MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

MISSOURI AIR CONSERVATION COMMISSION

PERMIT TO CONSTRUCT

Under the authority of RSMo 643 and the Federal Clean Air Act the applicant is authorized to construct the air contaminant source(s) described below, in accordance with the laws, rules and conditions as set forth herein.

Permit Number: 082018-009

Project Number: 2018-03-007
Installation Number: 510-0066

Parent Company: Elementis Specialties, Inc.

Parent Company Address: 5548 Manchester Avenue, Saint Louis, MO 63110

Installation Name: Elementis Specialties, Inc.

Installation Address: 5548 Manchester Avenue, Saint Louis, MO 63110

Location Information: City of Saint Louis

Application for Authority to Construct was made for:
Operate two filter presses simultaneously. This review was conducted in accordance with Section (5), Missouri State Rule 10 CSR 10-6.060, *Construction Permits Required*.

☐ Standard Conditions (on reverse) are applicable to this permit.

☑ Standard Conditions (on reverse) and Special Conditions are applicable to this permit.

Prepared by
Chad Stephenson
New Source Review Unit

Director or Designee
Department of Natural Resources

AUG 07 2018

Effective Date

STANDARD CONDITIONS:

Permission to construct may be revoked if you fail to begin construction or modification within two years from the effective date of this permit. Permittee should notify the Enforcement and Compliance Section of the Air Pollution Control Program if construction or modification is not started within two years after the effective date of this permit, or if construction or modification is suspended for one year or more.

You will be in violation of 10 CSR 10-6.060 if you fail to adhere to the specifications and conditions listed in your application, this permit and the project review. In the event that there is a discrepancy between the permit application and this permit, the conditions of this permit shall take precedence. Specifically, all air contaminant control devices shall be operated and maintained as specified in the application, associated plans and specifications.

You must notify the Enforcement and Compliance Section of the Department's Air Pollution Control Program of the anticipated date of start up of this (these) air contaminant source(s). The information must be made available within 30 days of actual startup. Also, you must notify the Department's regional office responsible for the area within which you are located within 15 days after the actual start up of this (these) air contaminant source(s).

A copy of the permit application and this permit and permit review shall be kept at the installation address and shall be made available to Department's personnel upon request.

You may appeal this permit or any of the listed special conditions to the Administrative Hearing Commission (AHC), P.O. Box 1557, Jefferson City, MO 65102, as provided in RSMo 643.075.6 and 621.250.3. If you choose to appeal, you must file a petition with the AHC within 30 days after the date this decision was mailed or the date it was delivered, whichever date was earlier. If any such petition is sent by registered mail or certified mail, it will be deemed filed on the date it is mailed. If it is sent by any method other than registered mail or certified mail, it will be deemed filed on the date it is received by the AHC.

If you choose not to appeal, this certificate, the project review and your application and associated correspondence constitutes your permit to construct. The permit allows you to construct and operate your air contaminant source(s), but in no way relieves you of your obligation to comply with all applicable provisions of the Missouri Air Conservation Law, regulations of the Missouri Department of Natural Resources and other applicable federal, state and local laws and ordinances.

The Air Pollution Control Program invites your questions regarding this air pollution permit. Please contact the Construction Permit Unit using the contact information below.

<u>Contact Information</u>:
Missouri Department of Natural Resources
Air Pollution Control Program
P.O. Box 176
Jefferson City, MO 65102-0176
(573) 751-4817

The regional office information can be found at the following website:
http://dnr.mo.gov/regions/

SPECIAL CONDITIONS:
The permittee is authorized to construct and operate subject to the following special conditions:

The special conditions listed in this permit were included based on the authority granted the Missouri Air Pollution Control Program by the Missouri Air Conservation Law (specifically 643.075) and by the Missouri Rules listed in Title 10, Division 10 of the Code of State Regulations (specifically 10 CSR 10-6.060). For specific details regarding conditions, see 10 CSR 10-6.060 paragraph (12)(A)10. "Conditions required by permitting authority."

Elementis Specialties, Inc.
City of Saint Louis

1. Bentone Process Production Limit
   A. Elementis Specialties, Inc. shall not exceed a production limit of 14,330 tons from the Bentone process per twelve (12) consecutive month period.

   B. Elementis Specialties, Inc. shall record the monthly and the sum of the most recent consecutive 12 months production from the Bentone process at EP-86 (packing station). These records shall be kept on-site for five (5) years and shall be made immediately available for inspection to Department of Natural Resources' personnel upon request.

2. Control Device Requirement-Baghouse
   A. Elementis Specialties, Inc. shall control emissions from the following emission points using baghouses/fabric filters as specified in the permit application.

Table 1: Emission Points Controlled by Baghouses/Fabric Filters

Emission Point (Emission Unit)	Control Device Number	Description
EP-1 (EU0120)	CD-1	Clay Storage Silos
EP-2 (EU0140)	CD-2	Wet Process Day Silo
EP-3 (EU0100)	CD-3	Clay Receiver 1
EP-4 (EU0110)	CD-4	Clay Receiver 2
EP-9 (EU0150)	CD-9	Bentone Flash Dryer #1
EP-10 (EU0160)	CD-11	Bentone Flash Dryer #2
EP-12a (EU0240a)	CD-13	Bentone Pneumatic Transfer
EP-81 (EU0670)	CD-81	Soda Ash Pneumatic Transfer System
EP-82 (EU0680)	CD-82	Anion Pneumatic Transfer System
EP-83 (EU0690)	CD-83	Mill "A"
EP-84 (EU0700)	CD-84	Mill "B"
EP-85 (EU0710)	CD-85	Packing Hopper
EP-86 (EU0720)	CD-86	Packing Station

SPECIAL CONDITIONS:
The permittee is authorized to construct and operate subject to the following special conditions:

B. The baghouses/fabric filters shall be operated and maintained in accordance with the manufacturer's specifications. Replacement filters for the baghouses shall be kept on hand at all times. The bags/fabric filters shall be made of fibers appropriate for operating conditions expected to occur (i.e. temperature limits, acidic and alkali resistance, and abrasion resistance).

C. The baghouses/fabric filters shall be equipped with a gauge or meter, which indicates the pressure drop across the control device. These gauges or meters shall be located such that the Department of Natural Resources' employees may easily observe them.

D. Elementis Specialties, Inc. shall monitor and record the operating pressure drop across the baghouses/fabric filters at least once every 24 hours when the plant is in operation.

E. The operating pressure drop shall be maintained within the design conditions specified by the manufacturer's performance warranty. In the absence of a manufacturer's performance warranty, the baghouses/fabric filters shall be operated and maintained with a written standard operating procedures (SOP) developed by Elementis Specialties, Inc. The SOP shall incorporate baghouse/fabric filter industry design standards.

F. Elementis Specialties, Inc. shall maintain an operating and maintenance record for the baghouses/fabric filters (e.g. the Malfunction/Breakdown Reporting form) which shall include the following:
   1) Incidents of malfunction, with impact on emissions, duration of event, probable cause, and corrective actions; and
   2) Maintenance activities, with inspection schedule, repair actions, and replacements, etc.

SPECIAL CONDITIONS:
The permittee is authorized to construct and operate subject to the following special conditions:

3. Control Equipment –Thermal Oxidizer
   A. Elementis Specialties, Inc. shall control emissions from the North and South Horizontal Belt Filter (EP-37 and EP-38), the Parkson Filter Press (EP-39), the Bentone Reaction Tanks (EP-55), and the Ashbrook Simon Harley Filter Press (EP-80) using a thermal oxidizer at all times (S-64/CD-64) as specified in the permit application.

   B. The thermal oxidizer shall be operated and maintained in accordance with the manufacturer's specifications.

   C. The Average Chamber Temperature of the thermal oxidizer shall be continuously monitored and Average Chamber Temperature shall be recorded every 15 minutes. Bed 1 and Bed 2 of the oxidizer shall have a temperature set point of 1500 F, controlled by the manufacturer.

   D. Elementis Specialties, Inc. shall maintain an operating and maintenance record for the thermal oxidizer (e.g. the Malfunction/Breakdown Reporting form) which shall include the following:
      1) Incidents of malfunction, with impact on emissions, duration of event, probable cause, and corrective actions; and
      2) A written record of regular inspection schedule, the date and results of all inspections including any actions or maintenance activities that result from that inspection.

4. Record Keeping and Reporting Requirements
   A. Elementis Specialties, Inc. shall maintain all records required by this permit for not less than five years and shall make them available immediately to any Missouri Department of Natural Resources' personnel upon request. These records shall include SDS for all materials used.

   B. Elementis Specialties, Inc. shall report to the Air Pollution Control Program's Compliance/Enforcement Section, by mail at P.O. Box 176, Jefferson City, MO 65102 or by email at AirComplianceReporting@dnr.mo.gov, no later than 10 days after the end of the month during which any record required by this permit shows an exceedance of a limitation imposed by this permit.

REVIEW OF APPLICATION FOR AUTHORITY TO CONSTRUCT AND OPERATE
SECTION (5) REVIEW
Project Number: 2018-03-007
Installation ID Number: 510-0066
Permit Number: 082018-009

Installation Address:
Elementis Specialties, Inc.
5548 Manchester Avenue
Saint Louis, MO 63110

Parent Company:
Elementis Specialties, Inc.
5548 Manchester Avenue
Saint Louis, MO 63110

City of Saint Louis

REVIEW SUMMARY

- Elementis Specialties, Inc. has applied for authority to increase production by operating two filter presses simultaneously.
- The application was deemed complete on March 27, 2018.
- HAP emissions are expected from the proposed equipment. HAPs of concern from this process are from the combustion of natural gas.
- New Source Performance Standards (NSPS) 40 CFR 60 Subpart Dc, *Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units* applies to the Water Heater (EP-87).
- None of the NESHAPs apply to this installation. None of the currently promulgated MACT regulations apply to the proposed equipment.
- An RTO is being used to control the VOC emissions from the equipment in this permit. Baghouses are being used to control particulate emissions.
- This review was conducted in accordance with Section (5) of Missouri State Rule 10 CSR 10-6.060, *Construction Permits Required.* Potential emissions of all pollutants are conditioned below de minimis levels.
- This installation is located in City of Saint Louis, a nonattainment area for the 1997 $PM_{2.5}$ NAAQS and the 2008 8-hr ozone NAAQS and an attainment area for all other criteria pollutants.
- This installation is not on the List of Named Installations found in 10 CSR 10-6.020(3)(B), Table 2. The installation's major source level is 250 tons per year and fugitive emissions are not counted toward major source applicability.

- Ambient air quality modeling was not performed since potential emissions of the application are conditioned below de minimis levels.

- Emissions testing is not initially required for the equipment as a part of this permit but may be required if control device excursions exceed 3%. Testing may be required as part of other state, federal or applicable rules

- An update to Part 70 Operating Permit application, Project 2016-05-076, is required for this installation within 1 year of equipment startup.

- Approval of this permit is recommended with special conditions.

INSTALLATION DESCRIPTION

Elementis Specialties, Inc. owns and operates a rheological additives manufacturing plant in St. Louis, MO. Two types of clay and five types of amines are used as raw materials. The main product at the plant is Bentone Organoclay. This installation is currently a major source under both construction and operating permits. A Part 70 Operating Permit (OP2011-058) was issued to the facility in 2011. An application for a renewal to the Part 70 Operating Permit was submitted on May 27, 2016 and logged in under project number 2016-05-076. The following construction permits have been issued to the installation from the Air Pollution Control Program.

Table 2: Permit History

Permit Number	Description
98-07-048	Plant rebagging station
05-09-008	Raw material change
012007-018	PUG mill production
07-08-014	Packing System
09-06-014	Pneumatic transfer system.
122013-006	Pug Mill

PROJECT DESCRIPTION

Elementis Specialties, Inc. (Elementis) manufactures rheological clays at the company's Saint Louis Plant at 5548 Manchester Road. Elementis desires to increase the production capacity of the Bentone Wet Process. In 2014 a new Ashbrook Simon-Harley Filter Press (Ashbrook Filter Press) was installed with the intention of replacing an older existing filter press, the Parkson Filter Press. At the time the new press was installed, Elementis agreed to only operate one press at a time, using the Parkson until the Ashbrook was made fully operational (project number 2013-12-039).

At this time, Elementis is applying for a permit to operate both presses simultaneously which will increase the annual capacity of the plant to 14,330 tons (13,000 metric tons). Modifications will be made to downstream milling and packaging equipment to facilitate

the additional throughput of material. No additional equipment will be needed upstream of the filter presses, nor will physical modification of the upstream equipment be necessary.

Pollutants that are emitted from the Bentone Wet Process include particulate matter, VOC from process and handling activities, and natural gas combustion products.

The scope of the project will entail:

- The modification of the exhaust ventilation to both filter presses to exhaust simultaneously to the thermal oxidizer to control VOC emissions;
- The replacement and relocation of the blower and baghouse on the Pneumatic Transfer System (EP12a) to increase operability, reliability, and throughput capacity of the system and the control device;
- The modification of the mill system, which consists of two mills, to equip each mill with an individual baghouse, replacing a baghouse (CD-12) that currently is shared by both mills, which will enable an increase in the instantaneous throughput of each mill;
- The installation of one larger packing station (EP-85) to replace the two existing packing hoppers (EP47 and EP71);
- The installation of a bin vent filter to control emissions from the new packing hopper;
- Removal of the baghouses (CD-47 and CD-71) that currently control the two packing hoppers; and
- Replacement of the existing packaging station and associated baghouse (EP-13 and CD-14) with a new automated packing station (EP-86) that will have higher throughput capacity and updated baghouse.

The following table list the equipment associated with the project.

Table 3: Project Equipment List

Emission Point	Emission Unit	Description
EP01	EU-0120	Clay Storage Silos
EP02	EU-0140	Wet Process Day Silo
EP03	EU-0100	Clay Receiver #1
EP04	EU-0110	Clay Receiver #2
EP05	EU-0600	Powerhouse Boiler
EP06	EU-0300	Amine Tank #4 (Working Losses)
EP07	EU-0310	Amine Tank #8 (Working Losses)
EP08	EU-0320	Amine Tank #7 (Working Losses)
EP09	EU-0150	Bentone Flash Dryer #1 (Natural Gas Combustion)
EP09	EU-0150	Bentone Flash Dryer #1 (Product Conveying & Drying)
EP10	EU-0160	Bentone Flash Dryer #2 (Natural Gas Combustion)
EP10	EU-0160	Bentone Flash Dryer #2 (Product Conveying & Drying)

Emission Point	Emission Unit	Description
EP12a	EU-0240a	Bentone Pneumatic Transfer
EP33	EU-0640	Amine Tank Heater
EP37	EU-0270	South Horizontal Belt Filter
EP38	EU-0280	North Horizontal Belt Filter
EP39	EU-0040	Parkson Filter Press
EP45	EU-0060	Bentone Dispersion Tanks
EP55	EU-0090	Bentone Reaction Tanks
EP80	EU-0660	Ashbrook Simon Hartley Filter Press
EP81	EU-0670	Anion Pneumatic Transfer System
EP82	EU-0680	Soda Ash Pneumatic Transfer System
EP83	EU-0690	Mill "A"
EP84	EU-0700	Mill "B"
EP85	EU-0710	New Packing Hopper
EP86	EU-0720	New Packing Station
EP87	EU-0730	Water Heater
EP36	EU-0530	Seal Water Tank

The increased throughput will necessitate an increase in the annual throughput for the raw materials and the finished products, including: the Clay Storage Silos for raw clay, the Day Silo for raw clay; the Clay Receivers for raw clay, the Dispersion Tanks where clay is slurried with the water; the Blending Tanks, the Bentone Reaction Tanks, where the raw clay is reacted with quaternary amine, the Amine Storage Tanks; the Horizontal Belt Filters, the Filter Presses, the Flash Dryers, the Pneumatic Transfer System, the Milling System, and the Packaging System.

The raw materials, clay and soda ash, are dry until they enter the Dispersion Tanks where they are slurried in water. The anion is dry until it enters the Bentone Reaction Tanks. From those tanks the material is slurried until it is dried in the Flash Dryers. As a wet material there are no particulate emissions. In and after the dryers, the handling and processing of the material generates particulate emissions. Liquid amine with ethanol as a solvent is added to the slurry in the Bentone Reaction Tanks. The operations from the reaction tanks to the dryers generate ethanol (VOC) emissions.

None of the emitting sources upstream of the filter presses will need to be physically modified in order to achieve the increased annual throughput.

A process diagram submitted by the installation is available in Appendixes B and C.

EMISSIONS/CONTROLS EVALUATION

Particulate Emissions – Material Processing

There are two dryers (EP-9 and EP-10) that are used to dry Bentone. The dryers are cage rotary type dryers. The emission factors used for the dryers were obtained from the EPA document AP-42, *Compilation of Air Pollutant Emission Factors*, Fifth Edition, Clay Processing, Section 11.25 (January 1995). The exhausts from the flash dryers are each controlled by a cyclone and a fabric filter. The controlled emission factors from Table 11.25-10 were used. Size distribution data is provided for controlled emissions in Table 11.25-11. Using the particle size distribution in Table 11.25-11, $PM_{2.5}$ is 12% of the total PM.

Material transfer operations exits from the silos (EP-1 and EP-2), receivers (EP-3 and EP-4), tanks (EP12a, EP81, and EP-82), and the hopper (EP-85). The emission factors used for the material transfer were obtained from AP-42 Section 11.12 "Concrete Batching" (June 2006). There are no emission factors for material transfer in AP-42 Chapter 11.25 for Clay Processing and with the clay and dried Bentone being a relatively fine powder and transferred pneumatically, the concrete batching emission factors were the most representative. Each of the material transfer operations is controlled by a fabric filter so the controlled emission factor in Table 11.12-2 was used. $PM_{2.5}$ was conservatively assumed to equal PM_{10}.

Solids are dropped (EP-45) into the water in the dispersion tanks. The most representative reference in AP-42 was Section 11.12 "Concrete Batching" (June 2006). Equation 11.12.1 provides a method to calculate emissions factors for PM_{10} and $PM_{2.5}$ for central mixer loading, dropping dry materials into a wetted vessel. The inputs for the equations include a particle size multiplier, a size constant, wind speed in miles per hour, and moisture content in percent. Since the dispersion tanks are located indoors, a wind speed of 1 mph was used and a minimum moisture content of 0.1 was used. These emissions are uncontrolled.

There are two mills (EP-83 and EP-84). The most representative reference found for emissions from milling clay was AP-42 Section 11.3 "Brick and Structural Clay Product Manufacturing" (August 1997). A PM_{10} emission factor for grinding and screening clay is presented for uncontrolled and filter controlled emissions in Table 11.3-2. Each of the mills is controlled by a fabric filter so the controlled emission factor was used. Since there was no particle size distribution, the same factor for PM_{10} was used for $PM_{2.5}$.

Emission factors for the packing station (EP-86) were obtained from AP42 Section 8.2 "Urea" (July 1993). Table 8.2-1 presents an emission factor for uncontrolled total particulate matter from bagging finished urea product with no size distribution. The total PM factor per ton of material was used for both PM_{10} and $PM_{2.5}$. The packing station is controlled by a baghouse/fabric filter so a 99% control was applied to PM, PM_{10}, and $PM_{2.5}$.

VOC Emissions – Material Processing

There are four material processing operations that emit VOC emissions. They are reaction, vacuum filtering, press filtering, and drying. The reaction tanks, vacuum filtering, and press filtering are controlled by an RTO. The RTO was given 95% control of VOC, which is the default used by the Air Pollution Control Program. The malfunction emissions from the RTO have been tracked since 2008. The RTO is started before the process is started and remains in operation until after the process is shut down. In the event the oxidizer is not in operation during operation of the process, the event is recorded. There was one malfunction since 2008, when the oxidizer was not in operation while the Bentone process was in operation. The oxidizer failed and shut down resulting in 54.9 pounds of VOC emission before the process could be shut down. The potential emissions in the permit use 54.9 pounds of VOC for malfunction per year.

In the reaction tanks (EP55) the amine ethanol mixture is added to the slurry from the blending tanks. The amine reacts with the clay in the slurry. The reactor functions in a semi batch manner, with material reacting in one reactor tank while reacted material is pumped from the other reactor tank to the vacuum filters. The vent is common from both reactors and flows to the RTO.

The reacted slurry is pumped to the South (EP-37) and North (EP-38) Horizontal Belt Filters where vacuum is used to remove a portion of liquid from the slurry. The exhaust from the vacuum filters is ducted to RTO.

The filter cake is conveyed from the North and South Horizontal Belt Filters to filter presses, the Ashbrook Simon-Hartley (EP-80) and the Parkson (EP-39) where the cake is pressed to remove more of the liquid from the solids. Emissions from the filter presses are captured by a hood with the exhausts flowing to the RTO.

The filter cake is conveyed from the filter presses to the Flash Dryers (EP-9 and EP-10) where the majority of the remainder of the liquid is removed by heating and flowing air through the material. The flash dryers each exhaust through a cyclone and a fabric filter to collect the product material.

There are no emission factors published for the VOC emission from process operations in Bentone manufacturing. Emission factors for these operations were developed from stack testing that was performed on each of the process operations while manufacturing one specific formulation, Bentone 34. The stack test was performed at the facility in 2001 as part of a VOC RACT analysis and was submitted and approved by the City of St. Louis - Division of Air Pollution Control Program.

The initial test was performed while one specific product, Bentone 34, was being produced. The process is capable of producing nine different Bentone products. All of the products are produced using the same process operations in the same manner; the mix of clay and the amine reactants are varied to produce different products.

The origin of the VOC emissions is the alcohol that is in the amine solutions (which also contain water) to make the amines liquid and reduce the viscosity to enable the handling as liquids. VOC emissions result from the storage of the amine solutions, the mixing of the amine solutions with the clay slurries in the reactors, and the processes used to remove the water from the reacted slurries, belt (vacuum) filters, filter presses, and heated dryers. Ancillary to the water removal are VOC emissions from the seal water tank for the vacuum pumps for the belt filters.

The VOC emission calculations from the process equipment were based upon stack testing that was performed on the vent streams from each of the process operations, including the seal water tank. The uncontrolled VOC concentrations and mass flow rates were determined during the testing project. Uncontrolled emission factors in units of pounds of VOC per ton of product produced were calculated for each of the processes operations utilizing the initial testing. The results of the initial testing and the emission factors derived from that testing are shown in the following table.

Table 4: Emission factors from RACT Analysis

Process Operation	Manufactured Bentone 34 During Test *				
	VOC Concentration (ppmv)	Gas Flow Rate (acfm)	VOC Emission Rate (lbs/hr)	Production Rate (lbs/hr)	Emission Factor During Test (lbs VOC/ ton product)
Bentone Reaction Tank	2,399	381	6.47	1.25	5.176
Belt Vacuum Filter	1,309	914	8.89	1.45	6.131
Press Filter	67	5,586	3.56	1.19	2.992
Flash Dryer	60	22,122	14.06	1.23	11.431
Seal Water Tank	179	100	0.48	1.30	0.367

*Amine solution usage during test was 0.444 lbs/lbs of product, the amine solution consisted of 10.79% IPA, 7% water, 82.21% Di(hydrogenated tallow) dimethylammonium chloride.

To use the emission factors for other products, the quantity of amine solution used and the concentration of alcohol in the amine was considered. It was assumed that the quantity of emissions from each of the process operations is proportional to the quantity of VOC (alcohol) that enters the process with the amine solution. The quantity of alcohol used per ton of product produced is proportional to the ratio of amine solution to product produced and to the concentration of alcohol in the amine solution. The adjustment to the factors is calculated by the following equation:

$$EF_{B_iA_{B_i}} = EF_{B_{34}A_{B34}}\left(\frac{R_{B_i}}{R_{B_{34}}}\right)\left(\frac{C_{IPA-B_i}}{C_{IPA-B_{34}}}\right) = EF_{EP_aB_{34}A_{B34}}\left(\frac{R_{B_i}}{0.444}\right)\left(\frac{C_{B_i}}{0.1079}\right)$$
$$= (20.8735)R_{B_i}C_{B_i}(EF_{B_{34}A_{B34}})$$

Where:

$EF_{B_iA_{B_i}} = Emission\ factor\ emission\ unit$ "a" $for\ Bentone$ "i" with Amine A_{B_i}

$R_{B_{34}}$ = amine usage for Bentone 34 in pounds of amine solution per pound of product

R_{B_i} = amine usage for Bentone "i" in pounds of amine solution per pound of product.

$C_{IPA-B_{34}}$ = Concentration of VOC in amine solution used for Bentone 34 as weight fraction

C_{IPA-B_i} = Concentration of VOC in amine solution used for Bentone "i" as weight fraction.

The usage correction factor for the emission factors for all of the process operations ($EF_{B_iA_{B_i}}$) for a given Bentone product is given by: $(20.8735)R_{B_i}C_{B_i}$

The usage ratio, alcohol concentrations, water concentrations and the usage correction factor for Bentone 34 and the product mix in 2011/2012 and the expected worst case emission factor for the potential product mix are shown in the table below. Elementis produces a mix of products that use varying amounts of amine and that the amine used has varying amounts of alcohol. The product that has the highest emission factor (# of VOC/ton of Product) is Bentone SD-3. The units of the alcohol and water concentrations are weight fraction.

Table 5: Usage Ratios

Bentone	**Bentone 34**	**2011 Product Mix**	**2012 Product Mix**	**Potential Product Mix – Bentone SD-3**
Amine Usage (lb/lb product)	0.4440	0.0389	0.413	0.515
Alcohol (Wt. Fraction)	0.1079	0.1541	0.1514	0.1126
Water (Wt. Fraction)	0.0700	0.0700	0.0700	0.0700
Amine Usage Correction Factor	1.000	1.2503	1.3052	1.2104

Since the initial testing, the amine suppliers have switched the alcohol in the amine solutions from iso-propyl alcohol to ethanol. All of the VOC emissions from the process operations are evaporative emissions. To calculate the emission factors from the process operations for each Bentone product, the ethanol vapor concentration relative to the propanol vapor concentration of the amine solution were used to determine an alcohol correction factor.

Because both alcohols are completely miscible in water, the vapor concentrations are considered to be represented by alcohol in water vapor equilibrium, ignoring the amine. The reference temperature for the vapor pressure is 135.5 °F for the reactor, 120 °F for the belt vacuum filter, 87 °F for the press filter, 178 °F for dryer 1B, 185 °F for dryer 2B and 88 °F for the seal water tank. The relative vapor mass concentrations are given by:

$$\frac{(P_{vap_{EtOH}})(Mw_{EtOH})}{(P_{vap_{IPA}})(Mw_{IPA})}$$

Where: $(P_{vap_{EtOH}})$ *and* $(P_{vap_{IPA}})$ *are the vapor pressures of ethanol and iso − propanol over water at the given liquid concentrations, respectively.*
and,
(Mw_{EtOH}) *and* (Mw_{IPA}) *are the molecular weights of ethanol,* 46.07 *and isopropanol,* 60.09, *respectively.*

The alcohol correction factor, to correct for the difference in vapor pressure and molecular weight, is the ratio of vapor mass concentrations calculated by the equation above. The calculated values are shown in the table below.

Table 6: Alcohol Correction Factors

Parameter	2011 Product Mix	2012 Product Mix	Potential Product Mix Bentone SD-3
Alcohol (Wt. Fraction)	0.1541	0.1514	0.1126
Water (Wt. Fraction)	0.0700	0.0700	0.0700
IPA (Liquid Mole Fraction)	0.3907	0.393	0.325
IPA (Partial Pressure mmHg) Reactor	276.3598	276.24	274.13
IPA (Partial Pressure mmHg) Belt Vacuum Filter	182.04	181.96	180.68
IPA (Partial Pressure mmHg) Press Filter	67.22	67.20	66.76
IPA (Partial Pressure mmHg) Dryer 1B	758.05	757.62	750.21
IPA (Partial Pressure mmHg) Dryer 2B	894.06	893.52	884.35
IPA (Partial Pressure mmHg) Seal Water Tank	69.23	69.20	68.75
IPA Vapor Mass Conc. (P_{IPA})(Mw) Reactor	16606.46	16599.02	16472.57
IPA Vapor Mass Conc. (P_{IPA})(Mw) Belt Vacuum Filter	10938.68	10934.13	10856.77
IPA Vapor Mass Conc. (P_{IPA})(Mw) Press Filter	4039.41	4037.87	4011.82
IPA Vapor Mass Conc. (P_{IPA})(Mw) Dryer 1B	45551.48	45525.29	45080.03
IPA Vapor Mass Conc. (P_{IPA})(Mw) Dryer 2B	53723.88	53691.47	53140.41
IPA Vapor Mass Conc. (P_{IPA})(Mw) Seal Water Tank	4159.89	4158.31	4131.45
Ethanol (Mole Fraction)	0.462	0.458	0.388
Ethanol (Partial Pressure mmHg) Reactor	292.97	292.55	284.94
Ethanol (Partial Pressure mmHg) Belt Vacuum Filter	194.82	194.53	189.36

Parameter	2011 Product Mix	2012 Product Mix	Potential Product Mix Bentone SD-3
Ethanol (Partial Pressure mmHg) Press Filter	74.22	74.10	71.99
Ethanol (Partial Pressure mmHg) Dryer 1B	792.30	791.18	771.06
Ethanol (Partial Pressure mmHg) Dryer 2B	933.36	932.04	908.30
Ethanol (Partial Pressure mmHg) Seal Water Tank	76.35	76.23	74.06
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Reactor	13497.06	13477.60	13127.34
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Belt Vacuum Filter	8975.21	8961.99	8723.98
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Press Filter	3419.36	3413.94	3316.45
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Dryer 1B	36501.11	36449.61	35522.59
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Dryer 2B	43000.06	42939.30	41845.58
Ethanol Vapor Mass Conc. (P_{EtOH})(Mw) Seal Water Tank	3517.50	3511.94	3411.91
Alcohol Vapor Correction Factor Reactor	0.8128	0.812	0.7969
Alcohol Vapor Correction Factor Belt Vacuum Filter	0.8205	0.8196	0.8036
Alcohol Vapor Correction Factor Press Filter	0.8465	0.8455	0.8267
Alcohol Vapor Correction Factor Dryer 1B	0.8013	0.8006	0.7880
Alcohol Vapor Correction Factor Dryer 2B	0.8004	0.7997	0.7875
Alcohol Vapor Correction Factor Reactor	0.8456	0.8446	0.8258

To correct for the amine usage, amine alcohol concentration for the product mix and the change from IPA to ethanol, the emission factors for each of the alcohol emitting units derived by the testing was multiplied by the Amine Usage Correction Factor and the Alcohol Vapor Correction Factor. The following table lists the units, the correction factors, and the emission factors, for the affected units.

Table 7: Emission Factors for New Product Mix – SD-3

Process Operation	Bentone 34	Product Mix Emission Factors		
	Emission Factor During Test (lbs VOC/ ton product)	Amine Usage Correction Factor	Alcohol Vapor Correction Factor	Emission Factor Product Mix (lbs VOC/ ton product)
Bentone Reaction Tank (EP55)	5.102	1.2104	0.7969	4.993
Belt Vacuum Filter (EP37, EP38)	6.136	1.2104	0.8036	5.964
Press Filter (EP39, EP80)	3.005	1.2104	0.8036	2.994
Flash Dryer (EP09)	8.816	1.2104	0.7880	10.903
Flash Dryer (EP10)	8.816	1.2104	0.7875	10.896
Seal Water Tank (EP36)	0.367	1.2104	0.8258	0.366

VOC Emissions – Storage Tanks

AP-42 Section 7.1 "Organic Liquid Storage Tanks" (November 2006) was used to calculate the emissions of the Amine Storage Tanks since they are heated. VOC emissions result from ethanol in the mixture of amine and ethanol.

Combustion Emissions

The project involves a number of natural gas combustion sources. The Powerhouse Boiler (EP-5) supplies steam for the entire plant. The Amine Tank Heater (EP-33) produces heated water that is used to control the temperature of the amine in the Amine Storage Tanks. The Bentone Flash Dryers (EP-9 and EP-10) are heated with natural gas. The Bentone Water Heater (EP-87) produces heated water that is used in the Bentone Wet process. The Powerhouse Boiler has a heat input capacity of 12.56 MMBtu/hr. The dryers each have a heat input capacity of 1.03 MMBtu/hr. The amine tank heater has a heat input capacity of 0.48 MMBtu/hr. The water heater has a heat input capacity of 15 MMBtu/hr. Natural gas combustion emissions were calculated using AP-42 Section 1.4 "Natural Gas Combustion" (July 1998).

Emission Summary

Since this project involves a modification of an existing emissions unit, the VOC emissions increase was determined by calculating the difference between the potential VOC emissions and the baseline actual VOC emissions of the modified equipment. The potential VOC emissions are based on an annual production rate of 14,330 tons (13,000 metric tons). Special Condition 1 of this permit limits the production rate for any consecutive 12 month period to 14,330 tons. The BAE were calculated using the production data from 2011 and 2012 using the same method outlined for the potential emissions calculations. Baseline actual emissions from pollutants other than VOC were not considered since potential emissions were already below de minimis levels when calculated at the production rate of 14,330 tons per year. Table 8 below lists the numbers used in the PTE minus BAE calculations.

Table 8: Project Emissions Calculations (tpy)

Pollutants	New PTE	2011 Actuals	2012 Actuals	BAE	PTE-BAE
VOC	89.10	62.69	59.56	61.13	27.97

The following table provides an emissions summary for this project. Existing potential emissions were not determined. However, according to information taken from previous permits, this installation is a major source for PM_{10} and VOC under construction permits. Existing actual emissions were taken from the installation's 2017 EIQ. Potential emissions of the application represent the potential of the new and modified equipment assuming continuous operation (8760 hours per year).

Table 9: Emissions Summary (tons per year)

Pollutant	Regulatory *De Minimis* Levels	Existing Potential Emissions	Existing Actual Emissions (2017 EIQ)	Potential Emissions of the Application
PM	25.0	N/D	N/A	7.34
PM_{10}	15.0	Major	2.16	3.39
$PM_{2.5}$	10.0	N/D	1.99	1.57
SOx	40.0	N/D	0.02	0.08
NOx	40.0	N/D	4.25	12.94
VOC	40.0	Major	37.87	89.10
CO	100.0	N/D	3.58	10.87
HAPs	10.0/25.0	N/D	0.23	0.24

N/A = Not Applicable; N/D = Not Determined

PERMIT RULE APPLICABILITY

This review was conducted in accordance with Section (5) of Missouri State Rule 10 CSR 10-6.060, *Construction Permits Required*. Potential emissions of all pollutants

except for VOC are conditioned below de minimis levels. The net emissions increase of VOC is below de minimis levels.

APPLICABLE REQUIREMENTS

Elementis Specialties, Inc. shall comply with the following applicable requirements. The Missouri Air Conservation Laws and Regulations should be consulted for specific record keeping, monitoring, and reporting requirements. Compliance with these emission standards, based on information submitted in the application, has been verified at the time this application was approved. For a complete list of applicable requirements for your installation, please consult your operating permit.

GENERAL REQUIREMENTS

- *Operating Permits*, 10 CSR 10-6.065
- *Start-Up, Shutdown, and Malfunction Conditions,* 10 CSR 10-6.050
- *Submission of Emission Data, Emission Fees and Process Information,* 10 CSR 10-6.110
    - Per 10 CSR 10-6.110(4)(B)2.B(II) and (4)(B)2.C(II) a full EIQ is required for the first full calendar year the equipment (or modifications) approved by this permit are in operation.
- *Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin*, 10 CSR 10-6.170
- *Restriction of Emission of Visible Air Contaminants*, 10 CSR 10-6.220
- *Restriction of Emission of Odors*, 10 CSR 10-6.165

SPECIFIC REQUIREMENTS

- *Control of Volatile Organic Compound Emissions from Existing Major Sources* 10 CSR 10-5.520
- *Restriction of Emissions of Particulate Matter from Industrial Processes 10 CSR 10-6.400*
- *New Source Performance Regulations*, 10 CSR 10-6.070
    - *Standards of Performance for Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units*, 40 CFR Part 60, Subpart Dc

STAFF RECOMMENDATION

On the basis of this review conducted in accordance with Section (5), Missouri State Rule 10 CSR 10-6.060, *Construction Permits Required*, it is recommended that this permit be granted with special conditions.

PERMIT DOCUMENTS

The following documents are incorporated by reference into this permit:

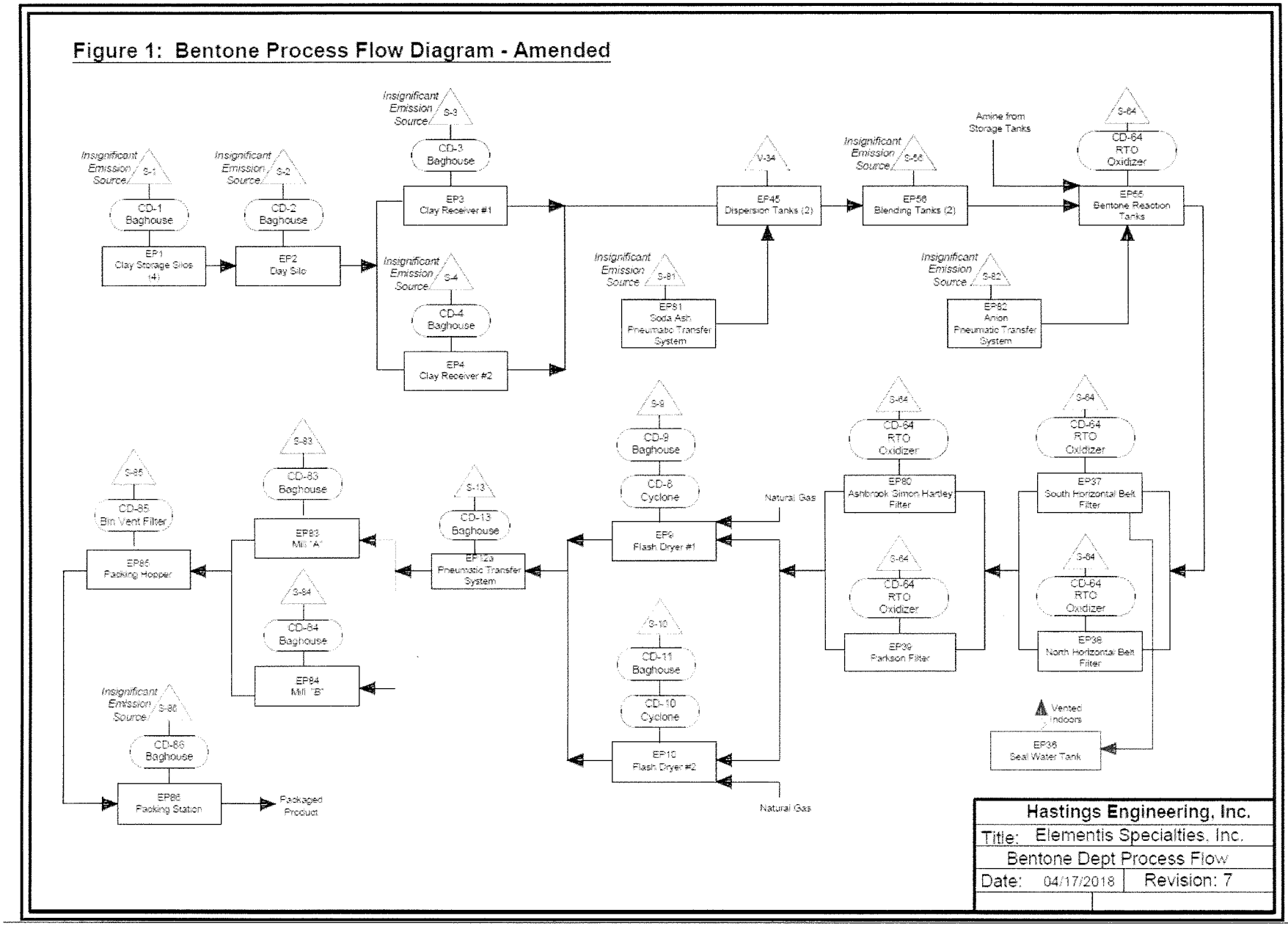
- The Application for Authority to Construct form, dated March 2, 2018, received March 5, 2018, designating Elementis Specialties, Inc. as the owner and operator of the installation.
- Amended application forms, received by email April 23, 2018, from Hastings Engineering, Inc.

APPENDIX A

Abbreviations and Acronyms

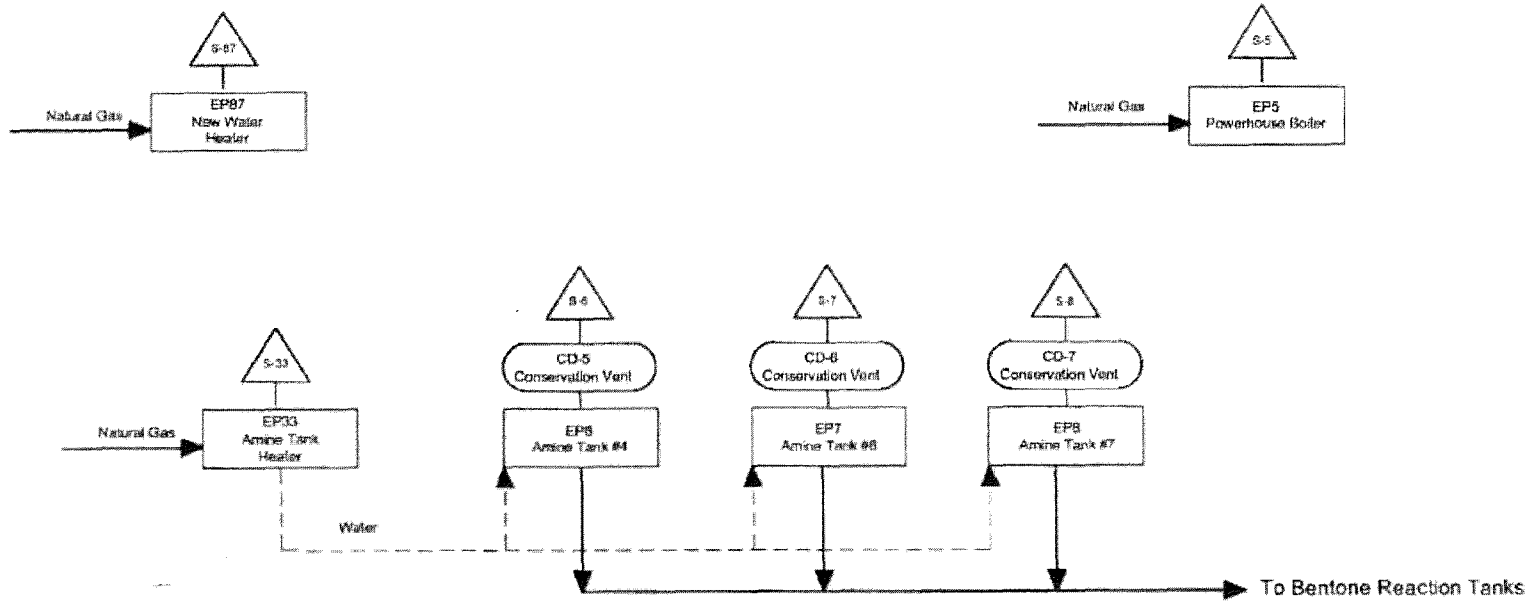
% ..... percent
°F ..... degrees Fahrenheit
acfm ..... actual cubic feet per minute
BACT ..... Best Available Control Technology
BMPs ..... Best Management Practices
Btu ..... British thermal unit
CAM ..... Compliance Assurance Monitoring
CAS ..... Chemical Abstracts Service
CEMS ..... Continuous Emission Monitor System
CFR ..... Code of Federal Regulations
CO ..... carbon monoxide
CO_2 ..... carbon dioxide
CO_2e ..... carbon dioxide equivalent
COMS ..... Continuous Opacity Monitoring System
CSR ..... Code of State Regulations
dscf ..... dry standard cubic feet
EIQ ..... Emission Inventory Questionnaire
EP ..... Emission Point
EPA ..... Environmental Protection Agency
EU ..... Emission Unit
fps ..... feet per second
ft ..... feet
GACT ..... Generally Available Control Technology
GHG ..... Greenhouse Gas
gpm ..... gallons per minute
gr ..... grains
GWP ..... Global Warming Potential
HAP ..... Hazardous Air Pollutant
hr ..... hour
hp ..... horsepower
lb ..... pound
lbs/hr ..... pounds per hour
MACT ..... Maximum Achievable Control Technology
$\mu g/m^3$ ..... micrograms per cubic meter
m/s ..... meters per second
Mgal ..... 1,000 gallons
MW ..... megawatt
MHDR ..... maximum hourly design rate
MMBtu ..... Million British thermal units
MMCF ..... million cubic feet
MSDS ..... Material Safety Data Sheet
NAAQS ..... National Ambient Air Quality Standards
NESHAPs National Emissions Standards for Hazardous Air Pollutants
NO_x ..... nitrogen oxides
NSPS ..... New Source Performance Standards
NSR ..... New Source Review
PM ..... particulate matter
$PM_{2.5}$ ..... particulate matter less than 2.5 microns in aerodynamic diameter
PM_{10} ..... particulate matter less than 10 microns in aerodynamic diameter
ppm ..... parts per million
PSD ..... Prevention of Significant Deterioration
PTE ..... potential to emit
RACT ..... Reasonable Available Control Technology
RAL ..... Risk Assessment Level
SCC ..... Source Classification Code
scfm ..... standard cubic feet per minute
SDS ..... Safety Data Sheet
SIC ..... Standard Industrial Classification
SIP ..... State Implementation Plan
SMAL ..... Screening Model Action Levels
SO_x ..... sulfur oxides
SO_2 ..... sulfur dioxide
SSM ..... Startup, Shutdown & Malfunction
tph ..... tons per hour
tpy ..... tons per year
VMT ..... vehicle miles traveled
VOC ..... Volatile Organic Compound

APPENDIX B: Process Flow Diagram



APPENDIX C: Amine Tanks & Combustion Sources Process Flow Diagram

Figure 2: Amine Tanks & Combustion Sources



Hastings Engineering, Inc.	
Title: Elementis Specialties, Inc.	
Storage Tanks	
Date: 02/23/2018	Revision: 2

Missouri Department of NATURAL RESOURCES
dnr.mo.gov
Michael L. Parson, Governor
Carol S. Comer, Director

AUG 07 2018

Mr. Bryan Fuhr
EHS Manager
Elementis Specialties, Inc.
5548 Manchester Avenue
Saint Louis, MO 63110

RE: New Source Review Permit - Project Number: 2018-03-007

Dear Mr. Fuhr:

Enclosed with this letter is your permit to construct. Please study it carefully and refer to Appendix A for a list of common abbreviations and acronyms used in the permit. Also, note the special conditions on the accompanying pages. The document entitled, "Review of Application for Authority to Construct," is part of the permit and should be kept with this permit in your files. Operation in accordance with these conditions, your new source review permit application and with your amended operating permit is necessary for continued compliance. The reverse side of your permit certificate has important information concerning standard permit conditions and your rights and obligations under the laws and regulations of the State of Missouri.

This permit may include requirements with which you may not be familiar. If you would like the department to meet with you to discuss how to understand and satisfy the requirements contained in this permit, an appointment referred to as a Compliance Assistance Visit (CAV) can be set up with you. To request a CAV, please contact your local regional office or fill out an online request. The regional office contact information can be found at the following website: http://dnr.mo.gov/regions/. The online CAV request can be found at http://dnr.mo.gov/cav/compliance.htm.

If you were adversely affected by this permit decision, you may be entitled to pursue an appeal before the administrative hearing commission pursuant to Sections 621.250 and 643.075.6 RSMo. To appeal, you must file a petition with the administrative hearing commission within thirty days after the date this decision was mailed or the date it was delivered, whichever date was earlier. If any such petition is sent by registered mail or certified mail, it will be deemed filed on the date it is mailed; if it is sent by any method other than registered mail or certified mail, it will be deemed filed on the date it is received by the administrative hearing commission, whose contact information is: Administrative Hearing Commission, United States Post Office Building, 131 West High Street, Third Floor, P.O. Box 1557, Jefferson City, Missouri 65102, phone: 573-751-2422, fax: 573-751-5018, website: www.oa.mo.gov/ahc.

Recycled paper

If you have any questions regarding this permit, please do not hesitate to contact Chad Stephenson, at the Department of Natural Resources' Air Pollution Control Program, P.O. Box 176, Jefferson City, MO 65102 or at (573) 751-4817. Thank you for your attention to this matter.

Sincerely,

AIR POLLUTION CONTROL PROGRAM

Susan Heckenkamp
New Source Review Unit Chief

SH:csj

Enclosures

c: Saint Louis Regional Office
PAMS File: 2018-03-007

Permit Number: 082018-009

Emission Calcs

ID	Emission Unit	SCC	Emisison Factor Source	Throughput	Units	Max Design Rate	Emission Factors: PM Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	SO_x Emission Factor	NO_x Emission Factor	VOC Emission Factor	CO Emission Factor	Control: Capture Efficiency (%)	PM10 Control Eff (%)	Secondary PM10 Control Eff (%)	VOC Control Eff (%)	PM (tons)	Annual Emission Rates: PM10 (tons)	PM 2.5 (tons)	SO_x (tons)	NO_x (tons)	VOC (tons)	CO (tons)
EP01	Clay Storage Silos	30501117	Webfire	21,704	Tons	29.23	0.0089	0.0049	0.0049									0.097	0.053	0.053				
EP02	Wet Process Day Silo	30501117	Webfire	19,770	Tons	13.49	0.0089	0.0049	0.0049									0.088	0.048	0.048				
EP03	Clay Receiver #1	30501117	Webfire	9,885	Tons	2.95	0.0089	0.0049	0.0049									0.044	0.024	0.024				
EP04	Clay Receiver #2	30501117	Webfire	9,885	Tons	2.95	0.0089	0.0049	0.0049									0.044	0.024	0.024				
EP05	Powerhouse Boiler	10200602	AP-42 Section 1.4	109.1	MMCF	0.01256													See Natural Gas Combustion					
EP06	Amine Tank #4 (Working Losses)	40703202	AP-42 Section 7.1	587	1000 Gal	4.0																	0.764	
EP07	Amine Tank #8 (Working Losses)	40703202	AP-42 Section 7.1	587	1000 Gal	4.0																	0.764	
EP08	Amine Tank #7 (Working Losses)	40703202	AP-42 Section 7.1	587	1000 Gal	4.0																	1.129	
EP09	Bentone Flash Dryer #1 (Natural Gas Combustion)	10200603	AP-42 Section 1.4	54.1	MMCF	0.01								100		99			See Natural Gas Combustion					
EP09	Bentone Flash Dryer #1 (Product Conveying & Drying)	30504430	AP-42 Section 11.25 and RACT Anaylsis for VOC	7,164	Tons	1.94	0.1	0.074	0.012			10.903						0.358	0.265	0.043			39.054	
EP10	Bentone Flash Dryer #2 (Natural Gas Combustion)	10200603	AP-42 Section 1.4	54.1	MMCF	0.01								100		99			See Natural Gas Combustion					
EP10	Bentone Flash Dryer #2 (Product Conveying & Drying)	30504430	AP-42 Section 11.25 and RACT Anaylsis for VOC	7,164	Tons	1.94	0.1	0.074	0.012			10.896						0.358	0.265	0.043			39.029	
EP12	Bentone Pneumatic Transfer	30501117	Webfire	14,330	Tons	2.95	0.0089	0.0049	0.0049									0.064	0.035	0.035				
EP33	Amine Tank Heater	10200603	AP-42 Section 1.4	9.4	MMCF	0.00045													See Natural Gas Combustion					
EP37	South Horizontal Belt Filter	30112199	RACT Anaylsis	7,164	Tons	1.94						5.96		100			95						1.068	
EP38	North Horizontal Belt Filter	30112199	RACT Anaylsis	7,164	Tons	1.94						5.964		100			95						1.068	
EP39	Parkson Filter Press	30112199	RACT Anaylsis	7,164	Tons	1.94						2.994		100			95						0.536	
EP45	Bentone Dispersion Tanks	30501109	Equation 11.12.1 Ap-42	19,880	Tons	2.95	0.4967	0.1626	0.0243									4.937	1.616	0.242				
EP55	Bentone Reaction Tanks	30112199	RACT Anaylsis	14,330	Tons	2.95						4.993		100			95						1.789	
EP80	Ashbrook Simon Hartley Filter Press	30112199	RACT Anaylsis	7,164	Tons	1.94						2.994		100			95						0.536	
EP81	Anion Pneumatic Transfer System	30501117	Webfire	156	Tons	0.5	0.0089	0.0049	0.0049									6.94E-04	3.82E-04	3.82E-04				
EP82	Soda Ash Pneumatic Transfer System	30501117	Webfire	288	Tons	0.5	0.0089	0.0049	0.0049									1.28E-03	7.06E-04	7.06E-04				
EP83	Mill "A"	30500302	Webfire	7,165	Tons	2.95	0.0062	0.0032	0.0032									0.022	0.011	0.011				
EP84	Mill "B"	30500302	Webfire	7,165	Tons	2.95	0.0062	0.0032	0.0032									0.022	0.011	0.011				
EP85	New Packing Hopper	30501117	Webfire	14,330	Tons	3.88	0.0089	0.0049	0.0049									0.064	0.035	0.035				
EP86	New Packing Station	30104006	Webfire	14,330	Tons	3.88	0.19	0.16	0.16					100	99			0.0136	0.0115	0.0115				
EP87	Water Heater	10200603	AP-42 Section 1.4	131.4	MMCF	0.015													See Natural Gas Combustion					
EP36	Seal Water Tank	30112199	RACT Anaylsis	14,330	Tons	2.95						0.366							0.000	0.000			2.622	
	Natural Gas Combustion		AP-42 Section 1.4															1.23	0.984	0.984	0.08	12.94	0.712	10.872
	RTO SSM - Malfunction emissions over the last nine years show only one malfunction in 2008. Resulted in 54.9 pounds of VOC emissions																						0.027	
																		PM	PM10	PM2.5	SO_x	NO_x	VOC	CO
	Highlighted means controlled emission factor was used																Totals	7.34	3.39	1.57	0.08	12.94	89.10	10.87

Source Description	Test Data: Emission Rate (lb/hr)	Production Rate (tph)	Emission Factor (lb/ton)	SD-3 Factor Adjustments: Amine Usage Correction Factor	Alcohol Vapor Correction Factor	Emission Factor (lb/ton)
Bentone Reaction Tank	6.47	1.25	5.176	1.2104	0.7969	4.993
Vacuum Filter #1	8.89	1.45	6.131	1.2104	0.8036	5.964
Vacuum Filter #2	8.89	1.45	6.131	1.2104	0.8036	5.964
Filter Press	3.56	1.19	2.992	1.2104	0.8267	2.994
Flash Dryer #1	14.06	1.23	11.431	1.2104	0.7880	10.903
Flash Dryer #2	14.06	1.23	11.431	1.2104	0.7875	10.896
Seal Water Tank	0.48	1.30	0.367	1.2104	0.8258	0.366

ID	Segment	Emission Unit	Throughput	Units	VOC Emission Factor	Capture Efficiency (%)	VOC Control Eff (%)	VOC (tons)
EP05	1	Powerhouse Boiler	109.1	MMCF	5.5			0.300
EP06	1	Amine Tank #4 (Working Losses)	254	1000 Gal	4.353			0.554
EP07	1	Amine Tank #8 (Working Losses)	219	1000 Gal	4.445			0.487
EP08	1	Amine Tank #7 (Working Losses)	569	1000 Gal	4.004			1.139
EP09	1	Bentone Flash Dryer #1 (Natural Gas Combustion)	30.5	MMCF	5.5			0.084
EP09	2	Bentone Flash Dryer #1 (Product Conveying & Drying)	4,779	Tons	11.452			27.367
EP10	1	Bentone Flash Dryer #2 (Natural Gas Combustion)	19.8	MMCF	5.5			0.054
EP10	2	Bentone Flash Dryer #2 (Product Conveying & Drying)	4,779	Tons	11.439			27.336
EP33	1	Amine Tank Heater	0.0	MMCF	5.5			0.000
EP37	1	South Horizontal Belt Filter	4,779	Tons	6.290	100	95	0.752
EP38	1	North Horizontal Belt Filter	4,779	Tons	6.290	100	95	0.752
EP39	1	Parkson Filter Press	9,559	Tons	3.166	100	95	0.757
EP55	1	Bentone Reaction Tanks	9,559	Tons	5.260	100	95	1.257
EP80	1	Ashbrook Simon Hartley Filter Press	0	Tons	3.166	100	95	0.000
EP87	1	Water Heater	0.0	MMCF	5.5			0.000
EP36	1	Seal Water Tank	9,559	Tons	0.388			1.854
								VOC
							Total	62.69

Source Description	Test Data			2011 Product Factor Adjustments		
	Emission Rate (lb/hr)	Production Rate (tph)	Emission Factor (lb/ton)	Amine Usage Correction Factor	Alcohol Vapor Correction Factor	Emission Factor (lb/ton)
Bentone Reaction Tank	6.47	1.25	5.176	1.2503	0.8128	5.26
Vacuum Filter #1	8.89	1.45	6.131	1.2503	0.8205	6.29
Vacuum Filter #2	8.89	1.45	6.131	1.2503	0.8205	6.29
Filter Press	3.56	1.19	2.992	1.2503	0.8465	3.166
Flash Dryer #1	14.06	1.23	11.431	1.2503	0.8013	11.452
Flash Dryer #2	14.06	1.23	11.431	1.2503	0.8004	11.439
Seal Water Tank	0.48	1.30	0.367	1.2503	0.8456	0.388

##

ID	Segment	Emission Unit	Throughput	Units	VOC Emission Factor	Capture Efficiency (%)	VOC Control Eff (%)	VOC (tons)
EP05	1	Powerhouse Boiler	51.5	MMCF	5.5			0.142
EP06	1	Amine Tank #4 (Working Losses)	233.695	1000 Gal	3.285			0.384
EP07	1	Amine Tank #8 (Working Losses)	123.052	1000 Gal	3.395			0.209
EP08	1	Amine Tank #7 (Working Losses)	662.374	1000 Gal	3.231			1.070
EP09	1	Bentone Flash Dryer #1 (Natural Gas Combustion)	18.7	MMCF	5.5			0.051
EP09	2	Bentone Flash Dryer #1 (Product Conveying & Drying)	4,395	Tons	11.945			26.249
EP10	1	Bentone Flash Dryer #2 (Natural Gas Combustion)	34.2	MMCF	5.5			0.094
EP10	2	Bentone Flash Dryer #2 (Product Conveying & Drying)	4,395	Tons	11.931			26.218
EP33	1	Amine Tank Heater	0.0	MMCF	5.5			0.000
EP37	1	South Horizontal Belt Filter	4,395	Tons	6.559	100	95	0.721
EP38	1	North Horizontal Belt Filter	4,395	Tons	6.559	100	95	0.721
EP39	1	Parkson Filter Press	8,790	Tons	3.301	100	95	0.725
EP55	1	Bentone Reaction Tanks	8,790	Tons	5.486	100	95	1.206
EP80	1	Ashbrook Simon Hartley Filter Press	0	Tons	3.301	100	95	0.000
EP87	1	Water Heater	0.0	MMCF	5.5			0.000
EP36	1	Seal Water Tank	8,790	Tons	0.404			1.776
								VOC
							Totals	59.56

Source Description	Test Data			2012 Product Factor Adjustments		
	Emission Rate (lb/hr)	Production Rate (lph)	Emission Factor (lb/ton)	Amine Usage Correction Factor	Alcohol Vapor Correction Factor	Emission Factor (lb/ton)
Bentone Reaction Tank	6.47	1.25	5.178	1.3052	0.812	5.486
Vacuum Filter #1	8.89	1.45	6.131	1.3052	0.8196	6.559
Vacuum Filter #2	8.89	1.45	6.131	1.3052	0.8196	6.559
Filter Press	3.56	1.19	2.992	1.3052	0.8455	3.301
Flash Dryer #1	14.06	1.23	11.431	1.3052	0.8006	11.945
Flash Dryer #2	14.06	1.23	11.431	1.3052	0.7997	11.931
Seal Water Tank	0.48	1.30	0.367	1.3052	0.8446	0.404

Parameter Description[1]	Equation[1]	Tank 4
Material Stored		Quantenary Amine -Ethanol
Tank Type (Vertical or Horizontal)		Vertical
Roof Type		Fixed
Roof Shape (Dome, Cone, or Flat)		Cone
Tank Color		White
Roof Color		White
Paint Condition (Good or Poor)		Good
Heated (Yes or No)		Yes
Tank Diameter (D), ft		10
Effective Diameter (D_E), ft	Vertical tanks: $D = D_E$ Horizontal tanks: $D_E = (LD/(\pi/4))^{1/2}$	10
Tank Shell Radius (R_S), ft	$R_S = D/2$	5
Tank Dome Roof Radius (R_R), ft	Dome roofs: Assumed $R_R = D$ Flat roofs: N/A	N/A
Tank Shell Height (H_S), ft		17
Effective Height (H_E), ft	Vertical tanks: $H_E = H_E$ Horizontal tanks: $H_E = (\pi/4)D$	17
Cone Height (H_C), ft		0
Tank Capacity Volume (V), ft^3	$V = \pi(D/2)^2H_S + 1/3\pi(D/2)^2H_C$	1,335
Tank Capacity Volume (V), gal	$V = ft^3 * 7.4805$ gal/ft^3	9,988
Liquid Height (H_L), ft	Assumed $H_L = 0.95H_S$	16.15
Tank Cone Roof Slope (S_R), ft/ft	Flat roofs: $S_R = 0$ Dome roofs: S_R = N/A Cone roofs: $S_R = 0.0625$	0.0625
Tank Roof Height (H_R), ft	Dome roofs: $H_R = R_R - (R_R^2 - R_S^2)^{1/2}$ Cone and flat roofs: $H_R = S_RR_S$	0.3125
Roof Outage (H_{RO}), ft	Dome roofs: $H_{RO} = H_R [(1/2)+(1/6)(H_R/R_S)^2]$ Cone roofs: $H_{RO} = 1/3H_R$ Flat roofs: $H_{RO} = 0$	0.104166667
Vapor Space Outage (H_{VO}), ft	Vertical tanks: $H_{VO} = H_S - H_L + H_{RO}$ Horizontal tanks: $H_{VO} = H_E$	0.95
Vapor Space Volume (V_V), ft^3	$V_V = \pi/4(D_E^2H_{VO})$	74.94
Ideal Gas Constant (R), psia ft^3/lb-mole R		10.731
Daily Maximum Ambient Temperature (T_{AX}), R		599.67
Daily Minimum Ambient Temperature (T_{AN}), R		599.67
Daily Average Ambient Temperature (T_{AA}), R	$T_{AA} = (T_{AX} + T_{AN})/2$	599.67
Roof Paint Solar Absorptance (α_R), dimensionless	AP-42, Table 7.1-6	0.17
Shell Paint Solar Absorptance (α_S), dimensionless	AP-42, Table 7.1-6	0.17
Paint Solar Absorptance (α), dimensionless	$\alpha = (\alpha_R + \alpha_S)/2$	0.17
Liquid Bulk Temperature (T_B), R		599.67
Daily Total Solar Insolation Factor (I), Btu/ft^2·d	TANKS 4.0 for Paducah, KY	1,262
Daily Average Liquid Surface Temperature (T_{LA}), R	$T_{LA} = 0.44T_{AA} + 0.56T_B + 0.0079\alpha I$	599.67
Vapor Molecular Weight (M_V), lb/lb-mole [3]		46.11
Vapor Pressure at T_{LA} (P_{VA}), psia [3]		3.50
Vapor Density (W_V), lb/ft^3	$W_V = M_VP_{VA}/RT_{LA}$	2.51E-02
Daily Ambient Temperature Range (T_A), R	$T_A = T_{AX} - T_{AN}$	-
Daily Vapor Temperature Range (T_V), R	$T_V = 0.72T_A + 0.028\alpha I$	6.01
Vapor Pressure at T_{AN} (P_{VN}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Vapor Pressure at T_{AX} (P_{VX}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Daily Vapor Pressure Range (P_V), psia	$P_V = P_{VX} - P_{VN}$	-
Breather Vent Pressure Setting Range (P_B), psig	$P_B = P_{BP} - P_{BV}$ (Assumed = 0.06)	0.06
Atmospheric Pressure (P_A), psia		14.6959
Vapor Space Expansion Factor (K_E), dimensionless	$K_E = T_V/T_{LA} + (P_V - P_B)/(P_A - P_{VA})$	4.66E-03
Vented Vapor Saturation Factor (K_S), dimensionless	$K_S = 1/(1 + 0.053P_{VA}H_{VO})$	0.85
Number of Days/Year in Operation		365
Standing Storage Losses (L_S), lb/year	**L_S = (Days/Year) * $V_VW_VK_EK_S$**	**2.71**
Typical Annual Throughput (Q), gal		587,000
Typical Annual Throughput (Q), bbl	Throughput is in bbls (42 gal/bbl)	13,976
Maximum Liquid Height (H_{LX}), ft		17.00
Tank Maximum Liquid Volume (V_{LX}), ft^3	$V_{LX} = \pi/4\ D^2H_{LX}$	1,335
Turnovers (N), dimensionless	$N = 5.614Q/V_{LX}$	58.77
Turnover Factor (K_N), dimensionless	For $N \leq 36$: $K_N = 1$ For $N > 36$: $K_N = (180 + N)/6N$	0.68
Working Loss Factor (K_P), dimensionless	For crude oils: $K_P = 0.75$ For other liquids: $K_P = 1$	1
Working Losses (L_W), lb/year	**$L_W = 0.0010M_VP_{VA}QK_NK_P$**	**1,526**
Total Annual Losses (L_T), lb	$T_L = L_S + L_W$	1,529
Total Annual Losses (L_T), ton	2,000 lb/ton	0.76

Parameter Description[1]	Equation[1]	Tank 8
Material Stored		Quantenary Amine- Ethanol
Tank Type (Vertical or Horizontal)		Vertical
Roof Type		Fixed
Roof Shape (Dome, Cone, or Flat)		Cone
Tank Color		White
Roof Color		White
Paint Condition (Good or Poor)		Good
Heated (Yes or No)		Yes
Tank Diameter (D), ft		10
Effective Diameter (D_E), ft	Vertical tanks: $D = D_E$ Horizontal tanks: $D_E = (LD/(\pi/4))^{1/2}$	10
Tank Shell Radius (R_S), ft	$R_S = D/2$	5
Tank Dome Roof Radius (R_R), ft	Dome roofs: Assumed $R_R = D$ Flat roofs: N/A	N/A
Tank Shell Height (H_S), ft		17
Effective Height (H_E), ft	Vertical tanks: $H_S = H_E$ Horizontal tanks: $H_E = (\pi/4)D$	17
Cone Height (H_C), ft		0
Tank Capacity Volume (V), ft^3	$V = \pi(D/2)^2H_S + 1/3\pi(D/2)^2H_C$	1,335
Tank Capacity Volume (V), gal	$V = ft^3 * 7.4805\ gal/ft^3$	9,988
Liquid Height (H_L), ft	Assumed $H_L = 0.95H_S$	16.15
Tank Cone Roof Slope (S_R), ft/ft	Flat roofs: $S_R = 0$ Dome roofs: S_R = N/A Cone roofs: $S_R = 0.0625$	0.0625
Tank Roof Height (H_R), ft	Dome roofs: $H_R = R_R - (R_R^2 - R_S^2)^{1/2}$ Cone and flat roofs: $H_R = S_RR_S$	0.3125
Roof Outage (H_{RO}), ft	Dome roofs: $H_{RO} = H_R [(1/2)+(1/6)(H_R/R_S)^2]$ Cone roofs: $H_{RO} = 1/3H_R$ Flat roofs: $H_{RO} = 0$	0.104166667
Vapor Space Outage (H_{VO}), ft	Vertical tanks: $H_{VO} = H_S - H_L + H_{RO}$ Horizontal tanks: $H_{VO} = H_E$	0.95
Vapor Space Volume (V_V), ft^3	$V_V = \pi/4(D_E^2H_{VO})$	74.94
Ideal Gas Constant (R), psia ft^3/lb-mole R		10.731
Daily Maximum Ambient Temperature (T_{AX}), R		599.67
Daily Minimum Ambient Temperature (T_{AN}), R		599.67
Daily Average Ambient Temperature (T_{AA}), R	$T_{AA} = (T_{AX} + T_{AN})/2$	599.67
Roof Paint Solar Absorptance (α_R), dimensionless	AP-42, Table 7.1-6	0.17
Shell Paint Solar Absorptance (α_S), dimensionless	AP-42, Table 7.1-6	0.17
Paint Solar Absorptance (α), dimensionless	$\alpha = (\alpha_R + \alpha_S)/2$	0.17
Liquid Bulk Temperature (T_B), R		599.67
Daily Total Solar Insolation Factor (I), Btu/ft^2·d	TANKS 4.0 for Paducah, KY	1,262
Daily Average Liquid Surface Temperature (T_{LA}), R	$T_{LA} = 0.44T_{AA} + 0.56T_B + 0.0079\alpha I$	599.67
Vapor Molecular Weight (M_V), lb/lb-mole [3]		46.11
Vapor Pressure at T_{LA} (P_{VA}), psia [3]		3.50
Vapor Density (W_V), lb/ft^3	$W_V = M_VP_{VA}/RT_{LA}$	2.51E-02
Daily Ambient Temperature Range (T_A), R	$T_A = T_{AX} - T_{AN}$	-
Daily Vapor Temperature Range (T_V), R	$T_V = 0.72T_A + 0.028\alpha I$	6.01
Vapor Pressure at T_{AN} (P_{VN}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Vapor Pressure at T_{AX} (P_{VX}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Daily Vapor Pressure Range (P_V), psia	$P_V = P_{VX} - P_{VN}$	-
Breather Vent Pressure Setting Range (P_B), psig	$P_B = P_{BP} - P_{BV}$ (Assumed = 0.06)	0.06
Atmospheric Pressure (P_A), psia		14.6959
Vapor Space Expansion Factor (K_E), dimensionless	$K_E = T_V/T_{LA} + (P_V - P_B)/(P_A - P_{VA})$	4.66E-03
Vented Vapor Saturation Factor (K_S), dimensionless	$K_S = 1/(1 + 0.053P_{VA}H_{VO})$	0.85
Number of Days/Year in Operation		365
Standing Storage Losses (L_S), lb/year	**L_S = (Days/Year) * $V_VW_VK_EK_S$**	**2.71**
Typical Annual Throughput (Q), gal		587,000
Typical Annual Throughput (Q), bbl	Throughput is in bbls (42 gal/bbl)	13,976
Maximum Liquid Height (H_{LX}), ft		17.00
Tank Maximum Liquid Volume (V_{LX}), ft^3	$V_{LX} = \pi/4\ D^2H_{LX}$	1,335
Turnovers (N), dimensionless	$N = 5.614Q/V_{LX}$	58.77
Turnover Factor (K_N), dimensionless	For $N \leq 36$: $K_N = 1$ For $N > 36$: $K_N = (180 + N)/6N$	0.68
Working Loss Factor (K_P), dimensionless	For crude oils: $K_P = 0.75$ For other liquids: $K_P = 1$	1
Working Losses (L_W), lb/year	**$L_W = 0.0010M_VP_{VA}QK_NK_P$**	**1,526**
Total Annual Losses (L_T), lb	$T_L = L_S + L_W$	1,529
Total Annual Losses (L_T), ton	2,000 lb/ton	0.76

Parameter Description[1]	Equation[2]	Tank 7
Material Stored		Quanternary Amine -Ethanol
Tank Type (Vertical or Horizontal)		Vertical
Roof Type		Fixed
Roof Shape (Dome, Cone, or Flat)		Cone
Tank Color		White
Roof Color		White
Paint Condition (Good or Poor)		Good
Heated (Yes or No)		Yes
Tank Diameter (D), ft		12
Effective Diameter (D_E), ft	Vertical tanks: $D = D_E$ Horizontal tanks: $D_E = (LD/(\pi/4))^{1/2}$	12
Tank Shell Radius (R_S), ft	$R_S = D/2$	6
Tank Dome Roof Radius (R_R), ft	Dome roofs: Assumed $R_R = D$ Flat roofs: N/A	N/A
Tank Shell Height (H_S), ft		20.8
Effective Height (H_E), ft	Vertical tanks: $H_S = H_E$ Horizontal tanks: $H_E = (\pi/4)D$	20.8
Cone Height (H_C), ft		0
Tank Capacity Volume (V), ft^3	$V = \pi(D/2)^2H_S + 1/3\pi(D/2)^2H_C$	2,352
Tank Capacity Volume (V), gal	$V = ft^3 * 7.4805$ gal/ft^3	17,597
Liquid Height (H_L), ft	Assumed $H_L = 0.95H_S$	19.76
Tank Cone Roof Slope (S_R), ft/ft	Flat roofs: $S_R = 0$ Dome roofs: S_R = N/A Cone roofs: $S_R = 0.0625$	0.0625
Tank Roof Height (H_R), ft	Dome roofs: $H_R = R_R - (R_R^2 - R_S^2)^{1/2}$ Cone and flat roofs: $H_R = S_RR_S$	0.375
Roof Outage (H_{RO}), ft	Dome roofs: $H_{RO} = H_R\{(1/2)+(1/6)(H_R/R_S)^2\}$ Cone roofs: $H_{RO} = 1/3H_R$ Flat roofs: $H_{RO} = 0$	0.125
Vapor Space Outage (H_{VO}), ft	Vertical tanks: $H_{VO} = H_S - H_L + H_{RO}$ Horizontal tanks: $H_{VO} = H_E$	1.17
Vapor Space Volume (V_V), ft^3	$V_V = \pi/4(D_E^2H_{VO})$	131.76
Ideal Gas Constant (R), psia ft^3/lb-mole R		10.731
Daily Maximum Ambient Temperature (T_{AX}), R		599.67
Daily Minimum Ambient Temperature (T_{AN}), R		599.67
Daily Average Ambient Temperature (T_{AA}), R	$T_{AA} = (T_{AX} + T_{AN})/2$	599.67
Roof Paint Solar Absorptance (α_R), dimensionless	AP-42, Table 7.1-6	0.17
Shell Paint Solar Absorptance (α_S), dimensionless	AP-42, Table 7.1-6	0.17
Paint Solar Absorptance (α), dimensionless	$\alpha = (\alpha_R + \alpha_S)/2$	0.17
Liquid Bulk Temperature (T_B), R		599.67
Daily Total Solar Insolation Factor (I), Btu/ft^2·d	TANKS 4.0 for Paducah, KY	1,262
Daily Average Liquid Surface Temperature (T_{LA}), R		599.67
Vapor Molecular Weight (M_V), lb/lb-mole [3]		46.11
Vapor Pressure at T_{LA} (P_{VA}), psia [3]		3.50
Vapor Density (W_V), lb/ft^3	$W_V = M_VP_{VA}/RT_{LA}$	2.51E-02
Daily Ambient Temperature Range (T_A), R	$T_A = T_{AX} - T_{AN}$	-
Daily Vapor Temperature Range (T_V), R	$T_V = 0.72T_A + 0.028$ al	6.01
Vapor Pressure at T_{AN} (P_{VN}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Vapor Pressure at T_{AX} (P_{VX}), psia [3]	TANKS 4.0 Applicant Provided	3.50
Daily Vapor Pressure Range (P_V), psia	$P_V = P_{VX} - P_{VN}$	-
Breather Vent Pressure Setting Range (P_B), psig	$P_B = P_{BP} - P_{BV}$ (Assumed = 0.06)	0.06
Atmospheric Pressure (P_A), psia		14.6959
Vapor Space Expansion Factor (K_E), dimensionless	$K_E = T_V/T_{LA} + (P_V - P_B)/(P_A - P_{VA})$	4.66E-03
Vented Vapor Saturation Factor (K_S), dimensionless	$K_S = 1/(1 + 0.053P_{VA}H_{VO})$	0.82
Number of Days/Year in Operation		365
Standing Storage Losses (L_S), lb/year	**L_S = (Days/Year) * $V_VW_VK_EK_S$**	**4.62**
Typical Annual Throughput (Q), gal		587,000
Typical Annual Throughput (Q), bbl	Throughput is in bbls (42 gal/bbl)	13,976
Maximum Liquid Height (H_{LX}), ft		20.80
Tank Maximum Liquid Volume (V_{LX}), ft^3	$V_{LX} = \pi/4\ D^2H_{LX}$	2,352
Turnovers (N), dimensionless	$N = 5.614Q/V_{LX}$	33.35
Turnover Factor (K_N), dimensionless	For $N \leq 36$: $K_N = 1$ For $N > 36$: $K_N = (180 + N)/6N$	1.00
Working Loss Factor (K_P), dimensionless	For crude oils: $K_P = 0.75$ For other liquids: $K_P = 1$	1
Working Losses (L_W), lb/year	**$L_W = 0.0010M_VP_{VA}QK_NK_P$**	**2,254**
Total Annual Losses (L_T), lb	$T_L = L_S + L_W$	2,259
Total Annual Losses (L_T), ton	2,000 lb/ton	1.13

Emission Unit	Description	Installation's Designation	MHDR (MMBtu/hr input)	Combined MHDR (MMBtu/hr input)	MHDR (MMcf/hr)
EP5	Powerhouse Boiler		12.6	30.14	0.030
EP9	Bentone Flash Dryer #1		1.1		
EP10	Bentone Flash Dryer #2		1.1		
EP33	Amine Tank Heater		0.5		
EP87	Water Heater		15		

Natural Gas HHV (Btu/cf)
1,020

100yr GWP 40 CFR 98
Table A-1, Jan 1 2014

CO2	1
CH4	25
N2O	298

	Pollutant	CAS	HAP?	Emission Factor (lb / mmcf)	Emission Factor Source (SCC)	Available Pollutant (lb/hr)	Control Device	PTE (lb/hr)	PTE (tpy)
	PM filterable			1.9	1-02-006-02 industrial boiler, natural gas, 10-100MMBtu and 1-02-006-03 < 10MMBtu	0.0561	none	0.0561	0.25
	PM10			7.6		0.2246	none	0.2246	0.98
	PM2.5			7.6		0.2246	none	0.2246	0.98
	SOx			0.6		0.0177	none	0.0177	0.08
	NOx			100		2.9549	none	2.9549	12.94
	VOC			5.5		0.1625	none	0.1625	0.71
	CO			84		2.4821	none	2.4821	10.87
	Combined HAPs			1.888		0.0558	none	0.0558	0.24
	POM aggregate group			6.98E-04		2.06E-05	none	2.06E-05	9.04E-05
pom	2-Methylnaphthalene	91-57-6	y	2.40E-05		7.092E-07	none	7.09E-07	3.11E-06
pom	3-Methylchloranthrene	56-49-5	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	7,12-Dimethylbenzanthracene	57-97-6	y	1.60E-05		4.728E-07	none	4.73E-07	2.07E-06
pom	Acenaphthene	83-32-9	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	Acenaphthylene	203-96-8	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	Anthracene	120-12-7	y	2.40E-06		7.092E-08	none	7.09E-08	3.11E-07
pom	Benzanthracene	56-55-3	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
	Benzene	71-43-2	y	2.10E-03		6.205E-05	none	6.21E-05	2.72E-04
pom	Benzo(a)pyrene	50-32-8	y	1.20E-06		3.546E-08	none	3.55E-08	1.55E-07
pom	Benzo(b)fluoranthene	205-99-2	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	Benzo(g,h,i)perylene	191-24-2	y	1.20E-06		3.546E-08	none	3.55E-08	1.55E-07
pom	Benzo(k)fluoranthene	205-82-3	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
	Butane	106-97-8		2.10E+00		6.205E-02	none	6.21E-02	2.72E-01
pom	Chrysene	218-01-9	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	Dibenzo(a,h)anthracene	53-70-3	y	1.20E-06		3.546E-08	none	3.55E-08	1.55E-07
	Dichlorobenzene	25321-22-6	y	1.20E-03		3.546E-05	none	3.55E-05	1.55E-04
	Ethane	74-84-0		3.10E+00		9.160E-02	none	9.16E-02	4.01E-01
pom	Fluoranthene	206-44-0	y	3.00E-06		8.865E-08	none	8.86E-08	3.88E-07
pom	Fluorene	86-73-7	y	2.80E-06		8.274E-08	none	8.27E-08	3.62E-07
	Formaldehyde	50-00-0	y	7.50E-02		2.216E-03	none	2.22E-03	9.71E-03
	Hexane	110-54-3	y	1.80E+00		5.319E-02	none	0.0532	0.23
pom	Indeno(1,2,3-cd)pyrene	193-39-5	y	1.80E-06		5.319E-08	none	5.32E-08	2.33E-07
pom	Naphthalene	91-20-3	y	6.10E-04		1.802E-05	none	1.80E-05	7.89E-05
	Pentane	109-66-0		2.60E+00		7.683E-02	none	7.68E-02	3.37E-01
pom	Phenanathrene	85-01-8	y	1.70E-05		5.023E-07	none	5.02E-07	2.20E-06
	Propane	74-98-6		1.60E+00		4.728E-02	none	4.73E-02	2.07E-01
pom	Pyrene	129-00-0	y	5.00E-06		1.477E-07	none	1.48E-07	6.47E-07
	Toluene	108-88-3	y	3.40E-03		1.005E-04	none	1.00E-04	4.40E-04
	Arsenic	7440-38-2	y	2.00E-04		5.910E-06	none	5.91E-06	2.59E-05
	Barium	7440-39-3		4.40E-03		1.300E-04	none	1.30E-04	5.69E-04
	Beryllium	7440-41-7	y	1.20E-05		3.546E-07	none	3.55E-07	1.55E-06
	Cadmium	7440-43-9	y	1.10E-03		3.250E-05	none	3.25E-05	1.42E-04
	Chromium	7440-47-3	y	1.40E-03		4.137E-05	none	4.14E-05	1.81E-04
	Cobalt	7440-48-4	y	8.40E-05		2.482E-06	none	2.48E-06	1.09E-05
	Copper	7440-50-8		8.50E-04		2.512E-05	none	2.51E-05	1.10E-04
	Manganese	7439-96-5	y	3.80E-04		1.123E-05	none	1.12E-05	4.92E-05
	Mercury	7439-97-6	y	2.60E-04		7.683E-06	none	7.68E-06	3.37E-05
	Molybdenum	7439-98-7		1.10E-03		3.250E-05	none	3.25E-05	1.42E-04
	Nickel	7440-02-0	y	2.10E-03		6.205E-05	none	6.21E-05	2.72E-04
	Selenium	7782-49-2	y	2.40E-05		7.092E-07	none	7.09E-07	3.11E-06
	Vanadium	7440-62-2		2.30E-03		6.796E-05	none	6.80E-05	2.98E-04
	Zinc	7440-66-6		2.90E-02		8.569E-04	none	8.57E-04	3.75E-03
	CO2			120,000		3545.8824	none	3545.882	15,530.96
	Methane			2.3		0.0680	none	0.0680	0.30
	N2O			2.2		0.0650	none	0.0650	0.28
	GHG (mass)								15,531.547
	GHG (CO2e)								15,823.26

Natural gas HHV of 1,020 Btu/cf cited from AP-42 Section 1.4, July 1998.
Dichlorobenzene group CAS 25321-22-6 conservatively assumed as 100% 1,4-dichlorobenzene CAS 106-46-7.
HAPs updated per "Air Pollution Control Program Table of Hazardous Air Pollutants, Screening Model Action Levels, and Risk Assessment Levels" Revision 10, 5/3/2012

	SD-3 and Historic		Testing Conditions		
	Amine Usage	Alcohol Wt Fraction	Amine Usage	Alcohol Wt Fraction	Amine Usage Correction Factor
2011	0.389	0.1541	0.444	0.1079	1.2503
2012	0.413	0.1514	0.444	0.1079	1.3052
SD-3	0.515	0.1126	0.444	0.1079	1.2104

Alcohol Vapor Corrections

Process	Temp (°F)	Temp (°C)	IPA Wt. Fraction (IPA)	IPA Wt. Fraction (Water)	IPA Mole Weight (IPA)	IPA Mole Conc.	IPA P_{vap} (kPa)	IPA P_{vap} (mmHg)	IPA $(P_{IPA})(Mw)$	EtOH Wt. Fraction (EtOH)	EtOH Wt. Fraction (Water)	EtOH Mole Weight (EtOH)	EtOH Mole Conc.	EtOH P_{vap} (kPa)	EtOH P_{vap} (mmHg)	EtOH $(P_{EtOH})(Mw)$	Alchol Vapor Correction Factor
								2011									
Reactor	135.5	57.5	0.1541	0.07	60.09	0.397	36.845022	276.3598	16606.4587	0.1541	0.07	46.07	0.462	39.059336	292.9685	13497.0567	0.8128
Belt Vacuum Filter	120	48.9	0.1541	0.07	60.09	0.397	24.269828	182.0383	10938.6798	0.1541	0.07	46.07	0.462	25.973492	194.8168	8975.20878	0.8205
Press Filter	87	30.6	0.1541	0.07	60.09	0.397	8.9622994	67.22262	4039.40741	0.1541	0.07	46.07	0.462	9.8953308	74.22092	3419.3577	0.8465
Dryer 1B	178	81.1	0.1541	0.07	60.09	0.397	101.065816	758.0543	45551.4805	0.1541	0.07	46.07	0.462	105.63112	792.2968	36501.1126	0.8013
Dryer 2B	185	85	0.1541	0.07	60.09	0.397	119.19806	894.057	53723.8833	0.1541	0.07	46.07	0.462	124.43852	933.3636	43000.0594	0.8004
Seal Water Tank	88	31.1	0.1541	0.07	60.09	0.397	9.2296208	69.22769	4159.89212	0.1541	0.07	46.07	0.462	10.1793596	76.3513	3517.5046	0.8456
								2012									
Reactor	135.5	57.5	0.1514	0.07	60.09	0.393	36.828518	276.236	16599.0202	0.1514	0.07	46.07	0.458	39.003024	292.5461	13477.598	0.812
Belt Vacuum Filter	120	48.9	0.1514	0.07	60.09	0.393	24.259732	181.9625	10934.1294	0.1514	0.07	46.07	0.458	25.935228	194.5298	8961.98656	0.8196
Press Filter	87	30.6	0.1514	0.07	60.09	0.393	8.9588986	67.19711	4037.87463	0.1514	0.07	46.07	0.458	9.8796572	74.10336	3413.94165	0.8455
Dryer 1B	178	81.1	0.1514	0.07	60.09	0.393	101.007704	757.6184	45525.2887	0.1514	0.07	46.07	0.458	105.48208	791.1789	36449.6114	0.8006
Dryer 2B	185	85	0.1514	0.07	60.09	0.393	119.12614	893.5175	53691.4681	0.1514	0.07	46.07	0.458	124.26268	932.0447	42939.2974	0.7997
Seal Water Tank	88	31.1	0.1514	0.07	60.09	0.393	9.2261152	69.2014	4158.31211	0.1514	0.07	46.07	0.458	10.1632764	76.23067	3511.94701	0.8446
								SD-3									
Reactor	135.5	57.5	0.1126	0.07	60.09	0.325	36.54795	274.1316	16472.5651	0.1126	0.07	46.07	0.386	37.989408	284.9434	13127.3403	0.7969
Belt Vacuum Filter	120	48.9	0.1126	0.07	60.09	0.325	24.0881	180.6752	10856.7729	0.1126	0.07	46.07	0.386	25.246476	189.3637	8723.98648	0.8036
Press Filter	87	30.6	0.1126	0.07	60.09	0.325	8.901085	66.76348	4011.8174	0.1126	0.07	46.07	0.386	9.5975324	71.98725	3316.45268	0.8267
Dryer 1B	178	81.1	0.1126	0.07	60.09	0.325	100.0198	750.2085	45080.0295	0.1126	0.07	46.07	0.386	102.79936	771.0569	35522.5904	0.7880
Dryer 2B	185.8	85.4	0.1126	0.07	60.09	0.325	117.9035	884.347	53140.4108	0.1126	0.07	46.07	0.386	121.09756	908.3044	41845.5818	0.7875
Seal Water Tank	88	31.1	0.1126	0.07	60.09	0.325	9.16652	68.7544	4131.45189	0.1126	0.07	46.07	0.386	9.8737788	74.05927	3411.91035	0.8258

IPA 57.5 °C
136 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
17.9785	0	0
21.7052	0.01	0.179502
24.6394	0.02	0.283315
26.9592	0.03	0.349935
28.7998	0.04	0.395592
31.434	0.06	0.452531
33.1183	0.08	0.485044
34.2031	0.1	0.504898
35.5318	0.15	0.528918
36.0175	0.2	0.538252
36.2541	0.25	0.543379
36.4448	0.3	0.548195
36.6511	0.35	0.554402
36.8805	0.4	0.562836
37.1196	0.45	0.573973
37.3473	0.5	0.588143
37.5407	0.55	0.605633
37.6764	0.6	0.626755
37.7321	0.65	0.651875
37.6865	0.7	0.68145
37.5196	0.75	0.716061
37.2124	0.8	0.75645
36.7472	0.85	0.803577
36.1071	0.9	0.858691
35.7986	0.92	0.883324
35.4586	0.94	0.909619
35.0862	0.96	0.937719
34.8875	0.97	0.952495
34.6804	0.98	0.967785
34.4648	0.99	0.983611
34.2405	1	1

EtOH 57.5 °C
136 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
17.9785	0	0
19.9519	0.01	0.107643
21.6878	0.02	0.186625
23.2197	0.03	0.246933
24.5756	0.04	0.294411
26.8518	0.06	0.36421
28.6683	0.08	0.41291
30.1357	0.1	0.448763
32.7666	0.15	0.507453
34.4919	0.2	0.543762
35.7251	0.25	0.569798
36.6831	0.3	0.590859
37.4826	0.35	0.609634
38.1865	0.4	0.627649
38.8279	0.45	0.645857
39.4225	0.5	0.664914
39.9754	0.55	0.685314
40.4855	0.6	0.707472
40.9471	0.65	0.731768
41.3519	0.7	0.758583
41.6896	0.75	0.788324
41.948	0.8	0.821446
42.1141	0.85	0.858477
42.1734	0.9	0.900043
42.1638	0.92	0.918104
42.1337	0.94	0.937067
42.082	0.96	0.956992
42.0477	0.97	0.967335
42.0077	0.98	0.977945
41.9617	0.99	0.98883
41.9096	1	1

IPA 48.9 °C
120 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
11.8636	0	0
14.2682	0.01	0.176377
16.1743	0.02	0.279608
17.691	0.03	0.346389
18.9017	0.04	0.392437
20.6484	0.06	0.450261
21.7769	0.08	0.483549
22.5105	0.1	0.504017
23.4189	0.15	0.52898
23.7512	0.2	0.538659
23.9065	0.25	0.543749
24.025	0.3	0.548281
24.1512	0.35	0.554045
24.292	0.4	0.561937
24.4396	0.45	0.572478
24.5803	0.5	0.58603
24.6987	0.55	0.602911
24.7787	0.6	0.623458
24.805	0.65	0.64807
24.7626	0.7	0.677239
24.6372	0.75	0.711593
24.4152	0.8	0.75194
24.0835	0.85	0.799329
23.63	0.9	0.855138
23.4118	0.92	0.880211
23.1715	0.94	0.90706
22.9084	0.96	0.935848
22.768	0.97	0.951026
22.6217	0.98	0.966758
22.4694	0.99	0.983074
22.3109	1	1

EtOH 48.9 °C
120 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
11.8636	0	0
13.146	0.01	0.106306
14.2798	0.02	0.184868
15.2852	0.03	0.245189
16.1791	0.04	0.292889
17.6892	0.06	0.363369
18.9033	0.08	0.412812
19.8907	0.1	0.449355
21.6758	0.15	0.509419
22.8559	0.2	0.54665
23.7013	0.25	0.573276
24.357	0.3	0.594682
24.9021	0.35	0.613622
25.3804	0.4	0.631666
25.8151	0.45	0.6498
26.2179	0.5	0.668701
26.5928	0.55	0.688882
26.9398	0.6	0.710767
27.2553	0.65	0.734748
27.534	0.7	0.761213
27.7691	0.75	0.790573
27.9524	0.8	0.823287
28.0752	0.85	0.859886
28.1276	0.9	0.901
28.1265	0.92	0.918875
28.1118	0.94	0.937649
28.0828	0.96	0.957382
28.0626	0.97	0.967629
28.0386	0.98	0.978141
28.0107	0.99	0.988928
27.9787	1	1

IPA 30.6 °C
87 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
4.43404	0	0
5.26965	0.01	0.166546
5.94148	0.02	0.267135
6.48332	0.03	0.333601
6.92151	0.04	0.38017
7.56519	0.06	0.439714
7.99106	0.08	0.474726
8.27428	0.1	0.496668
8.63694	0.15	0.524184
8.77462	0.2	0.535187
8.837	0.25	0.540778
8.87983	0.3	0.545256
8.92234	0.35	0.550591
8.96879	0.4	0.557803
9.01717	0.45	0.567503
9.06279	0.5	0.580125
9.09988	0.55	0.596047
9.12233	0.6	0.615667
9.12393	0.65	0.639443
9.09855	0.7	0.667947
9.04018	0.75	0.701905
8.94294	0.8	0.74226
8.80111	0.85	0.790256
8.60911	0.9	0.847556
8.51704	0.92	0.873561
8.41574	0.94	0.901587
8.30487	0.96	0.931839
8.24574	0.97	0.947872
8.18409	0.98	0.964552
8.11989	0.99	0.981916
8.05309	1	1

EtOH 30.6 °C
87 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
4.43404	0	0
4.8956	0.01	0.103097
5.30811	0.02	0.180502
5.67764	0.03	0.240677
6.00947	0.04	0.288744
6.57761	0.06	0.360603
7.04222	0.08	0.411658
7.42585	0.1	0.449764
8.13437	0.15	0.51311
8.61379	0.2	0.552734
8.96157	0.25	0.581057
9.23212	0.3	0.603635
9.45647	0.35	0.623343
9.65239	0.4	0.641836
9.82988	0.45	0.660161
9.99424	0.5	0.679034
10.1478	0.55	0.698998
10.2911	0.6	0.720496
10.4233	0.65	0.743929
10.5425	0.7	0.769686
10.6466	0.75	0.798174
10.7325	0.8	0.82984
10.797	0.85	0.865193
10.8364	0.9	0.904832
10.8443	0.92	0.922043
10.8472	0.94	0.940106
10.8449	0.96	0.959077
10.8418	0.97	0.968923
10.8372	0.98	0.979019
10.8312	0.99	0.989375
10.8237	1	1

IPA 65.6 °C
150 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
25.9673	0	0
31.4327	0.01	0.18165
35.7081	0.02	0.285685
39.0679	0.03	0.352008
41.7187	0.04	0.397233
45.4841	0.06	0.453313
47.8697	0.08	0.485124
49.3944	0.1	0.504447
51.2487	0.15	0.527724
51.9331	0.2	0.536885
52.2846	0.25	0.542194
52.5816	0.3	0.547416
52.9046	0.35	0.554165
53.2605	0.4	0.563221
53.6284	0.45	0.575019
53.9781	0.5	0.589857
54.2769	0.55	0.607996
54.4928	0.6	0.62972
54.5952	0.65	0.655369
54.5556	0.7	0.685363
54.3471	0.75	0.72024
53.945	0.8	0.760682
53.3261	0.85	0.807566
52.4687	0.9	0.862021
52.0545	0.92	0.886238
51.5976	0.94	0.91201
51.097	0.96	0.939463
50.8299	0.97	0.953864
50.5514	0.98	0.96874
50.2614	0.99	0.984111
49.9598	1	1

EtOH 65.6 °C
150 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
25.9673	0	0
28.8546	0.01	0.108777
31.382	0.02	0.18807
33.6021	0.03	0.248312
35.5589	0.04	0.295547
38.825	0.06	0.364676
41.4135	0.08	0.412683
43.4927	0.1	0.447908
47.1937	0.15	0.505398
49.6072	0.2	0.540949
51.3318	0.25	0.566549
52.6762	0.3	0.587401
53.8034	0.35	0.606129
54.7999	0.4	0.624217
55.7101	0.45	0.642588
56.5545	0.5	0.661871
57.3391	0.55	0.682545
58.0612	0.6	0.70501
58.7126	0.65	0.729637
59.2811	0.7	0.756795
59.7519	0.75	0.786884
60.1083	0.8	0.820349
60.3318	0.85	0.857709
60.4026	0.9	0.899578
60.3834	0.92	0.91775
60.3351	0.94	0.936815
60.2562	0.96	0.956835
60.2047	0.97	0.967222
60.1451	0.98	0.977872
60.0771	0.99	0.988795
60.0005	1	1

IPA 81.1 °C
178 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
49.5517	0	0
60.1378	0.01	0.183759
68.3147	0.02	0.287438
74.6663	0.03	0.352862
79.6246	0.04	0.397122
86.5722	0.06	0.451518
90.9046	0.08	0.482072
93.6417	0.1	0.500509
96.9569	0.15	0.522748
98.2404	0.2	0.531977
98.9835	0.25	0.538013
99.6566	0.3	0.544355
100.383	0.35	0.552451
101.164	0.4	0.562971
101.956	0.45	0.576271
102.703	0.5	0.592589
103.347	0.55	0.612138
103.834	0.6	0.635153
104.113	0.65	0.661917
104.138	0.7	0.692788
103.866	0.75	0.728217
103.26	0.8	0.768774
102.283	0.85	0.815181
100.904	0.9	0.868353
100.233	0.92	0.891767
99.4912	0.94	0.916536
98.6772	0.96	0.942756
98.2426	0.97	0.956444
97.7892	0.98	0.970537
97.3169	0.99	0.98505
96.8256	1	1

EtOH 81.1 °C
178 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
49.5517	0	0
55.1713	0.01	0.110531
60.0434	0.02	0.190149
64.2852	0.03	0.250093
67.9934	0.04	0.29676
74.1169	0.06	0.364523
78.9095	0.08	0.411213
82.7208	0.1	0.445296
89.4314	0.15	0.500735
93.7821	0.2	0.535145
96.9072	0.25	0.560226
99.3698	0.3	0.580986
101.458	0.35	0.599919
103.321	0.4	0.618418
105.031	0.45	0.63734
106.62	0.5	0.657268
108.095	0.55	0.678643
109.45	0.6	0.701835
110.668	0.65	0.727186
111.728	0.7	0.755042
112.603	0.75	0.785775
113.264	0.8	0.819801
113.68	0.85	0.857602
113.817	0.9	0.899751
113.786	0.92	0.917977
113.702	0.94	0.937058
113.564	0.96	0.957048
113.473	0.97	0.967403
113.368	0.98	0.978007
113.247	0.99	0.98887
113.112	1	1

iPA 157.8 °C
316 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
542.018	0	0
639.835	0.01	0.160685
710.42	0.02	0.25005
762.179	0.03	0.305735
800.718	0.04	0.343039
852.193	0.06	0.388628
883.397	0.08	0.414618
903.629	0.1	0.431184
933.049	0.15	0.455815
951.977	0.2	0.473036
968.451	0.25	0.489755
984.347	0.3	0.50797
999.901	0.35	0.528284
1014.92	0.4	0.55085
1029.15	0.45	0.57568
1042.34	0.5	0.602748
1054.3	0.55	0.632029
1064.89	0.6	0.663515
1074.02	0.65	0.697216
1081.6	0.7	0.733162
1087.6	0.75	0.771401
1092	0.8	0.812002
1094.78	0.85	0.85505
1095.96	0.9	0.900649
1095.98	0.92	0.919629
1095.75	0.94	0.939045
1095.26	0.96	0.958906
1094.92	0.97	0.969006
1094.52	0.98	0.979221
1094.06	0.99	0.989552
1093.54	1	1

EtOH 157.8 °C
316 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
542.018	0	0
600.384	0.01	0.105814
648.313	0.02	0.179169
688.126	0.03	0.232912
721.562	0.04	0.273953
774.289	0.06	0.332575
813.837	0.08	0.372709
844.672	0.1	0.402323
899.698	0.15	0.45299
938.491	0.2	0.488414
969.761	0.25	0.517812
997.085	0.3	0.544781
1022.04	0.35	0.570952
1045.33	0.4	0.597144
1067.29	0.45	0.623815
1088.07	0.5	0.651246
1107.7	0.55	0.679628
1126.19	0.6	0.70911
1143.52	0.65	0.73982
1159.65	0.7	0.771878
1174.53	0.75	0.805408
1188.12	0.8	0.840536
1200.37	0.85	0.877401
1211.21	0.9	0.916152
1215.14	0.92	0.932218
1218.84	0.94	0.948623
1222.29	0.96	0.96538
1223.93	0.97	0.973895
1225.5	0.98	0.982502
1227.01	0.99	0.991203
1228.46	1	1

IPA 85.4 °C
185.7 °F

VAPOR PRESSURE	x_1 (isopropanol)	y_1 (isopropanol)
kPa	mol/mol	mol/mol
58.5683	0	0
71.0938	0.01	0.183903
80.7343	0.02	0.287317
88.1987	0.03	0.352422
94.0087	0.04	0.396388
102.12	0.06	0.450311
107.159	0.08	0.480537
110.334	0.1	0.498758
114.185	0.15	0.520799
115.705	0.2	0.530138
116.617	0.25	0.53646
117.454	0.3	0.54319
118.353	0.35	0.551728
119.312	0.4	0.562713
120.278	0.45	0.576479
121.188	0.5	0.593251
121.975	0.55	0.613226
122.576	0.6	0.636627
122.935	0.65	0.663721
122.999	0.7	0.694849
122.721	0.75	0.730437
122.059	0.8	0.771026
120.974	0.85	0.817296
119.431	0.9	0.870105
118.679	0.92	0.893294
117.846	0.94	0.917782
116.931	0.96	0.943661
116.443	0.97	0.957152
115.933	0.98	0.971029
115.402	0.99	0.985307
114.85	1	1

EtOH 85.4 °C
185.7 °F

VAPOR PRESSURE	x_1 (ethanol)	y_1 (ethanol)
kPa	mol/mol	mol/mol
58.5683	0	0
65.2382	0.01	0.110904
71.0052	0.02	0.19054
76.0136	0.03	0.250357
80.3821	0.04	0.29684
87.5748	0.06	0.364202
93.1857	0.08	0.410527
97.6364	0.1	0.444308
105.455	0.15	0.499237
110.522	0.2	0.533402
114.171	0.25	0.558414
117.058	0.3	0.579221
119.515	0.35	0.598279
121.713	0.4	0.616954
123.733	0.45	0.636085
125.611	0.5	0.656241
127.354	0.55	0.677852
128.955	0.6	0.701277
130.395	0.65	0.726851
131.647	0.7	0.754911
132.683	0.75	0.785819
133.469	0.8	0.81998
133.969	0.85	0.857864
134.146	0.9	0.900027
134.117	0.92	0.918234
134.028	0.94	0.93728
133.875	0.96	0.957217
133.774	0.97	0.967538
133.656	0.98	0.978103
133.52	0.99	0.988921
133.368	1	1