

APPENDIX B-1

PCAPP EMISSIONS ESTIMATE

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CALCULATION COVER SHEET

PROJECT: Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP)	JOB NO. 24852	CALC NO. RD-M5C-000- B0004	SHEET 1
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SUBJECT PCAPP Emissions Estimate	GROUP Process
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CALCULATION STATUS	PRELIMINARY	COMMITTED PRELIMINARY	CONFIRMED	SUPERSEDED	VOIDED
DESIGNATION	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMPUTER PROGRAM/ TYPE	SCP <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	MAINFRAME <input type="checkbox"/>	PC <input checked="" type="checkbox"/>	PROGRAM NO. EPA TANKS	VERSION/RELEASE NO. 4.0.9d
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Notes/Comments:

FINAL – OPSEC Review Completed on 8/17/2007

QUALITY LEVEL: Q Non-Q N/A

004	Revised as Noted and Reissued for Use	64	Attachment 7, page 4	CGR	WSJ	PAW	5/5/15
003	Revised as Noted and Reissued for Use	62	Attachment 4, page 4	WGS	CGR	PAW	12/17/14
002	Revised to Include Air Permit APEN Tables, and Update Boiler and Generator Data	67	16	TM	WGS	CDS	03/16/09
001	Incorporated Government Comments; Reissued for Use	61	16	TM	WS	CDS	5/12/08
000	Issued for Use	61	16	TM	WS	GJF	9/25/07
NO.	REASON FOR REVISION	TOTAL NO. OF SHEETS	LAST SHEET NO.	BY	CHECKED	APPROVED/ACCEPTED	DATE

RECORD OF REVISIONS

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CALCULATION SHEET

PROJECT: **PCAPP**
JOB NUMBER: **24852**
CALC NO.: RD-M5C-000-B0004
SHEET NO.: 2
SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

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CALCULATION SHEET

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CALC NO.:	RD-M5C-000-B0004
SHEET NO.:	3
SHEET REV.:	004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

1 PURPOSE

This calculation estimates the maximum design case emissions from the PCAPP facility. The estimated emissions provide input for completion of the Multi Pathway Health Risk Assessment and for preparation of Air Pollution Emission Notices (APENs) and Applications.

Two significant differences from previous revisions are incorporated in this revision:

1. Munitions headspace analysis and concentration of chemicals of potential concern (COPCs) in the agent based on the September 29, 2010 Department of Transportation (DOT) Bottle Sampling Report (Ref #4), and
2. Removal of COPCs by carbon is reduced (see Section 5.6).

2 DESIGN CONDITIONS

- 1) The 155mm campaign has the highest agent throughput rates, and thus will emit the most COPCs. This calculation is based on the agent throughput rate of the 155mm campaign.
- 2) The agent neutralization reactors produce eight batches per day (ref #1)
- 3) A 100 acfm air sweep through the cavity access machines (CAMs) and Agent and Washwater Surge Drum captures emissions as the munitions are breached (ref #2).
- 4) There are two boilers for the site, each rated at 58 MMBTU/hr (Oil) and 60.4 MMBTU/hr (Natural Gas) (ref #13).
- 5) There are four diesel generators (two 3,300-kW, one 250-kW, and one 100-kW units) (ref #17, #19, and #34)
- 6) Offgas treatment system (OTS) scrubber removal efficiencies are as follows (ref #14, #20, and #28):
 - a. 99.9 percent removal of 12 micron particles and greater than 99 percent removal of 3.5 micron particles.
 - b. The off gas will contain no more than 30 ppmv HCl (about 99 percent removal).
 - c. The scrubber will remove sufficient SO₂ (about 98 percent) to discharge no more than 1.6 tons of SO₂ per year.
 - d. The off gas will contain no more than 13 ppmv Cl₂ (about 95 percent removal).
 - e. The venturi quenches the vent gas to less than 150°F in less than 0.3 seconds to prevent the formation of dioxins and furans
 - f. The scrubber removes 98 percent of the agent from the feed through hydrolysis.
- 7) The HEPA filters remove 99.97 percent of 0.3 micron particles (ref #15).
- 8) One percent (wt) agent and associated impurities remain in the MWS wash water in the agent water separator. (Ref #36)
- 9) The OTS bulk oxidizer destroys 99.9 percent of the agent in the feed (ref #28)
- 10) Deleted
- 11) Munitions washout in the CAMs is expected to leave virtually no residual agent heel (visually clean) in the cavity and remove 99.8 percent of the agent heel nominally.

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- The downstream MTU can handle up to 5 percent residual heel in the munitions. (ref #30). This calculation is based on the maximum 5% heel value.
- 12) The sulfur content of fuel oil is 0.0015 percent (ref #35)

3 ASSUMPTIONS

- 1) PCAPP emissions can be modeled using appropriately screened data collected from ABCDF hydrolysate, ABCDF SUMMA samples, ABCDF and PCAPP bench-scale test data, ACWA munitions headspace samples (ref #8), and DOT Bottle Sampling (ref #4).
- 2) The complete agent stockpile is processed through the hydrolyzers. This assumption, combined with design condition 11 above (i.e., 5 wt% heel processed through the MTU or 46.8 lb/hr) and Assumptions 8 and 9 (agent from room air), results in more than 100 percent of the stockpile agent being processed.
- 3) Hydrolysate concentration is based on Aberdeen Chemical Agent Disposal Facility (ABCDF) data. Diluted concentration is adjusted for dilution prior to feeding the ICBs.
- 4) All reactor batches follow the batch recipe as given on PFD 24852-RD-M5-B04-B0002 (ref. #4).
- 5) For emissions calculation purposes assume no agent is spilled from the MWS. This is a simplification to facilitate agent accounting. If spills occur, they will be cleaned up which will increase the amount of agent entering the spent decon solution tank. However, this agent will no longer be available for processing through the agent/water separators as concentrate. Since the agent vapor loading in the room is based on assumptions eight and nine, there will be no change in the final emission if this assumption is changed, only the distribution of emissions from individual tanks will be affected.
- 6) The list of compounds in headspace of the hydrolyzers, hold tanks, and 30-day storage tanks are the same, but the concentrations vary with pressure and temperature.
- 7) No removal credit is taken for non-HD organics in the OTS bulk oxidizer or scrubber (conservative estimate).
- 8) Ventilation flow from all level A HVAC areas has an agent load of 1 VSL.
- 9) Ventilation flow from all level B HVAC areas has an agent load of 0.5 VSL.
- 10) Deleted
- 11) The Carbon removal efficiency for HD is 99 percent. Carbon removal efficiencies for all other compounds were estimated based on vendor information and ABCDF sample data, see section 5.6.
- 12) One boiler will be in operation at all times. Adding time for firing both boilers during switchovers, the annual time on natural gas will be 8,787 hours. The boilers are permitted as natural gas boilers and will only burn fuel oil during periods of gas curtailment, during natural gas supply emergencies, and for periodic testing not to exceed 48 hours per year per boiler.
- 13) One of two main standby diesel generators, each generating 5,096 BHP (3,800 kW), operate during power outages. Fuel consumption is 244 gal/hour. Operational testing is limited to 100 hours for each generator (ref. #10).

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- 14) The security standby diesel generator has an output of 398 BHP and consumes fuel oil at a rate of 19.4 gal/hr. It will operate during power outages and is limited to 100 hours per year operational testing (ref. #9). The 198 BHP MSM/ESM generator consumes 10 gal/hr and has the same operational limits as the other generators.
- 15) Caterpillar's emission factor for Particulate Matter (PM) is assumed to be all PM10 for emission calculations
- 16) For the purpose of estimating PM10 emission potential it is conservatively assumed that 100 percent of the paint from the munitions is converted into PM10.
- 17) OTS scrubber removal efficiency for PM10 particles are not given, however based on design condition #6 the calculation uses a conservative estimate of 99 percent removal of PM10.
- 18) Destruction of organics in the ICBs is as shown in the Biotreatment Process Flow Diagrams (ref #21).
- 19) The PCAPP facility will operate on a 24 x 7 schedule.
- 20) Deleted

4 REFERENCES

- 1) PCAPP Design Criteria for Plant Process, 24852-RD-3DR-000-B0001, Rev 006
- 2) PFD, MWS Lines-155mm Munitions, 24852-RD-M5-B02-R0002, Rev S
- 3) MTU Material Balance for 155mm Campaign, 24852-RD-M5-B03-B0003, Rev 002
- 4) Evaluation of the Constituents of Potential Concern from Containers at Pueblo Chemical Depot, Final Report – Headspace Gas Analysis, Southwest Research Institute, Sept, 2010, Chron10-08550
- 5) Deleted
- 6) PFD, Bioreactor Offgas Treatment, 24852-RD-M5-B111-B0002, Rev 002
- 7) Airflow diagrams, 24852-RD-M5-M03-M0002 through M0005, and 24852-RD-M07-M0001 through M0004, and 24852-RD-M5-M02-M0003 though M0005
- 8) PCAPP:Testing:0708063.170: HD mortars headspace sample results, PMACWA report, June 05, 2002
- 9) Air Construction Permit Application to Construct and Operate The Department of the Army Pueblo Chemical Depot Assembled Weapons Alternatives Pueblo Chemical Agent-Destruction Pilot Plant, May 2004.
- 10) CDPHE Construction Permit 04PB0822
- 11) USEPA, AP-42, Stationary Internal Combustion Sources, 10/96
- 12) USEPA, AP-42, External Combustion Sources, 9/98
- 13) PCAPP Specification for Steam Boilers and Accessories, 24852-RD-3PS-000-M0014, Rev. 001
- 14) System Design Description for the Offgas Treatment System No. B20, 24852-RD-3YD-B20-B0001, Rev 002
- 15) System Design Description for Filtration System No. M07, 24852-RD-3YD-M07-M0001, Rev 004
- 16) P&ID, Fuel Oil Storage System SDG Fuel Oil Storage and Supply, 24852-RD-M6-M61-M0001, rev G
- 17) P&IDs, Essential Power Supply Standby Diesel Generator Unit 1A, and Unit 1B, 24852-RD-M6-E02-M0001, Rev 003 and M0002, Rev 003

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- 18) P&ID, Steam & Condensate System Steam Boilers, 24852-RD-M6-M20-M0002, Rev 006
- 19) P&ID, Security Systems Security Standby Diesel Generator, 24852-RD-M6-E40-M0001, Rev 003
- 20) Engineering Specification for Venturi/Scrubber Tower, 24852-RD-3PS-000-M0084, Rev 004
- 21) Biotreatment System (ICB) Material Balance, 24852-RD-M5-B09-B0003, Rev 001 and B0004, Rev 001
- 22) Perry's Chemical Engineers' Handbook, 7th edition
- 23) Handbook of Chemistry and Physics, 73rd edition
- 24) Handbook of Environmental Data on Organic Chemicals, 4th edition
- 25) Yaws Handbook of Antoine Coefficients for Vapor Pressure, Electronic edition, 2005
- 26) www.chemfinder.com
- 27) www.syrres.com/esc/physdemo.htm
- 28) Off Gas Treatment (OTS) Material and Energy Balance, 24852-RD-M5C-B20-B0002, Rev 001
- 29) PFD, Offgas Treatment System, 24852-RD-M5-B20-B0003, Rev 001
- 30) SDD for Munitions Washout System, 24852-RD-3YD-B02-R0001, Rev 004
- 31) UMCDF RCRA Permit Application, Table C-1-13
- 32) Caterpillar Specifications, LEHM7107-00, C280-12 Auxiliary & Diesel Electric Propulsion, 1/19/2007
- 33) Hamworthy Peabody Combustion, Emission Guarantees to English Boiler and Tube, Inc., June 27, 2008
- 34) Data Sheet for ESM and MSM Standby Diesel Generator, 24852-RD-MGD-E02-M0001, Rev 000
- 35) Fuel Oil Certification, Chron14-01362
- 36) Material & Energy Balance, Agent Collection and Neutralization System, 155MM Munitions Campaign, 24852-RD-M5-B04-B0005, Rev 003
- 37) Agent Hydrolyzer Drawing, 24852-V1A-MV00-0006s01-010
- 38) Agent Hydrolysate Hold Tanks Assembly & Details, 24852-V1A-MVS0-0040s01-007
- 39) Stack Concentrations at Proposed DREs for Agent, Vinyl Chloride, and 1,2-Dichlorethane, 24852-RD-M5C-000-B0006

5 CALCULATION

This calculation uses process design information, calculated vapor pressures, Raoult's law, and ideal gas law equations to estimate process emissions. Hydrolysate sample data collected during operations at the ABCDF and headspace analysis of DOT Bottles at PCD provide initial liquid composition and concentration information that are used to identify and quantify the constituents being emitted. Note that the complete list of possible HD degradation products that can be found in literature is not included in this calculation. This is because many compounds were not detected in the ABCDF samples, and therefore no initial concentration data were available. Emissions from non-process sources are estimated using published EPA and vendor supplied emissions factors.

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Vapor-liquid equilibria provide sufficient information to calculate vapor concentrations, but vent flow rates are also required in order to quantify an emission rate. Flow rates were determined primarily by calculating the volume of vapor released when vessels are filled with liquid and determining the frequency of each tank venting based on the amount of agent processed.

In addition, APB/ERB emissions are also calculated based on stack measurements made during operation of the Aberdeen facility. The exhaust stacks from the ABCDF Process Neutralization Building were analyzed 23 times by collecting SUMMA canisters, typically sampled for 24 hours. Of these 23 data sets, four were excluded: two data sets because the two simultaneous samples disagreed with each other by an order of magnitude; and two data sets because they were collected after completion of operations and therefore not considered representative. The average emission rate was then calculated from the remaining data sets and applied to PCAPP. These analyses showed higher emission rates for some constituents than what was expected based on vapor-liquid equilibria. Since the ABCDF PNB was equivalent in function and processing capacity to the PCAPP APB/ERB, the ABCDF mass rates of these emissions are used directly for the APB/ERB portion of the facility. Compounds found in concentrations that were only estimated (greater than minimum detection limit but less than minimum quantifiable limit) or that were only identified once in a single stack but not in the parallel stack were not considered.

The final emissions estimates for each compound presented in this document are the higher of the two APB/ERB values (based on vapor-liquid equilibria or based on ABCDF stack analyses) plus the emissions from all other sources.

This calculation is based on the 155mm projectile campaign (Design Condition 1). According to the Design Criteria for Plant Process (Ref 1), the design munition rate is 64 rounds per hour. At an agent weight per munition of 11.7 pounds, this corresponds to a daily agent throughput rate of 17,971 which is rounded up to 18,000 lb/day in the Design Criteria.

Below is a short explanation of the rational for using Raoult's law in this calculation:

Vapor liquid equilibria is expressed as:

$$y_i P = \gamma_i x_i P_{vpi} F_i \quad (1)$$

where:

y_i = mol fraction of component i in vapor

P = system pressure

γ_i = activity coefficient

x_i = mol fraction of component i in liquid

P_{vpi} = vapor pressure of component i at system temperature

F_i = correction factor for the fugacity coefficient of component i

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For subcritical components, the correction factor F_i is often near unity when the total pressure P is sufficiently low. Even at moderate pressures, setting $F_i = 1$ is justified if experimental information is unreliable, giving large uncertainties in γ . If, in addition to setting $F_i = 1$, it is assumed that $\gamma_i = 1$, equation (1) reduces to Raoult's law.

In order to improve on the approximation of vapor-liquid equilibria provided by Raoult's law, it is necessary to determine more accurate values for the activity coefficients. Classical thermodynamics relates the effect of temperature on the activity coefficient to the partial molar enthalpy. Unfortunately, this is of very limited value because good data for the partial molar enthalpy are rare.

The Gibbs-Duhem equation can be used to extrapolate or interpolate experimental data for different compositions. The utility of the Gibbs-Duhem equation is best realized through the concept of excess Gibbs energy, i.e., the observed Gibbs energy of a mixture above and beyond what it would be for an ideal solution at the same temperature, pressure, and composition. Several equations exist that can be used to relate the molar excess Gibbs energy to composition. All these equations contain adjustable constants. Accurate determination of these adjustable constants requires the availability of experimental vapor-liquid data; higher numbers of data and higher reliability permits more accurate determination of the values for these constants.

There are techniques for estimating activity coefficients, but there is little useful theory available for mixtures containing large molecules, especially if they are polar or form hydrogen bonds. The few available correlations are essentially empirical. This means that predictions of activity coefficients can be made only for systems similar to those used to establish the empirical correlation. Even with this restriction, it must be emphasized that, with few exceptions, the accuracy of prediction is not likely to be high whenever predictions for a binary system do not utilize at least some reliable binary data for that system or for another that is closely related.

Considering the lack of experimental data with which to determine the activity coefficients required to improve upon the estimate provided by application of Raoult's law, and the significant increase in complexity of the calculations required for multi-component systems, the use of Raoult's law appears justified.

Vapor liquid equilibrium using Raoult's law was compared with the output of an ASPEN calculation indicating the material and energy balance for the Off Gas Treatment System's venturi scrubber. Due to lack of data, most of the VOC compounds were not included in the ASPEN calculations; however a few compounds of interest were included in the model. The comparison is:

COMPOUND

	x_i	y_i	From Aspen	Percent Error
thiodiglycol	6.52E-07	1.48E-09	4.24E-11	3396%
1,2-dichloroethane	4.79E-08	1.75E-08	2.72E-08	-36%
trichloroethylene	3.35E-07	1.12E-07	1.74E-07	-36%

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tetrachloroethene	2.56E-06	2.52E-07	3.86E-07	-35%
1,1,2,2-Tetrachloroethane	2.00E-04	7.47E-06	1.07E-05	-30%
2-chlorobutane	1.34E-04	8.63E-05	1.35E-04	-36%

For the volatile organics, the manual application of Raoult's law underestimates emissions by about 35% compared with ASPEN predictions. Thiodiglycol is, by comparison with the other compounds listed above, relatively non-volatile. However, there is conflicting vapor pressure data for thiodiglycol; one source indicates much lower vapor pressures than the values used to determine the Antoine Coefficients used in this calculation. If that data set is used, the predicted value is 55% lower than the ASPEN predicted value.

5.1 AGENT PROCESSING BUILDING (APB) VENT RATES

In the APB, the munitions are removed from the pallets and sent to the MWS, where the agent is drained and the drained munition bodies are washed with heated high-pressure water to remove residual agent. The drained agent and wash water mixture is sent to the agent/water separators for separation and then the agent and wash water are sent to the agent hydrolyzer for hydrolysis and neutralization. The washed munition bodies are decontaminated by the munitions treatment unit (MTU) to the "clean" level. An induced draft of air flow from the room where the CAM is located through the CAM collection cup is maintained by a blower. The blower discharge flows to the off-gas treatment system (OTS) and subsequently to the AFA. Vent gases from vessels in the agent collection and neutralization system (ANS) are also tied into the OTS.

The chemical agent (HD) is hydrolyzed by reaction with hot water in the agent hydrolyzers located inside the neutralization cubicle of the APB. Caustic is added to the agent hydrolyzers after the hydrolysis is complete for pH adjustment. The resultant hydrolysate is pumped to a hydrolysate hold tank, where it is sampled for agent. If agent is detected, the agent hydrolysate is reprocessed through the agent hydrolyzers. If no agent is detected, the agent hydrolysate is pumped to the 30-day storage tanks, which are located outside the APB.

VOC emissions result from the off gassing of process vessels and unit operations. The following describes emissions point sources in the APB. A table containing vent rates in pounds per day, before and after controls, is given in Attachment 1.

B02 – Munitions Washout Station (MWS)

The emissions point sources in each MWS line are the CAMs, where the headspace in the munitions is released, and the washed agent and water surge drums which contain agent vapor in equilibrium with the agent and wash water mixture in the drums. A 100 acfm air sweep through each MWS line captures the headspace gas and vapor as it is released and flows through the surge drums before being sent to the OTS. The B02 material balance (ref #2) is the primary source for composition and flow rates of these vents.

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PROJECT:	PCAPP
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Additionally, the DOT Bottle Sampling Headspace Analysis (Ref #4) for COPC agent concentration is incorporated. In this analysis, the predominant COPC volatile in the headspace was 1,2-dichloroethane (DCA). Vinyl chloride was the only other COPC that was present in all the samples above detection limit. Tetrachloroethene (TCE) was reported in three containers (11 containers were sampled). It was detected at levels below the calibration level ("J Flagged") in seven containers.

The Headspace Analysis (Ref #4) was used to calculate the concentration of DCA and vinyl chloride in agent (Ref #39). The values for these compounds are significantly different from those indicated on the Mass and Energy Balance (Ref #2). The material balance feed rate of DCA is 6.10×10^{-2} lb/day; the calculated value using DOT bottle analysis indicates the feed rate would be 55.37 lb/day. The balance does not indicate any vinyl chloride in the munitions; the calculation using DOT bottle analysis indicates a feed rate of 1.396×10^{-2} lb/day. Using the same approach as that used in Ref #39, the TCE feed would be 0.758 lb/day (including the J Flagged data); the material balance value is 7.58×10^{-4} lb/day. In all cases, the larger value is used in assessing the release from the MWS. The results are given in the MWS column of Attachment 1.

B03 – Munitions Treatment Units (MTU)

Two MTUs treat the drained and rinsed munitions bodies by heating them to at least 1,000 °F for at least 15 minutes. The vents from these units are sent to the OTS. Mass flow rates for these vents are presented in the B03 material balance (ref #3) for two processing cases: 28.8 and 40 rounds/hr per line, both with 5% heel. Because neither of these cases is consistent with the design processing rate of 18,000 pounds of agent per day (corresponding to 32 rounds/hr/MTU), the values in the material balance are adjusted by ratio. The material balances are based on munitions containing 5 wt% heel being fed to the MTU. While this is considered an off-normal condition, the calculation is based on this value because it is a conservative high value.

The MTU emissions are based on a total of 64 rounds per hour each containing 5% heel. Since heel is treated as agent, and the initial charge of a 155 mm projectile is 11.7 pounds, there is an agent feed of 18.72 lb/hr to each MTU. While the MTU removes the agent from the munition bodies, credit for agent destruction in the MTU has not been taken in previous calculations; the agent vaporizes and is sent to the OTS. This agent will contain DCA, vinyl chloride, and TCE consistent with the DOT Bottle Sampling analysis. According to Reference 39, the mass fractions of DCA and vinyl chloride in agent are 3.1×10^{-3} and 7.8×10^{-7} respectively. Using the same approach, the TCE mass fraction is 4.21×10^{-5} . These constituents will also vaporize.

The MTU material balance indicates a flow of Cl₂, HCl, and SO₂. These are combustion products of HD. Since it is important to document the potential emissions of these acid gases, these are included in the estimate even though the agent is assumed to simply vaporize. This is a very conservative approach, but the impact on overall emissions will be minimal. Values for acid gases and particulates are obtained by ratio of the values in the material balance. The calculated flow rates are given in the MTU column of Attachment 1.

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SUBJECT: PCAPP Emissions Estimate

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This calculation does not consider metals emissions from the paint. Even by using a conservative maximum temperature of 1100°F, the pigments will not vaporize. The rationale for this statement is presented below.

Pigments used in commercially available white/gray paints at the time the munitions were painted included mixtures of lead basic carbonate, and barium sulfate. The green paint used to apply markings to the munitions likely contained chromium hydroxide trihydrate. Some nickel and cadmium would also be present due to contamination of the pigments from naturally occurring minerals.

Lead basic carbonate, known as white lead, was used extensively as white pigment in paint until its toxic properties became known. White lead, $2\text{PbCO}_3\cdot\text{Pb}(\text{OH})_2$, decomposes at 400°C (792°F) into lead monoxide (PbO), carbon dioxide and water. Lead monoxide melts at 888°C (1630°F), developing a vapor pressure of only 1 mm Hg at 943°C (1729°F), well above the maximum temperature of the MTU.

Barium sulfate occurs naturally as the mineral barite. The compound melts at 1580°C (2876°F). The green pigment, chromium hydroxide trihydrate decomposes to chromium(III) oxide upon heating. Cr_2O_3 melts at an extremely high temperature, 2665°C (4829°F).

The most likely nickel compounds to be found in pigment are basic nickel carbonate and nickel oxide. The carbonate decomposes upon heating to form the oxide, which has a melting temperature of 1955°C (3551°F).

Finally, the most likely form of cadmium is as the carbonate mineral otavite. This decomposes at 357°C (675°F). The resulting oxide sublimes, developing 1 mm Hg vapor pressure at 1000°C (1832°F).

Based on the stability of the various metal oxides, vaporization at MTU temperatures will not occur.

There is a potential for metal emissions in the form of particulates; however, the potential rate is extremely small. Particulate emissions are estimated in this calculation to be 1.1×10^{-7} pounds per day after controls. This result is based on the conservative assumption that all the paint chips (the inorganic constituents of the paint) are elutriated from the MTU as a fine particulate (PM_{10}) (i.e., none of the paint chips remain on the munitions bodies or are collected in the Paint Residue Removal Station (PRRS) or OTS filters). The MTU PM_{10} rate is therefore conservatively estimated to be 124 lb/day, which is reduced to 1.2 lb/day by the venturi/scrubber and then to 1.1×10^{-7} lb/day by the AFA HEPA filters (two 99.97% filters in series).

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CALC NO.:	RD-M5C-000-B0004
SHEET NO.:	12
SHEET REV.:	004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Another source (UMCDF RCRA Application, Ref #31) indicated the metals in the paint on the 155 MM Projectile are

	Lb/round
Pb	5.08×10^{-2}
Ba	2.81×10^{-2}
Cd	1.45×10^{-2}
Ni	1.47×10^{-2}
Cr	8.12×10^{-3}

Assuming the maximum capacity of eighty 155mm rounds per hour is sustained for 365 days per year, all metals in paint are released to the OTS as particulates, and the same particulate capture efficiencies are used as in the base calculation (99 percent in the scrubber and 99.97 percent in each of the two HEPA filters in series), the annual emissions would be approximately:

Pb	15 mg
Ba	8 mg
Cd	4 mg
Ni	4 mg
Cr	2 mg

These rates are sufficiently low to justify the claim that particulate metals emissions are not of concern.

B04 (APB) – Agent Collection and Neutralization System (ANS)

The B04 system tanks/vessels located in the APB are the Agent Water Separators, the Wash Water Collection Tanks, the Hydrolyzers, and the Hold Tanks. The first three sets of tanks are located in the Toxic Cubicle; the vents from each are combined into a vent header that directs the vent stream to the OTS. The Hold Tanks are located in a separate room dedicated to them; the vent from these tanks are combined and directed to the OTS, combining with the other vent header just upstream of the OTS Preheater.

Two agent water separators collect drained agent and wash water from the B02 system at 5.5 gpm each. The tanks vent at the same rate they are filled. The total moles of gas displaced are estimated using the ideal gas law, $n = PV/RT$. Raoult's law, $y_a \cdot P = x_a \cdot p_a$, is used to describe the multi-component gas liquid phase system at equilibrium (see discussion of Raoult's Law applicability in Section 5). The Wash Water layer occupies the top of the separators. This phase, which contains 1 wt% agent, is the liquid phase in equilibrium with the vapor.

The agent water separators periodically feed the MWS wash water collection tanks at a rate of 10 gpm. These four tanks manifold into the same vent header therefore they share the same head space. As one tank is emptied the other tank fills and there is no net vent from the system.

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PROJECT:	PCAPP
JOB NUMBER:	24852
CALC NO.:	RD-M5C-000-B0004
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

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The two agent hydrolyzers are fed by the agent water separators, the MWS wash water collection tanks, the spent decon tanks, and the hot process water tanks. The hydrolyzers are pressure controlled vessels that vent only when the pressure exceeds 12 psig during initial fill (Wash Water, Spent Decon, and Hot Process Water) and 25 psig thereafter. The hydrolyzer will not vent other than during the initial fill. When the hydrolyzer contents are pumped out, air is added to the hydrolyzer to maintain a minimum pressure of 10 psig. The ideal gas law is used to estimate the number of moles vented during fill and Raoult's law is used to describe hydrolysate liquid/vapor equilibrium. Since agent has not been added during the venting, the liquid contents in the hydrolyzer are not yet hydrolysate; using hydrolysate composition to estimate equilibrium is a conservative approach.

Liquid compositions for calculating vapor-liquid equilibrium for the surge drum and agent-water separators were based on agent analyses as previously described. Starting with the hydrolyzers, and carrying on through the downstream tanks and processes, the liquid analysis is based on ABCDF hydrolysate composition adjusted to contain the quantity of DCA estimated to be in the liquid based on the DOT Bottle Sampling effort as discussed in the B02 – MWS section. The total DCA feed rate is 55.37 lb/day and 1.02 lb/day are estimated to be released in the MWS. The hydrolysate concentration of DCA is determined by dividing the remaining 54.35 lb/day of DCA by the mass of hydrolysate produced per day. The Vinyl chloride and TCE values were not changed because the ABCDF hydrolysate values are greater than what would be derived using the agent concentrations of these constituents. The ABCDF hydrolysate should be representative of the hydrolysate that will be produced at PCAPP since both facilities use the same agent hydrolysis process.

Two agent hydrolysate hold tanks are fed by the agent hydrolyzers. Each tank will hold two reactor batches, slightly over 7,000 gallons total volume. The agent hydrolysate hold tanks are also pressure controlled vessels that only vent when the pressure exceeds the set point of 45 psig. A minimum pressure of 5 psig is maintained in the hold tanks during transfer of liquid to the 30-Day Storage Tanks. The Hold Tanks are sufficiently oversized that the increase in headspace pressure should never be sufficient to cause the tanks to vent; therefore there are no emissions from the Hold Tanks.

B05 – Spent Decon Tanks

It is assumed that no agent is spilled from the MWS, therefore no agent or agent breakdown products are in the spent decon system (assumption #5). As a result there are no VOC emissions from these tanks. This simplifying assumption is justified because any agent that is spilled and subsequently rinsed to the decon tank would not be present in the wash water; therefore, the same amount of agent is sent to the hydrolyzers and processed in either case. In addition assumptions #8 and #9 provide an allowance for agent in the HVAC system.

B20 – Off Gas Treatment System (OTS)

Vents from the B02, B03, B04, B05, and B24 system manifold to a header and are sent to the OTS. In the OTS the vents pass through a bulk oxidizer. The heat input to the

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BY: Clara Galbis-Reig

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bulk oxidizer limits the operating temperature to 850°F when all flows are directed through it. At this temperature, only 1 percent of the agent in the stream is expected to be destroyed. The vent from the Supplemental Decontamination Unit (SDU), part of System B24, can be configured to re-direct the SDU exhaust directly to the scrubber, thereby bypassing the oxidizer. The oxidizer is capable of exceeding 1150°F when operated in this manner; the agent destruction in the bulk oxidizer is expected to be 99.9%. For this calculation, the higher-temperature operation is used because we anticipate SDU by-passing the oxidizer will be the preferred configuration. Note that no VOC reduction is credited for the oxidizer at either operating condition.

After leaving the bulk oxidizer the gas is then rapidly quenched in a venturi, then passes through a scrubber. The scrubber removes 99 percent of the HCl, 98 percent of the SO₂, 95 percent of the Cl₂, and 98 percent of the remaining agent in the feed. For the purpose of the emissions calculation it is assumed that the OTS does not remove any VOCs from the feed (assumption #7). This provides a conservative estimate of emissions. After leaving the scrubber, the vents combine with the HVAC system and pass through carbon beds before discharging to the atmosphere. Mass flow rates for the B20 system are also given in Attachment 1.

B24 – Supplemental Decon Unit (SDU) and Autoclave

SDU and Autoclave emissions have been accounted for as part of the air flow through the HVAC system, and through assumptions 5 and 8 which in combination over estimate the total amount of agent the facility will process (100 percent from the munitions + 5 percent heel in the MTU + 1 VSL in the ventilation system).

5.2 B04 – 30-DAY STORAGE TANKS

The 30-day storage tanks provide buffer capacity prior to feeding the biotreatment area. A carbon filter vent system is provided on the 30-day storage tanks to mitigate odors. Assuming that flow out of the 30-day storage tanks is negligible, emissions will only occur during batch transfer from the agent hydrolysate hold tanks. The total moles of gas displaced and the multi-component vapor liquid system at equilibrium are estimated using the ideal gas law and Raoult’s law respectively. Mass flow rates in pounds per day, before and after carbon controls, are given in Attachment 2.

5.3 B09 – BIOTREATMENT AREA (BTA)

The hydrolysate from the 30-day storage tanks is diluted approximately 7 to 1 with process water in the immobilized cell bioreactor (ICB) feed tanks before being fed to the ICBs to achieve a feed TDG concentration of 7000 mg/liter. The ICB feed tanks, the ICBs, and the effluent tank vents manifold into the same vent header. The combined vents are fed through the BTA off gas treatment system, which consists of two carbon beds, before being released to the atmosphere.

The destruction of organics by biological oxidation within the ICBs and the off-gas composition are based on the biotreatment system material balance (Ref #21). Mass flow rates in pounds per day, before and after the BTA OTS, are given in Attachment 3.

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5.4 B12 AND B14 – BRINE REDUCTION SYSTEM (BRS) AND WATER RECOVERY SYSTEM (WRS)

The Brine Reduction System is designed to process 120 gpm of feed. The feed consists of effluent from the ICBs, Cooling Tower and Boiler Blowdown, and Reverse Osmosis (RO) reject. The blow down and RO reject streams contain no COPCs, and the effect of these streams is to slightly reduce liquid concentrations of constituents in the ICB effluent. Potential dilution of the ICB effluent is not considered in this calculation. There is a 300 acfm aeration on each of the three tanks. The total moles and composition of the gas in the vent are estimated using the ideal gas law and Raoult's law. The vapor concentrations for each component except ammonia were calculated to be in equilibrium with the feed to the tanks. This results in very little error since the fraction of the components reporting to the vapor stream is small, and the predicted losses are somewhat high. Due to ammonia's volatility, a much higher fraction reports to vapor, so the losses were calculated by iteration to be in equilibrium with the liquid in the tanks. Vents from the three tanks are sent to the same header, then through a carbon bed before being released to the atmosphere. The brine concentrator feed tanks provide buffer capacity for the BRS which produces a solid cake and water that is recycled to the process. Vents from the BRS are sent through a vent condenser and a carbon bed before being released to the atmosphere. Mass flow rates in pounds per day, before and after carbon controls, are given in Attachment 4.

5.5 APB AND ENHANCED RECONFIGURATION BUILDING (ERB) HVAC

Air flow diagrams (ref #7) give the acfm flows through the APB and ERB HVAC systems. Emissions are calculated by multiplying those flows by assumed agent concentrations of 1 VSL for level "A" areas and 0.5 VSL for level "B" areas per assumptions 8 and 9. HVAC flows combine with vents from the APB process vessels before going through carbon filters then releasing to the atmosphere. Vent rates in pounds per day, before and after controls, are given with the vents from the neutralization process in Attachment 1.

5.6 CARBON REMOVAL EFFICIENCY ESTIMATES

Information on most of the compounds relative affinity to activated carbon was obtained from a vendor (see Attachment 7). This data is a ranking from 1 to 5 indicating the ability of activated carbon to remove the compound from an air stream with 5 being the most easily removed. In a few instances where a ranking was not provided, a ranking was assigned by comparing the compound's molecular weight with that of a chemically similar compound whose ranking was known.

Removal efficiencies are assigned to each compound based on their rankings. In previous revisions of this calculation, removal efficiencies ranged from 50% for a compound with a ranking of 1 to 90% for one with a ranking of 5. In order to be more conservative, a removal efficiency of 66% is assigned to compounds with a ranking of 5 and 33% for those with a ranking of 4. No removal by carbon is taken for compounds with a ranking below 4.

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CALCULATION SHEET

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5.7 B13 – BULK CHEMICAL STORAGE AND DISTRIBUTION

The bulk chemical storage and distribution system contains storage tanks for 25 wt% caustic, 5 wt% caustic, di-ammonium phosphate, and urea. Due to the low vapor pressure of caustic (1.82×10^{-21} mmHg at 25 deg C) and urea (1.2×10^{-5} mmHg at 25 deg C), emissions from those tanks should be negligible. The di-ammonium phosphate also has a low vapor pressure and is only filled once every two months. Emissions from this tank will also be negligible.

5.8 BOILERS AND GENERATORS

BOILERS

There are two dual-fired boilers rated at 58 MMBtu/hr (Oil) and 60.4 MMBTU/hr (Natural Gas). The combined operations of the two boilers will not exceed 17,520 hours per year. Primary fuel for the boilers will be interrupted natural gas supply. If no natural gas interruptions occur, the boilers will operate entirely on natural gas. However, emission calculations are based on a permit allowable limit of 1,440 hours of fuel oil combustion. Emission factors stated in Ref #3 are used to estimate emissions of criteria pollutants. Emission factors published in USEPA AP-42 Manual (Ref #12) are used to estimate emissions of Hazardous Air Pollutants. Results for the boilers and generators are given in Attachment 5.

GENERATORS

Four standby diesel generators (SDG) (two 3,300-kW, one 250-kW, and one 100-kW units) are installed. Annual combustion of diesel fuel for the two main units combined is limited to 108,640 gallons by the current CDPHE Air Construction Permit, to 3,200 gallons for the security generator by the Air Construction Permit Application, and to 1,004 gallons for the MSM/ESM Emergency Generator. Emission factors stated in vendor specification for Tier III generators representative of the style of generators that will be installed at PCAPP are used to estimate emissions of criteria pollutants for the 250-kW generator. Emission factors stated in Caterpillar Specifications, Ref #32, are used to estimate emissions of criteria pollutants for the 3,300-kW generators. Emission factors published in USEPA AP-42 Manual are used to estimate emissions of Hazardous Air Pollutants.

5.9 FUEL OIL STORAGE

The fuel oil system stores No. 2 diesel fuel for the 3,300-kW generators and the boilers. Most of the fuel will be stored in a 75,000 gallon SDG fuel oil storage tank. This tank will feed two 1,900-gallon SDG day tanks and one 660-gallon fuel oil day tank for the boilers. Fuel for the 250-kW generator is stored separately in a 400-gallon tank. The EPA program TANKS 4.0.9d contains physical property data for fuel oil No. 2; therefore, the emissions estimates for these tanks were calculated with the TANKS program. Inputs and results from this program are given in Attachment 6.

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BY: Clara Galbis-Reig

DATE: 4/23/15

6 CONCLUSIONS

The total calculated daily emissions after controls from the process facilities previously described are listed below. The component list does not include all compounds generated by the boilers and generators, however the total organics value in that column does represent all boiler and generator estimated VOC emissions. See Attachment 5 for a full list of compounds emitted from the boiler and generators.

From the table below, the estimated daily emissions of organics are 26.3 pounds per day. Primary organic emissions are associated with 1,2-dichloroethane (9.7 pounds per day), vinyl chloride (5.2 pounds per day), 1,4-oxathiane (2.6 pounds per day), hexane (2.6 pounds per day), 1,4-dithiane (2.4 pounds per day), and Ethane (2-chloromethoxy) (2.1 pounds per day).

Component	APB/ERB		30-day storage tank	BTA	BRS/WR S	Boilers and Generators	Fuel Oil Storage	Total (using max APB/ERB value)
	From Vapor-Liquid Equilibria	Based on ABCDF Stack Analyses						
	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
NO2	2.6E-01					7.9E+01		7.9E+01
NO	1.7E+00							1.7E+00
SO2	7.2E+00					9.0E-01		8.1E+00
CO						6.2E+01		6.2E+01
PM10	1.1E-07					1.6E+01		1.6E+01
TSP	1.1E-07					1.6E+01		1.6E+01
Ammonia				1.1E+00	2.4E+01			2.5E+01
HCL	3.5E+00							3.5E+00
Cl2	3.0E+00							3.0E+00
1,1,2,2-Tetrachoroethane	6.2E-05		1.2E-05	5.0E-02	3.2E-06			5.0E-02
1,1-Dichloroethane	1.3E-03		3.9E-05	6.6E-03	1.2E-05			8.0E-03
1,2,3-trichlorobenzene	1.4E-09		5.1E-10	4.7E-05	1.1E-10			4.7E-05
1,2-Dichlorobutane	1.8E-04		1.3E-04	2.0E-01	3.6E-05			2.0E-01
1,2-Dichloroethane	3.8E+00	4.8E+00	1.1E-02	4.9E+00	3.4E-03			9.7E+00
1,2-dichloropropane	2.4E-07		1.9E-07	1.2E-04	5.7E-08			1.2E-04
1,3-Butadiene, 2-ethyl	9.2E-05		1.8E-06	5.7E-04	5.6E-07			6.6E-04
1,4-Dithiane	2.3E-03		1.1E-03	2.4E+00	2.6E-04			2.4E+00
1,4-Oxathiane	4.0E-03		2.1E-03	2.6E+00	5.0E-03			2.6E+00
1-Chlorobutane	1.8E-07		2.2E-08	8.0E-06	6.8E-09			8.2E-06
1-Hexene	1.4E-05		1.3E-05	2.8E-03	4.2E-06			2.8E-03
2-Butanone	7.9E-05	4.1E-03	7.0E-05	2.6E-02	2.1E-05			3.0E-02
2-Chlorobutane	1.9E-04		1.3E-04	3.3E-02	4.2E-05			3.3E-02
2-Hexanone	2.4E-06	1.2E-02	1.5E-06	3.5E-03	3.7E-07			1.6E-02
3&4-Methylphenol	6.6E-09		1.0E-09	1.4E-04	1.6E-10			1.4E-04

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CALCULATION SHEET

PROJECT: **PCAPP**

JOB NUMBER: **24852**

CALC NO.: RD-M5C-000-B0004

SHEET NO.: 18

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BY: Clara Galbis-Reig

DATE: 4/23/15

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Component	APB/ERB		30-day storage tank	BTA	BRS/WRS	Boilers and Generators	Fuel Oil Storage	Total (using max APB/ERB value)
	From Vapor-Liquid Equilibria	Based on ABCDF Stack Analyses						
	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
4-Methyl-2-Pentanone	4.0E-06		2.8E-06	4.1E-03	7.6E-07			4.1E-03
Acetone	6.7E-04	7.8E-02	6.6E-04	1.1E-01	2.1E-04			1.9E-01
Benzene	4.0E-06		3.6E-04	1.3E-03	1.1E-06	6.2E-03		7.9E-03
Chloroform	1.6E-05	3.4E-03	1.5E-05	3.0E-03	4.8E-06			6.4E-03
Chloromethane	2.2E-04	6.4E-03	3.3E-04	3.9E-03	1.2E-04			1.1E-02
Diethyl Ether	4.3E-05		5.0E-05	4.0E-03	1.7E-05			4.1E-03
Ethane	8.9E-02		1.3E-02	2.6E-02	5.8E-03			1.3E-01
Ethane (2- chloromethoxy)	6.0E-07			2.1E+00				2.1E+00
Ethane, 2- chloroethoxy	4.9E-06		1.4E-06	3.7E-01	2.8E-07			3.7E-01
HD	4.2E-04							4.2E-04
m&p-Xylenes	2.3E-08	7.2E-02	1.4E-08	4.5E-05	3.8E-09			7.2E-02
Methylene Chloride	2.1E-04	5.6E-03	2.3E-04	2.1E-02	7.4E-05			2.7E-02
Napthalene	2.4E-09		9.3E-10	6.3E-05	2.0E-10	1.5E-03		1.6E-03
TDG	3.9E-03		4.3E-03	2.4E-03	7.1E-03			1.8E-01
Tetrachloroethene	1.4E-02		3.0E-05	4.8E-02	8.2E-06			4.8E-02
Thiirane	1.3E-04		3.3E-05	5.2E-03	1.1E-05			5.4E-03
Toluene	1.5E-07	4.7E-02	1.1E-07	1.2E-04	3.2E-08	6.8E-03		5.4E-02
Trichloroethylene	1.2E-02		3.6E-05	1.7E-02	1.1E-05			2.9E-02
Vinyl Chloride	1.6E-02	5.0E+00	1.1E-02	1.9E-01	4.1E-03			5.2E+00
1,2,4-Trimethylbenzene		2.5E-03						2.5E-03
Acrolein		7.8E-03				6.6E-05		7.9E-03
Alpha Methyl Styrene		3.0E-03						3.0E-03
Carbon Disulfide		2.9E-02						2.9E-02
Chloroethane		8.6E-02						8.6E-02
Ethylbenzene		3.6E-02				7.1E-06		3.6E-02
Fuel Oil No. 2							6.8E-02	6.8E-02
Hexane		5.4E-03				2.6E+00		2.6E+00
Methyl t-butyl Ether		2.0E-02						2.0E-02
Octane		1.2E-02						1.2E-02
o-xylene		3.4E-02				1.2E-05		3.4E-02
Pentane		1.3E-02						1.3E-02
Propene		1.6E-02						1.6E-02
tert-Butyl Alcohol		9.9E-03						9.9E-03
Total organics (lbs/day)	3.97	10.3	0.045	13.209	0.026	2.6	0.068	26.3
Total (lbs/day)	19.6	10.3	0.045	14.275	24.3	175.7	0.068	241.0

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CALCULATION SHEET

PROJECT:	PCAPP
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SHEET REV.:	004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

7 ATTACHMENTS

- 1) Neutralization process and HVAC emissions calculation, 6 pages
- 2) 30-Day storage tanks emissions calculation, 4 pages
- 3) BTA emissions calculation, 4 pages
- 4) BRS/WRS emissions calculation, 3 pages
- 5) Boilers and Generators emissions, 6 pages
- 6) Fuel Storage Tanks emissions, 15 pages
- 7) Barnebey Sutcliffe Carbon Removal Affinities, 4 pages

CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: RD-M5C-000-B0004
 SHEET NO.: Attachment 1
 1 of 6
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 1

Calculation: Estimate the emissions from the APB and ERB

Basis: 155 mm Munitions Campaign, 8 reactor batches per day

Pressure relief valve set point in reactor is 12 psig during initial fill, and 25 psig during agent fill
 Mass flow rates for compounds in the **MWS** and **MTU** are given in material balances except for adjusting for DOT Bottle
 Sample Analyses as described in the text

Liquid mole fractions of the components in the agent water separators, the agent hydrolyzers, and the hold tanks are listed below
 Calculations for compounds in the remaining columns are as follows:

Agent/Water Separators

lbs/day x = total moles gas vented * mole percent x in vapor * molecular weight x
 where total moles gas vented, n = PV/RT * 1440
 min/day

$$n = [(24.81 \text{ psia}) * (\text{liquid feed rate, (11.06 gpm)} / 7.48 \text{ gal/ft}^3) / (10.73 \text{ ft}^3 \text{ psia} / \text{lb mol deg R}) (567.67 \text{ deg R})] * 1440 \text{ min/day}$$

Agent Hydrolyzers

lbs/day x = 8 batches/day * moles gas vented during reactor sequence * mole percent x in vapor * molecular weight x

Calculate moles of VOC's vented from the Hydrolyzer during fill sequence

From PFD, empty reactor =	6424	gal	conversion =	7.48	gal / ft ³
		ft ³ psia / lb mol deg	site pressure		
Gas constant =	10.73	R	=	12.41	Psia

1) Determine lb moles in vapor immediately after pumpout

Tank empty, P and T =	10	psig	206	deg F
lb moles in vapor = PV/RT =	2.69	lb mols		

2) Add MWS wash water, hot water, and spent decon. Find pressure. Will tank vent?

lb moles given in step 1, T =	122	deg F		
Vapor volume after initial fill =	503	ft ³		
P = nRT/V =	33.44	psia		
set point is 12 psig =	24.41	psia	Tank will vent	

3) How much will vent if SP is

	12	psig		
lb moles in vapor = PV/RT =	1.97	lb mols		
initial lb mols - new lb mols =	0.73	lb mols vented		

4) Add steam and Agent. Find new pressure. Will tank vent?

lbmoles after vent =	1.97	lb mols		
temp after steam addition =	175	deg F		
Vapor volume after agent + steam =	448	ft ³		
P = nRT/V =	29.89	psia		
set point is 25 psig =	37.41	psia	Tank will not vent	

5) Add Caustic. Find new pressure. Will tank vent?

lb moles in vapor =	1.97	lb mols		
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CALCULATION SHEET

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temp after caustic addition = 206 deg F
 Vapor volume after caustic = 391 ft³
 P = nRT/V = 35.92 psia
 set point is 37.41 psia Tank will not vent

6) What Pressure is reached 23.51 psig
 lb moles in vapor = PV/RT = 1.97 lb mols
 initial lb mols - new lb mols = 0.00

7) Total moles vented per batch = 0.73 lb mols vented

Hold Tanks

lbs/day x = 4 Hold tank fills/day * moles gas vented during reactor transfer * mole percent x in vapor * molecular weight x

Calculate moles of VOC's vented from Hold Tanks when filled

From PFD, empty hold tank = 12,540 gal
 Gas constant = 10.73 R
 conversion = 7.48 gal / ft³
 site pressure = 12.41 psia
 batch volume = 3,531 gal

1) Determine lb moles in vapor immediately after pumpout

Tank empty, P and T = 5 psig 206 deg F
 lb moles in vapor = PV/RT = 4.09 lb mols

2) Add 1st batch. Find pressure. Will tank vent?

lb moles given in step 1, T = 206 deg F
 Volume after 1st batch = 1,204 ft³
 P = nRT/V = 24.23 psia
 set point is 57.41 psia Tank will not vent

3) Add 2nd batch. Find new pressure. Will tank vent?

lb moles given in step 1, T = 206 deg F
 Volume after 2nd batch = 732 ft³
 P = nRT/V = 39.85 psia
 set point is 57.41 psia Tank will not vent

4) What pressure is reached 27.44 psig
 lb moles in vapor = PV/RT = 4.09 lb mols
 initial lb mols - new lb mols = 0.00 lb mols vented

OTS Feed

lbs/day x = (MWS + MTU + Agent/Water Separators + Agent Hydrolyzers + Hold Tanks)

Scrubber Feed

lbs/day x = (OTS Feed) * (1 - Oxidizer % Removal)

Note: Values for NO₂, NO, SO₂, HCl, Cl₂ are taken from the MTU material balance

CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: RD-M5C-000-B0004
 SHEET NO.: Attachment 1
 3 of 6
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Leaving OTS

lbs/day x = (Scrubber Feed) * (1 - Scrubber % Removal)

APB HVAC

lbs/day = lbs/day level A areas + lbs/day level B areas

lbs/day level A areas = (flow rate from A areas, (75875 cfm) * 0.0283 ft³/m³ * 1440 min/day * 0.003 mg HD/m³ * 2.205 E-6 mg/lb) = 0.02047

lbs/day level B areas = (flow rate from B areas, (2300 cfm) * 0.0283 ft³/m³ * 1440 min/day * 0.0015 mg HD/m³ * 2.205 E-6 mg/lb) = 0.0003102

ERB HVAC

lbs/day = lbs/day level B areas

lbs/day level B areas = (flow rate from B areas, (22140 cfm) * 0.0283 ft³/m³ * 1440 min/day * 0.0015 mg HD/m³ * 2.205 E-6 mg/lb) = 0.002986

Pre Carbon Total

lbs/day x = Leaving OTS + APB HVAC + ERB HVAC

Post Carbon

lbs/day x = Pre Carbon Total * (1 - Carbon Removal %Efficiency)

Compound	x _A liquid mole fraction	
	Agent/Water Separators	Agent Hydrolyzers and Hold Tanks
1,1,2,2-Tetrachloroethane	8.90E-08	7.07E-07
1,1-Dichloroethane	6.80E-09	5.40E-08
1,2,3-trichlorobenzene		2.09E-10
1,2-Dichlorobutane	2.40E-07	1.91E-06
1,2-Dichloroethane	5.65E-06	4.04E-05
1,2-dichloropropane		1.32E-09
1,3-Butadiene, 2-ethyl	7.01E-10	5.57E-09
1,4-Dithiane	9.81E-08	1.98E-04
1,4-Oxathiane	1.38E-07	9.32E-05
1-Chlorobutane	2.57E-11	2.04E-10
1-Hexene	4.96E-09	3.94E-08
2-Butanone		4.28E-07
2-Chlorobutane	5.48E-08	4.35E-07
2-Hexanone		4.23E-08
3&4-Methylphenol		3.03E-09
4-Methyl-2-Pentanone		4.98E-08
Acetone		1.50E-06
Benzene		4.04E-08
Chloroform	5.44E-09	2.99E-08
Chloromethane		6.19E-08
Diethyl Ether		4.33E-08

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CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: RD-M5C-000-B0004
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 4 of 6
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	x_A	
	liquid mole fraction	
	Agent/Water Separators	Agent Hydrolyzers and Hold Tanks
Ethane	8.82E-08	7.01E-07
Ethane (2- chloromethoxy)	4.00E-06	3.18E-05
Ethane, 2- chloroethoxy	5.98E-07	4.76E-06
HD	8.86E-10	0.00E+00
m&p-Xylenes		1.01E-09
Methylene Chloride		2.04E-07
Napthalene		1.16E-09
TDG		6.02E-03
Tetrachloroethene	1.06E-07	6.84E-07
Thiirane	8.78E-09	6.98E-08
Toluene		3.12E-09
Trichloroethylene	2.05E-07	1.58E-07
Vinyl Chloride	2.27E-09	2.52E-06

Note that vinyl chloride and TCE values in the Hydrolyzers and Hold Tanks are based on the Aberdeen hydrolysate. DCA values in the hydrolysate are based on the DOT bottle analyses; the higher of calculated concentration based on feed after upstream vapor-liquid equilibrium calculations or Aberdeen hydrolysate data is used. Also, liquid in the agent/water separators is water phase containing 1 wt% agent; hydrolysate is product with 8.6 wt% agent recipe.

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CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: **RD-M5C-000-B0004**
 Attachment 1
 SHEET NO.: **5 of 6**
 SHEET REV.: **004**

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Component	MWS lbs/day	MTU lbs/day	Agent/Water Separators lbs/day	Agent Hydrolyzers lbs/day	Hold Tanks lbs/day	OTS Feed lbs/day	Oxidizer % Removal	Scrubber Feed lbs/day	Scrubber % Removal	Leaving OTS lbs/day
Ammonia							0%		0%	
NO2		6.9E-02				6.9E-02	NA	2.6E-01	0%	2.6E-01
NO		2.0E-01				2.0E-01	NA	1.7E+00	0%	1.7E+00
SO2		3.6E+02				3.6E+02	NA	3.6E+02	98.0%	7.2E+00
HCL		3.5E+02				3.5E+02	NA	3.5E+02	99.0%	3.5E+00
Cl2		6.0E+01				6.0E+01	NA	6.0E+01	95.0%	3.0E+00
PM10		1.2E+02				1.2E+012	0%	1.2E+02	99.0%	1.2E-02
1,1,2,2-Tetrachoroethane	1.2E-04		1.6E-06	5.9E-05		1.8E-04	0%	1.8E-04	0%	1.8E-04
1,1-Dichloroethane	1.3E-03		1.3E-06	4.2E-05		1.3E-03	0%	1.3E-03	0%	1.3E-03
1,2,3-trichlorobenzene				1.4E-09		1.4E-09	0%	1.4E-09	0%	1.4E-09
1,2-Dichlorobutane			9.3E-06	2.6E-04		2.6E-04	0%	2.6E-04	0%	2.6E-04
1,2-Dichloroethane	1.0E+00	2.8E+00	6.4E-04	1.3E-02		3.8E+00	0%	3.8E+00	0%	3.8E+00
1,2-dichloropropane				3.5E-07		3.5E-07	0%	3.5E-07	0%	3.5E-07
1,3-Butadiene, 2-ethyl	9.0E-05		9.3E-08	2.0E-06		9.2E-05	0%	9.2E-05	0%	9.2E-05
1,4-Dioxane							0%		0%	
1,4-Dithiane	6.5E-06		1.9E-07	2.3E-03		2.3E-03	0%	2.3E-03	0%	2.3E-03
1,4-Oxathiane	3.1E-07		1.1E-06	4.0E-03		4.0E-03	0%	4.0E-03	0%	4.0E-03
1-Chlorobutane			4.5E-07	7.5E-08		5.3E-07	0%	5.3E-07	0%	5.3E-07
1-Hexene			1.0E-06	1.9E-05		2.1E-05	0%	2.1E-05	0%	2.1E-05
2-Butanone				1.2E-04		1.2E-04	0%	1.2E-04	0%	1.2E-04
2-Chlorobutane	4.4E-05		1.0E-05	2.3E-04		2.9E-04	0%	2.9E-04	0%	2.9E-04
2-Hexanone				3.6E-06		3.6E-06	0%	3.6E-06	0%	3.6E-06
3&4-Methylphenol				1.9E-08		1.9E-08	0%	1.9E-08	0%	1.9E-08
4-Methyl-2-Pentanone				6.0E-06		6.0E-06	0%	6.0E-06	0%	6.0E-06
Acetone				6.7E-04		6.7E-04	0%	6.7E-04	0%	6.7E-04
Benzene				1.2E-05		1.2E-05	0%	1.2E-05	0%	1.2E-05
Chloroform			1.7E-06	2.3E-05		2.5E-05	0%	2.5E-05	0%	2.5E-05
Chloromethane				2.2E-04		2.2E-04	0%	2.2E-04	0%	2.2E-04
Diethyl Ether				4.3E-05		4.3E-05	0%	4.3E-05	0%	4.3E-05
Ethane	8.1E-02		8.0E-04	7.3E-03		8.9E-02	0%	8.9E-02	0%	8.9E-02
Ethane (2- chloromethoxy)			1.8E-06			1.8E-06	0%	1.8E-06	0%	1.8E-06
Ethane, 2- chloroethoxy			3.1E-07	1.4E-05		1.4E-05	0%	1.4E-05	0%	1.4E-05
HD	6.5E-01	9.0E+02	5.0E-04			9.0E+02	99.9%	9.0E-01	98%	1.8E-02
m&p-Xylenes				6.7E-08		6.7E-08	0%	6.7E-08	0%	6.7E-08
Methylene Chloride				2.1E-04		2.1E-04	0%	2.1E-04	0%	2.1E-04
Napthalene				7.2E-09		7.2E-09	0%	7.2E-09	0%	7.2E-09
TDG				1.1E-02		1.1E-02	0%	1.1E-02	0%	1.1E-02
Tetrachloroethene	3.5E-03	3.8E-02	5.2E-06	1.3E-04		4.1E-02	0%	4.1E-02	0%	4.1E-02
Thiirane	9.6E-05		1.8E-06	3.2E-05		1.3E-04	0%	1.3E-04	0%	1.3E-04
Toluene				4.4E-07		4.4E-07	0%	4.4E-07	0%	4.4E-07
Trichloroethylene	1.8E-02		2.8E-05	6.2E-05		1.8E-02	0%	1.8E-02	0%	1.8E-02
Vinyl Chloride	7.9E-03	7.0E-04	4.5E-06	7.3E-03		1.6E-02	0%	1.6E-02	0%	1.6E-02
Total organics	1.786	901.4	0.002	0.048	0.000	903.2		4.905		4.024
Total	1.786	1796.0	0.002	0.048		1797.8		901.19		20.925

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CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: **RD-M5C-000-B0004**
 Attachment 1
 SHEET NO.: **6 of 6**
 SHEET REV.: **004**

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Component	Leaving OTS lbs/day	APB HVAC lbs/day	ERB HVAC lbs/day	Pre Carbon Total lbs/day	Carbon Removal Category	Carbon Removal % Efficiency	Post Carbon lbs/day
Ammonia							
NO2	2.6E-01			2.6E-01		0%	2.6E-01
NO	1.7E+00			1.7E+00		0%	1.7E+00
SO2	7.2E+00			7.2E+00		0%	7.2E+00
HCL	3.5E+00			3.5E+00		0%	3.5E+00
Cl2	3.0E+00			3.0E+00		0%	3.0E+00
PM10	1.2E-00			1.2E-00		99.97%	1.1E-07
1,1,2,2-Tetrachoroethane	1.8E-04			1.8E-04	5	66.00%	6.2E-05
1,1-Dichloroethane	1.3E-03			1.3E-03	3	0%	1.3E-03
1,2,3-trichlorobenzene	1.4E-09			1.4E-09	3	0%	1.4E-09
1,2-Dichlorobutane	2.6E-04			2.6E-04	4	33.00%	1.8E-04
1,2-Dichloroethane	3.8E+00			3.8E+00	3	0%	3.8E+00
1,2-dichloropropane	3.5E-07			3.5E-07	4	33.00%	2.4E-07
1,3-Butadiene, 2-ethyl	9.2E-05			9.2E-05	3	0%	9.2E-05
1,4-Dioxane					4	33.00%	
1,4-Dithiane	2.3E-03			2.3E-03	2	0%	2.3E-03
1,4-Oxathiane	4.0E-03			4.0E-03	3	0%	4.0E-03
1-Chlorobutane	5.3E-07			5.3E-07	5	66.00%	1.8E-07
1-Hexene	2.1E-05			2.1E-05	4	33.00%	1.4E-05
2-Butanone	1.2E-04			1.2E-04	4	33.00%	7.9E-05
2-Chlorobutane	2.9E-04			2.9E-04	4	33.00%	1.9E-04
2-Hexanone	3.6E-06			3.6E-06	4	33.00%	2.4E-06
3&4-Methylphenol	1.9E-08			1.9E-08	5	66.00%	6.6E-09
4-Methyl-2-Pentanone	6.0E-06			6.0E-06	4	33.00%	4.0E-06
Acetone	6.7E-04			6.7E-04	3	0%	6.7E-04
Benzene	1.2E-05			1.2E-05	5	66.00%	4.0E-06
Chloroform	2.5E-05			2.5E-05	4	33.00%	1.6E-05
Chloromethane	2.2E-04			2.2E-04	1	0%	2.2E-04
Diethyl Ether	4.3E-05			4.3E-05	3	0%	4.3E-05
Ethane	8.9E-02			8.9E-02	0	0%	8.9E-02
Ethane (2- chloromethoxy)	1.8E-06			1.8E-06	5	66.00%	6.0E-07
Ethane, 2- chloroethoxy	1.4E-05			1.4E-05	5	66.00%	4.9E-06
HD	1.8E-02	2.1E-02	3.0E-03	4.1E-02	5	99.00%	4.1E-04
m&p-Xylenes	6.7E-08			6.7E-08	5	66.00%	2.3E-08
Methylene Chloride	2.1E-04			2.1E-04	3	0%	2.1E-04
Napthalene	7.2E-09			7.2E-09	5	66.00%	2.4E-09
TDG	1.1E-02			1.1E-02	5	66.00%	3.9E-03
Tetrachloroethene	4.1E-02			4.1E-02	5	66.00%	1.4E-02
Thiirane	1.3E-04			1.3E-04	1	0%	1.3E-04
Toluene	4.4E-07			4.4E-07	5	66.00%	1.5E-07
Trichloroethylene	1.8E-02			1.8E-02	4	33.00%	1.2E-02
Vinyl Chloride	1.6E-02			1.6E-02	1	0%	1.6E-02
Total organics	4.024	0.021	0.003	4.047			3.965
Total	20.925	0.021	0.003	20.948			19.625

CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: **RD-M5C-000-B0004**
 Attachment 2
 SHEET NO.: **1 of 4**
 SHEET REV.: **004**

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 2

Calculation: Estimate VOC emissions from 30-day Hydrolysate Storage Tanks

Basis: Two hydrolysate hold tanks feed three 30-day hydrolysate feed tanks. The design rate is for 4 hold tank batches per day of 7,060 gal per batch. A maximum of 2 hold tanks can be discharged in one hour.

Hydrolysate hold tank:	7,060	gallons =	944	ft ³
Pump rate to 30-day tank:	440	gal/min		
Pump out time one hold tank:	16	minutes		
Total rate to ICB feed tanks:	12	gal/min		

To estimate emissions, we assume that the flow out of the 30-day tanks is negligible. Therefore, emissions would occur during filling of the 30-day tank from the hydrolysate hold tanks. The maximum hourly emission rate is based on two hold tank batches per hour. The maximum annual emission rate is based on four hold tank batches per day.

Assuming that the hydrolysate volume from one hold tank can displace an equal volume of saturated vapor in the 30-day tank, we can estimate the emissions from the 30-day tank during that filling event.

Raoult's Law can be used to describe multi-component gas-liquid phase systems at equilibrium:

$$y_A P = x_A p_A^*(T)$$

where:

y_A	=	mole fraction of compound A in the gas phase
P	=	system pressure
x_A	=	mole fraction of compound A in the liquid phase
$p_A^*(T)$	=	vapor pressure of pure liquid A at temperature T

The composition of the hydrolysate is known, therefore, we know P (12.41 psi), x_A , and p_A and can rearrange the equation to calculate y_A .

TABLE 1. HYDROLYSATE COMPOSITION

Compound	x_A liquid mole fraction	p_A (at 125 F) Ppsia	y_A gas mole fraction
Ammonia		3.1E+02	
1,1,2,2-Tetrachloroethane	7.1E-07	5.0E-01	2.9E-08
1,1-Dichloroethane	5.4E-08	1.2E+01	5.2E-08
1,2,3-trichlorobenzene	2.1E-10	2.2E-02	3.8E-13
1,2-Dichlorobutane	1.9E-06	1.3E+00	2.0E-07
1,2-Dichloroethane	4.0E-05	4.8E+00	1.5E-05
1,2-dichloropropane	1.3E-09	3.2E+00	3.4E-10
1,3-Butadiene, 2-ethyl	5.6E-09	6.6E+00	3.0E-09
1,4-Dithiane	2.0E-04	7.6E-02	1.2E-06
1,4-Oxathiane	9.3E-05	3.5E-01	2.6E-06
1-Chlorobutane	2.0E-10	5.8E+00	9.5E-11
1-Hexene	3.9E-08	9.9E+00	3.2E-08
2-Butanone	4.3E-07	5.7E+00	2.0E-07
2-Chlorobutane	4.4E-07	8.3E+00	2.9E-07
2-Hexanone	4.2E-08	8.5E-01	2.9E-09
3&4-Methylphenol	3.0E-09	1.5E-02	3.7E-12
4-Methyl-2-Pentanone	5.0E-08	1.4E+00	5.5E-09
Acetone	1.5E-06	1.3E+01	1.5E-06
Benzene	4.0E-08	5.6E00	1.8E-08

CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: **RD-M5C-000-B0004**
 Attachment 2
 SHEET NO.: **2 of 4**
 SHEET REV.: **004**

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	x _A liquid mole fraction	p _A (at 125 F) P _{sia}	y _A gas mole fraction
Chloroform	3.0E-08	1.1E+01	2.6E-08
Chloromethane	6.2E-08	1.7E+02	8.7E-07
Diethyl Ether	4.3E-08	2.6E+01	9.0E-08
Ethane	7.0E-07	1.0E+03	5.8E-05
Ethane (2-chloromethoxy)	3.2E-05		
Ethane, 2- chloroethoxy	4.8E-06	7.7E-03	2.9E-09
HD		1.6E-02	
m&p-Xylenes	1.0E-09	6.5E-01	5.3E-11
Methylene Chloride	2.0E-07	2.2E+01	3.6E-07
Napthalene	1.2E-09	3.0E-02	2.9E-12
TDG	6.0E-03	2.9E-02	1.4E-05
Tetrachloroethene	6.8E-07	1.3E+00	7.2E-08
Thiirane	7.0E-08	1.3E+01	7.4E-08
Toluene	3.1E-09	1.9E+00	4.8E-10
Trichloroethylene	1.6E-07	4.3E+00	5.5E-08
Vinyl Chloride	2.5E-06	1.2E+02	2.3E-05

The total moles of gas displaced can be estimated using the Ideal Gas Law:

$$n = PV/RT$$

where:

P	=	12.41	system pressure =	0.84	atm
V	=	944	volume displaced ft ³		
R	=	0.7302	(ft ³ atm/lb-mol R) ideal gas constant		
T	=	125	° F =	584.67	R

therefore:

n	=	1.9	lb-mol gas displaced
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TABLE 2. EMISSIONS BEFORE CONTROLS

Compound	y _A gas mole fraction	lb-mol _A = y _A x n	MW lb/lb-mol	lb _A /Hold Tank Transfer = lb-mol _A x MW	Max lb _A /hr = lb _A /Hold Tank x 2	lb _A /day = lb _A /Hold Tank x 4
Ammonia			17.04			
1,1,2,2-Tetrachoroethane	2.9E-08	5.3E-08	167.84	8.9E-06	1.8E-05	3.6E-05
1,1-Dichloroethane	5.2E-08	9.8E-08	98.96	9.7E-06	1.9E-05	3.9E-05
1,2,3-trichlorobenzene	3.8E-13	7.0E-13	181.45	1.3E-10	2.6E-10	5.1E-10
1,2-Dichlorobutane	2.0E-07	3.7E-07	127.01	4.8E-05	9.5E-05	1.9E-04
1,2-Dichloroethane	1.5E-05	2.9E-05	98.96	2.9E-03	5.7E-03	1.1E-02
1,2-dichloropropane	3.4E-10	6.4E-10	112.99	7.3E-08	1.5E-07	2.9E-07
1,3-Butadiene, 2-ethyl	3.0E-09	5.6E-09	82.14	4.6E-07	9.2E-07	1.8E-06
1,4-Dithiane	1.2E-06	2.3E-06	120.24	2.7E-04	5.5E-04	1.1E-03
1,4-Oxathiane	2.6E-06	4.9E-06	104.18	5.1E-04	1.0E-03	2.1E-03
1-Chlorobutane	9.5E-11	1.8E-10	92.58	1.6E-08	3.3E-08	6.6E-08
1-Hexene	3.2E-08	5.9E-08	84.16	5.0E-06	9.9E-06	2.0E-05
2-Butanone	2.0E-07	3.6E-07	72.12	2.6E-05	5.3E-05	1.1E-04
2-Chlorobutane	2.9E-07	5.4E-07	92.58	5.0E-05	1.0E-04	2.0E-04
2-Hexanone	2.9E-09	5.4E-09	100.18	5.4E-07	1.1E-06	2.2E-06

CALCULATION SHEET

PROJECT: **PCAPP**
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 SHEET NO.: **3 of 4**
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	y _A gas mole fraction	lb-mol _A = y _A x n	MW lb/lb-mol	lb _A /Hold Tank Transfer = lb-mol _A x MW	Max lb _A /hr = lb _A /Hold Tank x 2	lb _A /day = lb _A /Hold Tank x 4
3&4-Methylphenol	3.7E-12	7.0E-12	108.15	7.5E-10	1.5E-09	3.0E-09
4-Methyl-2-Pentanone	5.5E-09	1.0E-08	100.18	1.0E-06	2.1E-06	4.1E-06
Acetone	1.5E-06	2.9E-06	58.09	1.7E-04	3.3E-04	6.6E-04
Benzene	1.8E-08	3.4E-08	78.12	2.7E-06	5.3E-06	1.1E-05
Chloroform	2.6E-08	4.8E-08	119.37	5.7E-06	1.1E-05	2.3E-05
Chloromethane	8.7E-07	1.6E-06	50.49	8.2E-05	1.6E-04	3.3E-04
Diethyl Ether	9.0E-08	1.7E-07	74.14	1.2E-05	2.5E-05	5.0E-05
Ethane	5.8E-05	1.1E-04	30.08	3.3E-03	6.5E-03	1.3E-02
Ethane (2-chloromethoxy)			159.01			
Ethane, 2- chloroethoxy	2.9E-09	5.5E-09	187.1	1.0E-06	2.1E-06	4.1E-06
HD			159.1			
m&p-Xylenes	5.3E-11	9.9E-11	106.18	1.1E-08	2.1E-08	4.2E-08
Methylene Chloride	3.6E-07	6.7E-07	84.93	5.7E-05	1.1E-04	2.3E-04
Napthalene	2.9E-12	5.3E-12	128.18	6.8E-10	1.4E-09	2.7E-09
TDG	1.4E-05	2.6E-05	122.2	3.2E-03	6.4E-03	1.3E-02
Tetrachloroethene	7.2E-08	1.3E-07	165.82	2.2E-05	4.4E-05	8.9E-05
Thiirane	7.4E-08	1.4E-07	60.12	8.3E-06	1.7E-05	3.3E-05
Toluene	4.8E-10	9.0E-10	92.15	8.3E-08	1.7E-07	3.3E-07
Trichloroethylene	5.5E-08	1.0E-07	131.38	1.3E-05	2.7E-05	5.4E-05
Vinyl Chloride	2.3E-05	4.4E-05	62.5	2.7E-03	5.5E-03	1.1E-02
Totals		2.2E-04		1.3E-02	2.7E-02	5.3E-02

TABLE 3. EMISSIONS AFTER CONTROLS

Compound	Max lba/hr	lb _A /day	Carbon adsorption Category	Carbon control eff. %	Controlled emissions	
					lb _A /hr	lb _A /day
Ammonia						
1,1,2,2-Tetrachloroethane	1.8E-05	3.6E-05	5	66%	6.1E-06	1.2E-05
1,1-Dichloroethane	1.9E-05	3.9E-05	3		1.9E-05	3.9E-05
1,2,3-trichlorobenzene	2.6E-10	5.1E-10	3		2.6E-10	5.1E-10
1,2-Dichlorobutane	9.5E-05	1.9E-04	4	33%	6.4E-05	1.3E-04
1,2-Dichloroethane	5.7E-03	1.1E-02	3		5.7E-03	1.1E-02
1,2-dichloropropane	1.5E-07	2.9E-07	4	33%	9.7E-08	1.9E-07
1,3-Butadiene, 2-ethyl	9.2E-07	1.8E-06	3		9.2E-07	1.8E-06
1,4-Dithiane	5.5E-04	1.1E-03	2		5.5E-04	1.1E-03
1,4-Oxathiane	1.0E-03	2.1E-03	3		1.0E-03	2.1E-03
1-Chlorobutane	3.3E-08	6.6E-08	5	66%	1.1E-08	2.2E-08
1-Hexene	9.9E-06	2.0E-05	4	33%	6.7E-06	1.3E-05
2-Butanone	5.3E-05	1.1E-04	4	33%	3.5E-05	7.0E-05
2-Chlorobutane	1.0E-04	2.0E-04	4	33%	6.7E-05	1.3E-04
2-Hexanone	1.1E-06	2.2E-06	4	33%	7.3E-07	1.5E-06
3&4-Methylphenol	1.5E-09	3.0E-09	5	66%	5.1E-10	1.0E-09
4-Methyl-2-Pentanone	2.1E-06	4.1E-06	4	33%	1.4E-06	2.8E-06
Acetone	3.3E-04	6.6E-04	3		3.3E-04	6.6E-04

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CALCULATION SHEET

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	Max lba/hr	lba/day	Carbon adsorption Category	Carbon control eff. %	Controlled emissions	
					lba/hr	lba/day
Benzene	5.3E-06	1.1E-05	5	66%	1.8E-06	3.6E-06
Chloroform	1.1E-05	2.3E-05	4	33%	7.7E-06	1.5E-05
Chloromethane	1.6E-04	3.3E-04	1		1.6E-04	3.3E-04
Diethyl Ether	2.5E-05	5.0E-05	3		2.5E-05	5.0E-05
Ethane	6.5E-03	1.3E-02	0		6.5E-03	1.3E-02
Ethane (2- chloromethoxy)			5	66%		
Ethane, 2- chloroethoxy	2.1E-06	4.1E-06	5	66%	7.0E-07	1.4E-06
HD			5	99%		
m&p-Xylenes	2.1E-08	4.2E-08	5	66%	7.2E-09	1.4E-08
Methylene Chloride	1.1E-04	2.3E-04	3		1.1E-04	2.3E-04
Napthalene	1.4E-09	2.7E-09	5	66%	4.6E-10	9.3E-10
TDG	6.4E-03	1.3E-02	5	66%	2.2E-03	4.3E-03
Tetrachloroethene	4.4E-05	8.9E-05	5	66%	1.5E-05	3.0E-05
Thiirane	1.7E-05	3.3E-05	1		1.7E-05	3.3E-05
Toluene	1.7E-07	3.3E-07	5	66%	5.6E-08	1.1E-07
Trichloroethylene	2.7E-05	5.4E-05	4	33%	1.8E-05	3.6E-05
Vinyl Chloride	5.5E-03	1.1E-02	1		5.5E-03	1.1E-02
Total Organics	2.7E-02	5.3E-02			2.2E-02	4.5E-02
Total	2.7E-02	5.3E-02			2.2E-02	4.5E-02

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CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: RD-M5C-000-B0004
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 SHEET NO.: 1 of 4
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 3

Calculation: Estimate VOC emissions from Biotreatment Area

Basis:

The design rate for total feed to the ICB modules is 100 gal/min diluted hydrolysate

= 6,000 gal/hr
 = 22,712 l/hr

The yearly rate is 6,000 gal/hr x (24 hr/day) x (7 days/week) x (52 weeks/year)

= 52,416,000 gal/yr
 = 198,415,526 l/yr

TABLE 1. HYDROLYSATE COMPOSITION

Compound	Diluted Hydrolysate Concentration ug/l
Ammonia	1385.49
1,1,2,2-Tetrachloroethane	941.14
1,1-Dichloroethane	42.38
1,2,3-trichlorobenzene	0.30
1,2-Dichlorobutane	1920.84
1,2-Dichloroethane	31673.79
1,2-dichloropropane	1.19
1,3-Butadiene, 2-ethyl	3.63
1,4-Dioxane	0.00
1,4-Dithiane	188729.10
1,4-Oxathiane	76966.35
1-Chlorobutane	0.15
1-Hexene	26.32
2-Butanone	244.56
2-Chlorobutane	319.40
2-Hexanone	33.60
3&4-Methylphenol	2.59
4-Methyl-2-Pentanone	39.56
Acetone	692.49
Benzene	25.04
Chloroform	28.25
Chloromethane	24.76
Diethyl Ether	25.47
Ethane	167.06
Ethane (2- chloromethoxy)	40080.55
Ethane, 2- chloroethoxy	7054.45
HD	0.00
m&p-Xylenes	0.85
Methylene Chloride	137.21
Napthalene	1.18
TDG	5832079.13
Tetrachloroethene	899.74
Thiirane	33.25
Toluene	2.28
Trichloroethylene	164.19
Vinyl Chloride	1246.61

CALCULATION SHEET

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

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TABLE 2. HYDROLYSATE VOC FEED RATES, % VOC IN OFF-GAS, AND ICB REMOVAL EFFICIENCY

Compound	Feed Rate		% Feed in ICB Off-Gas
	lb/hr	lb/yr	
Ammonia	6.9E-02	6.1E+02	64.00%
1,1,2,2-Tetrachloroethane	4.7E-02	4.1E+02	13%
1,1-Dichloroethane	2.1E-03	1.9E+01	13%
1,2,3-trichlorobenzene	1.5E-05	1.3E-01	13%
1,2-Dichlorobutane	9.6E-02	8.4E+02	13%
1,2-Dichloroethane	1.6E+00	1.4E+04	13%
1,2-dichloropropane	5.9E-05	5.2E-01	13%
1,3-Butadiene, 2-ethyl	1.8E-04	1.6E+00	13%
1,4-Dithiane	9.5E+00	8.3E+04	1.06%
1,4-Oxathiane	3.9E+00	3.4E+04	2.8%
1-Chlorobutane	7.5E-06	6.6E-02	13%
1-Hexene	1.3E-03	1.2E+01	13%
2-Butanone	1.2E-02	1.1E+02	13%
2-Chlorobutane	1.6E-02	1.4E+02	13%
2-Hexanone	1.7E-03	1.5E+01	13%
3&4-Methylphenol	1.3E-04	1.1E+00	13%
4-Methyl-2-Pentanone	2.0E-03	1.7E+01	13%
Acetone	3.5E-02	3.0E+02	13%
Benzene	1.3E-03	1.1E+01	13%
Chloroform	1.4E-03	1.2E+01	13%
Chloromethane	1.2E-03	1.1E+01	13%
Diethyl Ether	1.3E-03	1.1E+01	13%
Ethane	8.4E-03	7.3E+01	13%
Ethane (2- chloromethoxy)	2.0E+00	1.8E+04	13%
Ethane, 2- chloroethoxy	3.5E-01	3.1E+03	13%
HD			
m&p-Xylenes	4.3E-05	3.7E-01	13%
Methylene Chloride	6.9E-03	6.0E+01	13%
Napthalene	5.9E-05	5.2E-01	13%
TDG	2.9E+02	2.6E+06	0.0001%
Tetrachloroethene	4.5E-02	3.9E+02	13%
Thiirane	1.7E-03	1.5E+01	13%
Toluene	1.1E-04	1.0E+00	13%
Trichloroethylene	8.2E-03	7.2E+01	13%
Vinyl Chloride	6.2E-02	5.5E+02	13%

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

TABLE 3. EMISSIONS BEFORE CONTROLS

Compound	Emissions Before Controls		Carbon Removal Ranking	Carbon Control Efficiency
	lb/hr	lb/yr		
Ammonia	4.4E-02	3.9E+02		
1,1,2,2-Tetrachloroethane	6.1E-03	5.4E+01	5	66%
1,1-Dichloroethane	2.8E-04	2.4E+00	3	
1,2,3-trichlorobenzene	2.0E-06	1.7E-02	3	
1,2-Dichlorobutane	1.3E-03	1.1E+02	4	33%
1,2-Dichloroethane	2.1E-01	1.8E+03	3	
1,2-dichloropropane	7.7E-06	6.7E-02	4	33%
1,3-Butadiene, 2-ethyl	2.4E-05	2.1E-01	3	
1,4-Dithiane	1.0E-01	8.8E+02	2	
1,4-Oxathiane	1.1E-01	9.4E+02	3	
1-Chlorobutane	9.8E-07	8.5E-03	5	66%
1-Hexene	1.7E-04	1.5E+00	4	33%
2-Butanone	1.6E-03	1.4E+01	4	33%
2-Chlorobutane	2.1E-03	1.8E+01	4	33%
2-Hexanone	2.2E-04	1.9E+00	4	33%
3&4-Methylphenol	1.7E-05	1.5E-01	5	66%
4-Methyl-2-Pentanone	2.6E-04	2.2E+00	4	33%
Acetone	4.5E-03	3.9E+01	3	
Benzene	1.6E-04	1.4E+00	5	66%
Chloroform	1.8E-04	1.6E+00	4	33%
Chloromethane	1.6E-05	1.4E+00	1	
Diethyl Ether	1.7E-04	1.4E+00	3	
Ethane	1.1E-03	9.5E+00	0	
Ethane (2- chloromethoxy)	2.6E-01	2.3E+03	5	66%
Ethane, 2- chloroethoxy	4.6E-02	4.0E+02	5	66%
HD	0.0E+00	0.0E+00	5	99%
m&p-Xylenes	5.5E-06	4.8E-02	5	66%
Methylene Chloride	8.9E-04	7.8E+00	3	
Napthalene	7.7E-06	6.7E-02	5	66%
TDG	2.9E-04	2.6E+00	5	66%
Tetrachloroethene	5.9E-03	5.1E+01	5	66%
Thiirane	2.2E-04	1.9E+00	1	
Toluene	1.5E-05	1.3E-01	5	66%
Trichloroethylene	1.1E-03	9.3E+00	4	33%
Vinyl Chloride	8.1E-03	7.1E+01	1	

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Emissions after controls can be calculated using the following equation:

$$\text{Emissions} = (\text{uncontrolled emissions}) \times (1 - \% \text{ carbon control eff.})$$

TABLE 4. EMISSIONS AFTER CONTROLS

Compound	Emissions After Controls		
	lb/hr	lb/yr	lb/day
Ammonia	4.4E-02	3.9E+02	1.1E+00
1,1,2,2-Tetrachloroethane	2.1E-03	1.8E+01	5.0E-02
1,1-Dichloroethane	2.8E-04	2.4E+00	6.6E-03
1,2,3-trichlorobenzene	2.0E-06	1.7E-02	4.7E-05
1,2-Dichlorobutane	8.4E-03	7.3E+01	2.0E-01
1,2-Dichloroethane	2.1E-01	1.8E+03	4.9E+00
1,2-dichloropropane	5.2E-06	4.5E-02	1.2E-04
1,3-Butadiene, 2-ethyl	2.4E-05	2.1E-01	5.7E-04
1,4-Dithiane	1.0E-01	8.8E+02	2.4E+00
1,4-Oxathiane	1.1E-01	9.4E+02	2.6E+00
1-Chlorobutane	3.3E-07	2.9E-03	8.0E-06
1-Hexene	1.1E-04	1.0E+00	2.8E-03
2-Butanone	1.1E-03	9.3E+00	2.6E-02
2-Chlorobutane	1.4E-03	1.2E+01	3.3E-02
2-Hexanone	1.5E-04	1.3E+00	3.5E-03
3&4-Methylphenol	5.7E-06	5.0E-02	1.4E-04
4-Methyl-2-Pentanone	1.7E-04	1.5E+00	4.1E-03
Acetone	4.5E-03	3.9E+01	1.1E-01
Benzene	5.5E-05	4.8E-01	1.3E-03
Chloroform	1.2E-04	1.1E+00	3.0E-03
Chloromethane	1.6E-04	1.4E+00	3.9E-03
Diethyl Ether	1.7E-04	1.4E+00	4.0E-03
Ethane	1.1E-03	9.5E+00	2.6E-02
Ethane (2- chloromethoxy)	8.9E-02	7.7E+02	2.1E+00
Ethane, 2- chloroethoxy	1.6E-02	1.4E+02	3.7E-01
HD			
m&p-Xylenes	1.9E-06	1.6E-02	4.5E-05
Methylene Chloride	8.9E-04	7.8E+00	2.1E-02
Napthalene	2.6E-06	2.3E-02	6.3E-05
TDG	9.9E-05	8.7E-01	2.4E-03
Tetrachloroethene	2.0E-03	1.7E+01	4.8E-02
Thiirane	2.2E-04	1.9E+00	5.2E-03
Toluene	5.0E-06	4.4E-02	1.2E-04
Trichloroethylene	7.2E-04	6.3E+00	1.7E-02
Vinyl Chloride	8.1E-03	7.1E+01	1.9E-01
Total Organics	5.5E-01	4.8E+03	13.209
Totals	5.9E-01	5.2E+03	14.275

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CALCULATION SHEET

PROJECT: **PCAPP**
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 SHEET NO.: 1 of 3
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 4

Calculation: Estimate the emissions from the BRS/WRS

Basis:

3 feed tanks, 100 gpm total feed, and 300 cfm/tank aeration	
Vapor Generated in WRS, lb/hr	900
Fixed Gases (CO ₂) Released, lb/hr	17
Vent Condenser Temperature, F	120
Vent Condenser Pressure, psig	0

The vapor compositions used for each compound are listed below the example calc

BC Feed Tank Vent

lbs/day x = total moles/day gas vented * mole percent x in vapor * molecular weight x
 where total moles gas vented, n = PV/RT

Cubic feet displaced = (100 gpm / 7.48 gal per ft³) + 300 cfm/tank = 913.37 ft³/min
 n = (12.41 psia * 913.37 ft³) / (10.73 ft³-psia/lb-mol-R * 559.67 deg R) = 1.9 moles/min, convert to moles/day = 2737

Tank Post Carbon

lbs/day x = BRS Feed Tank Vent * (1 - Carbon Filter Efficiency)

BRS vent condenser

lbs/day x = total moles gas vented * mole percent x in vapor * molecular weight x
 where mole percent x in vapor = moles in / [(vapor moles) + P/Vpx * (liquid moles)]

BRS Post Carbon

lbs/day = BRS vent condenser * (1 - Carbon Filter Efficiency)

Total from BRS/WRS

lbs/day = Tank Post Carbon + BRS Post Carbon

Compound	y _A mole fraction in vapor	
	BC Feed Tanks	BRS Vent Condenser
1,1,2,2-Tetrachloroethane	2.03E-11	8.73E-12
1,1-Dichloroethane	4.44E-11	2.52E-10
1,2,3-trichlorobenzene	2.29E-16	8.34E-18
1,2-Dichlorobutane	1.57E-10	1.32E-10
1,2-Dichloroethane	1.25E-08	3.19E-08
1,2-dichloropropane	2.78E-13	5.07E-13
1,3-Butadiene, 2-ethyl	2.49E-12	7.80E-12
1,4-Dithiane	7.88E-10	7.30E-11
1,4-Oxathiane	1.76E-08	6.80E-09

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CALCULATION SHEET

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	y _A mole fraction in vapor	
	BC Feed Tanks	BRS Vent Condenser
1-Chlorobutane	7.92E-14	2.34E-13
1-Hexene	2.73E-11	1.15E-10
2-Butanone	1.63E-10	4.62E-10
2-Chlorobutane	2.47E-10	1.06E-09
2-Hexanone	2.05E-12	1.50E-12
3&4-Methylphenol	1.64E-15	1.37E-16
4-Methyl-2-Pentanone	4.17E-12	4.15E-12
Acetone	1.30E-09	7.24E-09
Ammonia	5.87E-04	4.18E-02
Benzene	1.50E-11	4.17E-11
Chloroform	2.20E-11	1.01E-10
Chloromethane	8.69E-10	3.55E-08
Diethyl Ether	8.18E-11	7.45E-10
Ethane	6.35E-08	7.86E-06
Ethane (2- chloromethoxy)	0.00E+00	0.00E+00
Ethane, 2- chloroethoxy	1.64E-12	2.87E-14
HD	0.00E+00	0.00E+00
m&p-Xylenes	3.82E-14	2.06E-14
Methylene Chloride	3.16E-10	2.71E-09
Napthalene	1.70E-15	8.47E-17
TDG	6.26E-08	6.69E-10
Tetrachloroethene	5.38E-11	4.91E-11
Thiirane	6.56E-11	3.46E-10
Toluene	3.70E-13	4.49E-13
Trichloroethylene	4.40E-11	1.01E-10
Vinyl Chloride	2.35E-08	6.38E-07

**Bechtel
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CALCULATION SHEET

PROJECT: **PCAPP**
 JOB NUMBER: **24852**
 CALC NO.: RD-M5C-000-B0004
 Attachment 4
 SHEET NO.: 3 of 3
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Compound	MW	BC Feed Tank Vent lb/day	Tank Post Carbon lb/day	BRS vent condenser lb/day	Carbon Filter Efficiency	BRS Post Carbon lb/day	Total from BRS/WRS lb/day
Ammonia	17.04	2.2E+01	2.2E+01	1.8E+00		1.8E+00	2.4E+01
1,1,2,2-Tetrachloroethane	167.84	9.3E-06	3.2E-06	3.8E-09	66.00%	1.3E-09	3.2E-06
1,1-Dichloroethane	98.96	1.2E-05	1.2E-05	6.4E-08		6.4E-08	1.2E-05
1,2,3-trichlorobenzene	181.45	1.1E-10	1.1E-10	3.9E-15		3.9E-15	1.1E-10
1,2-Dichlorobutane	127.01	5.4E-05	3.6E-05	4.3E-08	33%	2.9E-08	3.6E-05
1,2-Dichloroethane	98.96	3.4E-03	3.4E-03	8.1E-06		8.1E-06	3.4E-03
1,2-dichloropropane	112.99	8.5E-08	5.7E-08	1.5E-10	33%	9.8E-11	5.7E-08
1,3-Butadiene, 2-ethyl	82.14	5.5E-07	5.6E-07	1.6E-09		1.6E-09	5.6E-07
1,4-Dithiane	120.24	2.6E-04	2.6E-04	2.3E-08		2.3E-08	2.6E-04
1,4-Oxathiane	104.18	5.0E-03	5.0E-03	1.8E-06		1.8E-06	5.0E-03
1-Chlorobutane	92.58	2.0E-08	6.8E-09	5.6E-11	66%	1.9E-11	6.8E-09
1-Hexene	84.16	6.2E-06	4.2E-06	2.5E-08	33%	1.7E-08	4.2E-06
2-Butanone	72.12	3.2E-05	2.1E-05	8.6E-08	33%	5.7E-08	2.1E-05
2-Chlorobutane	92.58	6.2E-05	4.2E-05	2.5E-07	33%	1.7E-07	4.2E-05
2-Hexanone	100.18	5.6E-07	3.7E-07	3.9E-10	33%	2.6E-10	3.7E-07
3&4-Methylphenol	108.15	4.8E-10	1.6E-10	3.8E-14	66.00%	1.3E-14	1.6E-10
4-Methyl-2-Pentanone	100.18	1.1E-06	7.6E-07	1.1E-09	33%	7.1E-10	7.6E-07
Acetone	58.09	2.1E-04	2.1E-04	1.1E-06		1.1E-06	2.1E-04
Benzene	78.12	3.2E-06	1.1E-06	8.4E-09	66.00%	2.8E-09	1.1E-06
Chloroform	119.37	7.1E-06	4.8E-06	3.1E-08	33%	2.1E-08	4.8E-06
Chloromethane	50.49	1.2E-04	1.2E-04	4.6E-06		4.6E-06	1.2E-04
Diethyl Ether	74.14	1.6E-05	1.6E-05	1.4E-07		1.4E-07	1.7E-05
Ethane	30.08	5.2E-03	5.2E-03	6.1E-04		6.1E-04	5.8E-03
Ethane (2- chloromethoxy)	159.01				66.00%		
Ethane, 2- chloroethoxy	187.1	8.3E-07	2.8E-07	1.4E-11	66.00%	4.7E-12	2.8E-07
HD	159.1				99.00%		
m&p-Xylenes	106.18	1.1E-08	3.7E-09	5.6E-12	66.00%	1.9E-12	3.8E-09
Methylene Chloride	84.93	7.3E-05	7.3E-05	5.9E-07		5.9E-07	7.4E-05
Napthalene	128.18	5.9E-10	2.0E-10	2.8E-14	66.00%	9.5E-15	2.0E-10
TDG	122.2	2.1E-02	7.1E-03	2.1E-07	66.00%	7.1E-08	7.1E-03
Tetrachloroethene	165.82	2.4E-05	8.2E-06	2.1E-08	66.00%	7.1E-09	8.2E-06
Thiirane	60.12	1.1E-05	1.1E-05	5.3E-08		5.3E-08	1.1E-05
Toluene	92.15	9.3E-08	3.1E-08	1.1E-10	66.00%	3.6E-11	3.2E-08
Trichloroethylene	131.38	1.6E-05	1.1E-05	3.4E-08	33%	2.3E-08	1.1E-05
Vinyl Chloride	62.5	4.0E-03	4.0E-03	1.0E-04		1.0E-04	4.1E-03
Total Organics (lb/day)		3.9E-02	2.5E-02	7.3E-04		7.3E-04	2.6E-02
Total (lb/day)		2.2E+01	2.2E+01	1.8E+00		1.8E+00	2.4E+01

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CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 5
 SHEET NO.: 1 of 9
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate
 BY: Clara Galbis-Reig DATE: 4/23/15

Attachment 5

Small Generator Estimate – Security

Notes

1. % Sulfur(0.0015)
2. THC Conversion $THC = TOC * 0.9346$, $VOC = TOC * 0.9841$, $NMHC = TOC * 0.920$
3. Hours = 100 hrs/yr for each generator
4. Power (output) per Vendor,
BHP = 398
5. NOx and CO uses Caterpillar's Emission Factors (defined as Tier 3)
6. PM-10 uses Caterpillars Emission Factor for PM and considers it all PM-10
7. VOCs uses Caterpillars Emissions Factor for THC and Note 2 conversion factors
8. SO2 (with Note 1) and Vendor Supplied Calculation - $SO_2 = 0.01998 \times \text{fuel rate (g/hr)} \times \text{\% sulfur in fuel by weight}$
9. Non-Criteria Pollutants use AP-42 Emission Factors for Diesel Combustion for fuel input (1 MMBtu/Hr = 392.6652 hp-hr)
10. PM_{2.5} uses Caterpillar's Emission Factor for PM and assumes 90% is $\leq 10 \mu\text{m}$ per AP-42, Appendix B.2-2

Criteria Pollutant	CAS	Stated Emission Factor	Units	Source	Emissions Factor lbs/hp-hr	Hourly Maximum lbs/hr	Yearly Maximum tons/yr
NOx		2.97	g/hp-hr	Caterpillar	0.006542	2.6037	0.1302
CO		0.36	g/hp-hr	Caterpillar	0.000793	0.3156	0.0158
SO2		0.0074	g/hp-hr	See Below	0.000016	0.0065	0.0003
PM-10		0.079	g/hp-hr	Caterpillar	0.000174	0.0693	0.0035
TSP		0.079	g/hp-hr	See 6 Above	0.000174	0.0693	0.0035
PM-2.5		0.0711	g/hp-hr	See 10 Above	0.000157	0.0623	0.0031
VOC		0.1053	g/hp-hr	Caterpillar & 7 Above	0.000232	0.0923	0.0046
Non-Criteria Pollutant							
Benzene	71-43-2	9.33E-04	lbs/MMBtu	AP-42, Section 3.3	2.37607E-06	9.45676E-04	4.728E-05
Propylene	115-07-1	2.58E-03	lbs/MMBtu	AP-42, Section 3.3	6.57048E-06	2.61505E-03	1.308E-04
Formaldehyde	50-00-0	1.18E-03	lbs/MMBtu	AP-42, Section 3.3	3.0051E-06	1.19603E-03	5.980E-05
Acetaldehyde	75-07-0	7.67E-04	lbs/MMBtu	AP-42, Section 3.3	1.95332E-06	7.77421E-04	3.887E-05
Acrolein	107-02-8	9.25E-05	lbs/MMBtu	AP-42, Section 3.3	2.3557E-07	9.37567E-05	4.688E-06

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CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 5
 SHEET NO.: 2 of 9
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Naphtalene	91-20-3	8.48E-05	lbs/MMBtu	AP-42, Section 3.3	2.1596E-07	8.59521E-05	4.298E-06
Toluene	108-88-3	4.09E-04	lbs/MMBtu	AP-42, Section 3.3	1.0416E-06	4.14557E-04	2.073E-05
o-xylene	1330-20-7	2.85E-04	lbs/MMBtu	AP-42, Section 3.3	7.25809E-07	2.88872E-04	1.444E-05
Total POM (see below)		8.33E-05	lbs/MMBtu	AP-42, Section 3.3	2.12043E-07	8.43933E-05	4.220E-06

POM/PAH

Acenaphthene	83-32-9	1.42E-06	lbs/MMBtu	AP-42, Section 3.3	3.61631E-09	1.43929E-06	7.196E-08
Acenaphthylene	203-96-8	5.06E-06	lbs/MMBtu	AP-42, Section 3.3	1.28863E-08	5.12875E-06	2.564E-07
Anthracene	120-12-7	1.87E-06	lbs/MMBtu	AP-42, Section 3.3	4.76233E-09	1.89541E-06	9.477E-08
Benz(a)anthracene	56-55-3	1.68E-06	lbs/MMBtu	AP-42, Section 3.3	4.27845E-09	1.70282E-06	8.514E-08
Benzo(b)fluoranthene	205-99-2	9.91E-08	lbs/MMBtu	AP-42, Section 3.3	2.52378E-10	1.00446E-07	5.022E-09
Benzo(k)fluoranthene	207-08-9	1.55E-07	lbs/MMBtu	AP-42, Section 3.3	3.94738E-10	1.57106E-07	7.855E-09
Benzo(g,h,i)perylene	191-24-2	4.89E-07	lbs/MMBtu	AP-42, Section 3.3	1.24534E-09	4.95644E-07	2.478E-08
Chrysene	218-01-9	3.53E-07	lbs/MMBtu	AP-42, Section 3.3	8.98985E-10	3.57796E-07	1.789E-08
Dibenzo(a,h)anthracene	53-70-3	5.83E-07	lbs/MMBtu	AP-42, Section 3.3	1.48473E-09	5.90921E-07	2.955E-08
Fluoranthene	206-44-0	7.61E-06	lbs/MMBtu	AP-42, Section 3.3	1.93804E-08	7.71339E-06	3.857E-07
Fluorene	86-73-7	2.92E-05	lbs/MMBtu	AP-42, Section 3.3	7.43636E-08	2.95967E-05	1.480E-06
Indeno(1,2,3-cd)pyrene	193-39-5	3.75E-07	lbs/MMBtu	AP-42, Section 3.3	9.55012E-10	3.80095E-07	1.900E-08
Phenanthrene	85-01-8	2.94E-05	lbs/MMBtu	AP-42, Section 3.3	7.48729E-08	2.97994E-05	1.490E-06
Pyrene	129-00-0	4.78E-06	lbs/MMBtu	AP-42, Section 3.3	1.21732E-08	4.84494E-06	2.422E-07
Bezo(a)pyrene	50-32-8	1.88E-07	lbs/MMBtu	AP-42, Section 3.3	4.78779E-10	1.90554E-07	9.528E-09
Total POM/PAH		8.33E-05	lbs/MMBtu	AP-42, Section 3.3	2.12043E-07	8.43933E-05	4.220E-06

SO2	19.40	gal/hr	
	7.006	lbs/gal	
	135.916	lbs/hr	
	453.59	grams/lb	
	61650.320	grams/hr	fuel
	0.01998		factor
	1231.77339		
	0.0015	percent	sulfur
	1.848	grams/hr	sulfur
	250	kW/hr	
	0.00739	grams/kW-hr	sulfur

**Bechtel
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CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 5
 SHEET NO.: 3 of 9
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate
 BY: Clara Galbis-Reig DATE: 4/23/15

Small Generator Estimate – MSM/ESM

Notes

1. % Sulfur(0.0015)
2. THC Conversion $THC = TOC * 0.9346$, $VOC = TOC * 0.9841$, $NMHC = TOC * 0.920$
3. Hours = 100 hrs/yr for each generator
4. Power (output) per Vendor, BHP = 198
5. NOx and CO uses vendor emission data (defined as Tier 3) and EPA data for this model engine
6. TSP & PM-10 uses vendor emission data for PM and considers it all PM-10
7. VOCs uses vendor emissions data for NMHC and Note 2 conversion factors
8. SO2 (with Note 1) and Vendor Supplied Calculation - $SO_2 = 0.01998 \times \text{fuel rate (g/hr)} \times \text{\% sulfur in fuel by weight}$
9. Non-Criteria Pollutants use AP-42 Emission Factors for Diesel Combustion for fuel input (1 MMBtu/Hr = 392.6652 hp-hr)
10. PM_{2.5} uses vendor emission data for PM and assumes 90% is $\leq 10 \mu\text{m}$ per AP-42, Appendix B.2-2

Criteria Pollutant	CAS	Stated Emission Factor	Units	Source	Emissions Factor lbs/hp-hr	Hourly Maximum lbs/hr	Yearly Maximum tons/yr
NOx		3.62	g/bkW-hr	vendor data	0.005950	1.1782	0.0589
CO		0.9	g/bkW-hr	vendor data	0.001479	0.2929	0.0146
SO2		0.0096	g/bkW-hr	See Below	0.000016	0.0031	0.0002
TSP		0.16	g/bkW-hr	vendor data, Note 6	0.000263	0.0521	0.0026
PM-10		0.16	g/bkW-hr	vendor data, Note 6	0.000263	0.0521	0.0026
PM-2.5		0.144	g/bkW-hr	See Note 10 Above	0.000237	0.0469	0.0023
VOC		0.1711	g/bkW-hr	See Note 7 above	0.000281	0.0557	0.0028
Non-Criteria Pollutant							
Benzene	71-43-2	9.33E-04	lbs/MMBtu	AP-42, Section 3.3	2.37607E-06	4.70462E-04	2.352E-05
Propylene	115-07-1	2.58E-03	lbs/MMBtu	AP-42, Section 3.3	6.57048E-06	1.30096E-03	6.505E-05
Formaldehyde	50-00-0	1.18E-03	lbs/MMBtu	AP-42, Section 3.3	3.0051E-06	5.95011E-04	2.975E-05
Acetaldehyde	75-07-0	7.67E-04	lbs/MMBtu	AP-42, Section 3.3	1.95332E-06	3.86757E-04	1.934E-05
Acrolein	107-02-8	9.25E-05	lbs/MMBtu	AP-42, Section 3.3	2.3557E-07	4.66428E-05	2.332E-06
Naphtalene	91-20-3	8.48E-05	lbs/MMBtu	AP-42, Section 3.3	2.1596E-07	4.27601E-05	2.138E-06
Toluene	108-88-3	4.09E-04	lbs/MMBtu	AP-42, Section 3.3	1.0416E-06	2.06237E-04	1.031E-05

**Bechtel
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CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 5
 SHEET NO.: 4 of 9
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

o-xylene	1330-20-7	2.85E-04	lbs/MMBtu	AP-42, Section 3.3	7.25809E-07	1.43710E-04	7.186E-06
Total POM (see below)		8.33E-05	lbs/MMBtu	AP-42, Section 3.3	2.12043E-07	4.19846E-05	2.099E-06

POM/PAH

Acenaphthene	83-32-9	1.42E-06	lbs/MMBtu	AP-42, Section 3.3	3.61631E-09	7.1603E-07	3.580E-08
Acenaphthylene	203-96-8	5.06E-06	lbs/MMBtu	AP-42, Section 3.3	1.28863E-08	2.55149E-06	1.276E-07
Anthracene	120-12-7	1.87E-06	lbs/MMBtu	AP-42, Section 3.3	4.76233E-09	9.42941E-07	4.715E-08
Benz(a)anthracene	56-55-3	1.68E-06	lbs/MMBtu	AP-42, Section 3.3	4.27845E-09	8.47134E-07	4.236E-08
Benzo(b)fluoranthene	205-99-2	9.91E-08	lbs/MMBtu	AP-42, Section 3.3	2.52378E-10	4.99708E-08	2.499E-09
Benzo(k)fluoranthene	207-08-9	1.55E-07	lbs/MMBtu	AP-42, Section 3.3	3.94738E-10	7.81582E-08	3.908E-09
Benzo(g,h,i)perylene	191-24-2	4.89E-07	lbs/MMBtu	AP-42, Section 3.3	1.24534E-09	2.46576E-07	1.233E-08
Chrysene	218-01-9	3.53E-07	lbs/MMBtu	AP-42, Section 3.3	8.98985E-10	1.77999E-07	8.900E-09
Dibenzo(a,h)anthracene	53-70-3	5.83E-07	lbs/MMBtu	AP-42, Section 3.3	1.48473E-09	2.93976E-07	1.470E-08
Fluoranthene	206-44-0	7.61E-06	lbs/MMBtu	AP-42, Section 3.3	1.93804E-08	3.83731E-06	1.919E-07
Fluorene	86-73-7	2.92E-05	lbs/MMBtu	AP-42, Section 3.3	7.43636E-08	1.4724E-05	7.362E-07
Indeno(1,2,3-cd)pyrene	193-39-5	3.75E-07	lbs/MMBtu	AP-42, Section 3.3	9.55012E-10	1.89092E-07	9.455E-09
Phenanthrene	85-01-8	2.94E-05	lbs/MMBtu	AP-42, Section 3.3	7.48729E-08	1.48248E-05	7.412E-07
Pyrene	129-00-0	4.78E-06	lbs/MMBtu	AP-42, Section 3.3	1.21732E-08	2.4103E-06	1.205E-07
Bezo(a)pyrene	50-32-8	1.88E-07	lbs/MMBtu	AP-42, Section 3.3	4.78779E-10	9.47983E-08	4.740E-09
Total POM/PAH		8.33E-05	lbs/MMBtu	AP-42, Section 3.3	2.12043E-07	4.19846E-05	2.099E-06

SO2	10.04	gal/hr	
	7.006	lbs/gal	
	70.340	lbs/hr	
	453.59	grams/lb	
	31905.629	grams/hr	
	0.01998		fuel conversion factor
	637.4745		
	0.0015	percent	sulfur
	0.956	grams/hr	sulfur
	100	kW/hr	
	0.00956	grams/kW-hr	sulfur

**Bechtel
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CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 5
 SHEET NO.: 5 of 9
 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Large Generators Estimate

Notes

1. % Sulfur(0.0015)
2. THC Conversion $THC = TOC * 0.9346$, $VOC = TOC * 0.9841$, $NMHC = TOC * 0.920$
3. Hours = 100 hrs/yr for each generator
4. Power (output) = 5096 BHP per Vendor Data
5. NOx and CO uses Caterpillar's Emission Factors (defined as Marine Tier II)
6. PM-10 uses Caterpillars Emission Factor for PM and considers it all PM-10
7. VOCs uses Caterpillars Emissions Factor for THC and Note 2 conversion factors
8. SO2 (with Note 1) and Vendor Supplied Calculation - $SO_2 = 0.01998 \times \text{fuel rate (g/hr)} \times \text{\% sulfur in fuel by weight}$
9. Non-Criteria Pollutants use AP-42 Emission Factors for Diesel Combustion for fuel input (1 MMBtu/Hr = 392.6652 hp-hr)
10. $PM_{2.5}$ uses Caterpillar's Emission Factor for PM and assumes 90% is $\leq 10 \mu\text{m}$ per AP-42, Appendix B.2-2

Criteria Pollutant	CAS	Stated Emission Factor	Units	Source	Emissions Factor lbs/hp-hr	Hourly Maximum lbs/hr	Yearly Maximum lbs/yr	Yearly Maximum tons/yr/unit
NOx		9.93	g/bkW-hr	Caterpillar	0.016323	83.1798	8317.98	4.1590
CO		0.96	g/bkW-hr	Caterpillar	0.001578	8.0416	804.16	0.4021
SO2		0.0061	g/bkW-hr	See Below	0.000010	0.0511	5.11	0.0026
PM-10		0.28	g/bkW-hr	Caterpillar	0.000460	2.3455	234.55	0.1173
TSP		0.28	g/bkW-hr	See 6 Above	0.000460	2.3455	234.55	0.1173
PM-2.5		0.252	g/bkW-hr	See 10 Above	0.000414	2.1109	211.09	0.1055
VOC		0.8634	g/bkW-hr	Caterpillar & 7 Above	0.001419	7.2326	723.26	0.3616
Non-Criteria Pollutant								
Benzene	71-43-2	7.76E-04	lbs/MMBtu	AP-42, Section 3.4	1.97624E-06	0.010071	1.007091	5.035E-04
Propylene	115-07-1	2.79E-03	lbs/MMBtu	AP-42, Section 3.4	7.10529E-06	0.036209	3.620856	1.810E-03
Formaldehyde	50-00-0	7.89E-05	lbs/MMBtu	AP-42, Section 3.4	2.00935E-07	0.001024	0.102396	5.120E-05
Acetaldehyde	75-07-0	2.52E-05	lbs/MMBtu	AP-42, Section 3.4	6.41768E-08	0.000327	0.032705	1.635E-05
Acrolein	107-02-8	7.88E-06	lbs/MMBtu	AP-42, Section 3.4	2.0068E-08	0.000102	0.010227	5.113E-06
Naphtalene	91-20-3	1.30E-04	lbs/MMBtu	AP-42, Section 3.4	3.31071E-07	0.001687	0.168714	8.436E-05
Toluene	108-88-3	2.81E-04	lbs/MMBtu	AP-42, Section 3.4	7.15622E-07	0.003647	0.364681	1.823E-04
o-xylene	1330-20-7	1.93E-04	lbs/MMBtu	AP-42, Section 3.4	4.91513E-07	0.002505	0.250475	1.252E-04
Total POM (see below)		8.15E-05	lbs/MMBtu	AP-42, Section 3.4	2.0764E-07	0.001058	0.105813	5.291E-05
POM/PAH								
Acenaphthene	83-32-9	4.68E-06	lbs/MMBtu	AP-42, Section 3.4	1.19186E-08	6.074E-05	6.074E-03	3.037E-06
Acenaphthylene	203-96-8	9.23E-06	lbs/MMBtu	AP-42, Section 3.4	2.3506E-08	1.198E-04	1.198E-02	5.989E-06
Anthracene	120-12-7	1.23E-06	lbs/MMBtu	AP-42, Section 3.4	3.13244E-09	1.596E-05	1.596E-03	7.981E-07
Benz(a)anthracene	56-55-3	6.22E-07	lbs/MMBtu	AP-42, Section 3.4	1.58405E-09	8.072E-06	8.072E-04	4.036E-07
Benzo(b)fluoranthene	205-99-2	1.11E-06	lbs/MMBtu	AP-42, Section 3.4	2.82684E-09	1.441E-05	1.441E-03	7.203E-07
Benzo(k)fluoranthene	207-08-9	2.18E-07	lbs/MMBtu	AP-42, Section 3.4	5.5518E-10	2.829E-06	2.829E-04	1.415E-07
Benzo(g,h,i)perylene	191-24-2	5.56E-07	lbs/MMBtu	AP-42, Section 3.4	1.41596E-09	7.216E-06	7.216E-04	3.608E-07
Chrysene	218-01-9	1.53E-06	lbs/MMBtu	AP-42, Section 3.4	3.89645E-09	1.986E-05	1.986E-03	9.928E-07

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Dibenzo(a,h)anthracene	53-70-3	3.46E-07	lbs/MMBtu	AP-42, Section 3.4	8.81158E-10	4.490E-06	4.490E-04	2.245E-07
Fluoranthene	206-44-0	4.03E-06	lbs/MMBtu	AP-42, Section 3.4	1.02632E-08	5.230E-05	5.230E-03	2.615E-06
Fluorene	86-73-7	1.28E-05	lbs/MMBtu	AP-42, Section 3.4	3.25977E-08	1.661E-04	1.661E-02	8.306E-06
Indeno(1,2,3-cd)pyrene	193-39-5	4.14E-07	lbs/MMBtu	AP-42, Section 3.4	1.05433E-09	5.373E-06	5.373E-04	2.686E-07
Phenanthrene	85-01-8	4.08E-05	lbs/MMBtu	AP-42, Section 3.4	1.03905E-07	5.295E-04	5.295E-02	2.648E-05
Pyrene	129-00-0	3.71E-06	lbs/MMBtu	AP-42, Section 3.4	9.44825E-09	4.815E-05	4.815E-03	2.407E-06
Bezo(a)pyrene	50-32-8	2.57E-07	lbs/MMBtu	AP-42, Section 3.4	6.54502E-10	3.335E-06	3.335E-04	1.668E-07
Total POM/PAH		8.15E-05	lbs/MMBtu	AP-42, Section 3.4	2.0764E-07	1.058E-03	1.058E-01	5.291E-05

SO2	243.84	gal/hr	
	7.006	lbs/gal	
	1708.326	lbs/hr	
	453.59	grams/lb	
	774879.586	grams/hr	fuel conversion factor
	0.01998		
	15482.09414		
	0.0015	percent	sulfur
	23.223	grams/hr	sulfur
	3800	kW/hr	
	0.00611	grams/kW-hr	sulfur

Fuel Consumption	3800	bkW
at 110% & 90% Confidence	204.1	grams/bkW-hr
Caterpillar Factors	775580	grams/hr
	454	grams/lb
	1708.33	lbs/hr
	7.006	lbs/gal
	243.84	gal./hr

CALCULATION SHEET

PROJECT: **PCAPP**
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 Attachment 5
 SHEET NO.: **7 of 9**
 SHEET REV.: **004**

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Boilers Estimate

Notes

- Two boilers each rated at 60.4 MMBTU/hr (Natural Gas), the boilers can also burn oil at 58 MMBtu/hr (Fuel Oil) however fuel oil firing is not expected or planned except as noted below
- Natural Gas firing rate = 60,400 scf/hr Oil firing rate = 423.3 gal/hr
- Calculation based on 8,787 total hours for both boilers using natural gas (see hrs estimate below) and 48 hours max for each boiler on ultra low sulfur diesel (ULSD) for testing, etc.
- Total fuel consumed per year -530,734,800 scf Natural Gas and 40,637 gal fuel oil for testing - see note below
- Emission estimate - Maximum pounds per hour is per boiler
- Emission estimate - Maximum pounds and tons per year is for both boilers
- Criteria pollutants emission factors (except TSP) from Hamworthy Peabody Combustion (Burner manufacturer)
- HAPs emission factors from AP-42 Section 1.4 (natural gas) and Section 1.3 (fuel oil)
- TSP emission factors from AP-42 Section 1.4 Table 1.4-2 (natural gas - all PM is < 1 mm; TSP = PM₁₀ = PM_{2.5}) and Section 1.3 (Table 1.3-6 (fuel oil - TSP = 2 * PM₁₀ PM_{2.5} = TSP * 0.12)
- SO₂ for natural gas (AP-42 Table 1.4-2) for fuel oil (see calcs below) % sulfur (0.0015) - SO₂ = 0.01998 x Fuel Rate (grams/hr) x % sulfur in fuel (AP-2 emission factors and mass balance calculations)

Pollutant	CAS	Natural Gas Emission Factor	Units - Reference	Oil Emission Factor	Units - Reference	Max. lbs/hr Emissions - NG	Max. lbs/hr Emissions - Oil	Max. lbs/yr (Oil & Gas)	Max. tons/yr (Oil & Gas)	Max. lbs/yr (All Gas)	Max. tons/yr (All Gas)
SO _x		0.00059	lb/MMBtu - AP-42 (Note 10)	0.0015	lb/MMBtu - AP-42 (Note 10)	3.564E-02	8.700E-02	3.215E+02	1.607E-01	3.131E+02	1.566E-01
NO _x		0.036	lb/MMBtu - Vend Spec	0.186	lb/MMBtu - Vend Spec	2.174E+00	1.079E+01	2.014E+04	1.007E+01	1.911E+04	9.553E+00
CO		0.04	lb/MMBtu - Vend Spec	0.07	lb/MMBtu - Vend Spec	2.416E+00	4.060E+00	2.162E+04	1.081E+01	2.123E+04	1.061E+01
VOC		0.005	lb/MMBtu - Vend Spec	0.005	lb/MMBtu - Vend Spec	3.020E-01	2.900E-01	2.682E+03	1.341E+00	2.654E+03	1.327E+00
TSP		0.01	lb/MMBtu - AP-42 (Note 9)	0.05	lb/MMBtu - AP-42 (Note 9)	6.040E-01	2.900E+00	5.586E+03	2.793E+00	5.307E+03	2.654E+00
PM ₁₀		0.01	lb/MMBtu - Vend Spec	0.025	lb/MMBtu - Vend Spec	6.040E-01	1.450E+00	5.447E+03	2.723E+00	5.307E+03	2.654E+00
PM _{2.5}		0.01	lb/MMBtu - AP-42 (Note 9)	0.006	lb/MMBtu - AP-42 (Note 9)	6.040E-01	3.480E-01	5.341E+03	2.670E+00	5.307E+03	2.654E+00
HAPs - Volatiles											
Hexane	110543	1.8	lbs/MMscf - AP42			1.087E-01		9.553E+02	4.777E-01	9.553E+02	4.777E-01
Benzene	71432	0.0021	lbs/MMscf - AP42	0.000214	lb/Mgal - AP42	1.268E-04	9.059E-05	1.123E+00	5.616E-04	1.115E+00	5.573E-04
Ethylbenzene	100414			0.0000636	lb/Mgal - AP42	0.000E+00	2.692E-05	2.585E-03	1.292E-06	0.000E+00	0.000E+00
Formaldehyde	50000	0.075	lbs/MMscf - AP42	0.061	lb/Mgal - AP42	4.530E-03	2.582E-02	4.228E+01	2.114E-02	3.981E+01	1.990E-02
Naphtalene	91203	0.00061	lbs/MMscf - AP42	0.00113	lb/Mgal - AP42	3.684E-05	4.783E-04	3.697E-01	1.848E-04	3.237E-01	1.619E-04
1,1,1-Trichloroethane	71556			0.000236	lb/Mgal - AP42	0.000E+00	9.990E-05	9.590E-03	4.795E-06	0.000E+00	0.000E+00
Toluene	108883	0.0034	lbs/MMscf - AP42	0.0062	lb/Mgal - AP42	2.054E-04	2.624E-03	2.056E+00	1.028E-03	1.804E+00	9.022E-04
o-xylene	95476			0.000109	lb/Mgal - AP42	0.000E+00	4.614E-05	4.429E-03	2.215E-06	0.000E+00	0.000E+00
POMs (See Below)		0.0000882	lbs/MMscf	0.00336	lb/Mgal - AP42	5.327E-06	1.422E-03	1.834E-01	9.168E-05	4.681E-02	2.341E-05

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

HAPs - Metals											
Arsenic	7440382	0.0002	lbs/MMscf - AP42	4	lb/10 ¹² BTU - AP42	1.208E-05	2.320E-04	1.284E-01	6.421E-05	1.061E-01	5.307E-05
Beryllium	7440417	0.000012	lbs/MMscf - AP42	3	lb/10 ¹² BTU - AP42	7.248E-07	1.740E-04	2.307E-02	1.154E-05	6.369E-03	3.184E-06
Cadmium	7440439	0.0011	lbs/MMscf - AP42	3	lb/10 ¹² BTU - AP42	6.644E-05	1.740E-04	6.005E-01	3.003E-04	5.838E-01	2.919E-04
Chromium	7440473	0.0014	lbs/MMscf - AP42	3	lb/10 ¹² BTU - AP42	8.456E-05	1.740E-04	7.597E-01	3.799E-04	7.430E-01	3.715E-04
Cobalt	7440484	0.000084	lbs/MMscf - AP42			5.074E-06	0.000E+00	4.458E-02	2.229E-05	4.458E-02	2.229E-05
Manganese	7439965	0.00038	lbs/MMscf - AP42	6	lb/10 ¹² BTU - AP42	2.295E-05	3.480E-04	2.351E-01	1.175E-04	2.017E-01	1.008E-04
Mercury	7439976	0.00026	lbs/MMscf - AP42	3	lb/10 ¹² BTU - AP42	1.570E-05	1.740E-04	1.547E-01	7.735E-05	1.380E-01	6.900E-05
Nickel	7440020	0.0021	lbs/MMscf - AP42	6	lb/10 ¹² BTU - AP42	1.268E-04	3.480E-04	1.148E+00	5.740E-04	1.115E+00	5.573E-04
Lead	7439921	0.0005	lbs/MMscf - AP42	9	lb/10 ¹² BTU - AP42	3.020E-05	5.220E-04	3.155E-01	1.577E-04	2.654E-01	1.327E-04
Selenium	7782492	0.000024	lbs/MMscf - AP42	15	lb/10 ¹² BTU - AP42	1.450E-06	8.700E-04	9.626E-02	4.813E-05	1.274E-02	6.369E-06
Arsenic	7440382	0.0002	lbs/MMscf - AP42	4	lb/10 ¹² BTU - AP42	1.208E-05	2.320E-04	1.284E-01	6.421E-05	1.061E-01	5.307E-05
Total HAPs Emissions									5.024E-01		
POMs											
2-Methylnaphthalene	91576	0.000024	lbs/MMscf - AP42								
3-Methylchloranthrene	56495	0.0000018	lbs/MMscf - AP42								
7,12-Dimethylbanz(a)anthracene	57976	0.000016	lbs/MMscf - AP42								
Acenaphthene	83329	0.0000018	lbs/MMscf - AP42	0.0000211	lb/Mgal - AP42						
Acenaphthylene	203968	0.0000018	lbs/MMscf - AP42	0.000000253	lb/Mgal - AP42						
Anthracene	120127	0.0000024	lbs/MMscf - AP42	0.00000122	lb/Mgal - AP42						
Benz(a)anthracene	56553	0.0000018	lbs/MMscf - AP42	0.00000401	lb/Mgal - AP42						
Bezo(a)pyrene	50328	0.0000012	lbs/MMscf - AP42								
Benzo(b,k)fluoranthene		0.0000036	lbs/MMscf - AP42	0.00000148	lb/Mgal - AP42						
Benzo(g,h,i)perylene	191242	0.0000012	lbs/MMscf - AP42	0.00000226	lb/Mgal - AP42						
Chrysene	218019	0.0000018	lbs/MMscf - AP42	0.00000238	lb/Mgal - AP42						
Dibenzo(a,h)anthracene	53703	0.0000012	lbs/MMscf - AP42	0.00000167	lb/Mgal - AP42						
Fluoranthene	206440	0.000003	lbs/MMscf - AP42	0.00000484	lb/Mgal - AP42						
Fluorene	86737	0.0000028	lbs/MMscf - AP42	0.00000447	lb/Mgal - AP42						
Indo(1,2,3-cd)pyrene	193395	0.0000018	lbs/MMscf - AP42	0.00000214	lb/Mgal - AP42						
Phenanthrene	85018	0.000017	lbs/MMscf - AP42	0.0000105	lb/Mgal - AP42						
Pyrene	129000	0.000005	lbs/MMscf - AP42	0.00000425	lb/Mgal - AP42						
OCDD				3.1E-09	lb/Mgal - AP42						
POM Particulate				0.0033	lb/Mgal - AP42						
Total POMs Emissions		0.0000882	lbs/MMscf - AP42	0.003360576	lb/Mgal - AP42						

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CALCULATION SHEET

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Boiler operating hours estimate

Only one boiler will operate at a time; however there will be periods of time when one boiler is being shut down and one unit is starting up

Boilers will switch over on a monthly basis and it takes approximately 2 hours to complete the switch

1 boiler 24 hrs/day x 365 days/yr 8760 hrs/yr

2 hrs/switch x 12 times/yr 24 hrs/yr

add additional 10% and round up 3 hrs/yr

8787 Total hrs/yr both boilers will operate

SO₂ calculation for fuel oil

Calculation for SO₂ (grams/hr) = 0.01998 x Fuel Rate (grams/hr) x % sulfur in fuel

423.3	gal/hr	fuel
7.006	lb/gal	fuel density
2965.6398	lbs/hr	fuel
453.59	grams/lb	
1345184.6	grams/hr	fuel
0.01998		conversion factor
26876.787	grams/hr	SO ₂
0.0015	% S in fuel	
40.315181	grams/hr	SO ₂
0.0888802	lbs/hr	SO ₂
0.0015324	lb/MMBtu	SO ₂

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CALCULATION SHEET

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CALC NO.:	RD-M5C-000-B0004
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 6

Calculate number of tank turnovers for each fuel storage tank:

Given:

Large generators consume 244 gal/hr. for a total of 200 hrs/yr.
Boilers fire fuel oil for 96 hours/yr at a max rate of 423.3 gal/hr
Standby Security generator consumes 19.4 gal/hr for 100 hrs/yr (stored separately)
MSM/ESM generator consumes 10 gal/hr for 100 hrs/yr (stored separately)
SDG Fuel Oil Storage tank working volume = 75,000 gallons
SDG Day tanks A and B working volume = 1,900 gallons each
Boiler Fuel Oil Day tank working volume = 660 gallons
Small Generator Day tank working volume = 400 gallons

Assumptions:

SDG Day tanks A and B dimensions; length = 10 ft, diameter = 6 ft
Boiler Fuel Oil Day tank dimensions; length = 8 ft, diameter = 4 ft
Small Generator Day tank dimensions; length = 5 ft, diameter = 4 ft

Security Generator Day tank turnover = 1940 gallons fuel / 400 gallon tank = 4.9 tank turnovers
ESM/MSM Generator Day Tank turnover = 1000 gal fuel / 400 gallon tank = 2.5 tank turnovers

Boiler Fuel Oil Day tank turnover:

Boiler annual usage = 423.3 gal/hr x 96 hours = 40,637 gal/yr
40,637 gallons / 660 gallon tank = 61.6 turnovers

SDG Day tank turnovers

Generator annual usage = 200 hrs x 244 gal/hr = 48,800 gal/yr
48,800 gallons fuel / (2 tanks x 1,900 gallon tank) = 12.8 tank turnovers.

SDG Fuel Oil Storage tank turnover:

Boiler fuel + SDG fuel = 89,437 gallons
89,437 gallons / 75,000 gallon tank = 1.2 tank turnovers.

Tank dimensions and turnover rates were entered into the EPA TANKS 4.0.9d program to estimate emissions of fuel oil no. 2 for each tank. The detailed program reports for the SDG Fuel Oil Storage tank, the SDG Day tanks, the Boiler Fuel Oil Day tank, and the Small Generators Day tanks are attached below.

The Tanks Program is no longer supported and does not run correctly on newer operating systems. Therefore, the original values are presented below. These were based on significantly more fuel oil than currently planned.

Total daily emissions for fuel oil storage tanks:

$19.29 \text{ lbs/year} + 2(1.39 \text{ lbs/year}) + 2.34 \text{ lbs/year} + 0.16 \text{ lbs/year} = 24.57 \text{ lbs / year}$
 $= 0.068 \text{ lbs / day}$

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BY: Clara Galbis-Reig

DATE: 4/23/15

TANKS 4.0.9d

Emissions Report - Detail Format

Tank Identification and Physical Characteristics

Identification

User Identification: SDG Fuel Oil Storage Tank

City:

State:

Company:

Type of Tank: Vertical Fixed Roof Tank

Description:

Tank Dimensions

Shell Height (ft): 24.00

Diameter (ft): 25.00

Liquid Height (ft): 20.42

Avg. Liquid Height (ft): 20.42

Volume (gallons): 75,000.00

Turnovers: 1.2

Net Throughput(gal/yr): 89.00

Is Tank Heated (y/n): N

Paint Characteristics

Shell Color/Shade: White/White

Shell Condition: Good

Roof Color/Shade: White/White

Roof Condition: Good

Roof Characteristics

Type: Dome

Height (ft): 3.00

Radius (ft) (Dome Roof): 25.00

Breather Vent Settings

Vacuum Settings (psig): -0.03

Pressure Settings (psig): 0.03

Meteorological Data used in Emissions Calculations: Pueblo, Colorado (Avg Atmospheric Pressure = 12.4 psia)

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

TANKS 4.0.9d

**Emissions Report - Detail Format
Liquid Contents of Storage Tank**

SDG Fuel Oil Storage Tank - Vertical Fixed Roof Tank

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F)			Liquid Bulk Temp (deg F)	Vapor Pressure (psia)			Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
		Avg.	Min.	Max.		Avg.	Min.	Max.					
Distillate fuel oil no. 2	All	54.85	47.26	62.45	52.74	0.0055	0.0041	0.0071	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

TANKS 4.0.9d

**Emissions Report - Detail Format
Detail Calculations (AP-42)**

SDG Fuel Oil Storage Tank - Vertical Fixed Roof Tank

Annual Emission Calculations

Standing Losses (lb):	6.4033
Vapor Space Volume (cu ft):	2,505.4118
Vapor Density (lb/cu ft):	0.0001
Vapor Space Expansion Factor:	0.0544
Vented Vapor Saturation Factor:	0.9985
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	2,505.4118
Tank Diameter (ft):	25.0000
Vapor Space Outage (ft):	5.1040
Tank Shell Height (ft):	24.0000
Average Liquid Height (ft):	20.4248
Roof Outage (ft):	1.5288
Roof Outage (Dome Roof)	
Roof Outage (ft):	1.5288
Dome Radius (ft):	25.0000
Shell Radius (ft):	12.5000

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Vapor Density	
Vapor Density (lb/cu ft):	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Daily Avg. Liquid Surface Temp. (deg. R):	514.5240
Daily Average Ambient Temp. (deg. F):	52.7250
Ideal Gas Constant R (psia cuft / (lb-mol-deg R):	10.731
Liquid Bulk Temperature (deg. R):	512.4150
Tank Paint Solar Absorptance (Shell):	0.1700
Tank Paint Solar Absorptance (Roof):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,576.8848
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0544
Daily Vapor Temperature Range (deg. R):	30.3780
Daily Vapor Pressure Range (psia):	0.0030
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0041
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0071
Daily Avg. Liquid Surface Temp. (deg R):	514.5240
Daily Min. Liquid Surface Temp. (deg R):	506.9295
Daily Max. Liquid Surface Temp. (deg R):	522.1184
Daily Ambient Temp. Range (deg. R):	31.7667
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9985
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Vapor Space Outage (ft):	5.1040
Working Losses (lb):	12.8902
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Annual Net Throughput (gal/yr.):	761,227.0000
Annual Turnovers:	10.0000
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	75,000.0000
Maximum Liquid Height (ft):	20.4248
Tank Diameter (ft):	25.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	19.2934

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Pueblo
Team**

CALCULATION SHEET

PROJECT: PCAPP
JOB NUMBER: 24852
CALC NO.: RD-M5C-000-B0004
Attachment 6
SHEET NO.: 5 of 15
SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

TANKS 4.0.9d

Emissions Report - Detail Format Individual Tank Emission Totals

Emissions Report for: Annual

SDG Fuel Oil Storage Tank - Vertical Fixed Roof Tank

Components	Losses(lbs)		
	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	12.89	6.40	19.29

TANKS 4.0.9d

Emissions Report - Detail Format Tank Identification and Physical Characteristics

Identification

User Identification: SDG day tank
City:
State:
Company:
Type of Tank: Horizontal Tank

**Bechtel
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Team**

CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
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 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Description:

Tank Dimensions

Shell Length (ft): 10.00
 Diameter (ft): 6.00
 Volume (gallons): 1,900.00
 Turnovers: 29.00
 Net Throughput(gal/yr): 55,100.00
 Is Tank Heated (y/n): N
 Is Tank Underground (y/n): N

Paint Characteristics

Shell Color/Shade: White/White
 Shell Condition: Good

Breather Vent Settings

Vacuum Settings (psig): -0.03
 Pressure Settings (psig): 0.03

Meteorological Data used in Emissions Calculations: Pueblo, Colorado (Avg Atmospheric Pressure = 12.4 psia)

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

SDG day tank - Horizontal Tank

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F)			Liquid Bulk Temp (deg F)	Vapor Pressure (psia)			Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
		Avg.	Min.	Max.		Avg.	Min.	Max.					
Distillate fuel oil no. 2	All	54.85	47.26	62.45	52.74	0.0055	0.0041	0.0071	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

**TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)**

**Bechtel
Pueblo
Team**

CALCULATION SHEET

PROJECT: PCAPP
 JOB NUMBER: 24852
 CALC NO.: RD-M5C-000-B0004
 Attachment 6
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 SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

SDG day tank - Horizontal Tank

Annual Emission Calculations

Standing Losses (lb):	0.4606
Vapor Space Volume (cu ft):	180.0913
Vapor Density (lb/cu ft):	0.0001
Vapor Space Expansion Factor:	0.0544
Vented Vapor Saturation Factor:	0.9991
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	180.0913
Tank Diameter (ft):	6.0000
Effective Diameter (ft):	8.7426
Vapor Space Outage (ft):	3.0000
Tank Shell Length (ft):	10.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Daily Avg. Liquid Surface Temp. (deg. R):	514.5240
Daily Average Ambient Temp. (deg. F):	52.7250
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	512.4150
Tank Paint Solar Absorptance (Shell):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,576.8848
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0544
Daily Vapor Temperature Range (deg. R):	30.3780
Daily Vapor Pressure Range (psia):	0.0030
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0041
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0071
Daily Avg. Liquid Surface Temp. (deg R):	514.5240
Daily Min. Liquid Surface Temp. (deg R):	506.9295
Daily Max. Liquid Surface Temp. (deg R):	522.1184
Daily Ambient Temp. Range (deg. R):	31.7667
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9991
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055

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CALCULATION SHEET

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BY: Clara Galbis-Reig

DATE: 4/23/15

Vapor Space Outage (ft): 3.0000
 Working Losses (lb): 0.9330
 Vapor Molecular Weight (lb/lb-mole): 130.0000
 Vapor Pressure at Daily Average Liquid
 Surface Temperature (psia): 0.0055
 Annual Net Throughput (gal/yr.): 55,100.0000
 Annual Turnovers: 29.0000
 Turnover Factor: 1.0000
 Tank Diameter (ft): 6.0000
 Working Loss Product Factor: 1.0000
 Total Losses (lb): 1.3936

**TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals**

Emissions Report for: Annual

SDG day tank - Horizontal Tank

Components	Losses(lbs)		
	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	0.93	0.46	1.39

**TANKS 4.0.9d
Emissions Report - Detail Format
Tank Identification and Physical Characteristics**

Identification

User Identification: boiler day tank
 City:

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Team**

CALCULATION SHEET

PROJECT: PCAPP
JOB NUMBER: 24852
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SHEET REV.: 004

SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

State:

Company:

Type of Tank:

Horizontal Tank

Description:

Tank Dimensions

Shell Length (ft): 8.00

Diameter (ft): 4.00

Volume (gallons): 660.00

Turnovers: 988.77

Net Throughput(gal/yr): 652,587.00

Is Tank Heated (y/n): N

Is Tank Underground (y/n): N

Paint Characteristics

Shell Color/Shade: White/White

Shell Condition: Good

Breather Vent Settings

Vacuum Settings (psig): -0.03

Pressure Settings (psig): 0.03

Meteorological Data used in Emissions Calculations: Pueblo, Colorado (Avg Atmospheric Pressure = 12.4 psia)

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

Boiler day tank - Horizontal Tank

**Bechtel
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CALCULATION SHEET

PROJECT: PCAPP
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F)			Liquid Bulk Temp (deg F)	Vapor Pressure (psia)			Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
		Avg.	Min.	Max.		Avg.	Min.	Max.					
Distillate fuel oil no. 2	All	54.85	47.26	62.45	52.74	0.0055	0.0041	0.0071	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

TANKS 4.0.9d

**Emissions Report - Detail Format
Detail Calculations (AP-42)**

Boiler day tank - Horizontal Tank

Annual Emission Calculations

Standing Losses (lb):	0.1638
Vapor Space Volume (cu ft):	64.0325
Vapor Density (lb/cu ft):	0.0001
Vapor Space Expansion Factor:	0.0544
Vented Vapor Saturation Factor:	0.9994
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	64.0325
Tank Diameter (ft):	4.0000
Effective Diameter (ft):	6.3847
Vapor Space Outage (ft):	2.0000
Tank Shell Length (ft):	8.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Daily Avg. Liquid Surface Temp. (deg. R):	514.5240
Daily Average Ambient Temp. (deg. F):	52.7250
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	512.4150
Tank Paint Solar Absorptance (Shell):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,576.8848
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0544
Daily Vapor Temperature Range (deg. R):	30.3780

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CALCULATION SHEET

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Daily Vapor Pressure Range (psia):	0.0030
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0041
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0071
Daily Avg. Liquid Surface Temp. (deg R):	514.5240
Daily Min. Liquid Surface Temp. (deg R):	506.9295
Daily Max. Liquid Surface Temp. (deg R):	522.1184
Daily Ambient Temp. Range (deg. R):	31.7667
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9994
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0055
Vapor Space Outage (ft):	2.0000
Working Losses (lb):	2.1770
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Annual Net Throughput (gal/yr.):	652,587.0000
Annual Turnovers:	988.7682
Turnover Factor:	0.1970
Tank Diameter (ft):	4.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	2.3408

**TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals**

Emissions Report for: Annual

Boiler day tank - Horizontal Tank

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CALCULATION SHEET

PROJECT: PCAPP
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BY: Clara Galbis-Reig

DATE: 4/23/15

Components	Losses(lbs)		
	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	2.18	0.16	2.34

**TANKS 4.0.9d
Emissions Report - Detail Format
Tank Identification and Physical Characteristics**

Identification

User Identification: small generator tank
 City:
 State:
 Company:
 Type of Tank: Horizontal Tank
 Description:

Tank Dimensions

Shell Length (ft): 5.00
 Diameter (ft): 4.00
 Volume (gallons): 400.00
 Turnovers: 8.00
 Net Throughput(gal/yr): 3,200.00
 Is Tank Heated (y/n): N
 Is Tank Underground (y/n): N

Paint Characteristics

Shell Color/Shade: White/White
 Shell Condition: Good

Breather Vent Settings

Vacuum Settings (psig): -0.03
 Pressure Settings (psig): 0.03

Meteorological Data used in Emissions Calculations: Pueblo, Colorado (Avg Atmospheric Pressure = 12.4 psia)

**TANKS 4.0.9d
Emissions Report - Detail Format**

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CALCULATION SHEET

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BY: Clara Galbis-Reig

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Liquid Contents of Storage Tank

small generator tank - Horizontal Tank

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F)			Liquid Bulk Temp (deg F)	Vapor Pressure (psia)			Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
		Avg.	Min.	Max.		Avg.	Min.	Max.					
Distillate fuel oil no. 2	All	54.85	47.26	62.45	52.74	0.0055	0.0041	0.0071	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

TANKS 4.0.9d

**Emissions Report - Detail Format
Detail Calculations (AP-42)**

small generator tank - Horizontal Tank

Annual Emission Calculations

Standing Losses (lb):	0.1024
Vapor Space Volume (cu ft):	40.0203
Vapor Density (lb/cu ft):	0.0001
Vapor Space Expansion Factor:	0.0544
Vented Vapor Saturation Factor:	0.9994
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	40.0203
Tank Diameter (ft):	4.0000
Effective Diameter (ft):	5.0475
Vapor Space Outage (ft):	2.0000
Tank Shell Length (ft):	5.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Daily Avg. Liquid Surface Temp. (deg. R):	514.5240
Daily Average Ambient Temp. (deg. F):	52.7250
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731

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Liquid Bulk Temperature (deg. R):	512.4150
Tank Paint Solar Absorptance (Shell):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,576.8848
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0544
Daily Vapor Temperature Range (deg. R):	30.3780
Daily Vapor Pressure Range (psia):	0.0030
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0041
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0071
Daily Avg. Liquid Surface Temp. (deg R):	514.5240
Daily Min. Liquid Surface Temp. (deg R):	506.9295
Daily Max. Liquid Surface Temp. (deg R):	522.1184
Daily Ambient Temp. Range (deg. R):	31.7667
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9994
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0055
Vapor Space Outage (ft):	2.0000
Working Losses (lb):	
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0055
Annual Net Throughput (gal/yr.):	3,200.0000
Annual Turnovers:	8.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	4.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	0.1566

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CALCULATION SHEET

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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

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

Emissions Report for: Annual

small generator tank - Horizontal Tank

Components	Losses(lbs)		
	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	0.05	0.10	0.16

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CALCULATION SHEET

PROJECT:	PCAPP
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Attachment 7

Barnebey Sutcliffe estimates of carbon adsorption affinity, 2 pages
Supplemental list obtained via email by Kelley Hand (formerly of Battelle), 1 page

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CALCULATION SHEET

PROJECT: **PCAPP**
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BY: Clara Galbis-Reig

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Key : 0 - 5 5 is highest adsorptive capacity, 0 is no capacity under normal conditions

Substance	Index	Substance	Index	Substance	Index
Acetaldehyde	*	Chlorine	3*	Ethane	0
Acetic acid	4	Chlorobenzene	5	Ether	3
Acetic anhydrite	4	Chlorobutadiene	4	Ethyl acetate	4
Acetone	3	Chloroform	4	Ethyl acrylate	4
Acetylene	0	Chloronitropropane	4	Ethyl alcohol	3
Acid gas	*	Chloronitropropane	4	Ethyl amine	*
Acrolein	3	Chloropicrin	4	Ethyl benzene	5
Acrylic acid	4	Cigarette smoke odor	4	Ethyl bromide	3
Acrylonitrile	4	Citrus and other fruits	4	Ethyl chloride	3
Adhesives	4	Cleaning compounds	4	Ethyl ether	3
Amines	*	Cooking odors	4	Ethyl formate	3
Ammonia	*	Corrosive gases	*	Ethyl mercaptan	3
Amyl acetate	4	Creosote	5	Ethyl silicate	4
Amyl alcohol	4	Cresol	5	Ethylene	0
Amyl ether	4	Crotonaldehyde	4	Ethylene chlorohydrin	3
Animal odors	3	Cyclohexane	5	Ethylene oxide	*
Anesthetics	3	Cyclohexanol	4	Essential oils	5
Aniline	5	Cyclohexanone	5	Eucalyptole	4
Asphalt	4	Cyclohexene	5		
Benzene	5	Decane	5	Fertilizer	4
Bleaching solutions	*	Deodorants	4	Film Processing Odors	3
Bromine	*	Detergents	4	Floral scents	4
Butadiene	3	Dibromomethane	3	Fluorotrichloromethane	3
Butane	2	Dichlorobenzene	5	Food aromas	4
Butanone	4	Dichlorodifluoromethane	3	Formaldehyde	*
Butyl acetate	4	Dichloroethane	3	Formic acid	*
Butyl alcohol	4	Dichloroethylene	3	Gasoline	5
Butyl cellosolve	4	Dichloroethyl ether	4	Heptane	5
Butyl chloride	4	Dichloromonofluoromethane	3	Heptylene	5
Butyl ether	4	Dichloronitroethane	4	Hexane	4
Butylene	2	Dichloropropane	4	Hexylene	4
Butyne	2	Dichlorotetrafluorethane	4	Hexyne	4
Butyraldehyde	3	Diesel fumes	4	Hospital odors	4
Butyric acid	4	Diethylamine	*	Household smells	4
Caprylic acid	4	Diethyl ketone	4	Hydrogen	0
Carbolic acid	4	Dimethylaniline	5	Hydrogen bromide	*
Carbon disulfide	2	Dimethylsulfide	3	Hydrogen chloride	*
Carbon dioxide	1	Dioxane	4	Hydrogen cyanide	*
Carbon monoxide	0	Dipropyl ketone	4	Hydrogen fluoride	*
Carbon tetrachloride	4	Epoxy	4		

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CALCULATION SHEET

PROJECT: **PCAPP**
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Key : 0 - 5 5 is highest adsorptive capacity, 0 is no capacity under normal conditions

<u>Substance</u>	<u>Index</u>	<u>Substance</u>	<u>Index</u>	<u>Substance</u>	<u>Index</u>
Hydrogen iodide	*	Naphtha	5	Propyl mercaptan	4
Hydrogen selenide	*	Naphthalene	5	Propylene	1
Hydrogen	*	Nicotine	4	Propyne	1
Ink Odors	3	Nitric acid	*	Putrescine	4
Iodine	4	Nitrobenzenes	5	Pyridine	4
Isophorone	4	Nitroethane	4	Radiation products	*
Isoprene	3	Nitrogen dioxide	*	Radioactive iodide	*
Isopropyl acetate	4	Nitroglycerine	4	Resins	4
Isopropyl alcohol	4	Nitromethane	2	Ripening fruits	4
Isopropyl ether	4	Nitropropane	4	Rubber	4
Kerosene	5	Nitrotoluene	5	Sewer odors	*
Kitchen odors	4	Nonane	5	Styrene monomer	5
Liquid fuels	5	Noxious gases	*	Sulfur dioxide	*
Lubricating oils	5	Octalene	5	Sulfur trioxide	*
Medicinal odors	4	Octane	5	Sulfuric acid	*
Menthol	4	Odorants	*	Tetrachloroethane	5
Mercaptans	*	Ozone	5	Tetrachloroethylene	5
Mercury	*	Paint odors	4	Toluene	5
Mesityl oxide	4	Palmitic acid	4	Toluidine	5
Methane	0	p-dichlorbenzene	5	Trichlorethylene	4
Methyl acetate	2	Paste	4	Trichloroethane	4
Methyl acrylate	3	Pentane	3	Turpentine	5
Methyl alcohol	1	Pentanone	4	Urea	4
Methyl bromide	2	Pentylene	3	Uric acid	4
Methyl butyl ketone	4	Pentyne	3	Valeric acid	4
Methyl cellosolve acetate	4	Perchloroethylene	4	Valeraldehyde	4
Methyl chloride	2	Perfumes	4	Varnish fumes	4
Methyl chloroform	4	Pet odors	3	Vinegar	4
Methyl ether	3	Phenol	5	Vinyl chloride	1
Methyl ethyl ketone	3	Phosgene	3	Xylene	5
Methyl formate	2	Pitch	5	War gases	*
Methyl iodine	*	Plastics	4		
Methyl isobutyl ketone	4	Poison gases	*		
Methylcyclohexane	5	Propane	1		
Methylcyclohexanol	5	Propionaldehyde	3		
Methylcyclohexanone	5	Propionic acid	4		
Methylene chloride	3	Propyl acetate	4		
Monochlorobenzene	5	Propyl alcohol	3		
		Propyl chloride	4		
		Propyl ether	4		

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CALCULATION SHEET

PROJECT: **PCAPP**
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SUBJECT: PCAPP Emissions Estimate

BY: Clara Galbis-Reig

DATE: 4/23/15

Kelley Hand
Battelle
614-424-7551

CAS No.	Chemical	Rank
120-82-1	1,2,4-trichlorobenzene	3
95-63-6	1,2,4-trimethyl benzene	2
96-12-8	1,2-dibromo-3-chloropropane	4
108-67-8	1,3,5-trimethylbenzene	3
505-29-3	1,4-dithiane	2
75-05-8	acetonitrile	2
98-83-9	alpha-methylstyrene	3
75-27-4	bromodichloromethane	2
74-83-9	bromomethane	2
75-00-3	chloroethane	2
74-87-3	chloromethane	1
124-48-1	dibromochloromethane	2
87-68-3	hexachlorobutadiene	5
67-72-1	hexachloroethane	4
75-69-4	trichlorofluoromethane	1

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