FREEPORT-McMoRAN

Tyrone Operations
P.O. Box 571
Tyrone, NM 88065

November 9, 2020

Via Electronic
Certified Mail #9171999991703579972722
Return Receipt Requested

New Mexico Environment Department
Air Quality Bureau
Permitting Section
525 Camino de los Marquez, Suite 1
Santa Fe, NM 87505-1816

Dear Permitting Section Manager:

Re: Freeport-McMoRan Tyrone Inc. - Tyrone Mine
NSR Significant Permit Revision Application for NSR Permit No. PSD2448-M5

Freeport-McMoRan Tyrone Inc. is submitting this enclosed NSR significant permit revision application for its existing Tyrone Mine facility, which is located 4.5 miles southwest of Tyrone, New Mexico in Grant County. This permit application is being submitted under 20.2.72.219.D NMAC to allow for mining and hauling activities in six (6) new operating scenarios. These new operating scenarios encompass the following pits in various combinations: Mohawk, Copper Mountain, Copper Leach, Burro Chief, and Little Rock 6. Each scenario, which is detailed in the enclosed permit application, contains two pits in operation at a time.

The existing operating scenario in the Gettysburg and Mohawk pits, as approved in NSR Permit No. PSD2448-M5, will continue to be utilized, so the new scenarios in this permit application will be in addition to the existing scenario. No other operating scenarios are currently needed by the Tyrone Mine, including the previously permitted operating scenarios in NSR Permit Nos. PSD2448-M2 and -M3.

New reclamation hauling and material handling activities are also represented in this permit application, which will supersede the reclamation activities allowed by NSR Permit Nos. PSD2448-M5, -M3, and -M2.

Other changes requested in this permit application include:

- The addition of two new boilers that will serve as the SX heat exchanger hot water heaters.
- Updates to the Crushing & Screening Plant (C&S Plant; previously listed in the permit as SP-7A) emissions due to the planned activities. The C&S Plant will be owned and operated by a contractor that has an approved registration to operate under General Construction Permit-

2 (GCP-2), Revision 3, dated 9/12/2006, an approved Relocation Notice, and an approved equipment list. The C&S Plant will be powered by facility-provided electric power.

- Updates to the existing Gasoline Dispensing Facilities (GDF1, GDF2) VOC emission calculations based on the June 2020 updated AP-42 Chapter 7 (Liquid Storage Tanks). The HAP emission calculations were also updated to reflect accurate gasoline HAP constituents. The throughput of each GDF was increased to a maximum of 9,950 gal/month.
- Updates to the SO_2 and VOC emission factors for the two existing cathode washing hot water heaters. The SO_2 emission factor was updated to reflect the correct sulfur content of propane and the VOC emission factor was updated to reflect only the non-methane portion of the TOC emission factor.
- Various updates to the diesel engine/pump emissions, which include some engine horsepower changes, emission factor changes, fuel usage rate changes, and greenhouse gas calculation changes.

For all of the other existing equipment, no changes are being requested.

As a result of these changes, annual stack emissions at the facility will decrease for all pollutants except CO, which will increase by 17.3 tpy. Annual fugitive emissions at the facility will increase for all pollutants except TSP/PM_{10}/$PM_{2.5}$ and HAPs.

The format and content of this application are consistent with the Air Quality Bureau's current policy regarding NSR applications and uses the most current required forms. Enclosed is one hard copy and one working copy of the application, including an original certification page and an application check. Electronic copies will be submitted via the Secure Electronic Transfer option.

If you have any questions or need additional information, please don't hesitate to contact me at (575) 912-5777 or via e-mail at lnix@fmi.com.

Sincerely,

Lee A. Nix

Lee A. Nix
Chief Environmental Engineer
Environmental Services

LAN
Enclosures: Significant Permit Revision Application
20201109-100

c: Array Environmental, LLC

Mail Application To:		For Department use only:
New Mexico Environment Department Air Quality Bureau Permits Section 525 Camino de los Marquez, Suite 1 Santa Fe, New Mexico, 87505 Phone: (505) 476-4300 Fax: (505) 476-4375 www.env.nm.gov/aqb		AIRS No.:

Universal Air Quality Permit Application

Use this application for NOI, NSR, or Title V sources.

Use this application for: the initial application, modifications, technical revisions, and renewals. For technical revisions, complete Sections, 1-A, 1-B, 2-E, 3, 9 and any other sections that are relevant to the requested action; coordination with the Air Quality Bureau permit staff prior to submittal is encouraged to clarify submittal requirements and to determine if more or less than these sections of the application are needed. Use this application for streamline permits as well. See Section 1-I for submittal instructions for other permits.

This application is submitted as (check all that apply)**:** ☐ Request for a No Permit Required Determination (no fee)
☐ **Updating** an application currently under NMED review. Include this page and all pages that are being updated (no fee required).
Construction Status: ☐ Not Constructed ☑ Existing Permitted (or NOI) Facility ☐ Existing Non-permitted (or NOI) Facility
Minor Source: ☐ a NOI 20.2.73 NMAC ☑ 20.2.72 NMAC application or revision ☐ 20.2.72.300 NMAC Streamline application
Title V Source: ☐ Title V (new) ☐ Title V renewal ☐ TV minor mod. ☐ TV significant mod. TV Acid Rain: ☐ New ☐ Renewal
PSD Major Source: ☐ PSD major source (new) ☐ minor modification to a PSD source ☐ a PSD major modification

Acknowledgements:
☑ I acknowledge that a pre-application meeting is available to me upon request. ☐ Title V Operating, Title IV Acid Rain, and NPR applications have no fees.
☑ $500 NSR application Filing Fee enclosed OR ☐ The full permit fee associated with 10 fee points (required w/ streamline applications).
☑ Check No.: **957563** in the amount of **$500**.
☑ I acknowledge the required submittal format for the hard copy application is printed double sided 'head-to-toe', 2-hole punched (except the Sect. 2 landscape tables is printed 'head-to-head'), numbered tab separators. Incl. a copy of the check on a separate page.
☐ This facility qualifies to receive assistance from the Small Business Environmental Assistance program (SBEAP) and qualifies for 50% of the normal application and permit fees. Enclosed is a check for 50% of the normal application fee which will be verified with the Small Business Certification Form for your company.
☐ This facility qualifies to receive assistance from the Small Business Environmental Assistance Program (SBEAP) but does not qualify for 50% of the normal application and permit fees. To see if you qualify for SBEAP assistance and for the small business certification form go to https://www.env.nm.gov/aqb/sbap/small_business_criteria.html).

Citation: Please provide the **low level citation** under which this application is being submitted: **20.2.72.219.D.(1)(a) NMAC**
(e.g. application for a new minor source would be 20.2.72.200.A NMAC, one example for a Technical Permit Revision is 20.2.72.219.B.1.b NMAC, a Title V acid rain application would be: 20.2.70.200.C NMAC)

Section 1 – Facility Information

Section 1-A: Company Information

		AI # if known (see 1st 3 to 5 #s of permit IDEA ID No.): **527**	Updating Permit/NOI #: **PSD2448-M5**
1	Facility Name: **Tyrone Mine**	Plant primary SIC Code (4 digits): **1021**	
		Plant NAIC code (6 digits): **212230**	
a	Facility Street Address (If no facility street address, provide directions from a prominent landmark): **Highway 90 South, Tyrone Mine Road, Tyrone, NM 88065**		
2	Plant Operator Company Name: **Freeport-McMoRan Tyrone Inc.**	Phone/Fax: **(575) 912-5101 / (575) 912-5021**	
a	Plant Operator Address: **P.O. Box 571, Tyrone, NM 88065**		
b	Plant Operator's New Mexico Corporate ID or Tax ID: **02-952187-004**		

3	Plant Owner(s) name(s): **Freeport-McMoRan Tyrone Inc.**	Phone/Fax: **(575) 912-5101 / (575) 912-5021**
a	Plant Owner(s) Mailing Address(s): **P.O. Box 571, Tyrone, NM 88065**	
4	Bill To (Company): **Freeport-McMoRan Tyrone Inc.**	Phone/Fax: **(575) 912-5101 / (575) 912-5021**
a	Mailing Address: **P.O. Box 571, Tyrone, NM 88065**	E-mail: **Ebower@fmi.com**
5	Ľ Preparer: ☑ Consultant: **Claire Booth, Array Environmental, LLC**	Phone/Fax: **(720) 316-9935**
a	Mailing Address: **1496 Conestoga Circle, Steamboat Springs, CO 80487**	E-mail: **claire@arrayenvironmental.com**
6	Plant Operator Contact: **Erich Bower**	Phone/Fax: **(575) 912-5101 / (575) 912-5021**
a	Address: **P.O. Box 571, Tyrone, NM 88065**	E-mail: **Ebower@fmi.com**
7	Air Permit Contact: **Lee Nix**	Title: **Chief Environmental Engineer**
a	E-mail: **lnix@fmi.com**	Phone/Fax: **(575) 912-5777 / (575) 912-5031**
b	Mailing Address: **P.O. Box 571, Tyrone, NM 88065**	
c	The designated Air permit Contact will receive all official correspondence (i.e. letters, permits) from the Air Quality Bureau.	

Section 1-B: Current Facility Status

1.a	Has this facility already been constructed? ☑ Yes Ľ No	1.b If yes to question 1.a, is it currently operating in New Mexico? ☑ Yes Ľ No
2	If yes to question 1.a, was the existing facility subject to a Notice of Intent (NOI) (20.2.73 NMAC) before submittal of this application? Ľ Yes ☑ No	If yes to question 1.a, was the existing facility subject to a construction permit (20.2.72 NMAC) before submittal of this application? ☑ Yes Ľ No
3	Is the facility currently shut down? Ľ Yes ☑ No	If yes, give month and year of shut down (MM/YY): **N/A**
4	Was this facility constructed before 8/31/1972 and continuously operated since 1972? ☑ Yes Ľ No	
5	If Yes to question 4, has this facility been modified (see 20.2.72.7.P NMAC) or the capacity increased since 8/31/1972? ☑ Yes Ľ No Ľ N/A	
6	Does this facility have a Title V operating permit (20.2.70 NMAC)? ☑ Yes Ľ No	If yes, the permit No. is: **P147-R2M1**
7	Has this facility been issued a No Permit Required (NPR)? Ľ Yes ☑ No	If yes, the NPR No. is: **N/A**
8	Has this facility been issued a Notice of Intent (NOI)? Ľ Yes ☑ No	If yes, the NOI No. is: **N/A**
9	Does this facility have a construction permit (20.2.72/20.2.74 NMAC)? ☑ Yes Ľ No	If yes, the permit No. is: **PSD2448-M5**
10	Is this facility registered under a General permit (GCP-1, GCP-2, etc.)? Ľ Yes ☑ No	If yes, the register No. is: **N/A**

Section 1-C: Facility Input Capacity & Production Rate

1	What is the facility's maximum input capacity, specify units (reference here and list capacities in Section 20, if more room is required)			
a	Current	Hourly: **N/A**	Daily: **400,000 tons rock (PSD2448-M5)**	Annually: **146,000,000 tons rock (PSD2448-M5)**
b	Proposed	Hourly: **N/A**	Daily: **400,000 tons rock (max)**	Annually: **146,000,000 tons rock (max)**
2	What is the facility's maximum production rate, specify units (reference here and list capacities in Section 20, if more room is required)			
a	Current	Hourly: **N/A**	Daily: **225 tons copper cathode**	Annually: **82,125 tons copper cathode**
b	Proposed	Hourly: **N/A**	Daily: **225 tons copper cathode**	Annually: **82,125 tons copper cathode**

Section 1-D: Facility Location Information

1	Section: **10, 11, 13-17, 21-28**	Range: **15W**	Township: **19S**	County: **Grant**	Elevation (ft): **5,801 ft**
2	UTM Zone: ☑ 12 or Ľ 13			Datum: Ľ NAD 27 Ľ NAD 83 **X** WGS 84	
a	UTM E (in meters, to nearest 10 meters): **744,430 m E**			UTM N (in meters, to nearest 10 meters): **3,618,400 m N**	
b	**AND** Latitude (deg., min., sec.): **32° 40' 34.5" N**			**AND** Longitude (deg., min., sec.): **-108º 23' 35.8" W**	
3	Name and zip code of nearest New Mexico town: **Tyrone, NM 88065**				
4	Detailed Driving Instructions from nearest NM town (attach a road map if necessary): **From Tyrone, NM head south on Hwy 90. After approximately 5 miles, the facility will be on the right.**				
5	The facility is **5 miles southwest of Tyrone.**				
6	Status of land at facility (check one): ☑ Private Ľ Indian/Pueblo ☑ Federal BLM ☑ Federal Forest Service ☑ Other: **State**				
7	List all municipalities, Indian tribes, and counties within a ten (10) mile radius (20.2.72.203.B.2 NMAC) of the property on which the facility is proposed to be constructed or operated: **Municipalities: Silver City, NM. Indian Tribes: None. Counties: Grant, Luna**				
8	**20.2.72** NMAC applications **only**: Will the property on which the facility is proposed to be constructed or operated be closer than 50 km (31 miles) to other states, Bernalillo County, or a Class I area (see www.env.nm.gov/aqb/modeling/class1areas.html)? ☑ Yes Ľ No (20.2.72.206.A.7 NMAC) If yes, list all with corresponding distances in kilometers: **Gila Wilderness Area, 37 km**				
9	Name nearest Class I area: **Gila Wilderness Area**				
10	Shortest distance (in km) from facility boundary to the boundary of the nearest Class I area (to the nearest 10 meters): **37 km**				
11	Distance (meters) from the perimeter of the Area of Operations (AO is defined as the plant site inclusive of all disturbed lands, including mining overburden removal areas) to nearest residence, school or occupied structure: **110 m**				
12	Method(s) used to delineate the Restricted Area: **Fencing, rugged physical terrain with steep grades.** "**Restricted Area**" is an area to which public entry is effectively precluded. Effective barriers include continuous fencing, continuous walls, or other continuous barriers approved by the Department, such as rugged physical terrain with steep grade that would require special equipment to traverse. If a large property is completely enclosed by fencing, a restricted area within the property may be identified with signage only. Public roads cannot be part of a Restricted Area.				
13	Does the owner/operator intend to operate this source as a portable stationary source as defined in 20.2.72.7.X NMAC? Ľ Yes ☑ No A portable stationary source is not a mobile source, such as an automobile, but a source that can be installed permanently at one location or that can be re-installed at various locations, such as a hot mix asphalt plant that is moved to different job sites.				
14	Will this facility operate in conjunction with other air regulated parties on the same property? ☑ No Ľ Yes If yes, what is the name and permit number (if known) of the other facility? **N/A**				

Section 1-E: Proposed Operating Schedule **(The 1-E.1 & 1-E.2 operating schedules may become conditions in the permit.)**

1	Facility **maximum** operating ($\frac{hours}{day}$): **24**	($\frac{days}{week}$): **7**	($\frac{weeks}{year}$): **52**	($\frac{hours}{year}$): **8,760**	
2	Facility's maximum daily operating schedule (if less than 24 $\frac{hours}{day}$)? Start: **N/A**	☐AM ☐PM	End: **N/A**	☐AM ☐PM	
3	Month and year of anticipated start of construction: **Upon receipt of permit and payment of application fees**				
4	Month and year of anticipated construction completion: **TBD**				
5	Month and year of anticipated startup of new or modified facility: **TBD**				
6	Will this facility operate at this site for more than one year? ☑ Yes Ľ No				

Section 1-F: Other Facility Information

1	Are there any current Notice of Violations (NOV), compliance orders, or any other compliance or enforcement issues related to this facility? ☐ Yes ☑ No If yes, specify: **N/A**		
a	If yes, NOV date or description of issue: **N/A**		If yes, NOV date or description of issue: **N/A**
b	Is this application in response to any issue listed in 1-F, 1 or 1a above? ☐ Yes ☑ No If Yes, provide the 1c & 1d info below: **N/A**		
c	Document Title: **N/A**	Date: **N/A**	Requirement # (or page # and paragraph #): **N/A**
d	Provide the required text to be inserted in this permit: **N/A**		
2	Is air quality dispersion modeling or modeling waiver being submitted with this application? ☑ Yes ☐ No		
3	Does this facility require an "Air Toxics" permit under 20.2.72.400 NMAC & 20.2.72.502, Tables A and/or B? ☐ Yes ☑ No		
4	Will this facility be a source of federal Hazardous Air Pollutants (HAP)? ☑ Yes ☐ No		
a	If Yes, what type of source? ☐ **Major** (☐ ≥10 tpy of any single HAP **OR** ☐ ≥25 tpy of any combination of HAPS) **OR** ☑ **Minor** (☑ <10 tpy of any single HAP **AND** ☑ <25 tpy of any combination of HAPS)		
5	Is any unit exempt under 20.2.72.202.B.3 NMAC? ☑ Yes ☐ No		
a	If yes, include the name of company providing commercial electric power to the facility: **PNM** Commercial power is purchased from a commercial utility company, which specifically does not include power generated on site for the sole purpose of the user.		

Section 1-G: Streamline Application

(This section applies to 20.2.72.300 NMAC Streamline applications only)

1	☐ I have filled out Section 18, "Addendum for Streamline Applications."	☑ N/A (This is not a Streamline application.)

Section 1-H: Current Title V Information - Required for all applications from TV Sources

(Title V-source required information for all applications submitted pursuant to 20.2.72 NMAC (Minor Construction Permits), or 20.2.74/20.2.79 NMAC (Major PSD/NNSR applications), and/or 20.2.70 NMAC (Title V))

1	Responsible Official (R.O.) (20.2.70.300.D.2 NMAC): **Erich J. Bower**	Phone: **(575) 912-5101**
a	R.O. Title: **President, General Manager**	R.O. e-mail: ebower@fmi.com
b	R. O. Address: **Hwy 90 South, Tyrone Mine Road, Tyrone, NM 88065**	
2	Alternate Responsible Official (20.2.70.300.D.2 NMAC): **Ronald Gerdes**	Phone: **(575) 912-5801**
a	A. R.O. Title: **Manager, Operations**	A. R.O. e-mail: rgerdes@fmi.com
b	A. R. O. Address: **Hwy 90 South, Tyrone Mine Road, Tyrone, NM 88065**	
3	Company's Corporate or Partnership Relationship to any other Air Quality Permittee (List the names of any companies that have operating (20.2.70 NMAC) permits and with whom the applicant for this permit has a corporate or partnership relationship): **Chino Mines Company**	
4	Name of Parent Company ("Parent Company" means the primary name of the organization that owns the company to be permitted wholly or in part.): **Freeport-McMoRan Inc.**	
a	Address of Parent Company: **333 N. Central Ave, Phoenix, AZ 85004**	
5	Names of Subsidiary Companies ("Subsidiary Companies" means organizations, branches, divisions or subsidiaries, which are owned, wholly or in part, by the company to be permitted.): **N/A**	
6	Telephone numbers & names of the owners' agents and site contacts familiar with plant operations: **N/A**	

7	Affected Programs to include Other States, local air pollution control programs (i.e. Bernalillo) and Indian tribes: Will the property on which the facility is proposed to be constructed or operated be closer than 80 km (50 miles) from other states, local pollution control programs, and Indian tribes and pueblos (20.2.70.402.A.2 and 20.2.70.7.B)? If yes, state which ones and provide the distances in kilometers: **Municipalities: Silver City (9.5 km), Deming (66 km). Indian Tribes: None. States: Arizona (57 km).**

Section 1-I – Submittal Requirements

Each 20.2.73 NMAC (**NOI**), a 20.2.70 NMAC (**Title V**), a 20.2.72 NMAC (**NSR** minor source), or 20.2.74 NMAC (**PSD**) application package shall consist of the following:

Hard Copy Submittal Requirements:

1) One hard copy **original signed and notarized application package printed double sided 'head-to-toe' 2-hole punched** as we bind the document on top, not on the side; except Section 2 (landscape tables), which should be head-to-head. Please use **numbered tab separators** in the hard copy submittal(s) as this facilitates the review process. For NOI submittals only, hard copies of UA1, Tables 2A, 2D & 2F, Section 3 and the signed Certification Page are required. Please include a copy of the check on a separate page.

2) If the application is for a minor NSR, PSD, NNSR, or Title V application, include one working hard **copy** for Department use. This copy should be printed in book form, 3-hole punched, and **must be double sided**. Note that this is in addition to the head-to-to 2-hole punched copy required in 1) above. Minor NSR Technical Permit revisions (20.2.72.219.B NMAC) only need to fill out Sections 1-A, 1-B, 3, and should fill out those portions of other Section(s) relevant to the technical permit revision. TV Minor Modifications need only fill out Sections 1-A, 1-B, 1-H, 3, and those portions of other Section(s) relevant to the minor modification. NMED may require additional portions of the application to be submitted, as needed.

3) The entire NOI or Permit application package, including the full modeling study, should be submitted electronically. Electronic files for applications for NOIs, any type of General Construction Permit (GCP), or technical revisions to NSRs must be submitted with compact disk (CD) or digital versatile disc (DVD). For these permit application submittals, two CD copies are required (in sleeves, not crystal cases, please), with additional CD copies as specified below. NOI applications require only a single CD submittal. Electronic files for other New Source Review (construction) permits/permit modifications or Title V permits/permit modifications can be submitted on CD/DVD or sent through AQB's secure file transfer service.

Electronic files sent by (check one):

☐ CD/DVD attached to paper application

☑ secure electronic transfer. Air Permit Contact Name: Lee Nix

Email: lnix@fmi.com

Phone number: (575) 912-5777

a. If the file transfer service is chosen by the applicant, after receipt of the application, the Bureau will email the applicant with instructions for submitting the electronic files through a secure file transfer service. Submission of the electronic files through the file transfer service needs to be completed within 3 business days after the invitation is received, so the applicant should ensure that the files are ready when sending the hard copy of the application. The applicant will not need a password to complete the transfer. **Do not use the file transfer service for NOIs, any type of GCP, or technical revisions to NSR permits.**

4) Optionally, the applicant may submit the files with the application on compact disk (CD) or digital versatile disc (DVD) following the instructions above and the instructions in 5 for applications subject to PSD review.

5) If **air dispersion modeling** is required by the application type, include the **NMED Modeling Waiver** and/or electronic air dispersion modeling report, input, and output files. The dispersion modeling ***summary report only*** should be submitted as hard copy(ies) unless otherwise indicated by the Bureau.

6) If the applicant submits the electronic files on CD and the application is subject to PSD review under 20.2.74 NMAC (PSD) or NNSR under 20.2.79 NMC include,
   a. one additional CD copy for US EPA,
   b. one additional CD copy for each federal land manager affected (NPS, USFS, FWS, USDI) and,
   c. one additional CD copy for each affected regulatory agency other than the Air Quality Bureau.

   If the application is submitted electronically through the secure file transfer service, these extra CDs do not need to be submitted.

Electronic Submittal Requirements [in addition to the required hard copy(ies)]:

1) All required electronic documents shall be submitted as 2 separate CDs or submitted through the AQB secure file transfer service. Submit a single PDF document of the entire application as submitted and the individual documents comprising the application.

2) The documents should also be submitted in Microsoft Office compatible file format (Word, Excel, etc.) allowing us to access the text and formulas in the documents (copy & paste). Any documents that cannot be submitted in a Microsoft Office compatible

format shall be saved as a PDF file from within the electronic document that created the file. If you are unable to provide Microsoft office compatible electronic files or internally generated PDF files of files (items that were not created electronically: i.e. brochures, maps, graphics, etc,), submit these items in hard copy format. We must be able to review the formulas and inputs that calculated the emissions.

3) It is preferred that this application form be submitted as 4 electronic files (3 MSWord docs: Universal Application section 1 [UA1], Universal Application section 3-19 [UA3], and Universal Application 4, the modeling report [UA4]) and 1 Excel file of the tables (Universal Application section 2 [UA2]). Please include as many of the 3-19 Sections as practical in a single MS Word electronic document. Create separate electronic file(s) if a single file becomes too large or if portions must be saved in a file format other than MS Word.

4) The electronic file names shall be a maximum of 25 characters long (including spaces, if any). The format of the electronic Universal Application shall be in the format: "A-3423-FacilityName". The "A" distinguishes the file as an application submittal, as opposed to other documents the Department itself puts into the database. Thus, all electronic application submittals should begin with "A-". Modifications to existing facilities should use the core permit number (i.e. '3423') the Department assigned to the facility as the next 4 digits. Use 'XXXX' for new facility applications. The format of any separate electronic submittals (additional submittals such as non-Word attachments, re-submittals, application updates) and Section document shall be in the format: "A-3423-9-description", where "9" stands for the section # (in this case Section 9-Public Notice). Please refrain, as much as possible, from submitting any scanned documents as this file format is extremely large, which uses up too much storage capacity in our database. Please take the time to fill out the header information throughout all submittals as this will identify any loose pages, including the Application Date (date submitted) & Revision number (0 for original, 1, 2, etc.; which will help keep track of subsequent partial update(s) to the original submittal. Do not use special symbols (#, @, etc.) in file names. The footer information should not be modified by the applicant.

Table of Contents

FREEPORT-McMoRAN

Freeport-McMoRan Inc.
Attention: Accounts Payable
4340 E Cotton Center Blvd, Suite 110
Phoenix, AZ. 85040

RETURN SERVICE REQUESTED

Check No.	0000957563
Check Date	10/05/2020
Check Amount	$500.00
Vendor No.	0000804346
Payment Reference No.	20605887321899

OD-000006 0001 0001 000006
NEW MEXICO ENVIRONMENT DEPT
AIR QUAILITY BUREAU
525 CAMINO DE LOS MARQUEZ STE 1
SANTE FE, NM 87505-1837

PLEASE DIRECT ANY INQUIRIES
TO THE AP HELP DESK:
AP@FMI.COM

Invoice Date	Invoice Number	PO#/Freeport Site/ Description	Invoice Amount	Discount Amount	Net Amount
10/02/2020	10022020LP	FM Tyrone Mining LLC 2020 NSR Application Filing Fe	$500.00		$500.00
		TOTAL			$500.00

⬇ PLEASE FOLD ON PERFORATION AND DETACH HERE ⬇

VERIFY THE AUTHENTICITY OF THIS MULTI-TONE SECURITY DOCUMENT. CHECK BACKGROUND AREA CHANGES COLOR GRADUALLY FROM TOP TO BOTTOM.

FREEPORT MINERALS CORPORATION
333 NORTH CENTRAL AVE
PHOENIX, AZ 85004-2121

FREEPORT-McMoRAN

0000957563
October 05, 2020
64-1278/611
VOID AFTER 180 DAYS
PAY IN US DOLLARS

Amount: **Five Hundred dollars and 00 cents**

$500.00

Pay to the order of NEW MEXICO ENVIRONMENT DEPT
AIR QUAILITY BUREAU

Bank of America N.A.
Atlanta, Dekalb County, Georgia

AUTHORIZED SIGNATURE

⑈0000957563⑈ ⑆061112788⑆ 329999844 5⑈

Table 2-A: Regulated Emission Sources

Unit and stack numbering must correspond throughout the application package. If applying for a NOI under 20.2.73 NMAC, equipment exemptions under 2.72.202 NMAC do not apply.

Unit Number[1]	Source Description	Make	Model #	Serial #	Manufacturer's Rated Capacity[3] (Specify Units)	Requested Permitted Capacity[3] (Specify Units)	Date of Manufacture[2] Date of Construction/ Reconstruction[2]	Controlled by Unit # Emissions vented to Stack #	Source Classi-fication Code (SCC)	For Each Piece of Equipment, Check One	RICE Ignition Type (CI, SI, 4SLB, 4SRB, 2SLB)[4]	Replacing Unit No.
SX/EW-1 (Fugitive)	Mixer/Settlers (6 Extraction & 4 Stripping)	N/A	N/A	N/A	61,366 SF	61,366 SF	1/2/2001 1/2/2001	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
SX/EW-2 (Fugitive)	SX/EW (3) Acid Tank House	N/A	N/A	N/A	24,000 gal/min	24,000 gal/min	1/2/1984 1/2/1984	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
SX/EW-3 (Fugitive)	Raffinate Tank 1 - Open	N/A	N/A	N/A	2 million gallons	2 million gallons	1/2/2001 1/2/2001	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
SX/EW-4 (Fugitive)	Raffinate Tank 2 - Open	N/A	N/A	N/A	0.4 million gallons	0.4 million gallons	1/2/2001 1/2/2001	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
B-748	Hot Water Boiler (Cathode Washing)	Lochinvar Corporation	Unknown	C11H00231748	1.256 MMBtu/hr	1.256 MMBtu/hr	6/26/2012 	N/A SXWBOIL	10201002	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
B-951	Hot Water Boiler (Cathode Washing)	Lochinvar Corporation	Unknown	DI2H00239951	1.256 MMBtu/hr	1.256 MMBtu/hr	2/28/2012 	N/A SXWBOIL	10201002	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
B-3891	Hot Water Boiler (Heat Exchanger)	Parker Boiler Co.	T3600	963891	3.6 MMBtu/hr	3.6 MMBtu/hr	2000 2020-2021	N/A B-3891	10201002	☐ Existing (unchanged) ☐ To be Removed ☑ **New/Additional** ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
B-1454	Hot Water Boiler (Heat Exchanger)	Parker Boiler Co.	T3600	961454	3.6 MMBtu/hr	3.6 MMBtu/hr	2000 2020-2021	N/A B-1454	10201002	☐ Existing (unchanged) ☐ To be Removed ☑ **New/Additional** ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
SD-1	Diesel Engine for Water Pump	Caterpillar	C9	JSC16214	300 hp	300 hp	9/2/2010 12/16/2010	N/A SD-1	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
SD-2	Diesel Engine for Water Pump	Caterpillar	C9	JSC25024	300 hp	300 hp	5/24/2012 2/1/2013	N/A SD-2	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-101	Diesel Engine for Water Pump	John Deere	4045TF250	T04045T780502	125 hp	125 hp	7/23/1998 1/25/2000	N/A ENV-101	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-111	Diesel Engine for Water Pump	John Deere	4045TF250	T04045T884613	125 hp	125 hp	5/16/2001 12/8/2004	N/A ENV-111	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-117	Diesel Engine for Water Pump	John Deere	4045TF275	PE4045T491314	115 hp	115 hp	10/22/2002 TBD	N/A ENV-117	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-122	Diesel Engine for Water Pump	Caterpillar	3054C	33408431	125 hp	125 hp	5/1/2005 6/3/2005	N/A ENV-122	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-123	Diesel Engine for Water Pump	Caterpillar	3126B	BEJ10905	225 hp	225 hp	6/29/2005 12/14/2005	N/A ENV-123	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
Mine Blasting (Fugitive)	Blasting	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
Mine Handling (Fugitive)	Handling	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
Mine Hauling (Fugitive)	Hauling	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
Mine Stockpiles (Fugitive)	Stockpiles	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☑ **To be Removed** **[combined with "Mine Handling (Fugitive)"]** ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A

Unit Number[1]	Source Description	Make	Model #	Serial #	Manufacturer's Rated Capacity[3] (Specify Units)	Requested Permitted Capacity[3] (Specify Units)	Date of Manufacture[2] Date of Construction/ Reconstruction[2]	Controlled by Unit # Emissions vented to Stack #	Source Classi-fication Code (SCC)	For Each Piece of Equipment, Check One	RICE Ignition Type (CI, SI, 4SLB, 4SRB, 2SLB)[4]	Replacing Unit No.
Reclamation Handling (Fugitive)	Handling	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
Reclamation Hauling (Fugitive)	Hauling	N/A	N/A	N/A	N/A	N/A	1/2/2001 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
C&S Plant (formerly SP-7A) Handling (Fugitive)	Crushing and Screening Plant Handling	N/A	N/A	N/A	N/A	N/A	7/16/2010 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
C&S Plant (formerly SP-7A) Hauling (Fugitive)	Crushing and Screening Plant Hauling	N/A	N/A	N/A	N/A	N/A	7/16/2010 	N/A N/A	30388801	☐ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☑ **To Be Modified** ☐ To be Replaced	N/A	N/A
SPCC-TYR-061 (GDF1)	Gasoline Dispensing Facility	N/A	N/A	N/A	20,000 gal	20,000 gal	N/A 1984	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
SPCC-TYR-119 (GDF2)	Gasoline Dispensing Facility	N/A	N/A	N/A	2,000 gal	2,000 gal	N/A 2008	N/A N/A	30388801	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	N/A	N/A
OP-2	Diesel Engine for Water Pump	Perkins	403C-15	401164N	32.5 hp	32.5 hp	2/27/2006 3/19/2008	N/A OP-2	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
OP-4	Diesel Engine for Water Pump	Caterpillar	C6.6	66609304	225 hp	225 hp	7/27/2008 2/4/2013	N/A OP-4	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
OP-7	Diesel Engine for Water Pump	Caterpillar	C7	JTF19093	225 hp	225 hp	2/26/2013 6/11/2013	N/A OP-7	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
OP-8	Diesel Engine for Water Pump	Caterpillar	C7	JTF16844	225 hp	225 hp	5/29/2012 11/21/2012	N/A OP-8	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
ENV-120	Diesel Engine for Water Pump	Caterpillar	C6.6	66609306	225 hp	225 hp	7/27/2008 7/16/2008	N/A ENV-120	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
EMP-1	Diesel Engine for Water Pump	Caterpillar	3126	7AS10507	190 hp	190 hp	4/21/1998 5/7/1998	N/A EMP-1	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
EMP-2	Diesel Engine for Water Pump	Caterpillar	3126B	BEJ08982	200 hp	200 hp	1/12/2005 7/29/2005	N/A EMP-2	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
CE-1	Diesel Cold Start Compressor Engine	Ford-New Holland	N/A	544593-T26KK	100 hp	100 hp	1/1/1967 7/11/2005	N/A CE-1	20200102	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	CI	N/A
PPG-1	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301202	3,090 hp	3,090 hp	1/1/1967 7/11/2005	N/A PPG-1	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-3	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301207	3,090 hp	3,090 hp	1/1/1967 7/11/2005	N/A PPG-3	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-4	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301208	3,090 hp	3,090 hp	1/1/1967 7/11/2005	N/A PPG-4	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-7	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301211	3,090 hp	3,090 hp	1/1/1967 7/11/2005	N/A PPG-7	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-8	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301212	3,090 hp	3,090 hp	1/1/1971 7/11/2005	N/A PPG-8	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A

Unit Number[1]	Source Description	Make	Model #	Serial #	Manufacturer's Rated Capacity[3] (Specify Units)	Requested Permitted Capacity[3] (Specify Units)	Date of Manufacture[2] Date of Construction/ Reconstruction[2]	Controlled by Unit # Emissions vented to Stack #	Source Classi-fication Code (SCC)	For Each Piece of Equipment, Check One	RICE Ignition Type (CI, SI, 4SLB, 4SRB, 2SLB)[4]	Replacing Unit No.
PPG-11	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301283	3,090 hp	3,090 hp	1/1/1971 7/11/2005	N/A PPG-11	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-12	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301304	3,090 hp	3,090 hp	1/1/1972 7/11/2005	N/A PPG-12	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-13	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301305	3,090 hp	3,090 hp	1/1/1972 7/11/2005	N/A PPG-13	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-14	Natural Gas/Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301306	3,090 hp	3,090 hp	1/1/1972 7/11/2005	N/A PPG-14	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A
PPG-15	Diesel Generator Engine	Nordberg	FSG-1316-HSC	10301307	3,090 hp	3,090 hp	1/1/1972 7/11/2005	N/A PPG-15	20200402	☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced	SI/CI	N/A

[1] □nit numbers must correspond to unit numbers in the previous permit unless a complete cross reference table of all units in both permits is provided.
[2] Specify dates re□uired to determine regulatory applicability.
[3] To properly account for power conversion efficiencies□generator set rated capacity shall be reported as the rated capacity of the engine in horsepower□not the □ilowatt capacity of the generator set.
□"□SLB" means four stro□e lean burn engine□"□SRB" means four stro□e rich burn engine□"2SLB" means two stro□e lean burn engine□"CI" means compression ignition□and "SI" means spar□ignition

Table 2-B: Insignificant Activities[1] (20.2.70 NMAC) OR Exempted Equipment (20.2.72 NMAC)

All 20.2.70 NMAC (Title V) applications must list all Insignificant Activities in this table. All 20.2.72 NMAC applications must list Exempted Equipment in this table. If equipment listed on this table is exempt under 20.2.72.202.B.5, include emissions calculations and emissions totals for 202.B.5 "similar functions" units, operations, and activities in Section 6, Calculations. Equipment and activities exempted under 20.2.72.202 NMAC may not necessarily be Insignificant under 20.2.70 NMAC (and vice versa). Unit & stack numbering must be consistent throughout the application package. Per Exemptions Policy 02-012.00 (see http://www.env.nm.gov/aqb/permit/aqb_pol.html), 20.2.72.202.B NMAC Exemptions do not apply, but 20.2.72.202.A NMAC exemptions do apply to NOI facilities under 20.2.73 NMAC. List 20.2.72.301.D.4 NMAC Auxiliary Equipment for Streamline applications in Table 2-A. The List of Insignificant Activities (for TV) can be found online at http://www.env.nm.gov/aqb/forms/InsignificantListTitleV.pdf . TV sources may elect to enter both TV Insignificant Activities and Part 72 Exemptions on this form.

Unit Number	Source Description	Manufacturer	Model No. / Serial No.	Max Capacity / Capacity Units	List Specific 20.2.72.202 NMAC Exemption (e.g. 20.2.72.202.B.5) / Insignificant Activity citation (e.g. IA List Item #1.a)	Date of Manufacture /Reconstruction[2] / Date of Installation /Construction[2]	For Each Piece of Equipment, Check Onc
SPCC-TYR-261	6000 weight lube oil	Advanced Pacific Tank Manufacturing, Inc.	N/A	2,000	20.2.72.202.B.2 NMAC	Unknown	☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5	Sep-16	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-264	Diesel Tank	Unknown	N/A	300	20.2.72.202.B.2 NMAC	Unknown	☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5	Aug-17	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Generac Emergency Generator 1	Generac Guardian Series 5872	Generac	5872	14,000	20.2.72.202.B.3 NMAC	6/9/2014	☑ Existing (unchanged) ☐ To be Removed
			E897264613305	W	Regulated under Title V	7/25/2015	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Generac Emergency Generator 2	Generac Guardian Series 5872	Generac	5872	14,000	20.2.72.202.B.3 NMAC	8/7/2015	☑ Existing (unchanged) ☐ To be Removed
			E922169515155	W	Regulated under Title V		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Generac Emergency Generator 3	Generac Guardian Series 6462	Generac	6462	16,000	20.2.72.202.B.3 NMAC	10/2015	☑ Existing (unchanged) ☐ To be Removed
			9001396	W	Regulated under Title V		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Generac Emergency Generator 4	Generac Guardian Series 6462	Generac	6462	16,000	20.2.72.202.B.3 NMAC	1/1/2016	☑ Existing (unchanged) ☐ To be Removed
			9972091	W	Regulated under Title V	5/2016	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
IPG	Indian Peak Generator	Generac	OHVI	19	20.2.72.202.B.3 NMAC	7/24/2018	☑ Existing (unchanged) ☐ To be Removed
			3003527048	hp	Regulated under Title V	10/2018	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
GO Generator Backup E1-128	Onan Genset	Onan Genset/Ford	LRG-425I6005A	97	20.2.72.202.B.3 NMAC	1/8/1999	☑ Existing (unchanged) ☐ To be Removed
			1494610899	hp	Regulated under Title V		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SX/EW Fire Water Pump	Cummins Fire Water Pump	Cummins	Cummins	122	20.2.72.202.A.4 NMAC	1/29/2000	☑ Existing (unchanged) ☐ To be Removed
			73388396	hp	Regulated under Title V		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SX Tankhouse Emergency Generator	Emergency Generator for Tankhouse Control Room	Caterpillar	DG60	67	20.2.72.202.B.3 NMAC	May 2019	☑ Existing (unchanged) ☐ To be Removed
			CT3700362	hp	Regulated under Title V	5/28/2019	☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Maintenance Area							
SPCC-TYR-001, -190	Diesel Storage Tanks	Unknown	N/A	500 to 550	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #8		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-002	Safety Kleen - Petroleum Based Solvent Storage Tank	Unknown	N/A	500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-003	Motor Oil Storage Tank	Unknown	N/A	550	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-004, -005, -006, -007	Power Drive Fluid Storage Tanks	Unknown	N/A	550	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-014	SAE 15W-40 Motor Oil Storage Tank	Unknown	N/A	132	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-015	SAE 10W Motor Oil Storage Tank	Unknown	N/A	132	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed
			N/A	gal	IA List Item #5		☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced

Unit Number	Source Description	Manufacturer	Model No. Serial No.	Max Capacity Capacity Units	List Specific 20.2.72.202 NMAC Exemption (e.g. 20.2.72.202.B.5) Insignificant Activity citation (e.g. IA List Item #1.a)	Date of Manufacture /Reconstruction[2] Date of Installation /Construction[2]	For Each Piece of Equipment, Check Onc
SPCC-TYR-016	SAE 30W Motor Oil Storage Tank	Unknown	N/A N/A	132 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-012, -017, -018, -019, -020, -021, -022, -023, -024, -166, -167, -189, -201, -205, -206, -207, -208, -253; Drum Storage Areas A and P	Used Oil Storage Tanks	Unknown	N/A N/A	55 to 5,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-177	Safety Kleen - Petroleum Based Solvent Storage Tank	Unknown	N/A N/A	460 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-191, -192	Clean Oil Storage Tanks	Unknown	N/A N/A	200 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Drum Storage Areas B, C, Z, D, AA, Y; SPCC-TYR-263	Lube and Oil Storage Tanks and Drums	Unknown	N/A N/A	55 to 2,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Powerhouse Area Tanks							
SPCC-TYR-025, -026, -027, -028, -031, -033, -034, -037, -038, -041, -042, -043, -044, -045	Diesel Storage Tanks	Unknown	N/A N/A	800 to 500,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-029, -059	Used Oil Storage Tank	Unknown	N/A N/A	270 to 20,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-030, -046, -048, -049, -052, -053, -056, -058, -209, -210, -211, -212, -213, -214, -215, -216, -217, -218, -219, -220; Drum Storage Area W	Lube Oil Storage Tanks	Unknown	N/A N/A	55 to 15,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-255	Oil Storage Tank	Unknown	N/A N/A	55 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Lube Shop Area Tanks							
SPCC-TYR-061	Unleaded Gasoline Storage Tank	Unknown	N/A N/A	20,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-062, -063	Red Dyed Diesel Storage Tanks	Unknown	N/A N/A	40,000 to 50,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-065, -074, -096, -097, -133, -238, -239, -240, -241, -242	Diesel Storage Tanks	Unknown	N/A N/A	300 to 40,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-066, -086, -087, -088, -089, -104, -165, -184, -231, -232, -233, -234, -245, -246, -247; Drum Storage Area G, O	Used Oil Storage Tanks	Unknown	N/A N/A	55 to 10,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-077	SAE 10 Motor Oil Storage Tank	Unknown	N/A N/A	1,500 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-080, -083, -094	SAE 10W Motor Oil Storage Tanks	Unknown	N/A N/A	450 to 2,700 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-073, -075, -079, -093, -237, -244	SAE 15W-40 Motor Oil Storage Tanks	Unknown	N/A N/A	70 to 2,700 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-076, -081, -082, -095	SAE 30 Motor Oil Storage Tanks	Unknown	N/A N/A	450 to 2,700 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced

Unit Number	Source Description	Manufacturer	Model No. / Serial No.	Max Capacity / Capacity Units	List Specific 20.2.72.202 NMAC Exemption (e.g. 20.2.72.202.B.5) / Insignificant Activity citation (e.g. IA List Item #1.a)	Date of Manufacture /Reconstruction[2] / Date of Installation /Construction[2]	For Each Piece of Equipment, Check Onc
SPCC-TYR-078	SAE 60 Motor Oil Storage Tank	Unknown	N/A N/A	2,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-084	Oily Water Storage Tank	Unknown	N/A N/A	10,000 (estimated) gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-174, -204	Megaplex XD5 #2 Grease Storage Tanks	Unknown	N/A N/A	333 to 1,050 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-230	Gear Oil Storage Tank	Unknown	N/A N/A	55 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-236; Drum Storage Area F	Turbine Oil Storage Tanks	Unknown	N/A N/A	55 to 100 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-250, -251, -252	Lube Oil Storage Tanks	Unknown	N/A N/A	150 to 250 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Drum Storage Area X	ATF and Lube Oil Storage Tank	Unknown	N/A N/A	55 (2) drums gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-235	Oil Storage Tank	Unknown	N/A N/A	70 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
Magazine Area Tanks							
SPCC-TYR-090, -091	Diesel Storage Tanks	Unknown	N/A N/A	1,000 to 9,500 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SX/EW Area Tanks							
SPCC-TYR-105, -106	Extractant Acorga M5910 Storage Tanks	Unknown	N/A N/A	10,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-107	Diluent (Organic) - Conosol 170 Storage Tank	Unknown	N/A N/A	34,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-109	Organic Makeup (Diluent-Conosol 170) Storage Tank	Unknown	N/A N/A	13,500 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-110	Barren Organic Surge Tank Storage Tank	Unknown	N/A N/A	120,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-111	Barren Organic Holding Tank Storage Tank	Unknown	N/A N/A	120,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-112, -113	"Organic Gunk" Storage Tanks	Unknown	N/A N/A	15,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-114, -115	Organic Recovery (Acorga M5910) Storage Tank	Unknown	N/A N/A	12,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-116	Organic Wash (Acorga M5910) Storage Tank	Unknown	N/A N/A	137,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
SPCC-TYR-117	Acorga M5910 Storage Tank	Unknown	N/A N/A	50,000 gal	20.2.72.202.B.(2) NMAC IA List Item #5		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced

Unit Number	Source Description	Manufacturer	Model No. / Serial No.	Max Capacity / Capacity Units	List Specific 20.2.72.202 NMAC Exemption (e.g. 20.2.72.202.B.5) / Insignificant Activity citation (e.g. IA List Item #1.a)	Date of Manufacture /Reconstruction[2] / Date of Installation /Construction[2]	For Each Piece of Equipment, Check Onc
SPCC-TYR-118, -120	Diesel Storage Tanks	Unknown	N/A	100 to 2,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-119	Unleaded Gasoline Storage Tank	Unknown	N/A	2,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-140, -141, -142, -143, -144, -145, -146, -147, -148, -149	Reagent Mix Storage Tanks	Unknown	N/A	Approx. 118,000 to 127,500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Drum Storage Area H	Super Hydraulic Oil Storage Tank	Unknown	N/A	55	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Drum Storage Area R	Lube Oil Storage Tank	Unknown	N/A	55	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Drum Storage Area I	Super Hydraulic Oil, Used Oil, 90W Motor Oil, 10W Motor Oil Storage Tank	Unknown	N/A	55 (7 drums)	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Drum Storage Area K	Used Oil and Motor Oil Storage Tank	Unknown	N/A	55	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-249	Organic Recovery Storage Tank	Unknown	N/A	500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Other Areas/Transformers							
SPCC-TYR-137A, -188, -254, -256, -257, -258, -260	Diesel Storage Tanks	Unknown	N/A	164 to 12,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Drum Storage Area M	Grease, Used Oil, Transformers, Used Absorbents Storage Tank	Unknown	N/A	55 (50 - 150 drums)	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
T1-T129 and misc. transformers	Transformer Oil Storage Tanks	Unknown	N/A	varies	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-103	Megaplex XD5 #2 Storage Tank	Unknown	N/A	540	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-172	Polyurea Grease #2 Storage Tank	Unknown	N/A	620	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-203, -248	Oily Water Storage Tanks	Unknown	N/A	2,000 to 20,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-243	Used Oil Storage Tank	Unknown	N/A	213	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-262	Grease Storage Tank	Unknown	N/A	625	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		

Unit Number	Source Description	Manufacturer	Model No.	Max Capacity	List Specific 20.2.72.202 NMAC Exemption (e.g. 20.2.72.202.B.5)	Date of Manufacture /Reconstruction[2]	For Each Piece of Equipment, Check Onc
			Serial No.	Capacity Units	Insignificant Activity citation (e.g. IA List Item #1.a)	Date of Installation /Construction[2]	
Mobile Service Tanks							
SPCC-TYR-151, -152, -153, -154, -155, -156, -157, -158, -159, -160, -161, -162, -163, -164, -170, -171, -173	Diesel Storage Tanks	Unknown	N/A	100 to 250	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-185, -186	Used Oil Storage Tanks	Unknown	N/A	130 to 500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Service Vehicles							
LS 3, 5, 8, 15, 16, 17; FM 8	Misc. Storage Tanks w/ Vapor Pressure < 10 mmHg	Unknown	N/A	900 to 1,400	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
LS 23	Grease Storage Tank	Unknown	N/A	75	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
FM19	Grease, Used Oil, Lube	Unknown	N/A	1500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
LS4, LS21; SPCC-TYR-268	Diesel Fuel Storage	Unknown	N/A	90 to 2,750	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
REC20	Diesel, Oil, and Grease Storage	Unknown	N/A	1000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Other Tanks							
SPCC-TYR-032, -035, -036, -039, -040, -125	Diesel Storage Tanks	Unknown	N/A	700 to 800	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-047, -050, -051, -054, -055, -057	Lube Oil Storage Tanks	Unknown	N/A	1,100 to 1,500	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-121	Oily Water Storage Tank	Unknown	N/A	20,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-194	Used Oil Storage Tank	Unknown	N/A	10,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
SPCC-TYR-202	Diesel Fuel Additive Storage Tank	Unknown	N/A	1,000	20.2.72.202.B.(2) NMAC		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	gal	IA List Item #5		
Non-Road Engines[3]							
NR1	Miscellaneous Pumps, Engines, Small Generators, Compressors	Varies	N/A	Varies	40 CFR 89; 40 CFR 90		☑ Existing (unchanged) ☐ To be Removed ☐ New/Additional ☐ Replacement Unit ☐ To Be Modified ☐ To be Replaced
			N/A	hp	IA List Item #6		

[1] Insignificant activities exempted due to size or production rate are defined in 20.2.70.300.D.6, 20.2.70.7.Q NMAC, and the NMED/AQB List of Insignificant Activities, dated September 15, 2008. Emissions from these insignificant activities do not need to be reported, unless specifically requested.

[2] Specify date(s) required to determine regulatory applicability.

[3] For informational purposes only. These engines satisfy the federal definition of "non-road engine" under 40 CFR §§ 89 and 90 (for compression and spark-ignition engines, respectively) and are therefore regulated by EPA as mobile sources and are not subject to state NSR and Title V permitting for stationary sources.

Table 2-C: Emissions Control Equipment

Unit and stack numbering must correspond throughout the application package. Only list control equipment for TAPs if the TAP's maximum uncontrolled emissions rate is over its respective threshold as listed in 20.2.72 NMAC, Subpart V, Tables A and B. In accordance with 20.2.72.203.A(3) and (8) NMAC, 20.2.70.300.D(5)(b) and (e) NMAC, and 20.2.73.200.B(7) NMAC, the permittee shall report all control devices and list each pollutant controlled by the control device regardless if the applicant takes credit for the reduction in emissions.

Control Equipment Unit No.	Control Equipment Description	Date Installed	Controlled Pollutant(s)	Controlling Emissions for Unit Number(s)[1]	Efficiency (% Control by Weight)	Method used to Estimate Efficiency
N/A	Water application, water sprays, and other method(s) approved by NMED to control fugitive dust.	N/A	PM_{10}, $PM_{2.5}$	Mine Fugitives (Hauling)	88.8%	NMED guidance; WRAP guidance
				C&S Plant (formerly SP-7A) Fugitives	80%	NMED guidance
N/A	Air Fuel Ratio Controllers (AFRs) on each of the Nordberg engines that were specifically designed for the Tyrone Power House to reduce emissions.	2000	NOx, CO, VOC	PPG-1, 3, 4, 7, 8, 11-15	Unknown	N/A

[1] List each control device on a separate line. For each control device, list all emission units controlled by the control device.

Table 2-D: Maximum Emissions (under normal operating conditions)

☐ **This Table was intentionally left blank because it would be identical to Table 2-E.**

Maximum Emissions are the emissions at maximum capacity and prior to (in the absence of) pollution control, emission-reducing process equipment, or any other emission reduction. Calculate the hourly emissions using the worst case hourly emissions for each pollutant. For each pollutant, calculate the annual emissions as if the facility were operating at maximum plant capacity without pollution controls for 8760 hours per year, unless otherwise approved by the Department. List Hazardous Air Pollutants (HAP) & Toxic Air Pollutants (TAPs) in Table 2-I. Unit & stack numbering must be consistent throughout the application package. Fill all cells in this table with the emission numbers or a "-" symbol. A "-" symbol indicates that emissions of this pollutant are not expected. Numbers shall be expressed to at least 2 decimal points (e.g. 0.41, 1.41, or 1.41E-4).

Unit No.	NOx		CO		VOC		SOx		PM[1,2]		PM10[1]		PM2.5[1]		H_2S		Lead	
	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
SX/EW-1 (Fugitive)	-	-	-	-	5.15	22.54	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	1.82	7.98	1.82	7.98	-	-	-	-	-	-
SX/EW-3 (Fugitive)	-	-	-	-	0.95	4.15	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-4 (Fugitive)	-	-	-	-	0.32	1.39	-	-	-	-	-	-	-	-	-	-	-	-
B-748	0.36	1.56	0.21	0.90	0.022	0.096	0.044	0.19	0.019	0.084	0.019	0.084	0.019	0.084	-	-	-	-
B-951															-	-	-	-
B-3891	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	-	-	-	-
B-1454	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	-	-	-	-
SD-1	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	-	-	-	-
SD-2	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	-	-	-	-
ENV-101	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	-	-	-	-
ENV-111	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	-	-	-	-
ENV-117	0.95	4.18	0.22	0.94	0.050	0.22	0.22	0.98	0.052	0.23	0.052	0.23	0.052	0.23	-	-	-	-
ENV-122	1.29	5.65	1.03	4.50	0.068	0.30	0.26	1.12	0.062	0.27	0.062	0.27	0.062	0.27	-	-	-	-
ENV-123	2.19	9.61	1.22	5.36	0.12	0.51	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
Mine Blasting (Fugitive)	180.00	114.98	4,064.00	2,595.88	-	-	0.36	0.23	618.72	451.66	321.73	234.87	18.56	13.55	-	-	-	-
Mine Handling (Fugitive)	-	-	-	-	-	-	-	-	0.70	6.10	0.27	2.34	0.040	0.35	-	-	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	3,989.06	21,276.60	1,016.67	5,422.62	101.67	542.26	-	-	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	0.12	0.53	0.047	0.20	0.0070	0.031	-	-	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	2,485.50	8,798.67	633.46	2,242.46	63.35	224.25	-	-	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	40.89	89.56	15.75	34.50	2.37	5.18	-	-	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	83.15	147.18	21.19	37.51	2.12	3.75	-	-	-	-
SPCC-TYR-061 (GDF1)	-	-	-	-	2.41	10.57	-	-	-	-	-	-	-	-	-	-	-	-
SPCC-TYR-119 (GDF2)	-	-	-	-	0.39	1.70	-	-	-	-	-	-	-	-	-	-	-	-
OP-2	0.36	1.58	0.28	1.22	0.019	0.083	0.063	0.28	0.030	0.13	0.030	0.13	0.030	0.13	-	-	-	-
OP-4	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
OP-7	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
OP-8	1.33	5.82	1.22	5.36	0.074	0.32	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
ENV-120	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
EMP-1	2.72	11.91	3.37	14.75	0.38	1.68	0.37	1.61	0.16	0.70	0.16	0.70	0.16	0.70	-	-	-	-
EMP-2	1.95	8.54	1.09	4.77	0.10	0.45	0.39	1.70	0.062	0.27	0.062	0.27	0.062	0.27	-	-	-	-
CE-1	3.10	0.78	0.67	0.17	0.25	0.063	0.21	0.051	0.22	0.055	0.22	0.055	0.22	0.055	-	-	-	-
PPG-1,3,4,7,8,11-15	499.70	56.20	257.13	37.39	29.00	2.12	12.50	0.49	15.08	0.73	12.39	0.64	10.36	0.58	-	-	-	-
Totals w/ Fugitives	**710.26**	**292.23**	**4,339.64**	**2,711.57**	**40.39**	**50.95**	**18.39**	**24.09**	**7,236.79**	**30,785.76**	**2,025.08**	**7,989.85**	**200.21**	**796.69**	**-**	**-**	**-**	**-**
Totals w/o Fugitives	**530.26**	**177.25**	**275.64**	**115.69**	**33.97**	**22.87**	**18.03**	**23.86**	**16.82**	**7.47**	**14.14**	**7.38**	**12.11**	**7.32**	**-**	**-**	**-**	**-**

[1]**Condensable Particulate Matter:** Include condensable particulate matter emissions for PM10 and PM2.5 if the source is a combustion source. Do not include condensable particulate matter for PM unless PM is set equal to PM10 and PM2.5. Particulate matter (PM) is not subject to an ambient air quality standard, but PM is a regulated air pollutant under PSD (20.2.74 NMAC) and Title V (20.2.70 NMAC).

[2] The TSP NMAAQS standard was repealed on November 30, 2018. PM emissions are included for informational purposes only.

Table 2-E: Requested Allowable Emissions

Unit & stack numbering must be consistent throughout the application package. Fill all cells in this table with the emission numbers or a "-" symbol. A "-" symbol indicates that emissions of this pollutant are not expected. Numbers shall be expressed to at least 2 decimal points (e.g. 0.41, 1.41, or 1.41E-4).

Unit No.	NOx		CO		VOC		SOx		PM[1,2]		PM10[1]		PM2.5[1]		H_2S		Lead	
	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
SX/EW-1 (Fugitive)	-	-	-	-	5.15	22.54	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	1.82	7.98	1.82	7.98	-	-	-	-	-	-
SX/EW-3 (Fugitive)	-	-	-	-	0.95	4.15	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-4 (Fugitive)	-	-	-	-	0.32	1.39	-	-	-	-	-	-	-	-	-	-	-	-
B-748 B-951	0.36	1.56	0.21	0.90	0.022	0.096	0.044	0.19	0.019	0.084	0.019	0.084	0.019	0.084	-	-	-	-
B-3891	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	-	-	-	-
B-1454	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	-	-	-	-
SD-1	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	-	-	-	-
SD-2	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	-	-	-	-
ENV-101	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	-	-	-	-
ENV-111	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	-	-	-	-
ENV-117	0.95	4.18	0.22	0.94	0.050	0.22	0.22	0.98	0.052	0.23	0.052	0.23	0.052	0.23	-	-	-	-
ENV-122	1.29	5.65	1.03	4.50	0.068	0.30	0.26	1.12	0.062	0.27	0.062	0.27	0.062	0.27	-	-	-	-
ENV-123	2.19	9.61	1.22	5.36	0.12	0.51	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
Mine Blasting (Fugitive)	180.00	114.98	4064.00	2595.88	-	-	0.36	0.23	618.72	451.66	321.73	234.87	18.56	13.55	-	-	-	-
Mine Handling (Fugitive)	-	-	-	-	-	-	-	-	0.70	6.10	0.27	2.34	0.040	0.35	-	-	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	446.78	2382.98	113.87	607.33	11.39	60.73	-	-	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	0.12	0.53	0.047	0.20	0.0070	0.031	-	-	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	278.38	985.45	70.95	251.16	7.09	25.12	-	-	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	8.45	18.50	3.68	8.07	0.57	1.25	-	-	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	9.31	16.48	2.37	4.20	0.24	0.42	-	-	-	-
SPCC-TYR-061 (GDF1)	-	-	-	-	2.41	10.57	-	-	-	-	-	-	-	-	-	-	-	-
SPCC-TYR-119 (GDF2)	-	-	-	-	0.39	1.70	-	-	-	-	-	-	-	-	-	-	-	-
OP-2	0.36	1.58	0.28	1.22	0.019	0.083	0.063	0.28	0.030	0.13	0.030	0.13	0.030	0.13	-	-	-	-
OP-4	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
OP-7	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
OP-8	1.33	5.82	1.22	5.36	0.074	0.32	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
ENV-120	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	-	-	-	-
EMP-1	2.72	11.91	3.37	14.75	0.38	1.68	0.37	1.61	0.16	0.70	0.16	0.70	0.16	0.70	-	-	-	-
EMP-2	1.95	8.54	1.09	4.77	0.10	0.45	0.39	1.70	0.062	0.27	0.062	0.27	0.062	0.27	-	-	-	-
CE-1	3.10	0.78	0.67	0.17	0.25	0.063	0.21	0.05	0.22	0.055	0.22	0.055	0.22	0.06	-	-	-	-
PPG-1,3,4,7,8,11-15	499.70	56.20	257.13	37.39	29.00	2.12	12.50	0.49	15.08	0.73	12.39	0.64	10.36	0.58	-	-	-	-
Totals w/ Fugitives	**710.26**	**292.23**	**4,339.64**	**2,711.57**	**40.39**	**50.95**	**18.39**	**24.09**	**1,381.09**	**3,877.16**	**528.88**	**1,123.53**	**50.01**	**108.77**	**-**	**-**	**-**	**-**
Totals w/o Fugitives	**530.26**	**177.25**	**275.64**	**115.69**	**33.97**	**22.87**	**18.03**	**23.86**	**16.82**	**7.47**	**14.14**	**7.38**	**12.11**	**7.32**	**-**	**-**	**-**	**-**

[1]**Condensable Particulate Matter:** Include condensable particulate matter emissions for PM10 and PM2.5 if the source is a combustion source. Do not include condensable particulate matter for PM unless PM is set equal to PM10 and PM2.5. Particulate matter (PM) is not subject to an ambient air quality standard, but PM is a regulated air pollutant under PSD (20.2.74 NMAC) and Title V (20.2.70 NMAC).

[2] The TSP NMAAQS standard was repealed on November 30, 2018. PM emissions are included for informational purposes only.

Table 2-F: Additional Emissions during Startup, Shutdown, and Routine Maintenance (SSM)

☑ This table is intentionally left blank since all emissions at this facility due to routine or predictable startup, shutdown, or scehduled maintenance are no higher than those listed in Table 2-E and a malfunction emission limit is not already permitted or requested. If you are required to report GHG emissions as described in Section 6a, include any GHG emissions during Startup, Shutdown, and/or Scheduled Maintenance (SSM) in Table 2-P. Provide an explanations of SSM emissions in Section 6 and 6a.

All applications for facilities that have emissions during routine our predictable startup, shutdown or scheduled maintenance (SSM)[1], including NOI applications, must include in this table the Maximum Emissions during routine or predictable startup, shutdown and scheduled maintenance (20.2.7 NMAC, 20.2.72.203.A.3 NMAC, 20.2.73.200.D.2 NMAC). In Section 6 and 6a, provide emissions calculations for all SSM emissions reported in this table. Refer to "Guidance for Submittal of Startup, Shutdown, Maintenance Emissions in Permit Applications (https://www.env.nm.gov/aqb/permit/aqb_pol.html) for more detailed instructions. Numbers shall be expressed to at least 2 decimal points (e.g. 0.41, 1.41, or 1.41E-4).

Unit No.	NOx		CO		VOC		SOx		PM[2]		PM10[2]		PM2.5[2]		H_2S		Lead	
	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
Totals																		

[1] **For instance**, if the short term steady-state Table 2-E emissions are 5 lb/hr and the SSM rate is 12 lb/hr, enter 7 lb/hr in this table. If the annual steady-state Table 2-E emissions are 21.9 TPY, and the number of scheduled SSM events result in annual emissions of 31.9 TPY, enter 10.0 TPY in the table below.

[2] **Condensable Particulate Matter:** Include condensable particulate matter emissions for PM10 and PM2.5 if the source is a combustion source. Do not include condensable particulate matter for PM unless PM is set equal to PM10 and PM2.5. Particulate matter (PM) is not subject to an ambient air quality standard, but it is a regulated air pollutant under PSD (20.2.74 NMAC) and Title V (20.2.70 NMAC).

Table 2-G: Stack Exit and Fugitive Emission Rates for Special Stacks

☐ I have elected to leave this table blank because this facility does not have any stacks/vents that split emissions from a single source or combine emissions from more than one source listed in table 2-A. Additionally, the emission rates of all stacks match the Requested allowable emission rates stated in Table 2-E.

Use this table to list stack emissions (requested allowable) from split and combined stacks. List Toxic Air Pollutants (TAPs) and Hazardous Air Pollutants (HAPs) in Table 2-I. List all fugitives that are associated with the normal, routine, and non-emergency operation of the facility. Unit and stack numbering must correspond throughout the application package. Refer to Table 2-E for instructions on use of the "-" symbol and on significant figures.

Stack No.	Serving Unit Number(s) from Table 2-A	NOx		CO		VOC		SOx		PM[1]		PM10		PM2.5		☐ H_2S or ☐ Lead	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
SXWBOIL (common stack)	B-748 B-951	0.36	1.56	0.21	0.90	0.022	0.096	0.044	0.19	0.019	0.084	0.019	0.084	0.019	0.084	-	-
B-1454 (dual stacks)	B-1454	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12		
Totals:		**0.87**	**3.80**	**0.50**	**2.19**	**0.053**	**0.23**	**0.11**	**0.47**	**0.047**	**0.20**	**0.047**	**0.20**	**0.047**	**0.20**	**-**	**-**

[1] The TSP NMAAQS standard was repealed on November 30, 2018. PM emissions are included for informational purposes only.

Table 2-H: Stack Exit Conditions

Unit and stack numbering must correspond throughout the application package. Include the stack exit conditions for each unit that emits from a stack, including blowdown venting parameters and tank emissions. If the facility has multiple operating scenarios, complete a separate Table 2-H for each scenario and, for each, type scenario name here:

Stack Number	Serving Unit Number(s) from Table 2-A	Orientation (H-Horizontal V=Vertical)	Rain Caps (Yes or No)	Height Above Ground (ft)	Temp. (F)	Flow Rate		Moisture by Volume (%)	Velocity (ft/sec)	Inside Diameter (ft)
						(acfs)	(dscfs)			
SXWBOIL (B-748 & B-951)	Cathode Washing Hot Water Boilers (B-951 & B-748; common stack)	V	Yes	35.1	401	2.6	-	-	31.2	0.33
B-3891	New Heat Exchanger Hot Water Boiler (Serial # 963891)	V	Yes	15.0	450	1.0	-	-	0.45	1.67
B-1454	New Heat Exchanger Hot Water Boiler (Serial # 961454) (dual stacks)	V	Yes	15.0	450	0.80	-	-	0.45	1.50
SD-1	SD-1	V	Yes	8.0	900	12.9	-	-	138.6	0.34
SD-2	SD-2	V	Yes	8.0	900	12.9	-	-	138.6	0.34
ENV-101	ENV-101	V	Yes	9.8	923	12.2	-	-	136.4	0.34
ENV-111	ENV-111	V	Yes	9.8	923	12.2	-	-	136.4	0.34
ENV-117	ENV-117	V	Yes	8.0	900	12.5	-	-	129.4	0.35
ENV-122	ENV-122	V	Yes	9.8	900	11.8	-	-	128.9	0.34
ENV-123	ENV-123	V	Yes	8.0	833	16.8	-	-	87.5	0.50
OP-2	OP-2	V	Yes	8.0	833	12.5	-	-	114.6	0.37
OP-4	OP-4	V	Yes	8.0	833	15.4	-	-	162.4	0.35
OP-7	OP-7	V	Yes	8.0	833	16.8	-	-	87.5	0.50
OP-8	OP-8	V	Yes	8.0	833	16.8	-	-	87.5	0.50
ENV-120	ENV-120	V	Yes	8.0	833	15.4	-	-	162.4	0.35
EMP-1	EMP-1	V	Yes	8.0	833	16.8	-	-	87.5	0.50
EMP-2	EMP-2	V	Yes	8.0	833	16.8	-	-	87.5	0.50
CE-1	CE-1	V	Yes	25.0	886.7	0.0	-	-	0.0	3.30
PPG-1	PPG-1	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-3	PPG-3	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-4	PPG-4	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-7	PPG-7	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-8	PPG-8	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-11	PPG-11	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-12	PPG-12	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-13	PPG-13	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-14	PPG-14	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26
PPG-15	PPG-15	V	Yes	60.7	830.9	435.8	-	-	108.3	2.26

Table 2-I: Stack Exit and Fugitive Emission Rates for HAPs and TAPs

In the table below, report the Potential to Emit for each HAP from each regulated emission unit listed in Table 2-A, only if the entire facility emits the HAP at a rate greater than or equal to one (1) ton per year For each such emission unit, HAPs shall be reported to the nearest 0.1 tpy. Each facility-wide Individual HAP total and the facility-wide Total HAPs shall be the sum of all HAP sources calculated to the nearest 0.1 ton per year. Per 20.2.72.403.A.1 NMAC, facilities not exempt [see 20.2.72.402.C NMAC] from TAP permitting shall report each TAP that has an uncontrolled emission rate in excess of its pounds per hour screening level specified in 20.2.72.502 NMAC. TAPs shall be reported using one more significant figure than the number of significant figures shown in the pound per hour threshold corresponding to the substance. Use the HAP nomenclature as it appears in Section 112 (b) of the 1990 CAAA and the TAP nomenclature as it listed in 20.2.72.502 NMAC. Include tank-flashing emissions estimates of HAPs in this table. For each HAP or TAP listed, fill all cells in this table with the emission numbers or a "-" symbol. A "-" symbol indicates that emissions of this pollutant are not expected or the pollutant is emitted in a quantity less than the threshold amounts described above.

Stack No.	Unit No.(s)	Total HAPs		Ethylbenzene ☑ HAP or ☐ TAP		Toluene ☑ HAP or ☐ TAP		Xylenes ☑ HAP or ☐ TAP		Provide Pollutant Name Here ☐ HAP or ☐ TAP	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
N/A	SX/EW-1 (Fugitive)	1.65	7.23	0.65	2.87	0.14	0.60	0.85	3.74		
N/A	SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-		
N/A	SX/EW-3 (Fugitive)	0.30	1.33	0.12	0.53	0.03	0.11	0.16	0.69		
N/A	SX/EW-4 (Fugitive)	0.10	0.42	0.04	0.17	0.01	0.03	0.05	0.22		
SXWBOIL	B-748 B-951	4.65E-03	2.04E-02	-	-	8.37E-06	3.67E-05	-	-		
B-3891	B-3891	6.67E-03	2.92E-02	-	-	1.20E-05	5.26E-05	-	-		
B-1454	B-1454	6.67E-03	2.92E-02	-	-	1.20E-05	5.26E-05	-	-		
SD-1	SD-1	6.80E-03	2.98E-02	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03		
SD-2	SD-2	6.80E-03	2.98E-02	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03		
ENV-101	ENV-101	3.46E-03	1.52E-02	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03		
ENV-111	ENV-111	3.46E-03	1.52E-02	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03		
ENV-117	ENV-117	2.61E-03	1.14E-02	-	-	3.12E-05	1.37E-04	2.18E-04	9.53E-04		
ENV-122	ENV-122	3.46E-03	1.52E-02	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03		
ENV-123	ENV-123	5.10E-03	2.23E-02	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03		
N/A	SPCC-TYR-061 (GDF1)	2.72E-01	1.19E+00	4.34E-03	1.90E-02	8.66E-02	3.79E-01	1.65E-02	7.25E-02		
N/A	SPCC-TYR-119 (GDF2)	4.38E-02	1.92E-01	7.00E-04	3.07E-03	1.40E-02	6.12E-02	2.67E-03	1.17E-02		
OP-2	OP-2	7.37E-04	3.23E-03	-	-	8.80E-06	3.86E-05	6.13E-05	2.69E-04		
OP-4	OP-4	5.10E-03	2.23E-02	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03		
OP-7	OP-7	5.10E-03	2.23E-02	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03		
OP-8	OP-8	5.10E-03	2.23E-02	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03		
ENV-120	ENV-120	5.10E-03	2.23E-02	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03		
EMP-1	EMP-1	4.31E-03	1.89E-02	-	-	5.15E-05	2.25E-04	3.59E-04	1.57E-03		
EMP-2	EMP-2	4.53E-03	1.99E-02	-	-	5.42E-05	2.37E-04	3.77E-04	1.65E-03		
CE-1	CE-1	2.77E-03	6.93E-04	-	-	2.86E-04	7.16E-05	2.00E-04	4.99E-05		
PPG-1,3,4,7,8,11-15	PPG-1,3,4,7,8,11-15	3.69E-01	1.11E-02	-	-	6.08E-02	1.82E-03	4.17E-02	1.25E-03		
Totals (w/ Fugitives):		**2.82**	**10.73**	**0.82**	**3.59**	**0.33**	**1.19**	**1.13**	**4.75**		
Totals (w/o Fugitives):		**0.77**	**1.74**	**0.0050**	**0.022**	**0.16**	**0.45**	**0.066**	**0.11**		

Table 2-J: Fuel

Specify fuel characteristics and usage. Unit and stack numbering must correspond throughout the application package.

Unit No.	Fuel Type (low sulfur Diesel, ultra low sulfur diesel, Natural Gas, Coal, …)	Fuel Source: purchased commercial, pipeline quality natural gas, residue gas, raw/field natural gas, process gas (e.g. SRU tail gas) or other	Specify Units				
			Lower Heating Value	Hourly Usage	Annual Usage	% Sulfur	% Ash
B-748	Propane	Purchased commercial	91.5 MMBtu/10^3 gal	13.7 gal	120,247 gal	N/A	N/A
B-951	Propane	Purchased commercial	91.5 MMBtu/10^3 gal	13.7 gal	120,247 gal	N/A	N/A
B-3891	Propane	Purchased commercial	91.5 MMBtu/10^3 gal	39.3 gal	344,656 gal	N/A	N/A
B-1454	Propane	Purchased commercial	91.5 MMBtu/10^3 gal	39.3 gal	344,656 gal	N/A	N/A
SD-1	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	14.5 gal	127,022 gal	0.0015%	N/A
SD-2	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	14.5 gal	127,022 gal	0.0015%	N/A
ENV-101	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	6.0 gal	52,560 gal	0.0015%	N/A
ENV-111	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	6.0 gal	52,560 gal	0.0015%	N/A
ENV-117	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	5.6 gal	48,831 gal	0.0015%	N/A
ENV-122	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	6.0 gal	52,560 gal	0.0015%	N/A
ENV-123	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	10.9 gal	95,267 gal	0.0015%	N/A
OP-2	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	0.98 gal	8,562 gal	0.0015%	N/A
OP-4	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	10.9 gal	95,267 gal	0.0015%	N/A
OP-7	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	10.9 gal	95,267 gal	0.0015%	N/A
OP-8	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	12.4 gal	108,765 gal	0.0015%	N/A
ENV-120	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	10.9 gal	95,267 gal	0.0015%	N/A
EMP-1	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	9.2 gal	80,447 gal	0.0015%	N/A
EMP-2	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	9.7 gal	84,682 gal	0.0015%	N/A
CE-1	Biodiesel/Diesel Blend	Purchased commercial	137,000 Btu/gal	158.0 gal	13,262 gal	0.0015%	N/A
Natural Gas Operation of Nordberg Engines							
PPG-1	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-3	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-4	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-7	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-8	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-11	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-12	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-13	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
PPG-14	Natural Gas	Purchased commercial	1,050 Btu/scf	20.97 Mscf	6,989.3 Mscf	0.05%	N/A
Diesel Operation of Nordberg Engines							
PPG-1	Diesel	Purchased commercial	137,000 Btu/gal	158 gal	13,262 gal	0.05%	N/A
PPG-3	Diesel	Purchased commercial	137,000 Btu/gal	159 gal	13,262 gal	0.05%	N/A
PPG-4	Diesel	Purchased commercial	137,000 Btu/gal	160 gal	13,262 gal	0.05%	N/A
PPG-7	Diesel	Purchased commercial	137,000 Btu/gal	161 gal	13,262 gal	0.05%	N/A
PPG-8	Diesel	Purchased commercial	137,000 Btu/gal	162 gal	13,262 gal	0.05%	N/A
PPG-11	Diesel	Purchased commercial	137,000 Btu/gal	163 gal	13,262 gal	0.05%	N/A
PPG-12	Diesel	Purchased commercial	137,000 Btu/gal	164 gal	13,262 gal	0.05%	N/A
PPG-13	Diesel	Purchased commercial	137,000 Btu/gal	165 gal	13,262 gal	0.05%	N/A
PPG-14	Diesel	Purchased commercial	137,000 Btu/gal	165 gal	13,262 gal	0.05%	N/A
PPG-15	Diesel	Purchased commercial	137,000 Btu/gal	166 gal	13,262 gal	0.05%	N/A

Table 2-K: Liquid Data for Tanks Listed in Table 2-L

For each tank, list the liquid(s) to be stored in each tank. If it is expected that a tank may store a variety of hydrocarbon liquids, enter "mixed hydrocarbons" in the Composition column for that tank and enter the corresponding data of the most volatile liquid to be stored in the tank. If tank is to be used for storage of different materials, list all the materials in the "All Calculations" attachment, run the newest version of TANKS on each, and use the material with the highest emission rate to determine maximum uncontrolled and requested allowable emissions rate. The permit will specify the most volatile category of liquids that may be stored in each tank. Include appropriate tank-flashing modeling input data. Use additional sheets if necessary. Unit and stack numbering must correspond throughout the application package.

Tank No.	SCC Code	Material Name	Composition	Liquid Density (lb/gal)	Vapor Molecular Weight (lb/lb*mol)	Average Annual Mininum Temperature		Average Annual Maximum Temperature	
						Temperature, T_{AN} (°F)	Vapor Pressure at T_{LA} (psia)	Temperature, T_{AX} (°F)	Vapor Pressure at T_{LA} (psia)
SPCC-TYR-061 (GDF1)	40400150	Gasoline	Mixed Hydrocarbons	6.17	66	46.2	6.554	76.6	6.554
SPCC-TYR-119 (GDF2)	40400150	Gasoline	Mixed Hydrocarbons	6.17	66	46.2	5.961	76.6	5.961

Table 2-L: Tank Data

Include appropriate tank-flashing modeling input data. Use an addendum to this table for unlisted data categories. Unit and stack numbering must correspond throughout the application package. Use additional sheets if necessary. See reference Table 2-L2. Note: 1.00 bbl = 10.159 M3 = 42.0 gal

Tank No.	Date Installed	Materials Stored	Seal Type (refer to Table 2-LR below)	Roof Type (refer to Table 2-LR below)	Capacity		Diameter (M)	Vapor Space (M)	Color (from Table VI-C)		Paint Condition (from Table VI-C)	Annual Throughput (gal/yr)	Turn-overs (per year)
					(bbl)	(M^3)			Roof	Shell			
SPCC-TYR-061 (GDF1)	1984	Gasoline	N/A	FX	476	75.7	3.35	See calcs	OT: Red	OT: Red	Poor	119,400	5.9
SPCC-TYR-119 (GDF2)	2008	Gasoline	N/A	FX	48	7.6	1.58	See calcs	OT: Beige	OT: Beige	Poor	119,400	115.6

Table 2-L2: Liquid Storage Tank Data Codes Reference Table

Roof Type	Seal Type, Welded Tank Seal Type		Seal Type, Riveted Tank Seal Type		Roof, Shell Color	Paint Condition
FX: Fixed Roof	**Mechanical Shoe Seal**	**Liquid-mounted resilient seal**	**Vapor-mounted resilient seal**	**Seal Type**	**WH**: White	Good
IF: Internal Floating Roof	**A**: Primary only	**A**: Primary only	**A**: Primary only	**A**: Mechanical shoe, primary only	**AS**: Aluminum (specular)	Poor
EF: External Floating Roof	**B**: Shoe-mounted secondary	**B**: Weather shield	**B**: Weather shield	**B**: Shoe-mounted secondary	**AD**: Aluminum (diffuse)	
P: Pressure	**C**: Rim-mounted secondary	**C**: Rim-mounted secondary	**C**: Rim-mounted secondary	**C**: Rim-mounted secondary	**LG**: Light Gray	
					MG: Medium Gray	
					BL: Black	
					OT: Other (specify)	

Note: 1.00 bbl = 0.159 M^3 = 42.0 gal

Table 2-M: Materials Processed and Produced (Use additional sheets as necessary.)

Material Processed				Material Produced			
Description	**Chemical Composition**	**Phase (Gas, Liquid, or Solid)**	**Quantity (specify units)[1]**	**Description**	**Chemical Composition**	**Phase**	**Quantity (specify units)[1]**
Mined Material	Copper, minerals, and trace metals	Solid	400,000 tons/day	Copper Cathode	Copper	Solid	225 tons/day

[1] Quantities specified here are for informational purposes only and are not intended to be used for permit conditions.

Table 2-N: CEM Equipment

Enter Continuous Emissions Measurement (CEM) Data in this table. If CEM data will be used as part of a federally enforceable permit condition, or used to satisfy the requirements of a state or federal regulation, include a copy of the CEM's manufacturer specification sheet in the Information Used to Determine Emissions attachment. Unit and stack numbering must correspond throughout the application package. Use additional sheets if necessary.

Stack No.	Pollutant(s)	Manufacturer	Model No.	Serial No.	Sample Frequency	Averaging Time	Range	Sensitivity	Accuracy
N/A - Facility does not have CEM equipment.									

Table 2-O: Parametric Emissions Measurement Equipment

Unit and stack numbering must correspond throughout the application package. Use additional sheets if necessary.

Unit No.	Parameter/Pollutant Measured	Location of Measurement	Unit of Measure	Acceptable Range	Frequency of Maintenance	Nature of Maintenance	Method of Recording	Averaging Time
N/A - Facility does not have PEM equipment.								

Table 2-P: Greenhouse Gas Emissions

Applications submitted under 20.2.70, 20.2.72, & 20.2.74 NMAC are required to complete this Table. Power plants, Title V major sources, and PSD major sources must report and calculate all GHG emissions for each unit. Applicants must report potential emission rates in short tons per year (see Section 6.a for assistance). Include GHG emissions during Startup, Shutdown, and Scheduled Maintenance in this table. For minor source facilities that are not power plants, are not Title V, or are not PSD, there are three options for reporting GHGs 1) report GHGs for each individual piece of equipment; 2) report all GHGs from a group of unit types, for example report all combustion source GHGs as a single unit and all venting GHG as a second separate unit; OR 3) check the following box ☐ By checking this box, the applicant acknowledges the total CO2e emissions are less than 75,000 tons per year.

		CO_2 ton/yr	CH_4 ton/yr	N_2O ton/yr	SF_6 ton/yr	PFC/HFC ton/yr[2]							Total GHG Mass Basis metric ton/yr[4]	Total CO_2e metric ton/yr[5]
Unit No.	**GWPs [1]**	**1.00**	**25**	**298**	**22,800**	**footnote 3**								
B-748/B-951	mass GHG	1,521.81	0.073	0.015	-	-							1,521.9	
	CO_2e	1,521.81	1.82	4.33	-	-								1,528.0
B-3891	mass GHG	2,180.94	0.10	0.021	-	-							2,181.1	
	CO_2e	2,180.94	2.60	6.20	-	-								2,189.7
B-1454	mass GHG	2,180.94	0.10	0.021	-	-							2,181.1	
	CO_2e	2,180.94	2.60	6.20	-	-								2,189.7
SD-1	mass GHG	1,296.45	0.053	0.011	-	-							1,296.5	
	CO_2e	1,296.45	1.31	3.13	-	-								1,300.9
SD-2	mass GHG	1,296.45	0.053	0.011	-	-							1,296.5	
	CO2e	1,296.45	1.31	3.13	-	-								1,300.9
ENV-101	mass GHG	536.45	0.022	0.0044	-	-							536.5	
	CO2e	536.45	0.54	1.30	-	-								538.3
ENV-111	mass GHG	536.45	0.022	0.0044	-	-							536.5	
	CO_2e	536.45	0.54	1.30	-	-								538.3
ENV-117	mass GHG	498.39	0.020	0.0040	-	-							498.4	
	CO_2e	498.39	0.51	1.20	-	-								500.1
ENV-122	mass GHG	536.45	0.022	0.0044	-	-							536.5	
	CO2e	536.45	0.54	1.30	-	-								538.3
ENV-123	mass GHG	972.34	0.039	0.0079	-	-							972.4	
	CO2e	972.34	0.99	2.35	-	-								975.7
Mine Blasting (Fugitive)	mass GHG	24,021.12	0.97	0.19	-	-							24,022.3	
	CO_2e	24,021.12	24.36	58.07	-	-								24,103.6
OP-2	mass GHG	87.39	0.0035	0.00071	-	-							87.4	
	CO2e	87.39	0.089	0.21	-	-								87.7
OP-4	mass GHG	972.34	0.039	0.0079	-	-							972.4	
	CO_2e	972.34	0.99	2.35	-	-								975.7
OP-7	mass GHG	972.34	0.039	0.0079	-	-							972.4	
	CO_2e	972.34	0.99	2.35	-	-								975.7
OP-8	mass GHG	1,110.11	0.045	0.0090	-	-							1,110.2	
	CO_2e	1,110.11	1.13	2.68	-	-								1,113.9
ENV-120	mass GHG	972.34	0.039	0.0079	-	-							972.4	
	CO2e	972.34	0.99	2.35	-	-								975.7
EMP-1	mass GHG	821.09	0.033	0.0067	-	-							821.1	
	CO_2e	821.09	0.83	1.98	-	-								823.9
EMP-2	mass GHG	864.30	0.035	0.0070	-	-							864.3	
	CO_2e	864.30	0.88	2.09	-	-								867.3
CE-1	mass GHG	882.37	0.036	0.0072	-	-							882.4	
	CO2e	882.37	0.89	2.13	-	-								885.4
PPG-1,3,4,7,8,11-15	mass GHG	5,668.15	0.23	0.046	-	-							5,668.4	
	CO_2e	5,668.15	5.75	13.70	-	-								5,687.6
Total w/ Fugitives	**mass GHG**	**47,928.21**	**1.99**	**0.40**	**-**	**-**							**47,930.6**	
	CO_2e	**47,928.21**	**49.65**	**118.38**	**-**	**-**								**48,096.2**
Total w/o Fugitives	**mass GHG**	**23,907.09**	**1.01**	**0.20**	**-**	**-**							**23,908.3**	
	CO_2e	**23,907.09**	**25.30**	**60.30**	**-**	**-**								**23,992.7**

[1] **GWP** (Global Warming Potential): Applicants must use the most current GWPs codified in Table A-1 of 40 CFR part 98. GWPs are subject to change, therefore, applicants need to check 40 CFR 98 to confirm GWP values.

[2] For **HFCs** or **PFCs** describe the specific HFC or PFC compound and use a separate column for each individual compound.

[3] For each new compound, enter the appropriate GWP for each HFC or PFC compound from Table A-1 in 40 CFR 98.

[4] Green house gas emissions on a **mass basis** is the ton per year green house gas emission before adjustment with its GWP.

[5] **CO_2e** means Carbon Dioxide Equivalent and is calculated by multiplying the TPY mass emissions of the green house gas by its GWP.

Section 3

Application Summary

The **Application Summary** shall include a brief description of the facility and its process, the type of permit application, the applicable regulation (i.e. 20.2.72.200.A.X, or 20.2.73 NMAC) under which the application is being submitted, and any air quality permit numbers associated with this site. If this facility is to be collocated with another facility, provide details of the other facility including permit number(s). In case of a revision or modification to a facility, provide the lowest level regulatory citation (i.e. 20.2.72.219.B.1.d NMAC) under which the revision or modification is being requested. Also describe the proposed changes from the original permit, how the proposed modification will affect the facility's operations and emissions, de-bottlenecking impacts, and changes to the facility's major/minor status (both PSD & Title V).

The **Process Summary** shall include a brief description of the facility and its processes.

Startup, Shutdown, and Maintenance (SSM) routine or predictable emissions: Provide an overview of how SSM emissions are accounted for in this application. Refer to "Guidance for Submittal of Startup, Shutdown, Maintenance Emissions in Permit Applications (http://www.env.nm.gov/aqb/permit/app_form.html) for more detailed instructions on SSM emissions.

Freeport-McMoRan Tyrone Inc. (Tyrone) operates the Tyrone Mine, which is located near Tyrone, New Mexico within Grant County. The Tyrone Mine's major product is copper cathode, which is produced using the solution extraction/electrowinning (SX/EW) process. Boilers are used to heat water at the SX/EW process to rinse the copper cathode product. In addition to the SX/EW plant and associated processes, the Tyrone Mine operations include blasting; hauling and dumping of ore and waste rock; the emergency operation of a power plant; and environmental pumping systems.

Tyrone has prepared a significant permit revision application pursuant to 20.2.72.219.D.(1)(a) NMAC for its Tyrone Mine currently permitted under NSR Permit No. PSD2448-M5 and Title V Permit No. P147-R2M1. The proposed action will allow for mining and hauling activities in six (6) new operating scenarios that encompass the following pits in various combinations: Mohawk, Copper Mountain, Copper Leach, Burro Chief, and Little Rock 6. Each scenario, which is detailed in Section 10 of this application, contains two pits in operation at a time.

The existing operating scenario in the Gettysburg and Mohawk pits, as approved in NSR Permit No. PSD2448-M5, will continue to be utilized, so the new scenarios in this permit application will be in addition to the existing scenario. No other operating scenarios are currently needed by the Tyrone Mine, including the previously permitted operating scenarios in NSR Permit Nos. PSD2448-M2 and -M3.

New reclamation hauling and material handling activities are also represented in this permit application, which will supersede the reclamation activities allowed by NSR Permit Nos. PSD2448-M5, -M3, and -M2.

Other changes requested in this permit application include:

- The addition of two new boilers that will serve as the SX heat exchanger hot water heaters.
- Updates to the Crushing & Screening Plant (C&S Plant; previously listed in the permit as SP-7A) emissions due to the planned activities. The C&S Plant will be owned and operated by a contractor that has an approved registration to operate under General Construction Permit-2 (GCP-2), Revision 3, dated 9/12/2006, an approved Relocation Notice, and an approved equipment list. The C&S Plant will be powered by facility-provided electric power.
- Updates to the existing Gasoline Dispensing Facilities (GDF1, GDF2) VOC emission calculations based on the June 2020 updated AP-42 Chapter 7 (Liquid Storage Tanks). The HAP emission calculations were also updated to reflect accurate gasoline HAP constituents. The throughput of each GDF was increased to a maximum of 9,950 gal/month.
- Updates to the SO_2 and VOC emission factors for the two existing cathode washing hot water heaters. The SO_2 emission factor was updated to reflect the correct sulfur content of propane and the VOC emission factor was updated to reflect only the non-methane portion of the TOC emission factor.
- Various updates to the diesel engine/pump emissions, which include some engine horsepower changes, emission factor changes, fuel usage rate changes, and greenhouse gas calculation changes.

For all of the other existing equipment, no changes are being requested.

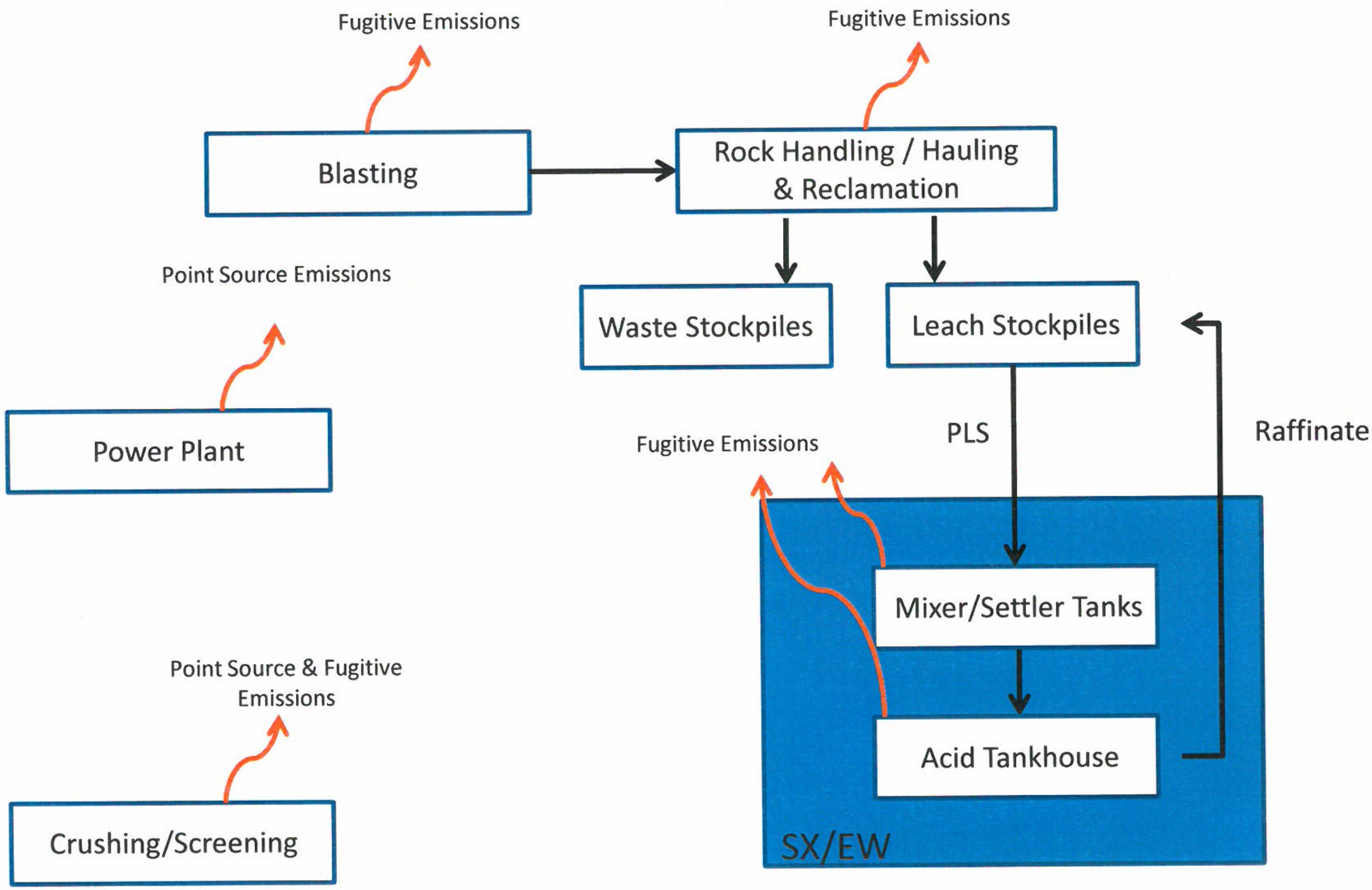
Tyrone's emissions during startup, shutdown, and maintenance (SSM) do not differ from normal operations and Tyrone is not requesting different limits during these times. The facility will remain a Title V major and PSD minor source with the proposed changes.

Section 4

Process Flow Sheet

A **process flow sheet** and/or block diagram indicating the individual equipment, all emission points and types of control applied to those points. The unit numbering system should be consistent throughout this application.

Please see the enclosed process flow sheet.



FREEPORT-MCMORAN COPPER & GOLD Freeport-McMoRan Tyrone Inc.	**Figure 1: Tyrone Mine Process Flow Diagram**

Section 5

Plot Plan Drawn To Scale

A **plot plan drawn to scale** showing emissions points, roads, structures, tanks, and fences of property owned, leased, or under direct control of the applicant. This plot plan must clearly designate the restricted area as defined in UA1, Section 1-D.12. The unit numbering system should be consistent throughout this application.

Please see the enclosed plot plan.

C&S Plant N and C&S Plant S are the two possible locations for the C&S Plant. The worst-case location is C&S Plant N, which is what was modeled.

FREEPORT-McMoRAN

Tyrone Mine

Title V & NSR Permit M6 Plot Plan

Scale: As Noted	Date: 10-16-2020	Notes:
Dept. Environmental Services		
Drawn By: SMG	Checked By: Array Environmental LLC	

Section 6

All Calculations

Show all calculations used to determine both the hourly and annual controlled and uncontrolled emission rates. All calculations shall be performed keeping a minimum of three significant figures. Document the source of each emission factor used (if an emission rate is carried forward and not revised, then a statement to that effect is required). If identical units are being permitted and will be subject to the same operating conditions, submit calculations for only one unit and a note specifying what other units to which the calculations apply. All formulas and calculations used to calculate emissions must be submitted. The "Calculations" tab in the UA2 has been provided to allow calculations to be linked to the emissions tables. Add additional "Calc" tabs as needed. If the UA2 or other spread sheets are used, all calculation spread sheet(s) shall be submitted electronically in Microsoft Excel compatible format so that formulas and input values can be checked. Format all spread sheets and calculations such that the reviewer can follow the logic and verify the input values. Define all variables. If calculation spread sheets are not used, provide the original formulas with defined variables. Additionally, provide subsequent formulas showing the input values for each variable in the formula. All calculations, including those calculations are imbedded in the Calc tab of the UA2 portion of the application, the printed Calc tab(s), should be submitted under this section.

Tank Flashing Calculations: The information provided to the AQB shall include a discussion of the method used to estimate tank-flashing emissions, relative thresholds (i.e., NOI, permit, or major source (NSPS, PSD or Title V)), accuracy of the model, the input and output from simulation models and software, all calculations, documentation of any assumptions used, descriptions of sampling methods and conditions, copies of any lab sample analysis. If Hysis is used, all relevant input parameters shall be reported, including separator pressure, gas throughput, and all other relevant parameters necessary for flashing calculation.

SSM Calculations: It is the applicant's responsibility to provide an estimate of SSM emissions or to provide justification for not doing so. In this Section, provide emissions calculations for Startup, Shutdown, and Routine Maintenance (SSM) emissions listed in the Section 2 SSM and/or Section 22 GHG Tables and the rational for why the others are reported as zero (or left blank in the SSM/GHG Tables). Refer to "Guidance for Submittal of Startup, Shutdown, Maintenance Emissions in Permit Applications (http://www.env.nm.gov/aqb/permit/app_form.html) for more detailed instructions on calculating SSM emissions. If SSM emissions are greater than those reported in the Section 2, Requested Allowables Table, modeling may be required to ensure compliance with the standards whether the application is NSR or Title V. Refer to the Modeling Section of this application for more guidance on modeling requirements.

Glycol Dehydrator Calculations: The information provided to the AQB shall include the manufacturer's maximum design recirculation rate for the glycol pump. If GRI-Glycalc is used, the full input summary report shall be included as well as a copy of the gas analysis that was used.

Road Calculations: Calculate fugitive particulate emissions and enter haul road fugitives in Tables 2-A, 2-D and 2-E for:
1. If you transport raw material, process material and/or product into or out of or within the facility and have PER emissions greater than 0.5 tpy.
2. If you transport raw material, process material and/or product into or out of the facility more frequently than one round trip per day.

Significant Figures:
A. All emissions standards are deemed to have at least two significant figures, but not more than three significant figures.
B. At least 5 significant figures shall be retained in all intermediate calculations.
C. In calculating emissions to determine compliance with an emission standard, the following rounding off procedures shall be used:
- **(1)** If the first digit to be discarded is less than the number 5, the last digit retained shall not be changed;
- **(2)** If the first digit discarded is greater than the number 5, or if it is the number 5 followed by at least one digit other than the number zero, the last figure retained shall be increased by one unit; **and**
- **(3)** If the first digit discarded is exactly the number 5, followed only by zeros, the last digit retained shall be rounded upward if it is an odd number, but no adjustment shall be made if it is an even number.
- **(4)** The final result of the calculation shall be expressed in the units of the standard.

Control Devices: In accordance with 20.2.72.203.A(3) and (8) NMAC, 20.2.70.300.D(5)(b) and (e) NMAC, and 20.2.73.200.B(7) NMAC, the permittee shall report all control devices and list each pollutant controlled by the control device regardless if the applicant takes credit for the reduction in emissions. The applicant can indicate in this section of the application if they chose to not take credit for the reduction in emission rates. For notices of intent submitted under 20.2.73 NMAC, only uncontrolled emission rates can be considered to determine applicability unless the state or federal Acts require the control. This information is necessary to determine if federally enforceable conditions are necessary for the control device, and/or if the control device produces its own regulated pollutants or increases emission rates of other pollutants.

This section describes the emissions calculations for units that were updated as part of this permit application. Detailed information on the emission calculation inputs, assumptions, and emission factors are provided in the following tables. Calculations for all other emission sources are included in this section for informational purposes only.

Mine Blasting (Fugitive)
For the new operating scenarios, gaseous emissions from blasting are calculated based on the pounds of blasting agent used per blast per pit and the number of blasts per day per pit according to the table below. No pit will have more than two (2) blasts per day. Particulate matter emissions from blasting are based on a maximum blast area of 125,000 ft^2/blast.

Operating Scenario	Pit Name	Maximum Blasting Agent Usage per Blast (lbs/blast)	Maximum No. of Blasts per Day	Maximum Daily Blasting Agent Usage (lbs/day)	Maximum Blast Area per Blast (ft^2/blast)
2, 3, 4, 7	Mohawk	150,000	2	300,000	125,000
2	Copper Mountain	100,000	1	100,000	125,000
4, 6	Copper Leach	50,000	1	50,000	125,000
5, 6, 7	Burro Chief	200,000	2	400,000	125,000
3, 5	Little Rock 6	100,000	1	100,000	125,000

From permit M5, both Gettysburg and Mohawk pits are allowed a maximum of 160,000 lbs of blasting agent per blast with the option of two (2) blasts per day.

There are no changes to the previously used emission factors. The NOx emission factor is the average of measurements from "NOx Emissions from Blasting Operations in Open-Cut Coal Mining" by Moetaz I. Attalla, Stuart J. Day, Tony Lange, William Lilley, and Scott Morgan (2008). The CO emission factor is the average of the measurements in "Factors Affecting Anfo Fumes Production" by James H. Rowland III and Richard Mainiero (2001). The SO_2 emissions are based on a diesel sulfur content of 15 ppm assuming complete conversion to SO_2. Particulate blasting emissions are based on emission factors from AP-42 Table 11.9-1. Greenhouse gas emissions associated with blasting are calculated using emission factors from 40 CFR 98 Subpart C, Tables C-1 and C-2 and global warming potentials from 40 CFR 98 Subpart A, Table A-1.

Mine and Reclamation Handling (Fugitive)
Mining material handling emissions are calculated based on emission factors from AP-42 Chapter 11.19.2 and a maximum mining material throughput that varies by pit. See the table below. The stockpile material handling emissions have been combined with the pit material handling such that the emissions from both activities are represented in this permit application as “Mining Material Handling”.

Operating Scenario	Pit Name	Maximum Mining Rates (tons/day)
2, 3, 4, 7	Mohawk	200,000
2	Copper Mountain	200,000
4, 6	Copper Leach	90,000
5, 6, 7	Burro Chief	200,000
3, 5	Little Rock 6	90,000

Reclamation material handling emissions are also calculated based on emission factors from AP-42 Chapter 11.19.2 and a maximum material throughput that varies by reclamation area. See the table below.

Reclamation Area	Maximum Reclamation Rates (tons/day)
Launder Line	5,000
Thickener	15,000
P-Plant	15,000
1A/1B Stockpile	20,000
2A/2B Stockpile	20,000
CLW Stockpile	15,000

Crushing & Screening Plant (formerly SP-7A) Handling (Fugitive)
Material handling emissions from the contractor C&S Plant are based on AP-42 Chapters 11.19.2 and 13.2.4.

Mine, Reclamation, and Crushing & Screening Plant (formerly SP-7A) Hauling (Fugitive)
Emissions from unpaved haul road truck traffic are calculated using the methodology from AP-42 Chapter 13.2.2. A control efficiency of 88.8%, consistent with the M5 calculations, was applied to the uncontrolled emissions, which is based on 80% control for base course and watering (NMED guidance, January 1, 2017) and 44% control for an average speed limit of 25 mph (WRAP Fugitive Dust Handbook, September 7, 2006).

Gasoline Dispensing Facilities (GDF1 and GDF2)
Emissions from GDF1 and GDF2 are calculated using the updated June 2020 AP-42 Chapter 7 methodology and an updated throughput. The gasoline HAP constituents are based on data from EPA's SPECIATE 5.0 database. Specifically, the HAP values are based on the maximum percentages measured for a non-ethanol gasoline headspace vapor sample and a 10% ethanol gasoline headspace vapor sample since Tyrone's gasoline can be 10% or less ethanol.

SX Heat Exchanger Hot Water Boilers (B-3891 and B-1454)
Emissions from the new boilers are calculated based on AP-42 Chapter 1.5, a sulfur content of 15.9 grains/100 ft^3 for propane, AP-42 Chapter 1.4 for the HAP emission factors, and 40 CFR 98 methodology for the GHG emissions.

Engines
Emissions of NO_X, CO, VOC, and PM are based on EPA Tier emissions standards for units SD-1, SD-2, ENV-122, ENV-123, OP-2, OP-4, OP-7, OP-8, ENV-120, EMP-1, and EMP-2. Emissions of NOx, CO, VOC, and PM are based on the EPA FEL Certification Test results for ENV-117. Emissions of NO_X, CO, PM, SO_2, and VOC are based on AP-42 Chapter 3.3 for units ENV-101 and ENV-111. SO_2 and HAP emissions are based on factors from AP-42 Chapter 3.3. Greenhouse gas emissions are calculated using the factors and calculation methodology from 40 CFR 98 Subparts A and C.

No changes were made to the emergency engines (Generac GEN1-GEN4, IPG, GO Generator Backup EI-128, SX/EW Fire Water Pump, and SX Tankhouse Emergency Generator), which are exempt from construction permitting, so no calculations are provided for these engines in this permit application.

Section 6.a

Green House Gas Emissions

(Submitting under 20.2.70, 20.2.72 20.2.74 NMAC)

Title V (20.2.70 NMAC), Minor NSR (20.2.72 NMAC), and PSD (20.2.74 NMAC) applicants must estimate and report greenhouse gas (GHG) emissions to verify the emission rates reported in the public notice, determine applicability to 40 CFR 60 Subparts, and to evaluate Prevention of Significant Deterioration (PSD) applicability. GHG emissions that are subject to air permit regulations consist of the sum of an aggregate group of these six greenhouse gases: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Calculating GHG Emissions:

1. Calculate the ton per year (tpy) GHG mass emissions and GHG CO_2e emissions from your facility.
2. GHG mass emissions are the sum of the total annual tons of greenhouse gases without adjusting with the global warming potentials (GWPs). GHG CO_2e emissions are the sum of the mass emissions of each individual GHG multiplied by its GWP found in Table A-1 in 40 CFR 98 Mandatory Greenhouse Gas Reporting.
3. Emissions from routine or predictable start up, shut down, and maintenance must be included.
4. Report GHG mass and GHG CO_2e emissions in Table 2-P of this application. Emissions are reported in **short** tons per year and represent each emission unit's Potential to Emit (PTE).
5. All Title V major sources, PSD major sources, and all power plants, whether major or not, must calculate and report GHG mass and CO2e emissions for each unit in Table 2-P.
6. For minor source facilities that are not power plants, are not Title V, and are not PSD there are three options for reporting GHGs in Table 2-P: 1) report GHGs for each individual piece of equipment; 2) report all GHGs from a group of unit types, for example report all combustion source GHGs as a single unit and all venting GHGs as a second separate unit; 3) or check the following ☐ By checking this box, the applicant acknowledges the total CO2e emissions are less than 75,000 tons per year.

Sources for Calculating GHG Emissions:

- Manufacturer's Data
- AP-42 Compilation of Air Pollutant Emission Factors at http://www.epa.gov/ttn/chief/ap42/index.html
- EPA's Internet emission factor database WebFIRE at http://cfpub.epa.gov/webfire/
- 40 CFR 98 Mandatory Green House Gas Reporting except that tons should be reported in short tons rather than in metric tons for the purpose of PSD applicability.
- API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. August 2009 or most recent version.
- Sources listed on EPA's NSR Resources for Estimating GHG Emissions at http://www.epa.gov/nsr/clean-air-act-permitting-greenhouse-gases:

Global Warming Potentials (GWP):
Applicants must use the Global Warming Potentials codified in Table A-1 of the most recent version of 40 CFR 98 Mandatory Greenhouse Gas Reporting. The GWP for a particular GHG is the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 over a specified time period.

"Greenhouse gas" for the purpose of air permit regulations is defined as the aggregate group of the following six gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. **(20.2.70.7 NMAC, 20.2.74.7 NMAC).** You may also find GHGs defined in 40 CFR 86.1818-12(a).

Metric to Short Ton Conversion:
Short tons for GHGs and other regulated pollutants are the standard unit of measure for PSD and title V permitting programs. 40 CFR 98 Mandatory Greenhouse Reporting requires metric tons.
1 metric ton = 1.10231 short tons (per Table A-2 to Subpart A of Part 98 – Units of Measure Conversions)

Freeport-McMoRan Tyrone Inc.
Facility-Wide Emissions Summary

Uncontrolled Emissions

Unit	NOx		CO		VOC		SO_2		TSP		PM_{10}		$PM_{2.5}$		Total HAP	
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy
SX/EW-1 (Fugitive)	-	-	-	-	5.15	22.54	-	-	-	-	-	-	-	-	1.65	7.23
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	1.82	7.98	1.82	7.98	-	-	-	-
SX/EW-3 (Fugitive)	-	-	-	-	0.95	4.15	-	-	-	-	-	-	-	-	0.30	1.33
SX/EW-4 (Fugitive)	-	-	-	-	0.32	1.39	-	-	-	-	-	-	-	-	0.097	0.42
Water Boiler B-748[1] Water Boiler B-951[1]	0.36	1.56	0.21	0.90	0.022	0.096	0.044	0.19	0.019	0.084	0.019	0.084	0.019	0.084	0.0047	0.020
Water Boiler B-3891	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	0.0067	0.029
Water Boiler B-1454	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	0.0067	0.029
SD-1	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	0.0068	0.030
SD-2	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	0.0068	0.030
ENV-101	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	0.0035	0.015
ENV-111	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	0.0035	0.015
ENV-117	0.95	4.18	0.22	0.94	0.050	0.22	0.22	0.98	0.052	0.23	0.052	0.23	0.052	0.23	0.0026	0.011
ENV-122	1.29	5.65	1.03	4.50	0.068	0.30	0.26	1.12	0.062	0.27	0.062	0.27	0.062	0.27	0.0035	0.015
ENV-123	2.19	9.61	1.22	5.36	0.12	0.51	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
Mine Blasting (Fugitive)	180.00	114.98	4,064.0	2,595.88	-	-	0.36	0.23	618.72	451.66	321.73	234.87	18.56	13.55	-	-
Mine Handling (Fugitive) (Pit and Stockpile)	-	-	-	-	-	-	-	-	0.70	6.10	0.27	2.34	0.040	0.35	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	3,989.06	21,276.60	1,016.67	5,422.62	101.67	542.26	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	0.12	0.53	0.047	0.20	0.0070	0.031	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	2,485.50	8,798.67	633.46	2,242.46	63.35	224.25	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	40.89	89.56	15.75	34.50	2.37	5.18	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	83.15	147.18	21.19	37.51	2.12	3.75	-	-
SPCC-TYR-061 (GDF1)	-	-	-	-	2.41	10.57	-	-	-	-	-	-	-	-	0.27	1.19
SPCC-TYR-119 (GDF2)	-	-	-	-	0.39	1.70	-	-	-	-	-	-	-	-	0.044	0.19
OP-2	0.36	1.58	0.28	1.22	0.019	0.083	0.063	0.28	0.030	0.13	0.030	0.13	0.030	0.13	0.00074	0.0032
OP-4	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
OP-7	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
OP-8	1.33	5.82	1.22	5.36	0.074	0.32	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
ENV-120	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
EMP-1	2.72	11.91	3.37	14.75	0.38	1.68	0.37	1.61	0.16	0.70	0.16	0.70	0.16	0.70	0.0043	0.019
EMP-2	1.95	8.54	1.09	4.77	0.10	0.45	0.39	1.70	0.062	0.27	0.062	0.27	0.062	0.27	0.0045	0.020
CE-1	3.10	0.78	0.67	0.17	0.25	0.06	0.21	0.051	0.22	0.055	0.22	0.055	0.22	0.055	0.0028	0.00069
PPG-1, 3, 4, 7, 8, 11-15	499.70	56.20	257.13	37.39	29.00	2.12	12.50	0.49	15.08	0.73	12.39	0.64	10.36	0.58	0.37	0.011
Total	**710.26**	**292.23**	**4,339.64**	**2,711.57**	**40.39**	**50.95**	**18.39**	**24.09**	**7,236.79**	**30,785.76**	**2,025.08**	**7,989.85**	**200.21**	**796.69**	**2.82**	**10.73**
Total w/o Fugitives[2]	**530.26**	**177.25**	**275.64**	**115.69**	**33.97**	**22.87**	**18.03**	**23.86**	**16.82**	**7.47**	**14.14**	**7.38**	**12.11**	**7.32**	**0.77**	**1.75**

Unit	Ethylbenzene		Benzene		Hexane		2,2,4-Trimethylpentane		Toluene		Xylenes		Formaldehyde		CO_2	CH_4	N_2O	CO_2e
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	metric tpy	metric tpy	metric tpy	metric tpy
SX/EW-1 (Fugitive)	6.55E-01	2.87E+00	6.92E-03	3.03E-02	-	-	-	-	1.36E-01	5.98E-01	8.53E-01	3.74E+00	-	-	-	-	-	-
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-3 (Fugitive)	1.21E-01	5.28E-01	1.28E-03	5.59E-03	-	-	-	-	2.51E-02	1.10E-01	1.57E-01	6.88E-01	-	-	-	-	-	-
SX/EW-4 (Fugitive)	3.85E-02	1.68E-01	3.88E-04	1.70E-03	-	-	-	-	7.69E-03	3.37E-02	5.01E-02	2.19E-01	-	-	-	-	-	-
Water Boiler B-748[1] Water Boiler B-951[1]	-	-	-	-	-	-	-	-	8.37E-06	3.67E-05	-	-	1.85E-04	8.09E-04	1,521.81	0.073	0.015	1,527.95
Water Boiler B-3891	-	-	-	-	-	-	-	-	1.20E-05	5.26E-05	-	-	2.65E-04	1.16E-03	2,180.94	0.10	0.021	2,189.74
Water Boiler B-1454	-	-	-	-	-	-	-	-	1.20E-05	5.26E-05	-	-	2.65E-04	1.16E-03	2,180.94	0.10	0.021	2,189.74
SD-1	-	-	-	-	-	-	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03	2.34E-03	1.03E-02	1,296.45	0.053	0.011	1,300.90
SD-2	-	-	-	-	-	-	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03	2.34E-03	1.03E-02	1,296.45	0.053	0.011	1,300.90
ENV-101	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-111	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-117	-	-	-	-	-	-	-	-	3.12E-05	1.37E-04	2.18E-04	9.53E-04	9.01E-04	3.95E-03	498.39	0.020	0.0040	500.10
ENV-122	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-123	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
Mine Blasting (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24,021.12	0.97	0.19	24,103.55
Mine Handling (Fugitive) (Pit and Stockpile)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPCC-TYR-061 (GDF1)	4.34E-03	1.90E-02	8.33E-03	3.65E-02	2.59E-02	1.14E-01	1.30E-01	5.71E-01	8.67E-02	3.80E-01	1.66E-02	7.25E-02	-	-	-	-	-	-
SPCC-TYR-119 (GDF2)	7.01E-04	3.07E-03	1.34E-03	5.88E-03	4.18E-03	1.83E-02	2.10E-02	9.21E-02	1.40E-02	6.12E-02	2.67E-03	1.17E-02	-	-	-	-	-	-
OP-2	-	-	-	-	-	-	-	-	8.80E-06	3.86E-05	6.13E-05	2.69E-04	2.54E-04	1.11E-03	87.39	0.0035	0.00071	87.69
OP-4	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
OP-7	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
OP-8	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	1,110.11	0.045	0.0090	1,113.92
ENV-120	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
EMP-1	-	-	-	-	-	-	-	-	5.15E-05	2.25E-04	3.59E-04	1.57E-03	1.48E-03	6.50E-03	821.09	0.033	0.0067	823.90
EMP-2	-	-	-	-	-	-	-	-	5.42E-05	2.37E-04	3.77E-04	1.65E-03	1.56E-03	6.84E-03	864.30	0.035	0.0070	867.27
CE-1	-	-	6.53E-04	1.63E-04	-	-	-	-	2.86E-04	7.16E-05	2.00E-04	4.99E-05	8.26E-04	2.07E-04	882.37	0.036	0.0072	885.39
PPG-1, 3, 4, 7, 8, 11-15	-	-	1.68E-01	5.04E-03	-	-	-	-	6.08E-02	1.82E-03	4.17E-02	1.25E-03	1.10E+01	2.56E-03	5,668.15	0.23	0.046	5,687.60
Total	**0.82**	**3.59**	**0.19**	**0.085**	**0.030**	**0.13**	**0.15**	**0.66**	**0.33**	**1.19**	**1.13**	**4.75**	**11.04**	**0.10**	**47,928.21**	**1.99**	**0.40**	**48,096.24**
Total w/o Fugitives[2]	**0.0050**	**0.022**	**0.18**	**0.048**	**0.030**	**0.13**	**0.15**	**0.66**	**0.16**	**0.45**	**0.07**	**0.11**	**11.04**	**0.10**	**23,907.09**	**1.01**	**0.20**	**23,992.69**

Footnotes:

[1] These two boilers share a common stack, so their emissions are combined.

[2] Fugitive criterial pollutant emissions do not count towards the TV and PSD applicability of the facility; therefore, they are not included in the permittable limit.

Freeport-McMoRan Tyrone Inc.
Facility-Wide Emissions Summary

Controlled Emissions

Unit	NOX		CO		VOC		SO_2		TSP		PM_{10}		$PM_{2.5}$		Total HAP	
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy
SX/EW-1 (Fugitive)	-	-	-	-	5.15	22.54	-	-	-	-	-	-	-	-	1.65	7.23
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	1.82	7.98	1.82	7.98	-	-	-	-
SX/EW-3 (Fugitive)	-	-	-	-	0.95	4.15	-	-	-	-	-	-	-	-	0.30	1.33
SX/EW-4 (Fugitive)	-	-	-	-	0.32	1.39	-	-	-	-	-	-	-	-	0.097	0.42
Water Boiler B-748[1] Water Boiler B-951[1]	0.36	1.56	0.21	0.90	0.022	0.096	0.044	0.19	0.019	0.084	0.019	0.084	0.019	0.084	0.0047	0.020
Water Boiler B-3891	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	0.0067	0.029
Water Boiler B-1454	0.51	2.24	0.30	1.29	0.031	0.14	0.063	0.27	0.028	0.12	0.028	0.12	0.028	0.12	0.0067	0.029
SD-1	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	0.0068	0.030
SD-2	1.77	7.77	1.63	7.15	0.093	0.41	0.58	2.55	0.093	0.41	0.093	0.41	0.093	0.41	0.0068	0.030
ENV-101	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	0.0035	0.015
ENV-111	3.88	16.97	0.84	3.67	0.31	1.37	0.26	1.12	0.28	1.20	0.28	1.20	0.28	1.20	0.0035	0.015
ENV-117	0.95	4.18	0.22	0.94	0.050	0.22	0.22	0.98	0.052	0.23	0.052	0.23	0.052	0.23	0.0026	0.011
ENV-122	1.29	5.65	1.03	4.50	0.068	0.30	0.26	1.12	0.062	0.27	0.062	0.27	0.062	0.27	0.0035	0.015
ENV-123	2.19	9.61	1.22	5.36	0.115	0.51	0.44	1.91	0.0700	0.307	0.0700	0.307	0.070	0.31	0.0051	0.022
Mine Blasting (Fugitive)	180.00	114.98	4,064.00	2,595.88	-	-	0.36	0.23	618.72	451.66	321.73	234.87	18.56	13.55	-	-
Mine Handling (Fugitive) (Pit and Stockpile)	-	-	-	-	-	-	-	-	0.70	6.10	0.27	2.34	0.040	0.35	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	446.78	2,382.98	113.87	607.33	11.39	60.73	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	0.12	0.53	0.047	0.20	0.0070	0.031	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	278.38	985.45	70.95	251.16	7.09	25.12	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	8.45	18.50	3.68	8.07	0.57	1.25	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	9.31	16.48	2.37	4.20	0.24	0.42	-	-
SPCC-TYR-061 (GDF1)	-	-	-	-	2.41	10.57	-	-	-	-	-	-	-	-	0.27	1.19
SPCC-TYR-119 (GDF2)	-	-	-	-	0.39	1.70	-	-	-	-	-	-	-	-	0.044	0.19
OP-2	0.36	1.58	0.28	1.22	0.019	0.083	0.063	0.28	0.030	0.13	0.030	0.13	0.030	0.13	0.00074	0.0032
OP-4	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
OP-7	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
OP-8	1.33	5.82	1.22	5.36	0.074	0.32	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
ENV-120	1.33	5.82	1.22	5.36	0.070	0.31	0.44	1.91	0.070	0.31	0.070	0.31	0.070	0.31	0.0051	0.022
EMP-1	2.72	11.91	3.37	14.75	0.38	1.68	0.37	1.61	0.160	0.70	0.16	0.70	0.16	0.70	0.0043	0.019
EMP-2	1.95	8.54	1.09	4.77	0.10	0.45	0.39	1.70	0.062	0.27	0.062	0.27	0.062	0.27	0.0045	0.020
CE-1	3.10	0.78	0.67	0.17	0.25	0.063	0.21	0.051	0.22	0.055	0.22	0.055	0.22	0.055	0.0028	0.00069
PPG-1, 3, 4, 7, 8, 11-15	499.70	56.20	257.13	37.39	29.00	2.12	12.50	0.49	15.08	0.73	12.39	0.64	10.36	0.58	0.37	0.011
Total	**710.26**	**292.23**	**4,339.64**	**2,711.57**	**40.39**	**50.95**	**18.39**	**24.09**	**1,381.09**	**3,877.16**	**528.88**	**1,123.53**	**50.01**	**108.77**	**2.82**	**10.73**
Total w/o Fugitives[2]	**530.26**	**177.25**	**275.64**	**115.69**	**33.97**	**22.87**	**18.03**	**23.86**	**16.82**	**7.47**	**14.14**	**7.38**	**12.11**	**7.32**	**0.77**	**1.75**

Unit	Ethylbenzene		Benzene		Hexane		2,2,4-Trimethylpentane		Toluene		Xylenes		Formaldehyde		CO_2	CH_4	N_2O	CO_2e
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	metric tpy	metric tpy	metric tpy	metric tpy
SX/EW-1 (Fugitive)	6.55E-01	2.87E+00	6.92E-03	3.03E-02	-	-	-	-	1.36E-01	5.98E-01	8.53E-01	3.74E+00	-	-	-	-	-	-
SX/EW-2 (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SX/EW-3 (Fugitive)	1.21E-01	5.28E-01	1.28E-03	5.59E-03	-	-	-	-	2.51E-02	1.10E-01	1.57E-01	6.88E-01	-	-	-	-	-	-
SX/EW-4 (Fugitive)	3.85E-02	1.68E-01	3.88E-04	1.70E-03	-	-	-	-	7.69E-03	3.37E-02	5.01E-02	2.19E-01	-	-	-	-	-	-
Water Boiler B-748[1] Water Boiler B-951[1]	-	-	-	-	-	-	-	-	8.37E-06	3.67E-05	-	-	1.85E-04	8.09E-04	1,521.81	0.073	0.015	1,527.95
Water Boiler B-3891	-	-	-	-	-	-	-	-	1.20E-05	5.26E-05	-	-	2.65E-04	1.16E-03	2,180.94	0.10	0.021	2,189.74
Water Boiler B-1454	-	-	-	-	-	-	-	-	1.20E-05	5.26E-05	-	-	2.65E-04	1.16E-03	2,180.94	0.10	0.021	2,189.74
SD-1	-	-	-	-	-	-	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03	2.34E-03	1.03E-02	1,296.45	0.053	0.011	1,300.90
SD-2	-	-	-	-	-	-	-	-	8.12E-05	3.56E-04	5.66E-04	2.48E-03	2.34E-03	1.03E-02	1,296.45	0.053	0.011	1,300.90
ENV-101	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-111	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-117	-	-	-	-	-	-	-	-	3.12E-05	1.37E-04	2.18E-04	9.53E-04	9.01E-04	3.95E-03	498.39	0.020	0.0040	500.10
ENV-122	-	-	-	-	-	-	-	-	3.58E-04	1.57E-03	2.49E-04	1.09E-03	1.03E-03	4.52E-03	536.45	0.022	0.0044	538.29
ENV-123	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
Mine Blasting (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-			24,021.12	0.97	0.19	24,103.55
Mine Handling (Fugitive) (Pit and Stockpile)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mine Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reclamation Handling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reclamation Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C&S Plant (formerly SP-7A) Handling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C&S Plant (formerly SP-7A) Hauling (Fugitive)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPCC-TYR-061 (GDF1)	4.34E-03	1.90E-02	8.33E-03	3.65E-02	2.59E-02	1.14E-01	1.30E-01	5.71E-01	8.67E-02	3.80E-01	1.66E-02	7.25E-02	-	-	-	-	-	-
SPCC-TYR-119 (GDF2)	7.01E-04	3.07E-03	1.34E-03	5.88E-03	4.18E-03	1.83E-02	2.10E-02	9.21E-02	1.40E-02	6.12E-02	2.67E-03	1.17E-02	-	-	-	-	-	-
OP-2	-	-	-	-	-	-	-	-	8.80E-06	3.86E-05	6.13E-05	2.69E-04	2.54E-04	1.11E-03	87.39	0.0035	0.00071	87.69
OP-4	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
OP-7	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
OP-8	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	1,110.11	0.045	0.0090	1,113.92
ENV-120	-	-	-	-	-	-	-	-	6.09E-05	2.67E-04	4.25E-04	1.86E-03	1.76E-03	7.70E-03	972.34	0.039	0.0079	975.68
EMP-1	-	-	-	-	-	-	-	-	5.15E-05	2.25E-04	3.59E-04	1.57E-03	1.48E-03	6.50E-03	821.09	0.033	0.0067	823.90
EMP-2	-	-	-	-	-	-	-	-	5.42E-05	2.37E-04	3.77E-04	1.65E-03	1.56E-03	6.84E-03	864.30	0.035	0.0070	867.27
CE-1	-	-	6.53E-04	1.63E-04	-	-	-	-	2.86E-04	7.16E-05	2.00E-04	4.99E-05	8.26E-04	2.07E-04	882.37	0.036	0.0072	885.39
PPG-1, 3, 4, 7, 8, 11-15	-	-	1.68E-01	5.04E-03	-	-	-	-	6.08E-02	1.82E-03	4.17E-02	1.25E-03	1.10E+01	2.56E-03	5,668.15	0.23	0.046	5,687.60
Total	**0.82**	**3.59**	**0.19**	**0.085**	**0.030**	**0.13**	**0.15**	**0.66**	**0.33**	**1.19**	**1.13**	**4.75**	**11.04**	**0.097**	**47,928.21**	**1.99**	**0.40**	**48,096.24**
Total w/o Fugitives[2]	**0.0050**	**0.022**	**0.18**	**0.048**	**0.030**	**0.13**	**0.15**	**0.66**	**0.16**	**0.45**	**0.066**	**0.11**	**11.04**	**0.097**	**23,907.09**	**1.01**	**0.20**	**23,992.69**

Footnotes:

[1] These two boilers share a common stack.

[2] Fugitive emissions do not count towards the TV and PSD applicability of the facility; therefore, they are not included in the permittable limit.

Freeport-McMoRan Tyrone Inc.
Blasting Emissions

Table 1: Input Parameters

Maximum Blasting Operational Scenario	700,000	lbs blasting agent/day	*See Table 3 below*
	125,000	ft^2 blast area/blast	*See Table 3 below*
	365	days/yr	
	200,000	lbs blasting agent/blast event	*See Table 3 below*
	127,750	tons blasting agent/year	
Maximum Diesel Fuel in Blasting Agent	6%	blasting agent fuel oil %	
	6.5	lb/gal density	
	0.138	MMBtu/gal	*40 CFR 98, Subpart C, Table C–1 (default HHV for GHG calculations)*
	6,462	gal/day	
	1,846	gal/blast event	
	2,358,462	gal/yr	

Table 2: Maximum Emissions from Blasting

Pollutant	Emission Factor	Emission Factor Units	Emission Factor Reference	Maximum Operational Scenario Potential Emission Rates[a]			
				(lb/hr)	(lb/day)	(ton/yr)	
Uncontrolled and Controlled[b]							
NO_x	1.8	lb/ton blasting agent	1	180.00	630.00	114.98	
CO	40.64	lb/ton blasting agent	2	4,064.00	14,224.00	2,595.88	
SO_2	0.0036	lb/ton blasting agent	3	0.36	1.26	0.23	
TSP	618.72	lb/blast event	4	618.72	2,474.87	451.66	
PM_{10}	321.73	lb/blast event	4	321.73	1,286.93	234.87	
$PM_{2.5}$	18.56	lb/blast event	4	18.56	74.25	13.55	
CO_2	162.71	lb/MMBtu	5	41,454.01	145,089.04	26,478.75	24,021.12 metric tons/yr
N_2O	0.0013	lb/MMBtu	6	0.34	1.18	0.21	0.19 metric tons/yr
CH_4	0.0066	lb/MMBtu	6	1.68	5.89	1.07	0.97 metric tons/yr
CO_2e[c]	--	--	--	41,596.26	145,586.92	26,569.61	24,103.55 metric tons/yr

Emission Factor References:

1. NOx emission factor is the average of measurements from "NOx Emissions from Blasting Operations in Open-Cut Coal Mining" by Moetaz I. Attalla, Stuart J. Day, Tony Lange, William Lilley, and Scott Morgan (2008).
2. CO emission factor is the average of the measurements in "Factors Affecting Anfo Fumes Production" by James H. Rowland III and Richard Mainiero (2001).
3. SO_2 emission factor is based on a stoichiometric conversion of all the sulfur in the diesel fuel in ANFO to SO_2. The conversion was based on 6% fuel oil in the blasting agent and a diesel fuel sulfur content of 15 ppm.
4. PM emission factors are based on emission factors from AP-42, Chapter 11.9, Table 11.9-1 (July 1998).
5. CO_2 emission factor is based on 40 CFR 98 Subpart C, Table C–1 for Distillate Fuel Oil No. 2. The emission factor is converted from kg/MMBtu to lb/MMBtu using a conversion factor of 2.2 lb/kg.
6. N_2O and CH_4 emission factors are based on 40 CFR 98 Subpart C, Table C–2 for Petroleum Products. The emission factors are converted from kg/MMBtu to lb/MMBtu using a conversion factor of 2.2 lb/kg.

Footnotes:

[a] Because only one pit can be blasted in an hour, the maximum hourly emissions are based on the maximum emissions at an individual pit; whereas the maximum daily and annual emissions are based on the maximum of the sum of both pits operating within each scenario.

[b] For blasting, uncontrolled emissions equal controlled emissions because no additional control measures are applied during blasting.

[c] Calculated based on a Global Warming Potential (GWP) of 1 for CO_2, 298 for N_2O, and 25 for CH_4 as per 40 CFR 98, Table A-1.

Table 3: Proposed Mining Scenarios

Operating Scenario	Pit Name	Maximum Blasting Agent Usage per Blast (lbs/blast)	Maximum No. of Blasts per Day	Maximum Daily Blasting Agent Usage (lbs/day)	Maximum Blast Area per Blast (ft^2/blast)
2, 3, 4, 7	Mohawk	150,000	2	300,000	125,000
2	Copper Mountain	100,000	1	100,000	125,000
4, 6	Copper Leach	50,000	1	50,000	125,000
5, 6, 7	Burro Chief	200,000	2	400,000	125,000
3, 5	Little Rock 6	100,000	1	100,000	125,000

Scenario 1, which was permitted in M5 for Gettysburg and Mohawk, is not being repeated here. Scenarios 2 through 5 are being proposed in addition to the M5 scenario as potential operating scenarios. None of the scenarios, including Scenario 1 in M5, can operate simultaneously.

Table 4: Scenario-Specific Blasting Emission Rates

Mining Area	NOx			CO			SO_2			TSP			PM_{10}			$PM_{2.5}$		
	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)
Scenario 2																		
Mohawk	135.00	270.00	49.28	3,048.00	6,096.00	1,112.52	0.27	0.54	0.10	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Copper Mountain	90.00	90.00	16.43	2,032.00	2,032.00	370.84	0.18	0.18	0.03	618.72	618.72	112.92	321.73	321.73	58.72	18.56	18.56	3.39
Scenario 3																		
Mohawk	135.00	270.00	49.28	3,048.00	6,096.00	1,112.52	0.27	0.54	0.10	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Little Rock 6	90.00	90.00	16.43	2,032.00	2,032.00	370.84	0.18	0.18	0.03	618.72	618.72	112.92	321.73	321.73	58.72	18.56	18.56	3.39
Scenario 4																		
Mohawk	135.00	270.00	49.28	3,048.00	6,096.00	1,112.52	0.27	0.54	0.10	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Copper Leach	45.00	45.00	8.21	1,016.00	1,016.00	185.42	0.090	0.090	0.016	618.72	618.72	112.92	321.73	321.73	58.72	18.56	18.56	3.39
Scenario 5																		
Burro Chief	180.00	360.00	65.70	4,064.00	8,128.00	1,483.36	0.36	0.72	0.13	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Little Rock 6	90.00	90.00	16.43	2,032.00	2,032.00	370.84	0.18	0.18	0.03	618.72	618.72	112.92	321.73	321.73	58.72	18.56	18.56	3.39
Scenario 6																		
Burro Chief	180.00	360.00	65.70	4,064.00	8,128.00	1,483.36	0.36	0.72	0.13	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Copper Leach	45.00	45.00	8.21	1,016.00	1,016.00	185.42	0.090	0.090	0.016	618.72	618.72	112.92	321.73	321.73	58.72	18.56	18.56	3.39
Scenario 7																		
Mohawk	135.00	270.00	49.28	3,048.00	6,096.00	1,112.52	0.27	0.54	0.10	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77
Burro Chief	180.00	360.00	65.70	4,064.00	8,128.00	1,483.36	0.36	0.72	0.13	618.72	1,237.44	225.83	321.73	643.47	117.43	18.56	37.12	6.77

Freeport-McMoRan Tyrone Inc.
Mining Material Handling Emissions

Table 1: Input Parameters

Uncontrolled Emission Factors	PM_{10}	1.60E-05	lb/ton[1]
	Ratio of $PM_{2.5}$ / PM_{10}	0.15 [2]	
	$PM_{2.5}$	2.40E-06	lb/ton[2]
	Ratio of TSP / PM_{10}	2.61 [3]	
	TSP	4.18E-05	lb/ton[3]
Hours of Operation	24	hours/day	
	365	days/year	
	8,760	hours/year	

Footnotes:

[1] The PM_{10} emission factor is based on AP-42, Chapter 11.19.2, Table 11.19.2-2 Crushed Stone Processing Operations (August 2004) for Truck Unloading - Fragmented Stone. The Truck Unloading emission factor is used for truck loading and truck unloading since the quantity of emissions from unloading would essentially be the same as loading. No TSP or $PM_{2.5}$ emission factors for Truck Unloading are provided in the AP-42 table.

[2] The $PM_{2.5}$ emission factor was calculated from the available PM_{10} emission factor using the ratio of 0.15 $PM_{2.5}$ / PM_{10} as recommended in the AP-42 *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* (November 2006).

[3] An uncontrolled TSP emission factor was calculated based on an average of the TSP/PM_{10} ratios using the available uncontrolled emission factors in AP-42 Table 11.19.2-2. The associated ratios are: Tertiary Crushing (0.0054/0.0024 = 2.25); Fines Crushing (0.0390/0.0150 = 2.60); Screening (0.025/0.0087 = 2.87; and Conveyor Transfer Point (0.0030/0.00110 = 2.73). The average of these ratios is 2.61.

Table 2: Maximum Emissions from Mine Material Handling

Pollutant	Maximum Operational Scenario Potential Emission Rates[1]		
	(lb/hr)	(lb/day)	(ton/yr)
Uncontrolled and Controlled[2]			
TSP	0.70	33.41	6.10
PM_{10}	0.27	12.80	2.34
$PM_{2.5}$	0.040	1.92	0.35

Footnotes:

[1] Because only one pit can be blasted in an hour, the maximum hourly emissions are based on the maximum emissions at an individual pit; whereas the maximum daily and annual emissions are based on the maximum of the sum of both pits operating within each scenario.

[2] Uncontrolled emissions equal controlled emissions for these activities.

Table 3: Proposed Mining Scenarios

Operating Scenario	Pit Name	Maximum Mining Rates (tons/day)	No. of Handling Steps[1]
2, 3, 4, 7	Mohawk	200,000	2
2	Copper Mountain	200,000	2
4, 6	Copper Leach	90,000	2
5, 6, 7	Burro Chief	200,000	2
3, 5	Little Rock 6	90,000	2

Scenario 1, which was permitted in M5 for Gettysburg and Mohawk, is not being repeated here. Scenarios 2 through 5 are being proposed in addition to the M5 scenario as potential operating scenarios. None of the scenarios, including Scenario 1 in M5, can operate simultaneously.

Footnotes:

[1] The handling instances consists of truck loading at the pit and truck unloading at the waste or leach stockpile.

Table 4: Scenario-Specific Mining Material Handling Emission Rates

Mining Area *(Material Origination)*	Worst-Case Stockpiles in the Model *(Material Destination)*	Maximum Mining Rates (tons/day)	No. of Handling Steps[1]	Maximum Hourly Emission Rates (lb/hr)[2]			Maximum Daily Emission Rates (lb/day)[2]			Maximum Annual Emission Rates (ton/yr)[2]		
				TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Scenario 2												
Mohawk	VAO	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Copper Mountain[3]	CMO (33%), 4DO (33%), 4CO (33%)	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.175
Scenario 3												
Mohawk	VAO	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Little Rock 6	CLW	90,000	2	0.31	0.12	0.018	7.52	2.88	0.43	1.37	0.53	0.08
Scenario 4												
Mohawk	VAO	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Copper Leach	CLW	90,000	2	0.30	0.11	0.017	7.10	2.72	0.41	1.30	0.50	0.07
Scenario 5												
Burro Chief	2AO (50%), 2BW (50%)	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Little Rock 6	CLW	90,000	2	0.31	0.12	0.018	7.52	2.88	0.43	1.37	0.53	0.08
Scenario 6												
Burro Chief	2AO (50%), 2BW (50%)	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Copper Leach	CLW	90,000	2	0.30	0.11	0.017	7.10	2.72	0.41	1.30	0.50	0.07
Scenario 7												
Mohawk	6DO	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18
Burro Chief	5AW	200,000	2	0.70	0.27	0.040	16.70	6.40	0.96	3.05	1.17	0.18

Footnotes:

[1] The handling steps consist of truck loading at the pit and truck unloading at the waste or leach stockpile.

[2] Uncontrolled emissions equal controlled emissions for these activities.

[3] Unlike the other mining areas, Copper Mountain will not have material loaded, hauled, or unloaded from the pit when the material destination is CMO. CMO is an in-pit stockpile, but to be conservative, we are accounting for the same number of material handling steps as the other pits.

Freeport-McMoRan Tyrone Inc.
Mining Haul Road Emissions

Table 1: Input Parameters

Mining Haul Truck Inputs	**Truck Type**		**Large (Cat 793)**	
	Empty Vehicle Weight (tons)		170.6	
	Max Load Capacity (tons)		297.0	
	Full Vehicle Weight (tons)		467.6	
	Average Vehicle Weight (tons)[1]		319.1	
Mining Haul Road Inputs	Silt Content (%)		4.8	
	Control Efficiency (%)[2]		88.8	
	No. of Precip. Days, P[3]		70	
	Hours of Operation (hrs/day)		24	
	Hours of Operation (days/yr)		365	
	Hours of Operation (hrs/yr)		8,760	
Emission Factor Equation Inputs[4]	**Constant**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
	k (lb/VMT)	4.9	1.5	0.15
	a	0.7	0.9	0.9
	b	0.45	0.45	0.45
Calculated Emission Factors	**Pollutant**	**Uncontrolled**	**Controlled**	
	TSP (lb/VMT)	21.07	2.36	
	PM_{10} (lb/VMT)	5.37	0.60	
	$PM_{2.5}$ (lb/VMT)	0.54	0.060	

Footnotes:

[1] AP-42 13.2.2 (Unpaved Roads) Equation 1a is applicable to industrial roads with a mean vehicle weight from 2 to 290 tons. The Average Vehicle Weight is based on the haul trucks being full traveling in one direction and being empty traveling in the other direction.

[2] The combined control efficiency of 88.8% is based on 80% control for base course and watering (NMED guidance, January 1, 2017) and 44% control for an average speed of 25 mph (WRAP Fugitive Dust Handbook, September 7, 2006).

[3] This refers to the number of days in a year with at least 0.01 inches of precipitation and is based on Figure 13.2.2-1 in AP-42. This factor is only taken into account in the annual emissions calculation.

[4] These emission equation constants are provided in Table 13.2.2-2 in AP-42 for Industrial Roads (Equation 1a).

Table 2: Maximum Emissions from Mine Hauling

Pollutant	**Maximum Operational Scenario Potential Emission Rates[1]**		
	(lb/hr)	**(lb/day)**	**(ton/yr)**
Uncontrolled			
TSP	3,989.06	144,248.16	21,276.60
PM_{10}	1,016.67	36,763.55	5,422.62
$PM_{2.5}$	101.67	3,676.36	542.26
Controlled			
TSP	446.78	16,155.79	2,382.98
PM_{10}	113.87	4,117.52	607.33
$PM_{2.5}$	11.39	411.75	60.73

Footnotes:

[1] Because only one pit can be blasted in an hour, the maximum hourly emissions are based on the maximum emissions at an individual pit; whereas the maximum daily and annual emissions are based on the maximum of the sum of both pits operating within each scenario.

Table 3: Scenario-Specific Mine Hauling Uncontrolled Emission Rates

Mining Area *(Material Origination)*	Worst-Case Stockpiles in the Model *(Material Destination)*	Worst-Case Haul Roads in the Model	Total Length of Worst-Case Roads (ft, one-way)	Maximum Haulage Rate (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr*	Maximum Uncontrolled Hourly Emission Rates (lb/hr)			Maximum Uncontrolled Daily Emission Rates (lb/day)			Maximum Uncontrolled Annual Emission Rates (ton/yr)		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Scenario 2																
Mohawk	VAO	Roads 11G, 30	7,340	200,000	673.4	28.1	78.0	1,643.8	418.9	41.9	39,451	10,055	1,005	5,819.0	1,483.0	148.3
Copper Mountain	CMO (33%), 4DO (33%), 4CO (33%)	Roads 16A, 16B, 18J, 20A	10,587	200,000	673.4	28.1	112.5	2,370.9	604.3	60.4	56,902	14,502	1,450	8,393.1	2,139.1	213.9
Scenario 3																
Mohawk	VAO	Roads 11G, 30	7,340	200,000	673.4	28.1	78.0	1,643.8	418.9	41.9	39,451	10,055	1,005	5,819.0	1,483.0	148.3
Little Rock 6	CLW	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	1,317.9	335.9	33.6	31,630	8,061	806	4,665.4	1,189.0	118.9
Scenario 4																
Mohawk	VAO	Roads 11G, 30	4,829	200,000	673.4	28.1	51.3	1,081.4	275.6	27.6	25,954	6,615	661	3,828.3	975.7	97.6
Copper Leach	L6R	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	1,317.9	335.9	33.6	31,630	8,061	806	4,665.4	1,189.0	118.9
Scenario 5																
Burro Chief	2BW (50%), 2AO (50%)	Roads 17, 18, 21	17,813	200,000	673.4	28.1	189.3	3,989.1	1,016.7	101.7	95,738	24,400	2,440	14,121.3	3,599.0	359.9
Little Rock 6	CLW	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	1,317.9	335.9	33.6	31,630	8,061	806	4,665.4	1,189.0	118.9
Scenario 6																
Burro Chief	2BW (50%), 2AO (50%)	Roads 17, 18, 21	10,341	200,000	673.4	28.1	109.9	2,315.7	590.2	59.0	55,578	14,165	1,416	8,197.8	2,089.3	208.9
Copper Leach	L6R	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	1,317.9	335.9	33.6	31,630	8,061	806	4,665.4	1,189.0	118.9
Scenario 7																
Mohawk	6DO	Roads 9, 11C, 11E, 11F, 12B	11,937	200,000	673.4	28.1	126.9	2,673.2	681.3	68.1	64,157	16,351	1,635	9,463.1	2,411.8	241.2
Burro Chief	5AW	Roads 6, 7, 11E, 12B, 30A, 30B	14,902	200,000	673.4	28.1	158.4	3,337.2	850.5	85.1	80,092	20,412	2,041	11,813.5	3,010.8	301.1

Table 4: Scenario-Specific Mine Hauling Controlled Emission Rates

Mining Area *(Material Origination)*	Worst-Case Stockpiles in the Model *(Material Destination)*	Worst-Case Haul Roads in the Model	Total Length of Worst-Case Roads (ft, one-way)	Maximum Haulage Rate (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr*	Maximum Controlled Hourly Emission Rates (lb/hr)			Maximum Controlled Daily Emission Rates (lb/day)			Maximum Controlled Annual Emission Rates (ton/yr)		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Scenario 2																
Mohawk	VAO	Roads 11G, 30	7,340	200,000	673.4	28.1	78.0	184.1	46.9	4.7	4,418	1,126	113	651.7	166.1	16.6
Copper Mountain	CMO (33%), 4DO (33%), 4CO (33%)	Roads 16A, 16B, 18J, 20A	10,587	200,000	673.4	28.1	112.5	265.5	67.7	6.8	6,373	1,624	162	940.0	239.6	24.0
Scenario 3																
Mohawk	VAO	Roads 11G, 30	7,340	200,000	673.4	28.1	78.0	184.1	46.9	4.7	4,418	1,126	113	651.7	166.1	16.6
Little Rock 6	CLW	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	147.6	37.6	3.8	3,543	903	90	522.5	133.2	13.3
Scenario 4																
Mohawk	VAO	Roads 11G, 30	4,829	200,000	673.4	28.1	51.3	121.1	30.9	3.1	2,907	741	74	428.8	109.3	10.9
Copper Leach	L6R	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	147.6	37.6	3.8	3,543	903	90	522.5	133.2	13.3
Scenario 5																
Burro Chief	2BW (50%), 2AO (50%)	Roads 17, 18, 21	17,813	200,000	673.4	28.1	189.3	446.8	113.9	11.4	10,723	2,733	273	1,581.6	403.1	40.3
Little Rock 6	CLW	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	147.6	37.6	3.8	3,543	903	90	522.5	133.2	13.3
Scenario 6																
Burro Chief	2BW (50%), 2AO (50%)	Roads 17, 18, 21	10,341	200,000	673.4	28.1	109.9	259.4	66.1	6.6	6,225	1,586	159	918.1	234.0	23.4
Copper Leach	L6R	Roads 18D, 18E, 18G, 18H	13,528	90,000	303.0	12.6	62.5	147.6	37.6	3.8	3,543	903	90	522.5	133.2	13.3
Scenario 7																
Mohawk	6DO	Roads 9, 11C, 11E, 11F, 12B	11,937	200,000	673.4	28.1	126.9	299.4	76.3	7.6	7,186	1,831	183	1,059.9	270.1	27.0
Burro Chief	5AW	Roads 6, 7, 11E, 12B, 30A, 30B	14,902	200,000	673.4	28.1	158.4	373.8	95.3	9.5	8,970	2,286	229	1,323.1	337.2	33.7

Table 5: Individual Mining Haul Road Uncontrolled Emissions

Haul Road	Total Length of Road (ft, one-way)	Max Haulage Rate (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr*	Uncontrolled Hourly Emission Rates (lb/hr)			Uncontrolled Daily Emission Rates (lb/day)			Uncontrolled Annual Emission Rates (ton/yr)		
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Road4	2,809	200,000	673.4	28.1	29.9	629.1	160.3	16.0	15,098	3,848	385	2,226.9	567.6	56.8
Road4A	885	200,000	673.4	28.1	9.4	198.1	50.5	5.0	4,754	1,212	121	701.2	178.7	17.9
Road5A	6,321	200,000	673.4	28.1	67.2	1,415.6	360.8	36.1	33,974	8,659	866	5,011.1	1,277.2	127.7
Road5B	3,501	200,000	673.4	28.1	37.2	783.9	199.8	20.0	18,815	4,795	480	2,775.2	707.3	70.7
Road5C	3,320	200,000	673.4	28.1	35.3	743.5	189.5	18.9	17,843	4,548	455	2,631.8	670.8	67.1
Road6	2,927	200,000	673.4	28.1	31.1	655.4	167.0	16.7	15,731	4,009	401	2,320.3	591.3	59.1
Road7	3,729	200,000	673.4	28.1	39.6	835.2	212.8	21.3	20,044	5,108	511	2,956.4	753.5	75.3
Road8	1,255	200,000	673.4	28.1	13.3	281.0	71.6	7.2	6,745	1,719	172	994.8	253.5	25.4
Road9	4,112	200,000	673.4	28.1	43.7	920.9	234.7	23.5	22,101	5,633	563	3,260.0	830.8	83.1
Road10	6,905	200,000	673.4	28.1	73.4	1,546.3	394.1	39.4	37,111	9,458	946	5,473.8	1,395.1	139.5
Road11	3,625	200,000	673.4	28.1	38.5	811.8	206.9	20.7	19,483	4,965	497	2,873.7	732.4	73.2
Road11A	714	200,000	673.4	28.1	7.6	159.8	40.7	4.1	3,835	977	98	565.7	144.2	14.4
Road11B2	1,306	200,000	673.4	28.1	13.9	292.6	74.6	7.5	7,022	1,790	179	1,035.7	264.0	26.4
Road11C	3,010	200,000	673.4	28.1	32.0	674.2	171.8	17.2	16,180	4,124	412	2,386.6	608.3	60.8
Road11D	1,683	200,000	673.4	28.1	17.9	377.0	96.1	9.6	9,048	2,306	231	1,334.5	340.1	34.0
Road11E	1,191	200,000	673.4	28.1	12.7	266.7	68.0	6.8	6,401	1,631	163	944.1	240.6	24.1
Road11F	1,158	200,000	673.4	28.1	12.3	259.3	66.1	6.6	6,223	1,586	159	917.9	233.9	23.4
Road11G	1,847	200,000	673.4	28.1	19.6	413.6	105.4	10.5	9,927	2,530	253	1,464.3	373.2	37.3
Road12B	2,466	200,000	673.4	28.1	26.2	552.1	140.7	14.1	13,251	3,377	338	1,954.6	498.1	49.8
Road13	2,905	200,000	673.4	28.1	30.9	650.6	165.8	16.6	15,614	3,979	398	2,303.1	587.0	58.7
Road13A	4,311	200,000	673.4	28.1	45.8	965.3	246.0	24.6	23,168	5,905	590	3,417.3	870.9	87.1
Road13B	1,533	200,000	673.4	28.1	16.3	343.3	87.5	8.7	8,238	2,100	210	1,215.1	309.7	31.0
Road15	2,689	200,000	673.4	28.1	28.6	602.2	153.5	15.3	14,454	3,684	368	2,132.0	543.4	54.3
Road16A	6,397	200,000	673.4	28.1	68.0	1,432.5	365.1	36.5	34,379	8,762	876	5,071.0	1,292.4	129.2
Road16B	1,587	200,000	673.4	28.1	16.9	355.3	90.6	9.1	8,527	2,173	217	1,257.8	320.6	32.1
Road17	3,498	200,000	673.4	28.1	37.2	783.4	199.7	20.0	18,802	4,792	479	2,773.3	706.8	70.7
Road18	8,193	200,000	673.4	28.1	87.1	1,834.8	467.6	46.8	44,035	11,223	1,122	6,495.2	1,655.4	165.5
Road18C	1,083	200,000	673.4	28.1	11.5	242.5	61.8	6.2	5,821	1,483	148	858.6	218.8	21.9
Road18D	3,290	90,000	303.0	12.6	15.7	331.5	84.5	8.4	7,957	2,028	203	1,173.7	299.1	29.9
Road18E	5,156	90,000	303.0	12.6	24.7	519.6	132.4	13.2	12,471	3,178	318	1,839.4	468.8	46.9
Road18F	917	200,000	673.4	28.1	9.7	205.4	52.4	5.2	4,930	1,257	126	727.2	185.3	18.5
Road18G	1,030	90,000	303.0	12.6	4.9	103.8	26.5	2.6	2,492	635	64	367.5	93.7	9.4
Road18H	4,052	80,000	269.4	11.2	17.2	362.9	92.5	9.3	8,711	2,220	222	1,284.8	327.5	32.7
Road18I	512	200,000	673.4	28.1	5.4	114.7	29.2	2.9	2,753	702	70	406.0	103.5	10.3
Road18J	1,497	200,000	673.4	28.1	15.9	335.3	85.4	8.5	8,046	2,051	205	1,186.8	302.5	30.2
Road19	6,258	200,000	673.4	28.1	66.5	1,401.3	357.1	35.7	33,632	8,571	857	4,960.7	1,264.3	126.4
Road19B	5,724	200,000	673.4	28.1	60.8	1,281.9	326.7	32.7	30,765	7,841	784	4,537.8	1,156.5	115.7
Road20	5,737	200,000	673.4	28.1	61.0	1,284.6	327.4	32.7	30,832	7,858	786	4,547.7	1,159.0	115.9
Road20A	1,107	200,000	673.4	28.1	11.8	247.9	63.2	6.3	5,949	1,516	152	877.5	223.7	22.4
Road21	6,121	200,000	673.4	28.1	65.1	1,370.8	349.4	34.9	32,900	8,385	838	4,852.7	1,236.8	123.7
Road22	3,001	200,000	673.4	28.1	31.9	672.0	171.3	17.1	16,129	4,111	411	2,379.0	606.3	60.6
Road30	5,493	200,000	673.4	28.1	58.4	1,230.1	313.5	31.4	29,523	7,524	752	4,354.7	1,109.8	111.0
Road30A	1,895	200,000	673.4	28.1	20.1	424.3	108.1	10.8	10,183	2,595	260	1,502.0	382.8	38.3
Road30B	2,695	200,000	673.4	28.1	28.6	603.4	153.8	15.4	14,482	3,691	369	2,136.1	544.4	54.4
Road30C	518	200,000	673.4	28.1	5.5	116.1	29.6	3.0	2,786	710	71	410.9	104.7	10.5

Table 6: Individual Mining Haul Road Controlled Emissions

Haul Road	Total Length of Road (ft, one-way)	Max Haulage Rate (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr*	Controlled Hourly Emission Rates (lb/hr)			Controlled Daily Emission Rates (lb/day)			Controlled Annual Emission Rates (ton/yr)		
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Road4	2,809	200,000	673.4	28.1	29.9	70.5	18.0	1.8	1,691	431	43	249.4	63.6	6.4
Road4A	885	200,000	673.4	28.1	9.4	22.2	5.7	0.6	532	136	14	78.5	20.0	2.0
Road5A	6,321	200,000	673.4	28.1	67.2	158.5	40.4	4.0	3,805	970	97	561.2	143.0	14.3
Road5B	3,501	200,000	673.4	28.1	37.2	87.8	22.4	2.2	2,107	537	54	310.8	79.2	7.9
Road5C	3,320	200,000	673.4	28.1	35.3	83.3	21.2	2.1	1,998	509	51	294.8	75.1	7.5
Road6	2,927	200,000	673.4	28.1	31.1	73.4	18.7	1.9	1,762	449	45	259.9	66.2	6.6
Road7	3,729	200,000	673.4	28.1	39.6	93.5	23.8	2.4	2,245	572	57	331.1	84.4	8.4
Road8	1,255	200,000	673.4	28.1	13.3	31.5	8.0	0.8	755	193	19	111.4	28.4	2.8
Road9	4,112	200,000	673.4	28.1	43.7	103.1	26.3	2.6	2,475	631	63	365.1	93.1	9.3
Road10	6,905	200,000	673.4	28.1	73.4	173.2	44.1	4.4	4,156	1,059	106	613.1	156.2	15.6
Road11	3,625	200,000	673.4	28.1	38.5	90.9	23.2	2.3	2,182	556	56	321.9	82.0	8.2
Road11A	714	200,000	673.4	28.1	7.6	17.9	4.6	0.5	430	109	11	63.4	16.1	1.6
Road11B2	1,306	200,000	673.4	28.1	13.9	32.8	8.4	0.8	786	200	20	116.0	29.6	3.0
Road11C	3,010	200,000	673.4	28.1	32.0	75.5	19.2	1.9	1,812	462	46	267.3	68.1	6.8
Road11D	1,683	200,000	673.4	28.1	17.9	42.2	10.8	1.1	1,013	258	26	149.5	38.1	3.8
Road11E	1,191	200,000	673.4	28.1	12.7	29.9	7.6	0.8	717	183	18	105.7	26.9	2.7
Road11F	1,158	200,000	673.4	28.1	12.3	29.0	7.4	0.7	697	178	18	102.8	26.2	2.6
Road11G	1,847	200,000	673.4	28.1	19.6	46.3	11.8	1.2	1,112	283	28	164.0	41.8	4.2
Road12B	2,466	200,000	673.4	28.1	26.2	61.8	15.8	1.6	1,484	378	38	218.9	55.8	5.6
Road13	2,905	200,000	673.4	28.1	30.9	72.9	18.6	1.9	1,749	446	45	257.9	65.7	6.6
Road13A	4,311	200,000	673.4	28.1	45.8	108.1	27.6	2.8	2,595	661	66	382.7	97.5	9.8
Road13B	1,533	200,000	673.4	28.1	16.3	38.4	9.8	1.0	923	235	24	136.1	34.7	3.5
Road15	2,689	200,000	673.4	28.1	28.6	67.5	17.2	1.7	1,619	413	41	238.8	60.9	6.1
Road16A	6,397	200,000	673.4	28.1	68.0	160.4	40.9	4.1	3,850	981	98	567.9	144.7	14.5
Road16B	1,587	200,000	673.4	28.1	16.9	39.8	10.1	1.0	955	243	24	140.9	35.9	3.6
Road17	3,498	200,000	673.4	28.1	37.2	87.7	22.4	2.2	2,106	537	54	310.6	79.2	7.9
Road18	8,193	200,000	673.4	28.1	87.1	205.5	52.4	5.2	4,932	1,257	126	727.5	185.4	18.5
Road18C	1,083	200,000	673.4	28.1	11.5	27.2	6.9	0.7	652	166	17	96.2	24.5	2.5
Road18D	3,290	90,000	303.0	12.6	15.7	37.1	9.5	0.9	891	227	23	131.5	33.5	3.4
Road18E	5,156	90,000	303.0	12.6	24.7	58.2	14.8	1.5	1,397	356	36	206.0	52.5	5.3
Road18F	917	200,000	673.4	28.1	9.7	23.0	5.9	0.6	552	141	14	81.4	20.8	2.1
Road18G	1,030	90,000	303.0	12.6	4.9	11.6	3.0	0.3	279	71	7	41.2	10.5	1.0
Road18H	4,052	80,000	269.4	11.2	17.2	40.7	10.4	1.0	976	249	25	143.9	36.7	3.7
Road18I	512	200,000	673.4	28.1	5.4	12.8	3.3	0.3	308	79	8	45.5	11.6	1.2
Road18J	1,497	200,000	673.4	28.1	15.9	37.5	9.6	1.0	901	230	23	132.9	33.9	3.4
Road19	6,258	200,000	673.4	28.1	66.5	156.9	40.0	4.0	3,767	960	96	555.6	141.6	14.2
Road19B	5,724	200,000	673.4	28.1	60.8	143.6	36.6	3.7	3,446	878	88	508.2	129.5	13.0
Road20	5,737	200,000	673.4	28.1	61.0	143.9	36.7	3.7	3,453	880	88	509.3	129.8	13.0
Road20A	1,107	200,000	673.4	28.1	11.8	27.8	7.1	0.7	666	170	17	98.3	25.0	2.5
Road21	6,121	200,000	673.4	28.1	65.1	153.5	39.1	3.9	3,685	939	94	543.5	138.5	13.9
Road22	3,001	200,000	673.4	28.1	31.9	75.3	19.2	1.9	1,806	460	46	266.5	67.9	6.8
Road30	5,493	200,000	673.4	28.1	58.4	137.8	35.1	3.5	3,307	843	84	487.7	124.3	12.4
Road30A	1,895	200,000	673.4	28.1	20.1	47.5	12.1	1.2	1,141	291	29	168.2	42.9	4.3
Road30B	2,695	200,000	673.4	28.1	28.6	67.6	17.2	1.7	1,622	413	41	239.2	61.0	6.1
Road30C	518	200,000	673.4	28.1	5.5	13.0	3.3	0.3	312	80	8	46.0	11.7	1.2

Freeport-McMoRan Tyrone Inc.
Reclamation Material Handling Emissions

Table 1: Input Parameters

Uncontrolled Emission Factors	PM_{10}	1.60E-05	lb/ton[1]
	Ratio of $PM_{2.5}$ / PM_{10}	0.15 [2]	
	$PM_{2.5}$	2.40E-06	lb/ton[2]
	Ratio of TSP / PM_{10}	2.61 [3]	
	TSP	4.18E-05	lb/ton[3]
Hours of Operation	24	hours/day	
	365	days/year	
	8,760	hours/year	

Footnotes:

[1] The PM_{10} emission factor is based on AP-42, Chapter 11.19.2, Table 11.19.2-2 Crushed Stone Processing Operations (August 2004) for Truck Unloading - Fragmented Stone. The Truck Unloading emission factor is used for truck loading and truck unloading since the quantity of emissions from unloading would essentially be the same as loading. No TSP or $PM_{2.5}$ emission factors for Truck Unloading are provided in the AP-42 table.

[2] The $PM_{2.5}$ emission factor was calculated from the available PM_{10} emission factor using the ratio of 0.15 $PM_{2.5}$ / PM_{10} as recommended in the AP-42 *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* (November 2006).

[3] An uncontrolled TSP emission factor was calculated based on an average of the TSP/PM_{10} ratios using the available uncontrolled emission factors in AP-42 Table 11.19.2-2. The associated ratios are: Tertiary Crushing (0.0054/0.0024 = 2.25); Fines Crushing (0.0390/0.0150 = 2.60); Screening (0.025/0.0087 = 2.87; and Conveyor Transfer Point (0.0030/0.00110 = 2.73). The average of these ratios is 2.61.

Table 2: Maximum Emissions from Reclamation Material Handling

Pollutant	**Maximum Operational Scenario Potential Emission Rates[1]**		
	(lb/hr)	**(lb/day)**	**(ton/yr)**
Uncontrolled and Controlled[2]			
TSP	0.12	2.92	0.53
PM_{10}	0.047	1.12	0.20
$PM_{2.5}$	0.0070	0.17	0.031

Footnotes:

[1] The maximum emissions are based on the maximum of the sum of both reclamation areas operating within each active mining scenario.

[2] Uncontrolled emissions equal controlled emissions for these activities.

Table 3: Scenario-Specific Reclamation Material Handling Emission Rates

Reclamation Area	**Maximum Reclamation Rates (tons/day)**	**No. of Handling Instances[1]**	**Maximum Hourly Emission Rates (lb/hr)[2]**			**Maximum Daily Emission Rates (lb/day)[2]**			**Maximum Annual Emission Rates (ton/yr)[2]**		
			TSP	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Scenario 2 - Mohawk + Copper Mountain											
P-Plant	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.072	0.23	0.088	0.013
2A/2B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018
Scenario 3 - Mohawk + Little Rock 6											
1A/1B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018
Thickener	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.072	0.23	0.09	0.013
Scenario 4 - Mohawk + Copper Leach											
1A/1B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018
Thickener	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.072	0.23	0.09	0.013
Scenario 5 - Burro Chief + Little Rock 6											
Launder Line	5,000	2	0.017	0.007	0.0010	0.42	0.16	0.024	0.076	0.029	0.0044
2A/2B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018
Scenario 6 - Burro Chief + Copper Leach											
Launder Line	5,000	2	0.017	0.007	0.0010	0.42	0.16	0.024	0.076	0.029	0.0044
2A/2B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018
Scenario 7 - Mohawk + Burro Chief											
CLW Stockpile	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.072	0.23	0.088	0.013
2A/2B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.096	0.30	0.12	0.018

Footnotes:

[1] Handling instances consist of truck loading at the material origination location and truck unloading at the material destination location (i.e., the reclamation area).

[2] Uncontrolled emissions are equal to controlled emissions for these activities.

Table 4: Individual Reclamation Material Handling Emissions

Reclamation Area	Maximum Reclamation Rates (tons/day)	No. of Handling Instances[1]	Hourly Emission Rates (lb/hr)[2]			Daily Emission Rates (lb/day)[2]			Annual Emission Rates (ton/yr)[2]		
			TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Launder Line	5,000	2	0.017	0.007	0.0010	0.42	0.16	0.02	0.08	0.03	0.004
Thickener	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.07	0.23	0.09	0.013
P-Plant	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.07	0.23	0.09	0.013
1A/1B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.10	0.30	0.12	0.018
2A/2B Stockpile	20,000	2	0.070	0.027	0.0040	1.67	0.64	0.10	0.30	0.12	0.018
CLW Stockpile	15,000	2	0.052	0.020	0.0030	1.25	0.48	0.07	0.23	0.09	0.013

Footnotes:

[1] Handling instances consist of truck loading at the material origination location and truck unloading at the reclamation area.

[2] Uncontrolled emissions are equal to controlled emissions for these activities.

Freeport-McMoRan Tyrone Inc.
Reclamation Haul Road Emissions

Table 1: Input Parameters

	Truck Type		Small Trucks[1]	Large Trucks	
Reclamation Haul Truck Inputs	Empty Vehicle Weight (tons)		33.0	170.6	
	Max Load Capacity (tons)		37.6	297.0	
	Full Vehicle Weight (tons)		68.5	467.6	
	Average Vehicle Weight (tons)[2]		50.7	319.1	
Reclamation Haul Road Inputs	Silt Content (%)		4.8		
	Control Efficiency (%)[3]		88.8		
	No. of Precip. Days, P[4]		70		
	Hours of Operation (hrs/day)		24		
	Hours of Operation (days/year)		365		
	Hours of Operation (hrs/yr)		8,760		
Emission Factor Equation Inputs[5]	**Constant**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	
	k (lb/VMT)	4.9	1.5	0.15	
	a	0.7	0.9	0.9	
	b	0.45	0.45	0.45	
Calculated Emission Factors	**Pollutant**	**Small Trucks**		**Large Trucks**	
		Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
	TSP (lb/VMT)	9.21	1.03	21.07	2.36
	PM_{10} (lb/VMT)	2.35	0.26	5.37	0.60
	$PM_{2.5}$ (lb/VMT)	0.23	0.026	0.54	0.060

Footnotes:

[1] Both Cat 730s and Cat 769s small vehicles can operate on the reclamation roads, so for the small vehicle routes, we are representing the emissions based on an average of the Cat 730 and Cat 769 specifications.

[2] The Average Vehicle Weight is based on the haul trucks being full traveling in one direction and being empty traveling in the other direction.

[3] The combined control efficiency of 88.8% is based on 80% control for base course and watering (NMED guidance, January 1, 2017) and 44% control for an average speed limit of 25 mph (WRAP Fugitive Dust Handbook, September 7, 2006).

[4] This refers to the number of days in a year with at least 0.01 inches of precipitation and is based on Figure 13.2.2-1 in AP-42. This factor is only taken into account in the annual emissions calculation.

[5] These emission equation constants are provided in Table 13.2.2-2 in AP-42 for Industrial Roads (Equation 1a).

Table 2: Maximum Emissions from Reclamation Hauling

Pollutant	**Maximum Operational Scenario Potential Emission Rates**		
	(lb/hr)	**(lb/day)**	**(ton/yr)**
Uncontrolled			
TSP	2,485.50	59,651.99	8,798.67
PM_{10}	633.46	15,203.10	2,242.46
$PM_{2.5}$	63.35	1,520.31	224.25
Controlled			
TSP	278.38	6,681.02	985.45
PM_{10}	70.95	1,702.75	251.16
$PM_{2.5}$	7.09	170.27	25.12

Footnotes:

[1] The maximum emissions are based on the maximum of the sum of both reclamation areas operating within each active mining scenario.

Table 3: Scenario-Specific Reclamation Hauling Uncontrolled Emission Rates

Reclamation Area	Road Numbers	Total Length of Road (ft, one-way)	Vehicle Type on Reclamation Route	Maximum Reclamation Rates (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr	Maximum Uncontrolled Hourly Emission Rates (lb/hr)[2]			Maximum Uncontrolled Daily Emission Rates (lb/day)[2]			Maximum Uncontrolled Annual Emission Rates (ton/yr)[2]		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Scenario 2 - Mohawk + Copper Mountain																
P-Plant	RECPPR1,2,3	3,947	Small	15,000	398.9	16.6	24.9	228.9	58.3	5.8	5,494.4	1,400.3	140.0	810.4	206.5	20.7
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	407.4	103.8	10.4	9,776.9	2,491.8	249.2	1,442.1	367.5	36.8
Scenario 3 - Mohawk + Little Rock 6																
Thickener	RECTHR1,3	2,759	Small	15,000	398.9	16.6	17.4	160.0	40.8	4.1	3,840.5	978.8	97.9	566.5	144.4	14.4
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	288.4	73.5	7.3	6,920.8	1,763.9	176.4	1,020.8	260.2	26.0
Scenario 4 - Mohawk + Copper Leach																
Thickener	RECTHR1,3	2,759	Small	15,000	398.9	16.6	17.4	160.0	40.8	4.1	3,840.5	978.8	97.9	566.5	144.4	14.4
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	288.4	73.5	7.3	6,920.8	1,763.9	176.4	1,020.8	260.2	26.0
Scenario 5 - Burro Chief + Little Rock 6																
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	449.7	114.6	11.5	10,793.0	2,750.7	275.1	1,592.0	405.7	40.6
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	407.4	103.8	10.4	9,776.9	2,491.8	249.2	1,442.1	367.5	36.8
Scenario 6 - Burro Chief + Copper Leach																
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	449.7	114.6	11.5	10,793.0	2,750.7	275.1	1,592.0	405.7	40.6
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	407.4	103.8	10.4	9,776.9	2,491.8	249.2	1,442.1	367.5	36.8
Scenario 7 - Mohawk + Burro Chief																
CLW Stockpile	RECCLWR2,6	35,830	Small	15,000	398.9	16.6	225.6	2,078.1	529.6	53.0	49,875.1	12,711.3	1,271.1	7,356.6	1,874.9	187.5
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	407.4	103.8	10.4	9,776.9	2,491.8	249.2	1,442.1	367.5	36.8

Table 4: Scenario-Specific Reclamation Hauling Controlled Emission Rates

Reclamation Area	Road Numbers	Total Length of Road (ft, one-way)	Vehicle Type on Reclamation Route	Maximum Reclamation Rates (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr	Maximum Controlled Hourly Emission Rates (lb/hr)[2]			Maximum Controlled Daily Emission Rates (lb/day)[2]			Maximum Controlled Annual Emission Rates (ton/yr)[2]		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Scenario 2 - Mohawk + Copper Mountain																
P-Plant	RECPPR1,2,3	3,947	Small	15,000	398.9	16.6	24.9	25.6	6.5	0.7	615.4	156.8	15.7	90.8	23.1	2.3
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	45.6	11.6	1.2	1,095.0	279.1	27.9	161.5	41.2	4.1
Scenario 3 - Mohawk + Little Rock 6																
Thickener	RECTHR1,3	2,759	Small	15,000	398.9	16.6	17.4	17.9	4.6	0.5	430.1	109.6	11.0	63.4	16.2	1.6
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	32.3	8.2	0.8	775.1	197.6	19.8	114.3	29.1	2.9
Scenario 4 - Mohawk + Copper Leach																
Thickener	RECTHR1,3	2,759	Small	15,000	398.9	16.6	17.4	17.9	4.6	0.5	430.1	109.6	11.0	63.4	16.2	1.6
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	32.3	8.2	0.8	775.1	197.6	19.8	114.3	29.1	2.9
Scenario 5 - Burro Chief + Little Rock 6																
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	50.4	12.8	1.3	1,208.8	308.1	30.8	178.3	45.4	4.5
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	45.6	11.6	1.2	1,095.0	279.1	27.9	161.5	41.2	4.1
Scenario 6 - Burro Chief + Copper Leach																
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	50.4	12.8	1.3	1,208.8	308.1	30.8	178.3	45.4	4.5
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	45.6	11.6	1.2	1,095.0	279.1	27.9	161.5	41.2	4.1
Scenario 7 - Mohawk + Burro Chief																
CLW Stockpile	RECCLWR2,6	35,830	Small	15,000	398.9	16.6	225.6	232.8	59.3	5.9	5,586.0	1,423.7	142.4	823.9	210.0	21.0
2A/2B Stockpile	REC2ALR1,2	18,191	Large	20,000	67.3	2.8	19.3	45.6	11.6	1.2	1,095.0	279.1	27.9	161.5	41.2	4.1

Table 5: Individual Reclamation Haul Road Uncontrolled Emissions

Reclamation Area	Road Number	Total Length of Road (ft, one-way)	Vehicle Type on Reclamation Route	Maximum Reclamation Rates (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr	Uncontrolled Hourly Emission Rates (lb/hr)			Uncontrolled Daily Emission Rates (lb/day)			Uncontrolled Annual Emission Rates (ton/yr)		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	449.7	114.6	11.5	10,793.0	2,750.7	275.1	1,592.0	405.7	40.6
	RECLLR1,3	52,068		5,000	133.0	5.5	109.3	1,006.6	256.6	25.7	24,159.2	6,157.3	615.7	3,563.5	908.2	90.8
Thickener	RECTHR1,2	14,271	Small	15,000	398.9	16.6	89.9	827.7	211.0	21.1	19,865.6	5,063.0	506.3	2,930.2	746.8	74.7
	RECTHR1,4	18,150		15,000	398.9	16.6	114.3	1,052.7	268.3	26.8	25,265.0	6,439.1	643.9	3,726.6	949.8	95.0
	RECTHR1,3	2,759		15,000	398.9	16.6	17.4	160.0	40.8	4.1	3,840.5	978.8	97.9	566.5	144.4	14.4
P-Plant	RECPPR1,2,3	3,947	Small	15,000	398.9	16.6	24.9	228.9	58.3	5.8	5,494.4	1,400.3	140.0	810.4	206.5	20.7
	RECPPR1,6,4,3	5,350		15,000	398.9	16.6	33.7	310.3	79.1	7.9	7,447.7	1,898.1	189.8	1,098.5	280.0	28.0
	RECPPR1,6,5	11,185		15,000	398.9	16.6	70.4	648.7	165.3	16.5	15,569.0	3,968.0	396.8	2,296.4	585.3	58.5
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	288.4	73.5	7.3	6,920.8	1,763.9	176.4	1,020.8	260.2	26.0
	REC1ASR1	7,849	Small (in-pit)	15,000	398.9	16.6	49.4	455.3	116.0	11.6	10,926.3	2,784.7	278.5	1,611.6	410.7	41.1
2A/2B Stockpile	REC2ALR1,3	8,099	Large	20,000	67.3	2.8	8.6	181.4	46.2	4.6	4,353.1	1,109.4	110.9	642.1	163.6	16.4
	REC2ALR1,2	18,191		20,000	67.3	2.8	19.3	407.4	103.8	10.4	9,776.9	2,491.8	249.2	1,442.1	367.5	36.8
	REC2ASR1,2	8,779	Small	15,000	398.9	16.6	55.3	509.2	129.8	13.0	12,219.7	3,114.3	311.4	1,802.4	459.4	45.9
	REC2ASR1,3	22,299		15,000	398.9	16.6	140.4	1,293.3	329.6	33.0	31,039.8	7,910.9	791.1	4,578.4	1,166.9	116.7
CLW Stockpile	RECCLWR1	1,583	Small	15,000	398.9	16.6	10.0	91.8	23.4	2.3	2,204.0	561.7	56.2	325.1	82.9	8.3
	RECCLWR2,4	22,310		15,000	398.9	16.6	140.5	1,294.0	329.8	33.0	31,054.9	7,914.8	791.5	4,580.6	1,167.4	116.7
	RECCLWR3,4	12,839		15,000	398.9	16.6	80.8	744.6	189.8	19.0	17,871.2	4,554.7	455.5	2,636.0	671.8	67.2
	RECCLWR2,5	21,613		15,000	398.9	16.6	136.1	1,253.6	319.5	31.9	30,085.4	7,667.7	766.8	4,437.6	1,131.0	113.1
	RECCLWR3,5	12,142		15,000	398.9	16.6	76.5	704.2	179.5	17.9	16,901.6	4,307.6	430.8	2,493.0	635.4	63.5
	RECCLWR2,6	35,830		15,000	398.9	16.6	225.6	2,078.1	529.6	53.0	49,875.1	12,711.3	1,271.1	7,356.6	1,874.9	187.5
	RECCLWR3,6	26,359		15,000	398.9	16.6	166.0	1,528.8	389.6	39.0	36,691.4	9,351.3	935.1	5,412.0	1,379.3	137.9

Table 6: Individual Reclamation Haul Road Controlled Emissions

Reclamation Area	Road Number	Total Length of Road (ft, one-way)	Vehicle Type on Reclamation Route	Max Haulage Rate (tons/day)	Max No. of Trips/Day	Max No. of Trips/Hour	VMT/hr	Controlled Hourly Emission Rates (lb/hr)			Controlled Daily Emission Rates (lb/day)			Controlled Annual Emission Rates (ton/yr)		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Launder Line	RECLLR1,2	23,261	Small	5,000	133.0	5.5	48.8	50.4	12.8	1.3	1,208.8	308.1	30.8	178.3	45.4	4.5
	RECLLR1,3	52,068		5,000	133.0	5.5	109.3	112.7	28.7	2.9	2,705.8	689.6	69.0	399.1	101.7	10.2
Thickener	RECTHR1,2	14,271	Small	15,000	398.9	16.6	89.9	92.7	23.6	2.4	2,224.9	567.1	56.7	328.2	83.6	8.4
	RECTHR1,4	18,150		15,000	398.9	16.6	114.3	117.9	30.0	3.0	2,829.7	721.2	72.1	417.4	106.4	10.6
	RECTHR1,3	2,759		15,000	398.9	16.6	17.4	17.9	4.6	0.5	430.1	109.6	11.0	63.4	16.2	1.6
P-Plant	RECPPR1,2,3	3,947	Small	15,000	398.9	16.6	24.9	25.6	6.5	0.7	615.4	156.8	15.7	90.8	23.1	2.3
	RECPPR1,6,4,3	5,350		15,000	398.9	16.6	33.7	34.8	8.9	0.9	834.1	212.6	21.3	123.0	31.4	3.1
	RECPPR1,6,5	11,185		15,000	398.9	16.6	70.4	72.7	18.5	1.9	1,743.7	444.4	44.4	257.2	65.6	6.6
1A/1B Stockpile	REC1ALR1	12,877	Large	20,000	67.3	2.8	13.7	32.3	8.2	0.8	775.1	197.6	19.8	114.3	29.1	2.9
	REC1ASR1	7,849	Small (in-pit)	15,000	398.9	16.6	49.4	51.0	13.0	1.3	1,223.7	311.9	31.2	180.5	46.0	4.6
2A/2B Stockpile	REC2ALR1,3	8,099	Large	20,000	67.3	2.8	8.6	20.3	5.2	0.5	487.5	124.3	12.4	71.9	18.3	1.8
	REC2ALR1,2	18,191		20,000	67.3	2.8	19.3	45.6	11.6	1.2	1,095.0	279.1	27.9	161.5	41.2	4.1
	REC2ASR1,2	8,779	Small	15,000	398.9	16.6	55.3	57.0	14.5	1.5	1,368.6	348.8	34.9	201.9	51.4	5.1
	REC2ASR1,3	22,299		15,000	398.9	16.6	140.4	144.9	36.9	3.7	3,476.5	886.0	88.6	512.8	130.7	13.1
CLW Stockpile	RECCLWR1	1,583	Small	15,000	398.9	16.6	10.0	10.3	2.6	0.3	246.8	62.9	6.3	36.4	9.3	0.9
	RECCLWR2,4	22,310		15,000	398.9	16.6	140.5	144.9	36.9	3.7	3,478.2	886.5	88.6	513.0	130.8	13.1
	RECCLWR3,4	12,839		15,000	398.9	16.6	80.8	83.4	21.3	2.1	2,001.6	510.1	51.0	295.2	75.2	7.5
	RECCLWR2,5	21,613		15,000	398.9	16.6	136.1	140.4	35.8	3.6	3,369.6	858.8	85.9	497.0	126.7	12.7
	RECCLWR3,5	12,142		15,000	398.9	16.6	76.5	78.9	20.1	2.0	1,893.0	482.5	48.2	279.2	71.2	7.1
	RECCLWR2,6	35,830		15,000	398.9	16.6	225.6	232.8	59.3	5.9	5,586.0	1,423.7	142.4	823.9	210.0	21.0
	RECCLWR3,6	26,359		15,000	398.9	16.6	166.0	171.2	43.6	4.4	4,109.4	1,047.3	104.7	606.1	154.5	15.4

Freeport-McMoRan Tyrone Inc.
Crushing and Screening Plant Material Handling Emissions

Table 1: Input Parameters

GCP-2 Quarrying, Crushing, and Screening Facilities Operational Constraints (9/12/2006)	Hourly Production Rate (tons/hour)	600
	Daily Operating Hours (hours/day)	12
	Daily Production Rate (tons/day)	7,200
	Annual Operating Hours (hours/year)	4,380
	Annual Production Rate (tons/year)	2,628,000
Aggregate Handling Emission Factor Equation Inputs[1]	Particle Size Multiplier, k (TSP)	0.74
	Particle Size Multiplier, k (PM_{10})	0.35
	Particle Size Multiplier, k ($PM_{2.5}$)	0.053
	Mean Wind Speed, U (mph)[2]	7.6
	Material Moisture Content, M (%)[2]	4.3

Footnotes:

[1] AP-42, Chapter 13.2.4, Equation 1 (November 2006). This is an uncontrolled emission factor equation.

[2] Historically used average wind speed and material moisture content.

Table 2: Maximum Crushing and Screening Material Handling Uncontrolled Emission Rates

Activity	Uncontrolled Emission Factors (lb/ton)			Emission Factor Reference	No. of Handling Instances	Maximum Uncontrolled Hourly Emission Rates (lb/hr)			Maximum Uncontrolled Daily Emission Rates (lb/day)			Maximum Uncontrolled Annual Emission Rates (ton/yr)		
	TSP	**PM_{10}**	**$PM_{2.5}$**			**TSP**	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Crushing	5.40E-03	2.40E-03	3.60E-04	1,2	2	6.48	2.88	0.43	77.76	34.56	5.18	14.19	6.31	0.95
Screening	2.50E-02	8.70E-03	1.31E-03	1,2	1	15.00	5.22	0.78	180.00	62.64	9.40	32.85	11.43	1.71
Conveyor Transfers	3.00E-03	1.10E-03	1.65E-04	1,2	8	14.40	5.28	0.79	172.80	63.36	9.50	31.54	11.56	1.73
Drop onto Pile	1.39E-03	6.59E-04	9.98E-05	3	6	5.01	2.37	0.36	60.17	28.46	4.31	10.98	5.19	0.79
					Total Uncontrolled Emissions =	**40.89**	**15.75**	**2.37**	**490.73**	**189.02**	**28.39**	**89.56**	**34.50**	**5.18**

Emission Factor References:

1 AP-42, Chapter 11.19.2, Crushed Stone Processing Operations (August 2004).

2 The $PM_{2.5}$ emission factor was calculated from the available PM_{10} emission factors using the ratio of 0.15 $PM_{2.5}$ / PM_{10} as recommended in the AP-42 Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors (Nove

3 AP-42, Chapter 13.2.4, Aggregate Handling and Storage Piles, Equation 1 (November 2006).

Table 3: Maximum Crushing and Screening Material Handling Controlled Emission Rates

Activity	Controlled Emission Factors (lb/ton)			Emission Factor Reference	No. of Handling Instances	Maximum Controlled Hourly Emission Rates (lb/hr)			Maximum Controlled Daily Emission Rates (lb/day)			Maximum Controlled Annual Emission Rates (ton/yr)		
	TSP	**PM_{10}**	**$PM_{2.5}$**			**TSP**	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Crushing	1.20E-03	5.40E-04	1.00E-04	1	2	1.44	0.65	0.12	17.28	7.78	1.44	3.15	1.42	0.26
Screening	2.20E-03	7.40E-04	5.00E-05	1	1	1.32	0.44	0.03	15.84	5.33	0.36	2.89	0.97	0.07
Conveyor Transfers	1.40E-04	4.60E-05	1.30E-05	1	8	0.67	0.22	0.06	8.06	2.65	0.75	1.47	0.48	0.14
Drop onto Pile	1.39E-03	6.59E-04	9.98E-05	2	6	5.01	2.37	0.36	60.17	28.46	4.31	10.98	5.19	0.79
					Total Controlled Emissions =	**8.45**	**3.68**	**0.57**	**101.35**	**44.21**	**6.86**	**18.50**	**8.07**	**1.25**

Emission Factor References:

1 AP-42, Chapter 11.19.2, Crushed Stone Processing Operations (August 2004). Controls include wet suppression techniques.

2 AP-42, Chapter 13.2.4, Aggregate Handling and Storage Piles, Equation 1 (November 2006).

Freeport-McMoRan Tyrone Inc.
Crushing and Screening Plant Haul Road Emissions

Table 1: Input Parameters

Crushing and Screening Plant Haul Truck Inputs	**Truck Type**		**Small Trucks[1]**	**Large Trucks**
	Empty Vehicle Weight (tons)		33.0	170.6
	Max Load Capacity (tons)		35.5	297.0
	Full Vehicle Weight (tons)		68.5	467.6
	Average Vehicle Weight (tons)[2]		184.9	
Crushing and Screening Plant Haul Road Inputs	Silt Content (%)		4.8	
	Control Efficiency (%)[3]		88.8	
	No. of Precip. Days, P[4]		70	
	Hours of Operation (hrs/day)		12	
	Hours of Operation (days/year)		365	
	Hours of Operation (hrs/yr)		4,380	
Emission Factor Equation Inputs[5]	**Constant**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
	k (lb/VMT)	4.9	1.5	0.15
	a	0.7	0.9	0.9
	b	0.45	0.45	0.45
Calculated Emission Factors	**Pollutant**	**Uncontrolled**	**Controlled**	
	TSP (lb/VMT)	16.48	1.85	
	PM_{10} (lb/VMT)	4.20	0.47	
	$PM_{2.5}$ (lb/VMT)	0.42	0.047	

Footnotes:

[1] Both Cat 730s and Cat 769s small trucks can haul material to the crushing and screening plant, so the average of the small truck capacities are used to represent the small trucks.

[2] AP-42 13.2.2 (Unpaved Roads) Equation 1a is applicable to industrial roads with a mean vehicle weight from 2 to 290 tons. The Average Vehicle Weight is based on the haul trucks being full traveling in one direction and being empty traveling in the other direction and 50% small haul trucks and 50% large haul trucks.

[3] The combined control efficiency of 88.8% is based on 80% control for base course and watering (NMED guidance, January 1, 2017) and 44% control for an average speed limit of 25 mph (WRAP Fugitive Dust Handbook, September 7, 2006).

[4] This refers to the number of days in a year with at least 0.01 inches of precipitation and is based on Figure 13.2.2-1 in AP-42. This factor is only taken into account in the annual emissions calculation.

[5] These emission equation constants are provided in Table 13.2.2-2 in AP-42 for Industrial Roads (Equation 1a).

Table 2: Maximum Crushing and Screening Hauling Uncontrolled Emission Rates

Haul Road	Total Length of Road (ft, one-way)	Max Haulage Rate (tons/day)	Average No. of Trips/Day	Average No. of Trips/Hour	Average VMT/hr	Maximum Uncontrolled Hourly Emission Rates (lb/hr)			Maximum Uncontrolled Daily Emission Rates (lb/day)			Maximum Uncontrolled Annual Emission Rates (ton/yr)		
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Crushing and Screening Plant (CSROADN)	3,690	7,200	43.3	3.6	5.0	83.15	21.19	2.12	997.81	254.30	25.43	147.18	37.51	3.75

Table 3: Maximum Crushing and Screening Hauling Controlled Emission Rates

Haul Road	Total Length of Road (ft, one-way)	Max Haulage Rate (tons/day)	Average No. of Trips/Day	Average No. of Trips/Hour	Average VMT/hr	Maximum Controlled Hourly Emission Rates (lb/hr)			Maximum Controlled Daily Emission Rates (lb/day)			Maximum Controlled Annual Emission Rates (ton/yr)		
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Crushing and Screening Plant (CSROADN)	3,690	7,200	43.3	3.6	5.0	9.31	2.37	0.24	111.75	28.48	2.85	16.48	4.20	0.42

Freeport-McMoRan Tyrone Inc.
GDF1 and GDF2 VOC and HAP Emissions

Table 1: Maximum VOC Emissions

Emission Unit	Tank Size (gal)	Maximum Gasoline Usage Rate[1]		Maximum VOC Emissions[2]	
		gal/month	gal/yr	Total Losses (ton/yr)	Total Losses (lb/hr)
GDF1	20,000	9,950	119,400	10.57	2.41
GDF2	2,000	9,950	119,400	1.70	0.39
			Total =	**12.28**	**2.80**

Footnotes:

[1] Based on an estimated maximum gasoline usage rate.

[2] Based on the GDF calculation methodology in AP-42 Chapter 7 (June 2020). Separate tables detailing the tank VOC emission calculations are provided.

Table 2: Gasoline HAP Constituents

Constituent	% by weight[1]
Benzene	0.35
n-Hexane	1.07
Toluene	3.59
o,m,p-Xylene	0.69
Ethylbenzene	0.18
2,2,4-Trimethylpentane	5.40

Footnotes:

[1] Based on the maximum of the SPECIATE 5.0 database HAP percentages for non-ethanol gasoline (2009 sampling data, profile no. 8762, gasoline headspace vapor, data quality "A") and 10% ethanol gasoline (2009 sampling data, profile no. 8763, gasoline headspace vapor, data quality "A") since Tyrone's gasoline can be 10% or less ethanol.

Table 3: Maximum HAP Emissions

Emission Unit	Benzene		n-Hexane		Toluene		Xylene		Ethylbenzene		2,2,4-Trimethylpentane		Total HAPs	
	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr
GDF1	0.036	0.0083	0.11	0.026	0.38	0.087	0.073	0.017	0.019	0.0043	0.57	0.13	1.19	0.27
GDF2	0.0059	0.0013	0.018	0.0042	0.061	0.014	0.012	0.0027	0.0031	0.00070	0.092	0.021	0.19	0.044
Total	**0.042**	**0.0097**	**0.13**	**0.030**	**0.44**	**0.10**	**0.084**	**0.019**	**0.022**	**0.0050**	**0.66**	**0.15**	**1.38**	**0.32**

Footnotes:

[1] Based on applying the gasoline HAP constituent percentages in Table 2 to the total tank VOC emissions in Table 1.

Tyrone Mine
VOC Emissions from GDF1
AP-42 Chapter 7 (June 2020)

Tank Information

Tank identification	GDF1 (SPCC□TYR□061)
Description	Horizontal 20,000 Gallon Gasoline Tank
Location (city)	Tyrone Mine (Tyrone, New Mexico)

Tank Summary

	Value	Units	Description
Fuel type	Gasoline (RVP 10)	select one	Type of fuel stored in the tank.
Storage tank position	Above	select one	Fixed roof structure.
Actual hours operated	8,760	hours/year	Number of hours the tank is used.
Potential throughput	**119,400**	**gal/yr**	
VOC calculated emissions	**5.29**	**ton/yr**	Amount of VOCs potentially released over a 12-month period.
VOC potential emissions	**10.57**	**ton/yr**	Calculated VOC emissions □2.

Physical Properties of the Tank

		Value	Units	Description
Shell length	H_S	28.3	feet	This is actual length of the tank.
Shell diameter	D	11.0	feet	This is the actual width of the cylindrical shell.
Shell radius	R_S	5.5	feet	Calculated radius
Shell effective height	$H_□$	8.6□	feet	Calculated effective height of the tank.
Shell effective diameter	$D_□$	1□.□2	feet	Calculated effective diameter of the cylindrical shell.
Maximum liquid height	$H_{L□}$	8.6□	feet	Maximum height of the liquid within the tank shell. If unknown, assume pi□D□□
Average liquid height	H_L	5.50	feet	Average height of the liquid within the tank shell. If unknown, assume D/2.
Minimum liquid height	$H_{L□}$	0.00	feet	Minimum height of the liquid within the tank shell. If unknown, assume 0.
Working volume		20□1□1	gallons	Calculated volume
Turnovers per year	□	5.□	dimensionless	Equation 1-36 in AP-42 (June 2020)
Shell color/shade		Red/Primer shade	select one	Tank shell color and shade are used to identify paint solar absorptance.
Shell condition		Aged	select one	Tank condition is used to identify paint solar absorptance. Only aboveground.
Paint solar absorptance	□	0.□1	dimensionless	Insert value from table 7.1-6. Paint effectiveness in absorbing radiant energy.
Vacuum setting	P_{BV}	□0.03	psig	Vacuum setting is a value set for the tank at the facility.
Pressure setting	P_{BP}	0.03	psig	Breather vent pressure is a reading from the tank monitoring system.

Weather Data

		Value	Units	Description
Nearest major city		Deming, NM		Nearest major city to the tank location.
Average annual maximum temperature	$T_{A□}$	76.6	°F	Average over a calendar year.
Average annual minimum temperature	$T_{A□}$	□6.2	°F	Average over a calendar year.
Atmospheric pressure	P_A	12.5□	psia	Average for the location.
Solar insolation	I	1,772	Btu/(ft^2·day)	Total for a horizontal surface.

Calculation of VOC Emissions = Total Losses (L_T)

		Calculated value		Notes (equations are from AP-42, Chapter 7)
Total losses	L_T	**10,572.3**	**lb/yr**	Equation 1-1
Standing storage losses	L_S	**9,374.5**	**lb/yr**	Equation 1-2
Working losses	L_W	**1,197.9**	**lb/yr**	Equation 1-35
Annual net throughput	□	2□8□2.□	bbl/yr	Equation 1-37
Working loss turnover factor	$K_□$	1.00	dimensionless	Saturation turnovers □36 □(180 □ □) □6□□turnovers at 36 or lower □1
Stock vapor density	W_V	0.075	lb/ft^3	Equation 1-22
Vapor Molecular Weight at 60 °F	M_V	66	lb/lb-mole	Table 7.1-2
Vapor pressure	P_{VA}	6.55□	psia	Calculated based on T_{LA}.
Vapor space volume	V_V	13□6.30	ft^3	Equation 1-3
Vapor space tank outage	H_{VO}	□.32	feet	Equation 1-16, note for H_{VO} horizontal
Vapor space expansion factor	$K_□$	0.636	dimensionless	Equation 1-5
Vented vapor saturation factor	K_S	0.□0	dimensionless	Equation 1-21
Working loss product factor	K_P	1	dimensionless	Assume value of 1 for gasoline or diesel.
Ideal gas constant	R	10.731	psia-ft^3/lb-mole*°R	Constant, Equation 1-22
Average vapor temperature	T_V	537.06	°R	Equation 1-33
Daily average liquid surface temperature	T_{LA}	532.07	°R	Equation 1-28
Daily vapor temperature range	ΔT_V	53.53	°R	Equation 1-7
Daily ambient temperature range	ΔT_A	30.□0	°R	Equation 1-11
Daily maximum ambient temperature	$T_{A□}$	536.30	°R	Table 7□1□7. Conversion factor: Rankine □ Fahrenheit □ □5□.7
Daily minimum ambient temperature	$T_{A□}$	505.□0	°R	Table 7□1□7. Conversion factor: Rankine □ Fahrenheit □ □5□.7
Daily average ambient temperature	T_{AA}	521.10	°R	Equation 1-30
Liquid bulk temperature	T_B	525.□□	°R	Equation 1-31
Daily vapor pressure range	ΔP_V	3.26	psia	Equation 1-□
Breather vent pressure setting range	ΔP_B	0.06	psi	Equation 1-10
Vapor pressure equation constant	A	11.72□	dimensionless	Table 7.1-2
Vapor pressure equation constant	B	5237.3	°R	Table 7.1-2
Vapor pressure at $T_{L□}$	$P_{V□}$	8.3□□2	psia	Equation 1□□note 5
Vapor pressure at $T_{L□}$	$P_{V□}$	5.0870	psia	Equation 1□□note 5
Maximum T_{LA}	$T_{L□}$	5□5.□5	°R	Equation 1□□note to Figure 7.1-17
Minimum T_{LA}	$T_{L□}$	518.68	°R	Equation 1□□note to Figure 7.1-17

Tyrone Mine
VOC Emissions from GDF2
AP-42 Chapter 7 (June 2020)

Tank Information

Tank identification	GDF2 (SPCC□TYR□11□)
Description	Vertical Fi□ed Roof 2□000□Gallon Gasoline Tan□
Location (city)	Tyrone Mine (Tyrone□□ew Me□ico)

Tank Summary

Tank Summary	Value	Units	Description
Fuel type	Gasoline (RVP 10)	select one	Type of fuel stored in the tan□.
Type of roof	Cone	select one	Fi□ed roof structure.
Actual hours operated	8□760	hours□year	□umber of hours the tan□ is used.
Potential throughput	**119,400**	**gal/yr**	
VOC calculated emissions	**0.43**	**ton/yr**	Amount of VOCs potentially released over a 12□month period.
VOC potential emissions	**1.70**	**ton/yr**	Calculated VOC emissions □□.

Physical Properties of the Tank

Physical Properties of the Tank		Value	Units	Description
Shell height	H_S	8.58	feet	This is actual length of the tan□.
Shell diameter	D	5.17	feet	This is the width of the cylindrical shell.
Shell radius	R_S	2.58	feet	Calculated radius
Ma□imum li□uid height	$H_{L□}$	7.58	feet	Ma□imum height of the li□uid within the tan□ shell. If un□nown□ assume Hs □1.
Average li□uid height	H_L	□.2□	feet	Average height of the li□uid within the tan□ shell. If un□nown□ assume H□2.
Minimum li□uid height	$H_{L□}$	1.00	feet	Minimum height of the li□uid within the tan□ shell. If un□nown□ assume 1.
Wor□ing volume		1□18□.2	gallons	Calculated volume
Turnovers per year	□	115.6	dimensionless	□□uation 1□36 in AP□□2 (□une 2020)
Shell color□shade		Beige□Cream	select one	Tan□ shell color and shade are used to identify paint solar absorptance.
Shell condition		Aged	select one	Tan□ condition is used to identify paint solar absorptance.
Paint solar absorptance	□	0.□□	dimensionless	Insert value from table 7.1□6. Paint effectiveness in absorbing radiant energy.
Roof height	H_R	0.02	feet	Calculated roof height.
Dome roof radius	R_R	□□	feet	Calculated radius. Only applies to a "Dome" roof.
Cone roof slope	S_R	0.0625	ft□ft	If un□nown □ 0.0625. If □nown□ insert value. Only applies to a "Cone" roof.
Vacuum setting	P_{BV}	□0.03	psig	Vacuum setting is a value set for the tan□ at the facility.
Pressure setting	P_{BP}	0.03	psig	Breather vent pressure is a reading from the tan□ monitoring system.

Weather Data

Weather Data		Value	Units	Description
□earest ma□or city		Deming□□M	Select one	□earest ma□or city to the tan□ location.
Average annual ma□imum temperature	$T_{A□}$	76.6	°F	Average over a calendar year.
Average annual minimum temperature	$T_{A□}$	□6.2	°F	Average over a calendar year.
Atmospheric pressure	P_A	12.5□	psia	Average for the location.
Solar insolation	I	1□772	Btu□(ft²·day)	Total for a hori□ontal surface.

Calculation of VOC Emission = Total Losses (L_T)

Calculation of VOC Emission = Total Losses (L_T)		Calculated value		Notes (equations are from AP-42, Chapter 7)
Total losses	L_T	**852.5**	**lb/yr**	□□uation 1□1
Standing storage losses	L_S	**381.8**	**lb/yr**	□□uation 1□2
Working losses	L_W	**470.7**	**lb/yr**	□□uation 1□35
Annual net throughput	□	2□8□2.□	bbl□yr	□□uation 1□37
Wor□ing loss turnover factor	$□_□$	0.□3	dimensionless	Saturation□turnovers □36 □ (180 □ □) □6 □□□turnovers at 36 or lower □ 1
Stoc□ vapor density	W_V	0.06□	lb□ft³	□□uation 1□22
Vapor Molecular Weight at 60 °F	M_V	66	lb□lb□mole	Table 7.1□2
Vapor pressure	P_{VA}	5.□61	psia	Calculated based on T_{LA}.
Vapor space volume	V_V	□0.0□	ft³	□□uation 1□3
Vapor space roof outage	H_{RO}	0.01	feet	□□uation 1□17 Cone□□□uation 1□1□ Dome
Vapor space tan□ outage	H_{VO}	□.30	feet	□□uation 1□16□vertical
Vapor space e□pansion factor	$□_□$	0.□0		□□uation 1□5
Vented vapor saturation factor	$□_S$	0.□2	dimensionless	□□uation 1□21
Wor□ing loss product factor	$□_P$	1	dimensionless	Assume value of 1 for gasoline or diesel.
Ideal gas constant	R	10.731	psia□ft³/lb-mole*°R	Constant□□□uation 1□22
Average vapor temperature	T_V	52□.68	°R	□□uation 1□33
Daily average li□uid surface temperature	T_{LA}	526.□□	°R	□□uation 1□28
Daily vapor temperature range	$□T_V$	38.65	°R	□□uation 1□7
Daily ambient temperature range	$□T_A$	30.□0	°R	□□uation 1□11
Daily ma□imum ambient temperature	$T_{A□}$	536.2□	°R	Table 7□1□7. Conversion factor: Ran□ine □ Fahrenheit □ □5□7
Daily minimum ambient temperature	$T_{A□}$	505.88	°R	Table 7□1□7. Conversion factor: Ran□ine □ Fahrenheit □ □5□7
Daily average ambient temperature	T_{AA}	521.0□	°R	□□uation 1□30
Li□uid bul□ temperature	T_B	523.6□	°R	□□uation 1□31
Daily vapor pressure range	$□P_V$	2.18	psia	□□uation 1□□
Breather vent pressure setting range	$□P_B$	0.06	psi	□□uation 1□10
Vapor pressure e□uation constant	A	11.72□	dimensionless	Table 7.1□2
Vapor pressure e□uation constant	B	5237.3	°R	Table 7.1□2
Vapor pressure at $T_{L□}$	$P_{V□}$	7.13	psia	□□uation 1□□□note 5
Vapor pressure at $T_{L□}$	$P_{V□}$	□.□5	psia	□□uation 1□□□note 5
Ma□imum T_{LA}	$T_{L□}$	536.65	°R	□□uation 1□□□note to Figure 7.1□17
Minimum T_{LA}	$T_{L□}$	517.33	°R	□□uation 1□□□note to Figure 7.1□17

Freeport-McMoRan Tyrone Inc.

SX/EW Plant - Chemical Constituent Concentrations for SX/EW Extractants and Diluents

Please note that the information provided in the table below is considered CONFIDENTIAL BUSINESS INFORMATION by the chemical suppliers that provided the information.

	Chemical Concentration [ppm]						
Reagent Name	Benzene	Toluene	Ethylbenzene	Total Xylene	1,2,4 - TMB	1,3,5 - TMB	Other VOC
Extractants							
ACORGA M5640	5	17.9	23.3	34.8			
ACORGA M5774	5	17.9	23.3	34.8			
ACORGA M5850	5	17.9	23.3	34.8			
ACORGA M5910	3.35	7.25	3.4	8.6	6.35	3.35	13.9
Diluents							
Conosol 170ES	50	50	50	50			
SX-80	5.4	110	530	690	2100	830	
Escaid 110		169					

Data for ACORGA extractants provided by Cytec.
Data for Conosol 170ES provided by Calumet Specialty Products.
Data for SX-80 provided by Chevron Phillips.
Blank cells indicate that data for this chemical was not available from the chemical supplier.
1,2,4 - TMB = 1,2,4-trimethylbenzene
1,3,5 - TMB = 1,3,5-trimethylbenzene
Other VOCs represented by octane, heptane, hexane, and pentane.

Freeport-McMoRan Tyrone Inc.
SX/EW-1 - Plant Mixer/Settler Tank Emissions

The combination of chemicals which results in the highest emission rate is represented in the permit application.
The following calculations are based on the BHP Copper VOC study conducted in 1997.

Emissions from the use of ACORGA M5774 also represent emissions from the use of ACORGA M5640 and ACORGA M5850 since the chemical constituents are the same for all three extractants.

number of tanks	10	area of each tank	6,137	ft^2	total area	61,366	ft^2

Chemical Product	Percent
SX-80	90%
ACORGA M5774	10%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate lb/hr	Emission Rate tons/year
Benzene	0.090	78.11	5.360	0.017	0.0018	5.71E-06	1.53E-07	4.94E-07	0.007	0.030
Toluene	0.080	92.14	100.790	0.377	0.0668	2.50E-04	3.02E-06	9.74E-06	0.14	0.60
Ethylbenzene	0.070	106.2	479.330	2.067	0.0568	2.45E-04	1.45E-05	4.67E-05	0.65	2.87
Total Xylene	0.070	106.2	624.480	2.693	0.0371	1.60E-04	1.89E-05	6.09E-05	0.85	3.74
Total HAPs									**1.65**	**7.23**
1,2,4 - trimethylbenzene	0.060	120.2	1890.00	9.23	0.023	1.12E-04	5.54E-05	1.79E-04	2.51	10.97
1,3,5 - trimethylbenzene	0.060	120.2	747.00	3.65	0.010	4.93E-05	2.19E-05	7.07E-05	0.99	4.34
Other VOCs	0.000	0.0	0.00	0.0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00	0.00
Total VOCs									**5.15**	**22.54**

$$\mathrm{Diff\,F} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)
MW = constituent molecular weight
Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)
Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).
Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m
H = distance above liquid surface = 1 m from BHP study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
SX-80	5.4	110	530	690	2100	830	0	confidential information supplied by Chevron Phillips
ACORGA M5774	5.00	17.90	23.30	34.80	0.00	0.00	0.00	confidential information supplied by Cytec
Organic in ppm	5.36	100.79	479.33	624.48	1890.00	747.00	0.00	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
SX/EW-1 - Plant Mixer/Settler Tank Emissions

The combination of chemicals which results in the highest emission rate is represented in the permit application.

Chemical Product	Percent
Conosol 170ES	90%
ACORGA M5774	10%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate lb/hr	Emission Rate tons/year
Benzene	0.090	78.11	45.500	0.145	0.0018	5.73E-06	1.30E-06	4.21E-06	0.059	0.258
Toluene	0.080	92.14	46.790	0.176	0.0668	2.51E-04	1.40E-06	4.53E-06	0.06	0.278
Ethylbenzene	0.070	106.2	47.330	0.205	0.0568	2.46E-04	1.43E-06	4.62E-06	0.06	0.284
Total Xylene	0.070	106.2	48.480	0.210	0.0371	1.61E-04	1.47E-06	4.74E-06	0.07	0.291
Total HAPs									**0.25**	**1.11**
1,2,4 - trimethylbenzene	0.060	120.2	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00	0.00
1,3,5 - trimethylbenzene	0.060	120.2	0.00	0.00	0.000	0.00E+00	0.00E+00	0.00E+00	0.00	0.00
Other VOCs	0.000	0.0	0.00	0.0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00	0.00
Total VOCs									**0.25**	**1.11**

$$\text{DiffF} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)

MW = constituent molecular weight

Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)

Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).

Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m

H = distance above liquid surface = 1 m from BHP study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
Conosol 170ES	50	50	50	50	0	0	0	confidential information supplied by Calumet Specialty Products
ACORGA M5774	5.00	17.90	23.30	34.80	0.00	0.00	0.00	confidential information supplied by Cytec
Organic in ppm	45.50	46.79	47.33	48.48	0.00	0.00	0.00	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
SX/EW-1 - Plant Mixer/Settler Tank Emissions

The combination of chemicals which results in the highest emission rate is represented in the permit application.

Chemical Product	Percent
Conosol 170ES	95%
ACORGA M5910	5%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate $ton/yr-ft^2$	Emission Rate lb/hr	Emission Rate tons/year
Benzene	0.090	78.11	47.714	0.152	0.0018	5.73E-06	1.37E-06	4.42E-06	0.062	0.271
Toluene	0.080	92.14	47.905	0.180	0.0668	2.51E-04	1.44E-06	4.64E-06	0.07	0.285
Ethylbenzene	0.070	106.2	47.717	0.206	0.0568	2.46E-04	1.44E-06	4.66E-06	0.07	0.286
Total Xylene	0.070	106.2	47.971	0.208	0.0371	1.61E-04	1.45E-06	4.69E-06	0.07	0.288
Total HAPs									**0.26**	**1.13**
1,2,4 - trimethylbenzene	0.060	120.2	0.31	0.00	0.02	1.13E-04	8.47E-09	2.74E-08	3.83E-04	1.68E-03
1,3,5 - trimethylbenzene	0.060	120.2	0.16	0.00	0.010	4.95E-05	4.53E-09	1.46E-08	2.05E-04	8.97E-04
Other VOCs	0.070	112.1	0.68	0.0	0.00	0.00E+00	2.18E-08	7.03E-08	9.85E-04	4.32E-03
Total VOCs									**0.26**	**1.14**

$$\mathrm{Diff\,F} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)

MW = constituent molecular weight

Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)

Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).

Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m

H = distance above liquid surface = 1 m from BHP study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
Conosol 170ES	50	50	50	50	0	0	0	confidential information supplied by Calumet Specialty Products
ACORGA M5910	3.35	7.25	3.40	8.60	6.35	3.35	13.90	confidential information supplied by Cytec
Organic in ppm	47.71	47.91	47.72	47.97	0.31	0.16	0.68	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
SX/EW-1 - Plant Mixer/Settler Tank Emissions

The combination of chemicals which results in the highest emission rate is represented in the permit application.

Chemical Product	Percent
SX-80	90%
ACORGA M5910	10%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate lb/hr	Emission Rate tons/year
Benzene	0.090	78.11	5.195	0.016	0.0018	5.71E-06	1.48E-07	4.79E-07	0.007	0.029
Toluene	0.080	92.14	99.725	0.373	0.0668	2.50E-04	2.98E-06	9.64E-06	0.14	0.591
Ethylbenzene	0.070	106.2	477.340	2.059	0.0568	2.45E-04	1.44E-05	4.65E-05	0.65	2.856
Total Xylene	0.070	106.2	621.860	2.682	0.0371	1.60E-04	1.88E-05	6.06E-05	0.85	3.720
Total HAPs									**1.64**	**7.20**
1,2,4 - trimethylbenzene	0.060	120.2	1890.64	9.23	0.023	1.12E-04	5.54E-05	1.79E-04	2.51	10.98
1,3,5 - trimethylbenzene	0.060	120.2	747.34	3.65	0.010	4.93E-05	2.19E-05	7.07E-05	0.99	4.34
Other VOCs	0.070	112.1	1.39	0.01	1.69E+01	0.00E+00	4.43E-08	1.43E-07	0.00	0.01
Total VOCs									**5.14**	**22.52**

$$\mathrm{DiffF} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)

MW = constituent molecular weight

Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)

Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).

Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m

H = distance above liquid surface = 1 m from BHP study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
SX-80	5.4	110	530	690	2100	830	0	confidential information supplied by Chevron Phillips
ACORGA M5910	3.35	7.25	3.40	8.60	6.35	3.35	13.90	confidential information supplied by Cytec
Organic in ppm	5.20	99.73	477.34	621.86	1890.64	747.34	1.39	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
SX/EW-1 - Plant Mixer/Settler Tank Emissions

The combination of chemicals which results in the highest emission rate is represented in the permit application.

Chemical Product	Percent
Escaid 110	95%
ACORGA M5910	5%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate tons/year	Emission Rate lb/hr
Benzene	0.093	78.11	0.175	0.001	0.0018	5.73E-06	5.14E-09	1.66E-08	0.001	0.000
Toluene	0.083	92.14	160.557	0.603	0.0668	2.51E-04	5.02E-06	1.62E-05	0.995	0.23
Ethylbenzene	0.076	106.2	0.177	0.001	0.0568	2.46E-04	3.97E-09	1.28E-08	0.001	0.00
Total Xylene	0.076	106.2	0.449	0.002	0.0371	1.61E-04	1.35E-08	4.37E-08	0.003	0.00
Total HAPs									**1.00**	**0.23**
1,2,4 - trimethylbenzene	0.070	120.2	0.33	0.00	0.02	1.13E-04	1.06E-08	3.42E-08	0.00	0.00
1,3,5 - trimethylbenzene	0.070	120.2	0.17	0.00	0.010	4.95E-05	5.67E-09	1.83E-08	0.00	0.00
Other VOCs	0.070	112.1	0.73	0.00	16.92	0.00E+00	2.32E-08	7.49E-08	0.00	0.00
Total VOCs									**1.01**	**0.23**

$$\mathrm{Diff\,F} = (Ci - Ch) \times D/H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)

MW = constituent molecular weight

Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)

Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).

Ch = constituent concentration at 0.61 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m

H = distance above liquid surface = 1 m per BHP Study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
Escaid 110	0	169	0	0	0	0	0	confidential information supplied
ACORGA M5910	3.35	7.25	3.40	8.60	6.35	3.35	13.90	confidential information supplied
Organic in ppm	0.17	160.56	0.18	0.45	0.33	0.17	0.73	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.

SX/EW-2 - Sulfuric Acid Emissions Estimates for the Tyrone SX/EW Tank House

Parameter	Value	Units
A1 (Inlet Area)	1647	sqft
A2 (Outlet Area)	2625	sqft
H (Height separating inlet from outlet)	38.9	ft
Ti (Inside Temperature)	523	deg R
To (Outside Temperature)	515	deg R
h (Natural plane calculation)	**27.79**	ft
Cw (Orifice Constant)	0.55	-
Aw (Area of windward openings)	730	sqft
V (Wind speed)	10	MPH
Qw (Wind effect calc.)	**353,320**	cfm
A (Area)	1647	sqft
Cs (Coefficient of Openings)	0.55	-
h (Natural plane calculation)	27.79	ft
Ti (Inside Temperature)	523	deg R
dT (Temperature difference)	8	deg R
Fc (Correction Factor)	1.18	-
Qs (Thermal effect calc.)	**335,353**	cfm
Qtotal (combined wind & thermal)	**487,131**	**cfm**
H2SO4 Concentration	1	mg/cm
H2SO4 Concentration	6.237E-08	lb/cf
ACID MIST EMISSIONS (as PM10)	**15,969**	**lb/yr**
	7.98	**TPY**

1.82 lb/hr based on 8,760 hr/yr

Conversions:

1 lb = 454 grams
1 ft = 0.3048 m
cf = cubic foot
cm = cubic meter
cfm = cubic feet per minute

Freeport-McMoRan Tyrone Inc.
SX/EW-3 - 2,000,000 Gallon Raffinate Tank Emissions

The following calculations are based on the BHP Copper VOC study conducted in 1997.
Emissions from the use of ACORGA M5774 also represent emissions from the use of ACORGA M5640 and ACORGA M5850 since the chemical constituents are the same for all three extractants. SX-80 and ACORGA M5774 were used as the reagent mix in calculating emissions due to yielding the highest representative emissions.

Number of tanks	1	area of each tank	11,304	ft^2	total area	11,304	ft^2

Chemical Product	Percent
SX-80	90%
ACORGA M5774	10%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate lb/hr	Emission Rate tons/yr
Benzene	0.090	78.11	5.360	0.017	0.0018	5.71E-06	1.53E-07	4.94E-07	1.28E-03	5.59E-03
Toluene	0.080	92.14	100.790	0.377	0.0668	2.50E-04	3.02E-06	9.74E-06	2.51E-02	1.10E-01
Ethylbenzene	0.070	106.2	479.330	2.067	0.0568	2.45E-04	1.45E-05	4.67E-05	1.21E-01	5.28E-01
Total Xylene	0.070	106.2	624.480	2.693	0.0371	1.60E-04	1.89E-05	6.09E-05	1.57E-01	6.88E-01
Total HAPs									**0.30**	**1.33**
1,2,4 - trimethylbenzene	0.060	120.2	1890.00	9.23	0.023	1.12E-04	5.54E-05	1.79E-04	4.62E-01	2.02E+00
1,3,5 - trimethylbenzene	0.060	120.2	747.00	3.65	0.010	4.93E-05	2.19E-05	7.07E-05	1.82E-01	7.99E-01
Other VOCs	0.000	0.0	0.00	0.0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total VOCs									**0.95**	**4.15**

$$\text{DiffF} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)
MW = constituent molecular weight
Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)
Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).
Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m
H = distance above liquid surface = 1 m per BHP Study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
SX-80	5.4	110	530	690	2100	830	0.00	confidential information supplied by Chevron Phillips
ACORGA M5774	5.00	17.90	23.30	34.80	0.00	0.00	0.00	confidential information supplied by Cytec
Organic in ppm	5.36	100.79	479.33	624.48	1890.00	747.00	0.00	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
SX/EW 4 - 400,000 Gallon Raffinate Tank Emissions

The following calculations are based on the BHP Copper VOC study conducted in 1997.
Emissions from the use of ACORGA M5774 also represent emissions from the use of ACORGA M5640 and ACORGA M5850 since the chemical constituents are the same for all three extractants. SX-80 and ACORGA M5774 were used as the reagent mix in calculating emissions due to yielding the highest representative emissions.

Number of tanks	1	area of each tank	3,320.0	ft^2	total area	3,320.0	ft^2

Chemical Product	Percent
SX-80	90%
ACORGA M5774	10%

Component	D cm^2/sec	MW g/gmole	Ci ppm	Ci g/m^3	Ch ppm	Ch g/m^3	Diff F g/m^2-s	Emission Rate ton/yr-ft^2	Emission Rate lb/hr	Emission Rate tons/year
Benzene	0.093	78.11	5.360	0.017	0.0011	3.49E-06	1.59E-07	5.12E-07	3.88E-04	1.70E-03
Toluene	0.083	92.14	100.790	0.377	0.0065	2.41E-05	3.14E-06	1.01E-05	7.69E-03	3.37E-02
Ethylbenzene	0.076	106.2	479.330	2.067	0.0010	4.31E-06	1.57E-05	5.07E-05	3.85E-02	1.68E-01
Total Xylene	0.076	106.2	624.480	2.693	0.0020	8.54E-06	2.05E-05	6.61E-05	5.01E-02	2.19E-01
Total HAPs									**0.10**	**0.42**
1,2,4 - trimethylbenzene	0.070	120.2	1890.00	9.23	0.0022	1.07E-05	6.47E-05	2.09E-04	1.58E-01	6.94E-01
1,3,5 - trimethylbenzene	0.070	120.2	747.00	3.65	0.001	5.03E-06	2.56E-05	8.27E-05	6.27E-02	2.75E-01
Other VOCs	0.000	0.0	0.00	0.0	3.98	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total VOCs									**0.32**	**1.39**

$$\text{Diff F} = (Ci - Ch) \times D / H$$

Where: D = constituent diffusivity (from EPA Reference Link for Estimated Diffusion Coefficients in Air and Water; Assumed Pressure of 1 atm, and Temperature of 25.84 deg. C per 1995 met. data)
MW = constituent molecular weight
Ci = constituent concentration at liquid surface, ppm. (from manufacturer data)
Ci, g/m^3, calculated from ideal gas law. Conservative temperature of 25.84 deg. C used based on 1995 meteorological data (Average plus Standard Deviation).
Ch = constituent concentration at 1 meter, ppm. Assumed same as BHP's measured concentrations at H=1 m
H = distance above liquid surface = 1 m per BHP Study

	Concentration in ppm							
Chemical	Benzene	Toluene	Ethylbenzene	Xylene	1,2,4 - tmb	1,3,5 - tmb	Other	Notes
SX-80	5.4	110	530	690	2100	830	0	confidential information supplied by Chevron Phillips
ACORGA M5774	5.00	17.90	23.30	34.80	0.00	0.00	0.00	confidential information supplied by Cytec
Organic in ppm	5.36	100.79	479.33	624.48	1890.00	747.00	0.00	composite concentration, Ci

Freeport-McMoRan Tyrone Inc.
Cathode Washing Hot Water Boilers (B-951 and B-748) Emissions

Table 1: Input Parameters

Fuel Type =	Propane	
Maximum Heat Capacity (B-951) =	1.256	MMBtu/hr
Maximum Heat Capacity (B-748) =	1.256	MMBtu/hr
Maximum Heat Capacity (total) =	2.512	MMBtu/hr
Propane Heating Value =	91.5	MMBtu/10^3 gal
Annual Operating Hours =	8,760	hr/yr
Maximum Propane Usage (each) =	13.7	gal/hr
Maximum Propane Usage (each) =	329.4	gal/day
Maximum Propane Usage (each) =	120,246.6	gal/yr
Maximum Propane Usage (total) =	27.5	gal/hr
Maximum Propane Usage (total) =	658.9	gal/day
Maximum Propane Usage (total) =	240,493.1	gal/yr

Table 2: Maximum Emission Rates

Pollutant	Emission Factors	Emission Factor Ref	Conversion Factors[a]	Converted Emission Factors	Maximum Total Emission Rates		
					lb/hr	lb/day	tpy
NOx	13 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.14 lb/MMBtu	0.36	8.57	1.56
CO	7.5 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.082 lb/MMBtu	0.21	4.94	0.90
SO_2	1.59 lb/10^3 gallons	1,2	91.5 MMBtu/10^3 gal	0.017 lb/MMBtu	0.044	1.05	0.19
VOC	0.8 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0087 lb/MMBtu	0.022	0.53	0.096
PM	0.7 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0077 lb/MMBtu	0.019	0.46	0.084
Hexane	1.8 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	1.76E-03 lb/MMBtu	0.0022	0.05	0.000
Formaldehyde	7.5E-02 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	7.35E-05 lb/MMBtu	0.00018	0.0044	0.00081
Toluene	3.4E-03 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	3.33E-06 lb/MMBtu	8.37E-06	0.00020	3.67E-05
Total HAPs[c]	1.89 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	0.0019 lb/MMBtu	0.0047	0.11	0.020
CO_2	62.87 kg/MMBtu	4	2.2 lb/kg	138.31 lb/MMBtu	347.44	8,338.67	1,521.81
CH_4	0.003 kg/MMBtu	4	2.2 lb/kg	0.0066 lb/MMBtu	0.017	0.40	0.073
N_2O	0.0006 kg/MMBtu	4	2.2 lb/kg	0.0013 lb/MMBtu	0.0033	0.080	0.015
CO_2e	63.12 kg/MMBtu	5	2.2 lb/kg	138.87 lb/MMBtu	348.85	8,372.34	1,527.95

Emission Factor References:

1. AP-42, Table 1.5-1 (7/08). The emission factor for methane has been subtracted from the TOC emission factor to represent VOC emissions since TOC includes VOCs plus "exempt" compounds such as methane and ethane.
2. Per the Gas Processors Association, the sulfur content in commercial propane is 254 ppmv as S. Using the ideal gas law conversion factor of 359.05 scf/lb-mol at 32°F and 1 atm and a molecular weight of 32.065 lb/lb-mol for sulfur, the sulfur content for propane is 15.9 grains/100 ft^3.
3. AP-42, Tables 1.4-3 and 1.4-4 (7/98). The emission factors for natural gas combustion are used since there are no HAP emission factors for propane combustion. The three highest HAPs hexane, formaldehyde, and toluene are listed in the table.
4. 40 CFR 98, Subpart C, Tables C-1 and C-2. The emission factors for CH_4 and N_2O are based on the "Petroleum Products" category, which is not propane-specific.
5. 40 CFR 98, Subpart A, Table A-1. Global Warming Potentials are 1 for CO_2, 25 for CH_4, and 298 for N_2O. Emissions are reported in short tons. To convert to metric tons, divide the short tons by 1.1.

Footnotes:

[a] The higher heating values for propane and natural gas are used to convert the corresponding emission factors to lb/MMBtu.

[b] These emissions represent both boilers combined since they exhaust out a common stack.

[c] Includes HAPs not listed in the table.

Freeport-McMoRan Tyrone Inc.

Heat Exchanger Hot Water Boiler (B-3891) Emissions

Table 1: Input Parameters

Fuel Type =	Propane
Maximum Heat Capacity =	3.6 MMBtu/hr
Propane Heating Value =	91.5 MMBtu/10^3 gal
Annual Operating Hours =	8,760 hr/yr
Maximum Propane Usage =	39.3 gal/hr
Maximum Propane Usage =	944.3 gal/day
Maximum Propane Usage =	344,655.7 gal/yr

Table 2: Maximum Emission Rates

Pollutant	Emission Factors	Emission Factor Ref	Conversion Factors[a]	Converted Emission Factors	Maximum Emission Rates		
					lb/hr	lb/day	tpy
NOx	13 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.14 lb/MMBtu	0.51	12.28	2.24
CO	7.5 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.082 lb/MMBtu	0.30	7.08	1.29
SO_2	1.59 lb/10^3 gallons	1,2	91.5 MMBtu/10^3 gal	0.017 lb/MMBtu	0.063	1.50	0.27
VOC	0.8 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0087 lb/MMBtu	0.031	0.76	0.14
PM	0.7 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0077 lb/MMBtu	0.028	0.66	0.12
Hexane	1.8 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	1.76E-03 lb/MMBtu	0.0064	0.15	0.028
Formaldehyde	7.5E-02 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	7.35E-05 lb/MMBtu	0.00026	0.0064	0.0012
Toluene	3.4E-03 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	3.33E-06 lb/MMBtu	0.000012	0.00029	0.000053
Total HAPs[b]	1.89 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	0.00185 lb/MMBtu	0.0067	0.16	0.029
CO_2	62.87 kg/MMBtu	4	2.2 lb/kg	138.31 lb/MMBtu	497.93	11,950.33	2,180.94
CH_4	0.003 kg/MMBtu	4	2.2 lb/kg	0.0066 lb/MMBtu	0.024	0.57	0.10
N_2O	0.0006 kg/MMBtu	4	2.2 lb/kg	0.0013 lb/MMBtu	0.0048	0.11	0.021
CO_2e	63.12 kg/MMBtu	5	2.2 lb/kg	138.87 lb/MMBtu	499.94	11,998.57	2,189.74

Emission Factor References:

1. AP-42, Table 1.5-1 (7/08). The emission factor for methane has been subtracted from the TOC emission factor to represent VOC emissions since TOC includes VOCs plus "exempt" compounds such as methane and ethane.
2. Per the Gas Processors Association, the sulfur content in commercial propane is 254 ppmv as S. Using the ideal gas law conversion factor of 359.05 scf/lb-mol at 32°F and 1 atm and a molecular weight of 32.065 lb/lb-mol for sulfur, the sulfur content for propane is 15.9 grains/100 ft^3.
3. AP-42, Tables 1.4-3 and 1.4-4 (7/98). The emission factors for natural gas combustion are used since there are no HAP emission factors for propane combustion. The three highest HAPs hexane, formaldehyde, and toluene are listed in the table.
4. 40 CFR 98, Subpart C, Tables C-1 and C-2. The emission factors for CH_4 and N_2O are based on the "Petroleum Products" category, which is not propane-specific.
5. 40 CFR 98, Subpart A, Table A-1. Global Warming Potentials are 1 for CO_2, 25 for CH_4, and 298 for N_2O. Emissions are reported in short tons. To convert to metric tons, divide the short tons by 1.1.

Footnotes:

[a] The higher heating values for propane and natural gas are used to convert the corresponding emission factors to lb/MMBtu.

[b] Includes HAPs not listed in the table.

Freeport-McMoRan Tyrone Inc.
Heat Exchanger Hot Water Boiler (B-1454) Emissions

Table 1: Input Parameters

Fuel Type =	Propane	
Maximum Heat Capacity =	3.6	MMBtu/hr
Propane Heating Value =	91.5	MMBtu/10^3 gal
Annual Operating Hours =	8,760	hr/yr
Maximum Propane Usage =	39.3	gal/hr
Maximum Propane Usage =	944.3	gal/day
Maximum Propane Usage =	344,655.7	gal/yr

Table 2: Maximum Emission Rates

Pollutant	Emission Factors	Emission Factor Ref	Conversion Factors[a]	Converted Emission Factors	Maximum Emission Rates		
					lb/hr	lb/day	tpy
NOx	13 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.14 lb/MMBtu	0.51	12.28	2.24
CO	7.5 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.082 lb/MMBtu	0.30	7.08	1.29
SO_2	1.59 lb/10^3 gallons	1,2	91.5 MMBtu/10^3 gal	0.017 lb/MMBtu	0.063	1.50	0.27
VOC	0.8 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0087 lb/MMBtu	0.031	0.76	0.14
PM	0.7 lb/10^3 gallons	1	91.5 MMBtu/10^3 gal	0.0077 lb/MMBtu	0.028	0.66	0.12
Hexane	1.8 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	1.76E-03 lb/MMBtu	0.0064	0.15	0.028
Formaldehyde	7.5E-02 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	7.35E-05 lb/MMBtu	0.00026	0.0064	0.0012
Toluene	3.4E-03 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	3.33E-06 lb/MMBtu	0.000012	0.00029	0.000053
Total HAPs[b]	1.89 lb/MMscf nat gas	3	1,020 MMBtu/MMscf	0.0019 lb/MMBtu	0.0067	0.16	0.029
CO_2	62.87 kg/MMBtu	4	2.2 lb/kg	138.31 lb/MMBtu	497.93	11,950.33	2,180.94
CH_4	0.003 kg/MMBtu	4	2.2 lb/kg	0.0066 lb/MMBtu	0.024	0.57	0.10
N_2O	0.0006 kg/MMBtu	4	2.2 lb/kg	0.0013 lb/MMBtu	0.0048	0.11	0.021
CO_2e	63.12 kg/MMBtu	5	2.2 lb/kg	138.87 lb/MMBtu	499.94	11,998.57	2,189.74

Emission Factor References:
1. AP-42, Table 1.5-1 (7/08). The emission factor for methane has been subtracted from the TOC emission factor to represent VOC emissions since TOC includes VOCs plus "exempt" compounds such as methane and ethane.
2. Per the Gas Processors Association, the sulfur content in commercial propane is 254 ppmv as S. Using the ideal gas law conversion factor of 359.05 scf/lb-mol at 32°F and 1 atm and a molecular weight of 32.065 lb/lb-mol for sulfur, the sulfur content for propane is 15.9 grains/100 ft^3.
3. AP-42, Tables 1.4-3 and 1.4-4 (7/98). The emission factors for natural gas combustion are used since there are no HAP emission factors for propane combustion. The three highest HAPs hexane, formaldehyde, and toluene are listed in the table.
4. 40 CFR 98, Subpart C, Tables C-1 and C-2. The emission factors for CH_4 and N_2O are based on the "Petroleum Products" category, which is not propane-specific.
5. 40 CFR 98, Subpart A, Table A-1. Global Warming Potentials are 1 for CO_2, 25 for CH_4, and 298 for N_2O. Emissions are reported in short tons. To convert to metric tons, divide the short tons by 1.1.

Footnotes:
[a] The higher heating values for propane and natural gas are used to convert the corresponding emission factors to lb/MMBtu.
[b] Includes HAPs not listed in the table.

Freeport-McMoRan Tyrone Inc.

SD-1 [Caterpillar C9 300hp]

Unit Number:	SD-1		
Source Description:	Diesel Powered Engine		

Engine Info

Manufacturer:	Caterpillar		
Model:	C9		
Aspiration:	Turbocharged/ATAAC		
Engine speed:	2,200	rpm	Mfg data
Sea level hp:	300	hp	Mfg data
	3.0	%	Per 1,000 ft above 4,000 ft
Elevation	5,801	ft	Google Earth
Derated hp:	283.8	hp	Calculated
Conversion Factor	1.34	hp/kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Hours of Operation	8,760	hr/yr	
Fuel Heating Value:	137,000	Btu/gal	AP-42
Fuel Usage Rate:	14.5	gal/hr	Calculated based on 7,000 Btu/hp-hr
Fuel Usage Rate:	127,022	gal/yr	

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.0021	lb/hp-hr	AP-42 Table 3.3-1
1.77	**1.63**	**0.09**	**0.58**	lb/hr	Hourly emission rate
7.77	**7.15**	**0.41**	**2.55**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.42E-03	4.09E-05	2.85E-04	1.18E-03	lb/MMBtu	AP-42
0.093	**0.0068**	**8.12E-05**	**5.66E-04**	**2.34E-03**	lb/hr	Hourly emission rate
0.41	**0.030**	**3.56E-04**	**2.48E-03**	**1.03E-02**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.96	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	298		GWP	40 CFR 98 Table A-1
2□5.□□	0.012	0.002□	2□7.01	lb/hr	
1,296.45	**0.053**	**0.0105**	**1,300.90**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

1 Emission factor for NO_x is assumed to be 95% of the EPA Tier 3 emission factor for NO_x + NMHC.

2 It is assumed that TSP = PM_{10} = $PM_{2.5}$.

3 Sulfur content is taken from AP-42 Table 3.3-1.

4 Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NO_x + NMHC.

5 Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

SD-2 [Caterpillar C9 300hp]

Unit Number:	SD-2		
Source Description:	Diesel Powered Engine		

Engine Info

Manufacturer:	Caterpillar		
Model:	C9		
Aspiration:	Turbocharged-ATAAC		
Engine speed:	2,200	rpm	Mfg data
Sea level hp:	300	hp	Mfg data
	3.0	%	Per 1,000 ft above □,000 ft
Elevation	5,801	ft	Google Earth
Derated hp:	283.8	hp	Calculated
Conversion Factor	1.3□	hp/kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Hours of Operation	8,760	hr/yr	
Fuel Heating Value:	137,000	Btu/gal	AP-42
Fuel Usage Rate:	1□.5	gal/hr	Calculated based on 7,000 Btu/hp-hr
Fuel Usage Rate:	127,022	gal/yr	

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.0021	lb/hp-hr	AP-42 Table 3.3-1
1.77	**1.63**	**0.093**	**0.58**	lb/hr	Hourly emission rate
7.77	**7.15**	**0.41**	**2.55**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.□2E-03	□.0□E-05	2.85E-0□	1.18E-03	lb/MMBtu	AP-42
0.093	**0.0068**	**8.12E-05**	**5.66E-04**	**2.34E-03**	lb/hr	Hourly emission rate
0.41	**0.030**	**3.56E-04**	**2.48E-03**	**1.03E-02**	tpy	Annual emission rate

CO_2	**CH_4**	**N_2O**	**CO_2e**		
73.□6	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	2□8		GWP	40 CFR 98 Table A-1
2□5.□□	0.012	0.002□	2□7.01	lb/hr	
1,296.45	**0.053**	**0.0105**	**1,300.90**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NO_x is assumed to be □5% of the EPA Tier 3 emission factor for NO_x + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NO_x + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

ENV-101: Stormwater Pump Engine Emissions

Criteria Pollutant Emission Factors:

NOx:	Source: 2014 Title V Permit Renewal Application	
	NOx =	**0.0310 (lb/hp-hr)**
CO:	Source: 2014 Title V Permit Renewal Application	
	CO =	**0.0067 (lb/hp-hr)**
***PM:**	Source: 2014 Title V Permit Renewal Application	
	PM =	**0.0022 (lb/hp-hr)**
HC:	Source: 2014 Title V Permit Renewal Application	
	HC =	**0.0025 (lb/hp-hr)**
SO_2:	Source: 2014 Title V Permit Renewal Application	
	SO_2 =	**0.0021 (lb/hp-hr)**

* Tyrone uses the same emission factor for PM, PM_{10}, and $PM_{2.5}$

HAP Emission Factors:

Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-2.

Pollutant	Emission Factors	To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7,000 BTU/ hp-hr)
Benzene	9.33E-04 lb/MMBTU	6.53E-06 lb/hp-hr
Toluene	4.09E-04 lb/MMBTU	2.86E-06 lb/hp-hr
Xylenes	2.85E-04 lb/MMBTU	2.00E-06 lb/hp-hr
1,3-Butadiene	3.91E-05 lb/MMBTU	2.74E-07 lb/hp-hr
Formaldehyde	1.18E-03 lb/MMBTU	8.26E-06 lb/hp-hr
Acetaldehyde	7.67E-04 lb/MMBTU	5.37E-06 lb/hp-hr
Acrolein	9.25E-05 lb/MMBTU	6.48E-07 lb/hp-hr
Naphthalene	8.48E-05 lb/MMBTU	5.94E-07 lb/hp-hr
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.68E-04 lb/MMBTU	1.18E-06 lb/hp-hr
Total Hazardous Air Pollutants (HAPs)	3.96E-03 lb/MMBTU	2.77E-05 lb/hp-hr

Greenhouse Gas Emission Factors:

CO_2	73.96	kg/MMBtu	40 CFR 98 Table C-1
CH_4	0.003	kg/MMBtu	40 CFR 98 Table C-2
N_2O	0.0006	kg/MMBtu	40 CFR 98 Table C-2

Fuel	Diesel		
Equipment	Stationary Stormwater Pump Engine		
Number of Units	1		
Hours of Operation [hr/year]	8,760		
Fuel Heat Value (Btu/gal) (AP-42)	137,000		
Fuel Usage Rate (gal/hr)	6		
Fuel Usage Rate (gal/yr)	52,560		
Heat Rate (MMBtu/hr)	0.82		
Capacity [hp]	125		
	Diesel Combustion		
Criteria Pollutants	**Emission Factor [lb/hr]**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**
Nitrogen Oxides (NO_x)	3.875	33,945	16.973
Carbon Monoxide (CO)	0.838	7,337	3.6683
Particulate Matter (PM)	0.275	2,409	1.205
Hydrocarbons (HC)	0.313	2,738	1.369
Sulfur Dioxide (SO_2)	0.256	2,245	1.122
HAPs			
Benzene	8.16E-04	7.15	3.58E-03
Toluene	3.58E-04	3.13	1.57E-03
Xylenes	2.49E-04	2.18	1.09E-03
1,3-Butadiene	3.42E-05	0.30	1.50E-04
Formaldehyde	1.03E-03	9.04	4.52E-03
Acetaldehyde	6.71E-04	5.88	2.94E-03
Acrolein	8.09E-05	0.71	3.55E-04
Naphthalene	7.42E-05	0.65	3.25E-04
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.47E-04	1.29	6.44E-04
Total Hazardous Air Pollutants (HAPs)	3.46E-03	30.34	1.52E-02
Greenhouse Gases			
CO_2 (metric tpy)	122.48	1,072,905	536.45
CH_4 (metric tpy)	0.0050	43.5	0.022
N_2O (metric tpy)	0.00099	8.7	0.0044
CO_2e [1] (metric tpy)	--	--	**538.29**

Notes:

1. Based on Global Warming Potentials from □0 CFR □8□Table A□1 and a default HHV of 0.138 MMBtu□gal

Freeport-McMoRan Tyrone Inc.
ENV-111: Stormwater Pump Engine Emissions

Criteria Pollutant Emission Factors:

NOx:	Source: 2014 Title V Permit Renewal Application	
	NOx =	**0.0310 (lb/hp-hr)**
CO:	Source: 2014 Title V Permit Renewal Application	
	CO =	**0.0067 (lb/hp-hr)**
***PM:**	Source: 2014 Title V Permit Renewal Application	
	PM =	**0.0022 (lb/hp-hr)**
HC:	Source: 2014 Title V Permit Renewal Application	
	HC =	**0.0025 (lb/hp-hr)**
SO_2:	Source: 2014 Title V Permit Renewal Application	
	SO_2 =	**0.0021 (lb/hp-hr)**

* Tyrone uses the same emission factor for PM, PM_{10}, and $PM_{2.5}$

HAP Emission Factors:

Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-2.

Pollutant	Emission Factors	To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7,000 BTU/ hp-hr)
Benzene	9.33E-04 lb/MMBTU	6.53E-06 lb/hp-hr
Toluene	4.09E-04 lb/MMBTU	2.86E-06 lb/hp-hr
Xylenes	2.85E-04 lb/MMBTU	2.00E-06 lb/hp-hr
1,3-Butadiene	3.91E-05 lb/MMBTU	2.74E-07 lb/hp-hr
Formaldehyde	1.18E-03 lb/MMBTU	8.26E-06 lb/hp-hr
Acetaldehyde	7.67E-04 lb/MMBTU	5.37E-06 lb/hp-hr
Acrolein	9.25E-05 lb/MMBTU	6.48E-07 lb/hp-hr
Naphthalene	8.48E-05 lb/MMBTU	5.94E-07 lb/hp-hr
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.68E-04 lb/MMBTU	1.18E-06 lb/hp-hr
Total Hazardous Air Pollutants (HAPs)	3.96E-03 lb/MMBTU	2.77E-05 lb/hp-hr

Greenhouse Gas Emission Factors:

CO_2	73.96	kg/MMBtu	40 CFR 98 Table C-1
CH_4	0.003	kg/MMBtu	40 CFR 98 Table C-2
N_2O	0.0006	kg/MMBtu	40 CFR 98 Table C-2

Fuel	Diesel		
Equipment	Stationary Stormwater Pump Engine		
Number of Units	1		
Hours of Operation [hr/year] [1]	8,760		
Fuel Heat Value (Btu/gal) (AP-42)	137,000		
Fuel Usage Rate (gal/hr)	6		
Fuel Usage Rate (gal/yr)	52,560		
Heat Rate (MMBtu/hr)	0.82		
Capacity [hp]	125		
	Diesel Combustion		
Criteria Pollutants	**Emission Factor [lb/hr]**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**
Nitrogen Oxides (NO_x)	3.875	33,945	16.973
Carbon Monoxide (CO)	0.838	7,337	3.668
Particulate Matter (PM)	0.275	2,409	1.205
Hydrocarbons (HC)	0.313	2,738	1.369
Sulfur Dioxide (SO_2)	0.256	2,245	1.122
HAPs			
Benzene	8.16E-04	7.15	3.58E-03
Toluene	3.58E-04	3.13	1.57E-03
Xylenes	2.49E-04	2.18	1.09E-03
1,3-Butadiene	3.42E-05	0.30	1.50E-04
Formaldehyde	1.03E-03	9.04	4.52E-03
Acetaldehyde	6.71E-04	5.88	2.94E-03
Acrolein	8.09E-05	0.71	3.55E-04
Naphthalene	7.42E-05	0.65	3.25E-04
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.47E-04	1.29	6.44E-04
Total Hazardous Air Pollutants (HAPs)	3.46E-03	30.34	1.52E-02
Greenhouse Gases			
CO_2 (metric tpy)	122.48	1,072,905	536.45
CH_4 (metric tpy)	0.0050	43.5	0.022
N_2O (metric tpy)	0.00099	8.7	0.0044
CO_2e [1] (metric tpy)	--	--	**538.29**

Notes:

1. Based on Global Warming Potentials from 40 CFR 98 Table A-1 and a default HHV of 0.138 MMBtu/gal

Freeport-McMoRan Tyrone Inc.

ENV-117 [John Deere 4045TF275 115hp]

□nit □umber:	□□V□117		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	□ohn Deere		
Model:	□0□5TF275		
Sea level hp:	115	hp	□ngine □ameplate
	3	%	Per 1□000 ft above □000 ft
□levation	5□801	ft	
Derated hp:	10□.1	hp	
Derated □W:	81.35	□W	
Conversion Factor	0.0022	g□lb	
Conversion Factor	2□000	lb□ton	
Conversion Factor	1.3□	hp□□W	
Hours of Operation	8□760	hr□yr	
Diesel Heating Value	137□000	Btu□gal	From AP□□2
Fuel □sage Rate:	5.6	gal□hr	Calculated based on 7□000 Btu□hp□hr
Fuel □sage Rate:	□8□831	gal□yr	

Emission Calculations

□O□[1]	CO	PM[2]	SO_2[3]		
3.□7	0.8□	0.22		g□hp□hr	F□L Certification Test for □PA Family □o. 5□D□L06.8082 (nameplate)
			0.00205	lb□hp□hr	AP□□2 Table 3.3□1
0.95	**0.22**	**0.05**	**0.22**	lb□hr	Hourly emission rate
4.18	**0.94**	**0.23**	**0.98**	tpy	Annual emission rate

VOC[□]	Total HAPs[5]	Toluene	□ylenes	Formaldehyde		
0.21					g□hp□hr	F□L Certification Test for □PA Family □o. 5□D□L06.8082 (nameplate)
	3.□2□□03	□.0□□□05	2.85□□0□	1.18□□03	lb□MMBtu	AP□□2
0.050	**0.0026**	**3.12E-05**	**2.18E-04**	**9.01E-04**	lb□hr	Hourly emission rate
0.22	**0.011**	**1.37E-04**	**9.53E-04**	**0.0039**	tpy	Annual emission rate

CO_2	**CH_4**	**N_2O**	**CO_2e**		
73.□6	0.003	0.0006		□g□MMBtu	□0 CFR □8□Tables C□1 and C□2
163.1	0.0066	0.00132		lb□MMBtu	
1	25	2□8		GWP	□0 CFR □8□Table A□1
113.7□	0.00□6	0.000□	11□.18	lb□hr	
498.39	**2.02E-02**	**4.04E-03**	**500.10**	**tpy (metric)**	□0 CFR □8□□□uations C□1 and C□8□Table C□1 (default HHV of 0.138 MMBtu□gal)

Footnotes:

[1] □mission factor for □O□ is based on □5% of the F□L Certification Test for □PA Family □o. 5□D□L06.8082 emission factor for □O□ □ □MHC.

[2] It is assumed that TSP □ PM_{10} □ $PM_{2.5}$.

[3] Sulfur content is ta□en from AP□□2 Table 3.3□1.

[□] □mission factor for VOC is based on 5% of the F□L Certification Test for □PA Family □o. 5□D□L06.8082 emission factor for □O□ □ □MHC.

[5] Total HAPs are based on AP□□2 Table 3.3.2 and an average bra□e□specific fuel consumption rate of 7□000 Btu□hp□hr.

Freeport-McMoRan Tyrone Inc.

ENV-122: Stormwater Pump Engine Emissions

Criteria Pollutant Emission Factors:

NOx:	Source: Tier 2 Emission Standards; 95% of NOx+NMHC		
	NOx =	**0.010**	**(lb/hp-hr)**
CO:	Source: Tier 2 Emission Standards		
	CO =	**0.0082**	**(lb/hp-hr)**
***PM:**	Source: Tier 2 Emission Standards		
	PM =	**0.00049**	**(lb/hp-hr)**
VOC:	Source: Tier 2 Emission Standards; 5% of NOx+NMHC		
	VOC =	**0.00054**	**(lb/hp-hr)**
SO_2:	Source: 2014 Title V Permit Renewal Application		
	SO_2 =	**0.0021**	**(lb/hp-hr)**

* Tyrone uses the same emission factor for PM, PM_{10}, and $PM_{2.5}$

HAP Emission Factors:

Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-2.

Pollutant	Emission Factors	To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7,000 BTU/ hp-hr)
Benzene	9.33E-04 lb/MMBTU	6.53E-06 lb/hp-hr
Toluene	4.09E-04 lb/MMBTU	2.86E-06 lb/hp-hr
Xylenes	2.85E-04 lb/MMBTU	2.00E-06 lb/hp-hr
1,3-Butadiene	3.91E-05 lb/MMBTU	2.74E-07 lb/hp-hr
Formaldehyde	1.18E-03 lb/MMBTU	8.26E-06 lb/hp-hr
Acetaldehyde	7.67E-04 lb/MMBTU	5.37E-06 lb/hp-hr
Acrolein	9.25E-05 lb/MMBTU	6.48E-07 lb/hp-hr
Naphthalene	8.48E-05 lb/MMBTU	5.94E-07 lb/hp-hr
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.68E-04 lb/MMBTU	1.18E-06 lb/hp-hr
Total Hazardous Air Pollutants (HAPs)	3.96E-03 lb/MMBTU	2.77E-05 lb/hp-hr

Greenhouse Gas Emission Factors:

CO_2	73.96	kg/MMBtu	40 CFR 98 Table C-1
CH_4	0.003	kg/MMBtu	40 CFR 98 Table C-2
N_2O	0.0006	kg/MMBtu	40 CFR 98 Table C-2

Fuel	Diesel		
Equipment	Stationary Stormwater Pump Engine (Cat 3054C)		
Number of Units	1		
Hours of Operation [hr/year]	8,760		
Fuel Heat Value (Btu/gal) (AP-42)	137,000		
Fuel Usage Rate (gal/hr)	6		
Fuel Usage Rate (gal/yr)	52,560		
Heat Rate (MMBtu/hr)	0.82		
Capacity [hp]	125		
	Diesel Combustion		
Criteria Pollutants	**Emission Factor [lb/hr]**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**
Nitrogen Oxides (NO_x)	1.29	11,295	5.65
Carbon Monoxide (CO)	1.03	9,008	4.50
Particulate Matter (PM)	0.062	540	0.27
Hydrocarbons (HC)	0.068	594	0.30
Sulfur Dioxide (SO_2)	0.26	2,245	1.12
HAPs			
Benzene	8.16E-04	7.15	3.58E-03
Toluene	3.58E-04	3.13	1.57E-03
Xylenes	2.49E-04	2.18	1.09E-03
1,3-Butadiene	3.42E-05	0.30	1.50E-04
Formaldehyde	1.03E-03	9.04	4.52E-03
Acetaldehyde	6.71E-04	5.88	2.94E-03
Acrolein	8.09E-05	0.71	3.55E-04
Naphthalene	7.42E-05	0.65	3.25E-04
Total Polycyclic Aromatic Hydrocarbons (PAHs)	1.47E-04	1.29	6.44E-04
Total Hazardous Air Pollutants (HAPs)	3.46E-03	30.34	1.52E-02
Greenhouse Gases			
CO_2 (metric tpy)	122.48	1,072,905	536.45
CH_4 (metric tpy)	0.0050	43.5	0.022
N_2O (metric tpy)	0.00099	8.7	0.0044
CO_2e [1] (metric tpy)	--	--	**538.29**

Notes:

1. Based on Global Warming Potentials from □0 CFR □8□Table A□1 and a default HHV of 0.138 MMBtu□gal

Freeport-McMoRan Tyrone Inc.

ENV-123 [Caterpillar 3126B 225hp]

□nit □umber:	□□V□123		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	Caterpillar		
Model:	3126B		
Sea level hp:	225	hp	Mfg data
	3	%	Per 1□000 ft above □000 ft
□levation	5□801	ft	
Derated hp:	212.8	hp	
Derated □W:	158.72	□W	
Conversion Factor	0.0022	g□lb	
Conversion Factor	2000	lb□ton	
Conversion Factor	1.3□	hp□□W	
Hours of Operation	8□760	hr□yr	
Bra□e Specific Fuel Consumption	7□000	Btu□hp□hr	AP□□2 Section 3.3
Diesel Heating Value	137□000	Btu□gal	From AP□□2
Fuel □sage Rate:	10.□	gal□hr	Calculated
Fuel □sage Rate:	□5□267	gal□yr	Calculated

Emission Calculations

□O□[1]	CO	PM[2]	SO_2[3]		
□.68	2.61	0.15		g□hp□hr	□PA Tier 2 □missions Standards
			0.00205	lb□hp□hr	AP□□2 Table 3.3□1
2.19	**1.22**	**0.0700**	**0.44**	lb□hr	Hourly emission rate
9.61	**5.36**	**0.307**	**1.91**	tpy	Annual emission rate

VOC□	Total HAPs[5]	Toluene	□ylenes	Formaldehyde		
0.25					g□hp□hr	□PA Tier 2 □missions Standards
	3.□2□□03	□.0□□□05	2.85□□0□	1.18□□03	lb□MMBtu	AP□□2
0.115	**0.0051**	**6.09E-05**	**4.25E-04**	**1.76E-03**	lb□hr	Hourly emission rate
0.51	**0.022**	**2.67E-04**	**1.86E-03**	**7.70E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.□6	0.003	0.0006		□g□MMBtu	□0 CFR □8□Tables C□1 and C□2
163.1	0.0066	0.00132		lb□MMBtu	
1	25	2□8		GWP	□0 CFR □8□Table A□1
222.00	0.00□	0.0018	222.76	lb□hr	
972.34	**0.039**	**0.0079**	**975.68**	**tpy (metric)**	□0 CFR □8□□□uations C□1 and C□8□Table C□1 (default HHV of 0.138 MMBtu□gal)

Footnotes:

[1] □mission factor for □O□ is assumed to be □5% of the □PA Tier 2 emission factor for □O□ □ □MHC.

[2] It is assumed that TSP □ PM_{10} □ $PM_{2.5}$.

[3] Sulfur content is ta□en from AP□□2 Table 3.3□1

[□] □mission factor for VOC is assumed to be 5% of the □PA Tier 2 emission factor for □O□ □ □MHC.

[5] Total HAPs are based on AP□□2 Table 3.3.2 and an average bra□e□specific fuel consumption rate of 7□000 Btu□hp□hr.

OP-2 [Perkins 403C-15 32.5hp]

Unit Number:	OP-2		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	Perkins		
Model:	403C-15		
Engine speed:	3,000	rpm	Mfg data
Sea level hp:	32.5	hp	Mfg data
	3.0	%	Per 1,000 ft above □,000 ft
Elevation	5,801	ft	Google Earth
Derated hp:	30.7□	hp	Calculated
Conversion Factor	1.3□	hp/kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Hours of Operation	8,760	hr/yr	
Fuel Rate	3.70	L/hr	Manufacturer
Fuel Rate	0.□8	gal/hr	
Fuel Usage Rate:	8,562	gal/yr	Calculated
Fuel Heating Value:	137,000	Btu/gal	AP-42

Emission Calculations

NOx[1]	CO	PM[2]	SO_2[3]		
5.3	□.10	0.□5		g/hp-hr	EPA Tier 2 Emission Standards
			0.00205	lb/hp-hr	AP-42 Table 3.3-1
0.36	**0.28**	**0.030**	**0.0630**	lb/hr	Hourly emission rate
1.58	**1.22**	**0.13**	**0.28**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.28					g/hp-hr	EPA Tier 2 Emission Standards
	3.□2E-03	□.0□E-05	2.85E-0□	1.18E-03	lb/MMBtu	AP-42
0.019	**0.00074**	**8.80E-06**	**6.13E-05**	**2.54E-04**	lb/hr	Hourly emission rate
0.083	**3.23E-03**	**3.86E-05**	**2.69E-04**	**1.11E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.□6	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	2□8		GWP	40 CFR 98 Table A-1
1□.□5	8.0□E-0□	1.62E-0□		lb/hr	
87.39	**3.54E-03**	**7.09E-04**	**87.7**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NOx is assumed to be □5% of the EPA Tier 2 emission factor for NOx + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 2 emission factor for NOx + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

OP-4 [Caterpillar C6.6 225hp]

Unit Number:	OP-4		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	Caterpillar		
Model:	C6.6		
Sea level hp:	225	hp	Mfg data
	3	%	Per 1,000 ft above 4,000 ft
Elevation	5801	ft	
Derated hp:	212.8	hp	
Derated kW:	158.7	kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Conversion Factor	1.34	hp/kW	
Hours of Operation	8,760	hr/yr	
Brake Specific Fuel Consumption	7,000	Btu/hp-hr	AP-42 Section 3.3
Diesel Heating Value	137,000	Btu/gal	From AP-42
Fuel Usage	10.9	gal/hr	Calculated
Fuel Usage	95,267	gal/yr	Calculated

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.00205	lb/hp-hr	AP-42 Table 3.3-1
1.33	**1.22**	**0.070**	**0.44**	lb/hr	Hourly emission rate
5.82	**5.36**	**0.31**	**1.91**	tpy	Annual emission rate

VOC[4]	Total HAPs	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.42E-03	4.09E-05	2.85E-04	1.18E-03	lb/MMBtu	AP-42
0.070	**0.0051**	**6.09E-05**	**4.25E-04**	**1.76E-03**	lb/hr	Hourly emission rate
0.31	**0.022**	**2.67E-04**	**1.86E-03**	**7.70E-03**	tpy	Annual emission rate

CO_2	**CH_4**	**N_2O**	**CO_2e**		
73.96	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	298		GWP	40 CFR 98 Table A-1
222.00	0.0040	0.0018	222.76	lb/hr	
972.34	**0.039**	**0.0079**	**975.68**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NO_x is assumed to be 95% of the EPA Tier 3 emission factor for NO_x + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NO_x + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

OP-7 [Caterpillar C7 225hp]

Unit Number:	OP-7		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	Caterpillar		
Model:	C7		
Sea level hp:	225	hp	Mfg data
	3	%	Per 1,000 ft above 4,000 ft
Elevation	5801	ft	
Derated hp:	212.8	hp	
Derated kW:	158.7	kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Conversion Factor	1.34	hp/kW	
Hours of Operation	8,760	hr/yr	
Brake Specific Fuel Consumption	7,000	Btu/hp-hr	AP-42 Section 3.3
Diesel Heating Value	137,000	Btu/gal	From AP-42
Fuel Usage	10.88	gal/hr	Calculated
Fuel Usage	95,267	gal/yr	Calculated

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.00205	lb/hp-hr	AP-42 Table 3.3-1
1.33	**1.22**	**0.0700**	**0.44**	lb/hr	Hourly emission rate
5.82	**5.36**	**0.31**	**1.91**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.42E-03	4.09E-05	2.85E-04	1.18E-03	lb/MMBtu	AP-42
0.070	**0.0051**	**6.09E-05**	**4.25E-04**	**1.76E-03**	lb/hr	Hourly emission rate
0.31	**0.022**	**2.67E-04**	**1.86E-03**	**7.70E-03**	tpy	Annual emission rate

CO_2	**CH_4**	**N_2O**	**CO_2e**		
73.96	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	298		GWP	40 CFR 98 Table A-1
222.00	0.00□0	0.0018	222.76	lb/hr	
972.34	**0.039**	**0.0079**	**975.68**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NO_x is assumed to be 95% of the EPA Tier 3 emission factor for NO_x + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NO_x + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

OP-8 [Caterpillar C7 225hp]

Unit Number:	OP-8
Source Description:	Diesel Engine

Engine Info

Manufacturer:	Caterpillar		
Model:	C7		
Aspiration:	Turbocharged/ATAAC		
Engine speed:	2,200	rpm	Manufacturer data
Sea level hp:	225	hp	Manufacturer data
	3.0	%	Per 1,000 ft above 4,000 ft
Elevation	5,801	ft	Google Earth
Derated hp:	212.84	hp	Calculated
Conversion Factor	1.34	hp/kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Hours of Operation	8,760	hr/yr	
Fuel Usage Rate	47.00	L/hr	Manufacturer data
Fuel Usage Rate	12.42	gal/hr	
Fuel Usage Rate	108,765	gal/yr	
Fuel Heating Value:	137,000	Btu/gal	AP-42

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.0021	lb/hp-hr	AP-42 Table 3.3-1
1.33	**1.22**	**0.070**	**0.4363**	lb/hr	Hourly emission rate
5.82	**5.36**	**0.31**	**1.91**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.42E-03	4.09E-05	2.85E-04	1.18E-03	lb/MMBtu	AP-42
0.074	**0.0051**	**6.09E-05**	**4.25E-04**	**1.76E-03**	lb/hr	Hourly emission rate
0.32	**0.022**	**2.67E-04**	**1.86E-03**	**7.70E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.96	0.003	0.0006		kg/MMBtu	40 CFR 98, Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	298		GWP	40 CFR 98, Table A-1
253.95	0.010	0.0021	254.3	lb/hr	
1,110.11	**0.045**	**0.0090**	**1,113.9**	**tpy (metric)**	40 CFR 98, Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NO_x is assumed to be 95% of the EPA Tier 3 emission factor for NO_x + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NO_x + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

ENV-120 [Caterpillar C6.6 225hp]

Unit Number:	ENV-120		
Source Description:	Diesel Engine		

Engine Info

Manufacturer:	Caterpillar		
Model:	C6.6		
Engine speed:	2,200	rpm	Mfg data
Sea level hp:	225	hp	Mfg data
	3.0	%	Per 1,000 ft above □,000 ft
Elevation	5,801	ft	
Derated hp:	212.8	hp	
Conversion Factor	1.3□	hp/kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Hours of Operation	8,760	hr/yr	
Fuel Usage	10.□	gal/hr	Calculated
Fuel Usage	□5,267	gal/yr	Calculated
Fuel Heating Value:	137,000	Btu/gal	AP-42

Emission Calculations

NO_x[1]	CO	PM[2]	SO_2[3]		
2.83	2.61	0.15		g/hp-hr	EPA Tier 3 Emission Standards
			0.00205	lb/hp-hr	AP-42 Table 3.3-1
1.33	**1.22**	**0.070**	**0.436**	lb/hr	Hourly emission rate
5.82	**5.36**	**0.31**	**1.91**	tpy	Annual emission rate

VOC[4]	Total HAPs[5]	Toluene	Xylenes	Formaldehyde		
0.15					g/hp-hr	EPA Tier 3 Emission Standards
	3.□2E-03	□.0□E-05	2.85E-0□	1.18E-03	lb/MMBtu	AP-42
0.070	**0.0051**	**6.09E-05**	**4.25E-04**	**1.76E-03**	lb/hr	Hourly emission rate
0.31	**0.022**	**2.67E-04**	**1.86E-03**	**7.70E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.□6	0.003	0.0006		kg/MMBtu	40 CFR 98 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	2□8		GWP	40 CFR 98 Table A-1
222.00	0.00□	0.0018	222.8	lb/hr	
972.34	**0.039**	**0.0079**	**975.7**	**tpy (metric)**	40 CFR 98 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factor for NO_x is assumed to be □5% of the EPA Tier 3 emission factor for NOx + NMHC.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Emission factor for VOC is assumed to be 5% of the EPA Tier 3 emission factor for NOx + NMHC.

[5] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

Freeport-McMoRan Tyrone Inc.

EMP-1 [Caterpillar 3126 190hp]

Unit Number:	EMP-1		
Source Description:	Diesel Powered Pump		

Engine Info

Manufacturer:	Caterpillar		
Model:	3126		
Sea level hp:	1□0	hp	Mfg data
	3	%	Per 1,000 ft above □,000 ft
Elevation	5801	ft	
Derated hp:	17□.7	hp	
Derated kW:	13□.0	kW	
Conversion Factor	0.0022	g/lb	
Conversion Factor	2,000	lb/ton	
Conversion Factor	1.3□	hp/kW	
Hours of Operation	8,760	hr/yr	
Brake Specific Fuel Consumption	7,000	Btu/hp-hr	AP-42 Section 3.3
Diesel Heating Value	137,000	Btu/gal	From AP-42
Fuel Usage	□.2	gal/hr	Calculated
Fuel Usage	80,□□□.7	gal/yr	Calculated

Emission Calculations

NO_x[1]	CO[1]	PM[1,2]	SO_2[3]		
6.□	8.5	0.□0		g/hp-hr	EPA Tier 1 Emission Standards
			0.00205	lb/hp-hr	AP-42 Table 3.3-1
2.72	**3.37**	**0.160**	**0.37**	lb/hr	Hourly emission rate
11.91	**14.75**	**0.70**	**1.61**	tpy	Annual emission rate

VOC[1]	Total HAPs[4]	Toluene	Xylenes	Formaldehyde		
1.0					g/hp-hr	EPA Tier 1 Emission Standards
					lb/hp-hr	AP-42 Table 3.3-1
	0.003□2	□.0□□-05	2.85E-0□	0.00118	lb/MMBtu	AP-42 Table 3.3-2
0.38	**0.0043**	**5.15E-05**	**3.59E-04**	**1.48E-03**	lb/hr	Hourly emission rate
1.68	**0.019**	**2.25E-04**	**1.57E-03**	**6.50E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.□6	0.003	0.0006		kg/MMBtu	□0 CFR □8 Tables C-1 and C-2
163.1	0.0066	0.00132		lb/MMBtu	
1	25	2□8		GWP	□0 CFR □8 Table A-1
187.□6	0.0076	0.0015	188.11	lb/hr	
821.09	**0.033**	**0.0067**	**823.90**	**tpy (metric)**	□0 CFR □8 Equations C-1 and C-8, Table C-1 (default HHV of 0.138 MMBtu/gal)

Footnotes:

[1] Emission factors for NO_x, CO, PM, and VOC are based on Tier 1 Emission Standards.

[2] It is assumed that TSP = PM_{10} = $PM_{2.5}$.

[3] Sulfur content is taken from AP-42 Table 3.3-1.

[4] Total HAPs are based on AP-42 Table 3.3.2 and an average brake-specific fuel consumption rate of 7,000 Btu/hp-hr.

EMP-2 [Caterpillar 3126B 200hp]

□nit □umber:	□MP□2
Source Description:	Diesel Powered Pump

Engine Info

Manufacturer:	Caterpillar		
Model:	3126B		
Sea level hp:	200	hp	Mfg data
	3	%	Per 1□000 ft above □000 ft
□levation	5801	ft	
Derated hp:	18□.2	hp	
Derated □W:	1□1.1	□W	
Conversion Factor	0.0022	g□lb	
Conversion Factor	2□000	lb□ton	
Conversion Factor	1.3□	hp□□W	
Hours of Operation	8□760	hr□yr	
Bra□e Specific Fuel Consumption	7□000	Btu□hp□hr	AP□□2 Section 3.3
Diesel Heating Value	137□000	Btu□gal	From AP□□2
Fuel □sage	□.7	gal□hr	Calculated
Fuel □sage	8□□682	gal□yr	Calculated

Emission Calculations

□O□[1]	CO	PM[2]	SO_2[3]		
□.68	2.61	0.15		g□hp□hr	□PA Tier 2 □missions Standards
			0.00205	lb□hp□hr	AP□□2 Table 3.3□1
1.95	**1.09**	**0.062**	**0.39**	lb□hr	Hourly emission rate
8.54	**4.77**	**0.27**	**1.70**	tpy	Annual emission rate

VOC[□]	Total HAPs[5]	Toluene	□ylenes	Formaldehyde		
0.25					g□hp□hr	□PA Tier 2 □missions Standards
	3.□2□□03	□.0□□□05	2.85□□0□	1.18□□03	lb□MMBtu	AP□□2
0.103	**0.0045**	**5.42E-05**	**3.77E-04**	**1.56E-03**	lb□hr	Hourly emission rate
0.45	**0.020**	**2.37E-04**	**1.65E-03**	**6.84E-03**	tpy	Annual emission rate

CO_2	CH_4	N_2O	CO_2e		
73.□6	0.003	0.0006		□g□MMBtu	□0 CFR □8□Tables C□1 and C□2
163.1	0.0066	0.00132		lb□MMBtu	
1	25	2□8		GWP	□0 CFR □8□Table A□1
1□7.33	0.008	0.0016	1□8.0	lb□hr	
864.30	**0.035**	**0.007**	**867.3**	**tpy (metric)**	□0 CFR □8□□□uations C□1 and C□8□Table C□1 (default HHV of 0.138 MMBtu□gal)

Footnotes:

[1] □mission factor for □O□is assumed to be □5% of the □PA Tier 2 emission factor for □O□ □ □MHC.

[2] It is assumed that TSP □ PM_{10} □ $PM_{2.5}$.

[3] Sulfur content is ta□en from AP□□2 Table 3.3□1.

[□] □mission factor for VOC is assumed to be 5% of the □PA Tier 2 emission factor for □O□ □ □MHC.

[5] Total HAPs are based on AP□□2 Table 3.3.2 and an average bra□e□specific fuel consumption rate of 7□000 Btu□hp□hr.

Indian Peak Generator

Unit No(s): IPG
Description: Indian Pea□Generator

Engine Data

Horsepower:	18.8	hp	Manufacturer Data	(1□□W)
Fuel usage:	27□	ft3□hr	MFG Data	
Fuel heat value:	2500	Btu□scf	□ominal for propane	
Heating rate:	0.70	MMBtu□hr		
Fuel usage:	2.7□□□0□	MMscf□hr		
	2.□	MMscf□yr		
Operating hours:	8760.0	hours□year		

Emission Rates

HC + NO_X[1]	NO_x[1]	CO[1]	HC (VOC)[1]	SO_2[2]	PM[3]	Total HAPs[4]	Toluene[4]	Xylenes[4]		
7.5	7.125	610	0.375						g□□W□hr	□SPS □□□□ limit
					0.010				lb□MMBtu	AP□□2 Table 3.2□2
0.23	**0.22**	**18.83**	**0.012**	**0.0028**	**6.97E-03**	**9.91E-03**	**4.57E-05**	**2.28E-05**	**lb/hr**	
1.01	**0.96**	**82.46**	**0.051**	**0.012**	**0.031**	**0.043**	**2.00E-04**	**1.00E-04**	**tpy (8760 hours)**	

Greenhouse Gas Emissions

CO_2	CH_4	N_2O	CO_2e		
53.06	0.0010	0.00010		□g□MMBtu	□0 CFR □8 Subpart C
357.37	**6.74E-03**	**6.74E-04**	**357.74**	**tpy**	
1	25	2□8		GWP	

Notes

1 □O□□CO□and VOC emissions based on □SPS □□□□ limits for nonhandheld Class II engines. □MHC and □O□ combined emission factor was bro□en down assuming 5% □MHC and □5% □O□ per CARB policy dated □une 28□200□.

2 SO_2 emissions are based on the average national sulfur content of LPG which is 0.012% by mass (appro□imately 2.6 g of SO2□G□of heat input) per Appendi□□□2 of undated document at □S Department of □nergy website: http:□□www1.eere.energy.gov□buildings□appliance□standards□residential□pdfs□□□2.pdf

3 PM emission were calculated using AP□□2 Table 3.2□2. It is assumed that TSP □ PM_{10} = $PM_{2.5}$

□ HAPs calculated using GRI HAPCalc 3.01

Nordberg Engine and CE-1 Emission Factors

A. Dual Fuel Engine - Natural Gas with Diesel

CO: Source: NSR Permit No. 2448A-R1, Condition 2.d)
Average Value = **2.857E+01 [lb/hr]**

NOx: Source: 2005 Cubix Emission Tests
Average Value = **3.434E+01 [lb/hr]**

Note: AP-42 Chapter 3.4, Large Stationary Diesel and All Stationary Dual-Fuel Engines, does not have emission factors for particulates. Therefore, particulate emission factors from AP-42 Chapter 3.2, Natural Gas-Fired Reciprocating Engines, were selected to estimate particulate emissions for dual fuel engine combustion of natural gas.

Natural gas-fired engine Brake Specific Fuel Consumption of 7500 Btu/hp-hr is from US Department of the Interior document

$PM_{2.5}$: Source: AP-42 Chapter 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-3
$PM_{2.5}$ = 9.50E-03 lb/MMBtu
9.50E-03 lb/MMBtu * 7500 Btu/hp-hr * 1MMBtu/1E06Btu = **7.13E-05 [lb/hp-hr]**

PM_{10} : Source: AP-42 Chapter 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-3
PM_{10} = 9.50E-03 lb/MMBtu
9.50E-03 lb/MMBtu * 7500 Btu/hp-hr * 1MMBtu/1E06Btu = **7.13E-05 [lb/hp-hr]**

TSP: Source: AP-42 Chapter 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-3
TSP = 9.91E-03 lb/MMBtu
9.91E-03 lb/MMBtu * 7500 Btu/hp-hr * 1MMBtu/1E06Btu = **7.43E-05 [lb/hp-hr]**

SO_2 : Source: AP-42, Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Table 3.4-1
$SO_2 = 4.06E\text{-}4*S_1 + 9.57E\text{-}3*S_2$ [lb/hp-hr] where: S_1 = % sulfur in fuel oil
S_2 = % sulfur in natural gas

For Tyrone:	% sulfur in fuel oil	0.05	% (500 ppm low sulfur diesel fuel)
	% sulfur in natural gas	0.00104	% (10.4 ppm S in natural gas)

SO_2 = **3.0253E-05 (lb/hp-hr)**

VOC: Source: 1997 Cubix Emission Tests
Average Value = **1.040 (lb/hr)**

HAPs: Source: AP-42, Chapter 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-2

Pollutant	Emission Factor	To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7500 BTU/ hp-hr) =
Formaldehyde	5.28E-02 lb/MMBTU	**3.96E-04 lb/hp-hr**

B. Non-Dual Fuel Engine - Diesel Combustion

CO: Source: 2005 Cubix Emission Tests
Average Value = **1.036E+01 (lb/hr)**

NOx: Source: 2004 Cubix Emission Tests
Average Value = **4.997E+01 (lb/hr)**

$PM_{2.5}$: Source: AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Table 3.4-2
$PM_{2.5}$ = 0.0479 (lb/MMBTU)

To convert from lb/MMBTU to lb/hp-hr:
(0.0479 lb/1E06 BTU) * (7000 BTU/ hp-hr) = **3.353E-04 (lb/hp-hr)**

Diesel Brake Specific Fuel Consumption of 7000 Btu/hp-hr is from Note e of Table 3.4-1.

PM_{10}: Source: AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Table 3.4-2
PM_{10} = 0.0573 (lb/MMBTU)

(0.0573 lb/1E06 BTU) * (7000 BTU/ hp-hr) = **4.01E-04 (lb/hp-hr)**

TSP: Source: AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Table 3.4-2
TSP = 0.0697 (lb/MMBTU)

To convert from lb/MMBTU to lb/hp-hr:
(0.0697 lb/1E06 BTU) * (7000 BTU/ hp-hr) = **4.88E-04 (lb/hp-hr)**

SO_2: Source: AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Table 3.4-1
$SO_2 = 8.09E\text{-}03*S_1$ [lb/hp-hr] where S_1 = % sulfur in fuel oil

For Tyrone % sulfur in fuel oil = 0.05 % (500 ppm low sulfur diesel fuel)
Emission factor for SO_2 = **4.045E-04 (lb/hp-hr)**

VOC: 1997 Cubix Emission Tests
Average Value = **2.9 (lb/hr)**

HAPs: Source: AP-42, Chapter 3.4 Large Stationary Diesel and All Stationary Dual-Fuel Engines, Tables 3.4-3 and 3.4-4

Pollutant	Emission Factors	To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7000 BTU/ hp-hr) =
Benzene	7.76E-04 lb/MMBTU	**5.43E-06 lb/hp-hr**
Toluene	2.81E-04 lb/MMBTU	**1.97E-06 lb/hp-hr**
Xylenes	1.93E-04 lb/MMBTU	**1.35E-06 lb/hp-hr**
Formaldehyde	7.89E-05 lb/MMBTU	**5.52E-07 lb/hp-hr**
Acetaldehyde	2.52E-05 lb/MMBTU	**1.76E-07 lb/hp-hr**
Acrolein	7.88E-06 lb/MMBTU	**5.52E-08 lb/hp-hr**
Naphthalene	1.30E-04 lb/MMBTU	**9.10E-07 lb/hp-hr**
Total Polycyclic Aromatic	2.12E-04 lb/MMBTU	**1.48E-06 lb/hp-hr**
Total Hazardous Air Pollutants	1.70E-03 lb/MMBTU	**1.19E-05 lb/hp-hr**

C. Cold Start Compressor Engine and 7A Screening Plant Engine - Diesel Combustion

CO: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
CO = **6.68E-03 (lb/hp-hr)**

NOx: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
NOx = **0.031 (lb/hp-hr)**

$PM_{2.5}$: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
$PM_{2.5}$ = **2.20E-03 (lb/hp-hr)**
Note: no published value for $PM_{2.5}$, assumed equal to PM_{10}

PM_{10}: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
PM_{10} = **2.20E-03 (lb/hp-hr)**

TSP : Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
PT = No Data

SO_2: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
SO_2 = **2.05E-03 (lb/hp-hr)**

VOC: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-1
VOC = **2.51E-03 (lb/hp-hr)** (VOC as total TOC)

D. Cold Start Compressor Engine and 1A, 7A Screening Plant Engines - Diesel Combustion
HAPs: Source: AP-42 Chapter 3.3 Gasoline and Diesel Industrial Engines, Table 3.3-2.

Pollutant	Emission Factors		To convert from lb/MMBTU to lb/hp-hr: (Emission Factor/1E06 BTU) * (7,000 BTU/ hp-hr) =	
Benzene	9.33E-04	lb/MMBTU	**6.53E-06**	**lb/hp-hr**
Toluene	4.09E-04	lb/MMBTU	**2.86E-06**	**lb/hp-hr**
Xylenes	2.85E-04	lb/MMBTU	**2.00E-06**	**lb/hp-hr**
1,3-Butadiene	3.91E-05	lb/MMBTU	**2.74E-07**	**lb/hp-hr**
Formaldehyde	1.18E-03	lb/MMBTU	**8.26E-06**	**lb/hp-hr**
Acetaldehyde	7.67E-04	lb/MMBTU	**5.37E-06**	**lb/hp-hr**
Acrolein	9.25E-05	lb/MMBTU	**6.48E-07**	**lb/hp-hr**
Naphthalene	8.48E-05	lb/MMBTU	**5.94E-07**	**lb/hp-hr**
Total Polycyclic Aromatic	1.68E-04	lb/MMBTU	**1.18E-06**	**lb/hp-hr**
Total Hazardous Air Pollutants	3.96E-03	lb/MMBTU	**2.77E-05**	**lb/hp-hr**

Note: Brake Specific Fuel Consumption of 7,000 Btu/hp-hr is from Note E of Table 3.4-1.

Nordberg Engines and CE-1 Emission Calculations

Power Plant Emissions - PPG-3 Diesel																
Fuel	Dual-Fuel				Diesel				Diesel				**Permitted Operating Hours**			
Equipment	Nordberg FSG-1316-HSC Engines (Units PPG-1, 3, 4, 7, 8, 11, 12, 13, and 14)				Nordberg FSG-1316-HSC Engines (Units PPG-1, 3, 4, 7, 8, 11, 12, 13, 14, and 15)				Ford-New Holland Compressor (Unit CE-1)				3,000	Nordberg Engine Permitted Hours		
Number of Units	1				1				1				500	CE-1 Permitted Hours		
Hours of Operation [hr/year]	255				255				500							
Fuel Usage	7,500	Btu/hp-hr	US Dept. of Interior		7,000	Btu/hp-hr										
Capacity [hp]	3,090				3,090				100				**Total PPG Emissions (Does not include compressor engine)**			
	Dual-Fuel Combustion (PPGs)				**Diesel Combustion (PPGs)**				**Diesel Combustion (CE-1)**							
Criteria Pollutants	**Emission Factor[1]**	**Units**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**	**Emission Factor**	**Units**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**	**Emission Factor [lb/hp-hr]**	**Emission Rate [lb/yr]**	**Emission Rate [ton/yr]**	**Emission Rate [lb/hr]**	**Annual Dual-Fuel Emission Rate [ton/yr][2]**	**Hourly Dual-Fuel Emission Rate [lb/hr][3, 4]**	**Hourly Diesel Emission Rate [lb/hr][5]**	**Annual Maximum Emission Rate (tpy)**
Nitrogen Oxides (NO_x)	34.34	[lb/hr]	8,756.7	**4.38**	49.97	[lb/hr]	12,742.4	**6.37**	0.031	1,550.0	**0.78**	3.10	4.38	34.34	**49.97**	6.37
Carbon Monoxide (CO)	28.57	[lb/hr]	7,285.4	**3.64**	10.36	[lb/hr]	2,641.8	**1.32**	6.68E-03	334.0	**0.17**	0.67	3.64	**28.57**	10.36	3.64
Particulate Matter ($PM_{2.5}$)	7.13E-05	[lb/hp-hr]	56.1	**0.028**	3.35E-04	[lb/hp-hr]	264.2	**0.13**	2.20E-03	110.0	**0.055**	0.22	0.03	0.22	**1.04**	0.13
Particulate Matter (PM_{10})	7.13E-05	[lb/hp-hr]	56.1	**0.028**	4.01E-04	[lb/hp-hr]	316.0	**0.16**	2.20E-03	110.0	**0.055**	0.22	0.03	0.22	**1.24**	0.16
Total Suspended Particulates (TSP)	7.43E-05	[lb/hp-hr]	58.6	**0.029**	4.88E-04	[lb/hp-hr]	384.4	**0.19**	2.20E-03	110.0	**0.055**	0.22	0.03	0.23	**1.51**	0.19
Sulfur Dioxide (SO_2)	3.03E-05	[lb/hp-hr]	23.8	**0.012**	4.05E-04	[lb/hp-hr]	318.7	**0.16**	2.05E-03	102.5	**0.051**	0.21	0.01	0.09	**1.25**	0.16
Volatile Organic Compounds (VOC)	1.04	[lb/hr]	265.2	**0.13**	2.9	[lb/hr]	739.5	**0.37**	2.51E-03	125.5	**0.063**	0.25	0.13	1.04	**2.90**	0.37
Hazardous Air Pollutants (HAPs) [6]																
Benzene	-	-	-	-	5.43E-06	[lb/hp-hr]	4.28	**2.14E-03**	6.53E-06	0.33	**1.63E-04**	6.53E-04	-	-	**1.68E-02**	2.14E-03
Toluene	-	-	-	-	1.97E-06	[lb/hp-hr]	1.55	**7.75E-04**	2.86E-06	0.14	**7.16E-05**	2.86E-04	-	-	**6.08E-03**	7.75E-04
Xylenes	-	-	-	-	1.35E-06	[lb/hp-hr]	1.06	**5.32E-04**	2.00E-06	0.10	**4.99E-05**	2.00E-04	-	-	**4.17E-03**	5.32E-04
1,3-Butadiene	-	-	-	-	-	-	-	-	2.74E-07	0.014	**6.84E-06**	2.74E-05	-	-	-	--
Formaldehyde	3.96E-04	[lb/hp-hr]	312.0	**0.16**	5.52E-07	[lb/hp-hr]	0.44	**2.18E-04**	8.26E-06	0.41	**2.07E-04**	8.26E-04	0.16	**1.22**	1.71E-03	1.56E-01
Acetaldehyde	-	-		-	1.76E-07	[lb/hp-hr]	0.14	**6.95E-05**	5.37E-06	0.27	**1.34E-04**	5.37E-04	-	-	**5.45E-04**	6.95E-05
Acrolein	-	-	-	-	5.52E-08	[lb/hp-hr]	0.043	**2.17E-05**	6.48E-07	0.032	**1.62E-05**	6.48E-05	-	-	**1.70E-04**	2.17E-05
Naphthalene	-	-	-	-	9.10E-07	[lb/hp-hr]	0.72	**3.59E-04**	5.94E-07	0.030	**1.48E-05**	5.94E-05	-	-	**2.81E-03**	3.59E-04
Total PAHs	-	-	-	-	1.48E-06	[lb/hp-hr]	1.17	**5.85E-04**	1.18E-06	0.059	**2.94E-05**	1.18E-04	-	-	**4.59E-03**	5.85E-04
Total HAPs	-	-	-	-	1.19E-05	[lb/hp-hr]	9.40	**4.70E-03**	2.77E-05	1.39	**6.93E-04**	2.77E-03	-	-	**3.69E-02**	4.70E-03

Footnotes:

1 See 'Engine Emission Factors' tab for specific emission factor references.

2 The annual dual-fuel emission rate is the sum of dual-fuel operation for 2,400 hr/yr and diesel operation for 600 hr/yr. The 2,400 hr/yr of dual-fuel operaion is 80% of the total 3,000 allowable hours and the 600 hr/yr of diesel operation is 20% of the total 3,000 allowable hours.

3 Hourly dual-fuel emission rates are based on applying the hourly dual-fuel emission factor to all 10 Nordbergs operating simultaneously. The actual average daily hourly rate would be less than this value.

4 Hourly dual-fuel HAPs emission rates for HAPs without a lb/hp-hr emission factor are based on the annual emission rate divided by 3,000 hr/yr.

5 The hourly diesel emission rate is based on applying the hourly diesel emission factor to all 10 Nordbergs operating simultaneously. The actual average daily hourly rate would be less than this value.

6 Among the HAP emission factors available in AP-42, Chapter 3.2, Natural Gas-Fired Reciprocating Engines, the emission factor for formaldehyde is the highest and is used here to represent HAP emissions. AP-42 emission factors for other HAPs genererated from natural gas combustion in reciprocating engines are orders of magnitude less than formaldehyde and result in negligible emissions even when combined with formaldehyde emissions.

Freeport-McMoRan Tyrone Inc.

Nordberg Engines and CE-1 Greenhouse Gas Calculations

□nit □umbers:	PPG□1□3□□□7□8□11□15□C□□1
Source description:	Dual fire engines□Diesel cold□start engine

Nordberg Engines Units PPG-1, 3, 4, 7, 8, 11-15

Hours of Operation	3000	Ma□imum annual hours of operation for all engines
Horsepower	30□0	hp
Fuel □sage	7□500	Btu□hp□hr For dual fire scenario□from □S Department of Interior
Heat Rate	23.2	MMBtu□hr
□umber of engines	10	

Total Emissions

Diesel

	CO_2	CH_4	N_2O	CO_2e		
	73.□6	0.003	0.0006		□g□MMBtu	□0 CFR □8 Subpart C
	163.1	0.0066	0.00132		lb□MMBtu	
	5668.15	**0.23**	**0.046**	**5687.60**	**tpy**	

Dual-Fired

	CO_2	CH_4	N_2O	CO_2e		
	53.06	0.001	0.0001		□g□MMBtu	□0 CFR □8 Subpart C
	117.0	0.0022	0.00022		lb□MMBtu	
	□066.□2	0.077	0.0077	□070.62	tpy	

Maximum

	CO_2	CH_4	N_2O	CO_2e	
	5668.15	**0.23**	**0.05**	**5687.60**	**tpy**

Diesel Cold-Start Engine Unit CE-1

Hours of Operation	500	Ma□imum annual hours of operation
Horsepower	1000	hp
Fuel □sage	158	gal□hr
Fuel Heating Value	137000	Btu□gal
Heat Rate	21.6	MMBtu□hr

	CO_2	CH_4	N_2O	CO_2e		
	73.□6	0.003	0.0006		□g□MMBtu	□0 CFR □8 Subpart C
	163.1	0.0066	0.0013		lb□MMBtu	
	882.37	**0.036**	**0.0072**	**885.39**	**tpy**	

	CO_2	CH_4	N_2O	
GWP	1	25	2□8	Table A□1 of □0 CFR □8 Subpart A

Section 7

Information Used To Determine Emissions

<u>Information Used to Determine Emissions</u> shall include the following:

- ☑ If manufacturer data are used, include specifications for emissions units <u>and</u> control equipment, including control efficiencies specifications and sufficient engineering data for verification of control equipment operation, including design drawings, test reports, and design parameters that affect normal operation.
- ☐ If test data are used, include a copy of the complete test report. If the test data are for an emissions unit other than the one being permitted, the emission units must be identical. Test data may not be used if any difference in operating conditions of the unit being permitted and the unit represented in the test report significantly effect emission rates.
- ☑ If the most current copy of AP-42 is used, reference the section and date located at the bottom of the page. Include a copy of the page containing the emissions factors, and clearly mark the factors used in the calculations.
- ☐ If an older version of AP-42 is used, include a complete copy of the section.
- ☑ If an EPA document or other material is referenced, include a complete copy.
- ☐ Fuel specifications sheet.
- ☐ If computer models are used to estimate emissions, include an input summary (if available) and a detailed report, and a disk containing the input file(s) used to run the model. For tank-flashing emissions, include a discussion of the method used to estimate tank-flashing emissions, relative thresholds (i.e., permit or major source (NSPS, PSD or Title V)), accuracy of the model, the input and output from simulation models and software, all calculations, documentation of any assumptions used, descriptions of sampling methods and conditions, copies of any lab sample analysis.

This section describes the information used to determine emissions for the units that were updated as part of this permit application. Calculations for all other emission sources have remained the same since Permit No. PSD2448-M5 was issued and are included in this section for informational purposes only.

Mine Blasting (Fugitive)

- "NOx Emissions from Blasting Operations in Open-Cut Coal Mining" by Moetaz I. Attalla, Stuart J. Day, Tony Lange, William Lilley, and Scott Morgan (2008).
- "Factors Affecting Anfo Fumes Production" by James H. Rowland III and Richard Mainiero (2001)
- AP-42 Table 11.9-1
- 40 CFR 98 Subpart A, Table A-1
- 40 CFR 98 Subpart C, Tables C-1 and C-2

Mine, Reclamation, and Crushing & Screening Plant (formerly SP-7A) Handling (Fugitive)

- AP-42 Chapter 11.19.2
- AP-42 Chapter 13.2.4

Mine, Reclamation, and Crushing & Screening Plant (formerly SP-7A) Hauling (Fugitive)

- AP-42 Chapter 13.2.2
- NMED Memo: "Department Accepted Values for: Aggregate Handling, Storage Pile, and Haul Road Emissions"
- Western Regional Air Partnership (WRAP) Fugitive Dust Handbook, September 7, 2006

Gasoline Dispensing Facilities (GDF1 and GDF2)

- AP-42 Chapter 7, Sections 7.1.1, 7.1.2, and 7.1.3.1
- EPA's SPECIATE 5.0 database profiles for HAP data source

Boilers

- AP-42 Table 1.5-1
- Propane sulfur content references
- AP-42 Tables 1.4-3 and 1.4-4
- 40 CFR 98 Subpart A, Table A-1 (not repeated)
- 40 CFR 98 Subpart C, Tables C-1 and C-2 (not repeated)

Engines

- AP-42 Tables 3.3-1 and 3.3-2
- EPA Tier 1, 2, and 3 Emission Standards
- Engine spec sheets
  No changes were made to the emergency engines (Generac GEN1-GEN4, IPG, GO Generator Backup EI-128, SX/EW Fire Water Pump, and SX Tankhouse Emergency Generator), which are exempt from construction permitting, so no calculations are provided for these engines in this permit application. However, for completeness, the spec sheets associated with these engines are enclosed.
- 40 CFR 98 Subpart A, Table A-1 (not repeated)
- 40 CFR 98 Subpart C, Tables C-1 and C-2 (not repeated)
- CARB Policy dated June 28, 2004: Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx

SX/EW Mixer/Settler Tank and Raffinate Tanks (Units SX/EW-1, SX/EW-3, and SX/EW-4)

- "Quantification of Volatile Organic Compound Emissions from the Solvent Extraction Process" prepared for BHP Copper, July 16, 1997.

Section 7

Information Used to Determine Emissions

Mine Blasting (Fugitives)

- "NOx Emissions from Blasting Operations in Open-Cut Coal Mining" by Moetaz I. Attalla, Stuart J. Day, Tony Lange, William Lilley, and Scott Morgan (2008).
- "Factors Affecting Anfo Fumes Production" by James H. Rowland III and Richard Mainiero (2001)
- AP-42 Table 11.9-1
- 40 CFR 98 Subpart A, Table A-1
- 40 CFR 98 Subpart C, Tables C-1 and C-2

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NO_x emissions from blasting operations in open-cut coal mining

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ABSTRACT

The Australian coal mining industry, as with other industries is coming under greater constraints with respect to their environmental impacts. Emissions of acid gases such as NO_x and SO_x to the atmosphere have been regulated for many years because of their adverse health effects. Although NO_x from blasting in open-cut coal mining may represent only a very small proportion of mining operations' total NO_x emissions, the rapid release and high concentration associated with such activities may pose a health risk. This paper presents the results of a new approach to measure these gas emissions by scanning the resulting plume from an open-cut mine blast with a miniaturised ultraviolet spectrometer. The work presented here was undertaken in the Hunter Valley, New South Wales, Australia during 2006. Overall this technique was found to be simpler, safer and more successful than other approaches that in the past have proved to be ineffective in monitoring these short lived plumes. The average emission flux of NO_x from the blasts studied was about 0.9 kt t^{-1} of explosive. Numerical modelling indicated that NO_x concentrations resulting from the blast would be indistinguishable from background levels at distances greater than about 5 km from the source.

1. Introduction

Open-cut coal mining is widespread in the upper Hunter Valley in New South Wales (NSW) with several large mines operating within close proximity to the towns of Muswellbrook and Singleton. Consequently, there is community concern about the potential environmental impacts of mining on nearby populations.

Blasting, in particular, has the potential to affect areas outside the mine boundary and accordingly, vibration and dust emission limits are set in each mine's environmental licence. However, gaseous emissions of environmental concern, such as nitrogen dioxide (NO_2) may also be released during blasting operations. Currently, there are very little quantitative data relating to the magnitude of these emissions and it is not yet possible to determine if they contribute significantly to ambient levels in the main population centres.

The explosive ammonium nitrate/fuel oil (ANFO) is used almost universally throughout the open-cut coal mining industry. Under ideal conditions, the only gaseous products from the explosion are carbon dioxide (CO_2), water (H_2O) and nitrogen (N_2).

$$3NH_4NO_3 + CH_2 \rightarrow 3N_2 + CO_2 + 7H_2O \quad (1)$$

However, even quite small changes in the stoichiometry (either in the bulk material or caused by localised conditions such as moisture in the blast hole, mineral matter or other factors) can lead to the formation of substantial amounts of the toxic gases carbon monoxide (CO) and nitric oxide (NO) as shown.

$$2NH_4NO_3 + CH_2 \rightarrow 2N_2 + CO + 5H_2O \quad (2)$$

$$5NH_4NO_3 + CH_2 \rightarrow 4N_2 + 2NO + CO_2 + 7H_2O \quad (3)$$

In addition, some of the NO formed may oxidise in the presence of oxygen (O_2) to produce NO_2.

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$$2NO + O_2 \rightarrow 2NO_2 \quad (4)$$

Often in practice, large quantities of NO_2 are released from blasts which are observed as intense orange plumes.

Although these gases are not considered in their environmental licences, each mine is required to estimate annual emissions of CO, NO_x and SO_2 for the National Pollutant Inventory (NPI), compiled each year by the Australian government. These estimates are made by multiplying the amount of explosive consumed by an emission factor which is currently 8 kg t^{-1} for NO_x, 34 kg t^{-1} for CO and 1 kg t^{-1} for SO_2 (National Pollutant Inventory, 1999). These emission factors, however, are based on limited overseas data and are subject to high uncertainty.

Most of the studies which have examined NO_x formation from blasting have used blast chambers. The results from these studies do not necessarily correlate with what is observed during actual blasts. Few studies have attempted to measure NO_x emissions under actual field conditions, presumably because of the practical difficulties involved. Plumes from blasting lack confinement, can be very large in size and are affected by prevailing weather conditions. There is also a large quantity of dust associated with the blast and these factors combine to make physical sampling of the plume very difficult. There are also the obvious safety implications which restrict access to blast sites. Consequently, quantitative measurements of plume characteristics are generally unavailable. Nevertheless, it is important for mine operators, particularly when their operations are close to residential areas, to have some method for assessing NO_x formation and more importantly, predicting the severity of the NO_x plume. At present predictions of NO_x formation are subjective and are based on the blast engineer's knowledge of the area to be blasted (e.g. rock type, area of the mine, presence of water in the holes, etc.) and the ratings obtained from blasts performed under similar conditions. Quantitative flux estimations of NO_x released from a blast require measurement of concentration through the plume in both the horizontal and vertical axes.

Some of the options available to make these measurements are given in the following sections.

1.1. Physical sampling

Sampling of blasting fumes involves taking a sample of gas from the plume for subsequent analysis, which could be either on site or in an off site laboratory. Although physical sampling could in principle provide sufficient information to characterise a plume, there are a number of serious logistical problems with this approach:

- The size of the plume means that a large number of sample points would be required to sample across the width and height of the plume.
- The force of the explosion and the resulting debris would restrict the proximity of any sampling packages to the initial gas release.
- The potential toxicity of the plume; personnel cannot move through it to take samples, hence sampling stations must be fixed prior to the blast. This means that the path of the plume must be anticipated before the blast.

1.2. Continuous analysis

Another option is to use portable analysers to measure NO_x concentrations in real time. There are, however, disadvantages with this approach since a sample of the plume must be presented to the instrument for analysis. Usually a pump draws air through a small diameter tube into the instrument, but to achieve the necessary spatial characterisation of the plume, sample tubes would need to be positioned at various points throughout the plume. Thus many of the problems identified for the physical sampling would also apply to the use of continuous analysers.

1.3. Optical methods

There are several optical methods of analysis currently available that may be applicable to field measurements of NO_x. These include open-path Fourier Transform Infra-Red Spectroscopy (FT-IR), Correlation Spectroscopy (COSPEC) and Differential Optical Absorption Spectroscopy (DOAS). FT-IR has often been used in air pollution studies (e.g. Levine and Russwurm, 1994). It has also been used in mine situations to measure fugitive methane emissions. Kirchgessner et al. (1993) used open-path FT-IR (op-FT-IR) to estimate methane emissions from open-cut coal mines in the United States. The technique relies on passing a collimated infrared beam through ambient air over a path length of up to several hundred metres. In the Kirchgessner et al. (1993) study, the concentration of methane across the plume was measured then wind speed data and a Gaussian plume dispersion model were used to estimate the methane emission rate from the mine. These authors subsequently developed a modification of their method which improved its accuracy (Piccot et al., 1994, 1996). The improved method was essentially the same as described above except that methane concentrations were measured at several elevations to better characterise the plume.

In principle, open-path FT-IR could be used to measure NO_x in blast plumes since it is sensitive to NO, NO_2, and CO along with other gases. Infrared radiation is also strongly absorbed in many parts of the spectrum by both CO_2 and water which are very likely to be present in high concentrations in blast plumes and this may tend to obscure the NO_x signal. High resolution instruments may resolve at least some of the NO_x absorption lines, however, a more serious drawback with op-FT-IR is that the infrared beam would be substantially attenuated by the dust thrown up by the blast. In the period immediately after the blast when the dust level is very high it is likely that the IR beam would be completely blocked thus making measurements impossible.

Another well established optical method is Correlation Spectroscopy (COSPEC). The system was first described by Moffat and Milan (1971) and was designed to measure point source emissions of SO_2 and NO_2 from industrial plants but found a niche application in the measurement of SO_2 fluxes from volcanoes (Galle et al., 2002). The COSPEC system utilises a "mask correlation" spectrometer and was designed to measure vertical or slant columns using sky-scattered sunlight. By traversing beneath plumes with the mobile instrument, the concentration of the column is calculated and, once multiplied by the plume velocity, produces a source emission rate. These instruments are limited to detecting only those species where masks are available. They also suffer from interferences from other atmospheric gases and light scattering from clouds or aerosols that can produce errors in column densities (Chalmers Radio and Space Science, website).

The DOAS technique is a relatively new technique that is gaining widespread acceptance as an air pollution monitoring method. Like the open-path FT-IR method, the DOAS can simultaneously measure concentrations of a number of species over path lengths which typically range from hundreds of metres to kilometres.

A DOAS, configured as an 'active system', Fig. 1, has three main parts – a light emitter, a light receiver and a spectrometer. The emitter sends a beam of light to the receiver (in some cases the emitter and receiver are contained in the same unit and the light beam is reflected off a remotely located passive reflector). The light beam contains a range of wavelengths, from ultraviolet to visible, although instruments are now available with an infrared source, which extends the range of compounds that can be detected. Different pollutant molecules absorb light at different wavelengths along the path between the emitter and receiver. The receiver is connected to the spectrometer which measures the intensity of the different wavelengths over the entire light path and through the data system converts this signal into concentrations for each of the species being monitored.

DOAS instruments are routinely used to measure SO_2, NO_2 and O_3.

More recently, advances in miniaturising UV–vis spectrometers has lead to the development of much more compact DOAS units, configured as a passive system (Fig. 1), which have come to be known as "mini-DOAS". The mini-DOAS system has so far been used mainly in the study of SO_2 fluxes in volcanic emissions (McGonigle et al., 2003).

2. Methodology

2.1. Field measurements

A portable DOAS (mini-DOAS) manufactured by Resonance Ltd was used in this study. The instrument covers a spectral range of 280–420 nm and can measure sub-part per million levels of NO_2 and SO_2. The unit, which comprises a telescope, scanning mirrors, calibration cells and a miniature CCD array spectrometer (Ocean Optics USB2000 spectrometer), is housed in a small package which is mounted on a tripod. Calibration of the instrument was carried out using the internal calibration cell. The concentration of the cell was equivalent 50 ppm m. No SO_x measurements were undertaken.

Data collection and processing were performed by Ocean Optics OOIBase32 software loaded in a laptop computer. This results in a more compact system that is easier to deploy at mine sites and provides greater flexibility in positioning the instrument in relation to the blast plume.

Prior to each monitored blast, a dark spectrum was collected by blocking light from entering the spectrometer and a scan was performed. To produce a reference spectrum, a further scan was performed in a clear sky background which contained background absorption from NO_2. The reference spectrum was required in order to determine the increase in concentration of NO_2 above ambient levels in the blast plumes.

The plume resulting from each blast was tracked with the spectrometer until the NO_2 concentration was indistinguishable from the surrounding sky. During each field measurement, the mini-DOAS and a video camera were positioned a safe operating distance from the blast at all times.

NO_2 concentrations in the plume were calculated by subtracting the dark spectrum from the measured spectrum and the reference spectrum using the supplied software.

The results obtained from the mini-DOAS are a path-averaged NO_2 concentration profile measured in units of parts per million metre (ppm m). The mini-DOAS results must be divided by the path length through the plume to yield a concentration. To estimate the amount of NO_2 released from each blast it was necessary to multiply the concentration by the volume of the plume. Hence it was necessary to estimate the dimensions of each plume.

All of the blasts monitored were video-taped using at least one, and sometimes two, video recorders. The distances between the cameras and the blast were measured by locating their positions with a handheld GPS receiver.

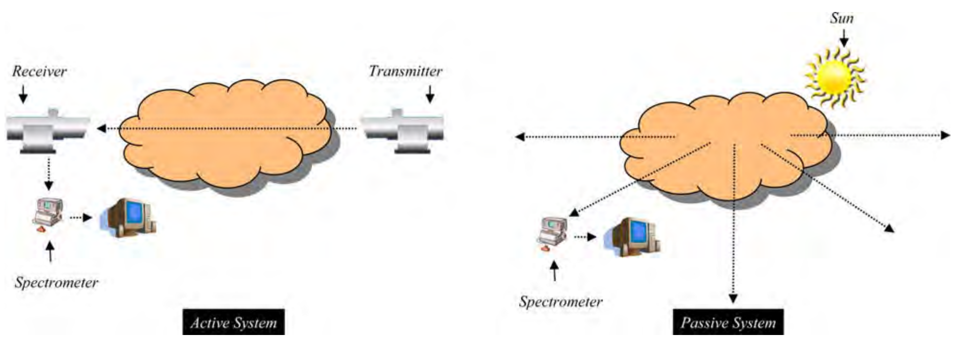

Fig. 1. Schematic diagram of DOAS systems operating in both active and passive modes.

Wind speed and directional data used to plot the directional path of the plume were obtained from a series of meteorological stations located around the mining lease. Simple trigonometry was employed to determine the distance from the video camera to the plume at the corresponding time intervals.

A rudimentary method of photogrammetry was then used to estimate the size of the plume based on still images extracted from the videos. Ratios of the plume to picture size in both the vertical and horizontal planes were made.

Once the plume to camera distance and the constraining angle for the plume is known, a crude three-dimensional estimate of the plume dimension was calculated using basic trigonometric functions. An example of the dimensions determined for a plume using this method is shown in Fig. 2.

Ground level measurements were carried out using a Greenline 8000 portable gas analyser. This instrument is capable of continuous, simultaneous analysis of O_2, CO_2, CO, SO_2, NO and NO_2. It is battery powered and can operate unattended for up to about 2 h. The instrument was calibrated against a standard gas mixture before each use. Data were logged on a laptop computer connected to the instrument.

For each experiment, the instrument was set up downwind of the blast in a location where the plume was expected to pass, but far enough away to avoid flying debris. The inlet probe was fixed at about 2 m above ground level.

It must be noted that selecting an appropriate location for the instrument was often difficult. In many cases, the wind conditions were quite variable, especially within the pit so it was not always possible to correctly anticipate the path of the blast plume. As well, the layout of the mine pit and safety considerations imposed constraints on where the instrument could be placed. Because of these problems, the plumes from many of the blasts did not pass over the analyser and data was not recorded.

2.2. Modelling

A simple modelling exercise was undertaken for this study to determine if the release of NO_2 from a blast could be of detriment to persons exposed to the plume within 5 km of the release. The results of this study are indicative and based on the assumption that the model used is appropriate. Modelling generally relies on local observational data to confirm the performance of the model. The difficulty in measuring emissions from mining blasts has meant that in this case the model is used as an indicator relying on the verifications used in the development of the chosen model. For this reason we have modelled concentrations directly downwind of theoretical blasts with AFTOX (Kunkel, 1991), a USEPA approved dispersion model (http://www.epa.gov/scram001/dispersion_alt.htm#aftox). The original DOS based QuickBasic code was transformed into Excel macros to enable many scenarios to be run.

AFTOX is a Gaussian Puff model developed for the United States Air Force to assess real time toxic chemical releases. The model uses information from US Air Weather Service (AWS) stations to calculate dispersion based on measured atmospheric conditions. As for all Gaussian models, the spread of pollutants is governed by dispersion coefficients in the horizontal (σ_y) and vertical (σ_z) directions. These coefficients depend on the atmospheric stability derived from the AWS data. In this study, the scenarios were modelled by predefining the wind speed and atmospheric stability classes. The wind speeds modelled ranged from very low ($0.5\ m\ s^{-1}$) to moderate ($10\ m\ s^{-1}$). Stability was modelled in six steps representing the standard Pasquill-Gifford stability classes, i.e. A–F, where A, B and C represent unstable conditions (where A is the most unstable), D is neutral and E and F are stable conditions. These stability classes are used to categorise the rate at which a plume will disperse. Unstable conditions might be found on a sunny day with light winds leading to rapid plume dispersion while the stable conditions may occur in clear skies with light winds and perhaps a temperature inversion present. Plume spread is slow in these circumstances.

AFTOX is operated by assuming an emission release from a single location. The emissions can be either continuous or instantaneous. In this study AFTOX was used to describe an area source by representing it as a large number of individual points. The area of the emission (i.e. the area over which the explosives were distributed) was

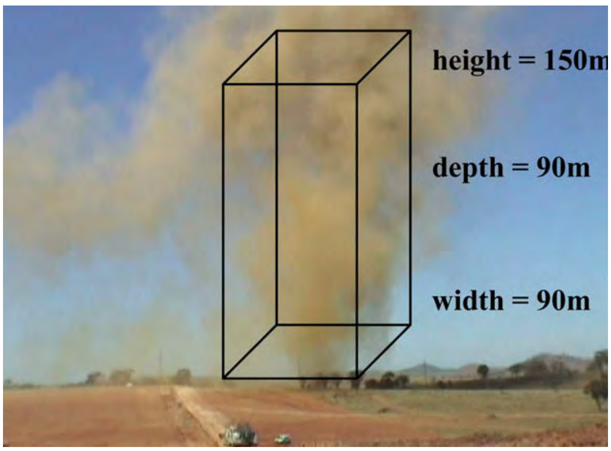

Fig. 2. Blast plume with estimated dimensions.

assumed to be 100 m × 200 m based upon sizes commonly observed during the field measurements. The area was subdivided into 10 m × 10 m units. Each square was represented by a point source with its source at the centre. In total, the area was modelled as 231 separate point sources (see Fig. 3). The total flux of emissions for the source was set at 100 kg. To estimate the maximum concentration and pollutant exposure values, the values should be multiplied by an appropriate scaling factor.

One hundred and twenty scenarios were modelled in which the 100 kg of emissions were spread randomly throughout the source area. A multi-stage process was employed for this task. In the first step, the total maximum number of points emitting was determined. This was defined by a random number between 20% and 80% of the maximum number of sources (in this case 231). The range chosen was an estimate from the portion of blasts that appeared to fume in conditions witnessed during this study. The total emission was then divided by this number. Each portion of the total emission was then placed randomly within the emission area. This process allowed certain points to receive multiple portions of the total emissions enabling the formation of hot spots. An example of one emission grid (Scenario 1 of 120) is displayed in Fig. 4.

Concentrations were determined for each of the 120 emission scenarios at distances of 200 m, 300 m, 400 m, 500 m, 750 m, 1 km, 1.25 km, 1.5 km, 2 km, 2.5 km, 3 km, 4 km and 5 km from the origin of the source. A concentration was determined for a number of discrete times that encompassed the complete plume travelling past the receptor. Further the concentrations were determined at 21 locations 10 m apart in a plane parallel and directly downwind of the source area (see Fig. 3). An average concentration from each of the receptors was determined; in this case with N equal to 21.

$$C^* = \frac{1}{N}\sum_{i=1}^{N} C_i \tag{5}$$

The average for each scenario was then used to create an ensemble average and standard deviation for the entire run (i.e. $N = 120$).

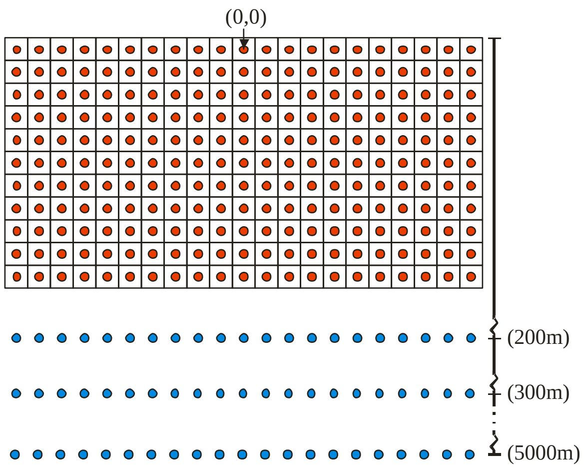

Fig. 3. Emission grid and receptor array setup.

$$\overline{C} = \frac{1}{N}\sum_{j=1}^{N} C_j^* \tag{6}$$

$$\sigma_{\overline{C}} = \frac{1}{N}\sum_{j=1}^{N}\left(C_j^* - \overline{C}\right)^2 \tag{7}$$

$$C_{\max} = \max_{k=1}^{N}[\overline{C}_k] \tag{8}$$

A dosage expressed in ppm s was determined from the times when the ensemble average plume travelled past the receptors located at each distance downwind of the source. Again N represents each discrete time step (dt) where $C' \neq 0$.

$$C_{\text{dose}} = \sum_{k=1}^{N}(\overline{C}_k)\text{d}t \tag{9}$$

The relative variation for the dosage is provided by similarly treating the ensemble standard deviation.

$$\sigma_{\text{dose}} = \sum_{k=1}^{N}(\sigma_{\overline{C}k})\text{d}t \tag{10}$$

3. Results and discussion

3.1. Field measurements

Plume measurements were made using the mini-DOAS spectrometer at two open-cut mine sites located in the Hunter Valley. The combination of the spectral analysis and the plume estimation technique allowed for NO_2 concentration and mass flux estimates to be made remotely, totally eliminating the requirement of physical sampling.

An example of the spectral output produced by the mini-DOAS is shown in Fig. 5. The spectral output consists of the NO_2 concentration (ppm m) as a function of time. The figure also contains a series of photographs depicting the formation of a blast plume at time intervals of 70, 110, 163, 250 and 350 s post-blast initiation. It is worth noting the change in intensity of the colour of plume and size as a function of time.

Reliable concentration measurements with the mini-DOAS may only be made when the spectrometer is aimed into a sky background above the horizon from the point of observation. In this example, a peak concentration of 580 ppm m was achieved in 163 s post-blast initiation (third image from the left). At this time the plume has risen above the horizon from the point of observation. The plume to mini-DOAS distance at this stage is approximately 500 m, with an estimated plume depth of 105 m. This results in a NO_2 concentration of 5.6 ppm at that particular stage of the plumes' dispersion.

After 350 s, the plume is barely visible and is now estimated to be approximately 650 m from the mini-DOAS unit. The plume depth has increased to 125 m with

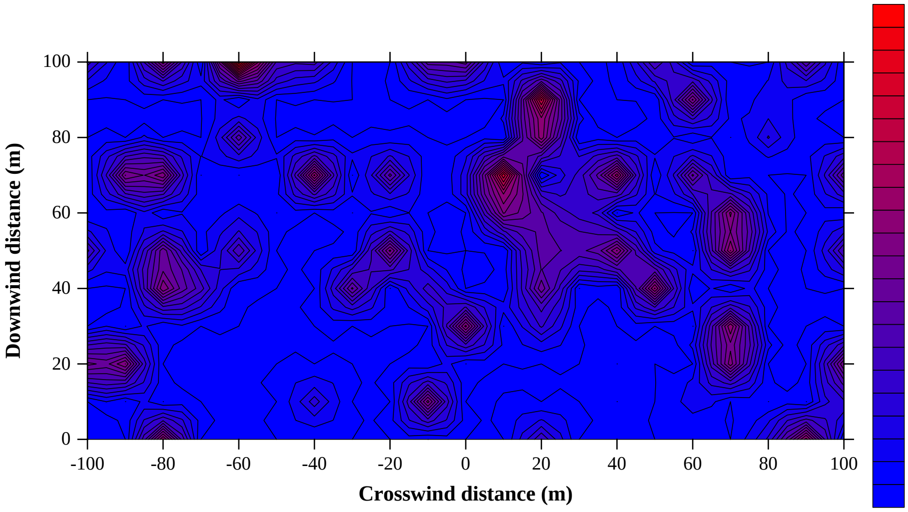

Fig. 4. Example of emission grid for 1 of the 120 scenarios modelled (the scale on the right hand side refers to NO_2 concentration in ppm).

a corresponding increase in plume volume by a factor of two. This expansion of the plume corresponds to a decrease in NO_2 concentration to 2.8 ppm.

At 360 s the plume was no longer visible to the eye and was lost for a short period of time to the mini-DOAS. This, however, was rectified with scanning of the sky with the spectrometer until the invisible plume was tracked for a further period.

Results for all plumes monitored during field work at both mine sites are given in Table 1. The table gives the peak NO_2 concentration as measured by the mini-DOAS above the horizon. Also given in the table is the plume volume at peak concentration and the calculated mass of NO_2 released from the blast. The mass of ANFO typically used in a blast was on average 210 tonnes, ranging from 60 to 565 tonnes. The explosive was distributed over an area of typically 200 m × 100 m containing approximately 200 bole holes with 200 mm diameter and to a depth of 25 m.

From the table the maximum NO_2 concentrations were found to range from 0 to about 7 ppm. This range of concentrations translated to 0–63.3 kg of NO_2 in the plume. However, no correlation can be made between blast charge and NO_2 levels.

During the measurements with the mini-DOAS ground level measurements were also carried out using a portable combustion gas analyser (Greenline 8000) to augment the airborne measurements made by the mini-DOAS. For NO_2 the ground level measures were higher than those observed using the mini-DOAS at higher altitudes. When the results of both measurement methods were applied to

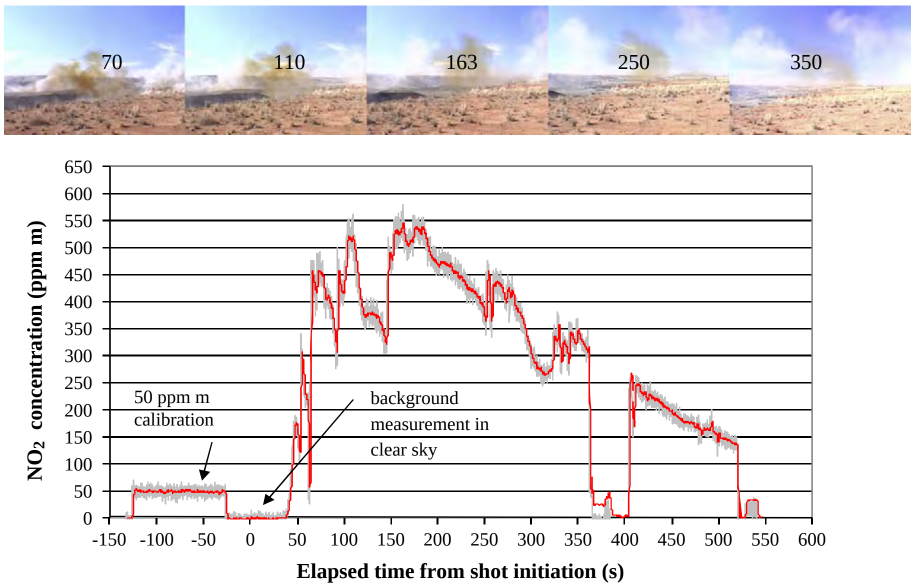

Fig. 5. Typical NO_2 spectrum demonstrating plume colour characteristics relative to concentration level.

Table 1
Through plume measurement results

Date	Total ANFO charge (t)	Peak NO_2 Conc (ppm)	Plume volume ($m^3 \times 10^{-6}$)	Mass of NO_2 (kg)	Emission flux ($kg\,t^{-1}$ ANFO)		
					NO	NO_2	NO_x
12/12/2005	281	3.7	1.4	9.9	0.5	0.03	0.6
13/12/2005	150	0.4	5.3	3.7	0.4	0.03	0.4
14/12/2005	119	0.0	0.0	0.0	0.0	0.00	0.0
21/12/2005	229	1.0	4.4	7.9	0.6	0.04	0.6
22/12/2005	211	0.0	0.0	0.0	0.0	0.00	0.0
23/12/2005	222	0.0	0.0	0.0	0.0	0.00	0.0
5/01/2006	177	1.0	0.2	0.4	0.0	0.00	0.0
6/01/2006	275	1.1	15.3	30.6	1.8	0.12	1.9
12/01/2006	225	1.6	6.2	18.3	1.3	0.08	1.4
18/01/2006	169	1.3	1.7	0.2	0.4	0.02	0.4
23/01/2006	139	2.1	4.2	16.7	1.9	0.12	2.0
25/01/2006	155	0.4	4.4	2.9	0.3	0.02	0.4
30/01/2006	132	0.7	5.3	7.1	0.8	0.05	0.9
22/02/2006	224	0.0	0.00	0.0	0.0	0.00	0.0
1/03/2006	194	1.6	20.6	63.3	5.0	0.32	5.3
12/05/2006	362	6.5	1.9	23.3	1.0	0.06	1.1
15/05/2006	131	0.3	3.2	1.7	0.2	0.01	0.2
19/05/2006	168	0.0	0.00	0.0	0.0	0.00	0.0
30/05/2006	100	0.8	0.00	1.0	0.0	0.00	0.0
1/06/2006	365	0.7	3.5	4.9	0.2	0.01	0.2
6/06/2006	145	0.8	11.5	17.5	1.9	0.12	2.0
15/06/2006	60	0.0	0.00	0.0	0.0	0.00	0.0
26/06/2006	254	4.3	0.3	2.1	0.1	0.01	0.2
27/06/2006	212	5.6	0.9	10.0	0.7	0.04	0.7
28/06/2006	241	0.0	0.00	0.0	0.0	0.00	0.0
6/07/2006	565	2.8	2.7	14.0	0.4	0.03	0.4
13/07/2006	184	7.0	1.0	12.6	1.1	0.07	1.2

dispersion modelling techniques strong agreement was observed.

Point measurements which were made on Greenline 8000 indicated that a loose relationship existed between NO and NO_2 concentration. Although a strong correlation was not found, there is a general trend of increasing NO_2 with increasing NO. It was generally found that the relative proportion of NO to NO_2 from our data set was 27 to 1. This

Table 2
Maximum calculated NO_2 concentrations downwind of source

	200 m	300 m	400 m	500 m	750 m	1000 m	1250 m	1500 m	2000 m	2500 m	3000 m	4000 m	5000 m
WSPD = 0.5 $m\,s^{-1}$													
Stab A	83.0	30.0	14.4	7.9	2.5	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0
Stab B	145.8	69.3	40.8	25.4	10.1	4.8	2.6	1.6	0.7	0.4	0.2	0.1	0.1
Stab C	219.4	122.0	80.8	55.9	26.8	14.3	8.6	5.6	2.8	1.6	1.0	0.5	0.3
Stab D	321.1	201.5	146.0	113.1	64.6	40.2	26.1	18.6	10.5	6.7	4.5	2.4	1.4
Stab E	390.2	267.4	204.3	165.5	109.6	75.9	54.6	41.3	26.4	17.9	12.7	7.1	4.5
Stab F	464.1	339.8	269.0	222.6	154.5	114.9	88.6	69.7	50.4	37.0	27.8	16.7	11.0
WSPD = 3 $m\,s^{-1}$													
Stab A	78.5	29.1	14.2	7.7	2.4	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0
Stab B	137.6	67.7	39.7	25.1	10.0	4.8	2.6	1.6	0.7	0.4	0.2	0.1	0.1
Stab C	211.6	118.7	77.6	55.2	26.0	14.0	8.6	5.6	2.8	1.6	1.0	0.5	0.3
Stab D	312.5	197.9	143.2	110.0	62.5	39.3	26.1	18.2	10.5	6.7	4.5	2.4	1.4
Stab E	383.0	267.0	202.1	162.6	106.3	73.7	54.1	40.3	26.1	17.7	12.5	7.2	4.5
Stab F	461.5	344.6	268.4	220.8	151.1	112.3	86.1	67.6	48.9	36.4	27.5	16.6	11.0
WSPD = 7.5 $m\,s^{-1}$													
Stab A	62.5	25.5	13.0	7.3	2.3	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0
Stab B	111.9	56.1	34.2	22.6	9.4	4.6	2.6	1.6	0.7	0.4	0.2	0.1	0.1
Stab C	173.3	100.4	66.5	47.7	23.8	13.2	8.2	5.4	2.7	1.6	1.0	0.5	0.3
Stab D	261.2	167.9	122.1	92.3	54.8	35.3	23.7	17.2	10.1	6.5	4.4	2.3	1.4
Stab E	325.9	232.2	175.8	139.6	89.5	63.8	46.7	36.0	23.9	16.8	12.1	7.0	4.4
Stab F	394.6	302.7	237.0	194.3	132.2	96.1	73.3	59.0	43.6	33.3	25.7	15.8	10.5
WSPD = 10 $m\,s^{-1}$													
Stab A	53.0	22.6	11.9	6.9	2.3	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0
Stab B	92.3	49.7	31.0	20.9	9.0	4.5	2.5	1.5	0.7	0.4	0.2	0.1	0.1
Stab C	140.1	84.2	57.7	42.1	21.7	12.6	7.9	5.3	2.7	1.6	1.0	0.5	0.3
Stab D	205.5	138.3	102.4	79.9	48.6	31.8	22.1	16.4	9.7	6.4	4.3	2.3	1.4
Stab E	254.0	184.0	143.0	116.4	78.0	56.2	42.6	33.1	22.7	16.0	11.6	6.9	4.4
Stab F	306.8	235.8	189.6	157.9	109.9	82.8	64.5	52.2	40.0	30.9	24.0	15.2	10.2

relationship enabled the estimation of the NO fluxes in the blast plume with a reasonable level of confidence.

The results obtained in this study are the only published quantitative data available on blast plume gas composition that the authors are aware of and it is useful to compare them to the emission factors currently used for NPI estimates.

Based on the NO_2 measurements and estimates of NO, the flux for NO_x was calculated to be in the range of 0.04–5.3 kg t^{-1} ANFO. The average flux level for all the blast plumes measured was 0.9 kg t^{-1}. This figure is considerably lower than the current NPI emission factor which is 8 kg t^{-1}.

3.2. Modelling

Results of the modelling runs are summarised in Table 2 and show the peak NO_2 concentrations (ppm) at various points downwind of the blast for the six atmospheric stability classes considered.

Examples of the modelled data are plotted in Fig. 6 and Fig. 7. In Fig. 6 a plot is displayed for the concentration estimate of one scenario at a distance of 200 m from the source origin and for a wind speed of 2 m s^{-1} and a stability class C. In this plot 21 lines are shown representing the dose received directly downwind of the source at the locations displayed in Fig. 3. In this figure it is apparent that there is a considerable difference in the concentration predicted at each of the 21 receptors. It should be noted that the distance of 200 m is defined from the origin of the source area (0, 0) as displayed in Fig. 3. At this distance emission sources at 100 m will cause significantly higher concentrations than those occurring at positions toward the origin. In comparison the concentrations predicted at the receptor array 1 km from the source show more normally defined distributions with maxima occurring towards the middle receptors as a result of crosswind diffusion. Receptors toward the edge of the sample array receive less crosswind influence and are, therefore, smaller in concentration. Also apparent in these two figures is the considerable difference in the predicted peak concentrations with the values at 1 km up to 25 times lower than at 200 m. When viewing Table 2, the peak values at 5 km approach ambient levels for all but the most stable conditions which are quite commonly over predicted with Gaussian models. For future studies it is recommended that a long path technique on a mining lease boundary may provide both a measure of the model accuracy as well as a direct measure of the impact in areas directly surrounding the mining area.

The data presented in this study represent a dose directly downwind of the source and as such are a worst case scenario for exposure. The averages of the 21 receptors (i.e. the average concentration directly downwind of the source) for each of the 120 scenarios modelled were used to determine the selected data. The number of scenarios modelled was arbitrarily chosen to allow 10 scenarios to be run on each machine in a cluster of 12 computers. The maximum concentration in Table 2 is the maximum ensemble average obtained from the average of the 21 receptors for the 120 scenarios modelled. Maximum concentrations at individual locations directly downwind of hot spots are obviously higher than the values reported in this table.

When viewing Table 2 it is apparent that the peak concentrations drop dramatically as the receptor moves away from the source. It is also apparent that the peak concentrations vary little as a function of wind speed although the plume width will vary. In AFTOX a downwind concentration is determined in two steps. In the first step the size of the initial plume envelope is estimated. In its default mode AFTOX determines the size of the envelope (assumed to be a cylinder of equal height and width) from the magnitude of the emission rate. In this report the size is set at 10 m to match the grid structure used for the area

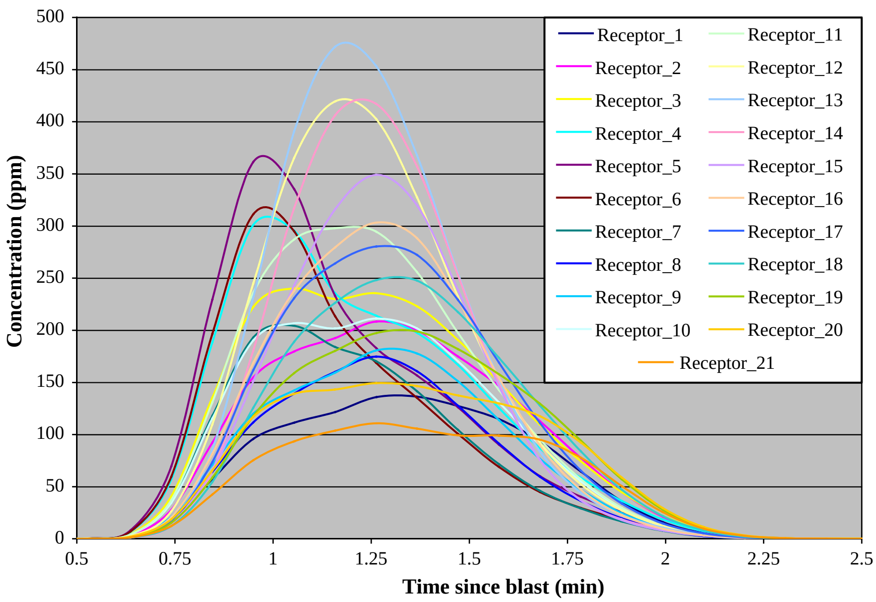

Fig. 6. Calculated NO_2 concentration profiles 200 m from source.

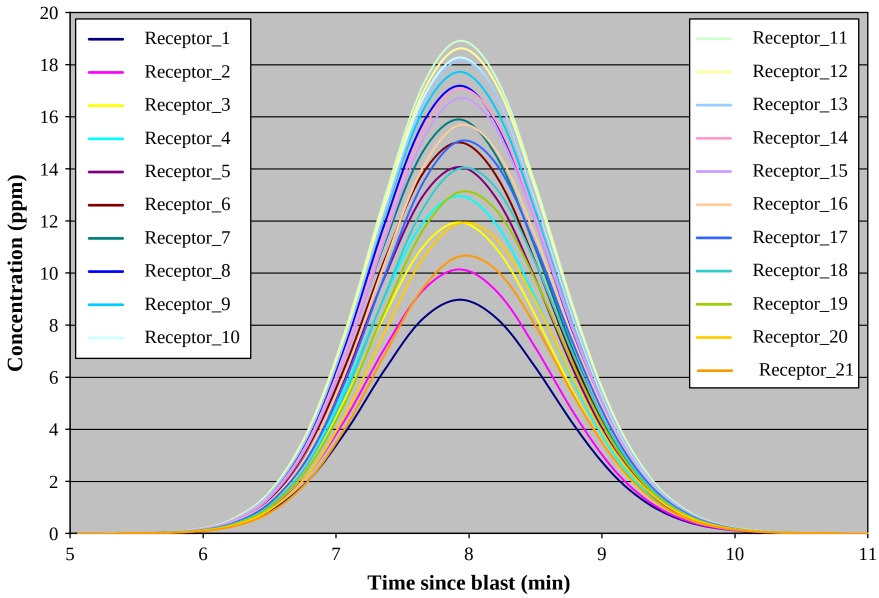

Fig. 7. Calculated NO_2 concentration profiles 1 km from source.

source. AFTOX in this regard ignores the effect of wind speed on the size of the initial envelope and as such the initial concentration of the plume is identical irrespective of wind speed by ignoring longitudinal (i.e. downwind) spread of the initial release. In the second step the concentration downwind of the initial release is determined by estimating the growth of a puff in three dimensions which in this case explicitly includes longitudinal plume spread which is assumed to be equal to the degree of crosswind spread. The degree of this spread is determined solely from the prescribed atmospheric stability class which ignores any wind speed dependence.

While the peak concentrations are similar, the dose received at a receptor is linearly dependent on wind speed. Emissions released into an atmosphere with higher wind speeds result in a receptor receiving doses for a smaller period of time. It should be noted that some of the differences in the peak concentrations displayed in Table 2 result from the number of discrete time steps used to calculate the concentrations. This was set at 25 intervals between the onset and finish of a plume as it passes by the receptor. This time is dependent on atmospheric stability and the distance from the source. In AFTOX, the puffs are assumed to disperse in the direction of plume travel proportionally with the degree of crosswind spread. As such, portions of the plume arrive before and after the main bulk of the emissions and the effect clearly demonstrated in Figs. 6 and 7. The moderate number of discrete times modelled to capture this effect while generally adequate may have led to a degree of variation particularly at larger distances from the source.

Again it should be noted that the modelled figures assume an area wide flux of 100 kg which is larger than observed in the blast recorded during this study. It should also be noted that while some of the concentrations are high close to the source the concentration at a particular location occurs for a brief period of time which is determined by the wind speed.

4. Conclusions

A portable open-path spectroscopic method was found to be effective for measuring NO_2 emissions from blasting. Overall this technique was found to be simpler, safer and more successful than other approaches that in the past have proved to be ineffective in monitoring these short lived plumes.

Quantitative measurements of NO_2 in plumes from blasting were made at two open-cut mines. The results showed that NO_2 was present in most of the plumes but in relatively low concentrations (typically ranging between 0 and 7 ppm). The highest concentration measured during all the field campaigns was about 17 ppm at ground level.

Based on field measurements, the emission factor currently used in compiling the Australian National Pollutant Inventory was found to be approximately eight times greater than that observed in our investigation. This would suggest that an over estimation of NO_x is made if the current factor is used.

Numerical modelling of the behaviour of plumes resulting from blasting was made to assess the possible downwind concentrations of NO_2. These results were compared to ambient NO_x measurements made in Muswellbrook.

- Modelling results were consistent with concentration measurements within the plumes at relatively short distances from the blast (i.e. up to about 1 km).
- Ambient monitoring did not detect NO_x events that could be attributed to individual blasts. Modelling suggested that these emissions would be very low at

distances greater than 5 km from the blast and may be indistinguishable from background levels; typically of the order of several parts per billion, in most cases.

Acknowledgements

We gratefully acknowledge the financial support of the Australian Coal Association Research Program (ACARP) and the staff at the Hunter Valley mine sites.

References

Chalmers Radio, Space Science. The optical remote sensing group. Available from: <http://www.rss.chalmers.se/ors/ >.

Galle, B., Oppenheimer, C., Geyer, A., McGonigle, A.J.S., Edmonds, M., Horrocks, L., 2002. A miniaturised ultraviolet spectrometer for remote sensing of SO_2 fluxes: a new tool for volcano surveillance. Journal of Volcanology and Geothermal Research 119, 241–254.

Kirchgessner, D.A., Piccot, S.D., Chadha, A., 1993. Estimation of methane emissions from a surface coal mine using open-path FTIR spectroscopy and modelling techniques. Chemosphere 26, 23–44.

Kunkel, B.A., 1991. AFTOX 4.0 – The Air Force Toxic Chemical Dispersion Model – A User's Guide. PL-TR-91-2119, Environmental Research Papers No. 1083, Phillips Laboratory, Directorate of Geophysics, Air Force Systems Command, Hanscom AFB, MA 01731-5000, p. 62.

Levine, S.P., Russwurm, G.M., 1994. Fourier transform infrared optical remote sensing for monitoring airborne gas and vapour contaminants in the field. Trends in Analytical Chemistry 13, 263–266.

Moffat, A.J., Milan, M.M., 1971. The applications of optical correlation techniques to the remote sensing of SO_2 plumes using sky light. Atmospheric Environment 5, 677–690.

McGonigle, A.J.S., Thomson, C.L., Tsanev, V.I., Oppenheimer, C., 2003. A simple technique for measuring power station SO_2 and NO_2 emissions. Atmospheric Environment 38, 21–25.

National Pollutant Inventory, 1999. Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges. Environment Australia. Available from: <http://www.npi.gov.au/handbooks/approved_handbooks/fexplos.html>.

Piccot, S., Masemore, S., Ringler, E., Srinivasan, S., Kirchgessner, D., Herget, W., 1994. Validation of a method for estimating pollution emission rates from area sources using open-path FTIR spectroscopy and dispersion modelling techniques. Journal of the Air & Waste Management Association 44, 271–279.

Piccot, S., Masemore, S., Ringler, E., Bevan, W.L., Harris, D.H., 1996. Field assessment of a new method for estimating emission rates from volume sources using open-path FTIR spectroscopy. Journal of the Air & Waste Management Association 46, 159–171.

FACTORS AFFECTING ANFO FUMES PRODUCTION

James H. Rowland III and Richard Mainiero

ABSTRACT

For many years there have been small scale tests available for evaluating the toxic fumes production by cap-sensitive explosives (DOT Class 1.1), but these could not be used with blasting agents due to the large charge sizes and heavy confinement required for proper detonation. Considering the extensive use of blasting agents in construction and mining, there is a need to determine the quantities of toxic fumes generated by blasting agents. At the International Society of Explosive Engineers Twenty Third Annual Conference on Explosives and Blasting Technique in 1997, the authors reported on a facility for detonating large (4.54 kg), confined blasting agent charges in a controlled volume that had been constructed at the National Institute for Occupational Safety and Health's Pittsburgh Research Lab's Experimental Mine. Since 1997, this facility has been used to collect data on toxic fumes produced by the detonation of various ammonium nitrate/fuel oil (ANFO) mixtures and several cap-sensitive explosives.

ANFO composition ranging from 1 to 10 percent (pct) fuel oil have been studied. As expected from previous studies, with an increase in fuel oil content the carbon monoxide production increases, while nitric oxide and nitrogen dioxide production decrease. The detonation velocity varies from 3,000 to 4,000 m/sec for the 1 to 10 pct range of fuel oil content, suggesting that ANFO mixes with improper fuel oil content may appear to detonate properly, while their fume production differs significantly from optimum. The study also considers such factors as degree of confinement, water contamination, and aluminum content on blasting agent fume production. Results indicate that water contamination of the ANFO has little effect on carbon monoxide production, but causes significant increase in nitric oxide and nitrogen dioxide production. Decreasing confinement from Schedule 80 steel pipe to 0.4-mm thick sheet metal also has little effect on carbon monoxide production, but significantly increases nitric oxide and nitrogen dioxide production. Adding 5 and 10 pct aluminum to the ANFO had no clear effect on carbon monoxide, nitric oxide, or nitrogen dioxide production.

INTRODUCTION

In February of 1997 a paper entitled " A Technique for Measuring Toxic Gases Produced by Blasting Agents" was presented at the 23rd Annual Conference on Explosives & Blasting Technique in Las Vegas, Nevada. That paper discussed a method for measuring toxic fumes produced by detonation of blasting agents. The research reported here is a continuation of that work.

Detonating ANFO in steel pipe in the Pittsburgh Research Lab (PRL) mine fumes chamber yields a baseline for comparing relative fumes production for blasting agents, but is by no means a predictor of what will happen in the field. In actual blasting operations, the confinement of the detonating ANFO will probably be less than that offered by the 4-in, Schedule 80 steel pipe employed in most tests. Additionally the ANFO evaluated in the PRL mine chamber is carefully mixed the day before and care is taken to prevent contamination. In practice, ANFO may not be exactly the 94/6 ammonium nitrate/fuel oil ratio desired or may be loaded into boreholes weeks before it is shot, exposing the explosive to water seeping into loaded boreholes and possible fuel oil evaporation. The current research looks at these factors and others in an effort to determine how they affect fumes production. Fumes measurements in the mine chamber were carried out for ANFO mixtures other than 94/6, ANFO contaminated with up to 10 pct water, ANFO detonated with less confinement than that offered by Schedule 80 steel pipe, and ANFO contaminated with limestone rock dust. Additionally, several cap-sensitive explosives, as well as ANFO containing up to10 pct aluminum were also studied to gain an understanding of how detonation behavior affects fumes production. In each case carbon monoxide, nitrogen oxides, and ammonia were the toxic gases of primary interest.

EXPERIMENTAL APPROACH

Detonating large blasting agent charges and confining the fumes requires a larger experimental chamber than was employed in past work on cap-sensitive explosives. Towards this end, a chamber was created in the experimental mine at PRL. The facility consists of a portion of mine entry enclosed between two explosion proof bulkheads. Each bulkhead is 40 inches (1 m) thick, constructed of solid concrete block hitched 1 foot (30 cm) into the roof, ribs, and floor. On the intake side, the bulkhead is fitted with a submarine mandoor and a small port for control and sampling lines. On the return side, the bulkhead is fitted with two sealed ventilation ports. Total volume of the chamber is 9,666 ft^3 (274 m^3). The chamber volume was determined by releasing a known quantity of carbon monoxide into the chamber and sampling the atmosphere after it had mixed. Following the shot, a fan mounted at one end of the chamber mixes the chamber atmosphere at 3,500 ft^3/min, after which the chamber is vented using the mine's airflow. The layout of the chamber is illustrated in Figure 1. Up to 10 pound (4.54 kg) charges can be detonated in the chamber using a variety of confinements.

EXPERIMENTAL

A 28-inch (71-cm) length of 4-inch (20-cm) Schedule 80 seamless steel pipe was chosen to provide confinement in most tests of blasting agents and cap-sensitive explosives. Prior to loading the pipe with explosive, a continuous velocity probe of the type described by Santis is taped to the inner surface of the pipe along its length[1]. In conducting a test of a blasting agent, the commercial blasting agent minus its wrapper, or premixed ANFO are loaded into the pipe to a weight of 10 lb (4.54 kg). Initiation is provided by a 2-inch (5-cm) diameter, 2-inch (5-cm) thick cast pentolite booster, initiated by a number 8 instantaneous electric blasting cap. In conducting a test of a cap-sensitive explosive, the cartridge explosive is loaded into the pipe to a weight of about 10 lb (4.54 kg). Cap-sensitive explosives are initiated by a number 8 instantaneous electric blasting cap.

Following detonation of an explosive in the chamber, the fan is run for about 10 minutes to uniformly mix the chamber atmosphere before fumes samples are taken out of the chamber through 1/4-inch (0.6-cm) Teflon or polyethylene tubes for analysis. Teflon sample lines are used for nitrogen oxides and ammonia to minimize loss of these constituents to absorption on the tube surface. Vacutainer[1] samples are taken and sent to the analytical laboratory for analysis; this technique is appropriate for components that are stable in the Vacutainer, namely hydrogen, carbon monoxide, and carbon dioxide. Nitrogen dioxide, nitrogen oxides, and ammonia are not amenable to analysis by the Vacutainer technique and are instead absorbed in chemical solutions in bubbler trains using the technique described by Santis[2]. That method was modified by eliminating the purging of the system with helium and using a gas meter to measure the volume of fumes bubbled through the solutions rather than measuring gas flow rate. An electrochemical carbon monoxide monitor was also employed to act as a backup to the analytical lab's carbon monoxide analysis of the Vacutainer and to allow monitoring of the mixing of the chamber atmosphere.

RESULTS

An ANFO mixture of 94 pct ammonium nitrate, 6 pct fuel oil is close to optimum from the perspective of minimum toxic fumes production. Previous research and theory show that the detonating ANFO will produce excessive levels of nitrogen oxides if the fuel oil content is too low and will produce excessive levels of carbon monoxide and ammonia if the fuel oil content is too high.[3,4,5] This behavior is supported by data collected in the current research, as illustrated in Figures 2, 3, and 4.

In Figure 5 the data from figures 2, 3, and 4 is presented in terms of oxygen balance. Figure 5 is a plot of carbon monoxide production versus oxygen balance for ANFO and several cap-sensitive explosives. As the oxygen balance is increased for ANFO the carbon monoxide production decreases. This would be expected since there is increasing oxygen to convert the carbon monoxide to carbon dioxide. ANFO mixed at 6 pct fuel oil produces approximately the same amount of carbon monoxide as cap-sensitive explosives of equivalent oxygen balance. The opposite is true when looking at nitrogen oxides production as a function of oxygen balance, as illustrated in Figure 6. When the oxygen balance is increased, the nitrogen oxides and nitrogen dioxide production increased. ANFO mixed at 6 pct fuel oil produced significantly more nitrogen oxides and nitrogen dioxide than cap-sensitive explosives. Figure 7 illustrates that as the oxygen balance for ANFO is increased the ammonia production decreases. With the exception of a couple data points that may be anomalous, ANFO mixed at 6 pct fuel oil produced about the same quantity of ammonia as cap-sensitive explosives of equivalent oxygen balance.

Figure 8 shows that adding water to an ANFO mixture of 94 pct ammonium nitrate and 6 pct fuel oil had little effect on carbon monoxide production for water percentages from 0 to 10 pct. However the nitrogen oxides and nitrogen dioxide increased dramatically when water is added to the ANFO mixture. This is demonstrated in Figure 9. Figure 10 shows the effect of water on ammonia fumes production; adding water to the ANFO yields an erratic trend, indicating that further study is needed.

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[1]Reference to Specific products is for informational purposes and does not imply endorsement by NIOSH.

As mentioned earlier, shooting ANFO in 4-inch schedule 80 seamless steel pipe is probably much more confinement than seen in the field. To examine the effect of reduced confinement on fumes production, ANFO was tested in sheet metal and PVC pipe. As seen in Figure 11, reduced confinement doesn't have much effect on carbon monoxide production. Carbon monoxide production for ANFO shot in the PVC pipe was much higher than that for the steel or sheet metal pipe. The high carbon monoxide might be attributed to burning of the PVC pipe. The degree to which the PVC pipe reacted was not studied in detail, but it is safe to assume that at least some of the PVC burned during the ANFO detonation. The high carbon monoxide production would be consistent with the earlier observation that the higher the fuel content of the explosive, the higher the carbon monoxide production.

Explosive packaging is an important consideration relative to toxic fumes production. For example, a blast pattern may contain a number of boreholes that are contaminated with water and the blaster may decide to insert sleeves into the boreholes contaminated with water to keep the ANFO dry. If the sleeves are made of a combustible material they could add to the carbon monoxide production. Figure 12 shows that the production of nitrogen oxides and nitrogen dioxide increases dramatically with lower confinement, while Figure 13 shows that with less confinement ammonia decreases.

Limestone rock dust (approximately 73 pct through 200 mesh) was added to the ANFO mixture to simulate drill cuttings being mixed with the ANFO as it was loaded into a borehole. The rock dust had little effect on the carbon monoxide production, as illustrated in Figure 14. Figure 15 shows that the addition of the rock dust led to an increase in nitrogen oxides production and a decrease in nitrogen dioxide production. Since the nitrogen oxides consist essentially of nitric oxide and nitrogen dioxide, this indicates that nitric oxide production increased significantly. Figure 16 shows that adding rock dust to the ANFO caused a significant increase in ammonia production .

Aluminum is sometimes added to ANFO to increase the velocity and the output energy. Figure 14 illustrates that the aluminum added to the ANFO mixture has little effect on the production of carbon monoxide. From Figure 15 it is not clear whether or not the nitrogen oxides and nitrogen dioxide production is affected by the added aluminum. The ammonia increased with the added aluminum, as illustrated in figure 16. It should be noted that the addition of aluminum had no clear effect on the ANFO's detonation velocity. The aluminum added to the ANFO mixture was Fine Aluminum Paint Pigment Powder, Alcoa # 422 flake. This type was used to give the fastest possible burning rate for experimental purposes. For commercial explosives, the lowest and least expensive grade of aluminum is typically used, consisting of ground scrap aluminum of various particle sizes.

DISCUSSION

Several factors that may effect the fumes production of ANFO have been investigated. Probably the easiest to control is the fuel oil content. To minimize toxic fumes production , the ANFO should be mixed at 6 pct fuel oil. Deviating from the 6 pct will lead to excessive fumes. Water contamination may not have an affect on carbon monoxide production, but it increases the production of nitrogen oxides and nitrogen dioxide. At the present time in our research it is not clear how the production of ammonia is affected. The confinement of ANFO doesn't appear to make a difference in the production of carbon monoxide, but it makes a difference in the production of nitrogen oxides , nitrogen dioxide, and ammonia.

In the case of nitrogen oxides and nitrogen dioxide the fumes production will increase, while the ammonia fumes production will decrease.

Adding aluminum or rock dust to ANFO does not affect the fumes production of carbon monoxide. The addition of aluminum does not have a significant affect on nitrogen oxides and nitrogen dioxide production, but the addition of rock dust leads to an increased production of nitrogen oxides. Additionally, the rock dust appears to have an effect on the ratio of nitric oxide to nitrogen dioxide. The addition of aluminum and rock dust increased the production of ammonia. The effect of rock dust on fume production was based on limited data and requires further study to look at the effect of particle size and dust type.

Its important to understand that the data reported here applies only to the test conditions under which the data was collected. For example, the schedule 80 steel pipe may provide more confinement than many field blasts. The research reported here shows that the confinement will affect the quantity of toxic fumes produced. In the field the toxic fumes released from a blast will differ significantly from the data reported here. There is a need to collect data from the field to develop an understanding of how data from the PRL fumes chamber compare to fumes production in the field. This, in return, will help in developing improved tests for evaluating fumes production.

1. Santis, L. D. and R. A. Cortese, A Method of Measuring Continuous Detonation Rates Using Off-the-Shelf Items, Proceedings of the Twenty-Second Annual Conference on Explosives and Blasting Technique, Orlando, FL, February 4-8, 1996.

2. Santis, L. D., J. H. Rowland, III, D. J. Viscusi, and M. H. Weslowski, The Large Chamber Test for Toxic Fumes Analysis for Permissible Explosives, Proceedings of the Twenty-First Annual Conference on Explosives and Blasting Technique, Nashville, TN, February 5-9, 1995.

3. Mainiero, R.J., A Technique for Measuring Toxic Gases Produced by Blasting Agents, Proceedings of the Twenty Third Annual Conference on Explosives and Blasting Technique, Las Vegas, NV, February 2-5, 1997.

4. Blaster's Handbook, Sixteenth Edition, E.I. du Pont de Nemours and Company, 1977, p. 59.

5. Explosives and Rock Blasting, Atlas Powder Company, 1987, p. 25-27.

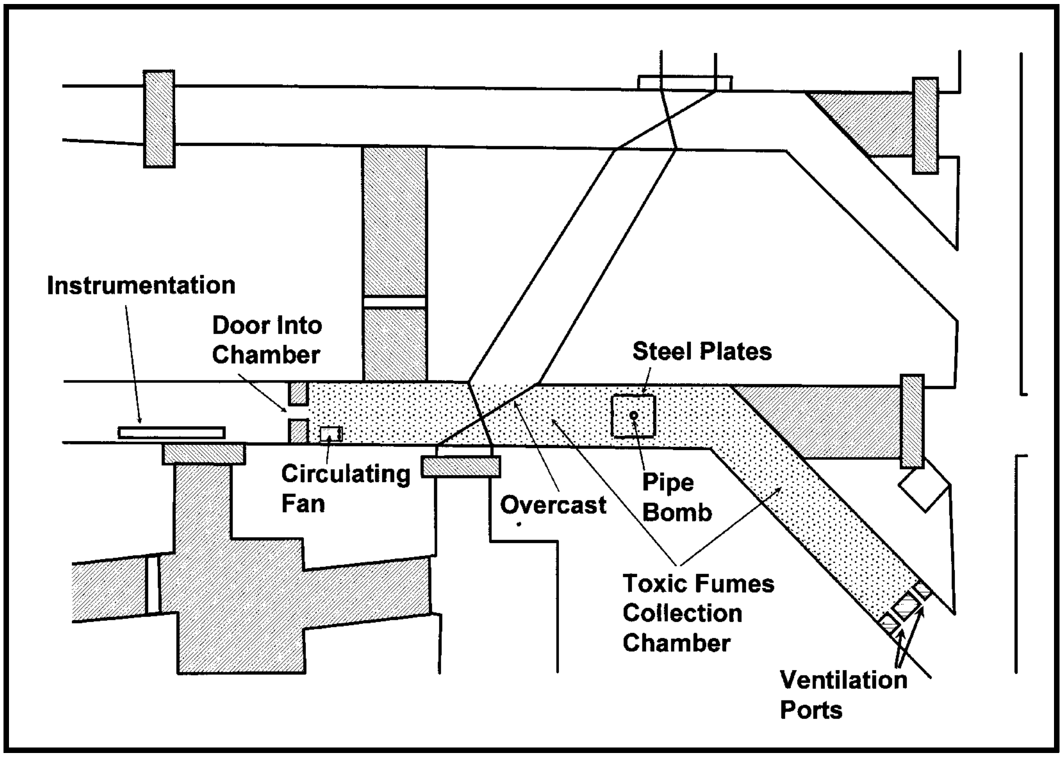

Figure 1. Research was conducted in a chamber created in the underground mine at the Pittsburgh Research Lab.

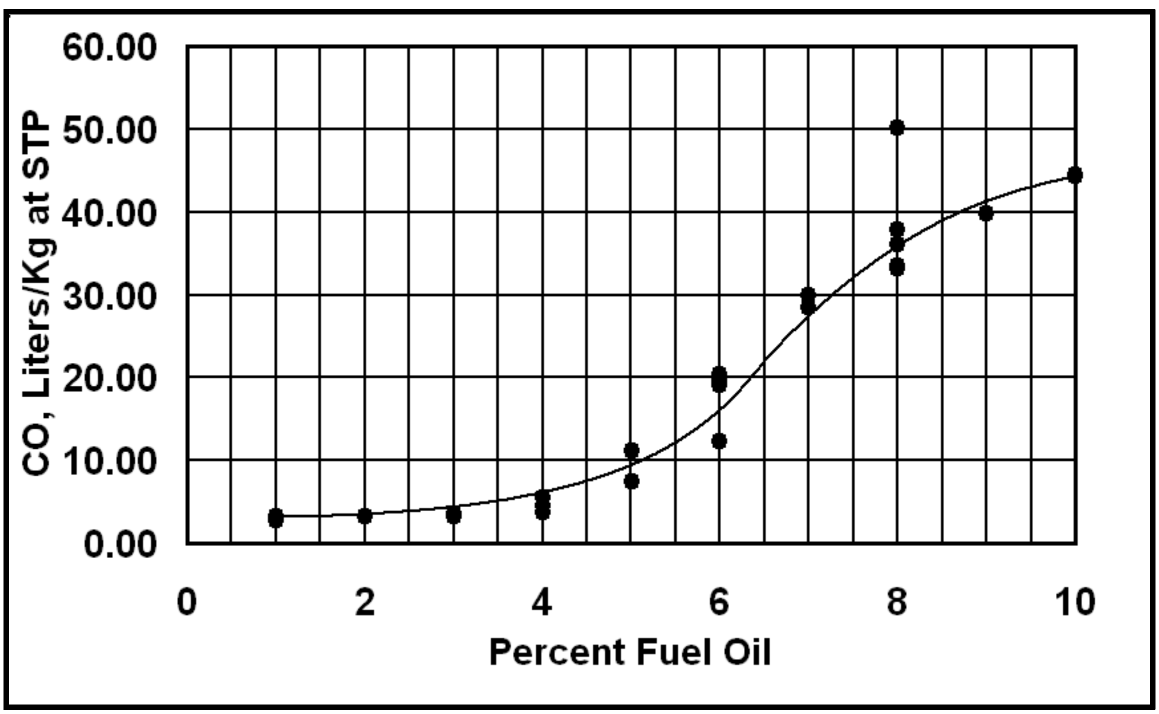

Figure 2. Effect of ANFO fuel oil content on carbon monoxide production. In all figures, the line is a polynomial fit to the data; it is included for illustrative purposes and does not represent a fit of theoretical results.

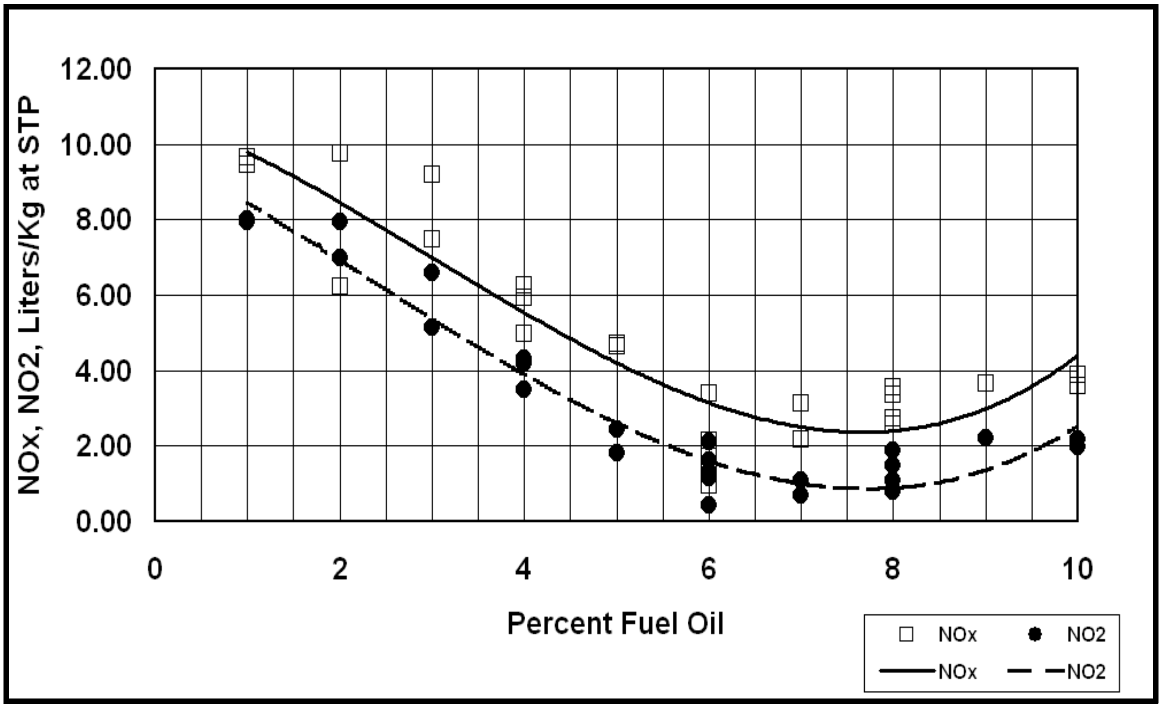

Figure 3. Effect of ANFO fuel oil content on nitrogen oxides and nitrogen dioxide production.

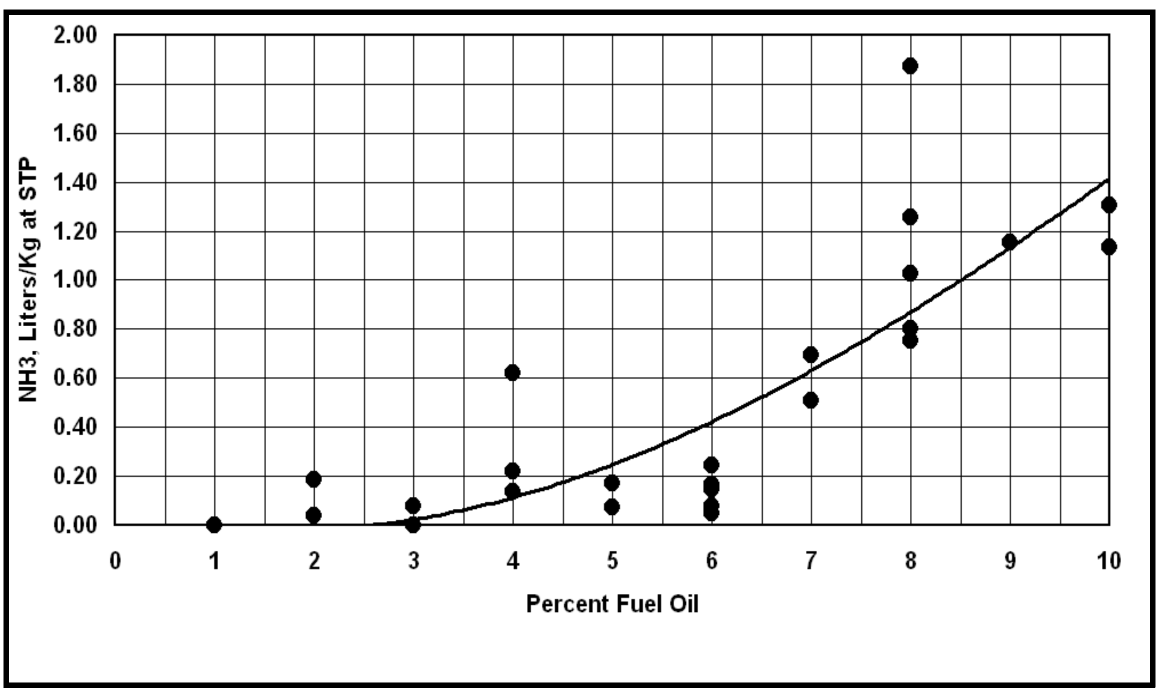

Figure 4. Effect of ANFO fuel oil content on ammonia production.

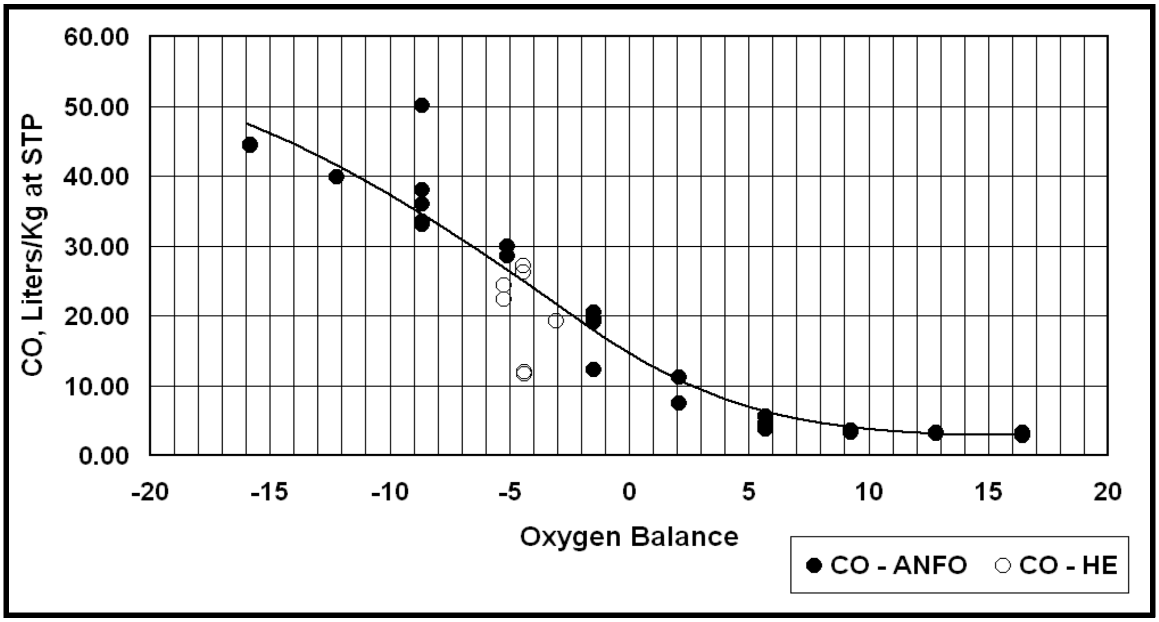

Figure 5. Effect of Oxygen Balance on carbon monoxide production for 94/6 ANFO and high explosives (cap-sensitive explosives).

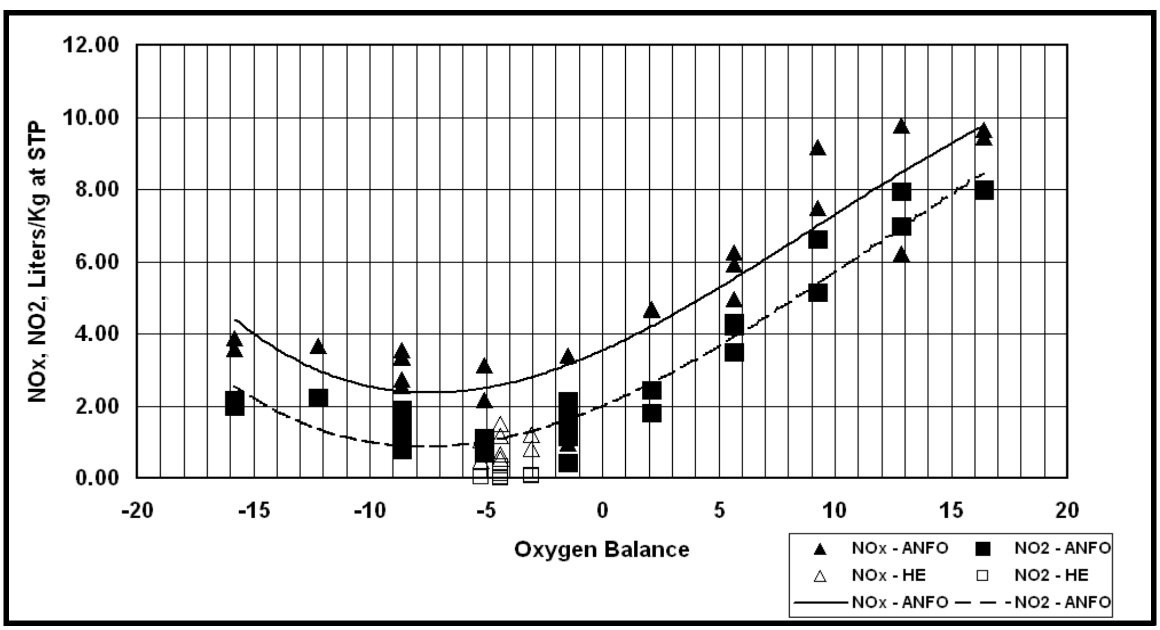

Figure 6. Effect of Oxygen Balance on nitrogen oxides and nitrogen dioxide production for 94/6 ANFO and high explosives (cap-sensitive explosives).

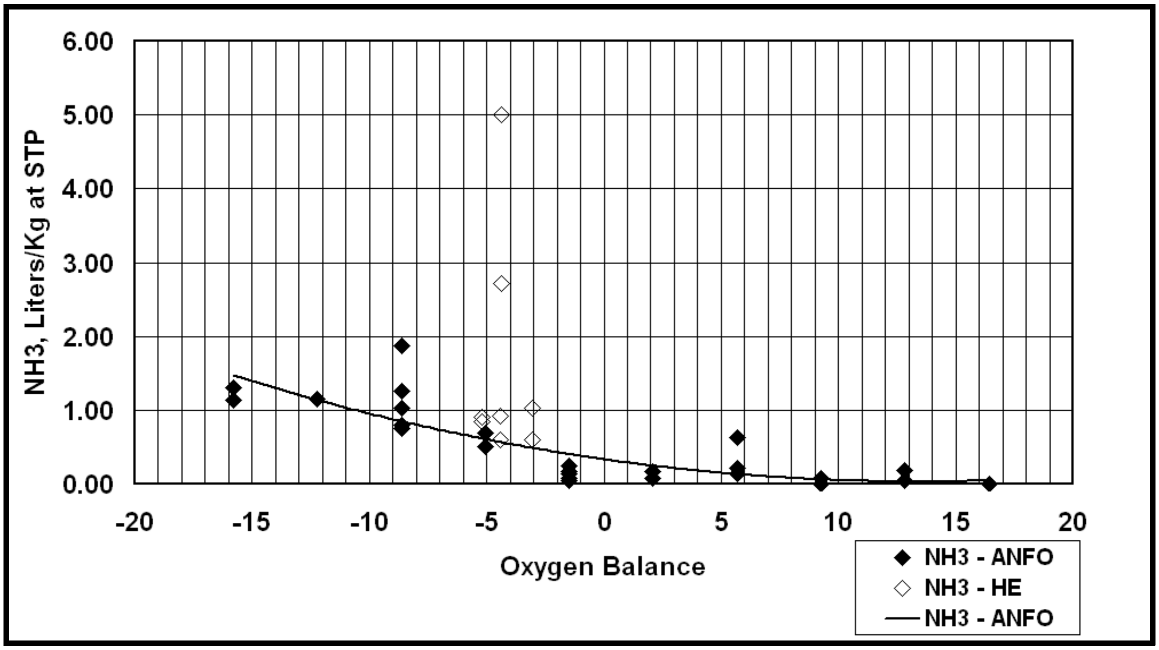

Figure 7. Effect of Oxygen Balance on ammonia production for 94/6 ANFO and high explosives (cap-sensitive explosives).

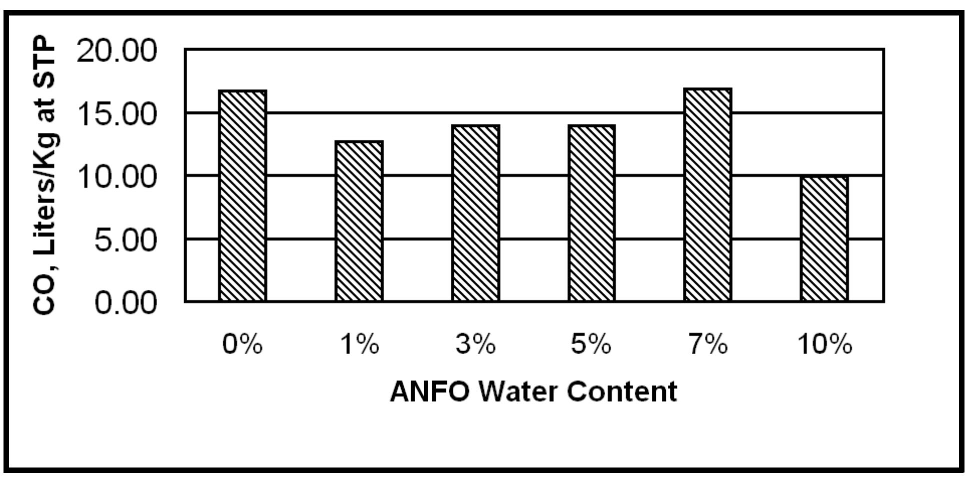

Figure 8. Effect of ANFO water content on carbon monoxide production for a 94/6 mix.

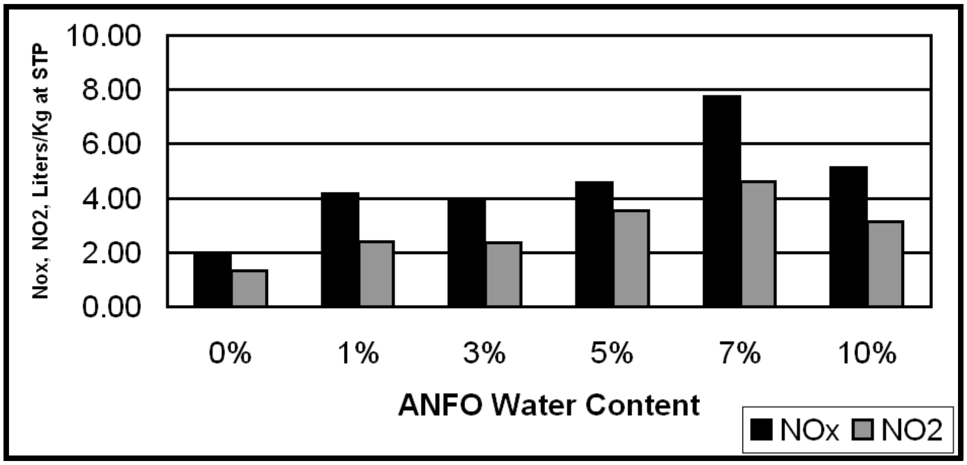

Figure 9. Effect of 94/6 ANFO water content on nitrogen oxides and nitrogen dioxide production.

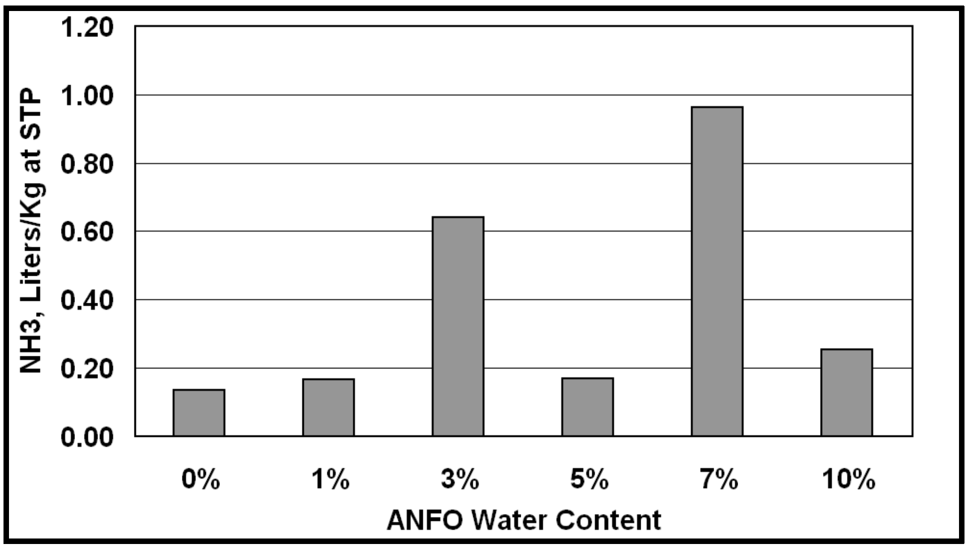

Figure 10. Effect of 94/6 ANFO water content on ammonia production.

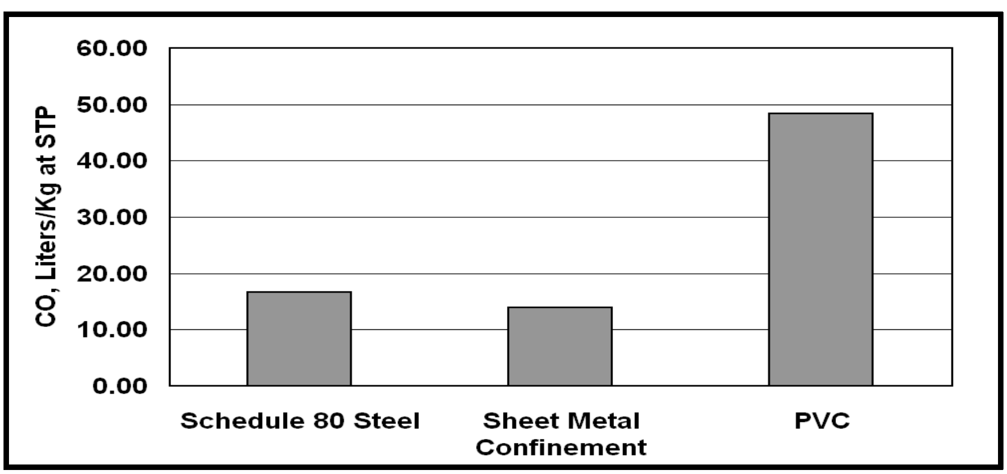

Figure 11. Effect of 94/6 ANFO confinement on carbon monoxide production.

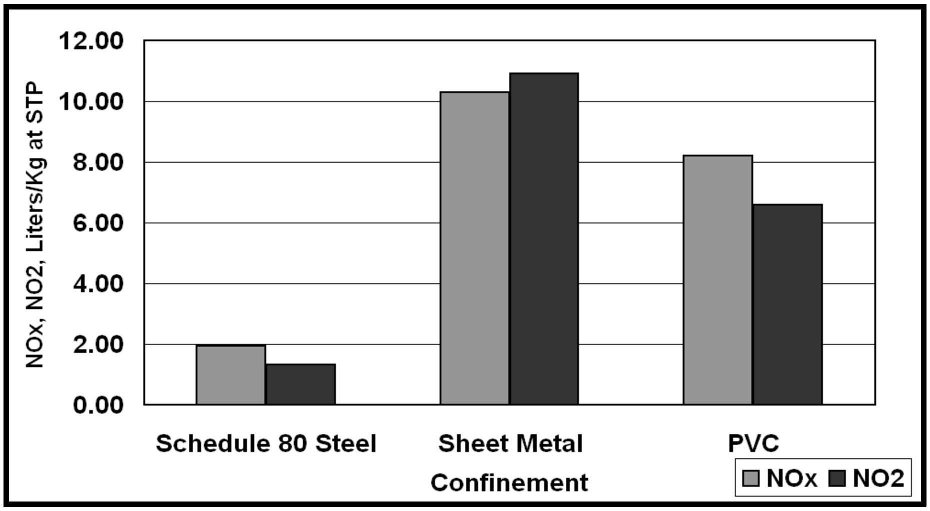

Figure 12. Effect of 94/6 ANFO confinement on nitrogen oxides and nitrogen dioxide production.

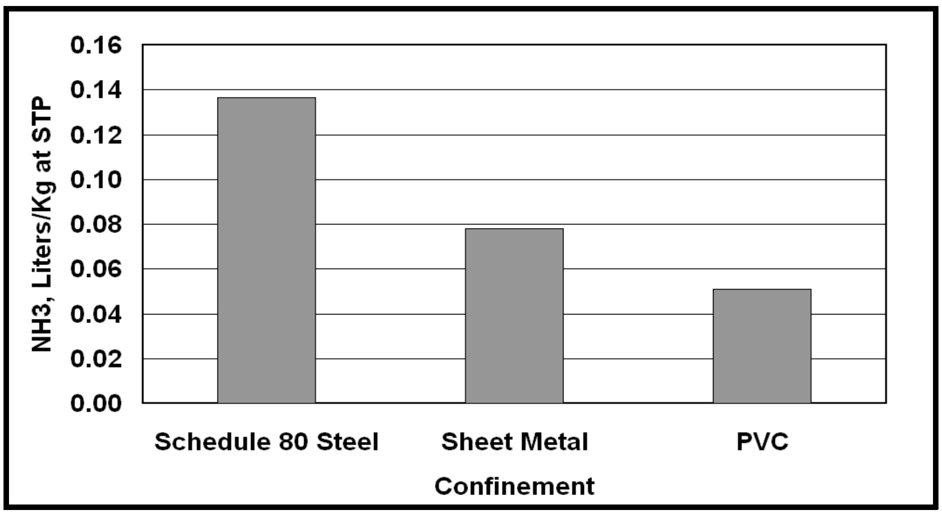

Figure 13. Effect of 94/6 ANFO confinement on ammonia production.

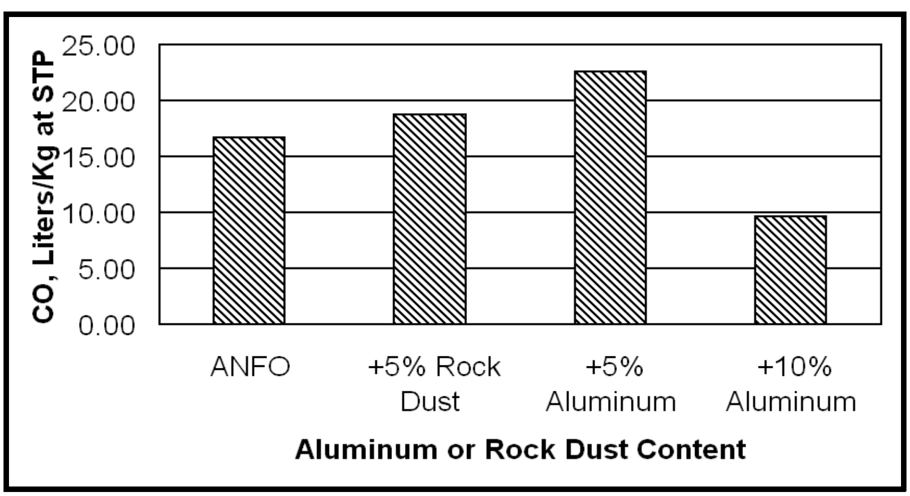

Figure 14. Effect of aluminum and rock dust content on carbon monoxide production.

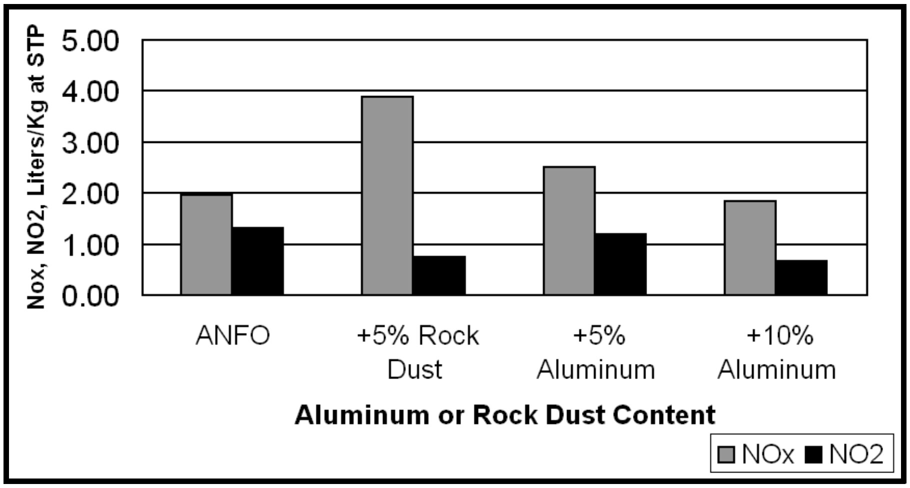

Figure 15. Effect of aluminum and rock dust content on nitrogen oxides and nitrogen dioxide production.

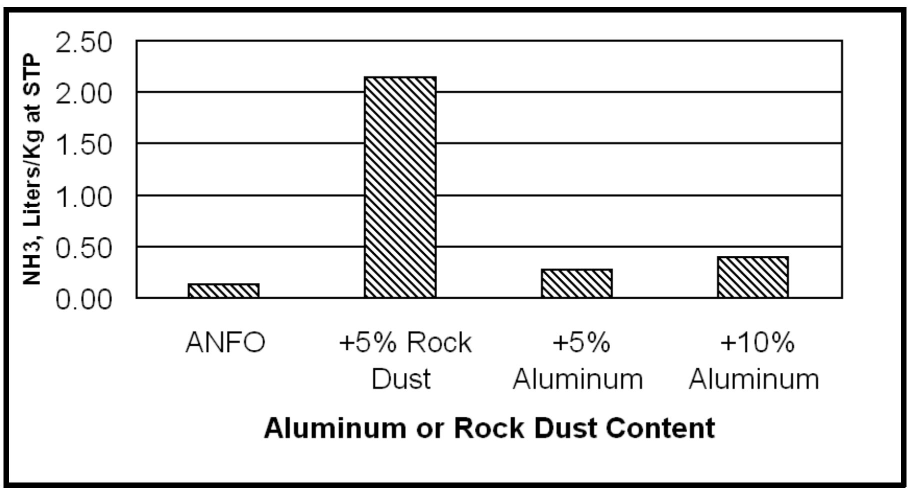

Figure 16. Effect of aluminum or rock dust content on ammonia production.

Table 11.9-1 (English Units). EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES[a]

Operation	Material	Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				Units	EMISSION FACTOR RATING
		Emission Factor Equations		Scaling Factors			
		TSP ≤30 µm	≤15 µm	≤10 µm[d]	≤2.5 µm/TSP[e]		
Blasting[f]	Coal or overburden	$0.000014(A)^{1.5}$	ND	0.52[e]	0.03	lb/blast	C_DD
Truck loading	Coal	$\frac{1.16}{(M)^{1.2}}$	$\frac{0.119}{(M)^{0.9}}$	0.75	0.019	lb/ton	BBCC
Bulldozing	Coal	$\frac{78.4\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{18.6\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.022	lb/hr	CCDD
	Overburden	$\frac{5.7\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{1.0\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.105	lb/hr	BCDD
Dragline	Overburden	$\frac{0.0021\ (d)^{1.1}}{(M)^{0.3}}$	$\frac{0.0021\ (d)^{0.7}}{(M)^{0.3}}$	0.75	0.017	lb/yd^3	BCDD
Vehicle traffic[g]							
Grading		$0.040\ (S)^{2.5}$	$0.051\ (S)^{2.0}$	0.60	0.031	lb/VMT	CCDD
Active storage pile[h] (wind erosion and maintenance)	Coal	0.72 u	ND	ND	ND	$\frac{lb}{(acre)(hr)}$	C[i]_ _ _

[a] Reference 1, except as noted. VMT = vehicle miles traveled. ND = no data. Quality ratings coded where "Q, X, Y, Z" are ratings for ≤30 µm, ≤15 µm, ≤10 µm, and ≤2.5 µm, respectively. See also note below.

[b] Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Symbols for equations:

- A = horizontal area (ft^2), with blasting depth ≤ 70 ft. Not for vertical face of a bench.
- M = material moisture content (%)
- s = material silt content (%)
- u = wind speed (mph)
- d = drop height (ft)
- W = mean vehicle weight (tons)
- S = mean vehicle speed (mph)
- w = mean number of wheels

ELECTRONIC CODE OF FEDERAL REGULATIONS

e-CFR data is current as of September 14, 2020

Title 40 → Chapter I → Subchapter C → Part 98 → Subpart A → Appendix

Title 40: Protection of Environment
PART 98—MANDATORY GREENHOUSE GAS REPORTING
Subpart A—General Provision

Table A-1 to Subpart A of Part 98—Global Warming Potentials

[100-Year Time Horizon]

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
Chemical-Specific GWPs			
Carbon dioxide	124-38-9	CO_2	1
Methane	74-82-8	CH_4	[a]25
Nitrous oxide	10024-97-2	N_2O	[a]298
Fully Fluorinated GHGs			
Sulfur hexafluoride	2551-62-4	SF_6	[a]22,800
Trifluoromethyl sulphur pentafluoride	373-80-8	SF_5CF_3	17,700
Nitrogen trifluoride	7783-54-2	NF_3	17,200
PFC-14 (Perfluoromethane)	75-73-0	CF_4	[a]7,390
PFC-116 (Perfluoroethane)	76-16-4	C_2F_6	[a]12,200
PFC-218 (Perfluoropropane)	76-19-7	C_3F_8	[a]8,830
Perfluorocyclopropane	931-91-9	$C\text{-}C_3F_6$	17,340
PFC-3-1-10 (Perfluorobutane)	355-25-9	C_4F_{10}	[a]8,860
PFC-318 (Perfluorocyclobutane)	115-25-3	$C\text{-}C_4F_8$	[a]10,300
PFC-4-1-12 (Perfluoropentane)	678-26-2	C_5F_{12}	[a]9,160
PFC-5-1-14 (Perfluorohexane, FC-72)	355-42-0	C_6F_{14}	[a]9,300
PFC-6-1-12	335-57-9	C_7F_{16}; $CF_3(CF_2)_5CF_3$	[b]7,820
PFC-7-1-18	307-34-6	C_8F_{18}; $CF_3(CF_2)_6CF_3$	[b]7,620
PFC-9-1-18	306-94-5	$C_{10}F_{18}$	7,500
PFPMIE (HT-70)	NA	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	10,300
Perfluorodecalin (cis)	60433-11-6	$Z\text{-}C_{10}F_{18}$	[b]7,236
Perfluorodecalin (trans)	60433-12-7	$E\text{-}C_{10}F_{18}$	[b]6,288
Saturated Hydrofluorocarbons (HFCs) With Two or Fewer Carbon-Hydrogen Bonds			
HFC-23	75-46-7	CHF_3	[a]14,800
HFC-32	75-10-5	CH_2F_2	[a]675
HFC-125	354-33-6	C_2HF_5	[a]3,500

HFC-134	359-35-3	$C_2H_2F_4$	[a]1,100
HFC-134a	811-97-2	CH_2FCF_3	[a]1,430
HFC-227ca	2252-84-8	$CF_3CF_2CHF_2$	[b]2640
HFC-227ea	431-89-0	C_3HF_7	[a]3,220
HFC-236cb	677-56-5	$CH_2FCF_2CF_3$	1,340
HFC-236ea	431-63-0	CHF_2CHFCF_3	1,370
HFC-236fa	690-39-1	$C_3H_2F_6$	[a]9,810
HFC-329p	375-17-7	$CHF_2CF_2CF_2CF_3$	[b]2360
HFC-43-10mee	138495-42-8	$CF_3CFHCFHCF_2CF_3$	[a]1,640
Saturated Hydrofluorocarbons (HFCs) With Three or More Carbon-Hydrogen Bonds			
HFC-41	593-53-3	CH_3F	[a]92
HFC-143	430-66-0	$C_2H_3F_3$	[a]353
HFC-143a	420-46-2	$C_2H_3F_3$	[a]4,470
HFC-152	624-72-6	CH_2FCH_2F	53
HFC-152a	75-37-6	CH_3CHF_2	[a]124
HFC-161	353-36-6	CH_3CH_2F	12
HFC-245ca	679-86-7	$C_3H_3F_5$	[a]693
HFC-245cb	1814-88-6	$CF_3CF_2CH_3$	[b]4620
HFC-245ea	24270-66-4	$CHF_2CHFCHF_2$	[b]235
HFC-245eb	431-31-2	$CH_2FCHFCF_3$	[b]290
HFC-245fa	460-73-1	$CHF_2CH_2CF_3$	1,030
HFC-263fb	421-07-8	$CH_3CH_2CF_3$	[b]76
HFC-272ca	420-45-1	$CH_3CF_2CH_3$	[b]144
HFC-365mfc	406-58-6	$CH_3CF_2CH_2CF_3$	794
Saturated Hydrofluoroethers (HFEs) and Hydrochlorofluoroethers (HCFEs) With One Carbon-Hydrogen Bond			
HFE-125	3822-68-2	CHF_2OCF_3	14,900
HFE-227ea	2356-62-9	$CF_3CHFOCF_3$	1,540
HFE-329mcc2	134769-21-4	$CF_3CF_2OCF_2CHF_2$	919
HFE-329me3	428454-68-6	$CF_3CFHCF_2OCF_3$	[b]4,550
1,1,1,2,2,3,3-Heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)-propane	3330-15-2	$CF_3CF_2CF_2OCHFCF_3$	[b]6,490
Saturated HFEs and HCFEs With Two Carbon-Hydrogen Bonds			
HFE-134 (HG-00)	1691-17-4	CHF_2OCHF_2	6,320
HFE-236ca	32778-11-3	$CHF_2OCF_2CHF_2$	[b]4,240
HFE-236ca12 (HG-10)	78522-47-1	$CHF_2OCF_2OCHF_2$	2,800
HFE-236ea2 (Desflurane)	57041-67-5	$CHF_2OCHFCF_3$	989
HFE-236fa	20193-67-3	$CF_3CH_2OCF_3$	487
HFE-338mcf2	156053-88-2	$CF_3CF_2OCH_2CF_3$	552
HFE-338mmz1	26103-08-2	$CHF_2OCH(CF_3)_2$	380
HFE-338pcc13 (HG-01)	188690-78-0	$CHF_2OCF_2CF_2OCHF_2$	1,500
HFE-43-10pccc (H-Galden 1040x, HG-11)	E1730133	$CHF_2OCF_2OC_2F_4OCHF_2$	1,870
HCFE-235ca2 (Enflurane)	13838-16-	CHF_2OCF_2CHFCl	[b]583

	9		
HCFE-235da2 (Isoflurane)	26675-46-7	$CHF_2OCHClCF_3$	350
HG-02	205367-61-9	$HF_2C\text{-}(OCF_2CF_2)_2\text{-}OCF_2H$	[b]3,825
HG-03	173350-37-3	$HF_2C\text{-}(OCF_2CF_2)_3\text{-}OCF_2H$	[b]3,670
HG-20	249932-25-0	$HF_2C\text{-}(OCF_2)_2\text{-}OCF_2H$	[b]5,300
HG-21	249932-26-1	$HF_2C\text{-}OCF_2CF_2OCF_2OCF_2O\text{-}CF_2H$	[b]3,890
HG-30	188690-77-9	$HF_2C\text{-}(OCF_2)_3\text{-}OCF_2H$	[b]7,330
1,1,3,3,4,4,6,6,7,7,9,9,10,10,12,12,13,13,15,15-eicosafluoro-2,5,8,11,14-Pentaoxapentadecane	173350-38-4	$HCF_2O(CF_2CF_2O)_4CF_2H$	[b]3,630
1,1,2-Trifluoro-2-(trifluoromethoxy)-ethane	84011-06-3	$CHF_2CHFOCF_3$	[b]1,240
Trifluoro(fluoromethoxy)methane	2261-01-0	CH_2FOCF_3	[b]751
Saturated HFEs and HCFEs With Three or More Carbon-Hydrogen Bonds			
HFE-143a	421-14-7	CH_3OCF_3	756
HFE-245cb2	22410-44-2	$CH_3OCF_2CF_3$	708
HFE-245fa1	84011-15-4	$CHF_2CH_2OCF_3$	286
HFE-245fa2	1885-48-9	$CHF_2OCH_2CF_3$	659
HFE-254cb2	425-88-7	$CH_3OCF_2CHF_2$	359
HFE-263fb2	460-43-5	$CF_3CH_2OCH_3$	11
HFE-263m1; R-E-143a	690-22-2	$CF_3OCH_2CH_3$	[b]29
HFE-347mcc3 (HFE-7000)	375-03-1	$CH_3OCF_2CF_2CF_3$	575
HFE-347mcf2	171182-95-9	$CF_3CF_2OCH_2CHF_2$	374
HFE-347mmy1	22052-84-2	$CH_3OCF(CF_3)_2$	343
HFE-347mmz1 (Sevoflurane)	28523-86-6	$(CF_3)_2CHOCH_2F$	[c]216
HFE-347pcf2	406-78-0	$CHF_2CF_2OCH_2CF_3$	580
HFE-356mec3	382-34-3	$CH_3OCF_2CHFCF_3$	101
HFE-356mff2	333-36-8	$CF_3CH_2OCH_2CF_3$	[b]17
HFE-356mmz1	13171-18-1	$(CF_3)_2CHOCH_3$	27
HFE-356pcc3	160620-20-2	$CH_3OCF_2CF_2CHF_2$	110
HFE-356pcf2	50807-77-7	$CHF_2CH_2OCF_2CHF_2$	265
HFE-356pcf3	35042-99-0	$CHF_2OCH_2CF_2CHF_2$	502
HFE-365mcf2	22052-81-9	$CF_3CF_2OCH_2CH_3$	[b]58
HFE-365mcf3	378-16-5	$CF_3CF_2CH_2OCH_3$	11
HFE-374pc2	512-51-6	$CH_3CH_2OCF_2CHF_2$	557
HFE-449s1 (HFE-7100) Chemical blend	163702-07-6	$C_4F_9OCH_3$	297
	163702-08-7	$(CF_3)_2CFCF_2OCH_3$	
HFE-569sf2 (HFE-7200) Chemical blend	163702-05-4	$C_4F_9OC_2H_5$	59

	163702-06-5	$(CF_3)_2CFCF_2OC_2H_5$	
HG'-01	73287-23-7	$CH_3OCF_2CF_2OCH_3$	[b]222
HG'-02	485399-46-0	$CH_3O(CF_2CF_2O)_2CH_3$	[b]236
HG'-03	485399-48-2	$CH_3O(CF_2CF_2O)_3CH_3$	[b]221
Difluoro(methoxy)methane	359-15-9	CH_3OCHF_2	[b]144
2-Chloro-1,1,2-trifluoro-1-methoxyethane	425-87-6	CH_3OCF_2CHFCl	[b]122
1-Ethoxy-1,1,2,2,3,3,3-heptafluoropropane	22052-86-4	$CF_3CF_2CF_2OCH_2CH_3$	[b]61
2-Ethoxy-3,3,4,4,5-pentafluorotetrahydro-2,5-bis[1,2,2,2-tetrafluoro-1-(trifluoromethyl)ethyl]-furan	920979-28-8	$C_{12}H_5F_{19}O_2$	[b]56
1-Ethoxy-1,1,2,3,3,3-hexafluoropropane	380-34-7	$CF_3CHFCF_2OCH_2CH_3$	[b]23
Fluoro(methoxy)methane	460-22-0	CH_3OCH_2F	[b]13
1,1,2,2-Tetrafluoro-3-methoxy-propane; Methyl 2,2,3,3-tetrafluoropropyl ether	60598-17-6	$CHF_2CF_2CH_2OCH_3$	[b]0.5
1,1,2,2-Tetrafluoro-1-(fluoromethoxy)ethane	37031-31-5	$CH_2FOCF_2CF_2H$	[b]871
Difluoro(fluoromethoxy)methane	461-63-2	CH_2FOCHF_2	[b]617
Fluoro(fluoromethoxy)methane	462-51-1	CH_2FOCH_2F	[b]130
Fluorinated Formates			
Trifluoromethyl formate	85358-65-2	$HCOOCF_3$	[b]588
Perfluoroethyl formate	313064-40-3	$HCOOCF_2CF_3$	[b]580
1,2,2,2-Tetrafluoroethyl formate	481631-19-0	$HCOOCHFCF_3$	[b]470
Perfluorobutyl formate	197218-56-7	$HCOOCF_2CF_2CF_2CF_3$	[b]392
Perfluoropropyl formate	271257-42-2	$HCOOCF_2CF_2CF_3$	[b]376
1,1,1,3,3,3-Hexafluoropropan-2-yl formate	856766-70-6	$HCOOCH(CF_3)_2$	[b]333
2,2,2-Trifluoroethyl formate	32042-38-9	$HCOOCH_2CF_3$	[b]33
3,3,3-Trifluoropropyl formate	1344118-09-7	$HCOOCH_2CH_2CF_3$	[b]17
Fluorinated Acetates			
Methyl 2,2,2-trifluoroacetate	431-47-0	CF_3COOCH_3	[b]52
1,1-Difluoroethyl 2,2,2-trifluoroacetate	1344118-13-3	$CF_3COOCF_2CH_3$	[b]31
Difluoromethyl 2,2,2-trifluoroacetate	2024-86-4	$CF_3COOCHF_2$	[b]27
2,2,2-Trifluoroethyl 2,2,2-trifluoroacetate	407-38-5	$CF_3COOCH_2CF_3$	[b]7
Methyl 2,2-difluoroacetate	433-53-4	HCF_2COOCH_3	[b]3
Perfluoroethyl acetate	343269-97-6	$CH_3COOCF_2CF_3$	[b]2.1
Trifluoromethyl acetate	74123-20-9	CH_3COOCF_3	[b]2.0
Perfluoropropyl acetate	1344118-10-0	$CH_3COOCF_2CF_2CF_3$	[b]1.8
Perfluorobutyl acetate	209597-28-4	$CH_3COOCF_2CF_2CF_2CF_3$	[b]1.6
Ethyl 2,2,2-trifluoroacetate	383-63-1	$CF_3COOCH_2CH_3$	[b]1.3
Carbonofluoridates			

Carbonofluoridates			
Methyl carbonofluoridate	1538-06-3	$FCOOCH_3$	[b]95
1,1-Difluoroethyl carbonofluoridate	1344118-11-1	$FCOOCF_2CH_3$	[b]27
Fluorinated Alcohols Other Than Fluorotelomer Alcohols			
Bis(trifluoromethyl)-methanol	920-66-1	$(CF_3)_2CHOH$	195
(Octafluorotetramethy-lene) hydroxymethyl group	NA	$X\text{-}(CF_2)_4CH(OH)\text{-}X$	73
2,2,3,3,3-Pentafluoropropanol	422-05-9	$CF_3CF_2CH_2OH$	42
2,2,3,3,4,4,4-Heptafluorobutan-1-ol	375-01-9	C_3F_7CH2OH	[b]25
2,2,2-Trifluoroethanol	75-89-8	CF_3CH_2OH	[b]20
2,2,3,4,4,4-Hexafluoro-1-butanol	382-31-0	$CF_3CHFCF_2CH_2OH$	[b]17
2,2,3,3-Tetrafluoro-1-propanol	76-37-9	$CHF_2CF_2CH_2OH$	[b]13
2,2-Difluoroethanol	359-13-7	CHF_2CH2OH	[b]3
2-Fluoroethanol	371-62-0	CH_2FCH_2OH	[b]1.1
4,4,4-Trifluorobutan-1-ol	461-18-7	$CF_3(CH_2)_2CH_2OH$	[b]0.05
Unsaturated Perfluorocarbons (PFCs)			
PFC-1114; TFE	116-14-3	$CF_2 = CF_2$; C_2F_4	[b]0.004
PFC-1216; Dyneon HFP	116-15-4	C_3F_6; $CF_3CF = CF_2$	[b]0.05
PFC C-1418	559-40-0	c-C_5F_8	[b]1.97
Perfluorobut-2-ene	360-89-4	$CF_3CF = CFCF_3$	[b]1.82
Perfluorobut-1-ene	357-26-6	$CF_3CF_2CF = CF_2$	[b]0.10
Perfluorobuta-1,3-diene	685-63-2	$CF_2 = CFCF = CF_2$	[b]0.003
Unsaturated Hydrofluorocarbons (HFCs) and Hydrochlorofluorocarbons (HCFCs)			
HFC-1132a; VF2	75-38-7	$C_2H_2F_2$, $CF_2 = CH_2$	[b]0.04
HFC-1141; VF	75-02-5	C_2H_3F, $CH_2 = CHF$	[b]0.02
(E)-HFC-1225ye	5595-10-8	$CF_3CF = CHF(E)$	[b]0.06
(Z)-HFC-1225ye	5528-43-8	$CF_3CF = CHF(Z)$	[b]0.22
Solstice 1233zd(E)	102687-65-0	$C_3H_2ClF_3$; $CHCl = CHCF_3$	[b]1.34
HFC-1234yf; HFO-1234yf	754-12-1	$C_3H_2F_4$; $CF_3CF = CH_2$	[b]0.31
HFC-1234ze(E)	1645-83-6	$C_3H_2F_4$; trans-$CF_3CH = CHF$	[b]0.97
HFC-1234ze(Z)	29118-25-0	$C_3H_2F_4$; cis-$CF_3CH = CHF$; $CF_3CH = CHF$	[b]0.29
HFC-1243zf; TFP	677-21-4	$C_3H_3F_3$, $CF_3CH = CH_2$	[b]0.12
(Z)-HFC-1336	692-49-9	$CF_3CH = CHCF_3(Z)$	[b]1.58
HFC-1345zfc	374-27-6	$C_2F_5CH = CH_2$	[b]0.09
Capstone 42-U	19430-93-4	$C_6H_3F_9$, $CF_3(CF_2)_3CH = CH_2$	[b]0.16
Capstone 62-U	25291-17-2	$C_8H_3F_{13}$, $CF_3(CF_2)_5CH = CH_2$	[b]0.11
Capstone 82-U	21652-58-4	$C_{10}H_3F_{17}$, $CF_3(CF_2)_7CH = CH_2$	[b]0.09
Unsaturated Halogenated Ethers			
PMVE; HFE-216	1187-93-5	$CF_3OCF = CF_2$	[b]0.17
Fluoroxene	406-90-6	$CF_3CH_2OCH = CH_2$	[b]0.05
Fluorinated Aldehydes			
3,3,3-Trifluoro-propanal	460-40-2	CF_3CH_2CHO	[b]0.01
Fluorinated Ketones			
Novec 1230 (perfluoro (2-methyl-3-pentanone))	756-13-8	$CF_3CF_2C(O)CF\ (CF3)_2$	[b]0.1
Fluorotelomer Alcohols			
3,3,4,4,5,5,6,6,7,7,7-Undecafluoroheptan-1-ol	185689-	$CF_3(CF_2)_4CH_2CH_2OH$	[b]0.43

	57-0		
3,3,3-Trifluoropropan-1-ol	2240-88-2	$CF_3CH_2CH_2OH$	[b]0.35
3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-Pentadecafluorononan-1-ol	755-02-2	$CF_3(CF_2)_6CH_2CH_2OH$	[b]0.33
3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,11-Nonadecafluoroundecan-1-ol	87017-97-8	$CF_3(CF_2)_8CH_2CH_2OH$	[b]0.19
Fluorinated GHGs With Carbon-Iodine Bond(s)			
Trifluoroiodomethane	2314-97-8	CF_3I	[b]0.4
Other Fluorinated Compounds			
Dibromodifluoromethane (Halon 1202)	75-61-6	CBR_2F_2	[b]231
2-Bromo-2-chloro-1,1,1-trifluoroethane (Halon-2311/Halothane)	151-67-7	$CHBrClCF_3$	[b]41

Fluorinated GHG Group[d]	**Global warming potential (100 yr.)**
Default GWPs for Compounds for Which Chemical-Specific GWPs Are Not Listed Above	
Fully fluorinated GHGs	10,000
Saturated hydrofluorocarbons (HFCs) with 2 or fewer carbon-hydrogen bonds	3,700
Saturated HFCs with 3 or more carbon-hydrogen bonds	930
Saturated hydrofluoroethers (HFEs) and hydrochlorofluoroethers (HCFEs) with 1 carbon-hydrogen bond	5,700
Saturated HFEs and HCFEs with 2 carbon-hydrogen bonds	2,600
Saturated HFEs and HCFEs with 3 or more carbon-hydrogen bonds	270
Fluorinated formates	350
Fluorinated acetates, carbonofluoridates, and fluorinated alcohols other than fluorotelomer alcohols	30
Unsaturated perfluorocarbons (PFCs), unsaturated HFCs, unsaturated hydrochlorofluorocarbons (HCFCs), unsaturated halogenated ethers, unsaturated halogenated esters, fluorinated aldehydes, and fluorinated ketones	1
Fluorotelomer alcohols	1
Fluorinated GHGs with carbon-iodine bond(s)	1
Other fluorinated GHGs	2,000

[a]The GWP for this compound was updated in the final rule published on November 29, 2013 [78 FR 71904] and effective on January 1, 2014.

[b]This compound was added to Table A-1 in the final rule published on December 11, 2014, and effective on January 1, 2015.

[c]The GWP for this compound was updated in the final rule published on December 11, 2014, and effective on January 1, 2015 .

[d]For electronics manufacturing (as defined in §98.90), the term “fluorinated GHGs” in the definition of each fluorinated GHG group in §98.6 shall include fluorinated heat transfer fluids (as defined in §98.98), whether or not they are also fluorinated GHGs.

[79 FR 73779, Dec. 11, 2014]

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ELECTRONIC CODE OF FEDERAL REGULATIONS

e-CFR data is current as of September 14, 2020

Title 40: Protection of Environment
PART 98—MANDATORY GREENHOUSE GAS REPORTING
Subpart C—General Stationary Fuel Combustion Sources

Table C-1 to Subpart C of Part 98—Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel

Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel

Fuel type	Default high heat value	Default CO_2 emission factor
Coal and coke	mmBtu/short ton	kg CO_2/mmBtu
Anthracite	25.09	103.69
Bituminous	24.93	93.28
Subbituminous	17.25	97.17
Lignite	14.21	97.72
Coal Coke	24.80	113.67
Mixed (Commercial sector)	21.39	94.27
Mixed (Industrial coking)	26.28	93.90
Mixed (Industrial sector)	22.35	94.67
Mixed (Electric Power sector)	19.73	95.52
Natural gas	mmBtu/scf	kg CO_2/mmBtu
(Weighted U.S. Average)	1.026×10^{-3}	53.06
Petroleum products—liquid	mmBtu/gallon	kg CO_2/mmBtu
Distillate Fuel Oil No. 1	0.139	73.25
Distillate Fuel Oil No. 2	0.138	73.96
Distillate Fuel Oil No. 4	0.146	75.04
Residual Fuel Oil No. 5	0.140	72.93
Residual Fuel Oil No. 6	0.150	75.10
Used Oil	0.138	74.00
Kerosene	0.135	75.20
Liquefied petroleum gases (LPG)[1]	0.092	61.71
Propane[1]	0.091	62.87
Propylene[2]	0.091	67.77
Ethane[1]	0.068	59.60
Ethanol	0.084	68.44
Ethylene[2]	0.058	65.96
Isobutane[1]	0.099	64.94
	0.103	68.86

Isobutylene[1]	0.103	68.86
Butane[1]	0.103	64.77
Butylene[1]	0.105	68.72
Naphtha (<401 deg F)	0.125	68.02
Natural Gasoline	0.110	66.88
Other Oil (>401 deg F)	0.139	76.22
Pentanes Plus	0.110	70.02
Petrochemical Feedstocks	0.125	71.02
Special Naphtha	0.125	72.34
Unfinished Oils	0.139	74.54
Heavy Gas Oils	0.148	74.92
Lubricants	0.144	74.27
Motor Gasoline	0.125	70.22
Aviation Gasoline	0.120	69.25
Kerosene-Type Jet Fuel	0.135	72.22
Asphalt and Road Oil	0.158	75.36
Crude Oil	0.138	74.54
Petroleum products—solid	mmBtu/short ton	kg CO_2/mmBtu.
Petroleum Coke	30.00	102.41.
Petroleum products—gaseous	mmBtu/scf	kg CO_2/mmBtu.
Propane Gas	2.516×10^{-3}	61.46.
Other fuels—solid	mmBtu/short ton	kg CO_2/mmBtu
Municipal Solid Waste	9.95[3]	90.7
Tires	28.00	85.97
Plastics	38.00	75.00
Other fuels—gaseous	mmBtu/scf	kg CO_2/mmBtu
Blast Furnace Gas	0.092×10^{-3}	274.32
Coke Oven Gas	0.599×10^{-3}	46.85
Fuel Gas[4]	1.388×10^{-3}	59.00
Biomass fuels—solid	mmBtu/short ton	kg CO_2/mmBtu
Wood and Wood Residuals (dry basis)[5]	17.48	93.80
Agricultural Byproducts	8.25	118.17
Peat	8.00	111.84
Solid Byproducts	10.39	105.51
Biomass fuels—gaseous	mmBtu/scf	kg CO_2/mmBtu
Landfill Gas	0.485×10^{-3}	52.07
Other Biomass Gases	0.655×10^{-3}	52.07
Biomass Fuels—Liquid	mmBtu/gallon	kg CO_2/mmBtu
Ethanol	0.084	68.44
Biodiesel (100%)	0.128	73.84
Rendered Animal Fat	0.125	71.06
Vegetable Oil	0.120	81.55

[1]The HHV for components of LPG determined at 60 °F and saturation pressure with the exception of ethylene.

[2]Ethylene HHV determined at 41 °F (5 °C) and saturation pressure.

[3]Use of this default HHV is allowed only for: (a) Units that combust MSW, do not generate steam, and are allowed to use Tier 1; (b) units that derive no more than 10 percent

of their annual heat input from MSW and/or tires; and (c) small batch incinerators that combust no more than 1,000 tons of MSW per year.

[4]Reporters subject to subpart X of this part that are complying with §98.243(d) or subpart Y of this part may only use the default HHV and the default CO_2 emission factor for fuel gas combustion under the conditions prescribed in §98.243(d)(2)(i) and (d)(2)(ii) and §98.252(a)(1) and (a)(2), respectively. Otherwise, reporters subject to subpart X or subpart Y shall use either Tier 3 (Equation C-5) or Tier 4.

[5]Use the following formula to calculate a wet basis HHV for use in Equation C-1: $HHV_w = ((100 - M)/100)*HHV_d$ where HHV_w = wet basis HHV, M = moisture content (percent) and HHV_d = dry basis HHV from Table C-1.

[78 FR 71950, Nov. 29, 2013, as amended at 81 FR 89252, Dec. 9, 2016]

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Title 40: Protection of Environment
PART 98—MANDATORY GREENHOUSE GAS REPORTING
Subpart C—General Stationary Fuel Combustion Sources

Table C-2 to Subpart C of Part 98—Default CH_4 and N_2O Emission Factors for Various Types of Fuel

Fuel type	Default CH_4 emission factor (kg CH_4/mmBtu)	Default N_2O emission factor (kg N_2O/mmBtu)
Coal and Coke (All fuel types in Table C-1)	1.1×10^{-02}	1.6×10^{-03}
Natural Gas	1.0×10^{-03}	1.0×10^{-04}
Petroleum Products (All fuel types in Table C-1)	3.0×10^{-03}	6.0×10^{-04}
Fuel Gas	3.0×10^{-03}	6.0×10^{-04}
Other Fuels—Solid	3.2×10^{-02}	4.2×10^{-03}
Blast Furnace Gas	2.2×10^{-05}	1.0×10^{-04}
Coke Oven Gas	4.8×10^{-04}	1.0×10^{-04}
Biomass Fuels—Solid (All fuel types in Table C-1, except wood and wood residuals)	3.2×10^{-02}	4.2×10^{-03}
Wood and wood residuals	7.2×10^{-03}	3.6×10^{-03}
Biomass Fuels—Gaseous (All fuel types in Table C-1)	3.2×10^{-03}	6.3×10^{-04}
Biomass Fuels—Liquid (All fuel types in Table C-1)	1.1×10^{-03}	1.1×10^{-04}

Note: Those employing this table are assumed to fall under the IPCC definitions of the “Energy Industry” or “Manufacturing Industries and Construction”. In all fuels except for coal the values for these two categories are identical. For coal combustion, those who fall within the IPCC “Energy Industry” category may employ a value of 1g of CH_4/mmBtu.

[78 FR 71952, Nov. 29, 2013, as amended at 81 FR 89252, Dec. 9, 2016]

Section 7

Information Used to Determine Emissions

Mine, Reclamation, and Crushing & Screening Plant (SP-7A) Handling (Fugitive)

- AP-42 Chapter 11.19.2
- AP-42 Chapter 13.2.4

Table 11.19.2-2 (English Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS (lb/Ton)[a]

Source [b]	Total Particulate Matter [r,s]	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Primary Crushing (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Primary Crushing (controlled) (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Secondary Crushing (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Secondary Crushing (controlled) (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Tertiary Crushing (SCC 3-050030-03)	0.0054[d]	E	0.0024[o]	C	ND[n]	
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0012[d]	E	0.00054[p]	C	0.00010[q]	E
Fines Crushing (SCC 3-05-020-05)	0.0390[e]	E	0.0150[e]	E	ND	
Fines Crushing (controlled) (SCC 3-05-020-05)	0.0030[f]	E	0.0012[f]	E	0.000070[q]	E
Screening (SCC 3-05-020-02, 03)	0.025[c]	E	0.0087[l]	C	ND	
Screening (controlled) (SCC 3-05-020-02, 03)	0.0022[d]	E	0.00074[m]	C	0.000050[q]	E
Fines Screening (SCC 3-05-020-21)	0.30[g]	E	0.072[g]	E	ND	
Fines Screening (controlled) (SCC 3-05-020-21)	0.0036[g]	E	0.0022[g]	E	ND	
Conveyor Transfer Point (SCC 3-05-020-06)	0.0030[h]	E	0.00110[h]	D	ND	
Conveyor Transfer Point (controlled) (SCC 3-05-020-06)	0.00014[i]	E	4.6×10^{-5}[i]	D	1.3×10^{-5}[q]	E
Wet Drilling - Unfragmented Stone (SCC 3-05-020-10)	ND		8.0×10^{-5}[j]	E	ND	
Truck Unloading -Fragmented Stone (SCC 3-05-020-31)	ND		1.6×10^{-5}[j]	E	ND	
Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32)	ND		0.00010[k]	E	ND	

a. Emission factors represent uncontrolled emissions unless noted. Emission factors in lb/Ton of material of throughput. SCC = Source Classification Code. ND = No data.

b. Controlled sources (with wet suppression) are those that are part of the processing plant that employs current wet suppression technology similar to the study group. The moisture content of the study group without wet suppression systems operating (uncontrolled) ranged from 0.21 to 1.3 percent, and the same facilities operating wet suppression systems (controlled) ranged from 0.55 to 2.88 percent. Due to carry over of the small amount of moisture required, it has been shown that each source, with the exception of crushers, does not need to employ direct water sprays. Although the moisture content was the only variable measured, other process features may have as much influence on emissions from a given source. Visual observations from each source under normal operating conditions are probably the best indicator of which emission factor is most appropriate. Plants that employ substandard control measures as indicated by visual observations should use the uncontrolled factor with an appropriate control efficiency that best reflects the effectiveness of the controls employed.

c. References 1, 3, 7, and 8

d. References 3, 7, and 8

13.2.4 Aggregate Handling And Storage Piles

13.2.4.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

13.2.4.2 Emissions And Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters of the condition of a particular storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and then the drying process is very slow.

Silt (particles equal to or less than 75 micrometers [µm] in diameter) content is determined by measuring the portion of dry aggregate material that passes through a 200-mesh screen, using ASTM-C-136 method.[1] Table 13.2.4-1 summarizes measured silt and moisture values for industrial aggregate materials.

Table 13.2.4-1. TYPICAL SILT AND MOISTURE CONTENTS OF MATERIALS AT VARIOUS INDUSTRIES[a]

Industry	No. Of Facilities	Material	Silt Content (%)			Moisture Content (%)		
			No. Of Samples	Range	Mean	No. Of Samples	Range	Mean
Iron and steel production	9	Pellet ore	13	1.3 - 13	4.3	11	0.64 - 4.0	2.2
		Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.0	5.4
		Coal	12	2.0 - 7.7	4.6	11	2.8 - 11	4.8
		Slag	3	3.0 - 7.3	5.3	3	0.25 - 2.0	0.92
		Flue dust	3	2.7 - 23	13	1	—	7
		Coke breeze	2	4.4 - 5.4	4.9	2	6.4 - 9.2	7.8
		Blended ore	1	—	15	1	—	6.6
		Sinter	1	—	0.7	0	—	—
		Limestone	3	0.4 - 2.3	1.0	2	ND	0.2
Stone quarrying and processing	2	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
		Various limestone products	8	0.8 - 14	3.9	8	0.46 - 5.0	2.1
Taconite mining and processing	1	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.0	0.9
		Tailings	2	ND	11	1	—	0.4
Western surface coal mining	4	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
		Overburden	15	3.8 - 15	7.5	0	—	—
		Exposed ground	3	5.1 - 21	15	3	0.8 - 6.4	3.4
Coal-fired power plant	1	Coal (as received)	60	0.6 - 4.8	2.2	59	2.7 - 7.4	4.5
Municipal solid waste landfills	4	Sand	1	—	2.6	1	—	7.4
		Slag	2	3.0 - 4.7	3.8	2	2.3 - 4.9	3.6
		Cover	5	5.0 - 16	9.0	5	8.9 - 16	12
		Clay/dirt mix	1	—	9.2	1	—	14
		Clay	2	4.5 - 7.4	6.0	2	8.9 - 11	10
		Fly ash	4	78 - 81	80	4	26 - 29	27
		Misc. fill materials	1	—	12	1	—	11

[a] References 1-10. ND = no data.

13.2.4.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016) \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (kg/megagram [Mg])}$$

$$E = k(0.0032) \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

[a] Multiplier for < 2.5 µm taken from Reference 14.

The equation retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows. Note that silt content is included, even though silt content does not appear as a correction parameter in the equation. While it is reasonable to expect that silt content and emission factors are interrelated, no significant correlation between the 2 was found during the derivation of the equation, probably because most tests with high silt contents were conducted under lower winds, and vice versa. It is recommended that estimates from the equation be reduced 1 quality rating level if the silt content used in a particular application falls outside the range given:

Ranges Of Source Conditions For Equation 1			
Silt Content (%)	Moisture Content (%)	Wind Speed	
		m/s	mph
0.44 - 19	0.25 - 4.8	0.6 - 6.7	1.3 - 15

To retain the quality rating of the equation when it is applied to a specific facility, reliable correction parameters must be determined for specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site-specific values for correction parameters cannot be obtained, the appropriate mean from Table 13.2.4-1 may be used, but the quality rating of the equation is reduced by 1 letter.

For emissions from equipment traffic (trucks, front-end loaders, dozers, etc.) traveling between or on piles, it is recommended that the equations for vehicle traffic on unpaved surfaces be used (see Section 13.2.2). For vehicle travel between storage piles, the silt value(s) for the areas among the piles (which may differ from the silt values for the stored materials) should be used.

Worst-case emissions from storage pile areas occur under dry, windy conditions. Worst-case emissions from materials-handling operations may be calculated by substituting into the equation appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for Section 13.2.2, vehicle traffic, "Unpaved Roads", follows the methodology described in that section centering on parameter p. A separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity also may be justified for the worst-case averaging period.

13.2.4.4 Controls[12-13]

Watering and the use of chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical agents (such as surfactants) that permit more extensive wetting. Continuous chemical treating of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.[12]

References For Section 13.2.4

1. C. Cowherd, Jr., *et al.*, *Development Of Emission Factors For Fugitive Dust Sources*, EPA-450/3-74-037, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

2. R. Bohn, *et al.*, *Fugitive Emissions From Integrated Iron And Steel Plants*, EPA-600/2-78-050, U. S. Environmental Protection Agency, Cincinnati, OH, March 1978.

3. C. Cowherd, Jr., *et al.*, *Iron And Steel Plant Open Dust Source Fugitive Emission Evaluation*, EPA-600/2-79-103, U. S. Environmental Protection Agency, Cincinnati, OH, May 1979.

4. *Evaluation Of Open Dust Sources In The Vicinity Of Buffalo, New York*, EPA Contract No. 68-02-2545, Midwest Research Institute, Kansas City, MO, March 1979.

5. C. Cowherd, Jr., and T. Cuscino, Jr., *Fugitive Emissions Evaluation*, MRI-4343-L, Midwest Research Institute, Kansas City, MO, February 1977.

6. T. Cuscino, Jr., *et al.*, *Taconite Mining Fugitive Emissions Study*, Minnesota Pollution Control Agency, Roseville, MN, June 1979.

7. *Improved Emission Factors For Fugitive Dust From Western Surface Coal Mining Sources*, 2 Volumes, EPA Contract No. 68-03-2924, PEDCo Environmental, Kansas City, MO, and Midwest Research Institute, Kansas City, MO, July 1981.

8. *Determination Of Fugitive Coal Dust Emissions From Rotary Railcar Dumping*, TRC, Hartford, CT, May 1984.

9. *PM-10 Emission Inventory Of Landfills In the Lake Calumet Area*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, September 1987.

10. *Chicago Area Particulate Matter Emission Inventory — Sampling And Analysis*, EPA Contract No. 68-02-4395, Midwest Research Institute, Kansas City, MO, May 1988.

11. *Update Of Fugitive Dust Emission Factors In AP-42 Section 11.2*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, July 1987.

12. G. A. Jutze, *et al.*, *Investigation Of Fugitive Dust Sources Emissions And Control*, EPA-450/3-74-036a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

13. C. Cowherd, Jr., *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

14. C. Cowherd, *Background Document for Revisions to Fine Fraction Ratios &sed for AP-42 Fugitive Dust Emission Factors*. Prepared by Midwest Research Institute for Western Governors Association, Western Regional Air Partnership, Denver, CO, February 1, 2006.

Section 7

Information Used to Determine Emissions

Mine, Reclamation, and Crushing & Screening Plant (SP-7A) Hauling (Fugitive)

- AP-42 Chapter 13.2.2
- NMED Memo: "Department Accepted Values for: Aggregate Handling, Storage Pile, and Haul Road Emissions"
- Western Regional Air Partnership (WRAP) Fugitive Dust Handbook, September 7, 2006.

13.2.2 Unpaved Roads

13.2.2.1 General

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.

The particulate emission factors presented in the previous draft version of this section of AP-42, dated October 2001, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material[25]. EPA included these sources in the emission factor equation for unpaved public roads (equation 1b in this section) since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the unpaved public road emission factor equation only estimates particulate emissions from resuspended road surface material [23, 26]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2 [24]. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOBILE6.2 to estimate particulate emissions from vehicle traffic on unpaved public roads. It also incorporates the decrease in exhaust emissions that has occurred since the unpaved public road emission factor equation was developed. The previous version of the unpaved public road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.2.2 Emissions Calculation And Correction Parameters[1-6]

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on source parameters that characterize the condition of a particular road and the associated vehicle traffic. Characterization of these source parameters allow for "correction" of emission estimates to specific road and traffic conditions present on public and industrial roadways.

Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 micrometers [µm] 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. A summary of this method is contained in Appendix C of AP-42. Table 13.2.2-1 summarizes measured silt values for industrial unpaved roads. Table 13.2.2-2 summarizes measured silt values for public unpaved roads. It should be noted that the ranges of silt content vary over two orders of magnitude. Therefore, the use of data from this table can potentially introduce considerable error. Use of this data is strongly discouraged when it is feasible to obtain locally gathered data.

Since the silt content of a rural dirt road will vary with geographic location, it should be measured for use in projecting emissions. As a conservative approximation, the silt content of the parent soil in the area can be used. Tests, however, 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.

Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight. On the other hand, there is far less variability in the weights of cars and pickup trucks that commonly travel publicly accessible unpaved roads throughout the United States. For those roads, the moisture content of the road surface material may be more dominant in determining differences in emission levels between, for example a hot, desert environment and a cool, moist location.

The PM-10 and TSP emission factors presented below are the outcomes from stepwise linear regressions of field emission test results of vehicles traveling over unpaved surfaces. Due to a limited amount of information available for PM-2.5, the expression for that particle size range has been scaled against the result for PM-10. Consequently, the quality rating for the PM-2.5 factor is lower than that for the PM-10 expression.

Table 13.2.2-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIAL ON INDUSTRIAL UNPAVED ROADS[a]

Industry	Road Use Or Surface Material	Plant Sites	No. Of Samples	Silt Content (%)	
				Range	Mean
Copper smelting	Plant road	1	3	16 - 19	17
Iron and steel production	Plant road	19	135	0.2 - 19	6.0
Sand and gravel processing	Plant road	1	3	4.1 - 6.0	4.8
	Material storage area	1	1	-	7.1
Stone quarrying and processing	Plant road	2	10	2.4 - 16	10
	Haul road to/from pit	4	20	5.0-15	8.3
Taconite mining and processing	Service road	1	8	2.4 - 7.1	4.3
	Haul road to/from pit	1	12	3.9 - 9.7	5.8
Western surface coal mining	Haul road to/from pit	3	21	2.8 - 18	8.4
	Plant road	2	2	4.9 - 5.3	5.1
	Scraper route	3	10	7.2 - 25	17
	Haul road (freshly graded)	2	5	18 - 29	24
Construction sites	Scraper routes	7	20	0.56-23	8.5
Lumber sawmills	Log yards	2	2	4.8-12	8.4
Municipal solid waste landfills	Disposal routes	4	20	2.2 - 21	6.4

[a]References 1,5-15.

The following empirical expressions may be used to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT):

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$E = k\ (s/12)^a (W/3)^b \tag{1a}$$

and, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions may be estimated from the following:

$$E = \frac{k\ (s/12)^a (S/30)^d}{(M/0.5)^c} - C \tag{1b}$$

where k, a, b, c and d are empirical constants (Reference 6) given below and

E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The source characteristics s, W and M are referred to as correction parameters for adjusting the emission estimates to local conditions. The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows:

1 lb/VMT = 281.9 g/VKT

The constants for Equations 1a and 1b based on the stated aerodynamic particle sizes are shown in Tables 13.2.2-2 and 13.2.2-4. The PM-2.5 particle size multipliers (k-factors) are taken from Reference 27.

Table 13.2.2-2. CONSTANTS FOR EQUATIONS 1a AND 1b

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 13.2.2-2 also contains the quality ratings for the various size-specific versions of Equation 1a and 1b. The equation retains the assigned quality rating, if applied within the ranges of source conditions, shown in Table 13.2.2-3, that were tested in developing the equation:

Table 13.2.2-3. RANGE OF SOURCE CONDITIONS USED IN DEVELOPING EQUATION 1a AND 1b

Emission Factor	Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
		Mg	ton	km/hr	mph		
Industrial Roads (Equation 1a)	1.8-25.2	1.8-260	2-290	8-69	5-43	4-17[a]	0.03-13
Public Roads (Equation 1b)	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

[a] See discussion in text.

As noted earlier, the models presented as Equations 1a and 1b were developed from tests of traffic on unpaved surfaces. Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering, because of traffic-enhanced natural evaporation. (Factors influencing how fast a road dries are discussed in Section 13.2.2.3, below.) The quality ratings given above pertain to the mid-range of the measured source conditions for the equation. A higher mean vehicle weight and a higher than normal traffic rate may be justified when performing a worst-case analysis of emissions from unpaved roads.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [23]. The emission factor also varies with aerodynamic size range as shown in Table 13.2.2-4

Table 13.2.2-4. EMISSION FACTOR FOR 1980'S VEHICLE FLEET EXHAUST, BRAKE WEAR AND TIRE WEAR

Particle Size Range[a]	*C*, Emission Factor for Exhaust, Brake Wear and Tire Wear[b] lb/VMT
$PM_{2.5}$	0.00036
PM_{10}	0.00047
PM_{30}[c]	0.00047

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.
[b] Units shown are pounds per vehicle mile traveled (lb/VMT).
[c] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

It is important to note that the vehicle-related source conditions refer to the average weight, speed, and number of wheels for all vehicles traveling the road. For example, if 98 percent of traffic on the road are 2-ton cars and trucks while the remaining 2 percent consists of 20-ton trucks, then the mean weight is 2.4 tons. More specifically, Equations 1a and 1b are *not* intended to be used to calculate a separate emission factor for each vehicle class within a mix of traffic on a given unpaved road. That is, in the example, one should *not* determine one factor for the 2-ton vehicles and a second factor for the 20-ton trucks. Instead, only one emission factor should be calculated that represents the "fleet" average of 2.4 tons for all vehicles traveling the road.

Moreover, to retain the quality ratings when addressing a group of unpaved roads, it is necessary that reliable correction parameter values be determined for the road in question. The field and laboratory procedures for determining road surface silt and moisture contents are given in AP-42 Appendices C.1 and C.2. Vehicle-related parameters should be developed by recording visual observations of traffic. In some cases, vehicle parameters for industrial unpaved roads can be determined by reviewing maintenance records or other information sources at the facility.

In the event that site-specific values for correction parameters cannot be obtained, then default values may be used.In the absence of site-specific silt content information, an appropriate mean value from Table 13.2.2-1 may be used as a default value, but the quality rating of the equation is reduced by two letters. Because of significant differences found between different types of road surfaces and between different areas of the country, use of the default moisture content value of 0.5 percent in Equation 1b is discouraged. The quality rating should be downgraded two letters when the default moisture content value is used. (It is assumed that readers addressing industrial roads have access to the information needed to develop average vehicle information in Equation 1a for their facility.)

The effect of routine watering to control emissions from unpaved roads is discussed below in Section 13.2.2.3, “Controls”. However, all roads are subject to some natural mitigation because of rainfall and other precipitation. The Equation 1a and 1b emission factors can be extrapolated to annual average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm [0.01 inch]) precipitation:

$$E_{ext} = E\ [(365 - P)/365] \tag{2}$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor from Equation 1a or 1b

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation (see below)

Figure 13.2.2-1 gives the geographical distribution for the mean annual number of "wet" days for the United States.

Equation 2 provides an estimate that accounts for precipitation on an annual average basis for the purpose of inventorying emissions. It should be noted that Equation 2 does not account for differences in the temporal distributions of the rain events, the quantity of rain during any event, or the potential for the rain to evaporate from the road surface. In the event that a finer temporal and spatial resolution is desired for inventories of public unpaved roads, estimates can be based on a more complex set of assumptions. These assumptions include:

1. The moisture content of the road surface material is increased in proportion to the quantity of water added;
2. The moisture content of the road surface material is reduced in proportion to the Class A pan evaporation rate;
3. The moisture content of the road surface material is reduced in proportion to the traffic volume; and
4. The moisture content of the road surface material varies between the extremes observed in the area. The CHIEF Web site (http://www.epa.gov/ttn/chief/ap42/ch13/related/c13s02-2.html) has a file which contains a spreadsheet program for calculating emission factors which are temporally and spatially resolved. Information required for use of the spreadsheet program includes monthly Class A pan evaporation values, hourly meteorological data for precipitation, humidity and snow cover, vehicle traffic information, and road surface material information.

It is emphasized that <u>the simple assumption underlying Equation 2 and the more complex set of assumptions underlying the use of the procedure which produces a finer temporal and spatial resolution</u> have not been verified in any rigorous manner. For this reason, the quality ratings for either approach should be downgraded one letter from the rating that would be applied to Equation 1.

13.2.2.3 Controls[18-22]

A wide variety of options exist to control emissions from unpaved roads. Options fall into the following three groupings:

1. <u>Vehicle restrictions</u> that limit the speed, weight or number of vehicles on the road;

2. Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and

3. Surface treatment, such as watering or treatment with chemical dust suppressants.

Available control options span broad ranges in terms of cost, efficiency, and applicability. For example, traffic controls provide moderate emission reductions (often at little cost) but are difficult to enforce. Although paving is highly effective, its high initial cost is often prohibitive. Furthermore, paving is not feasible for industrial roads subject to very heavy vehicles and/or spillage of material in transport. Watering and chemical suppressants, on the other hand, are potentially applicable to most industrial roads at moderate to low costs. However, these require frequent reapplication to maintain an acceptable level of control. Chemical suppressants are generally more cost-effective than water but not in cases of temporary roads (which are common at mines, landfills, and construction sites). In summary, then, one needs to consider not only the type and volume of traffic on the road but also how long the road will be in service when developing control plans.

Vehicle restrictions. These measures seek to limit the amount and type of traffic present on the road or to lower the mean vehicle speed. For example, many industrial plants have restricted employees from driving on plant property and have instead instituted bussing programs. This eliminates emissions due to employees traveling to/from their worksites. Although the heavier average vehicle weight of the busses increases the base emission factor, the decrease in vehicle-miles-traveled results in a lower overall emission rate.

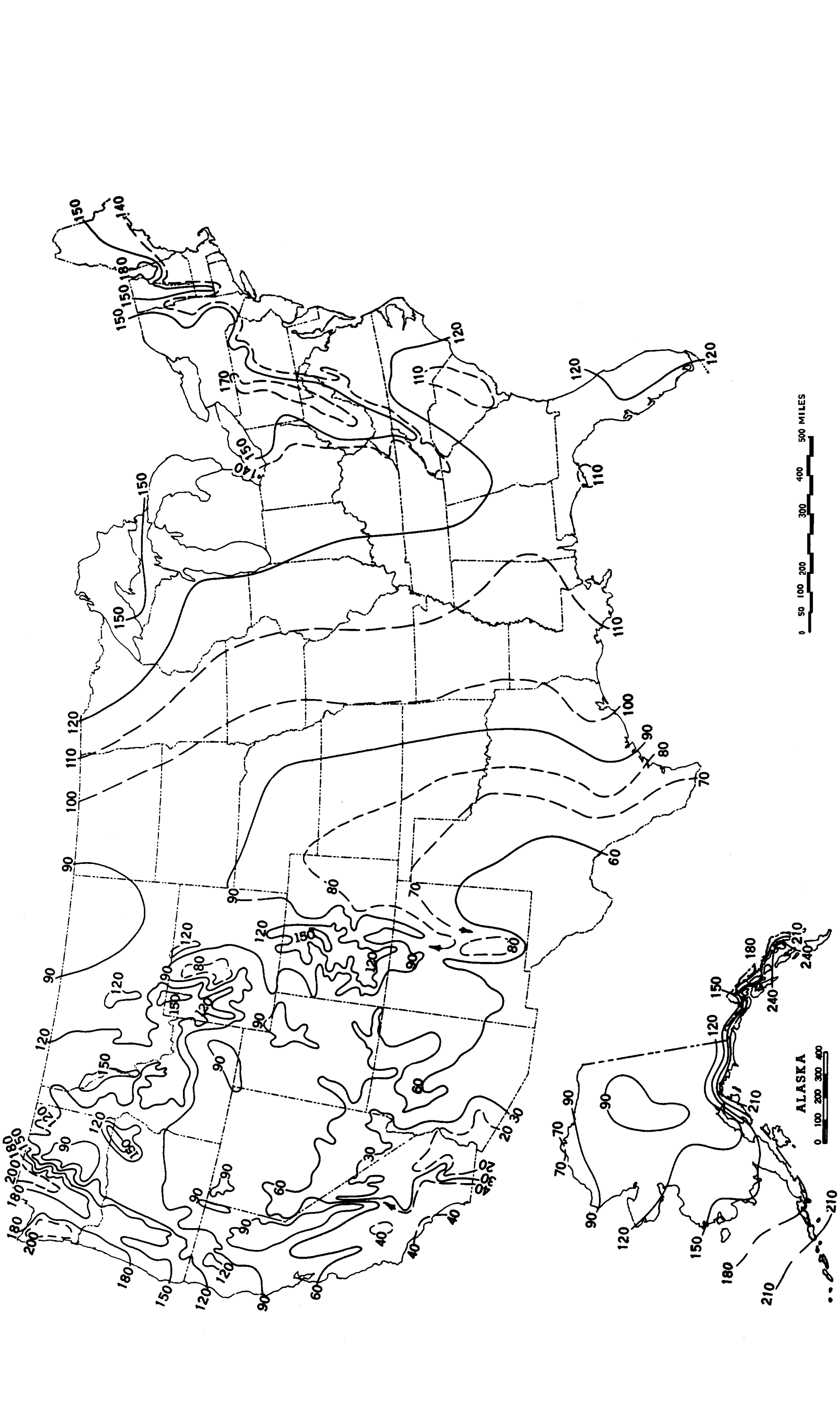

Figure 13.2.2-1. Mean number of days with 0.01 inch or more of precipitation in United States.

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DEPARTMENT ACCEPTED VALUES FOR:
AGGREGATE HANDLING, STORAGE PILE, and HAUL ROAD EMISSIONS

TO: Applicants and Air Quality Bureau Permitting Staff

SUBJECT: Department accepted default values for percent silt, wind speed, moisture content, and control efficiencies for haul road control measures

This guidance document provides the Department accepted default values for correction parameters in the emission calculation equations for aggregate handling and storage piles emissions in construction permit applications and notices of intent submitted under 20.2.72 and 20.2.73 NMAC; and the Department accepted control efficiencies for haul road control measures for applications submitted under 20.2.72 NMAC.

Aggregate Handling and Storage Pile Emission Calculations

Applicants should calculate the particulate matter emissions from aggregate handling and storage piles using the EPA's AP-42 Chapter 13.2.4.
http://www3.epa.gov/ttn/chief/ap42/ch13/final/c13s0204.pdf

Equation 1 from Chapter 13.2.4 requires users to input values for two correction parameters, U and M, where U = mean wind speed and M = material moisture content. Below are the accepted values for U and M:

Default Values for Chapter 13.2.4, Equation 1:

Parameter	Default Value
U = Mean wind speed (miles per hour)	11 mph
M = Material moisture content (% water)	2%

Applicants must receive preapproval from the Department if they wish to assume a higher moisture content and/or a lower wind speed in these calculations. Higher moisture contents may require site specific testing either as a permit condition or submitted with the application. Applicants may assume higher wind speeds and lower percent moisture content in their calculations without prior approval from the Department.

Haul Road Emissions and Control Measure Efficiencies

Applicants should calculate the particulate matter emissions from unpaved haul roads using the EPA's AP-42 Chapter 13.2.2. http://www3.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf

Equation 1(a) from Chapter 13.2.2 requires users to input values for two correction parameters, s and W, where s = surface material silt content (%) and W = mean vehicle weight (tons). The applicant should calculate the mean vehicle weight in accordance with the chapter's instructions. Below is the accepted value for the parameter s:

Default Values for Chapter 13.2.2, Equation 1(a):

Parameter	Default Value
s = surface material silt content (%)	4.8%

Applicants may use a higher silt content without prior approval from the Department. Use of a lower silt content requires prior approval from the Department and may require site specific testing in support of the request.

Equation 2 from Chapter 13.2.2 allows users to take credit for the number of days that receive precipitation in excess of 0.01 inches, in the annual emissions calculation, where P = number of days in a year with at least 0.01 inches of precipitation.

Default Values for Chapter 13.2.2, Equation 2:

Parameter	Default Value
P = number of days in a year with at least 0.01 inches of precipitation	70 days

Applications submitted under Part 72 may request to apply control measures to reduce the particulate matter emissions from facility haul roads. Applications submitted under Part 73 may not consider any emission reduction from control measures in the potential emission rate calculation, as registrations issued under Part 73 are not federally enforceable under the Clean Air Act or the New Mexico Air Quality Control Act. In order for those control measures to be federally enforceable, the controls must be a requirement in an air quality permit.

Below are the Department accepted control efficiencies for various haul road control measures:

Haul Road Control Measures and Control Efficiency:

Control Measure	Control Efficiency
None	0%
Base course **or** watering	60%
Base course **and** watering	80%
Base course **and** surfactant	90%
Paved **and** Swept	95%

WRAP Fugitive Dust Handbook

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(WGA Contract No. 30204-111)

September 7, 2006

Fugitive Dust Control Measures Applicable for the WRAP Region

Source Category	Control Measure	Published PM10 Control Efficiency
Agricultural Tilling	Reduce tilling during high winds	1 – 5%
	Roughen surface	15 – 64%
	Modify equipment	50%
	Employ sequential cropping	50%
	Increase soil moisture	90%
	Use other conservation management practices	25 - 100%
Agricultural Harvesting	Limited activity during high winds	5 – 70%
	Modify equipment	50%
	Night farming	10%
	New techniques for drying fruit	25 –60%
Construction/Demolition	Water unpaved surfaces	10 – 74%
	Limit on-site vehicle speed to 15 mph	57%
	Apply dust suppressant to unpaved areas	84%
	Prohibit activities during high winds	98%
Materials Handling	Implement wet suppression	50 – 90%
	Erect 3-sided enclosure around storage piles	75%
	Cover storage pile with a tarp during high winds	90%
Paved Roads	Sweep streets	4 – 26%
	Minimize trackout	40 – 80%
	Remove deposits on road ASAP	> 90%
Unpaved Roads	Limit vehicle speed to 25 mph	44%
	Apply water	10 – 74%
	Apply dust suppressant	84%
	Pave the surface	>90%
Mineral Products Industry	Cyclone or muliclone	68 –79%
	Wet scrubber	78 –98%
	Fabric filter	99 – 99.8%
	Electrostatic precipitator	90 – 99.5%
Abrasive Blasting	Water spray	50 – 93%
	Fabric filter	> 95%
Livestock Husbandry	Daily watering of corrals and pens	> 10%
	Add wood chips or mulch to working pens	> 10%
Wind Erosion (agricultural, open area, and storage piles)	Plant trees or shrubs as a windbreak	25%
	Create cross-wind ridges	24 – 93%
	Erect artificial wind barriers	4 – 88%
	Apply dust suppressant or gravel	84%
	Revegetate; apply cover crop	90%
	Water exposed area before high winds	90%

Section 7

Information Used to Determine Emissions

Gasoline Dispensing Facilities (GDF1 and GDF2)

- AP-42 Chapter 7, Sections 7.1.1, 7.1.2, and 7.1.3.1
- EPA's SPECIATE 5.0 database profiles for HAP data source

Table of Contents

7.1 Organic Liquid Storage Tanks

7.1.1 General

7.1.1.1 Scope

Section 7.1 presents emissions estimating methodologies for storage tanks of various types and operating conditions. The methodologies are intended for storage tanks that are properly maintained and in normal working condition. The methodologies do not address conditions of deteriorated or otherwise damaged materials of construction, nor do they address operating conditions that differ significantly from the scenarios described herein. To estimate losses that occur from underground gasoline storage tanks at service stations, please see AP-42 Section 5.2, "Transportation and Marketing of Petroleum Liquids."

Sections 7.1.3.1 and 7.1.3.2 present emissions estimating methodologies for routine emissions from fixed roof tanks and floating roof tanks. Use of the terminology "routine emissions" to refer to standing and working losses applies only for the purposes of this document, and not for any other air quality purposes such as New Source Review (NSR) permitting. The equations for routine emissions were developed to estimate average annual losses for storage tanks, but provisions for applying the equations to shorter periods of time are addressed in Section 7.1.3.8.1. The equations for routine emissions are a function of temperatures that are derived from a theoretical energy transfer model. In order to simplify the calculations, default values were assigned to certain parameters in the energy transfer equations. The accuracy of the resultant equations for an individual tank depends upon how closely that tank fits the assumptions inherent to these default values. The associated uncertainty may be mitigated by using measured values for the liquid bulk temperature. The equations for routine emissions are not intended to include emissions from the following events (these are addressed separately):

a) To estimate losses that result from the landing of a floating roof. A separate methodology is presented for floating roof landing losses in Section 7.1.3.3.

b) To estimate losses that result from cleaning a tank. A separate methodology is presented for tank cleaning losses in Section 7.1.3.4.

c) To estimate losses from variable vapor space tanks. Variable vapor space tanks are discussed in Section 7.1.3.6.

d) To estimate losses from equipment leaks associated with pressure tanks designed as closed systems without emissions to the atmosphere. Pressure tanks are discussed in Section 7.1.3.7.

Section 7.1.3.8 addresses the following additional scenarios that are outside the scope of the methodologies for routine emissions presented in Sections 7.1.3.1 and 7.1.3.2.

e) Time periods shorter than one year. Certain assumptions in the equations for routine emissions are based on annual averages, and thus the equations have greater uncertainty for a period of time less than a year. Section 7.1.3.8.1 addresses application of the equations to time periods shorter than one year, with the caveat that a one-month time frame is recommended as the shortest time period for which routine emissions should be estimated using these methodologies.

f) Internal floating roof tanks with closed vent systems. The equations for routine emissions from internal floating roof tanks assume that the tank has open vents in the fixed roof.

Section 7.1.3.8.2 addresses estimation of emissions when an internal floating roof tank has closed pressure/vacuum vents.

g) Case-specific liquid surface temperature determination. Several parameters pertaining to liquid surface temperature are assigned default values for incorporation into the equations for routine emissions. Section 7.1.3.8.3 presents methodology to account for these parameters as variables in the estimation of emissions from a particular storage tank at a particular location.

h) Heating cycles in fixed roof tanks. The equations for standing loss from fixed roof tanks are based on a daily cycle of warming and cooling of the vapor space due to heat exchange between the vapor space and ambient air through the shell and roof of the tank. This heat exchange results in daytime expansion and nighttime contraction of vapors in the vapor space, with each expansion causing some portion of the vapors to be expelled from the vapor space. A similar cycle of expansion and contraction of the vapors may be driven by cyclic heating of the bulk liquid. Section 7.1.3.8.4 provides guidance for adapting the equations for fixed roof tank standing loss to the case of cyclic heating of the bulk liquid.

Section 7.1.4 presents calculations for applying Raoult's Law to calculate the contribution of individual chemical species to the total emissions.

Section 7.1.5 presents worked examples, with estimated emissions shown to two significant figures. This level of precision is chosen arbitrarily and may overstate the accuracy of the loss estimates given the uncertainty associated with the multiple parameters affecting emissions from storage tanks.

Section 7.1.6 contains equations that have been used historically to obtain approximate values, but which have been replaced with more accurate equations.

7.1.1.2 Process Description[1-3]

Storage tanks 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.

Six basic types of designs are used for organic liquid storage tanks: fixed roof (vertical and horizontal), external floating roof, domed external (or covered) floating roof, internal floating roof, variable vapor space, and pressure (low and high). A brief description of each tank is provided below. Loss mechanisms associated with each type of tank are described in Section 7.1.2.

The emission estimating equations presented in Section 7.1 were developed by the American Petroleum Institute (API). API retains the copyright to these equations. API has granted permission for the nonexclusive; noncommercial distribution of this material to governmental and regulatory agencies. However, API reserves its rights regarding all commercial duplication and distribution of its material. Therefore, the material presented in Section 7.1 is available for public use, but the material cannot be sold without written permission from the American Petroleum Institute and the U. S. Environmental Protection Agency.

7.1.1.2.1 Fixed Roof Tanks

A typical vertical fixed roof tank is shown in Figure 7.1-1. 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. Losses from fixed roof tanks are caused by changes in temperature, pressure, and liquid level.

Fixed roof tanks are either freely vented or equipped with a pressure/vacuum vent. The latter allows the tanks to operate at a slight internal pressure or vacuum to prevent the release of vapors during small changes in temperature, pressure, or liquid level. Fixed roof tanks may have additional vents or hatches, referred to as emergency vents, to provide increased vent flow capacity in the event of excessive pressure in the tank. Of current tank designs, the fixed roof tank is the least expensive to construct and is generally considered the minimum acceptable equipment for storing organic liquids.

Horizontal fixed roof tanks are constructed for both above-ground and underground service and are usually constructed of steel, steel with a fiberglass overlay, or fiberglass-reinforced polyester. Horizontal tanks are generally small storage tanks with capacities of less than 40,000 gallons. Horizontal tanks are constructed such that the length of the tank is not greater than six times the diameter to ensure structural integrity. Horizontal tanks are usually equipped with pressure-vacuum vents, gauge hatches and sample wells, and manholes to provide access.

The potential emission sources for above-ground horizontal tanks are the same as those for vertical fixed roof tanks. Emissions from underground storage tanks are associated mainly with changes in the liquid level in the tank. Losses due to changes in temperature or barometric pressure are minimal for underground tanks because the surrounding earth limits the diurnal temperature change, and changes in the barometric pressure result in only small losses. However, standing losses from underground gasoline tanks, which can experience relatively fast vapor growth after the ingestion of air and dilution of the headspace, are addressed in Section 5.2 of AP-42.

7.1.1.2.2 External Floating Roof Tanks

A typical external floating roof tank (EFRT) consists of an open-top cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid. The floating roof consists of a deck, deck fittings, and a rim seal system. Floating decks that are currently in use are constructed of welded steel plate and are most commonly of two general types: pontoon or double-deck. Pontoon-type and double-deck-type external floating roof tanks are shown in Figures 7.1-2 and 7.1-3, respectively. With all types of external floating roof tanks, the roof rises and falls with the liquid level in the tank. External floating decks are equipped with a rim seal system, which is attached to the deck perimeter and contacts the tank wall. The purpose of the floating roof and rim seal system is to reduce evaporative loss of the stored liquid. Some annular space remains between the seal system and the tank wall. The seal system slides against the tank wall as the roof is raised and lowered. The floating deck is also equipped with deck fittings that penetrate the deck and serve operational functions. The external floating roof design is such that routine evaporative losses from the stored liquid are limited to losses from the rim seal system and deck fittings (standing loss) and any liquid on the tank walls that is exposed by the lowering of the liquid level associated with the withdrawal of liquid (working loss). Because of the open-top configuration of this tank, wind effects have a significant impact on evaporative losses from this type of tank.

7.1.1.2.3 Internal Floating Roof Tanks

An internal floating roof tank (IFRT) has both a permanent fixed roof and a floating roof inside. 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 use a floating roof are typically of the first type. External floating roof tanks that have been converted to internal floating roof tanks typically have a self-supporting roof. Newly constructed internal floating roof tanks may be of either type. The deck in internal floating roof tanks 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 majority of aluminum internal floating roofs currently in service have noncontact decks. A typical internal floating roof tank is shown in Figure 7.1-4.

Contact decks include (1) aluminum sandwich panels that are bolted together, with a honeycomb aluminum core floating in contact with the liquid; (2) pan steel decks floating in contact with the liquid, with or without pontoons; and (3) resin-coated, fiberglass reinforced polyester (FRP), buoyant panels floating in contact with the liquid. Variations on these designs are also available. The majority of internal contact floating decks currently in service are aluminum sandwich panel-type or pan steel-type. The FRP decks are less common. The panels of pan steel decks are usually welded together.

Noncontact decks are the most common type currently in use. Typical noncontact decks are constructed of an aluminum deck and an aluminum grid framework supported above the liquid surface by tubular aluminum pontoons or some other buoyant structure. The noncontact decks usually have bolted deck seams.

Installing a floating roof minimizes evaporative losses of the stored liquid. Both contact and noncontact decks incorporate rim seals and deck fittings for the same purposes previously described for external floating roof tanks. Evaporative losses from floating roofs may come from deck fittings, nonwelded deck seams, and the annular space between the deck and tank wall. 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 the tank vapor space in concentrations approaching the flammable range. An internal floating roof tank not freely vented is considered an internal floating roof tank with a closed vent system. Emission estimation methods for such tanks are addressed in Section 7.1.3.8.2.

7.1.1.2.4 Domed External Floating Roof Tanks

Domed external (or covered) floating roof tanks have the heavier type of deck used in external floating roof tanks as well as a fixed roof at the top of the shell like internal floating roof tanks. Domed external floating roof tanks usually result from retrofitting an external floating roof tank with a fixed roof. This type of tank is very similar to an internal floating roof tank with a welded deck and a self-supporting fixed roof. A typical domed external floating roof tank is shown in Figure 7.1-5.

As with the internal floating roof tanks, the function of the fixed roof with respect to emissions is not to act as a vapor barrier, but to block the wind. The estimations of rim seal losses and deck fitting losses include a loss component that is dependent on wind speed and a loss component that is independent of wind speed. When a tank is equipped with a fixed roof, the wind-dependent component is zero due to the blocking of the wind by the fixed roof, leaving only the wind-independent loss component.

The type of fixed roof most commonly used is a self-supporting aluminum dome roof, which is of bolted construction. Like the internal floating roof tanks, these tanks are freely vented by circulation vents at the top and around the perimeter of the fixed roof. The deck fittings and rim seals, however, are identical to those on external floating roof tanks. In the event that the floating deck is replaced with the lighter IFRT-type deck, the tank would then be considered an internal floating roof tank.

The distinction between a domed external floating roof tank and an internal floating roof tank is primarily for purposes of recognizing differences in the deck fittings when estimating emissions. In particular, the domed external floating roof deck typically has significantly taller leg sleeves than are typical of an internal floating roof deck. The longer leg sleeves of the domed external floating roof deck have lower associated emissions than the shorter leg sleeves of the internal floating roof deck. While a domed external floating roof tank is distinct from an internal floating roof tank for purposes of estimating emissions, the domed external floating roof tank would be deemed a type of internal floating roof tank under air regulations that do not separately specify requirements for a domed external floating roof tank.

7.1.1.2.5 Variable Vapor Space Tanks

Variable vapor space tanks are equipped with expandable vapor reservoirs to accommodate 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. A variable vapor space tank that utilizes a flexible diaphragm will emit standing losses to the extent that the flexible diaphragm is permeable or there is leakage through the seam where the flexible diaphragm is attached to the tank wall.

A variable vapor space tank will emit vapors during tank filling when vapor is displaced by liquid, if the tank's vapor storage capacity is exceeded.

7.1.1.2.6 Pressure Tanks

Two classes of pressure tanks are in general use: low pressure (2.5 to 15 psig) and high pressure (higher than 15 psig). Pressure tanks generally are used for storing organic liquids and gases with high vapor pressures and are found in many sizes and shapes, depending on the operating pressure of the tank. Low-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. Vapor losses from low-pressure tanks storing non-boiling liquids are estimated in the same manner as for fixed roof tanks, with the vent set pressure accounted for in both the standing and working loss equations.

7.1.2 Emission Mechanisms And Control[2-8]

Emissions from the storage of organic liquids occur because of evaporative loss of the liquid during its storage and as a result of changes in the liquid level. The emission mechanisms vary with tank design, as does the relative contribution of each type of emission mechanism. Emissions from fixed roof tanks are a result of evaporative losses during storage (known as breathing losses or standing losses) and evaporative losses during filling operations (known as working losses). External and internal floating roof tanks are emission sources because of evaporative losses that occur during standing storage and withdrawal of liquid from the tank. Standing losses are a result of evaporative losses through rim seals, deck fittings, and/or deck seams. The loss mechanisms for routine emissions from fixed roof and external and internal floating roof tanks are described in more detail in this section.

7.1.2.1 Fixed Roof Tanks

The two significant types of routine emissions from fixed roof tanks are standing and working losses. The standing loss mechanism for a fixed roof tank is known as breathing, which is the expulsion of vapor from a tank through vapor expansion and contraction that results from changes in temperature and barometric pressure. This loss occurs without any liquid level change in the tank. The emissions estimating methodology presented in Section 7.1 assumes the barometric pressure to be constant, and standing losses from fixed roof tanks are attributed only to changes in temperature. As vapors expand in the vapor space due to warming, the pressure of the vapor space increases and expels vapors from the tank through the vent(s) on the fixed roof. If the venting is of a type that is closed in the absence of pressure, such as a weighted-pallet pressure-vacuum vent, then vapors are assumed to not be expelled until the pressure in the vapor space exceeds the set pressure of the vent.

The evaporative loss from filling is called working loss. Emissions due to filling operations are the result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the vapor space increases and vapors are expelled from the tank through the vent(s) on the fixed roof as described above for standing loss. No emissions are attributed to emptying, in that the increasing size of the vapor space during emptying is assumed to exceed the rate at which evaporation increases the volume of vapors. That is, it would be expected that flow through the vents during emptying would be into the tank, and thus there are no emissions actually occurring during emptying of a fixed roof tank.

A third type of emissions from fixed roof tanks is commonly referred to as flashing losses. This emission type is not an evaporative loss, but rather involves entrained gases bubbling out of solution when a liquid stream experiences a pressure drop upon introduction into a storage tank. As such, it occurs only in storage tanks that receive pressurized liquid streams containing entrained gases. This scenario is typical of storage tanks receiving liquids from a separator in oil and gas production operations, but does not typically occur at downstream facilities. Flashing losses are discussed in Section 7.1.3.5, but guidance for estimating flashing losses is beyond the scope of this section.

Fixed roof tank emissions from standing and working vary as a function of tank capacity, vapor pressure of the stored liquid, utilization rate of the tank, and atmospheric conditions at the tank location.

Several methods are used to control emissions from fixed roof tanks. Emissions from fixed roof tanks can be controlled by installing 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.

Fixed roof tank emissions may also be reduced by increasing the vent set pressure, and routine emissions may be eliminated if the vent set pressure is higher than the pressure that develops in the vapor space during normal operations. See Section 7.1.3.7 for a discussion of estimating emissions from pressure tanks. However, the structural design of most storage tanks would not normally accommodate internal pressures of the magnitude required to significantly reduce emissions, and thus vent set pressures should not be altered without consideration of the tank design including all appropriate safety factors. Subjecting a storage tank to greater pressure or vacuum than that for which the tank was designed could potentially result in failure of the tank.

Vapor balancing is another means of emission control. Vapor balancing is probably most common in the filling of tanks at gasoline service stations. As the storage tank is filled, the vapors expelled from the storage tank are directed to the emptying gasoline tanker truck. The truck then transports the vapors to a centralized station where a vapor recovery or control system may be used to control emissions. Vapor balancing can have control efficiencies as high as 90 to 98 percent if the vapors are subjected to vapor recovery or control. If the truck vents the vapor to the atmosphere instead of to a recovery or control system, no control is achieved.

Vapor recovery systems collect emissions from storage tanks and convert 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.

Vapors from fixed roof tanks may also be collected and combusted. There are several types of units at facilities used to accomplish this, including various types of flares and thermal oxidation units.

7.1.2.2 Floating Roof Tanks

Routine emissions from floating roof tanks are the sum of working losses and standing losses. The working loss mechanism for a floating roof tank is also known as withdrawal loss, in that it occurs as the liquid level, and thus the floating roof, is lowered rather than raised. Some liquid remains on the inner tank wall surface and evaporates. For an internal floating roof tank that has a column supported fixed roof, some liquid also clings to the columns and evaporates. Evaporative loss occurs until the tank is filled and the exposed surfaces are again covered. Standing losses from floating roof tanks include rim seal and deck fitting losses for floating roof tanks with welded decks and include deck seam losses for constructions other than welded decks. Both the working and standing loss mechanisms for floating roof tanks pertain to the accumulation of vapors in the headspace above the floating roof. It is assumed that vapors in the headspace will eventually be expelled from the tank, but this emission estimating methodology does not address the rate or time at which the vapors actually leave the tank.

Rim seal losses can occur through many complex mechanisms, but for external floating roof tanks, the majority of rim seal vapor losses have been found to be wind induced. No dominant wind loss mechanism has been identified for internal floating roof or domed external floating roof tank rim seal losses. Losses can also occur due to permeation of the rim seal material by the vapor or via a wicking effect of the liquid, but permeation of the rim seal material generally does not occur if the correct seal fabric is used. Testing has indicated that breathing, solubility, and wicking loss mechanisms are small in comparison to the wind-induced loss. The rim seal factors presented in this section incorporate all types of losses.

The rim seal system is used to allow the floating roof to rise and fall within the tank as the liquid level changes. The rim seal system also helps to fill the annular space between the rim and the tank shell and therefore minimize evaporative losses from this area. A rim seal system may consist of just a primary seal or a primary and a secondary seal, which is mounted above the primary seal. Examples of primary and secondary seal configurations are shown in Figures 7.1-6, 7.1-7, and 7.1-8.

The primary seal serves as a vapor conservation device by closing the annular space between the edge of the floating deck and the tank wall. Three basic types of primary seals are used on floating roofs: mechanical (metallic) shoe, resilient filled (nonmetallic), and flexible wiper seals. Some primary seals on external floating roof tanks are protected by a weather shield. Weather shields may be of metallic, elastomeric, or composite construction and provide the primary seal with longer life by protecting the primary seal fabric from deterioration due to exposure to weather, debris, and sunlight. Mechanical shoe seals, resilient filled seals, and wiper seals are discussed below.

A mechanical shoe seal uses a light-gauge metallic band as the sliding contact with the shell of the tank, as shown in Figure 7.1-7. The band is formed as a series of sheets (shoes) which are joined together to form a ring and are held against the tank shell by a mechanical device. The shoes are normally 3 to 5 feet deep when used on an external floating roof and are often shorter when used on an internal floating roof. Expansion and contraction of the ring can be provided for as the ring passes over shell irregularities or rivets by jointing narrow pieces of fabric into the ring or by crimping the shoes at intervals. The bottoms of the shoes extend below the liquid surface to confine the rim vapor space between the shoe and the floating deck.

The rim vapor space, which is bounded by the shoe, the rim of the floating deck, and the liquid surface, is sealed from the atmosphere by bolting or clamping a coated fabric, called the primary seal fabric, which extends from the shoe to the rim to form an "envelope". Two locations are used for attaching the primary seal fabric. The fabric is most commonly attached to the top of the shoe and the rim of the floating deck. To reduce the rim vapor space, the fabric can be attached to the shoe and the floating deck rim near the liquid surface. Rim vents can be used to relieve any excess pressure or vacuum in the vapor space.

A resilient filled seal can be mounted to eliminate the vapor space between the rim seal and liquid surface (liquid mounted) or to allow a vapor space between the rim seal and the liquid surface (vapor mounted). Both configurations are shown in Figures 7.1-6 and 7.1-7. Resilient filled seals work because of the expansion and contraction of a resilient material to maintain contact with the tank shell while accommodating varying annular rim space widths. These rim seals allow the roof to move up and down freely, without binding.

Resilient filled seals typically consist of a core of open-cell foam encapsulated in a coated fabric. The seals are attached to a mounting on the deck perimeter and extend around the deck circumference. Polyurethane-coated nylon fabric and polyurethane foam are commonly used materials. For emission control, it is important that the attachment of the seal to the deck and the radial seal joints be vapor-tight and that the seal be in substantial contact with the tank shell.

Wiper seals generally consist of a continuous annular blade of flexible material fastened to a mounting bracket on the deck perimeter that spans the annular rim space and contacts the tank shell. This type of seal is depicted in Figure 7.1-6. New tanks with wiper seals may have dual wipers, one mounted above the other. The mounting is such that the blade is flexed, and its elasticity provides a sealing pressure against the tank shell.

Wiper seals are vapor mounted; a vapor space exists between the liquid stock and the bottom of the seal. For emission control, it is important that the mounting be vapor-tight, that the seal extend around the circumference of the deck and that the blade be in substantial contact with the tank shell. Two types of materials are commonly used to make the wipers. One type consists of a cellular, elastomeric material tapered in cross section with the thicker portion at the mounting. Rubber is a commonly used material; urethane and cellular plastic are also available. All radial joints in the blade are joined. The second type of material that can be used is a foam core wrapped with a coated fabric. Polyurethane on nylon fabric and polyurethane foam are common materials. The core provides the flexibility and support, while the fabric provides the vapor barrier and wear surface.

A secondary seal may be used to provide some additional evaporative loss control over that achieved by the primary seal. Secondary seals can be either flexible wiper seals or resilient filled seals. For mechanical shoe primary seals, two configurations of secondary seals are available: shoe mounted and rim mounted, as shown in Figure 7.1-8. Rim mounted secondary seals are more effective in reducing losses than shoe mounted secondary seals because they cover the entire rim vapor space. For internal floating roof tanks, the secondary seal is mounted to an extended vertical rim plate, above the primary seal, as shown in Figure 7.1-8. However, for some floating roof tanks, using a secondary seal further limits the tank's operating capacity due to the need to keep the seal from interfering with fixed roof rafters or to keep the secondary seal in contact with the tank shell when the tank is filled.

The deck fitting losses from floating roof tanks can be explained by the same mechanisms as the rim seal losses. While the relative contribution of each mechanism to the total emissions from a given deck fitting is not known, emission factors were developed for individual deck fittings by testing, thereby accounting for the combined effect of all of the mechanisms.

Numerous fittings pass through or are attached to floating roof decks to accommodate structural support components or allow for operational functions. Internal floating roof deck fittings are typically of different configuration than those for external floating roof decks. Rather than having tall housings to avoid rainwater entry, internal floating roof deck fittings tend to have lower profile housings to minimize the potential for the fitting to contact the fixed roof when the tank is filled. Deck fittings can be a source of evaporative loss when they require openings in the deck. The most common components that require openings in the deck are described below.

1. Access hatches. An access hatch is an opening in the deck with a peripheral vertical well that is large enough to provide passage for workers and materials through the deck for construction or servicing. Attached to the opening is a removable cover that may be bolted and/or gasketed to reduce evaporative loss. On internal floating roof tanks with noncontact decks, the well should extend down into the liquid to seal off the vapor space below the noncontact deck. A typical access hatch is shown in Figure 7.1-9.

2. Gauge-floats. A gauge-float is used to indicate the level of liquid within the tank. The float rests on the liquid surface and is housed inside a well that is closed by a cover. The cover may be bolted

and/or gasketed to reduce evaporation loss. As with other similar deck penetrations, the well extends down into the liquid on noncontact decks in internal floating roof tanks. A typical gauge-float and well are shown in Figure 7.1-9.

3. Gauge-hatch/sample ports. A gauge-hatch/sample port consists of a pipe sleeve through the deck for hand-gauging or sampling of the stored liquid. The gauge-hatch/sample port is usually located beneath the gauger's platform, which is mounted on top of the tank shell. A cover may be attached to the top of the opening, and the cover may be equipped with a gasket to reduce evaporative losses. A cord may be attached to the cover so that the cover can be opened from the platform. Alternatively, the opening may be covered with a slit-fabric seal. A funnel may be mounted above the opening to guide a sampling device or gauge stick through the opening. A typical gauge-hatch/sample port is shown in Figure 7.1-9.

4. Rim vents. Rim vents are used on tanks equipped with a seal design that creates a vapor pocket in the seal and rim area, such as a mechanical shoe seal. A typical rim vent is shown in Figure 7.1-10. The vent is used to release any excess pressure that is present in the vapor space bounded by the primary-seal shoe and the floating roof rim and the primary seal fabric and the liquid level. Rim vents usually consist of weighted pallets that rest over the vent opening.

5. Deck drains. Currently two types of deck drains are in use (closed and open deck drains) to remove rainwater from the floating deck. Open deck drains can be either flush or overflow drains. Both types of open deck drains consist of a pipe that extends below the deck to allow the rainwater to drain into the stored liquid. Only open deck drains are subject to evaporative loss. Flush drains are flush with the deck surface. Overflow drains are elevated above the deck surface. Typical overflow and flush deck drains are shown in Figure 7.1-10. Overflow drains are used to limit the maximum amount of rainwater that can accumulate on the floating deck, providing emergency drainage of rainwater if necessary. Closed deck drains carry rainwater from the surface of the deck though a flexible hose or some other type of piping system that runs through the stored liquid prior to exiting the tank. The rainwater does not come in contact with the liquid, so no evaporative losses result. Overflow drains are usually used in conjunction with a closed drain system to carry rainwater outside the tank.

6. Deck legs. Deck legs are used to prevent damage to fittings underneath the deck and to allow for tank cleaning or repair, by holding the deck at a predetermined distance off the tank bottom. These supports consist of adjustable or fixed legs attached to the floating deck or hangers suspended from the fixed roof. For adjustable legs or hangers, the load-carrying element may pass through a well or sleeve into the deck. With noncontact decks, the well should extend into the liquid. Evaporative losses may occur in the annulus between the deck leg and its sleeve. A typical deck leg is shown in Figure 7.1-10.

7. Unslotted guidepoles and wells. A guidepole is an antirotational device that is fixed to the top and bottom of the tank, passing through a well in the floating roof. The guidepole is used to prevent adverse movement of the roof and thus damage to deck fittings and the rim seal system. In some cases, an unslotted guidepole is used for gauging purposes, but there is a potential for differences in the pressure, level, and composition of the liquid inside and outside of the guidepole. A typical guidepole and well are shown in Figure 7.1-11.

8. Slotted (perforated) guidepoles and wells. The function of the slotted guidepole is similar to the unslotted guidepole but also has additional features. Perforated guidepoles can be either slotted or drilled hole guidepoles. A typical slotted guidepole and well are shown in Figure 7.1-11. As shown in this figure,

the guide pole is slotted to allow stored liquid to enter. The same can be accomplished with drilled holes. The liquid entering the guidepole has the same composition as the remainder of the stored liquid,and is at the same liquid level as the liquid in the tank. Representative samples can therefore be collected from the slotted or drilled hole guidepole. Evaporative loss from the guidepole can be reduced by some combination of modifying the guidepole or well with the addition of gaskets, sleeves, or enclosures or placing a float inside the guidepole, as shown in Figures 7.1-11 and 7.1-22. Guidepoles are also referred to as gauge poles, gauge pipes, or stilling wells.

9. Vacuum breakers. A vacuum breaker equalizes the pressure of the vapor space across the deck as the deck is either being landed on or floated off its legs. A typical vacuum breaker is shown in Figure 7.1-10. As depicted in this figure, the vacuum breaker consists of a well with a cover. Attached to the underside of the cover is a guided leg long enough to contact the tank bottom as the floating deck approaches. When in contact with the tank bottom, the guided leg mechanically opens the breaker by lifting the cover off the well; otherwise, the cover closes the well. The closure may be gasketed or ungasketed. Because the purpose of the vacuum breaker is to allow the free exchange of air and/or vapor, the well does not extend appreciably below the deck. While vacuum breakers have historically tended to be of the leg-actuated design described above, they may also be vacuum actuated similar to the pressure/vacuum vent on a fixed roof tank such that they do not begin to open until the floating roof has actually landed. In some cases, this is achieved by replacing the rim vent described above with a pressure/vacuum vent.

Fittings typically used only on internal floating roof tanks include column wells, ladder wells, and stub drains.

1. Columns and wells. Some fixed-roof designs are normally supported from inside the tank by means of vertical columns, which necessarily penetrate an internal floating deck. (Some fixed roofs are entirely self-supporting from the perimeter of the roof and, therefore, have no interior support columns.) Column wells are similar to unslotted guide pole wells on external floating roofs. Columns are made of pipe with circular cross sections or of structural shapes with irregular cross sections (built-up). The number of columns varies with tank diameter, from a minimum of 1 to over 50 for very large diameter tanks. A typical fixed roof support column and well are shown in Figure 7.1-9.

The columns pass through deck openings via peripheral vertical wells. With noncontact decks, the well should extend down into the liquid stock. Generally, a closure device exists between the top of the well and the column. Several proprietary designs exist for this closure, including sliding covers and fabric sleeves, which must accommodate the movements of the deck relative to the column as the liquid level changes. A sliding cover rests on the upper rim of the column well (which is normally fixed to the deck) and bridges the gap or space between the column well and the column. The cover, which has a cutout, or opening, around the column slides vertically relative to the column as the deck raises and lowers. At the same time, the cover may slide horizontally relative to the rim of the well to accommodate out-of-plumbness of the column. A gasket around the rim of the well reduces emissions from this fitting. A flexible fabric sleeve seal between the rim of the well and the column (with a cutout or opening, to allow vertical motion of the seal relative to the columns) similarly accommodates limited horizontal motion of the deck relative to the column.

2. Ladders and wells. Some tanks are equipped with internal ladders that extend from a manhole in the fixed roof to the tank bottom. The deck opening through which the ladder passes is constructed

with similar design details and considerations to deck openings for column wells, as previously discussed. A typical ladder well is shown in Figure 7.1-12.

Tanks are sometimes equipped with a ladder-slotted guidepole combination, in which one or both legs of the ladder is a slotted pipe that serves as a guidepole for purposes such as level gauging and sampling. A ladder-slotted guidepole combination is shown in Figure 7.1-21 with a ladder sleeve to reduce emissions.

3. Stub drains. Bolted internal floating roof decks are typically equipped with stub drains to allow any stored product that may be on the deck surface to drain back to the underside of the deck. The drains are attached so that they are flush with the upper deck. Stub drains are approximately 1 inch in diameter and extend down into the product on noncontact decks. A typical flush stub drain is shown in Figure 7.1-10. Stub drains may be equipped with floating balls to reduce emissions. The floating ball acts as a check valve, in that it remains covering the stub drain unless liquid is present to lift it.

Deck seams in internal floating roof tanks are a source of emissions to the extent that these seams may not be completely vapor tight if the deck is not welded. A weld sealing a deck seam does not have to be structural (i.e., may be a seal weld) to constitute a welded deck seam for purposes of estimating emissions, but a deck seam that is bolted or otherwise mechanically fastened and sealed with elastomeric materials or chemical adhesives is not a welded seam. Generally, the same loss mechanisms for deck fittings apply to deck seams. The predominant mechanism depends on whether or not the deck is in contact with the stored liquid. The deck seam loss equation accounts for the effects of all contributing loss mechanisms.

7.1.3 Emission Estimation Procedures

The following section presents the emission estimation procedures for fixed roof, external floating roof, domed external floating roof, and internal floating roof tanks. These procedures are valid for all volatile organic liquids and chemical mixtures. It is important to note that in all the emission estimation procedures the physical properties of the vapor do not include the noncondensibles in the atmosphere but only refer to the volatile components of the stored liquid. For example, the vapor-phase molecular weight is determined from the weighted average of the evaporated components of the stored liquid and does not include the contribution of atmospheric gases such as nitrogen and oxygen. To aid in the emission estimation procedures, a list of variables with their corresponding definitions was developed and is presented in Table 7.1-1.

The factors presented in AP-42 are those that are currently available and have been reviewed and approved by the U. S. Environmental Protection Agency. As storage tank equipment vendors design new floating decks and equipment, new emission factors may be developed based on that equipment. If the new emission factors are reviewed and approved, the emission factors will be added to AP-42 during the next update.

The emission estimation procedures outlined in this chapter have been used as the basis for the development of a software program to estimate emissions from storage tanks. The software program entitled "TANKS" is available through the U. S. Environmental Protection Agency website. While this software does not address all of the scenarios described in this chapter, is known to have errors, and is no longer supported, it is still made available for historical purposes.

There are also commercially available storage tank emissions estimation software programs. Users of these programs are advised to understand the extent of agreement with AP-42 Chapter 7 calculation methodology and assume responsibility of the accuracy of the output as they have not been reviewed or approved by the EPA.

7.1.3.1 Routine Losses From Fixed Roof Tanks[8-14,22]

The following equations, provided to estimate standing and working loss emissions, apply to tanks with vertical cylindrical shells and fixed roofs and to tanks with horizontal cylindrical shells. These tanks must be substantially liquid- and vapor-tight. The equations are not intended to be used in estimating losses from tanks which have air or other gases injected into the liquid, or which store unstable or boiling stocks or mixtures of hydrocarbons or petrochemicals for which the vapor pressure is not known or cannot be readily predicted. Tanks containing aqueous mixtures in which phase separation has occurred, resulting in a free layer of oil or other volatile materials floating on top of the water, should have emissions estimated on the basis of the properties of the free top layer.

Total routine losses from fixed roof tanks are equal to the sum of the standing loss and working loss:

$$L_T = L_S + L_W \tag{1-1}$$

where:

L_T = total routine losses, lb/yr
L_S = standing losses, lb/yr, see Equation 1-2
L_W = working losses, lb/yr, see Equation 1-35

7.1.3.1.1 Standing Loss

The standing loss, L_S, for a fixed roof tank refers to the loss of stock vapors as a result of tank vapor space breathing. Fixed roof tank standing losses can be estimated from Equation 1-2.

$$L_S = 365\ V_V\ W_V\ K_E\ K_S \tag{1-2}$$

where:

L_S = standing loss, lb/yr
V_V = vapor space volume, ft^3, see Equation 1-3
W_V = stock vapor density, lb/ft^3
K_E = vapor space expansion factor, per day
K_S = vented vapor saturation factor, dimensionless
365 = constant, the number of daily events in a year, (days/year)

<u>Tank Vapor Space Volume, V_V</u> - The tank vapor space volume is calculated using the following equation:

$$V_V = \left(\frac{\pi}{4} D^2\right) H_{VO} \tag{1-3}$$

where:

V_V = vapor space volume, ft^3
D = tank diameter, ft, see Equation 1-14 for horizontal tanks
H_{VO} = vapor space outage, ft, see Equation 1-16

The standing loss equation can be simplified by combining Equation 1-2 with Equation 1-3. The result is Equation 1-4.

$$L_S = 365 K_E \left(\frac{\pi}{4} D^2 \right) H_{VO} K_S W_V \tag{1-4}$$

where:

L_S = standing loss, lb/yr

K_E = vapor space expansion factor, per day, see Equation 1-5, 1-12, or 1-13

D = diameter, ft, see Equation 1-14 for horizontal tanks

H_{VO} = vapor space outage, ft, see Equation 1-16; use $H_E/2$ from Equation 1-15 for horizontal tanks

K_S = vented vapor saturation factor, dimensionless, see Equation 1-21

W_V = stock vapor density, lb/ft^3, see Equation 1-22

365 = constant, the number of daily events in a year, (days/year)

Vapor Space Expansion Factor, K_E

The calculation of the vapor space expansion factor, K_E, depends upon the properties of the liquid in the tank and the breather vent settings, as shown in Equation 1-5. As shown in the equation, K_E is greater than zero. If K_E is less than zero, standing losses will not occur. In that K_E represents the fraction of vapors in the vapor space that are expelled by a given increase in temperature, a value of 1 would indicate that the entire vapor space has been expelled. Thus the value of K_E must be less than 1, in that it is not physically possible to expel more than 100% of what is present to begin with.

$$0 < K_E \leq 1$$

$$K_E = \frac{\Delta T_V}{T_{LA}} + \frac{\Delta P_V - \Delta P_B}{P_A - P_{VA}} \tag{1-5}$$

where:

ΔT_V = average daily vapor temperature range, °R; see Note 1

ΔP_V = average daily vapor pressure range, psi; see Note 2

ΔP_B = breather vent pressure setting range, psi; see Note 3

P_A = atmospheric pressure, psia

P_{VA} = vapor pressure at average daily liquid surface temperature, psia; see Notes 1 and 2 for Equation 1-22

T_{LA} = average daily liquid surface temperature, °R; see Note 3 for Equation 1-22

Notes:

1. The average daily vapor temperature range, ΔT_V, refers to the daily temperature range of the tank vapor space averaged over all of the days in the given period of time, such as one year, and should

not be construed as being applicable to an individual day. The average daily vapor temperature range is calculated for an uninsulated tank using Equation 1-6.

$$\Delta T_V = \left(1 - \frac{0.8}{2.2\,(H_S/D) + 1.9}\right)\Delta T_A + \frac{0.042\alpha_R I + 0.026(H_S/D)\alpha_S I}{2.2\,(H_S/D) + 1.9} \tag{1-6}$$

where:

ΔT_V = average daily vapor temperature range, °R

H_S = tank shell height, ft

D = tank diameter, ft,

ΔT_A = average daily ambient temperature range, °R; see Note 4

α_R = tank roof surface solar absorptance, dimensionless; see Table 7.1-6

α_S = tank shell surface solar absorptance, dimensionless; see Table 7.1-6

I = average daily total insolation factor, Btu/ft^2 d; see Table 7.1-7.

API assigns a default value of $H_s/D = 0.5$ and an assumption of $\alpha_R = \alpha_S$, resulting in the simplified equation shown below for an uninsulated tank:[22]

$$\Delta T_V = 0.7\,\Delta T_A + 0.02\,\alpha\,I \tag{1-7}$$

where:

α = average tank surface solar absorptance, dimensionless

For purposes of estimating emissions, a storage tank should be deemed insulated only if the roof and shell are both sufficiently insulated so as to minimize heat exchange with ambient air. If only the shell is insulated, and not the roof, the temperature equations are independent of H_s/D. Also, there likely will be sufficient heat exchange through the roof such that Equation 1-7 would be applicable.

A more accurate method of accounting for the average daily vapor temperature range, ΔT_V, in partially insulated scenarios is given below. When the tank shell is insulated but the tank roof is not, heat gain to the tank from insolation is almost entirely through the tank roof and thus the liquid surface temperature is not sensitive to H_S/D.

$$\Delta T_V = 0.6\,\Delta T_A + 0.02\,\alpha_R\,I \tag{1-8}$$

In the case of a fully insulated tank maintained at constant temperature, the average daily vapor temperature range, ΔT_V, should be taken as zero. This assumption that ΔT_V is equal to zero addresses only temperature differentials resulting from the diurnal ambient temperature cycle. In the case of cyclic heating of the bulk liquid, see Section 7.1.3.8.4.

2. The average daily vapor pressure range, ΔP_V, refers to the daily vapor pressure range at the liquid surface temperature averaged over all of the days in the given period of time, such as one year, and should not be construed as being applicable to an individual day. The average daily vapor pressure range can be calculated using the following equation:

$$\Delta P_V = P_{VX} - P_{VN} \tag{1-9}$$

where:

ΔP_V = average daily vapor pressure range, psia
P_{VX} = vapor pressure at the average daily maximum liquid surface temperature, psia; see Note 5
P_{VN} = vapor pressure at the average daily minimum liquid surface temperature, psia; see Note 5

See Section 7.1.6.1 for a more approximate equation for ΔP_V that was used historically, but which is no longer recommended.

In the case of a fully insulated tank maintained at constant temperature, the average daily vapor pressure range, ΔP_V, should be taken as zero, as discussed for the vapor temperature range in Note 1.

3. The breather vent pressure setting range, ΔP_B, is calculated using the following equation:

$$\Delta P_B = P_{BP} - P_{BV} \tag{1-10}$$

where:

ΔP_B = breather vent pressure setting range, psig
P_{BP} = breather vent pressure setting, psig
P_{BV} = breather vent vacuum setting, psig

If specific information on the breather vent pressure setting and vacuum setting is not available, assume 0.03 psig for P_{BP} and -0.03 psig for P_{BV} as typical values. If the fixed roof tank is of bolted or riveted construction in which the roof or shell plates are not vapor tight, assume that $\Delta P_B = 0$, even if a breather vent is used.

4. The average daily ambient temperature range, ΔT_A, refers to the daily ambient temperature range averaged over all of the days in the given period of time, such as one year, and should not be construed as being applicable to an individual day. The average daily ambient temperature range is calculated using the following equation:

$$\Delta T_A = T_{AX} - T_{AN} \tag{1-11}$$

where:

ΔT_A = average daily ambient temperature range, °R
T_{AX} = average daily maximum ambient temperature, °R
T_{AN} = average daily minimum ambient temperature, °R

Table 7.1-7 gives historical values of T_{AX} and T_{AN} in degrees Fahrenheit for selected cities in the United States. These values are converted to degrees Rankine by adding 459.7.

5. The vapor pressures associated with the average daily maximum and minimum liquid surface temperatures, P_{VX} and P_{VN}, respectively, are calculated by substituting the corresponding temperatures, T_{LX} and T_{LN}, into Equation 1-25 or 1-26 after converting the temperatures to the units indicated for the respective equation. If T_{LX} and T_{LN} are unknown, Figure 7.1-17 can be used to calculate their values. In

the case of a fully insulated tank maintained at constant temperature, the average daily vapor pressure range, ΔP_V, should be taken as zero.

If the liquid stored in the fixed roof tank has a true vapor pressure less than 0.1 psia and the tank breather vent settings are not greater than ±0.03 psig, Equation 1-12 or Equation 1-13 may be used with an acceptable loss in accuracy.

If the tank location and tank color and condition are known, K_E may be calculated using the following equation in lieu of Equation 1-5:

$$K_E = 0.0018 \Delta T_V = 0.0018 [0.7 (T_{AX} - T_{AN}) + 0.02 \alpha I] \quad (1\text{-}12)$$

where:

K_E = vapor space expansion factor, per day

ΔT_V = average daily vapor temperature range, °R

T_{AX} = average daily maximum ambient temperature, °R

T_{AN} = average daily minimum ambient temperature, °R

α = tank surface solar absorptance, dimensionless

I = average daily total insolation on a horizontal surface, Btu/(ft^2 day)

0.0018 = constant, (°R)$^{-1}$

0.7 = constant, dimensionless

0.02 = constant, (°R ft^2 day)/Btu

Average daily maximum and minimum ambient temperatures and average daily total insolation can be determined from historical meteorological data for the location or may be obtained from historical meteorological data for a nearby location. Historical meteorological data for selected locations are given in Table 7.1-7, where values of T_{AX} and T_{AN} are given in degrees Fahrenheit. These values are converted to degrees Rankine by adding 459.7.

If the tank location is unknown, a value of K_E can be calculated using typical meteorological conditions for the lower 48 states. The typical value for daily insolation is 1,370 Btu/(ft^2 day), the average daily range of ambient temperature is 21°R, and the tank surface solar absorptance is 0.25 for white paint in average condition. Substituting these values into Equation 1-12 results in a value of 0.04, as shown in Equation 1-13.

$$K_E = 0.04 \quad (1\text{-}13)$$

Diameter

For vertical tanks, the diameter is straightforward. If a user needs to estimate emissions from a horizontal fixed roof tank, some of the tank parameters can be modified before using the vertical tank emission estimating equations. First, by assuming that the tank is one-half filled, the surface area of the liquid in the tank is approximately equal to the length of the tank times the diameter of the tank. Next, assume that this area represents a circle, i.e., that the liquid is an upright cylinder. Therefore, the effective diameter, D_E, is then equal to:

$$D_E = \sqrt{\frac{LD}{\frac{\pi}{4}}}$$ **(1-14)**

where:

D_E = effective tank diameter, ft

L = length of the horizontal tank, ft (for tanks with rounded ends, use the overall length)

D = diameter of a vertical cross-section of the horizontal tank, ft

By assuming the volume of the horizontal tank to be approximately equal to the cross-sectional area of the tank times the length of the tank, an effective height, H_E, of an equivalent upright cylinder may be calculated as:

$$H_E = \frac{\pi}{4} D$$ **(1-15)**

D_E should be used in place of D in Equation 1-4 for calculating the standing loss (or in Equation 1-3, if calculating the tank vapor space volume). One-half of the effective height, H_E, should be used as the vapor space outage, H_{VO}, in these equations. This method yields only a very approximate value for emissions from horizontal storage tanks. For underground horizontal tanks, assume that no breathing or standing losses occur ($L_S = 0$) because the insulating nature of the earth limits the diurnal temperature change. No modifications to the working loss equation are necessary for either aboveground or underground horizontal tanks. However, standing losses from underground gasoline tanks, which can experience relatively fast vapor growth after the ingestion of air and dilution of the headspace, are addressed in Section 5.2 of AP-42.

Vapor Space Outage

The vapor space outage, H_{VO} is the height of a cylinder of tank diameter, D, whose volume is equivalent to the vapor space volume of a fixed roof tank, including the volume under the cone or dome roof. The vapor space outage, H_{VO}, is estimated from:

$$H_{VO} = H_S - H_L + H_{RO}$$ (1-16)

where:

H_{VO} = vapor space outage, ft; use $H_E/2$ from Equation 1-15 for horizontal tanks

H_S = tank shell height, ft

H_L = liquid height, ft; typically assumed to be at the half-full level, unless known to be maintained at some other level

H_{RO} = roof outage, ft; see Note 1 for a cone roof or Note 2 for a dome roof

Notes:

1. For a cone roof, the roof outage, H_{RO}, is calculated as follows:

$$H_{RO} = (1/3)\ H_R \tag{1-17}$$

where:

H_{RO} = roof outage (or shell height equivalent to the volume contained under the roof), ft

H_R = tank roof height, ft

$$H_R = S_R\ R_S \tag{1-18}$$

where: S_R = tank cone roof slope, ft/ft; if unknown, a standard value of 0.0625 is used

R_S = tank shell radius, ft

2. For a dome roof, the roof outage, H_{RO}, is calculated as follows:

$$H_{RO} = H_R \left[\frac{1}{2} + \frac{1}{6} \left[\frac{H_R}{R_S} \right]^2 \right] \tag{1-19}$$

where:

H_{RO} = roof outage, ft

R_S = tank shell radius, ft

H_R = tank roof height, ft

$$H_R = R_R - \left(R_R^2 - R_S^2 \right)^{0.5} \tag{1-20}$$

H_R = tank roof height, ft R_R = tank dome roof radius, ft R_S = tank shell radius,ft

The value of R_R usually ranges from 0.8D - 1.2D, where D = 2 R_S. If R_R is unknown, the tank diameter is used in its place. If the tank diameter is used as the value for R_R, Equations 1-19 and 1-20 reduce to H_{RO} = 0.137 R_S and H_R = 0.268 R_S.

Vented Vapor Saturation Factor, K_S

The vented vapor saturation factor, K_S, is calculated using the following equation:

$$K_S = \frac{1}{1 + 0.053 P_{VA}\ H_{VO}} \tag{1-21}$$

where:

K_S = vented vapor saturation factor, dimensionless

P_{VA} = vapor pressure at average daily liquid surface temperature, psia; see Notes 1 and 2 to Equation 1-22

H_{VO} = vapor space outage, ft, see Equation 1-16

0.053 = constant, $(psia\text{-}ft)^{-1}$

Stock Vapor Density, W_V - The density of the vapor is calculated using the following equation:

$$W_V = \frac{M_V P_{VA}}{R T_V} \qquad \textbf{(1-22)}$$

where:

W_V = vapor density, lb/ft^3

M_V = vapor molecular weight, lb/lb-mole; see Note 1

R = the ideal gas constant, 10.731 psia ft^3/lb-mole °R

P_{VA} = vapor pressure at average daily liquid surface temperature, psia; see Notes 1 and 2

T_V = average vapor temperature, °R; see Note 6

Notes:

1. The molecular weight of the vapor, M_V, can be determined from Table 7.1-2 and 7.1-3 for selected petroleum liquids and selected petrochemicals, respectively, or by analyzing vapor samples. Where mixtures of organic liquids are stored in a tank, M_V can be calculated from the liquid composition. The molecular weight of the vapor, M_V, is equal to the sum of the molecular weight, M_i, multiplied by the vapor mole fraction, y_i, for each component. The vapor mole fraction is equal to the partial pressure of component i divided by the total vapor pressure. The partial pressure of component i is equal to the true vapor pressure of component i (P) multiplied by the liquid mole fraction, (x_i). Therefore,

$$M_V = \sum M_i \, y_i = \sum M_i \left(\frac{Px_i}{P_{VA}} \right) \qquad \textbf{(1-23)}$$

where:

P_{VA}, total vapor pressure of the stored liquid, by Raoult's Law[30], is:

$$P_{VA} = \sum Px_i \qquad \textbf{(1-24)}$$

For more detailed information on Raoult's Law, please refer to Section 7.1.4. Frequently, however, the vapor pressure is not known for each component in a mixture. For more guidance on determining the total vapor pressure at a given temperature (*i.e.*, the true vapor pressure), see Note 2 below.

2. True vapor pressure is defined in various ways for different purposes within the industry, such as "bubble point" for transportation specifications, but for purposes of these emissions estimating methodologies it is the sum of the equilibrium partial pressures exerted by the components of a volatile organic liquid, as shown in Equation 1-24. True vapor pressure may be determined by ASTM D 2879 (or ASTM D 6377 for crude oils with a true vapor pressure greater than 3.6 psia) or obtained from standard reference texts. For certain petroleum liquids, true vapor pressure may be predicted from Reid vapor pressure, which is the absolute vapor pressure of volatile crude oil and volatile non-viscous petroleum

liquids, as determined by ASTM D 323. ASTM D 5191 may be used as an alternative method for determining Reid vapor pressure for petroleum products, however, it should not be used for crude oils.

Caution should be exercised when considering ASTM D 2879 for determining the true vapor pressure of certain types of mixtures. Vapor pressure is sensitive to the lightest components in a mixture, and the de-gassing step in ASTM D 2879 can remove lighter fractions from mixtures such as No. 6 fuel oil if it is not done with care (*i.e.* at an appropriately low pressure and temperature). In addition, any dewatering of a sample prior to measuring its vapor pressure must be done using a technique that has been demonstrated to not remove the lightest organic compounds in the mixture. Alternatives to the method may be developed after publication of this chapter.

True vapor pressure can be determined for crude oils from Reid vapor pressure using Figures 7.1-13a and 7.1-13b. However, the nomograph in Figure 7.1-13a and the correlation equation in Figure 7.1-13b for crude oil are known to have an upward bias, and thus use of ASTM D 6377 is more accurate for crude oils with a true vapor pressure greater than 3.6 psia. ASTM D 6377 may be used to directly measure true vapor pressure at a given temperature. In order to utilize ASTM D 6377 to predict true vapor pressure values over a range of temperatures, the method should be applied at multiple temperatures. A regression of the log-transformed temperature versus vapor pressure data thus obtained may be performed to obtain A and B constants for use in Equation 1-25. In order to determine true vapor pressure for purposes of estimating emissions of volatile organic compounds, ASTM D 6377 should be performed using a vapor-to-liquid ratio of 4:1, which is expressed in the method as $VPCR_4$.

For light refined stocks (gasolines and naphthas) for which the Reid vapor pressure and distillation slope are known, Figures 7.1-14a and 7.1-14b can be used. For refined stocks with Reid vapor pressure below the 1 psi applicability limit of Figures 7.1-14a and 7.1-14b, true vapor pressure can be determined using ASTM D 2879. In order to use Figures 7.1-13a, 7.1-13b, 7.1-14a, or 7.1-14b, the stored liquid surface temperature, T_{LA}, must be determined in degrees Fahrenheit. See Note 3 to determine T_{LA}.

Alternatively, true vapor pressure for selected petroleum liquid stocks, at the stored liquid surface temperature, can be determined using the following equation:

$$P_{VA} = \exp\left[A - \left(\frac{B}{T_{LA}}\right)\right] \quad \textbf{(1-25)}$$

where:

exp = exponential function

A = constant in the vapor pressure equation, dimensionless

B = constant in the vapor pressure equation, °R

T_{LA} = average daily liquid surface temperature, °R; see Note 3

P_{VA} = true vapor pressure, psia

For selected petroleum liquid stocks, physical property data including vapor pressure constants A and B for use in Equation 1-25 are presented in Table 7.1-2. For refined petroleum stocks with Reid vapor pressure within the limits specified in the scope of ASTM D 323, the constants A and B can be calculated from the equations presented in Figure 7.1-15 and the distillation slopes presented in Table 7.1-2. For crude oil stocks, the constants A and B can be calculated from Reid vapor pressure using the equations presented in Figure 7.1-16. However, the equations in Figure 7.1-16 are known to have an upward bias[29], and thus use of ASTM D 6377 is more accurate. Note that in Equation 1-25, T_{LA} is determined in degrees Rankine instead of degrees Fahrenheit.

The true vapor pressure of organic liquids at the stored liquid temperature can also be estimated by Antoine's equation:

$$\log P_{VA} = A - \left(\frac{B}{T_{LA} + C} \right) \tag{1-26}$$

where:

- log = log 10
- A = constant in vapor pressure equation, dimensionless
- B = constant in vapor pressure equation, °C
- C = constant in vapor pressure equation, °C
- T_{LA} = average daily liquid surface temperature, °C
- P_{VA} = vapor pressure at average liquid surface temperature, mm Hg

For selected pure chemicals, the values for the constants A, B, and C are listed in Table 7.1-3. Note that in Equation 1-26, T_{LA} is determined in degrees Celsius instead of degrees Rankine. Also, in Equation 1-26, P_{VA} is determined in mm of Hg rather than psia (760 mm Hg = 14.7 psia).

More rigorous thermodynamic equations of state are available in process simulation software packages. The use of such programs may be preferable in determining the true vapor pressure of mixtures that are not adequately characterized by Raoult's Law.

3. The average daily liquid surface temperature, T_{LA}, refers to the liquid surface temperature averaged over all of the days in the given period of time, such as one year, and should not be construed as being applicable to an individual day. While the accepted methodology is to use the average temperature, this approach introduces a bias in that the true vapor pressure, P_{VA}, is a non-linear function of temperature. However, the greater accuracy that would be achieved by accounting for this logarithmic function is not warranted, given the associated computational burden. The average daily liquid surface temperature is calculated for an uninsulated fixed roof tank using Equation 1-27.

$$T_{LA} = \left(0.5 - \frac{0.8}{4.4(H_S/D) + 3.8}\right) T_{AA} + \left(0.5 + \frac{0.8}{4.4(H_S/D) + 3.8}\right) T_B + \frac{0.021 \propto_R I + 0.013(H_S/D) \propto_S I}{4.4(H_S/D) + 3.8} \tag{1-27}$$

where:

- T_{LA} = average daily liquid surface temperature, °R
- H_S = tank shell height, ft
- D = tank diameter, ft,
- T_{AA} = average daily ambient temperature, °R; see Note 4
- T_B = liquid bulk temperature, °R; see Note 5

α_R = tank roof surface solar absorptance, dimensionless; see Table 7.1-6
α_S = tank shell surface solar absorptance, dimensionless; see Table 7.1-6
I = average daily total insolation factor, Btu/(ft^2 day); see Table 7.1-7

API assigns a default value of $H_s/D = 0.5$ and an assumption of $\alpha_R = \alpha_S$, resulting in the simplified equation shown below for an uninsulated fixed roof tank:[22]

$$T_{LA} = 0.4T_{AA} + 0.6T_B + 0.005\,\alpha\,I \tag{1-28}$$

where:

α = average tank surface solar absorptance, dimensionless

Equation 1-27 and Equation 1-28 should not be used to estimate liquid surface temperature for insulated tanks. In the case of fully insulated tanks, the average liquid surface temperature should be assumed to equal the average liquid bulk temperature (see Note 5). For purposes of estimating emissions, a storage tank should be deemed insulated only if the roof and shell are both fully insulated so as to minimize heat exchange with ambient air. If only the shell is insulated, and not the roof, there likely will be sufficient heat exchange through the roof such that Equation 1-28 would be applicable.

A more accurate method of estimating the average liquid surface temperature, T_{LA}, in partially insulated fixed roof tanks is given below. When the tank shell is insulated but the tank roof is not, heat gain to the tank from insolation is almost entirely through the tank roof and thus the liquid surface temperature is not sensitive to H_S/D.

$$T_{LA} = 0.3\,T_{AA} + 0.7\,T_B + 0.005\,\alpha_R\,I \tag{1-29}$$

If T_{LA} is used to calculate P_{VA} from Figures 7.1-13a, 7.1-13b, 7.1-14a, or 7.1-14b, T_{LA} must be converted from degrees Rankine to degrees Fahrenheit (°F = °R – 459.7). If T_{LA} is used to calculate P_{VA} from Equation 1-26, T_{LA} must be converted from degrees Rankine to degrees Celsius (°C = [°R – 491.7]/1.8).

4. The average daily ambient temperature, T_{AA}, is calculated using the following equation:

$$T_{AA} = \left(\frac{T_{AX} + T_{AN}}{2}\right) \tag{1-30}$$

where:

T_{AA} = average daily ambient temperature, °R
T_{AX} = average daily maximum ambient temperature, °R
T_{AN} = average daily minimum ambient temperature, °R

Table 7.1-7 gives historical values of T_{AX} and T_{AN} in degrees Fahrenheit for selected U.S. cities. These values are converted to degrees Rankine by adding 459.7.

5. The liquid bulk temperature, T_B, should preferably be based on measurements or estimated from process knowledge. For uninsulated fixed roof tanks known to be in approximate equilibrium with

ambient air, heat gain to the bulk liquid from insolation is almost entirely through the tank shell; thus the liquid bulk temperature is not sensitive to H_S/D and may be calculated using the following equation:

$$T_B = T_{AA} + 0.003\ \alpha_S\ I \tag{1-31}$$

where:

T_B = liquid bulk temperature, °R

T_{AA} = average daily ambient temperature, °R, as calculated in Note 4

α_S = tank shell surface solar absorptance, dimensionless; see Table 7.1-6

I = average daily total insolation factor, Btu/(ft^2 day); see Table 7.1-7.

6. The average vapor temperature, T_V, for an uninsulated tank may be calculated using the following equation:

$$T_V = \frac{[2.2\ (H_S/D)+1.1]\ T_{AA} + 0.8\ T_B + 0.021\alpha_R I + 0.013(H_S/D)\alpha_S I}{2.2\ (H_S/D) + 1.9} \tag{1-32}$$

where:

H_S = tank shell height, ft

D = tank diameter, ft,

T_{AA} = average daily ambient temperature, °R

T_B = liquid bulk temperature, °R

α_R = tank roof surface solar absorptance, dimensionless

α_S = tank shell surface solar absorptance, dimensionless

I = average daily total insolation factor, Btu/(ft^2 day).

API assigns a default value of $H_s/D = 0.5$ and an assumption of $\alpha_R = \alpha_S$, resulting in the simplified equation shown below for an uninsulated tank:[22]

$$T_V = 0.7T_{AA} + 0.3T_B + 0.009\ \alpha\ I \tag{1-33}$$

where:

α = average tank surface solar absorptance, dimensionless

When the shell is insulated, but not the roof, the temperature equations are independent of H_s/D.

$$T_V = 0.6T_{AA} + 0.4T_B + 0.01\ \alpha_R\ I \tag{1-34}$$

When the tank shell and roof are fully insulated, the temperatures of the vapor space and the liquid surface are taken as equal to the temperature of the bulk liquid.

7.1.3.1.2 Working Loss

The fixed roof tank working loss, L_W, refers to the loss of stock vapors as a result of tank filling operations. Fixed roof tank working losses can be estimated from:

$$L_W = V_Q K_N K_P W_V K_B \quad \textbf{(1-35)}$$

where:

L_W = working loss, lb/yr

V_Q = net working loss throughput, ft^3/yr, see Note 1

K_N = working loss turnover (saturation) factor, dimensionless

for turnovers > 36, $K_N = (180 + N)/6N$

for turnovers ≤ 36, $K_N = 1$

for tanks that are vapor balanced and tanks in which flashing occurs, $K_N = 1$ regardless of the number of turnovers; further adjustment of K_N may be appropriate in the case of splash loading into a tank.

N = number of turnovers per year, dimensionless:

$$N = \Sigma H_{QI} / (H_{LX} - H_{LN}) \quad \textbf{(1-36)}$$

ΣH_{QI} = the annual sum of the increases in liquid level, ft/yr

If ΣH_{QI} is unknown, it can be estimated from pump utilization records. Over the course of a year, the sum of increases in liquid level, ΣH_{QI}, and the sum of decreases in liquid level, ΣH_{QD}, will be approximately the same. Alternatively, ΣH_{QI} may be approximated as follows:

$$\Sigma H_{QI} = (5.614\ Q) / ((\pi/4)\ D^2) \quad (1\text{-}37)$$

5.614 =the conversion of barrels to cubic feet, ft^3/bbl

Q = annual net throughput, bbl/yr

For horizontal tanks, use D_E (Equation 1-14) in place of D in Equation 1-37

H_{LX} = maximum liquid height, ft

If the maximum liquid height is unknown, for vertical tanks use one foot less than the shell height and for horizontal tanks use (π/4) D where D is the diameter of a vertical cross-section of the horizontal tank

H_{LN} = minimum liquid height, ft

If the minimum liquid height is unknown, for vertical tanks use 1 and for horizontal tanks use 0

K_P = working loss product factor, dimensionless

for crude oils, $K_P = 0.75$; adjustment of K_P may be appropriate in the case of splash loading into a tank

for all other organic liquids, $K_P = 1$

W_V = vapor density, lb/ft^3, see Equation 1-22

K_B = vent setting correction factor, dimensionless, see Note 2 for open vents and for a vent setting range up to ± 0.03 psig, $K_B = 1$

1. Net Working Loss Throughput.

The net working loss throughput, V_Q, is the volume associated with increases in the liquid level, and is calculated as follows:

$$V_Q = (\Sigma H_{QI})(\pi/4)\, D^2 \tag{1-38}$$

where:

ΣH_{QI} = the annual sum of the increases in liquid level, ft/yr

D_E should be used for horizontal tanks in place of D in Equation 1-38.

If ΣH_{QI} is unknown, ΣH_{QI} can be estimated from pump utilization records. Over the course of a year, the sum of increases in liquid level, ΣH_{QI}, and the sum of decreases in liquid level, ΣH_{QD}, will be approximately the same. Alternatively, V_Q may be approximated as follows:

$$V_Q = 5.614\ Q \tag{1-39}$$

where:

5.614 = the conversion of barrels to cubic feet, ft^3/bbl

Q = annual net throughput, bbl/yr
Use of gross throughput to approximate the sum of increases in liquid level will significantly overstate emissions if pumping in and pumping out take place at the same time. However, use of gross throughput is still allowed, since it is clearly a conservative estimate of emissions.

2. Vent Setting Correction Factor

When the breather vent settings are greater than the typical values of ± 0.03 psig, and the condition expressed in Equation 1-40 is met, a vent setting correction factor, K_B, must be determined using Equation 1-41. This value of K_B will be used in Equation 1-35 to calculate working losses.

When:

(1-40)

$$K_N\left[\frac{P_{BP}+P_A}{P_I+P_A}\right]>1.0$$

Then:

(1-41)

$$K_B=\left[\frac{\dfrac{P_I+P_A}{K_N}-P_{VA}}{P_{BP}+P_A-P_{VA}}\right]$$

where:

K_B = vent setting correction factor, dimensionless

P_I = pressure of the vapor space at normal operating conditions, psig
P_I is an actual pressure reading (the gauge pressure). If the tank is held at atmospheric pressure (not held under a vacuum or at a steady pressure) P_I would be 0.

P_A = atmospheric pressure, psia

K_N = working loss turnover (saturation) factor (dimensionless), see Equation 1-35

P_{VA} = vapor pressure at the average daily liquid surface temperature, psia; see Notes 1 and 2 to Equation 1-22

P_{BP} = breather vent pressure setting, psig.

See Section 7.1.6.2 for a more approximate equation for fixed roof tank working loss that was used historically, but which is no longer recommended.

SPECIATE 5.0 DATABASE

PROFILE NAME: Gasoline Headspace Vapor using 0% Ethanol - Composite Profile provided by EPA OTAQ

TEST METHOD: Canisters containing headspace vapor samples of gasoline were analyzed.

PROFILE CODE	PROFILE TYPE	NAME	CAS	HAP?	WEIGHT PERCENT	ANALYTICAL METHOD	SPEC MW	MOLECULAR FORMULA	QUALITY	CONTROLS	PROFILE DATE	TEST YEAR	CATEGORY LEVEL 1 Generation Mechanism	CATEGORY LEVEL 2 Sector Equipment	CATEGORY LEVEL 3 Fuel Product
8762	GAS	Benzene	71-43-2	Yes	0.35	GC-FID	78.11184	C6H6	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8762	GAS	N-hexane	110-54-3	Yes	1.07	GC-FID	86.17536	C6H14	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8762	GAS	Toluene	108-88-3	Yes	3.31	GC-FID	92.13842	C7H8	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8762	GAS	Xylene (o, m, & p)	95-47-6; 108 38-3; 106-42 3	Yes	0.58	GC-FID	106.165	C8H10	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8762	GAS	Ethylbenzene	100-41-4	Yes	0.15	GC-FID	106.165	C8H10	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8762	GAS	2,2,4-trimethylpentane	540-84-1	Yes	5.21	GC-FID	114.22852	C8H18	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline

SPECIATE 5.0 DATABASE

PROFILE NAME: Gasoline Headspace Vapor using 10% Ethanol - Composite Profile provided by EPA OTAQ

TEST METHOD: Canisters containing headspace vapor samples of gasoline were analyzed.

PROFILE CODE	PROFILE TYPE	NAME	CAS	HAP?	WEIGHT PERCENT	ANALYTICAL METHOD	SPEC MW	MOLECULAR FORMULA	QUALITY	CONTROLS	PROFILE DATE	TEST YEAR	CATEGORY LEVEL 1 Generation Mechanism	CATEGORY LEVEL 2 Sector Equipment	CATEGORY LEVEL 3 Fuel Product
8763	GAS	Benzene	71-43-2	Yes	0.30	GC-FID	78.11184	C6H6	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8763	GAS	N-hexane	110-54-3	Yes	0.98	GC-FID	86.17536	C6H14	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8763	GAS	Toluene	108-88-3	Yes	3.59	GC-FID	92.13842	C7H8	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8763	GAS	Xylene (o, m, & p)	95-47-6; 108-38-3; 106-42-3	Yes	0.69	GC-FID	106.165	C8H10	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8763	GAS	Ethylbenzene	100-41-4	Yes	0.18	GC-FID	106.165	C8H10	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline
8763	GAS	2,2,4-trimethylpentane	540-84-1	Yes	5.40	GC-FID	114.22852	C8H18	A	Uncontrolled	10/2/2009	2009	Volatilization	Mobile	Gasoline

Section 7

Information Used to Determine Emissions

Boilers

- AP-42 Table 1.5-1
- Propane sulfur content references
- AP-42 Tables 1.4-3 and 1.4-4
- 40 CFR 98, Subpart A, Table A-1 (not repeated)
- 40 CFR 98, Subpart C, Tables C-1 and C-2 (not repeated)

Table 1.5-1. EMISSION FACTORS FOR LPG COMBUSTION[a]

EMISSION FACTOR RATING: E

Pollutant	Butane Emission Factor ($lb/10^3$ gal)		Propane Emission Factor ($lb/10^3$ gal)	
	Industrial Boilers[b] (SCC 1-02-010-01)	Commercial Boilers[c] (SCC 1-03-010-01)	Industrial Boilers[b] (SCC 1-02-010-02)	Commercial Boilers[c] (SCC 1-03-010-02)
PM, Filterable [d]	0.2	0.2	0.2	0.2
PM, Condensable	0.6	0.6	0.5	0.5
PM, Total	0.8	0.8	0.7	0.7
SO_2[e]	0.09S	0.09S	0.10S	0.10S
NO_x[f]	15	15	13	13
N_2O[g]	0.9	0.9	0.9	0.9
CO_2[h,j]	14,300	14,300	12,500	12,500
CO	8.4	8.4	7.5	7.5
TOC	1.1	1.1	1.0	1.0
CH_4[k]	0.2	0.2	0.2	0.2

[a] Assumes PM, CO, and TOC emissions are the same, on a heat input basis, as for natural gas combustion. Use heat contents of 91.5 x 10^6 Btu/10^3 gallon for propane, 102 x 10^6 Btu/10^3 gallon for butane, 1020 x 10^6 Btu/10^6 scf for methane when calculating an equivalent heat input basis. For example, the equation for converting from methane's emissions factors to propane's emissions factors is as follows: lb pollutant/10^3 gallons of propane = (lb pollutant /10^6 ft^3 methane) * (91.5 x 10^6 Btu/10^3 gallons of propane) / (1020 x 10^6 Btu/10^6 scf of methane). The NO_x emission factors have been multiplied by a correction factor of 1.5, which is the approximate ratio of propane/butane NO_x emissions to natural gas NO_x emissions. To convert from lb/10^3 gal to kg/10^3 L, multiply by 0.12. SCC = Source Classification Code.

[b] Heat input capacities generally between 10 and 100 million Btu/hour.

[c] Heat input capacities generally between 0.3 and 10 million Btu/hour.

[d] Filterable particulate matter (PM) is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. For natural gas, a fuel with similar combustion characteristics, all PM is less than 10 µm in aerodynamic equivalent diameter (PM-10).

[e] S equals the sulfur content expressed in gr/100 ft^3 gas vapor. For example, if the butane sulfur content is 0.18 gr/100 ft^3, the emission factor would be (0.09 x 0.18) = 0.016 lb of SO_2/10^3 gal butane burned.

[f] Expressed as NO_2.

[g] Reference 12.

[h] Assuming 99.5% conversion of fuel carbon to CO_2.

[j] EMISSION FACTOR RATING = C.

[k] Reference 13.

air pollution control district
SANTA BARBARA COUNTY

Frequently Asked Questions

DOING BUSINESS

Public Records Request

Fuel Heat Content:

Q: *How many Btus are there in a therm?*

A: There are 100,000 British Thermal Units ("Btus") per therm. A therm is a unit of gross heating value.

▲TOP

Fuel Heating Value Conversion

Q: *How do I convert from Lower Heating Value (LHV) to Higher Heating Value (HHV) based emission factors?*

A: For gaseous fuels multiply the LHV value by 1.10 and for liquid fuels multiply the LHV value by 1.06.

▲TOP

Sulfur Specs – Natural Gas

Q: *What are the sulfur specifications for PUC Quality natural gas?*

A: The Public Utilities Commission of the State of California has issued General Order 58-A titled "Standards For Gas Service In The State of California" (last revised April 12, 1989). Title 7 (Purity of Gas) of the General Order specifies hydrogen sulfide and total sulfur standards for any gas supplied by a utility. Section (a) limits hydrogen sulfide to 0.25 grain per 100 standard cubic feet. Section (b) limits total sulfur to 5 grains per 100 standard cubic feet (which is equivalent to 85 ppmv as S or 80 ppmv as H_2S.

▲TOP

Sulfur Specs – Propane

Q: *What are the sulfur specifications for propane?*

A: The Gas Processors Association ("GPA") provides product specifications for liquefied petroleum gases. These specifications may be found in Figure 2-1 (GPA Liquefied Petroleum Gas Speficications – GPA Standard 2140-92) of the Engineering Data Book (10th Edition, 1994) published by the Gas Processors Suppliers Association. Total sulfur standards are provided in units of ppmw. For commercial propane, the standard is 185 ppmw as S (254 ppmv as S, 239 ppmv as H2S).

▲TOP

Boiler Rating Conversion

Q: *How do I convert a boiler rating from units of boiler horsepower (bhp) to heat input (lb/MMBtu)?*

A: This conversion requires two steps. First the boiler horsepower value is converted to an energy basis by muliplying by 33,446 Btu/hr per Bhp. Since Bhp ratings are based on the amount on useful work a boiler performs, the efficiency losses in converting the heat input to this useful work must be accounted for. In general, a boiler is about 80 percent efficient in converting the fuel's energy into useful work. Thus, the "Btu/hr" value must be corrected to account for the 20 percent loss. Example: 500 Bhp = 20.904 MMBtu/hr (500 bhp * 33,446 Btu/hr/Bhp * 1/0.80).

▲TOP

For more information or assistance, call the Engineering Division at (805) 961-8800, or e-mail us at engr@sbcapcd.org.

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Gaseous Fuel SO_x Emission Factor:

Applicability: External Combustion units such as boilers and process heaters for gaseous fuels (e.g., natural gas, oil field produced gas and propane).

Equations: Two equations are presented. The first is the fundamental equation showing how the emission factor is generated. The second is a reduced form of the basic equation for streamlined use. Finally, a check on the units is shown.

$$EF = [ppmvd\ \mathrm{S}] \times \left[\frac{1}{HHV}\right] \times \left[\frac{1}{mol\ vol}\right] \times [mol\ ratio] \times [MW_{SO_2}]$$

$$EF = [0.169] \times \left[\frac{ppmvd\ \mathrm{S}}{HHV}\right]$$

$$\frac{lb}{MMBtu} = \left[\frac{ft^3\ \mathrm{S}}{MM\ ft^3\ \mathrm{Fuel}}\right] \times \left[\frac{ft^3\ \mathrm{Fuel}}{Btu}\right] \times \left[\frac{lb-mole\ \mathrm{S}}{379\ ft^3\ \mathrm{S}}\right] \times \left[\frac{lb-mole\ \mathrm{SO_2}}{lb-mole\ \mathrm{S}}\right] \times \left[\frac{64\ lb\ \mathrm{SO_2}}{lb-mole\ \mathrm{SO_2}}\right]$$

where:

EF	=	SO_x emission factor in units of lb/MMBtu (HHV based, as SO_2)
ppmvd S	=	total sulfur concentration in fuel (as S)
HHV	=	higher heating value of the fuel (Btu/scf)
mol vol	=	molar volume of the fuel at standard conditions (1 atm & 60 °F, equals 379 std ft^3/lb-mole)
mol ratio	=	stoichiometric molar ratio for the combustion of sulfur (1 S + 1 O_2 ⇒ 1 SO_2)
MM	=	million

Defaults: Default emission factors can be arrived at by using standard default values for the heating value and sulfur concentrations for each fuel.

Fuel	ppmvd (as S)	ppmvd (as H_2S)	HHV (Btu/scf)	SO_x Emission Factor (lb/MMBtu)
PUC Natural Gas	85	80	1,050	0.0137
GPA Commercial Propane	254	239	2,522	0.0170
GPA HD-5 Propane	169	159	2,522	0.0113
Produced Gas - South Zone	254	239	1,050	0.0409
Produced Gas - North Zone	846	796	1,050	0.1362

where:

(a) PUC Natural Gas: Sulfur concentration based on maximum allowed total sulfur content of 5 gr/100 scf (as S) per General Order 58-A. The calculations below show how the equivalent concentrations are derived (depending on the "basis"):

{ppmvd as S = (5 gr S/100 scf)*(10^6 scf fuel/MM scf fuel)*(lb S/7000 gr S)*(379 scf S/lb-mole S)/(32 lb S/lb-mole S) = 85 ppmvd as S}

{ppmvd as H_2S = (5 gr H_2S/100 scf)*(10^6 scf fuel/MM scf fuel)*(lb H_2S/7000 gr H_2S)*(379 scf H_2S/lb-mole H_2S)/(34 lb H_2S/lb-mole H_2S) = 80 ppmvd as H_2S}.

Heating value based on USEPA AP-42, Appendix A (*Thermal Equivalents of Various Fuels*)

(b) Propane: Sulfur concentration based on Gas Processors Association Engineering Data Book (Ninth Edition, 1972), Figure 15-50 (GPA Liquefied Petroleum Gas Specifications, rev. 1979), Commercial Propane = 15 gr/100 scf, HD-5 Propane = 10 gr/100 scf (both as S). Same equation as listed in (a) above for the ppmvd "as S" calculation. Heating value based on Perry's Chemical Engineers Handbook, Chapter 9, 5th Edition, Table 9-16.

(c) Produced Gas: Sulfur concentration based on APCD Rule 311 - Southern Zone limit of 15 gr/100 scf (as H_2S) and Northern Zone limit of 50 gr/100 scf (as H_2S). To use in the calculations (which are based on an "as S" basis), these limits are adjusted to an as sulfur (as S) basis by use of the equation in note (a) above. This has the same affect as taking the ratio of the molecular weights (MW_S/MW_{H2S}) such that the respective Zone limits are 14.12 gr/100 scf and 47.06 gr/100 scf (as S). Heating value based on USEPA AP-42, Appendix A (*Thermal Equivalents of Various Fuels*)

(d) Reporting References: Reporting "as H_2S" means the total sulfur values are converted to an H_2S basis by taking the ratio of the molecular weights (MW_S/MW_{H2S}). This is needed to determine compliance with Rule 311 and permit conditions that require reporting "as H_2S". For PUC and GPA standards and the emission calculations, sulfur content "as S" is used. "S" in this case is mono-atomic sulfur (MW = 32 lb/lb-mole). When reviewing fuel analyses with di-atomic sulfur species, such as CS_2, the amount of sulfur from the compound in question must be doubled to account for the extra mole of sulfur.

(e) Permit Condition Limits and Reporting: Since permits require sulfur content of fuels to be reported "as H_2S", the associated limits for non-Rule 311 sulfur concentrations need to be also stated in an "as H_2S" basis so as to minimize the confusion of reporting in two ways. As such, for PUC natural gas the standard of 85 ppmvd "as S" is listed in the permit condition as 80 ppmv "as H_2S". For GPA propane/LPG, the standard of 254 ppmvd "as S" is listed in the permit condition as 239 ppmvd "as H_2S".

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TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b, c]	2.4E-05	D
56-49-5	3-Methylcholanthrene[b, c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
207-08-9	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D
74-98-6	Propane	1.6E+00	E

TABL□ 1.□3. □MISSIO□ FACTORS FOR SP□CIAT□D ORGA□IC COMPO□□DS FROM □AT□RAL GAS COMB□STIO□ (Continued)

CAS No.	Pollutant	Emission Factor (lb/10^6 scf)	Emission Factor Rating
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from lb/10^6 scf to kg/10^6 m^3, multiply by 16. To convert from 1b/10^6 scf to lb/MMBtu, divide by 1,020. Emission Factors preceeded with a less-than symbol are based on method detection limits.

[b] Hazardous Air Pollutant (HAP) as defined by Section 112(b) of the Clean Air Act.

[c] HAP because it is Polycyclic Organic Matter (POM). POM is a HAP as defined by Section 112(b) of the Clean Air Act.

[d] The sum of individual organic compounds may exceed the VOC and TOC emission factors due to differences in test methods and the availability of test data for each pollutant.

TABLE 1.4-4. EMISSION FACTORS FOR METALS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
7440-38-2	Arsenic[b]	2.0E-04	E
7440-39-3	Barium	4.4E-03	D
7440-41-7	Beryllium[b]	<1.2E-05	E
7440-43-9	Cadmium[b]	1.1E-03	D
7440-47-3	Chromium[b]	1.4E-03	D
7440-48-4	Cobalt[b]	8.4E-05	D
7440-50-8	Copper	8.5E-04	C
7439-96-5	Manganese[b]	3.8E-04	D
7439-97-6	Mercury[b]	2.6E-04	D
7439-98-7	Molybdenum	1.1E-03	D
7440-02-0	Nickel[b]	2.1E-03	C
7782-49-2	Selenium[b]	<2.4E-05	E
7440-62-2	Vanadium	2.3E-03	D
7440-66-6	Zinc	2.9E-02	E

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. Emission factors preceeded by a less-than symbol are based on method detection limits. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by l6. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020.

[b] Hazardous Air Pollutant as defined by Section 112(b) of the Clean Air Act.

Section 7

Information Used to Determine Emissions

Engines

- AP-42 Tables 3.3-1 and 3.3-2
- EPA Tier 1, 2, and 3 Emission Standards
- Engine spec sheets

  No changes were made to the emergency engines (Generac GEN1-GEN4, IPG, GO Generator Backup EI-128, SX/EW Fire Water Pump, and SX Tankhouse Emergency Generator), which are exempt from construction permitting, so no calculations are provided for these engines in this permit application. However, for completeness purposes, the spec sheets associated with these engines are enclosed.
- 40 CFR 98 Subpart A, Table A-1 (not repeated)
- 40 CFR 98 Subpart C, Tables C-1 and C-2 (not repeated)
- CARB Policy dated June 28, 2004: Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx

Table 3.3-1. EMISSION FACTORS FOR UNCONTROLLED GASOLINE AND DIESEL INDUSTRIAL ENGINES[a]

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01)		Diesel Fuel (SCC 2-02-001-02, 2-03-001-01)		EMISSION FACTOR RATING
	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	
NO_x	0.011	1.63	0.031	4.41	D
CO	6.96 E-03[d]	0.99[d]	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

[a] References 2,5-6,9-14. When necessary, an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr was used to convert from lb/MMBtu to lb/hp-hr. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code. TOC = total organic compounds.

[b] PM-10 = particulate matter less than or equal to 10 μm aerodynamic diameter. All particulate is assumed to be ≤ 1 μm in size.

[c] Assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 86 weight % carbon in gasoline, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and gasoline heating value of 20,300 Btu/lb.

[d] Instead of 0.439 lb/hp-hr (power output) and 62.7 lb/mmBtu (fuel input), the correct emissions factors values are 6.96 E-03 lb/hp-hr (power output) and 0.99 lb/mmBtu (fuel input), respectively. This is an editorial correction. March 24, 2009

Table 3.3-2. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR UNCONTROLLED DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)
Benzene[b]	9.33 E-04
Toluene[b]	4.09 E-04
Xylenes[b]	2.85 E-04
Propylene	2.58 E-03
1,3-Butadiene[b,c]	<3.91 E-05
Formaldehyde[b]	1.18 E-03
Acetaldehyde[b]	7.67 E-04
Acrolein[b]	<9.25 E-05
Polycyclic aromatic hydrocarbons (PAH)	
Naphthalene[b]	8.48 E-05
Acenaphthylene	<5.06 E-06
Acenaphthene	<1.42 E-06
Fluorene	2.92 E-05
Phenanthrene	2.94 E-05
Anthracene	1.87 E-06
Fluoranthene	7.61 E-06
Pyrene	4.78 E-06
Benzo(a)anthracene	1.68 E-06
Chrysene	3.53 E-07
Benzo(b)fluoranthene	<9.91 E-08
Benzo(k)fluoranthene	<1.55 E-07
Benzo(a)pyrene	<1.88 E-07
Indeno(1,2,3-cd)pyrene	<3.75 E-07
Dibenz(a,h)anthracene	<5.83 E-07
Benzo(g,h,l)perylene	<4.89 E-07
TOTAL PAH	1.68 E-04

[a] Based on the uncontrolled levels of 2 diesel engines from References 6-7. Source Classification Codes 2-02-001-02, 2-03-001-01. To convert from lb/MMBtu to ng/J, multiply by 430.
[b] Hazardous air pollutant listed in the *Clean Air Act*.
[c] Based on data from 1 engine.