Addendum

Air Quality Technical Report for the Final Environmental Impact Statement for the Mandan, Hidatsa, and Arikara Nation's Proposed Clean Fuels Refinery Project

March 9, 2011

See EPA's May 9, 2011 letter regarding the applicability of the Clean Air Act requirements to the proposed MHA Nation Refinery. EPA did not concur with this report's conclusion that the proposed refinery would have potential emissions less than the Prevention of Significant Deterioration (PSD) permitting threshold. The preliminary design information and estimated air emission used in the EIS process are estimates of anticipated air emission. Whereas the determination of "potential to emit" for PSD permit applicability are a summation of the maximum air emissions that could be emitted from each specified refinery unit or air pollution unit.

Table of Contents

List of Tables

List of Appendices

Chapter 1 - Introduction

This document has been prepared as an addendum to the December 2007 Air Quality Technical Report for the Final Environmental Impact Statement for the Mandan, Hidatsa, and Arikara Nation's Proposed Clean Fuels Refinery Project (MHA Refinery). The final analyses and assumptions included in this document are a result of a meeting with EPA Air Quality Technical Staff and Tribal Representatives held on March 8, 2011.

This addendum addresses the Potential To Emit (PTE) calculations for oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), non-methane-ethane volatile organic compounds (VOC), and particulate matter (PM) for the sources at the MHA Refinery shown on Table 1.

Table 1 MHA Refinery Sources Included in the PTE Calculations

Source ID	Source
00001	Atmospheric Crude Heater
00002	Reformer Heater 1
00003	Reformer Heater 2
00004	Reformer Heater 3
00005	Reformer Heater 4
00006	Reformer Heater 5
00007	Hydrocracker 1
00008	Hydrocracker 2
00009	Hydrocracker 3
00010	Hydrocracker 4
00011	Olefin
00012	Hydrogen
00013	Boiler 1
00014	Boiler 2
00015	Boiler 3
00016	Flare
00017a	Sulfur Recovery Tail Gas (main)
00017b	Sulfur Recovery Tail Gas (backup)
00018	Vacuum Crude Heater
00019	Decant Oil Tank Heater 1
00020	Decant Oil Tank Heater 2

The Vacuum Crude Heater and two Decant Oil Tank Heaters have been added to this analysis since the December 2007 Air Quality Technical Report. In addition, fugitive emissions of VOC from the Vacuum Unit process and the two Decant Oil Tanks have been included in this analysis.

A backup Amine, Sulfur Recovery Unit (SRU), and Tail Gas system has also been added to the MHA Refinery Design to limit SRU downtime and SO_2 emissions from the flare. This backup system will only operate when the main SRU system is not operating.

Table 2 summarizes the revised estimated annual emissions of NO_x, CO, SO_2, VOC, and PM for the MHA Nation's proposed clean fuels refinery.

Emissions of NO_x, CO, and SO_2 from the emergency generator and fire pump engine have not been updated. Therefore the previous estimates for these sources included in the December 2007 Air Quality Technical Report have been included in these totals.

Table 2 Revised Estimated Potential Annual Emissions for the MHA Refinery

Pollutant	Annual Project Emission Rate (ton/yr)
NO_x	55.8
CO	83.2
SO_2	80.5
VOC	86.2
PM	38.8

Chapter 2 - MHA Refinery PTE Calculations

Local Williston Basin crude with a preference for MHA wells will be used as the feedstock for the MHA Refinery. This crude is currently transported by truck to refineries in North Dakota and Oklahoma. Processing this crude locally will result in a net reduction in truck traffic and associated impacts.

Emission factors and assumptions for the revised calculations are presented below. Documentation for vendor data is provided in Appendix A. Additional data and calculations are provided in Appendix B.

Heater Normal Operation Calculations

Heater NO_x emission estimates and fuel sulfur concentrations (to estimate SO_2 emissions) are based on maximum allowable concentrations under the federal regulation 40 CFR Part 60 Subpart Ja (Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007). Heater CO emissions are based on information provided by John Zink.

General assumptions:

- Boilers operate at 100% load and continuous operation except for startup, shutdown, and malfunction events.
- 10 percent contingency added to normal emission rate estimates.

The normal heater emission estimates are based on the following concentrations:

- NO_x emissions = 40 parts per million (ppm) corrected to 0 percent oxygen (O_2).
- CO emissions = 50 ppm corrected to 3 percent O_2.
- SO_2 emissions based on fuel sulfur (as hydrogen sulfide (H_2S)) concentration of 60 ppm (annual average).
- VOC emissions = 5.5 pounds per million standard cubic feet (lb/MMscf) (USEPA uncontrolled emission factor from AP-42 Table 1.4-2).
- PM emissions = 7.6 lb/MMscf (USEPA uncontrolled emission factor from AP-42 Table 1.4-2).

John Zink has also provided an estimate of 20 ppm corrected to 3 percent O_2 for NO_x emissions. Therefore the NO_x emission concentration used in the calculations is approximately twice the anticipated concentration. The John Zink NO_x emission concentration is based on the following assumptions:

- Ultra LoNox burners,
- No air preheat (APH), and
- Natural gas and fuel gas combust at similar temperatures.

The CO emission concentration is based on the following assumption:

- Natural gas and fuel gas burn at similar temperatures.

Boiler Normal Operation Calculations

Boiler NOx and CO emissions are based on information published by Webster Engineering and Blesi Evans, a Webster vendor, in Minneapolis, Minnesota. Documentation for these data is provided in Appendix A.

General assumptions:

- Assume 100% load and continuous operation except for startup, shutdown, and malfunction events.
- NO_x and CO data assumed to be based on 3 percent excess oxygen.
- 10 percent contingency added to normal emission rate estimates.

The normal boiler emission estimates are based on the following concentrations:

- NO_x emissions = 30 ppm (Webster Engineering burners can achieve 9 ppm).
- CO emissions = 50 ppm (Webster Engineering and Manufacturing flyer and Blesi Evans).
- SO_2 emissions based on fuel sulfur concentration of 60 ppm.
- VOC emissions = 5.5 lb/MMscf (USEPA uncontrolled emission factor from AP-42 Table 1.4-2).
- PM emissions = 7.6 lb/MMscf (USEPA uncontrolled emission factor from AP-42 Table 1.4-2).

Heater and Boiler Startup, Shutdown, and Malfunction Calculations

General assumptions:

- 500 hours per year of startup, shutdown, or malfunction (SSM) events for each heater and boiler.
- This estimated startup emission rates represent 1-hour averages.

The industry standard is to run the refinery for five years, with the exception of mandated inspection intervals. The mandated inspections may shut down equipment for one or two days each year. Once every five years, the refinery will shutdown for approximately 20 days for maintenance.

As stated above, the heaters and boilers are assumed to operate continuously. For the startup and shutdown emission calculations, emissions were increased to startup and shutdown emissions levels, but no downtime emissions (zero emissions) were included in the calculations.

For NO_x, the USEPA uncontrolled emission factor for natural gas boilers less than 100 million BTU per hour (MMBTU/hour) in size (AP-42 Table 1.4-1) was used to represent startup/shutdown emissions.

- NO_x emissions = 100 pounds per million standard cubic feet (lb/MMscf)
- CO emissions = 200 ppm. Maximum startup concentration provided by John Zink.
- SO_2 emissions based on fuel sulfur (as H_2S) concentration of 162 ppm (allowable 3-hour average under 40 CFR Part 60 Subpart Ja).
- VOC and PM based on the same AP-42 emission factors used for normal operation calculations.

Sulfur Recovery Unit Calculations

To calculate the Sulfur Recovery Unit (SRU) emissions, the project tail gas data from Table 14 in the Air Quality Technical Report were used to calculate emissions presented on Table 3. These estimated tail gas emissions were based on Canadian synthetic crude processing, thus should reflect conservative sulfur concentrations relative to Williston Basin crude processing.

Table 3 SRU Emission Estimates

Species	SRU Tail Gas Exhaust Flow (lb-mol/hr)	Molecular Weight (lb/lb-mol)	Emission Rate (lb/hr)
CO	0.17	28.010	4.8
SO_2	0.11	64.063	7.0

The SO_2 concentration shown on Table 3 is equivalent to an SRU Tail Gas exhaust concentration of 2,490 ppm. Under 40 CFR Part 60 Subpart Ja, the allowable concentration is 3,000 ppm. Therefore the SRU Tail Gas exhaust rate for SO_2 was increased to 0.13 lb-mol/hr (which is equivalent to 3,000 ppm) to recalculate the SO_2 emissions from this source. Only one SRU Tail Gas system will be running at any time, therefore the emission calculations treat this as a single source.

No preheating or tail gas incineration is included in the refinery design, therefore it is assumed that NO_x emissions from this source would be negligible.

Flare Calculations

For estimating normal and SSM flaring emissions of NO_x and CO, USEPA flaring emission factors were used along with a normal operation heat input of 10 million British thermal units per hour (MMBtu/hr). The flare emission were taken from AP-42 Table 13.5-1 (English Units) - Emission Factors for Flare Operations.

As was stated in the 2007 Air Quality Technical Report, the normal loading at the Flare is designed for a loading rate of 15 pounds per hour (lb/hr). This loading rate accounts for potential upsets during normal operations.

The 15 lb/hr loading rate was increased to 500 lb/hr - or 10 MMBtu/hr – in order to calculate conservative emission estimates that would account for extreme process upsets. This 500 lb/hr loading rate was used for calculating normal NO_x, CO, VOC, SO_2, and PM_{10} emissions. This loading rate was also used for calculating startup and shutdown NO_x, CO, VOC, and PM_{10} emissions.

The loading rate of 500 lb/hr is over 30 times the normal operation loading rate of 15 lb/hr, and would likely represent an event that would shut down the refinery, and would result in a period of zero emissions. This period of zero emissions is not accounted for in the emission estimates for this source. Flare operations were assumed to be continuous.

Normal SO_2 emissions were based on fuel sulfur (as H_2S) concentration of 60 ppm (annual average).

General assumptions:

- Normal emission calculations are based on a 10 MMBtu/hr loading rate.
- SSM emission calculations are based on a 10 MMBtu/hr loading rate for CO and NO_x.
- Potential SSM SO_2 emissions are based on the SRU capacity of 3 long-tons per day of sulfur and 100 hours of SRU shutdown (note that the backup Amine, SRU, and Tail Gas system would make any operating hours without sulfur recovery very unlikely, therefore the 100 hours of SRU shutdown is more of a force majeure event).
- During SRU shutdown the sulfur would be routed to the flare would be completely converted to SO_2.
- Additional SSM sulfur loading from other sources is assumed to be negligible relative to the SRU shutdown sulfur loading.

Reformer Catalyst Regeneration

The MHA Refinery design for reformer catalyst regeneration employs "in-situ" regeneration. This will occur infrequently over the period of a year and may only occur once per year. During in-situ regeneration the reformer will be shut down and the catalyst will be regenerated inside the reformer. Because the reformer must be shut down for this process, it's assumed that regeneration would result in a negligible increase and, possibly, a reduction of criteria pollutant emissions.

In addition, no hydrofluoric acid will be used in any of the MHA Refinery processes.

Fugitive VOC Calculations

The addition of the Vacuum Unit and two Decant Oil Tanks will create additional emissions of VOC.

Fugitive emissions from loading docks, pumps, seals, valves, etc. associated with the Vacuum Unit would be controlled as described for fugitive VOC sources in the 2007 Air Quality Technical report. Although an accounting of potential fugitive emission sources associated with the Vacuum Unit is not currently available, it is assumed that this source will increase the current estimated fugitive VOC by 20 percent. This assumes a 20 percent increase in fugitive VOC sources which is a very conservative assumption.

Emissions from the two Decant Oil Tanks were estimated using EPA's TANKS software. For these calculations it was assumed that the decant oil would be physically similar to residual oil no. 6.

Vehicle Traffic Fugitive PM_{10} Calculations

The amount of additional traffic required for the Vacuum Unit and Decant Oil Tanks was accounted for by increasing the current estimated vehicle traffic fugitive PM_{10} by 20 percent. As with the Vacuum Unit fugitive VOC calculation, this is a very conservative assumption.

Appendix A - Vendor Documentation

From: Clayton, Jim [jim.clayton@johnzink.com]
Sent: Wednesday, November 03, 2010 4:05 PM
To: Frisbie, Gordon/DEN
Subject: RE: Refinery Heater Specs

Gordon,

The basis provided looks pretty typical for process heaters that do not have air preheat (APH) systems included.

In general, and for the basis of these values, I have assumed Natural gas with "some heavies" (not much with a specified heating value of 1000 btu/scf (net)), 1400 deg F bridgewall temperature (BWT), 3% excess firebox O2, and ambient combustion air. I have included NOx values for a standard burner (no NOx control), Staged Fuel LoNOx burner, and Ultra LoNOx burner.

Standard Burner
100 ppm predicted - Note; We do not make NOx guarantees on standard burners as there is no means to make design adjustments to meet emissions guarantees.

Staged Fuel LoNOx Burner
30 ppm predicted / 35 ppm guaranteed

Ultra LoNOx Burner
17 ppm predicted / 20 ppm guaranteed

A rough correction for firebox temperature increases above the specified 1400 deg F BWT is ~ 8-10% increase for every 100 deg F above the 1400 values.

CO values would be pretty close for all designs. BWTs above 1250 deg F would be <50 ppm. It is common for sites to request & receive a variance for start-up, shut-down, and upset conditions as CO generation is temperature dependant. If possible, I recommend requesting <200 ppm.

Another rule-of-thumb multiplier is that for APH. Should they choose to add combustion APH systems, 600 deg F APH will about double NOx emissions from ambient air operation. The line is pretty straight, so 300 deg APH will add ~ 50% to ambient air NOx emissions.

As you get more definitive information, please do not hesitate to call and we'll firm-up these values.

Thanks & Best Regards,

Jim Clayton
Director, North American Sales
John Zink Company
11920 East Apache
Tulsa, Oklahoma 74116
Tel: (918) 234-5741

Cell: (713) 502-3097
Fax: (918) 234-1806
jim.clayton@johnzink.com
http://www.johnzink.com

From: Gordon.Frisbie@CH2M.com [mailto:Gordon.Frisbie@CH2M.com]
Sent: Thursday, October 21, 2010 12:11 PM
To: Clayton, Jim
Subject: Refinery Heater Specs
Jim,

Thanks for taking the time to talk with me this morning.

As I said, I'm looking for air pollutant emission specs (primarily NOx and CO) for various process heaters that will be part of a proposed refinery in North Dakota. It's currently proposed to fire the heaters on both natural gas and refinery fuel gas.

The general specs on the heaters are as follows:

Atmospheric Crude Heater 35 MMbtu/hr
Reformer Heaters 1.5 to 8 MMbtu/hr
Hydrocrackers 6 to 10 MMbtu/hr
Olefin Process 30 MMbtu/hr
Hydrogen Process 50 MMbtu/hr
Vacuum Crude Heater 5 MMbtu/hr
Oil Tank Heaters 1 MMbtu/hr

I don't have much on the fuel gas, but I would assume it's heat content would be 950 - 1000 btu/scf and would have an H_2S concentration of about 100 ppm.

Let me know if you have any questions or need more information.

Thanks,

Gordon

Gordon Frisbie
Senior Air Quality Specialist
Industrial Systems Business Group

CH2M HILL
9193 South Jamaica Street
Englewood, CO 80112-5946
Direct 720.286.1585
Fax 720.286.9719
Mobile 303.330.4347
Email gordon.frisbie@ch2m.com
www.ch2mhill.com

From: Betsy Torvick [etorvick@blesi-evans.com]
Sent: Thursday, December 23, 2010 8:40 AM
To: Frisbie, Gordon/DEN
Subject: Webster Burners and CO

Hello Gordon,

Ideally, there would be no CO in the flue gases of a boiler/burner using natural gas. It is desired to keep it under 100 ppm. 50 ppm should not be a problem.

Have a good Holiday!
Betsy

Betsy Evans Torvick
Blesi Evans Company
612-721-6237 ph
612-721-7466 fax
952-457-6052 cell

WEBSTER
Engineering and Manufacturing Co LLC

Don't Get Burned! Use Webster's Proven Ultra Low NOx Technology

Your 9ppm project is too important to trust anyone but Webster and our Rapid Mix Burner (RMB). The RMB has been a dependable ultra low NOx solution for nearly 20 years.

The **Model HDRMB** provides reliable ultra low emissions utilizing the patented* rapid mix burner technology, which has been proven on hundreds of applications. Combined with the well established performance of Webster's HD series burners, and the unique capability to easily fire gas or oil without any modifications to the burner, the Webster **HDRMB** is the perfect choice for ultra low NOx applications.

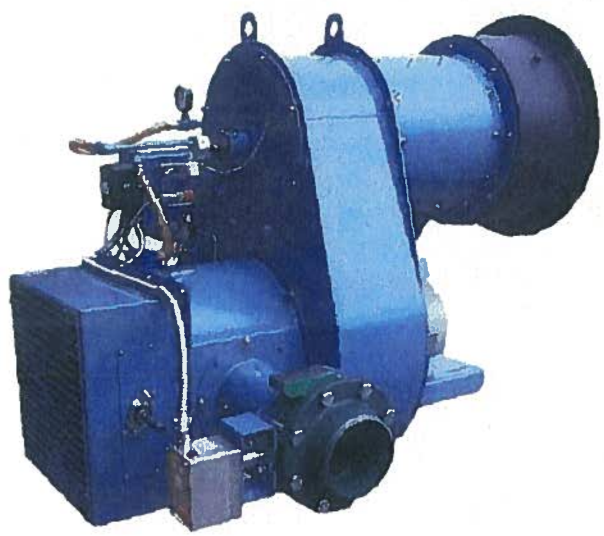
Webster burners – The Fastest Payback for Your Investment

The inherently low excess air design of the HDRMB ensures fuel and energy will not be wasted and your equipment will run efficiently. Webster customers enjoy the lowest energy costs, and fastest payback on their investment. Please visit our web site for more details at www.webster-engineering.com.

* United States of America Patent Numbers 5,407,347 and 5,470,224

Model HDRMB™

Ultra-Low Emissions Rapid Mix Burner for Gas or Gas-Oil Firing Applications



Webster Engineering & Manufacturing Co. L.L.C.
619 Industrial Rd.
Winfield, KS 67156
Phone; 620-221-7464
Email: sales@webster-engineering.com
www.webster-engineering.com

The Leader in Combustion Innovation

Standard Equipment

General

- Blower motor and fan
- Air inlet louver box
- Air-FGR mixing box
- Modulating FGR control Damper

Control Cabinet

- Combustion flame safeguard control
- Indicator lights and control switch
- Linkage-less control system
- Motor starter with overload protection
- Raised terminal strip for easy service and accessibility

Gas Control

- Safety pilot burner
- Ignition transformer
- Pilot solenoid valve
- Pilot shutoff cock
- Pilot regulator
- Safety test cock
- Automatic gas valves

All Webster burners are factory –wired, assembled and tested.

Refractory front plates are supplied with every HDRMB.

Due to their high performance requirements, all HDRMB burners must be started-up by a Webster Factory Authorized service technician.

For complete engineering data contact your local Webster representative.

Model HDRMB™

Ultra-Low Emissions Rapid Mix Burner

Features

- Linkage-less controls systems.
- Patented design reduces both prompt and thermal NOx for ultra-low emissions.
- Compact, stable flame is ideal for firetube and watertube boilers.

Capacities

- 5 – 105 MMBtu/hr
- 125 – 2500 boiler horsepower.

A wide range of sizes are available for maximum efficiency and performance

Applications

- Firetube boilers
- Watertube boilers
- Thermal heaters.

Fuels Burned

Gases:

- Natural, LP, Bio Gases

Oil:

- #2 Oil, Low Sulfur Diesel or Amber 363 firing for applications requiring back-up fuel

Emissions

Guaranteed emissions firing gas as low as:

- Less than 9 ppm NOx.
- Less than 50 ppm CO

Contact your local Webster representative for emissions and performance guarantees

WEBSTER
Engineering and Manufacturing Co LLC

Appendix B - Emission Calculations

MHA Refinery Potential Air Pollutant Emission Calculations

Total Emissions

Source ID	Source	Annual Hours	NOx (ton/yr)	CO (ton/yr)	SO2 (ton/yr)	VOC (ton/yr)	PM (ton/yr)
00001	Atmospheric Crude Heater	8784	6.940	6.595	2.145	1.011	1.397
00002	Reformer Heater 1	8784	0.595	0.565	0.184	0.087	0.120
00003	Reformer Heater 2	8784	0.595	0.565	0.184	0.087	0.120
00004	Reformer Heater 3	8784	1.586	1.507	0.490	0.231	0.319
00005	Reformer Heater 4	8784	1.190	1.131	0.368	0.173	0.240
00006	Reformer Heater 5	8784	0.297	0.283	0.092	0.043	0.060
00007	Hydrocracker 1	8784	1.190	1.131	0.368	0.173	0.240
00008	Hydrocracker 2	8784	1.388	1.319	0.429	0.202	0.279
00009	Hydrocracker 3	8784	1.983	1.884	0.613	0.289	0.399
00010	Hydrocracker 4	8784	1.388	1.319	0.429	0.202	0.279
00011	Olefin	8784	5.948	5.653	1.839	0.867	1.198
00012	Hydrogen	8784	9.914	9.422	3.064	1.444	1.996
00013	Boiler 1	8784	3.538	3.769	1.226	0.578	0.798
00014	Boiler 2	8784	3.538	3.769	1.226	0.578	0.798
00015	Boiler 3	8784	3.538	3.769	1.226	0.578	0.798
00016	Flare	8784	2.987	16.250	28.560	6.757	0.401
00017	S Recovery Tail Gas	8784	0.000	20.675	36.868	0.000	0.000
00018	Vacuum Crude Heater	8784	2.974	2.827	0.919	0.433	0.599
00019	Decant Oil Tank Heater 1	8784	0.198	0.188	0.061	0.029	0.040
00020	Decant Oil Tank Heater 2	8784	0.198	0.188	0.061	0.029	0.040
	Emergency Generator		4.920	0.360	0.120	0.100	0.040
	Fire Pump Engine		0.910	0.040	0.020	0.010	0.010
	Fugitive VOC (Original)					38.020	
	Fugitive VOC (Additional)					7.604	
	Storage Tank VOC (Original)					26.700	
	Storage Tank VOC (Additional)					0.006	
	Soybean Processing						8.510
	Vehicle Traffic Fugitive Dust (Original)						16.740
	Vehicle Traffic Fugitive Dust (Additional)						3.348
	Total		**55.814**	**83.209**	**80.491**	**86.232**	**38.769**

MHA Refinery Potential Air Pollutant Emission Calculations

Normal Operations

Source ID	Source	Annual Hours	NOx (ton/yr)	CO (ton/yr)	SO2 (ton/yr)	VOC (ton/yr)	PM (ton/yr)
00001	Atmospheric Crude Heater	8284	5.983	5.313	1.868	0.959	1.325
00002	Reformer Heater 1	8284	0.513	0.455	0.160	0.082	0.114
00003	Reformer Heater 2	8284	0.513	0.455	0.160	0.082	0.114
00004	Reformer Heater 3	8284	1.368	1.214	0.427	0.219	0.303
00005	Reformer Heater 4	8284	1.026	0.911	0.320	0.164	0.227
00006	Reformer Heater 5	8284	0.256	0.228	0.080	0.041	0.057
00007	Hydrocracker 1	8284	1.026	0.911	0.320	0.164	0.227
00008	Hydrocracker 2	8284	1.197	1.063	0.374	0.192	0.265
00009	Hydrocracker 3	8284	1.710	1.518	0.534	0.274	0.378
00010	Hydrocracker 4	8284	1.197	1.063	0.374	0.192	0.265
00011	Olefin	8284	5.129	4.554	1.601	0.822	1.135
00012	Hydrogen	8284	8.548	7.589	2.669	1.369	1.892
00013	Boiler 1	8284	2.992	3.036	1.068	0.548	0.757
00014	Boiler 2	8284	2.992	3.036	1.068	0.548	0.757
00015	Boiler 3	8284	2.992	3.036	1.068	0.548	0.757
00016	Flare	8684	2.953	16.065	0.560	6.687	0.397
00017	S Recovery Tail Gas	8684	0.000	20.675	36.868	0.000	0.000
00018	Vacuum Crude Heater	8284	2.564	2.277	0.801	0.411	0.568
00019	Decant Oil Tank Heater 1	8284	0.171	0.152	0.053	0.027	0.038
00020	Decant Oil Tank Heater 2	8284	0.171	0.152	0.053	0.027	0.038
	Total		43.297	73.701	50.425	13.355	9.612

MHA Refinery Potential Air Pollutant Emission Calculations

Startup/Shutdown Operations

Source ID	Source	Annual Hours	NOx (ton/yr)	CO (ton/yr)	SO2 (ton/yr)	VOC (ton/yr)	PM (ton/yr)
00001	Atmospheric Crude Heater	500	0.956	1.283	0.277	0.053	0.073
00002	Reformer Heater 1	500	0.082	0.110	0.024	0.005	0.006
00003	Reformer Heater 2	500	0.082	0.110	0.024	0.005	0.006
00004	Reformer Heater 3	500	0.219	0.293	0.063	0.012	0.017
00005	Reformer Heater 4	500	0.164	0.220	0.047	0.009	0.012
00006	Reformer Heater 5	500	0.041	0.055	0.012	0.002	0.003
00007	Hydrocracker 1	500	0.164	0.220	0.047	0.009	0.012
00008	Hydrocracker 2	500	0.191	0.257	0.055	0.011	0.015
00009	Hydrocracker 3	500	0.273	0.366	0.079	0.015	0.021
00010	Hydrocracker 4	500	0.191	0.257	0.055	0.011	0.015
00011	Olefin	500	0.820	1.099	0.237	0.045	0.062
00012	Hydrogen	500	1.366	1.832	0.395	0.075	0.104
00013	Boiler 1	500	0.546	0.733	0.158	0.030	0.042
00014	Boiler 2	500	0.546	0.733	0.158	0.030	0.042
00015	Boiler 3	500	0.546	0.733	0.158	0.030	0.042
00016	Flare	100	0.034	0.185	28.000	0.070	0.004
00017	S Recovery Tail Gas	100	0.000	0.000	0.000	0.000	0.000
00018	Vacuum Crude Heater	500	0.410	0.550	0.119	0.023	0.031
00019	Decant Oil Tank Heater 1	500	0.027	0.037	0.008	0.002	0.002
00020	Decant Oil Tank Heater 2	500	0.027	0.037	0.008	0.002	0.002
	Total		6.687	9.108	29.926	0.436	0.510

MHA Refinery Potential Air Pollutant Emission Calculations

Calculation Constants

Pollutant	**Mol Wt lb/lbmol**
NO2	46.005
CO	28.010
VOC (as CH4)	16.043
SO2	64.063
S	32.065

Normal Operations Fuel - Natural Gas and Fuel Gas

Fuel S Content 60 ppmvd

$$\frac{60 \text{ lb-mol S}}{1000000 \text{ lb-mol CH4}} \times 32.065 \frac{\text{lb S}}{\text{lb-mol S}} \times \frac{1 \text{ lb-mol CH4}}{359 \text{ scf}} = 5.36\text{E-}06 \text{ lb S/scf}$$

Nat Gas Heat Content (LHV) 915.0 BTU/scf
Nat Gas Heat Content (HHV) 1050.0 BTU/scf

Startup/Shutdown/Maintenance (SSM) Operations Fuel - Natural Gas and Fuel Gas

Fuel S Content 162 ppmvd Allowable 3-hour average under 40 CFR Part 60 Subpart Ja

$$\frac{162 \text{ lb-mol S}}{1000000 \text{ lb-mol CH4}} \times 32.065 \frac{\text{lb S}}{\text{lb-mol S}} \times \frac{1 \text{ lb-mol CH4}}{359 \text{ scf}} = 1.45\text{E-}05 \text{ lb S/scf}$$

Fuel Gas Heat Content (LHV)	968.2	BTU/scf
Fuel Gas Heat Content (HHV)	968.2	BTU/scf
Base Temperature =	459.69	deg R
Standard Temperature =	32	deg F
Standard Temperature =	491.69	deg F
Standard Pressure	14.696	psi 1 atm
Gas Constant	0.73	atm*scf/lbmol*R
Exhaust Molar Density =	359	scf/lb-mol
NOx Factor Excess O2	0	percent
CO Factor Excess O2	3	percent
Heat Rate and Exhaust Flow Adjustment Factor =	1	
Site Elevation	2080	feet
Site Ambient Pressure	13.59	psi
Emission Rate Contingency	10%	

mha-pte-02mar11.xlsx, Constants, 3/2/2011, G. Frisbie

MHA Refinery Process and Exhaust Data and Calculations

Source ID	Furnace	Duty	Net Heat Const (LHV) (BTU/h)	Adjusted CT Heat Const (LHV) (BTU/h)	Natural Gas Usage (scf/hr)	Fuel Gas Usage (scf/hr)	Mfg's Exhaust Flow (lb/hr)	Adjusted Exhaust Flow (1) (lb/hr)
00001	Atmospheric Crude Heater	100%	35,000,000	35,000,000	38,251	36,150	28,216	28,216
00002	Reformer Heater 1	100%	3,000,000	3,000,000	3,279	3,099	2,419	2,419
00003	Reformer Heater 2	100%	3,000,000	3,000,000	3,279	3,099	2,419	2,419
00004	Reformer Heater 3	100%	8,000,000	8,000,000	8,743	8,263	6,449	6,449
00005	Reformer Heater 4	100%	6,000,000	6,000,000	6,557	6,197	4,837	4,837
00006	Reformer Heater 5	100%	1,500,000	1,500,000	1,639	1,549	1,209	1,209
00007	Hydrocracker 1	100%	6,000,000	6,000,000	6,557	6,197	4,837	4,837
00008	Hydrocracker 2	100%	7,000,000	7,000,000	7,650	7,230	5,643	5,643
00009	Hydrocracker 3	100%	10,000,000	10,000,000	10,929	10,328	8,062	8,062
00010	Hydrocracker 4	100%	7,000,000	7,000,000	7,650	7,230	5,643	5,643
00011	Olefin	100%	30,000,000	30,000,000	32,787	30,985	24,185	24,185
00012	Hydrogen	100%	50,000,000	50,000,000	54,645	51,642	40,309	40,309
00013	Boiler 1	100%	20,000,000	20,000,000	21,858	20,657	16,124	16,124
00014	Boiler 2	100%	20,000,000	20,000,000	21,858	20,657	16,124	16,124
00015	Boiler 3	100%	20,000,000	20,000,000	21,858	20,657	16,124	16,124
00016	Flare	100%	10,000,000	10,000,000	10,929	10,328	500	500
00017	S Recovery Tail Gas							
00018	Vacuum Crude Heater	100%	15,000,000	15,000,000	16,393	15,493	12,093	12,093
00019	Decant Oil Tank Heater 1	100%	1,000,000	1,000,000	1,093	1,033	806	806
00020	Decant Oil Tank Heater 2	100%	1,000,000	1,000,000	1,093	1,033	806	806

MHA Refinery Process and Exhaust Data and Calculations

Furnace	Duty	Exhaust Flow Wet (lbmol/hr)	Exhaust Flow Dry (lbmol/hr)	Exhaust Flow Dry @0%O2 (lbmol/hr)	Exhaust Flow Dry @3%O2 (lbmol/hr)	Exhaust Flow (scfm)	Exhaust Temp (F)	Calc Exhaust Flow (acfm)
Atmospheric Crude Heater	100%	1,019	833	714	833	6,096	410	11,662
Reformer Heater 1	100%	87	71	61	71	523	410	1,000
Reformer Heater 2	100%	87	71	61	71	523	410	1,000
Reformer Heater 3	100%	233	190	163	190	1,393	410	2,666
Reformer Heater 4	100%	175	143	122	143	1,045	410	1,999
Reformer Heater 5	100%	44	36	31	36	261	410	500
Hydrocracker 1	100%	175	143	122	143	1,045	410	1,999
Hydrocracker 2	100%	204	167	143	167	1,219	410	2,332
Hydrocracker 3	100%	291	238	204	238	1,742	410	3,332
Hydrocracker 4	100%	204	167	143	167	1,219	410	2,332
Olefin	100%	873	714	612	714	5,225	410	9,996
Hydrogen	100%	1,456	1,189	1,019	1,189	8,708	410	16,660
Boiler 1	100%	582	476	408	476	3,483	410	6,664
Boiler 2	100%	582	476	408	476	3,483	410	6,664
Boiler 3	100%	582	476	408	476	3,483	410	6,664
Flare	100%	18	15	13	15	108	410	207
S Recovery Tail Gas		55	44	17	19	0	100	0
Vacuum Crude Heater	100%	437	357	306	357	2,613	410	4,998
Decant Oil Tank Heater 1	100%	29	24	20	24	174	410	333
Decant Oil Tank Heater 2	100%	29	24	20	24	174	410	333

MHA Refinery Process and Exhaust Data and Calculations

		Molecular Weights (lb/lbmol)						
		39.92	28.01	32.00	44.01	18.02		
		Wet Exhaust Analysis (% Volume)					Total	Total
Furnace	**Duty**	**Ar**	**N2**	**O2**	**CO2**	**H2O**	**Wet**	**Dry**
Atmospheric Crude Heater	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Reformer Heater 1	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Reformer Heater 2	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Reformer Heater 3	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Reformer Heater 4	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Reformer Heater 5	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Hydrocracker 1	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Hydrocracker 2	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Hydrocracker 3	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Hydrocracker 4	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Olefin	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Hydrogen	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Boiler 1	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Boiler 2	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Boiler 3	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Flare	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
S Recovery Tail Gas		0.72%	0.58%	2.88%	17.86%	20.05%	0.42	0.22
Vacuum Crude Heater	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Decant Oil Tank Heater 1	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82
Decant Oil Tank Heater 2	100%	0.84%	70.21%	2.45%	8.19%	18.30%	1.00	0.82

MHA Refinery Process and Exhaust Data and Calculations

Furnace	Duty	Total Mol Wt Wet (lb/lbmol)	Total Mol Wt Dry (lb/lbmol)	Dry Exhaust Analysis (% Volume) Ar	N2	O2	CO2
Atmospheric Crude Heater	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Reformer Heater 1	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Reformer Heater 2	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Reformer Heater 3	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Reformer Heater 4	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Reformer Heater 5	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Hydrocracker 1	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Hydrocracker 2	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Hydrocracker 3	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Hydrocracker 4	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Olefin	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Hydrogen	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Boiler 1	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Boiler 2	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Boiler 3	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Flare	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
S Recovery Tail Gas		30.52	41.89	3.28%	2.62%	13.06%	81.04%
Vacuum Crude Heater	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Decant Oil Tank Heater 1	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%
Decant Oil Tank Heater 2	100%	27.69	29.86	1.03%	85.95%	3.00%	10.03%

MHA Refinery Potential Air Pollutant Emission Calculations - Normal Operations

Source ID	Engine	Load	Normal NOx Conc(1) (ppmvd@0%O2)	Normal NOx as NO2 (lb/hr)	Normal Calc NOx (lb/MMBTU)	Normal CO Conc (ppmvd@3%O2)	Normal Calc CO (lb/hr)	Normal Calc CO (lb/MMBTU)
00001	Atmospheric Crude	100%	40	1.4	0.041	50	1.3	0.037
00002	Reformer Heater 1	100%	40	0.1	0.041	50	0.1	0.037
00003	Reformer Heater 2	100%	40	0.1	0.041	50	0.1	0.037
00004	Reformer Heater 3	100%	40	0.3	0.041	50	0.3	0.037
00005	Reformer Heater 4	100%	40	0.2	0.041	50	0.2	0.037
00006	Reformer Heater 5	100%	40	0.1	0.041	50	0.1	0.037
00007	Hydrocracker 1	100%	40	0.2	0.041	50	0.2	0.037
00008	Hydrocracker 2	100%	40	0.3	0.041	50	0.3	0.037
00009	Hydrocracker 3	100%	40	0.4	0.041	50	0.4	0.037
00010	Hydrocracker 4	100%	40	0.3	0.041	50	0.3	0.037
00011	Olefin	100%	40	1.2	0.041	50	1.1	0.037
00012	Hydrogen	100%	40	2.1	0.041	50	1.8	0.037
00013	Boiler 1	100%	30	0.7	0.036	50	0.7	0.037
00014	Boiler 2	100%	30	0.7	0.036	50	0.7	0.037
00015	Boiler 3	100%	30	0.7	0.036	50	0.7	0.037
00016	Flare	100%		0.7	0.068		3.7	0.370
00017	S Recovery Tail Ga:	0%					4.8	
00018	Vacuum Crude Hea	100%	40	0.6	0.041	50	0.5	0.037
00019	Decant Oil Tank He	100%	40	0.04	0.041	50	0.04	0.037
00020	Decant Oil Tank He	100%	40	0.04	0.041	50	0.04	0.037

(1) - Boiler NOx units are ppmvd@3%O2

MHA Refinery Potential Air Pollutant Emission Calculations - Normal Operations

Engine	Load	Normal Fuel S Conc (lb S/MMscf)	Normal Calc SO2 (lb/hr)	Normal Calc SO2 (lb/MMBTU)	Normal VOC Factor (lb/MMscf)	Normal Calc VOC (lb/hr)	Normal Calc VOC lb/MMBTU	Normal PM Factor (lb/MMscf)	Normal Calc PM (lb/hr)	Normal Calc PM lb/MMBTU
Atmospheric Crude	100%	5.36	0.45	0.0129	5.5	0.23	0.0066	7.6	0.32	0.0091
Reformer Heater 1	100%	5.36	0.04	0.0129	5.5	0.02	0.0066	7.6	0.03	0.0091
Reformer Heater 2	100%	5.36	0.04	0.0129	5.5	0.02	0.0066	7.6	0.03	0.0091
Reformer Heater 3	100%	5.36	0.10	0.0129	5.5	0.05	0.0066	7.6	0.07	0.0091
Reformer Heater 4	100%	5.36	0.08	0.0129	5.5	0.04	0.0066	7.6	0.05	0.0091
Reformer Heater 5	100%	5.36	0.02	0.0129	5.5	0.01	0.0066	7.6	0.01	0.0091
Hydrocracker 1	100%	5.36	0.08	0.0129	5.5	0.04	0.0066	7.6	0.05	0.0091
Hydrocracker 2	100%	5.36	0.09	0.0129	5.5	0.05	0.0066	7.6	0.06	0.0091
Hydrocracker 3	100%	5.36	0.13	0.0129	5.5	0.07	0.0066	7.6	0.09	0.0091
Hydrocracker 4	100%	5.36	0.09	0.0129	5.5	0.05	0.0066	7.6	0.06	0.0091
Olefin	100%	5.36	0.39	0.0129	5.5	0.20	0.0066	7.6	0.27	0.0091
Hydrogen	100%	5.36	0.64	0.0129	5.5	0.33	0.0066	7.6	0.46	0.0091
Boiler 1	100%	5.36	0.26	0.0129	5.5	0.13	0.0066	7.6	0.18	0.0091
Boiler 2	100%	5.36	0.26	0.0129	5.5	0.13	0.0066	7.6	0.18	0.0091
Boiler 3	100%	5.36	0.26	0.0129	5.5	0.13	0.0066	7.6	0.18	0.0091
Flare	100%	5.36	0.13	0.0258		1.5	0.1540	7.6	0.09	0.0091
S Recovery Tail Ga	0%		8.49							
Vacuum Crude Hea	100%	5.36	0.19	0.0129	5.5	0.10	0.0066	7.6	0.14	0.0091
Decant Oil Tank He	100%	5.36	0.01	0.0129	5.5	0.01	0.0066	7.6	0.01	0.0091
Decant Oil Tank He	100%	5.36	0.01	0.0129	5.5	0.01	0.0066	7.6	0.01	0.0091

MHA Refinery Potential Air Pollutant Emission Calculations - Startup Operations

Source ID	Engine	Load	Startup Factor NOx (lb/MMscf)	Startup NOx as NO2 (lb/hr)	Startup Calc NOx (lb/MMBTU)	Startup Factor CO (ppmvd@3%O2)	Startup Calc CO (lb/hr)	Startup Calc CO (lb/MMBTU)
00001	Atmospheric Crude	100%	100	3.8	0.109	200	5.1	0.147
00002	Reformer Heater 1	100%	100	0.3	0.109	200	0.4	0.147
00003	Reformer Heater 2	100%	100	0.3	0.109	200	0.4	0.147
00004	Reformer Heater 3	100%	100	0.9	0.109	200	1.2	0.147
00005	Reformer Heater 4	100%	100	0.7	0.109	200	0.9	0.147
00006	Reformer Heater 5	100%	100	0.2	0.109	200	0.2	0.147
00007	Hydrocracker 1	100%	100	0.7	0.109	200	0.9	0.147
00008	Hydrocracker 2	100%	100	0.8	0.109	200	1.0	0.147
00009	Hydrocracker 3	100%	100	1.1	0.109	200	1.5	0.147
00010	Hydrocracker 4	100%	100	0.8	0.109	200	1.0	0.147
00011	Olefin	100%	100	3.3	0.109	200	4.4	0.147
00012	Hydrogen	100%	100	5.5	0.109	200	7.3	0.147
00013	Boiler 1	100%	100	2.2	0.109	200	2.9	0.147
00014	Boiler 2	100%	100	2.2	0.109	200	2.9	0.147
00015	Boiler 3	100%	100	2.2	0.109	200	2.9	0.147
00016	Flare	100%		0.7	0.068		3.7	0.370
00017	S Recovery Tail Ga:	0%						
00018	Vacuum Crude Hea	100%	100	1.6	0.109	200	2.2	0.147
00019	Decant Oil Tank He	100%	100	0.1	0.109	200	0.1	0.147
00020	Decant Oil Tank He	100%	100	0.1	0.109	200	0.1	0.147

NOx startup emissions are based on uncontrolled emissions for Small Boilers in Table 1.4-1. Emission Factors for Nitrogen Oxides (NOx).
CO startup concentrations provided by vendor.

MHA Refinery Potential Air Pollutant Emission Calculations - Startup Operations

Engine	Load	Startup Fuel S Conc (lb S/MMscf)	Startup Calc SO2 (lb/hr)	Startup Calc SO2 (lb/MMBTU)	Startup VOC Factor (lb/MMscf)	Startup Calc VOC (lb/hr)	Startup Calc VOC lb/MMBTU	Startup PM Factor (lb/MMscf)	Startup Calc PM (lb/hr)	Startup Calc PM lb/MMBTU
Atmospheric Crude	100%	14.47	1.11	0.0316	5.5	0.21	0.0060	7.6	0.29	0.0083
Reformer Heater 1	100%	14.47	0.09	0.0316	5.5	0.02	0.0060	7.6	0.02	0.0083
Reformer Heater 2	100%	14.47	0.09	0.0316	5.5	0.02	0.0060	7.6	0.02	0.0083
Reformer Heater 3	100%	14.47	0.25	0.0316	5.5	0.05	0.0060	7.6	0.07	0.0083
Reformer Heater 4	100%	14.47	0.19	0.0316	5.5	0.04	0.0060	7.6	0.05	0.0083
Reformer Heater 5	100%	14.47	0.05	0.0316	5.5	0.01	0.0060	7.6	0.01	0.0083
Hydrocracker 1	100%	14.47	0.19	0.0316	5.5	0.04	0.0060	7.6	0.05	0.0083
Hydrocracker 2	100%	14.47	0.22	0.0316	5.5	0.04	0.0060	7.6	0.06	0.0083
Hydrocracker 3	100%	14.47	0.32	0.0316	5.5	0.06	0.0060	7.6	0.08	0.0083
Hydrocracker 4	100%	14.47	0.22	0.0316	5.5	0.04	0.0060	7.6	0.06	0.0083
Olefin	100%	14.47	0.95	0.0316	5.5	0.18	0.0060	7.6	0.25	0.0083
Hydrogen	100%	14.47	1.58	0.0316	5.5	0.30	0.0060	7.6	0.42	0.0083
Boiler 1	100%	14.47	0.63	0.0316	5.5	0.12	0.0060	7.6	0.17	0.0083
Boiler 2	100%	14.47	0.63	0.0316	5.5	0.12	0.0060	7.6	0.17	0.0083
Boiler 3	100%	14.47	0.63	0.0316	5.5	0.12	0.0060	7.6	0.17	0.0083
Flare	100%	14.47	560.00	56.0000		1.4		7.6	0.08	0.0083
S Recovery Tail Ga	0%									
Vacuum Crude Hea	100%	14.47	0.47	0.0316	5.5	0.09	0.0060	7.6	0.12	0.0083
Decant Oil Tank He	100%	14.47	0.03	0.0316	5.5	0.01	0.0060	7.6	0.01	0.0083
Decant Oil Tank He	100%	14.47	0.03	0.0316	5.5	0.01	0.0060	7.6	0.01	0.0083

mha-pte-02mar11.xlsx, Startup Criteria Emission Calcs, 3/2/2011, G. Frisbie

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Normal NOx Exhaust Flow and Mass Emission Rate Calculation

Boiler
Atmospheric Crude Heater

Annual Hours	8284 hours	
Exhaust Flow	28,216 lb/hr	Engineering Data
Exhaust Mol Weight Wet	27.69 lb/lbmol	Engineering Data
Exhaust Mol Weight Dry	29.86 lb/lbmol	Engineering Data
Exhaust H2O	18.30%	Engineering Data
Exhaust O2 Wet	2.45%	Engineering Data
Ehaust O2 Dry	3.00%	Engineering Data
Ideal Gas Density	358.9337 scf/lbmol	
NOx Mol Weight	46.005 lb/lbmol	
Exhaust Temp	410 deg F	
Base Temperature	460 deg F	
Standard Temperature	32 deg F	
Ambient Pressure	13.59 psi	
Standard Pressure	14.70 psi	

Exhaust Flow

$$\frac{28,216}{1}\ \frac{\text{lb}}{\text{hr}} * \frac{1}{27.69}\ \frac{\text{lbmol}}{\text{lb}} = 1,019\ \frac{\text{lbmol wet}}{\text{hr}}$$

$$1,019\ \frac{\text{lbmol wet}}{\text{hr}} * 359\ \frac{\text{scf}}{\text{lbmol}} = 365,822\ \frac{\text{scf}}{\text{hr}}$$

$$365,822\ \frac{\text{scf}}{\text{hr}} * \left(\frac{460 + 410}{460 + 32}\right) * \frac{14.70}{13.59} = 699,843\ \frac{\text{acf}}{\text{hr}}$$

$$699,843\ \frac{\text{acf}}{\text{hr}} * \frac{1\ \text{hr}}{60\ \text{min}} = 11,664\ \frac{\text{acf}}{\text{min}}$$

Mass Emission Calculation

Remove H2O from Exhaust

H2O Volume

$$1,019\ \text{lbmol} * 18.30\% = 186\ \frac{\text{lbmol H2O}}{\text{hr}}$$

$$1,019\ \text{lbmol} - 186 = 833\ \frac{\text{lbmol exhaust dry}}{\text{hr}}$$

Correct to 0 percent O2

$$21.00\% - 3.00\% = 18.00\%$$

$$21.00\% - 0.00\% = 21.00\%$$

$$833 * \left(\frac{18.00\%}{21.00\%}\right) = 714\ \frac{\text{lbmol exhaust dry corrected to}}{\text{hr}}\ \text{0 percent O2}$$

NOx Emissions = 40 ppmvd @ 0 percent O2

$$714 * \frac{40}{1.00E+06} = 0.03\ \frac{\text{lbmol NOx}}{\text{hr}}$$

$$\frac{0.03}{1}\ \frac{\text{lbmol NOx}}{\text{hr}} * \frac{46.005}{1}\ \frac{\text{lb}}{\text{lbmol}} = 1.31\ \frac{\text{lb NOx}}{\text{hr}}$$

10% Contingency

$$1.3 * (1 + 0.10) = 1.44\ \frac{\text{lb NOx}}{\text{hr}}$$

Annual Emissions

$$1.44\ \frac{\text{lb}}{\text{hr}} * \frac{8284}{1}\ \frac{\text{hr}}{\text{yr}} * \frac{1}{2,000}\ \frac{\text{ton}}{\text{lbs}} = 5.98\ \frac{\text{ton}}{\text{yr}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Startup NOx Mass Emission Rate Calculation

Boiler
Atmospheric Crude Heater

Annual Hours	500 hours
Power Rating	35 MMBTU/hr
Fuel Heat Content	915 BTU/scf

NOx emissions = 100 lb/MMscf AP-42 Table 1.4-1

$$100 \frac{\text{lb}}{\text{MMscf}} * \frac{1 \text{ MMscf}}{915 \text{ MMBTU}} = 0.109 \text{ lb/MMBtu}$$

$$0.109 \frac{\text{lb}}{\text{MMBTU}} * 35 \frac{\text{MMBtu}}{\text{hr}} = 3.83 \frac{\text{lb}}{\text{hr}}$$

Annual Emissions

$$3.83 \frac{\text{lb}}{\text{hr}} * \frac{500 \text{ hr}}{1 \text{ yr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 0.96 \frac{\text{ton}}{\text{yr}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Normal CO Exhaust Flow and Mass Emission Rate Calculation

Boiler

Atmospheric Crude Heater

Annual Hours	8284 hours	
Exhaust Flow	28,216 lb/hr	Engineering Data
Exhaust Mol Weight Wet	27.69 lb/lbmol	Engineering Data
Exhaust Mol Weight Dry	29.86 lb/lbmol	Engineering Data
Exhaust H2O	18.30%	Engineering Data
Exhaust O2 Wet	2.45%	Engineering Data
Ehaust O2 Dry	3.00%	Engineering Data
Ideal Gas Density	358.9337 scf/lbmol	
CO Mol Weight	28.01 lb/lbmol	
Exhaust Temp	410 deg F	
Base Temperature	460 deg F	
Standard Temperature	32 deg F	
Ambient Pressure	13.59 psi	
Standard Pressure	14.70 psi	

Exhaust Flow

$$\frac{28{,}216}{1}\ \frac{\text{lb}}{\text{hr}} * \frac{1}{27.69}\ \frac{\text{lbmol}}{\text{lb}} = 1{,}019\ \frac{\text{lbmol wet}}{\text{hr}}$$

$$1{,}019\ \frac{\text{lbmol wet}}{\text{hr}} * 359\ \frac{\text{scf}}{\text{lbmol}} = 365{,}822\ \frac{\text{scf}}{\text{hr}}$$

$$365{,}822\ \frac{\text{scf}}{\text{hr}} * \left(\frac{460 + 410}{460 + 32}\right) * \frac{14.70}{13.59} = 699{,}843\ \frac{\text{acf}}{\text{hr}}$$

$$699{,}843\ \frac{\text{acf}}{\text{hr}} * \frac{1\ \text{hr}}{60\ \text{min}} = 11{,}664\ \frac{\text{acf}}{\text{min}}$$

Mass Emission Calculation

Remove H2O from Exhaust

H2O Volume

$$1{,}019\ \text{lbmol} * 18.30\% = 186\ \frac{\text{lbmol H2O}}{\text{hr}}$$

$$1{,}019\ \text{lbmol} - 186 = 833\ \frac{\text{lbmol exhaust dry}}{\text{hr}}$$

Correct to 3 percent O2

$$21.00\% - 3.00\% = 18.00\%$$

$$21.00\% - 3.00\% = 18.00\%$$

$$833 * \left(\frac{18.00\%}{18.00\%}\right) = 833\ \frac{\text{lbmol exhaust dry corrected to}}{\text{hr}}\ \text{3 percent O2}$$

CO Emissions = 50 ppmvd @ 3 percent O2

$$833 * \frac{50}{1.00\text{E}+06} = 0.04\ \frac{\text{lbmol CO}}{\text{hr}}$$

$$\frac{0.04}{1}\ \frac{\text{lbmol CO}}{\text{hr}} * \frac{28.01}{1}\ \frac{\text{lb}}{\text{lbmol}} = 1.2\ \frac{\text{lb CO}}{\text{hr}}$$

10% Contingency

$$1.2 * (1 + 0.10) = 1.28\ \frac{\text{lb CO}}{\text{hr}}$$

Annual Emissions

$$1.28\ \frac{\text{lb}}{\text{hr}} * \frac{8284}{1}\ \frac{\text{hr}}{\text{yr}} * \frac{1}{2{,}000}\ \frac{\text{ton}}{\text{lbs}} = 5.31\ \frac{\text{ton}}{\text{yr}}$$

mha-pte-02mar11.xlsx, Normal-Boiler-Heater-CO, 3/2/2011, G. Frisbie

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Startup CO Exhaust Flow and Mass Emission Rate Calculation

Boiler
Atmospheric Crude Heater

Annual Hours	500 hours	
Exhaust Flow	28,216 lb/hr	Engineering Data
Exhaust Mol Weight Wet	27.69 lb/lbmol	Engineering Data
Exhaust Mol Weight Dry	29.86 lb/lbmol	Engineering Data
Exhaust H2O	18.30%	Engineering Data
Exhaust O2 Wet	2.45%	Engineering Data
Ehaust O2 Dry	3.00%	Engineering Data
Ideal Gas Density	358.9337 scf/lbmol	
CO Mol Weight	28.01 lb/lbmol	
Exhaust Temp	410 deg F	
Base Temperature	460 deg F	
Standard Temperature	32 deg F	
Ambient Pressure	13.59 psi	
Standard Pressure	14.70 psi	

Exhaust Flow

$$\frac{28{,}216\ \text{lb}}{1\ \text{hr}} * \frac{1\ \text{lbmol}}{27.69\ \text{lb}} = \frac{1{,}019\ \text{lbmol wet}}{\text{hr}}$$

$$\frac{1{,}019\ \text{lbmol wet}}{\text{hr}} * \frac{359\ \text{scf}}{\text{lbmol}} = \frac{365{,}822\ \text{scf}}{\text{hr}}$$

$$\frac{365{,}822\ \text{scf}}{\text{hr}} * \frac{(460 + 410)}{(460 + 32)} * \frac{14.70}{13.59} = \frac{699{,}843\ \text{acf}}{\text{hr}}$$

$$\frac{699{,}843\ \text{acf}}{\text{hr}} * \frac{1\ \text{hr}}{60\ \text{min}} = \frac{11{,}664\ \text{acf}}{\text{min}}$$

Mass Emission Calculation

Remove H2O from Exhaust

H2O Volume

$$1{,}019\ \text{lbmol} * 18.30\% = 186\ \frac{\text{lbmol H2O}}{\text{hr}}$$

$$1{,}019\ \text{lbmol} - 186 = 833\ \frac{\text{lbmol exhaust dry}}{\text{hr}}$$

Correct to 0 percent O2

$$21.00\% - 3.00\% = 18.00\%$$

$$21.00\% - 0.00\% = 21.00\%$$

$$833 * \left(\frac{18.00\%}{21.00\%}\right) = 714\ \frac{\text{lbmol exhaust dry corrected to}}{\text{hr}}\ \text{0 percent O2}$$

CO Emissions = 200 ppmvd @ 0 percent O2

$$714 * \frac{200}{1.00E+06} = 0.14\ \frac{\text{lbmol CO}}{\text{hr}}$$

$$\frac{0.14\ \text{lbmol CO}}{1\ \text{hr}} * \frac{28.01\ \text{lb}}{1\ \text{lbmol}} = 4.0\ \frac{\text{lb CO}}{\text{hr}}$$

10% Contingency

$$4.0 * (1 + 0.10) = 4.40\ \frac{\text{lb CO}}{\text{hr}}$$

Annual Emissions

$$4.40\ \frac{\text{lb}}{\text{hr}} * \frac{500\ \text{hr}}{1\ \text{yr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 1.10\ \frac{\text{ton}}{\text{yr}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Normal Boiler SO2 Calculation

Boiler
Atmospheric Crude Heater

Annual Hours	8284 hours
Fuel Heat Content (LHV) =	915.0 BTU/scf
Heat Input =	35 MMBTU/hr
Ideal Gas Density	358.9 scf/lbmol
S Mol Weight	32.065 lb
SO2 Mol Weight	64.063 lb

Fuel S Concentration 60 ppmvd

Calculate Fuel Flow

$$\frac{35{,}000{,}000\ \text{BTU}}{\text{hr}} * \frac{1\ \text{scf}}{915\ \text{BTU}} = 38{,}251\ \frac{\text{scf}}{\text{hr}}$$

Calculate Sulfur Emissions

$$\frac{60\ \text{lb-mol S}}{1000000\ \text{lb-mol CH4}} * 32.065\ \frac{\text{lb S}}{\text{lb-mol S}} * \frac{1\ \text{lb-mol CH4}}{358.9\ \text{scf}} = 5.36\text{E-06}\ \frac{\text{lb S}}{\text{scf}}$$

$$5.36\text{E-06}\ \frac{\text{lb S}}{\text{scf}} * 38{,}251\ \frac{\text{scf}}{\text{hr}} = 0.205\ \frac{\text{lb S}}{\text{hr}}$$

$$0.2050\ \frac{\text{lb S}}{\text{hr}} * \frac{64\ \text{lb SO2}}{32\ \text{lb S}} = 0.41\ \frac{\text{lb SO2}}{\text{hr}}$$

10% Contingency

$$0.41 * (1 + 0.10) = 0.45\ \frac{\text{lb SO2}}{\text{hr}}$$

Annual Emissions

$$0.45\ \frac{\text{lb}}{\text{hr}} * \frac{8284\ \text{hr}}{1\ \text{yr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 1.87\ \frac{\text{ton}}{\text{yr}}$$

mha-pte-02mar11.xlsx, Normal-Boiler-SO2, 3/2/2011, G. Frisbie

MHA Refinery Potential Air Pollutant Emission Calculations

Sample Startup Boiler SO2 Calculation

Boiler

Atmospheric Crude Heater

Annual Hours	500 hours
Fuel Heat Content (LHV) =	915.0 BTU/scf
Heat Input =	35 MMBTU/hr
Ideal Gas Density	358.9 scf/lbmol
S Mol Weight	32.065 lb
SO2 Mol Weight	64.063 lb
Fuel S Concentration	162 ppmvd

Calculate Fuel Flow

$$\frac{35{,}000{,}000\ \text{BTU}}{\text{hr}} * \frac{1\ \text{scf}}{915\ \text{BTU}} = 38{,}251\ \frac{\text{scf}}{\text{hr}}$$

Calculate Sulfur Emissions

$$\frac{162\ \text{lb-mol S}}{1000000\ \text{lb-mol CH4}} * 32.065\ \frac{\text{lb S}}{\text{lb-mol S}} * \frac{1\ \text{lb-mol CH4}}{358.9\ \text{scf}} = 1.45\text{E-05}\ \frac{\text{lb S}}{\text{scf}}$$

$$1.45\text{E-05}\ \frac{\text{lb S}}{\text{scf}} * 38{,}251\ \frac{\text{scf}}{\text{hr}} = 0.554\ \frac{\text{lb S}}{\text{hr}}$$

$$0.5536\ \frac{\text{lb S}}{\text{hr}} * \frac{64\ \text{lb SO2}}{32\ \text{lb S}} = 1.11\ \frac{\text{lb SO2}}{\text{hr}}$$

Annual Emissions

$$1.11\ \frac{\text{lb}}{\text{hr}} * \frac{500\ \text{hr}}{1\ \text{yr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 0.28\ \frac{\text{ton}}{\text{yr}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Normal and Startup Startup VOC Mass Emission Rate Calculation

Boiler
Atmospheric Crude Heater

Annual Normal Hours	8284 hours
Annual Startup Hours	500 hours
Power Rating	35 MMBTU/hr
Fuel Heat Content	915 BTU/scf

VOC emissions = 5.5 lb/MMscf AP-42 Table 1.4-2

$$6 \frac{\text{lb}}{\text{MMscf}} * \frac{1 \text{ MMscf}}{915 \text{ MMBTU}} = 0.006 \text{ lb/MMBtu}$$

$$0.006 \frac{\text{lb}}{\text{MMBTU}} * 35 \frac{\text{MMBtu}}{\text{hr}} = 0.21 \frac{\text{lb}}{\text{hr}}$$

Annual Normal Emissions

$$0.21 \frac{\text{lb}}{\text{hr}} * \frac{8284 \text{ hr}}{1 \text{ yr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 0.87 \frac{\text{ton}}{\text{yr}}$$

Annual Startup Emissions

$$0.21 \frac{\text{lb}}{\text{hr}} * \frac{500 \text{ hr}}{1 \text{ yr}} * \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 0.05 \frac{\text{ton}}{\text{yr}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Normal and Startup Startup PM Mass Emission Rate Calculation

Boiler
Atmospheric Crude Heater

Annual Normal Hours	8284 hours
Annual Startup Hours	500 hours
Power Rating	35 MMBTU/hr
Fuel Heat Content	915 BTU/scf

PM emissions = 7.6 lb/MMscf AP-42 Table 1.4-2

$$8\ \frac{\text{lb}}{\text{MMscf}} * \frac{1\ \text{MMscf}}{915\ \text{MMBTU}} = 0.008\ \text{lb/MMBtu}$$

$$0.008\ \frac{\text{lb}}{\text{MMBTU}} * 35\ \frac{\text{MMBtu}}{\text{hr}} = 0.29\ \frac{\text{lb}}{\text{hr}}$$

Annual Normal Emissions

$$0.29\ \frac{\text{lb}}{\text{hr}} * \frac{8284\ \text{hr}}{1\ \text{yr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 1.20\ \frac{\text{ton}}{\text{yr}}$$

Annual Startup Emissions

$$0.29\ \frac{\text{lb}}{\text{hr}} * \frac{500\ \text{hr}}{1\ \text{yr}} * \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 0.07\ \frac{\text{ton}}{\text{yr}}$$

mha-pte-02mar11.xlsx, Sample-Boiler-Heater-PM, 3/2/2011, G. Frisbie

MHA Refinery

MHA Refinery Potential Air Pollutant Emission Calculations

Tail Gas Exhaust Calculations

Annual Hours 8584

Engineering Estimate of Tail Gas Composition

Species	Exhaust Flow (lb-mol/hr)	Molecular Weight (lb/lb-mol)	Emission Rate (lb/hr)	(ton/yr)
Ar	0.40	39.948	16.0	68.6
CO	0.17	28.010	4.8	20.4
CO2	9.87	44.009	434.4	1864.3
H2	0.17	2.016	0.3	1.5
H2O	11.08	18.015	199.6	856.7
N2	31.87	28.014	892.8	3831.9
O2	1.59	31.998	50.9	218.4
SO2	0.11	64.063	7.0	30.2
Total Wet	55.26			
Total Dry	44.18			
SO2 Concentration	2,490	ppmvd		
Recalculate SO2 at	3,000	ppmvd		
SO2	0.13	64.063	8.5	36.4

MHA Refinery Potential Air Pollutant Emission Calculations

Flare Normal Emissions

AP-42 Table 13.5-1 (English Units). Emission Factors for Flare Operations

NOx	0.068	lb/MMBTU
CO	0.37	lb/MMBTU

Normal Hours	8684	hours	
Fuel S Concentration	5.36E-06	lb S/scf	See worksheet "Normal-Boiler-SO2"
Fuel Heat Content	915	BTU/scf	
Fuel Heat Input	10	MMBTU/hr	
Fuel Rate	0.011	MMscf/hr	

Normal Emissions

NOx

$$0.068\ \frac{\text{lb}}{\text{MMBTU}} * 10\ \frac{\text{MMBTU}}{\text{hr}} = \boxed{0.68\ \frac{\text{lb}}{\text{hr}}}$$

$$0.68\ \frac{\text{lb}}{\text{hr}} * 8684\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = \boxed{2.95\ \frac{\text{ton}}{\text{yr}}}$$

CO

$$0.37\ \frac{\text{lb}}{\text{MMBTU}} * 10\ \frac{\text{MMBTU}}{\text{hr}} = \boxed{3.7\ \frac{\text{lb}}{\text{hr}}}$$

$$3.7\ \frac{\text{lb}}{\text{hr}} * 8684\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = \boxed{16.07\ \frac{\text{ton}}{\text{yr}}}$$

SO2

$$5.36\text{E-06}\ \frac{\text{lb S}}{\text{scf}} * 1.00\text{E+06}\ \frac{\text{scf}}{\text{MMscf}} * 0.011\ \frac{\text{MMscf}}{\text{hr}} * 2\ \frac{\text{lb SO2}}{\text{lb S}} = \boxed{0.12\ \frac{\text{lb}}{\text{hr}}}$$

$$0.12\ \frac{\text{lb}}{\text{hr}} * 8684\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = \boxed{0.51\ \frac{\text{ton}}{\text{yr}}}$$

MHA Refinery Potential Air Pollutant Emission Calculations

Flare Startup Emissions

AP-42 Table 13.5-1 (English Units). Emission Factors for Flare Operations

NOx	0.068 lb/MMBTU
CO	0.37 lb/MMBTU

Startup Hours	100 hours
Fuel Heat Input	10 MMBTU/hr
SRU Capacity	3 long-tons/day

Startup Emissions

NOx

$$0.068\ \frac{\text{lb}}{\text{MMBTU}} * 10\ \frac{\text{MMBTU}}{\text{hr}} = 0.68\ \frac{\text{lb}}{\text{hr}}$$

$$0.68\ \frac{\text{lb}}{\text{hr}} * 100\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = 0.03\ \frac{\text{ton}}{\text{yr}}$$

CO

$$0.37\ \frac{\text{lb}}{\text{MMBTU}} * 10\ \frac{\text{MMBTU}}{\text{hr}} = 3.7\ \frac{\text{lb}}{\text{hr}}$$

$$3.7\ \frac{\text{lb}}{\text{hr}} * 100\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = 0.19\ \frac{\text{ton}}{\text{yr}}$$

SO2

$$3\ \frac{\text{long-tons S}}{\text{day}} * 2{,}240\ \frac{\text{lb S}}{\text{long-tons}} = 6{,}720\ \frac{\text{lb S}}{\text{day}} = 280\ \frac{\text{lb S}}{\text{hr}}$$

$$280.0\ \frac{\text{lb S}}{\text{hr}} * 2\ \frac{\text{Mol SO2}}{\text{Mol S}} = 560.0\ \frac{\text{lb}}{\text{hr}}$$

$$560.0\ \frac{\text{lb}}{\text{hr}} * 100\ \frac{\text{hr}}{\text{yr}} * \frac{1\ \text{ton}}{2000\ \text{lb}} = 28.0\ \frac{\text{ton}}{\text{yr}}$$

Updated Fugitive VOC Calculations

Original Storage Tank Total	26.7	ton/yr
2 Decant Oil Tanks	12.56	lb/yr
	0.00628	ton/yr
New Storage Tank Total	**26.7**	
Original Area Fugitives	38.02	
Assume 20% Increase from New Vacuum Unit	7.604	
New Area Fugitive Total	**45.6**	

Updated Fugitive PM Calculations

Original Fugitive Vehicle Traffic PM10	16.74
Assume 20% Increase from New Vacuum Unit	3.348
New Fugitive Vehicle Traffic PM10 Total	**20.088**

TANKS 4.0.9d
Emissions Report - Summary Format
Tank Indentification and Physical Characteristics

Identification		
User Identification:	Decant Oil Tank 1	
City:	Bismarck	
State:	North Dakota	
Company:		
Type of Tank:	Vertical Fixed Roof Tank	
Description:	Decant Oil Tank	
Tank Dimensions		
Shell Height (ft):		40.00
Diameter (ft):		40.00
Liquid Height (ft) :		35.00
Avg. Liquid Height (ft):		25.00
Volume (gallons):		329,011.52
Turnovers:		50.00
Net Throughput(gal/yr):		16,450,576.00
Is Tank Heated (y/n):	Y	
Paint Characteristics		
Shell Color/Shade:	White/White	
Shell Condition	Good	
Roof Color/Shade:	White/White	
Roof Condition:	Good	
Roof Characteristics		
Type:	Dome	
Height (ft)		5.00
Radius (ft) (Dome Roof)		40.00
Breather Vent Settings		
Vacuum Settings (psig):		-0.03
Pressure Settings (psig)		0.03

Meterological Data used in Emissions Calculations: Fargo, North Dakota (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0.9d
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Decant Oil Tank 1 - Vertical Fixed Roof Tank
Bismarck, North Dakota

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Residual oil no. 6	All	85.00	85.00	85.00	85.00	0.0001	0.0001	0.0001	190.0000			387.00	Option 1: VP70 = .00006 VP80 = .00009

TANKS 4.0.9d
Emissions Report - Summary Format
Individual Tank Emission Totals

Emissions Report for: Annual

Decant Oil Tank 1 - Vertical Fixed Roof Tank
Bismarck, North Dakota

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Residual oil no. 6	6.28	0.00	6.28