound        A  aromatic
     density  (g/cc)                                            1.14
     molecular weight                                           128.2
     diffusion coef. water (cm2/s)                              .0000075
     diffusion coef. air  (cm2/s)                               .059
     vapor pressure (mm Hg)                                     .23
     Henry's law constant (atm-m3/mol)                          .000483
     vapor pressure temp. coefficients                          7.3729
                                                                 1968.36
                                                                 222.61

     zero order biorate constant (mg/g-hr)                      42.47
     first order biorate constant (l/mg-s)                      1
     octanol water partition coefficient                        3.37
     UNIFAC code                                               28:2;000000000
     The estimated vapor diffusion coefficient is .0526  cm2/s
     The estimated vapor pressure is .26448  mm Hg.


  SUMMARY OF AIR EMISSIONS FROM UNITS     Version 2

SOURCE                                 RATE     Fraction   Fraction     est. conc
                                   (grams/sec)    Air      Remaining     (ng/m3)


equalization                       2.984266E-03 0.7461     0.1999      0.493E+06
TOTALS, ALL UNITS                  2.984266E-03 0.7461     0.1999
total fraction absorbed                                     5.402486E-02
```

$\frac{\text{grams}}{\text{sec}} * 69,462.55 = \frac{\text{lbs}}{\text{yr}}$

2.984266×10^{-3} grams/sec * 69,462.55 = 207.2947 lbs/yr

or

= 0.1036 tons/yr

```
    Version 2

        WASTEWATER TREATMENT SUMMARY  COLSAP8.CWD  03-01-1995

COMPOUND                                     RATE      Fraction  Fraction  Fraction
                                            (g/s)        Air       Bio      Remain
NAPHTHALENE                              0.2984E-02  0.74607   0.00000   0.1999
```

Wastewater Treatment System Emissions

Facility Columbus

Unit	Water 7 Emissions	@ 60°C Water 8 Emissions lbs/yr
POW TANKS (2)		74.4
SOW		323.2
SURGE TANK		96.3
AERATED TANK NO. 1		473.5
NO. 2		1.3
NO. 3		0.003
GW O/WS @ 10°C		201.0
TOTAL		1,169.7 tpy = 0.58

HOT SUMP 20.6

TANKS 2.0

```
                              TANKS PROGRAM 2.0                                02/23/95
                      EMISSIONS REPORT - DETAIL FORMAT                         PAGE 1
                TANK IDENTIFICATION AND PHYSICAL CHARACTERISTICS

dentification
  Identification No.:      WK TANK 1
  City:                    Columbus
  State:                   MS
  Company:                 KERR MCGEE
  Type of Tank:            Vertical Fixed Roof

ank Dimensions
  Shell Height (ft):                30
  Diameter (ft):                    18
  Liquid Height (ft):               30
  Avg. Liquid Height (ft):          27
  Volume (gallons):              57113
  Turnovers:                       216
  Net Throughput (gal/yr):    12347831

aint Characteristics
  Shell Color/Shade:          Gray/Medium
  Shell Condition:            Good
  Roof Color/Shade:           Gray/Medium
  Roof Condition:             Good

oof Characteristics
  Type:                       Dome
  Height (ft):                      0.50
  Radius (ft) (Dome Roof):          9.00
  Slope (ft/ft) (Cone Roof):      0.0000

reather Vent Settings
  Vacuum Setting (psig):           -0.03
  Pressure Setting (psig):          0.03

eteorological Data Used in Emission Calculations:  Jackson, Mississippi
```

```
                                           TANKS PROGRAM 2.0                                    02/23/95
                                   EMISSIONS REPORT - DETAIL FORMAT                             PAGE 2
                                    LIQUID CONTENTS OF STORAGE TANK


                                                      Liquid
                                    Daily Liquid Surf.  Bulk                                  Vapor  Liquid  Vapor
                                    Temperatures (deg F) Temp.   Vapor Pressures (psia)  Mol.   Mass    Mass    Mol.   Basis for Vapor Pressure
ixture/Component             Month Avg.   Min.   Max.   (deg F) Avg.     Min.     Max.    Weight Fract.  Fract.  Weight Calculations
------------------------------------------------------------------------------------------------------------------------------------------------

APHTHALENE                   All   180.00 169.08 190.92 67.68   0.0680   0.0670   0.0681  41.660
```

```
Annual Emission Calculations

Standing Losses (lb):                              21.4723
  Vapor Space Volume (cu ft):                      2290.22
  Vapor Density (lb/cu ft):                         0.0004
  Vapor Space Expansion Factor:                   0.064260
  Vented Vapor Saturation Factor:                 0.968583

Tank Vapor Space Volume
  Vapor Space Volume (cu ft):                      2290.22
  Tank Diameter (ft):                                   18
  Vapor Space Outage (ft):                            9.00
  Tank Shell Height (ft):                               30
  Average Liquid Height (ft):                           27
  Roof Outage (ft):                                   6.00

Roof Outage (Dome Roof)
  Roof Outage (ft):                                   6.00
  Dome Radius (ft):                                      9
  Shell Radius (ft):                                     9

Vapor Density
  Vapor Density (lb/cu ft):                         0.0004
  Vapor Molecular Weight (lb/lb-mole):           41.660000
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                     0.068000
  Daily Avg. Liquid Surface Temp.(deg. R):          639.67
  Daily Average Ambient Temp. (deg. R):             524.27
  Ideal Gas Constant R
    (psia cuft /(lb-mole-deg R)):                   10.731
  Liquid Bulk Temperature (deg. R):                 527.35
  Tank Paint Solar Absorptance (Shell):               0.68
  Tank Paint Solar Absorptance (Roof):                0.68
  Daily Total Solar Insolation
  Factor (Btu/sqftday):                            1409.00

Vapor Space Expansion Factor
  Vapor Space Expansion Factor:                   0.064260
  Daily Vapor Temperature Range (deg.R):             43.68
  Daily Vapor Pressure Range (psia):              0.001100
  Breather Vent Press. Setting Range(psia):           0.06
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                     0.068000
  Vapor Pressure at Daily Minimum Liquid
  Surface Temperature (psia):                     0.067000
  Vapor Pressure at Daily Maximum Liquid
  Surface Temperature (psia):                     0.068100
  Daily Avg. Liquid Surface Temp. (deg R):          639.67
  Daily Min. Liquid Surface Temp. (deg R):          628.75
  Daily Max. Liquid Surface Temp. (deg R):          650.59
  Daily Ambient Temp. Range (deg.R):                 23.40
```

```
nnual Emission Calculations
ented Vapor Saturation Factor
  Vented Vapor Saturation Factor:                0.968583
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                    0.068000
  Vapor Space Outage (ft):                           9.00

ithdrawal Losses (lb):                           254.3760
  Vapor Molecular Weight (lb/lb-mole):          41.660000
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                    0.068000
  Annual Net Throughput (gal/yr):                12347831
  Turnover Factor:                                 0.3054
  Maximum Liquid Volume (cuft):                      7634
  Maximum Liquid Height (ft):                          30
  Tank Diameter (ft):                                  18
  Working Loss Product Factor:                       1.00

otal Losses (lb):                                  275.85
```

```
nnual Emissions Report

                                        Losses (lbs.):
iquid Contents                          Standing    Withdrawal        Total
-----------------------------------------------------------------------------
APHTHALENE                                 21.47        254.38       275.85

otal:                                      21.47        254.38       275.85
```

TANKS PROGRAM 2.0
EMISSIONS REPORT - DETAIL FORMAT
TANK IDENTIFICATION AND PHYSICAL CHARACTERISTICS

```
dentification
  Identification No.:     WK TANK 4
  City:                   Columbus
  State:                  MS
  Company:                KERR MCGEE
  Type of Tank:           Vertical Fixed Roof

ank Dimensions
  Shell Height (ft):                28
  Diameter (ft):                    22
  Liquid Height (ft):               28
  Avg. Liquid Height (ft):          24
  Volume (gallons):              79629
  Turnovers:                       216
  Net Throughput (gal/yr):    17215790

aint Characteristics
  Shell Color/Shade:          Gray/Medium
  Shell Condition:            Good
  Roof Color/Shade:           Gray/Medium
  Roof Condition:             Good

Roof Characteristics
  Type:                       Dome
  Height (ft):                    0.50
  Radius (ft) (Dome Roof):       11.00
  Slope (ft/ft) (Cone Roof):    0.0000

Breather Vent Settings
  Vacuum Setting (psig):         -0.03
  Pressure Setting (psig):        0.03


Meteorological Data Used in Emission Calculations:  Jackson, Mississippi
```

```
                                        TANKS PROGRAM 2.0                                       02/23/95
                                 EMISSIONS REPORT - DETAIL FORMAT                               PAGE 2
                                  LIQUID CONTENTS OF STORAGE TANK

                                                     Liquid
                                  Daily Liquid Surf. Bulk                                Vapor  Liquid  Vapor
                                  Temperatures (deg F) Temp.  Vapor Pressures (psia)     Mol.   Mass    Mass    Mol.   Basis for Vapor Pressure
Mixture/Component           Month Avg.   Min.   Max.  (deg F) Avg.    Min.    Max.      Weight Fract.  Fract.  Weight Calculations
------------------------------------------------------------------------------------------------------------------------------------------

NAPHTHALENE                 All   180.00 169.08 190.92 67.68  0.0680  0.0670  0.0681    41.660
```

```
Annual Emission Calculations

Standing Losses (lb):                            40.0655
  Vapor Space Volume (cu ft):                    4308.17
  Vapor Density (lb/cu ft):                       0.0004
  Vapor Space Expansion Factor:                 0.064260
  Vented Vapor Saturation Factor:               0.960758

Tank Vapor Space Volume
  Vapor Space Volume (cu ft):                    4308.17
  Tank Diameter (ft):                                 22
  Vapor Space Outage (ft):                         11.33
  Tank Shell Height (ft):                             28
  Average Liquid Height (ft):                         24
  Roof Outage (ft):                                 7.33

Roof Outage (Dome Roof)
  Roof Outage (ft):                                 7.33
  Dome Radius (ft):                                   11
  Shell Radius (ft):                                  11

Vapor Density
  Vapor Density (lb/cu ft):                       0.0004
  Vapor Molecular Weight (lb/lb-mole):         41.660000
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                   0.068000
  Daily Avg. Liquid Surface Temp.(deg. R):        639.67
  Daily Average Ambient Temp. (deg. R):           524.27
  Ideal Gas Constant R
    (psia cuft /(lb-mole-deg R)):                 10.731
  Liquid Bulk Temperature (deg. R):               527.35
  Tank Paint Solar Absorptance (Shell):             0.68
  Tank Paint Solar Absorptance (Roof):              0.68
  Daily Total Solar Insolation
  Factor (Btu/sqftday):                          1409.00

Vapor Space Expansion Factor
  Vapor Space Expansion Factor:                 0.064260
  Daily Vapor Temperature Range (deg.R):           43.68
  Daily Vapor Pressure Range (psia):            0.001100
  Breather Vent Press. Setting Range(psia):         0.06
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                   0.068000
  Vapor Pressure at Daily Minimum Liquid
  Surface Temperature (psia):                   0.067000
  Vapor Pressure at Daily Maximum Liquid
  Surface Temperature (psia):                   0.068100
  Daily Avg. Liquid Surface Temp. (deg R):        639.67
  Daily Min. Liquid Surface Temp. (deg R):        628.75
  Daily Max. Liquid Surface Temp. (deg R):        650.59
  Daily Ambient Temp. Range (deg.R):               23.40
```

TANKS PROGRAM 2.0
EMISSIONS REPORT - DETAIL FORMAT
DETAIL CALCULATIONS (AP-42)

```
Annual Emission Calculations
Vented Vapor Saturation Factor
  Vented Vapor Saturation Factor:                 0.960758
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                     0.068000
  Vapor Space Outage (ft):                           11.33

Withdrawal Losses (lb):                           354.6605
  Vapor Molecular Weight (lb/lb-mole):           41.660000
  Vapor Pressure at Daily Average Liquid
  Surface Temperature (psia):                     0.068000
  Annual Net Throughput (gal/yr):                 17215790
  Turnover Factor:                                  0.3054
  Maximum Liquid Volume (cuft):                      10644
  Maximum Liquid Height (ft):                           28
  Tank Diameter (ft):                                   22
  Working Loss Product Factor:                        1.00

Total Losses (lb):                                  394.73
```

```
Annual Emissions Report

                                       Losses (lbs.):
Liquid Contents                        Standing    Withdrawal       Total
-------------------------------------------------------------------------
NAPHTHALENE                               40.07        354.66      394.73

Total:                                    40.07        354.66      394.73
```

JOB 940163/3

SHEET NO. 1 OF

CALCULATED BY DEM DATE 2-23-95

CHECKED BY DATE

SCALE

AquAeTer
215 Jamestown Park, Suite 204
Brentwood, TN 37027
(615) 373-8532 FAX (615) 373-8512

TANK 2 ASSUMPTIONS ← Physical Charac.

① shell height (ft) = $\frac{V(gal)}{7.48} \times \frac{4}{\pi d^2}$ V = tank capacity
d = diameter

② Max liquid height = shell height

③ Let program calculate working volume
(will approx equal tank capacity)

④ Let program calculate net throughput

⑤ Black ≡ Gray/Medium
Shell condition = Good
Roof type = dome
Height = 0.5
? Radius = diameter/2
Slope = 0
* vacuum setting = -0.03
* pressure setting = 0.03

← Liquid Info.

⑥ organic liquids
Multiple component
? No speciation

⑦ Type in Naphthalene
– use data from Columbus construction permit

WARNING MESSAGE → "LIQUID TEMPERATURES DIFFER FROM CALCULATED TEMP" → NOT SURE WHAT THIS MEANS

JOB 940168/3
SHEET NO. 1 OF
CALCULATED BY STM DATE 2-27-95
CHECKED BY DATE
SCALE

AquAeTer
215 Jamestown Park, Suite 204
Brentwood, TN 37027
(615) 373-8532 FAX (615) 373-8512

KMCC-COLUMBUS
EMISSIONS CALCULATIONS

▶ TANKS 2.0 PROGRAM ADJUSTMENTS FOR PRODUCT FACTOR (0.1)

Work Tanks 1, 2, and 3
Model = 275.85 lbs/yr * 0.1 = 27.59 lbs/yr
AP42 = 75.19 lbs/yr
% diff = 63.3

Work Tank 4
Model = 394.73 lbs/yr * 0.1 = 39.47 lbs/yr
AP42 = 34.53 lbs/yr
% diff = -14.3

APPENDIX 7

BLACK TIE STORAGE EMISSION FACTORS AND CALCULATIONS

FUGITIVE EMISSIONS FROM CREOSOTE TREATED WOOD PRODUCTS

by

Stephen Smith, Koppers, Industries
Nicholas E. Bock, Kerr-McGee Chemical
Michael R. Corn, **AquAeTer, Inc.**

In 1990, Congress passed a major new environmental law called the Clean Air Act Amendment of 1990 (CAAA). The law calls for control of the traditional criteria pollutants, carbon monoxide (CO), sulfur dioxides (SO_x), nitrous oxides (NO_x), ozone (includes VOC_s and NO_x), and particulates for emissions greater than 100 tons/yr for any individual pollutant. In addition, Congress also specified that a list of 189 chemicals be controlled as hazardous air pollutants (HAPs) if any listed HAP was emitted at a rate of 10 tons/yr or more or any combination of HAPs was emitted at a rate of 25 tons/yr or more. If these emission limits for either criteria pollutants or HAPs were exceeded, he industry would have to install maximum achievable control technology (MACT) on these sources. A regulatory schematic of Title V key emissions decision points is presented in Figure 1.

The U.S. Environmental Protection Agency (EPA) is responsible for developing regulations that interpret the CAAA law passed by Congress. As part of the development of the regulations, EPA was to pre-identify industries that they considered to be major emitters of HAPs and/or criteria pollutants so that MACT could be specified and implemented at these major industries at early in the permitting process for the individual industries. EPA had initially listed the wood treating industry as a major source for both creosote and pentachlorophenol (PCP). EPA has agreed to remove PCP treaters from the major source list because of its low volatility; however, creosote treaters were still being considered as major source primarily because of high fugitive emissions calculated by EPA from creosote-treated wood products emissions in wood storage yards. The storage yard emissions were based on a data set collected by Koppers on creosote-treated poles as part of a superfund investigation at the Koppers Feather River site located in Oroville, California.

DATABASE

As part of the negotiations with EPA by the AWPI Technical Committee on trying to remove PCP and creosote treaters from the EPA list of major sources under the new CAAA, an independent analysis of the data was authorized by AWPI. The available data included the following:

- Creosote-treated pole emissions data collected of the Koppers Feather River site in Oroville, California;
- Temperature data from creosote-treated poles during the first 24-hrs following treatment collected at the Koppers Grenada, Mississippi site; and
- Temperature data from creosote-treated ties collected at the Kerr-McGee Indianapolis, Indiana site.

The pole emission data from the Koppers Feather River test had an unexplained initial rise in naphthalene emissions during the first 20 minutes following removal of the poles from the retort and then a sharp decrease as shown in Figure 2. The collective thoughts by the AWPI Technical Members were that this was related to temperature. Subsequently, temperature measurements on freshly treated poles were made at Grenada, Mississippi and on freshly treated ties at Indianapolis, Indiana as presented in Figures 3 and 4. These data indicated that the initial outside temperature of the poles/ties had been lowered by the final vacuum, but that the residual heat within the poles/ties increased the outside temperature during the first 20 minutes following removal of the mat wood from the retort. Thereafter, a rapid decline in temperature occurred with ambient being reached about 12 hours following removal from the retort.

CALCULATION OF EMISSION FACTORS

The temperature data helped explain the Feather River emissions data. Naphthalene emissions increase exponentially with increasing temperature and decrease exponentially with decreasing temperature as shown in Figure 5. The Feather River data were analyzed for three distinct regions which represent different temperature regimes. Exponential curve fits (first-order equation or curve fit that gives a straight line on semi-log paper) were calculated for Time 0 to Time 6 hrs, Time 6 to 24 hrs, and Time > 24 hrs, as presented in Figure 6. The emission rate for T > 24 hrs was checked against a theoretical calculation of the naphthalene emission rate expected from inplace treated crossties over a 40-yr lifetime as shown in Figure 7. The Feather River data gives a long-term naphthalene emission decay rate of 0.044 per day while the theoretical long-term emission decay rate was calculated to be 0.039 per day. Good agreement between the measured and the theoretical rates was obtained.

APPLICATION OF EMISSION RATES

The emission rates developed from the Feather River data were based on full exposure of all surfaces of a pole and the equations presented give lbs of naphthalene/ft^2 of surface area exposed. It becomes immediately obvious that the total naphthalene emissions in a pole or black-tie storage yard are dependent upon several factors which include:

1. Total surface area exposed;
2. Inventory; and
3. Time of year.

The total surface area exposed is dependent upon the stacking geometry of the ties or poles from the time they leave the retort to the time they leave the site. Typical stacking geometries for both poles and crossties are presented in Figures 8 and 9. Inventory for poles typically does not vary over the year because poles are being installed year round. Railroad crosstie replacements are generally scheduled for warmer weather periods. Therefore, crossties are inventoried during the winter months and shipped usually beginning in April. A typical crosstie inventory over the year is presented in Figure 10.

The other factor that affects the emissions is ambient temperature. Annual temperature graphs for 4 areas across the country are presented in Figure 11. Emissions should be adjusted for both the yard inventory and the time of year. The storage yard emissions under different climatic conditions can now be calculated as presented in Tables 1 and 2 for poles and Table 3 for black ties. If we assume an identical annual inventory of blackties, then we can compare emissions for a cool climate in Oregon versus a warmer climate of Mississippi. For identical maximum tie inventories of 200,000 ties, the storage yard naphthalene emissions are 2.1 tons/yr for the Oregon site versus 2.85 tons/yr for the Mississippi site.

SUMMARY AND CONCLUSIONS

A methodology has been developed to estimate emissions from creosote-treated poles and blackties while they are on the woodtreater's site. The methodology, based on data collected at three woodtreating sites, has been used to demonstrate to EPA that storage yards, although a significant portion of the site naphthalene emissions, are not high enough to push the industry over the 10 tons of a single HAP, naphthalene, that would require woodtreaters to become a major source with its accompanying requirements for MACT controls.

TABLE 1. ESTIMATED NAPHTHALENE EMISSIONS FROM A BLACK POLE STORAGE YARD

Facility	A Creosote Wood Treating Facility - Poles					
Location	Oregon					
Max. Poles On Site	2,600					
Min. Poles On Site	2,600					
Poles/Unit	2,600					
S.A. of 80-Pole Stack	3,031	ft² (modeled as planar surfaces)				
Diameter of Test Pole	11	in				
Length of Test Pole	40	ft	These are the creosote-treated poles which			
No. of Test Poles	6	poles	provided the naphthalene emission kinetic data.			
S.A. of Test Poles	699	ft²				
Emissions (mg/hr):	N1(t) =	18,104	* exp (	0.46683	* t),	t <= 0.25 days
(Based on 6 poles with a	N2(t) =	36,697	* exp (	-2.43497	* t),	0.25 < t <= 1.0 day
699 ft² surface area)	N3(t) =	3,347	* exp (	-0.04358	* t),	t > 1.0 day
Emissions (lb/day/ft²):	N1(t) =	1.370E-03	* exp (	0.46683	* t),	t <= 0.25 days
(Based on 6 poles with a	N2(t) =	2.777E-03	* exp (	-2.43497	* t),	0.25 < t <= 1.0 day
699 ft² surface area)	N3(t) =	2.533E-04	* exp (	-0.04358	* t),	t > 1.0 day

Calculated 24-hr Average California Pole Test Temperature = 80 °F

Temperature Correction Factor for Other Geographic Locations = exp[-11,161.25*(1/(T, °F+460)-1/(80+460)]

Assumes 30 days/month

Month	No. of Black Poles	Total Surface Area (ft²)	Percent of Poles __ Months Old			Tram Layout		100 Pole Layout			Yard Emissions * Percent of Poles ____ Months Old [Rate N3(t) Emissions] (lb naphthalene)		
			0 mo.	1 mo.	2 mo.	Surface Area (2,600 poles/mo) (ft²/month)	N1 Rate (lb)	Surface Area (2,600 poles/mo) (ft²/month)	N2 Rate (lb)	N3 Rate (lb)			
			0-30 d	30-60 d	60-90 d		0-0.25 d		0.25-1.0 d	1.0-1.5 d	1.5-30 d	30-60 d	60-90 d
1	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
2	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
3	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
4	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
5	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
6	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
7	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
8	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
9	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
10	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
11	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
12	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10

Month	Emissions Summary (lb of Naphthalene)			Oregon Average Temperature (°F)	Temperature Correction Factor	Total Naphthalene Emissions (lb)
	Tram Sum	100 Layout Sum	Yard Sum			
1	30	139	175	35.3	0.155	53
2	30	139	175	40.5	0.196	67
3	30	139	175	46.9	0.259	89
4	30	139	175	54.1	0.353	121
5	30	139	175	61.3	0.476	164
6	30	139	175	68.0	0.625	215
7	30	139	175	73.8	0.787	270
8	30	139	175	73.3	0.771	265
9	30	139	175	66.4	0.586	202
10	30	139	175	55.4	0.373	128
11	30	139	175	43.8	0.226	78
12	30	139	175	37.4	0.170	59
Annual Production:	31,200 poles/yr				Total (lb/yr)	1,711
	0.750 million ft²/yr				Total (ton/yr)	0.86

TABLE 2. ESTIMATED NAPHTHALENE EMISSIONS FROM A BLACK POLE STORAGE YARD

Facility	A Creosote Wood Treating Facility - Poles		
Location	Mississippi		
Max. Poles On Site	2,600		
Min. Poles On Site	2,600		
Poles/Unit	2,600		
S.A. of 80-Pole Stack	3,031	ft² (modeled as planar surfaces)	
Diameter of Test Pole	11	in	
Length of Test Pole	40	ft	These are the creosote-treated poles which
No. of Test Poles	6	poles	provided the naphthalene emission kinetic data.
S.A. of Test Poles	699	ft²	
Emissions (mg/hr):	N1(t) =	18,104 * exp (0.46683 * t),	t <= 0.25 days
(Based on 6 poles with a	N2(t) =	36,697 * exp (-2.43497 * t),	0.25 < t <= 1.0 day
699 ft² surface area)	N3(t) =	3,347 * exp (-0.04358 * t),	t > 1.0 day
Emissions (lb/day/ft²):	N1(t) =	1.370E-03 * exp (0.46683 * t),	t <= 0.25 days
(Based on 6 poles with a	N2(t) =	2.777E-03 * exp (-2.43497 * t),	0.25 < t <= 1.0 day
699 ft² surface area)	N3(t) =	2.533E-04 * exp (-0.04358 * t),	t > 1.0 day

Calculated 24-hr Average California Pole Test Temperature = 80 °F

Temperature Correction Factor for Other Geographic Locations = exp[-11,161.25*(1/(T, °F+460)-1/(80+460)]

Assumes 30 days/month

Month	No. of Black Poles	Total Surface Area (ft²)	Percent of Poles __ Months Old			Tram Layout		100 Pole Layout			Yard Emissions * Percent of Poles ____ Months Old [Rate N3(t) Emissions] (lb naphthalene)		
			0 mo.	1 mo.	2 mo.	Surface Area (2,600 poles/mo) (ft²/month)	N1 Rate (lb)	Surface Area (2,600 poles/mo) (ft²/month)	N2 Rate (lb)	N3 Rate (lb)			
			0-30 d	30-60 d	60-90 d		0-0.25 d		0.25-1.0 d	1.0-1.5 d	1.5-30 d	30-60 d	60-90 d
1	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
2	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
3	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
4	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
5	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
6	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
7	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
8	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
9	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
10	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
11	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10
12	2,600	98,508	33.3	33.3	33.3	81,575	30	217,100	113	26	127	38	10

Month	Emissions Summary (lb of Naphthalene)			Mississippi Average Temperature (°F)	Temperature Correction Factor	Total Naphthalene Emissions (lb)
	Tram Sum	100 Layout Sum	Yard Sum			
1	30	139	175	41.2	0.202	69
2	30	139	175	44.9	0.238	82
3	30	139	175	52.6	0.331	114
4	30	139	175	62.6	0.502	173
5	30	139	175	70.4	0.688	236
6	30	139	175	77.7	0.915	315
7	30	139	175	80.9	1.035	356
8	30	139	175	80.1	1.004	345
9	30	139	175	74.1	0.796	274
10	30	139	175	62.3	0.496	171
11	30	139	175	51.1	0.311	107
12	30	139	175	44.1	0.229	79
Annual Production:	31,200 poles/yr				Total (lb/yr)	2,320
	0.750 million ft²/yr				Total (ton/yr)	1.16

TABLE 3. ESTIMATED NAPHTHALENE EMISSIONS FROM A BLACK TIE STORAGE YARD

Facility	A Creosote Wood Preserving Facility - Ties			
Location	Oregon			
Max. Ties On Site	200,000			
Min. Ties On Site	40,000			The surface area of the 288-tie stack
Ties/Unit	40,000			represents the most conservative geometry
S.A. of Six 48-tie Bundles	984 ft^2			(e.g., the greatest surface area - all sides exposed).
Diameter of Test Pole	11 in			
Length of Test Pole	40 ft			These are the creosote-treated poles which
No. of Test Poles	6 poles			provided the naphthalene emission kinetic data.
S.A. of Test Poles	699 ft^2			
Emissions (mg/hr):	N1(t) =	18,104	* exp (	0.46683 * t), t <= 0.25 days
(Based on 6 poles with a	N2(t) =	36,697	* exp (	-2.43497 * t), 0.25 < t <= 1.0 day
699 ft^2 surface area)	N3(t) =	3,347	* exp (	-0.04358 * t), t > 1.0 day
Emissions (lb/day/ft^2):	N1(t) =	1.370E-03	* exp (	0.46683 * t), t <= 0.25 days
(Based on 6 poles with a	N2(t) =	2.777E-03	* exp (	-2.43497 * t), 0.25 < t <= 1.0 day
699 ft^2 surface area)	N3(t) =	2.533E-04	* exp (	-0.04358 * t), t > 1.0 day
Calculated 24-hr Average California Pole Test Temperature =				80 °F
Temperature Correction Factor for Other Geographic Locations = exp[-11,161.25*(1/(T, °F+460)-1/(80+460)]				
Assumes 30 days/month				

Month	No. of Black Ties	Total Yard Surface Area (ft^2)	Percent of Ties __ Months Old					Tram Naphthalene Emissions			Yard Emissions * Percent of Ties __ Months Old [N3(t) Rate Emissions] (lb naphthalene)				
			0 mo. 0-30 d	1 mo. 30-60 d	2 mo. 60-90 d	3 mo. 90-120 d	4 mo. 120-150 d	Surface Area (40000 ties/mo) (ft^2/month)	N1 Rate (lb) 0-0.25 d	N2 Rate (lb) 0.25-1.0 d	1.0-30 d	30-60 d	60-90 d	90-120 d	120-150 d
1	120,000	410,000	33.3	33.3	33.3			159,565	58	83	546	157	42		
2	160,000	546,667	25.0	25.0	25.0	25.0		159,565	58	83	546	157	42	11	
3	200,000	683,333	20.0	20.0	20.0	20.0	20.0	159,565	58	83	546	157	42	11	3
4	177,143	605,238	22.6	22.6	22.6	22.6	9.7	159,565	58	83	546	157	42	11	1
5	154,286	527,143	25.9	25.9	25.9	22.2		159,565	58	83	546	157	42	10	
6	131,429	449,048	30.4	30.4	30.4	8.7		159,565	58	83	546	157	42	3	
7	108,571	370,952	36.8	36.8	26.3			159,565	58	83	546	157	30		
8	85,714	292,857	46.7	46.7	6.7			159,565	58	83	546	157	6		
9	62,857	214,762	63.6	36.4				159,565	58	83	546	90			
10	40,000	136,667	100.0					159,565	58	83	546				
11	40,000	136,667	100.0					159,565	58	83	546				
12	80,000	273,333	50.0	50.0				159,565	58	83	546	157			

Month	Emissions Summary (lb naphthalene)		Oregon Average Temperature (°F)	Temperature Correction Factor	Total Naphthalene Emissions (lb)
	Tram Sum	Yard Sum			
1	141	745	35.3	0.155	137
2	141	756	40.5	0.196	176
3	141	759	46.9	0.259	234
4	141	758	54.1	0.353	317
5	141	755	61.3	0.476	427
6	141	748	68.0	0.625	556
7	141	733	73.8	0.787	687
8	141	709	73.3	0.771	655
9	141	635	66.4	0.586	455
10	141	546	55.4	0.373	256
11	141	546	43.8	0.226	156
12	141	702	37.4	0.170	144
Annual Production:	0.480 million ties/yr			Total (lb/yr)	4,199
	1.785 million ft^2			Total (tons/yr)	2.10

ABLE 4. ESTIMATED NAPHTHALENE EMISSIONS FROM A BLACK TIE STORAGE YARD

acility	A Creosote Wood Preserving Facility - Ties		
ocation	Mississippi		
ax. Ties On Site	200,000		
in. Ties On Site	40,000		The surface area of the 288-tie stack
ies/Unit	40,000		represents the most conservative geometry
.A. of Six 48-tie Bundles	984 ft²		(e.g., the greatest surface area - all sides exposed).
iameter of Test Pole	11 in		
ength of Test Pole	40 ft		These are the creosote-treated poles which
o. of Test Poles	6 poles		provided the naphthalene emission kinetic data.
.A. of Test Poles	699 ft²		
Emissions (mg/hr):	N1(t) =	18,104	* exp (0.46683 * t), t <= 0.25 days
Based on 6 poles with a	N2(t) =	36,697	* exp (-2.43497 * t), 0.25 < t <= 1.0 day
99 ft² surface area)	N3(t) =	3,347	* exp (-0.04358 * t), t > 1.0 day
Emissions (lb/day/ft²):	N1(t) =	1.370E-03	* exp (0.46683 * t), t <= 0.25 days
(Based on 6 poles with a	N2(t) =	2.777E-03	* exp (-2.43497 * t), 0.25 < t <= 1.0 day
699 ft² surface area)	N3(t) =	2.533E-04	* exp (-0.04358 * t), t > 1.0 day

Calculated 24-hr Average California Pole Test Temperature = 80 °F

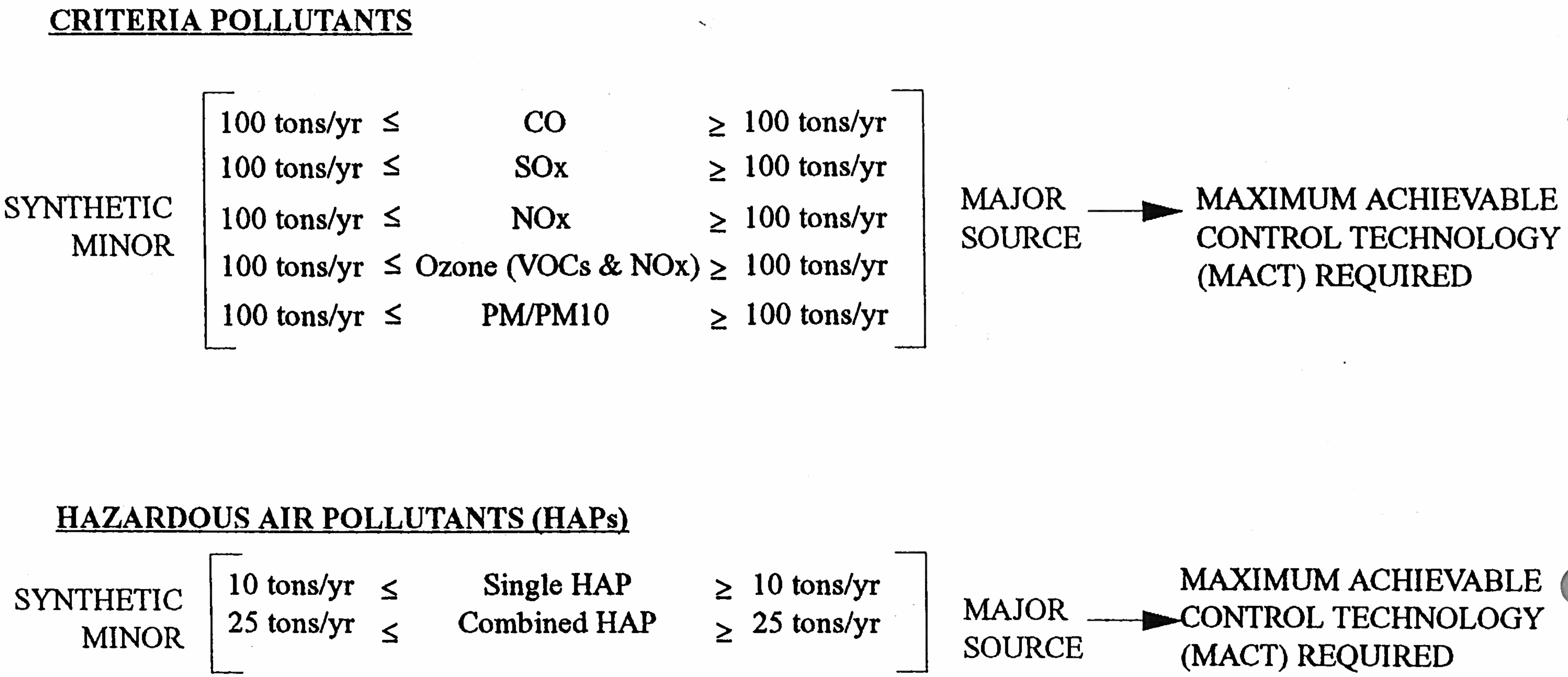
Temperature Correction Factor for Other Geographic Locations = exp[-11,161.25*(1/(T, °F+460)-1/(80+460)]

Assumes 30 days/month

Month	No. of Black Ties	Total Yard Surface Area (ft²)	Percent of Ties __ Months Old					Tram Naphthalene Emissions			Yard Emissions * Percent of Ties __ Months Old [N3(t) Rate Emissions] (lb naphthalene)				
			0 mo.	1 mo.	2 mo.	3 mo.	4 mo.	Surface Area (40000 ties/mo) (ft²/month)	N1 Rate (lb)	N2 Rate (lb)					
			0-30 d	30-60 d	60-90 d	90-120 d	120-150 d		0-0.25 d	0.25-1.0 d	1.0-30 d	30-60 d	60-90 d	90-120 d	120-150 d
1	120,000	410,000	33.3	33.3	33.3			159,565	58	83	546	157	42		
2	160,000	546,667	25.0	25.0	25.0	25.0		159,565	58	83	546	157	42	11	
3	200,000	683,333	20.0	20.0	20.0	20.0	20.0	159,565	58	83	546	157	42	11	3
4	177,143	605,238	22.6	22.6	22.6	22.6	9.7	159,565	58	83	546	157	42	11	1
5	154,286	527,143	25.9	25.9	25.9	22.2		159,565	58	83	546	157	42	10	
6	131,429	449,048	30.4	30.4	30.4	8.7		159,565	58	83	546	157	42	3	
7	108,571	370,952	36.8	36.8	26.3			159,565	58	83	546	157	30		
8	85,714	292,857	46.7	46.7	6.7			159,565	58	83	546	157	6		
9	62,857	214,762	63.6	36.4				159,565	58	83	546	90			
10	40,000	136,667	100.0					159,565	58	83	546				
11	40,000	136,667	100.0					159,565	58	83	546				
12	80,000	273,333	50.0	50.0				159,565	58	83	546	157			

Month	Emissions Summary (lb naphthalene)		Mississippi Average Temperature (°F)	Temperature Correction Factor	Total Naphthalene Emissions (lb)
	Tram Sum	Yard Sum			
1	141	745	41.2	0.202	179
2	141	756	44.9	0.238	213
3	141	759	52.6	0.331	298
4	141	758	62.6	0.502	452
5	141	755	70.4	0.688	616
6	141	748	77.7	0.915	814
7	141	733	80.9	1.035	904
8	141	709	80.1	1.004	853
9	141	635	74.1	0.796	618
10	141	546	62.3	0.496	341
11	141	546	51.1	0.311	213
12	141	702	44.1	0.229	194
Annual Production:	0.480 million ties/yr			Total (lb/yr)	5,695
	1.785 million ft²			Total (tons/yr)	2.85

FIGURE 1
TITLE V PERMITTING DECISION TREE



NOTE: Assumes site is attainment for criteria pollutants

FIGURE 2

EMISSION RATES FROM CREOSOTE-TREATED POLES

RAW DATA

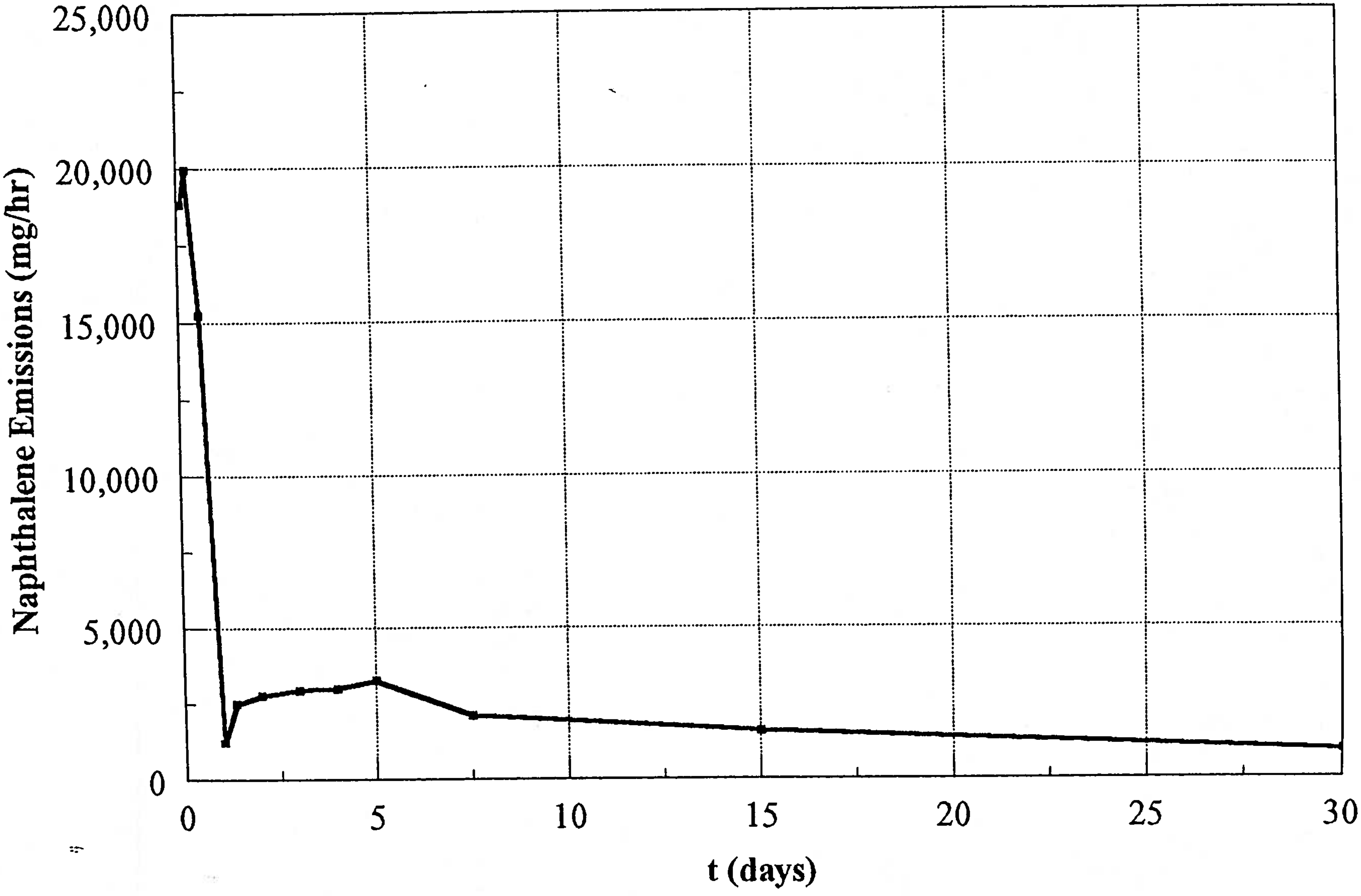


FIGURE 3

KOPPERS POLE TEMPERATURE MEASUREMENTS

Sept 27, 94 10:35AM to Sept 28,94 2:30PM

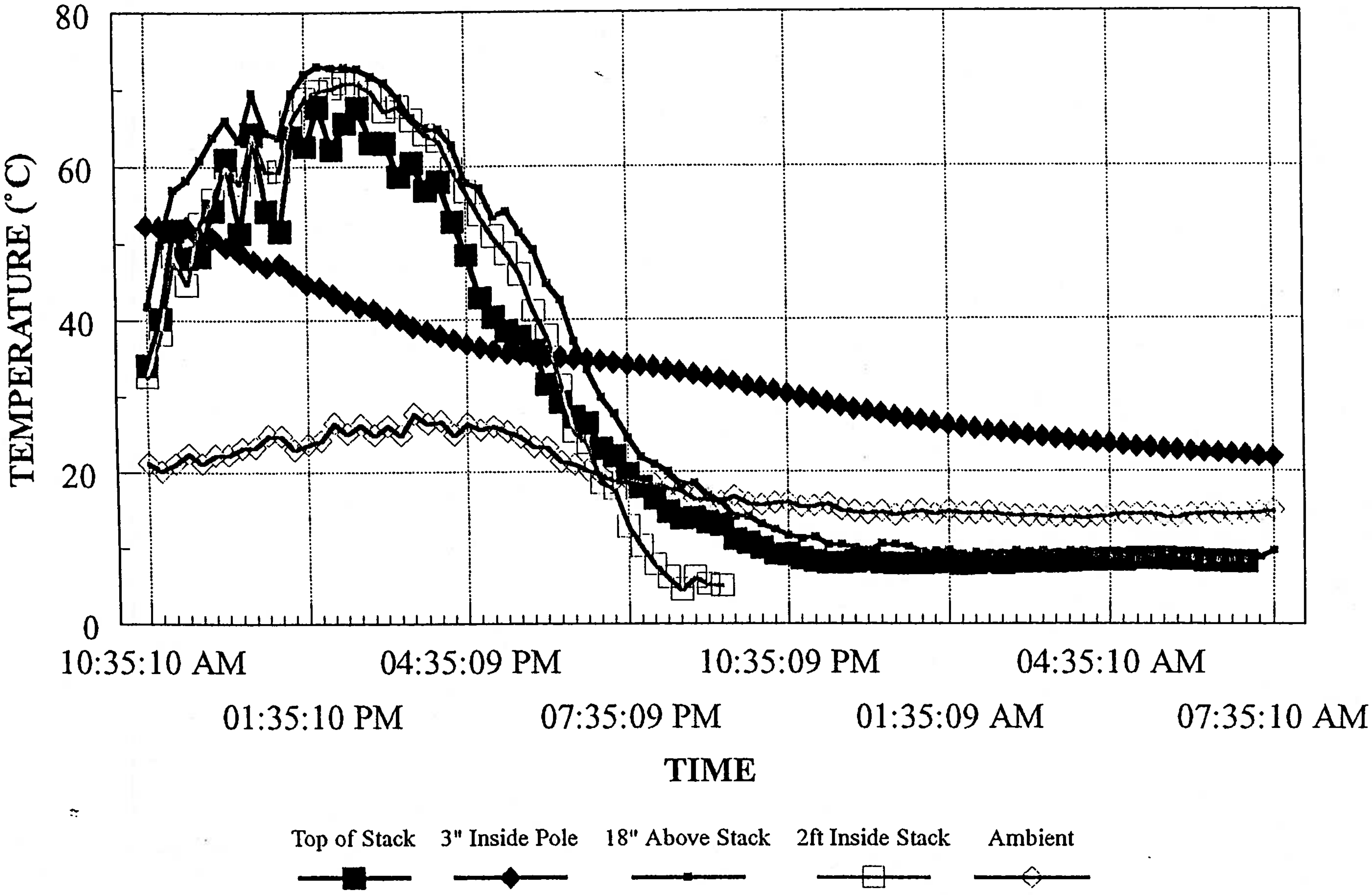


FIGURE 4

KOPPERS POLE TEMPERATURE MEASUREMENTS

Sept 27, 94 10:35AM to Sept 28,94 2:30PM

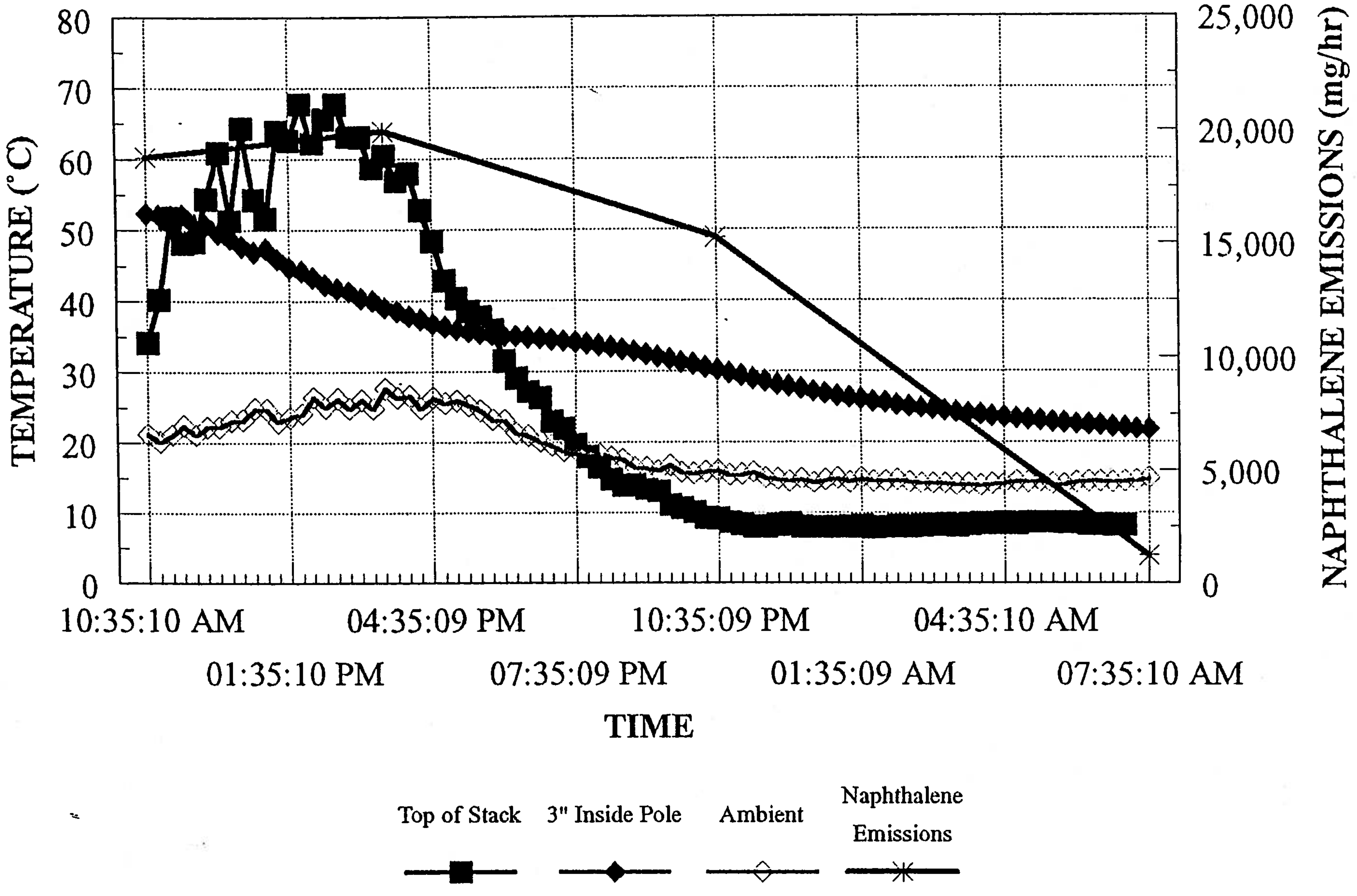


FIGURE 5

VARIATION OF NAPHTHALENE VAPOR PRESSURE WITH TEMPERATURE

Source: Perry's Chemical Engineer's Handbook, 6th Ed.

Temperature		VP (mm Hg)	1/Temp (1/R)	ln(VP)	Calc. VP (mm Hg)	% Diff.
°C	°F					
52.6	126.68	1	0.001705	0.000000	1.4	43.0
74.2	165.56	5	0.001599	1.609438	4.7	-6.7
85.8	186.44	10	0.001547	2.302585	8.3	-17.0
101.7	215.06	20	0.001481	2.995732	17.3	-13.7
119.3	246.74	40	0.001415	3.688879	36.2	-9.5
130.2	266.36	60	0.001377	4.094345	55.5	-7.5
145.5	293.90	100	0.001326	4.605170	97.3	-2.7
167.7	333.86	200	0.001260	5.298317	204.9	2.5
193.2	379.76	400	0.001191	5.991465	441.9	10.5
217.9	424.22	760	0.001131	6.633318	862.2	13.4

Regression Output:

Constant		19.38216
Std Err of Y Est		0.170405
R Squared		0.993869
No. of Observations		10
Degrees of Freedom		8
X Coefficient(s)	-11161.25	
Std Err of Coef.	309.9363	

VP (mm Hg) = 2.616E+08 * exp [-11161.25 /(T, °F + 460)]

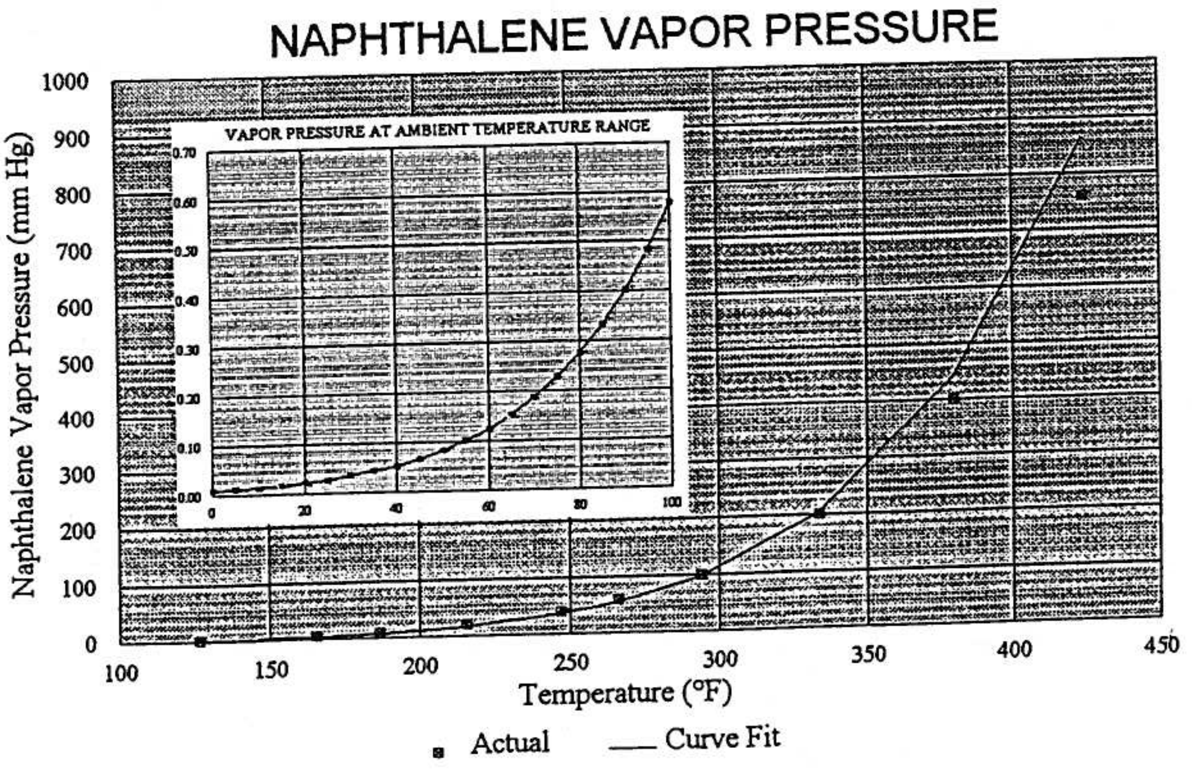


FIGURE 6

EMISSION RATES FROM SIX CREOSOTE-TREATED POLES

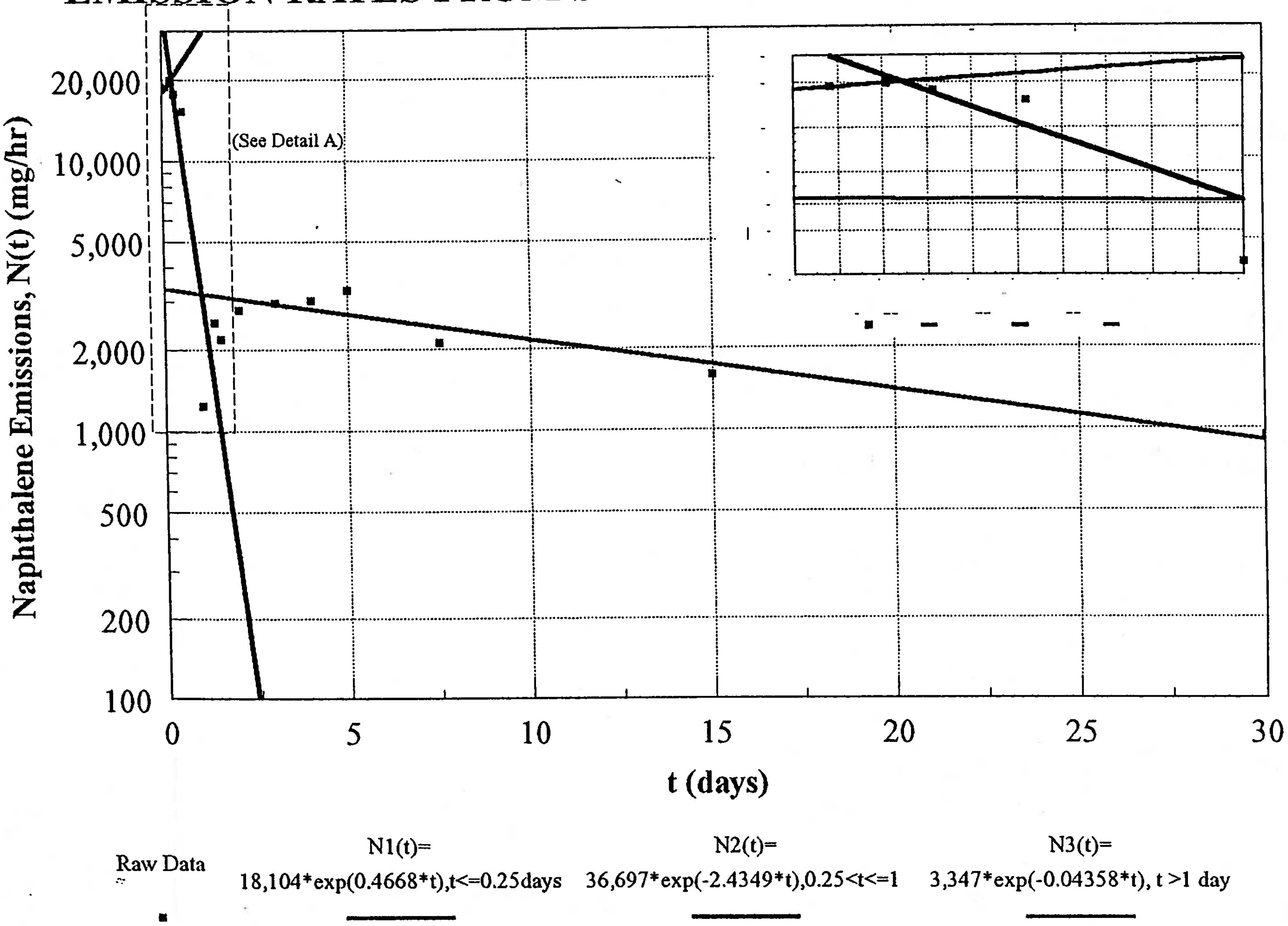
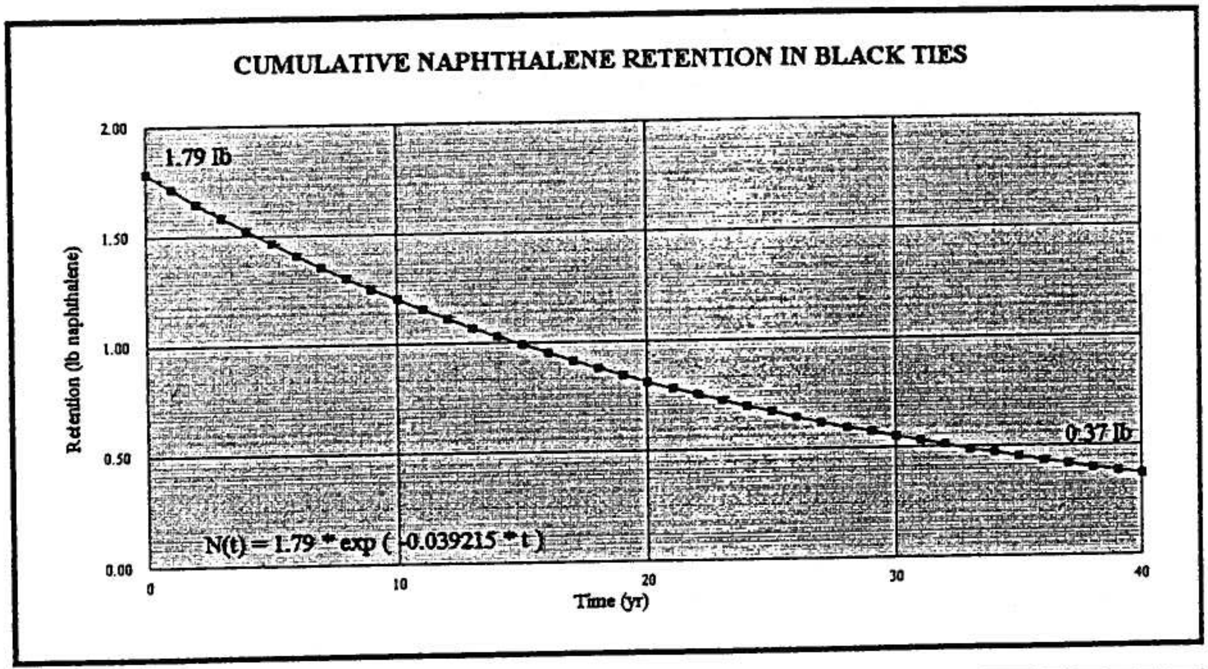


FIGURE 7

EXAMPLE NAPHTHALENE RETENTION AND EMISSION CURVES FOR BLACK TIES

Basis and Assumptions		
Basis	3.72	cu. ft of treated wood (one 7" x 9" x 8.5' tie)
Creosote Retention	8.0	lb creosote/cu. ft of wood
Percent Naphthalene in Creosote	6.0	%
Initial Naphthalene Retention	1.79	lb naphthalene
Life of Tie	40	yr
Naphthalene Retained @ End of Life	0.37	lb
General First-Order Equation		N(t) = No * exp[-k * t]
		N(t) = lb naphthalene
		t = years
Emission Rate, k	0.000107	1/day
	0.039215	1/year
Retention Equation Under These Conditions		N(t) = 1.79 * exp (-0.039215 * t) N(t) = lb naphthalene retained t = years
Emission Equation Under These Conditions		N(t) = 1.79 * [1 - exp (-0.039215 * t)] N(t) = lb naphthalene emitted t = years


CUMULATIVE NAPHTHALENE RETENTION IN BLACK TIES

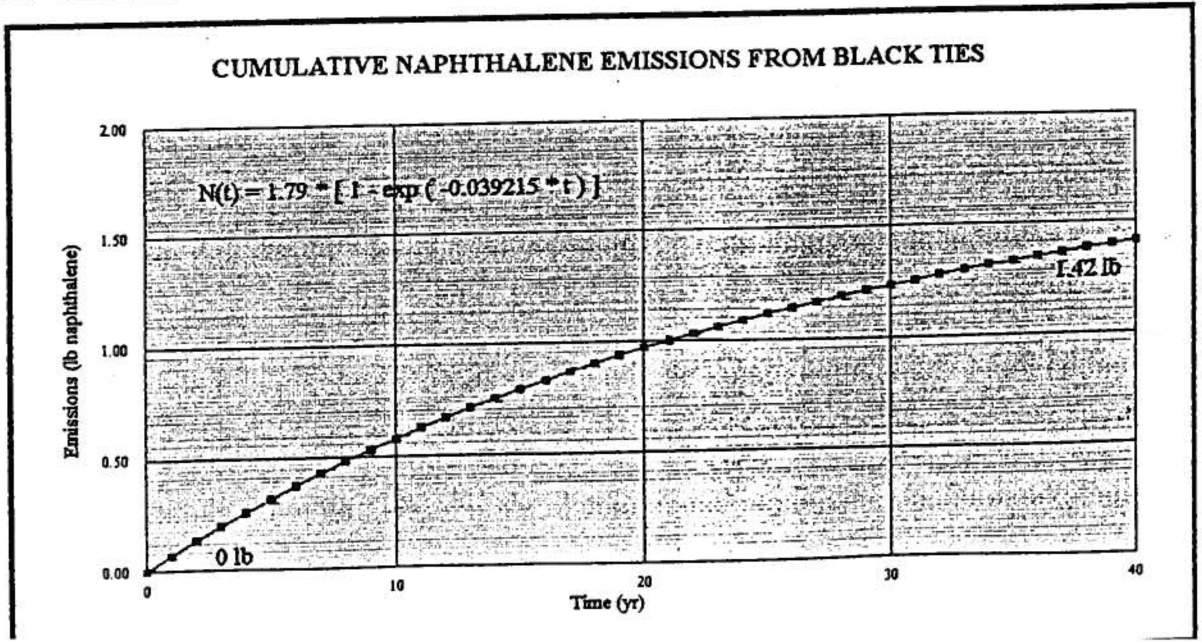
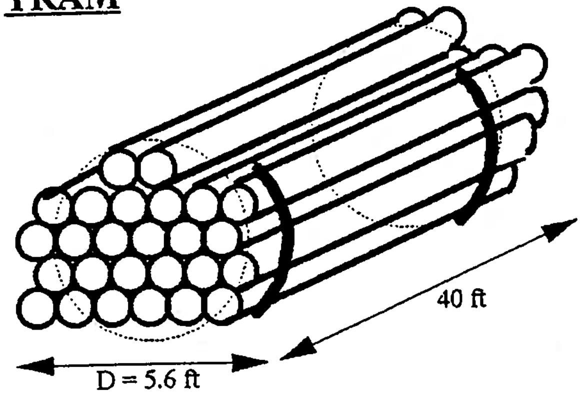

CUMULATIVE NAPHTHALENE EMISSIONS FROM BLACK TIES

FIGURE 8

GEOMETRY of POLE STACKS

① TRAM

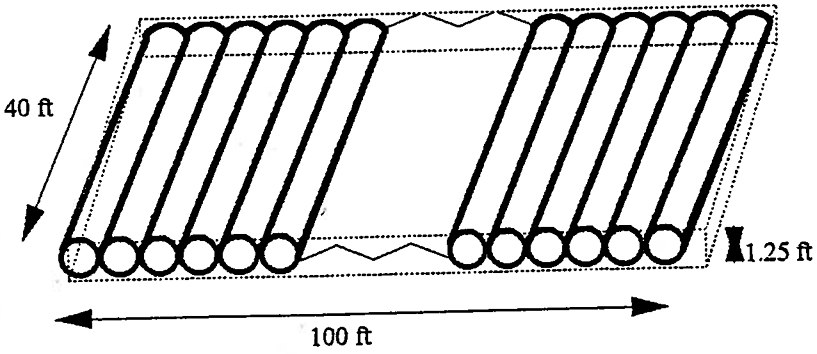


CYLINDRICAL SHAPE
24-28 POLES per TRAM
4-5 TRAMS per CHARGE
MAX EMISSION RATES ON TRAM

TIME ON TRAM	7-8 hours
TIME IN RAILTRUCK	16 hours

TOTAL TRAM SURFACE AREA =
753 ft²/TRAM

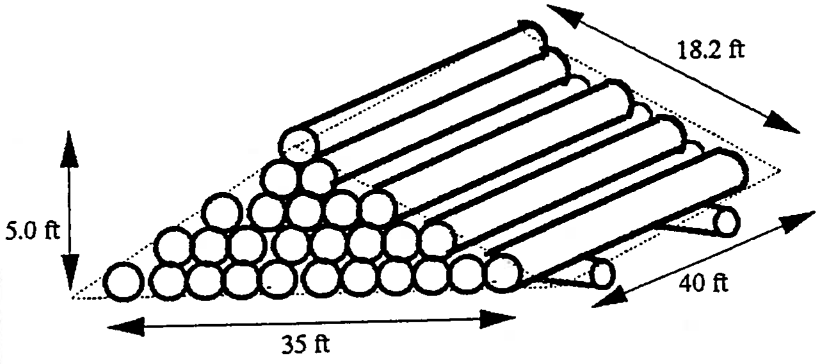
② 100 LAYOUT



RECTANGULAR
100 POLES - 100% ASSAY
1 LAYOUT AREA

TIME IN LAYOUT MAX 36 hours
SHIPPED OFF-SITE
LAYOUT SURFACE AREA =
8,350 ft²/LAYOUT

③ YARD LAYOUT



PYRAMIDAL SHAPE
80 POLES PER STACK
YARD AREA = 2,856 ft²/STACK

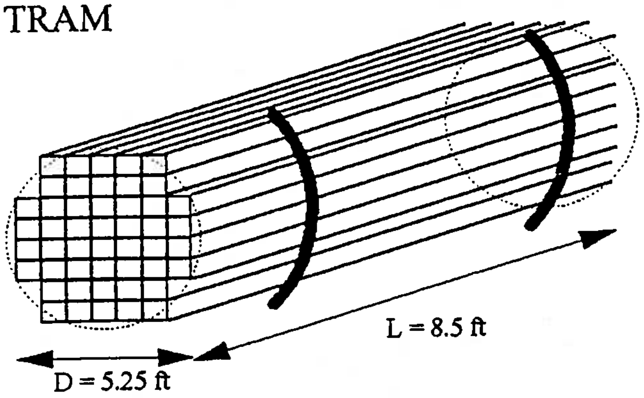
TIME IN YARD 3-4 months
MAXIMUM INVENTORY =
2,000 POLES

FIGURE 9

GEOMETRY OF TIE STACKS

ONE TIE SURFACE AREA (7 in x 9 in x 8.5 ft) = 23.55 ft²

① TRAM



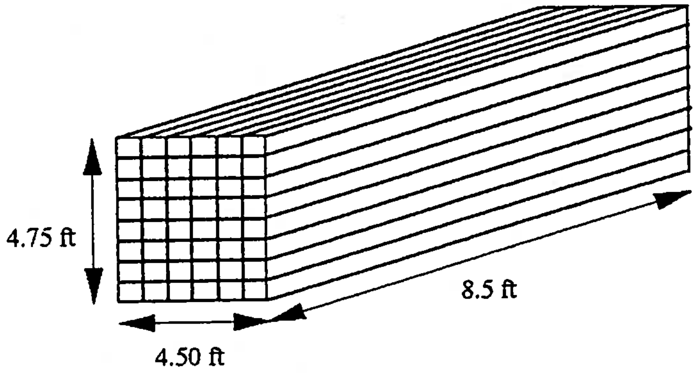
CYLINDRICAL SHAPE

46 TIES PER TRAM

17 TRAMS PER CHARGE

TOTAL TRAM SURFACE AREA = 183.5 ft²

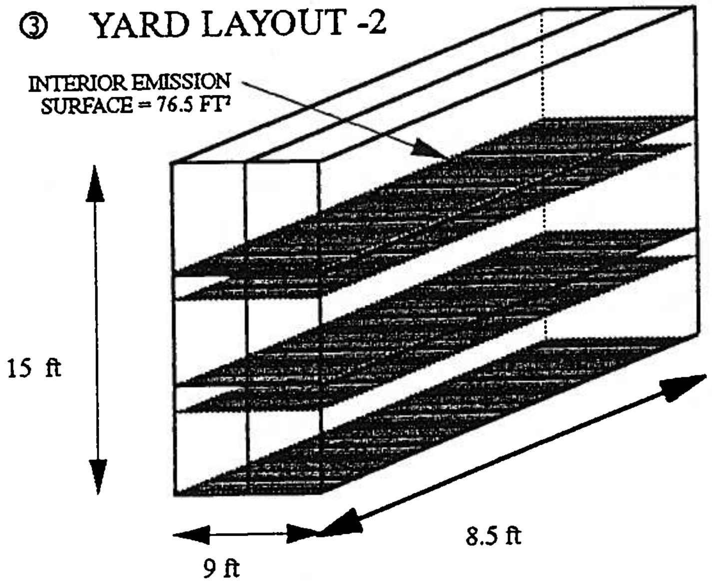
② BUNDLE



ASSUME 48 TIES = 1 BUNDLE

SURFACE AREA = 197.83 ft²

③ YARD LAYOUT -2



288 TIES IN 6 BUNDLES = 1 STACK

OUTSIDE SURFACE AREA = 601.5 ft²

5 - 1 ft INTERIOR EMISSION SURFACES = 382.5 ft²

TOTAL MODEL SURFACE AREA = 984 ft²

SURFACE AREA OF 288 STACKED TIES = SURFACE AREA OF INDIVIDUAL TIES

$$= \frac{984 \text{ ft}^2}{(23.55 \text{ ft}^2)(288)} \quad \frac{984 \text{ ft}^2}{6{,}782.4} = 0.15$$

STACKING RESULTS IN 85% REDUCTION IN SURFACE AREA FROM SINGLE TIES

93,888 TIES PLACED IN 326 STACKS = 1 UNIT/MONTH PRODUCED

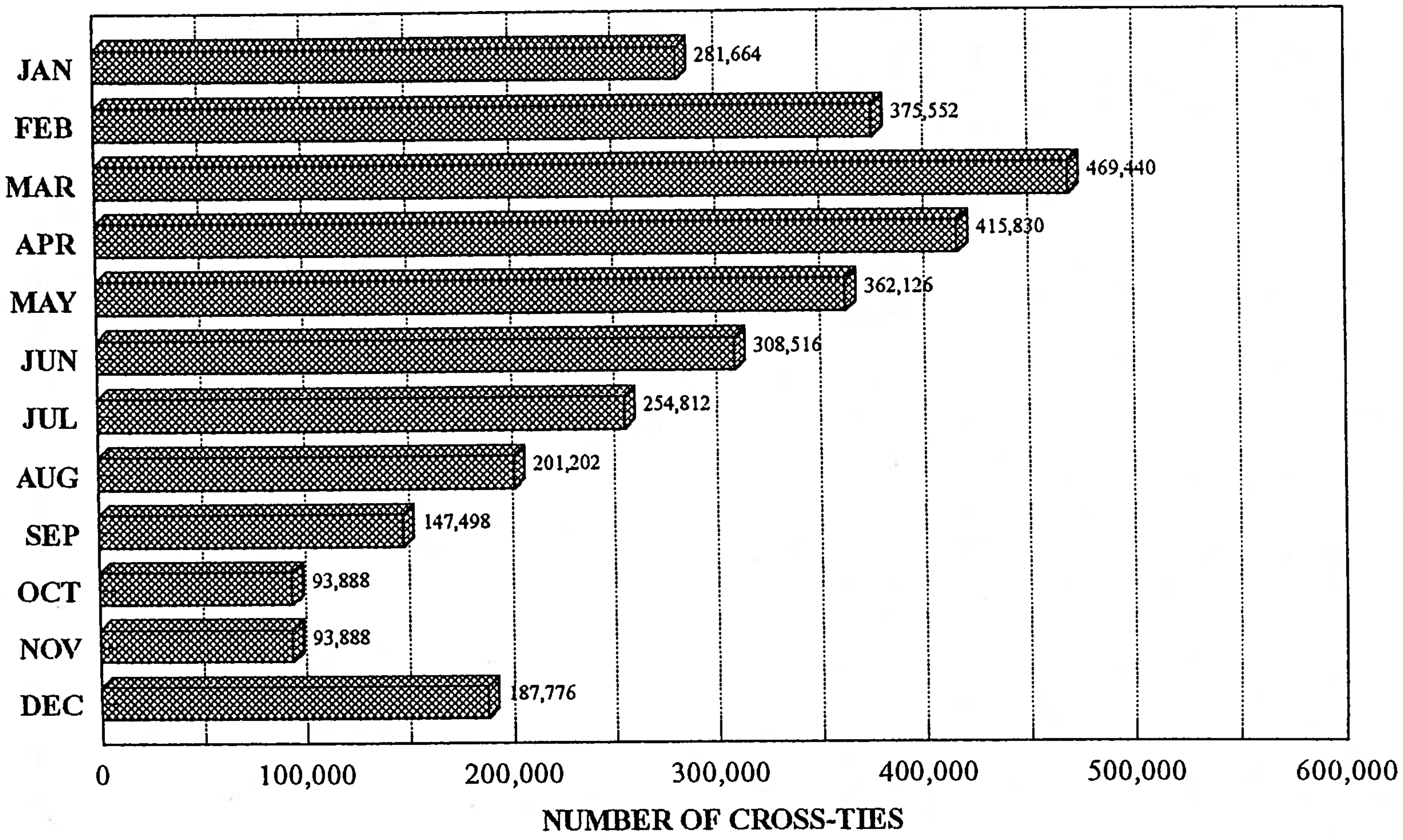
SURFACE AREA = SURFACE AREA OF ONE STACK * 326 STACKS

or

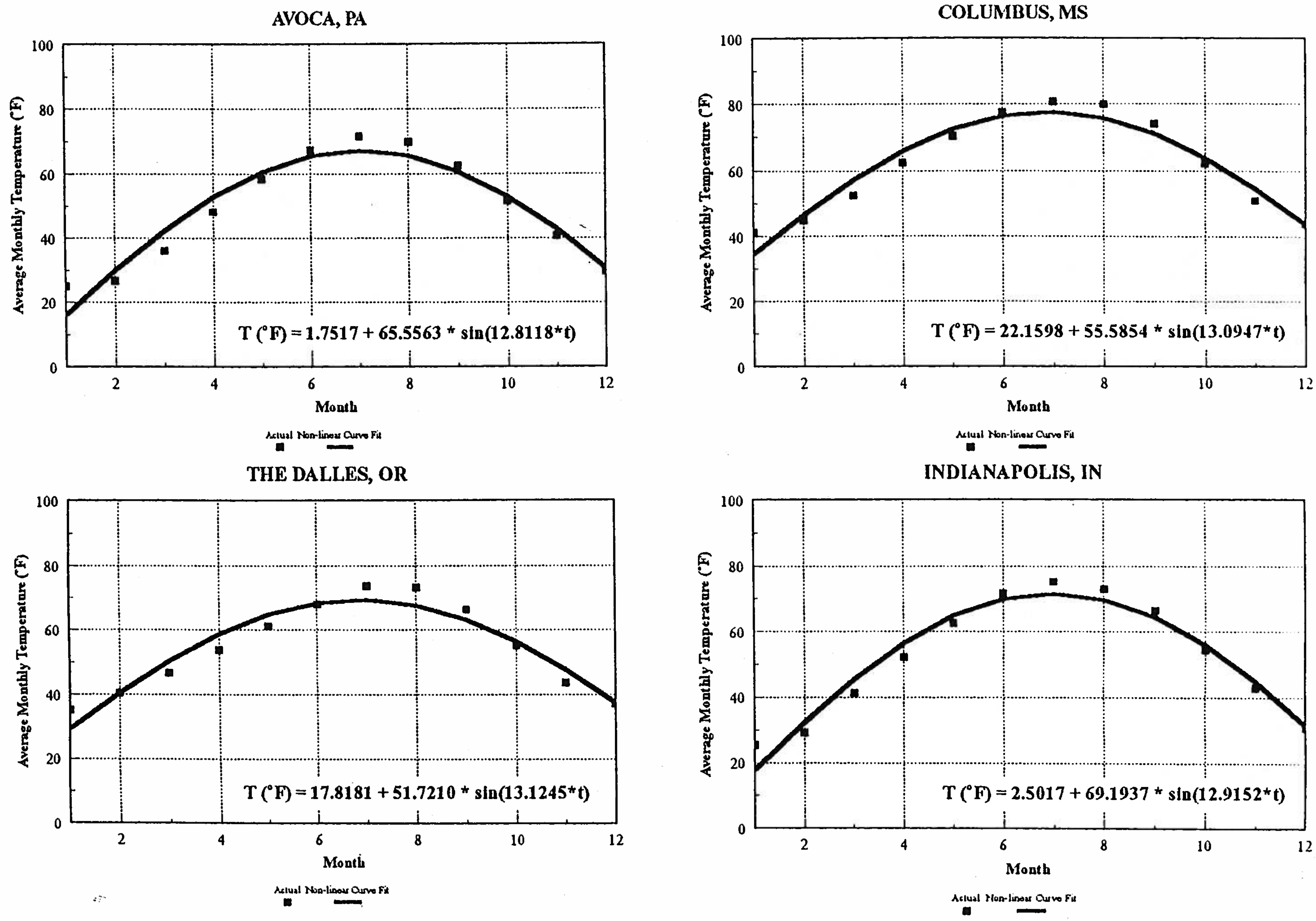
984 ft² * 326 STACKS = 320,784 ft²/UNIT

FIGURE 10

STORAGE DISTRIBUTION FOR BLACK TIE STORAGE YARD



Treated Ties Stored On-Site	
Maximum	469,440
Minimum	93,888



AVOCA, PA

T (°F) = 1.7517 + 65.5563 * sin(12.8118*t)

COLUMBUS, MS

T (°F) = 22.1598 + 55.5854 * sin(13.0947*t)

THE DALLES, OR

T (°F) = 17.8181 + 51.7210 * sin(13.1245*t)

INDIANAPOLIS, IN

T (°F) = 2.5017 + 69.1937 * sin(12.9152*t)

FIGURE 11

AVERAGE MONTHLY TEMPERATURES FOR KMCC FACILITIES

CALCULATED NAPHTHALENE EMISSIONS FROM BLACK TIE STORAGE YARDS

These calculations were derived to calculate the naphthalene emissions from creosote-treated railroad ties in a storage yard. Naphthalene emissions from black ties were based on emissions monitoring data from creosote-treated telephone poles at the Koppers plant in Oroville, CA (the Feather River Plant). The first step was to determine a relationship between the emissions and time. Three curves were fit to the available data, because it was found that one curve would not adequately represent all of the data. It was determined that the emissions data represented three distinct phenomena: **1)** temperature-driven emissions: the emissions of newly-treated ties increased briefly after removal from the retort (0 to 6 hr), **2)** thin-film evaporative emissions: emission rates then decreased rapidly (6 to 24 hr), and **3)** ambient-temperature emissions: emissions stabilized at a lower level once the initial film dissipated (24+ hr). The emission equations representing these three rates are shown in Equation (1). Emissions during the first day after treatment are driven by retort temperature effects, and emissions after the first day are driven by ambient temperature effects. The second equation of each set is based on the 699 ft^2 surface area of the six creosote-treated poles on which the original emissions test was done.

Temperature-Driven Emissions (Rate 1):

$$N_1(t)\left(\frac{mg\ naphthalene}{hr}\right) = 18{,}104\, e^{(0.46683*t)},\quad t \le 0.25\ days$$

$$N_1(t)\left(\frac{lb\ naphthalene}{ft^2\text{-}day}\right) = 1.370*10^{-3}\, e^{(0.46683*t)},\quad t \le 0.25\ days$$

Thin-Film Emissions (Rate 2):

$$N_2(t)\left(\frac{mg\ naphthalene}{hr}\right) = 36{,}697\, e^{(-2.43497*t)},\quad 0.25 < t \le 1.0\ day \tag{1}$$

$$N_2(t)\left(\frac{lb\ naphthalene}{ft^2\text{-}day}\right) = 2.777*10^{-3}\, e^{(-2.43497*t)},\quad 0.25 < t \le 1.0\ day$$

Pore-Space Emissions (Rate 3):

$$N_3(t)\left(\frac{mg\ naphthalene}{hr}\right) = 3{,}347\, e^{(-0.04358*t)},\quad t > 1.0\ day$$

$$N_3(t)\left(\frac{lb\ naphthalene}{ft^2\text{-}day}\right) = 2.533*10^{-4}\, e^{(-0.04358*t)},\quad t > 1.0\ day$$

An age distribution was constructed which determined the percentage of stored black ties at a given age during any month. The percentage age distribution can apply to any KMCC site, because each facility follows the same general treating and shipping schedule. It was assumed that:

- The same number of ties was treated every month,
- When shipping occurred, the oldest treated wood was shipped off-site,
- When shipping occurred, the same number of ties were shipped off-site,
- No ties were shipped between December and March (building inventory), and
- Ties were shipped off-site during the months of April through November only.

Using January as an example, one-third of the treated wood would be newly-treated (0 months old), one-third would be 1 month old, and one-third would be 2 months old. During February, one-quarter of treated wood would be newly-treated, one-quarter would be 1 month old, one-quarter would be 2 months old, and one-quarter would be 3 months old. This age distribution showed that no stored ties were more than 4 months old. The distribution is also conservative in that aged black ties (with fewer emissions) were shipped out first each month, keeping the higher-emitting newly-treated wood ties on-site. The age distribution is shown below.

AGE DISTRIBUTION EXPRESSED AS A PERCENTAGE OF STORED BLACK TIES

Month	**Percent of Ties __ Months Old:**				
	0 Month	**1 Month**	**2 Months**	**3 Months**	**4 Months**
1	33	33	33		
2	25	25	25	25	
3	20	20	20	20	20
4	22.6	22.6	22.6	22.6	9.7
5	26	26	26	22	
6	30.4	30.4	30.4	8.7	
7	37	37	26		
8	47	47	6.7		
9	64	36			
10	100				
11	100				
12	50	50			

The stacking geometry assumed six bundles of 48 poles each, stacked 2 bundles wide and 3 bundles high. Between the bundles stacked 3 high are 6 inch spacers. The 6 inch spaces between the stacked bundles were assumed to contain air saturated with naphthalene, and therefore those spaces were treated as if they contained treated ties. Each of the stacks therefore contained 288 treated ties, with an external surface area of 601.5 ft^2.

Black tie emissions were calculated from the time the treated wood was removed from the retort. All treated ties were assumed to remain on trams for 24 hours before being moved to the storage yard and restacked in the 288-pole geometry described above. The age distribution only applies to the storage yard.

For emissions calculation purposes, each month was assumed to have 30 days. Using January as an example, the following conditions applied:

◆	Black Ties On Site:	281,664 ties
◆	Black Ties Produced:	93,888 ties
◆	Surface Area of Black Ties on Trams:	349,529 ft^2
	[(93,888 ties/month)/(46 ties/tram)]*(171.25 ft^2/tram)=	349,529 ft^2
◆	Number of 288-Tie Bundles:	978 bundles
◆	Surface Area of Each 288-Tie Bundle:	601.5 ft^2
◆	Total Surface Area of Yard Stacks:	588,267 ft^2
◆	Percent of Black Ties On-site in January which are:	

0 Months Old	33.3 %
1 Month Old	33.3 %
2 Months Old	33.3 %

The total emission loading for any time period is simply the area under the appropriate rate curve for that time period. Therefore, integration between times t_1 and t_2 (days) was performed as shown in Equation 2. The emission expressions are of the form Ae^{-kt}, as was demonstrated in Equation (1).

$$\int_{t_1}^{t_2} Ae^{-kt}\,dt = A\int_{t_1}^{t_2} e^{-kt}\,dt = -\left(\frac{A}{k}\right)\left[e^{-kt}\right]_{t_1}^{t_2} = -\left(\frac{A}{k}\right)\left(e^{-kt_2}-e^{-kt_1}\right), \qquad (2)$$

where A *and* k *are constants.*

Black ties were assumed to be stored on the trams for 24 hours (1 day), which is a very conservative estimate. The tram emissions must therefore be divided into Rate 1 Emissions (0 to 0.25 days) and Rate 2 emissions (0.25 to 1.0 days). Rate 1 tram emissions for January were integrated between the limits of t = 0 to 0.25 days. The result is shown in Equation (3).

$$\int_{0}^{0.25} 1.370*10^{-3} e^{0.46683t}\, dt = \left(\frac{1.370*10^{-3}}{0.46683}\right)\left(e^{(0.46683*0.25)} - e^{(0.46683*0)}\right) \tag{3}$$

$$= 0.000363 \; \frac{lb\ naphthalene}{ft^2\ of\ treated\ surface\ area}$$

Rate 2 emissions from black ties on trams for 0.25 to 1.0 days were calculated as shown in Equation (4).

$$\int_{0.25}^{1.0} 2.777*10^{-3} e^{-2.43497t}\, dt = -\left(\frac{2.777*10^{-3}}{2.43497}\right)\left(e^{(-2.43497*1.0)} - e^{(-2.43497*0.25)}\right) \tag{4}$$

$$= 0.000521 \; \frac{lb\ naphthalene}{ft^2\ of\ treated\ surface\ area}$$

After 1 day on the trams, ties were moved to the storage yard. Rate 3 emissions for black ties which are between 1 and 30 days old and on-site during January are calculated in Equation (5). The age distribution factor of 33.3% is also applied in the equation.

$$\int_{1}^{30} 2.533*10^{-4} e^{-0.04358t}\, dt = -\left(\frac{2.533*10^{-3}}{-0.04358}\right)\left(e^{(-0.04358*30)} - e^{(-0.04358*1)}\right) * (0.333) \tag{5}$$

$$= 0.00133 \; \frac{lb\ naphthalene}{ft^2\ of\ treated\ surface\ area}$$

Emissions for month 2 (60 to 90 days), month 3 (90 to 120 days), and month 4 (120 to 150 days) were calculated by changing the time limits in Equation (5). The total emissions for January are equal to the sum of the integrated emissions from 0 to 90 days, because the January age distribution showed no ties older than 2 months (0 to 90 days). Note that all January yard emissions have the same age distribution factor of 33.3%.

A summation of the January emissions is shown in Equation (6).

January Emissions:

From Trams:

$$0 \textit{ to } 0.25 \textit{ days} = 0.000363 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$0.25 \textit{ to } 1.0 \textit{ day} = 0.000521 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$\sum_{t=0}^{t=1} = 0.000884 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$0.000884 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right) * 349{,}529\ (ft^2\ treated\ area)$$

$$= 309\ (lb\ naphthalene)$$

From Storage Yard:

(6)

$$1.0 \textit{ to } 30 \textit{ days} = 0.003993 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$30 \textit{ to } 60 \textit{ days} = 0.001147 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$60 \textit{ to } 90 \textit{ days} = 0.000310 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$\sum_{t=1}^{90\ days} N_i(t) = 0.00545 \left(\frac{lb\ naphthalene}{ft^2\ treated\ area}\right)$$

$$* 588{,}267\ ft^2\ treated\ area * 0.333\ (age\ distribution)$$

$$= 1{,}067.6\ lb\ naphthalene\ emitted\ during\ January\ from\ Yard$$

$$January\ Total\ Emissions = 309 + 1{,}067.7 = 1{,}376.6\ lb\ naphthalene$$

The vapor pressure of naphthalene increases exponentially as the temperature increases, and therefore naphthalene emissions from black ties are expected to do the same. It follows that the temperature correction factor should also be represented by an exponential expression. A temperature correction factor was needed to adjust the emissions as the ambient temperature of the storage yard location varied from the 24-hour average test temperature of 80 °F in California. Intuition, and the naphthalene vapor pressure data, indicated that emission rates should rise as the temperature rises, and fall as the temperature falls. The temperature correction factor was defined as the ratio of naphthalene's vapor pressure at the average monthly temperature of the wood treating site to the vapor pressure evaluated at the average test temperature of 80 °F. Equation 7 shows the derivation of the temperature correction factor equation, and its calculation for Kerr-McGee's Avoca, PA site.

$$\text{Naphthalene Vapor Pressure (mm Hg)} = 2.616 * 10^{8} e^{\left(\frac{-11,161.25}{T°F + 460}\right)} = A e^{\left(\frac{B}{T}\right)}$$

$$\frac{VP(T_{avg})}{VP(T_{test})} = \frac{A e^{\left(\frac{B}{T_{avg}}\right)}}{A e^{\left(\frac{B}{T_{test}}\right)}} = \frac{e^{\left(\frac{B}{T_{avg}}\right)}}{e^{\left(\frac{B}{T_{test}}\right)}} = e^{B\left(\frac{1}{T_{avg}} - \frac{1}{T_{test}}\right)} = e^{B\left(\frac{1}{(T_{avg}°F+460)} - \frac{1}{(80°F+460)}\right)}$$

$$\text{Temperature Correction Factor} = e^{-11,161.25\left(\frac{1}{(T_{avg}°F+460)} - \frac{1}{(80°F+460)}\right)} \tag{7}$$

For January, $T_{avg} = 25.2$ °*F, which is less than the original test temperature of* 80 °*F, so the temperature correction factor will be less than one*:

$$\text{Temperature Correction Factor} = e^{-11,161.25\left(\frac{1}{(25.2°F+460)} - \frac{1}{(80°F+460)}\right)} = 0.097$$

Note that a temperature correction factor of 1 *results if* $T_{avg} = 80°F$.

The total monthly emissions for January were calculated as the product of the monthly emissions in lb naphthalene/ft^2, the surface area of treated wood on-site during January, and the age distribution factors for treated wood in January, as shown previously. Application of the temperature correction factor is shown mathematically in Equation (8). This essentially translates the test emissions from the test site with a temperature of 80 °F (California) to a site with a colder temperature of 25.2 °F (Pennsylvania). The naphthalene vapor pressure is lower at Pennsylvania, and therefore, the emissions will be lower due to the decreased temperature.

Temperature-Corrected Emissions for January:

$$1,376.6\ (\text{lb naphthalene}) * (0.097) = 133\ \text{lb naphthalene} \tag{8}$$

The procedure shown in Equations (1) through (8) was followed to determine a naphthalene emission rate for the other months in the year. The monthly rates were added to determine the annual naphthalene emissions. The calculated annual naphthalene emissions from the Avoca, PA facility's black tie storage yard was 2.78 tons/yr, assuming a maximum on-site quantity of black ties of about 470,000 ties. However, the Avoca facility generally has a yearly on-site maximum of about 234,000 black ties, which equates to 1.39 tons/year.

APPENDIX 8

AP42 AND SOCMI EMISSIONS FACTORS

PB86-124906
PART 1 OF 2

AP-42
Fourth Edition
September 1985

COMPILATION OF AIR POLLUTANT EMISSION FACTORS

Volume I: Stationary Point And Area Sources

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office Of Air And Radiation
Office Of Air Quality Planning And Standards
Research Triangle Park, North Carolina 27711

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1.3 FUEL OIL COMBUSTION

1.3.1 General[1,2,22]

Fuel oils are broadly classified into two major types, distillate and residual. Distillate oils (fuel oil grade Nos. 1 and 2) are used mainly in domestic and small commercial applications in which easy fuel burning is required. Distillates are more volatile and less viscous than residual oils, having negligible ash and nitrogen contents and usually containing less than 0.3 weight percent sulfur. Residual oils (grade Nos. 4, 5 and 6), on the other hand, are used mainly in utility, industrial and large commercial applications with sophisticated combustion equipment. No. 4 oil is sometimes classified as a distillate, and No. 6 is sometimes referred to as Bunker C. Being more viscous and less volatile than distillate oils, the heavier residual oils (Nos. 5 and 6) must be heated to facilitate handling and proper atomization. Because residual oils are produced from the residue left after lighter fractions (gasoline, kerosene and distillate oils) have been removed from the crude oil, they contain significant quantities of ash, nitrogen and sulfur. Properties of typical fuel oils are given in Appendix A.

1.3.2 Emissions

Emissions from fuel oil combustion are dependent on the grade and composition of the fuel, the type and size of the boiler, the firing and loading practices used, and the level of equipment maintenance. Table 1.3-1 presents emission factors for fuel oil combustion in units without control equipment. The emission factors for industrial and commercial boilers are divided into distillate and residual oil categories because the combustion of each produces significantly different emissions of particulates, SO_x and NO_x. The reader is urged to consult the references for a detailed discussion of the parameters that affect emissions from oil combustion.

Particulate Matter[3-7,12-13,24,26-27] - Particulate emissions are most dependent on the grade of fuel fired. The lighter distillate oils result in significantly lower particulate formation than do the heavier residual oils. Among residual oils, Nos. 4 and 5 usually result in less particulate than does the heavier No. 6.

In boilers firing No. 6, particulate emissions can be described, on the average, as a function of the sulfur content of the oil. As shown in Table 1.3-1 (Footnote g), particulate emissions can be reduced considerably when low-sulfur grade 6 oil is fired. This is because low sulfur No. 6, whether refined from naturally occurring low sulfur crude oil or desulfurized by one of several current processes, exhibits substantially lower viscosity and reduced asphaltene, ash and sulfur - all of which results in better atomization and cleaner combustion.

TABLE 1.3-1. UNCONTROLLED EMISSION FACTORS FOR FUEL OIL COMBUSTION

EMISSION FACTOR RATING: A

Boiler Type[a]	Particulate Matter[b]		Sulfur Dioxide[c]		Sulfur Trioxide		Carbon Monoxide[d]		Nitrogen Oxide[e]		Volatile Organics[f] Nonmethane		Volatile Organics[f] Methane	
	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal	kg/10^3l	lb/10^3gal
Utility Boilers														
Residual Oil	g	g	19S	157S	0.34S[h]	2.9S[h]	0.6	5	8.0 (12.6)(5)[i]	67 (105)(42)[i]	0.09	0.76	0.03	0.28
Industrial Boilers														
Residual Oil	g	g	19S	157S	0.24S	2S	0.6	5	6.6[j]	55[j]	0.034	0.28	0.12	1.0
Distillate Oil	0.24	2	17S	142S	0.24S	2S	0.6	5	2.4	20	0.024	0.2	0.006	0.052
Commercial Boilers														
Residual Oil	g	g	19S	157S	0.24S	2S	0.6	5	6.6	55	0.14	1.13	0.057	0.475
Distillate Oil	0.24	2	17S	142S	0.24S	2S	0.6	5	2.4	20	0.04	0.34	0.026	0.216
Residential Furnaces														
Distillate Oil	0.3	2.5	17S	142S	0.24S	2S	0.6	5	2.2	18	0.085	0.713	0.214	1.78

[a] Boilers can be approximately classified according to their gross (higher) heat rate as shown below:

Utility (power plant) boilers: >106 x 10^9 J/hr (>100 x 10^6 Btu/hr)
Industrial boilers: 10.6 x 10^9 to 106 x 10^9 J/hr (10 x 10^6 to 100 x 10^6 Btu/hr)
Commercial boilers: 0.5 x 10^9 to 10.6 x 10^9 J/hr (0.5 x 10^6 to 10 x 10^6 Btu/hr)
Residential furnaces: <0.5 x 10^9 J/hr (<0.5 x 10^6 Btu/hr)

[b] References 3-7 and 24-25. Particulate matter is defined in this section as that material collected by EPA Method 5 (front half catch).

[c] References 1-5. S indicates that the weight % of sulfur in the oil should be multiplied by the value given.

[d] References 3-5 and 8-10. Carbon monoxide emissions may increase by factors of 10 to 100 if the unit is improperly operated or not well maintained.

[e] Expressed as NO_2. References 1-5, 8-11, 17 and 26. Test results indicate that at least 95% by weight of NO_x is NO for all boiler types except residential furnaces, where about 75% is NO.

[f] References 18-21. Volatile organic compound emissions are generally negligible unless boiler is improperly operated or not well maintained, in which case emissions may increase by several orders of magnitude.

[g] Particulate emission factors for residual oil combustion are, on average, a function of fuel oil grade and sulfur content:

Grade 6 oil: 1.25(S) + 0.38 kg/10^3 liter [10(S) + 3 lb/10^3 gal] where S is the weight % of sulfur in the oil. This relationship is based on 81 individual tests and has a correlation coefficient of 0.65.
Grade 5 oil: 1.25 kg/10^3 liter (10 lb/10^3 gal)
Grade 4 oil: 0.88 kg/10^3 liter (7 lb/10^3 gal)

[h] Reference 25.

[i] Use 5 kg/10^3 liters (42 lb/10^3 gal) for tangentially fired boilers, 12.6 kg/10^3 liters (105 lb/10^3gal) for vertical fired boilers, and 8.0 kg/10^3 liters (67 lb/10^3 gal) for all others, at full load and normal (>15%) excess air. Several combustion modifications can be employed for NO_x reduction: (1) limited excess air can reduce NO_x emissions 5-20%, (2) staged combustion 20-40%, (3) using low NO_x burners 20-50%, and (4) ammonia injection can reduce NO_x emissions 40-70% but may increase emissions of ammonia. Combinations of these modifications have been employed for further reductions in certain boilers. See Reference 23 for a discussion of these and other NO_x reducing techniques and their operational and environmental impacts.

[j] Nitrogen oxides emissions from residual oil combustion in industrial and commercial boilers are strongly related to fuel nitrogen content, estimated more accurately by the empirical relationship:

kg NO_2/10^3 liters = 2.75 + 50$(N)^2$ [lb NO_2/10^3gal = 22 + 400$(N)^2$] where N is the weight % of nitrogen in the oil. For residual oils having high (>0.5 weight %) nitrogen content, use 15 kg NO_2/10^3 liter (120 lb NO_2/10^3gal) as an emission factor.

Boiler load can also affect particulate emissions in units firing No. 6 oil. At low load conditions, particulate emissions may be lowered by 30 to 40 percent from utility boilers and by as much as 60 percent from small industrial and commercial units. No significant particulate reductions have been noted at low loads from boilers firing any of the lighter grades, however. At too low a load condition, proper combustion conditions cannot be maintained, and particulate emissions may increase drastically. It should be noted, in this regard, that any condition that prevents proper boiler operation can result in excessive particulate formation.

Sulfur Oxides (SO_x)[1-5,25,27] – Total sulfur oxide emissions are almost entirely dependent on the sulfur content of the fuel and are not affected by boiler size burner design, or grade of fuel being fired. On the average, more than 95 percent of the fuel sulfur is emitted as SO_2, about 1 to 5 percent as SO_3 and about 1 to 3 percent as particulate sulfates. Sulfur trioxide readily reacts with water vapor (both in air and in flue gases) to form a sulfuric acid mist.

Nitrogen Oxides (NO_x)[1-11,14,17,23,27] – Two mechanisms form nitrogen oxides, oxidation of fuelbound nitrogen and thermal fixation of the nitrogen in combustion air. Fuel NO_x are primarily a function of the nitrogen content of the fuel and the available oxygen (on the average, about 45 percent of the fuel nitrogen is converted to NO_x, but this may vary from 20 to 70 percent). Thermal NO_x, on the other hand, are largely a function of peak flame temperature and available oxygen – factors which depend on boiler size, firing configuration and operating practices.

Fuel nitrogen conversion is the more important NO_x forming mechanism in residual oil boilers. Except in certain large units having unusually high peak flame temperatures, or in units firing a low nitrogen residual oil, fuel NO_x will generally account for over 50 percent of the total NO_x generated. Thermal fixation, on the other hand, is the dominant NO_x forming mechanism in units firing distillate oils, primarily because of the negligible nitrogen content in these lighter oils. Because distillate oil fired boilers usually have low heat release rates, however, the quantity of thermal NO_x formed in them is less than that of larger units.

A number of variables influence how much NO_x is formed by these two mechanisms. One important variable is firing configuration. Nitrogen oxide emissions from tangentially (corner) fired boilers are, on the average, less than those of horizontally opposed units. Also important are the firing practices employed during boiler operation. Limited excess air firing, flue gas recirculation, staged combustion, or some combination thereof may result in NO_x reductions from 5 to 60 percent. See Section 1.4 for a discussion of these techniques. Load reduction can likewise decrease NO_x production. Nitrogen oxides emissions may be reduced from 0.5 to 1 percent for each percentage reduction in load from full load operation. It should be noted that most of these variables, with the exception of excess air, influence the NO_x emissions only of large oil fired boilers. Limited excess air firing is possible in many small boilers, but the resulting NO_x reductions are not nearly as significant.

Other Pollutants[18-21] - As a rule, only minor amounts of volatile organic compounds (VOC) and carbon monoxide will be emitted from the combustion of fuel oil. The rate at which VOCs are emitted depends on combustion efficiency. Emissions of trace elements from oil fired boilers are relative to the trace element concentrations of the oil.

Organic compounds present in the flue gas streams of boilers include aliphatic and aromatic hydrocarbons, esters, ethers, alcohols, carbonyls, carboxylic acids and polycylic organic matter. The last includes all organic matter having two or more benzene rings.

Trace elements are also emitted from the combustion of fuel oil. The quantity of trace elements emitted depends on combustion temperature, fuel feed mechanism and the composition of the fuel. The temperature determines the degree of volatilization of specific compounds contained in the fuel. The fuel feed mechanism affects the separation of emissions into bottom ash and fly ash.

If a boiler unit is operated improperly or is poorly maintained, the concentrations of carbon monoxide and VOCs may increase by several orders of magnitude.

1.3.3 Controls

The various control devices and/or techniques employed on oil fired boilers depend on the type of boiler and the pollutant being controlled. All such controls may be classified into three categories, boiler modification, fuel substitution and flue gas cleaning.

Boiler Modification[1-4,8-9,13-14,23] - Boiler modification includes any physical change in the boiler apparatus itself or in its operation. Maintenance of the burner system, for example, is important to assure proper atomization and subsequent minimization of any unburned combustibles. Periodic tuning is important in small units for maximum operating efficiency and emission control, particularly of smoke and CO. Combustion modifications, such as limited excess air firing, flue gas recirculation, staged combustion and reduced load operation, result in lowered NO_x emissions in large facilities. See Table 1.3-1 for specific reductions possible through these combustion modifications.

Fuel Substitution[3,5,12,28] - Fuel substitution, the firing of "cleaner" fuel oils, can substantially reduce emissions of a number of pollutants. Lower sulfur oils, for instance, will reduce SO_x emissions in all boilers, regardless of size or type of unit or grade of oil fired. Particulates generally will be reduced when a lighter grade of oil is fired. Nitrogen oxide emissions will be reduced by switching to either a distillate oil or a residual oil with less nitrogen. The practice of fuel substitution, however, may be limited by the ability of a given operation to fire a better grade of oil and by the cost and availability thereof.

Flue Gas Cleaning[15-16,28] - Flue gas cleaning equipment generally is employed only on large oil fired boilers. Mechanical collectors, a prevalent type of control device, are primarily useful in controlling particulates generated during soot blowing, during upset conditions, or when a very dirty, heavy oil is fired. During these situations, high efficiency cyclonic collectors can effect up to 85 percent control of particulate. Under normal firing conditions or when a clean oil is combusted, cyclonic collectors will not be nearly as effective due to a high percentage of small particles (less than 3 microns diameter) being emitted.

Electrostatic precipitators are commonly used in oil fired power plants. Older precipitators which are also small precipitators generally remove 40 to 60 percent of the particulate matter emissions. Due to the low ash content of the oil, greater collection efficiency may not be required. Today, new or rebuilt electrostatic precipitators have collection efficiencies of up to 90 percent.

Scrubbing systems have been installed on oil-fired boilers, especially of late, to control both sulfur oxides and particulate. These systems can achieve SO_2 removal efficiencies of up to 90 to 95 percent and provide particulate control efficiencies on the order of 50 to 60 percent.

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1.4 NATURAL GAS COMBUSTION

1.4.1 General[1,2]

Natural gas is one of the major fuels used throughout the country. It is used mainly for power generation, for industrial process steam and heat production, and for domestic and commercial space heating. The primary component of natural gas is methane, although varying amounts of ethane and smaller amounts of nitrogen, helium and carbon dioxide are also present. Gas processing plants are required for recovery of liquefiable constituents and removal of hydrogen sulfide (H_2S) before the gas is used (see Natural Gas Processing, Section 9.2). The average gross heating value of natural gas is approximately 9350 kilocalories per standard cubic meter (1050 British thermal units/standard cubic foot), usually varying from 8900 to 9800 kcal/scm (1000 to 1100 Btu/scf).

Because natural gas in its original state is a gaseous, homogenous fluid, its combustion is simple and can be precisely controlled. Common excess air rates range from 10 to 15 percent, but some large units operate at lower excess air rates to increase efficiency and reduce nitrogen oxide (NO_x) emissions.

1.4.2 Emissions and Controls[3-26]

Even though natural gas is considered to be a relatively clean fuel, some emissions can occur from the combustion reaction. For example, improper operating conditions, including poor mixing, insufficient air, etc., may cause large amounts of smoke, carbon monoxide and hydrocarbons to be produced. Moreover, because a sulfur containing mercaptan is added to natural gas for detection purposes, small amounts of sulfur oxides will also be produced in the combustion process.

Nitrogen oxides are the major pollutants of concern when burning natural gas. Nitrogen oxide emissions are functions of combustion chamber temperature and combustion product cooling rate. Emission levels vary considerably with the type and size of unit and with operating conditions.

In some large boilers, several operating modifications may be employed for NO control. Staged combustion for example, including off-stoichiometric firing and/or two stage combustion, can reduce NO emissions by 5 to 50 percent.[26] In off-stoichiometric firing, also called "biased firing", some burners are operated fuel rich, some fuel lean, and others may supply air only. In two stage combustion, the burners are operated fuel rich (by introducing only 70 to 90 percent stoichiometric air), with combustion being completed by air injected above the flame zone through second stage "NO-ports". In staged combustion, NO_x emissions are reduced because the bulk of combustion occurs under fuel rich conditions.

Other NO_x reducing modifications include low excess air firing and flue gas recirculation. In low excess air firing, excess air levels are kept as low as possible without producing unacceptable levels of unburned combustibles (carbon monoxide, volatile organic compounds and smoke) and/or other operational problems. This technique can reduce NO_x emissions by 5 to 35 percent, primarily because of lack of oxygen during combustion. Flue gas recirculation into the primary combustion zone, because the flue gas is relatively cool and oxygen deficient, can also lower NO_x emissions by 4 to 85 percent, depending on the amount of gas recirculated. Flue gas recirculation is best suited for new boilers. Retrofit application would require extensive burner modifications. Initial studies indicate that low NO_x burners (20 to 50 percent reduction) and ammonia injection (40 to 70 percent reduction) also offer NO_x emission reductions.

Combinations of the above combustion modifications may also be employed to reduce NO_x emissions further. In some boilers, for instance, NO_x reductions as high as 70 to 90 percent have been produced by employing several of these techniques simultaneously. In general, however, because the net effect of any of these combinations varies greatly, it is difficult to predict what the reductions will be in any given unit.

Emission factors for natural gas combustion are presented in Table 1.4-1, and factor ratings in Table 1.4-2.

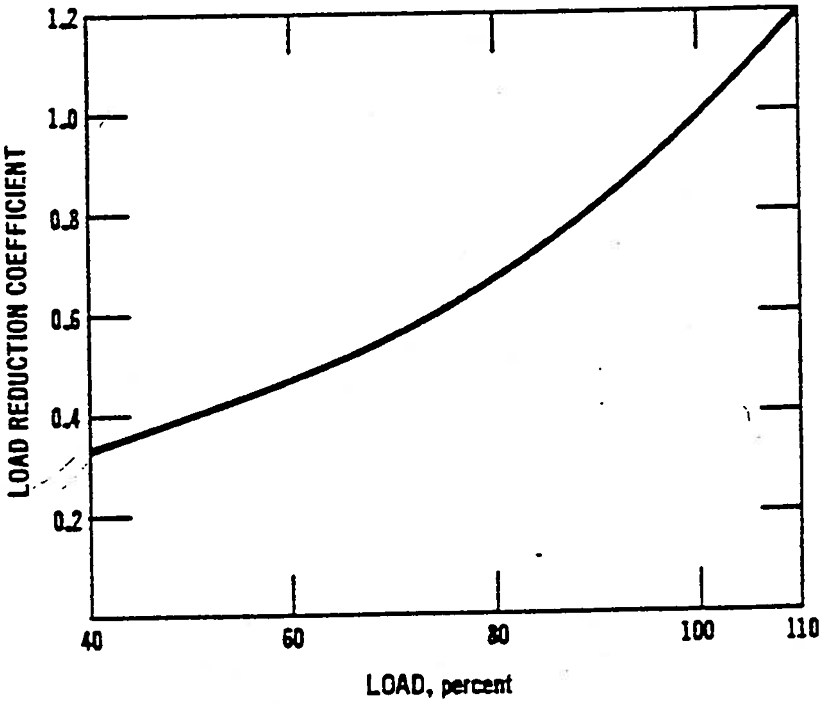

Figure 1.4-1. Load reduction coefficient as function of boiler load. (Used to determine NO_x reductions at reduced loads in large boilers.)

TABLE 1.4-1. UNCONTROLLED EMISSION FACTORS FOR NATURAL GAS COMBUSTION[a]

Furnace Size & Type (10^6 Btu/hr heat input)	Particulates[b]		Sulfur[c] Dioxide		Nitrogen[d,e] Oxide		Carbon[f,g] Monoxide		Volatile Organics			
									Nonmethane		Methane	
	kg/10^6m^3	lb/10^6ft^3	kg/10^6m^3	lb/10^6ft^3	kg/10^6m^3	lb/10^6ft^3	kg/10^6m^3	lb/10^6ft^3	kg/10^6m^3	lb/10^6ft^3	kg/10^6m^3	lb/10^6ft^3
Utility boilers (>100)	16-80	1-5	9.6	0.6	8800[h]	550[h]	640	40	23	1.4	4.8	0.3
Industrial boilers (10 - 100)	16-80	1-5	9.6	0.6	2240	140	560	35	44	2.8	48	3
Domestic and commercial boilers (<10)	16-80	1-5	9.6	0.6	1600	100	320	20	84	5.3	43	2.7

[a] All emission factors are expressed as weight per volume fuel fired.
[b] References 15-18.
[c] Reference 4 (based on an average sulfur content of natural gas of 4600 g/10^6 Nm^3 (2000 gr/10^6 scf).
[d] References 4-5,7-8,11,14,18-19,21.
[e] Expressed as NO_2. Test results indicate that about 95 weight % of NO_x is NO.
[f] References 4,7-8,16,18,22-25.
[g] References 16 and 18. May increase 10 to 100 times with improper operation or maintenance.
[h] Use 4400 kg/10^6 m^3 (275 lb/10^6ft^3) for tangentially fired units. At reduced loads, multiply this factor by the load reduction coefficient given in Figure 1.4-1. See text for potential NO_x reductions by combustion modifications. Note that the NO_x reduction from these modifications will also occur at reduced load conditions.

TABLE 1.4-2. FACTOR RATINGS FOR NATURAL GAS COMBUSTION

Furnace Type	Particulates	Sulfur Oxides	Nitrogen Oxides	Carbon Monoxides	VOC Nonmethane	VOC Methane
Utility boiler	B	A	A	A	C	C
Industrial boiler	B	A	A	A	C	C
Commercial boiler	B	A	A	A	D	D
Residential furnace	B	A	A	A	D	D

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4.3 STORAGE OF ORGANIC LIQUIDS

4.3.1 Process Description

Storage vessels containing organic liquids can be found in many industries, including (1) petroleum producing and refining, (2) petrochemical and chemical manufacturing, (3) bulk storage and transfer operations, and (4) other industries consuming or producing organic liquids. Organic liquids in the petroleum industry, usually called petroleum liquids, generally are mixtures of hydrocarbons having dissimilar true vapor pressures (for example, gasoline and crude oil). Organic liquids in the chemical industry, usually called volatile organic liquids, are composed of pure chemicals or mixtures of chemicals with similar true vapor pressures (for example, benzene or a mixture of isopropyl and butyl alcohols).

Five basic tank designs are used for organic liquid storage vessels, fixed roof, external floating roof, internal floating roof, variable vapor space, and pressure (low and high).

Fixed Roof Tanks - A typical fixed roof tank is shown in Figure 4.3-1. This type of tank consists of a cylindrical steel shell with a permanently affixed roof, which may vary in design from cone or dome shaped to flat.

Fixed roof tanks are commonly equipped with a pressure/vacuum vent that allows them to operate at a slight internal pressure or vacuum to prevent the release of vapors during very small changes in temperature, pressure or liquid level. Of current tank designs, the fixed roof tank is the least expensive to construct and is generally considered the minimum acceptable equipment for storage of organic liquids.

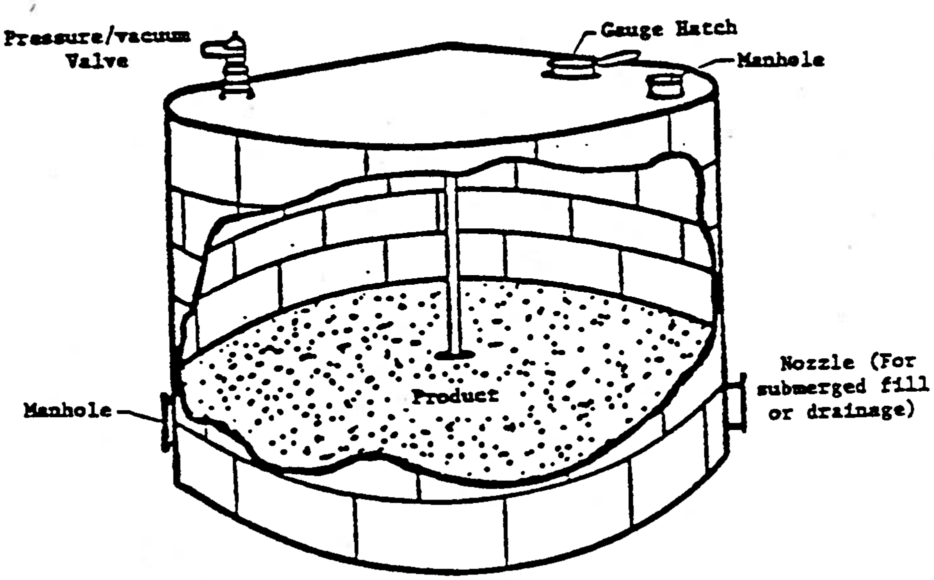


Figure 4.3-1. Typical fixed roof tank.[1]

External Floating Roof Tanks - A typical external floating roof tank is shown in Figure 4.3-2. This type of tank consists of a cylindrical steel shell equipped with a roof which floats on the surface of the stored liquid, rising and falling with the liquid level. The liquid surface is completely covered by the floating roof, except at the small annular space between the roof and the tank wall. A seal (or seal system) attached to the roof contacts the tank wall (with small gaps, in some cases) and covers the annular space. The seal slides against the tank wall as the roof is raised or lowered. The purpose of the floating roof and the seal (or seal system) is to reduce the evaporation loss of the stored liquid.

Internal Floating Roof Tanks - An internal floating roof tank has both a permanent fixed roof and a deck inside. The deck rises and falls with the liquid level and either floats directly on the liquid surface (contact deck) or rests on pontoons several inches above the liquid surface (noncontact deck). The terms "deck" and "floating roof" can be used interchangeably in reference to the structure floating on the liquid inside the tank. There are two basic types of internal floating roof tanks, tanks in which the fixed roof is supported by vertical columns within the tank, and tanks with a self-supporting fixed roof and no internal support columns. Fixed roof tanks that have been retrofitted to employ a floating deck are typically of the first type, while external floating roof tanks typically have a self-supporting roof when converted to an internal floating roof tank. Tanks initially constructed with both a fixed roof and a floating deck may be of either type.

The deck serves to restrict evaporation of the organic liquid stock. Evaporation losses from decks may come from deck fittings, nonwelded deck seams, and the annular space between the deck and tank wall. Typical contact deck and noncontact deck internal floating roof tanks are shown in

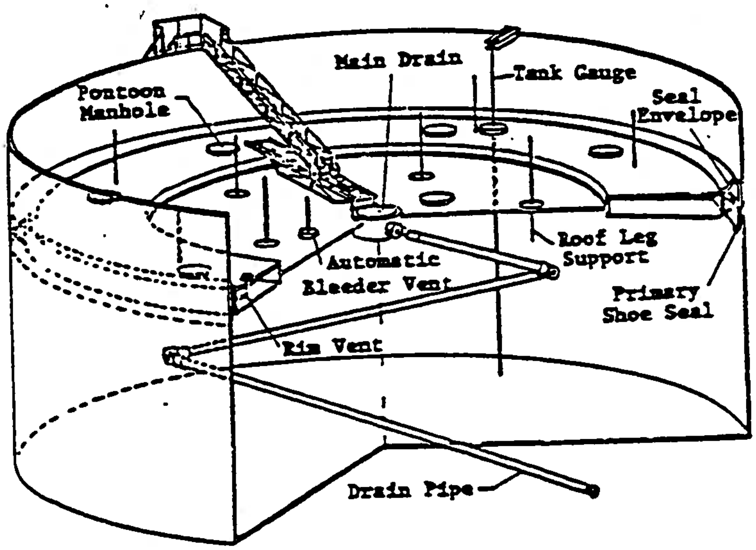


Figure 4.3-2. External floating roof tank.[1]

Figure 4.3-3. Contact decks can be aluminum sandwich panels with a honeycomb aluminum core floating in contact with the liquid, or pan steel decks floating in contact with the liquid, with or without pontoons. Typical noncontact decks have an aluminum deck or an aluminum grid framework supported above the liquid surface by tubular aluminum pontoons or other bouyant structures. Both types of deck incorporate rim seals, which slide against the tank wall as the deck moves up and down. In addition, these tanks are freely vented by circulation vents at the top of the fixed roof. The vents minimize the possibility of organic vapor accumulation in concentrations approaching the flammable range. An internal floating roof tank not freely vented is considered a pressure tank.

Pressure Tanks - There are two classes of pressure tanks in general use, low pressure (2.5 to 15 psig) and high pressure (higher than 15 psig). Pressure tanks generally are used for storage of organic liquids and gases with high vapor pressures and are found in many sizes and shapes, depending on the operating pressure of the tank. Pressure tanks are equipped with a pressure/vacuum vent that is set to prevent venting loss from boiling and breathing loss from daily temperature or barometric pressure changes. High pressure storage tanks can be operated so that virtually no evaporative or working losses occur. In low pressure tanks, working losses can occur with atmospheric venting of the tank during filling operations.

Variable Vapor Space Tanks - Variable vapor space tanks are equipped with expandable vapor reservoirs to accomodate vapor volume fluctuations attributable to temperature and barometric pressure changes. Although variable vapor space tanks are sometimes used independently, they are normally connected to the vapor spaces of one or more fixed roof tanks. The two most common types of variable vapor space tanks are lifter roof tanks and flexible diaphragm tanks.

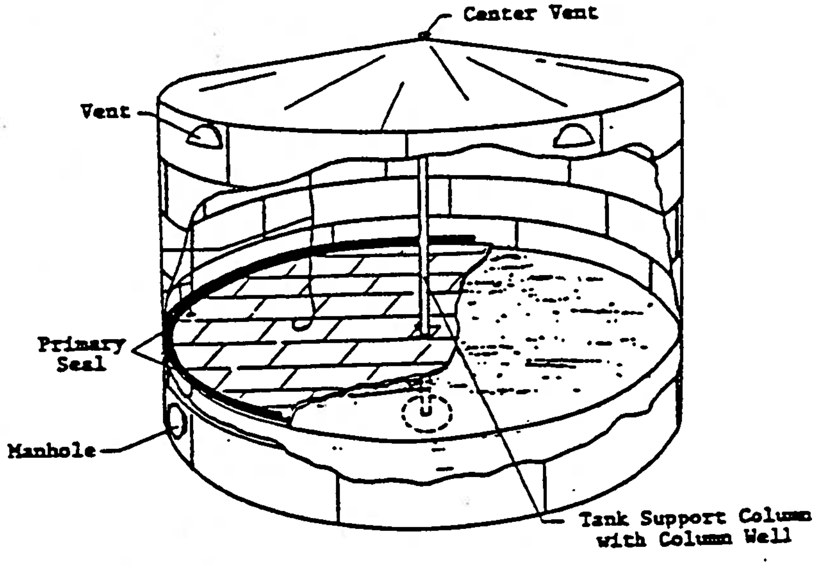
Lifter roof tanks have a telescoping roof that fits loosely around the outside of the main tank wall. The space between the roof and the wall is closed by either a wet seal, which is a trough filled with liquid, or a dry seal, which uses a flexible coated fabric.

Flexible diaphragm tanks use flexible membranes to provide expandable volume. They may be either separate gasholder units or integral units mounted atop fixed roof tanks.

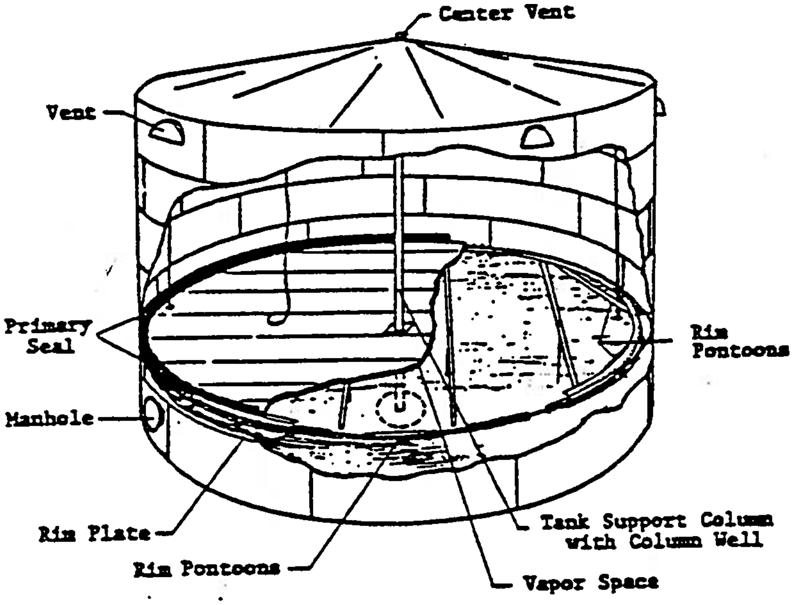
4.3.2 Emissions And Controls

Emission sources from organic liquids in storage depend upon the tank type. Fixed roof tank emission sources are breathing loss and working loss. External or internal floating roof tank emission sources are standing storage loss and withdrawal loss. Standing storage loss includes rim seal loss, deck fitting loss and deck seam loss. Pressure tanks and variable vapor space tanks are also emission sources.

Fixed Roof Tanks - Two significant types of emissions from fixed roof tanks are breathing loss and working loss. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction, which are the results of changes in temperature and barometric pressure. This loss occurs without any liquid level change in the tank.



Contact Deck Type



Noncontact Deck Type

Figure 4.3-3. Internal floating roof tanks.[1]

The combined loss from filling and emptying is called working loss. Filling loss comes with an increase of the liquid level in the tank, when the pressure inside the tank exceeds the relief pressure and vapors are expelled from the tank. Emptying loss occurs when air drawn into the tank during liquid removal becomes saturated with organic vapor and expands, thus exceeding the capacity of the vapor space.

The following equations, provided to estimate emissions, are applicable to tanks with vertical cylindrical shells and fixed roofs. These tanks must be substantially liquid and vapor tight and must operate approximately at atmospheric pressure. Fixed roof tank breathing losses can be estimated from[2]:

$$L_B = 2.26 \times 10^{-2} M_V \left(\frac{P}{P_A - P}\right)^{0.68} D^{1.73} H^{0.51} \Delta T^{0.50} F_P C K_C \qquad (1)$$

where:

L_B = fixed roof breathing loss (lb/yr)

M_V = molecular weight of vapor in storage tank (lb/lb mole), see Note 1

P_A = average atmospheric pressure at tank location (psia)

P = true vapor pressure at bulk liquid conditions (psia), see Note 2

D = tank diameter (ft)

H = average vapor space height, including roof volume correction (ft), see Note 3

ΔT = average ambient diurnal temperature change (°F)

F_P = paint factor (dimensionless), see Table 4.3-1

C = adjustment factor for small diameter tanks (dimensionless), see Figure 4.3-4

K_C = product factor (dimensionless), see Note 4

Notes: (1) The molecular weight of the vapor, M_V, can be determined by Table 4.3-2 for selected petroleum liquids and volatile organic liquids or by analysis of vapor samples. Where mixtures of organic liquids are stored in a tank, M_V can be estimated from the liquid composition. As an example of the latter calculation, consider a liquid known to be composed of components A and B with mole fractions in the liquid X_a and X_b, respectively. Given the vapor pressures of the pure

TABLE 4.3-1. PAINT FACTORS FOR FIXED ROOF TANKS[a]

Tank color		Paint factors (F_p) Paint condition	
Roof	Shell	Good	Poor
White	White	1.00	1.15
Aluminum (specular)	White	1.04	1.18
White	Aluminum (specular)	1.16	1.24
Aluminum (specular)	Aluminum (specular)	1.20	1.29
White	Aluminum (diffuse)	1.30	1.38
Aluminum (diffuse)	Aluminum (diffuse)	1.39	1.46
White	Gray	1.30	1.38
Light gray	Light gray	1.33	1.44[b]
Medium gray	Medium gray	1.40	1.58[b]

[a] Reference 2.
[b] Estimated from the ratios of the seven preceding paint factors.

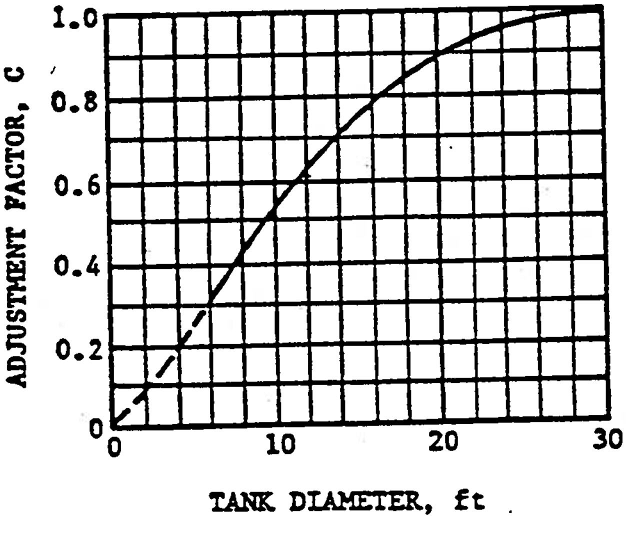


Figure 4.3-4. Adjustment factor (C) for small diameter tanks.[2]

TABLE 4.3-2. PHYSICAL PROPERTIES OF TYPICAL ORGANIC LIQUIDS[a]

Organic liquid[b]	Vapor molecular weight @ 60°F	Product density (d), lb/gal @ 60°F	Condensed vapor density (w), lb/gal @ 60°F	True vapor pressure in psia at: 40°F	50°F	60°F	70°F	80°F	90°F	100°F
Petroleum Liquids[c]										
Gasoline RVP 13	62	5.6	4.9	4.7	5.7	6.9	8.3	9.9	11.7	13.8
Gasoline RVP 10	66	5.6	5.1	3.4	4.2	5.2	6.2	7.4	8.8	10.5
Gasoline RVP 7	68	5.6	5.2	2.3	2.9	3.5	4.3	5.2	6.2	7.4
Crude oil RVP 5	50	7.1	4.5	1.8	2.3	2.8	3.4	4.0	4.8	5.7
Jet naphtha (JP-4)	80	6.4	5.4	0.8	1.0	1.3	1.6	1.9	2.4	2.7
Jet kerosene	130	7.0	6.1	0.0041	0.0060	0.0085	0.011	0.015	0.021	0.029
Distillate fuel no. 2	130	7.1	6.1	0.0031	0.0045	0.0074	0.0090	0.012	0.016	0.022
Residual oil no. 6	190	7.9	6.4	0.00002	0.00003	0.00004	0.00006	0.00009	0.00013	0.00019
Volatile Organic Liquids										
Acetone	58	6.6	6.6	1.7	2.2	2.9	3.7	4.7	5.9	7.3
Acrylonitrile	53	6.8	6.8	0.8	1.0	1.4	1.8	2.4	3.1	4.0
Benzene	78	7.4	7.4	0.6	0.9	1.2	1.5	2.0	2.6	3.3
Carbon disulfide	76	10.6	10.6	3.0	3.9	4.8	6.0	7.4	9.2	11.2
Carbon tetrachloride	154	13.4	13.4	0.8	1.1	1.4	1.8	2.3	3.0	3.8
Chloroform	119	12.5	12.5	1.5	1.9	2.5	3.2	4.1	5.2	6.3
Cyclohexane	84	6.5	6.5	0.7	0.9	1.2	1.6	2.1	2.6	3.2
1,2-Dichloroethane	99	10.5	10.5	0.6	0.8	1.0	1.4	1.7	2.2	2.8
Ethylacetate	88	7.6	7.6	0.6	0.8	1.1	1.5	1.9	2.5	3.2
Ethyl alcohol	46	6.6	6.6	0.2	0.4	0.6	0.9	1.2	1.7	2.3
Isopropyl alcohol	60	6.6	6.6	0.2	0.3	0.6	0.7	0.9	1.3	1.8
Methyl alcohol	32	6.6	6.6	0.7	1.0	1.4	2.0	2.6	3.5	4.5
Methylene chloride	85	11.1	11.1	3.1	4.3	5.4	6.8	8.7	10.3	13.3
Methylethyl ketone	72	6.7	6.7	0.7	0.9	1.2	1.5	2.1	2.7	3.3
Methylmethacrylate	100	7.9	7.9	0.1	0.2	0.3	0.6	0.8	1.1	1.4
1,1,1-Trichloroethane	133	11.2	11.2	0.9	1.2	1.6	2.0	2.6	3.3	4.2
Trichloroethylene	131	12.3	12.3	0.5	0.7	0.9	1.2	1.5	2.0	1.0
Toluene	92	7.3	7.3	0.2	0.2	0.3	0.4	0.6	0.8	1.0
Vinylacetate	86	7.8	7.8	0.7	1.0	1.3	1.7	2.3	3.1	4.0

[a] References 3-4.

[b] For a more comprehensive listing of volatile organic liquids, see Reference 3.

[c] RVP = Reid vapor pressure in psia.

components, P_a and P_b, and the molecular weights of the pure components, M_a and M_b, M_V is calculated:

$$M_V = M_a \left(\frac{P_a X_a}{P_t} \right) + M_b \left(\frac{P_b X_b}{P_t} \right)$$

OK

where: P_t, by Raoult's law, is:

$$P_t = P_a X_a + P_b X_b$$

(2) True vapor pressures for organic liquids can be determined from Figures 4.3-5 or 4.3-6, or Table 4.3-2. In order to use Figures 4.3-5 or 4.3-6, the stored liquid temperature, T_S, must be determined in degrees Fahrenheit. T_S is determined from Table 4.3-3, given the average annual ambient temperature, T_A, in degrees Fahrenheit. True vapor pressure is the equilibrium partial pressure exerted by a volatile organic liquid, as defined by ASTM-D-2879 or as obtained from standard reference texts. Reid vapor pressure is the absolute vapor pressure of volatile crude oil and volatile nonviscous petroleum liquids, except liquified petroleum gases, as determined by ASTM-D-323. Am. Society for testing Materials

RVP—
(expect to be [illegible]) ≈3

a measure in
a test basis
of vapor
pressure in
lbs pressure of
a sample of
gasoline at 100°F

(3) The vapor space in a cone roof is equal in volume to a cylinder, which has the same base diameter as the cone and is one third the height of the cone. If information is not available, assume H equals one half tank height.

true pressure
≈ 1.0

(4) For crude oil, $K_C = 0.65$. For all other organic liquids, $K_C = 1.0$.

Fixed roof tank working losses can be estimated from[2]:

$$L_W = 2.40 \times 10^{-5} \, M_V P V N K_N K_C \qquad (2)$$

where:

L_W = fixed roof working loss (lb/year)

M_V = molecular weight of vapor in storage tank (lb/lb mole), see Note 1 to Equation 1

P = true vapor pressure at bulk liquid temperature (psia), see Note 2 to Equation 1

V = tank capacity (gal)

N = number of turnovers per year (dimensionless)

$$N = \frac{\text{Total throughput per year (gal)}}{\text{Tank capacity, V (gal)}}$$

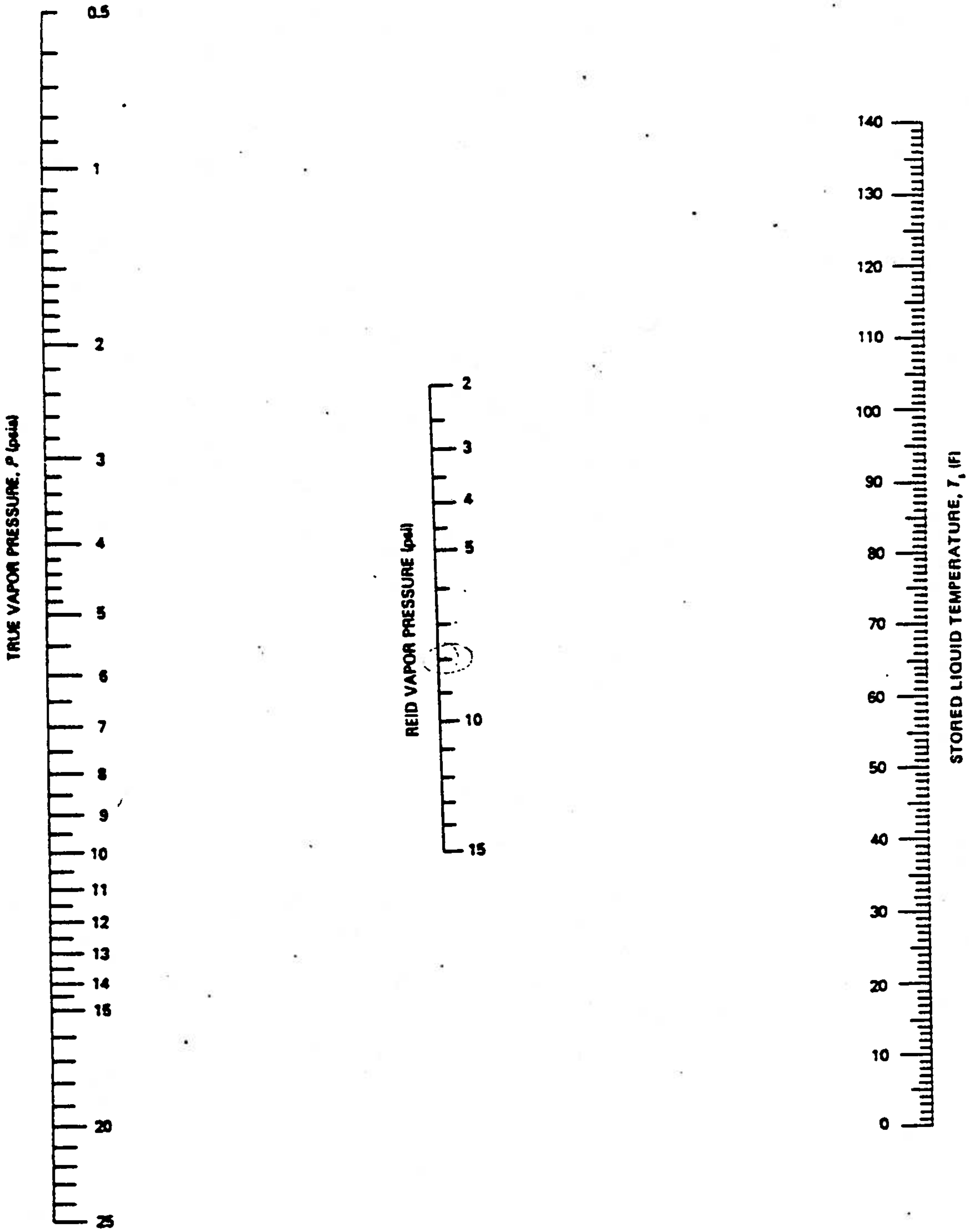
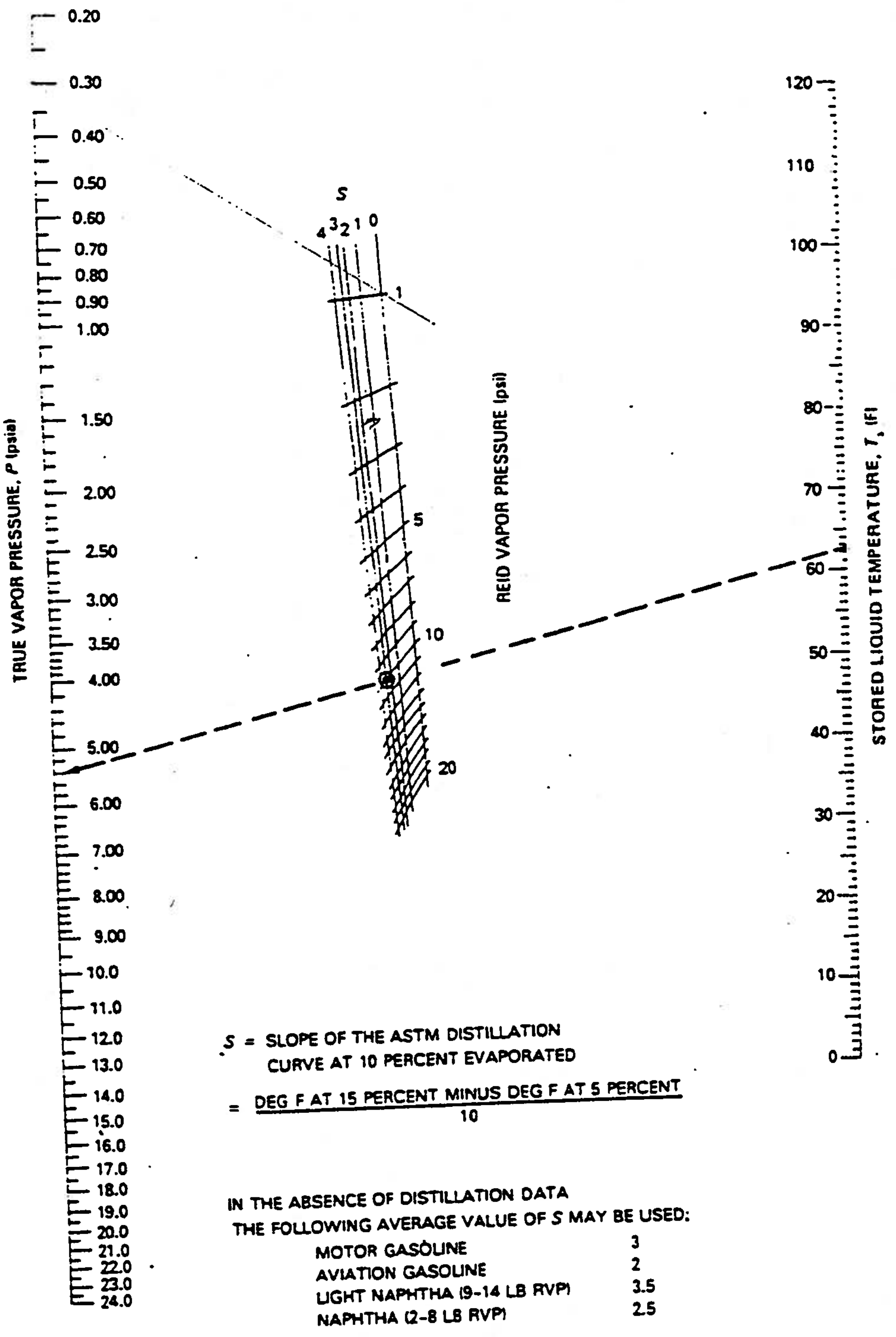


Figure 4.3-5. True vapor pressure (P) of crude oils (2-15 psi RVP).[6]



S = SLOPE OF THE ASTM DISTILLATION CURVE AT 10 PERCENT EVAPORATED

$= \frac{\text{DEG F AT 15 PERCENT MINUS DEG F AT 5 PERCENT}}{10}$

IN THE ABSENCE OF DISTILLATION DATA THE FOLLOWING AVERAGE VALUE OF S MAY BE USED:

MOTOR GASOLINE	3
AVIATION GASOLINE	2
LIGHT NAPHTHA (9-14 LB RVP)	3.5
NAPHTHA (2-8 LB RVP)	2.5

NOTE: Dashed line illustrates sample problem for RVP = 10 pounds per square inch, gasoline (S = 3), and T_L = 62.5 F

SOURCE: Nomograph drawn from the data of the National Bureau of Standards.

Figure 4.3-6. True vapor presure (P) of refined petroleum liquids like gasoline and napththas (1-20 psi RVP).[6]

K_N = turnover factor (dimensionless), see Figure 4.3-7

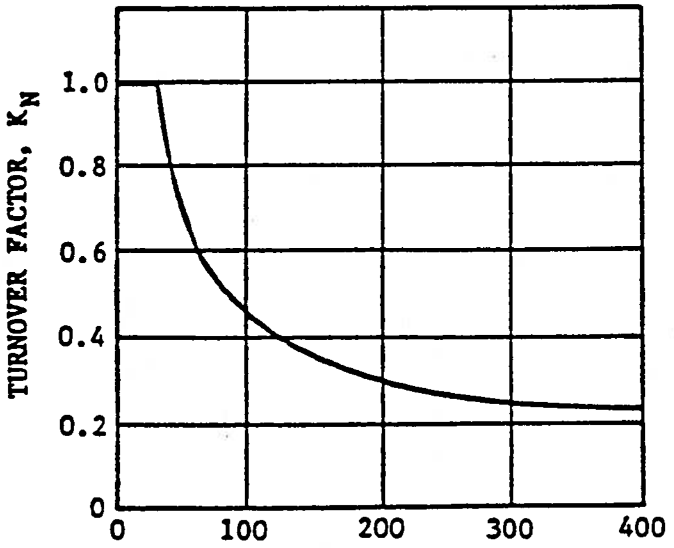
K_C = product factor (dimensionless), see Note 1

Note: (1) For crude oil, $K_C = 0.84$. For all other organic liquids, $K_C = 1.0$.

TABLE 4.3-3. AVERAGE STORAGE TEMPERATURE (T_S) AS A FUNCTION OF TANK PAINT COLOR[a]

Tank color	Average storage temperature, T_S
White	$T_A{}^b + 0$
Aluminum	$T_A + 2.5$
Gray	$T_A + 3.5$
Black	$T_A + 5.0$

[a] Reference 5.
[b] T_A is the average annual ambient temperature in degrees Fahrenheit.



$$\text{TURNOVERS PER YEAR} = \frac{\text{ANNUAL THROUGHPUT}}{\text{TANK CAPACITY}}$$

Note: For 36 turnovers per year or less, $K_N = 1.0$

Figure 4.3-7. Turnover factor (K_N) for fixed roof tanks.

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Several methods are used to control emissions from fixed roof tanks. Emissions from fixed roof tanks can be controlled by the installation of an internal floating roof and seals to minimize evaporation of the product being stored. The control efficiency of this method ranges from 60 to 99 percent, depending on the type of roof and seals installed and on the type of organic liquid stored.

The vapor recovery system collects emissions from storage vessels and converts them to liquid product. Several vapor recovery procedures may be used, including vapor/liquid absorption, vapor compression, vapor cooling, vapor/solid adsorption, or a combination of these. The overall control efficiencies of vapor recovery systems are as high as 90 to 98 percent, depending on the method used, the design of the unit, the composition of vapors recovered, and the mechanical condition of the system.

Another method of emission control on fixed roof tanks is thermal oxidation. In a typical thermal oxidation system, the air/vapor mixture is injected through a burner manifold into the combustion area of an incinerator. Control efficiencies for this system can range from 96 to 99 percent.

External And Internal Floating Roof Tanks - Total emissions from floating roof tanks are the sum of standing storage losses and withdrawal losses. Standing storage loss from internal floating roof tanks includes rim seal, deck fitting, and deck seam losses. Standing storage loss from external floating roof tanks, as discussed here, includes only rim seal loss, since deck fitting loss equations have not been developed. There is no deck seam loss, because the decks have welded sections.

Standing storage loss from external floating roof tanks, the major element of evaporative loss, results from wind induced mechanisms as air flows across the top of an external floating roof tank. These mechanisms may vary, depending upon the type of seals used to close the annular vapor space between the floating roof and the tank wall. Standing storage emissions from external floating roof tanks are controlled by one or two separate seals. The first seal is called the primary seal, and the other, mounted above the primary seal, is called the secondary seal. There are three basic types of primary seals used on external floating roofs, mechanical (metallic shoe), resilient (nonmetallic), and flexible wiper. The resilient seal can be mounted to eliminate the vapor space between the seal and liquid surface (liquid mounted), or to allow a vapor space between the seal and liquid surface (vapor mounted). A primary seal serves as a vapor conservation device by closing the annular space between the edge of the floating roof and the tank wall. Some primary seals are protected by a metallic weather shield. Additional evaporative loss may be controlled by a secondary seal. Secondary seals can be either flexible wiper seals or resilient filled seals. Two configurations of secondary seal are currently available, shoe mounted and rim mounted. Although there are other seal system designs, the systems described here compose the majority in use today. See Figure 4.3-8 for examples of primary and secondary seal configurations.

Typical internal floating roofs generally incorporate two types of primary seals, resilient foam filled seals and wipers. Similar in design

(b) Withdrawal Loss - Calculate using Equation 5.

$$L_W = (0.943)\ \frac{QCW_L}{D}\ \left[1 + \left(\frac{N_C F_C}{D}\right)\right] \qquad (5)$$

where:

L_W = withdrawal loss (lb/yr)

Q = 1.5 x 10^6 bbl/yr (calculated in Problem II)

C = 0.0015 bbl/1,000 ft^2 (from Table 4.3-5, light rust)

W_L = 6.1 lb/gal (given)

D = 100 ft (given)

N_C = 6 (given)

F_C = 1.0 (default value since column construction details are unknown)

$$L_W = \frac{(0.943)(1.5\text{x}10^6)(0.0015)(6.1)}{100}\ \left[1 + \left(\frac{(6)(1.0)}{100}\right)\right]$$

$$= 137 \text{ lb/yr}$$

For the 3 months, $L_W = \frac{137}{4} = 34$ lb

(c) Deck Fitting Loss - Calculate using Equation 6.

$$L_F = F_F P^* M_V K_C \qquad (6)$$

where:

L_F = deck fitting loss (lb/yr)

F_F = 700 lb-mole/yr (interpreted from Figure 4.3-10, given tank diameter of 100 ft)

P^* = 0.114 (calculated in Problem II)

M_V = 66 lb/lb-mole (from Table 4.3-2 and RVP 10 gasoline)

K_C = 1.0 (value appropriate for all liquid organics except crude oil)

$$L_F = 700(0.114)(66)(1.0)$$

$$= 5{,}267 \text{ lb/yr}$$

For the 3 months, $L_F = \frac{5{,}267}{4} = 1{,}317$ lb

(d) Deck Seam Loss - Calculate using Equation 7.

$$L_D = K_D S_D D^2 P^* M_V K_C \tag{7}$$

where:

L_D = deck seam loss (lb/yr)

K_D = 0 for welded seam deck, therefore

$L_D = 0$

(e) Total Loss for 3 months - Calculate from Equation 3.

$$L_T = L_R + L_W + L_F + L_D \tag{3}$$

where:

L_T = total loss (lb/yr)

L_R = 1,260 lb/3 mo

L_W = 34 lb/3 mo

L_F = 1,317 lb/3 mo

$L_D = 0$

$$L_T = 1{,}260 + 34 + 1{,}317 + 0$$

For the 3 months, L_T = 2,611 lb

References for Section 4.3 -

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6. Evaporation Loss From Internal Floating Roof Tanks, Third Edition, Bulletin No. 2519, American Petroleum Institute, Washington, D. C., 1983.

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PETROLEUM INDUSTRY

9.1 PETROLEUM REFINING[1]

9.1.1 General Description

The petroleum refining industry converts crude oil into more than 2500 refined products, including liquefied petroleum gas, gasoline, kerosene, aviation fuel, diesel fuel, fuel oils, lubricating oils, and feedstocks for the petrochemical industry. Petroleum refinery activities start with receipt of crude for storage at the refinery, include all petroleum handling and refining operations, and terminate with storage preparatory to shipping the refined products from the refinery.

The petroleum refining industry employs a wide variety of processes. A refinery's processing flow scheme is largely determined by the composition of the crude oil feedstock and the chosen slate of petroleum products. The example refinery flow scheme presented in Figure 9.1-1 shows the general processing arrangement used by refineries in the United States for major refinery processes. The arrangement of these processes will vary among refineries, and few, if any, employ all of these processes. Petroleum refining processes having direct emission sources are presented in bold-line boxes on the figure.

Listed below are five categories of general refinery processes and associated operations:

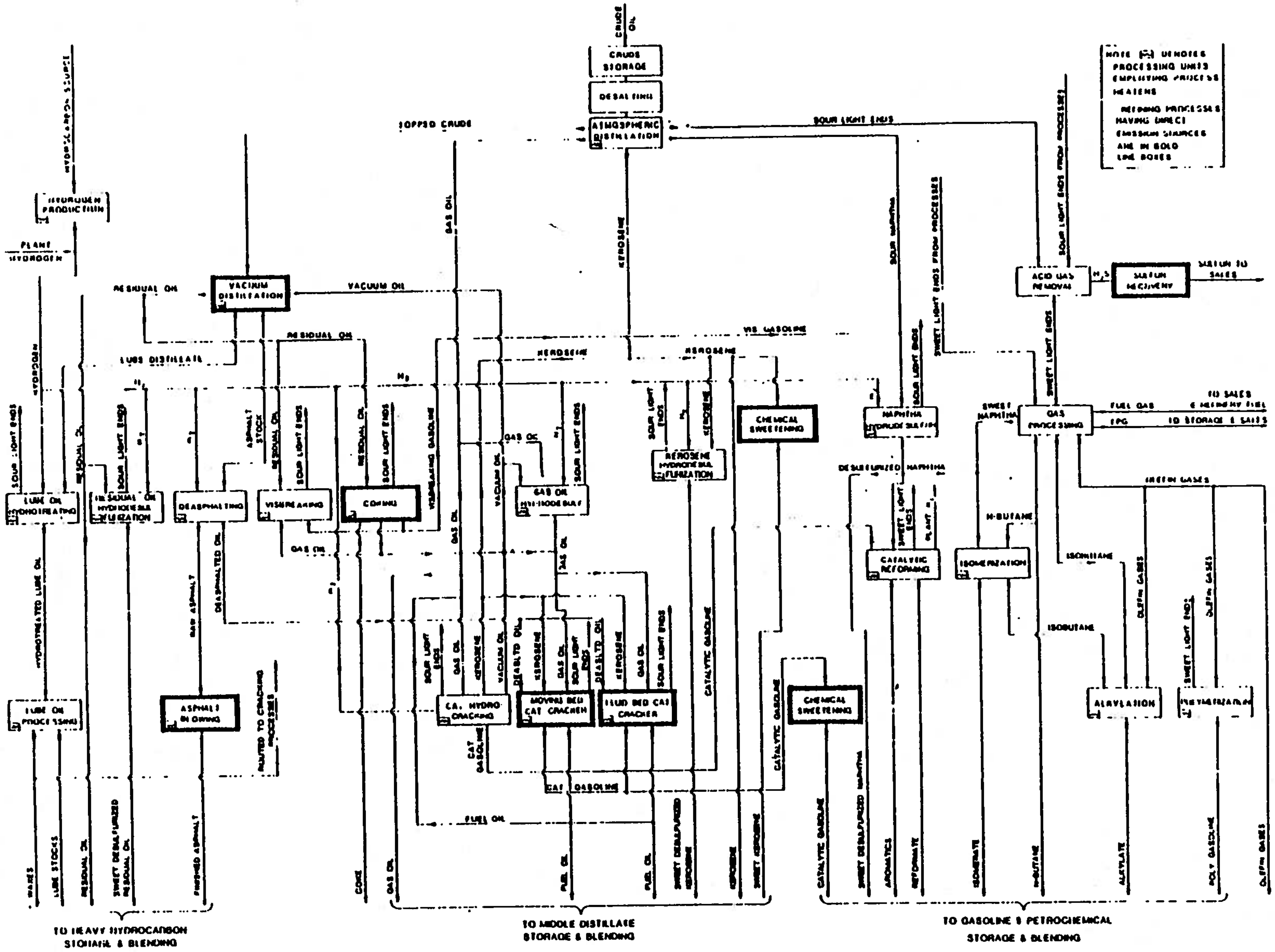
1. Separation processes
   a. atmospheric distillation
   b. vacuum distillation
   c. light ends recovery (gas processing)

2. Petroleum conversion processes
   a. cracking (thermal and catalytic)
   b. reforming
   c. alkylation
   d. polymerization
   e. isomerization
   f. coking
   g. visbreaking

3. Petroleum treating processes
   a. hydrodesulfurization
   b. hydrotreating
   c. chemical sweetening
   d. acid gas removal
   e. deasphalting

4. Feedstock and product handling
   a. storage
   b. blending
   c. loading
   d. unloading

5. Auxiliary facilities
   a. boilers
   b. wastewater treatment
   c. hydrogen production



9.1-1. Schematic of an example integrated petroleum refinery.

d. sulfur recovery plant
e. cooling towers
f. blowdown system
g. compressor engines

These refinery processes are defined in the following section and their emission characteristics and applicable emission control technology are discussed.

9.1.1.1. Separation Processes — The first phase in petroleum refining operations is the separation of crude oil into its major constituents using three petroleum separation processes: atmospheric distillation, vacuum distillation, and light ends recovery (gas processing). Crude oil consists of a mixture of hydrocarbon compounds including paraffinic, naphthenic, and aromatic hydrocarbons plus small amounts of impurities including sulfur, nitrogen, oxygen, and metals. Refinery separation processes separate these crude oil constituents into common-boiling-point fractions.

9.1.1.2. Conversion Processes—To meet the demands for high-octane gasoline, jet fuel, and diesel fuel, components such as residual oils, fuel oils, and light ends are converted to gasolines and other light fractions. Cracking, coking, and visbreaking processes are used to break large petroleum molecules into smaller petroleum molecules. Polymerization and alkylation processes are used to combine small petroleum molecules into larger ones. Isomerization and reforming processes are applied to rearrange the structure of petroleum molecules to produce higher-value molecules of a similar molecular size.

9.1.1.3. Treating Processes—Petroleum treating processes stabilize and upgrade petroleum products by separating them from less desirable products and by removing objectionable elements. Undesirable elements such as sulfur, nitrogen, and oxygen are removed by hydrodesulfurization, hydrotreating, chemical sweetening and acid gas removal. Treating processes employed primarily for the separation of petroleum products include such processes as deasphalting. Desalting is used to remove salt, minerals, grit, and water from crude oil feed stocks prior to refining. Asphalt blowing is used for polymerizing and stabilizing asphalt to improve its weathering characteristics.

9.1.1.4. Feedstock and Product Handling—The refinery feedstock and product handling operations consist of unloading, storage, blending, and loading activities.

9.1.1.5. Auxiliary Facilities—A wide assortment of processes and equipment not directly involved in the refining of crude oil are used in functions vital to the operation of the refinery. Examples are boilers, wastewater treatment facilities, hydrogen plants, cooling towers, and sulfur recovery units. Products from auxiliary facilities (clean water, steam, and process heat) are required by most refinery process units throughout the refinery.

9.1.2 Process Emission Sources and Control Technology

This section presents descriptions of those refining processes that are significant air pollutant contributors. Process flow schemes, emission characteristics, and emission control technology are discussed for each process. Table 9.1-1 lists the emission factors for direct-process emissions in petroleum refineries. The following process emission sources are discussed in this section on petroleum refining emissions:

1. Vacuum distillation.
2. Catalytic cracking.
3. Thermal cracking processes.
4. Utility boilers.
5. Heaters.

6. Compressor engines.
7. Blowdown systems.
8. Sulfur recovery.

9.1.2.1. Vacuum Distillation—Topped crude withdrawn from the bottom of the atmospheric distillation column is composed of high-boiling-point hydrocarbons. When distilled at atmospheric pressures, the crude oil decomposes and polymerizes to foul equipment. To separate topped crude into components, it must be distilled in a vacuum column at a very low pressure and in a steam atmosphere.

In the vacuum distillation unit, topped crude is heated with a process heater to temperatures ranging from 700 to 800° F (370 to 425° C). The heated topped crude is flashed into a multi-tray vacuum distillation column operating at vacuums ranging from 0.5 to 2 psia (350 to 1400 kg/m^2). In the vacuum column, the topped crude is separated into common-boiling-point fractions by vaporization and condensation. Stripping steam is normally injected into the bottom of the vacuum distillation column to assist in the separation by lowering the effective partial pressures of the components. Standard petroleum fractions withdrawn from the vacuum distillation column include lube distillates, vacuum oil, asphalt stocks, and residual oils. The vacuum in the vacuum distillation column is normally maintained by the use of steam ejectors but may be maintained by the use of vacuum pumps.

The major sources of atmospheric emissions from the vacuum distillation column are associated with the steam ejectors or vacuum pumps. A major portion of the vapors withdrawn from the column by the ejectors or pumps are recovered in condensers. Historically, the noncondensable portion of the vapors has been vented to the atmosphere from the condensers. There are approximately 50 pounds (23 kg) of noncondensable hydrocarbons per 1000 barrels of topped crude processed in the vacuum distillation column.[2,12,13] A second source of atmospheric emissions from vacuum distillation columns is combustion products from the process heater. Process heater requirements for the vacuum distillation column are approximately 37,000 Btu per barrel (245 Joules/cm^3) of topped crude processed in the vacuum column. Process heater emissions and their control are discussed later in this section. Fugitive hydrocarbon emissions from leaking seals and fittings are also associated with the vacuum distillation unit, but these are minimized by the low operating pressures and low vapor pressures in the unit. Fugitive emission sources are also discussed later in this section.

Control technology applicable to the noncondensable emissions vented from the vacuum ejectors or pumps include venting into blowdown systems or fuel gas systems, and incineration in furnaces or waste heat boilers.[2,12,13] These control techniques are generally greater than 99 percent efficient in the control of hydrocarbon emissions, but they also contribute to the emission of combustion products.

9.1.2.2. Catalytic Cracking—Catalytic cracking, using heat, pressure, and catalysts, converts heavy oils into lighter products with product distributions favoring the more valuable gasoline and distillate blending components. Feedstocks are usually gas oils from atmospheric distillation, vacuum distillation, coking, and deasphalting processes. These feedstocks typically have a boiling range of 650 to 1000° F (340 to 540° C). All of the catalytic cracking processes in use today can be classified as either fluidized-bed or moving-bed units.

Fluidized-bed Catalytic Cracking (FCC) — The FCC process uses a catalyst in the form of very fine particles that act as a fluid when aerated with a vapor. Fresh feed is preheated in a process heater and introduced into the bottom of a vertical transfer line or riser with hot regenerated catalyst. The hot catalyst vaporizes the feed bringing both to the desired reaction temperature, 880 to 980° F (470 to 525° C). The high activity of modern catalysts causes most of the cracking reactions to take place in the riser as the catalyst and oil mixture flows upward into the reactor. The hydrocarbon vapors are separated from the catalyst particles by cyclones in the reactor. The reaction products are sent to a fractionator for separation.

The spent catalyst falls to the bottom of the reactor and is steam stripped as it exists the reactor bottom to remove absorbed hydrocarbons. The spent catalyst is then conveyed to a regenerator. In the regenerator, coke deposited on the catalyst as a result of the cracking reactions is burned off in a controlled combustion process with preheated air. Regenerator temperature is usually 1100 to 1250° F (590 to 675° C). The catalyst is then recycled to be mixed with fresh hydrocarbon feed.

Moving-bed Catalytic Cracking (TCC)— In the TCC process, catalyst beads (~0.5 cm) flow by gravity into the top of the reactor where they contact a mixed-phase hydrocarbon feed. Cracking reactions take place as the catalyst and hydrocarbons move concurrently downward through the reactor to a zone where the catalyst is separated from the vapors. The gaseous reaction products flow out of the reactor to the fractionation section of the unit. The catalyst is steam stripped to remove any adsorbed hydrocarbons. It then falls into the regenerator where coke is burned from the catalyst with air. The regenerated catalyst is separated from the flue gases and recycled to be mixed with fresh hydrocarbon feed. The operating temperatures of the reactor and regenerator in the TCC process are comparable to those in the FCC process.

Air emissions from catalytic cracking processes are (1) combustion products from process heaters and (2) flue gas from catalyst regeneration. Emissions from process heaters are discussed later in this section. Emissions from the catalyst regenerator include hydrocarbons, oxides of sulfur, ammonia, aldehydes, oxides of nitrogen, cyanides, carbon monoxide, and particulates (Table 9.1-1). The particulate emissions from FCC units are much greater than those from TCC units because of the higher catalyst circulation rates used.[2,3,5]

FCC particulate emissions are controlled by cyclones and/or electrostatic precipitators. Particulate control efficiencies are as high as 80 to 85 percent.[3,5] Carbon monoxide wasteheat boilers reduce the carbon monoxide and hydrocarbon emissions from FCC units to negligible levels.[3] TCC catalyst regeneration produces similar pollutants to FCC units but in much smaller quantities (Table 9.1-1). The particulate emissions from a TCC unit are normally controlled by high-efficiency cyclones. Carbon monoxide and hydrocarbon emissions from a TCC unit are incinerated to negligible levels by passing the flue gases through a process heater fire-box or smoke plume burner. In some installations, sulfur oxides are removed by passing the regenerator flue gases through a water or caustic scrubber.[2,3,5]

9.1.2.3 Thermal Cracking — Thermal cracking processes include visbreaking and coking, which break heavy oil molecules by exposing them to high temperatures.

Visbreaking — Topped crude or vacuum residuals are heated and thermally cracked (850 to 900° F, 50 to 250 psig) (455 to 480° C, 3.5 to 17.6 kg/cm^2) in the visbreaker furnace to reduce the viscosity or pour point of the charge. The cracked products are quenched with gas oil and flashed into a fractionator. The vapor overhead from the fractionator is separated into light distillate products. A heavy distillate recovered from the fractionator liquid can be used as a fuel oil blending component or used as catalytic cracking feed.

Coking — Coking is a thermal cracking process used to convert low value residual fuel oil to higher value gas oil and petroleum coke. Vacuum residuals and thermal tars are cracked in the coking process at high temperature and low pressure. Products are petroleum coke, gas oils, and lighter petroleum stocks. Delayed coking is the most widely used process today, but fluid coking is expected to become an important process in the future.

In the delayed coking process, heated charge stock is fed into the bottom section of a fractionator where light ends are stripped from the feed. The stripped feed is then combined with recycle products from the coke drum and rapidly heated in the coking heater to a temperature of 900 to 1100° F (480 to 590° C). Steam injection is used to control the residence time in the heater. The vapor-liquid feed leaves the heater, passing to a coke drum where, with controlled residence time, pressure (25 to 30 psig) (1.8 to 2.1 kg/cm^2), and temperature (750° F) (400° C), it is cracked to form coke and vapors. Vapors from the drum return to the fractionator where the thermal cracking products are recovered.

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Table 9.1-1. EMISSION FACTORS FOR PETROLEUM REFINERIES

Process	Particulates	Sulfur oxides (as SO_2)	Carbon monoxide	Total hydro-carbons[a]	Nitrogen oxides (as NO_2)	Aldehydes	Ammonia	Emission factor rating
Boilers and process heaters,								
Fuel Oil	See Section 1.3 - Fuel Oil Combustion							
Natural Gas	See Section 1.4 - Natural Gas Combustion							
Fluid catalytic cracking units[b]								
Uncontrolled								
lb/10³bbl fresh feed	242 (93 to 340)[c]	493 (100 to 525)	13,700	220	71.0 (37.1 to 145.0)	19	54	B
kg/10³ liters fresh feed	0.695 (0.267 to 0.976)	1.413 (0.288 to 1.505)	39.2	0.630	0.204 (0.107 to 0.416)	0.054	0.155	B
Electrostatic precipitator and CO boiler								
lb/10³ bbl fresh fed	45[d] (7 to 150)	493 (100 to 525)	Neg[e]	Neg	71.0[f] (37.1 to 145.0)	Neg	Neg	B
kg/10³ liters fresh feed	0.128 (0.020 to 0.428)	1.413 (0.288 to 1.505)	Neg	Neg	0.204 (0.107 to 0.416)	Neg	Neg	B
Moving-bed catalytic cracking units[g]								
lb/10³ bbl fresh feed	17	60	3,800	87	5	12	6	B
kg/10³ liters fresh feed	0.049	0.171	10.8	0.250	0.014	0.034	0.017	B
Fluid coking units[h]								
Uncontrolled								
lb/10³ bbl fresh feed	523	NA[i]	NA	NA	NA	NA	NA	C
kg/10³ liters fresh feed	1.50	NA	NA	NA	NA	NA	NA	C
Electrostatic precipitator and CO boiler								
lb/10³ bbl fresh feed	6.85	NA	Neg	Neg	NA	Neg	Neg	C
kg/10³ liters fresh feed	0.0196	NA	Neg	Neg	NA	Neg	Neg	C
Delayed coking units	NA	NA	NA	NA	NA	NA	NA	
Compressor engines[j]								
Reciprocating engines								
lb/10³ ft³ gas burned	Neg	2s[k]	0.43	1.4	3.4	0.1	0.2	B
kg/10³ m³ gas burned	Neg	32s	7.02	21.8	55.4	1.61	3.2	B
Gas turbines								
lb/10³ ft³ gas burned	Neg	2s	0.12	0.02	0.3	NA	NA	B
kg/10³ m³ gas burned	Neg	32s	1.94	0.28	4.7	NA	NA	B

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Table 9.1-1. (Continued) EMISSION FACTORS FOR PETROLEUM REFINERIES

Process	Particulates	Sulfur oxides (as SO_2)	Carbon monoxide	Total hydro-carbons	Nitrogen oxides (as NO_2)	Aldehydes	Ammonia	Emission factor rating
Blowdown systems[f]								
Uncontrolled								
lb/10³ bbl refinery feed	Neg	Neg	Neg	580	Neg	Neg	Neg	C
kg/10³ liters refinery feed	Neg	Neg	Neg	1.662	Neg	Neg	Neg	C
Vapor recovery system and flaring								
lb/10³ bbl refinery feed	Neg	26.9	4.3	0.8	18.9	Neg	Neg	C
kg/10³ liters refinery feed	Neg	0.077	0.012	0.002	0.054	Neg	Neg	C
Vacuum distillation[m] column condensers								
Uncontrolled								
lb/10³ bbl refinery feed	Neg	Neg	Neg	18	Neg	Neg	Neg	C
kg/10³ liters refinery feed	Neg	Neg	Neg	0.052	Neg	Neg	Neg	C
lb/10³ bbl vacuum feed	Neg	Neg	Neg	50 (0-130)	Neg	Neg	Neg	C
kg/10³ liters vacuum feed	Neg	Neg	Neg	0.144	Neg	Neg	Neg	C
Controlled	Neg	Neg	Neg	Neg	Neg	Neg	Neg	C
Claus plant and tail gas treatment		See section 5.18						

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[a] Overall, less than 1 percent by weight of the total hydrocarbon emissions are methane.

[b] References 2 through 8.

[c] Numbers in parenthesis indicate range of values observed.

[d] Under the New Source Performance Standards, controlled FCC regenerators will have particulate emissions lower than 19 lb/10³ bbl fresh feed.

[e] Negligible emission.

[f] May be higher due to the combustion of ammonia.

[g] Reference 2.

[h] Reference 5.

[i] NA, Not Available.

[j] References 9, 10.

[k] s = Refinery gas sulfur content (lb/1000 ft³): Factors based on 100 percent combustion of sulfur to SO_2.

[l] References 2, 11.

[m] References 2, 12, 13.

In the fluid coking process, typified by Flexicoking, residual oil feeds are injected into the reactor where they are thermally cracked, yielding coke and a wide range of vapor products. Vapors leave the reactor and are quenched in a scrubber where entrained coke fines are removed. The vapors are then fractionated. Coke from the reactor enters a heater and is devolatilized. The volatiles from the heater are treated for fines and sulfur removal to yield a particulate free, low-sulfur fuel gas. The devolatilized coke is circulated from the heater to a gasifier where 95 percent of the reactor coke is gasified at high temperature with steam and air or oxygen. The gaseous products and coke from the gasifier are returned to the heater to supply heat for the devolatilization. These gases exit the heater with the heater volatiles through the same fines and sulfur removal processes.

From available literature, it is unclear what emissions are released and where they are released. Air emissions from thermal cracking processes include coke dust from decoking operations, combustion gases from the visbreaking and coking process heaters, and fugitive emissions. Emissions from the process heaters are discussed later in this section. Fugitive emissions from miscellaneous leaks are significant because of the high temperatures involved, and are dependent upon equipment type and configuration, operating conditions, and general maintenance practices. Fugitive emissions are also discussed later in this section. Particulate emissions from delayed coking operations are potentially very significant. These emissions are associated with removing the coke from the coke drum and subsequent handling and storage operations. Hydrocarbon emissions are also associated with cooling and venting the coke drum prior to coke removal. However, comprehensive data for delayed coking emissions have not been included in available literature. [4,5]

Particulate emission control is accomplished in the decoking operation by wetting down the coke.[5] Generally, there is no control of hydrocarbon emissions from delayed coking. However, some facilities are now collecting coke drum emissions in an enclosed system and routing them to a refinery flare.[4,5]

9.1.2.4 Utilities Plant — The utilities plant supplies the steam necessary for the refinery. Although the steam can be used to produce electricity by throttling through a turbine, it is primarily used for heating and separating hydrocarbon streams. When used for heating, the steam usually heats the petroleum indirectly in heat exchangers and returns to the boiler. In direct contact operations, the steam can serve as a stripping medium or a process fluid. Steam may also be used in vacuum ejectors to produce a vacuum. Emissions from boilers and applicable emission control technology are discussed in much greater detail in Chapter 1.0.

9.1.2.5 Sulfur Recovery Plant — Sulfur recovery plants are used in petroleum refineries to convert hydrogen sulfide (H_2S) separated from refinery gas streams into the more disposable by-product, elemental sulfur. Emissions from sulfur recovery plants and their control are discussed in Section 5.18..

9.1.2.6 Blowdown System — The blowdown system provides for the safe disposal of hydrocarbons (vapor and liquid) discharged from pressure relief devices.

Most refining processing units and equipment subject to planned or unplanned hydrocarbon discharges are manifolded into a collection unit, called the blowdown system. By using a series of flash drums and condensers arranged in decreasing pressure, the blowdown is separated into vapor and liquid cuts. The separated liquid is recycled into the refinery. The gaseous cuts can either be smokelessly flared or recycled.

Uncontrolled blowdown emissions primarily consist of hydrocarbons, but can also include any of the other criteria pollutants. The emission rate in a blowdown system is a function of the amount of equipment manifolded into the system, the frequency of equipment discharges, and the blowdown system controls.

Emissions from the blowdown system can be effectively controlled by combustion of the noncondensables in a flare. To obtain complete combustion or smokeless burning (as required by most states), steam is injected in the combustion zone of the flare to provide turbulence and to inspirate air. Steam injection also reduces emissions of nitrogen oxides by lowering the flame temperature. Controlled emissions are listed in Table 9.1-1.[2,11]

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9.1.2.7 Process Heaters - Process heaters (furnaces) are used extensively in refineries to supply the heat necessary to raise the temperature of feed materials to reaction or distillation level. They are designed to raise petroleum fluid temperatures to a maximum of about 950°F (510°C). The fuel burned may be refinery gas, natural gas, residual fuel oils, or combinations, depending on economics, operating conditions and emission requirements. Process heaters may also use carbon monoxide-rich regenerator flue gas as fuel.

All the criteria pollutants are emitted from process heaters. The quantity of these emissions is a function of the type of fuel burned, the nature of the contaminants in the fuel, and the heat duty of the furnace. Sulfur oxide can be controlled by fuel desulfurization or flue gas treatment. Carbon monoxide and hydrocarbons can be limited by more combustion efficiency. Currently, four general techniques or modifications for the control of nitrogen oxides are being investigated: combustion modification, fuel modification, furnace design and flue gas treatment. Several of these techniques are presently being applied to large utility boilers, but their applicability to process heaters has not been established.[2,14]

9.1.2.8 Compressor Engines - Many older refineries run high pressure compressors with reciprocating and gas turbine engines fired with natural gas. Natural gas has usually been a cheap, abundant source of energy. Examples of refining units operating at high pressure include hydrodesulfurization, isomerization, reforming and hydrocracking. Internal combustion engines are less reliable and harder to maintain than steam engines or electric motors. For this reason, and because of increasing natural gas costs, very few such units have been installed in the last few years.

The major source of emissions from compressor engines is combustion products in the exhaust gas. These emissions include carbon monoxide, hydrocarbons, nitrogen oxides, aldehydes and ammonia. Sulfur oxides may also be present, depending on the sulfur content of the natural gas. All these emissions are significantly higher in exhaust of reciprocating engines than from turbine engines.

The major emission control technique applied to compressor engines is carburetion adjustment similar to that applied on automobiles. Catalyst systems similar to those applied to automobiles may also be effective in reducing emissions, but their use has not been reported.

9.1.2.9 Sweetening - Sweetening of distillates is accomplished by the conversion of mercaptans to alkyl disulfides in the presence of a catalyst. Conversion may be followed by an extraction step for the removal of the alkyl disulfides. In the conversion process, sulfur is added to the sour distillate with a small amount of caustic and air. The mixture is then passed upward through a fixed bed catalyst counter to a flow of caustic entering at the top of the vessel. In the conversion and extraction process, the sour distillate is washed with caustic and then is contacted in the extractor with a solution of catalyst and

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Table 9.1-2. FUGITIVE EMISSION FACTORS FOR PETROLEUM REFINERIES[a]

Emission Source	Process Stream Type[b]	Emission Factor Units	Emission Factors: Uncontrolled Emissions[c]	Emission Factors: Controlled Emissions	Applicable Control Technology	Emission Factor Rating
Pipeline valves[d]	II	lb/hr-source kg/day-source	0.059 (0.030 - 0.110) 0.64 (0.32 - 1.19)	NA	Monitoring and maintenance programs	A
	III	" "	0.024 (0.017 - 0.036) 0.26 (0.18 - 0.39)	NA		A
	IV	" "	0.0005 (0.0002- 0.0015) 0.005 (0.002 - 0.016)	NA		A
	V	" "	0.018 (0.007 - 0.045) 0.20 (0.08 - 0.49)	NA		A
Open ended valves[d,e]	I	" "	0.005 (0.0016- 0.016) 0.05 (0.017 - 0.17)	NA	Installation of cap or plug on open end of valve/line	A
Flanges[d]	I	"	0.00056 (0.0002- 0.0025) 0.0061 (0.002 - 0.027)	NA	Monitoring and maintenance programs	A
Pump seals[d]	III	" "	0.25 (0.16 - 0.37) 2.7 (1.7 - 4.0)	NA	Mechanical seals, dual seals, purged seals, monitoring and maintenance programs, controlled degassing vents	A
	IV	" "	0.046 (0.019 - 0.11) 0.50 (0.21 - 1.2)	NA		A
Compressor seals[d]	II	" "	1.4 (0.66 - 2.9) 15 (7.1 - 31)	NA	Mechanical seals, dual seals, purged seals, monitoring and maintenance programs, controlled degassing vents	A
	V	" "	0.11 (0.05 - 0.23) 1.2 (0.5 - 2.5)	NA		A
Process drains[d]	I	" "	0.070 (0.023 - 0.20) 0.76 (0.25 - 2.2)	NA	Traps and covers	A
Pressure vessel relief valves (gas service)[d,f]	II	" "	0.36 (0.10 - 1.3) 3.9 (1.1 - 14)	Negligible	Rupture disks upstream of relief valves and/or venting to a flare	A
Cooling towers	-	lb/10^6 gal cooling water	6	0.70	Minimization of hydrocarbon leaks into cooling water system. Monitoring of cooling water for hydrocarbons	D
		kg/10^6 liters cooling water	0.7	0.083		
		lb/10^3 bbl refinery feed[g]	10	1.2		
		kg/10^3 liters refinery feed	0.03	0.004		
Oil/water separators	-	lb/10^3 gal wastewater	5	0.2	Covered separators and/or vapor recovery Systems	D
		kg/10^3 liter waste water	0.6	0.024		
		lb/10^3 bbl refinery feed	200	10		
		kg/10^3 liters refinery feed	0.6	0.03		
Storage		See Section 4.3				
Loading		See Section 4.4				

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[a] Data from References 2, 4, 12 and 13 except as noted. Overall, less than 1% by weight of the total VOC emissions are methane. NA = Not Available.

[b] The volatility and hydrogen content of the process streams have a substantial effect on the emission rate of some fugitive emission sources. The stream identification numerals and group names and descriptions are:

Stream Identification Numeral	Stream Name	Stream Group Description
I	All streams	All streams
II	Gas streams	Hydrocarbon gas/vapor at process conditions (containing less than 50% hydrogen, by volume)
III	Light liquid and gas/liquid streams	Liquid or gas/liquid stream with a vapor pressure greater than that of kerosene (> 0.1 psia @ 100°F or 689 Pa @ 38°C), based on the most volatile class present at > 20% by volume
IV	Heavy liquid streams	Liquid stream with a vapor pressure equal to or less than that of kerosene (≤ 0.1 psia @ 100°F or 689 Pa @ 38°C), based on the most volatile class present at ≥ 20% by volume
V	Hydrogen streams	Gas streams containing more than 50% hydrogen by volume

[c] Numbers in parentheses are the upper and lower bounds of the 95% confidence interval for the emission factor.

[d] Data from Reference 17.

[e] The downstream side of these valves is open to the atmosphere. Emissions are through the valve seat of the closed valve.

[f] Emission factor for relief valves in gas service is for leakage, not for emissions caused by vessel pressure relief.

[g] Refinery rate is defined as the crude oil feed rate to the atmospheric distillation column.

caustic. The extracted distillate is then contacted with air to convert mercaptans to disulfides. After oxidation, the distillate is settled, inhibitors are added, and the distillate is sent to storage. Regeneration is accomplished by mixing caustic from the bottom of the extractor with air and then separating the disulfides and excess air.

The major emission problem is hydrocarbons from contact between the distillate product and air in the "air blowing" step. These emissions are related to equipment type and configuration, as well as to operating conditions and maintenance practices.[4]

9.1.2.10 Asphalt Blowing - The asphalt blowing process polymerizes asphaltic residual oils by oxidation, increasing their melting temperature and hardness to achieve an increased resistance to weathering. The oils, containing a large quantity of polycyclic aromatic compounds (asphaltic oils), are oxidized by blowing heated air through a heated batch mixture or, in continuous process, by passing hot air countercurrent to the oil flow. The reaction is exothermic, and quench steam is sometimes needed for temperature control. In some cases, ferric chloride or phosphorus pentoxide is used as a catalyst to increase the reaction rate and to impart special characteristics to the asphalt.

Air emissions from asphalt blowing are primarily hydrocarbon vapors vented with the blowing air. The quantities of emissions are small because of the prior removal of volatile hydrocarbons in the distillation units, but the emissions may contain hazardous polynuclear organics. Emission are 60 pounds per ton of asphalt.[13] Emissions from asphalt blowing can be controlled to negligible levels by vapor scrubbing, incineration, or both[4,13]

9.1.3 Fugitive Emissions and Controls

Fugitive emission sources are generally defined as volatile organic compound (VOC) emission sources not associated with a specific process but scattered throughout the refinery. Fugitive emission sources include valves of all types, flanges, pump and compressor seals, process drains, cooling towers, and oil/water separators. Fugitive VOC emissions are attributable to the evaporation of leaked or spilled petroleum liquids and gases. Normally, control of fugitive emissions involves minimizing leaks and spills through equipment changes, procedure changes, and improved monitoring, housekeeping and maintenance practices. Controlled and uncontrolled fugitive emission factors for the following sources are listed in Table 9.1-2.

- valves (pipeline, open ended, vessel relief)
- flanges
- seals (pump, compressor)
- process drains
- oil/water separators (wastewater treatment)
- storage
- transfer operations
- cooling towers

9.1.3.1 Valves, Flanges, Seals and Drains - For these sources, a very high correlation has been found between mass emission rates and the type of stream service in which the sources are employed. Except for compressed gases, streams are classified into one of three stream groups, (1) gas/vapor streams, (2) light liquid/two phase streams, and (3) kerosene and heavier liquid streams. Gases passing through compressors are classified as either hydrogen or hydrocarbon service. It is found that sources in gas/vapor stream service have higher emission rates than those in heavier stream service. This trend is especially pronounced for valves and pump seals. The size of sources like valves, flanges, pump seals, compressor seals, relief valves and process drains does not affect the leak rates.[17] The emission factors are independent of process unit or refinery throughput.

Emission factors are given for compressor seals in each of the two gas service classifications. Valves, because of their number and relatively high emission factor, are the major emission source among the source types. This conclusion is based on an analysis of a hypothetical refinery coupled with the emission rates. The total quantity of fugitive VOC emissions in a typical oil refinery with a capacity of 330,000 barrels (52,500 m^3) per day is estimated as 45,000 pounds (20.4 MT) per day. See Table 9.1-3.

9.1.3.2 Storage - All refineries have a feedstock and product storage area, termed a "tank farm", which provides surge storage capacity to assure smooth, uninterrupted refinery operations. Individual storage tank capacities range from less than 1000 barrels to more than 500,000 barrels (160 - 79,500 m^3). Storage tank designs, emissions and emission control technologies are discussed in detail in Section 4.3.

9.1.3.3 Transfer Operations - Although most refinery feedstocks and products are transported by pipeline, some are transported by trucks, rail cars and marine vessels. They are transferred to and from these transport vehicles in the refinery tank farm area by specialized pumps and piping systems. The emissions from transfer operations and applicable emission control technology are discussed in much greater detail in Section 4.4.

9.1.3.4 Wastewater Treatment Plant - All refineries employ some form of wastewater treatment so water effluents can safely be returned to the environment or reused in the refinery. The design of wastewater treatment plants is complicated by the diversity of refinery pollutants, including oil, phenols, sulfides, dissolved solids, and toxic chemicals. Although the wastewater treatment processes employed by refineries vary greatly, they generally include neutralizers, oil/water separators, settling chambers, clarifiers, dissolved air flotation systems, coagulators, aerated lagoons, and activated sludge ponds. Refinery water effluents are collected from various processing units and are conveyed through sewers and ditches to the wastewater treatment plant. Most of the wastewater treatment occurs in open ponds and tanks.

The main components of atmospheric emissions from wastewater treatment plants are fugitive VOC and dissolved gases that evaporate from the surfaces of wastewater residing in open process drains, wastewater separators, and wastewater ponds (Table 9.1-2). Treatment processes that involve extensive contact of wastewater and air, such as aeration ponds and dissolved air flotation, have an even greater potential for atmospheric emissions.

The control of wastewater treatment plant emissions involves covering wastewater systems where emission generation is greatest (such as covering American Petroleum Institute separators and settling basins) and removing dissolved gases from wastewater streams with sour water strippers and phenol recovery units prior to their contact with the atmosphere. These control techniques potentially can achieve greater than 90 percent reduction of wastewater system emissions.[13]

TABLE 9.1-3. FUGITIVE VOC EMISSIONS FROM AN OIL REFINERY[17]

Source	Number	VOC Emissions lb/day	VOC Emissions kg/day
Valves	11,500	6,800	3,084
Flanges	46,500	600	272
Pump Seals	350	1,300	590
Compressors	70	1,100	499
Relief Valves	100	500	227
Drains	650	1,000	454
Cooling Towers[a]	-	1,600	726
Oil/Water Separators (uncovered)[a]	-	32,100	14,558
TOTAL		45,000	20,408

[a] Emissions from the cooling towers and oil/water separators are based on limited data. EPA is currently involved in further research to provide better data on wastewater system fugitive emissions.

9.1.3.5 Cooling Towers - Cooling towers are used extensively in refinery cooling water systems to transfer waste heat from the cooling water to the atmosphere. The only refineries not employing cooling towers are those with once-through cooling. The increasing scarcity of large water supplies required for once-through cooling is contributing to the disappearance of that form of refinery cooling. In the cooling tower, warm cooling water returning from refinery processes is contacted with air by cascading through packing. Cooling water circulation rates for refineries commonly range from 0.3 to 3.0 gallons (1.1 - 11.0 liters) per minute per barrel per day of refinery capacity.[2,16]

Atmospheric emissions from the cooling tower consist of fugitive VOC and gases stripped from the cooling water as the air and water come into contact. These contaminants enter the cooling water system from leaking heat exchangers and condensers. Although the predominant contaminant in cooling water is VOC, dissolved gases such as hydrogen sulfide and ammonia may also be found (Table 9.1-2).[2,4,17]

Control of cooling tower emissions is accomplished by reducing contamination of cooling water through the proper maintenance of heat exchangers and condensers. The effectiveness of cooling tower controls is highly variable, depending on refinery configuration and existing maintenance practices.[4]

References for Section 9.1

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13. *Hydrocarbon Emissions from Refineries*, API Publication No. 928, American Petroleum Institute, Washington, DC, 1973.

14. R. A. Brown, *et al.*, *Systems Analysis Requirements for Nitrogen Oxide Control of Stationary Sources*, EPA-650/2-74-091, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1974.

15. R. P. Hangebrauck, *et al.*, *Sources of Polynuclear Hydrocarbons in the Atmosphere*, 999-AP-33, Public Health Service, U.S. Department of Health, Education and Welfare, Washington, DC, 1967.

16. W. S. Crumlish, "Review of Thermal Pollution Problems, Standards, and Controls at the State Government Level", Presented at the Cooling Tower Institute Symposium, New Orleans, LA, January 30, 1966.

17. *Assessment of Atmospheric Emissions from Petroleum Refining*, EPA-600/2-80-075a through -075d, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1980.

9.2 NATURAL GAS PROCESSING

9.2.1 General[1]

Natural gas from high-pressure wells is usually passed through field separators to remove hydrocarbon condensate and water at the well. Natural gasoline, butane, and propane are usually present in the gas, and gas processing plants are required for the recovery of these liquefiable constituents (see Figure 9.2-1). Natural gas is considered "sour" if hydrogen sulfide is present in amounts greater than 0.25 grain per 100 standard cubic feet. The hydrogen sulfide (H_2S) must be removed (called "sweetening" the gas) before the gas can be utilized. If H_2S is present, the gas is usually sweetened by absorption of the H_2S in an amine solution. Amine processes are used for over 95 percent of all gas sweetening in the United States. Processes such as carbonate processes, solid bed absorbents, and physical absorption methods are employed in the other sweetening plants. Emissions data for sweetening processes other than amine types are very meager.

The major emission sources in the natural gas processing industry are compressor engines and acid gas wastes from gas sweetening plants. Compressor engine emissions are discussed in section 3.3.2; therefore, only gas sweetening plant emissions are discussed here.

9.2.2 Process Description[2,3]

Many chemical processes are available for sweetening natural gas. However, at present, the most widely used method for H_2S removal or gas sweetening is the amine type process (also known as the Girdler process) in which various amine solutions are utilized for absorbing H_2S. The process is summarized in reaction 1 and illustrated in Figure 9.2-2.

$$2\ RNH_2 + H_2S \longrightarrow (RNH_3)_2S \tag{1}$$

where:

R = mono, di, or tri-ethanol

N = nitrogen

H = hydrogen

S = sulfur

The recovered hydrogen sulfide gas stream may be (1) vented, (2) flared in waste gas flares or modern smokeless flares, (3) incinerated, or (4) utilized for the production of elemental sulfur or other commercial products. If the recovered H_2S gas stream is not to be utilized as a feedstock for commercial applications, the gas is usually passed to a tail gas incinerator in which the H_2S is oxidized to sulfur dioxide and then passed to the atmosphere via a stack. For more details, the reader should consult Reference 8.

9.2.3 Emissions[4,5]

Emissions will only result from gas sweetening plants if the acid waste gas from the amine process is flared or incinerated. Most often, the acid waste gas is used as a feedstock in nearby sulfur recovery or sulfuric acid plants.

When flaring or incineration is practiced, the major pollutant of concern is sulfur dioxide. Most plants employ elevated smokeless flares or tail gas incinerators to ensure complete combustion of all waste gas constituents, including virtually 100 percent conversion of H_2S to SO_2. Little particulate, smoke, or hydrocarbons result from these devices, and because gas temperatures do not usually exceed 1200°F (650°C), significant quantities of nitrogen oxides are not formed. Emission factors for gas sweetening plants with smokeless flares or incinerators are presented in Table 9.2-1.

10.4 WOODWORKING WASTE COLLECTION OPERATIONS

10.4.1 General[1-5]

Woodworking, as defined in this section, includes any operation that involves the generation of small wood waste particles (shavings, sanderdust, sawdust, etc.) by any kind of mechanical manipulation of wood, bark, or wood byproducts. Common woodworking operations include sawing, planing, chipping, shaping, moulding, hogging, lathing, and sanding. Woodworking operations are found in numerous industries, such as sawmills, plywood, particleboard, and hardboard plants, and furniture manufacturing plants.

Most plants engaged in woodworking employ pneumatic transfer systems to remove the generated wood waste from the immediate proximity of each woodworking operation. These systems are necessary as a housekeeping measure to eliminate the vast quantity of waste material that would otherwise accumulate. They are also a convenient means of transporting the waste material to common collection points for ultimate disposal. Large diameter cyclones have historically been the primary means of separating the waste material from the airstreams in the pneumatic transfer systems, although baghouses have recently been installed in some plants for this purpose.

The waste material collected in the cyclones or baghouses may be burned in wood waste boilers, utilized in the manufacture of other products (such as pulp or particleboard), or incinerated in conical (teepee/wigwam) burners. The latter practice is declining with the advent of more stringent air pollution control regulations and because of the economic attractiveness of utilizing wood waste as a resource.

10.4.2 Emissions[1-6]

The only pollutant of concern in woodworking waste collection operations is particulate matter. The major emission points are the cyclones utilized in the pneumatic transfer systems. The quantity of particulate emissions from a given cyclone will depend on the dimensions of the cyclone, the velocity of the airstream, and the nature of the operation generating the waste. Typical large diameter cyclones found in the industry will only effectively collect particles greater than 40 micrometers in diameter. Baghouses, when employed, collect essentially all of the waste material in the airstream. The wastes from numerous pieces of equipment often feed into the same cyclone, and it is common for the material collected in one or several cyclones to be conveyed to another cyclone. It is also possible for portions of the waste generated by a single operation to be directed to different cyclones.

Because of this complexity, it is useful when evaluating emissions from a given facility to consider the waste handling cyclones as air pollution sources instead of the various woodworking operations that actually generate the particulate matter. Emission factors for typical large diameter cyclones utilized for waste collection in woodworking operations are given in Table 10.4-1.

Emission factors for wood waste boilers, conical burners, and various drying operations—often found in facilities employing woodworking operations—are given in Sections 1.6, 2.3, 10.2, and 10.3.

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Table 10.4.1. PARTICULATE EMISSION FACTORS FOR LARGE DIAMETER CYCLONES IN WOODWORKING WASTE COLLECTION SYSTEMS[a]

EMISSION FACTOR RATING: D

Types of waste handled	Particulate emissions[b,c]			
	gr/scf	g/Nm3	lb/hr	kg/hr
Sanderdust[d]	0.055 (0.005-0.16)	0.126 (0.0114-0.37)	5 (0.2-30.0)	2.3 (0.09-13.6)
Other[e]	0.03 (0.001-0.16)	0.07 (0.002-0.37)	2 (0.03-24.0)	0.91 (0.014-10.9)

[a] Typical waste collection cyclones range from 4 to 16 feet (1.2 to 4.9 meters) in diameter and employ airflows ranging from 2,000 to 26,000 standard cubic feet (57 to 740 normal cubic meters) per minute. Note: if baghouses are used for waste collection, particulate emissions will be negligible.

[b] References 1 through 3.

[c] Observed value ranges are in parentheses.

[d] These factors should be used whenever waste from sanding operations is fed directly into the cyclone in question.

[e] These factors should be used for cyclones handling waste from all operations other than sanding. This includes cyclones that handle waste (including sanderdust) already collected by another cyclone.

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5. A. Mick and D. McCargar, "Air Pollution Problems in Plywood, Particleboard, and Hardboard Mills in the Mid-Willamette Valley", Mid-Williamette Valley Air Pollution Authority, Salem, OR, March 24, 1969.
6. Information supplied by the North Carolina Department of Natural and Economic Resources, Raleigh, NC, December 1975.

10.4.3 Fugitive Emission Factors

Since most woodworking operations control emissions out of necessity. fugitive emissions are seldom a problem. However. the wood waste storage bins are a common source of fugitive emissions. Table 10.4-2 shows these emission sources and their corresponding emission factors.

Information concerning size characteristics is very limited. Data collected in a western red cedar furniture factory equipped with exhaust ventilation on most woodworking equipment showed most suspended particles in the working environment to be less than 2 μm in diameter.[7]

Table 10.4-2. POTENTIAL UNCONTROLLED FUGITIVE PARTICULATE EMISSION FACTORS FOR WOODWORKING OPERATIONS

EMISSION FACTOR RATING: C

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Wood waste storage bin vent[b]	1.0	0.5
Wood waste storage bin loadout[b]	2.0	1.0

[a] Factors expressed as units per unit weight of wood waste handled.

[b] Engineering judgment based on plant visits.

Additional Reference for Section 10.4

7. Lester V. Cralley, *et al.*, *Industrial Enivronmental Health, the Worker and the Community*, Academic Press, New York and London, 1972.

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11.2 FUGITIVE DUST SOURCES

Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction operations.

For the above categories of fugitive dust sources, the dust generation process is caused by two basic physical phenomena:

1. Pulverization and abrasion of surface materials by application of mechanical force through implements (wheels, blades, etc.).

2. Entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 19 kilometers per hour (12 miles/hr).

The air pollution impact of a fugitive dust source depends on the quantity and drift potential of the dust particles injected into the atmosphere. In addition to large dust particles that settle out near the source (often creating a local nuisance problem), considerable amounts of fine particles are also emitted and dispersed over much greater distances from the source.

The potential drift distance of particles is governed by the initial injection height of the particle, the particle's terminal settling velocity, and the degree of atmospheric turbulence. Theoretical drift distances, as a function of particle diameter and mean wind speed, have been computed for fugitive dust emissions.[1] These results indicate that, for a typical mean wind speed of 16 kilometers per hour (10 miles/hr), particles larger than about 100 micrometers are likely to settle out within 6 to 9 meters (20 to 30 ft) from the edge of the road. Particles that are 30 to 100 micrometers in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within a few hundred feet from the road. Smaller particles, particularly those less than 10 to 15 micrometers in diameter, have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence. Thus, based on the presently available data, it appears appropriate to report only those particles smaller than 30 micrometers. Future updates to this document are expected to define appropriate factors for other particle sizes.

Several of the emission factors presented in this Section are expressed in terms of total suspended particulate (TSP). TSP denotes what is measured by a standard high volume sampler. Recent wind tunnel studies have shown that the particle mass capture efficiency curve for the high volume sampler is very broad, extending from 100 percent capture of particles smaller than 10 micrometers to a few percent capture of particles as large as 100 micrometers. Also, the capture efficiency curve varies with

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wind speed and wind direction, relative to roof ridge orientation. Thus, high volume samplers do not provide definitive particle size information for emission factors. However, an effective cutpoint of 30 micrometers aerodynamic diameter is frequently assigned to the standard high volume sampler.

Control techniques for fugitive dust sources generally involve watering, chemical stabilization, or reduction of surface wind speed with windbreaks or source enclosures. Watering, the most common and generally least expensive method, provides only temporary dust control. The use of chemicals to treat exposed surfaces provides longer dust suppression but may be costly, have adverse effects on plant and animal life, or contaminate the treated material. Windbreaks and source enclosures are often impractical because of the size of fugitive dust sources.

11.2.1 UNPAVED ROADS

11.2.1.1 General

Dust plumes trailing behind vehicles traveling on unpaved roads are a familiar sight in rural areas of the United States. When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

11.2.1.2 Emissions And Correction Parameters

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Also, field investigations have shown that emissions depend on correction parameters (average vehicle speed, average vehicle weight, average number of wheels per vehicle, road surface texture and road surface moisture) that characterize the condition of a particular road and the associated vehicle traffic.[1-4]

Dust emissions from unpaved roads have been found to vary in direct proportion to the fraction of silt (particles smaller than 75 micrometers in diameter) in the road surface materials.[1] The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200 mesh screen, using the ASTM-C-136 method. Table 11.2.1-1 summarizes measured silt values for industrial and rural unpaved roads.

The silt content of a rural dirt road will vary with location, and it should be measured. As a conservative approximation, the silt content of the parent soil in the area can be used. However, tests show that road silt content is normally lower than in the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles.

Unpaved roads have a hard nonporous surface that usually dries quickly after a rainfall. The temporary reduction in emissions because of precipitation may be accounted for by not considering emissions on "wet" days (more than 0.254 millimeters [0.01 inches] of precipitation).

The following empirical expression may be used to estimate the quantity of size specific particulate emissions from an unpaved road, per vehicle kilometer traveled (VKT) or vehicle mile traveled (VMT), with a rating of A:

$$E = k(1.7) \left(\frac{s}{12}\right) \left(\frac{S}{48}\right) \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{w}{4}\right)^{0.5} \left(\frac{365-p}{365}\right) \quad \text{(kg/VKT)} \qquad (1)$$

$$E = k(5.9) \left(\frac{s}{12}\right) \left(\frac{S}{30}\right) \left(\frac{W}{3}\right)^{0.7} \left(\frac{w}{4}\right)^{0.5} \left(\frac{365-p}{365}\right) \quad \text{(lb/VMT)}$$

TABLE 11.2.1-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIALS ON INDUSTRIAL AND RURAL UNPAVED ROADS[a]

Industry	Road Use Or Surface Material	Plant Sites	Test Samples	Silt (%, w/w)	
				Range	Mean
Copper smelting	Plant road	1	3	[15.9 - 19.1]	[17.0]
Iron and steel production	Plant road	9	20	4.0 - 16.0	8.0
Sand and gravel processing	Plant road	1	3	[4.1 - 6.0]	[4.8]
Stone quarrying and processing	Plant road	1	5	[10.5 - 15.6]	[14.1]
Taconite mining and processing	Haul road	1	12	[3.7 - 9.7]	[5.8]
	Service road	1	8	[2.4 - 7.1]	[4.3]
Western surface coal mining	Access road	2	2	4.9 - 5.3	5.1
	Haul road	3	21	2.8 - 18	8.4
	Scraper road	3	10	7.2 - 25	17
	Haul road (freshly graded)	2	5	18 - 29	24
Rural roads	Gravel	1	1	NA	[5.0]
	Dirt	2	5	5.8 - 68	28.5
	Crushed limestone	2	8	7.7 - 13	9.6

[a] References 4 - 11. Brackets indicate silt values based on samples from only one plant site.
NA = Not available.

where: E = emission factor
k = particle size multiplier (dimensionless)
s = silt content of road surface material (%)
S = mean vehicle speed, km/hr (mph)
W = mean vehicle weight, Mg (ton)
w = mean number of wheels
p = number of days with at least 0.254 mm (0.01 in.) of precipitation per year

The particle size multiplier, k, in Equation 1 varies with aerodynamic particle size range as follows:

Aerodynamic Particle Size Multiplier For Equation 1

≤30 µm	≤15 µm	≤10 µm	≤5 µm	≤2.5 µm
0.80	0.50	0.36	0.20	0.095

The number of wet days per year, p, for the geographical area of interest should be determined from local climatic data. Figure 11.2.1-1 gives the geographical distribution of the mean annual number of wet days per year in the United States.

Equation 1 retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows:

RANGES OF SOURCE CONDITIONS FOR EQUATION 1

Equation	Road silt content (%, w/w)	Mean vehicle weight		Mean vehicle speed		Mean no. of wheels
		Mg	ton	km/hr	mph	
1	4.3 - 20	2.7 - 142	3 - 157	21 - 64	13 - 40	4 - 13

Also, to retain the quality rating of the equation applied to a specific unpaved road, it is necessary that reliable correction parameter values for the specific road in question be determined. The field and laboratory procedures for determining road surface silt content are given in Reference 4. In the event that site specific values for correction parameters cannot be obtained, the appropriate mean values from Table 11.2.1-1 may be used, but the quality rating of the equation is reduced to B.

Equation 1 was developed for calculation of annual average emissions, and thus, is to be multiplied by annual vehicle distance traveled (VDT). Annual average values for each of the correction parameters are to be substituted into

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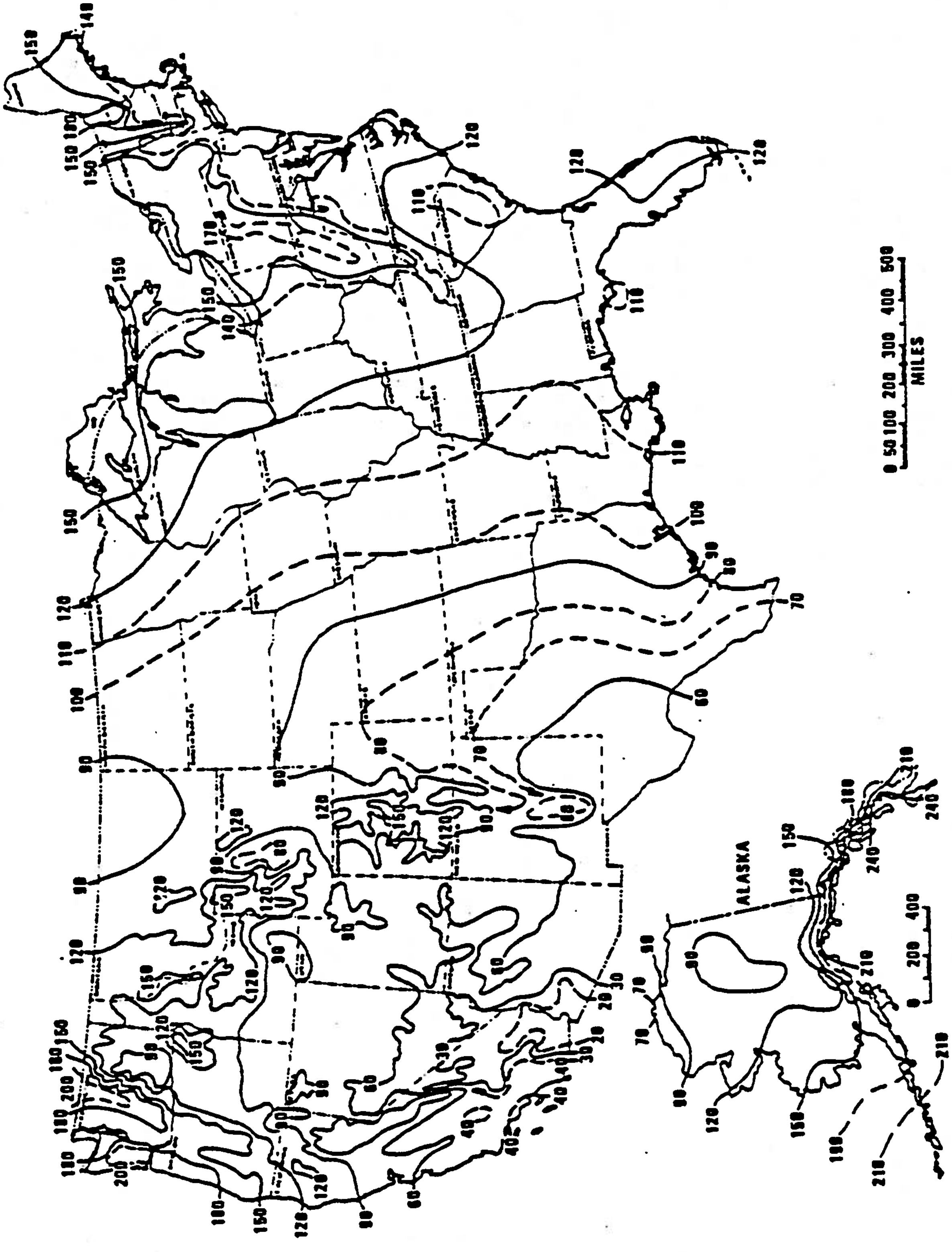

Figure 11.2.1-1. Mean number of days with 0.01 inch or more of precipitation in United States.[10]

the equation. Worst case emissions, corresponding to dry road conditions, may be calculated by setting p = 0 in the equation (which is equivalent to dropping the last term from the equation). A separate set of nonclimatic correction parameters and a higher than normal VDT value may also be justified for the worst case averaging period (usually 24 hours). Similarly, to calculate emissions for a 91 day season of the year using Equation 1, replace the term (365-p)/365 with the term (91-p)/91, and set p equal to the number of wet days in the 91 day period. Also, use appropriate seasonal values for the nonclimatic correction parameters and for VDT.

11.2.1.3 Control Methods

Common control techniques for unpaved roads are paving, surface treating with penetration chemicals, working into the roadbed of chemical stabilization chemicals, watering, and traffic control regulations. Chemical stabilizers work either by binding the surface material or by enhancing moisture retention. Paving, as a control technique, is often not economically practical. Surface chemical treatment and watering can be accomplished with moderate to low costs, but frequent retreatments are required. Traffic controls, such as speed limits and traffic volume restrictions, provide moderate emission reductions but may be difficult to enforce. The control efficiency obtained by speed reduction can be calculated using the predictive emission factor equation given above.

The control efficiencies achievable by paving can be estimated by comparing emission factors for unpaved and paved road conditions, relative to airborne particle size range of interest. The predictive emission factor equation for paved roads, given in Section 11.2.6, requires estimation of the silt loading on the traveled portion of the paved surface, which in turn depends on whether the pavement is periodically cleaned. Unless curbing is to be installed, the effects of vehicle excursion onto shoulders (berms) also must be taken into account in estimating control efficiency.

The control efficiencies afforded by the periodic use of road stabilization chemicals are much more difficult to estimate. The application parameters which determine control efficiency include dilution ratio, application intensity (mass of diluted chemical per road area) and application frequency. Between applications, the control efficiency is usually found to decay at a rate which is proportional to the traffic count. Therefore, for a specific chemical application program, the average efficiency is inversely proportional to the average daily traffic count. Other factors that affect the performance of chemical stabilizers include vehicle characteristics (e. g., average weight) and road characteristics (e. g., bearing strength).

Water acts as a road dust suppressant by forming cohesive moisture films among the discrete grains of road surface material. The average moisture level in the road surface material depends on the moisture added by watering and natural precipitation and on the moisture removed by evaporation. The natural evaporative forces, which vary with geographic location, are enhanced by the movement of traffic over the road surface. Watering, because of the frequency of treatments required, is generally not feasible for public roads and is used effectively only where water and watering equipment are available and where roads are confined to a single site, such as a construction location.

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December 1984

Technology Transfer

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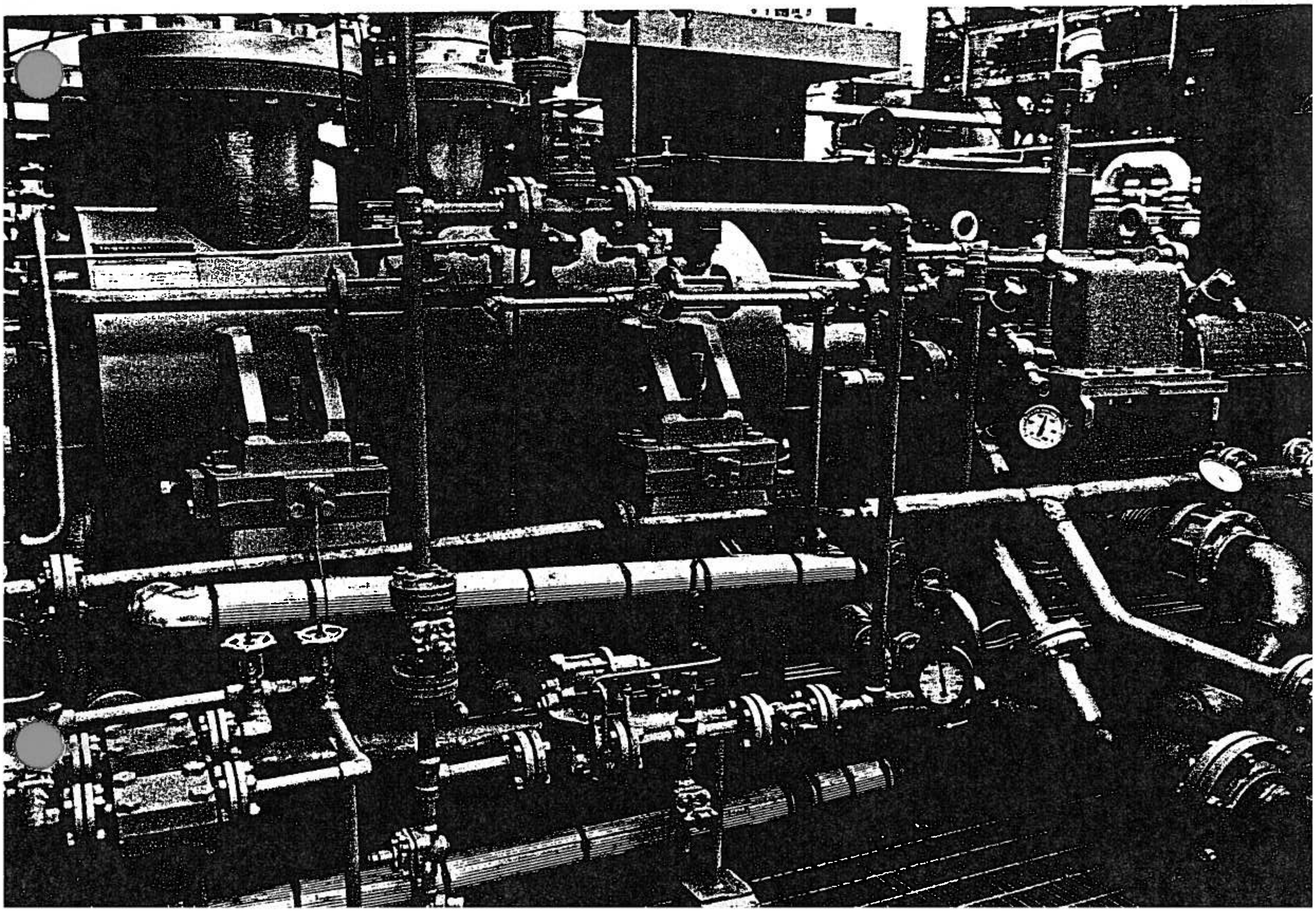
Fugitive VOC Emissions in the Synthetic Organic Chemicals Manufacturing Industry



ALAN PEDIGO

Environmental Regulations and Technology

Fugitive VOC Emissions in the Synthetic Organic Chemicals Manufacturing Industry

December 1984

This report was prepared jointly by
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Office of Air and Radiation
Research Triangle Park, NC 27711
and
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Office of Research and Development
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This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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1. Overview

Section 111 of the Clean Air Act, as amended in 1977, directed the U.S. Environmental Protection Agency (EPA) to set standards of performance for any newly constructed, modified, or reconstructed sources of air pollution which may endanger public health or welfare. These New Source Performance Standards (NSPS) were to be promulgated for each of the dozens of industries recognized as being significant contributors to air pollution. To direct standards-setting activities in an orderly fashion, industries were prioritized according to: (1) total emissions from the source industry, (2) the extent to which each pollutant endangers public health or welfare, and (3) the mobility and competitive nature of each source industry.

This ranking process resulted in a Priority List of industries (categories) for which EPA was mandated to promulgate standards within a given time. After the list and its supporting materials were reviewed, the final Priority List was promulgated on August 12, 1979. The Synthetic Organic Chemicals Manufacturing Industry (SOCMI) was first on the list as the single most significant contributor to air pollution.

In this same period, an extensive assessment of emissions from petroleum refineries showed that fugitive emissions of volatile organic compounds (VOC) were a major contributor of VOC emissions to the atmosphere. Used in this context, *fugitive emissions* refer to leaks of VOC from equipment such as valves, pumps, compressors, pressure relief devices, and connectors.

Using the results of the refinery assessment and information gathered in an EPA research study of SOCMI, standards of performance for fugitive emissions of VOC in SOCMI were developed and proposed by EPA in January 1981. Coincident with the development of the proposed standards, EPA's research group conducted additional studies of fugitive emissions from chemical plants to validate the transfer of technical information from the refining industry. Twenty-four separate chemical process units were evaluated, six of which were investigated more closely to examine the effectiveness of emission control techniques and programs. From these and previous studies, sufficient information was gathered to permit development of emission factors for types of equipment in SOCMI, as well as procedures for estimating the effectiveness of emission reduction techniques.

These new findings were compiled into an Additional Information Document (AID) on fugitive emissions of VOC in SOCMI. In addition to the new findings, the AID presented a comprehensive review of the fugitive emissions studies completed to date. More importantly, the AID set forth EPA's conclusions about fugitive emissions in SOCMI, including:

- How to estimate emissions
- What emission reductions are achievable
- The costs of controlling emissions.

Thus, the AID established the technical framework on which EPA based its final standards for equipment leaks in SOCMI. The final standards were promulgated on October 18, 1983.

The standards, summarized in Table 1, apply only to facilities constructed or modified after January 5, 1981 which produce (as a product, coproduct, or intermediate) one or more of the 378 organic chemicals listed inside the back cover of this publication. The standards also apply only to specific pieces of equipment which contain 10 percent or more VOC.

The standards require a leak detection and repair program to reduce VOC emissions from valves. They require the use of certain equipment to reduce VOC emissions from pumps, compressors, process sampling connections, and open-ended lines. In addition, records must be maintained and semiannual reports must be submitted to EPA by the owners and operators of facilities subject to these standards.

This Environmental Regulations and Technology publication is intended as an introduction to these SOCMI fugitive VOC emissions standards. It is not intended as a detailed discussion of them. This publication also does not cover other standards with which owners or operators of organic chemical units may have to comply such as those for distillation unit operations, benzene equipment leaks, volatile organic liquid storage vessels, air oxidation unit processes, and vinyl chloride.

The standards for fugitive VOC emissions in SOCMI can be found in the notice of the final regulation in the Federal Register of October 18, 1983; they will eventually appear in updated copies of Title 40, Part 60 of the Code of Federal Regulations (40 CFR 60). Title 40, Part 60 also contains general requirements for all new source standards. Details on how to obtain these and other documents relating to this standard are provided below under "Sources of Information." The numbers appearing in brackets throughout this text refer to specific sections in 40 CFR 60.

Table 1.

New Source Performance Standards for Synthetic Organic Chemicals Manufacturing Industry — Fugitive VOC Emission Requirements

- Requires monthly leak detection and repair of valves
- Requires monthly leak detection and repair of pumps
- Requires control equipment for compressors
- Requires no detectable emissions from safety relief devices
- Requires caps, plugs, blinds, or second valves on open-ended lines
- Requires repairs of pipe connections
- Requires closed-purge or closed-vent systems for sampling connections
- Requires control devices on vented systems
- Requires recordkeeping and semiannual reporting

2. Applicability of the Standards

Any chemical plant producing one or more of the SOCMI chemicals may be subject to the standards for fugitive VOC emissions in SOCMI. Before discussing the applicability of these standards to a plant, a few definitions are in order:

An *affected facility* is defined, for the purposes of this standard, as the group of all equipment within a process unit. The owner or operator of any affected facility on which construction or modification is begun after January 5, 1981 must be able to demonstrate that the requirements of fugitive VOC emissions standards have been met within 180 days after initial startup.

Equipment refers to sources of fugitive VOC emissions including pumps, compressors, valves, pressure relief devices, sampling connection systems, and open-ended lines or flanges.

A *process unit* consists of the components assembled to produce one or more SOCMI chemicals as an intermediate chemical or a final product. The production of the chemicals may entail separation or purification techniques; it is not merely limited to the production of chemicals through reaction processes. As such, what is generally accepted as a "chemical plant" may actually consist of several process units under this definition. There are, of course, several qualifications and exemptions to this statement. These are the subject of the remainder of this section.

Intermediate Products, Co-Products, and By-Products

The production of intermediate chemicals and co-products as well as final products are covered by the standards. Intermediate chemicals are produced from raw materials; their production, however, is typically for captive use in the production of the desired final product. If there is sufficient storage for raw materials and for the intermediate chemical, the equipment used to produce the intermediate chemical would constitute a process unit. Ketene is an example of an intermediate chemical produced for captive use; it is an acetylating agent used to produce a variety of products. Co-products are produced together and both could be recovered for subsequent use. Again, they are covered if there is sufficient storage for the raw materials and for the co-products. Phenol and acetone produced from the cleavage of cumene hydroperoxide are examples of co-products subject to the standards.

By-products occur as a consequence of producing other chemicals and are not necessarily of subsequent purpose or use; they may be found as trace contaminants in the final product of a chemical production unit. Production of a SOCMI chemical as a by-product would only bring a process unit under the standard if the unit produces it for subsequent use.

Equipment "In VOC Service"

Because the standards are intended to reduce fugitive emissions from significant sources of VOC, only those sources "in VOC service" in an affected facility must comply with the standards. Equipment is in VOC service if the fluid it contains comprises 10 percent or more VOC by weight. All organic compounds are regulated as VOC with the following exceptions:

- Methylene chloride, 1,1,1-trichloroethane, trichlorofluoromethane, dichlorodifluoromethane, and chlorodifluoromethane are not regulated as VOC but their manufacture is covered by the standards because their manufacture involves the use or production of VOC.
- Methane, ethane, trifluoromethane, trichlorotrifluoromethane, dichlorotetrafluoroethane, and chloropentafluoroethane are not regulated as VOC and their manufacture is not covered by the standards.

If there is a question about whether equipment is considered to be in VOC service, ASTM Methods E-260, E-168, and E-169 may be used to determine the VOC content of the process fluid contained in the equipment. The standards also allow the owner or operator to elect to use engineering judgment in making this determination. However, the ASTM methods will always be used if there is any disagreement between EPA (or the state or local agency) and the owner or operator of an affected facility.

When equipment has been judged not to be in VOC service, the data and the information developed by the owner or operator supporting this determination must be recorded [60.486(i) (3) and (j)].

Exemptions

In a further effort to exclude from coverage those pieces of equipment with little potential for significant VOC emissions, specific subcategories of VOC service were identified by EPA. This classification scheme is shown in Table 2.

Using these classifications, two exemptions from the standards are allowed. A facility is exempt from the SOCMI fugitive emissions standard if it:

- Is designed to process light liquids and gaseous VOC at less than 1,000 Mg/yr [60.480(d) (2)]
- Produces only heavy liquids [60.480(d) (3)].

In addition, a facility is exempt from the SOCMI standards if it:

- Has no equipment in VOC service [60.480(d) (5)]
- Produces only beverage alcohol [60.480(d) (4)].

Table 2.

Classification of VOC Services

VOC Service	
Gas/Vapor	Gaseous state at operating conditions
Light Liquid	Liquid state at operating conditions Vapor pressure of at least one component is greater than 0.3 kPa at 20°C Concentration of all components (with vapor pressure above 0.3 kPa) is not less than 20 percent
Heavy Liquid	Not gas/vapor or light liquid service

The last exemption applies only to fermentation alcohol process units making products for human consumption. Process units within beverage alcohol manufacturing operations are covered by the standards if they process non-beverage alcohol products.

To qualify for any of these exemptions, the owner or operator must maintain proper records [60.486(i)]. These records basically consist of the information, data, and analyses necessary to demonstrate (1) processing rate, or (2) composition and nature of raw materials, intermediates, and products.

Modification and Reconstruction

Modification and reconstruction provisions pertain to facilities whose construction was begun before January 5, 1981. As a result, older process units may be subject to these standards.

Modification is defined as any physical or operational change (with a few exceptions) to an existing facility that results in an increase in emissions from that facility [60.14]. The key point for invoking the modification provisions is that there must be an overall increase in emissions. Therefore, if an increase in VOC emissions resulting from changing or adding equipment (i.e., valves or pumps) is offset by a reduction in VOC emissions from other equipment within the same process unit, the owner or operator may avoid being covered by the NSPS standard under the modification provisions.

Estimates of fugitive emissions from a process unit may be made by using the techniques described in the Background Information Document for Promulgated Standards and in the Additional Information Document for Fugitive Emissions in Organic Compounds (see "Sources of Information"). For each equipment type, the number of pieces of equipment before changes were made is multiplied by an emission factor and 8760 hours/year to estimate emissions on an annual basis. The total fugitive emissions for a process unit is simply the sum of the annual emissions for each equipment type. The same is done for the number of pieces of equipment after changes are made. The difference is the increase or decrease in uncontrolled emissions resulting from changes to the existing facility. Estimates of controlled emissions can be made by applying control efficiency estimates to the uncontrolled emissions estimates for each type of equipment. Emissions estimates made in this manner allow evaluation of emissions increases for a determination of modification. Table 3 includes emission factors and estimated control efficiencies for equipment operating in compliance with the standards.

Table 3.

Emission and Control Efficiency Factors Used in Estimating VOC Emissions for a Process Unit

Equipment Type (Service)	Emission Factor (kg/hr)	Estimated Control Efficiency
Valves (Gas/Vapor)	0.0056	0.73
Valves (Light Liquid)	0.0071	0.58
Pumps (Light Liquid)	0.0494	0.61*
Compressors	0.2280	1.00
Pressure Relief Valves (Gas/Vapor)	0.1040	1.00
Sampling Connections	0.0150	1.00
Open-Ended Lines	0.0017	1.00

*Average estimated control efficiency for pumps complying with leak detection and repair program.

SOURCE: Fugitive Emission Sources of Organic Compounds — Additional Information on Emissions, Emission Reductions, and Costs. U.S. Environmental Protection Agency. 1982.

The three changes (physical or operational) that are considered exceptions under the modification provisions are:

- Changes such as routine maintenance, repair, and replacement
- An increase in the number of hours of operation
- An increase in production rate that is effected without a capital expenditure. NOTE: Capital expenditure is defined in the General Provisions [60.2] and in the standards [60.481].

A specific clarification was added to the SOCMI standards on this last point. The addition or replacement of equipment such as valves or pumps for the purpose of process improvement does not of itself constitute a modification. More simply stated, this modification provision is not triggered merely because equipment components have been added or replaced to keep the process operating efficiently.

Reconstruction is determined solely on the basis of capital costs expended on an affected facility. A facility is reconstructed if the fixed capital cost of the components replaced in the existing facility exceeds 50 percent of the fixed capital cost of constructing an entirely new facility. The key concept here is "affected facility." Since the affected facility consists solely of fugitive emission sources, other process sources and equipment are not included in the cost analysis. Reconstruction determinations are generally evaluated on a case-by-case basis [60.15].

3. Fugitive Emission Sources

The term *fugitive emissions* in this context means the loss of VOC through sealing mechanisms separating process fluid from the atmosphere. Fugitive emissions are also referred to as equipment leaks and come from the hundreds or thousands of valves, pumps, compressors, pressure relief devices, open-ended valves or lines, sampling connection systems, and flanges and other connectors within a processing plant. As shown in Figure 1, they comprise a large percentage of total VOC emissions in the industry (about 35 percent) even though the emissions on a "per component" basis may be small.

The techniques used to control fugitive VOC emissions are quite different from those used to control process emissions, due in large part to the fact that process emissions are generally vented from a definable point or stack, while fugitive emission sources are more diffuse. Combustion control techniques are generally used in controlling process emissions. No single control technique is applicable to the control of all types of fugitive emissions, nor is a single emission limit universally applicable. Each type of fugitive emission source must be considered separately in establishing appropriate, applicable control techniques. The following discussion describes each of these sources with respect to the origin and control of potential emissions.

Valves

Valves, among the more common elements in the chemical plant, are available in numerous designs for widely varying applications: gate, globe, control, plug, ball, check, diaphragm, and relief. Most of these designs (check and relief valves excepted) have a valve stem which operates to restrict or to open the valve for fluid flow. Typically the stem is sealed by a packing gland or O-ring to prevent the leakage of process fluids to the atmosphere. Packing glands are most commonly used and a wide variety of packing materials are available to suit most operational requirements of temperature, pressure, and compatibility.

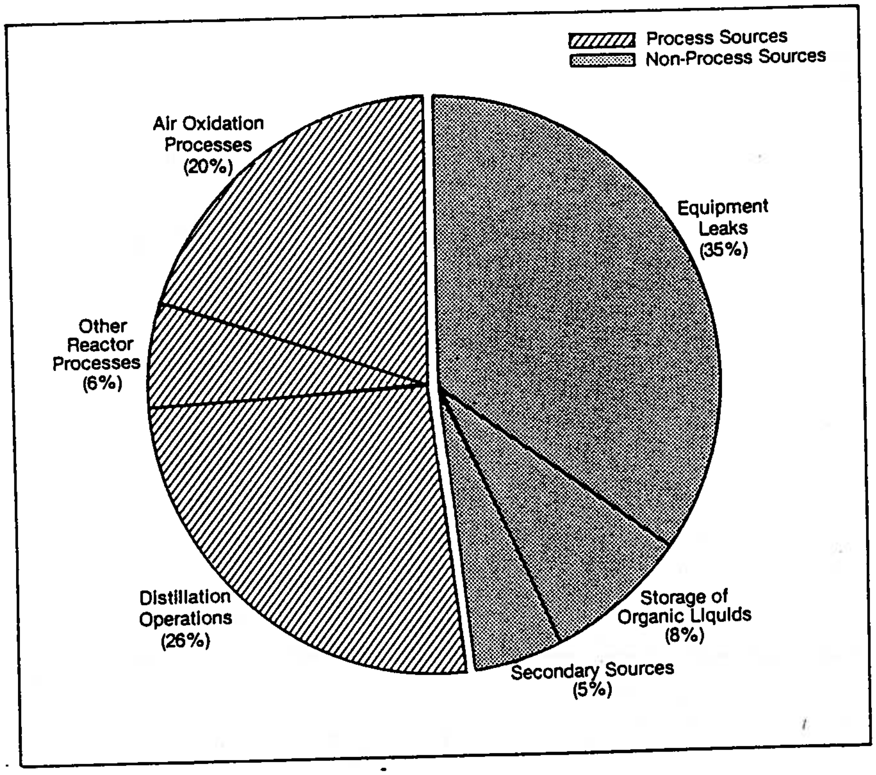


Figure 1. Contribution of Source Subcategories to Total SOCMI VOC Emissions

O-rings are much less common because of design and materials limitations. With time and prolonged use, both the packing gland and O-ring fail, resulting in VOC emissions.

Repair techniques range from simple on-line maintenance to complex techniques. Basic repairs that can be performed on a valve while it remains in place and in service include tightening or replacing bonnet bolts, and tightening packing gland nuts. These valve components are illustrated in Figure 2.

However, on-line repair techniques are not always applicable or effective in reducing emissions. For example, operational or safety requirements may preclude the repair of valves by simple means. Other valves simply cannot be repaired effectively on-line or easily removed from service. In some instances, repair of valves can be effected through more sophisticated repair techniques. Though relatively expensive, sealant injection has been proven effective in petroleum refining applications in California, where complete elimination of VOC leaks has been mandated. In cases where maintenance or repair of valves is not possible, valve replacement may be required.

Valve designs that have little or no potential for leaking of process fluids are referred to as "leakless" or "sealless." Two examples are bellows sealed valves and diaphragm valves. Bellows seals are the most effective gland seal mechanism for valves and have been used primarily in the nuclear power industry, where their relatively high cost can be justified by stringent safety requirements. A typical design of a bellows seal is shown in Figure 3.

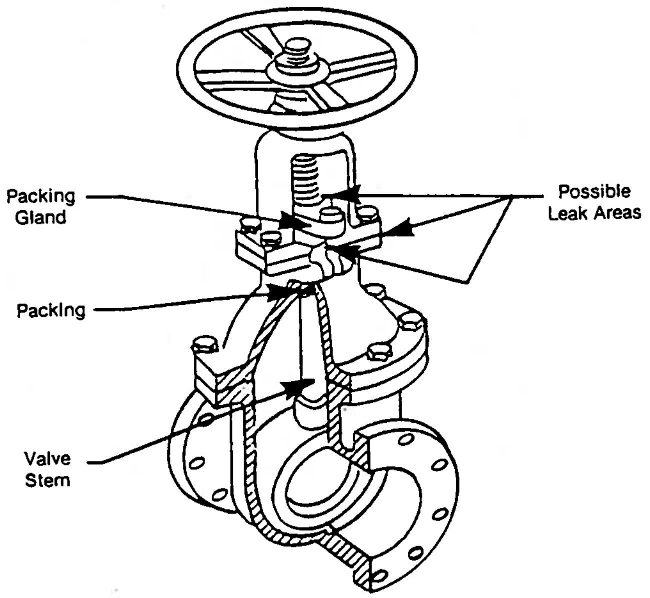


Figure 2. Primary Valve Maintenance Points

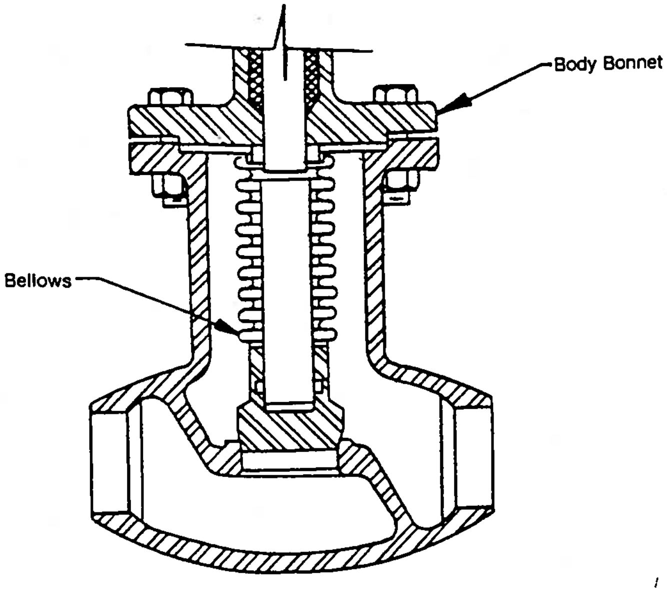


Figure 3. Typical Design of a Bellows Seal

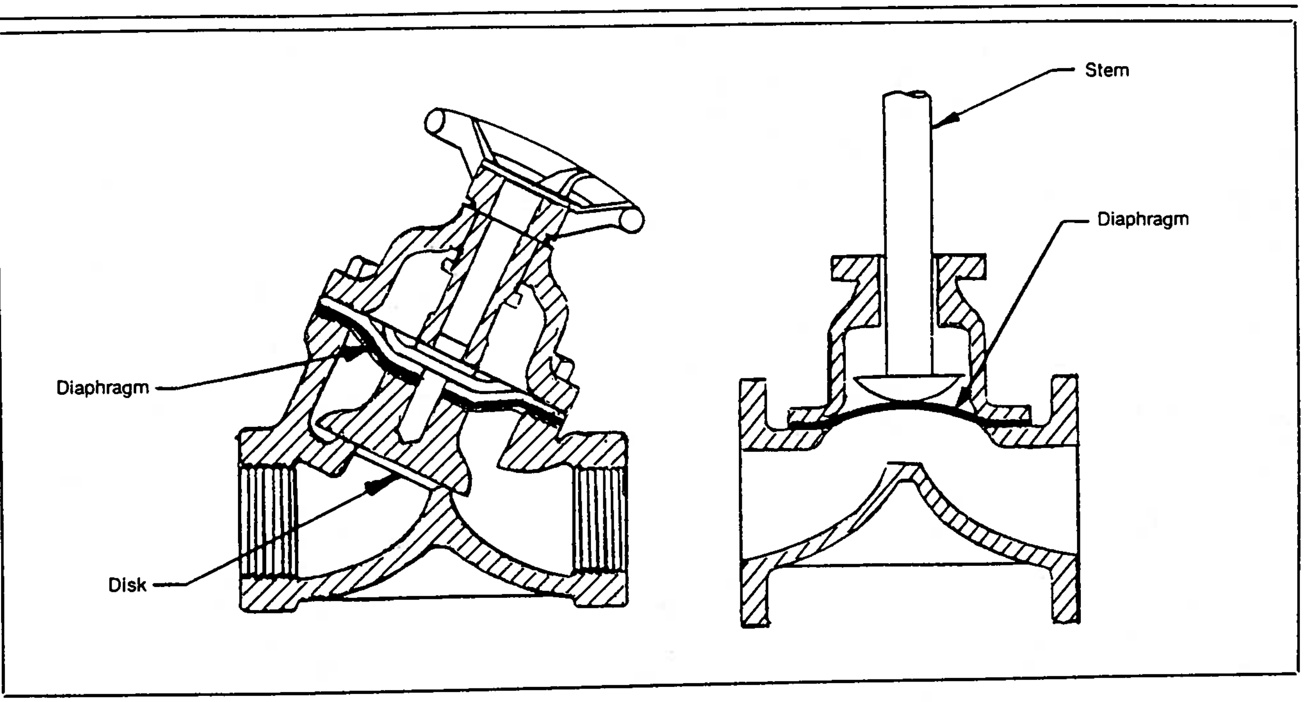


Figure 4. Typical Designs of Diaphragm Valves

Diaphragm valves use a diaphragm of some appropriate material to seal the process fluid from the stem of the valve. In some designs, the diaphragm acts as the flow control element as well as the sealing mechanism. Diaphragm valves, however, may be a source of fugitive emissions if the diaphragm fails. Two typical designs of diaphragm valves are shown in Figure 4.

Pumps

Pumps are integral pieces of equipment in most chemical processes, providing the motive force for transporting liquids throughout a plant. The centrifugal pump is the chief design used in SOCMI, but other pump types are also used. Packed seals and mechanical seals are commonly used to prevent leakage of process fluid to the atmosphere where the moving pump shaft meets the stationary casing.

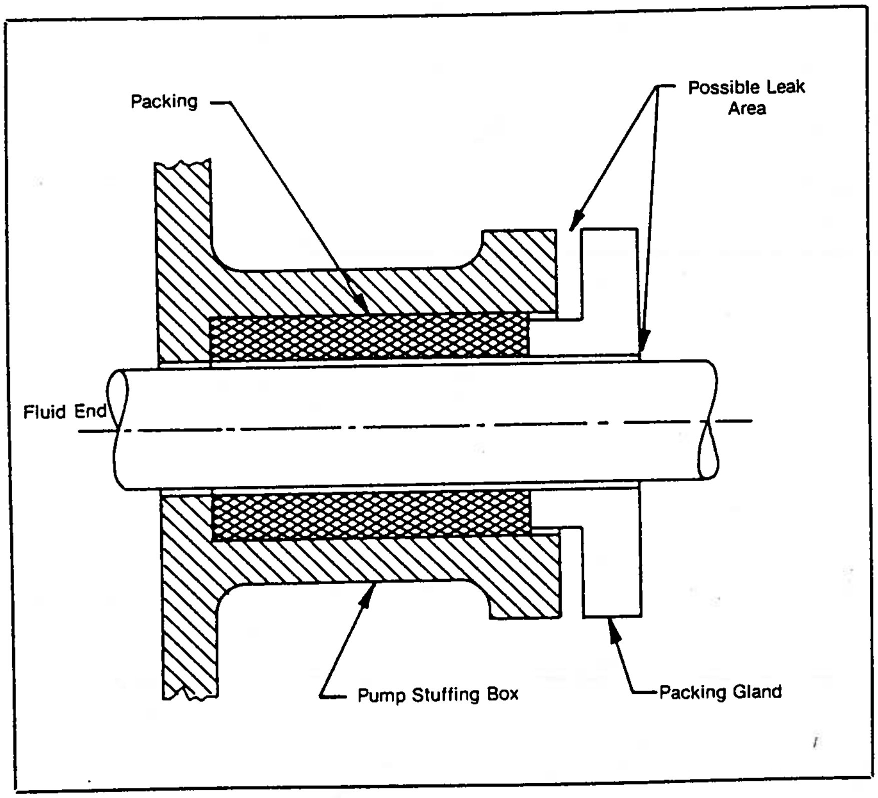


Figure 5. Typical Design of a Packed Seal

Packed seals are used on pumps with either reciprocating or rotating shafts. Specially selected packing materials (chosen on the basis of the process materials and environment) are compressed into a "stuffing box" in the pump casing and retained by a packing gland, resulting in a tight seal around the shaft. Figure 5 shows an example of a packed seal. Lubrication must be applied to prevent excessive heat generation from friction between the moving shaft and the stationary packing.

Pumps with packed seals have a greater leak potential than do pumps with more sophisticated sealing mechanisms. Leaks from packed seals typically result from the degradation of the packing. These leaks can often be reduced by tightening the packing gland. But at some point, the packing will have deteriorated so much that it must be replaced. In most cases, pump packing can be replaced only when the pump is out of service.

Mechanical seals are used to seal pumps with rotating shafts only. A variety of designs are in common use; all have a lapped seal face between a stationary element and a rotating seal ring. The leakage of process fluid from the seal is minimized by maintaining close tolerances on the interface between the shaft and the sealing mechanism. Figure 6 shows the basic design of a single mechanical seal.

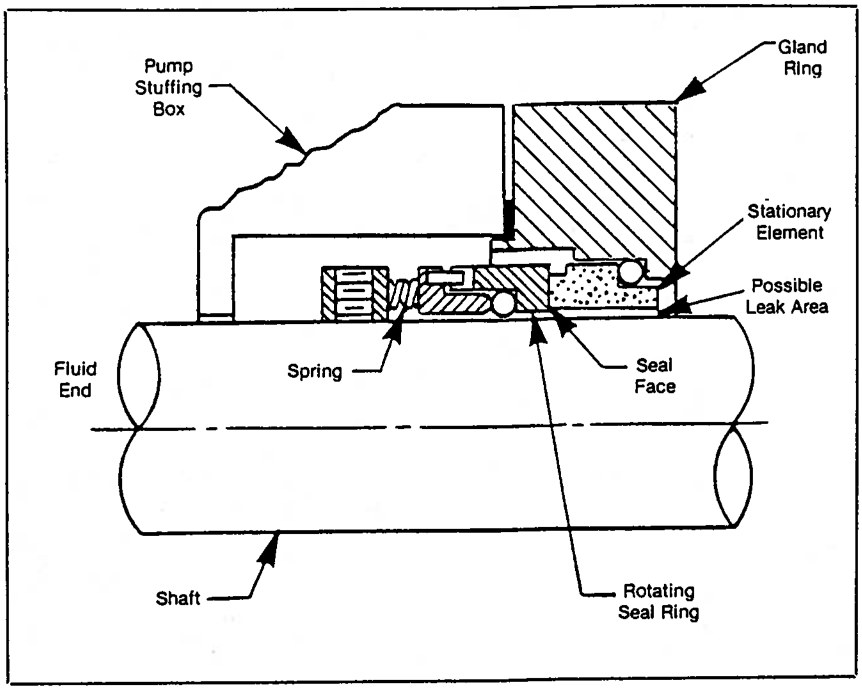
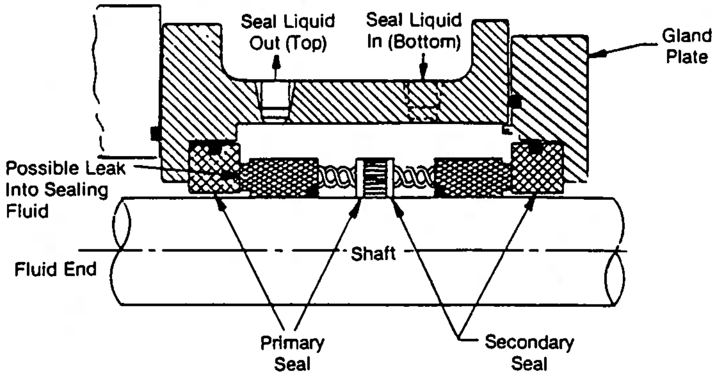


Figure 6. Basic Design of a Single Mechanical Pump Seal

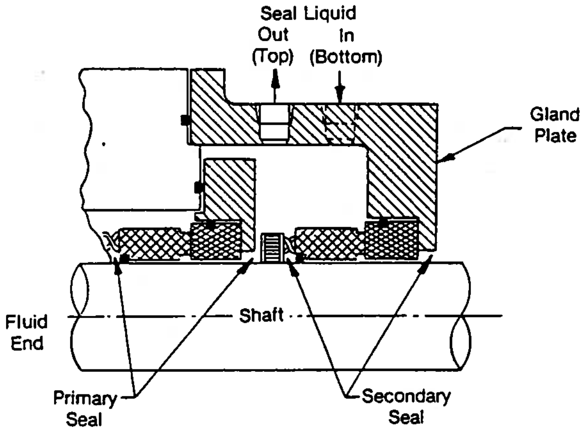
Since a mechanical seal also may leak occasionally, redundant sealing mechanisms can be used. For instance, a single mechanical seal may also have a packed seal as an auxiliary sealing mechanism to reduce fugitive emissions. The same purpose might also be accomplished with a dual mechanical seal arrangement, either back-to-back or tandem, as shown in Figure 7. In the back-to-back arrangement, a barrier fluid (also referred to as a seal or buffer liquid) circulates between the two seals. The barrier fluid pressure is maintained above the pump operating pressure. As a result, leakage is normally of the barrier fluid across the primary seal into the process fluid and across the secondary seal to the atmosphere. The tandem arrangement basically has a single seal backed up by another single seal; both seals face the same direction. The barrier fluid is circulated through the space between the seals.

In general, mechanical seals have the advantage of low leak potential. However, their repair can be both costly and time consuming. To repair a leak from a pump equipped with a mechanical seal, the pump must be taken off-line and dismantled. In addition, care must be taken to minimize emissions when dismantling the pump.

In addition to these pump types and seal designs, there are several "sealless" technologies available. Three



Back-to-Back Arrangement



Tandem Arrangement

Figure 7. Typical Arrangements of Dual Mechanical Pump Seals

designs have been applied in SOCMI where leakage cannot be tolerated. The canned-motor pump is a shaftless design in which the pump bearings run in the process fluid. The motor rotor housing and pump casing are interconnected. Diaphragm pumps use a flexible diaphragm as the driver for moving the fluid; as a result, seals and packing are not exposed to the process fluid. Magnetic-drive pumps also have no seals in contact with the process fluid; the impeller in the pump casing is driven by an externally mounted magnet coupled to the motor.

Compressors

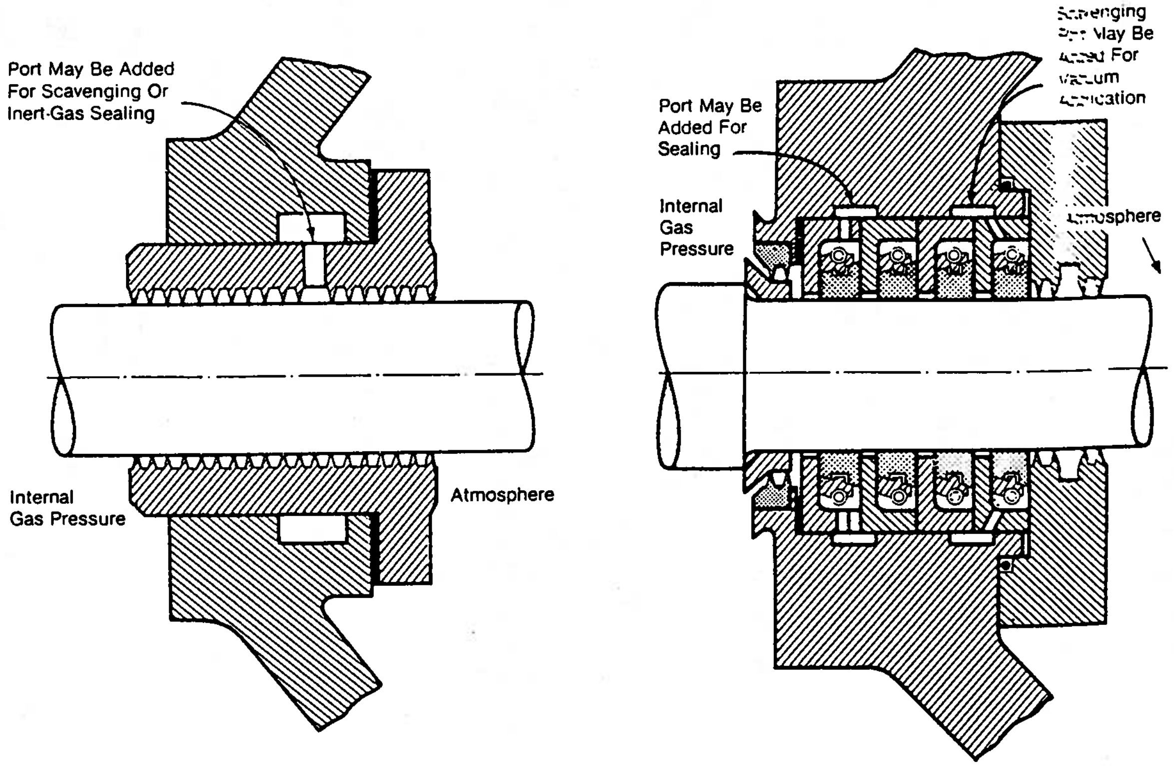
Compressors transport gases throughout a process unit in much the same manner that pumps transport liquids. They are driven by rotating or reciprocating shafts. Thus, the sealing mechanisms for compressors are similar to those for pumps, i.e., packed and mechanical seals. Again, it is the sealing mechanism that is the greatest potential source of fugitive VOC emissions. Packed seals are generally restricted to reciprocating compressors where mechanical seal designs cannot be used. Leakage from packed seals may be reduced by tightening the packing gland. On some reciprocating compressors (particularly newer compressors), the distance piece, which is the housing connecting the compressor cylinder and the drive crankcase, can be vented to a control device to treat any leakage through the packing. On older models, however, this practice may not be possible without recasting the distance piece to accommodate the vent line.

The mechanical seals used on compressors reduce but do not eliminate leakage of the process fluid. The types of seals commonly used on compressors include:

- Labyrinth, comprising interlocking teeth to restrict flow
- Restrictive ring, comprising multiple stationary carbon rings
- Mechanical contact, similar to the mechanical seal for pumps
- Liquid film, employing an oil film between the rotating shaft and stationary gland.

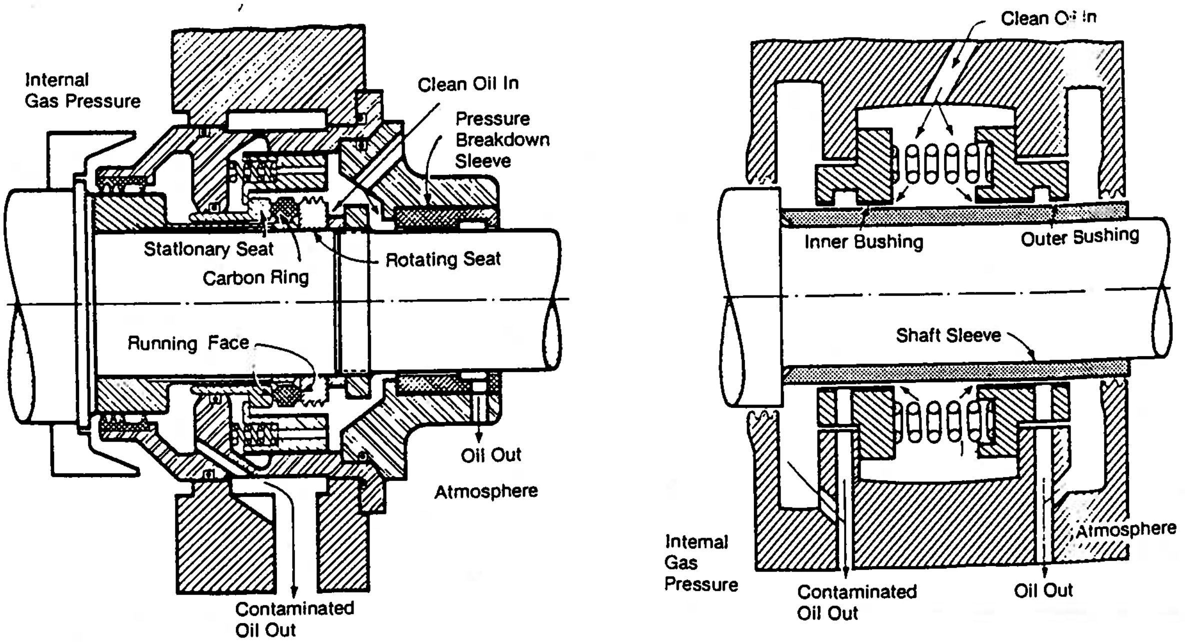
These mechanical seals, as shown in Figure 8, can be vented in various ways to a control device for the elimination of VOC which may leak from the process.

The repair of mechanical seals requires removing the compressor from operation. Since compressors in SOCMI do not typically have spares, immediate repair may not be practical or possible without a process unit shutdown. Optional control techniques for controlling emissions from these mechanical seals are available, such as venting the barrier fluid system or the seal to a control device.



Labyrinth Seal

Restrictive Ring Seal



Single Mechanical Seal

Liquid Film Seal

Figure 8. Typical Designs of Mechanical Compressor Seals

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Pressure Relief Devices

Pressure relief devices are safety devices commonly used throughout SOCMI to prevent operating pressures from exceeding the maximum allowable working pressures of the process equipment. The most common pressure relief device is a spring-loaded pressure relief valve (PRV), such as that shown in Figure 9. The PRV is designed to open when the operating pressure exceeds a set pressure, and to reseat after the operating pressure has decreased to below the set pressure.

Leaks of VOC from pressure relief devices occur through the valve seat as a result of the improper reseating of the valve after a release, and of the process being operated at or near the valve set pressure. In addition, leakage is possible from seating element degradation over a period of time. Leakage as a result of improper reseating is often referred to as "simmering" or "popping." Reseating problems can be resolved by soft-seat technology, which consists of an elastomeric O-ring to provide an improved seal when the valve reseats after an overpressure release.

Rupture disks (RD) are pressure relief devices that allow no fugitive emissions unless the disk is ruptured. Excessive pressure causes the disk to burst. Rupture disks can be used in conjunction with PRVs to eliminate potential fugitive emissions from the PRVs. When mounted upstream of a relief valve, fugitive emissions are blocked prior to the potential leak source, the valve seat.

Fugitive emissions from PRVs can also be eliminated by routing the discharge of the PRV to an appropriate control device. The most common example of this procedure is a flare header.

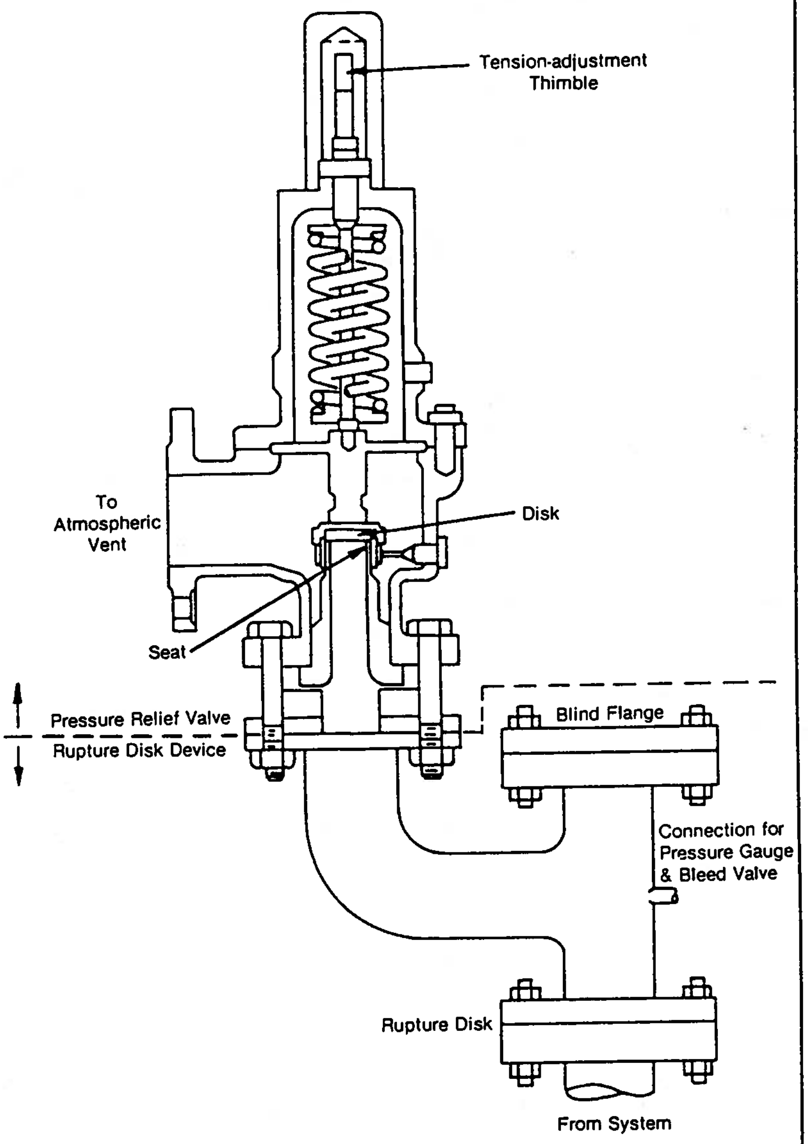

Figure 9. Typical Design of a Pressure Relief Valve Mounted on a Rupture Disk Device

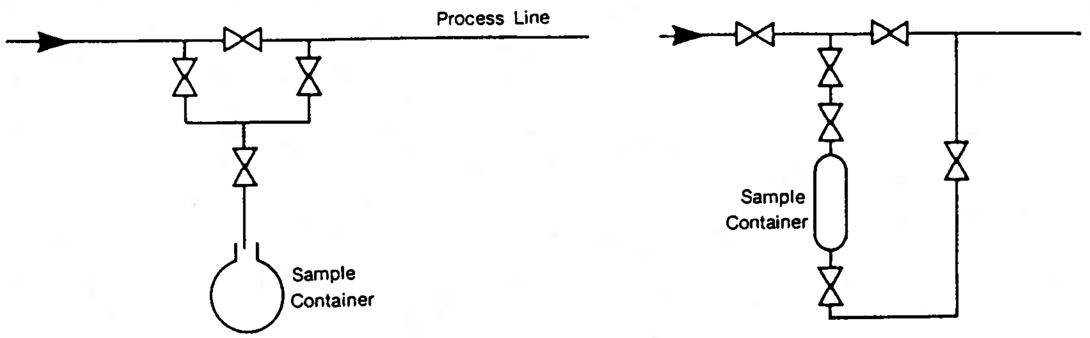

Figure 10. Examples of Closed Purge Sampling Systems

Open-Ended Valves and Lines

Open-ended valves and lines are found throughout chemical plants to drain, purge, or vent a process fluid to the atmosphere, a container, or to a closed system for recovery. Process fluids may be emitted directly to the atmosphere through incompletely closed or faulty valve seats. To prevent such atmospheric emissions, a pipe plug, cap, or blind flange can be installed on the open end of the valve or its drain pipe. Another option is using a second valve in a "block-and-bleed" arrangement. In these cases it is best to close the valve upstream first so that no process fluid will be trapped between the two valves, as this may cause leakage of VOC as a result of temperature expansion.

Sampling Connection Systems

Periodic checks of process operations are often made by sampling process streams to evaluate the performance of reactors, distillation units and other operations, and to verify the purity and composition of feedstocks, intermediates, and products. Process fluids already in the sample lines must be purged prior to sampling in order to obtain a representative sample for analysis. The purged fluid is often merely drained onto the ground or into the sewer drains, releasing VOC into the atmosphere.

Sampling emissions can be reduced by using a closed purge sampling system which returns the purged VOC back to the process, or by routing the purged VOC to a control device. Two examples of closed purge sampling systems are shown schematically in Figure 10. In one case, the sample is collected as a side-cut stream from the purge stream, which flows around a flow-restricting device (such as an orifice or valve) in the main proess line. In the second example, the purge is directed through the sample container. Closed purge sampling may also be done with partially evacuated sample containers.

Flanges and Other Connectors

In terms of total numbers, flanges and other connectors comprise the single largest class of fugitive emission sources in a process unit. Flanges are gasket-sealed junctions used to mate pipe and other equipment such as valves, vessels, and pumps. Flanges may be used in pipe 50 mm (0.2 inches) or greater in diameter. Other connectors, such as

Table 4.

Emission Factors for Fugitive Emission Sources

Equipment Type	Process Fluid	Emission Factor (kg/hr)	lb/hr	Percent of Total VOC Fugitive Emissions
Valve	Gas/Vapor	0.0056		47
	Light Liquid	0.0071	0.0157	
	Heavy Liquid	0.00023	0.000507	
Pump	Light Liquid	0.0494	0.1089	16
	Heavy Liquid	0.0214	0.0472	
Compressor	—	0.228	0.5027	4
Pressure Relief Valve	Gas/Vapor	0.1040	0.2293	9
Sampling Connection	—	0.0150	0.0331	3
Open-ended Line	—	0.0017	0.00374	6
Flange	—	0.00083	0.00183	15
				100

SOURCE: Fugitive Emission Sources of Organic Compounds — Additional Information on Emissions, Emission Reductions, and Costs.

threaded connections and nut-and-ferrule connections, are used on smaller lines and perform the same function as flanges.

Flanges and other connectors may leak VOC as a result of improperly selected gaskets, poorly assembled flanges, poorly assembled nut-and-ferrule combinations, or poorly assembled pipe connections. However, the major cause of VOC leakage from flanges and other connectors is the deformation of sealing surfaces as a result of thermal stress. In some cases, merely tightening the bolts on a flange is effective in sealing a VOC leak. Generally, however, correction of a leaking connector by, for example, replacing a flange gasket requires partial or complete shutdown of the process unit.

Comparing Emissions from Different Types of Fugitive Emission Sources

There are two ways to compare emissions associated with the fugitive emission sources described above. First, the emissions from each type of fugitive source (or component) can be considered. Individual emission factors for components are shown in Table 4. This Table indicates that compressor seals and pressure relief devices are the most significant VOC emitters, and that flanges are the least significant VOC emitters on a "per component" basis.

However valves, which have one of the smaller emission factors, are responsible for 47 percent of total VOC emissions because of their relative abundance. Compressors, which have a larger emission factor, represent only a small portion of the total emissions for the unit.

4. Standard Provisions

Each type of equipment is covered by specific provisions in the standards. For some types of equipment such as open-ended lines, the choice of controls is limited by the standards to a single technique. For other sources, several control options are allowed, providing that the desired emissions reduction is achieved. For sources such as valves, a basic standard has been written, but several options are allowed as long as each achieves an equivalent level of control. Finally, since new emissions reduction techniques may yet be developed, the standards are structured to permit the use of equivalent means of emissions reduction not already in the standards. The source-specific requirements will be discussed below. There are, however, a number of provisions and concepts which apply to all or several equipment types, or to the process unit as a whole. They include:

- Delay of repair provisions
- Provisions for "leakless" equipment
- Provisions for closed vent systems
- Equivalency determination provisions
- Provisions for equipment in vacuum service
- Reporting.

Delay of Repair Provisions

Each of the standards for the individual equipment types specify a schedule for repairing the equipment once a "leak" is detected. Precisely what constitutes a "leak" varies from one equipment type to another. However, the schedule for repair typically requires that an attempt be made to repair the leak within five days of detection, and that repairs be successfully completed within 15 days of detection.

This compliance schedule is not unreasonable providing the repairs can be effected without requiring that the entire process unit be shut down. This is often possible, but some fugitive emission sources may not be repairable by on-line repair techniques. Under certain conditions, specific provisions of the standards permit a repair delay [60.482-9].

In general, a repair delay is allowed for any piece of equipment if it is technically infeasible to accomplish the repair without a process unit shutdown. Repair delay is also allowed for equipment which can be isolated from the process and removed from VOC service. Where a repair is delayed due to "technical infeasibility," the repair must be made before the end of the next process unit shutdown.

These delay of repair provisions apply to any fugitive emission source in a facility. There are additional delay of repair provisions for valves and pumps under certain circumstances. These additional provisions are addressed in the discussions on valves and pumps. There are strict recordkeeping requirements for delay of repair of leaking equipment. Records for the following must be made and the records maintained for at least two years:

- The reasons for the delay
- Signature of the owner or operator (or designee) who determined that a process unit shutdown would be necessary to repair the leak
- Expected date of repair
- Dates of process unit shutdowns while the equipment leak remained unrepaired
- Date of successful repair.

Provisions for Leakless Equipment

Certain valves, pumps and compressors are exempt from most of the monitoring and repair requirements. Examples of equipment to which leakless technology provisions apply include diaphragm valves and canned pumps.

A valve, pump or compressor designated for no detectable emissions must operate with monitoring instrument readings of less than 500 ppmv above background. Upon initially determining that the equipment qualifies for no detectable emissions status, the identification number of the component must be entered into a permanent log. After the initial determination is made, the equipment must be monitored annually and must continue to exhibit instrument readings of less than 500 ppmv above background [60.482-2(3), 482-3(i), and 482-7(f)].

Closed Vent Systems

Several portions of the standards require the use of a closed vent system coupled with a control device. A closed vent system consists of the piping, connections, and flow-inducing devices (e.g., fans, compressors) necessary to transport gas or vapor from a piece of equipment to a control device. Systems which are open to the atmosphere are not considered closed vent systems. Control devices include enclosed combustion devices, vapor recovery systems, and flares. The design and operational requirements for each of these systems are specified in the standards [60.482-10].

Equivalency Determinations

The standards for control of fugitive emissions of VOC incorporate a number of techniques ranging from work practices (e.g., leak detection and repair programs) which achieve only a degree of emissions reduction, to leakless technology (e.g., sealed bellows valves and canned pumps). However, there is always the possibility that new techniques may be developed that achieve emission reductions equivalent to those which would be achieved under the standards.

The fugitive emissions standards account for this situation in the equivalency determinations provision [60.484]. An equivalent means of emission reduction is allowed through a petitioning procedure, not unlike the standards-setting process. The owner or operator of a SOCMI plant or the manufacturer of control equipment may petition EPA for an equivalency determination by documenting the equivalency of the technique in reducing emissions. The petitioning procedure is available for all equipment, design, operational, and work practice standards.

The owner or operator desiring an equivalency determination must present data on emissions and control effectiveness to support a determination. In each instance, emission reductions must at least equal the control techniques required by the applicable standard. In requesting an equivalency determination, the owner or operator must commit in writing to the equivalent means of emission reduction, if granted. The evidence presented to date on the required control techniques will then be assessed. If approval appears justified, a public hearing on the equivalency determination will be requested. Finally, based upon evaluation of the request and input from the public hearing, EPA may (a) grant approval of the control technique as equivalent, (b) approve the control technique as equivalent with conditions, or (c) deny the equivalency request.

Any determination of equivalence granted through the petitioning procedure is proposed and promulgated in the Federal Register. Such "equivalent" practices then become adopted as appropriate means of emissions reduction for fugitive VOC emissions control under the Clean Air Act. Any owner or operator may then elect to use the equivalent practice in his process units, without further equivalency determination.

Vacuum Service

Equipment in vacuum service is exempt from the monitoring and equipment requirements of the standards. Equipment is considered to be in vacuum service if it operates at an internal pressure at least 5 kPa below ambient pressure. Records must be kept for equipment in vacuum service.

Reporting

To comply with the standards for fugitive VOC emissions from the SOCMI, four types of reports must be submitted to EPA [60.8 and 60.487]:

- Routine semiannual reports
- Notifications of construction and startup
- Notifications of performance testing to demonstrate compliance
- Reports of performance test results.

The reporting requirements may change slightly where the EPA has delegated enforcement authority to a state and has approved alternative reporting requirements.

The initial semiannual report must be submitted within six months after the initial startup date of the process unit. It must identify the process unit and contain the following information about equipment in the process unit:

- The number of valves subject to the leak detection and repair provisions
- The number of pumps subject to the monthly leak detection and repair program, and to the dual mechanical seal requirements
- The number of compressors, excluding those designated NO DETECTABLE EMISSIONS (NDE) and those with seals connected to a closed vent system and control device.

Subsequent semiannual reports must provide an accounting of leak identification data for each month during the reporting period. The numbers of valves, pumps, and compressors that were determined to be leaking and the corresponding numbers of those equipment types not found leaking must be reported for each month.

The semiannual reports also include a monthly accounting of the facts explaining each delay of repair (if applicable). The reasons for the technical infeasibility of a process unit shutdown must be reported if that was a cause of a delay of repair. The dates of any process unit shutdowns during the semiannual reporting period are noted in the report as well. Finally, if any information reported in the initial semiannual report changed during the current semiannual period, these changes must be noted.

According to the General Provisions (40 CFR Part 60, Subpart A), notification must be made of construction and startup. There are two other circumstances where notification is required as stipulated in Subpart VV. First, with respect to certain options allowed for valves, an owner or operator must give notification at least 90 days prior to implementing an option's provisions. Second, EPA must be notified of the schedule of initial performance testing at least 30 days prior to testing. The results of each test must also be reported.

5. Detailed Provisions of the Standards

For each type of fugitive emission source which is covered by the standards there is a basic standard and its associated leak definition, there may be options or exclusions from the standard, and there are reporting and recordkeeping requirements. These will be discussed below for each equipment type. These sources and the reference to the relevant standard in the Code of Federal Regulations are:

- Valves [60.482-7, 483-1, 483-2]
- Pumps [60.482-2]
- Compressors [60.482-3]
- Pressure relief devices [60.482-4]
- Sampling connection systems [60.482-5]
- Open-ended valves and lines [60.482-6]
- Miscellaneous sources [60.482-8]
- Closed vent systems and control devices [60.482-10].

Valves

The requirements for valves described in this section apply only to valves in gas/vapor and light liquid VOC service. The requirements for valves in heavy liquid service are minimal and are described under Miscellaneous Sources, below.

Requirements. The valve standard is a work practice standard based on a monthly leak detection and repair program. While the concept of the program is rather straightforward, there are numerous requirements for monitoring, identification of leak sources, repair, and recordkeeping. In its simplest form, the standard requires monthly monitoring of all valves with a portable VOC analyzer to identify sources that are leaking. A valve is leaking if the instrument reading at the leak interface (for example, at the packing gland or at the bonnet) is 10,000 ppmv or greater. A valve identified as leaking must be tagged for repair and repaired within 15 days of detection. An initial attempt at repair must be made within five days of detection.

Repair of a valve means reducing the instrument reading below 10,000 ppmv. The recommended practices for initial repairs include tightening bonnet bolts, replacing bonnet bolts, tightening packing gland nuts, and injecting lubricant into lubricated packing. Repair methods are not restricted to these techniques. The VOC purged from the equipment at the time of repair should be collected and recovered or destroyed at that time.

If the repair cannot be made within the allotted time period, the general delay-of-repair provisions may apply as well as the following valve-specific provisions.

First, a delay of repair is allowed if the VOC emissions resulting from immediate repair would be greater than the emissions resulting from the equipment leak if allowed to leak until the next process unit shutdown. Furthermore, a delay of repair for valves may be permitted beyond a process unit shutdown if repair is contingent upon valve replacement parts, and if the replacement parts which are otherwise adequately stocked are not available due to depletion through extraordinary demand for replacements. This provision provides some flexibility for owners or operators facing unscheduled shutdowns and parts shortages through no fault or negligence on their part.

The standards require that only leaking valves be tagged. An owner or operator may, however, choose to identify those valves in the process unit that require routine monitoring (especially since only valves in VOC gas/vapor and light liquid services must be monitored under the rule).

Options. There are at least four options to the basic standard for valves. All are related to the monthly leak detection and repair program.

Option 1 is the basic requirement of the standard. It permits a quarterly monitoring program of those valves that have not leaked for two consecutive monthly monitoring periods [60.482-7(c)]. Only leaking valves must receive monthly attention.

Option 2 is not a work practice standard; rather it is a performance standard. In meeting and maintaining a certain performance level, routine monitoring and maintenance are not required. The performance standard requires that no more than 2 percent of all valves (the composite total) in gas/vapor and light liquid service can leak at any given time. In lieu of

Table 5.

Recordkeeping Requirements for Detected Equipment Leaks

When a leak is detected:
  - Instrument and operator identification numbers
  - Equipment identification number
  - Date of leak detection

When repairs are attempted:
  - Dates of each attempt to repair the leak
  - Repair methods used for each attempt at repair
  - Notation of failed repair attempt (if the maximum instrument reading after the repair attempt is equal to or greater than 10,000 ppmv

When repairs are delayed more than 15 days:
  - The reasons for the delay
  - Signature of the owner or operator (or designee) who determined that a process unit shutdown would be necessary to repair the leak
  - Expected date of repair
  - Dates of process unit shutdowns while the equipment leak remained unrepaired
  - Date of successful repair

monthly or quarterly monitoring, initial and annual compliance tests are used to demonstrate compliance. All monitoring under this option must be completed within one calendar week. EPA must be notified at least 90 days prior to the planned performance test [60.483-1]. Failure to maintain this performance level constitutes a violation of the standard. This is a significant difference between Option 2 and Option 1. Under Option 1, a violation only occurs if the required monitoring and maintenance is not performed correctly.

Option 2 is best suited for well-designed, low-leak process units. EPA test results show that there are many units that could meet such a performance standard. The option provides maximum flexibility in that the owner/operator can determine the means (equipment or work practice) to achieve and maintain the performance level.

Option 3 allows less frequent monitoring if, in implementing the basic requirements (Option 1), a level of performance in which fewer than 2 percent of the valves are leaking can be maintained for two quarters.

Under these circumstances, monitoring can be performed on a semi-annual basis. If the percentage of leaking valves exceeds 2 percent, the standard requires implementation of Option 1. Option 3 may be reinstated but to qualify, EPA must be notified and the performance history (i.e., fewer than 2 percent leaking) must again be demonstrated [60.483-2(b)(2)].

Option 4 is a work practice which is implemented much like Option 3. It too is initiated with implementation of the basic requirements (Option 1). Option 4 permits annual monitoring if the performance level of 2 percent or fewer valves leaking is maintained for five consecutive quarterly monitoring periods. As with Option 3, the standard requires implementation of Option 1 if the 2 percent level is exceeded. Upon notification to the Administrator and demonstration of performance, Option 4 can be reinstated in the same manner as Option 3, except that a five-quarter period of 2 percent performance is necessary before beginning annual monitoring.

Option 4 and Option 2 appear to be annual monitoring programs. But there are some fundamental differences. Option 4 is an extension of the basic standard's leak detection and repair program through the application of skip-period sampling techniques. Skipping to annual monitoring is permitted, and is based on demonstrated performance. Since it is an extension of the basic standard, exceedance of the 2 percent limit again requires only that the basic requirements of Option 1 be reinstituted. On the other hand, under Option 2, exceeding the 2 percent performance limit constitutes a violation of the standard.

Recordkeeping. Recordkeeping is a key element in demonstrating compliance with work practice standards. Records on the valve leak detection and repair programs that are part of the SOCMI fugitive emissions standards must be maintained and available for inspection for two years. The information that must be recorded for all valve leaks is listed in Table 5. These requirements apply to the basic standard and all of the options. Options 3 and 4 are based on a demonstrated performance level, thus they have additional recordkeeping requirements: the schedule for monitoring, and the percentage of valves found leaking during each monitoring period.

Exemptions. Provided certain recordkeeping requirements are met, exemptions from the routine monitoring requirements are allowed for valves designated as "leakless," "unsafe-to-monitor," or "difficult-to-monitor." Leakless valves need only be monitored annually, as described earlier in this section.

A valve may be considered unsafe-to-monitor if the owner or operator can demonstrate that monitoring personnel would be exposed to an immediate danger or hazard as a result of screening the valve. A plan must be developed that provides for monitoring as frequently as is practical. The plan, a list of the sources, and the reasons for their listing must be recorded [60.482(g)].

A valve is difficult-to-monitor if the owner or operator can demonstrate that monitoring personnel must be elevated more than 2 meters (or about 6 feet) above a support structure to screen the valve. This exemption is only applicable to existing process units to which the standards apply as a result of modification or reconstruction. Difficult-to-monitor valves must be listed along with the reason(s) for listing each valve. Also, a plan for monitoring these valves as frequently as practical (but at least annually) must be recorded and implemented [60.486(f) (2)].

Pumps

The pump standard applies only to pumps in light liquid VOC service. It is a work practice standard calling for monthly instrument inspections and weekly visual inspections. A leak from a pump is defined as a 10,000 ppmv or greater instrument reading when using a portable VOC analyzer, or as evidence of liquids dripping from a pump seal observed during the weekly visual inspections of each seal.

The repair required by the pump standard is the elimination of liquids dripping from the seal and the reduction of the instrument reading below the 10,000 ppmv value. Pumps in SOCMI processes are generally installed in pairs, which allows one to be used as a spare. This allows continued operation during repair.

In addition to the general delay-of-repair provisions, there is an additional delay-of-repair provision for pumps. Repair of a chronic pump leak may eventually warrant the installation of a dual seal system and associated barrier fluid system, connected to a closed vent system and control device. In this event, the repair may be delayed beyond the 15-day period until the installation has been completed. The delay of repair may not exceed six months.

Exemptions. Routine monitoring is not required for sealless pumps, some pumps with dual mechanical seal systems, and some pumps with enclosed seal areas. To be eligible for an exemption, the dual mechanical seal system must have a barrier fluid system either:

- With a degassing reservoir connected to an accepted closed vent system and control device, or
- Operated at a pressure higher than the pump stuffing box pressure, or
- That purges the barrier fluid into the process with no VOC emissions to the atmosphere.

The barrier fluid must be a heavy liquid or a non-VOC, and the barrier fluid system must have a sensor to indicate failure of the seal, the barrier fluid system, or both. The owner or operator selects the type of sensor to be used in the barrier fluid system based on design considerations and operating experience [60.482-2(d)]. Records must be maintained on the design criteria for the barrier fluid system sensor, including an explanation of these criteria, changes to the criteria, and reasons for the changes.

While pumps with these systems are exempt from monthly instrument monitoring, they must still be visually inspected on a weekly basis for indications of liquids dripping from the seal. For pumps so equipped, a leak is detected by the sensor (indicating failure of the seal, barrier fluid system, or both) or by visual evidence of liquids dripping from the seal. Upon detection of a leak, the same repair requirements for the basic standard apply for pumps with dual mechanical seal systems.

Pumps equipped with an enclosed seal that are vented to a closed vent system/control device have an exemption from the monthly monitoring requirements of the basic pump standard. However the recordkeeping requirements for these pumps are the same as the requirements for pumps complying with the basic standard. There are, however, additional requirements for the closed vent system/control device [60.482-2(f)].

Compressors

Rather than relying upon work practices, the standards for compressors are directed toward the installation of equipment, since spare compressors are not generally used in SOCMI. The compressor standard requires a seal system to be installed to prevent VOC emissions to the atmosphere. The seal system must include a barrier fluid system and a sensor, such as a pressure indicator or level indicator, which will indicate a failure of the system. Failure of the seal or barrier fluid system, as indicated by an audible alarm or through daily inspections of the sensor, is indicative of a leak and requires repair. The owner or operator must determine the specific criteria which indicates a failure of the seal system. The design details of the barrier fluid system and any changes to the system must be recorded in a log that is available for inspection.

After a leak is detected repairs must be effected as soon as practicable on the seal or barrier fluid system, or both. The first attempt at repair must be within five days of leak detection; repair must be completed within 15 days of leak detection, unless a delay of repair is warranted.

In addition to installing this equipment, certain operational requirements for the barrier fluid system are the same as the requirements for pumps.

Exemptions. The standard for compressors allows three exemptions:

- Compressors equipped with enclosed seal areas connected through a closed vent system to an acceptable control device are exempt from the control equipment requirements provided the arrangement captures, transports, and treats any VOC leakage from the seal.
- Compressors complying with the NDE limit are also exempt from the equipment requirements, provided they meet certain testing, recordkeeping, and reporting requirements.

- Certain existing reciprocating compressors may be completely exempt from compliance with the standard. The linear shaft motion of reciprocating compressors makes sealing extremely difficult. Most newer reciprocating compressor designs provide for venting of the distance piece (between the compressor and drive) in accordance with ASME Codes. (Venting the distance piece through a closed vent system to a control device would essentially meet the requirements of the first exemption.) Older designs, however, may not incorporate this venting capability. An exemption is allowed for such older compressors, provided the owner or operator can demonstrate that the distance piece must be recast (not merely replaced) with a vent port or that the entire compressor would have to be replaced to comply with the standard.

Pressure Relief Devices

These standards apply only to pressure relief devices in gas/vapor service; other pressure relief devices are covered by the standard on Miscellaneous Sources. The VOC emitted to the atmosphere during unplanned process upsets are not considered fugitive emissions, and are not subject to the standard.

The standard is a performance standard with a limit of no detectable emissions (NDE). NDE is defined as a difference of 500 ppmv or less between the instrument reading at the leak surface and the reading for the background. In addition there must be no visible evidence of leakage. A test of each pressure relief device is required at least annually to verify compliance. No specific equipment or operational requirements are given in the regulation; the owner or operator is free to select any means of controlling the fugitive emissions that will meet the NDE limit. However, an exceedance of the NDE limit is considered noncompliance. Connection of the discharge of a pressure relief device through a closed vent system to a control device would effectively eliminate emissions from a relief device; this practice is specifically exempt from the annual monitoring requirements for pressure relief devices.

Additional Requirements. When emergency releases through the pressure relief device do occur, leaks may result from a poorly seated valve or the loss of seal in a rupture disk. The repair requirements associated with this standard refer to returning the relief device to a condition of NDE after the device is activated. For example, replacing the failed rupture disk or reseating the relief valve properly would generally return the pressure relief device to an NDE status. This repair must be made within five days of the release, and the pressure relief device must be monitored at that time to ensure its return to a condition of NDE. Meeting this time constraint is facilitated if a dual relief valve arrangement is used.

Recordkeeping for all equipment designated for NDE is minimal. Only the identification numbers of the pressure relief devices, the dates, and results (that is, the maximum instrument reading at the leak interface and the instrument reading of the surroundings) of each compliance test need to be recorded and available for inspection. The results of monitoring after each overpressure release are considered test results and thus must be recorded.

Open-Ended Valves or Lines

Emissions from open-ended valves or lines (not pressure relief devices) must be eliminated through the use of a pipe cap, plug, blind flange, or a second valve. The open end must be sealed at all times, except during the operation of the open end, such as during sampling, draining, or vessel purging.

If a second valve is used to close the open end, the valve closest to the process must be closed first. This procedure ensures that the space between the two valves will not contain fluid, creating a leak potential if the trapped fluid expands with increasing temperature.

Sampling Connection Systems

A closed purge system or a closed vent system must be used on all sampling connection systems. Certain operational requirements also apply. For example, when taking liquid samples in a process unit, some process fluid would typically be bled from the sample lines into a waste container before collecting the sample for analysis. To comply with the rule, this "waste" material and any unused sample (after analysis) must either be returned to the process, or be treated in a control device. One option is to capture and transport any purged fluid through a closed vent system to a control device. This option is particularly useful for gaseous VOC sampling systems. Another alternative is the use of *in situ* (in-line or nonextractive) sampling systems, which are specifically exempt from the standard.

Miscellaneous Sources

Miscellaneous sources are those fugitive emission sources with a somewhat smaller potential to leak VOC to the atmosphere. They include:

- Pumps and valves in heavy liquid service
- Pressure relief devices in liquid service
- Flanges and other connectors.

There is no established emission reduction plan for these sources. They need only be monitored with a portable instrument if a VOC leak is suspected by visual, audible, sense of smell, or other means. Potential leaks from miscellaneous sources are verified through instrument monitoring using an instrument reading of 10,000 ppmv as the leak definition.

Any verified leak must be repaired so that the instrument reading is reduced below the 10,000 ppmv leak definition. Typical on-line repair techniques include tightening packing glands, reseating pressure relief valves, or tightening flange bolts and screwed connections. As with all source leaks, repair must begin as soon as is practical, with an initial attempt within 5 days of leak detection, and repair completed within 15 days.

Closed Vent Systems and Control Devices

Closed vent systems must be operated with NDE to the atmosphere (i.e., the difference in instrument readings between the leak interface and the surroundings is less than 500 ppmv, and there is no visible evidence of leakage). The closed vent system and its control device must be monitored for compliance initially and at least annually thereafter.

Three options are available for VOC emission control devices:

- Vapor recovery systems
- Enclosed combustion devices
- Flares.

All three options are capable of achieving VOC emissions reductions of at least 95 percent. But since each is very different in terms of design and operating characteristics, there are separate requirements for each.

Vapor recovery systems include devices which recover VOC without destroying them. Adsorbers, absorbers, and condensers are all examples of vapor recovery systems. Any vapor recovery system achieving a VOC removal efficiency of at least 95 percent is an allowable control device under the standards.

Enclosed combustion devices, such as incinerators, boilers, and process heaters, are destructive control devices. At least 95 percent efficiency in removing VOC is required for enclosed combustion devices. In lieu of demonstrating the 95 percent efficiency, an owner or operator may elect to comply with the requirements by maintaining an operating temperature of 816°C (1500°F) and a residence time of 0.75 seconds.

Flares may also be used to comply with the standard for control devices, provided some important design and operational criteria are met: it must be designed and operated with smokeless operation, and a flame must be present at all times. Smokeless operation means that visible emissions may be present for no more than a cumulative five minutes during any consecutive two-hour period, using EPA Reference Method 22.

There are specific requirements for flares relating to the velocity and the net heating value of the gas; these must be periodically tested. The net heating value is computed based upon chemical analyses and/or established data. Concentrations of individual components in the flared gas are determined using gas chromatography as prescribed in Reference Method 18 and ASTM D2504-67 (reapproved 1977).

Specific monitoring requirements have been established for flares used to comply with the standards. The presence of a flare pilot flame must be monitored at all times using a thermocouple or equivalent sensor. Monitoring is also required for the other control devices, but no specific requirements are listed in the regulation. Owners or operators must select an appropriate parameter to monitor that ensures the control device is maintained and operated within the specified design. Several options for monitoring methods for control devices are discussed in the Background Information Document for the promulgated standards.

The recordkeeping requirements for control devices focus on design specifications and periods when the device is not in service. For each control device, the following information must be recorded and maintained:

- Schematics, drawings, and design specifications
- Dates and changes to the design specifications
- Parameter(s) monitored with a rationale for the selection of each parameter
- Dates for periods during which the control device was not operating
- Dates of startup and shutdown of the control device.

6. Leak Detection Methods

The detection of leaks is a critical aspect of complying with the fugitive VOC emissions standards. All leak detection procedures must be in accordance with the specific requirements detailed in the standards [60.485] and in Reference Method 21 (located in Appendix A of 40 CFR 60).

Noninstrument Methods

Noninstrument leak detection can be done visually, audibly, or by sense of smell. The standard for miscellaneous sources (pumps and valves in heavy liquid service; pressure relief devices in liquid service; and flanges and other connectors) cites the use of these noninstrument techniques for determining leaks. The standard for pumps in light liquid service relies upon weekly visual inspections for determining liquid leaks dripping from the seal.

Soap bubble testing, or soaping, is one noninstrument technique which Reference Method 21 cites as an aid to screening certain sources for VOC leaks. Soaping is only applicable to sources with nonmoving seals, with moderate surface temperatures, without large openings to the atmosphere, and without evidence of liquid leakage. Thus, soaping cannot be used to screen pump seals, sources with surface temperatures above the boiling point or below the freezing point of the soap solution, open-ended lines or valves, or pressure relief valves.

Basically, the technique involves the application of a soap solution around the potential leak surface such as a valve stem packing gland. A potential leak is indicated by the appearance of bubbles. The leak must then be verified using the instrument techniques given in Reference Method 21 and the applicable standard [60.485]. The absence of bubbles is indicative of NDE or no leak. However, soaping is only a supplemental method for screening sources prior to instrument monitoring.

Instrument Techniques

Instrument techniques include fixed point monitors and portable VOC analyzers. Based upon an evaluation by EPA, fixed point monitoring systems (or area monitors) may be subject to outside influences such as meterological conditions. Further, they are not as effective in determining leaks as individual component screening with portable monitors. Area monitors, however, are useful in monitoring continuously for the appearance of large leaks.

For the SOCMI standards, a leak is identified if an instrument measurement is above one of two levels. In routine monitoring for leak detection, an instrument reading of 10,000 ppmv or greater indicates a leak. This should trigger several actions: tagging, recording, and repairing. The 10,000 ppmv leak definition is applicable to pumps (light liquid service), and valves (gas/vapor and light liquid services). NDE is also determined with instrument screening. A reading of 500 ppmv or greater above background is a leak and violates the performance standard.

Compliance Monitoring Program. For any affected process unit, compliance with the fugitive emission standard must be demonstrated within 180 days after the initial startup of the process unit. A leak detection program, then, must be designed in advance of the startup so that it can be fully implemented within the six-month period. As part of the program design, instrumentation should be promptly acquired so that operating personnel can begin training. These instruments include portable VOC analyzers that meet the performance criteria specified in Method 21. In addition, calibration gases for the selected monitoring system (i.e., instrument and calibrant) should be procured well in advance of implementing the program so that calibration and monitoring techniques can be mastered prior to routine monitoring.

Portable Instruments. Reference Method 21 describes the procedure for leak detection using a portable analyzer and specifies the requisite performance characteristics for the analyzer. The instrument detector must respond to the VOC that is to be measured. The instrument may be calibrated using one easily-obtainable reference gas in order to measure the VOC if the relationship between the calibration gas and the VOC (the so-called response factor) is known. Response factors differ for different combinations of compounds and instruments. A response factor of less than 10 is required for the individual compounds. If a measured or published response factor is greater than 10, it may be necessary to use a different type of analyzer to obtain reasonable precision.

The types of detectors that may be used include catalytic oxidation, flame ionization, infrared absorption, and photoionization. The instrument must:

- Sample continuously at a nominal rate of 0.5 to 3 liters per minute
- Be intrinsically safe for use in an explosive atmosphere
- Have a scale readable to within 5 percent of the defined leak concentration level.

Table 6.

Specifications and Performance Criteria for Portable VOC Monitors

Instrument Specification	
Detector	Examples: Catalytic oxidation Flame ionization Infrared absorption Photoionization
Detection Range	Leak definition concentrations
Readable Range	To 5 percent of the leak definition
Sample Flow Rate	Nominally 0.5 to 3.0 liters per minute
Safety	Intrinsically safe operation in explosive atmospheres
Performance Criteria	
Response Factor	Less than 10 for each constituent
Response Time	Less than or equal to 30 seconds
Calibration Precision	Less than or equal to 10 percent of the calibration gas value

SOURCE: Reference Method 21

Table 6 shows additional performance criteria in terms of response and precision. Century Systems' Organic Vapor Analyzer (OVA)®, the Bacharach Instruments' TLV Sniffer (TLV)®, and the H-Nu® photoionization instrument have been used successfully in some of the fugitive emissions research projects conducted by the EPA and other groups.*

Calibration. Portable monitoring instruments are calibrated in terms of concentration (ppmv) of a reference compound. At least two calibration gases must be used. First, a zero gas, which is air containing less than 10 ppmv VOC, is used to set the instrument baseline. Second, a calibration gas, which contains a reference compound (methane or n-hexane) in air at the leak definition concentration, is used to set the instrument span. Calibrants, either purchased or prepared by the user, must be analyzed and certified to within ± 2 percent accuracy. The shelf life must be specified for purchased calibrants; prepared calibrants must be replaced daily, unless no degradation can be proved.

How Sources Are Monitored. In general, sources are monitored by placing the instrument probe inlet at the surface where leakage would occur (i.e., the leak interface). For each component, the entire leak interface must be traversed. For example, valves are monitored at the seal between the stem and the housing and at the interface of the packing gland take-up flange seat. For compressors and pumps, the probe is traversed around the circumference at the interface of the shaft and seal. For pressure relief devices and open-ended lines and valves, the probe is placed at the center of the opening to the atmosphere. To determine the instrument reading of the background for evaluation of NDE, the probe inlet is moved randomly 1 to 2 meters upwind and downwind of the source.

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*Mention of trade names does not constitute endorsement by EPA.

7. Other Standards

In addition to the fugitive emissions standards there are other standards with which owners or operators of organic chemical units may have to comply. Standards have been proposed or promulgated for the following source categories:

- Standards of Performance for New Stationary Sources; VOC Emissions from the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Unit Operations — proposed on December 30, 1983 (48 FR 57538-57561).
- National Emission Standards for Hazardous Air Pollutants; Benzene Equipment Leaks (Fugitive Emission Sources) — promulgated on June 6, 1984 (49 FR 23498-23520).
- Standards of Performance for New Stationary Sources, Volatile Organic Liquid Storage Vessels (including Petroleum Liquid Storage Vessels) constructed after July 23, 1984 — proposed on July 23, 1984 (49 FR 29698-29718).
- National Emission Standards for Hazardous Air Pollutants; Vinyl Chloride — promulgated on October 21, 1976 (41 FR 46559-46573).
- Standards of Performance for New Stationary Sources; VOC Emissions from the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Air Oxidation Unit Processes — proposed on October 21, 1983 (48 FR 48932-48958).

8. Sources of Information

There is no one reference that describes in detail how to comply with the SOCMI fugitive emission standards. This publication is designed to help owners and operators of SOCMI plants by explaining in plain English what the standards require. There are other references and documents that provide additional information. References that may be helpful are listed in this section with some comments on the material each contains.

Federal Register Notices

The Federal Register contains notices of regulations and notices of proposed final regulatory actions. It is published by the Office of the Federal Register, National Archives and Records Service of the General Services Administration and is available for sale from:

> Superintendent of Documents.
> U.S. Government Printing Office.
> Washington, DC 20402.

The final standard on fugitive VOC emissions in SOCMI is published in the following Federal Register notice:

> U.S. Environmental Protection Agency. Standards of Performance for New Stationary Sources: Synthetic Organic Chemical Manufacturing Industry; Equipment Leaks of VOC, Reference Methods 18 and 22. Federal Register, Volume 48, 48328-48361, October 18, 1983.

Minor amendments to the SOCMI standards for fugitive emissions of VOC were published in the following Federal Register notice:

> U.S. Environmental Protection Agency. Standards of Performance for New Stationary Sources: Equipment Leaks of VOC Petroleum Refineries and Synthetic Organic Chemical Manufacturing Industry. Federal Register, Volume 49, 22598-22608, May 30, 1984.

Anyone needing to comply with the standards should obtain a copy and read it carefully because it contains the official standards. It also contains a small amount of explanatory material and a discussion of comments received when the standards were proposed.

The following Federal Register notice contains information about EPA's method for leak detection. It is the final method as added to the Code of Federal Regulations. The leak detection required by the standards must be done according to Reference Method 21. Anyone needing to comply with the SOCMI fugitive emission standards should obtain a copy of the final method and read it carefully.

> U.S. Environmental Protection Agency. Addition of Reference Method 21 to Appendix A. Federal Register, Volume 48, 37598-37602. August 18, 1983.

As standards and reference methods are finalized, they are published in the Code of Federal Regulations. Title 40 contains environmental rules, standards, and regulations. Part 60 of Title 40 deals with new source performance standards. In addition to the individual new source performance standards, there are General Provisions which apply to all facilities that must comply with these standards. Anyone needing to comply with the SOCMI fugitive emission standards should read carefully the General Provisions of 40 CFR Part 60.

> U.S. Environmental Protection Agency. Code of Federal Regulations. Title 40, Protection of Environment. Part 60, Standards of Performance for New Stationary Sources. Superintendent of Documents. U.S. Government Printing Office, Washington, DC 20402.

Control Technique Guidelines Documents

Control Techniques Guidelines Documents are written to aid State agencies in writing State Implementation Plans for areas which have not attained national ambient air quality standards. They provide information useful in determining what reasonably available control technology should be. The following guideline document has recently been published for fugitive emissions in SOCMI and polymer plants. It contains sections on emissions, control techniques, environmental impacts of control, and costs for control.

> U.S. Environmental Protection Agency. Guideline Series — Control of Volatile Organic Compound Leaks from Synthetic Organic Chemical and Polymer Manufacturing Equipment. Research Triangle Park, NC. Publication Number EPA-450/3-83-006. March 1984. [NTIS: PB84-105311]

Background Information Documents for Standards

Background information documents present the technical information EPA used in developing a standard. Topics covered include descriptions of emissions, control techniques, costs, and environmental and energy impacts.

There are two technical background information documents for the SOCMI fugitive emission standards, one written in support of the proposed standards and an additional information document which details technical information developed after the standard was proposed.

> U.S. Environmental Protection Agency. Background Informaton for Proposed Standards for VOC Fugitive Emissions in the Synthetic Organic Chemicals Manufacturing Industry. Research Triangle Park, NC. Publication Number EPA-450/3-80-033a. November 1980. [NTIS: PB81-152167]
>
> U.S. Environmental Protection Agency. Fugitive Emission Sources of Organic Compounds — Additional Information on Emissions, Emission Reductions, and Costs. Research Triangle Park, NC. Publication Number EPA-450/3-82-010. April 1982. [NTIS: PB82-217126]

A third background document provides support for the standards as finally promulgated. It contains a summary of the public comments received on the proposed standards and EPA's responses to those comments.

> U.S. Environmental Protection Agency. Background Information for Promulgated Standards for VOC Fugitive Emissions in the Synthetic Organic Chemicals Manufacturing Industry. Research Triangle Park, NC. Publication Number EPA-450/3-80-033b. June 1982. [NTIS: PB84-189372]

These background documents were prepared by EPA. In some cases the document may still be available from EPA and can be requested from:

U.S. EPA Library (MD-35),
Research Triangle Park, NC
27711. Telephone: (919)
541-2777

If EPA does not have the publication, it can be obtained from:

National Technical Information
Service, U.S. Department of
Commerce, Springfield, VA 22161.

Affected Synthetic Organic Chemicals

*CAS No.**	*Chemical*
105-57-7	Acetal.
75-07-0	Acetaldehyde.
107-89-1	Acetaldol.
60-35-5	Acetamide.
103-84-4	Acetanilide.
64-19-7	Acetic acid.
108-24-7	Acetic anhydride.
67-64-1	Acetone.
75-86-5	Acetone cyanohydrin.
75-05-8	Acetonitrile.
98-86-2	Acetophenone.
75-36-5	Acetyl chloride.
74-86-2	Acetylene.
107-02-8	Acrolein.
79-06-1	Acrylamide.
79-10-7	Acrylic acid.
107-13-1	Acrylonitrile.
124-04-9	Adipic acid.
111-69-3	Adiponitrile.
(b)	Alkyl naphthalenes.
107-18-6	Allyl alcohol.
107-05-1	Allyl chloride.
1321-11-5	Aminobenzoic acid.
111-41-1	Aminoethylethanolamine.
123-30-8	p-Aminophenol.
628-63-7, 123-92-2	Amyl acetates.
71-41-0*c*	Amyl alcohols.
110-58-7	Amyl amine.
543-59-9	Amyl chloride.
110-66-7*c*	Amyl mercaptans.
1322-06-1	Amyl phenol.
62-53-3	Aniline.
142-04-1	Aniline hydrochloride.
29191-52-4	Anisidine.
100-66-3	Anisole.
118-92-3	Anthranilic acid.
84-65-1	Anthraquinone.
100-52-7	Benzaldehyde.
55-21-0	Benzamide.
71-43-2	Benzene.
98-48-6	Benzenedisulfonic acid.
98-11-3	Benzenesulfonic acid.
134-81-6	Benzil.
76-93-7	Benzilic acid.
65-85-0	Benzoic acid.
119-53-9	Benzoin.
100-47-0	Benzonitrile.
119-61-9	Benzophenone.
98-07-7	Benzotrichloride.
98-88-4	Benzoyl chloride
100-51-6	Benzyl alcohol.
100-46-9	Benzylamine.
120-51-4	Benzyl benzoate.
100-44-7	Benzyl chloride.
98-87-3	Benzyl dichloride.
92-52-4	Biphenyl.
80-05-7	Bisphenol A.
10-86-1	Bromobenzene.
27497-51-4	Bromonaphthalene.
106-99-0	Butadiene.
106-98-9	1-butene.
123-86-4	n-butyl acetate.
141-32-2	n-butyl acrylate.
71-36-3	n-butyl alcohol.
78-92-2	s-butyl alcohol.
75-65-0	t-butyl alcohol.
109-73-9	n-butylamine.
13952-84-6	s-butylamine.
75-64-9	t-butylamine.
98-73-7	p-tert-butyl benzoic acid.
107-88-0	1,3-butylene glycol.
123-72-8	n-butyraldehyde.
107-92-6	Butyric acid.
106-31-0	Butyric anhydride.
109-74-0	Butyronitrile.
105-60-2	Caprolactam.
75-1-50	Carbon disulfide.
558-13-4	Carbon tetrabromide.
56-23-5	Carbon tetrachloride.
9004-35-7	Cellulose acetate.
79-11-8	Chloroacetic acid.
108-42-9	m-chloroaniline.
95-51-2	o-chloroaniline.
106-47-8	p-chloroaniline.
35913-09-8	Chlorobenzaldehyde.
108-90-7	Chlorobenzene.
118-91-2, 535-80-8, 74-11-3*c*	Chlorobenzoic acid.
2136-81-4,2136-89-2, 5216-25-1*c*	Chlorobenzotrichloride.
1321-03-5	Chlorbenzoyl chloride.
25497-29-4	Chlorodifluoromethane.
75-45-6	Chlorodifluoroethane.
67-66-3	Chloroform.
25586-43-0	Chloronapthalene.
88-73-3	o-chloronitrobenzene.
100-00-5	p-chloronitrobenzene.
25167-80-0	Chlorophenols.
126-99-8	Chloroprene.
7790-94-5	Chlorosulfonic acid.
108-41-8	m-chlorotoluene.
95-49-8	o-chlorotoluene.
106-43-4	p-chlorotoluene.
75-72-9	Chlorotrifluoromethane.
108-39-4	m-cresol.
95-48-7	o-cresol.
106-44-5	p-cresol.
1319-77-3	Mixed cresols.
1319-77-3	Cresylic acid.
4170-30-0	Crotonaldehyde.
3724-65-0	Crotonic acid.
98-82-8	Cumene.
80-15-9	Cumene hydroperoxide.
372-09-8	Cyanoacetic acid.
506-77-4	Cyanogen chloride.
108-80-5	Cyanuric acid.
108-77-0	Cyanuric chloride.
110-82-7	Cyclohexane.
108-93-0	Cyclohexanol.
108-94-1	Cyclohexanone.
110-83-8	Cyclohexene.
108-91-8	Cyclohexylamine.
111-78-4	Cyclooctadiene.
112-30-1	Decanol.
123-42-2	Diacetone alcohol.
27576-04-1	Diaminobenzoic acid.
95-76-1, 95-82-9, 554-00-7, 608-27-5, 608-31-1, 626-43-7, 27134-27-6, 57311-92-9*c*	Dichloroaniline.
541-73-1	m-dichlorobenzene.
95-50-1	o-dichlorobenzene.
106-46-7	p-dichlorobenzene.
75-71-8	Dichlorodifluoromethane.
111-44-4	Dichloroethyl ether.
107-06-2	1,2-dichloroethane (EDC).
96-23-1	Dichlorohydrin.
26952-23-8	Dichloropropene.
101-83-7	Dicyclohexylamine.
109-89-7	Diethylamine.
111-46-6	Diethylene glycol.
112-36-7	Diethylene glycol diethyl ether.
111-96-6	Diethylene glycol dimethyl ether.
112-34-5	Diethylene glycol monobutyl ether.
124-17-7	Diethylene glycol monobutyl ether acetate.
111-90-0	Diethylene glycol monoethyl ether.
112-15-2	Diethylene glycol monoethyl ether acetate.
111-77-3	Diethylene glycol monomethyl ether.
64-67-5	Diethyl sulfate.
75-37-6	Difluoroethane.
25167-70-8	Diisobutylene.
26761-40-0	Diisodecyl phathalate.
27554-26-3	Diisooctyl phthalate.
674-82-8	Diketene.
124-40-3	Dimethylamine.
121-69-7	N,N-dimethylaniline.
115-10-6	N,N-dimethyl ether.
68-12-2	N,N-dimethylformamide.
57-14-7	Dimethylhydrazine.
77-78-1	Dimethyl sulfate.
75-18-3	Dimethyl sulfide.
67-68-5	Dimethyl sulfoxide.
120-61-6	Dimethyl terephthalate.
99-34-3	3,5-dinitrobenzoic acid.
51-28-5	Dinitrophenol.
25321-14-6	Dinitrotoluene.
123-91-1	Dioxane.
646-06-0	Dioxilane.
122-39-4	Diphenylamine.
101-84-8	Diphenyl oxide.
102-08-9	Diphenyl thiourea.
25265-71-8	Dipropylene glycol.
25378-22-7	Dodecene.
28675-17-4	Dodecylaniline.
27193-86-8	Dodecylphenol.
106-89-8	Epicholorhydrin.
64-17-5	Ethanol.
141-43-5*c*	Ethanolamines
141-78-6	Ethyl acetate.
141-97-9	Ethyl acetoacetate.
140-88-5	Ethyl acrylate.
75-04-7	Ethylamine.
100-41-4	Ethylbenzene.
74-96-4	Ethyl bromide.
9004-57-3	Ethylcellulose.
75-00-3	Ethyl chloride.
105-39-5	Ethyl chloroacetate.
105-56-6	Ethylcyanoacetate.
74-85-1	Ethylene.
96-49-1	Ethylne carbonate.
107-07-3	Ethylene chlorohydrin.
107-15-3	Ethylenediamine.
106-93-4	Ethylene dibromide.
107-21-1	Ethylene glycol.
111-55-7	Ethylene glycol diacetate.
110-71-4	Ethylene glycol dimethyl ether.
111-76-2	Ethylene glycol monobutyl ether.
112-07-2	Ethylene glycol monobutyl ether acetate.
110-80-5	Ethylene glycol monoethyl ether.
111-15-9	Ethylene glycol monoethyl ether acetate.
109-86-4	Ethylene glycol monomethyl ether.
110-49-6	Ethylene glycol monomethyl ether acetate.

Affected Synthetic Organic Chemicals (continued)

*CAS No.**	*Chemical*
122-99-6	Ethylene glycol monophenyl ether.
2807-30-9	Ethylene glycol monopropyl ether.
75-21-8	Ethylene oxide.
60-29-7	Ethyl ether.
104-76-7	2-ethylhexanol.
122-51-0	Ethyl orthoformate.
95-92-1	Ethyl oxalate.
41892-71-1	Ethyl sodium oxalacetate.
50-00-0	Formaldehyde.
75-12-7	Formamide.
64-18-6	Formic acid.
110-17-8	Fumaric acid.
98-01-1	Furfural.
56-81-5	Glycerol.
26545-73-7	Glycerol dichlorohydrin.
25791-96-2	Glycerol triether.
56-40-6	Glycine.
107-22-2	Glyoxal.
118-74-1	Hexachlorobenzene.
67-72-1	Hexachloroethane.
36653-82-4	Hexadecyl alcohol.
124-09-4	Hexamethylenediamine.
629-11-8	Hexamethylene glycol.
100-97-0	Hexamethylenetetramine.
74-90-8	Hydrogen cyanide.
123-31-9	Hydroquinone.
99-96-7	p-hydroxybenzoic acid.
26760-64-5	Isoamylene.
78-83-1	Isobutanol.
110-19-0	Isobutyl acetate.
115-11-7	Isobutylene.
78-84-2	Isobutyraldehyde.
79-31-2	Isobutyric acid.
25339-17-7	Isodecanol.
26952-21-6	Isooctyl alcohol.
78-78-4	Isopentane.
78-59-1	Isophorone.
121-91-5	Isophthalic acid.
78-79-5	Isoprene.
67-63-0	Isopropanol.
108-21-4	Isopropyl acetate.
75-31-0	Isopropylamine.
75-29-6	Isopropyl chloride.
25168-06-3	Isopropylphenol.
463-51-4	Ketene.
(b)	Linear alkyl sulfonate.
123-01-3	Linear alkylbenzene (linear dodecylbenzene).
110-16-7	Maleic acid.
108-31-6	Maleic anhydride.
6915-15-7	Malic acid.
141-79-7	Mesityl oxide.
121-47-1	metanilic acid.
79-41-4	Methacrylic acid.
563-47-3	Methallyl chloride.
67-56-1	Methanol.
79-20-9	Methyl acetate.
105-45-3	Methyl acetoacetate.
74-89-5	Methylamine.
100-61-8	n-methylaniline.
74-83-9	Methyl bromide.
37365-71-2	Methyl butynol.
74-87-3	Methyl chloride.
108-87-2	Methylcyclohexane.
1331-22-2	Methylcyclohexanone.
75-09-2	Methylene chloride.
101-77-9	Methylene dianiline.
101-68-8	Methylene diphenyl diisocyanate.
78-93-3	Methyl ethyl ketone.
107-31-3	Methyl formate.
108-11-2	Methyl isobutyl carbinol.
108-10-1	Methyl isobutyl ketone.
80-62-6	Methyl methacrylate.
77-75-8	Methylpentynol.
98-83-9	a-methylstyrene.
110-91-8	Morpholine.
85-47-2	a-napthalene sulfonic acid.
120-18-3	b-napthlene sulfonic acid.
90-15-3	a-naphthol.
135-19-3	b-naphthol.
75-98-9	Neopentanoic acid.
88-74-4	o-nitroaniline.
100-01-6	p-nitroaniline.
91-23-6	o-nitroanisole.
100-17-4	p-nitroanisole.
98-95-3	Nitrobenzene.
27178-83-2*c*	Nitrobenzoic acid, (o,m, and p).
79-24-3	Nitroethane.
75-52-5	Nitromethane.
88-75-5	2-Nitrophenol.
25322-01-4	Nitropropane.
1321-12-6	Nitrotoluene.
27215-95-8	Nonene
25154-52-3	Nonylphenol.
27193-28-8	Octylphenol.
123-63-7	Paraldehyde.
115-77-5	Pentaerythritol.
109-66-0	n-pentane.
109-67-1	1-pentene.
127-18-4	Perchloroethylene.
594-42-3	Perchloromethyl mercaptan.
94-70-2	o-phenetidine.
156-43-4	p-phenetidine.
108-95-2	Phenol.
98-67-9, 585-38-6, 609-46-1, 1333-39-7*c*	Phenolsulfonic acids.
91-40-7	Phenyl anthranilic acid.
(b)	Phenylenedlamine.
75-44-5	Phosgene.
85-44-9	Phthalic anhydride.
85-41-6	Phthalimide.
108-99-6	b-picoline.
110-85-0	Piperazine.
9003-29-6, 25036-29-7*c*	Polybutenes.
25322-68-3	Polyethylene glycol.
25322-69-4	Polypropylene glycol.
123-38-6	Propional dehyde.
79-09-4	Propionic acid.
71-23-8	n-propyl alcohol.
107-10-8	Propylamine.
540-54-4	Propyl chloride.
115-07-1	Propylene.
127-00-4	Propylene chlorohydrin.
78-87-5	Propylene dichloride.
57-55-6	Propylene glycol.
75-56-9	Propylene oxide.
110-86-1	Pyridine.
106-51-4	Quinone.
108-46-3	Resorcinol.
27138-57-4	Resorcylic acid.
69-72-7	Salicylic acid.
127-09-3	Sodium acetate.
532-32-1	Sodium benzoate.
9004-32-4	Sodium carboxymethyl cellulose.
3926-62-3	Sodium chloroacetate.
141-53-7	Sodium formate.
139-02-6	Sodium phenate.
110-44-1	Sorbic acid.
100-42-5	Styrene.
110-15-6	Succinic acid.
110-61-2	Succinonitrile.
121-57-3	Sulfanilic acid.
126-33-0	Sulfolane.
1401-55-4	Tannic acid.
100-21-0	Terephthalic acid.
79-34-5*c*	Tetrachloroethanes.
117-08-8	Tetrachlorophthalic anhydride.
78-00-2	Tetraethyl lead.
119-64-2	Tetrahydronapthalene.
85-43-8	Tetrahydrophthalic anhydride.
75-74-1	Tetramethyl lead.
100-60-1	Tetramethylenediamine.
100-18-9	Tetramethylethylenediamine.
108-88-3	Toluene.
95-80-7	Toluene-2,4-diamine.
584-84-9	Toluene-2,4-diisocyanate.
26471-62-5	Toluene diisocyanates (mixture).
1333-07-9	Toluenesulfonamide.
104-15-4*c*	Toluenesulfonic acids.
98-59-9	Toluenesulfonyl chloride.
26915-12-8	Toluidines.
87-61-6, 108-70-3, 120-82-1*c*	Trichlorobenzenes.
71-55-6	1,1,1-trichloroethane.
79-00-5	1,1,2-trichloroethane.
79-01-6	Trichloroethylene.
75-69-4	Trichlorofluoromethane.
96-18-4	1,2,3-trichloropropane.
76-13-1	1,1,2-trichloro-1,2,2-trifluoroethane.
121-44-8	Triethylamine.
112-27-6	Triethylene glycol.
112-49-2	Triethylene glycol dimethyl ether.
7756-94-7	Triisobutylene.
75-50-3	Trimethylamine.
57-13-6	Urea.
108-05-4	Vinyl acetate.
75-01-4	Vinyl chloride.
75-35-4	Vinylidene chloride.
25013-15-4	Vinyl toluene.
1330-20-7	Xylenes (mixed).
95-47-6	o-xylene.
106-42-3	p-xylene.
1300-71-6	Xylenol.
1300-73-8	Xylidine.

a CAS numbers refer to the Chemical Abstracts Registry numbers assigned to specific chemicals, isomers, or mixtures of chemicals. Some isomers or mixtures that are covered by the standards do not have CAS numbers assigned to them. The standards apply to all of the chemicals listed, whether CAS numbers have been assigned or not.

b No CAS numbers(s) have been assigned to this chemical, its isomers, or mixtures containing these chemicals.

c CAS numbers for some of the isomers are listed; the standards apply to all of the isomers and mixtures, even if CAS numbers have not been assigned.

APPENDIX 9

WEATHER DATA

Precipitation Summary Table

LOCATION	TOTAL NO. OF DAYS OF 0.01 in OR MORE PRECIP (per year)	TOTAL NO. OF DAYS OF 0.25 in OR MORE PRECIP (per year)	MEAN NO. DAYS WITH AVG. DAILY TEMP BELOW 32oF (per year)	MEAN NO. DAYS SNOW COVER (per year)
Columbus, MS (Tupelo, MS)	107.2	No Data	5.9	1.4

Ambient Temperatures and Pressure

LOCATION	TEMPERATURE			PRESSURE (in)
	DAY MAX (oF)	DAY MIN (oF)	DELTA TEMP (oF)	
Columbus, MS (Tupelo, MS)	73.7	50	23.7	14.58

Average Monthly Temperature and Wind Velocity

	Columbus, MS (Tupelo, MS)
January	
Temp (oF)	41.2
Wind Speed (mph)	7.5
Evaporation Rate(inches)	
February	
Temp (oF)	44.9
Wind Speed (mph)	8.3
Evaporation Rate(inches)	
March	
Temp (oF)	52.6
Wind Speed (mph)	8.1
Evaporation Rate(inches)	
April	
Temp (oF)	62.6
Wind Speed (mph)	7.6
Evaporation Rate(inches)	
May	
Temp (oF)	70.4
Wind Speed (mph)	6.9
Evaporation Rate(inches)	
June	
Temp (oF)	77.7
Wind Speed (mph)	5.8
Evaporation Rate(inches)	
July	
Temp (oF)	80.9
Wind Speed (mph)	5.8
Evaporation Rate(inches)	
August	
Temp (oF)	80.1
Wind Speed (mph)	5.6
Evaporation Rate(inches)	
September	
Temp (oF)	74.1
Wind Speed (mph)	6.5
Evaporation Rate(inches)	
October	
Temp (oF)	62.3
Wind Speed (mph)	6.2
Evaporation Rate(inches)	
November	
Temp (oF)	51.1
Wind Speed (mph)	7.7
Evaporation Rate(inches)	
December	
Temp (oF)	44.1
Wind Speed (mph)	7.9
Evaporation Rate(inches)	

(a) Units are given in inches squared.